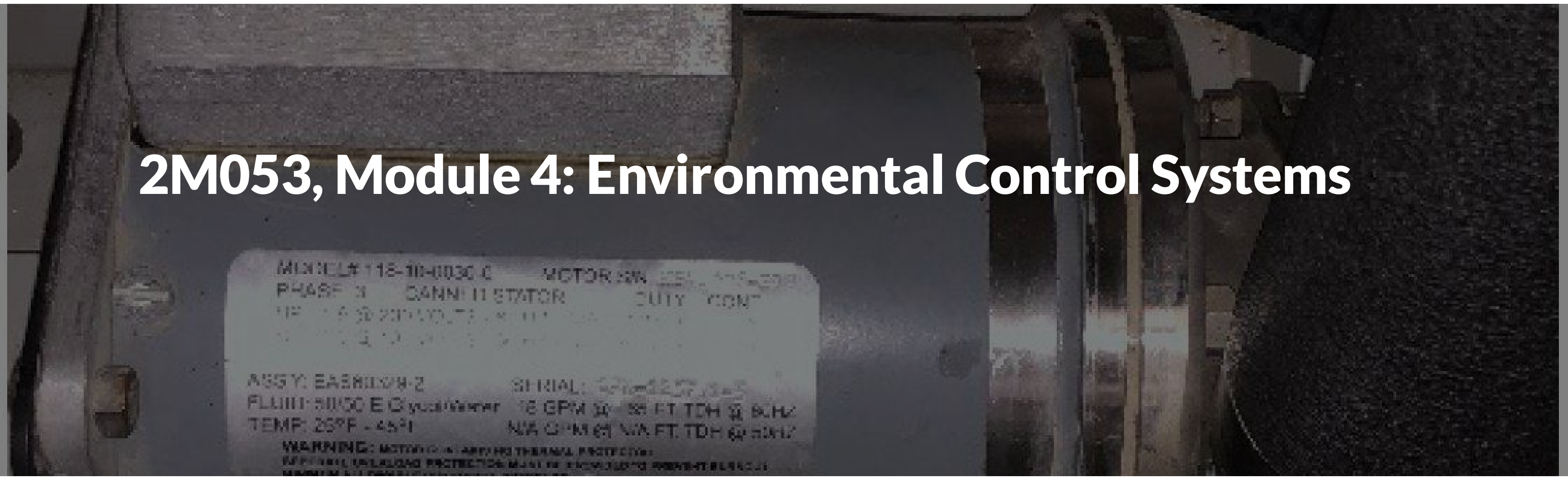


2M053, Module 4: Environmental Control Systems

This fourth module of career development course (CDC) 2M053, Missile and Space Facilities Journeyman, will provide an in-depth look at environmental control systems. There will be refrigeration fundamentals with an in-depth look at how to use test equipment, and how the components operate. Then the launch facility and missile alert facility environmental control systems will be broken down to ensure you are familiar with them. These lessons will teach you how to read and interpret environmental control system schematics and wiring diagrams.

Lesson 1 provides fundamentals of refrigeration. You will learn terms and principles about refrigeration and learn about refrigerant itself. This lesson will also provide in-depth information on typical components used in refrigeration in our environmental control system. Lastly, we will look at the devices that control and monitor our refrigeration system. Lesson 2 provides an in-depth look at test equipment used to monitor, diagnose, and repair a refrigeration system. This lesson will also introduce you to test equipment used for maintenance on the remainder of the environmental control system and will begin launching into the system itself by exploring the control net and fiber-optic devices of the launch facility and missile alert facility systems. Lesson 3 presents a step-by-step look at the subsystems that comprise the launcher support building and launcher equipment room portions of the environmental control systems. You will learn how the system works and how to read and interpret schematics and wiring diagrams. Lesson 4 concludes our look at environmental control systems by exploring the systems on the missile alert facility. The lesson is split into sections that cover the launch control equipment building and the launch control center subsystems, primarily of Wings 3 and 5. The differences between Wing 1 and these systems are explained where necessary.

Code numbers on figures are for preparing agency identification only. The use of a name of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

To get a response to your questions concerning subject matter in this course, or to point out technical errors in this module, knowledge checks, practice exercises, or course examination, please have your supervisor/UTM e-mail Air Force Career Development Academy (AFCDA) Support Services at 2AF.AFCDA.SupportServices@us.af.mil or call commercial: 228-377-7044/DSN: 597-7044, if you have any issues with AFCDA courseware. Support Services hours are: 0730-1630 Central standard time (CST).

Lesson 1. Fundamentals of Refrigeration

MAIN POINTS

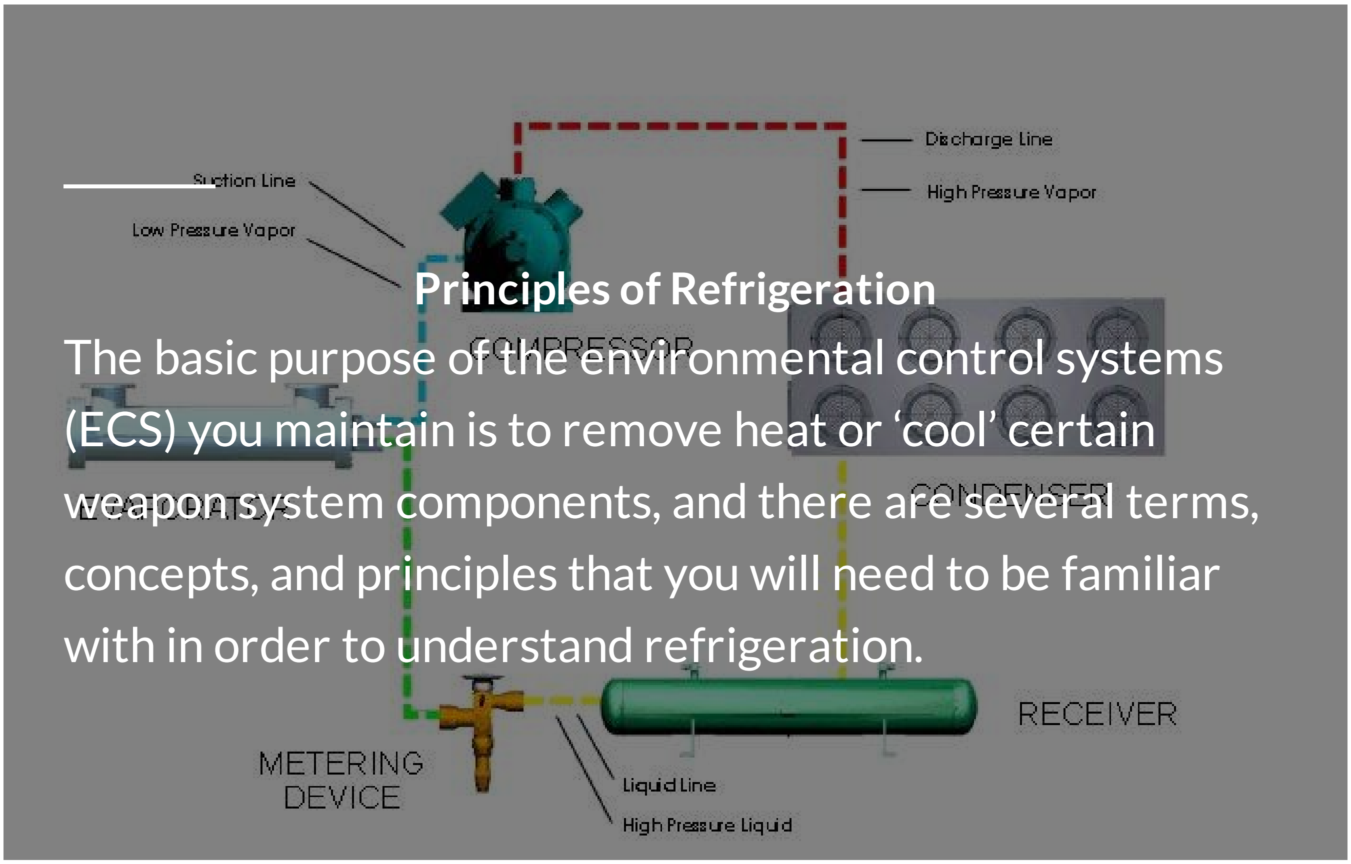
1. Principles of refrigeration
2. Heat transfer process
3. High-pressure refrigeration system components
4. Low-pressure refrigeration system components

Refrigeration systems are dynamic systems that serve as the central method of cooling electronic equipment at missile alert facilities (MAF), launch facilities (LF), and in the support vehicles used to transport and store missile system components. As a facilities maintenance section (FMS) technician you must have a sound understanding of how a refrigeration system works and the components that make it operate.

This lesson will cover refrigeration fundamentals and the heat transfer process as a whole. It will also detail the high- and low-

pressure components in a standard refrigeration system before explaining the devices used to control and monitor the system. All of this information is vital to understand the remainder of this module.

Click here to begin Lesson 1 of Module 4.



Principles of Refrigeration

The basic purpose of the environmental control systems (ECS) you maintain is to remove heat or 'cool' certain weapon system components, and there are several terms, concepts, and principles that you will need to be familiar with in order to understand refrigeration.

Refrigeration Terms and Laws

There are several terms we use when working with or explaining the ECS, and it is important that you understand what these terms mean. There are also laws that explain the science behind how a refrigeration cycle works. Let's break down the laws of thermodynamics and explore these terms.

Refrigeration Terms and Laws

Heat Transfer

When learning about any system that cools (removes heat) a space or an object, it is important to know that heat only travels from a hot substance to a colder substance. An example is a hot mug of coffee—the heat from the coffee travels through the cooler material of the mug and into your hand, not the other way around.

Refrigeration Terms and Laws

Refrigeration

In general, refrigeration is the process of removing heat from a substance or space where it isn't wanted and transferring it to another substance or space where it is less objectionable. An example of this is your refrigerator—you want the food and beverages inside of it to be cold, so heat is removed from the inside of the container. The heat transfers through the refrigerant to the outside of the container where it is of less concern.

All of the ECS you will maintain work in this exact same way. The system removes heat from a space or specific piece of equipment and transfers it elsewhere.

Refrigeration Terms and Laws

Heat

Heat is a form of energy that affects the molecular movement of a substance. All substances possess some amount of heat, and some have more than others. Adding heat causes the molecules to become 'excited' and move around more quickly, which causes the substance to expand. Removing heat has the opposite effect on the molecules, which causes the substance to contract. Most substances undergo a change in their physical state when adding or removing heat. For instance, water freezes at 32 degrees Fahrenheit (°F), meaning that molecular movement has slowed to the point that the water is able to maintain its own shape (ice cube). Adding heat to the ice will cause the ice cube to melt; adding more

heat causes the water to boil and turn into a vapor. This basic principle is the foundation for the refrigeration cycle.
The terms heat and temperature can be easily confused, and the terms heat intensity and heat quantity will help to clarify.

1. Heat intensity

Heat intensity indicates how quickly the molecules in a substance are moving. A thermometer measures heat intensity in degrees. Think of a single drop of water and then another entire gallon of water heated to 200°F—both quantities of water have the same heat intensity, or temperature, of 200°F regardless of their quantity.

2. Heat quantity

The term for expressing how much heat a substance possesses is British thermal units (BTU) which is derived from a combination of a substance's temperature and mass. This is where the comparison of the drop of water versus the gallon of water begins to make more sense. A drop of 200°F water would be useless for making hard-boiled eggs, whereas a gallon of 200°F water would do the job nicely. The drop of water is technically hot enough to boil eggs but does not possess enough mass. The cool shell of the first egg will cause heat from the drop of water to immediately dissipate because there simply is not enough hot water to boil the eggs.

Using the term BTU, in reference to a refrigeration system, indicates how much heat the system can remove in one hour. For example, if 5,000 BTU need to be removed from your refrigerator per hour in order to keep your food and beverages cool, but the refrigeration system is only capable of removing 4,000 BTU per hour, your food and beverages will not stay as cold.

Refrigeration Terms and Laws

Cold

Cold is a comparative term meaning one substance contains less heat than another substance. Cold is not product itself but merely the result of removing heat. For example, the hot water in your bath will eventually lose all of its heat to your body, the bathtub, and the surrounding air. If you sat in the bath water long enough, the heat transfer process (hot to cold) would cease when your body, the water, the bathtub, and the air were all the same temperature. This would mean that the molecules in all four substances were moving at the same speed. You would have to add more hot water into the bath to make the water hot again, and the heat transfer process would start over again as well. Without some outside source of energy, you, your bathwater, and your surroundings would exchange heat until all were the same temperature.

Refrigeration Terms and Laws

Pressure

A refrigeration system cannot operate optimally without pressure differences among its various units and components. Pressure is the amount of force that is exerted per unit of an area and is expressed in pounds per square inch (psi). For example, if the air in the tube inside of your bicycle tire increases to 30 psi, 30 pounds of pressure are pressing on every 1 square inch of the tube. More pressure would cause your bicycle tire to feel harder because more pressure exists inside the tube. Conversely, when there is not enough pressure inside of your bicycle tube, the tire feels softer.
The three different pressure measurements you need to understand are atmospheric, gauge, and absolute.

1. Atmospheric pressure
This is the downward pressure that the weight of the atmosphere exerts on the earth's surface. It is 14.7 psi at sea level and decreases as elevation increases.

2. Gauge pressure
This is the pressure measured in pounds per square inch gauge (psig) and most gauges already have atmospheric pressure factored in. For example, a gauge reading of 10 psig, indicates that the pressure is 10 psi above atmospheric. Most gauge calibrations include adjustment for altitude changes.

3. Absolute pressure

This is the sum of atmospheric and gauge pressures. For example, if a gauge reading indicates 190 psig and atmospheric pressure is 12 psi, then the absolute pressure is:

190 psig + 12 psi = 202 psi absolute (psia)

Refrigeration Terms and Laws

Volume/Temperature/Pressure Relationships

Volume, temperature, and pressure all have a direct effect on one another, and the unique relationship between them is the basis for the foundation of a refrigeration system.

1. Temperature and pressure

Temperature and pressure are directly proportional, meaning that an increase in one will cause a proportional increase in the other, and vice versa. All refrigeration systems rely on this relationship between temperature and pressure. Controlling the pressure inside the refrigeration system is what enables the system to control the temperature of the refrigerant—the temperature of the refrigerant directly controls the temperature of the object being cooled. Refrigerant continuously changes states (liquid to gas and gas to liquid) during the refrigeration cycle and controlling the pressure within the system allows control of what temperature the refrigerant changes state. Figure 1–1 illustrates an example of how water boils at different temperatures based on the atmospheric pressure at different altitudes:

- Atmospheric pressure is 14.7 psi at sea level, and water will boil at 212°F.
- The atmospheric pressure is 10.1 psi at 10,000 feet of elevation, and water will boil at 193°F, meaning that less heat is required to make the water boil.
- Conversely, atmospheric pressure increases below sea level and more heat is needed to make the water boil.
- The pressure in the system controls the temperature at which the refrigerant changes state.

2. Volume

Temperature and pressure increase when volume decreases—meaning they are inversely proportional. As the piston in the diesel engine moves upward, the volume inside of the cylinder decreases—the air inside the cylinder then increases in both pressure and temperature. The reverse happens when the piston moves downward—the volume of air inside increases and the pressure and temperature decrease (fig 1–2). Deliberately forcing the refrigerant to flow through tubing of different diameters causes changes in pressure.

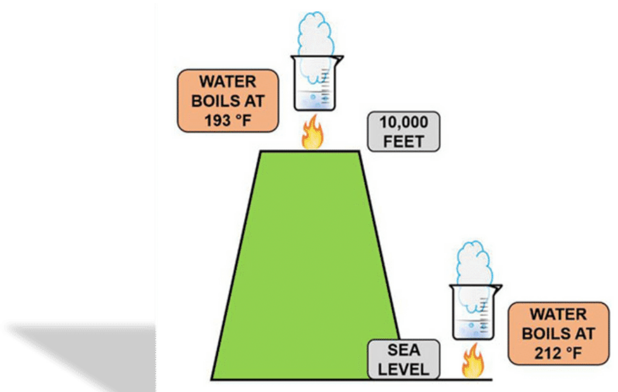


Figure 1–1. Temperature/pressure relationship.

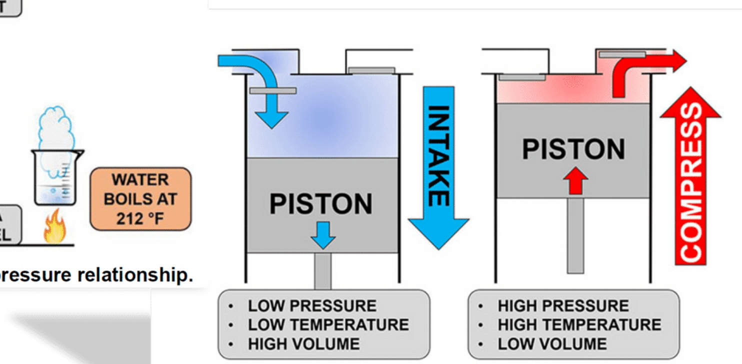


Figure 1–2. Volume/temperature/pressure relationship.

Review content before moving on in the lesson.

Refrigerant Characteristics and Types

The refrigerants used in the systems you perform maintenance on were specifically chosen because of their characteristics. A refrigerant is any substance that can change state to remove and transfer heat; in fact, early refrigeration systems used ice, air, ammonia, and carbon dioxide. Although many different substances are available, special chemical compounds work best because they have certain qualities that are desirable in a refrigerant.

Characteristics

The following are desirable characteristics for a refrigerant to possess:

1. Safe
2. Low boiling point
3. Low condensing pressure
4. Stable
5. Noncorrosive
6. Small relative displacement

Characteristics For a Refrigerant

Safe

Safe refrigerant are nonflammable, nonexplosive, and nontoxic.

Characteristics For a Refrigerant

Low boiling point

A low boiling point is necessary so that the refrigerant can absorb heat even at very low temperatures. For example, the most common refrigerants used in our missile site and support equipment systems have a boiling point of -15.7°F to -41.7°F at sea level.

Characteristics For a Refrigerant

Low condensing pressure

At lower pressures, a gas will condense (change from a gas to a liquid) at a lower temperature, which allows the use of condensers that are air cooled. It is also desirable to maintain the refrigeration cycle pressures as close to atmospheric pressure as possible. This is important because any great differences in pressure tend to cause leaks, overwhelm the compressor, and reduce the overall efficiency of the system.

Characteristics For a Refrigerant

Stable

A refrigerant constantly changes state while it is traveling through the refrigeration system—at one location it may be a high-pressure/high-temperature vapor, and a low-pressure/low-temperature at another location. The refrigerant needs to remain chemically unchanged and not deteriorate, separate, or dilute when it comes into contact with moisture (water in the system). Refrigerant cannot react chemically with the lubricating oil that also circulates throughout the system.

Characteristics For a Refrigerant

Noncorrosive

The refrigerant in our systems must be noncorrosive in order to avoid deterioration of the metal tubing and parts through which it flows. Leaks could develop if there was a reaction between the refrigerant and the components in the system.

Characteristics For a Refrigerant

Small relative displacement

Because of the positive characteristics of having a low boiling point and low condensing pressure, the refrigerant used in our systems has a small displacement. This means that a small amount of refrigerant can absorb a relatively large amount of heat, which reduces the total amount needed for a system to operate properly. This in turn reduces costs and potential harm to the environment.

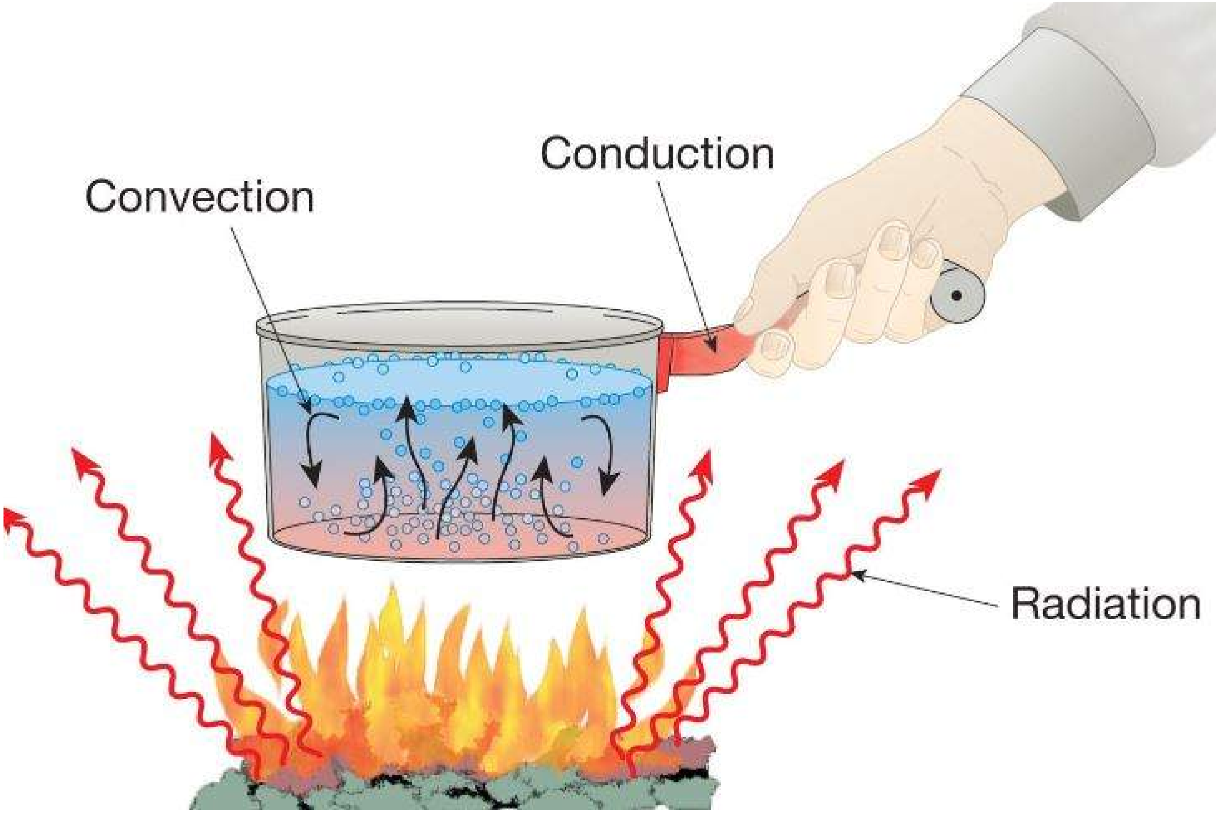
This lesson focused on the terms and basic concepts you will need to be familiar with in order to understand how a refrigeration system operates, as well as the desirable characteristics of a good refrigerant.

Review content before moving on in the lesson.

Heat Transfer Process

Whether the ECS removes heat from the electronic racks or controls the temperature inside the trailer of a loaded payload transporter, the refrigeration process relies on the transfer of heat. This lesson will explore the different ways that heat is transferred and we will also take a look at the locations where heat is transferred with the launch facility ECS.

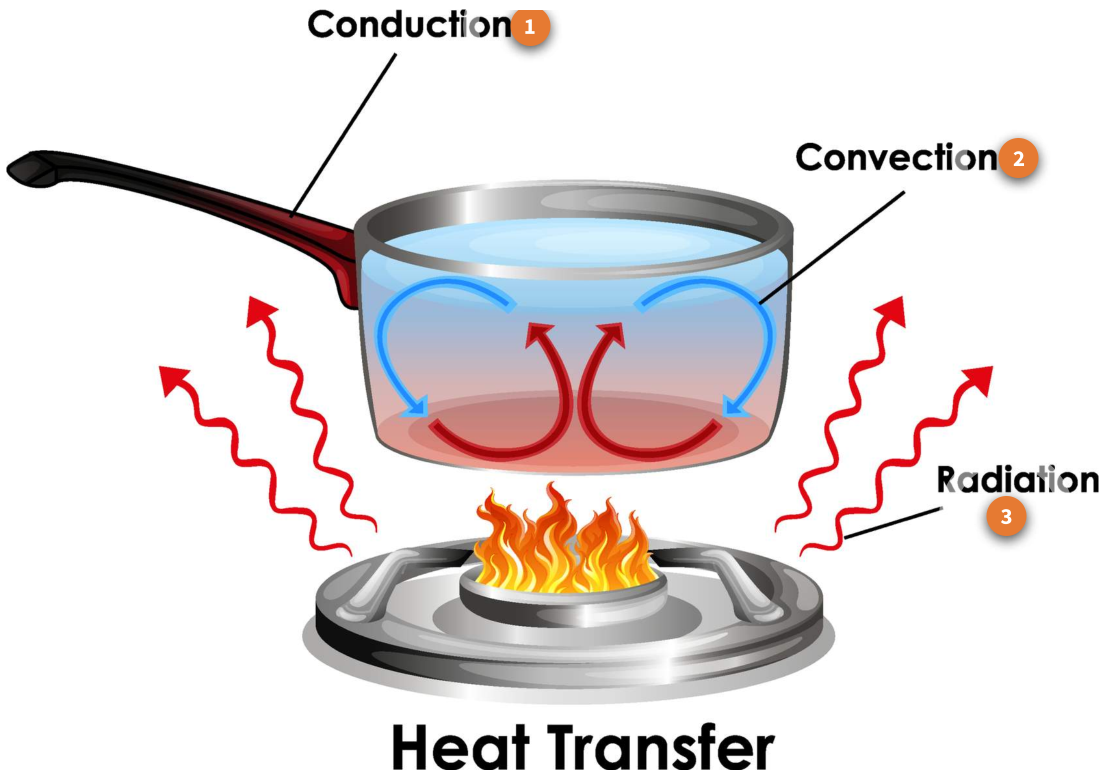
Complete the content above before moving on.

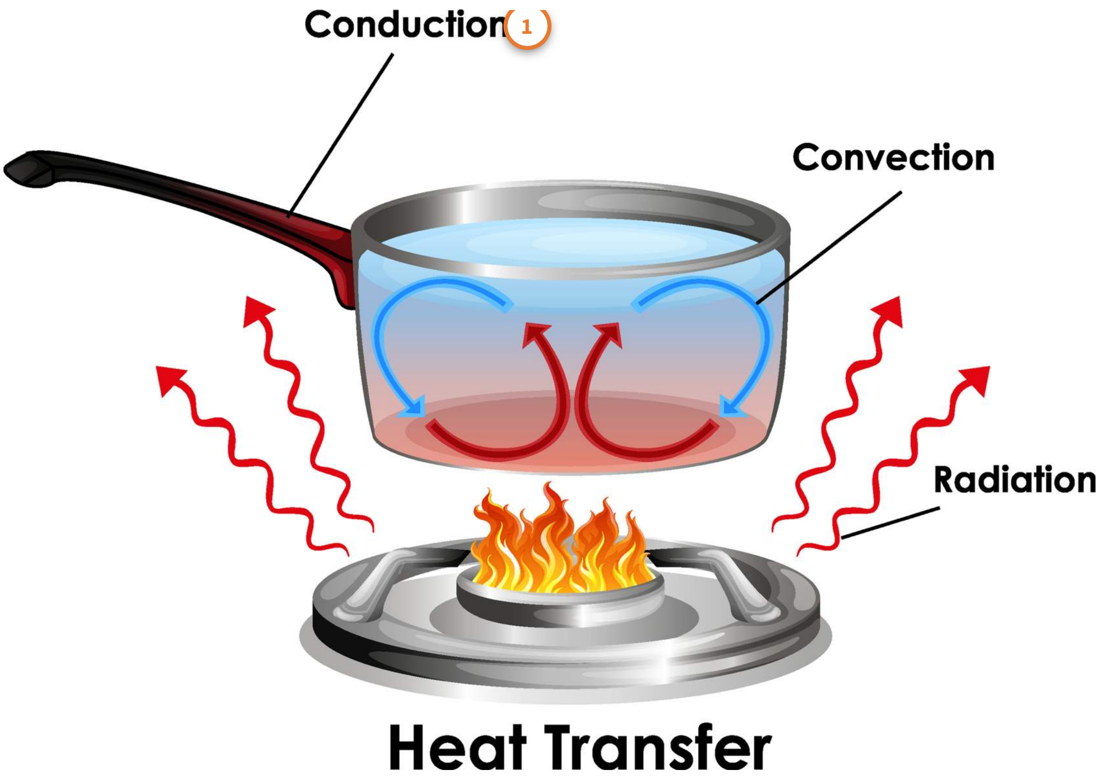


Different Types of Heat Transfs.

Heat Transfer Methods

You know that heat transfer will only continue until all substances involved reach the same temperature—refer back to the example of your bathwater getting cold. The speed of heat transfer depends on the size of the temperature difference between the substances; the greater the temperature difference, the faster the heat transfer will take place. Conduction, convection, or radiation, or a combination of these methods will transfer heat.


Conduction 1
Convection 2
Radiation 3
Heat Transfer



Conduction

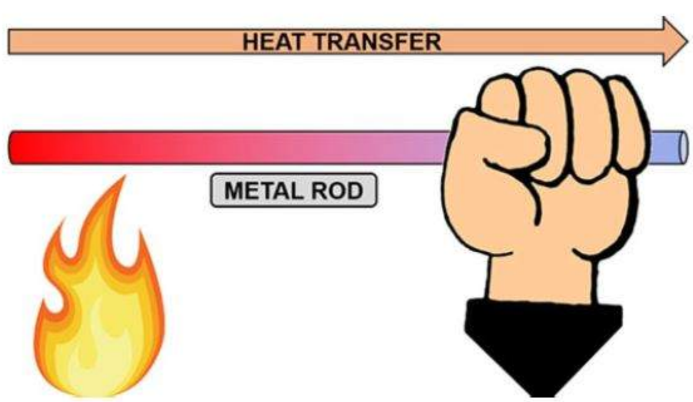
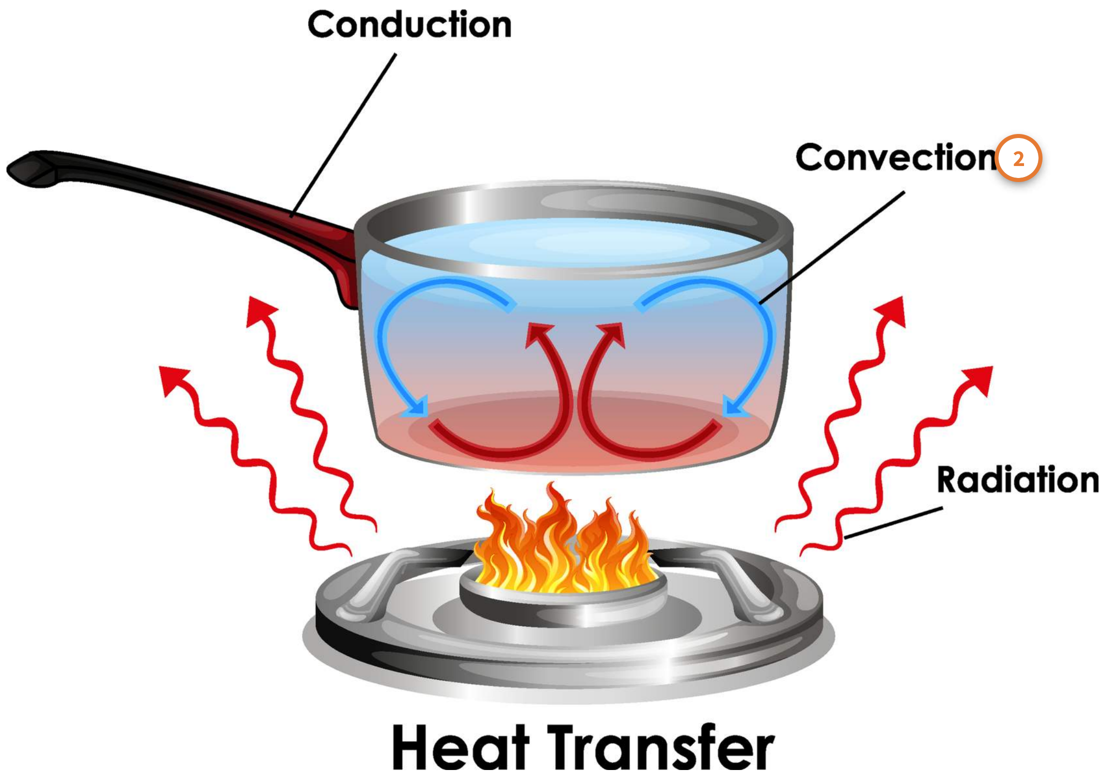


Figure 1–3. Heat transfer by conduction.

Heat transfer by conduction (fig 1–3) occurs when objects or substances are in direct contact. For example, the heat from the fire will move from the hot molecules of the rod to the cooler ones until it reaches your hand. Heat also transfers to the air molecules surrounding the rod.

Conduction only works with substances that have good conductivity. Metals and liquids are usually good conductors, whereas substances like glass or cork are poor conductors. If a substance conducts heat poorly or does not conduct it at all, it is an insulator that can prevent heat transfer through conduction.



Convection

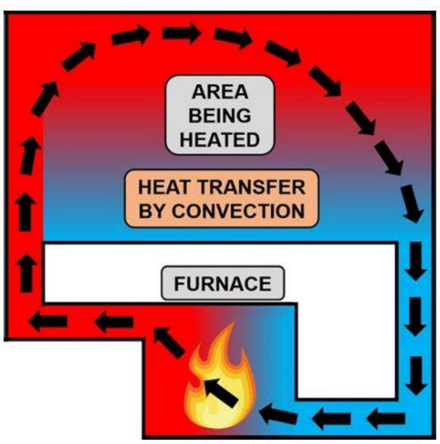


Figure 1–4. Heat transfer by convection.

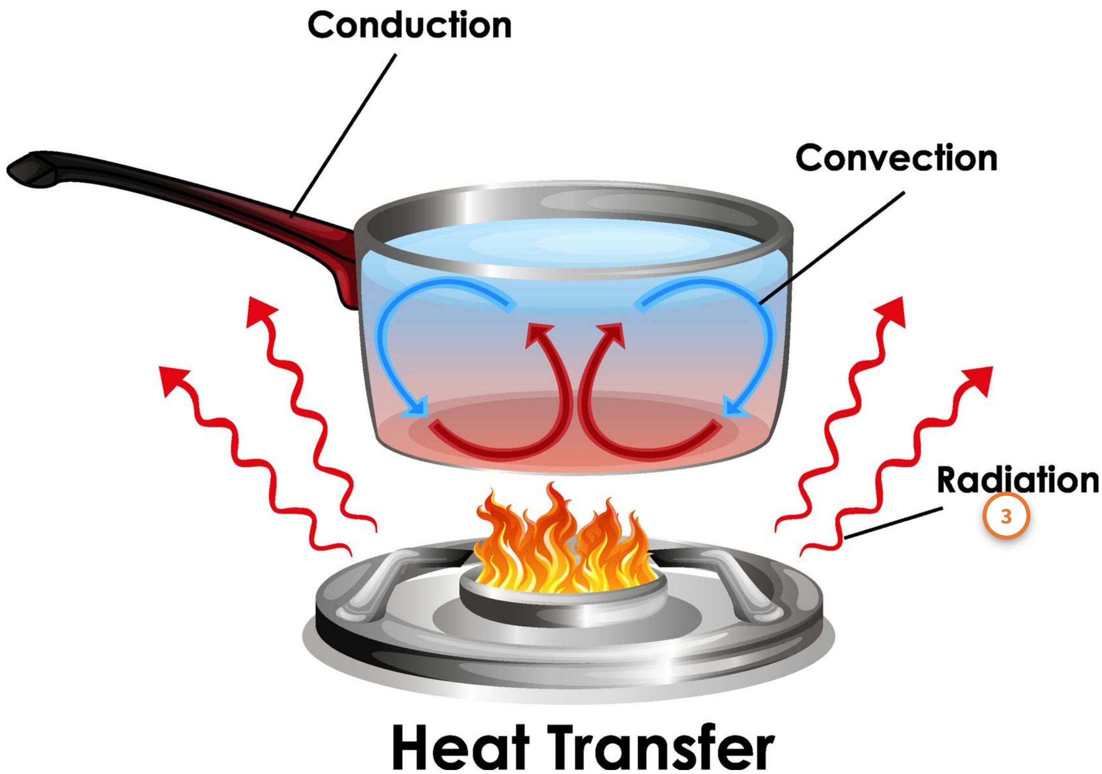
Convection is the movement of heat from one substance or object to another through a fluid or air. There are two types of convection—natural and forced.

Natural convection

In natural convection (fig 1–4), a heat source heats fluid or air, which changes the density of the substance. The hotter fluid or air will rise and then cool as it transfers its heat to another substance. Other hot fluid or air displaces the now cooler, denser fluid or air moving it downward, back toward the heat source to reheat again. This cycle of hot fluid or air displacing cooler fluid or air will continue indefinitely as long as there is a heat source.

Forced convection

Forced convection follows the same process as natural convection, but an internal source such as a fan or pump moves the fluid or air. A fan blowing cool air over a hotter object is an example of forced convection.



Radiation

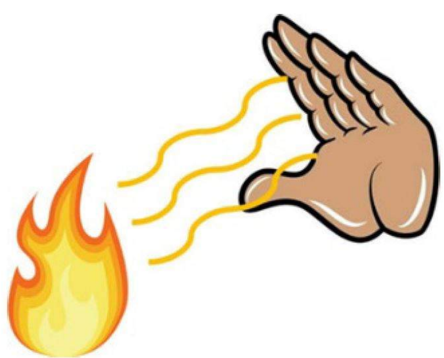


Figure 1–5. Heat transfer by radiation.

Radiation (fig 1–5) is the transfer of heat from a central source without a material carrier, and a great example is the heat you feel from a flame even though you are not touching it.

Click on each number on the image before moving forward in the lesson.

Heat Terminology

The refrigeration cycle that the ECS in our missile sites and support equipment primarily uses conduction and forced convection for heat transfer. There are several other terms related to heat transfer that you should know before we dive into the refrigeration cycle.

Sensible Heat

Sensible heat is heat added to or removed from a substance that causes a change in temperature but does not cause a change in state. This type of heat is mostly limited, meaning that the substance will eventually change state (liquid to gas, gas to liquid) if you add or remove too much heat. A gas can receive an unlimited amount of sensible heat because there is no other state for it to change into.

There are different terms to describe adding and removing heat to both a liquid and a gas as described in the following sections.

Flip each flash card to learn about the different terms to describe adding and removing heat to both a liquid and a gas.

Subcooling

Removing sensible heat from a liquid is called subcooling. This is limited because removing too much heat from a liquid will simply cause it to undergo a change state and transform it into a solid.

Saturation

Saturation is the process of adding sensible heat to a liquid. This is limited because adding too much heat to a liquid will simply cause it to undergo a change state and transform it into a gas.

Desuperheating

Desuperheating is the process of removing sensible heat from a gas. This is limited because removing too much heat from a gas will simply cause it to change state into a liquid.

Superheating

Superheating is adding heat to a gas. This is unlimited because adding heat to a gas will only cause an increase in temperature since the gas cannot undergo another change of state.

Click and flip each card before moving forward in the lesson.

Latent Heat

Latent heat is adding heat to or removing heat from a substance that causes a change in state but does not cause a change in temperature.

Latent Heat

Latent heat of melting

If you were to add heat to a container of ice, you would see the temperature rise on a thermometer until it reached 32°F and began to melt. More heat would still need to be added to the ice in order for it to continue to melt, but the thermometer would not indicate any further rise in temperature past 32°F until all of the ice had melted into water. In other words, any change shown by the thermometer before or after the ice changed to water would be in the form of sensible heat. The heat added between when the thermometer hit 32°F and the ice completely melted would be latent heat of melting.

Latent Heat

Latent heat of vaporization

If you were to add heat to a container of water, you would see the temperature increase on a thermometer until the water reached 212°F and began to boil. More heat would still need to be added to the water in order for it to continue to evaporate, but the thermometer would not indicate any further rise in temperature past 212°F until all of the water had changed state into steam. In other words, any change shown by the thermometer before or after the water changed to steam would be in the form of sensible heat. The heat added between when the thermometer hit 32°F and the water completely evaporated would be latent heat of vaporization.

Remember, latent heat works in both directions. If you were attempting to turn water into ice, you would be able to see the temperature drop on the thermometer until it reached 32°F—at which point it would no longer display any decrease in temperature until all of the water had turned to ice. The same would be true when removing heat to condense steam into water.

Refrigeration Cycle

The refrigeration cycle (fig 1–6) is a great example of the heat transfer process, and it is the core of any ECS. The following two principles are very important to the refrigeration cycle:

1. The dividing points for pressure in the system are the compressor and the thermal expansion valve (TXV).

2. The dividing points for the state of the refrigerant (liquid or gas) are the condenser and the evaporator.

We will discuss these components in the next lesson.

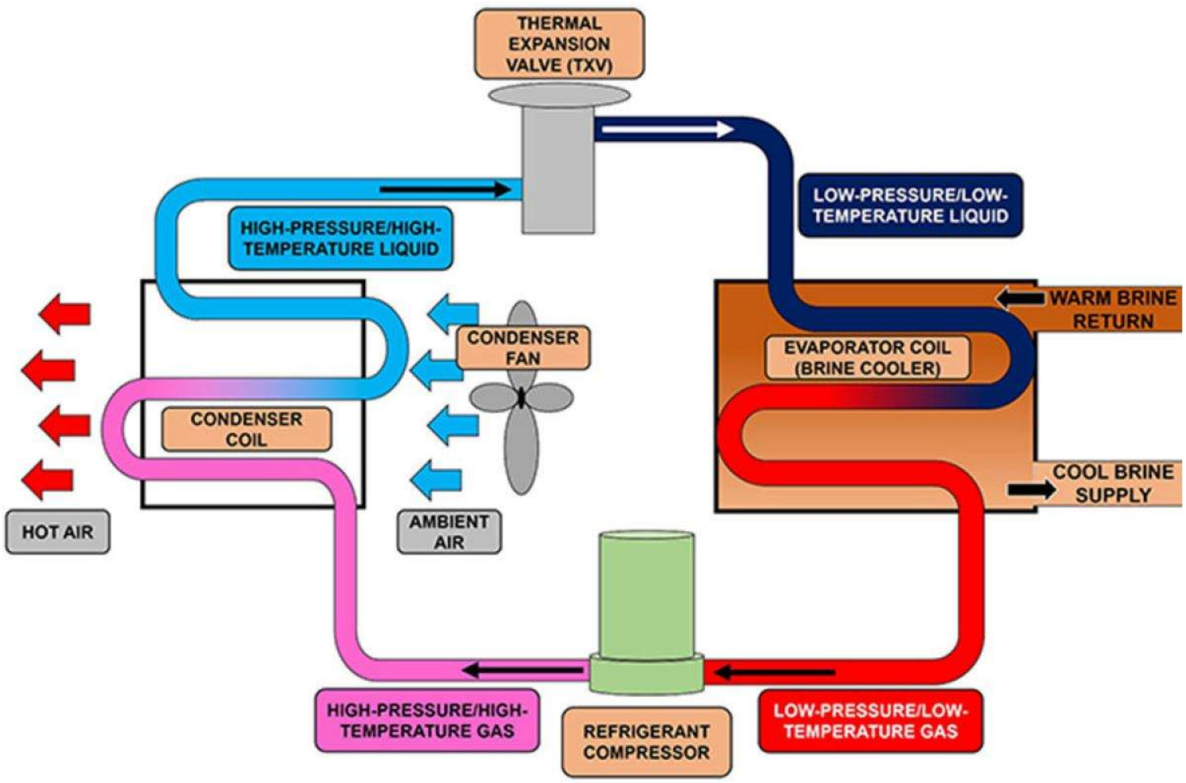


Figure 1–6. Refrigeration Cycle.

Refrigerant Compressor Operation

The refrigerant compressor (fig 1–6 as shown above.) is the heart of the refrigeration cycle and is the component that causes refrigerant to circulate throughout the system. Refrigerant is drawn into the compressor as a low-pressure/low-temperature gas, is compressed, and exits the compressor as a high-pressure/high-temperature gas. The volume of the refrigerant decreases inside the compressor causing an increase in temperature and pressure. This is the first point in the system where a change in pressure occurs.

Condenser Operation

The condenser (fig 1–7) is the component in the refrigeration system that removes heat from the refrigerant. A continuous length of copper tube that winds back and forth in an 'S' pattern is used so that the refrigerant spends enough time in the condenser to transfer its heat to the cooling medium. Desuperheating takes place in the condenser since the refrigerant is still in the form of a high-pressure/high-temperature gas. Most of the systems you perform maintenance on as a 2M0X3 use condensers that transfer heat from the refrigerant to air being drawn through the condenser coil by a large fan.

Remember that the refrigerant can only be desuperheated to a certain point before it condenses back into a liquid. The heat removed that causes the refrigerant to change state from a gas back to a liquid is referred to as latent heat of condensation, and the point at which the refrigerant begins to change into a liquid is called the condensing point. Latent heat of condensation will continue to take place until all refrigerant has changed into a liquid, which is the liquid point. All remaining gaseous refrigerant liquefies in the last few coils of the condenser and will continue to lose some sensible heat. Subcooling takes place when a liquid continues to lose sensible heat and subcooling will continue until the refrigerant reaches the next major component in line, the expansion valve.

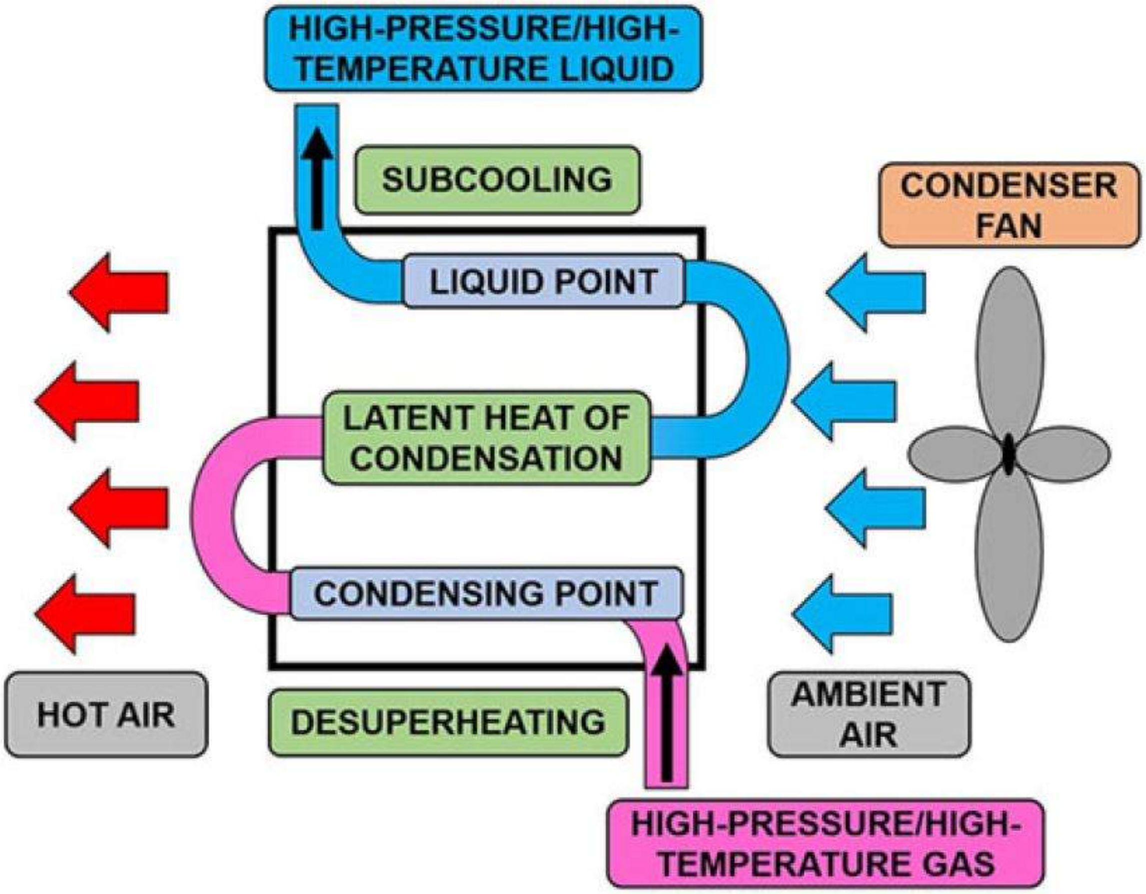


Figure 1–7. Condenser Operation.

Thermal Expansion Valve Operation

The refrigerant exits the condenser as a high-pressure/high-temperature liquid and flows through another line of copper tubing before entering the TXV (fig 1–8). The TXV increases the volume of the refrigerant line, causing the refrigerant to decrease in both pressure and temperature. This simple process of decreasing refrigerant pressure and temperature without transferring any heat is known as adiabatic expansion. Low-pressure/low-temperature liquid refrigerant exits the TXV and moves into the low side of the refrigeration system.

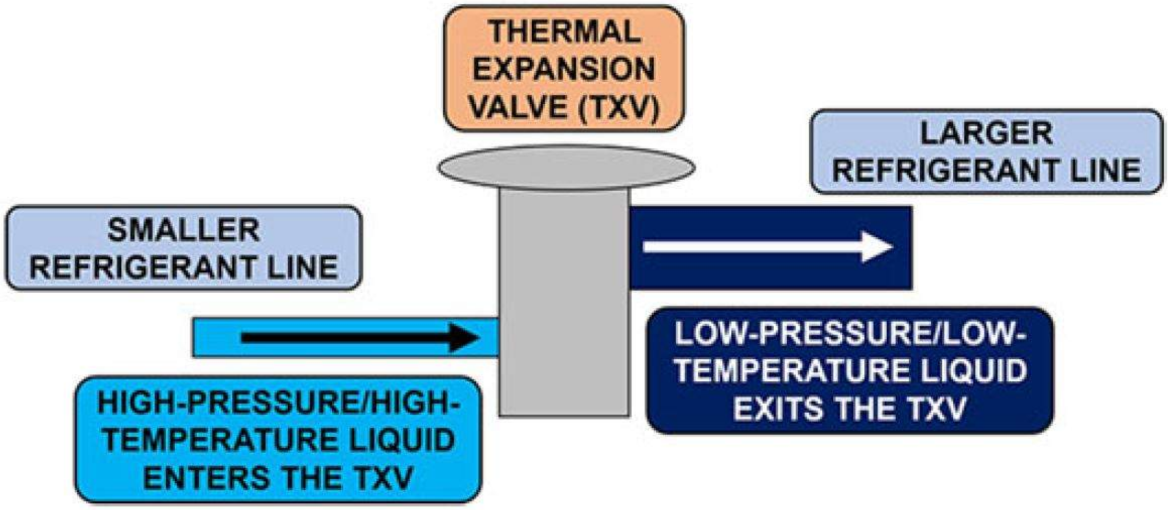


Figure 1–8. Thermal Expansion Valve Operation.

Evaporator Operation

Refrigerant flows out of the expansion valve, through another length copper tubing, and enters the evaporator. The evaporator (fig 1–9) is where the low-pressure/low-temperature liquid refrigerant removes heat from the medium that needs to be cooled, and this is where the refrigerant begins to gain sensible heat. This starts the limited process of saturation; remember that a liquid can only gain a certain amount of heat before it evaporates into a gas, and the point at which it begins to change into a gas is called the saturation point, or boiling point. Latent heat of evaporation will continue to take place until all liquid refrigerant has transformed into a gas, which is the vapor point.

The refrigerant completely changes state into a gas in the last few coils of the condenser and will continue to gain some sensible heat. As the gaseous refrigerant exits the evaporator, it continues to superheat as it removes sensible heat from the brine. The refrigerant leaving the evaporator is now a low-pressure/low-temperature gas. This low-pressure/low-temperature gas enters the compressor and starts the refrigeration cycle all over again, and this process will continue to take place as long as the compressor is operating.

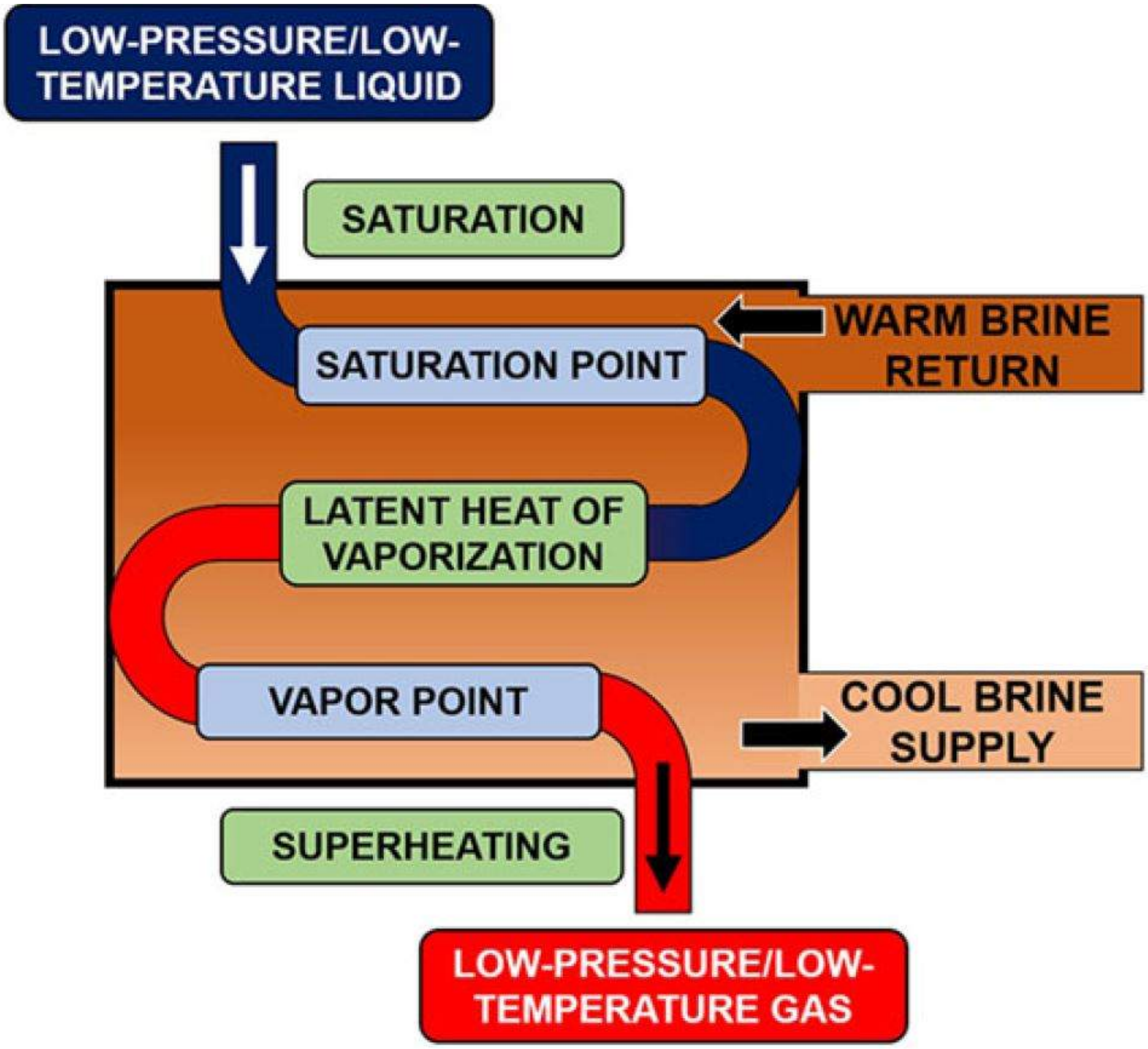


Figure 1–9. Evaporator Operation.

Summing Up the Heat Transfer Process

The refrigeration cycle is how heat is removed from a system, and the main objective of our ECS is to remove heat from a location where it is not wanted (the electronic racks, the back of the payload transporter, etc.) and expel it where it is less objectionable (launcher support building [LSB] or topside). Let's use the launch facility ECS (fig 1–10) to illustrate how heat is removed from the electronic racks in the launcher equipment room (LER) and eventually expelled through the exhaust shaft of the LSB.

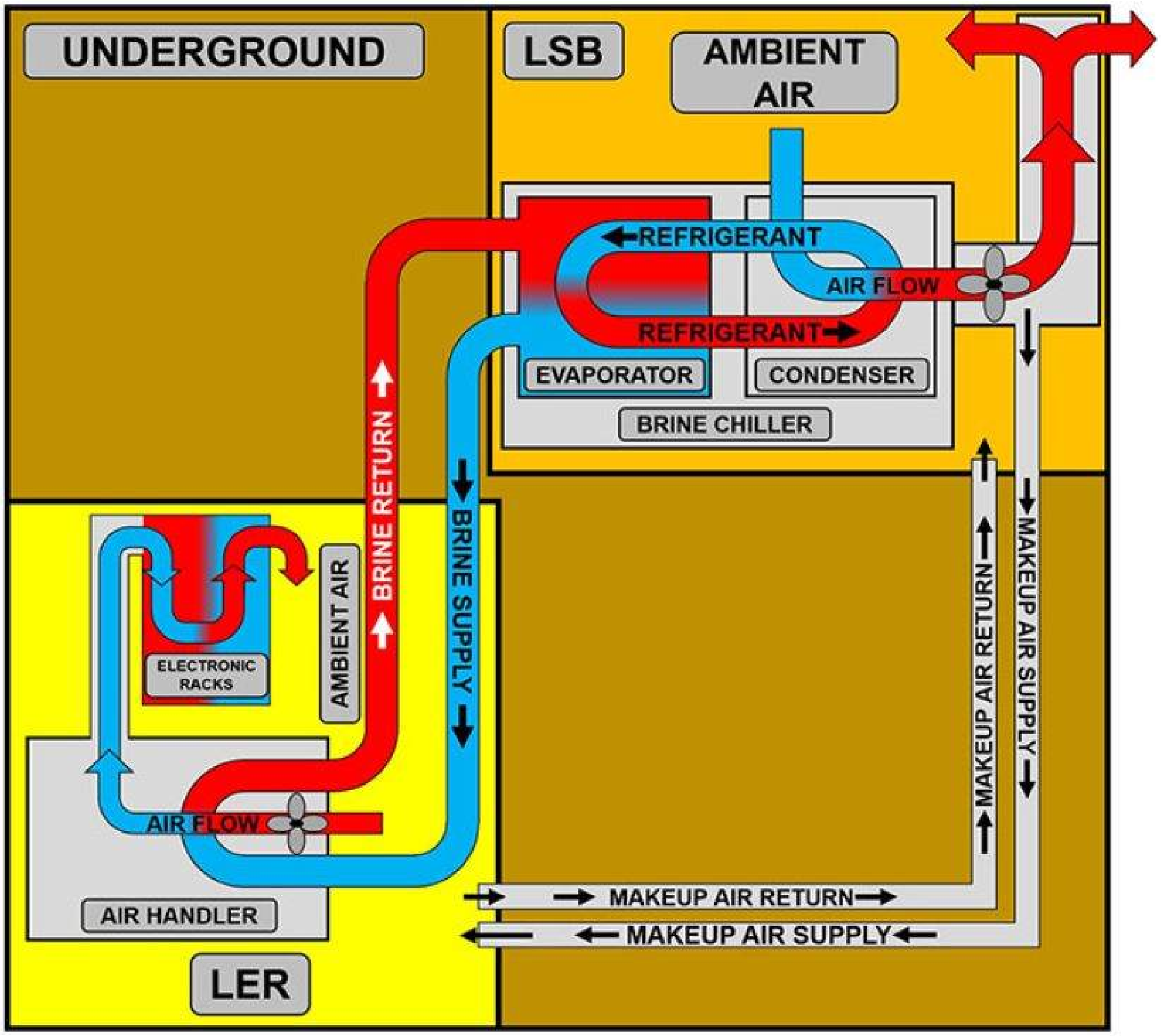


Figure 1–10. Heat Transfer in The Launch Facility ECS.

Click on each tab below to learn about the three different heat transfers as it relates to the brine.

AIR TO BRINE	BRINE TO REFRIGERANT	REFRIGERANT-TO-AIR

The air handler in the LER houses a cooling coil and the air handler fan. The cooling coil contains cool brine, and the air handler fan draws ambient air from the LER across the cooling coil. The cool brine inside the cooling coil removes heat from the air passing across it—this cool air travels through a duct and distributed to the electronic racks. The cool air removes heat from the electronic racks and expels it into the LER. This is technically where the first heat exchange in the ECS takes place, but keep in mind that there are other heat loads in the LER, such as the launch tube heater and the guidance section liquid cooler (not shown), that add heat to the air traveling through the air handler. The LER ambient air moves through the air handler to repeat the process outlined above. The cool brine has removed heat from the air passing through the air handler's cooling coil—the brine then flows through the underground return line into the LSB and into the brine chiller unit.

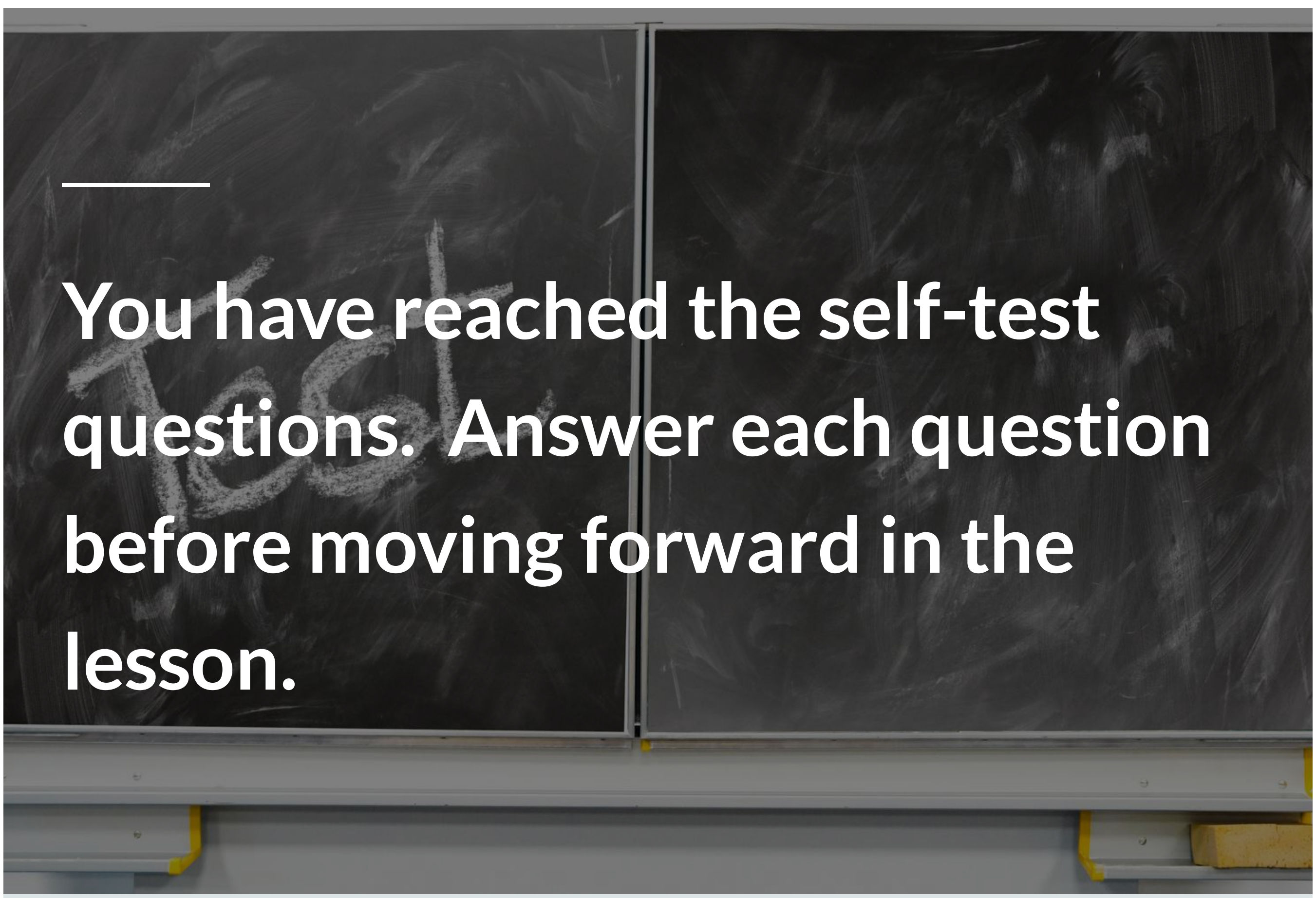
AIR TO BRINE | BRINE TO REFRIGERANT | REFRIGERANT-TO-AIR

The brine pump is responsible for circulating brine between the brine chiller in the LSB and the air handler in the LER. Warm brine and cool, low-pressure/low-temperature refrigerant meet each other in the evaporator, but do not mix—heat exchanges because the two substances run through a series of coils that are very close to one another. The refrigerant will evaporate in the coil as it removes heat from the brine, as outlined above. The now cool brine recirculates back to the LER and into the air handler to repeat this process.

AIR TO BRINE | BRINE TO REFRIGERANT | REFRIGERANT-TO-AIR

The hot, gaseous refrigerant exits the evaporator coil, is compressed by the compressor, and then flows back through the condenser coil. Just as you read earlier, heat is removed from the refrigerant as the condenser fan pulls air through the coil. The heat then enters the ambient air in the LSB where the ventilation system will either use it to heat the room or expel it topside. This process is continually repeating itself 24 hours a day, 365 days a year at both the missile alert facility and launch facility.

Click on each tab before moving forward in the lesson.



You have reached the self-test questions. Answer each question before moving forward in the lesson.

KNOWLEDGE CHECK TIME!

For the fill-in the blank questions, you will need to add (.) periods to the end of the sentences.

Click here to answer the self-test questions pertaining to the principles of refrigeration.

1. What occurs when adding or removing heat from a substance?

Type your answer here

SUBMIT

2. What does heat intensity indicate?

Type your answer here

SUBMIT

3. What does the term pressure indicate?

Type your answer here

SUBMIT

4. What is the atmospheric pressure at sea level?

- 11.7 psi.
- 13 psi.
- 14.7 psi.
- 15.2 psi.

SUBMIT

5. Why does a substance boil at a lower temperature at increased altitudes?

Type your answer here

SUBMIT

6. Why must the refrigerant in our systems be noncorrosive?

Type your answer here

SUBMIT

Answer each question before moving on to the next set of questions.

Click here to answer the self-test questions pertaining to the Heat transfer process.

1. Define heat transfer by convection.

Type your answer here

SUBMIT

2. Define heat transfer by radiation.

Type your answer here

SUBMIT

3. What is subcooling?

Type your answer here

SUBMIT

4. Explain latent heat of evaporation.

Type your answer here

SUBMIT

5. Explain the adiabatic expansion that occurs within a refrigeration system's thermal expansion valve.

Type your answer here

SUBMIT

6. Explain the brine-to-refrigerant heat transfer that occurs in the launch facility environmental control system.

Type your answer here

SUBMIT

Answer all self-test questions before moving forward in the lesson.

High-Pressure Refrigeration System Components

In previous lessons, we touched on some of the components in the refrigerant system and the roles they play in the refrigeration cycle and heat transfer process. This section will focus in more detail on the components in the high-pressure side of a refrigerant system beginning at the discharge outlet of the refrigerant compressor and ending at the moisture indicator sight glass. Additionally, this lesson section will address several additional components installed in the refrigeration system that help the system function.

1. Refrigerant compressor
2. High-pressure cutout switch
3. Refrigerant discharge pressure port
4. Hot gas and liquid line pump down solenoid valves
5. Hot gas bypass valve
6. Head pressure control valve
7. Refrigerant condenser coil
8. Refrigerant receiver tank
9. Pressure relief device rupture disk
10. Filter drier
11. Moisture indicator sight glass

1. Refrigerant Compressor

The discharge side of the refrigerant compressor is the best place to start because this is where the refrigerant begins its journey through the system.

a. Compressor purpose

Besides pumping refrigerant through the system, the refrigerant compressor serves two additional purposes:

1. Raises the refrigerant pressure to allow control of the refrigerant boiling point.
2. Raises the refrigerant temperature to make it hotter than the ambient air so that a heat transfer will take place.

The refrigerant in the ECS system boils between –15°F and –45°F, which means that it will simply boil away when exposed to normal, room temperature air. The refrigerant compressor increases the boiling point of the refrigerant by increasing the pressure in the system, and if the pressure inside of the system is not high enough, the ambient temperature of the refrigerant lines would cause the refrigerant inside to remain in a gaseous state all of the time.

The compressor transforms the refrigerant into a high-pressure/high-temperature gas. Remember that the refrigerant must be hotter than the surrounding air or no heat transfer will occur.

b. Compressor types

Refrigerant compressors vary with the type of refrigerant used and the size of the system they support. Compressors are also classified according to how they operate. All compressors in our missile system and support equipment are hermetic, meaning the motor and compressor are contained in one shell and access to internal components to perform individual repairs is not available. Our systems use either reciprocating- or orbiting scroll-type compressors.

Orbiting scroll compressor

All brine chiller units in the missile field use the orbiting scroll compressor (fig 1–11). A scroll compressor has two scrolls: a fixed or stationary scroll and an orbiting scroll. It is easiest to visualize these two scrolls as two spirals that fit neatly into one another. There are two inlet ports 180° from one another, and this is where refrigerant enters the mechanism. When the motor of the compressor operates, it drives a shaft that forces the orbiting scroll to move in a circular motion. Note that the orbiting scroll does not rotate—it moves in a circular motion while maintaining the same orientation. The circular motion of the orbiting scroll against the stationary scroll creates crescent-shaped pockets where trapping and compressing of the refrigerant vapors occur. The refrigerant compresses more and more as it works its way to the discharge port located in the middle of the spiraling scroll, where it finally ejects into the refrigerant system as a high-pressure/high-temperature gas.

The scroll compressor provides more advantages than other compressor types. By eliminating a fixed cylinder and piston, the compressor eliminates wasted space in the compression chamber and avoids recompression that sometimes occurs with reciprocating compressors. This reduces energy wasted on compressing gas repeatedly during operation.

Reciprocating compressor

The action of a reciprocating refrigerant compressor (fig 1–12) is nearly identical to that of an air compressor. An electric motor drives the crankshaft which in-turn drives a piston, and as the electric motor turns, it rotates the crankshaft that forces the piston to move up and down. The suction side uses a one-way intake valve that opens due to the vacuum created when the piston is moving downward. The discharge valve works in the opposite fashion—it is forced open by the pressure created when the piston moves toward the top of the cylinder.

The discharge valve does not immediately open when the piston begins to move upward in the cylinder. A certain amount of pressure must build up in the cylinder, which means that the valve will not open until the piston is near the top of the cylinder and a sufficient amount of refrigerant pressure has built up.

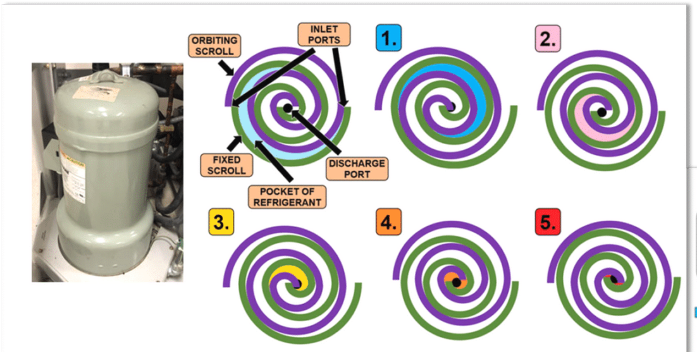


Figure 1–11. Orbiting scroll compressor operation.

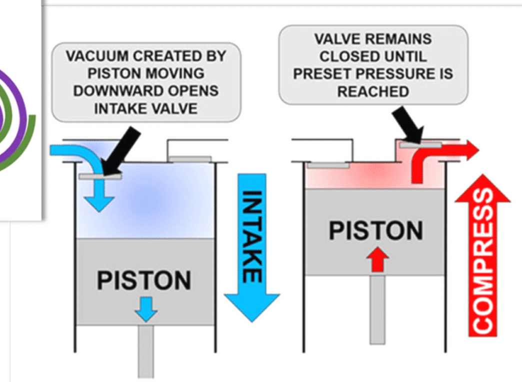


Figure 1–12. Reciprocating (piston-type) compressor operation.

Click on each number to learn about the different components on the high-pressure refrigeration system.

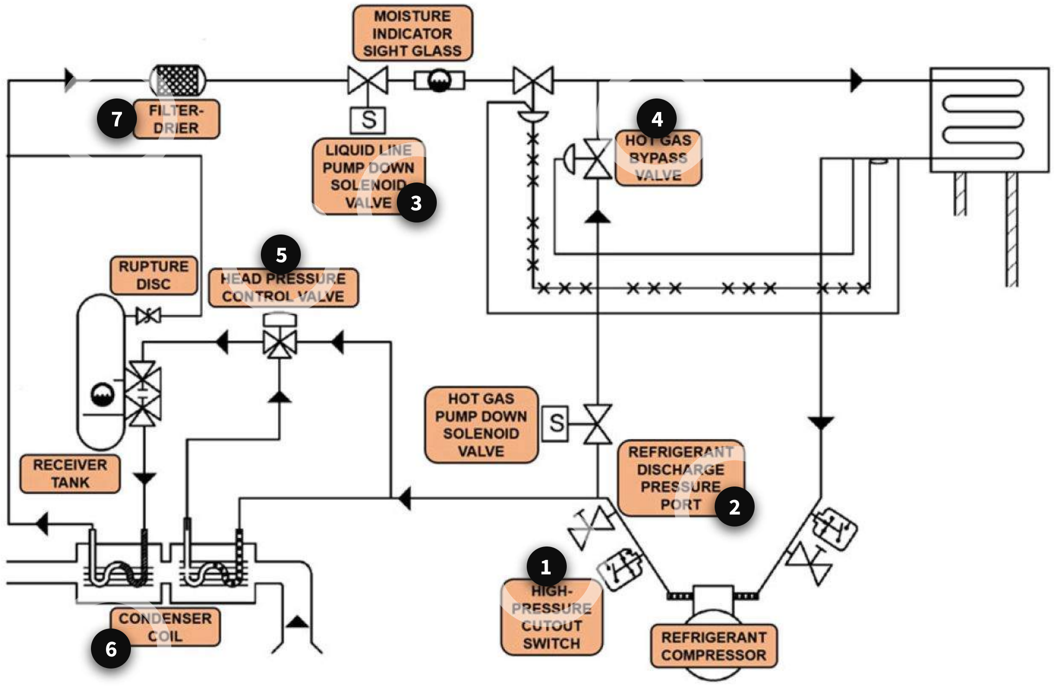


Figure 1–13. High-pressure refrigeration system components.

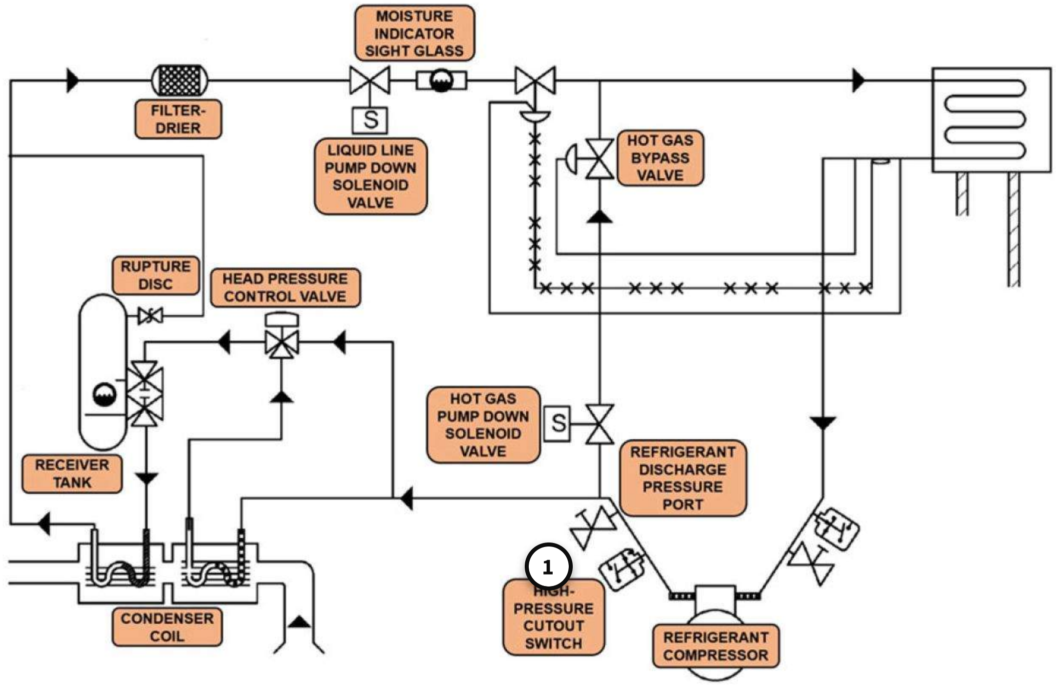


Figure 1–13. High-pressure refrigeration system components.

High-pressure cutout switch

The high-pressure cutout switch (fig 1–13) is a safety device that halts system operation if the discharge pressure exiting the refrigerant compressor is too high. It mounts directly into the refrigerant system and field removal is not possible. The programmable logic controller (PLC), which is the ‘brain’ of the ECS, monitors the discharge pressure and will command the brine chiller to shut down if the refrigerant compressor discharge pressure exceeds 370 (+/–15) psig.

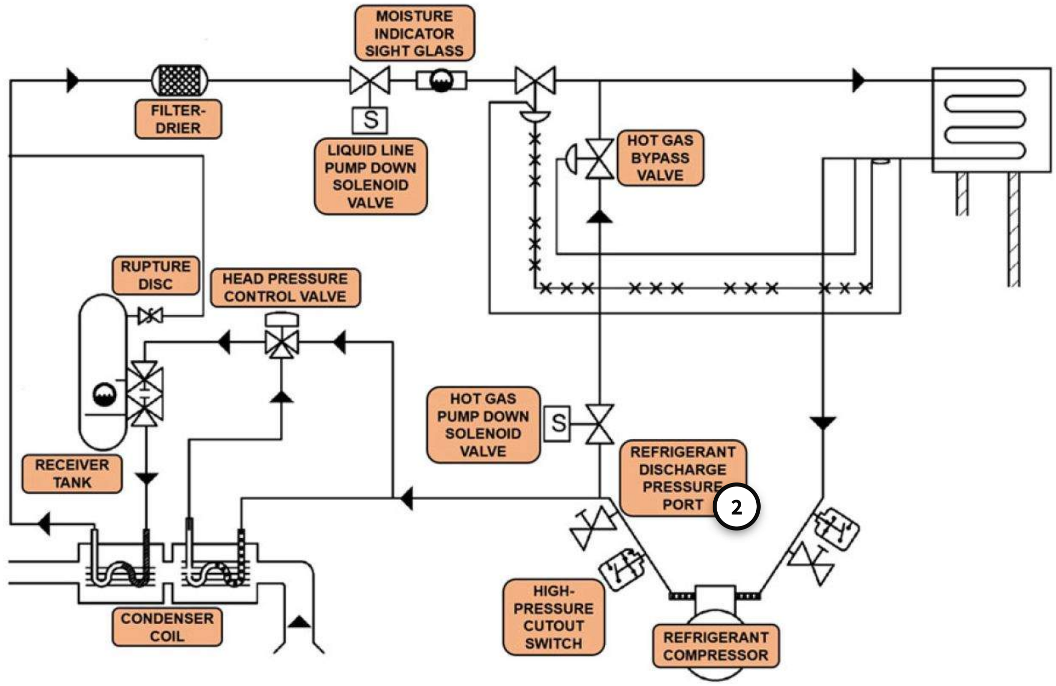


Figure 1–13. High-pressure refrigeration system components.

Refrigerant discharge pressure port

The refrigerant discharge pressure port (fig 1–13) is a valve where a manifold and gauge assembly hose attach to monitor the discharge pressure within the refrigeration system. This port utilizes a valve called a Schrader® valve, which is a valve similar to the valve used on bicycle tubes and automobile tires. A properly connected device such as a refrigerant manifold and gauge assembly hose depresses the valve, which allows refrigerant to flow through the open valve and into the hose. Unscrewing the manifold and gauge assembly hose fitting releases the valve allowing it to move back into place to block flow.

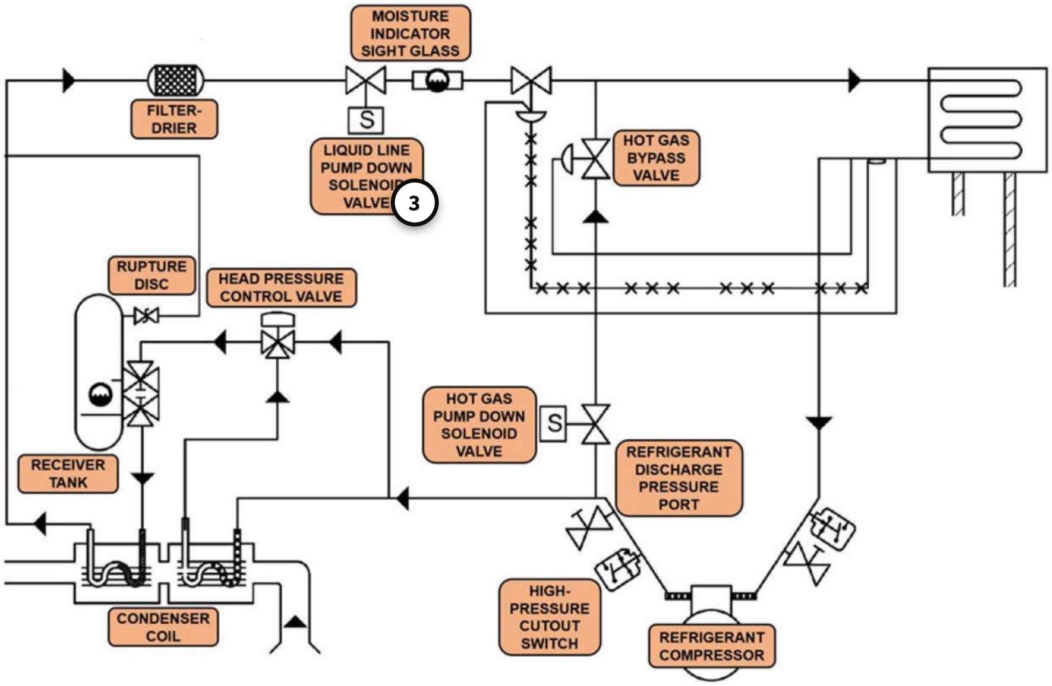


Figure 1–13. High-pressure refrigeration system components.

Hot gas and liquid line pump down solenoid valves

There are two solenoid valves (fig 1–13) installed on the brine chiller that allow the PLC to shut down the brine chiller. One valve is on the gaseous line prior to the hot gas bypass valve and the other is in the liquid line after the filter-drier. These solenoid valves are energized when the system is operating, which allows refrigerant to flow. When the PLC needs to shut down the brine chiller, it removes power from both solenoid valves while allowing the refrigerant compressor to continue to run. This causes the compressor to pump the majority of the refrigerant in the system to the receiver tank while at the same time drawing the low side of the system into a vacuum. Once the refrigerant pressure drops between 2 and 15 psig, the low-pressure cutout switch closes, and this is what actually causes the brine chiller to shut down.

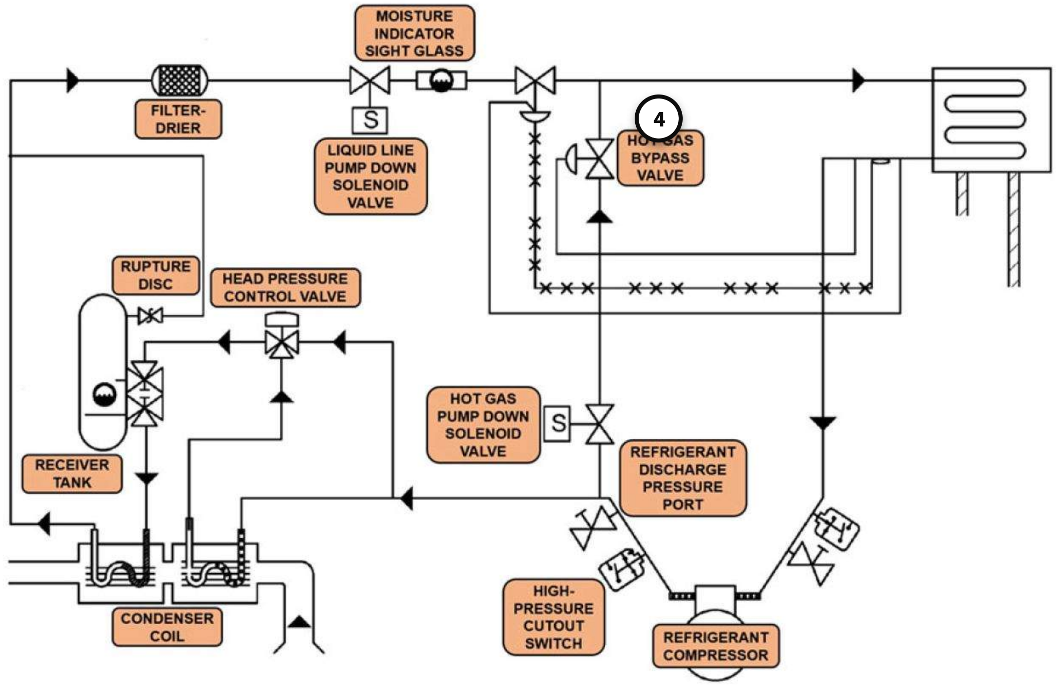


Figure 1–13. High-pressure refrigeration system components.

Hot gas bypass valve

The hot gas bypass valve (fig 1–13) controls brine supply temperature by either sending refrigerant to the condenser coil or diverting refrigerant straight to the evaporator coil. Where the refrigerant diverts depends on the pressure of the refrigerant exiting the evaporator coil. The hot gas bypass valve is set to maintain the brine supply temperature at 35 (±4) degrees Fahrenheit. If the brine supply temperature is too high, the temperature of the refrigerant exiting the evaporator coil will also be high.
As brine temperature increases, so will the pressure of the refrigerant that is exiting the evaporator coil. This increase in pressure closes the hot gas bypass valve, which decreases the brine temperature by sending more refrigerant to the condenser to be cooled.

As brine temperature decreases, the refrigerant pressure exiting the evaporator coil will also decrease. This decrease in pressure closes the hot gas bypass valve, which increases the brine temperature by sending less refrigerant to the condenser to be cooled.

The hot gas bypass valve is never fully open or fully closed—it constantly modulates, or makes minute adjustments, to maintain brine supply temperature.

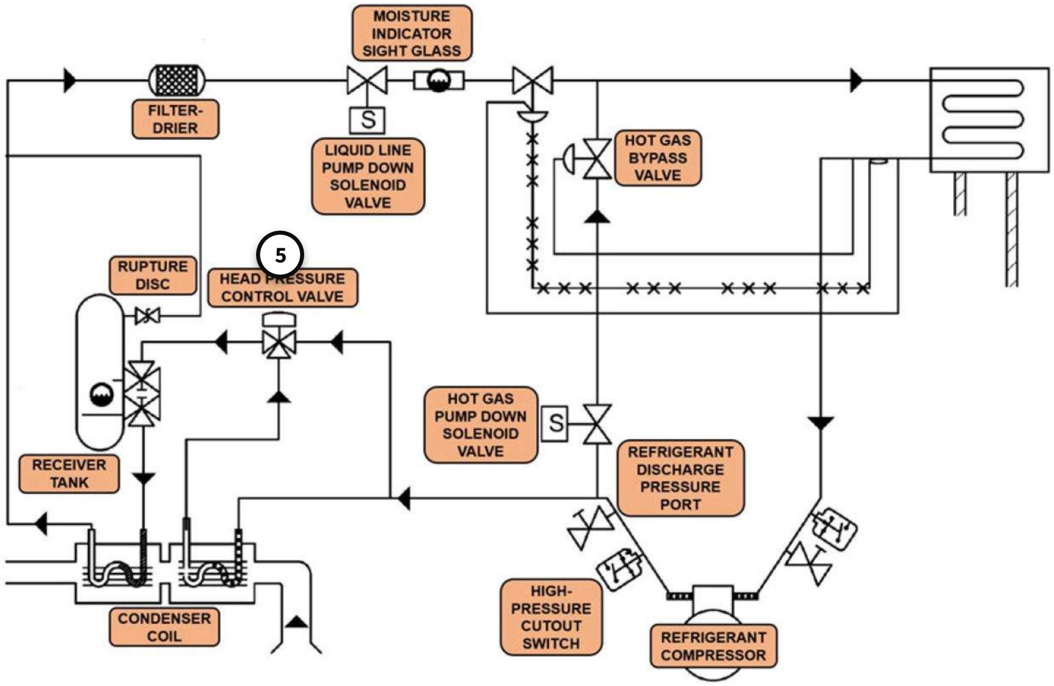


Figure 1–13. High-pressure refrigeration system components.

Head pressure control valve

The purpose of the head pressure control valve (fig 1–13) is to maintain compressor discharge pressure, or head pressure, at a minimum of 100 psig. Low refrigerant discharge pressure reduces the overall cooling capacity of the brine chiller and can reduce the flow of lubricating oil through the system, which will cause the refrigerant compressor to wear out faster. The head pressure control valve is a three-way modulating valve that responds to compressor discharge pressure. Discharge pressure bleeds around the pushrod to the underside of the diaphragm, and acts in the opposite direction of the dome pressure.

During the winter months the temperature of the air moving across the condenser coil will be lower, causing condensing and discharge pressures to also decrease accordingly. When the discharge pressure falls below the dome pressure, the head pressure control valve modulates open to allow refrigerant to bypass the condenser and flow straight to the receiver tank. Less heat is removed from the refrigerant because it is not passing through the condenser, which in turn causes the overall pressure of the system to increase.

During the summer months the temperature of the air moving across the condenser coil will be higher, causing condensing and discharge pressures to also increase accordingly. When discharge pressure rises above the dome pressure, the head pressure control valve modulates closed to direct refrigerant straight to the condenser coil. More heat leaves the refrigerant because it is passing through the condenser coil, which in turn causes the overall pressure of the system to decrease.

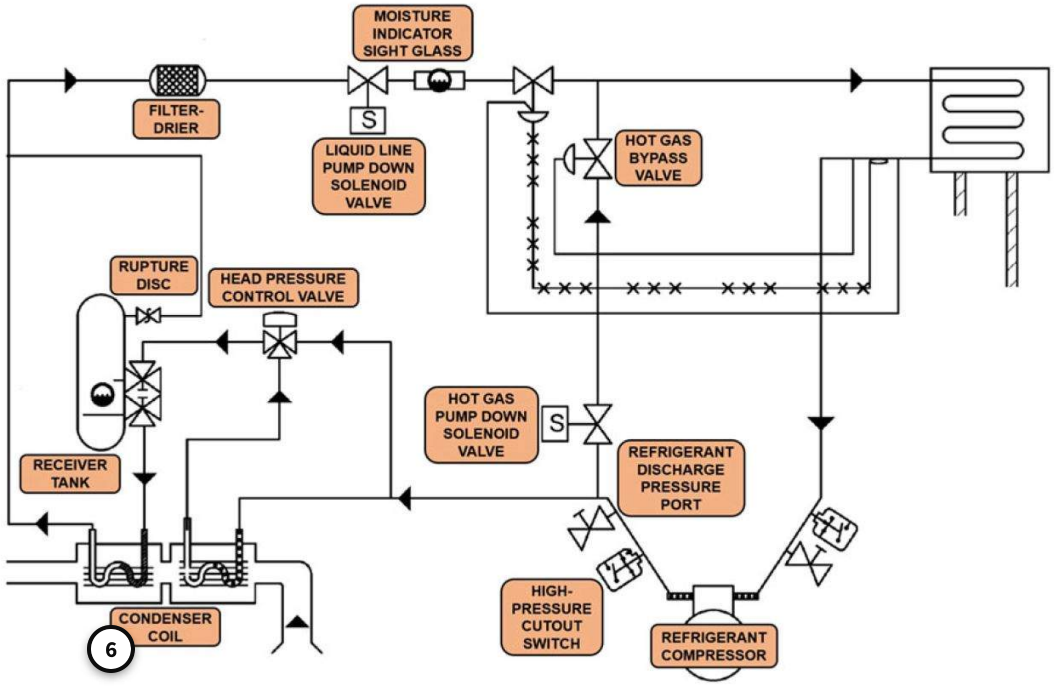


Figure 1–13. High-pressure refrigeration system components.

Refrigerant condenser coil

You already learned that a gas will condense into a liquid if it loses enough heat. The condenser coil (fig 1–13) is where the hot refrigerant transfers its heat to another substance, which is usually air. Air-cooled condensers use ambient air as the cooling medium and can be either natural or forced convection. Natural convection is when heat naturally transfers to the surrounding ambient air. Forced convection is when heat transfers to air or a fluid driven across the condenser by a fan, pump, or some other means, and this is the method utilized by brine chiller units in the missile field. The following factors determine how effective a condenser is at disposing of heat:

- **Surface Area**—The physical size and surface area of the condenser will determine how much, and how quickly heat dissipates. This parameter is not adjustable, but the condenser is engineered to remove the amount of BTU that the unit is rated to handle.
- **Air Temperature**—The temperature of the air forced across the condenser has a direct effect on how much heat is lost, and the speed of heat transfer will decrease as the ambient air temperature approaches the temperature of the refrigerant. The refrigerant system automatically adjusts refrigerant flow based on the air temperature during different seasons. For instance, refrigerant will need to flow faster in the winter because the air moving across the condenser coil is colder.
- **Airflow**—Airflow across the condenser coil is a prime factor in the condenser's ability to discharge heat from the system. Sometimes dust and other debris clogs the condenser coil causing the system to work harder to remove the appropriate amount of heat from the refrigerant.

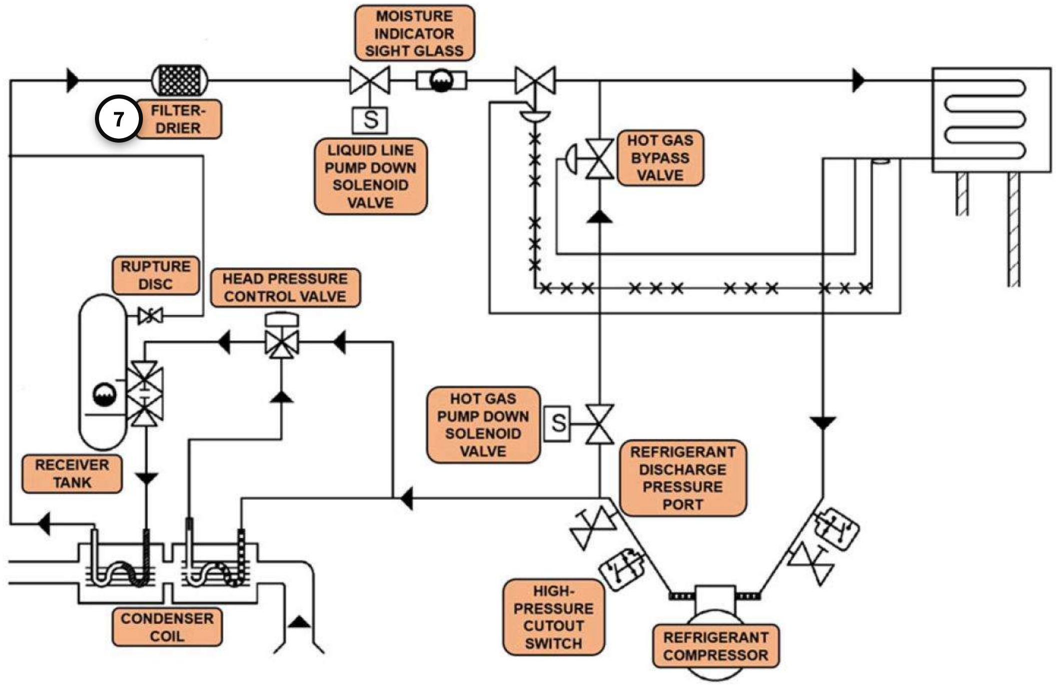


Figure 1–13. High-pressure refrigeration system components.

Filter-drier

In order for any refrigerant system to operate correctly, only clean refrigerant and oil with no water moisture should circulate through the system. It is for this reason that the refrigerant passes through a component called a filter-drier (fig 1–13) whose purpose is to remove both particle debris and water moisture from the system.

Debris in the system can clog lines, prevent lubricating oil from circulating, and hinder heat transfer in the condenser and evaporator. Various filters in the filter-drier remove debris for the system.

Moisture can develop in the refrigeration system when air enters the system from a leak, when air remains in the system during maintenance, or if air entered during servicing. Moisture will mix with lubricating oil in the system to create a type of acid that will then begin to corrode parts of the system. Desiccant material filters out unwanted moisture.

Click on each number on the image before moving forward in the lesson.

Refrigerant Receiver Tank

Refrigerant flows out of the condenser and into the receiver tank (fig 1–14). The receiver tank allows the system to operate properly over a wide range of ambient air temperatures and is also where refrigerant is stored when the system is in pump down mode.

Refrigerant enters through an inlet on the top of the receiver tank. Liquid refrigerant pools up on the bottom of the tank and the lighter gaseous refrigerant sits on top of the liquid. Since we only want liquid refrigerant to enter the TXV, the outlet has a dip tube that draws liquid from the bottom of the receiver tank.

Pressure Relief Device

If the high-pressure cutout switch has malfunctioned, the refrigerant pressure inside of the system will continue to rise. To prevent damage to the system, the receiver tank has a rupture disc (fig 1–14) which will "rupture" and vent all of the system's refrigerant outside of the launcher support building, launch control support building (LCSB), or launch control equipment building (LCEB) if the refrigerant pressure exceeds 450 psig.

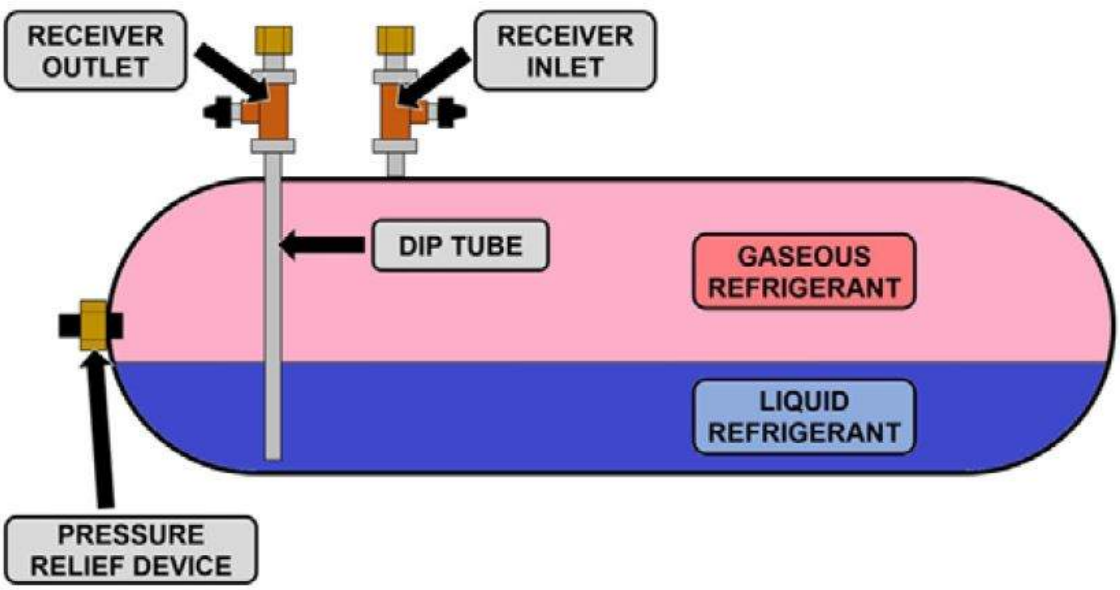


Figure 1–14. Receiver Tank.

Proper Operation Under a Wide Range of Temperature Conditions

The brine chiller at a missile alert facility or launch facility needs to operate properly under a wide range of temperature conditions. The amount of refrigerant required depends on the heat load. For example, there will be more gaseous refrigerant in the system on a hot summer day in the field where the LER has been open for many hours and hot air is passing across the condenser—there is more heat available in the surrounding area to evaporate the refrigerant. More liquid refrigerant will be in the system on a cold winter day because there is less heat available to evaporate the refrigerant.

Refrigeration systems that do not need to operate under a wide range of ambient temperature variations do not need a receiver tank. Systems like these are considered critically charged because they will not be able to operate properly if there is a large change in ambient temperature or heat load, or if they lose any refrigerant.

Refrigerant Storage During System Pump Down

As discussed earlier, the receiver tank is where the majority of the refrigerant in the system is stored once the PLC commands the hot gas and liquid line pump down solenoids closed. Confining all refrigerant to the receiver tank also makes it possible to perform some types of maintenance on the system without the need to remove all of the refrigerant.

Refrigerant then exits the receiver tank and enters the condenser, where any remaining gaseous refrigerant condenses to a liquid.

Moisture Indicator Sight Glass

Refrigerant exits the filter-drier and passes through the moisture indicator sight glass (fig 1–15). The moisture indicator sight glass allows a technician to visually inspect the refrigerant; the absence of bubbles indicates that there is an adequate amount of refrigerant and that the system is operating normally.

The moisture indicator portion is a small colored dot in the center of the site glass that is sensitive to moisture and acid in the system. The color of the dot indicates different conditions inside the system as follows:

- Green—there is no moisture or acid in the system.
- Yellow—there is moisture in the system; the brine chiller needs replacing.
- Black—there is acid in the system; it is possible that the refrigerant compressor has burnt out, and the brine chiller needs replacing.

Once refrigerant exits the moisture indicator sight glass, it moves to the expansion valve. The expansion valve is the dividing line of system pressure and moves us into our lesson on the low-pressure system components.

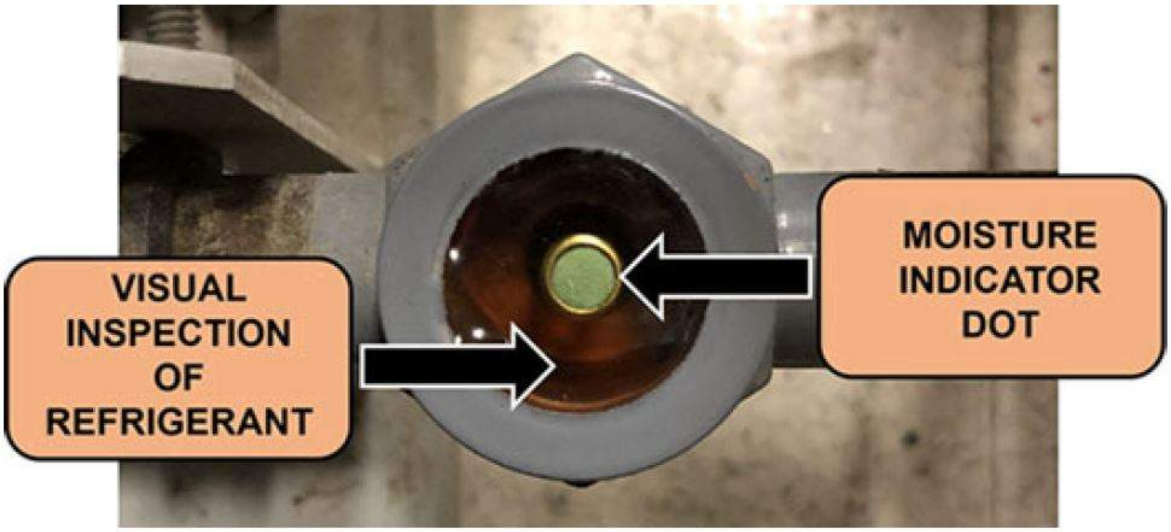
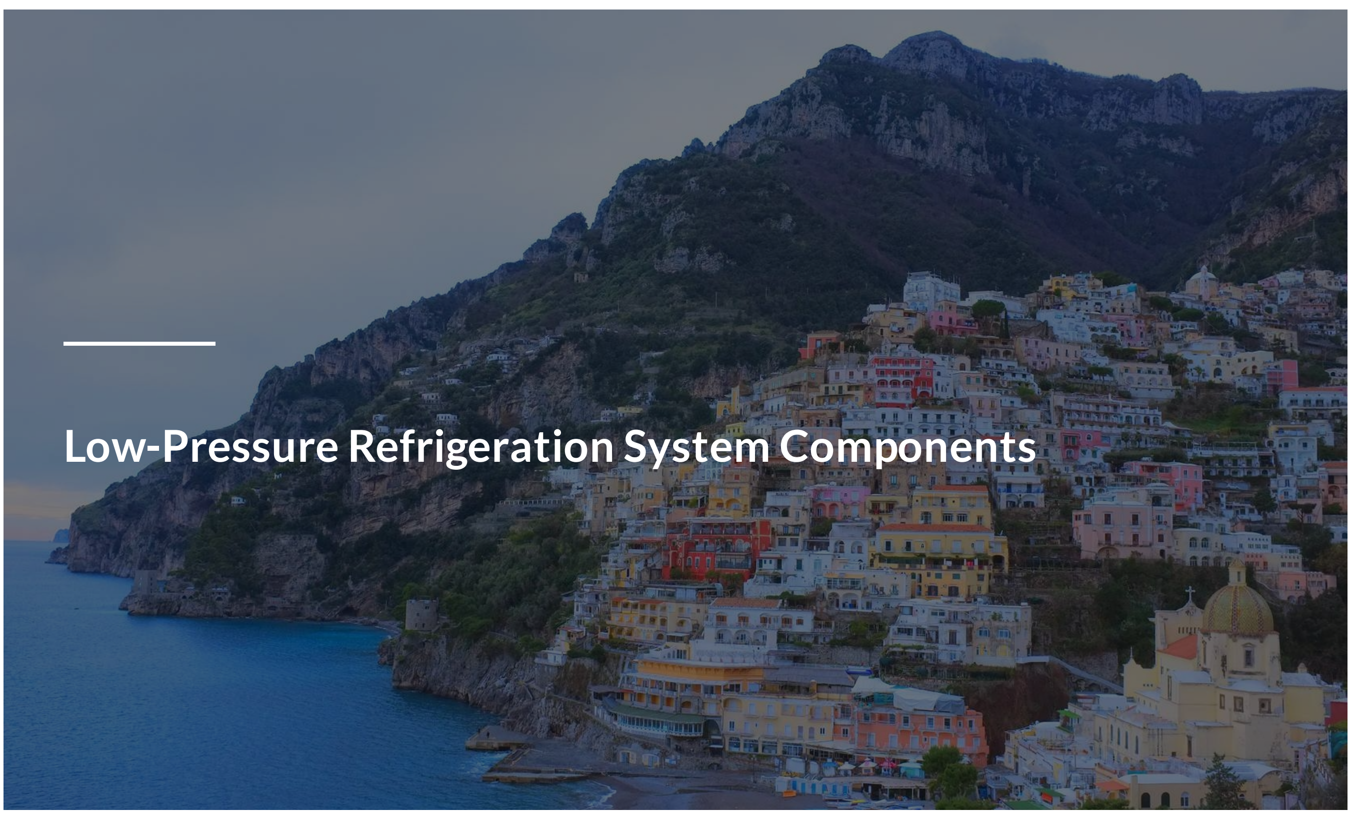


Figure 1–15. Moisture Indicator Sight Glass.



Low-Pressure Refrigeration System Components

This lesson will focus in more detail on the components in the low-pressure side of the refrigeration system, beginning at the thermal expansion valve and ending at the suction side of the refrigerant compressor. You can see the following components in figure 1–16:

- Thermal expansion valve
- Refrigerant evaporator coil
- Low-pressure cutout switch
- Refrigerant suction pressure port

Click on each number on the image to learn about the components of the low-pressure refrigeration system.

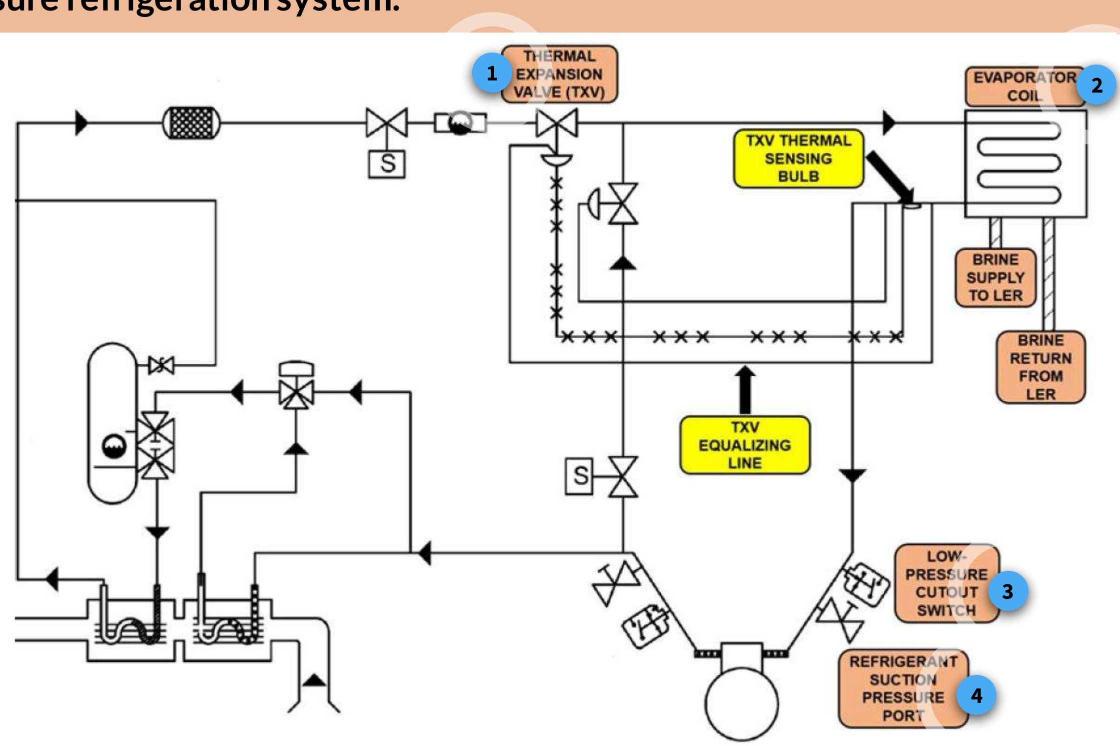


Figure 1–16. Low-pressure refrigeration system components.

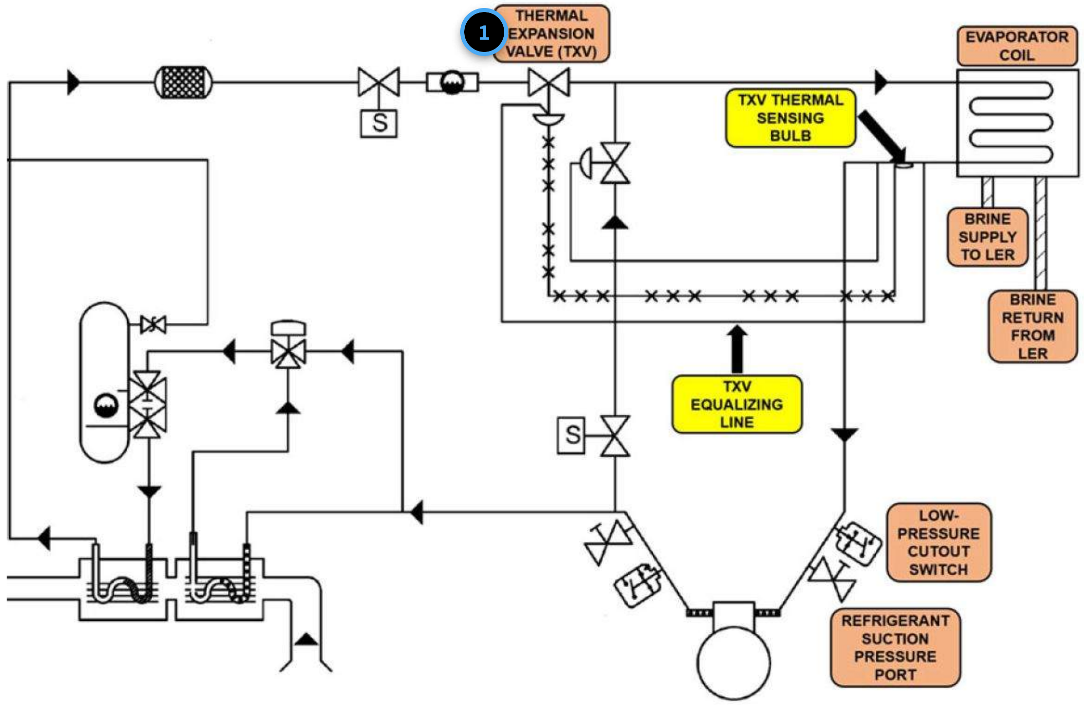


Figure 1–16. Low-pressure refrigeration system components.

Thermal expansion valve

The TXV (fig 1–16) is the second location in the system where refrigerant pressure changes significantly. The TXV serves the following purposes:

- Changes the high-pressure/high-temperature liquid into a low-pressure/low-temperature liquid.
- Controls the amount of refrigerant that enters the evaporator.

The TXV determines refrigerant flow rate by monitoring the temperature and pressure of the refrigerant exiting the evaporator coil. A thermal sensing bulb monitors condenser coil outlet temperature, and a very small refrigerant line monitors condenser coil outlet pressure.

Thermal sensing bulb operation

The thermal-sensing bulb (fig 1–16) is located on the outlet of the evaporator and its purpose is to monitor the amount of superheat in the refrigerant exiting the evaporator. High superheat indicates that the refrigerant is vaporizing in the beginning portion of the evaporator coil, and low superheat indicates that the refrigerant is vaporizing in the end portion of the evaporator coil. The thermal bulb contains its own refrigerant charge that expands and contracts to exert pressure through a small capillary tube and onto the spring of the TXV. Note that the refrigerant inside of the sensing bulb and capillary tube are sealed and are not part of the refrigeration system. If the thermal bulb senses high superheat, the refrigerant charge in the thermal bulb expands, causing the TXV to open, which will increase the amount of liquid refrigerant that enters the evaporator. If more liquid refrigerant enters, more latent heat will be required to vaporize it, and superheating will decrease.

Conversely, if the thermal bulb senses the superheat is low, the thermal bulb refrigerant charge will contract, which will lessen spring pressure to decrease the amount of refrigerant the TXV allows through. Decreasing refrigerant flow into the evaporator will cause the refrigerant to evaporate sooner and thus increase the amount of superheat that is absorbed before it exits the evaporator.

Equalizer line

The equalizer line (fig 1–16) works hand-in-hand with the thermal bulb to maintain proper evaporator pressure. It senses the pressure exiting the evaporator and runs between the line after the evaporator and the TXV, and uses refrigerant from the system. This allows the evaporator pressure to help modulate the TXV to ensure the pressure remains constant regardless of the amount of liquid refrigerant metered into the evaporator. As the TXV opens to allow more liquid refrigerant to enter the evaporator, the equalizer line will force the TXV spring to make small corrections instead of drastic ones, and without the equalizer line the TXV would constantly switch between flooding and starving the evaporator.

It is very important that liquid refrigerant does not flow out of the evaporator and into the compressor because the design or intent is not to compress liquid. Most refrigerant compressors can handle a minute amount of liquid flow; this is known as liquid slugging. The impact of liquid slugging can range from a noisy compressor to compressor damage or failure, and this is another reason that it is important that the TXV is functioning correctly.

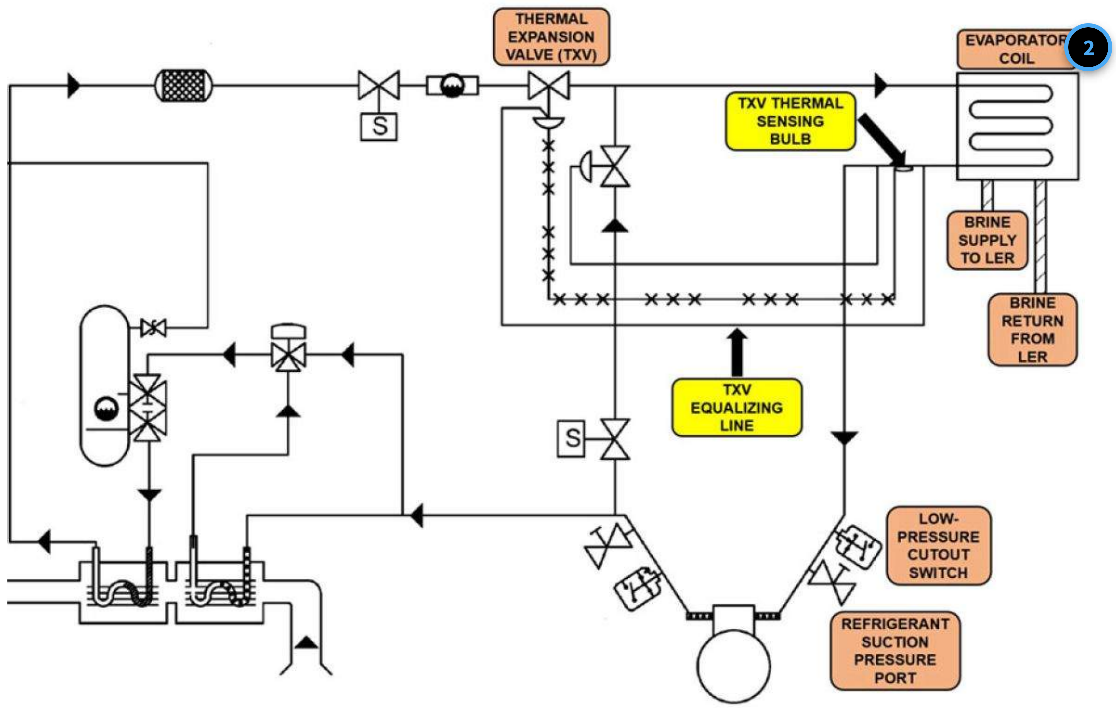


Figure 1–16. Low-pressure refrigeration system components.

Refrigerant evaporator coil

The evaporator (fig 1–16) is where cold liquid refrigerant removes heat from the brine, which is why the evaporator is sometimes referred to as the brine cooler. Refrigerant removes heat from the brine as it flows through the evaporator—the cool brine then circulates back to the LER. Refrigerant enters the evaporator as a liquid, undergoes a phase change due to heat absorption, and exits the evaporator as a hot gas.

The evaporator consists of multiple, thin, slightly separated plates that have very large surface areas and fluid flow passages for heat transfer. This stacked-plate arrangement is more effective than the tube and shell exchanger because it is smaller yet still removes the same amount of heat.

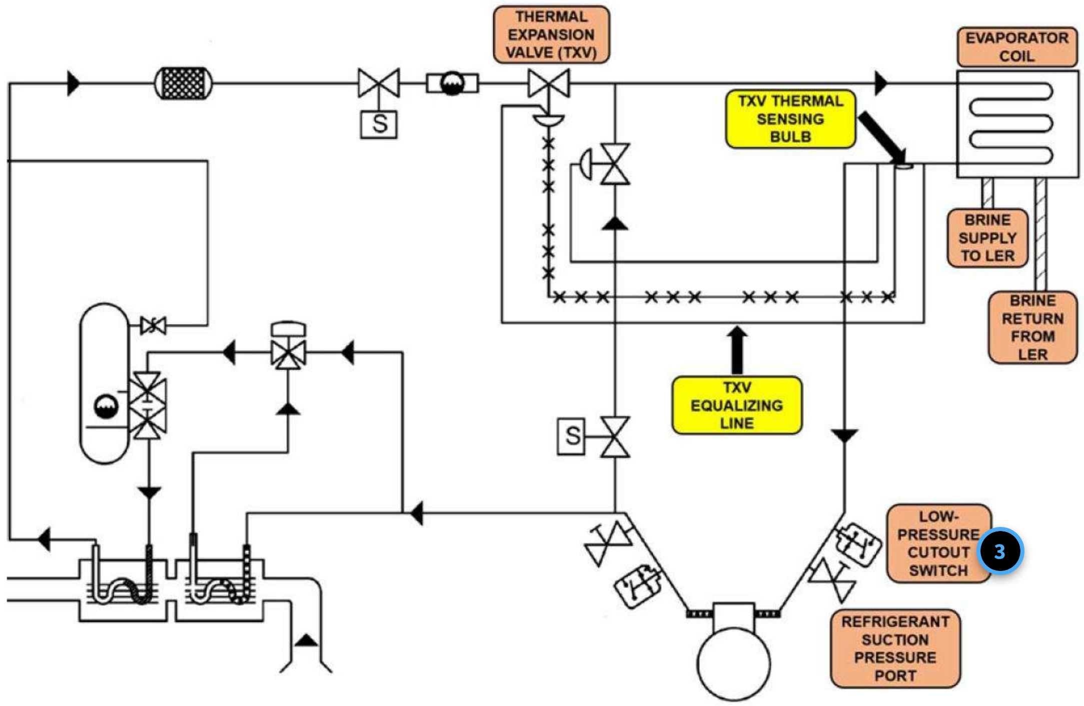


Figure 1–16. Low-pressure refrigeration system components.

Low-pressure cutout switch

The low-pressure cutout switch (fig 1–16) is a safety device designed to halt system operation if the suction pressure entering the refrigerant compressor becomes too low. The low-pressure cutout switch can be replaced in the field because it is mounts to the system tubing utilizing a Schrader® valve. The PLC monitors the suction pressure and will command the brine chiller to shut down if the refrigerant compressor suction pressure drops to between 2 and 15 psig.

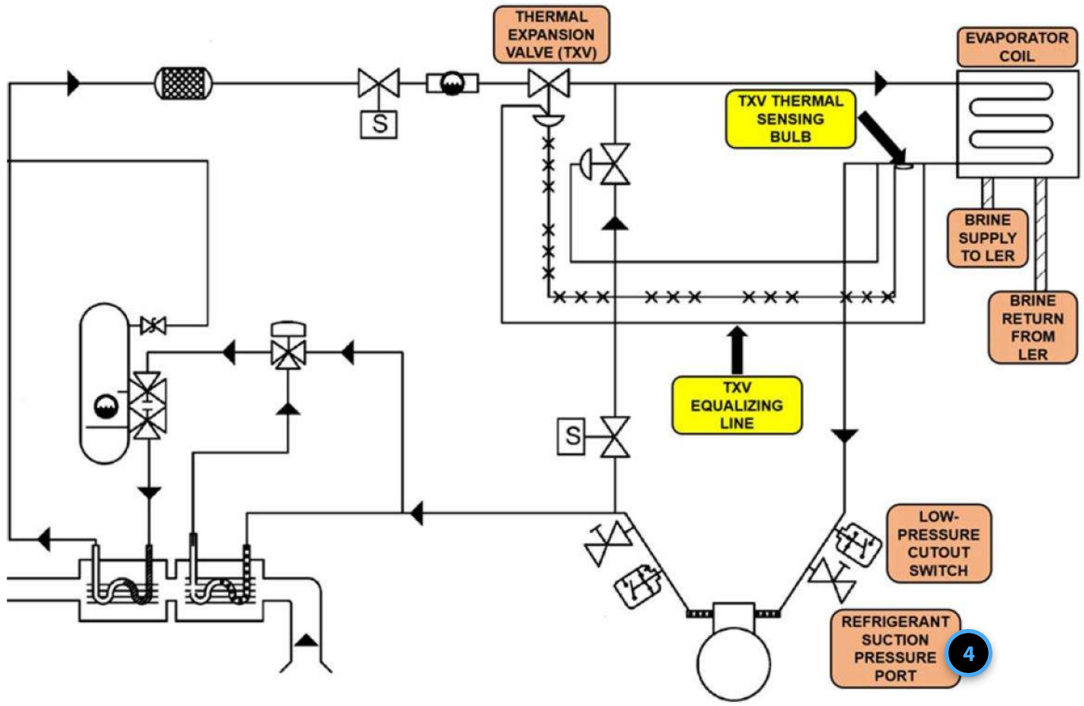


Figure 1–16. Low-pressure refrigeration system components.

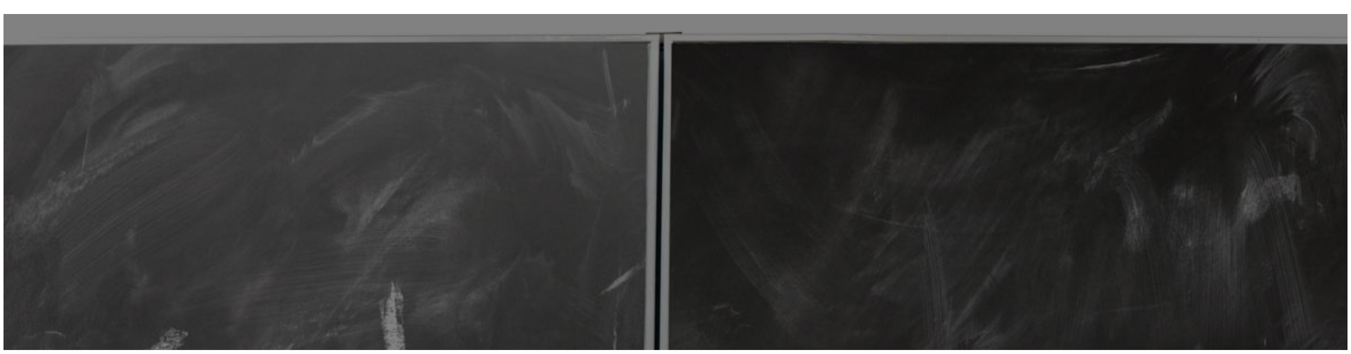
Refrigerant suction pressure port

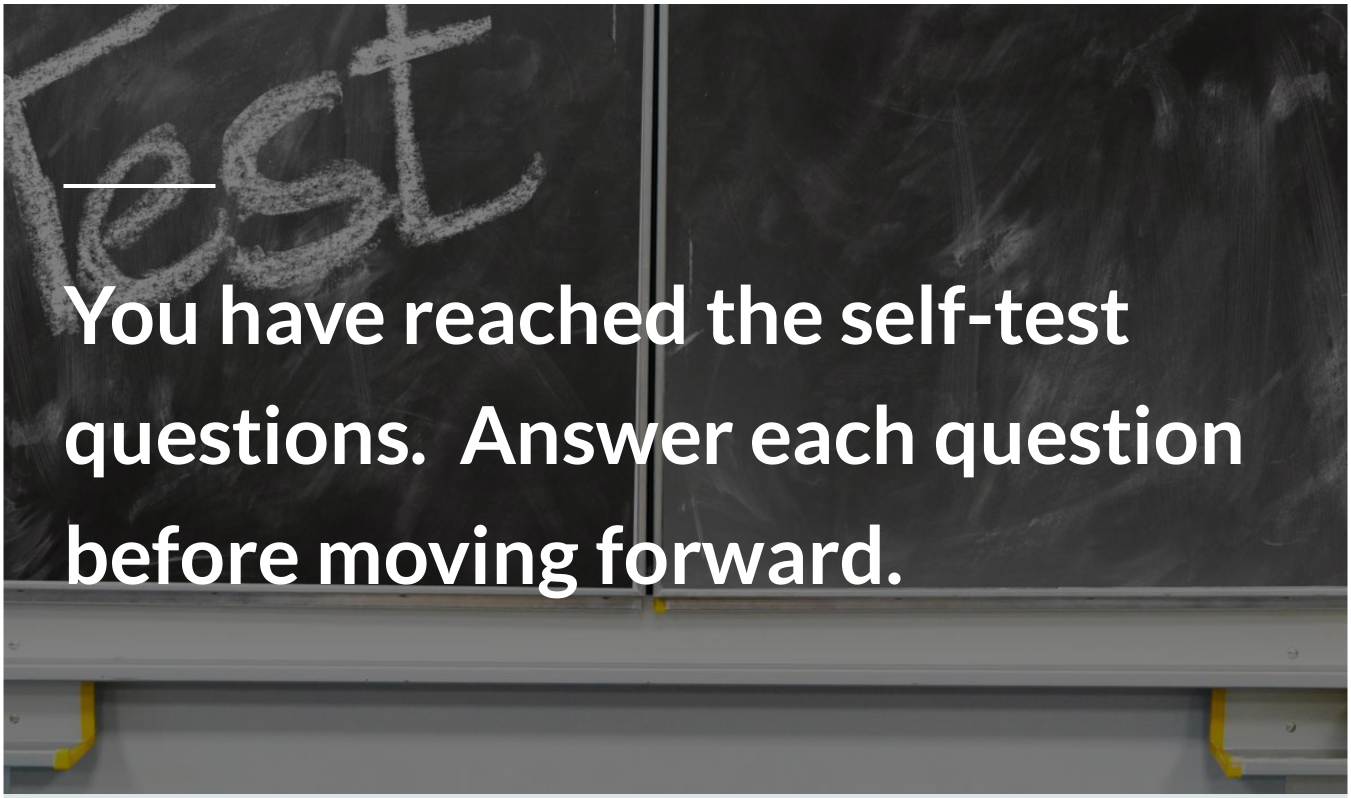
The refrigerant suction pressure port (fig 1–16) is a valve where a manifold and gauge assembly hose attaches to monitor the suction pressure within the refrigeration system. It functions exactly like the refrigerant discharge pressure port on the high-pressure side of the system. This port is also where you will connect an acid test kit if you suspect a compressor has burned out.

The refrigerant will now enter the suction side of the compressor and start its journey through the system again.

This lesson focused on the components that are located in the low-pressure side of the refrigeration system.

Click on each number on the image before moving forward in the lesson.





You have reached the self-test questions. Answer each question before moving forward.

KNOWLEDGE CHECK TIME!

For the fill-in the blank questions, you will need to add (.) period to the end of the sentences.

Click here to answer the self-test questions pertaining to the high-pressure refrigeration system components.

1. Which missile field refrigeration system(s) use a scroll type compressor?

Type your answer here

SUBMIT

2. What is the purpose of the refrigerant discharge pressure port on a brine chiller unit?

Type your answer here

SUBMIT

3. Explain what actions the hot gas bypass valve on the brine chiller unit takes when the brine supply temperature is too high.

Type your answer here

SUBMIT

4. Why does a dip tube extend to the bottom of the receiver tank in a refrigeration system?

Type your answer here

SUBMIT

5. What purpose does a filter-drier serve in a refrigeration system?

Type your answer here

SUBMIT

6. What does a green dot inside the brine chiller unit moisture indicating sight glass indicate?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the low-pressure refrigeration system components.

1. Explain how the sensing bulb used by the brine chiller unit thermal expansion valve operates.

Type your answer here

SUBMIT

2. Explain the construction of the evaporator, or brine cooler, used by the brine chiller unit.

Type your answer here

SUBMIT

3. What is the purpose of the refrigerant suction pressure port on a brine chiller unit?

Type your answer here

SUBMIT

This completes Lesson 1. You can find the answers to the self-test questions in the Module 4 table of contents.

Lesson 2. Environmental Control System Fundamentals

MAIN POINTS

1. Environmental Control System Test Equipment
    a. Refrigeration system test equipment
    b. Environmental control system test equipment
    c. Environmental control system remote monitoring system
2. Controlnet and Fiber-optic Components
    a. Environmental control system transmitting and receiving devices
    b. Environmental control system fiber-optic and coaxial system components

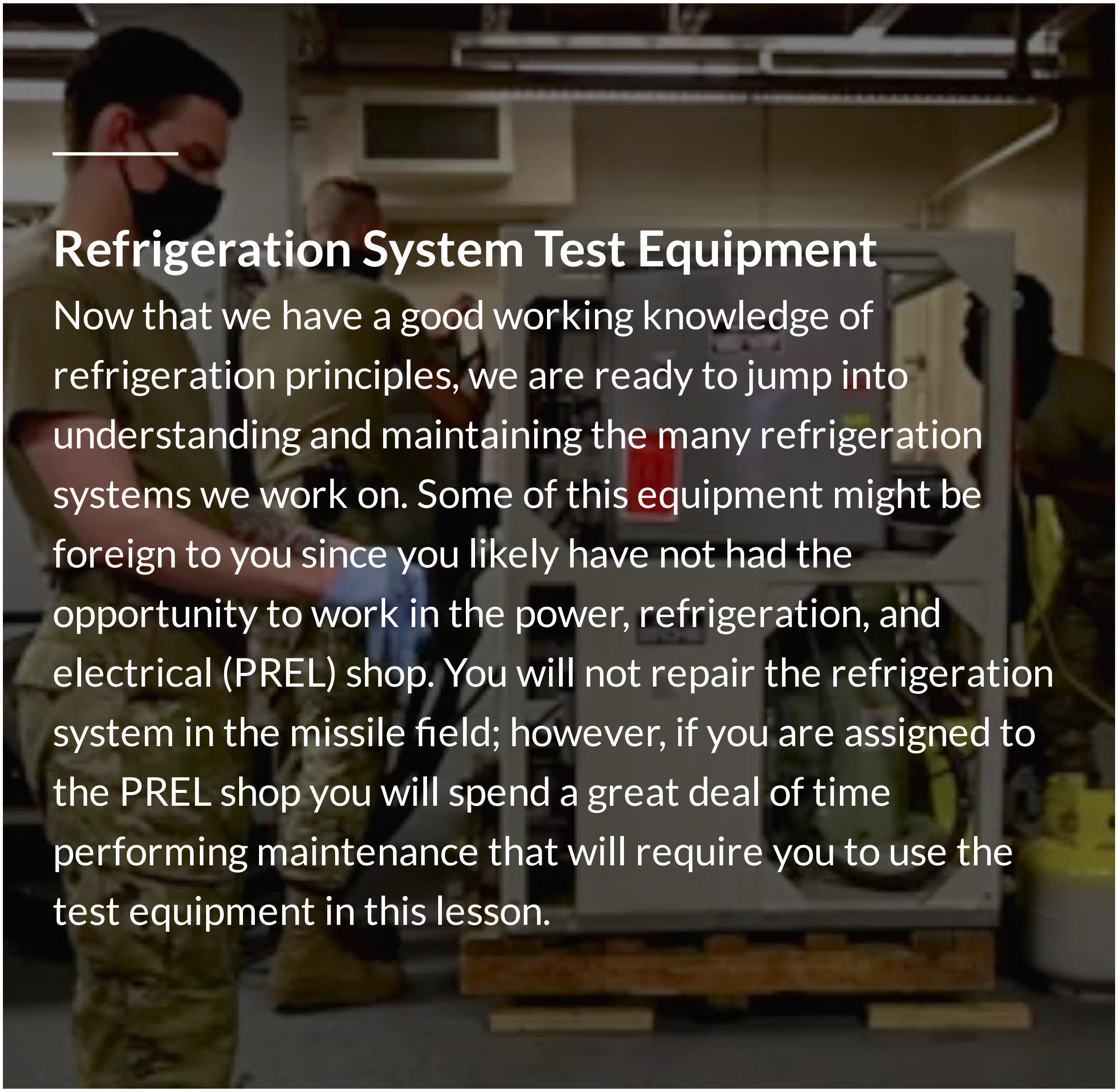
We have grasped the concepts behind the heart of the environmental control system (ECS)—the refrigeration system. Before we begin the explanation of the remainder of the ECS system, it is prudent to

discuss some of the test equipment that you will use in the field and on base to maintain the ECS on our missile systems and support equipment. Another fundamental to understanding the ECS as whole is understanding the components that make it operate.

Environmental Control System Test Equipment

There are many pieces of test equipment that a technician needs in order to maintain the various ECS systems, and knowing how to properly operate this equipment will help you successfully check, troubleshoot, and adjust these systems. This section will divide test equipment into two categories; those items used on the refrigeration system and those items used throughout the remainder of the ECS.

Complete the content above before moving on.



Refrigeration System Test Equipment

Now that we have a good working knowledge of refrigeration principles, we are ready to jump into understanding and maintaining the many refrigeration systems we work on. Some of this equipment might be foreign to you since you likely have not had the opportunity to work in the power, refrigeration, and electrical (PREL) shop. You will not repair the refrigeration system in the missile field; however, if you are assigned to the PREL shop you will spend a great deal of time performing maintenance that will require you to use the test equipment in this lesson.

NOTE: The step-by-step procedures found in this unit are for educational purposes only and do not replace civil engineering manuals (CEM) or technical orders (TO).

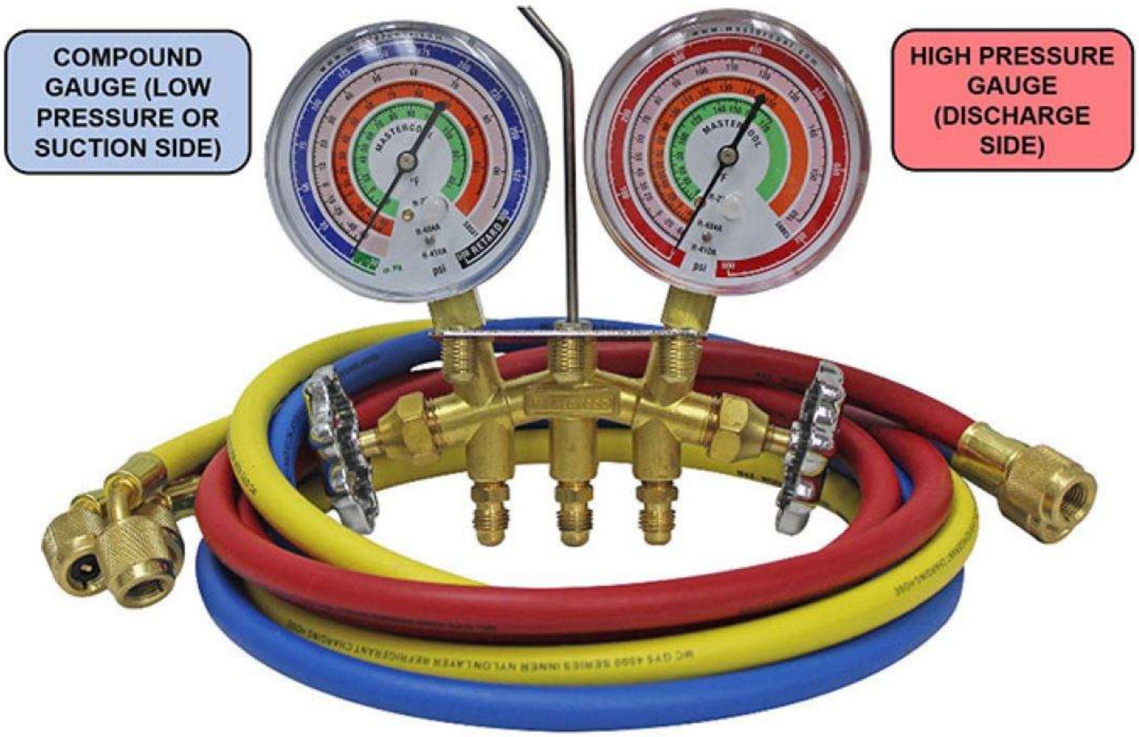


Figure 2–1. Manifold and Gauge Assembly.

Manifold and Gauge Assembly

The most important piece of refrigeration test equipment is the manifold and gauge assembly (fig 2–1), and you will use one as a technician in both FMS and PREL. The manifold and gauge assembly is a portable pressure gauge system that allows you to check out, troubleshoot and service refrigeration systems. The manifold and gauge assembly is used for many techniques and procedures including the following:

- Checking refrigerant suction and discharge pressures
- Checking refrigerant system pressure during nitrogen charging

- Charging the system with refrigerant

Components

The manifold and gauge assembly consists:

1. Manifold
2. High-pressure gauge
3. Compound gauge
4. Two valves
5. Three ports

One hose can be connected to each of the three ports on the manifold and gauge assembly, and most manifold and gauge assembly components will be color coded for ease of use. The high-pressure gauge, port, and hose are color coded red to indicate these are connected to the high side of the system (discharge), and the compound gauge, port, and hose are blue to indicate these are connected to the low side of the system (suction).

A third yellow hose can either be connected between the manifold and a refrigerant recovery bottle to purge the manifold and gauge assembly or be used for charging the system with refrigerant. If the hoses are not color coded, ensure you are connecting the proper side of the manifold and gauge assembly to the proper side of the system.

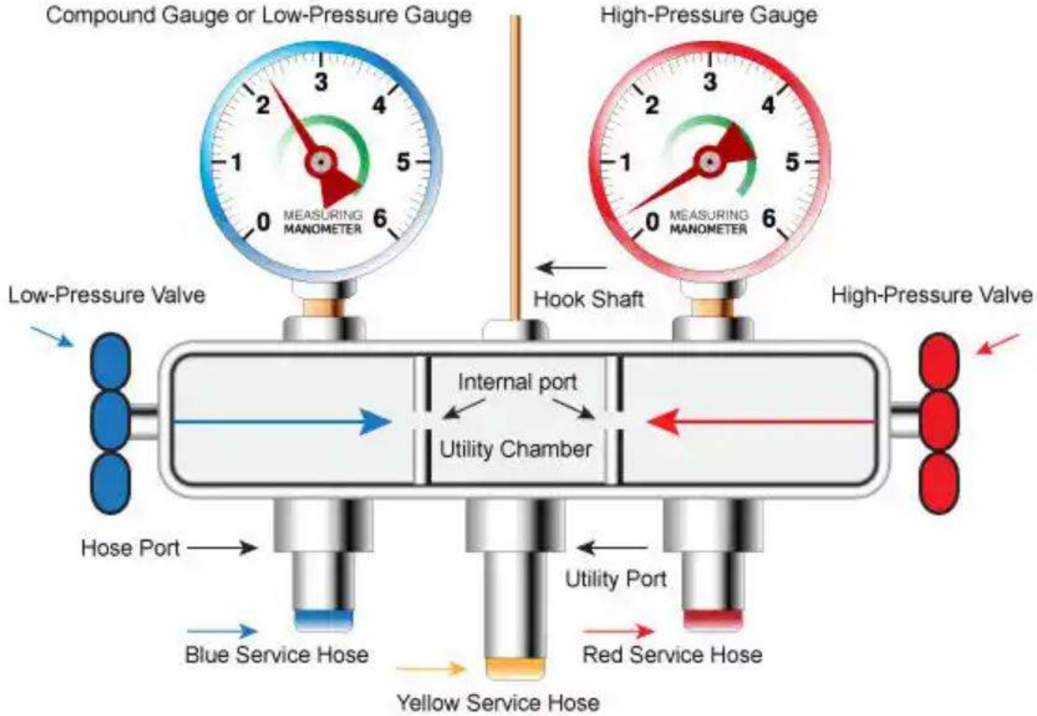
HOSES	GAUGES

Low-loss fittings are installed on one end of each of the hoses and are designed to close when a hose is disconnected in order to keep the residual refrigerant in the hose from escaping. It is important to note which side of the hose has the low-loss fitting valve when connecting your hoses. The side without the Schrader® valve is installed on the manifold and gauge assembly itself and the side with the low-loss fitting valve is connected to the refrigeration system. The hoses also contain rubber seals in both ends to ensure a tight seal to prevent refrigerant from leaking into the atmosphere.

HOSES

GAUGES

The manifold and gauge assembly consists of a high-pressure gauge and compound gauge. The red high-pressure gauge is connected to the high-pressure side of the system and will typically range from 0 to 500 pounds per square inch gauge (psig). The blue compound gauge can range from 0 to 200 psig and 0 to 30 inches of mercury (inHg). Any pressure below zero psig is considered a vacuum and will be measured in inHg.



Complete the content above before moving on.

Connecting and Disconnecting

Now that you're familiar with the components of the manifold and gauge assembly, let's see how it is used. Before using the manifold and gauge assembly, you must zero the gauges and purge the hoses.

Zeroing Gauges

Zeroing the pressure gauges ensures that they're properly calibrated before they're used to measure refrigerant pressure or vacuum. Remove all of the hoses from the manifold and gauge assembly before you zero the gauges. If you're using needle-type gauges, remove the clear front cover and use a fine-tip screwdriver to turn the adjusting screw (fig 2–2) on the face of the gauge until the needle reads zero. If you have been issued a set of digital gauges, remove the hoses and use the 'zero' function. With both gauges zeroed at atmospheric pressure, your gauge is considered calibrated.

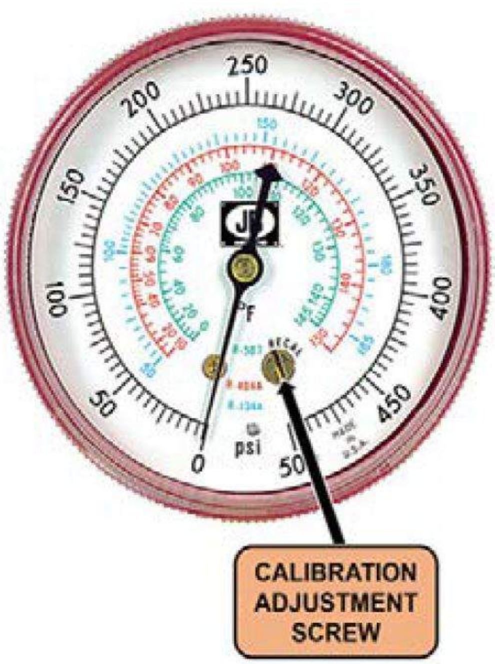


Figure 2–2. Gauge with zeroing screw.

Purging

Purging the hoses and manifold prior to use removes any ambient air that entered the hoses when they were removed from the manifold to zero the gauges. If you were to connect the hoses to the manifold and gauge assembly and then connect the manifold and gauge assembly to a refrigeration system, this ambient air would enter the system and eventually condense to liquid water and begin to corrode the system and possibly react with the lubricating oil. A small amount of air in a refrigeration system won't do any damage, but repetitively connecting hoses that have not been purged can add a significant amount of moisture to the refrigeration system over time. This is part of the reason that a moisture indicator sight glass is installed on all refrigeration systems. Use the following steps to purge the hoses of any contaminates that may be inside of them:

1. Ensure that you have a refrigerant bottle that has been drawn into a vacuum. If you have a bottle with a poor vacuum or no vacuum, you will not be able to purge the manifold and gauge assembly.
2. Ensure the valves on both the suction and discharge side of the manifold and gauge assembly are rotated to the fully clockwise position. This is called the "front seated" position, and this action isolates the high and low side from the center purge hose.
3. Connect the hose from the center port on the manifold and gauge assembly to a refrigerant bottle and then open the valve on the bottle.
4. Slowly open each valve on the manifold and gauge assembly to allow discharge and suction hoses to be purged. You will see the needle on the compound gauge drop below zero to a number corresponding to the amount of vacuum on the refrigerant bottle.
5. Close (front-seat) both valves on the manifold and gauge assembly, close the valve on the refrigerant bottle, and disconnect the hose from the refrigerant bottle.
6. Stow the refrigerant bottle and connect the manifold and gauge assembly to the refrigeration system.

Connecting and Removing the Manifold and Gauge Assembly

To attach the manifold and gauge assembly hoses to the refrigerant system, attach the loose end of the hose to the discharge or suction port on the refrigeration system. The Schrader® valve on the refrigerant pressure port will open the low-loss fitting on the hose and the gauge will automatically display the suction (or discharge) pressure.

To disconnect the manifold and gauge assembly hose from the system, quickly screw the fitting off of the service port. The Schrader® valve on the system and the low-loss fitting on the manifold and gauge assembly hose will both close. There will always be a miniscule amount of refrigerant that is lost when disconnecting the manifold and gauge assembly hoses—this is known as a de minimis amount, and you can minimize this by disconnecting the manifold and gauge assembly hose as quickly as possible.

Complete the content above before moving on.

Refrigerant Leak Detection Equipment

Refrigerant systems can develop leaks for many different reasons, and it is important to detect them and repair them as quickly as possible. There are several methods to locate a refrigerant leak, and in this section, we will look at the electronic leak detector, nitrogen bottle and regulator, and soap solution.

Electronic Refrigerant Leak Detector

The electronic refrigerant leak detector is a hand-held device used in the field by a FMS technician or in the bay by a PREL technician to detect refrigerant leaks. The device uses special circuitry that is calibrated to detect certain types of refrigerant, and it is equipped with a long, flexible stainless-steel probe that enables you to test areas that could otherwise conceal a small leak.

Oil circulates along with the refrigerant in a system; therefore, dirty or contaminated spots on refrigerant lines are great starting points when trying to locate a leak. If you do find a part of the system that has an obvious leak or oily residue, take note of the spot and be sure to remove the residue with a clean, dry rag only—do not use any sort of cleaning solution because this could contaminate the leak detector. Ensure the system that you're testing is turned off and has at least 5 psig of refrigerant remaining—it will be difficult to detect a leak if there is no refrigerant left in the system.

When you turn the leak detector on you should hear a repeating tone, or 'beep.' Once the unit has stabilized, pass the leak detector probe underneath the refrigerant lines and components at 1 inch per second, keeping the probe tip 1/4 inch from the surface being tested. Leaking refrigerant will move downward because it is heavier than air; therefore, keeping the probe below the line or component you are testing is adequate. Pay close attention to the fittings, refrigerant controls, soldered joints, and welds; these areas are more likely to develop a leak than a solid piece of pipe.

The leak detector will begin to beep faster if it comes in contact with refrigerant. If this happens, make note of the site of the leak and then continue to check the rest of the system. Once you have located and noted the leak or leaks in the system, the next step is to use a soap solution to pinpoint the exact spot of the leak. Escaping refrigerant will pass through the soap solution and make bubbles, and a steady stream of bubbles from a certain spot means that you've located the leak.

Below is the procedural process checking a brine chiller unit for refrigerant leaks. Click the "start" button to begin.

Nitrogen Bottle and Regulator

Figure 2–3. Nitrogen bottle and regulator assembly.

Unlike the refrigerant leak detector, charging a refrigeration system with nitrogen (fig 2–3) will only be accomplished by a technician in the PREL shop. The refrigeration system is pressurized with nitrogen gas in order to locate leaks. This method requires several steps and is very effective, but also very time consuming. Checking a brine chiller unit for refrigerant leaks

Step 1

Remove all of the refrigerant (if any remains) from the system.

Step 2

Connect the high-pressure gage of a manifold and gauge assembly to the refrigerant system discharge port.

Step 3

Connect the nitrogen pressure regulator to the inlet of the refrigerant receiver tank.

Step 4

Slowly open the nitrogen pressure regulator until the pressure gauge on the manifold and gauge assembly indicates 300 pounds per square inch (psi) and then allow the system to stabilize for several minutes.

Step 5

Once the system is stable at 300 psi, close the regulator on the nitrogen bottle and let the system sit for 1 hour.

Step 6

If the pressure gauge on the manifold and gauge assembly still reads 300 psi after 1 hour, the system is considered free of leaks—proceed to step 7. If the system has leaked any nitrogen, any leak(s) must be pinpointed using a soap solution and then repaired.

Step 7

Remove the nitrogen from the system, draw the system into a vacuum, and recharge with refrigerant.

Complete the content above before moving on.

Figure 2–4. Vacuum Pump (typical).

Vacuum Pump and Gauge

The vacuum pump (fig 2–4) is used to draw the refrigeration system into a deep vacuum after any leaks in the system have been located and repaired. This will not only remove any moisture, or ‘dehydrate’ the system, but will also make charging the system with fresh refrigerant easier.

Vacuum Pump and Gauge (continued)

The major components required for this task are a vacuum pump, micron gauge (fig 2–5), and associated manifolds and hoses. A micron gauge is simply a gauge that is meant to measure a deep vacuum. The configuration may differ slightly between the PREL sections at different units, but the concept is the same.

One end of the hose or manifold will be attached to the inlet of the vacuum pump, and the other end of the hose will be connected to the receiver tank on the brine chiller unit. The micron gauge will be connected to a point between the two so that it can measure the amount of vacuum on the system. With all components connected, turn on the vacuum pump and allow it to operate. This process takes a great amount of time, and you will typically let the vacuum pump operate overnight, and sometimes for several days. The process is not complete until the refrigeration system is in a vacuum of 500 microns or less. A deep vacuum is measured in 'microns' and this is measured in millimeters of mercury. One millimeter of mercury equals 1,000 microns, so 500 microns equals 0.5 millimeters of mercury. Depending on the type of micron gauge you're using, your gauge will either be connected to a pressure sensor via an electrical connector or connected directly with another hose.

Once the gauge reading indicates 500 microns, turn off the vacuum pump and monitor the gauge. Sometimes the gauge will read the vacuum at the manifold, but with the vacuum pump shutoff, the vacuum level will drop. If 500 microns cannot be sustained for at least 5 minutes after the vacuum pump has been turned off, the system still has moisture in it or may still have a leak. Once the system can sustain a 500-micron vacuum for 5 minutes or more, it is considered completely dehydrated and is ready to be charged with fresh refrigerant.

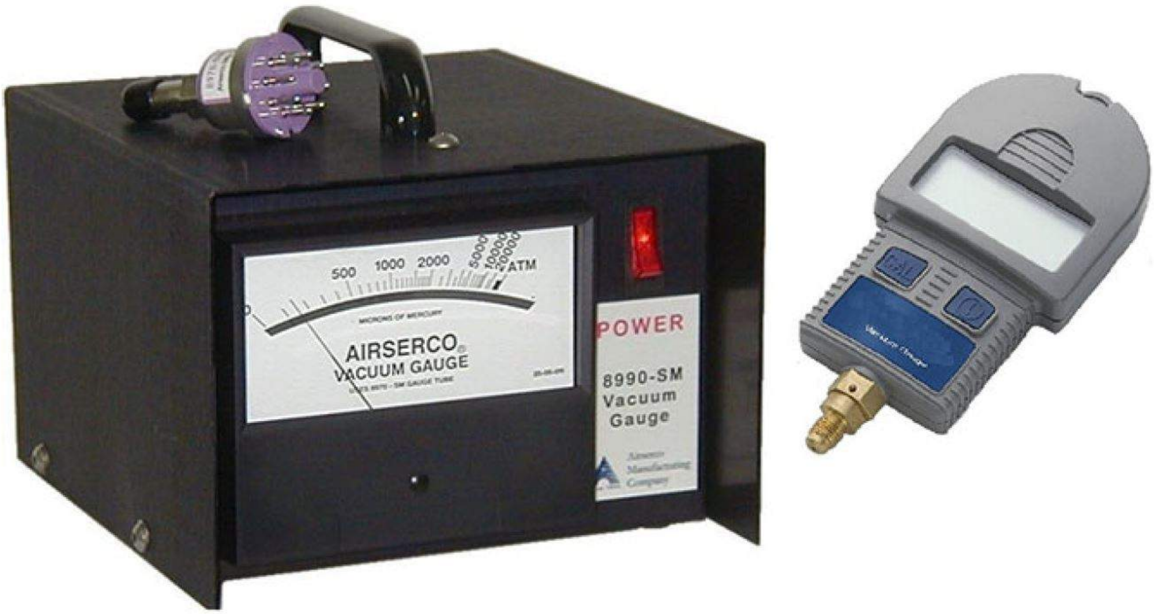


Figure 2–5. Micron Gauges.


REFRIGERANT
134a

Figure 2–6. Refrigerant Bottle.

Refrigerant Charging Equipment

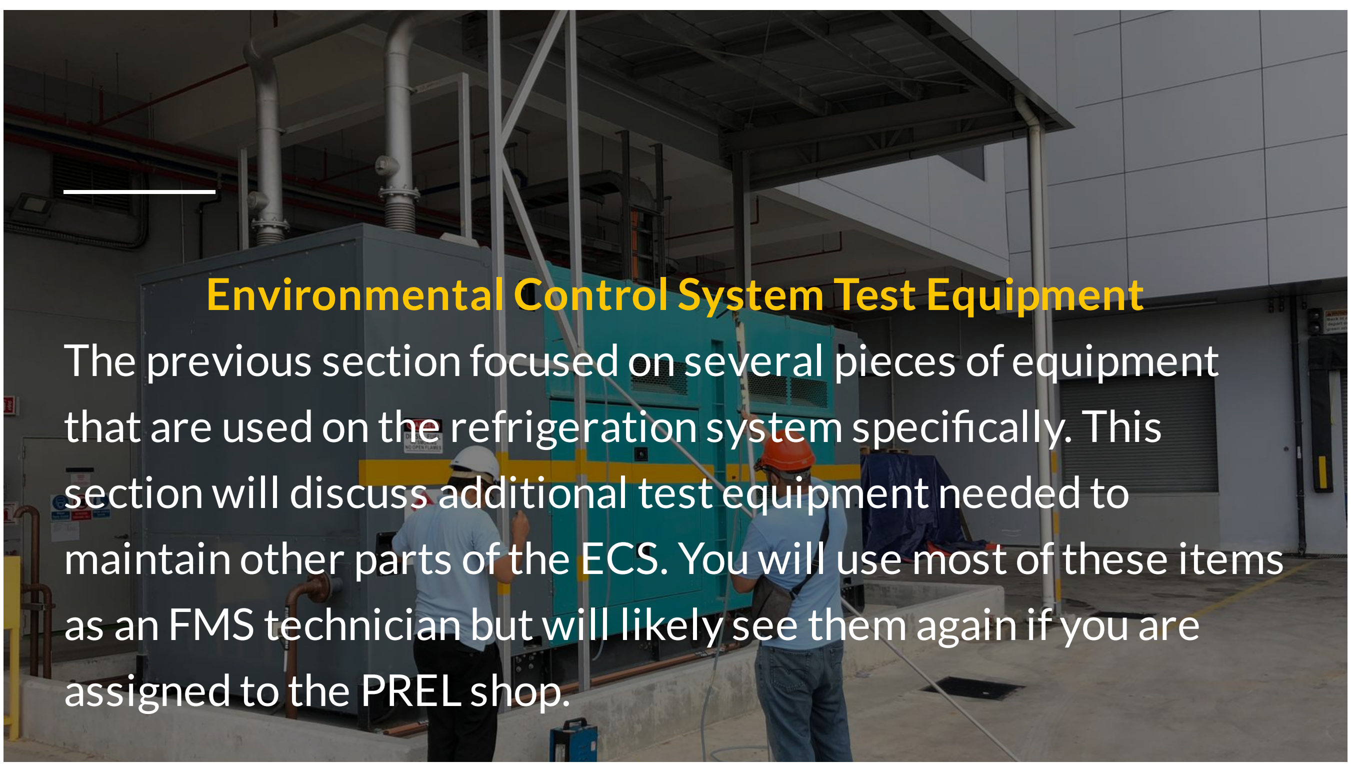
To service refrigerant, you will need the manifold and gauge assembly, a refrigerant scale, and a refrigerant bottle (fig 2–6). This will not be the same vacuum bottle that was used to purge the hoses of the manifold and gauge assembly, but rather another bottle full of refrigerant. The manifold and gauge assembly provides the hose connections between the refrigerant cylinder and the system. A refrigerant scale is used to monitor how much refrigerant has been added to the refrigerant system. Place the refrigerant bottle on the scale and annotate the starting weight. If your scale allows for a negative weight reading, you can zero the scale and then use the negative number to measure how much refrigerant has been transferred from the bottle to the system. Regardless of how this is accomplished, the key is to have the ability to annotate how much refrigerant has been transferred from the bottle to the system.

With the manifold and gauge assembly connected to the refrigerant bottle, open both the bottle and the system and monitor the weight of the bottle as refrigerant enters the system. Due to the deep vacuum, the system will pull the refrigerant from the bottle quickly and then slow to a stop as the charge in the system and the charge in the refrigerant bottle begin to equalize.

After the bottle and the system have equalized, the refrigerant bottle may need to be heated to increase its pressure above the pressure of the system so that a transfer of refrigerant will continue. Your shop will have either a bottle heating blanket or a warm water bath for this purpose. Your TO will tell you how much refrigerant to service depending on the type of system you're charging. For example, the launch facility (LF) brine chiller will hold 30 pounds of refrigerant. Once the weight on the bottle has dropped 30 pounds, no more refrigerant should be added to the system.

Once the system has been charged with refrigerant, your TO will likely instruct you to perform a functional checkout on the piece of equipment before it is returned to service in the field or the support base. This lesson has focused on several different pieces of equipment used for locating refrigerant leaks, placing a vacuum on, or dehydrating, the refrigerant system, and finally charging the system with fresh refrigerant.

Review all of the content above before moving on to learn about the ECS test equipment.



Environmental Control System Test Equipment

The previous section focused on several pieces of equipment that are used on the refrigeration system specifically. This section will discuss additional test equipment needed to maintain other parts of the ECS. You will use most of these items as an FMS technician but will likely see them again if you are assigned to the PREL shop.

Gas Detector System Calibrator Kit

The launcher equipment room (LER) is, for the most part, a nearly air tight atmosphere; therefore, a combustible gas detector (fig 2–7) is installed in the upper LER at each LF for the purpose of monitoring the atmosphere in the LER for any large accumulation of hydrogen gas. A ground maintenance response GMR-26 fault alarm will report to the launch control center (LCC) if a certain level of hydrogen gas has accumulated in the LER, and a separate alarm will report through the environmental control system remote monitoring system (ERMS) if the gas detector itself has failed.

A maintenance team will then be dispatched to the LF to either purge the LER using a purge system or troubleshoot a faulty combustible gas detector. If the LER does have a high concentration of combustible gasses, the maintenance team will also need to troubleshoot the cause.

Figure 2–7. Combustible Gas Detector GD-1.

Figure 2–8. Combustible Gas Detector Calibration Kit.

Gas Detector System Calibrator Kit (continued)

A high concentration of combustible gas is dangerous because, when mixed with the air in the enclosed atmosphere of the LER, all that is needed to ignite the mixture is a spark from a contactor repositioning or other ignition source.

The makeup air subsystem, which you will learn about in a later lesson, attempts to prevent this from happening by circulating fresh air from the launcher support building (LSB) through an underground pipe and into the lower LER.

During periodic inspections, and whenever the functionality of the gas detector is in question, a technician must use the gas calibration kit (fig 2–8) to ensure the gas detector is able to detect the difference between acceptable and combustible atmospheres. The calibration kit includes the following:

- Magnetic stick
- Calibration air cylinder
- Calibration hydrogen cylinder
- Regulator and fitting

The combustible gas detector is designed to operate in an explosive environment; therefore, its internal circuitry must be completely isolated from the environment that it monitors. This is the reason why there are no touch buttons or switches on the unit—a magnetic stick must be used to navigate through the menus. This magnetic stick is located in the gas detector calibration kit and is used to actuate the MODE, ENTER, UP (+) and DOWN (–) magnetic buttons (fig 2–9) on the face of the combustible gas detector.

The calibration air gas cylinder included in the kit provides the combustible gas detector with a 'clean' air or 'zero' baseline, and the hydrogen gas cylinder simulates a 50% lower explosive limit (LEL) atmosphere that provides the detector with the alarm limit.

Calibrator Kit

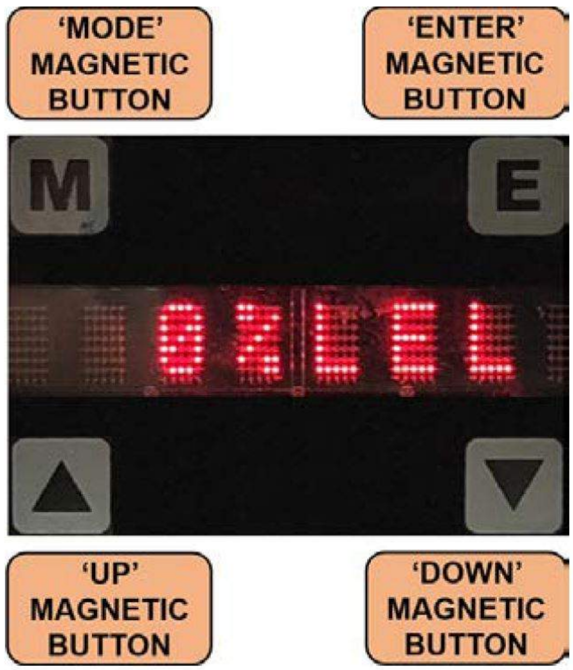


Figure 2–9. Combustible gas detector modes and display.

Listed below is the process you will go through for using the calibrator kit.

Step 1

Attach the regulator and fitting to the gas detector and then attach the air gas cylinder to the regulator.

Step 2

Touch the magnetic stick to the MODE button until CALIB appears in the gas detector's display. This indicates it is ready for calibration.

Step 3

Select ENTER once. When CAL-0% appears in the display, slowly open the air gas cylinder and allow gas to flow for a minimum of 3 minutes, and then press the ENTER button with the magnetic stick.

Step 4

When the display shows ACK, this indicates the calibration is successful and the gas detector now knows that a 0% LEL (clean atmosphere) exists.

Step 5

Now that the gas detector has a baseline for a clean atmosphere, you must give it a baseline for a contaminated atmosphere. The hydrogen gas cylinder is a mixture of explosive hydrogen and clean air with a 50 percent LEL quantity.

Step 6

When 50%-SPAN shows on the display, press ENTER with the magnetic stick and open the hydrogen cylinder. Again, leave the bottle attached with the gas flowing for at least 3 minutes.

Step 7

After a period of 3 minutes has elapsed, press ENTER with the magnetic stick—the display will show CAL-OK. The gas detector can now sense the difference between a clean atmosphere and one where too much gas has accumulated.

Summary

The gas detector will initiate its own 5-minute timer once the calibration is complete. Your TO will direct you to perform the ground maintenance response GMR-26 fault alarm functional checkout for the combustible gas detector to ensure that all systems are operating correctly.

Before moving forward in the lesson, click the "start" button to learn the process of using the calibrator kit.

Hydrometer

A hydrometer (fig 2–10) is used to measure the specific gravity of a liquid. Specific gravity is the ratio of a substance's mass as compared to water and indicates how thick a liquid is compared to water.

Water has a specific gravity of 1.000. A thicker substance will have higher specific gravity while a thinner substance will have a lower specific gravity. A hydrometer can be used to measure the specific gravity of any liquid, but FMS and PREL technicians use it primarily to verify specific gravity of the brine solution in the ECS. The reading correlates to how much ethylene glycol is present in the brine mixture, which determines the amount of freeze protection that it provides. Too much ethylene glycol will raise the freezing point, while too little will lower the freezing point.

All hydrometers are calibrated to provide accurate readings at a certain temperature, 60°F for example, and the liquid that is being tested must be at this temperature in order for the reading on the hydrometer to be accurate. The specific gravity of a substance will change depending on its temperature, so it is important that the brine be heated (or cooled) to match the temperature that the hydrometer is calibrated for.

You should also periodically check the accuracy of your hydrometer. If the hydrometer is calibrated to 60°F, and the specific gravity of water is 1.000, you can deduce that the hydrometer should show 1.000 when floating in water that is 60°F. Using an improperly calibrated hydrometer when mixing solutions will cause the freezing (or boiling) point to be out of tolerance.

Before drawing a sample of brine, open the valve to the brine expansion tank and allow the system to operate for 15 minutes. Doing this ensures that the brine you're about to draw is a sample of the entire system. Since the brine chiller unit cools the brine to approximately 35°F, your sample will be too cold to meet the calibration temperature on the hydrometer. You will either need to let the brine sit until it reaches the proper temperature or use an immersion heater to speed up the process.

Once the brine has been heated to the proper temperature, gently place the hydrometer in the graduated cylinder. The specific gravity of the brine solution is measured where the top of the liquid and the hydrometer meet, and an indication of 1.060 to 1.070 is normal. Your TO will direct you to add 1 gallon of pure ethylene glycol to the brine system if the reading on the hydrometer is less than 1.060, or add 1 gallon of purified water if the reading on the hydrometer is more than 1.070. After the system has run for a sufficient amount of time, you will need to draw another brine sample. A specific gravity less than 1.060 indicates that the freezing point of the brine solution is too high, and a specific gravity more than 1.070 indicates that the freezing point is too low. You will repeat this process until the specific gravity of the brine is between 1.060 and 1.070 at the specified temperature.

Figure 2–10. Hydrometer.

Static Air Pressure Manometer

You will use the static air pressure manometer (fig 2–11) to measure static air pressure that is indicated by the unit inches of water gauge or inwg. Static pressure is the resistance to the movement of air inside a tube or duct, which is why you will use a manometer whenever your TO directs you to check for adequate airflow at different locations in the environmental control system. Note that the manometer has several settings, but the only one you will ever use is “INWC” which stands for inches of water column. Your TO will direct you to check for inwg, but do not be confused by this because both have the same meaning.

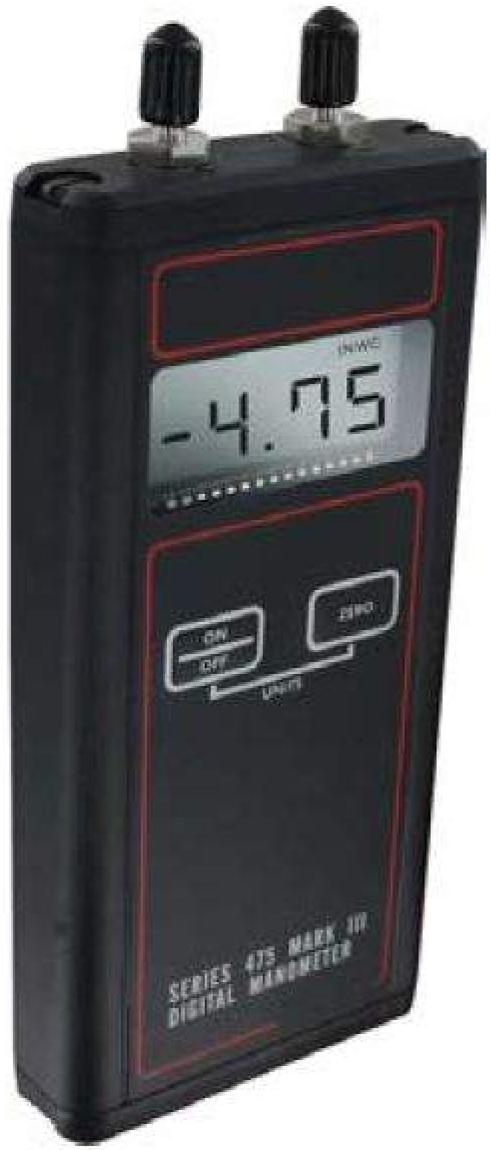


Figure 2–11. Static pressure manometer.

Figure 2–11. Static Pressure Manometer.

A manometer measures airflow in much the same way that a multimeter measures voltage—both meters sense a difference between two potentials. For example, sometimes you will be directed to install your manometer to a point before an air filter and to another point after the air filter. In this configuration the manometer is measuring how much airflow is being supplied to the filter versus how much is exiting the filter—this will indicate if the filter is clogged. At other times you will be directed to take a measurement using only one side (high or low) of your manometer. Regardless, both protective caps should always be removed from the high and low side ports on the manometer whenever you use it. Leaving one of the caps on will keep the manometer from measuring the difference in airflow. The digital manometer is easy to use:

1. Press the ON/OFF button to power the unit on.
2. Ensure INWC is showing in the display. If it is not, use either selector button to select "INWC".
3. Ensure that the unit shows "0.00" on the display (zeroed). Prior to connecting the manometer to any pressure port. If is not zeroed, press the "ZERO" button until "0.00" appears in the display.
4. Connect the manometer to the proper port or ports as directed by your TO.

Wet/Dry Manometer

The wet/dry manometer functions just like the static air pressure manometer, but you will instead use it to verify proper brine flow during the MAF or LF brine flow checkout.

To use the wet/dry manometer, you connect it to the inlet and outlet valves on the brine system's flow venturi FV-1. Follow these steps to get an accurate reading on the wet/dry manometer:

1.Turn the unit on, ensure it is zeroed, and set meter to the H20 scale and inches of water gauge (inwg).

2.Connect hoses between the high and low ports on the manometer and the inlet and outlet of the brine flow venturi. Leave the hose fittings at the manometer side slightly loose and place the manometer over a bucket or other container.

3.Open the brine flow venturi inlet and outlet valves on the brine chiller unit simultaneously. When liquid brine starts escaping from the hoses, tighten the hose fittings that were previously left loose. This step purges air from the liquid lines, which will ensure the most accurate reading.

4.Note the reading on the manometer. You can use the FILT button to stabilize the pressure reading if it is too erratic.

Temperature Control Test Set

The temperature control test set (TCTS) (fig 2–12) is used to simulate a specific temperature to a component in order to see how that component reacts to different temperatures and to verify proper operation.

To use the TCTS, plug the unit into any 120 volts alternating current (VAC) outlet and then set the desired temperature using a preset or by adjusting the temperature manually. Remove the temperature sensor that you'll be testing and wipe it with a clean rag before inserting it into the TCTS. In order for the TCTS to simulate the temperature accurately, use the smallest sleeve that the sensor or bulb will fit into snuggly.

The temperature that the TCTS is simulating at the probe or bulb will not be immediate. Therefore, you should wait a minimum of 6 minutes for all temperatures to stabilize before you continue with any checkout. You can use this time to complete another task. Once the TCTS and the system have completely stabilized, you can then verify that the system is responding as it should according to the temperature you have established with the TCTS.

Figure 2–12. Temperature Control Test Set (TCTS).

Fiber-Optic Test Set

Fiber-optic cables are used for temperature sensors as well as communication between the various control panels in the ECS. The fiber-optic test set (fig 2–13) verifies that the correct amount of light, and therefore a proper signal, is flowing through the fiber-optic lines. The fiber-optic test set consists of two major components: the light source and the power meter.

LIGHT SOURCE | POWER METER | USING THE TEST SET

To ensure that the test results provided by the power meter are accurate, a light source separate from the ones in the ECS is used to test fiber-optic cables. It provides infrared light, measured in nanometers (nm), at either the 660nm or 850nm range. All of the cables used in our ECS operate on 660nm infrared light, so this is the only light setting that will be used. It has a separate port on the top for each light source (660nm or 850nm) where the cable under test is connected.

LIGHT SOURCE | POWER METER | USING THE TEST SET

The power meter is calibrated to the light source and measures the amount of signal loss, in decibels (dB), that occurs throughout a length of fiber-optic cable. The two types of fiber-optic cables used in the ECS are the V-pin and straight tip (ST), which will be described in a later lesson.

Figure 2–13. Fiber-optic test set light source and power meter.

LIGHT SOURCE	POWER METER	USING THE TEST SET

You will need to calibrate the test set power meter to the light source before testing any fiber-optic cable. Doing this ensures that a proper baseline has been established so that the fiber-optic cable you're testing is the only component being accounted for. Any light lost through the jumper cables will have already been subtracted from the equation. Calibrate the power meter and light source as follows:

1. Turn the power meter on and set it to decibels.
2. Set the power meter to read 660 nm by pressing the "λ" button.
3. Install the straight tip connector adapter cap on top of the power meter.
4. Turn the light source on to 660 nm.
5. Connect one jumper cable to the power meter and another jumper cable to the light source.
6. Connect the loose ends of the two jumper cables together using the proper adapter bushing. The fiber-optic cable that you want to test should not be connected to the meters yet.

7. Press and hold the reference (REF) button on the power meter for 15 seconds. This zeroes the meter with the 660nm signal traveling between the light source and power meter—the meter will use this as the baseline signal.

Now the meter has a baseline for a serviceable cable signal. You will leave the two jumper cables installed that you used to calibrate the power meter and will use different adapters depending on whether you're testing a V-pin or ST cable. Test a fiber-optic cable as follows:

1. Connect the light source with a jumper cable and bushing to one end of the cable being tested. Use the same setup procedures above.
2. Connect the meter with a jumper cable and bushing to the other end of the cable that is being tested.
3. Check the display to ensure it reads less than 5 dB of signal loss. Signal loss indicates the difference between the baseline 660nm signal and the signal that is passing through the fiber-optic cable that you're testing.

Complete the content above before moving on.

Thermometers

A thermometer is used to indicate the temperature of a substance, and your TO will often direct you to use one when troubleshooting or performing a functional checkout on the ECS. You will use a digital thermometer (fig 2–14) while performing maintenance.

To use the thermometer, simply plug a probe into a socket. If no probe is installed when the unit is turned on, it will display "LO." When you turn the unit on with a probe installed, it will immediately begin to display the current temperature.

This lesson focused on many of the pieces of test equipment you will use to ensure that the ECS is functioning properly.

Figure 2–14. Digital Thermometer.

CONTINUE

Environmental Control System Remote Monitoring System

There are 150 LFs at each missile wing spread out over several thousand square miles of territory, and many hours of drive time as well as time spent penetrating the facility are necessary to gain access to the LER in order to perform a temperature check on the electronic racks. The ability to check ECS parameters from the support base without the need to generate a maintenance dispatch makes the ERMS an invaluable tool.

The ERMS allows the missile maintenance operations center (MMOC) and FMS supervision to monitor several parameters of the ECS (fig 2–15) directly from the support base. There are several sensors connected to a module called the ERMS communication module, which is located in the lower LER. Signals then run through the hardened intersite cable system (HICS), and to the pressure monitoring receiver-transmitter (PMRT) at the MAF. Signals then travel from the PMRT to the support base through telephone lines. The status of every ERMS communications module is queried every 10 minutes, and a user in FMS, HICS, or the MMOC with access to an ERMS terminal can also run a query at any time. The ERMS communications module sends data on the following parameters:

- Brine supply temperature.
- Brine return temperature.
- Temperature of air flowing to the electronic racks.
- Air temperature in the launch tube.
- Status of combustible gas detector GD-1.
- Status of makeup airflow.
- Status of the diesel fuel leak detection system.

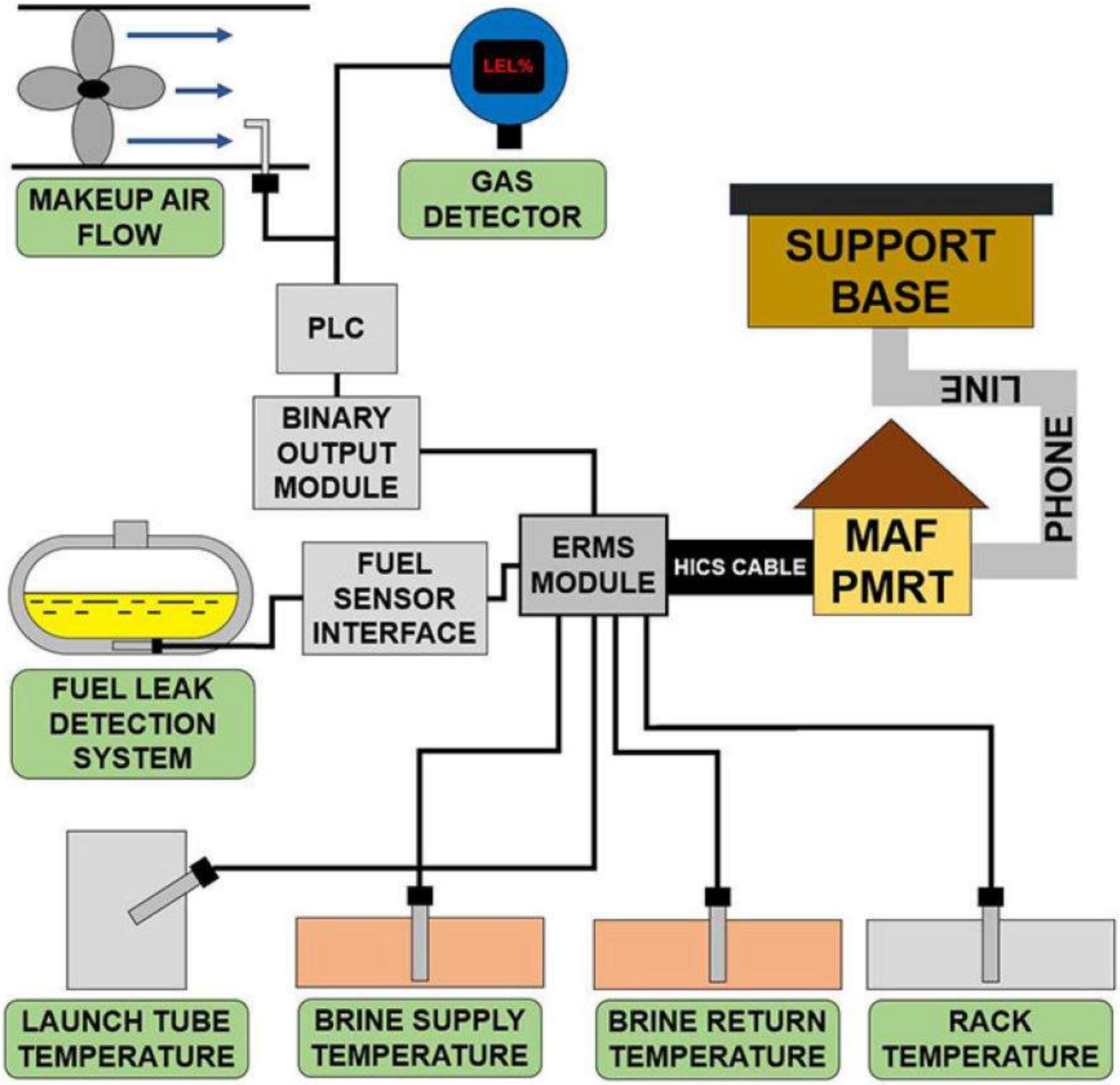


Figure 2–15. ECS Remote Monitoring System (ERMS).

Brine Supply Temperature

The ERMS brine supply temperature sensor TSR-7 is installed into a temperature well in the brine supply line just before it enters the air handler in the lower LER. This data will tell the user the temperature of the brine coming from the brine chiller unit in the LSB. This data is sent directly to the ERMS communication module.

Brine Return Temperature

The ERMS brine supply temperature sensor TSR-8 is installed into a temperature well in the brine return line directly after it exits the air handler in the lower LER. This data will tell the user the temperature of the brine exiting the cooling coil of the air handler. This data is sent directly to the ERMS communication module.

Temperature of Air Flowing to the Electronic Racks

The ERMS rack cooling air temperature sensor TSR-9 is installed in the upper LER in the duct between the air handler and the electronic racks. This data will tell the user the temperature of the air flowing to the electronic racks. This data is sent directly to the ERMS communication module.

Air Temperature in the Launch Tube

The ERMS launch tube air temperature senor TSR-10 is installed within the launch tube liner in the lower LER, near the launch tube heater, and this data will tell the user the temperature inside the launch tube. This data is sent directly to the ERMS communication module.

Status of Combustible Gas Detector GD-1

The ERMS does not have a dedicated sensor for this function. Instead, if the lower explosive limit is greater than 25% for 15 seconds or the output from the combustible gas detector is low for longer than 300 seconds, the programmable logic controller (PLC) will command a binary output (BO) module in the ECS to close a set of contacts that will then relay a signal to the ERMS communication module.

Status of Makeup Airflow

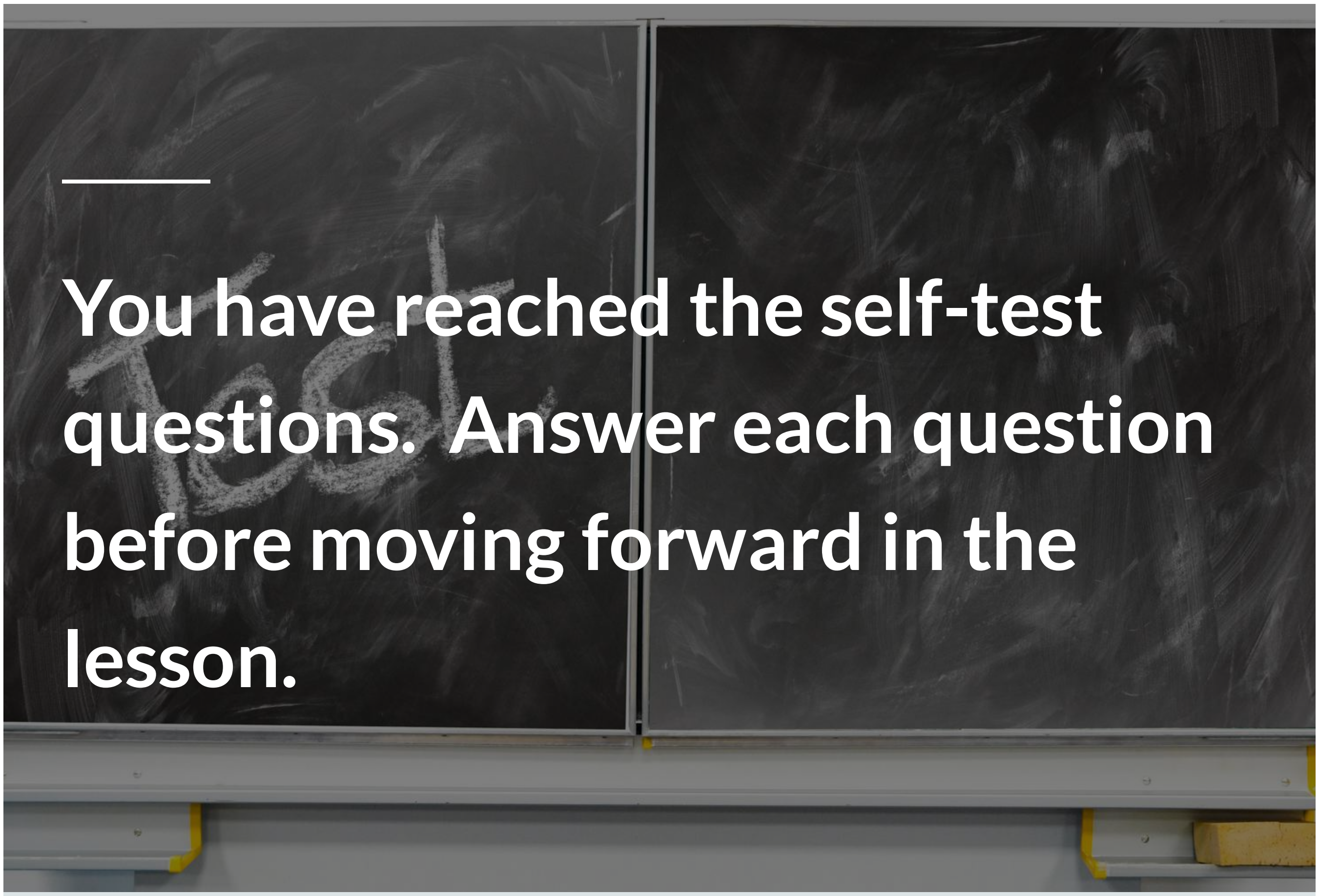
Similar to the status of combustible gas detector GD-1, the ERMS does not have a dedicated sensor for monitoring the status of makeup airflow. If the makeup airflow is less than 0.05 inches of water gauge at Wing 1, or less than 0.15 inches of water gauge at Wings 3 and 5, for longer than 15 seconds, the PLC will command a BO module in the ECS to close contacts which sends a signal to the ERMS communication module.

Status of the Diesel Fuel Leak Detection System

The ERMS fuel sensor interface FSI-1 is installed in the LSB. If a ground maintenance response GMR-5 fault alarm is reporting due to a fuel monitoring system fault, the relay in the ERMS fuel sensor interface energizes to close a set of contacts that will send a signal to the ERMS communications module. This data is especially useful for differentiating a ground maintenance response GMR-5 that is related to a fuel leak from a ground maintenance response GMR-5 that is related to a power generation and distribution system fault.

Missile maintenance operations center and FMS supervision use the data received from the ERMS to assist them in prioritizing maintenance responses and allocating resources. For example, if a ground maintenance response GMR-26 fault alarm is reporting for high air temperature flowing to the electronic racks, but the temperature is holding steady at 62°F, your leadership can elect to tackle other higher priority maintenance because they know that it will be some time before there is a need to perform an emergency shut down of the racks.

Complete the content above before moving on.



You have reached the self-test questions. Answer each question before moving forward in the lesson.

KNOWLEDGE CHECK TIME!

For the fill-in the blank questions, you will need to add (.) period to the end of the sentences.

Click here to answer the self-test questions pertaining to the refrigeration system test equipment.

1. What is the purpose of a low-loss fitting on the hose of a manifold and gauge assembly manifold and gauge assembly?

Type your answer here

SUBMIT

2. How do you 'zero' a refrigerant pressure gauge to atmospheric pressure before using it?

Type your answer here

SUBMIT

3. When purging a manifold and gauge assembly manifold and gauge assembly, why is it important to have a bottle with a sufficient amount of vacuum?

Type your answer here

SUBMIT

4. Why should you ensure that at least 5 pounds per square inch of refrigerant remain in the system when testing for a leak?

Type your answer here

SUBMIT

5. What is considered a sufficient vacuum for a refrigeration system?

Type your answer here

SUBMIT

6. What will aid you when first starting to add refrigerant to a refrigeration system?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the environmental control system test equipment.

1. What is the purpose of combustible gas detector GD-1 in the launcher equipment room?

Type your answer here

SUBMIT

2. Why are there no physical touch buttons on combustible gas detector GD-1?

Type your answer here

SUBMIT

3. What parameter does a hydrometer measure?

Type your answer here

SUBMIT

4. What action should be taken on the brine subsystem before drawing a sample to test its specific gravity?

Type your answer here

SUBMIT

5. What is static pressure?

Type your answer here

SUBMIT

6. What unit should you always ensure the static pressure manometer is set to display?

Type your answer here

SUBMIT

7. What can you do to stabilize an erratic reading on a wet/dry manometer?

Type your answer here

SUBMIT

8. What type of power source does the temperature control test set require?

- 75 VAC.
- 110 VAC.
- 100 VAC.
- 120 VAC.

SUBMIT

9. What two settings on the fiber-optic test set power meter should you always use?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the environmental control system remote monitoring system.

1. Where is the environmental control system remote monitoring system communication module located at a launch facility?

Type your answer here

SUBMIT

2. Where is the environmental control system remote monitoring system sensor for air temperature in the launch tube located?

Type your answer here

SUBMIT

3. Where is the environmental control system remote monitoring system fuel sensor interface FSI-1 installed?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Controlnet and Fiber-optic Components

The ECS at the MAF and LF use technology similar to systems used in the civilian sector. There are many communication devices, modules, and sensors. Understanding how these components interact with each other is fundamental to understanding how the ECS operates and how to troubleshoot it. The following lessons will help you do this.

Environmental Control System Transmitting and Receiving Devices

The ECS requires several devices in order to transmit and receive information. Transmitting devices are those that initiate commands, such as the PLC and button commands, sent by the user through the panel display when buttons are pressed. Receiver devices are the modules or pieces of equipment that receive commands. This lesson will focus on the different types of transmitting and receiving devices in the ECS.

PANEL DISPLAY	PROGRAMMABLE LOGIC CONTROLLER...	UNIVERSAL TERMINAL BASE

The panel display (fig 2–16) is a menu-driven interface that provides the capability to view system parameters and status and also sends inputs from a technician to the system. Each LF utilizes two panel displays, one in the LSB and one in the LER. Both will show you the same information, offer the same functionality, and are even interchangeable.

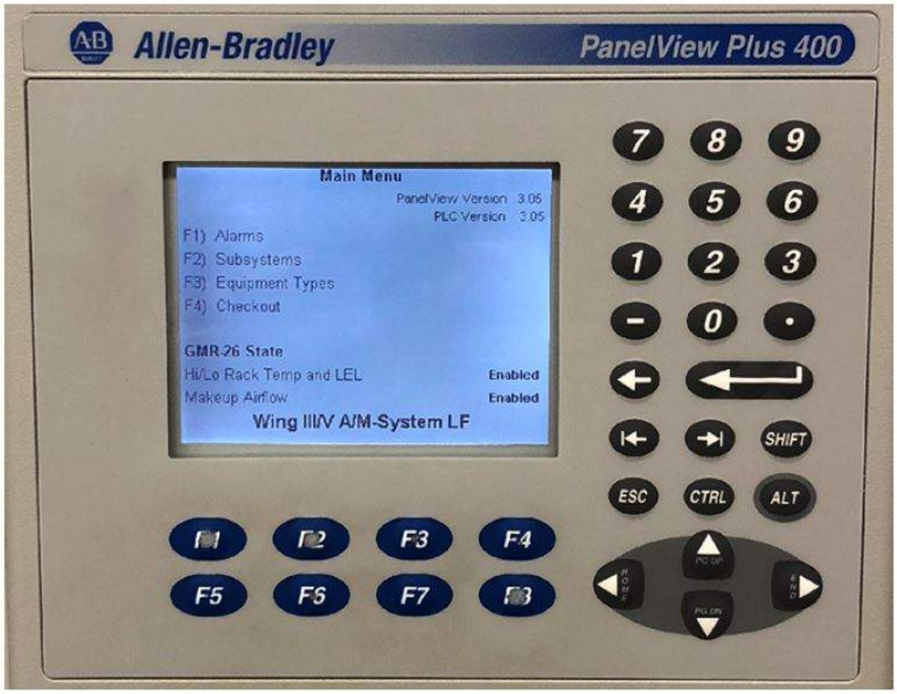


Figure 2–16. Panel display.

PANEL DISPLAY	PROGRAMMABLE LOGIC CONTROLLER...	UNIVERSAL TERMINAL BASE

The PLC (fig 2–17) is where the operating system for the ECS is installed and is located in the ventilation control panel in the LSB. The PLC uses a closed-loop feedback system to provide accurate, stable control to modulate ECS parameters such as brine supply and launch tube temperatures.

There are several panels in the ECS, including the brine chiller control panel, ventilation control panel, and the air handler control panel that must all have the ability to communicate with one another in real time. The controlnet daughtercard is a fiber-optic network adapter that allows the PLC to communicate with and control the ECS.

Figure 2–17. Programmable logic controller.

PANEL DISPLAY	PROGRAMMABLE LOGIC CONTROLLER...	UNIVERSAL TERMINAL BASE

Each of the modules we are about to cover provide several different functions, logically resulting in many wires entering and exiting them. To remedy the need to label and remove dozens of individual wires in order to replace a module, the system uses devices called terminal bases (fig 2–18) that stay in the panel—each module simply plugs into this terminal base.

The terminal base also houses the backplane connectors that allow for module-to-module communication. We will cover backplane connectors later in the unit.

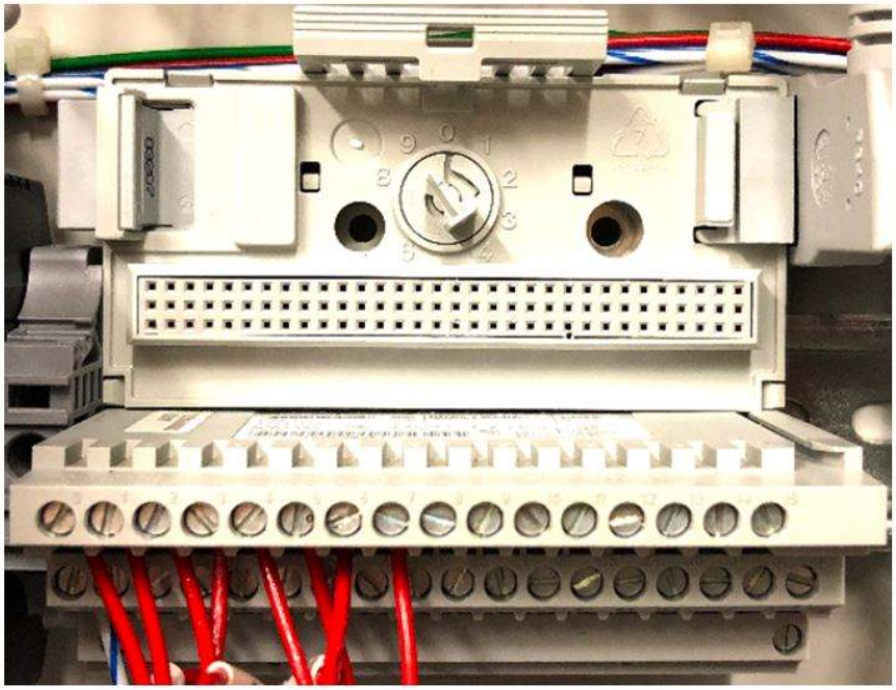


Figure 2–18. Terminal base.

Complete the content above before moving on.

Binary and Analog Modules

The PLC uses three different types of modules to receive input and provide output to the ECS. Let's take a look at how each module functions within the system as well as how you can easily identify them on a schematic or wiring diagram.

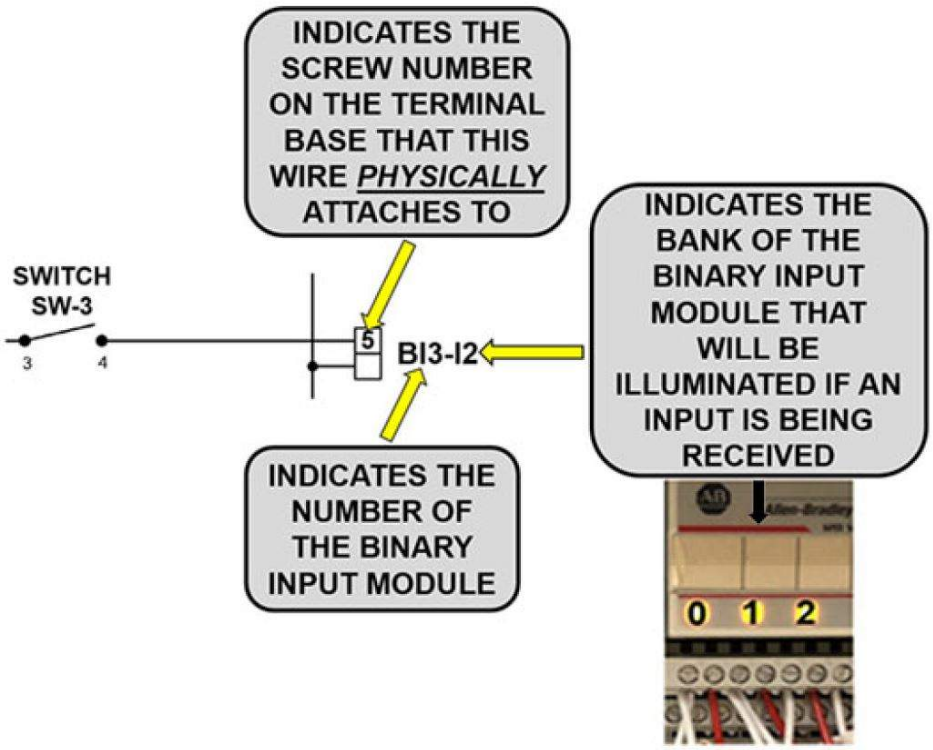
BINARY INPUT MODULE	BINARY OUTPUT MODULE	ANALOG INPUT/OUTPUT MODULE

The binary input (BI) module provides a two-position (binary) on or off status of system components to the PLC. You will commonly see them used in the system after a contact, switch, or overload. For example, if you were using the panel display in the LSB to view the status of the air handler fan in the LER, you would require information that was being relayed to the PLC by BI3. BI modules do not require their own power source because they receive power from the devices they monitor. You will notice that the terminal bases BI modules always have alternating power and ground wires because their only job is to receive input from the system and then relay this input to the PLC.

Refer to figure 2–19 below as you read the explanation of how a BI is labeled on a schematic.
On a schematic or wiring diagram in TO 21M-LGM30G-2-7-8, Launch Facility ECS, or TO 21M-LGM30G-2-7-9, Missile Alert Facility ECS, a BI module will be annotated by “BI” followed by the number of the module. For example, “BI3” would indicate binary input module # 3.

The number listed after the number of the module refers to the bank that will be illuminated if an input is being received. Remember, BI modules receive power from their inputs.

BI modules have many wires connected to them, so the schematic will also indicate which screw on the terminal base to which the wire is physically connected. This is the number listed inside of the square.



BINARY INPUT MODULE	BINARY OUTPUT MODULE	ANALOG INPUT/OUTPUT MODULE

The BO module allows the PLC to provide an output in order to control system operation. This module requires 24 volts direct current (VDC) to operate because it must reposition internal contacts to allow or disallow the flow of power to circuits in the system. A BO module is just a relay with many sets of contacts, which is why the terminal base will always have a power wire going into and exiting each individual set of contacts. This enables the PLC to control the system and open/close contacts and switches to make motors energize and so forth. Remember, this module provides a binary output to a component in the system—in other words, the component that is being controlled is either on or off.

BO modules are labeled nearly the same way on a schematic as a BI module, but the numbers that refer to the screw number on the terminal base come before and after the contact. Refer to figure 2–20 below as you read the explanation of how a BO is labeled on a schematic.

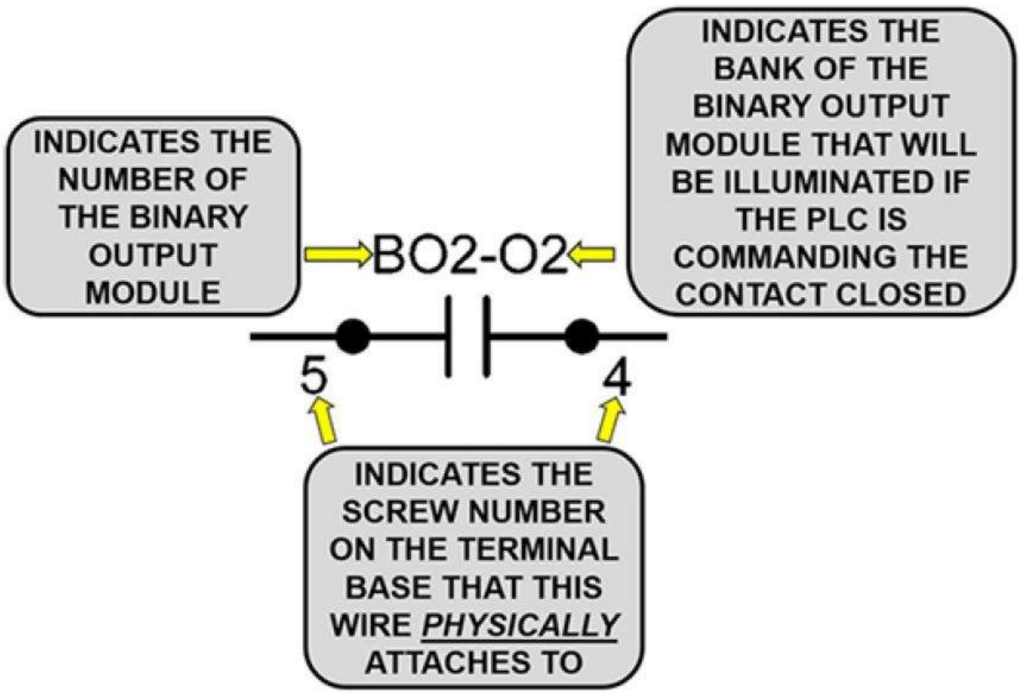


Figure 2–20. Binary output module on a schematic.

BINARY INPUT MODULE	BINARY OUTPUT MODULE	ANALOG INPUT/OUTPUT MODULE

The analog input/output (IO) module (fig 2–21) provides a varied or proportional means for the PLC to monitor and control the system and requires 24 VDC power to operate. Recall that the BI and BO modules were binary, meaning that a signal was either being sent or it was not being sent. An analog module is different because it can operate throughout an entire range of voltages.

An analog signal can vary constantly, and a damper actuator (DA) is a great example of a component that requires an analog control signal. The actuator needs to close the damper if too much air is flowing and needs to open the damper if too little air is flowing. The PLC sends the 'open' command to the DA through the IO module, which is then sent to the DA itself. Feedback on the exact position of the DA is then sent back through the IO module to tell the PLC how far open the DA is. This functionality allows you to use the panel display to view the position of the DA in the form of a percentage of how far it is open.

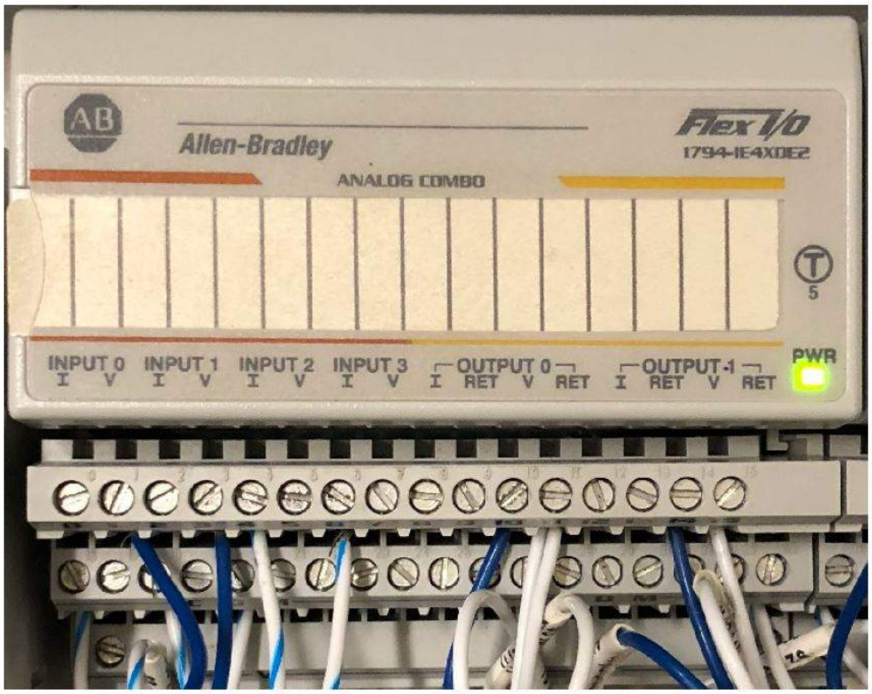


Figure 2–21. Analog input/output module.

Complete the content above before moving on.

Figure 2–22. Damper Actuator.

Damper Actuators

DAs (fig 2–22) are used to modulate (open and close) shutters or ‘dampers’ in order to control the amount of airflow through a duct. The motor that performs the work inside of the DA operates on 24 VAC, but the voltage used by the PLC to control the DA ranges between 0 and 10 VDC. The PLC sends the modulating signal to an IO module as we just described, and the position of the DA is returned to the IO module in a milliamp (mA) signal that will in turn notify the PLC that the DA has repositioned. There are four different types of damper actuators used:

1. Proportional spring return.
2. Proportional non-spring return.
3. Incremental non-spring return.
4. On/Off spring return.

Proportional Spring-Return

The proportional spring-return actuator is positioned by outputs from the PLC (through the IO module) in response to system conditions. This type of DA is used when the damper it is operating needs maximum control because of high-velocity airflow, such as the diesel radiator dampers. When power is removed from the actuator, the spring return will return the damper to its original position (normally closed or normally open). For example, when the diesel engine shuts down, the actuator de-energizes and the damper fully closes. There is no reason for the damper to be open when the diesel electric unit (DEU) is not operating.

Proportional Non-Spring Return

The proportional non-spring-return actuator operates just as the previous actuator—it responds proportionally to PLC commands in response to system conditions. The only difference is that when power is removed from the non-spring-return actuator, it remains in whatever position it was in when the power was removed.

Incremental Non-Spring Return

The incremental non-spring-return actuator is used where minimal control is needed. The PLC controls this DA through a BO module, meaning that the damper will be either fully open or fully closed (binary). The diesel exhaust recirculation damper is a good example. When the PLC senses that the LSB ambient temperature is too low while the DEU is operating, a signal will be sent to the BO module to fully open the recirculation damper in order to allow heat to flow into the LSB.

On/Off Spring Return

This is a two-position damper actuator. When power is applied or removed, the DA will reposition the damper to either the fully open or fully closed position—there is no incremental or proportional control. A good example is the air handler and emergency fan isolation dampers. When the air handler operates, the air handler isolation DA energizes to reposition the damper to the fully open position. Conversely, the DA for the emergency fan will energize to close the emergency fan isolation damper. When power is removed from the air handler and the emergency ECS fan needs to operate, both DAs de-energize and reposition the dampers to their opposite positions in order to allow air to flow from the emergency ECS fan.

Complete the content above before moving on.

Pressure Sensors

Pressure sensors (fig 2–23) are used to measure the amount of airflow in a duct and provide an analog feedback signal to the PLC. The pressure sensor sends this signal to an IO module, so the signal will vary depending on the airflow through the duct. This feedback signal will allow the amount of airflow to be viewed on the panel display, and the PLC is programmed to take certain actions if airflow becomes too low. For example, if the airflow in the air handler falls below 0.47 inwg for more than 15 seconds, the PLC is programmed to shut down the air handler, initiate a ground maintenance response GMR-27 fault alarm, and start the emergency ECS fan.

This lesson focused on the function of BI, BO, and IO modules as well as DA and pressure sensors. The PLC uses all of these components to receive input from and provide output to the ECS.

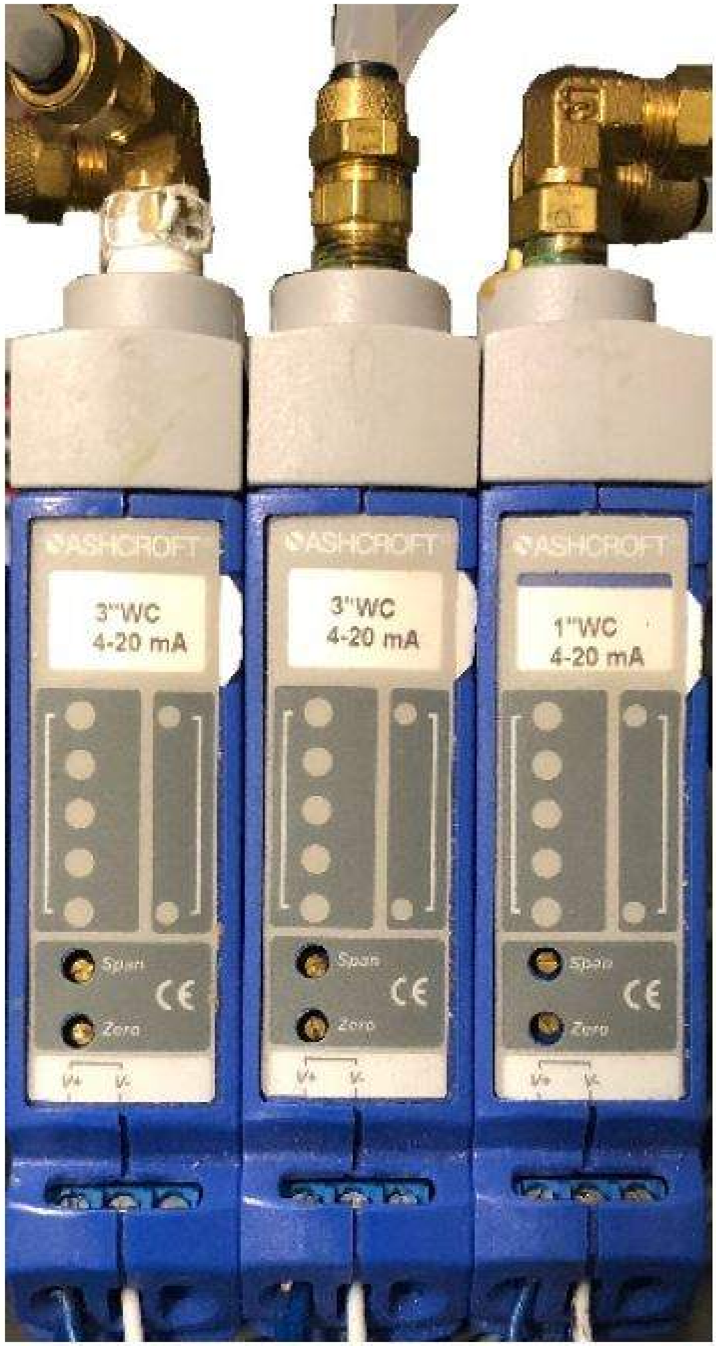


Figure 2–23. Pressure Sensors.

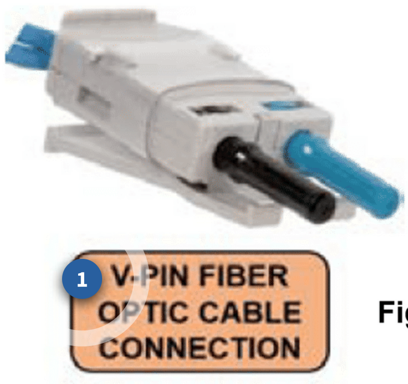
Environmental Control System Fiber-Optic and Coaxial System Components

Fiber-optic cables are capable of transferring an immense amount of data quickly by relaying signals that have been converted into beams of light. As you can imagine, the electricity that flows through the components within the different panels of the ECS cannot flow through the fiber-optic cables, and the light that flows through the fiber-optic cables cannot flow through the electrical wires in the panels. This lesson will focus on the modules and the types of cables that make these conversions.

Communication Network Components

The ECS is spread among two different locations and several different panels throughout the MAF and LF, and it would be impractical to have copper conductor wire running between these locations because it can only carry one signal per conductor. Fiber-optic cable is used instead because it has the ability to carry many different signals within one beam of light.

There are two different types of fiber-optic cable used in the system: V-pin and ST. Click on each number below to learn about the V-pin and ST fiber-optic cables.



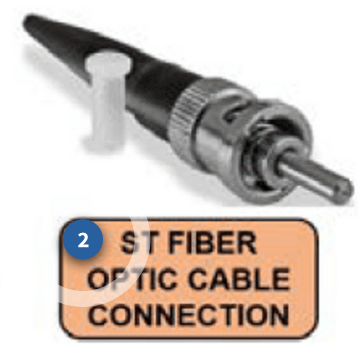
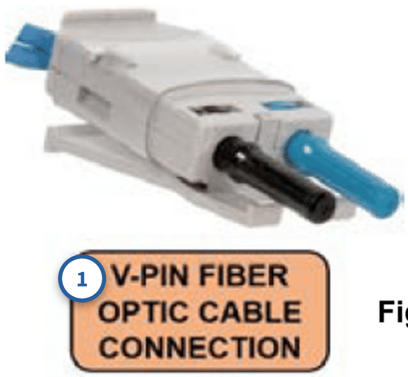


Figure 2–24. Fiber-optic cable connectors.



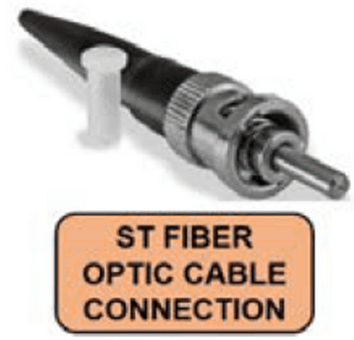
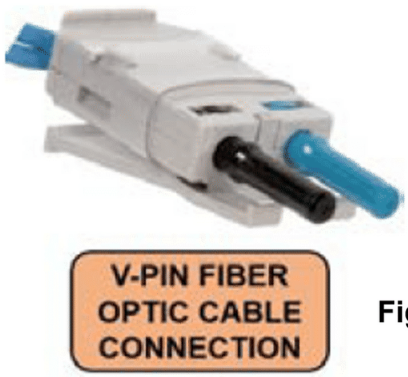


Figure 2–24. Fiber-optic cable connectors.

V-pin Fiber-optic Cable

The V-pin fiber-optic cable (fig 2–24) uses a ‘fluted’ tip and is used for panel-to-panel communications throughout the ECS. One length of fiber-optic cable runs between the PLC in the ventilation control panel and the brine chiller control panel, and another much longer length runs between the brine chiller control panel and the air handler control panel in the LER. Each length is actually two different fiber-optic cables—one for incoming signals into the panel and the other for outgoing signals from the panel. The two cables will run together between panels, and the tips are combined in a clip at each end.



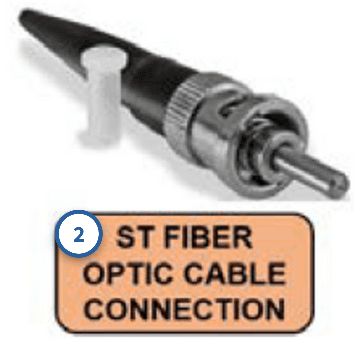


Figure 2–24. Fiber-optic cable connectors.

ST Fiber-optic Cable

The ST (fig 2–24) is a straight tip fiber-optic cable that is used for communication between the fiber-optic signal conditioner module and temperature sensors in the ECS and comes in the form of a single black cable. To help you differentiate between V-pin and ST fiber-optic cables, remember that the V-pin cable is two separate cables in one, while the ST is only a single cable.

Complete the content above before moving on.

Figure 2–25. Fiber-optic Repeater.

Fiber-optic Repeater

A fiber-optic repeater (fig 2–25) amplifies the fiber-optic signal and provides a link between the fiber-optic components in the three ECS control panels. A fiber-optic repeater is only necessary in the brine chiller and air handler control panels because the controlnet daughtercard on the PLC handles these duties in the ventilation control panel. The fiber-optic repeater communicates with the fiber-optic repeater adapter using a backplane connector.

BACKPLANE CONNECTOR	MODULE INTERCONNECT CABLE

A backplane connector is used for communication between adjacent modules. This can be confusing because it is only visible when a module is removed and the terminal base or side of the adjacent module is exposed. Let's use BO2 and BI2 in the ventilation control panel as an example. These two modules are mounted side-by-side, but you cannot tell just by looking at them that they are communicating directly with one another. You would need to rely on your knowledge of the system to know this. Wiring diagrams also illustrate the backplane connector as several horizontal lines (fig 2–26). The more you work with the ECS, the easier it will become to remember which modules communicate using backplane connectors. Your ECS TO will also show backplane connections in wiring diagrams and flow diagrams.

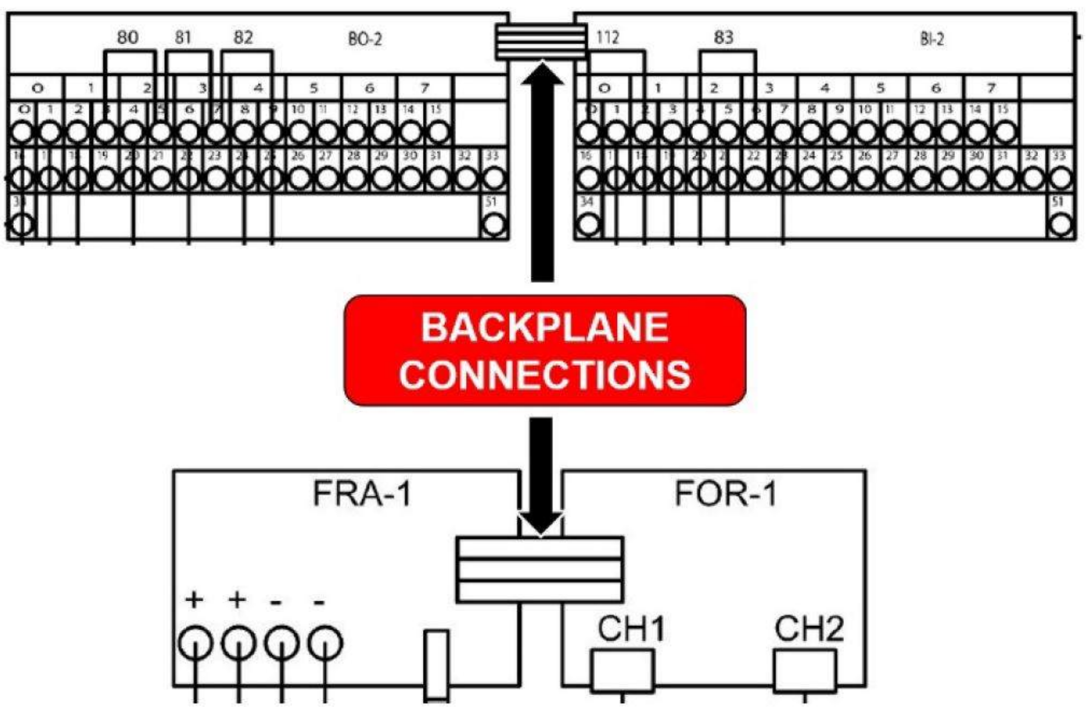


Figure 2–26. Backplane connector on a wiring diagram or schematic.

BACKPLANE CONNECTOR	MODULE INTERCONNECT CABLE

A module interconnect cable serves the same purpose as a backplane connector—module-to-module communication—but these connections are visible in the panel. You will find module interconnect cables running between the following modules:

- IO-2 and BI-2 in the ventilation control panel.
- BI-2 and BO-1 in the brine chiller control panel.
- IO-4 and BO-3 in the air handler control panel.

Complete the content above before moving on.

Fiber-optic Repeater Adapter

The fiber-optic repeater adapter (fig 2–27) is used to extend the length of the controlnet network by providing a connection point between the fiber-optic repeater and the controlnet adapter. The fiber-optic repeater adapter is the last link in the chain that uses fiber-optics since its data is sent over a coaxial cable to the controlnet adapter.

The fiber-optic repeater adapter operates on 26 VDC, and it cannot communicate with the controlnet adapter if voltage is not present. The ventilation control panel does not require a fiber-optic repeater adapter because the controlnet daughtercard on the PLC handles these duties.

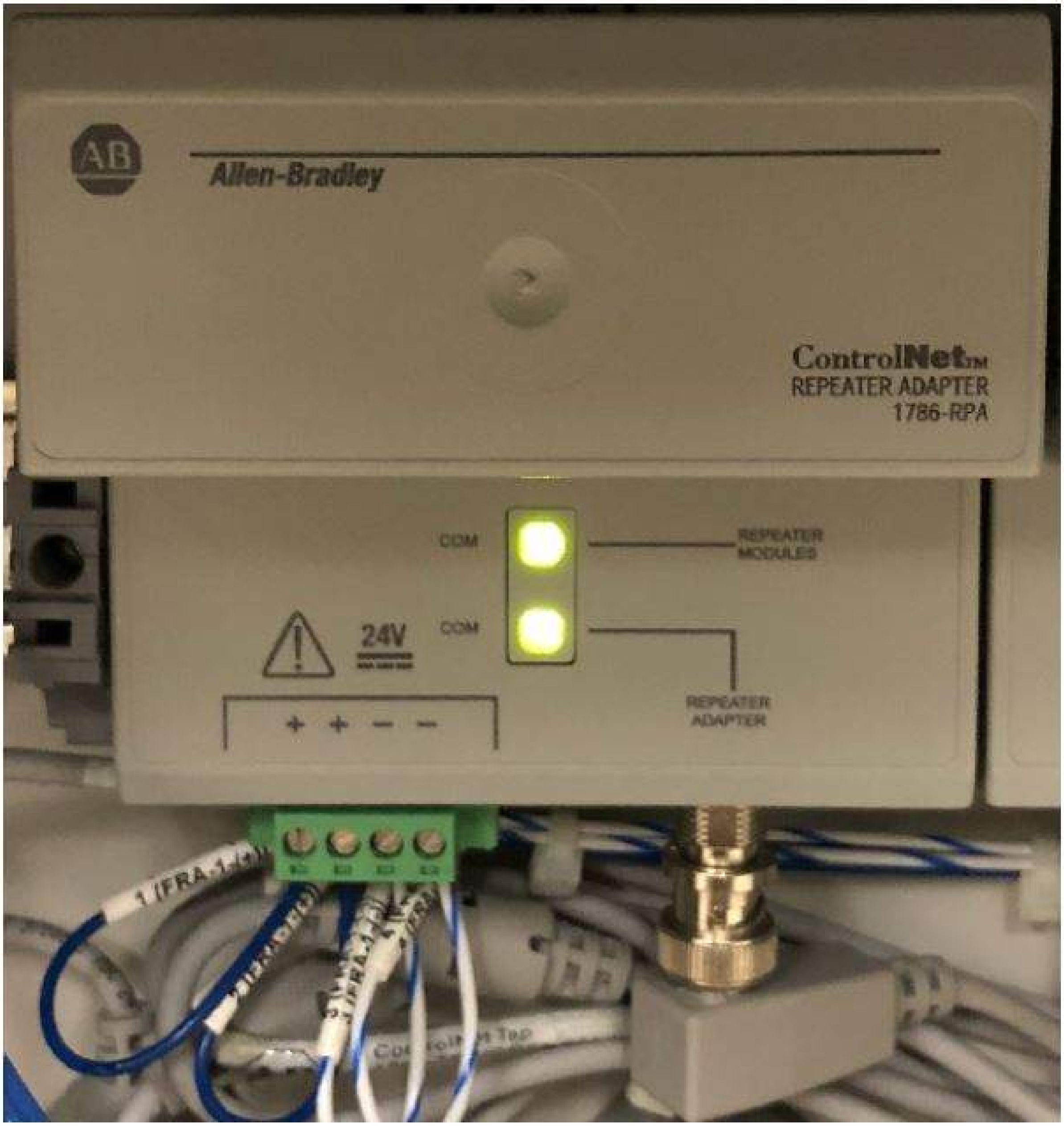


Figure 2–27. Fiber-optic Repeater Adapter.

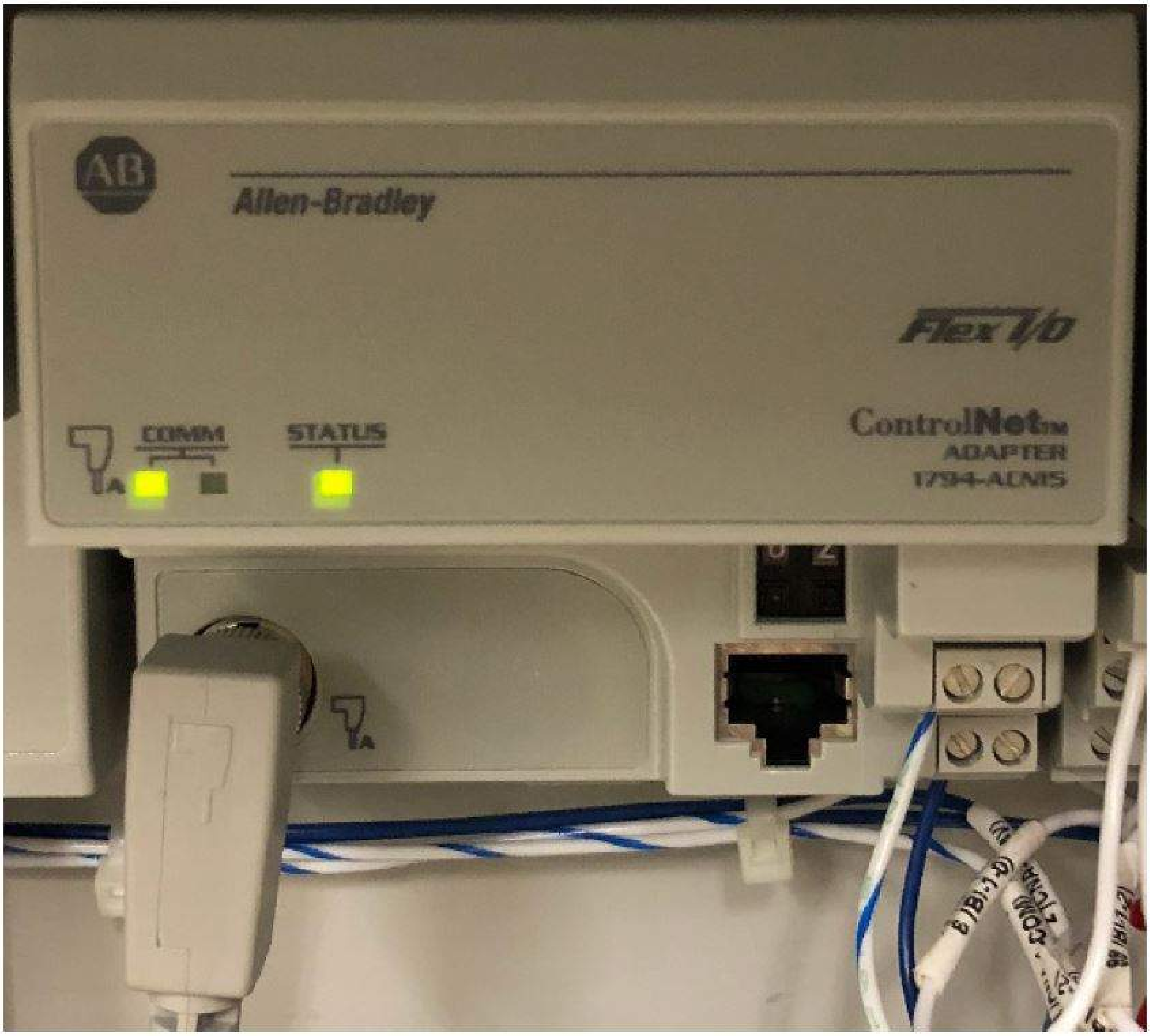


Figure 2–28. Controlnet Adapter.

Controlnet Adapter

The controlnet adapter (fig 2–28) provides the interface between the fiber-optic repeater adapter and the analog and binary modules in each panel. You will notice that the controlnet adapters in both the brine chiller and air handler control panels only have a coaxial cable on the front and power wires connected to the bottom-right of the module. You may be wondering how they communicate with the rest of the system. Do not be fooled—the controlnet adapter is communicating with the panel via a backplane connector. The ventilation control panel does not require a controlnet adapter because the controlnet daughtercard on the PLC handles these duties.

Fiber-optic Signal Conditioner and Temperature Sensors

Fiber-optic communication stops at the controlnet adapter, but there are additional components in the ECS system that use fiber-optics to communicate. All temperature sensors in the ECS interface with the modules in the panel through a component called a fiber-optic signal conditioner (fig 2–29).

Figure 2–29. Fiber-optic Signal Conditioner.

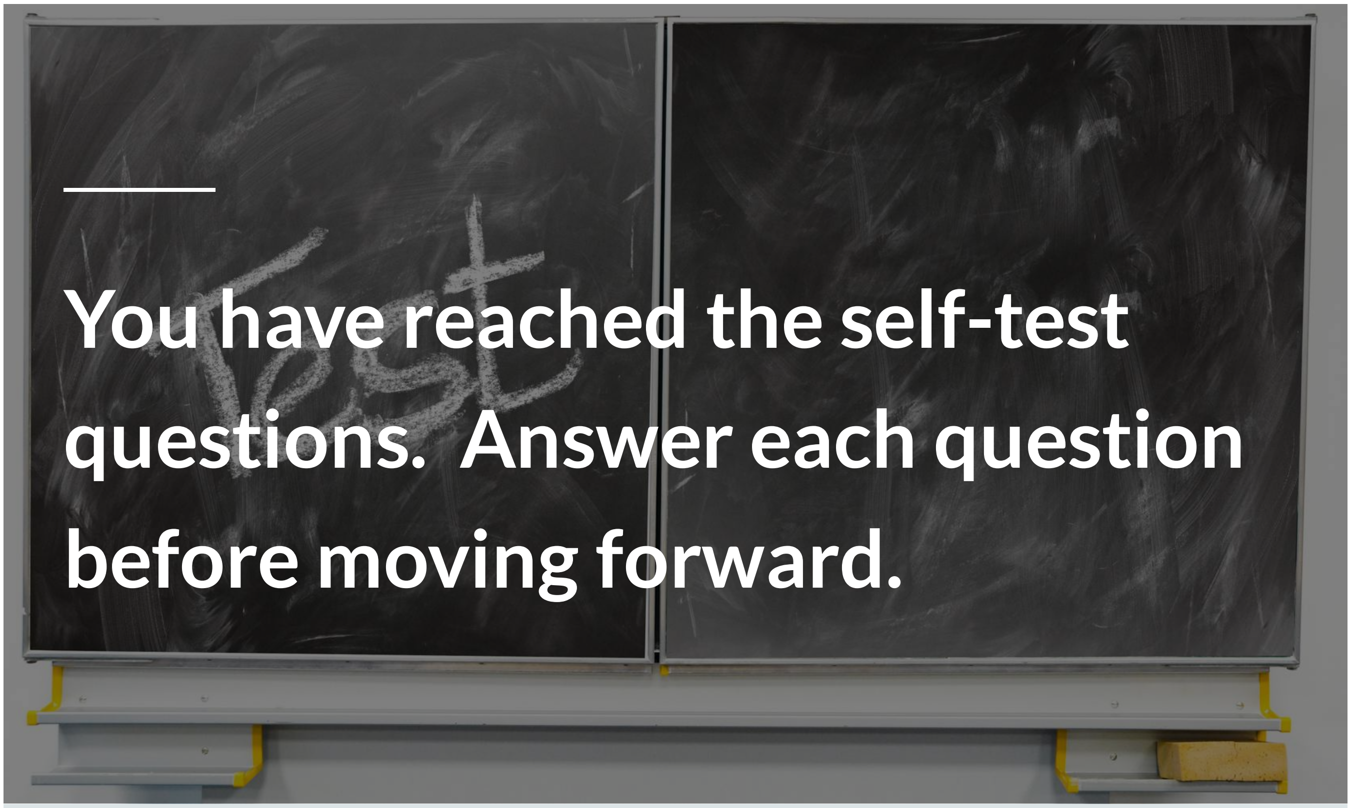
Figure 2–30. Temperature Sensor.

Fiber-optic Signal Conditioner and Temperature Sensors

The fiber-optic signal conditioner generates the light pulses that are then sent through the ST fiber-optic cables and into the temperature sensors (fig 2–30). A signal is then returned to the fiber-optic signal conditioner through the ST fiber-optic cable based on the temperature being detected by the sensor. The fiber-optic signal conditioner then converts the light signal being returned from the temperature sensor into an analog electrical signal that ranges between 0 and 10 VDC. This data is then sent through the system and to the PLC where it is used to modulate system components, generate ground maintenance response fault alarms (when necessary), and can also be viewed on the panel display.

This lesson focused on the fiber-optic and coaxial communication systems as well as the components needed to interface with the rest of the ECS.

Complete the content above before moving on.



You have reached the self-test questions. Answer each question before moving forward.

KNOWLEDGE CHECK TIME!

For the fill-in the blank questions, you will need to add (.) period to the end of the sentences.

Click here to answer the self-test questions pertaining to the environmental control system transmitting and receiving devices.

1. What environmental control system component eliminates the need to tag before disconnecting module wires if the module needs to be replaced?

Type your answer here

SUBMIT

2. Components that are controlled by a binary input module are in one of what two states?

Type your answer here

SUBMIT

3. Which component in the environmental control system is a good example of a component that requires an analog input?

Type your answer here

SUBMIT

4. What type of damper actuator returns to its normal position when power is removed?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the environmental control system fiber-optic and coaxial system components.

1. What function does the V-pin fiber-optic cable in the environmental control system serve?

Type your answer here

SUBMIT

2. How is the fiber-optic repeater in the environmental control system used?

Type your answer here

SUBMIT

3. What is the purpose of a backplane connector in the environmental control system?

Type your answer here

SUBMIT

4. How is data transferred between the fiber-optic repeater adapter and the controlnet adapter in the environmental control system?

Type your answer here

SUBMIT

5. What component in the environmental control system is used to interface all temperature sensors and standard fiber optic cables?

Type your answer here

SUBMIT

This completes Lesson 2. You can find the answers to the self-test questions in the Module 4 table of contents.

Lesson 3. Launch Facility Environmental Control System

MAIN POINTS

1. Launcher Support Building Operation
    a. Brine chiller brine subsystem
    b. Brine chiller control panel operation
    c. Ventilating air and heating subsystem operation
2. Launcher Equipment Room Operation
    a. Air handler subsystem operation
    b. Emergency fan subsystem operation
    c. Launch tube heater subsystem operation

Since the beginning of the Cold War, our missiles have stood ready to defend our country against attack and have deterred any enemy from using weapons of mass destruction against the United States or its

allies. This would not be possible if it weren't for the men and women in our specialty ensuring our weapon system is maintained in a state of readiness. This career field has changed over the years, but 2M0X3s have always maintained the environmental control systems on the launch facilities.

This lesson will familiarize you with the LF ECS that you are responsible for maintaining. Part of understanding this system is possessing the ability to read and interpret ECS schematics, so this unit will focus largely on that, while at the same time teaching you the function and operation of the individual subsystems within the ECS. This lesson will break down subsystems in the launcher support building (LSB) first and then cover the launcher equipment room (LER).

Click here to begin Lesson 3.

Launcher Support Building Operation

The LSB houses the support equipment for the ECS. Large items such as the brine chiller unit and condenser fan are located here as well as some of the smaller items, such as the room heater. The LSB at each of the three wings look different but have the same components for the most part. Important differences between the Wing 1 and Wings 3 and 5 configurations will be noted when necessary, but we will stick to large, overarching concepts the majority of the time.

Brine Chiller Brine Subsystem

The brine chiller unit, as we have learned, is a major component of the ECS. The brine chiller absorbs the heat that the air handler collects from the ambient air in the LER and dissipates the majority of the heat to the topside of the LF. The brine chiller unit can be broken down into two major subsystems, refrigerant and brine. You have already taken a deep dive into the refrigerant subsystem, so this lesson will cover the brine subsystem.

The brine subsystem is the other major subsystem of the brine chiller unit, and it is responsible for removing heat from the air entering the air handler. This heat-laden brine is then circulated by brine pump P-1 back to the brine chiller unit where it transfers its heat to the refrigerant. Let's discuss the major components and flow of the brine subsystem. Follow along on figure 3–1 as we trace the brine subsystem.

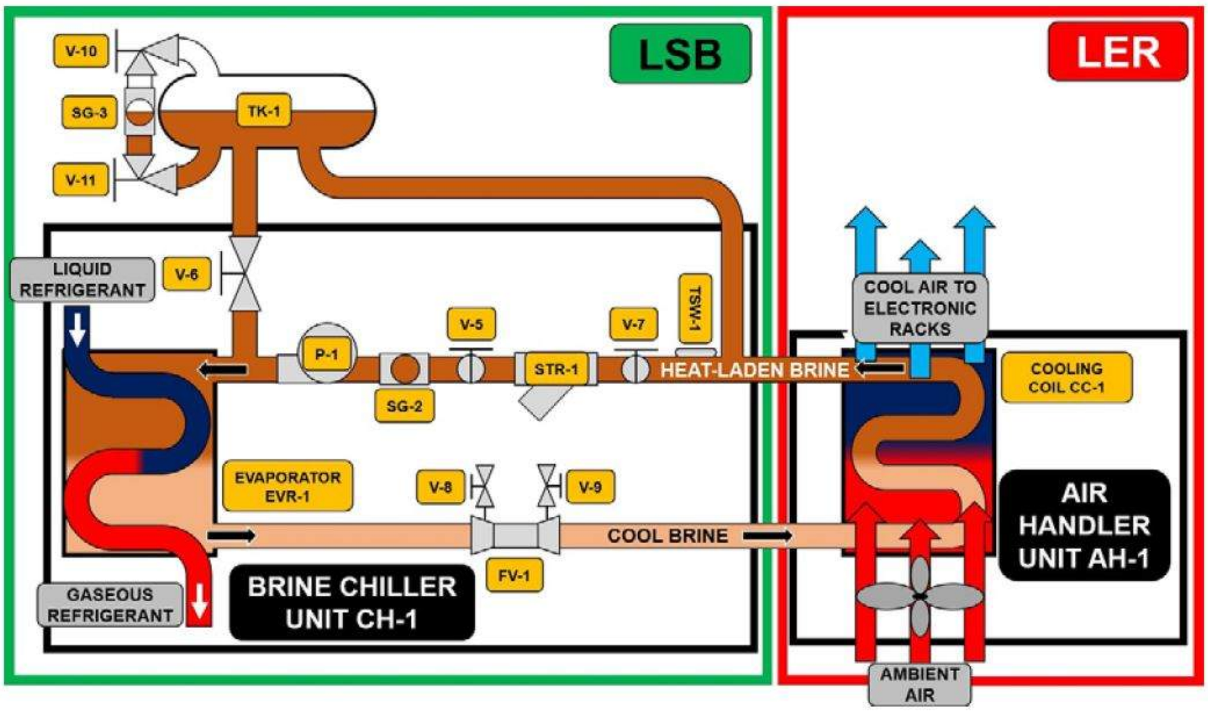


Figure 3–1. Brine Subsystem.

BRINE PUMP P-1	EVAPORATOR EVR-1	FLOW VENTURI	TEMPERATURE SENSING SWITCH	BRI AND

The brine pump (fig 3–2) is responsible for circulating brine between the brine chiller unit and the air handler in the lower LER. It operates on 208 volts alternating current (VAC), 3-phase, 60-hertz (Hz) power, and can be removed and replaced at the LF without the need to replace the entire brine chiller unit.

Figure 3–2. Brine pump P-1.

BRINE PUMP P-1 | EVAPORATOR EVR-1 | FLOW VENTURI | TEMPERATURE SENSING SWITCH | BRI AND

The evaporator (fig 3–3) is where heat collected by the brine subsystem in the air handler is transferred to the refrigerant subsystem. A stacked-plate evaporator is used, meaning that heat is transferred due to the fact that the brine and liquid refrigerant flow very close to one another. The cooled brine returns to the air handler at an optimal temperature of 31–39°F. It is important to note that even the brine returning from the air handler in the LER is not “hot.” It is warmer than the brine supplied to the air handler, but it will still feel cool to the touch.

Figure 3–3. Evaporator EVR-1.

BRINE PUMP P-1	EVAPORATOR EVR-1	FLOW VENTURI	TEMPERATURE SENSING SWITCH	BRI… AND…

The flow venturi FV-1 has no direct value to the brine subsystem, but it does provide a very important function to you, the technician. Valves V-8 and V-9 on the venturi are where you will connect a wet/dry manometer to test the flow rate of the brine through the system. The hourglass shape of the venturi creates a slight backpressure in the system. The more quickly the brine is moving, the less backpressure there will be. Since the wet/dry manometer measures the pressure difference between V-8 and V-9, the faster the brine is flowing, the higher the reading on the manometer will be.

After flowing through the venturi, brine exits the brine chiller unit, moves into a flexible hose and exits the LSB. Brine will then flow through an underground pipe and enter the air handler unit in the lower LER. The brine subsystem includes both the brine chiller unit and the air handler unit, but we will only discuss the portion included in the brine chiller unit in order to keep ideas organized. We will cover the air handler unit in another lesson—for now all you need to know is that the cool brine flowing from the brine chiller unit in the LSB picks up heat in cooling coil CC-1 of the air handler unit.

BRINE PUMP P-1	EVAPORATOR EVR-1	FLOW VENTURI	TEMPERATURE SENSING SWITCH	BRI… AND…

After leaving the LER, the brine flows back to the LSB, through a flexible hose, and back into the brine chiller unit. At this point you will see that there is a junction in the brine line—if valve V-6 is open, a portion of the brine will flow up and into the brine expansion tank TK-1. Since this valve is not normally open during typical system operation, brine will continue to flow through the brine line and past temperature sensing switch TSW-1. For the time being, let's trace the route toward the temperature switch.

The purpose of temperature sensing switch TSW-1 is to monitor the temperature of the brine returning from the LER and shut down the refrigerant compressor if the brine temperature drops below 29°F. This fault does not "latch", meaning that once the brine return temperature rises above 29°F the refrigerant compressor will again begin to operate.

BRINE PUMP P-1	EVAPORATOR EVR-1	FLOW VENTURI	TEMPERATURE SENSING SWITCH	BRI… AND…

The brine strainer STR-1 filters solid contaminates, such as scale and sediment, out the brine system. You more than likely performed the removal and replacement of the brine strainer during your technical training at Vandenberg Air Force Base. Sight glass SG-2 (fig 3–4) is located after the brine strainer and simply provides a means to visually inspect the brine as it flows through the system.

Figure 3–4. Brine sight glass SG-2.

BRINE PUMP P-1	EVAPORATOR EVR-1	FLOW VENTURI	TEMPERATURE SENSING SWITCH	BRI… AND…

Brine expansion tank TK-1 (fig 3–5) allows the brine solution to expand and contract with differing heat loads and also acts as a storage area and supply of extra brine to the system. Brine can be added to the system through the port on the top of the tank. Mounted on the wall of the LSB, the brine expansion tank automatically gravity-feeds brine to the system due to the fact that it is positioned higher than the brine chiller unit. Sight glass SG-3 is installed on the left-hand side of the brine expansion tank. A technician can view the brine level in the tank when valves V-10 and V-11 at the top and bottom of the sight glass are open.

A vent tube is located on the top of the brine expansion tank. Any air trapped in the brine subsystem will exit through the vent tube since air is lighter than the liquid and the vent tube is the highest point in the system. When open, valve V-6 located on the brine chiller unit allows a portion of the brine flow from the brine pump to circulate through the tank.

This lesson focused on the components of the brine subsystem, most of which are located on the brine chiller unit. Cooling coil CC-1 is located in the air handler unit in the LER. Knowing how brine flows through the system and its components will help you to complete periodic inspections and also troubleshoot the brine chiller unit more efficiently.

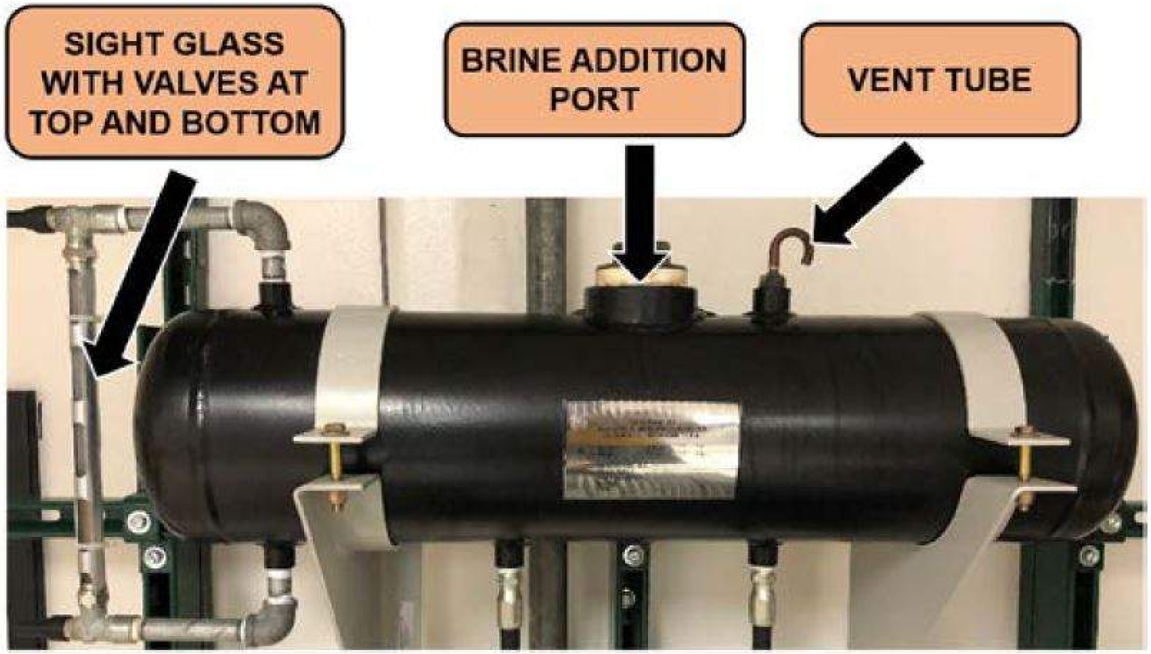


Figure 3–5. Brine expansion tank TK-1.

Complete the content above before moving on.

Brine Chiller Control Panel Operation

The brine chiller control panel (fig 3–6) contains all of the electrical and fiber-optic components necessary for the system to operate and communicate with the programmable logic controller (PLC) and the panel displays. This is an excellent point to learn how to interpret ECS schematics. Let's start at the source of power and work through the components on the brine chiller unit.

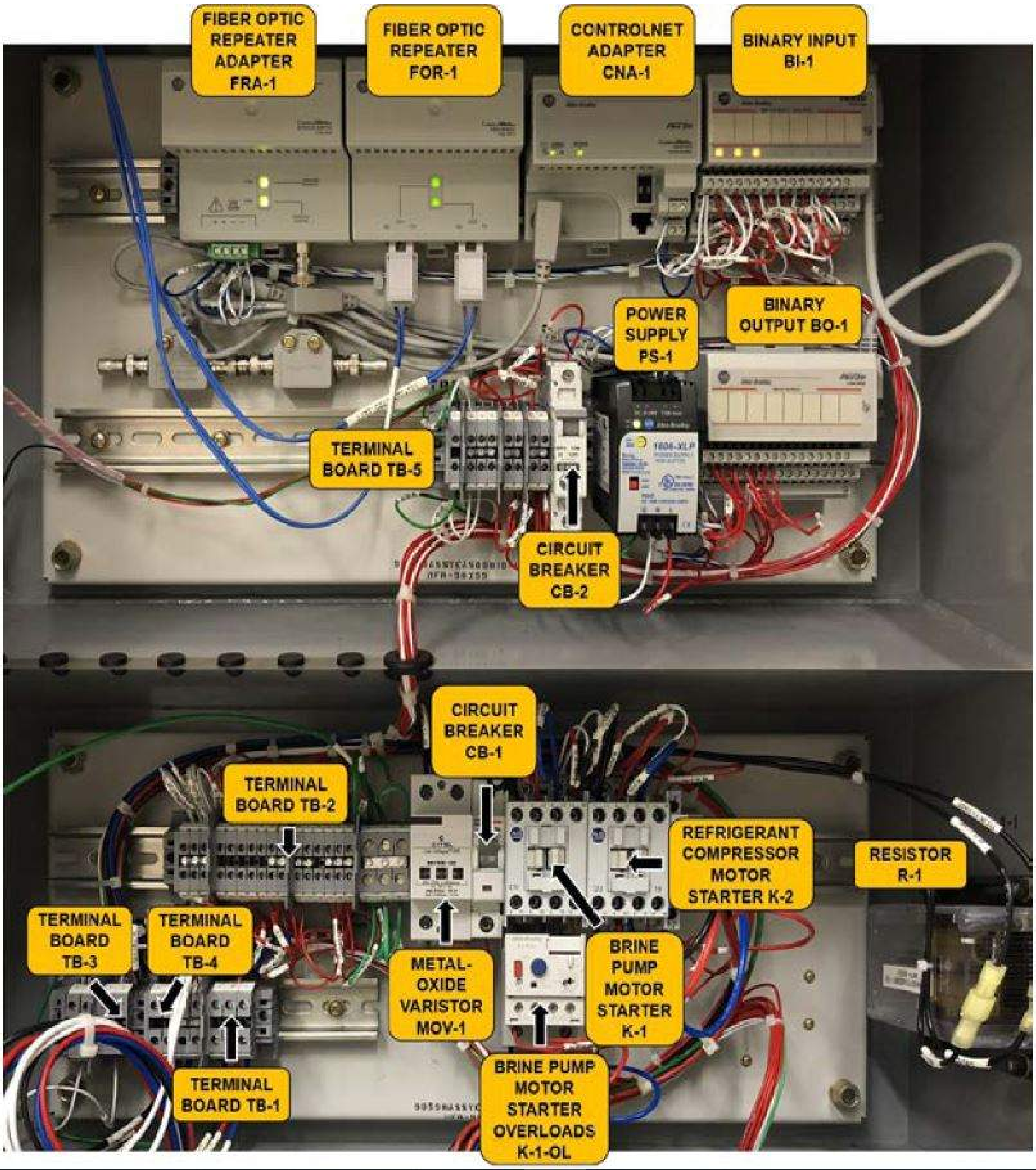
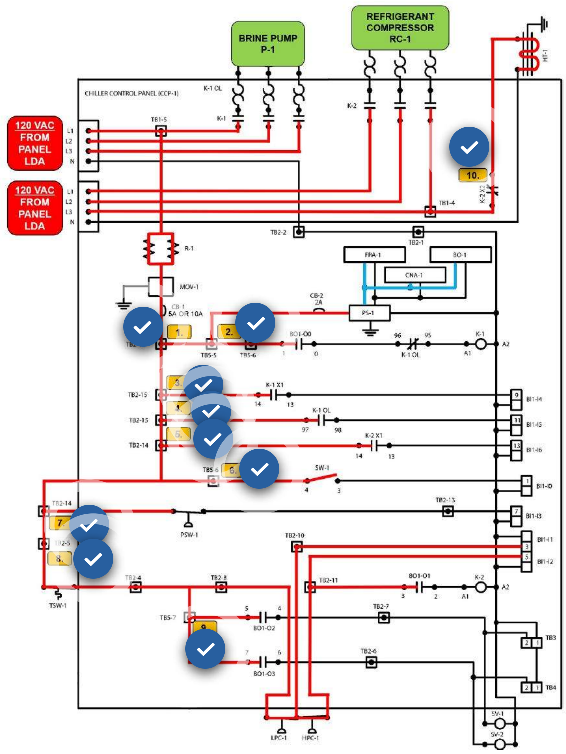


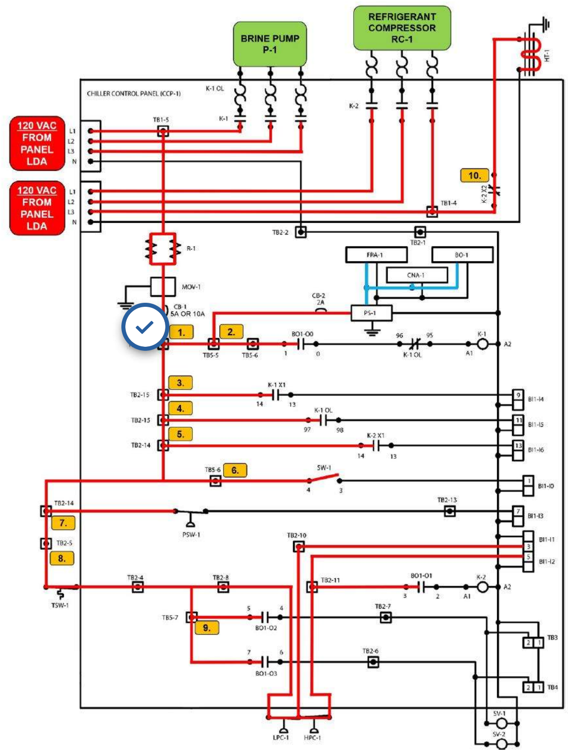
Figure 3–6. Brine Chiller Control Panel.

Power Source and Devices

Power is supplied to brine pump P-1 and refrigerant compressor RC-1 by two 3-phase circuit breakers.

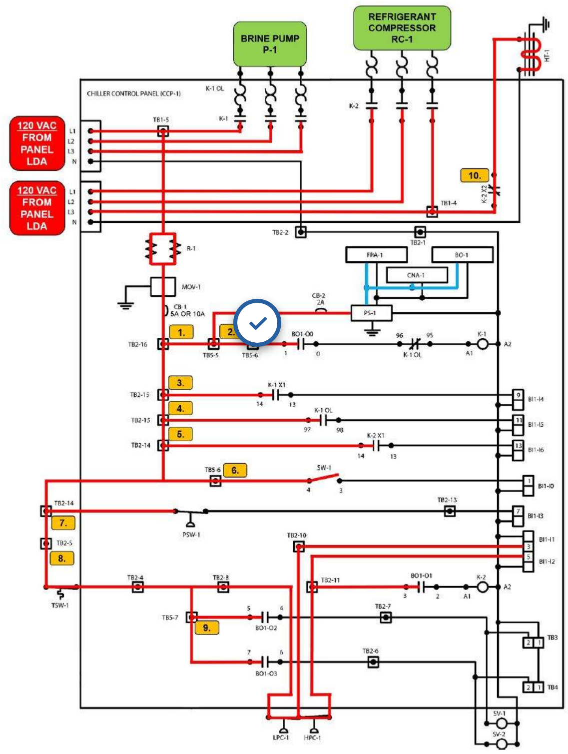
Power is supplied to the brine chiller control panel by a single phase of 120 VAC that branches off of power being supplied to the brine pump at terminal board TB1-5. The numbers below correspond to the numbers on figure 3–7:





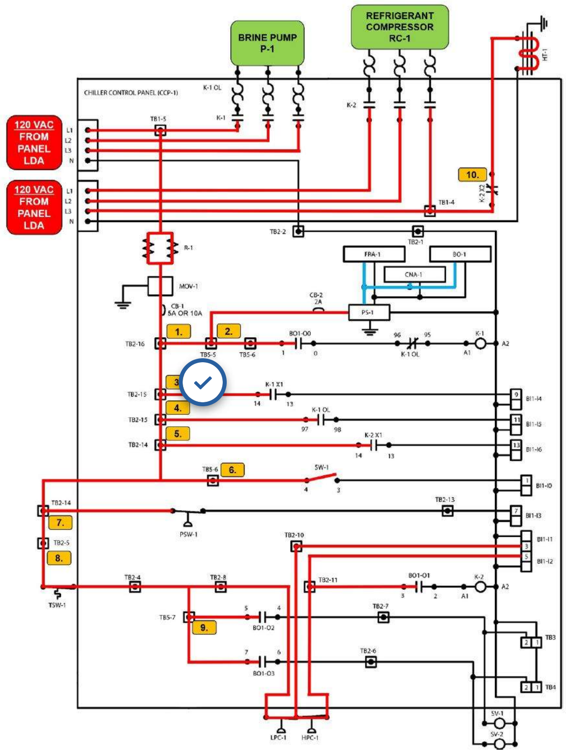
Item 1

At board TB2-16, power branches off and is converted to 26 VDC by power supply PS-1 for use by the fiber-optic/controlnet devices; controlnet adapter CNA-1, fiber-optic repeater adapter FRA-1, and binary output module BO-1.

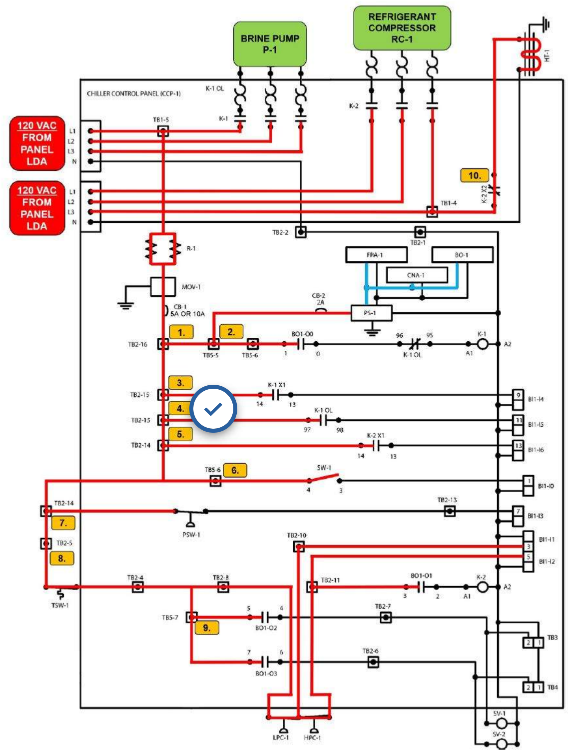


Item 2

At TB5-5, power continues to and then waits at binary output BO-1 O0 for the PLC to provide the brine pump ON command to energize motor starter K-1.

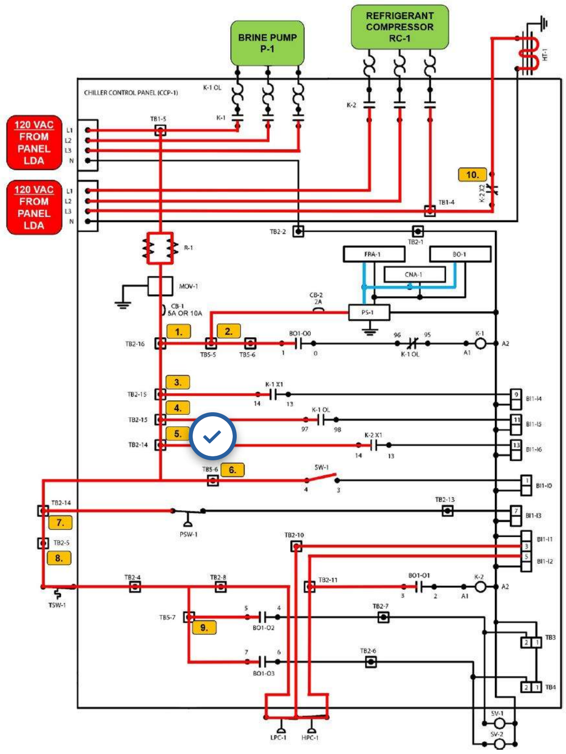


At board TB2-15, power waits on the X1 auxiliary contacts of motor starter K-1. When the brine pump motor starter energizes, this contact closes to start a 5-second time delay for compressor startup.



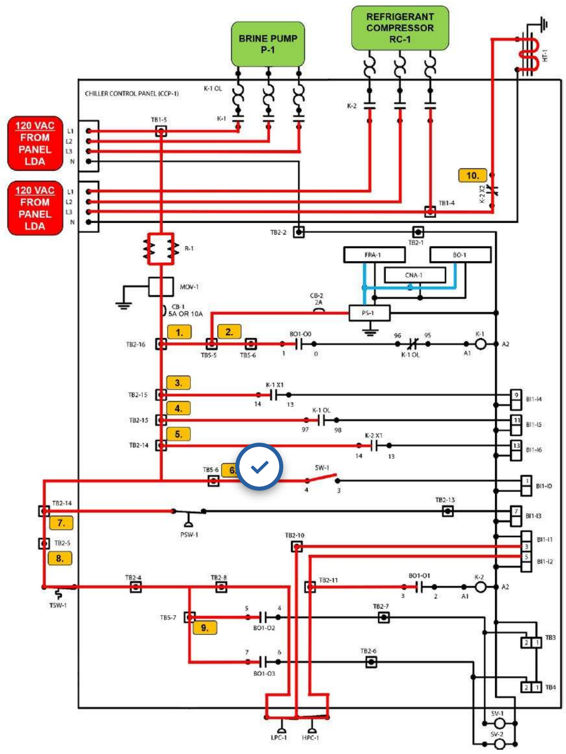
Item 4

Just below the first board TB2-15, power waits at the K-1 overload K-1 OL contact. If an overload condition occurs on the brine pump, this contact will close to notify the PLC that the brine pump has tripped on an overload condition.



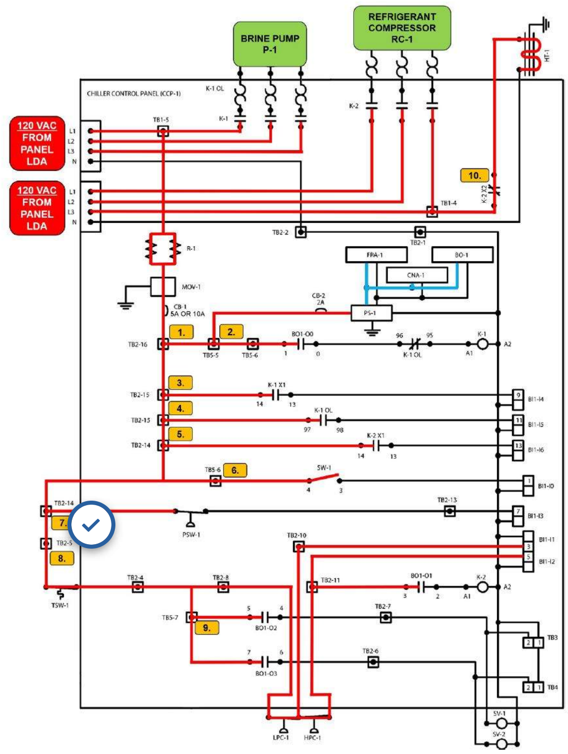
Item 5

At board TB2-14, power waits at the K-2 X1 auxiliary contacts. When the compressor motorstarter K-2 energizes, this contact closes to notify the PLC that the refrigerant compressor startedup. This will ensure the condenser fan does not start until after the compressor has started.



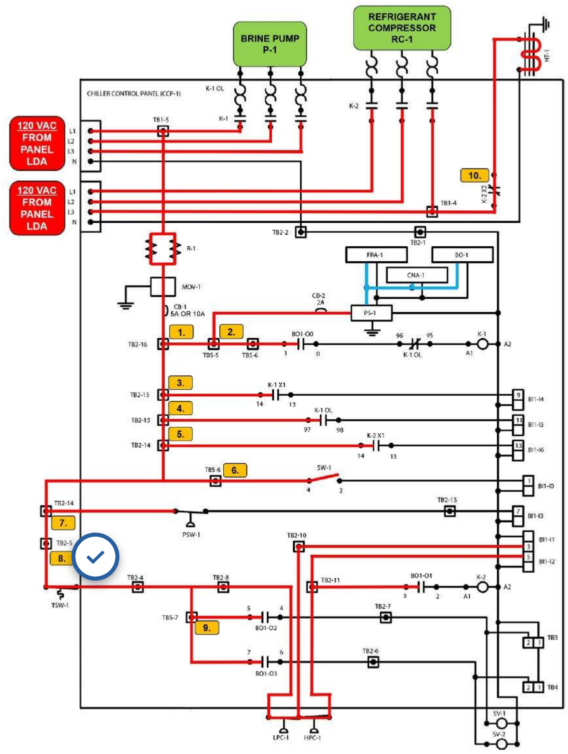
Item 6

At board TB5-6, power taps off and waits at the open brine chiller control switch SW-1. When this switch is on, a signal is sent to the PLC that will initiate brine chiller startup.



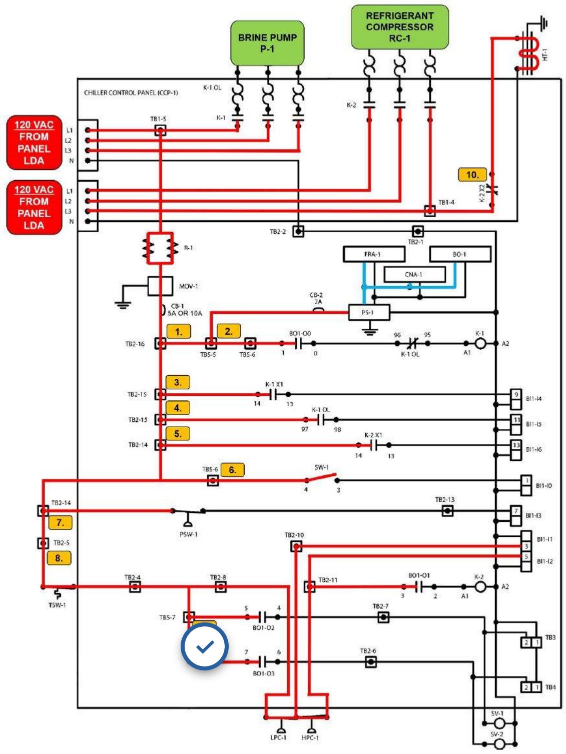
Item 7

At board TB2-14, power taps off and waits for head pressure switch PSW-1 to close. Once the PLC initiates the brine chiller startup, it will look to see if this switch is closed before it starts the condenser fan.

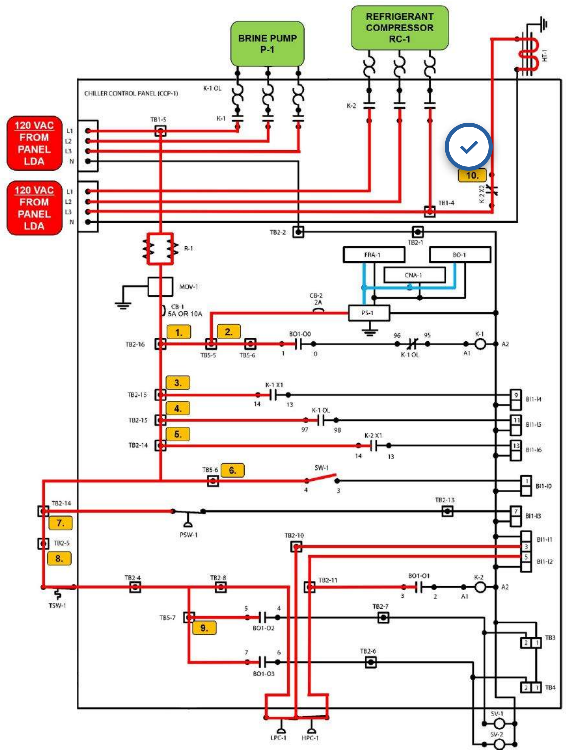


Item 8

Continuing past board TB2-5, power travels through the hardware interlock. If you trace through low brine temperature switch TSW-1, low-pressure cutout LPC-1, and high-pressure cutoutHPC-1, you will notice that they must all be closed in order for power to reach board TB2-11.Power at TB2-11 energizes the compressor motor starter K-2 once the PLC sends the command to close contacts 2 and 3 of binary output BO-1.



At board TB5-7, power branches off and waits for the PLC to start the brine chiller through binary output BO-1. When the PLC commands BO1-O1 to close O2 and O3, solenoid valves SV-1 and SV-2 energizes to allow refrigerant to flow through the system.



Item 10

Lastly, if you look at the compressor motor starter K-2 X2 auxiliary contacts towards the top of the schematic, you will see they receive power from the refrigerant compressor circuit breaker. These contacts will remain closed to power a crankcase heater for the refrigerant compressor. When the compressor is not operating, the refrigerant must remain in a gaseous state; liquid refrigerant should not be introduced to the compressor. When the compressor energizes, the heater is no longer needed, so these contacts open, de-energizing the crankcase heater.

Ensure to click on each check (√) mark before moving forward in the lesson.

Brine Chiller Startup

Now that we know all of the places where power is waiting in the brine chiller control panel, we are ready to start the brine chiller. Before the PLC will start up the brine chiller, it must have the following inputs from the remainder of the ECS:

- ECS control switch SW-2 on the ventilation control panel must be set to ON.
- Air handler motor starter K4 must be energized. The system will not allow the brine chiller unit to operate if the air handler is not operating.

Set the brine chiller control switch SW-1 to ON. This will allow 120 VAC to energize binary input BI1-I0. This will signal the PLC to startup the brine chiller. Through the fiber-optic network, the PLC will use binary output BO-1 to start the brine chiller (fig 3–8).

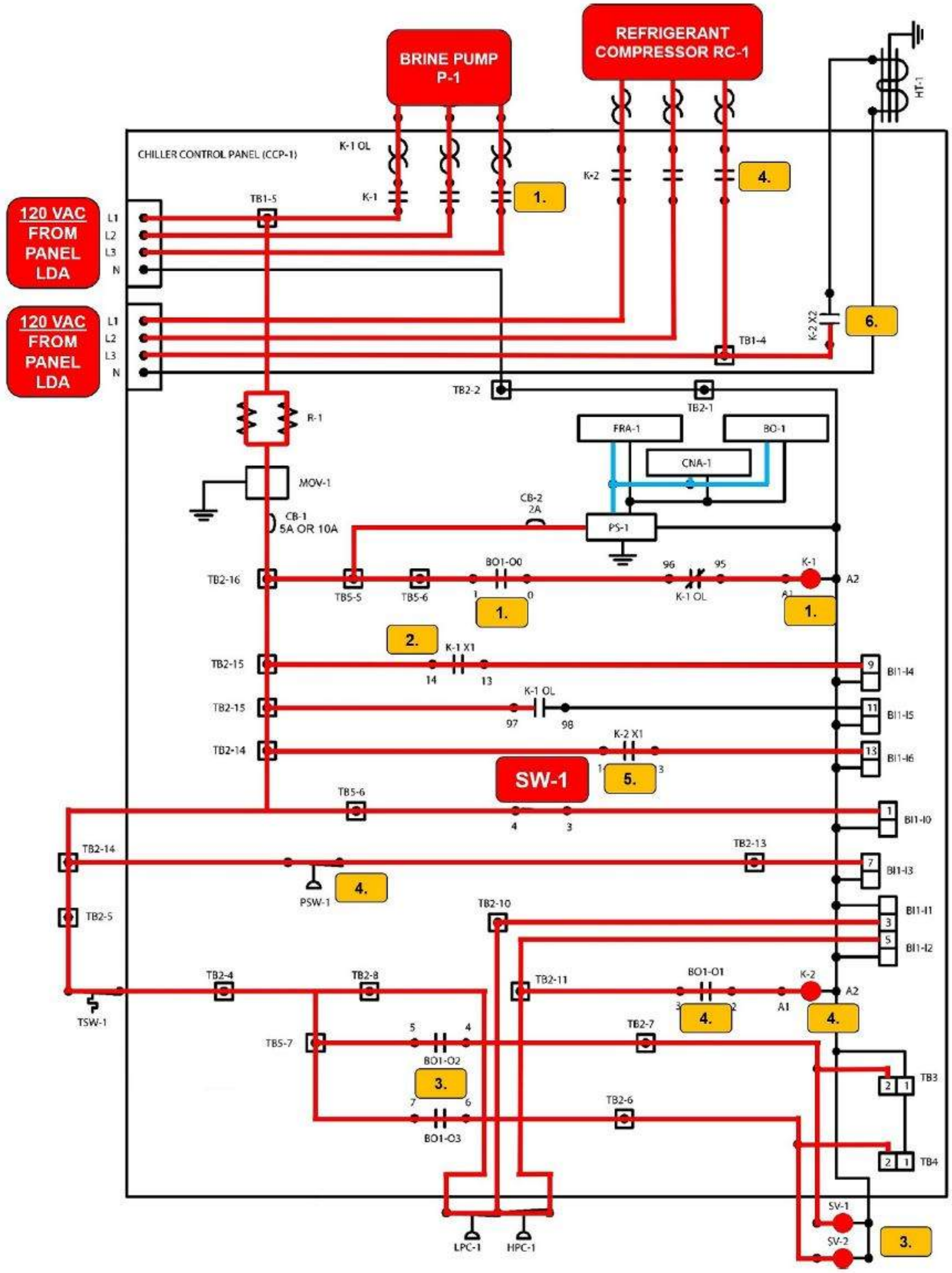


Figure 3–8. Brine chiller startup on schematic.

Figure 3–8. Brine Chiller Startup on Schematic.

Brine Chiller Startup

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Set the brine chiller control switch SW-1 to ON. This will allow 120 VAC to energize binary input BI1-I0. This will signal the PLC to startup the brine chiller. Through the fiber-optic network, the PLC will use binary output BO-1 to start the brine chiller (fig 3–8).

Brine Chiller Startup 1

The PLC commands binary output BO1-O0 to close allowing power to travel from board TB5-5to motor starter coil K-1. This is the brine pump ON command. K1's three main contacts will close to start the brine pump.

Brine Chiller Startup 2

When K-1 energizes, its X1 auxiliary contacts close and allow power to flow through and energize binary input BI1-I4, starting a 5-second timer. This 5-second timer provides a time delay between brine pump and compressor startup.

Brine Chiller Startup 3

The PLC will command solenoid valves SV-1 and SV-2 to open by energizing binary outputs BO1-O2 and O3. Energizing solenoid valves SV-1 and SV-2 allows refrigerant to flow throughout the system.

Brine Chiller Startup 4

If the hardware interlock circuit is intact, the PLC will issue the compressor ON command by powering binary output BO1-O1. This will close causing auxiliary contact K-2 to energize and the refrigerant compressor will start. Refrigerant pressure will build, and refrigerant pressure switch PSW-1 will close, allowing power to flow to binary input BI1-I3. Note that the condenser fan will not start unless switch PSW-1 is closed.

Brine Chiller Startup 5

When auxiliary contact K-2 energizes, auxiliary contacts X1 close to signal the PLC of compressor startup. This starts a 5-second delay between compressor startup and condenser fan startup.

Brine Chiller Startup 6

When K-2 energizes, auxiliary contacts X2 open to de-energize the refrigerant compressor crankcase heater.

Brine Chiller Startup 7

Five seconds after K-2 energizes, the PLC will command the condenser fan to start up. The motor starter and controls for the condenser fan are in the ventilation control panel.

Summary

The brine chiller is now operating! This lesson focused on the components in the brine chiller control panel as well as how the brine chiller is started. Knowing what commands the PLC will issue as well as the cause and effect of these commands will aid you greatly during your periodic inspections and troubleshooting.

Complete the content above before moving on.

Ventilating Air and Heating Subsystem Operation

The ventilation subsystem is also a critical piece of the ECS. In addition to dissipating the heat from the refrigerant that started out in the air handler, it must also maintain the temperature of the room as well as the diesel generator when it is operating. The different wings have different systems, but they all serve those basic functions. The configuration of Wing 1 is different whereas Wings 3 and 5 are similar; that is how we will address them. We will also discuss the control panel operation, but since electrically they operate the same, we will only focus on Wings 3 and 5 systems. This lesson will end with a look at the LSB heating subsystem.

Launcher Support Building Temperature Control (Wing 1)

When a refrigerant transfers its heat to the ambient air in the LSB, it is up to the PLC and the ventilation subsystem to expel the warmer air topside or use it to raise the room temperature. The ventilation subsystem major function is to maintain a specific temperature inside the LSB. Regardless of the outside temperature, the PLC will modulate damper actuators (DA) to keep the temperature of the LSB between 68 and 72°F. Whether or not the diesel electric unit (DEU) is running will determine how the PLC controls the LSB ambient temperature.

The LSB has three potential heat sources—hot air from the brine chiller condenser coil, hot air from the radiator of the running DEU, and the electric room heater. You will learn about the electric room heater later in this volume. There is no way to actively cool the LSB other than expelling hot air outside and drawing cool outside air in through the wall damper. On an abnormally hot summer day, the PLC may have trouble maintaining the LSB ambient temperature between 68 and 72°F. Temperature sensor TSR-1 senses the ambient air temperature and sends this data to the PLC through a fiber-optic signal conditioner.

Operation When Diesel Electric Unit Is Not Running

If the DEU is not running, heat will still be available from the brine chiller condenser coil and the electric room heater. This is the configuration that the LSB is in the majority of the time.

Temperature Below 68°F

If the PLC senses a room temperature below 68°F, it will command damper D-3A to open and damper D-3B to close. Dampers D-3A and D-3B are both controlled by damper DA-3 and will always be in opposite positions. When damper D-3A opens, heat from the condenser coil will be allowed to enter because the LSB is too cold. Damper D-3B closes to keep hot air from exiting the LSB. The PLC will also close wall damper D-1 to prevent outside air from entering the LSB. Figure 3–9 illustrates airflow under these conditions.

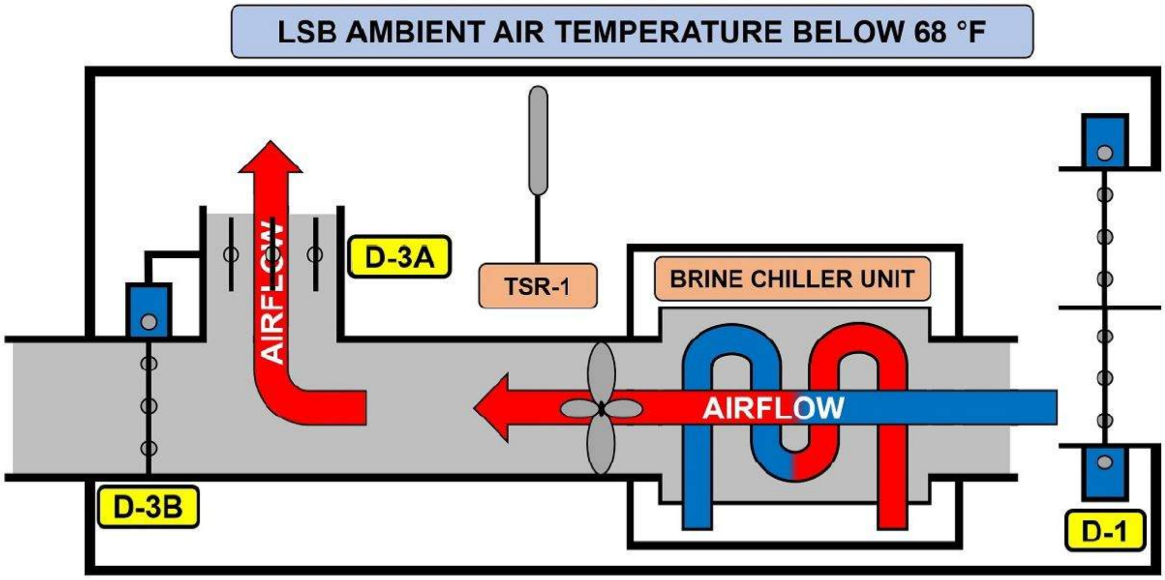

Figure 3–9. Wing 1 LSB below 68°F, DEU not operating.

Temperature Above 72°F

If the PLC senses a room temperature above 72°F, it will command damper D-3A to close and damper D-3B to open. When damper D-3A closes, heat from the condenser coil will not be allowed to enter the LSB because the room is already too hot. Damper D-3B opens to expel hot air from the LSB. The PLC will also open damper D-1 to allow outside air to enter. Figure 3–10 illustrates airflow under these conditions.

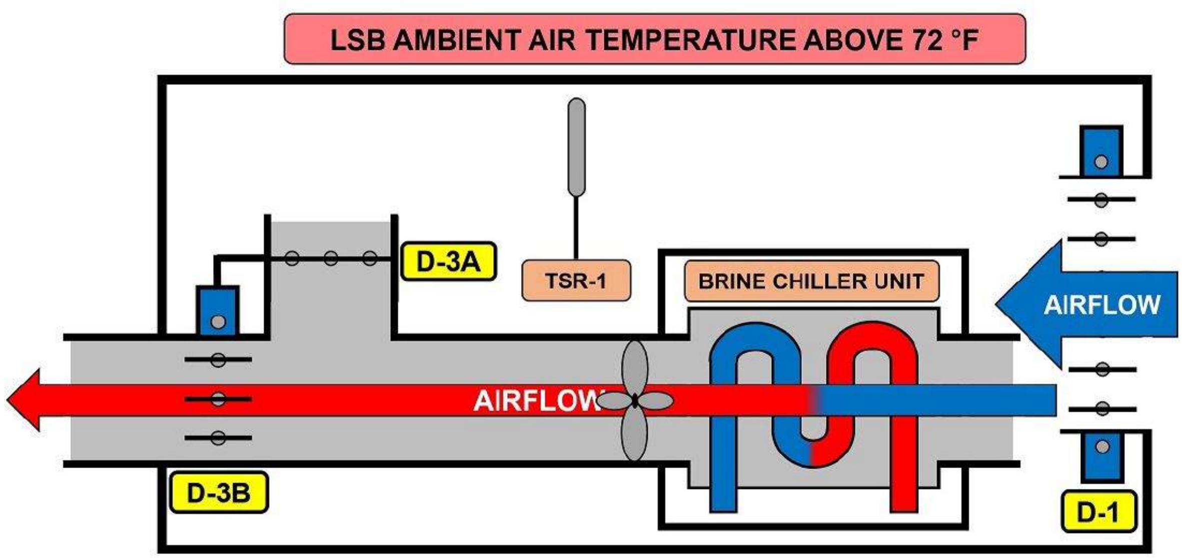

Figure 3–10. Wing 1 LSB above 72°F, DEU not operating.

Complete the content above before moving on.

Operation When Diesel Electric Unit Is Running

When the Wing 1 DEU is operating the PLC will circulate the heat from the DEU radiator to raise the LSB ambient temperature, if necessary.

Temperature Below 68°F

If the PLC senses a room temperature below 68°F while the DEU is operating, it will command damper D-5 to open and damper D-6 to close. When damper D-5 opens, heat from the DEU radiator enters the room in an attempt to raise the temperature. Damper D-6 closes to ensure that heat from the DEU does not escape through the exhaust shaft. Damper D-1 remains closed to prevent outside air from entering. Figure 3–11 illustrates airflow under these conditions.

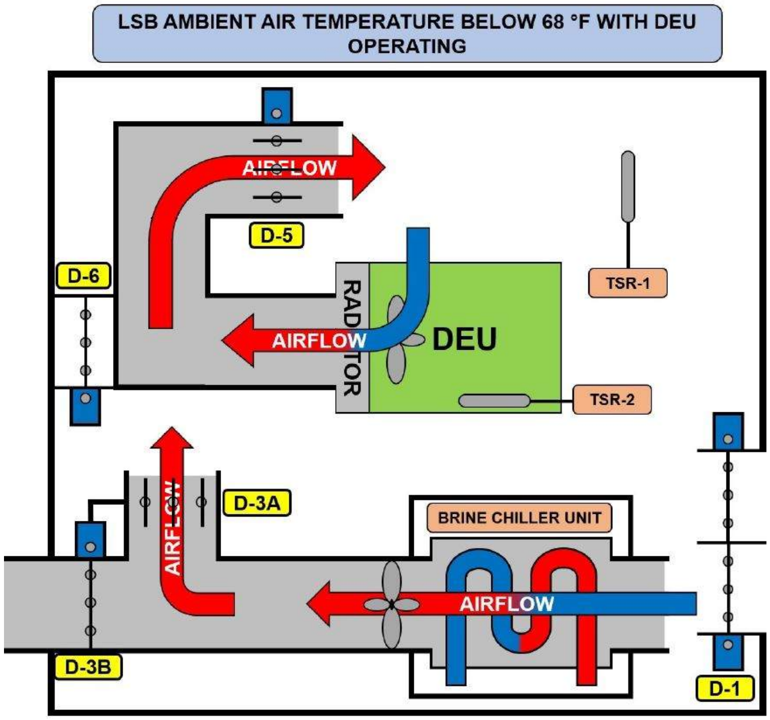

Figure 3–11. Wing 1 LSB below 68°F, DEU operating.

Temperature Above 72°F

If the PLC senses a room temperature above 72°F while the DEU is operating, it will command damper D-5 to close and damper D-6 to open. When damper D-5 closes, heat from the DEU radiator will not enter the LSB because the room is already too hot. Damper D-6 opens to allow hot air to exit the room, and damper D-1 opens to allow outside air to enter. Figure 3–12 illustrates airflow under these conditions.

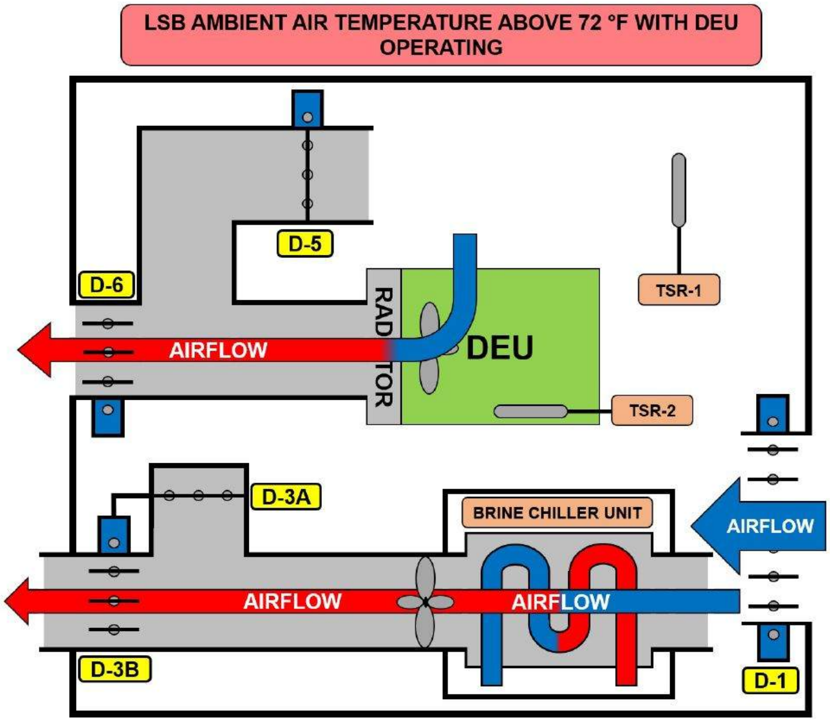

Figure 3–12. Wing 1 LSB above 72°F, DEU operating.

Complete the content above before moving on.

Launcher Support Building Temperature Control (Wings 3 and 5)

Wings 3 and 5 system operation is similar to the Wing 1 system, but there are slightly different components as well as different duct routing. You will notice that there is only one duct in the LSB to exhaust hot air. Let's explore how the system reacts when the DEU is not operating and then discuss the dampers that actuate when the DEU is operating. Temperature sensor TSR-1 senses the ambient air temperature and sends this data to the PLC through the fiber-optic signal conditioner.

Operation When Diesel Electric Unit Is Not Running

If the DEU is not running, heat will still be available from the brine chiller condenser coil and the electric room heater. This is the LSB's configuration the majority of the time.

Temperature Below 68°F

If the PLC senses a room temperature below 68°F, it will command damper D-13A to open and damper D-13B to close. Dampers D-13A and D-13B are both controlled by damper DA-13 and will always be in opposite positions. When damper D-13A opens, heat from the condenser coil enters the room because the LSB is too cold. Dampers D-13B and D-14 close to prevent hot air from exiting the LSB. The PLC will also close wall damper D-11 to prevent outside air from entering the building. Figure 3–13 illustrates airflow under these conditions.

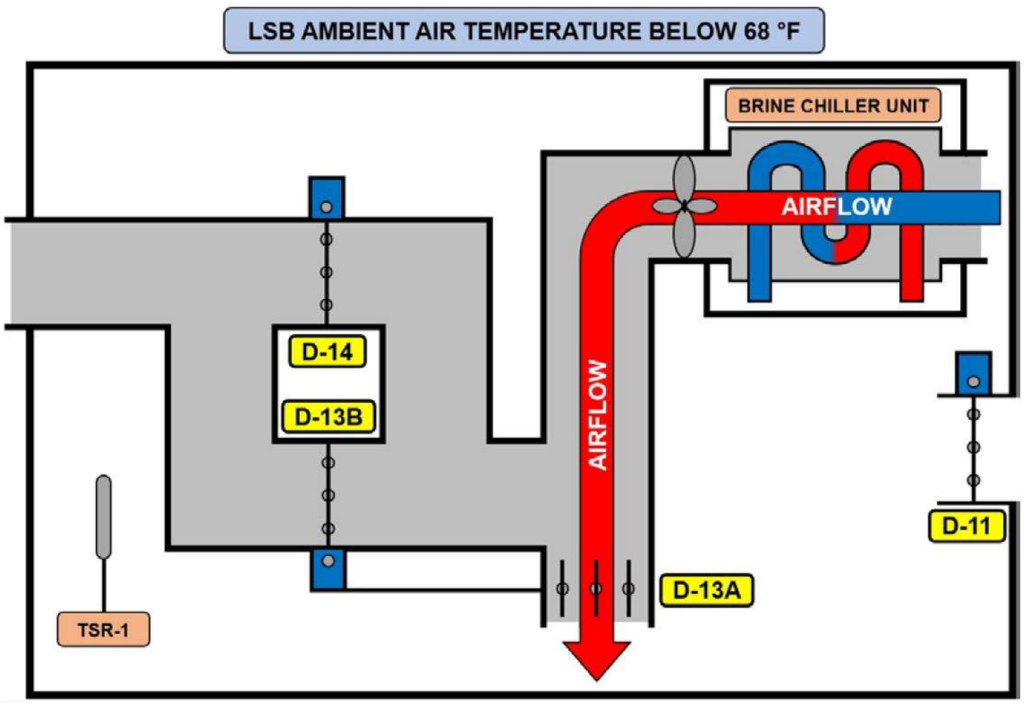

Figure 3–13. Wings 3 and 5 LSB below 68°F, DEU not operating.

Temperature Above 72°F

If the PLC senses a room temperature above 72°F, it commands damper D-13A to close and damper D-13B to open. When damper D-13A closes, heat from the condenser coil will not enter the room because the building is already too hot. Dampers D-13B and D-14 open to allow hot air to exit the building. The PLC will also open wall damper D-11 to allow outside air to enter the building. Figure 3–14 illustrates airflow under these conditions.

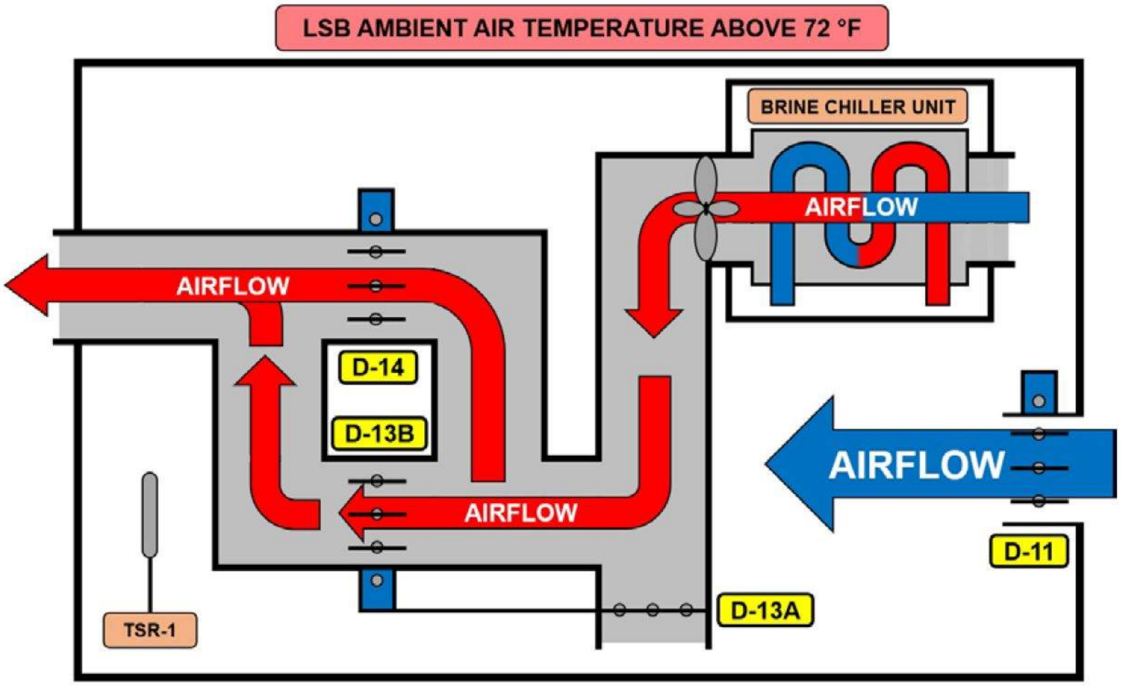

Figure 3–14. Wings 3 and 5 LSB above 72°F, DEU not operating.

Complete the content above before moving on.

Operation When Diesel Electric Unit Is Running

When the Wing 1 DEU is operating, the PLC will circulate heat from the DEU radiator to raise the temperature in the LSB, as necessary.

Temperature Below 68°F

If the PLC senses a room temperature below 68°F while the DEU is operating, it commands damper D-17 to open which allows hot air from the DEU radiator to enter the LSB. There is no damper to prevent this hot air from also exiting the LSB—the air simply takes the path of least resistance. Wall damper D-11 closes to prevent outside air from entering. Figure 3–15 illustrates airflow under these conditions.

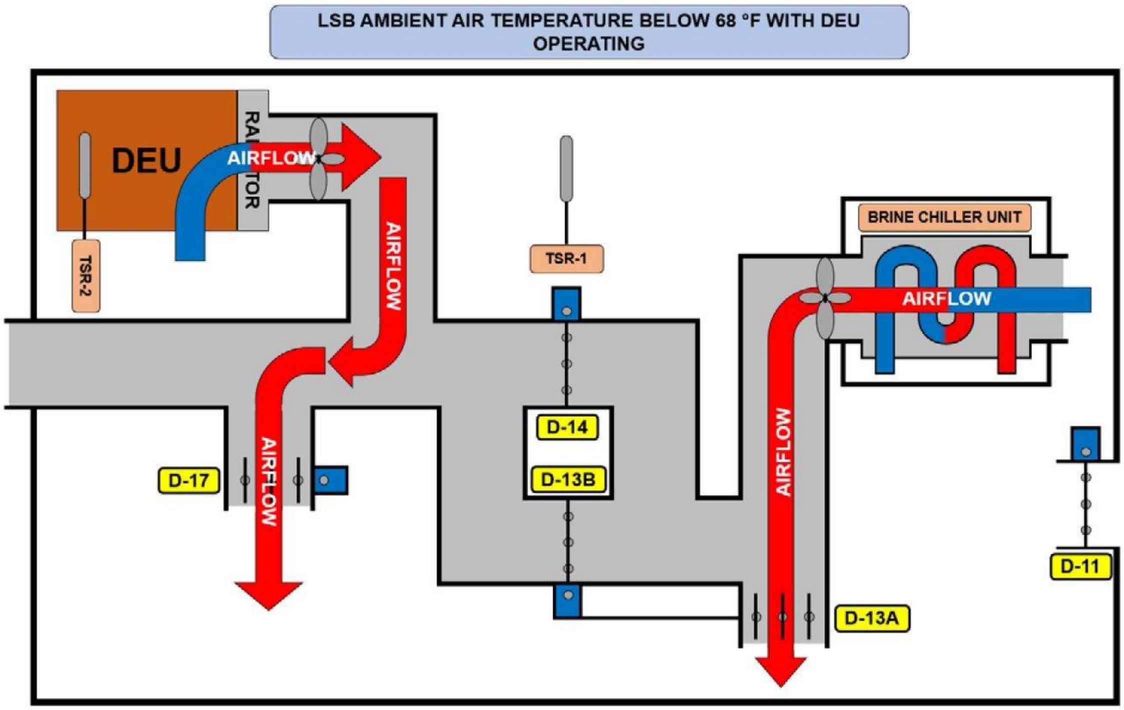

Figure 3–15. Wings 3 and 5 LSB below 68°F, DEU operating.

Temperature Above 72°F

If the PLC senses a room temperature above 72°F while the DEU is operating, it commands damper D-17 to close which prevents hot air from the DEU radiator from entering the LSB. Dampers D-13B and D-14 remain closed, and damper D-13A remains open, which continues to allow hot air from the condenser coil to enter the LSB. This happens to prevent the larger exhaust fan that pulls air across the DEU radiator from overwhelming the smaller condenser fan motor. Figure 3–16 illustrates airflow under these conditions.

Each wing operates on the same principle of expelling hot air away from the LSB if it is too hot and directing hot air into the room if it is too cold. The PLC does not wait until a temperature threshold is exceeded to take action—it consistently modulates the dampers to stay as close to 70°F as possible at all times.

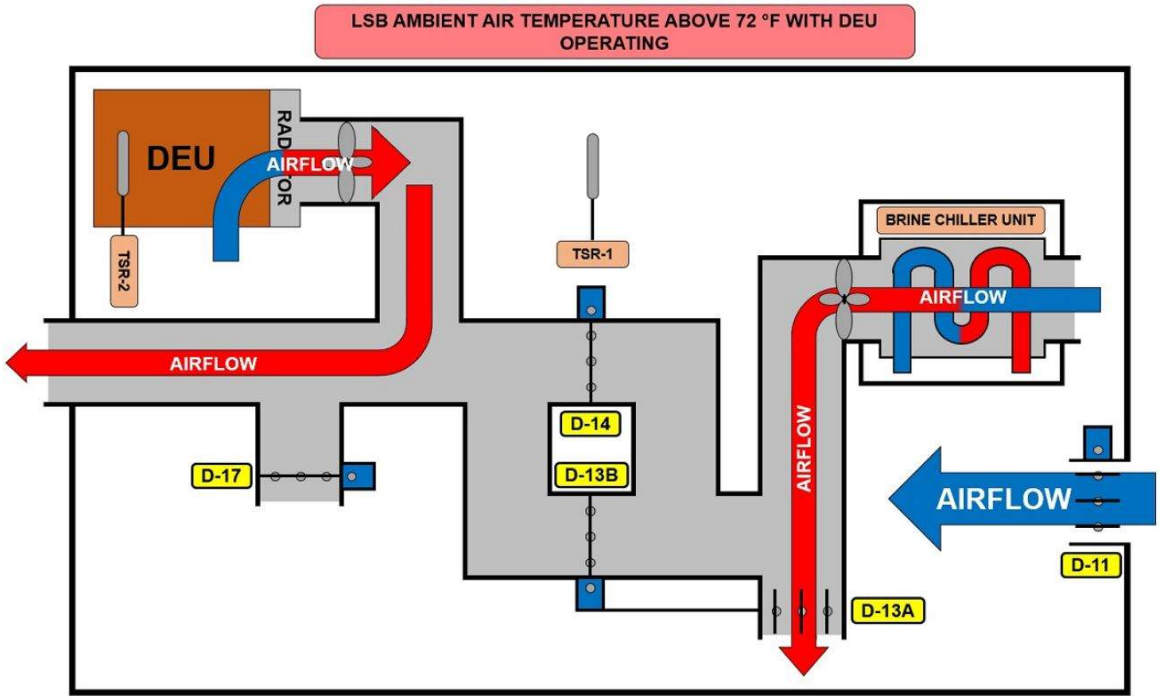

Figure 3–16. Wings 3 and 5 LSB above 72°F, DEU operating.

Complete the content above before moving on.

Diesel Engine Temperature Control System

Another major function of the ventilation subsystem is to maintain the correct operating temperature of the DEU. Just like the LSB ventilation system, damper actuators drive dampers in order to control the volume of air that crosses the radiator. The Wing 1 DEU utilizes a belt-driven radiator fan. The radiator fan runs continuously, but air will not move across the radiator if damper D-4 is closed.

WING 1 SYSTEM	WINGS 3 AND 5 SYSTEM

The Wing 1 DEU water jacket temperature control system (fig 3–17) is simple. Only one DA and one damper maintain the engine temperature. The PLC will command damper D-4 closed if the DEU temperature is below 168°F and will command damper D-4 open if the temperature is above 172°F. The PLC commands damper D-4 to close whenever the DEU is not operating.

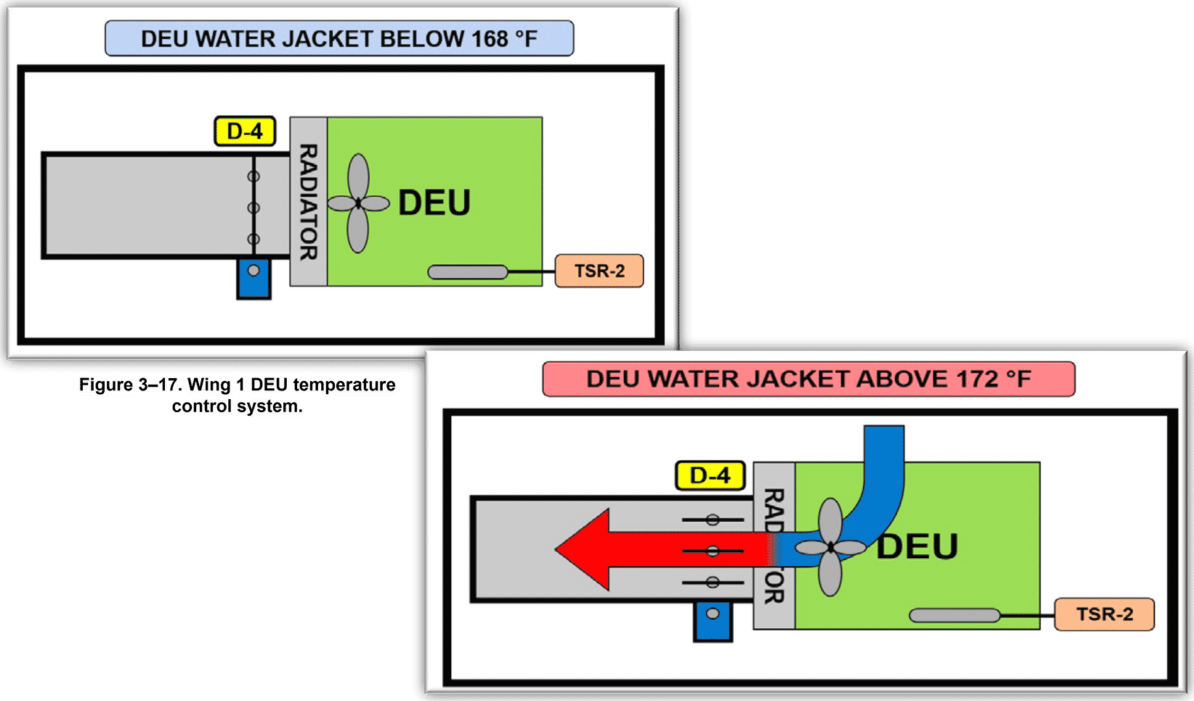

Figure 3–17. Wing 1 DEU temperature control system.

WING 1 SYSTEM	WINGS 3 AND 5 SYSTEM

Wings 3 and 5 water jacket temperature control systems (fig. 3–18) are slightly more complicated than their Wing 1 counterpart, and several components are utilized to control engine temperature. The Wings 3 and 5 DEU does not have its own radiator fan. Instead, exhaust fan F-6 pulls air across the radiator, which only runs when the DEU is operating or when started manually by a technician. Damper D-16 is in front of the DEU radiator and damper D-15 is in another adjacent duct that will allow air to bypass the radiator. You performed maintenance on this configuration during your technical training.

The PLC actuates these two dampers at slightly different temperatures at Wing 3 and Wing 5, but the actions are all the same. If the temperature sensed at DEU water jacket temperature sensor TSR-2 is below 173°F at Wing 3 or 178°F at Wing 5, the PLC will command damper D-16 closed to reduce airflow across the DEU radiator, which will in turn increase its operating temperature. Damper D-15 is commanded open to allow airflow to bypass the radiator.

If the temperature at sensor TSR-2 is above 177°F at Wing 3 or 182°F at Wing 5, the PLC will command damper D-16 open to increase airflow across the DEU radiator, which will decrease its operating temperature. Damper D-15 is commanded closed to increase the airflow across the radiator.

As you can see, this is a relatively simple system that reduces airflow across the radiator when the engine is too cold and increases airflow across the radiator when the engine is too hot. Remember that the PLC consistently modulates the dampers to maintain the DEU operating temperature at 170°F at Wing 1, 175°F at Wing 3, and 180°F at Wing 5.

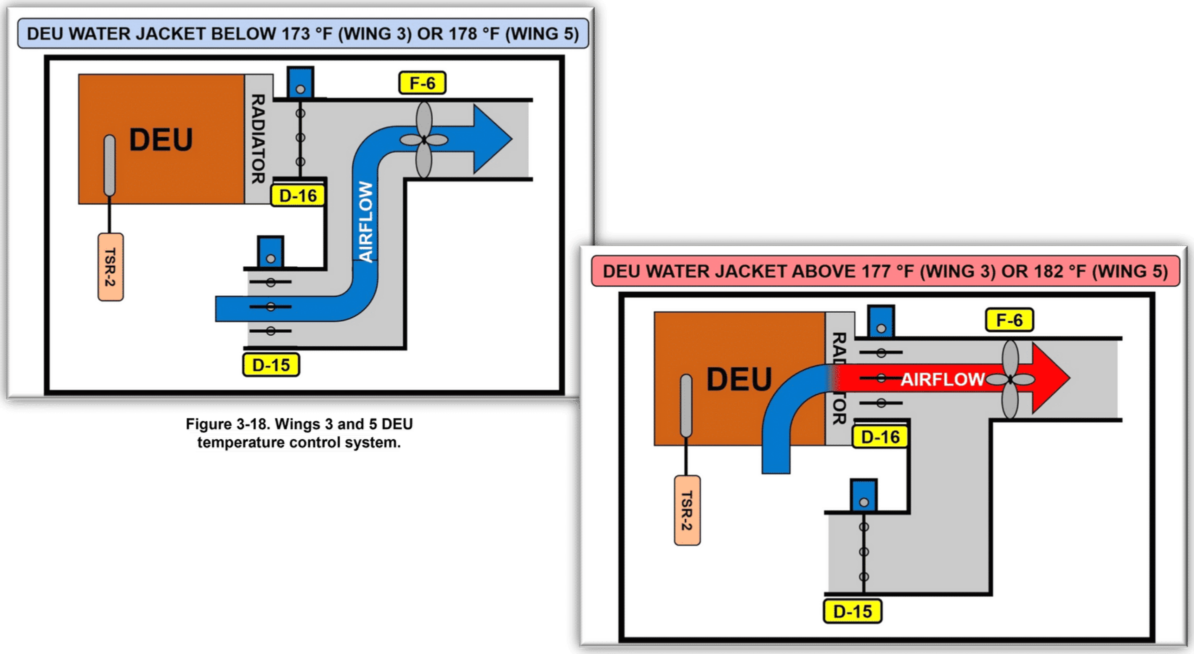

Figure 3-18. Wings 3 and 5 DEU temperature control system.

Complete the content above before moving on.

Ventilation Control Panel

Wing ventilation control panels have different arrangements: however, they all contain the same general components. Panels contain electrical controls for the condenser fan, exhaust fan, panel display, and PLC that control the entire facility ECS. The panel has three different voltage requirements; thus, you must always be aware of which type of voltage you are checking with your multimeter. Figure 3–19 shows the internal components of Wings 3 and 5 ventilation control panel. This panel uses the same modules as the brine chiller control panel.

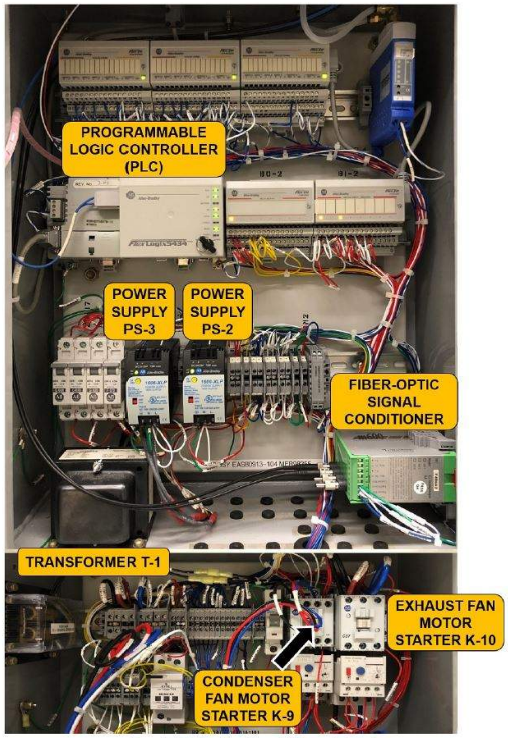

Figure 3–19. Wings 3 and 5 ventilation control panel.

Below is the procedural process for tracing the ventilation control panel for Wings 3 and 5.

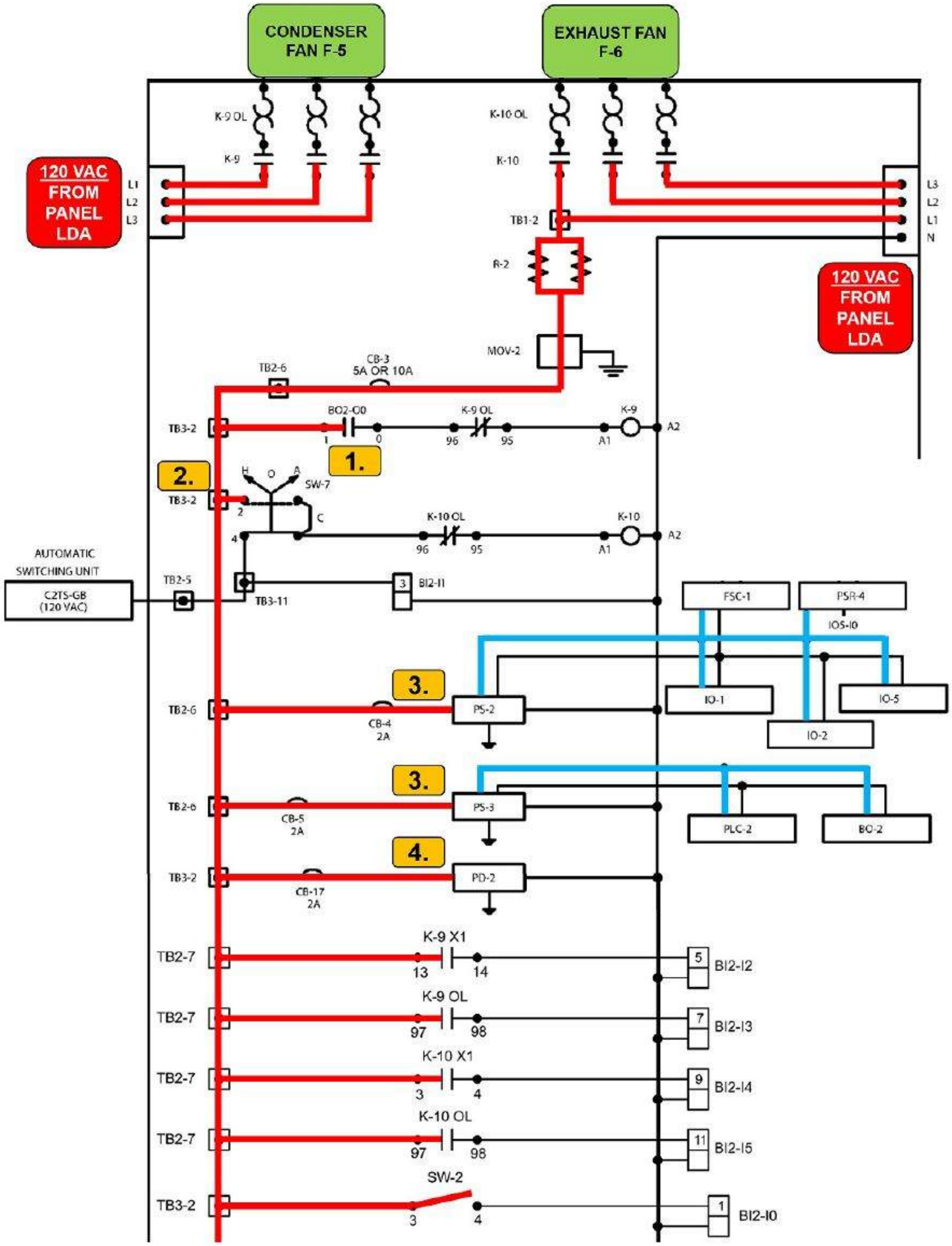

Figure 3-20. Ventilation Control Panel Schematic.

Wings 3 and 5 Ventilation Control Panel

Power is supplied to the ventilation control panel by two 3-pole circuit breakers, one for the condenser fan and another for the exhaust fan. One phase of power branches off the power line leading to exhaust fan F-6 to send 120 VAC through high-power resistor assembly R-2 and metal-oxide varistor MOV-2. After passing through a 5-amp circuit breaker, power will branch out in many different directions similar to the brine chiller control panel. Trace along in figure 3–20 as we discuss the operation of Wings 3 and 5 ventilation control panel.

Ventilation Control Panel 1

At terminal board TB3-2, power will travel to binary output BO2-O0 and wait for the condenser fan ON command to energize motor starter K-9. When this happens, the condenser fan will start.

Ventilation Control Panel 2

Further down the line at terminal board TB3-2, power will wait on one side of the panel's hand-off-auto switch SW-7. Two conditions will cause the exhaust fan to run: it will start automatically when the DEU is running because a 120 VAC signal is sent by the automatic switching unit(ASU) or the exhaust fan will start manually at any time with switch SW-7. When switch SW-7 is set to HAND, power will travel to motor starter K-10, and the exhaust fan under any circumstances. When it is set to AUTO, a 120 VAC input from the diesel generator is required at terminal board TB2-5. This 120 VAC signal will be sent directly to motor starter K-10. When this happens, the PLC is also informed that the diesel is running through binary input BI2-I1.

Ventilation Control Panel 3

At terminal board TB2-6, power passes through a 2-amp circuit breaker and then to power supplyPS-2 where it converts to 26 VDC for use by the fiber-optic components in the panel. Below that on the schematic is power supply PS-3 that serves as the power source for the PLC as well as binary output BO-2.

Ventilation Control Panel 4

At terminal board TB3-2 further down the line, power will pass through a 2-amp circuit breaker to energize the panel display.

Summary

The schematic shown is not all-inclusive, but these are the major functions and operations in the ventilation control panel, and tracing this schematic will be very similar to tracing the brine chiller control panel schematic. Once switch SW-2 is closed, the PLC closes binary output BO-2-O0 to allow power to flow to motor starter K-9 which will start the condenser fan.

The ventilation control panel also houses transformer T-1, which steps 120 VAC down to 24 VAC for use by the many damper actuators controlled by this panel. Remember from a previous lesson that damper actuators require a 24 VAC power source to operate, but their position is determined by a 0–10 VDC analog signal sent from the PLC.

Complete the content above before moving on.

Makeup Air Subsystem

When the primary access hatch (PAH) and the launcher closure door are both closed, the LER is nearly a completely sealed environment. Air is circulated around by the launch tube heater and the air handler fan, but it is for the most part the same ambient air that is being continuously cycled between the air handler and the electronic racks. The emergency storage batteries release hydrogen into the air when they're charging, and there are poisonous gasses located in the propulsion system rocket engine (PSRE) portion of the missile. The only fresh air that enters the LER is through the makeup air subsystem.

The makeup air subsystem (fig 3–21) consists of an underground supply pipe that runs from the LSB to the lower LER, which allows a portion of the air provided by the condenser fan to flow to the LER. Another parallel pipe allows air to flow from the LER back to the LSB. There is no dedicated fan for this function, the pressure created by the air supply to the LER causes air to flow back through the return pipe. Let's trace makeup airflow from the LSB to the LER and then discuss each component in this system. The following descriptions will not use specific component names, but identical components provide the same functions at all three wings.

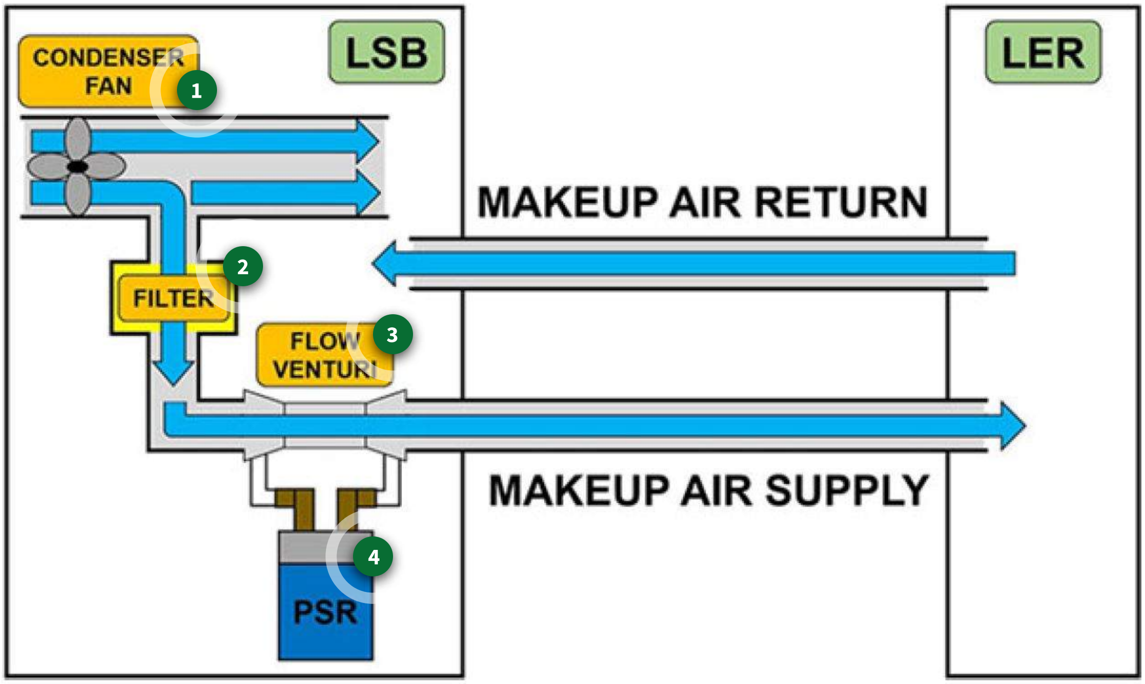

Figure 3–21. Makeup air subsystem.

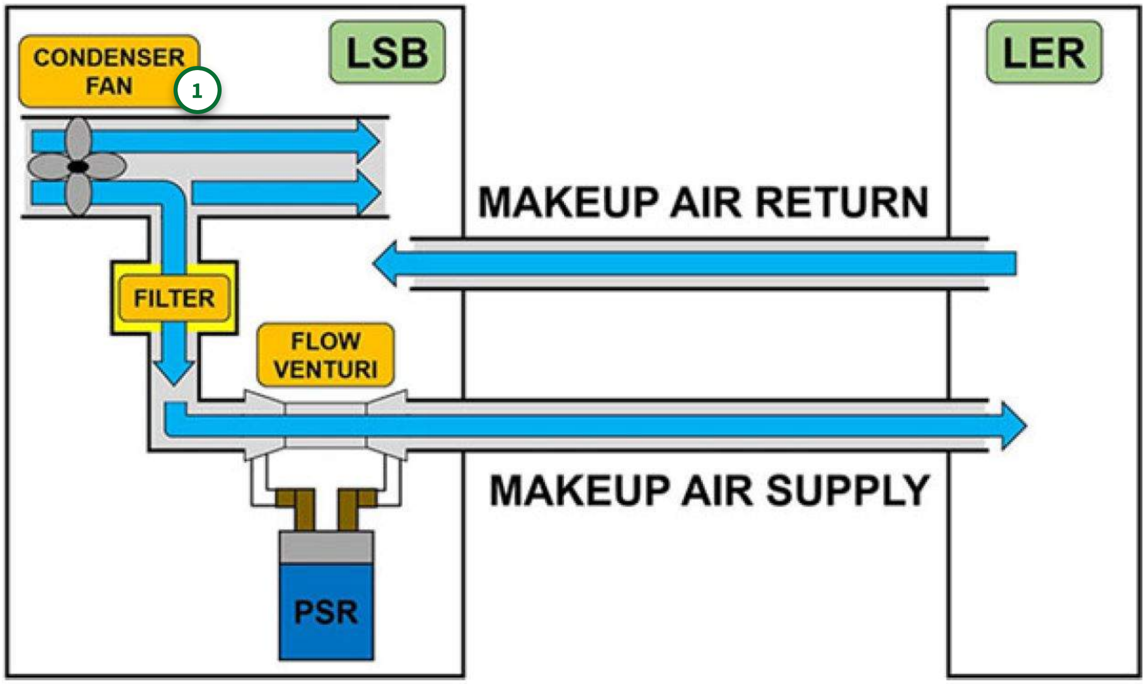

Figure 3–21. Makeup air subsystem.

Condenser Fan

The primary job of the condenser fan is to pull air across the brine chiller condenser coil—we know this from previous lessons. An adjustable plate creates backpressure in the ductwork to force a portion of this air to branch off into the makeup air subsystem.

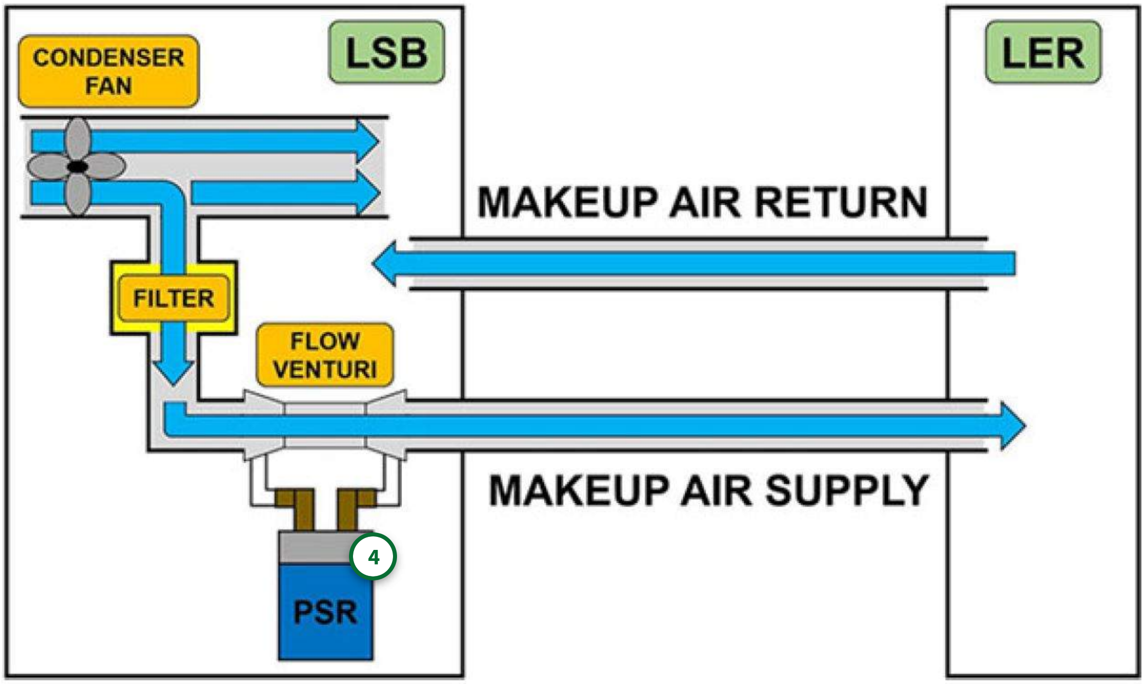

Figure 3–21. Makeup air subsystem.

Pressure Sensor

The purpose of the pressure sensor is to monitor airflow to the LER. It receives pressure readings through vinyl tubing from the high and low sides of the venturi and then converts them into electrical signals and sends the data to the PLC. This pressure sensor sends flow data to the PLC and also allows you to view this data on either of the two panel display screens. The alarm for makeup airflow has been bundled into the ground maintenance response GMR-26 alarm loop, and you will learn more about ground maintenance response fault alarms in a later lesson.
After air flows through the venturi it simply flows through the underground piping and enters the LER to be circulated.

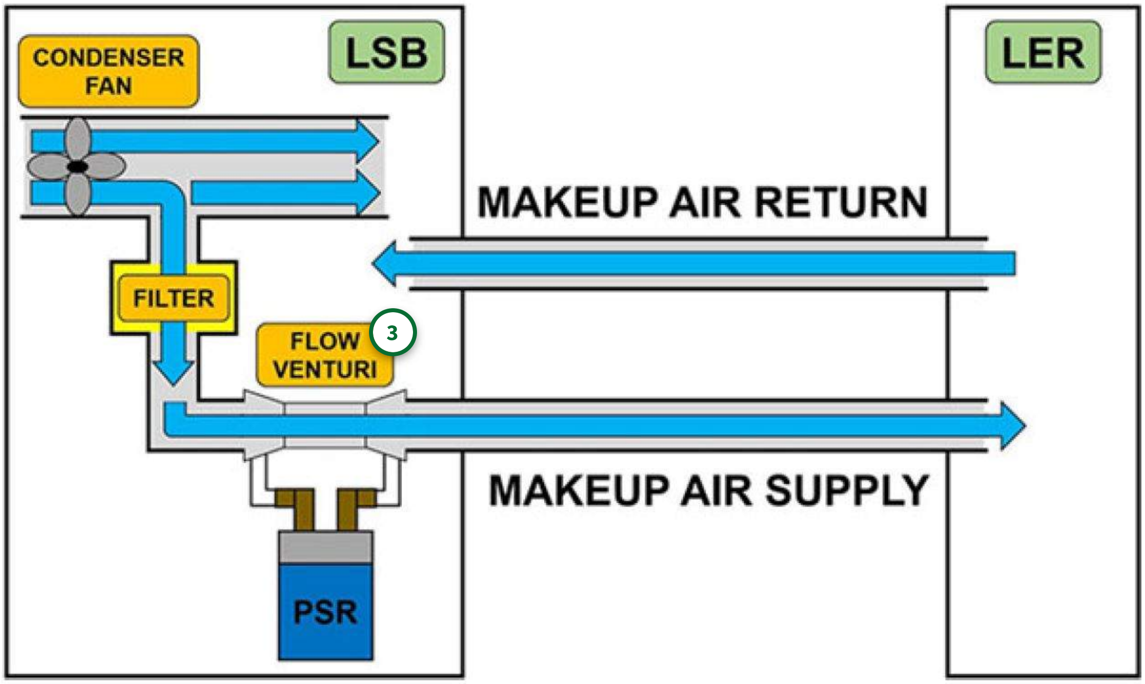

Figure 3–21. Makeup air subsystem.

Venturi

The next destination for the makeup airflow is the flow venturi, which functions just like the liquid venturi in the brine chiller unit. The purpose of the venturi is to create a slight backpressure to allow the pressure sensor to monitor the airflow to the LER, and this is also where you will connect your manometer when taking makeup airflow pressure readings for periodic inspections or trouble-shooting.

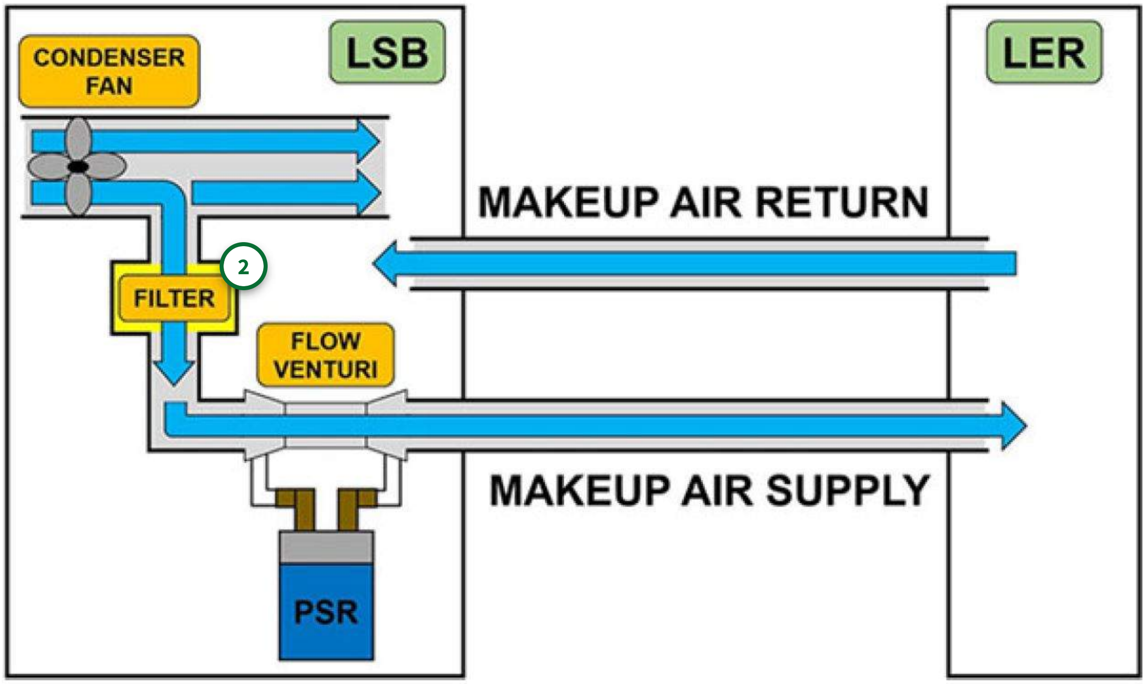

Figure 3–21. Makeup air subsystem.

Air Filter

The air then flows through a filter after it has branched into the makeup air subsystem tubing. This filter is necessary because there is no filtration of the air prior to this. The air filter removes bugs, dirt, pollen, and dust that has been drawn into the LSB by the condenser fan.

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Click on each number before you move forward in the lesson.

Launcher Support Building Heating Subsystem

Heat removed from the brine chiller condenser coil typically maintains the temperature of the LSB. However, when the ambient temperature is extremely cold or when the brine chiller is not operating, heat is provided by an electric unit heater (EUH) located in the LSB. We will look at the two different configurations of electric unit heaters: EUH 1 and EUH 3.

EUH-1	EUH-3

Supplemental heating for the LSB at Wing 1 and Wing 5 is provided by a two-stage resistive electric heater designated as EUH-1 (fig 3–22). The heater is controlled by a two-stage electric thermostat mounted on the LSB wall. It has a hand-off-auto (H-O-A) switch that can be used to operate the heater automatically or manually. The following table breaks down what happens with these two settings.

Setting	Action
AUTO	- When the temperature at the thermostat falls to 45°F, the heater's first stage energizes to provide heat. - If the temperature continues to fall and reaches 43°F, the heater's second stage will also energize to provide additional heat. - When the heater operates, the fan runs automatically to disperse heat throughout the LSB.
HAND	-Manually operates the fan and energizes only the first stage of heating elements.

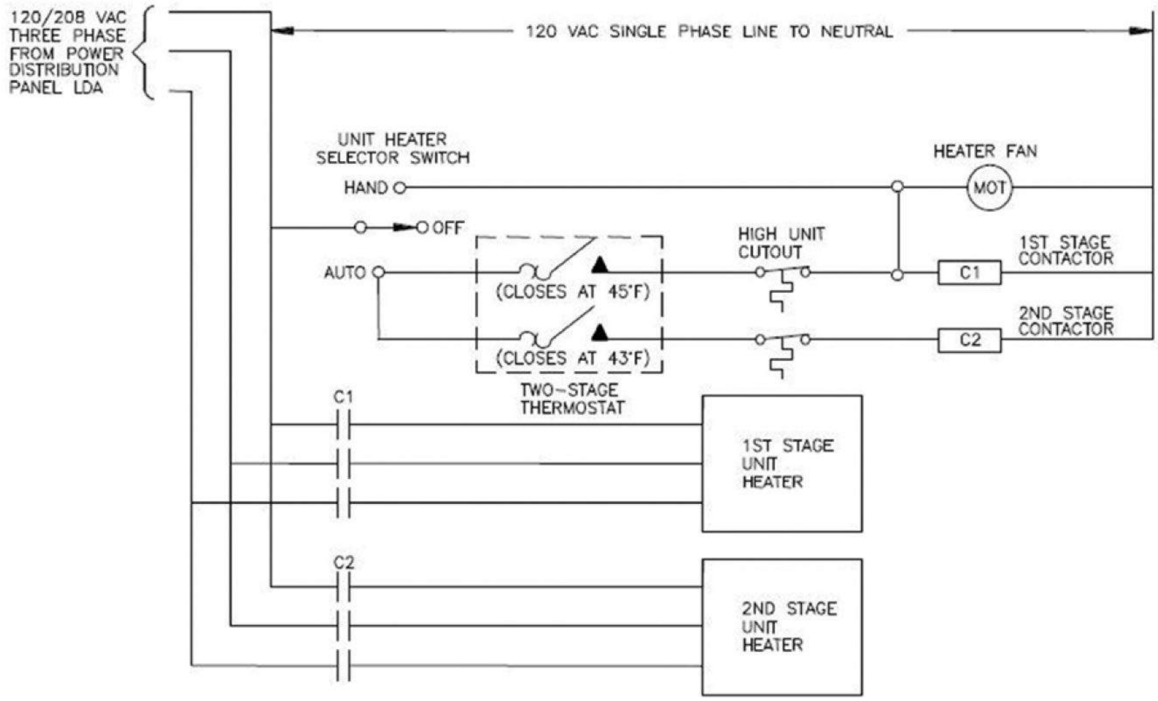


Figure 3–22. EUH-1 room heater schematic.

EUH-1

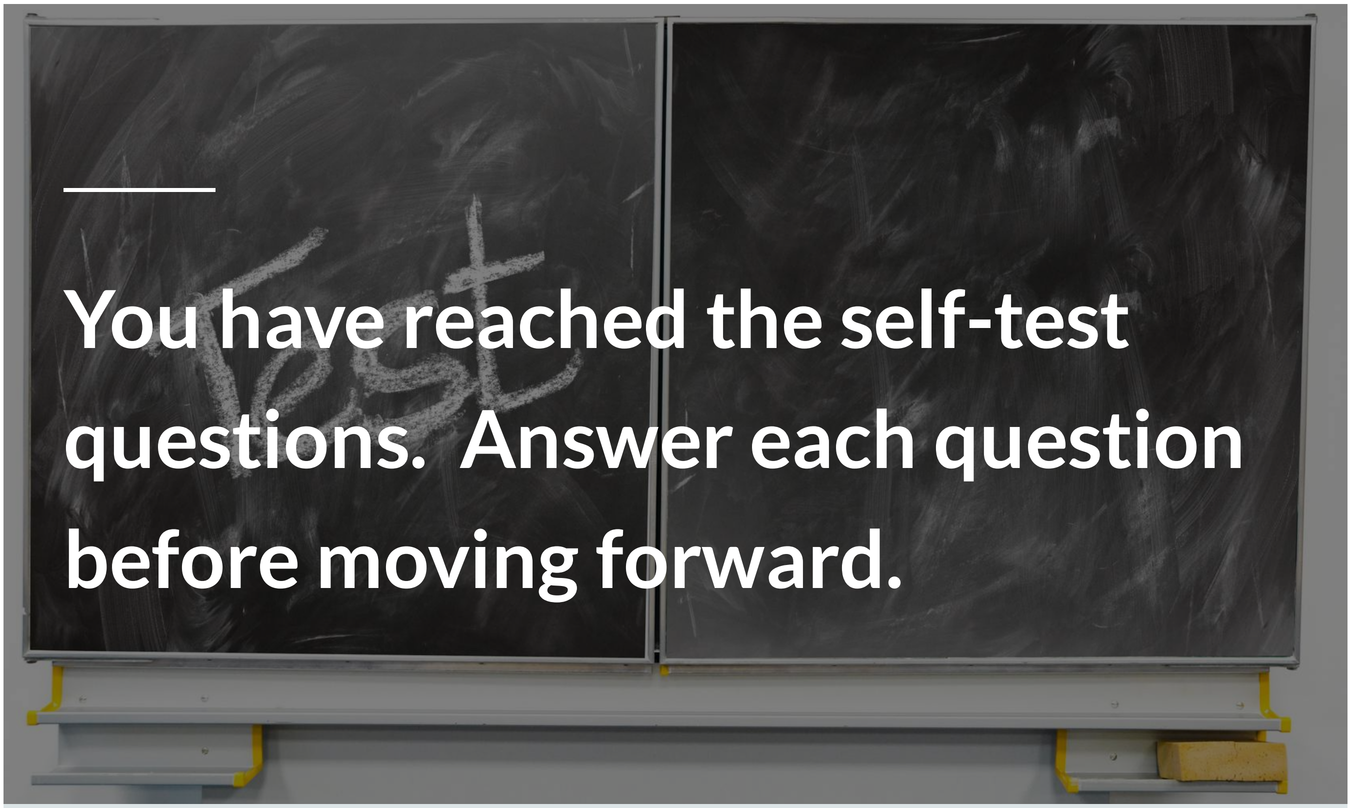
EUH-3

Wing 3 uses a heater that is almost identical to the EUH-1. This one is designated EUH-3 and is also a two-stage resistive electric unit heater. The only difference between the two heaters is that EUH-3's first stage energizes automatically at 46°F.

Both room heaters have a high-temperature cutout. If a malfunction with the room heater fan occurs, the heating elements will overheat and burn up, so this high-temperature cutout will de-energize the heating elements if they get too hot.

This lesson covered many launch facility systems designed to maintain the proper temperature of the launch support building and the DEU. Knowing this information will aid you greatly in your periodic maintenance and troubleshooting endeavors since the temperature variations are so severe at the northern tier missile bases.

Complete the content above before moving on.



You have reached the self-test questions. Answer each question before moving forward.

KNOWLEDGE CHECK TIME!

For the fill-in the blank questions, you will need to add (.) period to the end of the sentences.

Click here to answer the self-test questions pertaining to the brine chiller brine subsystem.

1. What is the purpose of the brine pump?

Type your answer here

SUBMIT

2. What is the purpose of valves V-8 and V-9 on the brine subsystem venturi?

Type your answer here

SUBMIT

3. Where will air trapped in the brine subsystem exit?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the brine chiller control panel operation.

1. Which components in the brine chiller control panel use 26 VDC provided by power supply PS-1?

Type your answer here

SUBMIT

2. What components located on the brine chiller unit form the hardware interlock?

Type your answer here

SUBMIT

3. What occurs when refrigerant subsystem solenoid valves SV-1 and SV-2 are energized?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the ventilating air and heating subsystem operation.

1. What general actions does the programmable logic controller take to cool the launcher support building if it is above 72°F?

Type your answer here

SUBMIT

2. At a Wing 3 or Wing 5 launch facility, when the diesel electric unit is running, why does hot air from the condenser coil continue into the launcher support building even when the room temperature is above 72°F?

Type your answer here

SUBMIT

3. How is air moved across the diesel electric unit radiator on a Wing 3 or Wing 5 launch facility?

Type your answer here

SUBMIT

4. What two conditions will cause the Wings 3 and 5 exhaust fan to operate?

Type your answer here

SUBMIT

5. Explain the general operation of the makeup air subsystem.

Type your answer here

SUBMIT

6. In regard to the electric unit heater at Wings 1 and 5, what will occur if the temperature of the launcher support building drops to 43°F?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Launcher Equipment Room Operation

Several other important ECS components are located in the LER. These include the air handler, emergency fan, and the launch tube heater. Similar to the previous lessons, using the figures in conjunction with the text will help you to better understand the concepts you are about to learn. The ECS components are in nearly the same location at each of the three missile wings, major differences will be annotated. (image location: https://minutemanmissile.com/lowerlauncherequipmentroom.html)

Air Handler Subsystem Operation

Up to this point you have had lessons on heat transfer as well as the many different components required to prepare the brine solution to absorb heat from the air in the LER. The air handler (fig 3–23) is the last major interface between the ECS and the electronic racks that must receive a constant flow of cool air. This lesson will provide a more in-depth look at the air handler while also furthering your knowledge by providing several schematics for you trace. This lesson will end with a look at what the air handler alarms are and what causes them to report.

Through several different components and functions, air handler unit AH-1 filters, cools, and dehumidifies ambient air in the LER and then sends this conditioned air to the electronic racks. Ground maintenance response fault alarms will report if the air handler encounters a problem or experiences a malfunction.

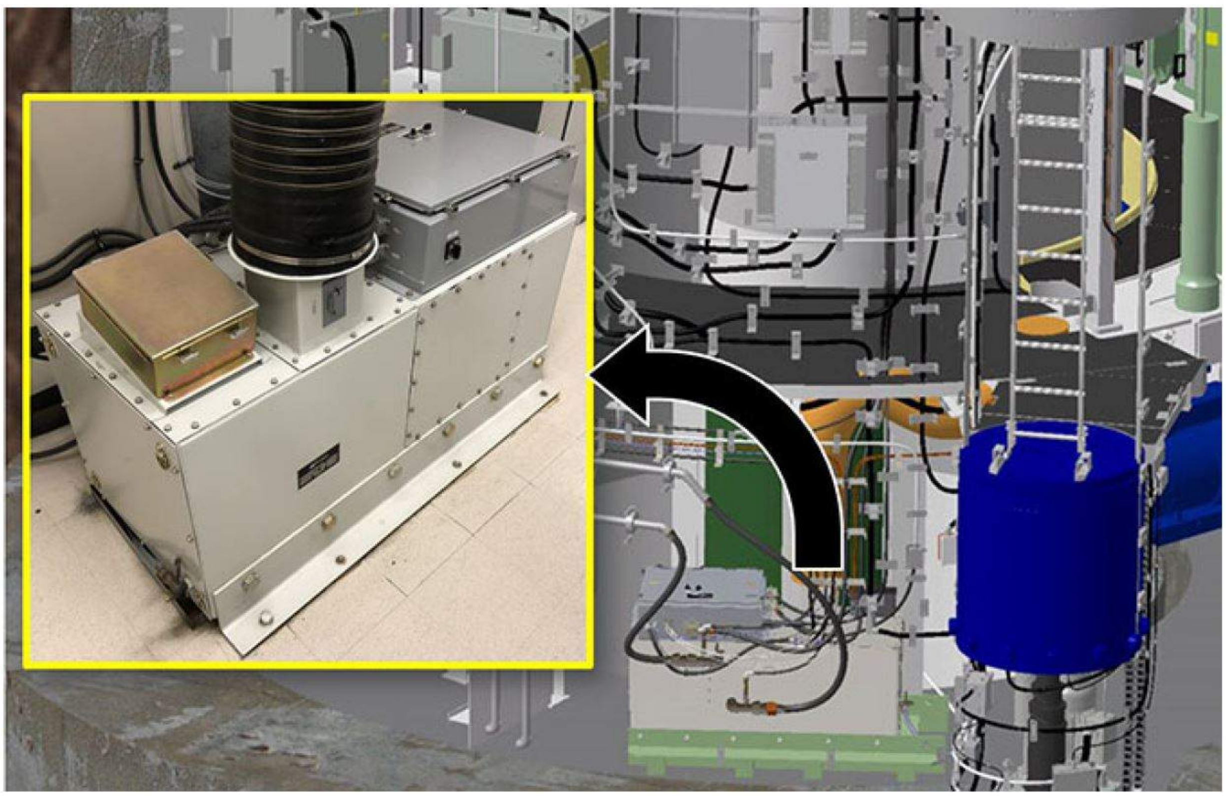


Figure 3–23. Air Handler Unit AH-1.

Components

The following are major components of the air handler unit AH-1:

1. Air filter AFL-1
2. Fan assembly F-2
3. Cooling coil CC-1
4. Cooling coil bypass damper D-7

Click and flip each flashcard to learn about the major components of the air handler unit.

Fan Assembly F-2

Air handler fan F-2 is responsible for drawing air into air handler unit AH-1. Fan F-2 pulls air first through air filter AFL-1 and then through cooling coil CC-1.

1 of 4

Cooling Coil CC-1

Cooling coil CC-1 is where heat from the ambient air in the LER transfers to the cool brine provided by the brine chiller unit.

Cooling Coil Bypass Damper D-7

Cooling coil bypass damper D-7 provides the means to modulate how much air passes across the cooling coil CC-1, and therefore controls the temperature of the air exiting the air handler. Damper D-7 and cooling coil CC-1 run parallel to one another—this means that air can either pass

Complete the content above before moving on.

Air Handler Control Panel Operation

The air handler control panel has several fiber-optic and electrical components whose purpose is to monitor and operate the air handler. This panel mounts on top of the air handler. The panel lid opens upward to provide access to the internal components. Figure 3–24 shows the inside of the control panel.

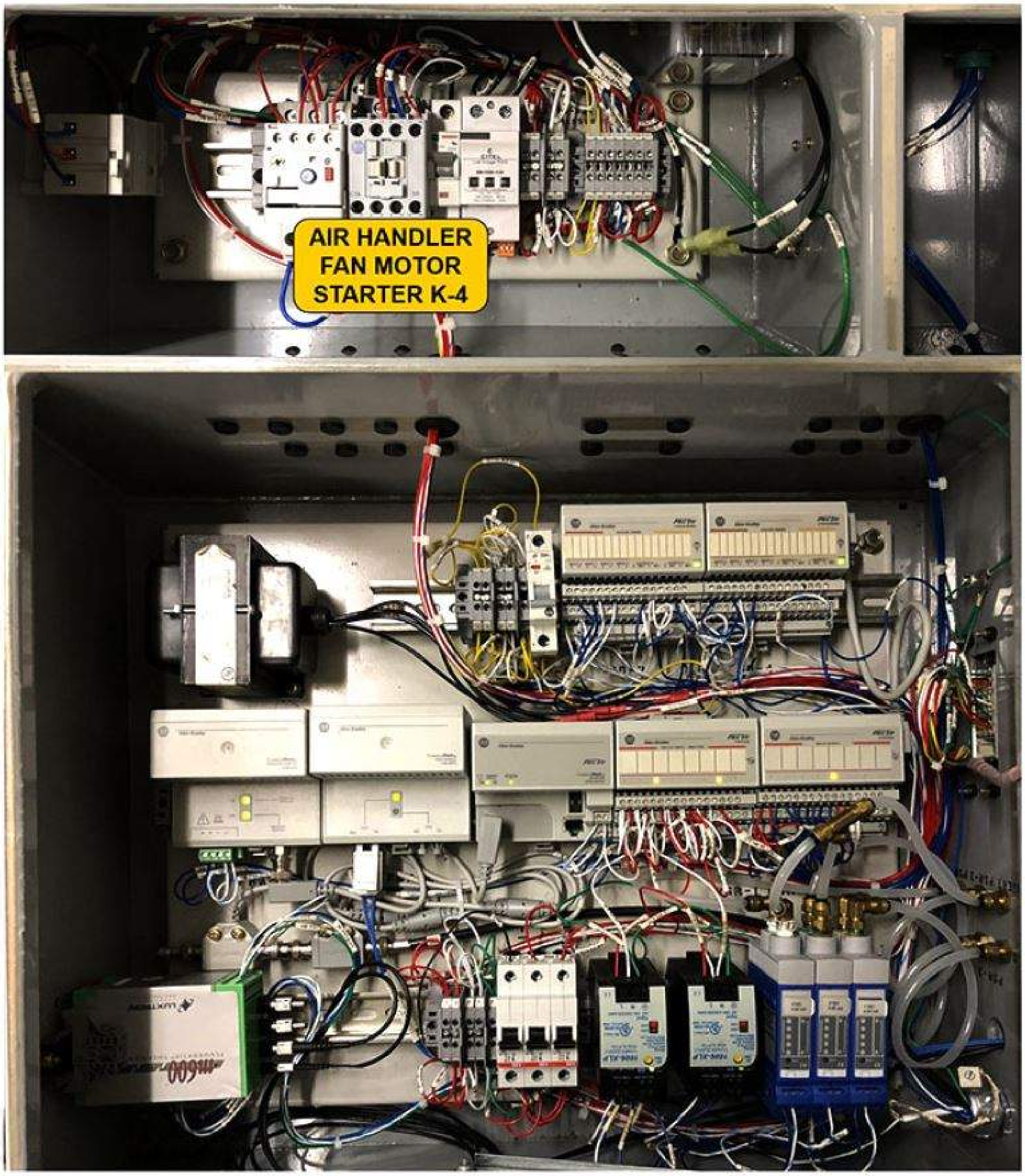


Figure 3-24. Air Handler Control Panel.

Click here to continue on in the lesson.

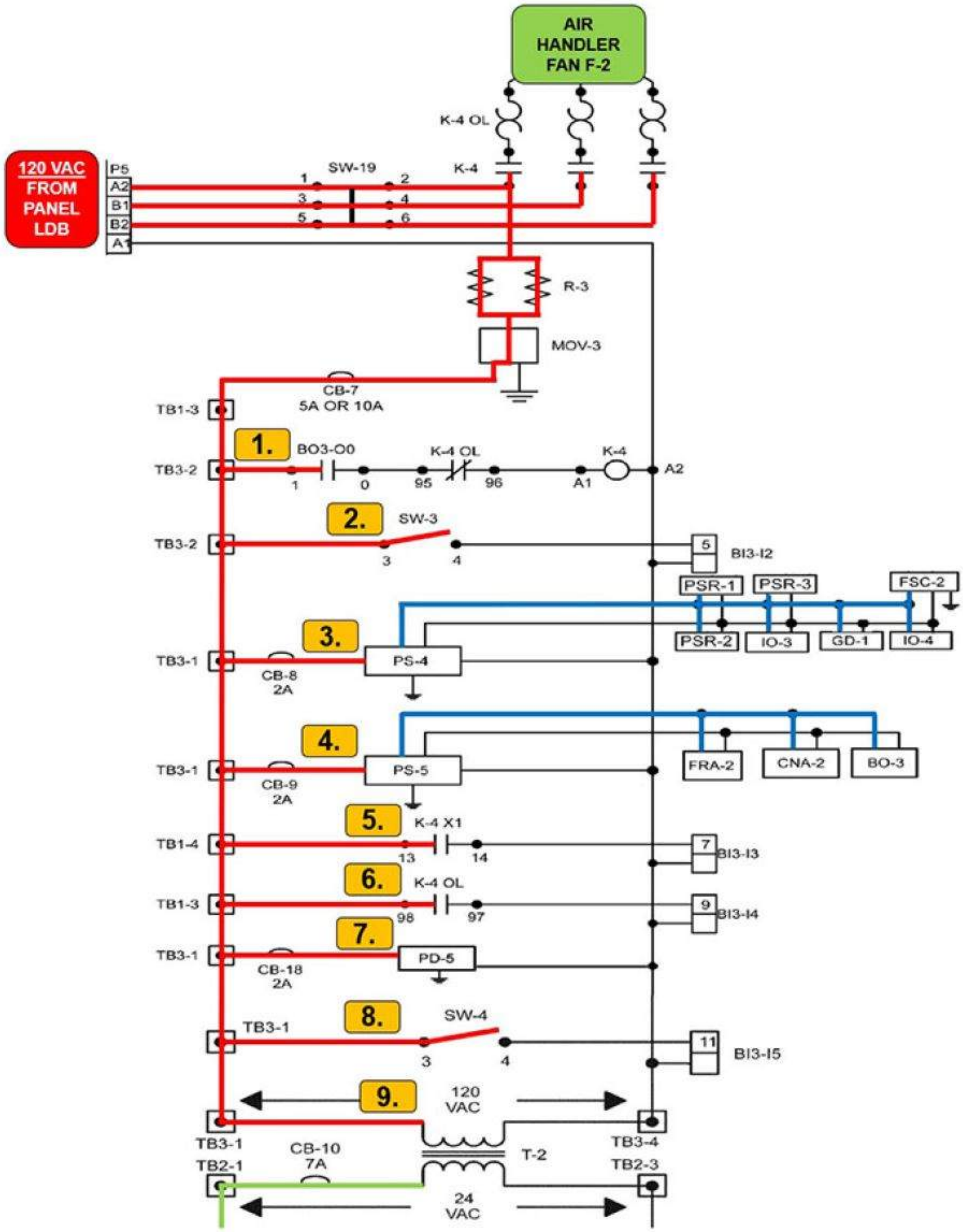


Figure 3–25. Air Handler waiting to Start on Schematic.

Power Sources and Devices

Power is supplied to air handler unit AH-1 through a 3-pole circuit breaker in the launcher distribution panel. Power enters the control panel and passes through air handler isolation switch SW-19 which can be used to manually shut down the air handler. One phase of 120 VAC power branches off this 3-phase circuit and is used to power the control panel components. Follow along in figure 3–25 as we trace the flow of power throughout the air handler control panel. Doing so will enhance your understanding of schematics and wiring diagrams.

Power passes through high-power resistor assembly R-3 and metal-oxide varistor MOV-3. It then passes through a 5-amp circuit breaker en route to terminal board TB3-2, where the following actions occurs.

Step 1

Power flows to binary output BO3-O0 and waits for the PLC to send the AIR HANDLER ON command.

Step 2

At terminal board TB3-2 power flows to and waits on switch SW-3. When SW-3 sets to on, BI3-I2 will energize enabling the air handler unit AH-1 to start.

Step 3

At terminal board TB3-1, power flows through circuit breaker CB-8 and energizes power supply PS-4. PS-4 supplies 26 VDC to several components including combustible gas detector GD-1, as shown in the figure.

Step 4

At terminal board TB3-1, power flows through circuit breaker CB-9 and energizes power supply PS-5. PS-5 supplies 26 VDC to fiber-optic repeater adapter FRA-2, controlnet adapter CNA-2, and binary output module BO-3.

Step 5

Power flows through terminal board TB1-4 and waits on one side of the open relay K-4 X1 contact. When motor starter K-4 energizes, K-4 X1 contacts will close to allow 120 VAC to flow to binary input module BI3-I3, which will inform the PLC that air handler unit AH-1 has started. If this input is not present the PLC will not start the brine chiller.

Step 6

Power flows through terminal board TB1-3 and waits on one side of the open motor starter overload K-4 OL contacts. If motor starter K-4 draws too much amperage and heats up, its thermal overloads will open and this contact will close to inform the PLC of the K-4 overload condition.

Step 7

At terminal board TB3-1, power flows through circuit breaker CB-18 and energizes the panel display located on top of the air handler.

Step 8

Power flows through terminal board TB3-1 and waits on the normally open airflow balancing switch SW-4. When this switch is set to ON position, damper DA-9 will modulate to automatically send the proper amount of airflow to each electronic rack.

Step 9

Lastly, power flows through terminal board TB3-1 to supply 120 VAC to transformer T-2.T-2 converts 120 VAC to the 24 VAC that is required by the damper actuators used by the air handler system.

Complete the content above before moving on.

Air Handler Startup

The emergency ECS operates whenever air handler unit AH-1 is not operating. These two systems are intertwined and commands to the air handler affect the emergency ECS and vice versa. In order for the PLC to start air handler unit AH-1, it must first disable emergency ECS.

To disable emergency ECS, the PLC must energize binary output BO3-O1. This allows 26 VDC to flow through and energize relay K-8 in the emergency air handler control panel. We'll see this circuit in more detail later, but this shuts down the emergency fan and causes the normal and emergency isolation dampers to reposition. The PLC will only start air handler unit AH-1 when it has sensed that the input has been removed from binary input BI3-I6.

The PLC starts air handler unit AH-1 by energizing binary output BO3-O0, which allows power to travel to motor starter K-4. The three main contacts of K-4 will close to allow fan F-2 to start. The air handler is now operating!

Air Handler Shutdown

There are only a few steps involved for the PLC to shut down air handler unit AH-1. You can manually shut down air handler unit AH-1 by setting switch SW-3 or SW-19 in the air handler control panel to the OFF position, by setting emergency operation switch SW-6 on the emergency fan control panel to the HAND position, or by setting switch SW-2 on the ventilation control panel to the OFF position. The PLC will shut down air handler unit AH-1 when the airflow sensed at electronic rack cooling airflow pressure sensor (PSR)-1 falls below 0.47 inches of water gauge (inwg) for more than 15 seconds. This condition tells the PLC that airflow to the electronic racks is not sufficient, and will cause the system to transfer to emergency ECS.

To shut down air handler unit AH-1, the PLC removes power from binary output BO3-O0, which in turn removes power from motor starter K-4 and causes air handler fan F-2 to stop operating. Additionally, the PLC will remove power from binary output BO3-O1, which will remove power from emergency mode disabling relay K-8. This will start the emergency fan and cause the normal and emergency isolation dampers to reposition. When this happens, the emergency fan will supply non-conditioned airflow to the electronic racks.

Combustible Gas Detector Function and Operation

You learned that the purpose for the makeup air subsystem is to circulate fresh air from the LSB to the LER, and that this flow is typically enough to prevent any dangerous accumulation of hydrogen gas. Hydrogen is produced when the emergency storage batteries in the lower LER are subjected to an equalize charge, and this will typically happen after an LF has been operating on emergency storage battery power for an extended amount of time and then returns to commercial power. Once the “lights are back on,” so to say, the emergency storage battery charger will immediately get to work recharging the batteries. If the makeup airflow subsystem is malfunctioning, or is unable to provide enough airflow, the hydrogen being released by the charging batteries could create an explosive atmosphere that would only require a tiny spark for ignition. This is where combustible gas detector GD-1 comes into play.

Combustible Gas Detector Function

You will recall from lesson 2 that the gas detector GD-1 is calibrated to report an alarm at 25% of the lower explosive limit (LEL) of hydrogen gas. One hundred percent of the LEL is the lowest concentration of hydrogen that could possibly ignite if an ignition source was present. Therefore, a ground maintenance response GMR-26 fault alarm will begin to report when one-quarter of the concentration required for ignition exists.

Combustible Gas Detector GD-1 Operation

Gas detector GD-1 is intentionally mounted at a very high point in the upper LER because hydrogen gas is lighter than air. Any accumulation will rise toward the ceiling and the placement of the gas detector GD-1 ensures gas is detected as early as possible. Gas detector GD-1 receives power from power supply PS-4 in the air handler control panel, and will continuously monitor for hydrogen gas after proper calibration. We have already covered calibrating the meter, but to recap, clean air is used first in order to provide a baseline for the gas detector GD-1. Next, a gas that contains 50% of the LEL of hydrogen gas is introduced to the meter so that it ‘knows’ what concentration to react to.

The casing of the gas detector GD-1 is completely sealed and has no exposed contacts or touch buttons. The reason for this is that the meter was designed to operate in an explosive atmosphere and therefore shall not produce any ignition source capable of igniting such an atmosphere. A technician will use a magnetized stick to interact with the four internal switches of the gas detector GD-1; this act simulates the pressing of buttons.

Gas detector GD-1 monitors the LER atmosphere for the presence of hydrogen gas. This detector reading converts to an analog electrical signal ranging between 4 and 20 milliamps (mA) and sent to analog input/output module IO4-I3. A signal of 8 mA or greater indicates that the atmosphere in the LER has reached 25% of the LEL, and the PLC will start a 15-second timer. If the LEL remains above 25% (8 mA) for longer than 15 seconds, the PLC will remove power from binary output BO3-O2, which will initiate a ground maintenance response GMR-26 fault alarm. The alarm is non-latching and will reset if the LEL falls below 25%.

In the event that the gas detector GD-1 fails, there are also preventive measures in place to ensure that a hazardous condition can still be detected. If the output of the gas detector GD-1 falls below 4 mA for longer than 300 seconds (5 minutes), the PLC will command binary output BO3-O7 closed to initiate an alarm through the ECS remote monitoring system (ERMS). Anyone viewing the data on the support base will automatically know that the output of gas detector GD-1 has failed since this malfunction reports through the ERMS instead of through a normal ground maintenance response fault alarm channel.

You are directed by your TO to use the panel display in the LSB to verify the percentage of LEL prior to penetrating the LER, and gas detector GD-1 must be calibrated annually, so you will likely become very familiar with the meter when you begin dispatching to the missile field.

Complete the content above before moving on.

Ground Maintenance Response Fault Alarms

The alarm parameters monitored by components in the air handler control panel include ground maintenance responses GMR-26, GMR-27, and GMR-28. The ground maintenance response GMR-28 fault alarm is related to the launch tube heater, and we will discuss that alarm circuit in a later lesson.

Ground Maintenance Response System Malfunctions

The ground maintenance response GMR-26 fault alarm has evolved over the years to encompass a variety of system malfunctions. The ground maintenance response GMR-26 fault alarm will report under any of the following conditions:

- Conditioned air temperature to the racks falls below 50°F or rises above 60°F.
- Combustible gas detector GD-1 has failed.
- Combustible gas detector GD-1 detects an LEL of greater than 25%.
- Makeup airflow to the LER is out of tolerance.

As a technician on the support base, you can use the ERMS to determine exactly what parameter has been exceeded. The ERMS will not tell you exactly what the fault is, but you can tell if the temperature is too high, or too low, or if the combustible gas detector GD-1 is causing an alarm. Let's take a closer look at the actions that occur in each of these situations.

Rack Temperature Out of Tolerance

The conditioned air temperature exiting the racks should be between 53° and 57°F as sensed by electronic rack cooling air temperature sensor TSR-3. Based on what TSR-3 senses, fiber-optic signal conditioner FSC-2 will send an analog signal to the PLC, which will then respond by modulating air handler cooling coil bypass damper D-7.

If the temperature of the air flowing to the electronic racks falls below 50°F, temperature sensor TSR-3 will send this signal through the fiber-optic signal conditioner FSC-2 to the PLC. The PLC will wait for a 15-second timer to elapse before taking action. This 15-second time delay prevents nuisance alarms and gives the system time to correct itself before initiating an alarm. If after 15 seconds the temperature is still below 50°F, the PLC removes power from binary output BO3-O02, which opens the ground maintenance response GMR-26 fault alarm circuit. This alarm will reset once the temperature rises above 51°F.

The same actions occur if the temperature of the air flowing to the electronic racks rises above 60°F, and the ground maintenance response GMR-26 fault alarm will reset to normal once the temperature drops to 59°F.

Combustible Gas Detector Failure

As stated above, combustible gas detector GD-1 (fig 3–26) monitors the LER for a potentially dangerous accumulation of hydrogen gas. If the gas detector GD-1 fails, we would have no means of detecting a potentially explosive atmosphere in the LER. A normally functioning gas detector GD-1 sends a 4–20 mA signal to the PLC to indicate its operating status. If the mA signal falls below 4 mA, the PLC will enable a 300-second timer. If the signal is not above 4 mA after 300 seconds have elapsed, the PLC will remove power from binary output BO3-O2 to initiate the ground maintenance response GMR-26 fault alarm.

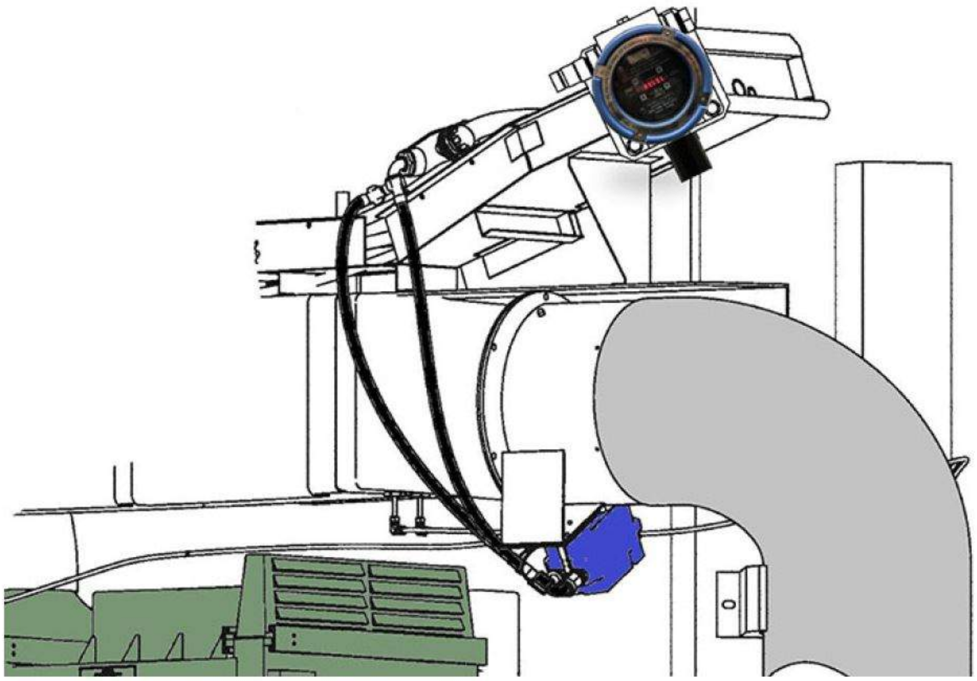


Figure 3–26. Combustible gas detector GD-1 in LER.

Combustible Gas Detector Senses 25% of the Launcher Equipment Room of Hydrogen Gas

Gas detector GD-1 converts the LEL signal of the lower explosive limit of hydrogen gas into an analog signal and sends it to the PLC through input/output IO4-I3. If the analog signal sent by gas detector GD-1 indicates that the atmosphere in the LER contains 25 percent or greater of the LEL, the PLC will initiate a 15-second timer. If this condition lasts longer than 15 seconds, the PLC will remove power from binary output BO3-O2 to initiate a ground maintenance response GMR-26 fault alarm. The alarm will not reset until the LEL falls below 24 percent.

Makeup Airflow Insufficient

A portion of the air from the brine chiller condenser fan in the LSB travels to the LER through the makeup air system. A perforated plate is installed at the outlet of damper D-13A to force air back to the makeup air system. Makeup air will flow through an air filter and into a venturi where pressure sensor PSR-4 will monitor the flow of makeup air.

If makeup airflow is insufficient, the PLC will initiate a 15-second timer to allow the system to correct itself. If after 15 seconds the makeup airflow is still below the allowable limit, the PLC will remove power from binary output BO3-O2, and a ground maintenance response GMR-26 fault alarm will be initiated. This alarm will reset automatically if the makeup airflow returns to acceptable limits.

Complete the content above before moving on.

Ground Maintenance Response GMR-27

The ground maintenance response GMR-27 fault alarm circuit monitors the volume of air that is flowing to the electronic racks. If airflow falls below a certain threshold for longer than 15 seconds, the PLC will remove power from air handler unit AH-1, start the emergency fan, and initiate a ground maintenance response GMR-27 fault alarm indicating that the site is operating on emergency ECS.

Pressure sensor PSR-1 measures airflow to the electronic racks and sends an analog signal to the PLC; this reading can be viewed on either of the panel displays. If airflow is less than 0.47 inwg for more than 15 seconds, the PLC will initiate the ground maintenance response GMR-27 fault alarm by removing power from binary output BO3-03.

This will also cause the PLC to switch over to the emergency ECS. This fault will not reset automatically. A technician can restart the air handler by setting switch SW-3 on the air handler control panel to OFF and then back to ON, or by setting SW-6 on the emergency fan control panel to OFF and then back to AUTO. A technician can also manually reset the system at either panel display to transfer back to normal operation.

If the problem causing the ground maintenance response GMR-27 still exists, the system will startup, but will soon shut down again.

Click here to learn about the emergency fan subsystem operation.

Emergency Fan Subsystem Operation

A constant flow of air must always be available to the electronic racks in the LER, and you have already learned that there are certain circumstances where air handler unit AH-1 must shut down. The emergency fan subsystem switches on whenever normal ECS fails; this lesson will focus on the operation of this subsystem.

The purpose of the emergency fan is to provide airflow to the electronic racks in the event that the normal ECS has failed. This fan draws air directly from the LER ambient air supply, and for this reason it will not provide conditioned or filtered air. As a 2M0X3, it is important to remember that even an unfiltered ambient flow of air is better than no airflow at all.

Components

The emergency fan is located on the upper level LER floor above the electronic racks and draws air from the lower LER, directly above the emergency storage battery set. The emergency fan subsystem includes the following components:

- Emergency fan F-4
- Normal and emergency isolation dampers D-8 and D-10.
- Emergency fan control panel.

The emergency fan is a vaneaxial-type (fig 3–27) fan that mounts directly inside the ductwork leading to the electronic racks.

Figure 3–27. Vaneaxial-type Fan (generic).

The normal and emergency isolation dampers D-8 and D-10 reposition in response to whichever system is operating. When air handler unit AH-1 is operating, damper D-8 is open to allow conditioned airflow to the electronic racks. If the system transfers to emergency ECS, damper D-8 will close and damper D-10 will open to allow airflow from emergency fan F-2 to cool the racks. You will learn more about how dampers D-8 and D-10 reposition in the next segment of the lesson. Figure 3–28 shows an overview of the normal and emergency airflow to the electronic racks. The last major component is the emergency fan control panel, which we will now cover in detail.

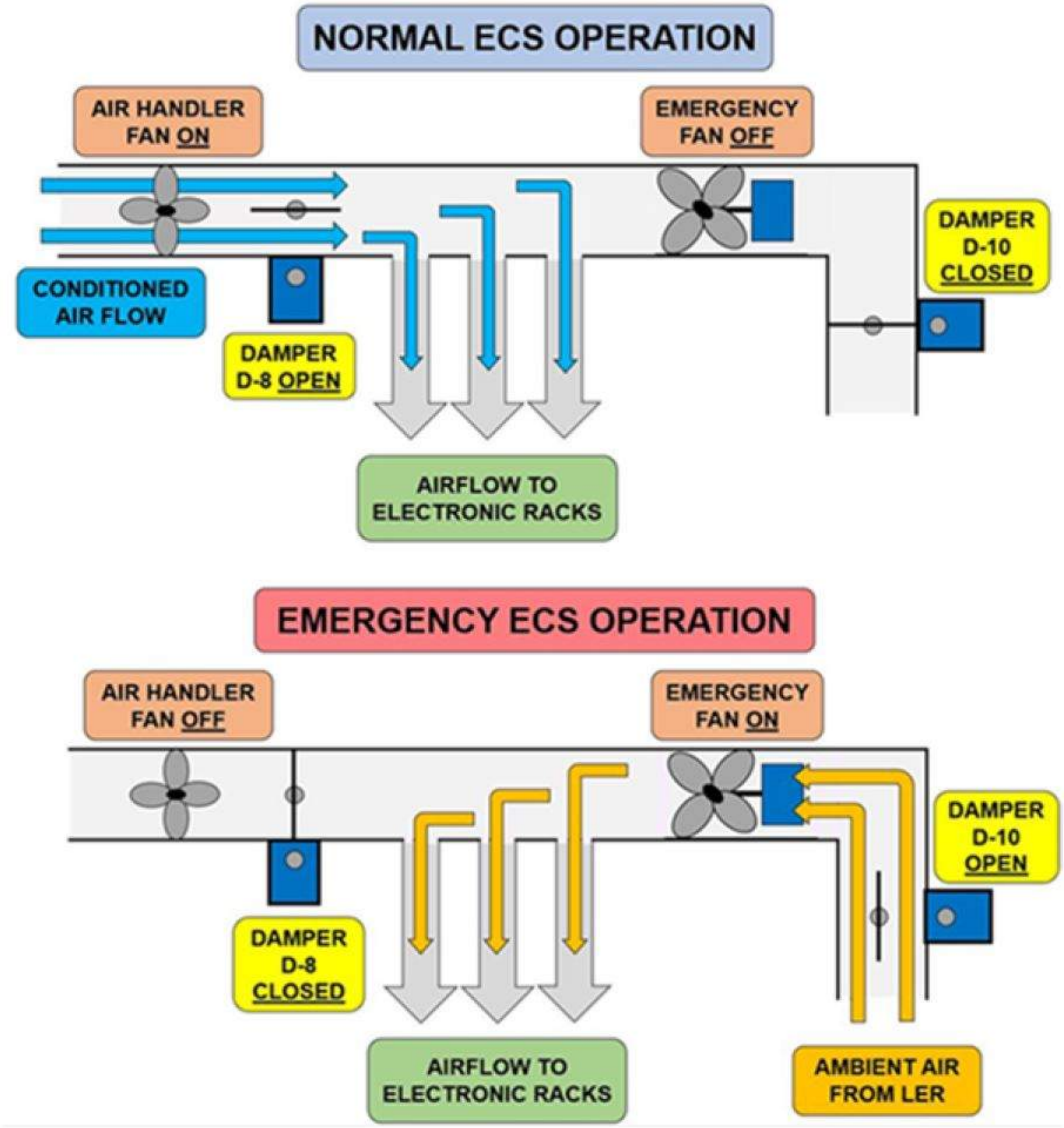


Figure 3–28. Normal and Emergency Airflow to the Electronic Racks.

Emergency Fan Control Panel Operation

The emergency fan control panel (fig 3–29) contains all of the components needed to start emergency fan F-2, reposition normal and emergency isolation dampers D-8 and D-10, and interface with air handler unit AH-1 and the PLC to determine if it needs to operate.

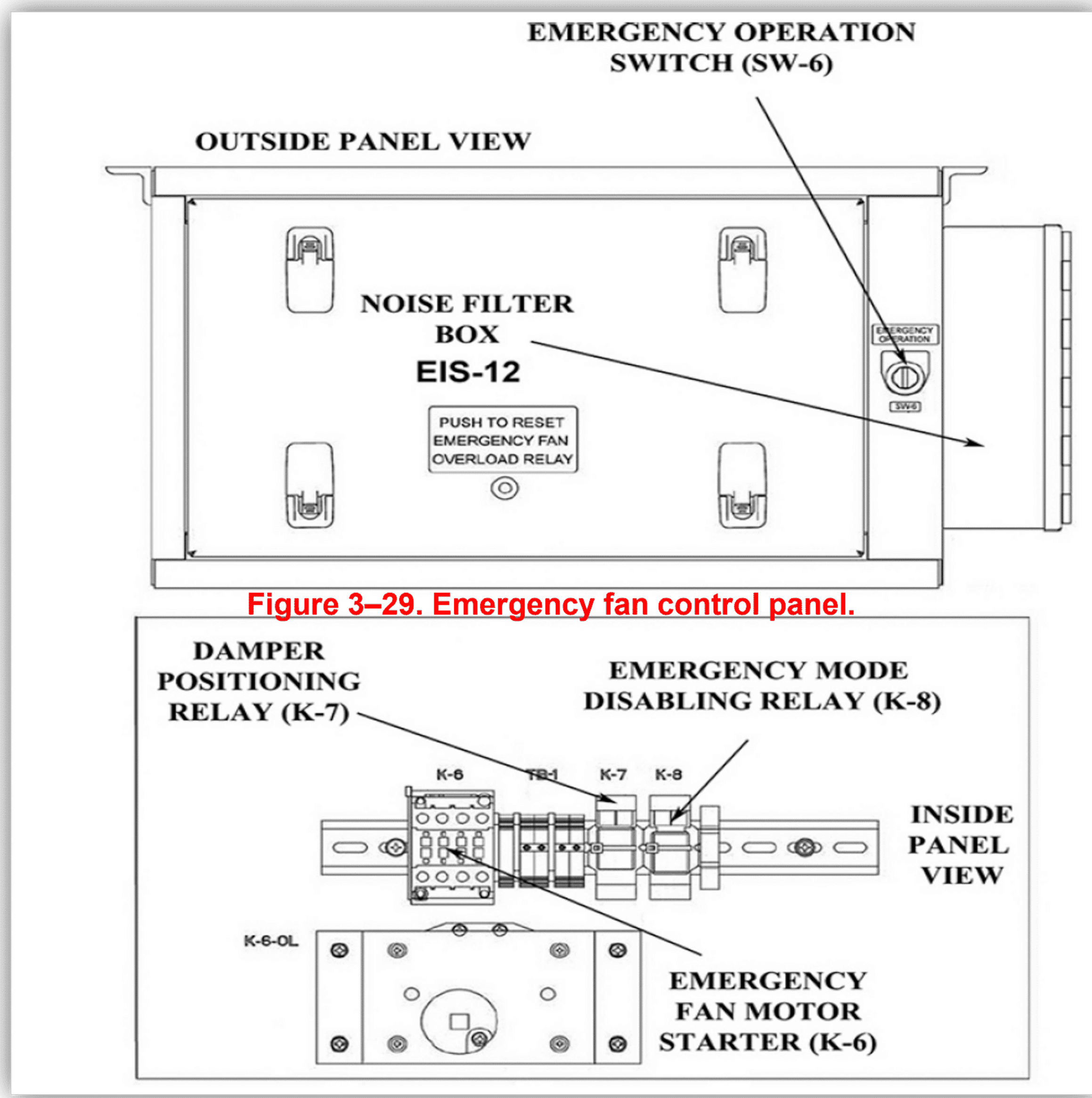
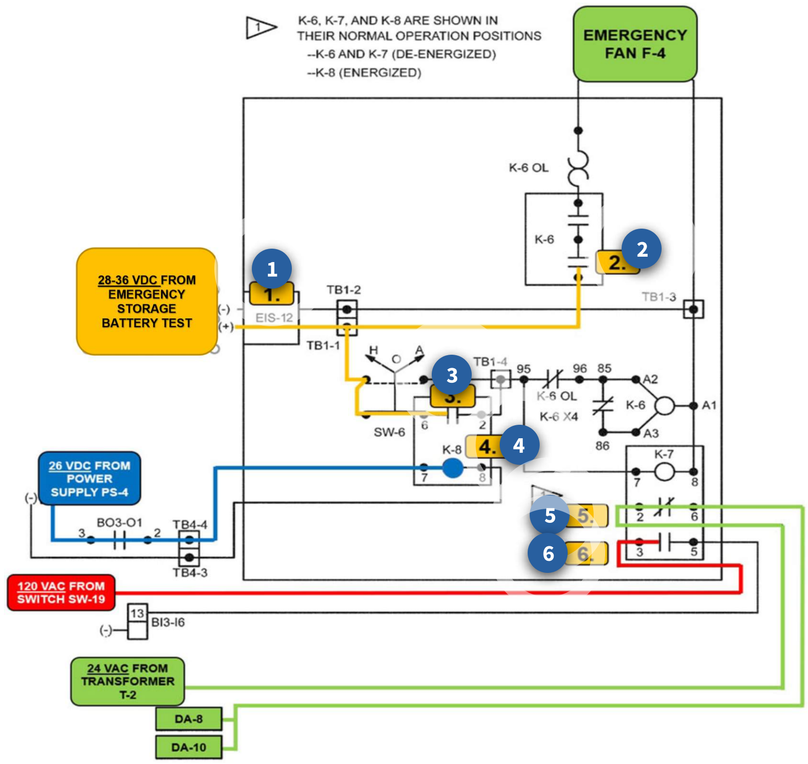


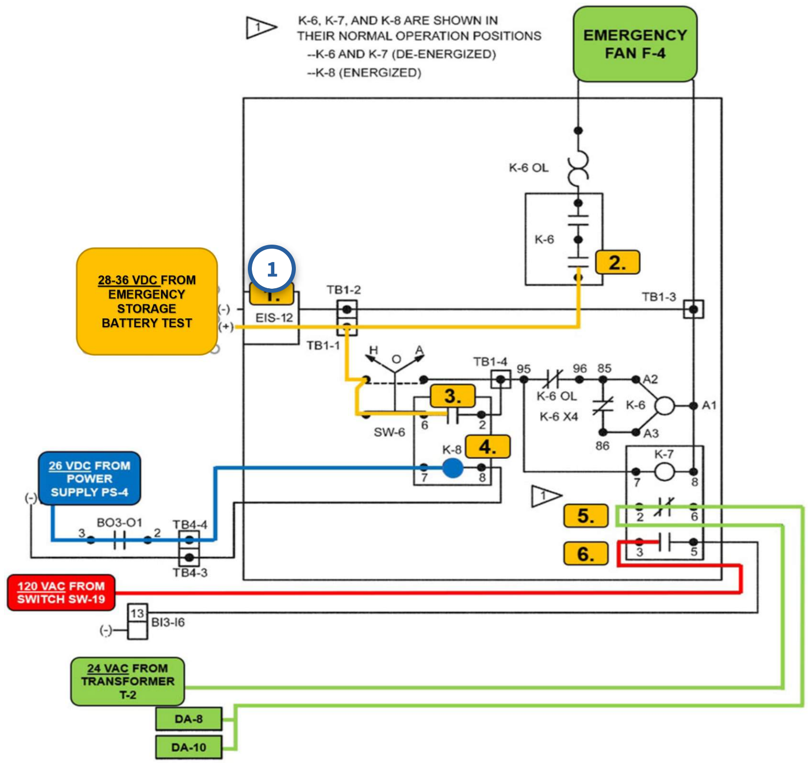
Figure 3–29. Emergency Fan Control Panel.

Power Sources and Devices

Follow along in figure 3–30 as we trace out power for this system, and keep in mind that this schematic has been simplified to enhance the learning process and is for training use only. The emergency ECS must be capable of running even when commercial and standby power are not available; therefore, emergency fan F-4 as well as the required components in the emergency fan control panel all run off 28-36 VDC power supplied by the emergency storage battery set in the LER.

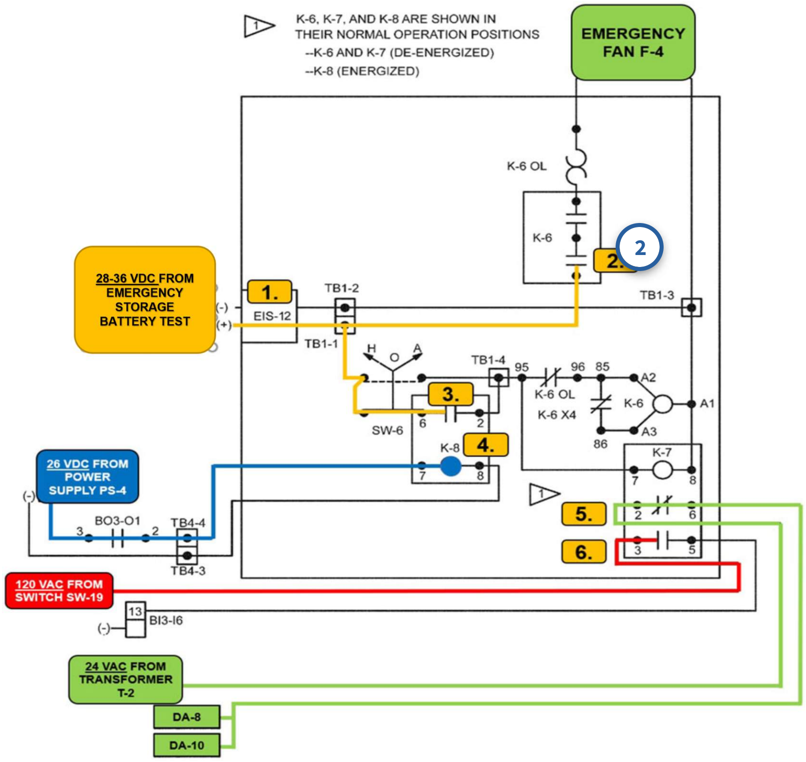
Click on each number in the procedural process to learn how to trace out the power of the system.


K-6, K-7, AND K-8 ARE SHOWN IN THEIR NORMAL OPERATION POSITIONS
--K-6 AND K-7 (DE-ENERGIZED)
--K-8 (ENERGIZED)
EMERGENCY FAN F-4
K-6 OL
K-6
28-36 VDC FROM EMERGENCY STORAGE BATTERY TEST
EIS-12
TB1-2
TB1-1
TB1-3
TB1-4
SW-6
K-8
K-6 X4
K-7
26 VDC FROM POWER SUPPLY PS-4
BO3-O1
TB4-4
TB4-3
120 VAC FROM SWITCH SW-19
BI3-I6
24 VAC FROM TRANSFORMER T-2
DA-8
DA-10



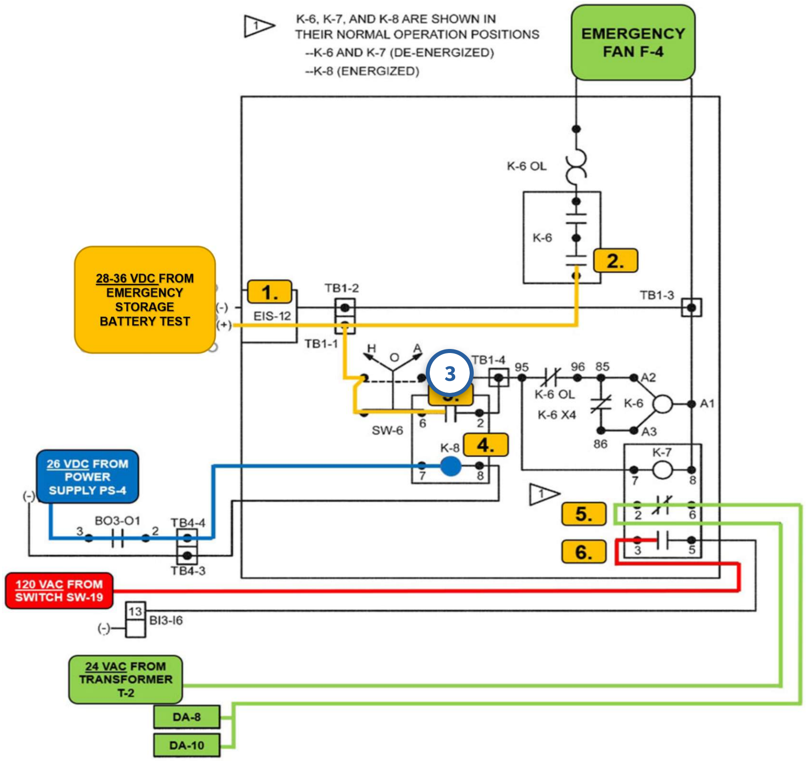
Step 1

28-36 VDC power enters the emergency fan control panel and passes through noise filterEIS-12.



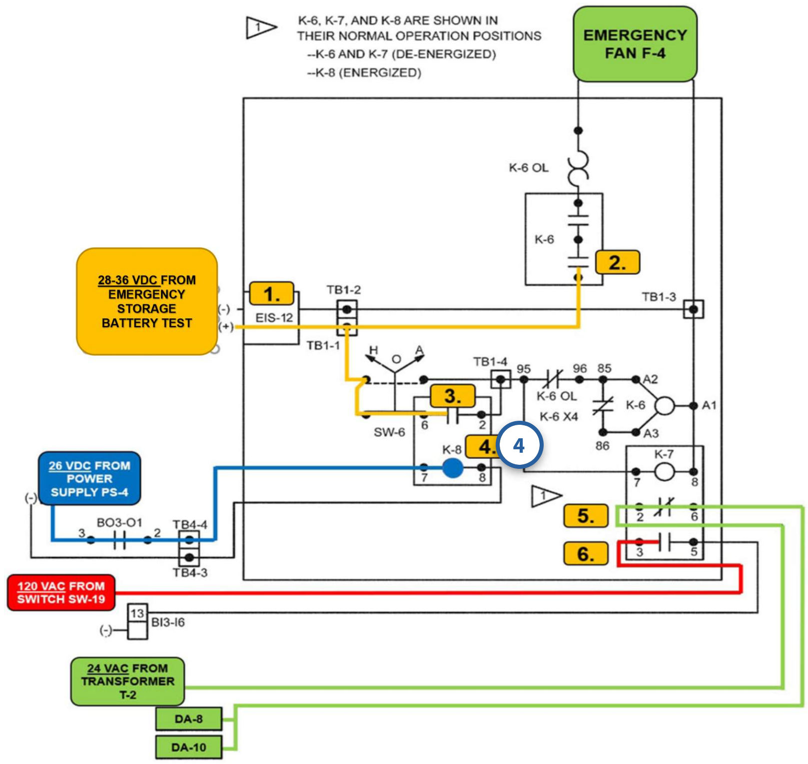
Step 2

28-36 VDC power flows through terminal board TB1-1 and waits on the main contacts of motor starter K-6.



Step 3

Power flows through terminal board TB1-1 and then through H-O-A switch SW-6 and waits on contact 6/2 of relay K-8.

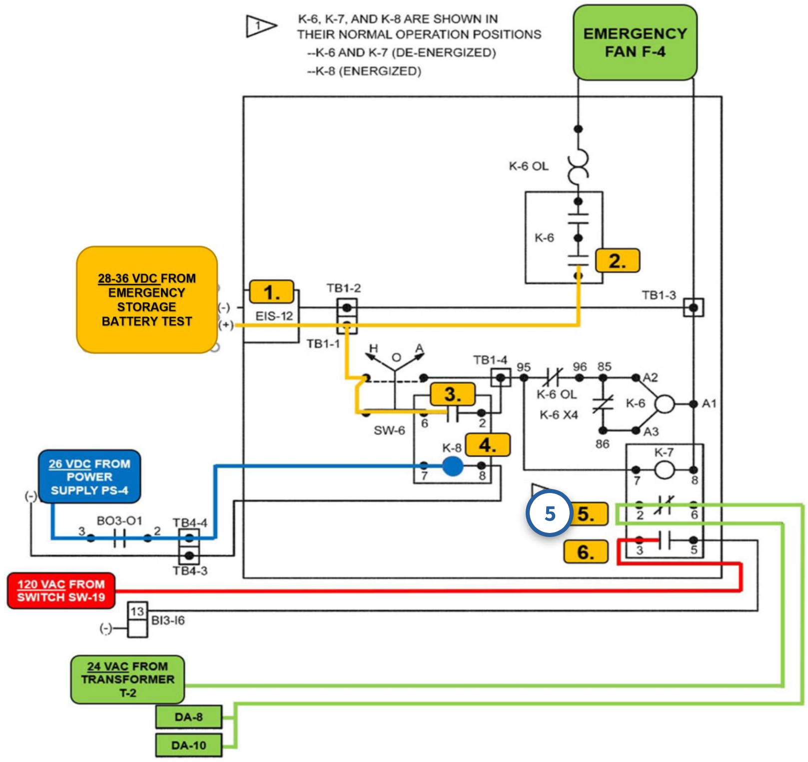


Step 4

24 VDC from power supply PS-4 flows through contacts 3/2 of binary output module BO3-O1 and energizes the coil of emergency mode disabling relay K-8. Note that the emergency fan will not run as long as the coil of relay K-8 is energized.

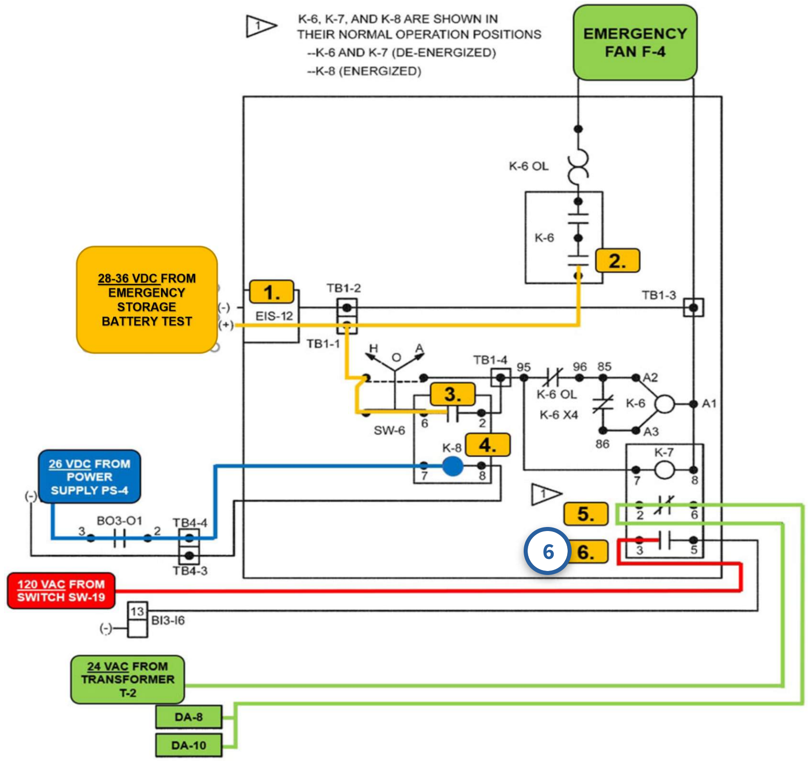
Emergency mode disabling relay K-8 is drawn in an energized state on the schematic, so don't be confused that the contact is drawn open. This is also annotated in flag note 1 at the top of the schematic.

Damper positioning relay K-7 does not receive power (de-energized) whenever normal ECS is operating.



Step 5

24 VAC from transformer T-2 flows through the normally-closed contacts 2/6 of relay K-7 to supply power to the normal and emergency isolation dampers DA-8 and DA-10, which keeps them in the proper position for normal ECS operation.



Step 6

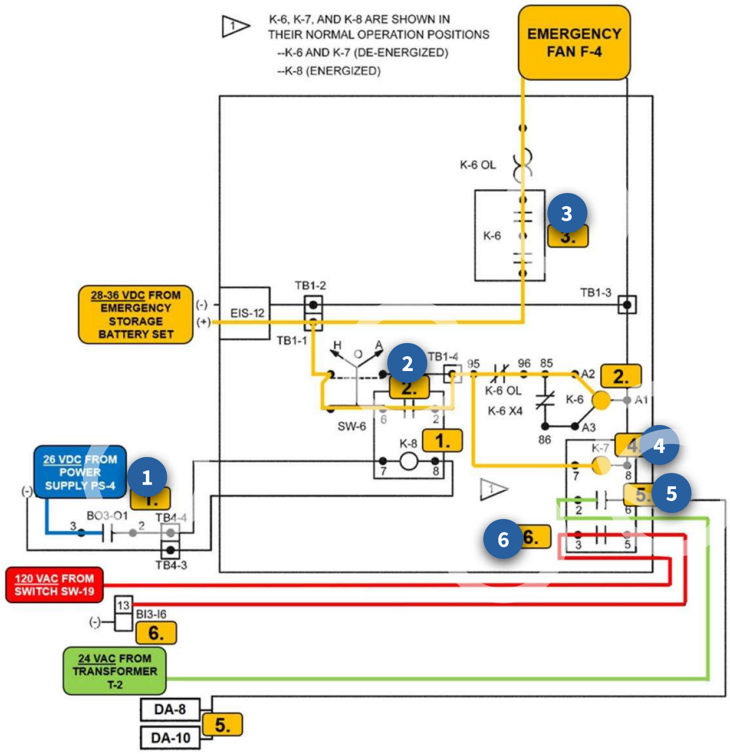
120 VAC from switch SW-19 waits on the normally-open contacts 3/5 of relay K-7.

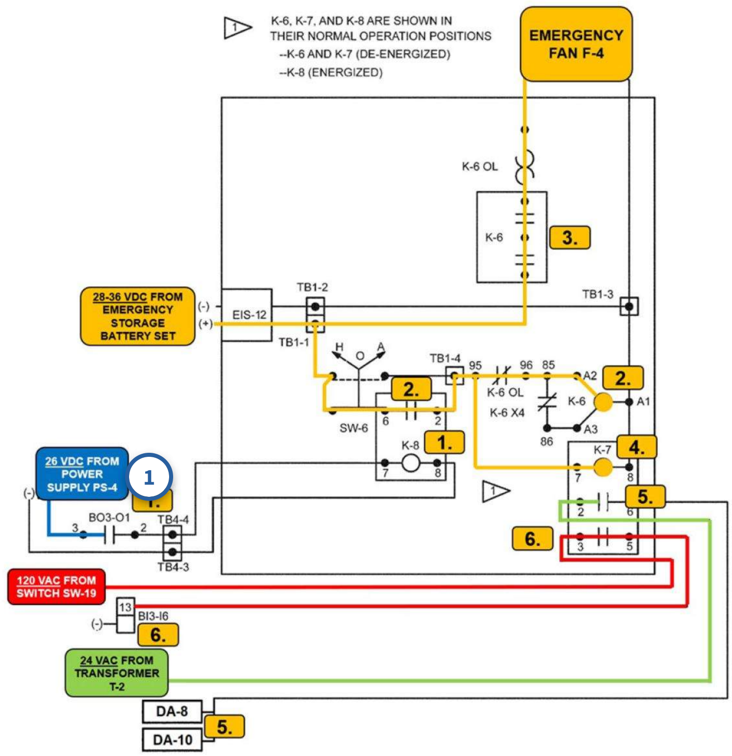
Dampers DA-8 and DA-10 remain in normal ECS position when powered, and internal springs return them to their emergency ECS positions when they are not receiving power. This is yet another fail-safe programmed into the system; when no primary power is available to the site, emergency fan F-4 starts and the springs inside of the isolation dampers return them to the emergency ECS position.

Complete the content above before moving on.

Transfer to Emergency ECS

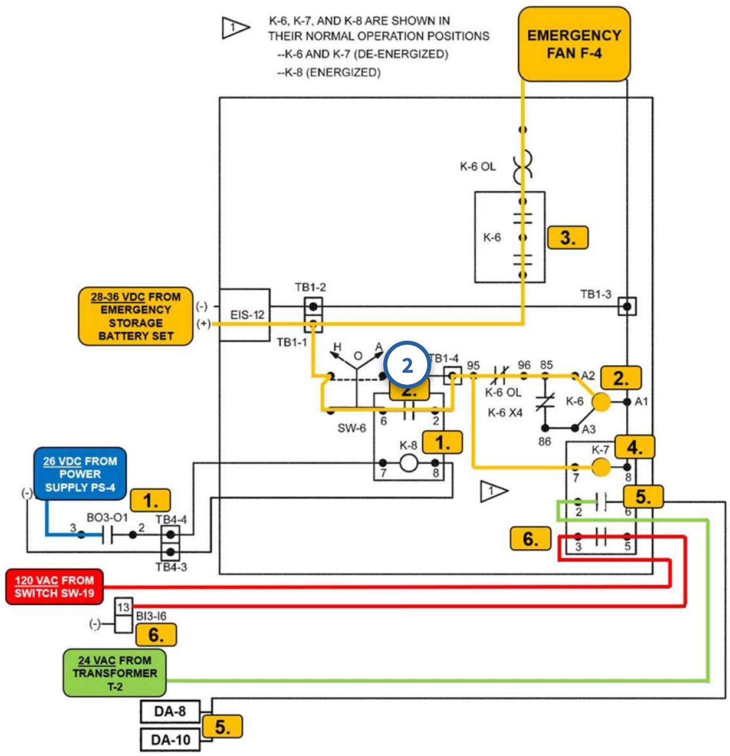
If primary power is lost, air handler unit AH-1 is not providing sufficient airflow, or if fiber-optic communications components fail, a transfer to emergency ECS will occur as long as emergency fan control panel H-O-A switch SW-6 is set to AUTO. Follow along on figure 3–31 to see how the site transitions to emergency ECS. Click on each number in the procedural process to learn how to transfer to the emergency ECS.





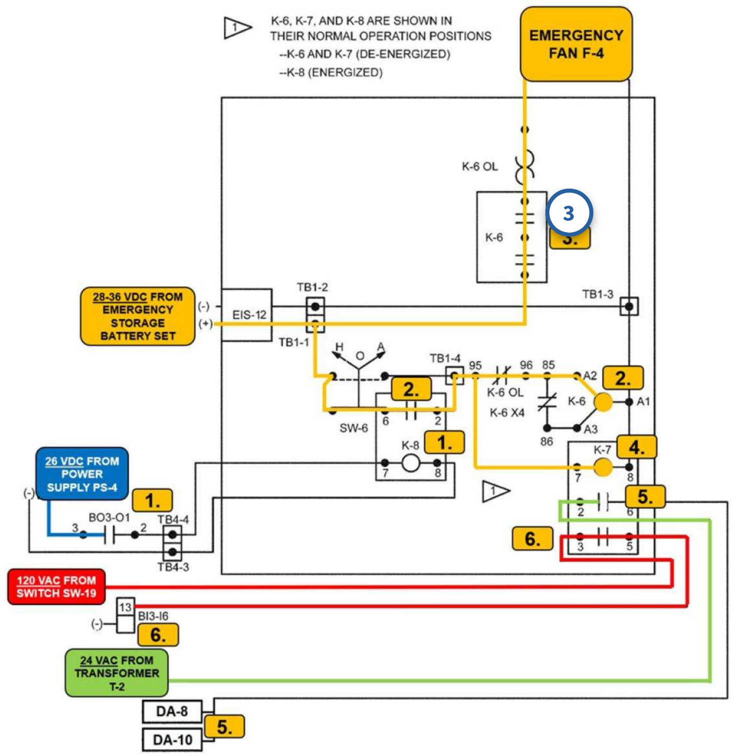
Item 1

The PLC will remove power from binary output BO3-O1, which will then remove power from the coil of emergency mode relay K-8.



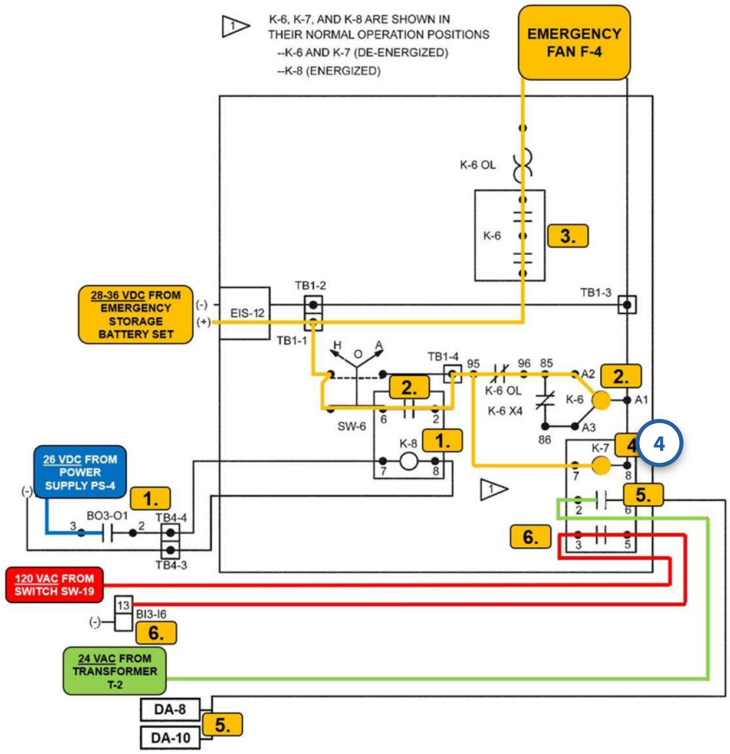
Item 2

Contacts 6/2 of relay K-8 will close to allow 28-36 VDC from the emergency storage battery set to flow to motor starter K-6.



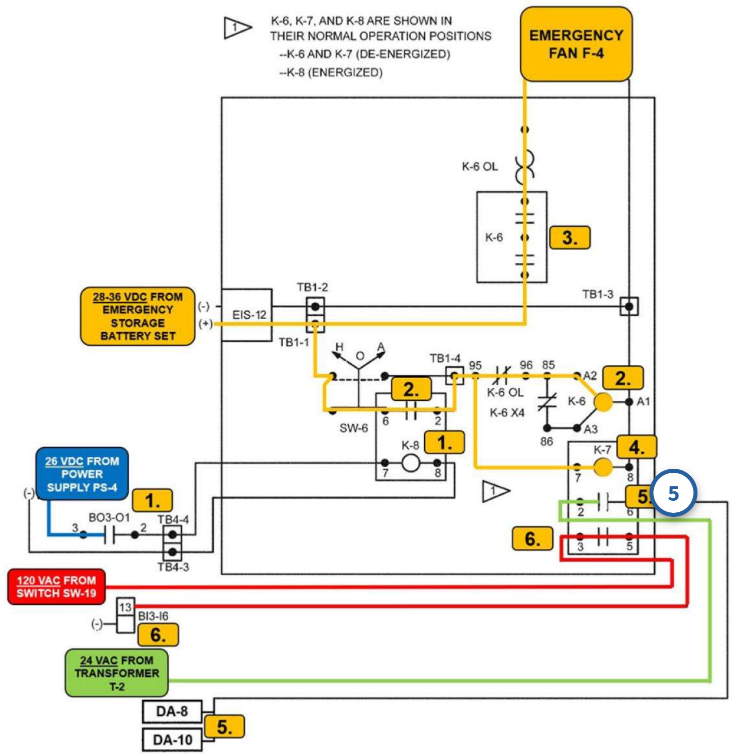
Item 3

The main contacts of motor starter K-6 close to allow 28-36 VDC to flow to emergency fanF-4.



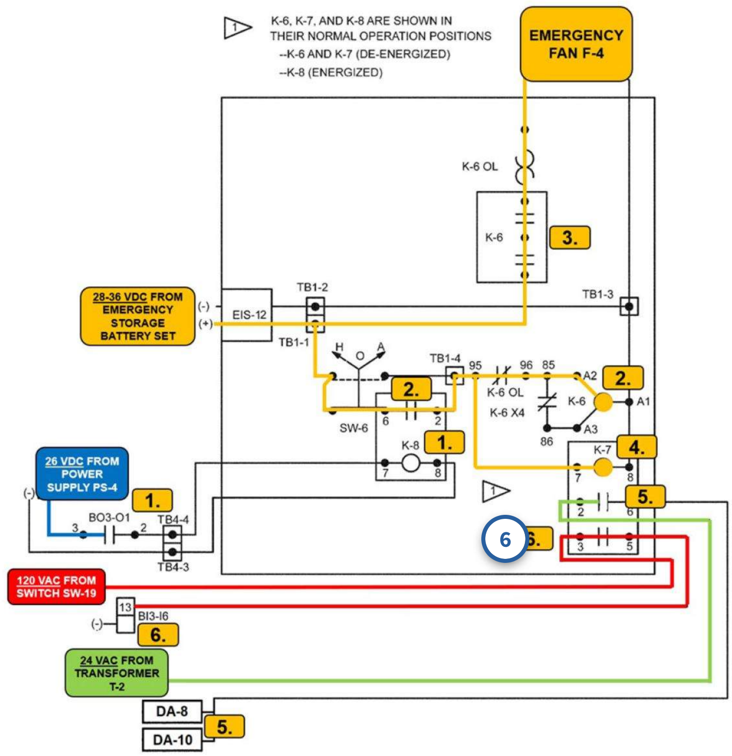
Item 4

28-36 VDC will also flow through to energize relay K-7.



Item 5

Normally-closed contacts 2/6 of relay K-7 will open to remove power from dampers DA-8 and DA-10, which will cause them to reposition to prepare for airflow from emergency fan F-4.



Item 6

Normally-open contacts 3/5 of relay K-7 will close to allow 120 VAC to flow to binary input BI3-I6 which will inform the PLC that the site is operating on emergency ECS.

Air handler unit AH-1 is now off and emergency fan F-4 is supplying cooling air to the electronic racks.

Setting emergency operation switch SW-6 on the emergency fan control panel will also cause the same actions to occur. This will allow 28-36 VDC from the emergency storage battery set to bypass relay K-8 and flow directly to motor starter K-6. When the PLC receives the 120 VAC input at binary input BI3-I6, it will shut down air handler unit AH-1.

This lesson focused on the operation of the emergency fan subsystem. While this system can be a bit confusing at first sight, you probably found it to be relatively simple after tracing the schematics. Knowing how to troubleshoot this system can prevent hours of frustration in the field.

Complete the content above before moving on.

Launch Tube Heater Subsystem Operation

The final major piece of the ECS that we will explore is the launch tube heater. As you learned in volume 2, all three booster stages of the Minuteman III missile use solid propellant, and this propellant will crack if it becomes too cold. This lesson will focus on the components of the launch tube heater system.

The purpose of the launch tube heater is to maintain the launch tube temperature between 60 and 80°F at all times. We will move through one more schematic as we explain the operation of components in the launch tube heater control panel and then conclude the lesson, and this unit, by exploring the ground maintenance response fault alarm that is associated with the launch tube heater system.

Components

Wing 1 Launch Tube Heater

Launch tube heater fan F-3 and the launch tube heater control panel are both located in the lower LER. Launch tube heater fan F-3 mounts on the side of the launch tube so it can pump ventilating air into the launch tube. The location of the launch tube heater control panel depends on the wing configuration; at Wing 1, the control panel is also mounted to the launch tube (fig 3–32) directly next to launch tube heater fan F-3.

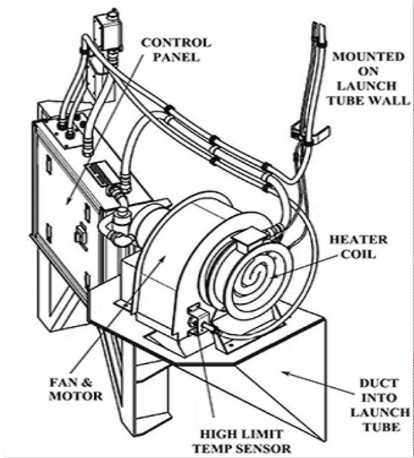
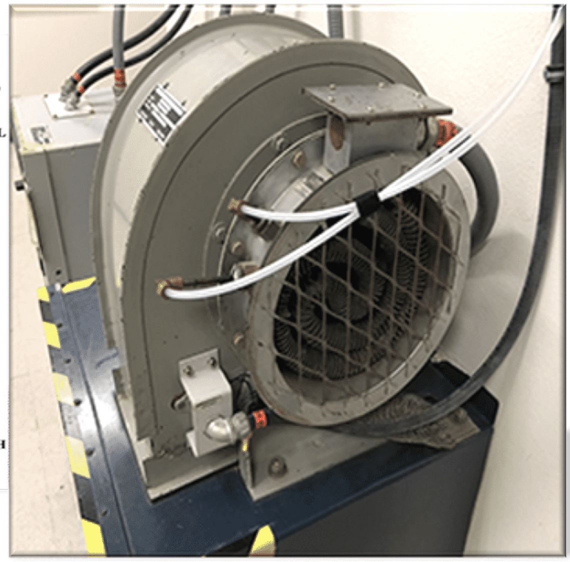


Figure 3–32. Wing 1 launch tube heater components



Components

Wings 3 and 5 Launch Tube Heater

At Wings 3 and 5, the control panel is mounted on the outer wall of the lower LER near the ladder (fig 3–33). Regardless of the wing configuration, the launch tube heater subsystem contains all of the following major components:

- Heating coil HT-2
- Launch tube heater fan F-3
- Pitot tubes PT-1 and PT-2 and launch tube heater airflow sensor PSR-3
- Launch tube air temperature sensor TSR-4

- Launch tube heater control panel

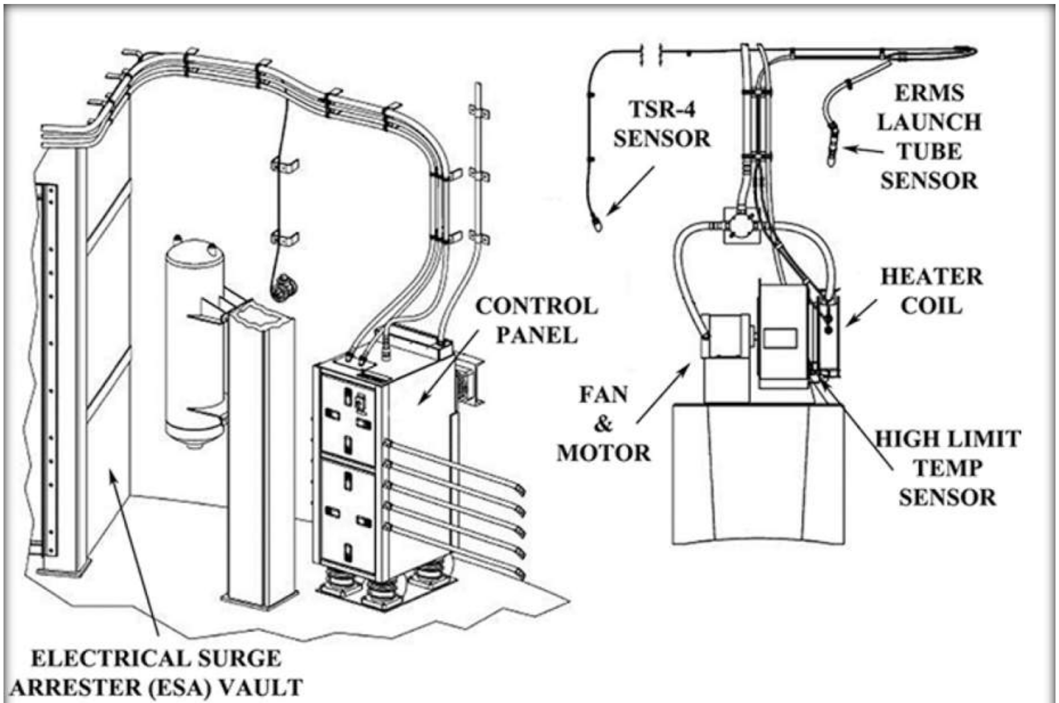


Figure 3–33. Wings 3 and 5 launch tube heater components.

Launch Tube Heater Subsystem

Heating Coil HT-2

Heating coil HT-2 utilizes two phases of power that converge to form a resistive element that generates heat.

Launch Tube Heater Subsystem

Launch Tube Heater Fan F-3

Launch tube heater fan F-3 pulls air in past heating coil HT-2 and into ductwork that runs to the bottom of the launch tube. The launch tube heater fan always runs when 120 VAC power is available; however, heating coil HT-2 only energizes to provide heat when necessary.

Launch Tube Heater Subsystem

Pitot Tubes PT-1 and PT-2, and Launch Tube Heater Airflow Sensor PSR-3

Pitot tubes PT-1 and PT-2 measure the amount of airflow provided by launch tube heater fan F-3. PT-1 is an "L" shaped pitot tube that points directly into the incoming airflow produced by launch tube heater fan F-3. PT-2 is a straight tube installed in the same area as PT-1 that senses static air pressure. Air pressure flows through past pitot tubes PT-1 and PT-2 and then through tubing to pressure sensing relay PSR-3. If airflow is high, PSR-3 will see a larger difference between the pressures on PT-1 and PT-2. If airflow is low, the difference sensed by PSR-3 will be smaller. PSR-3 takes the difference between the two pressures sensed at pitot tubes PT-1 and PT-2 and converts it into a 4-20 mA electrical signal that is then relayed to the PLC. The PLC will initiate a ground maintenance response GMR-28 fault alarm if airflow into the launch tube falls below a certain threshold.

Launch Tube Heater Subsystem

Launch Tube Air Temperature Sensor TSR-4

TSR-4 is responsible for sensing the air temperature of the launch tube, and attaches directly into the liner. Temperature data is sent through fiber-optic signal conditioner FSC-2 and then to the PLC. The

PLC uses the data from TSR-4 to control when heater coil HT-2 will be energized and also when to initiate a ground maintenance response GMR-28 fault alarm for high or low launch tube temperature.

Launch Tube Heater Subsystem

Launch Tube Heater Control Panel

The launch tube heater control panel (fig 3–34) houses launch tube heater power switch SW-5, launch tube heater coil starter K-5, launch tube heater fan motor starter K-26, and the wiring and terminal board necessary for launch tube heater operation. Note that launch tube heater power switch SW-5 on the front of the panel mechanically engages with the electrical portion of SW-5 inside of the panel. You cannot remove the panel front cover unless switch SW-5 is set to the OFF position.

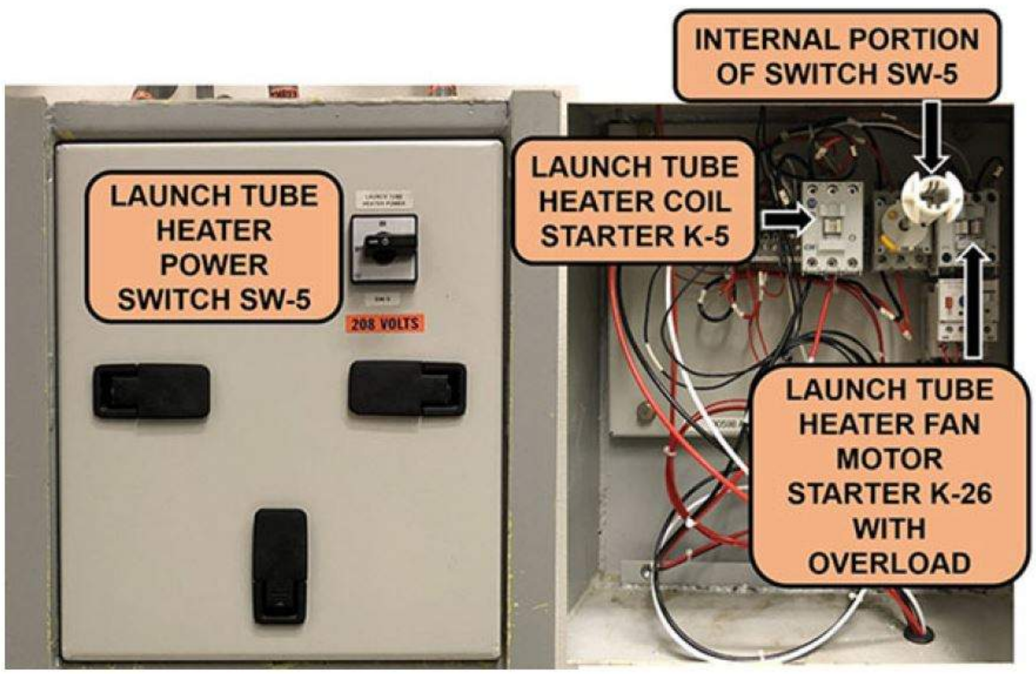
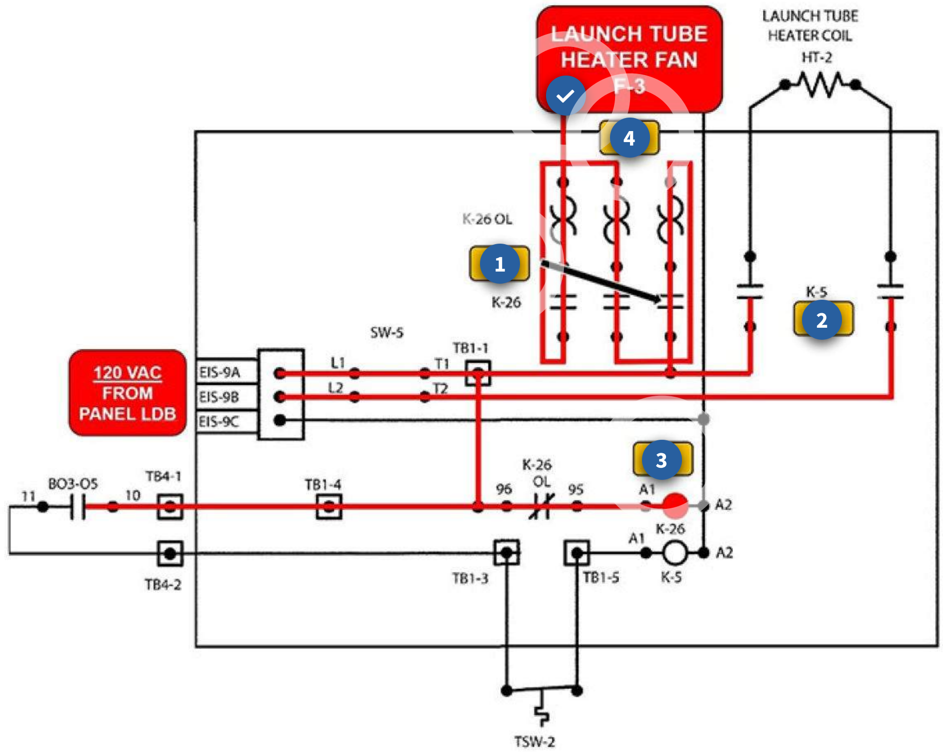
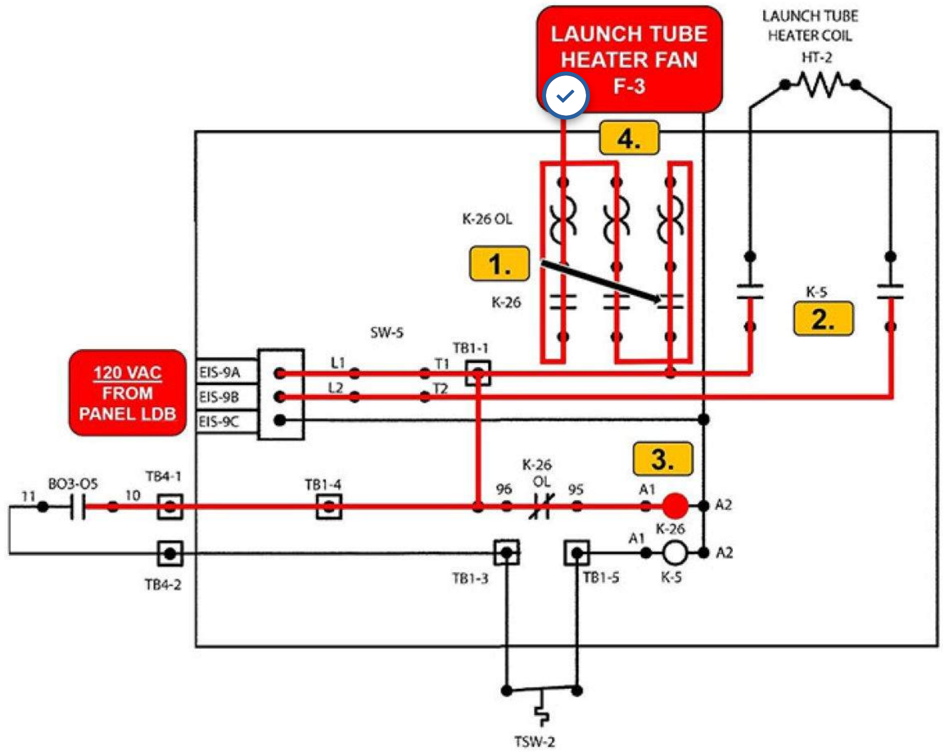


Figure 3–34. Wings 3 and 5 launch tube heater control panel.

Click here to move forward in the lesson.



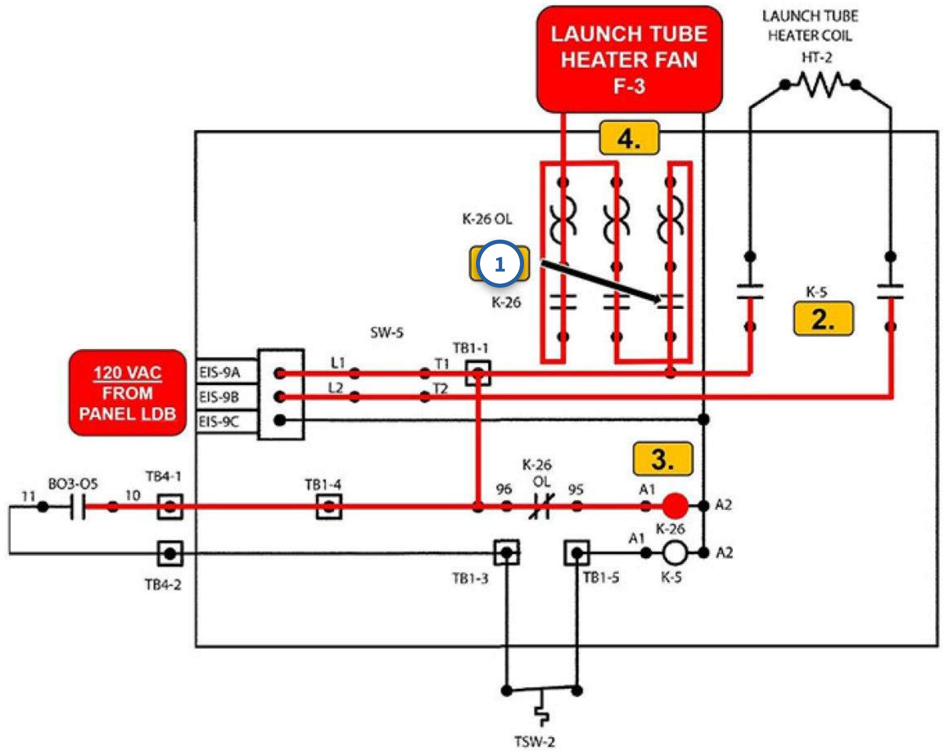


Launch Tube Heater Control Panel Operation

Use figure 3–35 to follow along as we go through the operation of the launch tube heater controls.

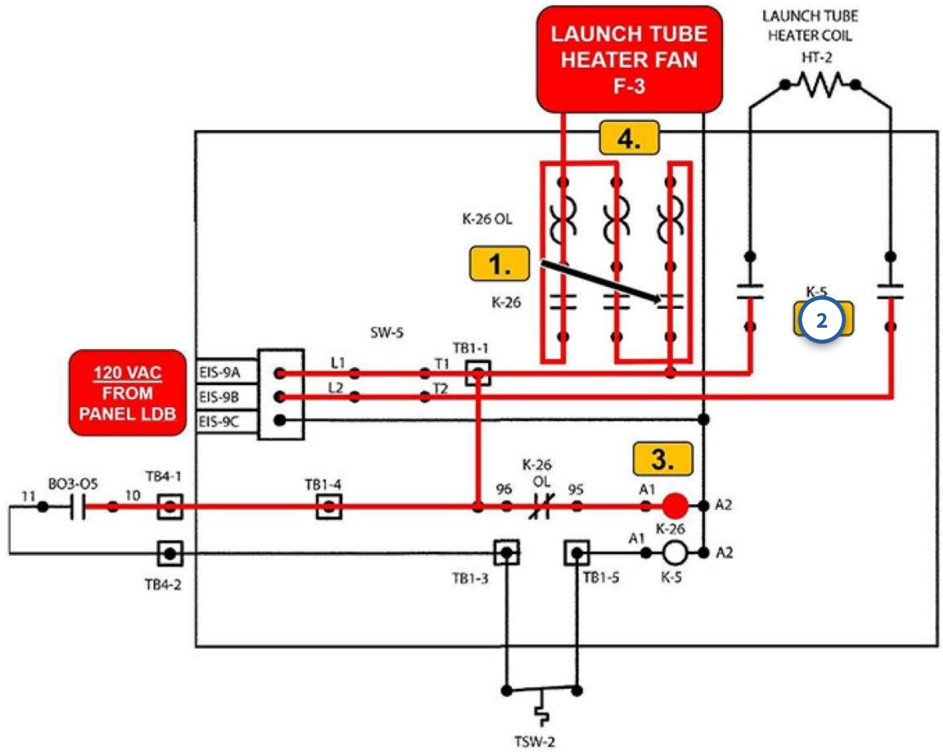
Power Sources and Devices

The launch tube heater control panel receives 120/208 VAC, two-phase power from the launcher distribution panel. Power will flow from the circuit breaker and through launch tube heater power switch SW-5.



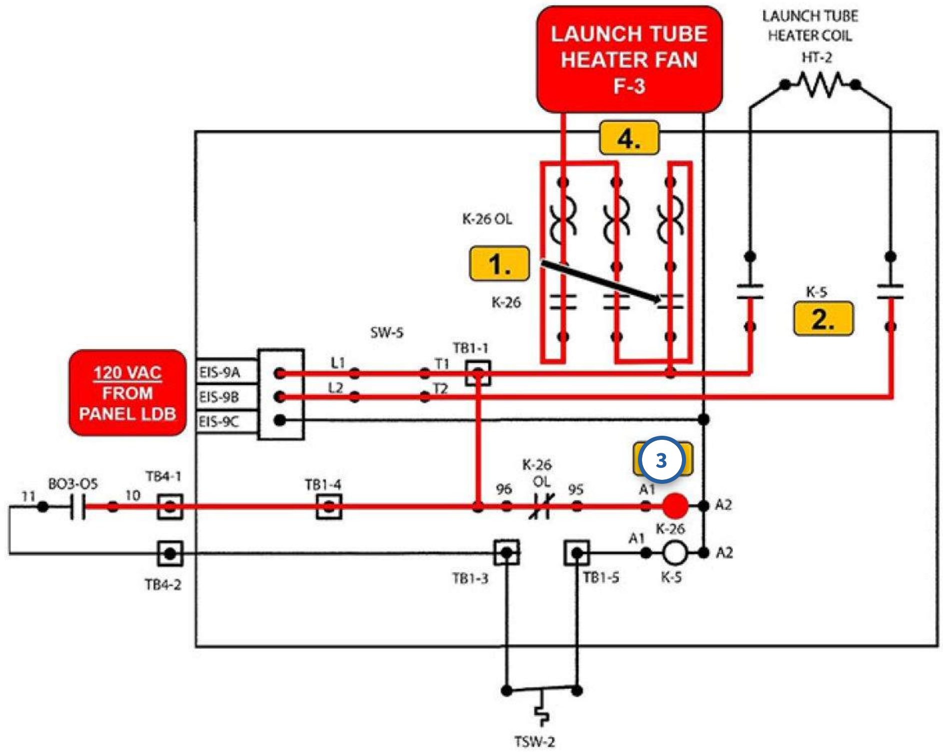
At terminal board TB1-1, power will branch off in different directions:

120 VAC will wait on the first contact of K-26.



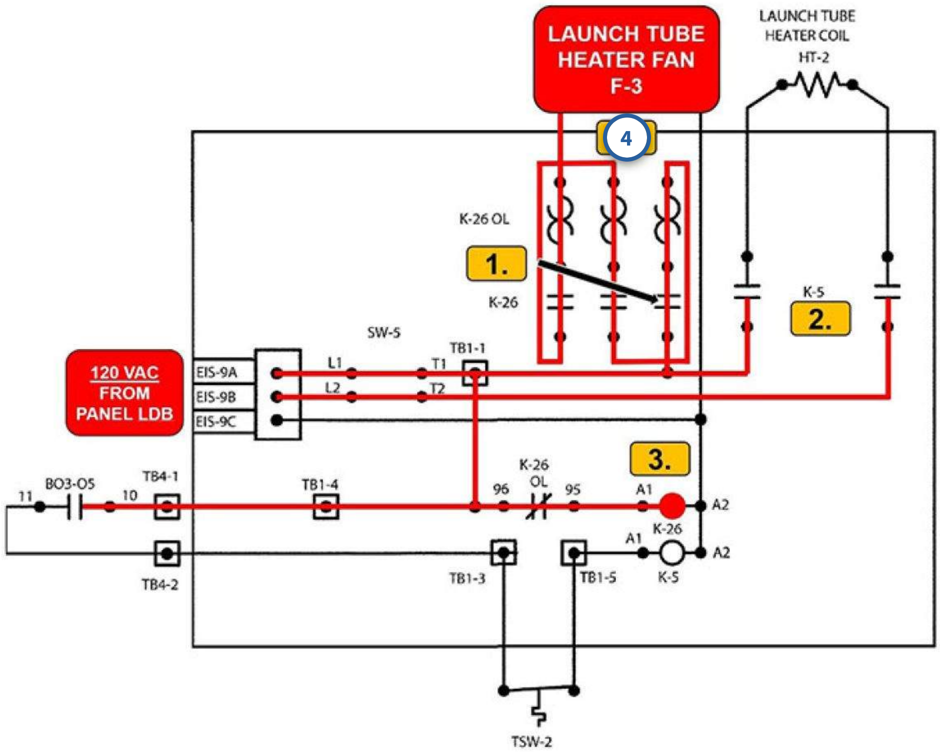
At terminal board TB1-1, power will branch off in different directions:

120 VAC will wait on the contacts for launch tube heater coil starter relay K-5.



At terminal board TB1-1, power will branch off in different directions:

120 VAC will travel through K-26 overloads and energize the coil of launch tube heater fan motor starter K-26.



At terminal board TB1-1, power will branch off in different directions:

The main contacts of motor starter K-26 close when its coil receives power. Notice that this is a single phase of power that winds its way through all three overloads and all three sets of contacts.

Click on each number before moving forward in the lesson.

Launch Tube Heater Control Panel Operation

You can see that the launch tube heater fan motor will run continuously as long as 120 VAC is flowing into the panel, but remember that launch tube heater coil HT-2 is not always energized. The system is now operating, but what conditions will cause heater coil HT-2 to energize?

Before we discuss this, it is important for you to know that there are situations when the PLC will not energize heater coil HT-2 even when the launch tube temperature is too cold:

- Emergency ECS is operating. Heater coil HT-2 should not operate when the emergency ECSis operating. We do not want to add any additional heat to the LER when ambient air is the only available medium for cooling the electronic racks. The system is already malfunctioning, and adding heat will result in the electronics racks needing to be shut down sooner than necessary.

- Air temperature to the racks is greater than 60°F. Again, we do not want to add additional heat to the LER if the ECS is already having trouble providing cooling air.

- Launch tube heater airflow is below 0.15 inwg. Heater coil HT-2 should not be energized if there is no air moving across it, and a lack of airflow could cause the coil to overheat.

- Refrigerant compressor RC-1 is not operating. Heat is not being removed from the brine if there is no refrigerant flowing, which means that air is not being cooled when it flows through air handler unit AH-1. Energizing launch tube heater coil HT-2 will only add unnecessary heat to the LER, which is undesirable when the ECS is already malfunctioning.

Click here to learn about the launch tube heater control.

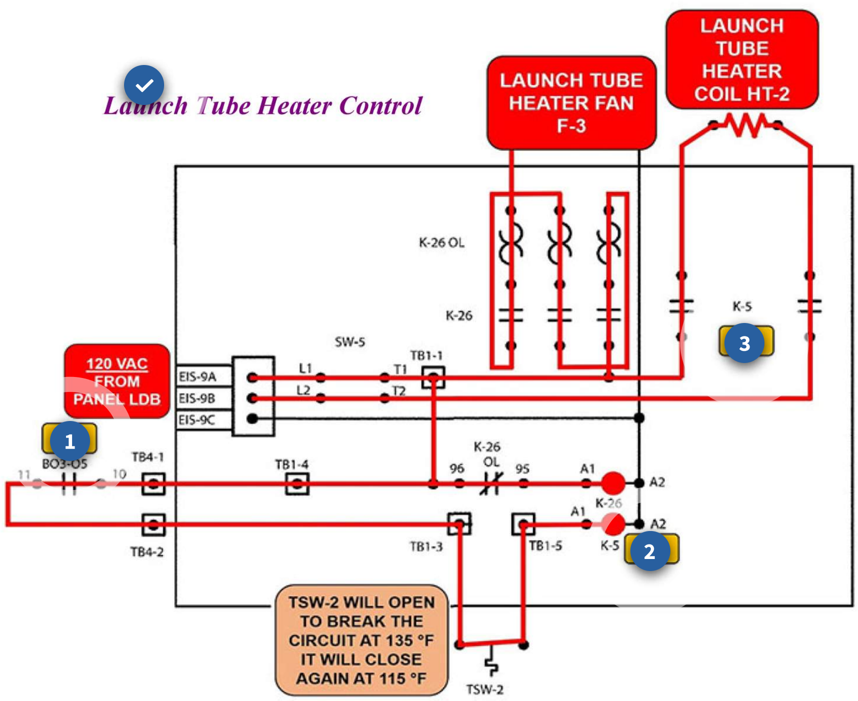


Figure 3–36. Launch tube heater starting on schematic.

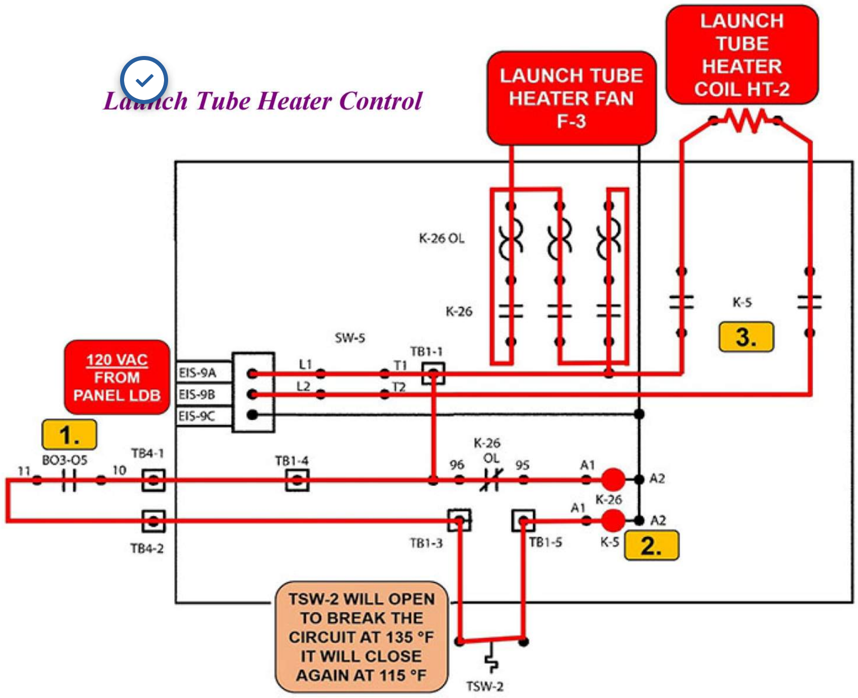


Figure 3–36. Launch tube heater starting on schematic.

Launch Tube Heater Control

In the following scenario we will assume that the LF is operating on normal ECS, and that the launch tube heater fan is producing sufficient airflow. The PLC attempts to maintain an ideal launch tube temperature of 67.5°F, plus or minus 1°F as sensed by temperature sensor TSR-4.

Follow along in figure 3–36 as we examine what causes launch tube heater coil HT-2 to energize.

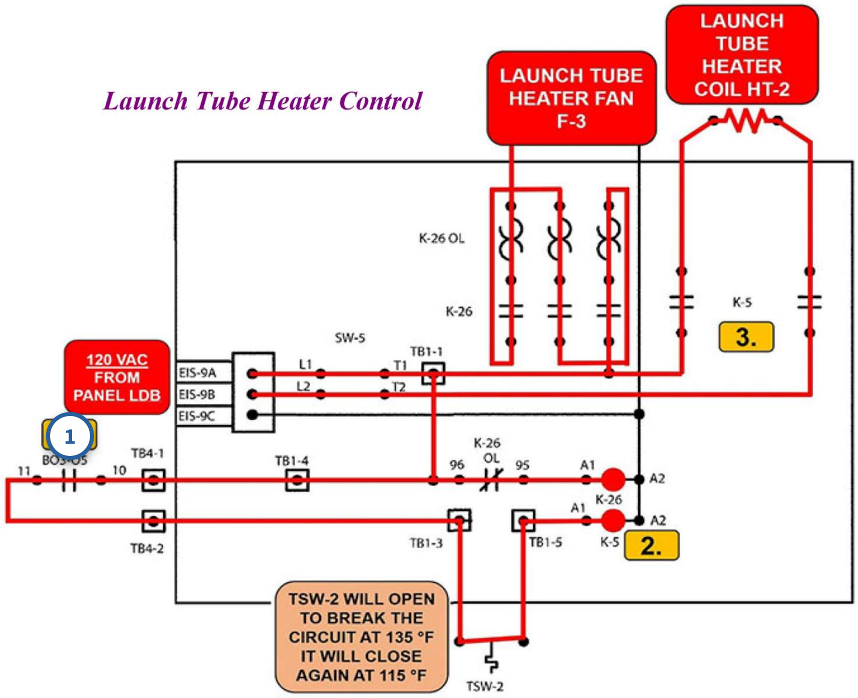


Figure 3–36. Launch tube heater starting on schematic.

If the launch tube temperature falls below 66.5°F, the PLC will initiate a 1-minute timer. If the launch tube temperature is still below 66.5°F after this 1-minute timer elapses, the PLC will energize binary output BO3-05 in the air handler control panel which will allow 120 VAC to flow to launch tube heater coil high temperature limit switch TSW-2.

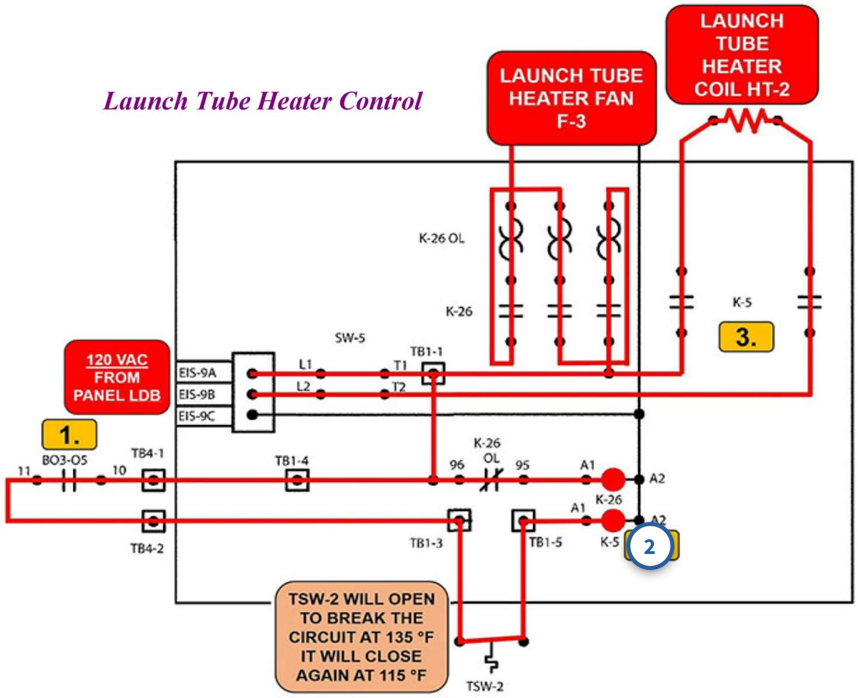


Figure 3–36. Launch tube heater starting on schematic.

If TSW-2 is closed, power will travel to the coil of launch tube heater coil starter relay K-5.

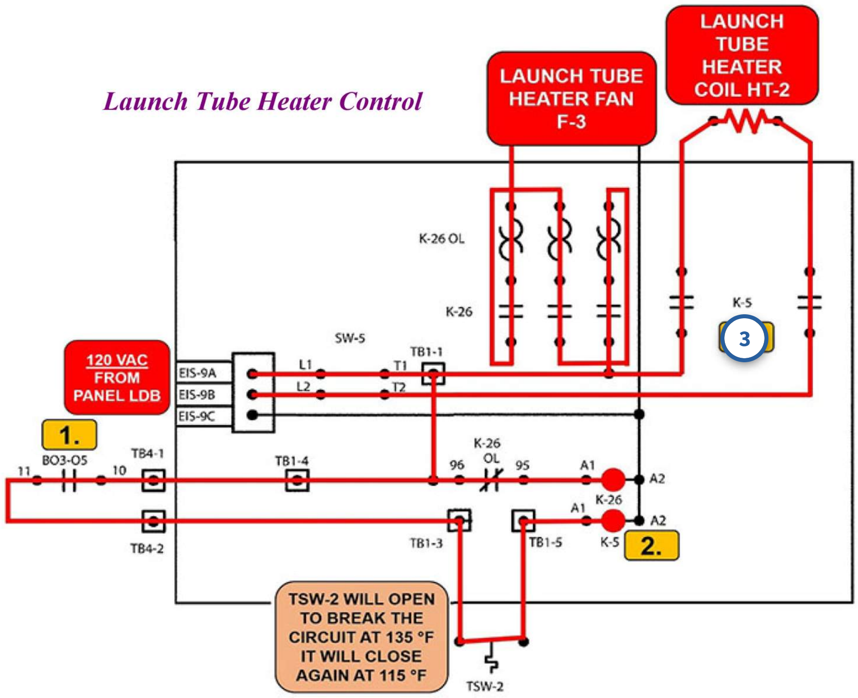


Figure 3–36. Launch tube heater starting on schematic.

When launch tube heater coil starter relay K-5 energizes, its two contacts will close to allow two phases 120 VAC to energize heater coil HT-2.

Once the temperature in the launch tube reaches 68.5°F, the PLC will remove power from BO3-05 which will in turn remove power from the coil of launch tube heater coil starter relay K-5. When K-5 de-energizes, heater coil HT-2 shuts off.

Temperature switch TSW-2 is a hardware interlock in the heater start circuit—it will open if the temperature of heater coil HT-2 exceeds 135°F. This is another failsafe in the system that is designed to keep heater coil HT-2 from overheating. TSW-2 will close again when the temperature falls below 115°F.

Complete the content above before moving on.

Alarms

The only fault alarm associated with the launch tube heater is ground maintenance response GMR-28. The controls and sensors for the alarm are in the air handler unit AH-1 control panel, and you already know that temperature sensor TSR-4 is installed in the launch tube liner. A ground maintenance response GMR-28 fault alarm reports to the LCC at the MAF if either of the following two conditions are met:

- The launch tube temperature falls below 60°F for more than 15 seconds or exceeds 80°F for more than 15 seconds.
- Airflow into the launch tube is less than 0.15 inwg for more than 15 seconds.

Temperature

Launch tube air temperature sensor TSR-4—the same temperature sensor that tells the PLC whether or not launch tube heater coil HT-2 needs to operate—also initiates an alarm if the launch tube temperature is too high or too low.

If the temperature is below 60°F for more than 15 seconds, the PLC removes power from binary output BO3-04 in the ground maintenance response GMR-28 fault alarm circuit, which will cause a GMR-28 fault alarm to report from the air handler unit AH-1 control panel. The ground maintenance response GMR-28 fault alarm will cease to report when the launch tube temperature rises above 61°F.

The same actions will occur if the launch tube temperature exceeds 80°F, and the ground maintenance response GMR-28 fault alarm resets when the temperature falls below 79°F.

Airflow

If launch tube heater airflow sensor PSR-3 senses an airflow below 0.15 inwg for more than 15 seconds, the PLC will de-energize binary output BO3-O4 in the air handler unit AH-1 control panel in order to initiate a ground maintenance response GMR-28 fault alarm. The ground maintenance response GMR-28 will cease to report when airflow rises above 0.20 inwg.

Launch Tube Heater Wiring Diagram

Up to this point you have been tracing the schematics in the figures while you read the text. This is an excellent point in the unit to show you how to interpret a wiring diagram (fig 3–37). What is the difference between a schematic and a wiring diagram anyway? A wiring diagram differs from a schematic because it shows you the actual numbers, gauges (thickness of the conductor), and colors of the wires that are used within the panel. For example, if you were tasked with replacing a charred wire in a panel, the wiring diagram would tell you the color and gauge of the replacement wire, as well as the number that you should mark. If you were to rely on a schematic in this situation, you would have no idea as to what color, gauge, or wire number you were supposed to use.

The wiring list at the top left of figure 3–37 is abridged, but most wiring diagrams will have complete lists of every wire in the panel. For now, though, you can see that wire #14 is supposed to be a red 18-gauge wire that runs from terminal board 1 pin 1 to the overload of K-26 motor starter K-26-OL pin 96. Wiring diagrams are straight to the point tools that show exact pin-to-pin configurations, and they are also another excellent tool that you can use to troubleshoot electrical faults. Believe it or not, one of these wiring diagrams exist for nearly every panel and junction box on the entire MAF or LF, and you should use them to your advantage.

This lesson focused on the components of the launch tube heating system, explained control panel operation and ground maintenance response fault alarms, and closed out with a step-by-step explanation of how to use a wiring diagram.

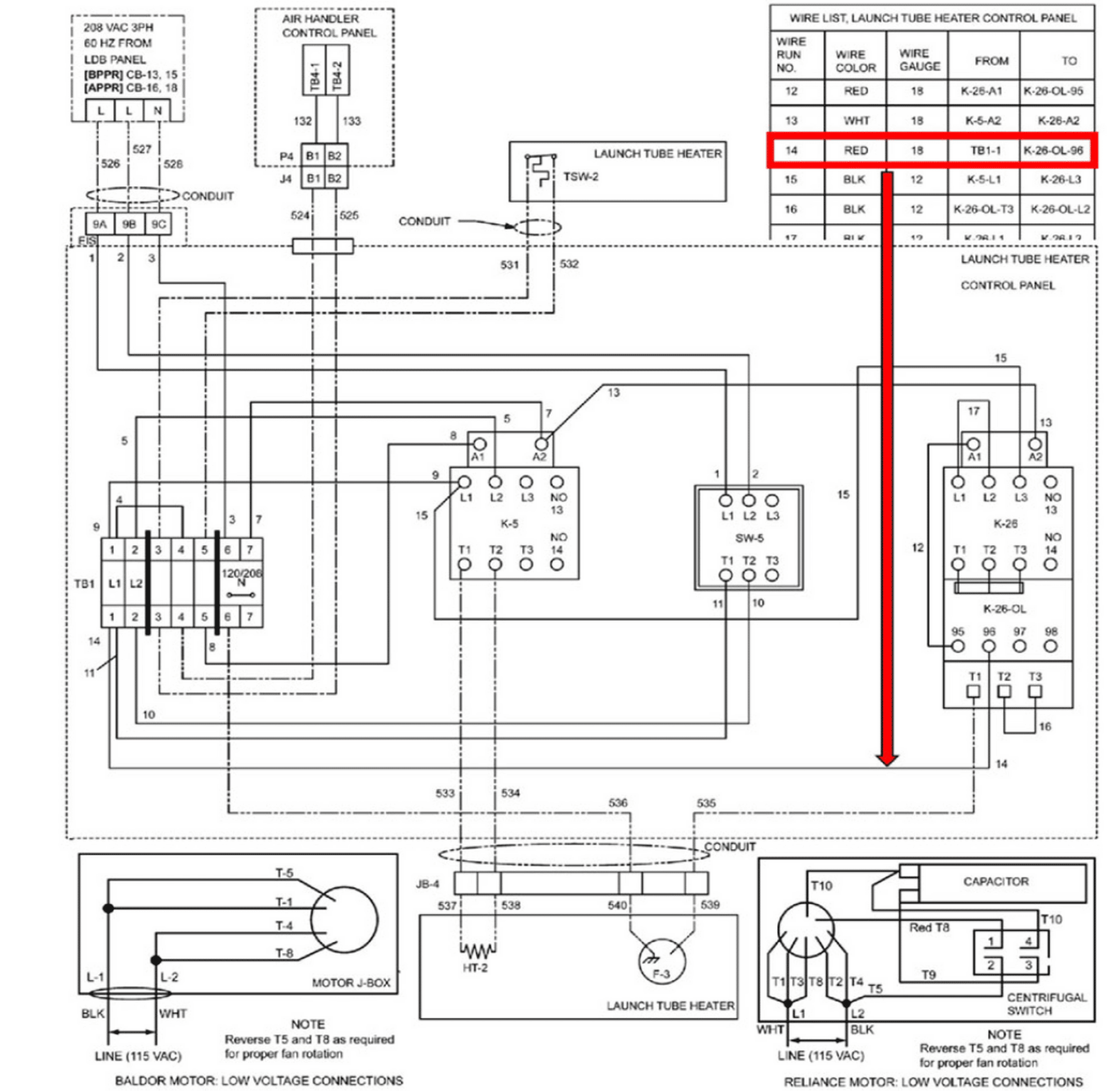
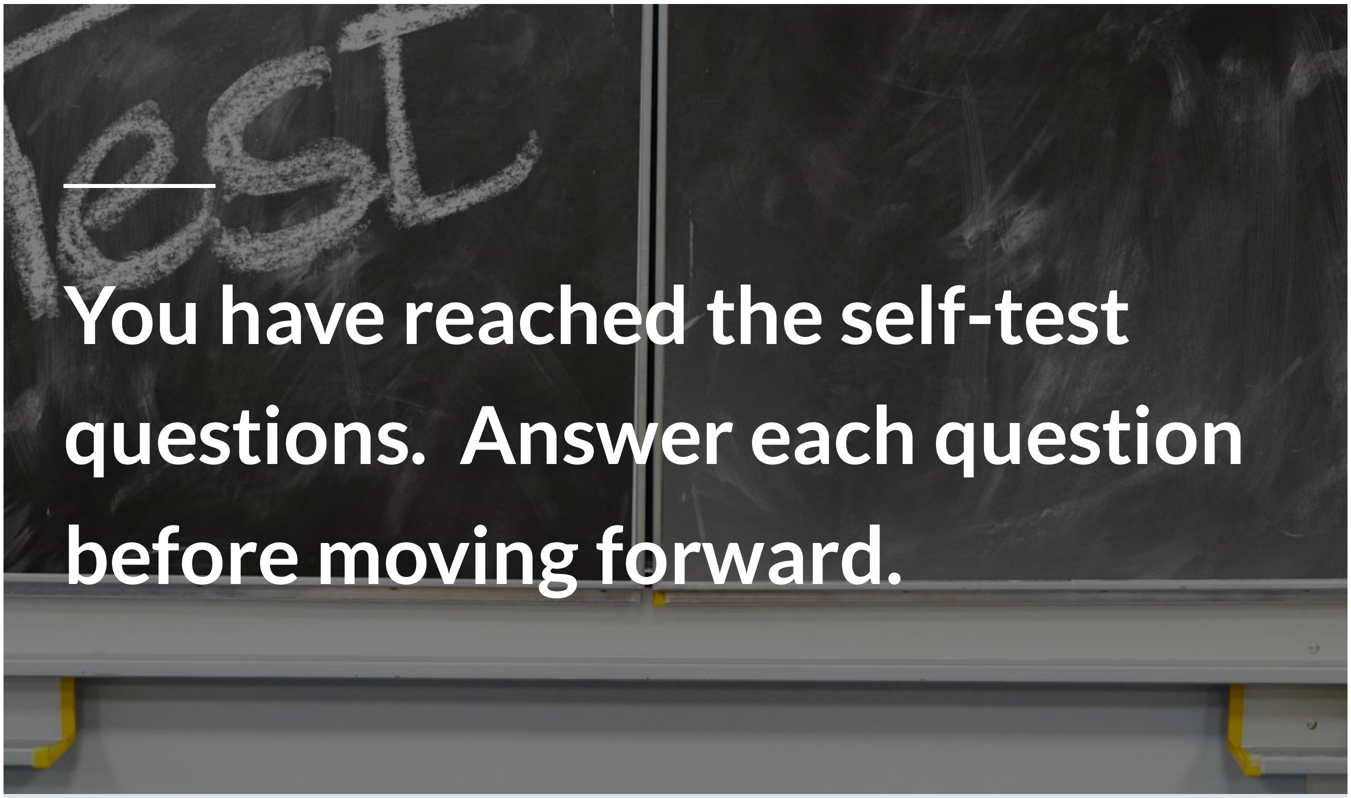


Figure 3–37. Launch tube heater control panel wiring diagram.

Figure 3–37. Launch Tube Heater Control Panel Wiring Diagram.



You have reached the self-test questions. Answer each question before moving forward.

KNOWLEDGE CHECK TIME!

For the fill-in the blank questions, you will need to add (.) period to the end of the sentences.

Click here to answer the self-test questions pertaining to the air handler subsystem operation.

1. Why will the failure of air handler fan K-4 auxiliary contactor X1 to close prevent brine chiller startup?

Type your answer here

SUBMIT

2. Why is the combustible gas detector GD-1 mounted in a very high location in the launcher equipment room?

Type your answer here

SUBMIT

3. What does an output signal of 8 mA or greater from combustible gas detector GD-1 indicate?

Type your answer here

SUBMIT

4. List the four conditions that will cause a ground maintenance response GMR-26 fault alarm.

Type your answer here

SUBMIT

5. What condition causes a ground maintenance response GMR-27 fault alarm to report to the launch control center?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the emergency fan subsystem operation.

1. Where is emergency fan F-4 located?

Type your answer here

SUBMIT

2. Why is emergency fan F-4 powered by the emergency storage batteries?

Type your answer here

SUBMIT

3. Explain how emergency fan F-4 and isolation dampers D-8 and D-10 react when primary power is lost.

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the launch tube heater subsystem operation.

1. Explain how launch tube heater heating coil HT-2 operates.

Type your answer here

SUBMIT

2. What conditions will cause the launch tube heater coil HT-2 to not energize, regardless of the actual temperature in the launch tube?

Type your answer here

SUBMIT

3. At what temperature does the programmable logic controller attempt to maintain the launch tube?

Type your answer here

SUBMIT

4. At what temperature does launch tube heater coil high temperature limit switch TSW-2 open?

- 130°F.
- 135°F.
- 140°F.
- 145°F.

SUBMIT

5. What amount of airflow through the launch tube heater initiates a ground maintenance response GMR-28 fault alarm?

Type your answer here

SUBMIT

This completes Lesson 3. You can find the answers to the self-test questions in the Module 4 table of contents.

Lesson 4. Missile Alert Facility Environmental Control System

MAIN POINTS

1. Launch Control Equipment Building and Support Building Operation
    a. Brine subsystem familiarization
    b. Brine chiller control panel familiarization
    c. Ventilating air subsystem function and operation
    d. Air handler subsystem familiarization
2. Launch Control Center Operation
    a. Emergency cooling unit familiarization
    b. Environmental control system alarms
    c. Oxygen regeneration unit familiarization

One missile alert facility (MAF) watches over the 10 launch facilities (LF) in its flight. Because of the simple fact that there are not as many

MAFs, you may not have as much “hands on” time with the equipment at the MAF as you will with the equipment at the LF. Most of what you know about the MAF will be gained through studying your technical order (TO) and civil engineering manuals (CEM), talking with other experienced technicians, and the information provided in this unit.

This unit will provide familiarization for many of the environmental control systems (ECS) at the MAF, to include in-depth functions and operation of the ventilating air subsystem, controls, and alarms. There are many similarities between the ECS components at the MAF and LF; the panels are filled with the same types of modules and fiber-optic communication equipment. This unit will focus mainly on familiarizing you with the differences in physical arrangement between the components at the MAF and those at the LF.

The northwest corner of the Oscar-1 Minuteman Missile Alert Facility on Whiteman Air Force Base, Missouri, June 18, 2020. The O-1 MAF was constructed in 1963 and determined to be eligible for the National Register of Historic Places (NRHP) by Missouri SHPO in 1998. The facility consists of a one-story surface structure, assembled as a Launch Control Support Building (LCSB), and two sub-surface, re-enforced concrete encapsulated steel pods- a Launch Control Center (LCC) and Launch Control Equipment Building (LCEB). These two sub-surface wings are connected by a Tunnel Junction and accessed by an elevator. (U.S. Air Force photo by Tech. Sgt. Alexander W. Riedel)

Click here to begin Lesson 4 of Module 4.

Launch Control Equipment Building and Support Building Operation

As you learned in the first module of this course, there is one very fundamental difference between the Wing 1 MAF and a Wings 3 and 5 MAF—ECS equipment at a Wing 1 MAF is housed topside in the launch control support building (LCSB). You may also see this topside building referred to as a MAF support building, or LCSB; however, the term LCSB will be used throughout this unit. At a Wing 3 or Wing 5 MAF, all of the ECS equipment is located underground in a structure called the launch control equipment building (LCEB). Figure 4–1 will refresh your memory of the structural differences between the two types of MAF.

The LCSB (Wing 1) and LCEB (Wings 3 and 5) are, for the most part, the MAF equivalent of the launcher support building (LSB) at the LF. These structures contain most of the normal ECS equipment, such as the brine chiller, air handler, and makeup air subsystem. This lesson will cover the brine chiller, brine chiller control panel operation, the various ventilation system functions, and lastly, the air handler subsystem and its operation.

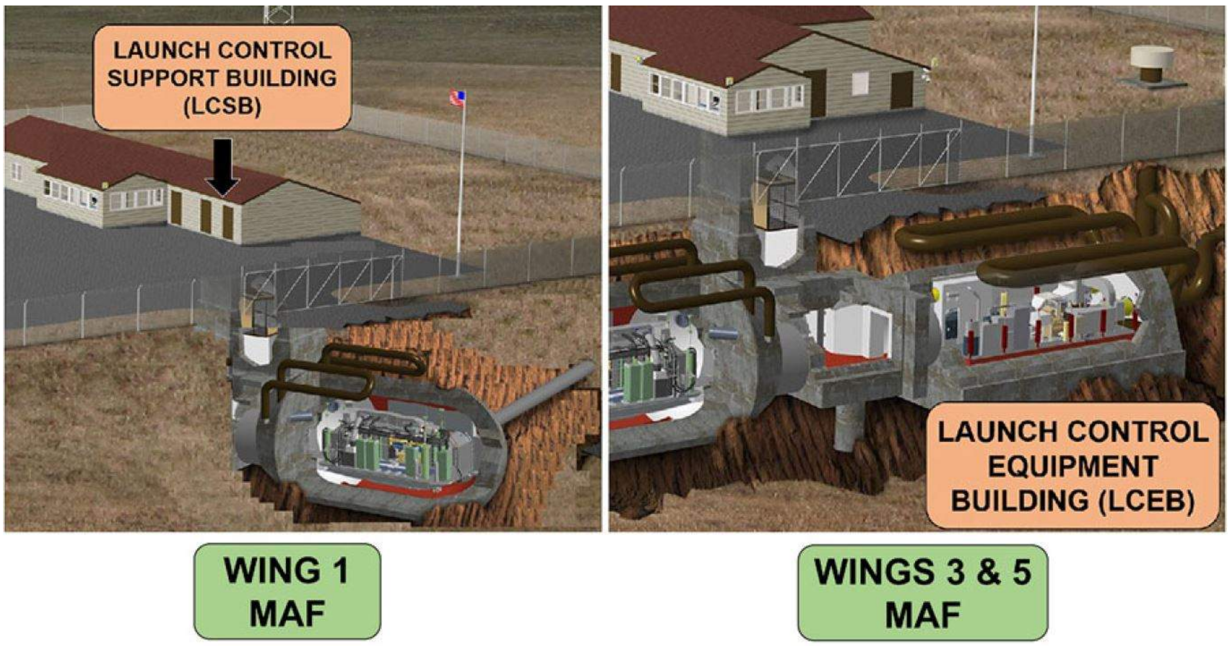


Figure 4–1. Missile Alert Facility Equipment Building Locations.

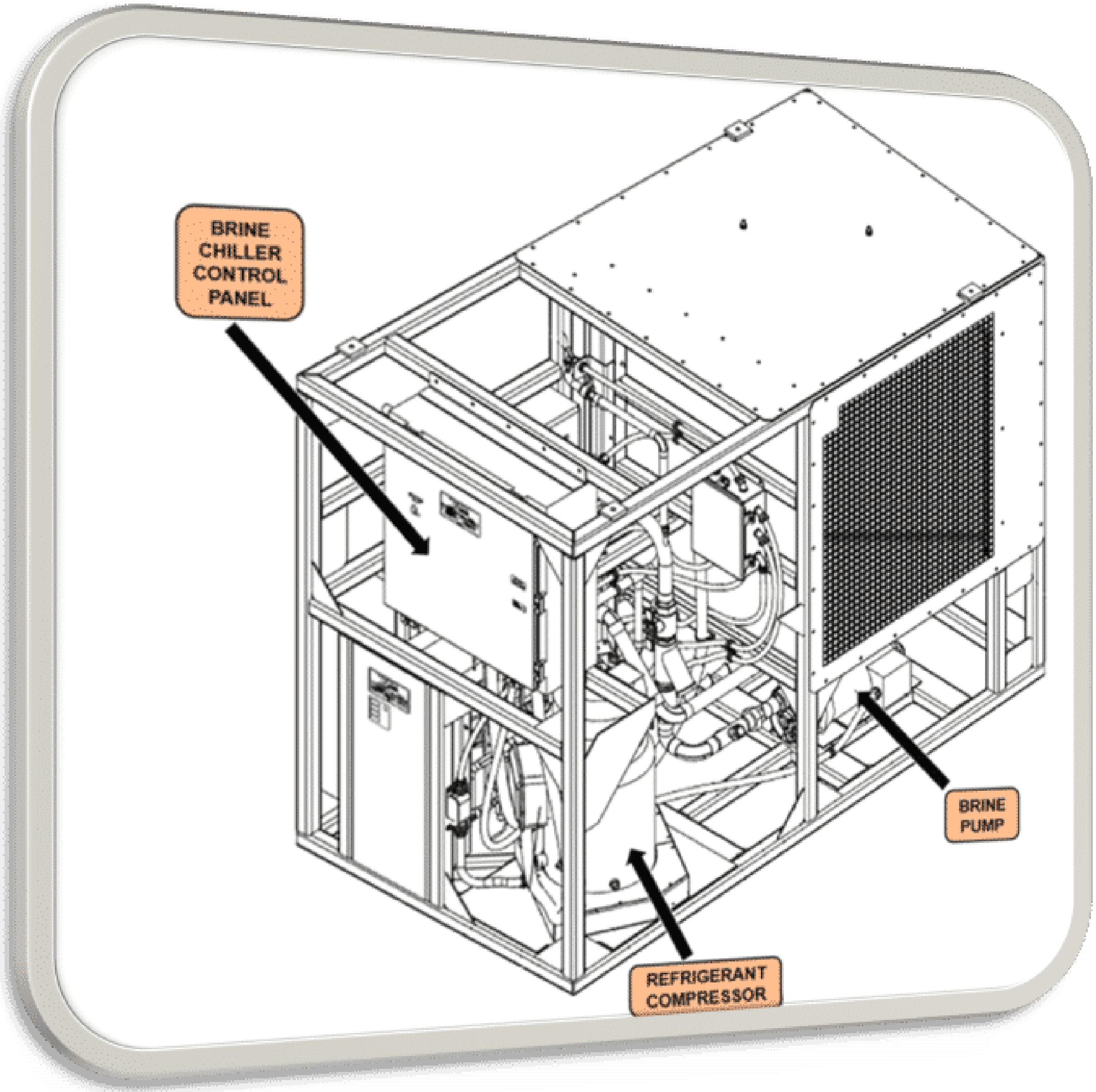


Figure 4–2. Missile Alert Facility Brine Chiller Unit CH-101.

Brine Subsystem Familiarization

The brine chiller at a MAF (fig 4–2) is slightly different than the brine chiller at the LF. It contains many of the same components, but it is larger and the brine chiller control panel is built straight into it. This lesson will focus on familiarizing you with the MAF brine subsystem.

The MAF brine subsystem has some similarities to the LF system, but some key differences exist once the brine exits the brine chiller. Figure 4–3 illustrates how brine lines branch off to flow to both the air handler cooling coil and the chilled water storage tank. This lesson will provide you with an overview of the brine subsystem and focus on the equipment differences.

You are already familiar with how heat is removed from the brine in evaporator EVR-101, and brine chiller CH-101 is nearly identical at all three wings. After cool brine leaves brine chiller CH-101, brine lines split off in two different directions, which is the main point you'll need to grasp about the brine subsystem at a MAF. Brine flows to both air handler unit AH-101 and chilled water storage tank TK-103.

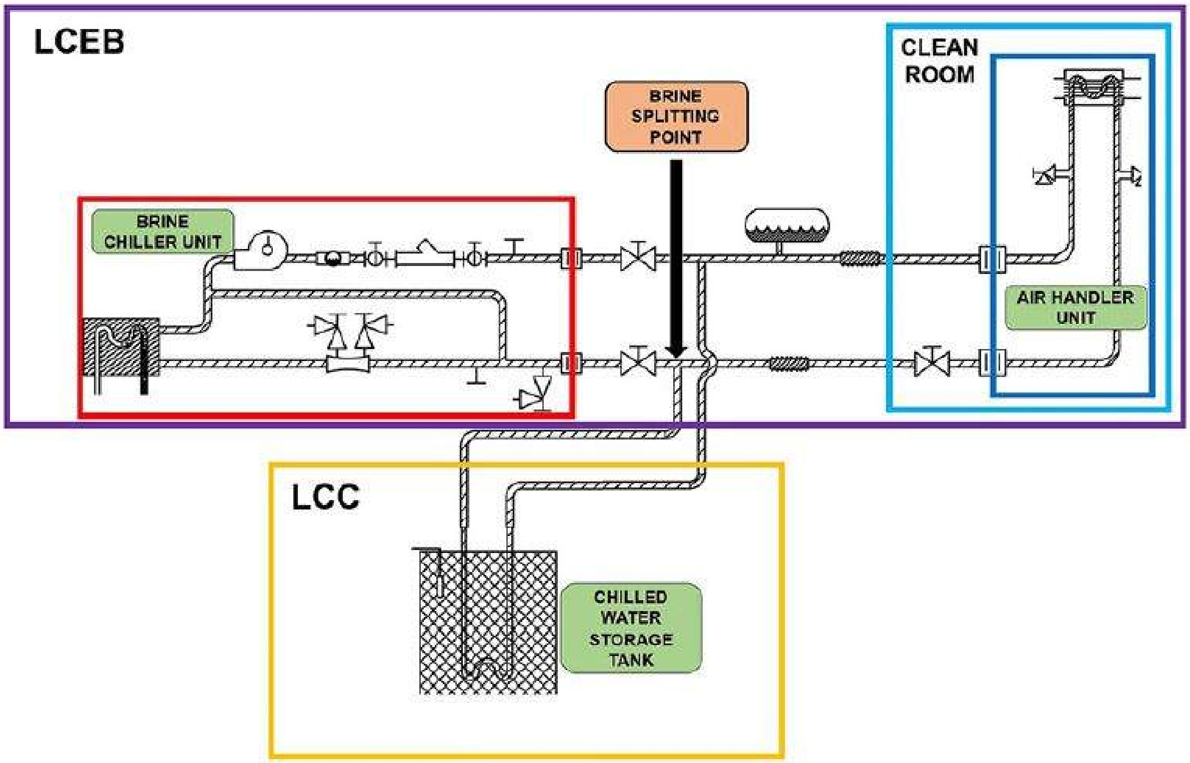


Figure 4–3. Brine Splitting Point.

Click on each (+) sign below to learn about the brine subsystems assigned to the MAF.

Brine Flow to Air Handler Unit AH-101

Brine flows through lines to a structure called a clean room, which you will learn about later in the unit. Once it enters the clean room it passes into air handler unit AH-101 and then runs through cooling coil CC-101. Brine removes heat from the air as it passes through cooling coil CC-101. The brine then circulates back to brine chiller CH-101 to be cooled again. The cool air will flow over to the launch control center (LCC) where it will be used to cool the electronic racks in a very similar fashion to the LF.

Brine Flow to Chilled Water Storage Tank TK-103

This is the routing of the brine subsystem at a MAF that is completely different from anything at the LF, so be sure to pay close attention. A portion of the brine that exits brine chiller CH-101 branches off and travels to a large tank in the LCC called chilled water storage tank TK-103. TK-103 is a large tank that is only used when the MAF is operating on emergency ECS. You will learn about the MAF emergency ECS in a later lesson.

The key concept to remember is that the brine subsystem gathers heat in two locations at a MAF—air handler unit AH-101 and chilled water storage tank TK-103.

Brine Flow Balancing Valve V-124

The purpose of brine flow balancing valve V-124 is to divide the amount of brine that flows to both air handler unit AH-101 and chilled water storage tank TK-103. The reason that the flow must be divided is because both systems require different amounts of cooling. In addition to this, there must also be a way to compensate for the drag on the brine solution created by the length of the brine lines.

This lesson focused on familiarization of the MAF brine subsystem and how brine chiller CH-101 must remove heat from the air flowing to the electronic racks in the LCC while cooling the brine in chilled water storage tank TK-103 as well.

Complete the content above before moving on.

Brine Chiller Control Panel Familiarization

The brine chiller control panel (fig 4–4) houses all of the electrical controls required for the operation of the brine pump and refrigerant compressor, as well as the binary and analog input and output modules that interface with the programmable logic controller (PLC).

The brine chiller control panel is physically located on the brine chiller CH-101, meaning that when the brine chiller is removed and replaced the entire panel comes with it. Figure 4–5 shows the schematic for the brine chiller control panel. Again, the components and functions are the same as the LF brine chiller control panel schematic, but the arrangement of the components is different. This schematic has not been traced for you since you should already be adept at doing this from the several schematics in unit 3, and a step-by-step walkthrough will not be provided since this lesson is only a familiarization.

120/208 VAC, 3-phase power is supplied to the brine chiller control panel by circuit breaker CB 20/22/24 in the LCEB distribution panel S. Tracing out this schematic will be nearly identical to tracing out the LF brine chiller schematic. Power to panel components is provided by branching one phase of 120 VAC off of power to brine pump P-101 at terminal board 1 pin 2. Power flows through high-power resistor R-101 and metal-oxide varistor MOV-101 before flowing to the other panel components.

This lesson focused on familiarization with the MAF brine chiller control panel, which uses the same components and functions very similarly to the LF brine chiller control panel.

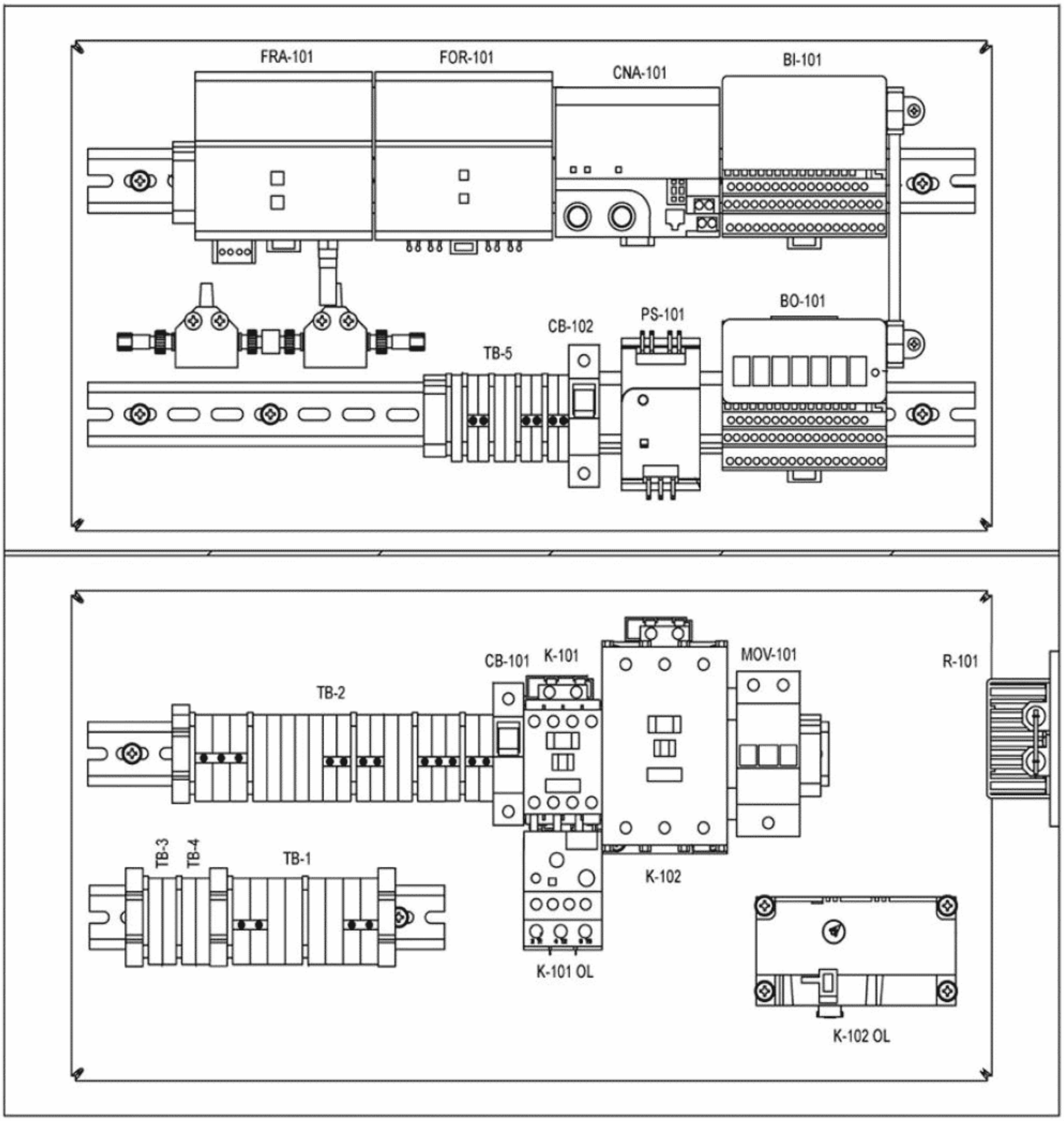


Figure 4–4. Brine Chiller Control Panel.

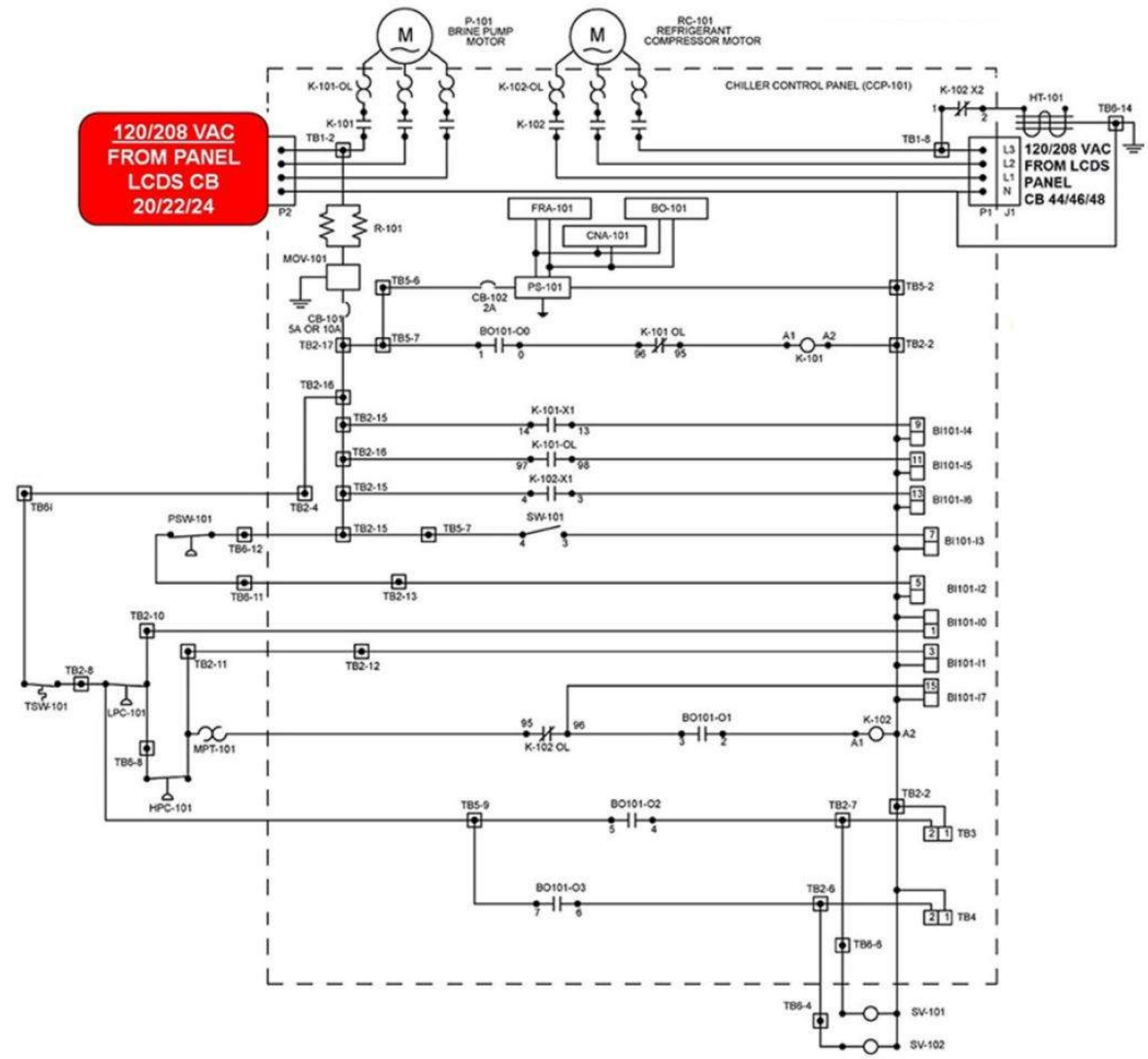


Figure 4–5. Brine Chiller Control Panel Schematic.

Click here to move forward in the lesson.

Ventilating Air Subsystem Function and Operation

The ventilating air subsystem at a MAF is more complicated than its counterpart at a LF. The room temperature of the LCSB (Wing 1) and LCEB (Wings 3 and 5) must be maintained, and so must the operating temperature of the diesel electric unit. There are also requirements at the MAF to ensure that the clean room, LCEB, and LCC all maintain a certain amount of overpressure in order to prevent contaminates in the atmosphere from seeping in.

LCSB Room Temperature Control (Wing 1)

At Wing 1, the equipment for the ventilation subsystem is topside in the LCSB, and a certain room temperature must be maintained to both prevent the room from getting too cold in the wintertime and also not so hot that refrigerant will not condense. Let's discuss the components that are involved in controlling the temperature of the LCSB.

- LCSB ambient air temperature sensor TSR-101 monitors the temperature of the LCSB and relays this data to the PLC.
- LCSB intake air damper D-101 opens to allow outside air to enter the room and closes to prevent outside air from entering the room.
- LCSB exhaust air damper D-102 opens to allow hot air from the condenser coil to exit the room and closes to prevent hot air from exiting the room.
- LCSB recirculating air dampers D-103 and D-104 open to allow hot air from the condenser coil to circulate back into the room and close to prevent hot air from recirculating back into the room.

Now, follow along in figure 4–6 as we describe how the LCSB room temperature is controlled.

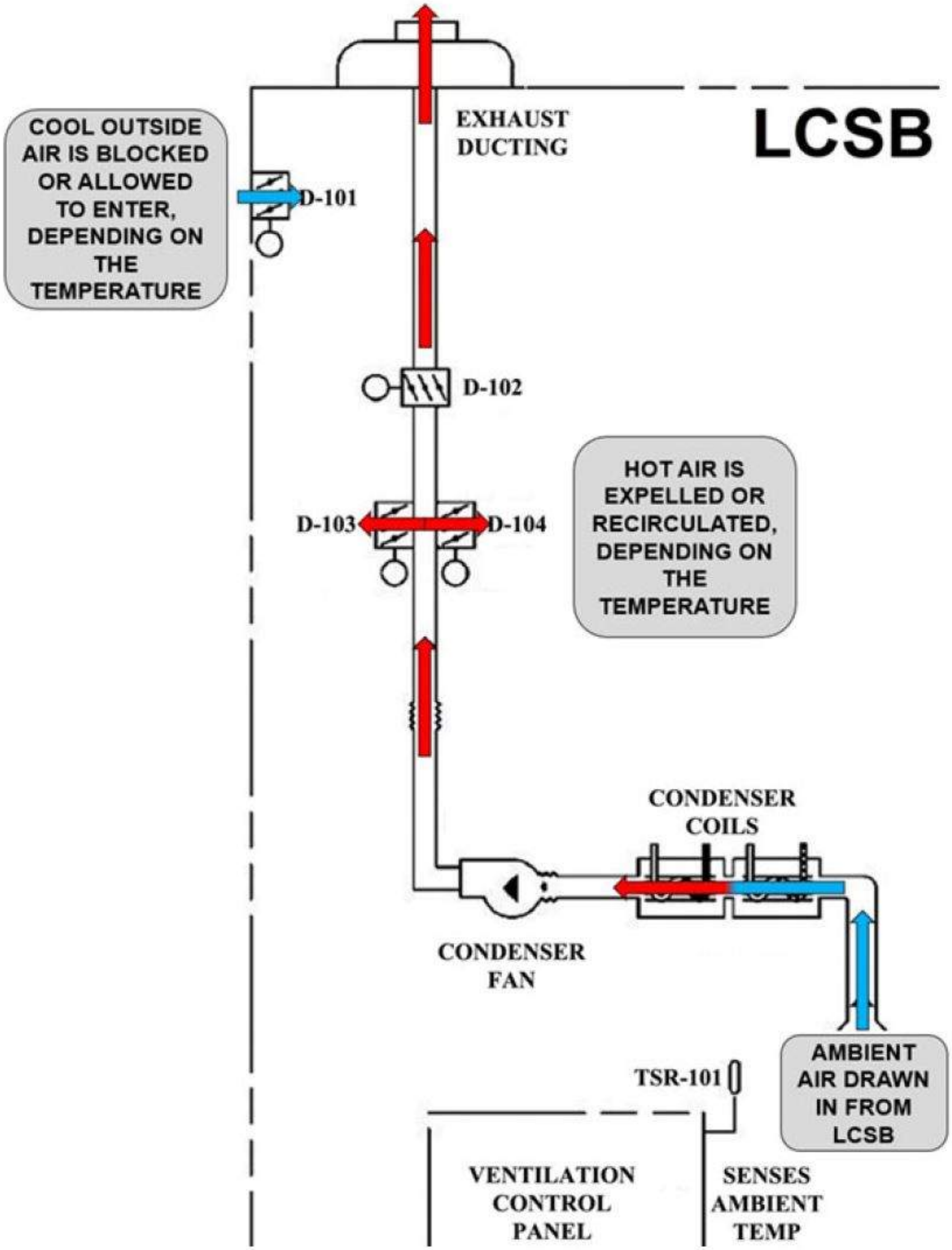


Figure 4–6. LCSB Room Temperature Control System Diagram.

LCSB TEMPERATURE BELOW 68°F	LCSB TEMPERATURE ABOVE 72°F

The LCSB at a MAF is very similar to the LSB at an LF in the way that it retains or discharges heat from the room to maintain the proper temperature. In this case, damper D-102 will close to recirculate hot air from the condenser coil back into the room, and dampers D-103 and D-104 will open to allow this hot air to recirculate back into the room. Damper D-101 will close to prevent outside air from entering the room.

LCSB TEMPERATURE BELOW 68°F	LCSB TEMPERATURE ABOVE 72°F

If the LCSB is too hot, dampers D-103 and D-104 will close to prevent hot air from the condenser coil from recirculating back into the room, and damper D-102 will open to allow the hot air to exit the room. Damper D-101 will open to allow outside air to enter the room.

Complete the content above before moving on.

LCEB Room Temperature Control (Wings 3 and 5)

The LCEB at Wings 3 and 5 is buried deep below the ground at the same depth as, and directly across from, LCC. For this reason, it should be noted that air is drawn into the room from ground level through a long duct and past a blast valve. Air is exhausted from the LCEB in the same manner but uses its own blast valve and duct that runs to ground level. Let's discuss the components that are involved in controlling the temperature of the LCEB.

- LCEB ambient air temperature sensor TSR-106 monitors the temperature of the LCEB and sends the data to the PLC.

- LCEB recirculation air damper D-120 opens to allow hot air from the condenser coil to recirculate into the room and closes to prevent hot air from recirculating into the room.
- LCEB exhaust air damper D-121 opens to allow hot air from the condenser coil to exit the room and closes to prevent hot air from exiting the room.

Follow along in figure 4–7 as we describe how the LCEB room temperature is controlled.

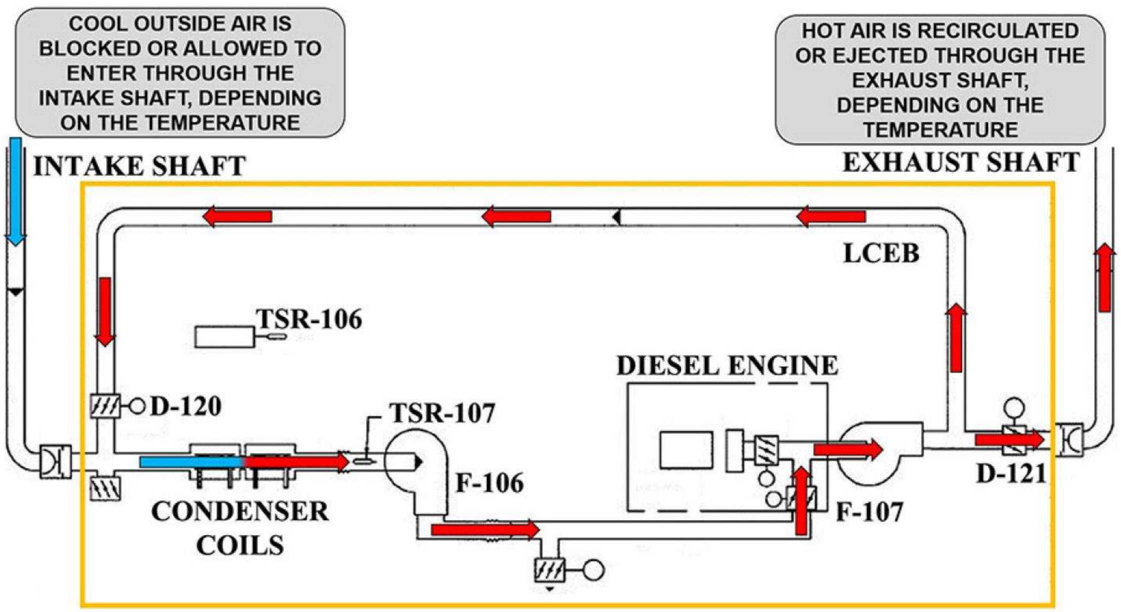


Figure 4–7. LCEB room temperature control system diagram.

LCEB TEMPERATURE BELOW 73°F	LCEB TEMPERATURE ABOVE 77°F

In this case, damper D-121 closes to prevent hot air from the condenser from exiting into the exhaust shaft, and damper D-120 opens to allow this air to recirculate through the duct and then into the LCEB through a perforated plate located in the duct after the condenser fan. Note that the PLC will not allow damper D-121 to modulate less than 25% open.

LCEB TEMPERATURE BELOW 73°F	LCEB TEMPERATURE ABOVE 77°F

If the LCEB is too hot, damper D-121 will open to allow hot air from the condenser coil to exit into the exhaust shaft. Damper D-120 will close to prevent any hot air from recirculating through the duct.

Complete the content above before moving on.

LCEB Room Pressure Control

Maintaining the room pressure is just as important as maintaining the room temperature, and the pressure in the LCEB must be maintained above atmospheric pressure to prevent harmful contaminates from entering. There are several different scenarios that occur depending on whether the exhaust fan or DEU are running. Let's discuss the components that are involved in controlling the temperature of the LCEB.

- LCEB versus outside differential pressure sensor PSR-105 measures the difference between the LCEB inside and outside pressures, and relays this data to the PLC.
- LCEB pressure control damper D-116 opens to allow air from the building to enter the ventilation ductwork and closes create the opposite effect.

- LCEB supply air damper D-117 opens to allow air from the ventilation ductwork to enter the room and closes to create the opposite effect.
- DEU radiator bypass damper D-119 opens to allow air to bypass the DEU radiator and closes to force more air across the DEU radiator.

NOTE: The PLC will wait 120 seconds after the exhaust fan stops to allow room pressure to stabilize before checking the LCEB room pressure.

NOTE: Exhaust fan F-107 will run any time the DEU runs and also when the temperature of the air exiting the condenser coil exceeds 115°F.

NOTE: When the DEU is not operating, the PLC closes DEU radiator face damper D-118 and modulates DEU radiator bypass damper to 50% open.

Follow along in figure 4–8 as we describe how the PLC controls the pressure inside the LCEB.

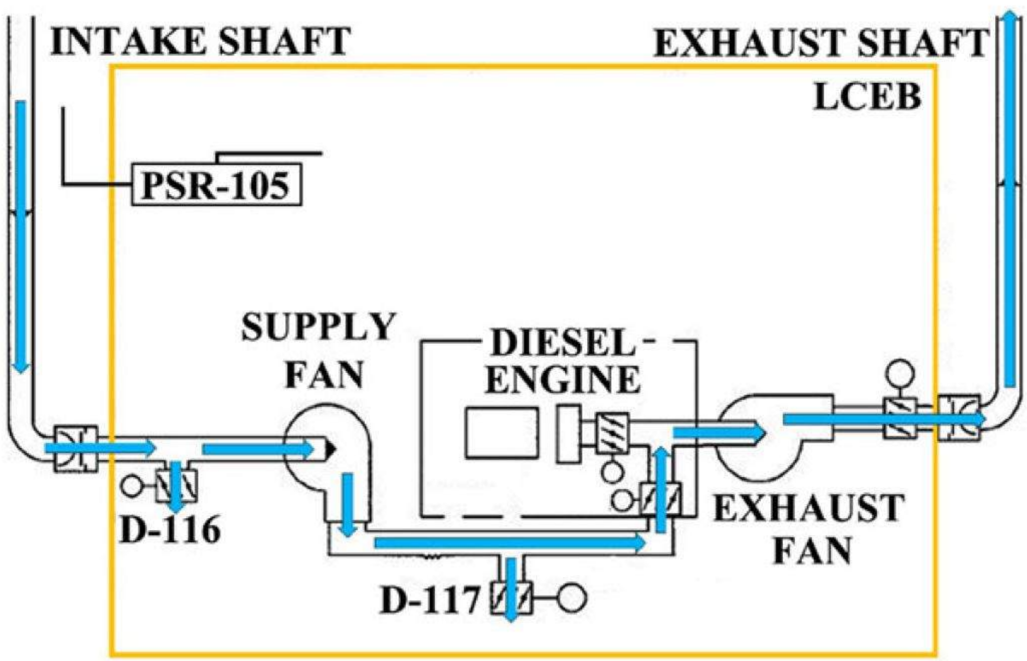


Figure 4–8. LCEB room pressure control system diagram.

LCEB Pressure Control When DEU or Exhaust Fan F-107 Are Operating

If the DEU is operating, the PLC will close LCEB pressure control damper D-116 and command the DEU radiator bypass damper to 50% open.

If the differential pressure between the building and the pressure outside of the LCEB is greater than 0.20 inches of water gauge (inwg), LCEB supply air damper D-117 will close to reduce the air pressure entering the room from the LCEB ventilation ductwork.

If the differential pressure is less than 0.10 inwg, damper D-117 will open to allow more pressure from the LCEB ventilation ductwork to enter the room.

LCEB Pressure Control When DEU or Exhaust Fan F-107 Are Not Operating

This will be the most common room pressure control scenario for the LCEB. After the 120-second timer has elapsed, if applicable, the PLC will close LCEB supply air damper D-117 and then check the differential pressure.

If the differential pressure is greater than 0.20 inwg the PLC will open LCEB pressure control damper D-116 to allow pressure from the LCEB to enter the LCEB ventilation ductwork. If the differential pressure is less than 0.10 inwg the PLC will close damper D-116 to increase the pressure differential between the LCEB and the LCEB ductwork.

Complete the content above before moving on.

Clean Room Pressure Control

The missile combat crew (MCC) at the MAF consists of two launch officers that wait on alert in the LCC to launch missiles in their flight if they receive an authenticated command to do so. This adds a new element to the ventilation equation because the MCC must be able to survive a nuclear or biological attack in order to execute this launch command. Fresh air must circulate down to the LCC at all times, and this must still happen even if there has been a nuclear detonation or biological weapon used near the facility. This is the reason the MAF ventilating air subsystem uses a nuclear, biological, and chemical (NBC) filter and a clean room.

The clean room is topside in the LCSB at a Wing 1 MAF and below ground in the LCEB at a Wing 3 or a Wing 5 MAF, but both serve the same function and operate the same way. The clean room is the only point of entry for air into the LCC, and the only air allowed into the clean room must pass through NBC filter unit NBC-101. Let's discuss the components that are involved in controlling clean room pressure at a Wing 3 or a Wing 5 MAF. Remember that the above ground clean room at a Wing 1 MAF functions the same way but with a slightly different damper arrangement.

- Clean room differential pressure sensor PSR-102 measures the pressure difference between the clean room and the LCEB and relays the data to the PLC.

- LCEB clean room exhaust isolation damper D-129 closes to increase clean room pressure andopens to decrease clean room pressure.

Follow along in figure 4–9 as we describe how the PLC controls clean room pressure. Regulating the pressure of the clean room is a simple process. If the differential pressure between the clean room and the LCEB is less than 0.10 inwg, the PLC will close clean room isolation damper D-129.This will decrease the flow of air out of the clean room and into the LCEB which will in turn raise the clean room pressure because more air is coming in and less is exiting. If the differential pressure is greater than 0.20 inwg, the PLC will open clean room isolation damper D-129 to allow more pressure to escape into the LCEB.

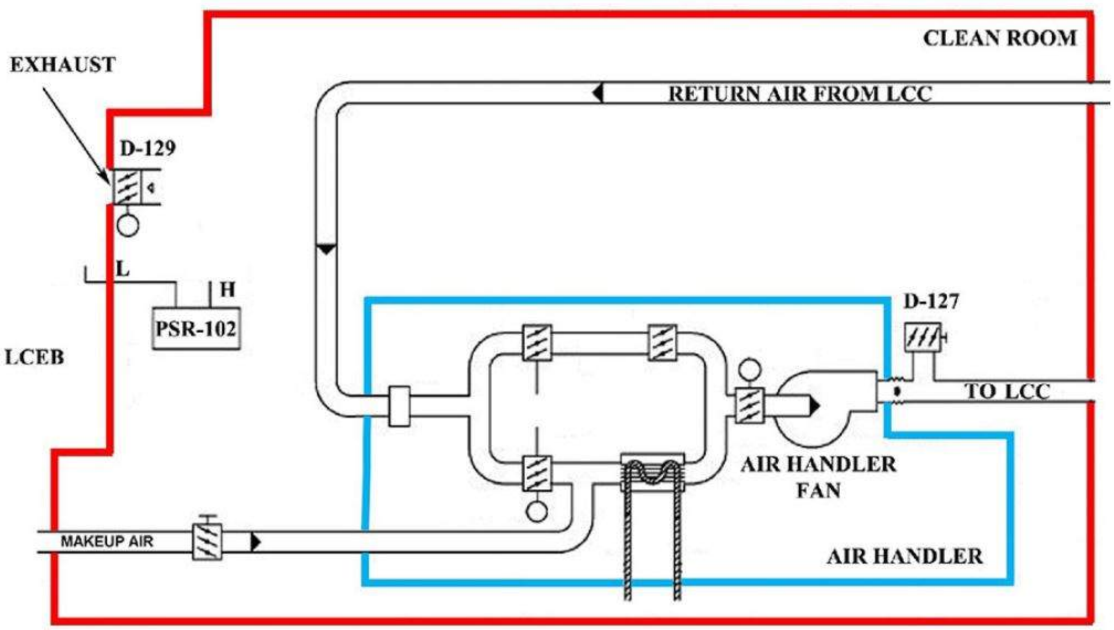


Figure 4–9. Clean Room Pressure Control System Diagram.

DEU Water Jacket Temperature Control System

Wings 3 and 5 use the ventilation air subsystem to help maintain the temperature of the DEU when it is operating. Wing 1 does not have this system as the DEU is in a room in the LCSB, separate from environmental support. It has its own method of maintaining temperature, but these items are not part of the ECS. Wings 3 and 5 maintain the DEU at slightly different water jacket temperatures but use the same method; therefore, we will only use the Wing 3 DEU as an example. Let's discuss the components that are involved in controlling the temperature of the LCSB.

- DEU water jacket temperature sensor TSR-105 tells the PLC the water jacket (operating)temperature of the DEU.
- DEU radiator face damper D-118 opens to allow more air to move through the DEU radiator and closes to allow less air to move through the radiator.
- DEU radiator bypass damper D-119 opens to allow air to bypass the DEU radiator and closes to force more air to be drawn through the DEU radiator.

Follow along in figure 4–10 as we describe how the DEU water jacket temperature is controlled. The following scenarios will seem familiar since the LF uses the same type of control.

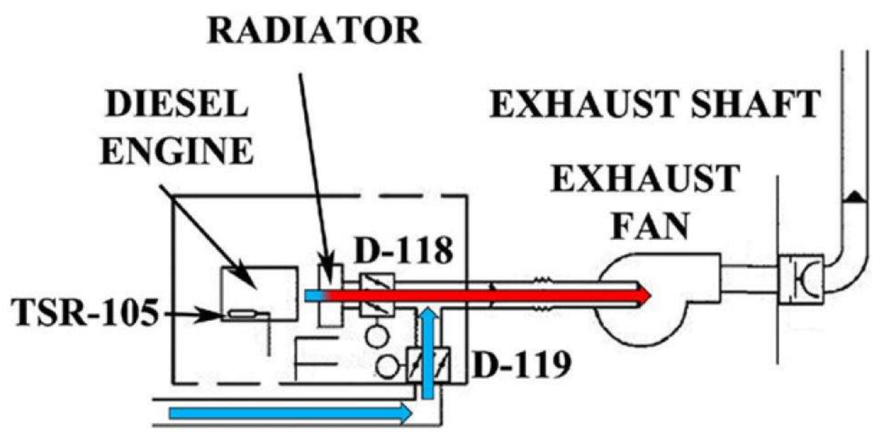


Figure 4–10. Wings 3 and 5 DEU temperature control system diagram.

DEU Water Jacket Temperature Below 173°F

If the DEU water jacket temperature is too low, radiator bypass damper D-119 will open and radiator face damper D-118 will close to restrict airflow across the radiator. This will cause the water jacket temperature to increase because less air is flowing through the radiator.

DEU Water Jacket Temperature Above 177°F

If the DEU water jacket temperature is too high, radiator bypass damper D-119 will close and radiator face damper D-118 will open to allow more airflow across the radiator. This will cause the water jacket temperature to decrease because more air is flowing through the radiator.

This lesson focused on the many facets of the MAF's ventilation and heating subsystem. This system is important for maintaining room and DEU operating temperatures and also vitally important for maintaining the correct pressures within the LCEB and clean room.

Complete the content above before moving on.

Air Handler Subsystem Familiarization

The air handler at the MAF must dissipate a larger heat load than the smaller air handler at the LF and is also responsible for providing an environment to sustain the MCC. Makeup airflow is filtered by the NBC filters and conditioned in the air handler to ensure the electronic equipment needed to launch the missile is kept at an optimal temperature. This system also ensures sustainment of the MCC to launch the missiles in their flight or squadron if they receive an authentic command to do so. Air handler unit AH-101 (fig 4–11) is located inside the clean room.

Air handler fan F-103 sends conditioned air from cooling coil CC-101, out of the clean room, through the ductwork and into the LCC. Fan F-103 only draws air circulated back from the LCC or drawn through the NBC filter. This is a major difference from the LF air handler since it draws ambient air from the entire LER.

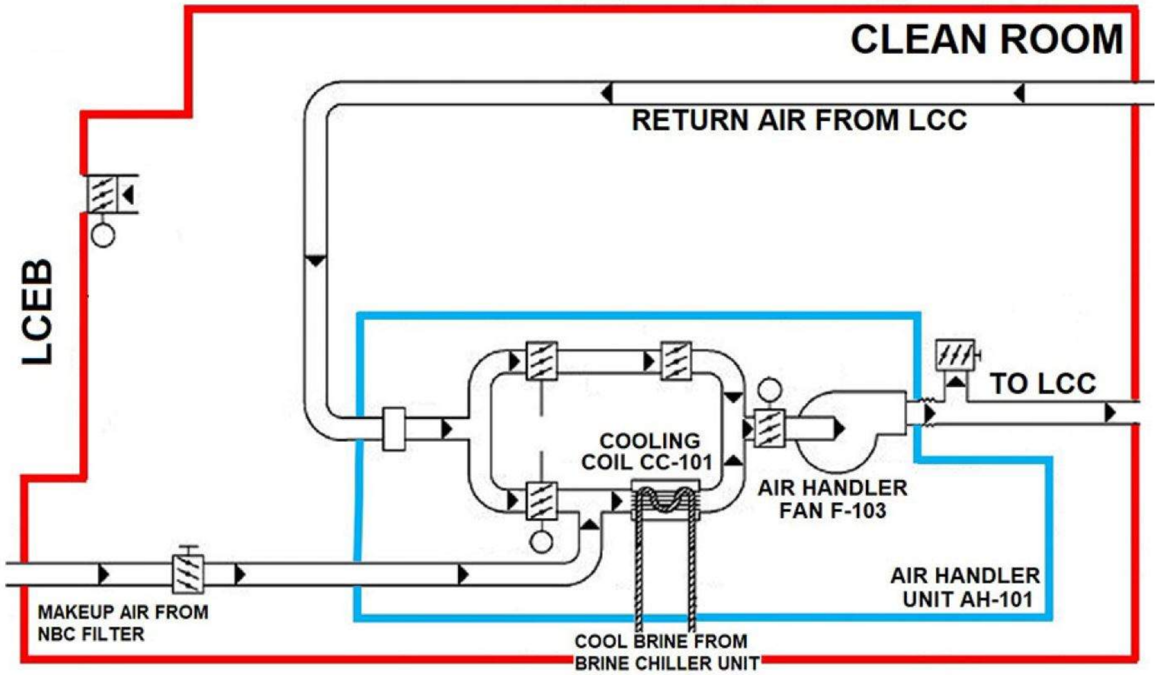


Figure 4–11. Air handler Unit AH-101 Subsystem Diagram.

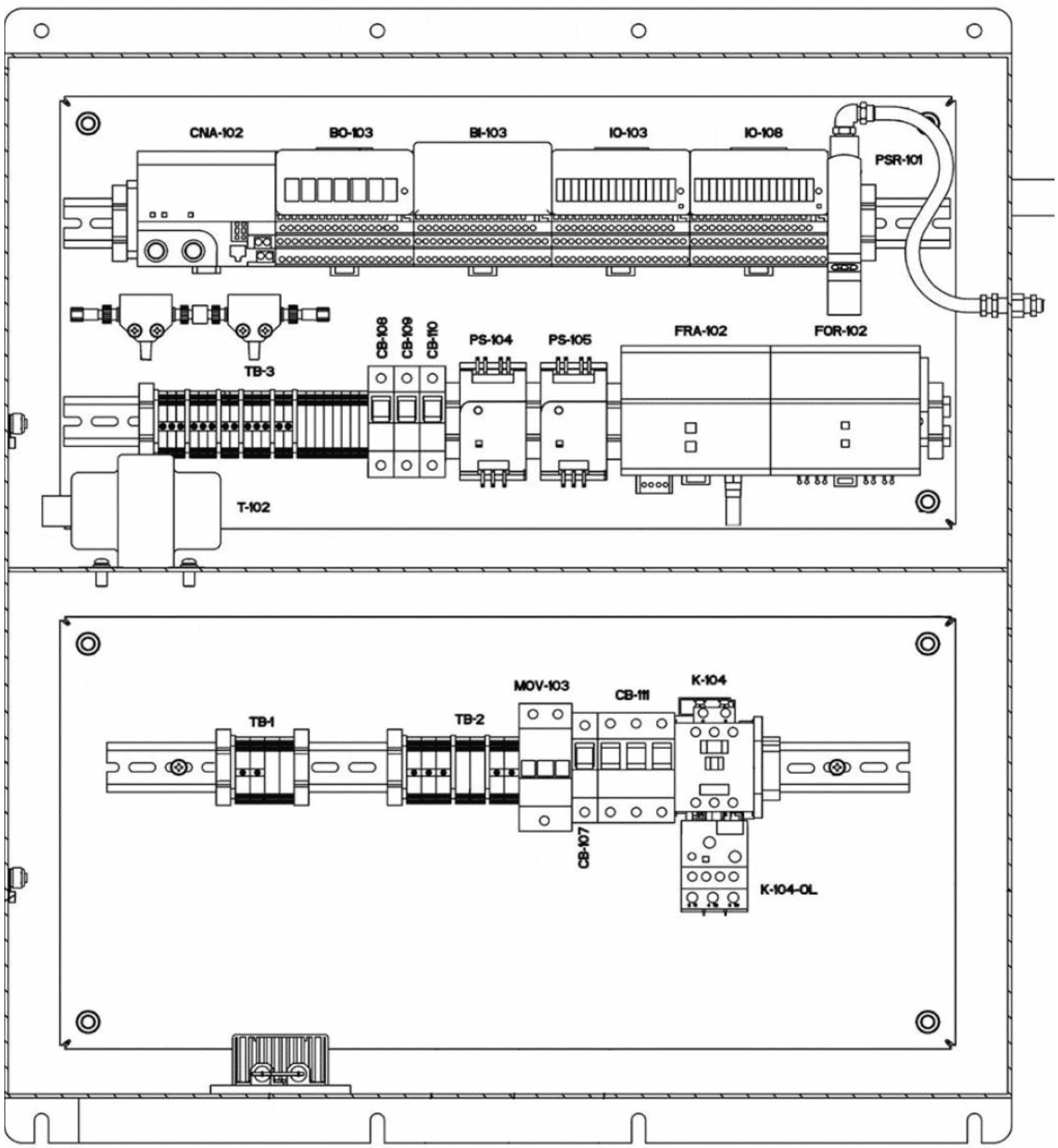


Figure 4–12. Air Handler Control Panel ACP-102.

Air handler control panel ACP-102 (fig 4–12) is installed in the clean room near the air handler, and houses all the electrical controls for the air handler fan motor as well as the binary and analog input and output modules that interface with the PLC.

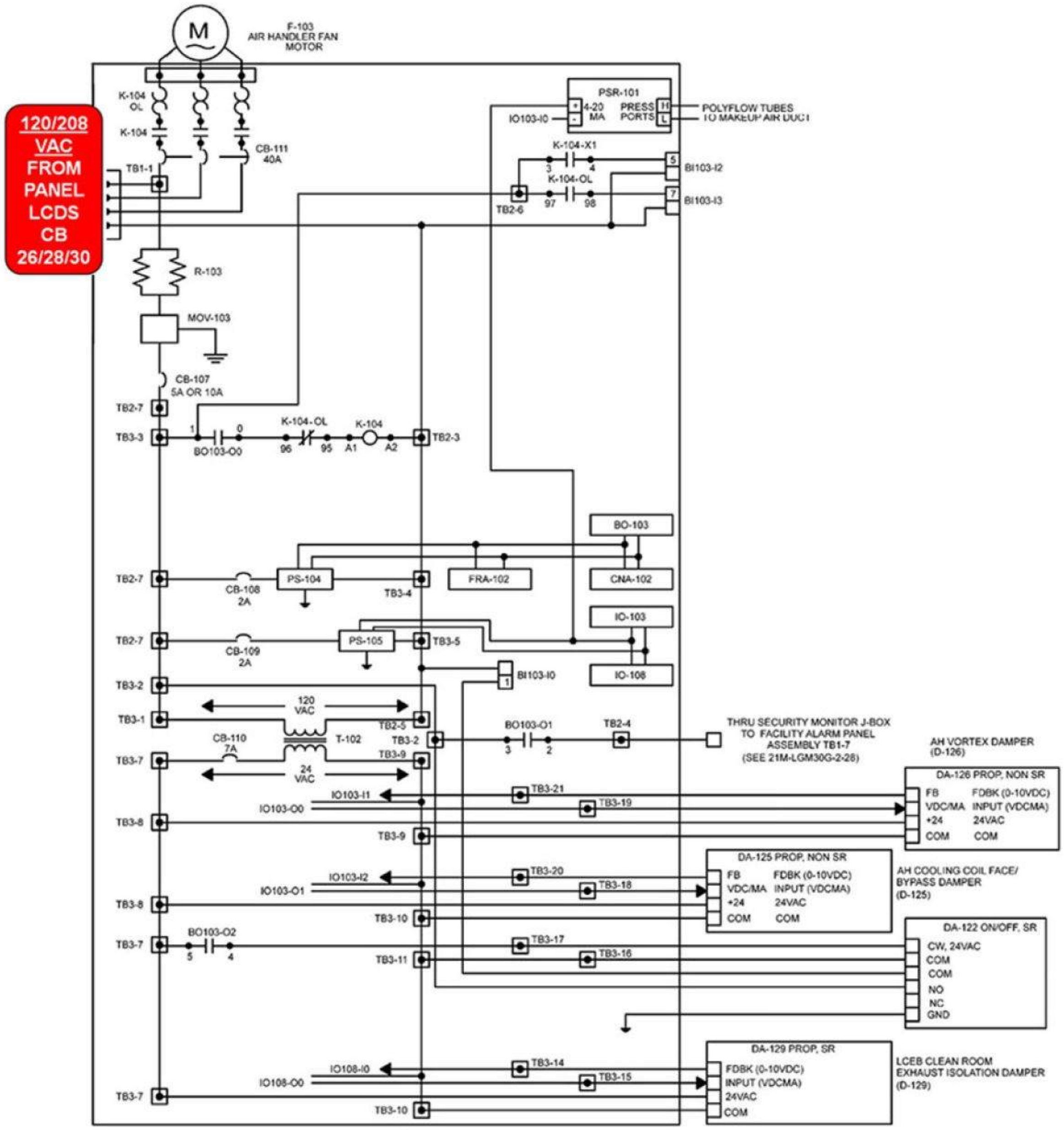


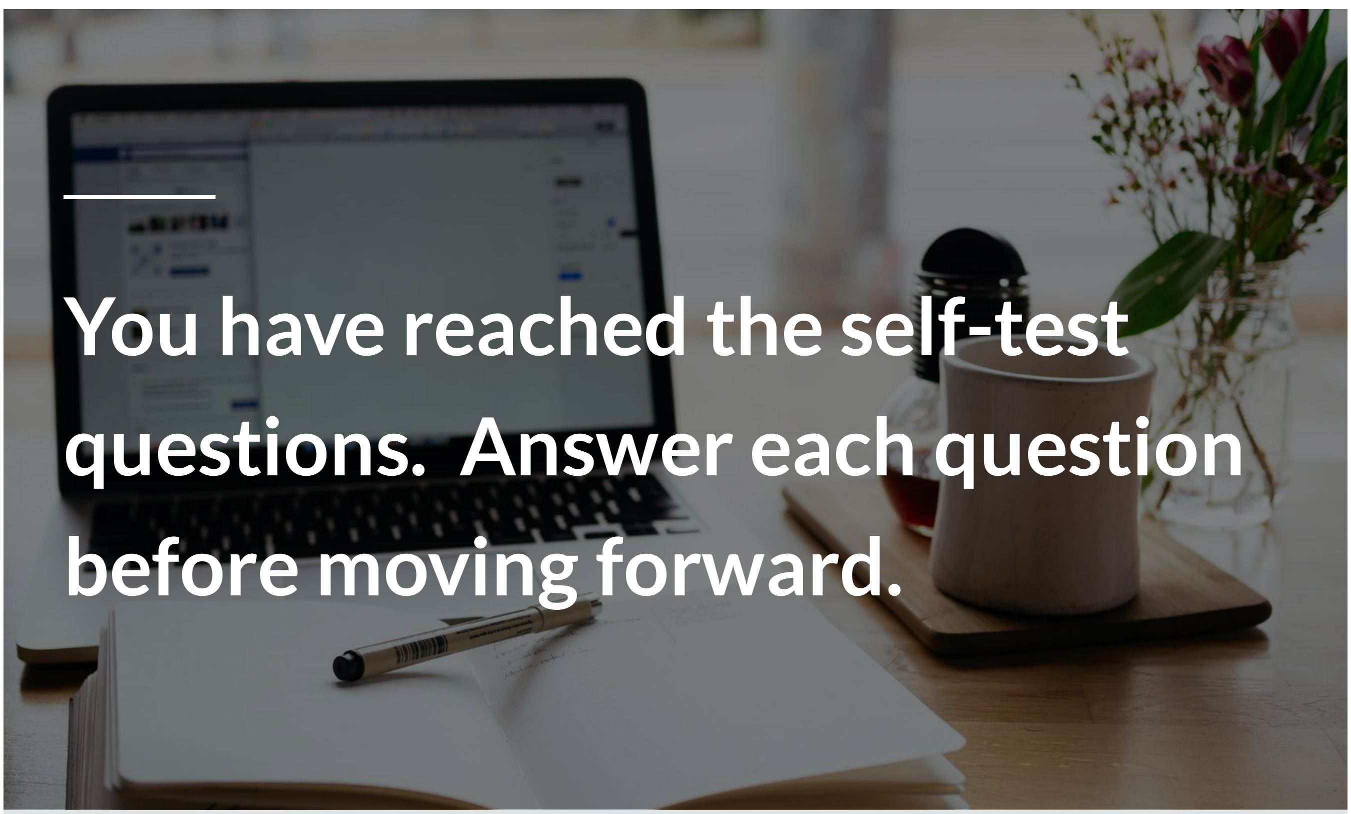
Figure 4–13. Air Handler Control Panel Schematic.

Figure 4–13 is the schematic for the air handler control panel. Again, the components and functions are the same as the LF air handler control panel schematic, but the arrangement and look are slightly different. Circuit breaker

CB 26/28/30 in LCEB distribution panel S supplies 120/208 VAC, 3-phase power to the air handler control panel.

Tracing out this schematic will be nearly identical to tracing out the LF air handler schematic; power is provided to the panel by one phase of 120 VAC that branches off of power to air handler fan motor F-103 at terminal board 1 pin 1. Power flows through high-power resistor R-103 and metal-oxide varistor MOV-103 before flowing to the other panel components.

This lesson focused on familiarization with the MAF air handler subsystem, controls, and alarms, which uses the same components and functions very similarly to its LF counterpart.



KNOWLEDGE CHECK TIME!

For the fill-in the blank questions, you will need to add (.) period to the end of the sentences.

Click here to answer the self-test questions pertaining to the brine subsystem familiarization.

1. Where does brine flow at the MAF after it leaves the brine chiller unit?

Type your answer here

SUBMIT

2. How is the chilled water storage tank at the MAF used?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the brine chiller control panel familiarization.

1. How is 120/208 VAC, 3-phase power supplied to the brine chiller control panel?

Type your answer here

SUBMIT

2. What components does the single phase of 120 VAC in the brine chiller control panel flow through before distribution to the components in the panel?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the ventilation air subsystem function and operation.

1. What actions occur when the Wing 1 launch support equipment building is too hot?

Type your answer here

SUBMIT

2. Why does the PLC wait 120 seconds after the exhaust fan stops before checking the LCEB room pressure?

Type your answer here

SUBMIT

3. How will the PLC react if the differential pressure between the clean room and the LCEB is more than 0.20 inwg?

Type your answer here

SUBMIT

4. How will Wings 3 and 5 MAF PLCs react if the DEU water jacket temperature is too high?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the air handler subsystem familiarization.

1. Where is the MAF air handler control panel ACP-102 located?

Type your answer here

SUBMIT

2. How is 120/208 VAC 3-phase power supplied to the air handler control panel?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Launch Control Center Operation

The primary purpose of the ECS at the MAF is to provide cooling air to the electronic equipment in the LCC. However, the LCC contains very few ECS components when compared to the LCEB. The components located in the LCC exist mainly for air distribution and sustainment of equipment and personnel during an emergency. The Wings 3 and 5 system and the Wing 1 system are very similar in configuration, and therefore we will focus on the Wings 3 and 5 system. This section will discuss emergency ECS, the alarms reported to the MCC by the ECS, and the oxygen regeneration unit.

Click here to move forward in the lesson.

Emergency Cooling Unit Familiarization

The MAF emergency cooling unit (ECU) and the LF emergency fan serve the same basic purpose but are very different. This lesson will provide familiarization on the major components of the MAF emergency air handler subsystem, including emergency cooling unit ECU-102 (fig 4–14), chilled water storage tank TK-103 and its piping, and emergency control panel (ECP-102).

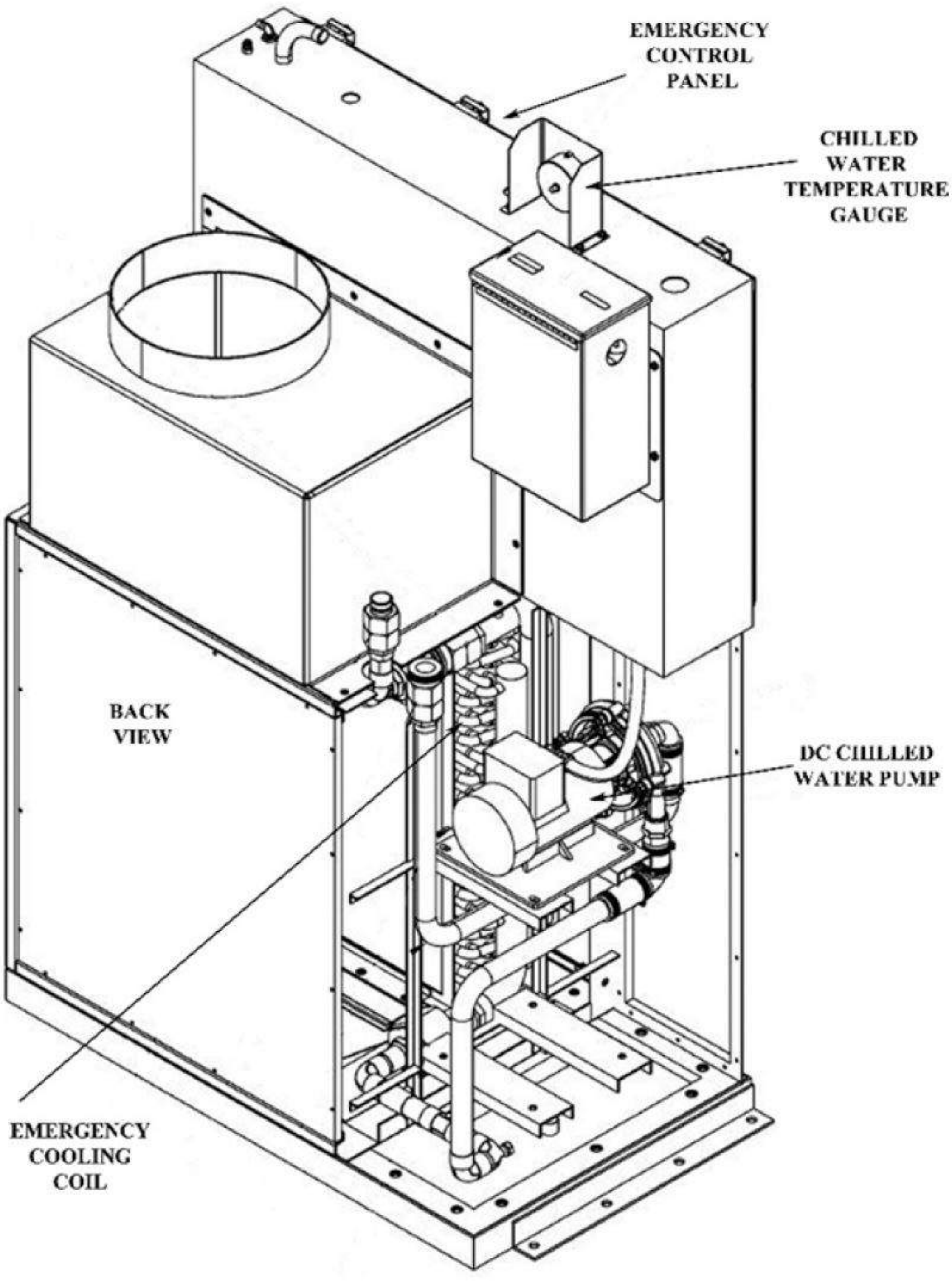


Figure 4–14. Emergency Cooling Unit ECU-102.

Chilled Water System

Before we dive into specifics on the function and operation of ECU-102, it is prudent for us to step back and look at the emergency chilled water system (fig 4–15), since this is the source of cool liquid for ECU-102. In this discussion, we will look at direct current (DC) chilled water pump P-103, cooling coil CC-102, as well as the piping and other components of the emergency chilled water system.

Recall from the lesson on the brine subsystem that a portion of the brine flow exiting brine chiller CH-101 is sent to the LCC to cool the liquid in chilled water storage tank TK-103.

When the LCC switches to emergency ECS operation, DC chilled water pump P-103 will energize to circulate water from chilled water storage tank TK-103 to emergency cooling coil CC-102. Pump P-103 draws liquid through strainer STR-102 and then before sending it through cooling coil CC-102. Emergency air handler fan F-104 draws ambient air from the LCC across cooling coil CC-102, where heat from the air is transferred to the chilled water. This water then returns to chilled water storage tank TK-103 to begin the process over again. Cool brine is not circulating in emergency mode, and the temperature of chilled water storage tank TK-103 will slowly rise until there is very little cooling taking place. This is a fundamental difference between the LCC and LER emergency ECS; the LCC uses chilled water to provide cool air to the racks, while the LER emergency ECS only circulates ambient air.

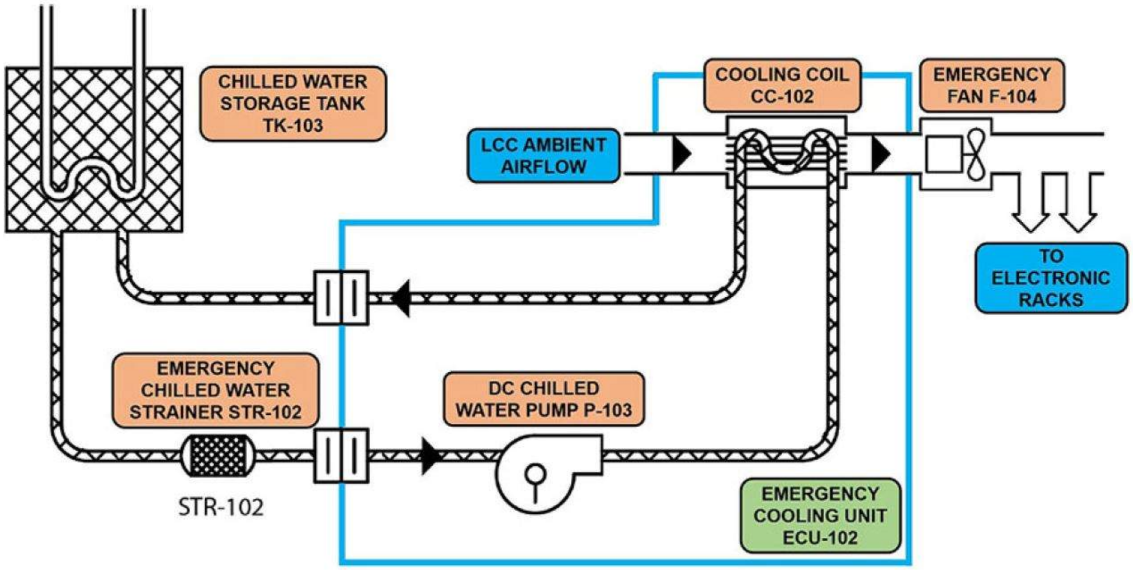


Figure 4–15. Emergency chilled water system diagram.

Emergency Control Panel ECP-102

Now that we know how the electronic equipment in the LCC is cooled during emergency ECS operation, let's see how the components in ECP-102 operate. Note that this lesson will only cover major system components. Emergency control panel ECP-102 (fig 4–16) contains the controls required for emergency ECS operation.

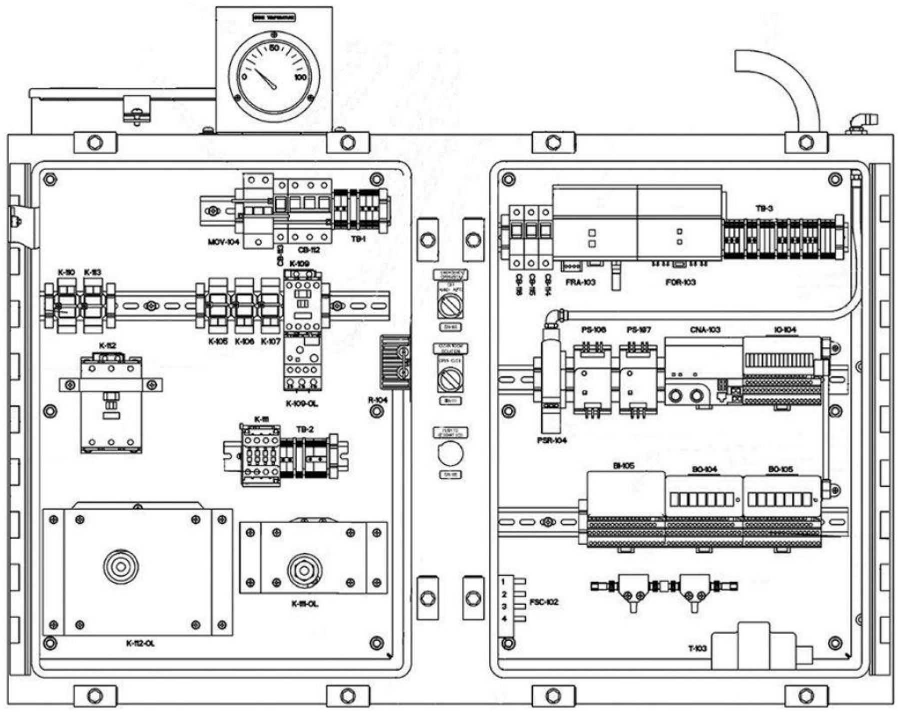


Figure 4–16. Emergency control panel ECP-102.

Emergency Control Panel ECP-102

The PLC determines when the emergency ECS should be started by checking for other parameters in the system. The following conditions must be met before the MAF will transfer to emergency ECS:

- If the temperature of the air flowing to the electronic racks reaches 70°F, a 60-second timer will start. This timer gives the system a chance to stabilize itself instead of immediately switching to emergency ECS at the instant the temperature exceeds 70°F. This is to prevent nuisance alarms and the unnecessary switching from normal to emergency ECS.
- The difference in airflow between the LCC and the pressure in the ductwork leading to the electronic racks should be above 0.82 inwg. A differential pressure below 0.82 inwg indicates that there is not enough airflow to the electronic racks, and the PLC will initiate a 30-secondtimer once this happens. If the pressure difference is still below 0.82 inwg after the 30-secondtimer has elapsed, the PLC will check the status of the 70-second damper repositioning delaytimer. If this timer count down is incomplete, the PLC continues monitoring airflow to theracks until the timer

expires. If the 70-second timer has also expired, the PLC will switch toemergency ECS. These built in timers are designed to prevent unnecessary switching between normal and emergency ECS.

- If EMERGENCY OPERATION hand-off-auto (H-O-A) switch SW-108 on emergency control panel ECP-102 is set to HAND, power will be applied directly to the fan and chilled water pump, and normal ECS will shut down.

Click here to continue in the lesson.

Power Sources and Devices

The emergency storage battery set below the floor of the LCC provides 28-36 VDC power for operation of emergency ECS components. Power flows through noise filter EIS-101 and waits at TB2-2. Follow along in figure 4–17 as we discuss the operation of the components in emergency control panel ECP-102. At TB2-2, 28-36 VDC power will branch to the following locations:

- EMERGENCY OPERATION H-O-A switch SW-108.
- The main contacts for the K-112 motor starter for the emergency fan F-104.
- The main contacts for the K-111 motor starter for DC chilled water pump P-103.

28–36 VDC energizes the coil of emergency mode disabling relay K-110 which keeps contacts 2/6 open. As you will remember, this is the same way that the PLC prevents the emergency fan at the LF from operating.

Damper repositioning relay K-113 is de-energized which holds the normal ECS dampers open and the emergency ECS dampers closed.

Emergency ECS Start Up

The following scenario will assume that the MAF has just lost primary power. When this happens, binary output BO104-O4 contacts will open to remove power from emergency mode disabling relay K-110 and initiate the following chain of events to start the emergency ECS:

1. Relay K-110's contact closes allowing 28-36 VDC power to pass through and energize the coil of chilled water pump P-103 motor starter K-111.
2. K-111 will close its two main contacts which will start DC chilled water pump P-103. Chilled water will now begin to flow from tank TK-103 to cooling coil CC-102.
3. The coil for emergency fan motor starter K-112 will energize, closing its three contacts, which will allow 28-36 VDC power to start emergency fan motor F-104, which will begin drawing air across cooling coil CC-102.
4. Damper positioning relay K-113 will energize, opening normally-closed contact 2/6. This will cause the normal and emergency isolation dampers to reposition. The normally-open contact 3/5 will close to allow 120 VAC to flow to binary input BI105-I7, which will tell the PLC that the system is operating in emergency mode.

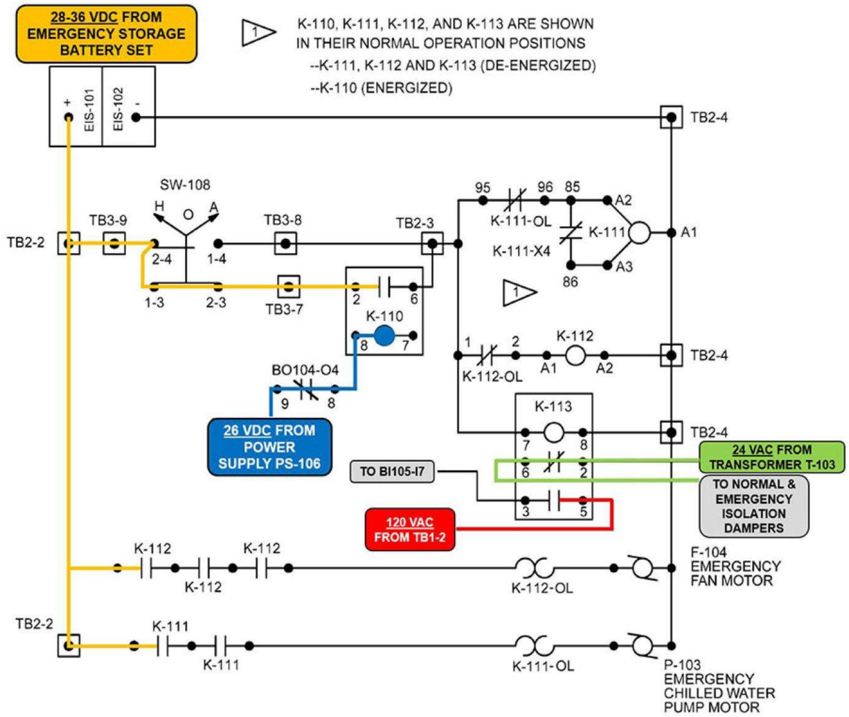


Figure 4-17. Emergency control panel ECP-102 schematic.

Chilled water circulates through cooling coil CC-102 and emergency fan F-104 moves air through an open damper to cool the electronic racks in the absence of normal air handler operation. This same process will also take place if emergency operation switch SW-108 on the front of emergency control panel ECP-102 is set to HAND, except relay K-110 will be bypassed and the PLC will only shut the normal air handler off after K-113's normally open contacts close to indicate emergency mode is on. If you remember, this is very similar to the way that the emergency ECS operates at the LF.

This lesson focused on the MAF's ECU and how liquid from chilled water storage tank TK-103 becomes the only source of cool air for the electronic racks in the LCC. Knowing how this system operates will save you hours of headache in the field when troubleshooting and performing periodic maintenance inspections.

Click here to continue on in the lesson.

Environmental Control System Alarms

Several parameters of the MAF's ECS are monitored for proper operation, and the main difference between the LF and MAF is how the alarms are reported. Since the MAF is a manned facility, the MCC are notified immediately if ECS faults occur. This section will discuss the parameters that cause fault alarms to report and also how the faults are displayed to the MCC. MAF ECS faults have not been discussed up to this point, and this lesson will provide you with the big picture.

ALARM REPORTING

Ground maintenance response GMR fault alarms are not required at a MAF because it is already manned. When ECS parameters are out of tolerance, the PLC will notify the MCC by closing a binary output (BO) module which will in turn illuminate indicator lights on the front of emergency control panel ECP-102 (fig 4–18). These alarms will all reset automatically, but personnel input might be required in some instances to return system operation back to a normal configuration. This usually involves restarting the ECS by pressing ECS RESTART switch SW-106 on the front of ECP-102.

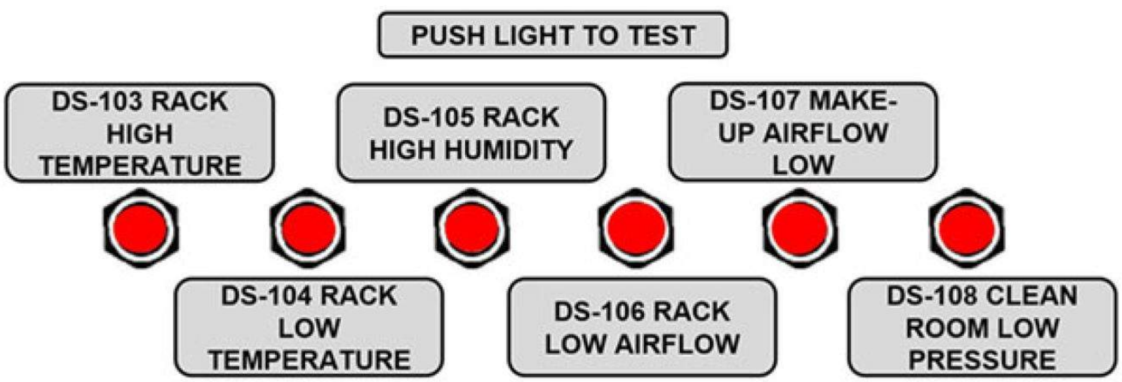


Figure 4–18. Alarm indicator lights on ECP-102.

Alarm Parameters

Six ECS parameters are monitored by the PLC, and one or more of the following indicator lights will illuminate on emergency control panel ECP-102 if any of them fall out of tolerance:

NOTE: The TO refers to the emergency control panel ECP indicator lights using the label 'DS'.

1. High air temperature to the racks (DS-103—RACK HIGH TEMPERATURE).
2. Low air temperature to the racks (DS-104—RACK LOW TEMPERATURE).
3. High humidity to the racks (DS-105—RACK HIGH HUMIDITY).
4. Low airflow to the racks (DS-106—RACK LOW AIRFLOW).
5. Low makeup air to the clean room (DS-107—MAKE-UP AIRFLOW LOW).
6. Low clean room pressure (DS-108—CLEAN ROOM LOW PRESSURE).

Let's take a deeper look at what causes each of these indications as well as how the system actually reports them. The following parameters are applicable to the Wings 3 and 5 MAF. For parameters applicable to the Wing 1 MAF, refer to Technical Order (TO) 21M-LGM30G-2-7-9, Missile Alert Facility ECS.

High Air Temperature to the Racks

Electronic rack cooling air temperature sensor TSR-104 is located in the air handler duct just after the normal air handler damper. If the temperature of the airflow to the racks is above 67°F for more than 15 seconds the PLC will illuminate ECP indicator light DS-103, RACK HIGH TEMPERATURE on

1 of 6

TSR-104 will also signal the PLC when the temperature to the

Low Air Temperature to the

racks is too low. If the temperature falls below 55°F

High Humidity to the Racks

Air handler cooling coil air temperature sensor TSR-102 is located inside of air hander unit AH-101 just after cooling coil CC-101. A temperature greater than 53°F indicates that the humidity of the air leaving the air handler is too high. If the temperature is above 53°F for more than 15 seconds the PLC

Low Airflow to the Racks

Rack cooling air pressure sensor PSR-104 monitors the differential pressure between the airflow in the duct supplying the electronic racks and the ambient air in the LCC. If this pressure is below 1.32 inwg for more than 15 seconds the PLC will illuminate ECP indicator light DS-106 RACK LOW

NBC filter makeup airflow

Low Clean Room Pressure

sensor PSR-101 senses the differential pressure at

LCEB versus clean room pressure sensor PSR-102 monitors the pressure difference between the clean room and the atmosphere in the LCEB. If this pressure difference is less than 0.05 inwg for more than 15 seconds the PLC will illuminate ECP indicator light DS-108 CLEAN

Complete the content above before moving on.

Oxygen Regeneration Unit Familiarization

Normally, ECS airflow from the clean room to the LCC provides the environment necessary to sustain the MCC. In the event of a nuclear event, the MCC will likely be confined to the LCC for a time period and airflow from the normal ECS will be unavailable because the blast valves will have closed to isolate the LCC from the outside environment. This lesson will focus on the piece of equipment that will supply the oxygen necessary to allow the MCC to survive in the isolated LCC once oxygen levels begin to drop.

The purpose of the LCC oxygen regeneration unit is to provide oxygen for the MCC to breathe in the event that the blast valves have closed and the LCC has been isolated from the outside environment.

Oxygen regeneration unit KU-101 (fig 4–19) is a stand-alone unit in the LCC situated adjacent to the ECU. It utilizes a manually operated air blower that is attached to a potassium oxide (K2O) canister. When the MCC member rotates the hand crank, KU-101 will draw the oxygen out of the canister to renew the oxygen content in the LCC. It has a flow indicator to notify the operator when oxygen is flowing.

A timer on the front of oxygen regeneration unit KU-101 will alert the MCC when it is time to operate the unit to create more oxygen. This is a manually operated timer, and the audible bell indicates that it is time to install a new canister. Spare canisters kept under the LCC floor can be accessed and swapped out if necessary.

This lesson focused on the LCC oxygen regeneration unit KU-101 which is a vital piece of life support equipment for the MCC in the event the LCC is sealed off from the outside environment.

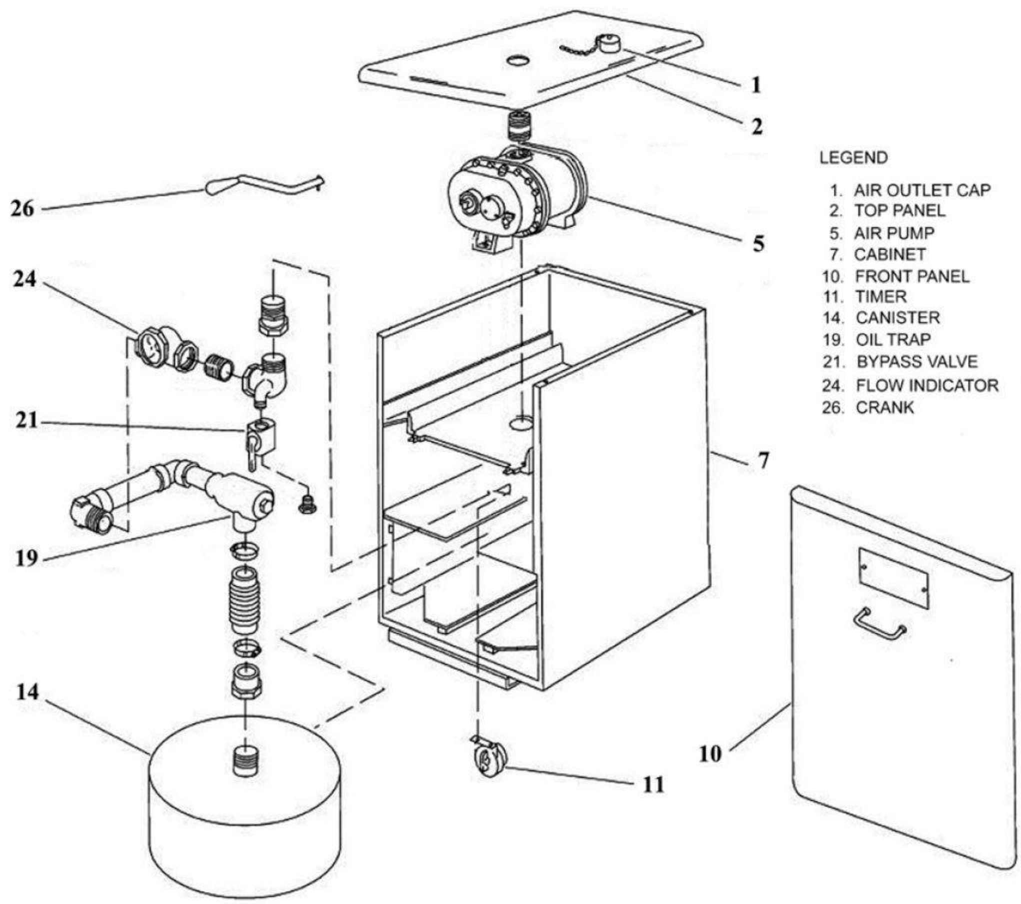
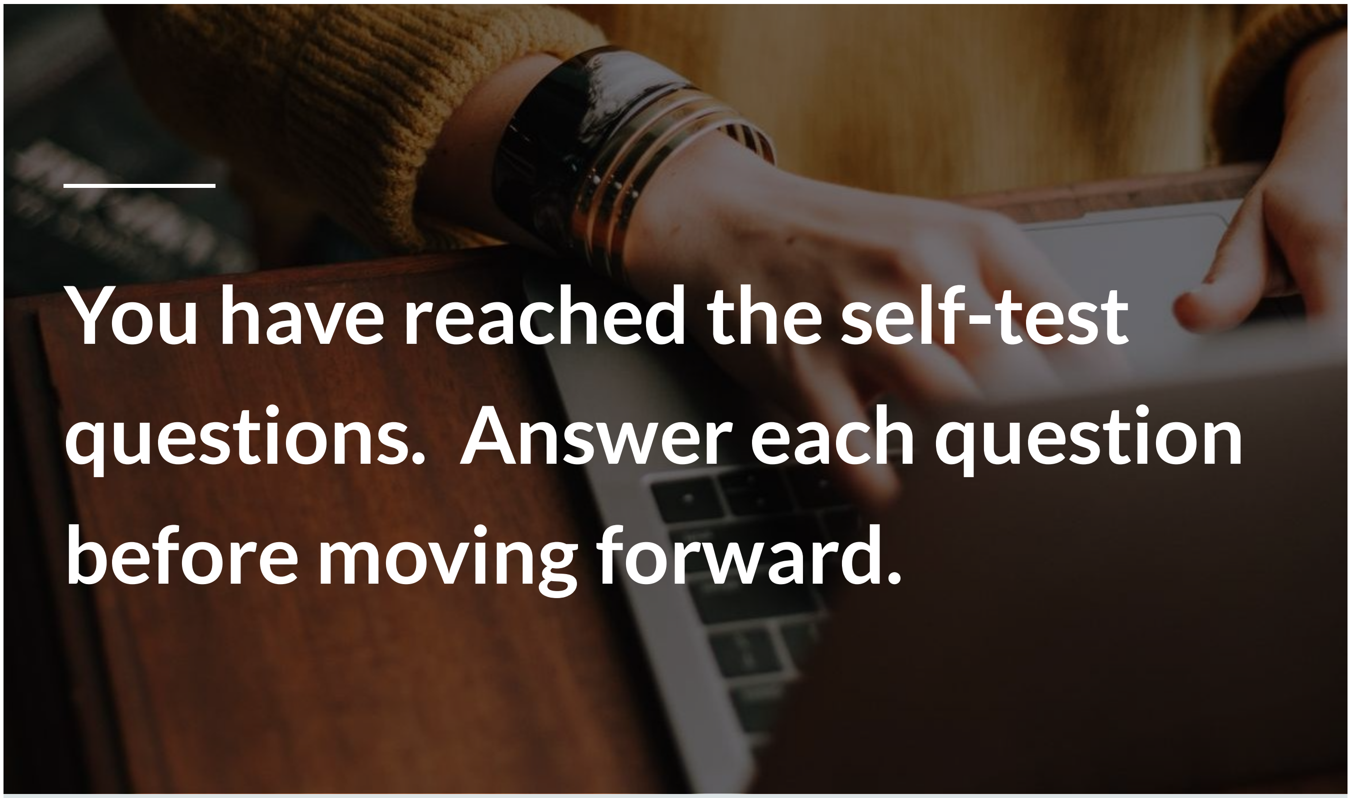


Figure 4–19. LCC Oxygen Regeneration Unit KU-101.



You have reached the self-test questions. Answer each question before moving forward.

KNOWLEDGE CHECK TIME!

For the fill-in the blank questions, you will need to add (.) period to the end of the sentences.

Click here to answer the self-test questions pertaining to the emergency cooling unit familiarization.

1. To what component does the chilled water storage tank provide chilled water?

Type your answer here

SUBMIT

2. What conditions will cause the MAF to transfer to the emergency ECS?

Type your answer here

SUBMIT

3. How does the PLC know that the MAF is on emergency ECS?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the environmental control system alarms.

1. Why is there no need for ground maintenance response fault alarms at a MAF?

Type your answer here

SUBMIT

2. What condition will cause the PLC to illuminate the DS-103 RACK HIGH TEMPERATURE indicator light on the front of emergency control panel ECP-102?

Type your answer here

SUBMIT

3. What condition will cause the PLC to illuminate the DS-106 RACK LOW AIRFLOW indicator light on the front of emergency control panel ECP-102?

Type your answer here

SUBMIT

Click on each tab before moving forward in the lesson.

Click here to answer the self-test questions pertaining to the oxygen regeneration unit familiarization.

1. How is the oxygen regeneration unit in the LCC operated?

Type your answer here

SUBMIT

2. Where are spare potassium oxide canisters for the oxygen regeneration unit stored?

Type your answer here

SUBMIT

This completes Lesson 4. You have reached the end of the last lesson in Module 4. Proceed to myLearning to take the practice exam.

Module 4: Self-Test Question Answers

Lesson 1: Fundamentals of Refrigeration

601. Principles of Refrigeration

1. Adding heat causes the substances to expand and removing heat causes them to contract.

2. How quickly the molecules in a substance are moving.

3. The amount of force exerted per unit of area.

4. 14.7 psi.

5. There is less atmospheric pressure so the boiling point decreases.

6. To avoid deterioration of the metal tubing and parts in the refrigeration system.

602. Heat Transfer Process

1. Movement of heat from one location to another by a fluid or air.

2. Transfer of heat without a material carrier.

3. Removing sensible heat from a liquid.

4. Heat added to boiling water that would not cause the reading on a thermometer to increase.

5. Refrigerant pressure decreases in pressure and temperature, but no heat is lost or gained.

6. Heat laden brine transfers its heat to cold refrigerant in the evaporator.

603. High-Pressure Refrigeration System Components

1. All brine chiller units.

2. Attaching a manifold and gauge assembly to monitor discharge pressure.

3. The hot gas bypass valve decreases the brine temperature by sending more refrigerant to the condenser to be cooled.

4. So that only liquid refrigerant is drawn into the thermal expansion valve.

5. Removes particle debris and moisture from the system.

6. The refrigeration system is free of moisture and acid.

604. Low-Pressure Refrigeration System Components

1. The thermal bulb contains its own refrigerant charge that expands and contracts to exert pressure through a small capillary tube and onto the spring of the thermal expansion valve.

2. Multiple, thin, slightly separated plates that have very large surface areas and fluid flow passages for heat transfer.

3. A manifold and gauge assembly can be attached in order to monitor the suction pressure within the refrigeration system.

Lesson 2: Environmental Control System Fundamentals

605. Refrigeration System Test Equipment

1. Fittings are designed to close when a hose is disconnected in order to keep the residual refrigerant in the hose from escaping.

2. Use a fine-tip screwdriver to turn the adjusting screw until the needle reads zero.

3. Contaminates cannot be removed if there is not a sufficient vacuum.

4. It will be difficult to locate a leak if there is not enough refrigerant in the system.

5. 500 microns or less.

6. The vacuum on the system.

606. Environmental control system test equipment

1. Monitor the LER for an abnormal accumulation of hydrogen gas.

2. It is designed to operate in an explosive environment.

3. The specific gravity of a liquid.

4. Open the valve to the brine expansion tank and allow the system to operate for 15 minutes.

5. Resistance to the movement of air inside a tube or duct.

6. Inches of water column.

7. Press the “FILT” button.

8. 120 VAC.

9. Decibels nanometer wavelength

607. Environmental control system remote monitoring system

1. In the lower launcher equipment room.

2. Within the launch tube liner near the launch tube heater.

3. In the launcher support building.

608. Environmental control system transmitting and receiving devices

1. Universal terminal base.

2. On or off (binary).

3. A damper actuator.

4. Proportional spring return.

609. Environmental control system fiber-optic and coaxial system components

1. Panel-to-panel communication.

2. Amplifies the fiber-optic signal and provides a link between the fiber-optic components in the three ECS control panels.

3. Communication between adjacent modules.

4. Coaxial cable.

5. Fiber-optic signal conditioner

Lesson 3: Launch Facility Environmental Control System

610. Brine chiller brine subsystem

1. Circulating brine between the brine chiller and the air handler.

2. This is a connection point for a wet/dry manometer used to test the flow rate of the brine through the system.

3. Through the vent on the brine expansion tank.

611. Brine chiller control panel operation

1. Controlnet adapter CNA-1, fiber-optic repeater adapter FRA-1, and binary output module BO-1.

2. Temperature switch TSW-1, low-pressure cutout LPC-1, and high-pressure cutout HPC-1.

3. Refrigerant is allowed to flow throughout the system.

612. Ventilating air and heating subsystem operation

1. It will eject hot air from the condenser coil out of the room and open the wall damper to attempt to bring cool outside air into the room.

2. So that the larger diesel electric unit exhaust fan does not overwhelm the smaller condenser coil fan.

3. The exhaust fan pulls air across the radiator.

4. 120 volts alternating current (VAC) sent by the automatic switching unit or turning the hand-off-auto switch SW-7 to HAND.

5. A portion of the air coming off of the condenser coil flows through and underground pipe to the launcher equipment room. The added air pressure then causes air from the room to return to the launcher support building through a second return pipe.

6. The heater's second stage energizes. Both heater stages are energize at this point.

613. Air handler subsystem operation

1. 120 volts alternating current will not reach binary input module BI3-I3, and the programmable logic controller will not know that the air handler fan has started.

2. Early detection of hydrogen gas. The gas is lighter than air, and will move toward the ceiling. High placement of the gas detector GD-1 will ensure that it detects a hazardous accumulation of the gas as soon as it possibly.

3. It senses 25% of the LEL of hydrogen gas.

4. Conditioned air temperature to the racks is below 50°F or above 60°F, combustible gas detector GD-1 has failed, gas detector GD-1 has detected a lower explosive limit in the launcher equipment room of greater than 25%, or makeup airflow to the launcher equipment room has dropped out of tolerance.

5. If airflow to the electronic racks is less than 0.47 inwg for more than 15 seconds.

614. Emergency fan subsystem operation

1. Directly inside the ductwork leading to the electronic racks.

2. It must run regardless of whether primary power is available.

3. The emergency fan starts and the dampers spring-return to the emergency ECS position.

615. Launch tube heater subsystem operation

1. Two separate phases of 120 VAC flow in and meet at a resistive element.

2. Emergency ECS is operating, temperature to the electronic racks greater than 60°F, launch tube heater airflow is below 0.15 inwg, refrigerant compressor RC-1 is not operating.

3. 67.5°F, plus or minus 1°F.

4. 135°F.

5. Airflow below 0.15 inwg for longer than 15 seconds.

Lesson 4: Missile Alert Facility Environmental Control System

616. Brine subsystem familiarization

1. Air handler and chilled water storage tank.

2. Cooling the electronic racks when the MAF is in emergency ECS operation.

617. Brine chiller control panel familiarization

1. By circuit breaker CB 20/22/24 in the LCEB distribution panel.

2. A high-power resistor and a metal-oxide varistor.

618. Ventilating air subsystem function and operation

1. Dampers will close to prevent heat from entering the room, and dampers will open to eject this heat from the room.

2. To allow room pressure to stabilize.

3. It will open the clean room isolation damper to allow more pressure to escape into the LCEB.

4. The radiator bypass damper will close and radiator face damper will open to allow more airflow across the radiator.

619. Air handler subsystem familiarization

1. In the clean room next to the air handler.

2. By circuit breaker CB 26/28/30 in the LCEB distribution panel.

620. Emergency cooling unit familiarization

1. ECU-102.

2. Temperature of the air flowing to the electronic racks reaches 70°F. The difference in airflow between the LCC and the pressure in the ductwork leading to the electronic racks drops below 0.82 inwg for more than70 seconds. EMERGENCY OPERATION H-O-A switch on ECP-102 is set to HAND.

3. The normally-open contact 3/5 of damper positioning relay K-113 will close to allow 120 VAC to flow through to binary input BI105-I7.

621. Environmental control system alarms

1. Because it is a manned facility.

2. Temperature of the airflow to the racks is above 67°F for more than 15 seconds.

3. If the differential pressure between the airflow in the duct supplying the electronic racks and the ambient air in the LCC falls below 1.32 inwg for more than 15 seconds.

622. Oxygen regeneration unit familiarization

1. Manually with a crank.

2. Underneath the LCC floor.

This is the end of the self-test answers for Module 4.