KEY POINTS OF DESIGN, INSTALLATION AND MAINTENANCE FOR CONFIGURING LIEBERT® XD™ SYSTEMS

Technical Note

The purpose of this technical note is to provide an overview of the primary design, installation and maintenance considerations for Liebert® XD™ systems. For complete details, always refer to the Liebert XD System Design Manual and appropriate users manuals.

Liebert XD Overview

The Liebert XD family of cooling units delivers efficient, sensible cooling to high heat environments. Liebert XD systems are designed to put cooling where the heat is. They cool computer racks and hot zones in a data center or computer room energy efficiently and without taking up expensive floor space for cooling components.

Liebert XD systems are intended for use with computer room precision air conditioning equipment, such as the Liebert DS. The precision cooling equipment is required to control the room's humidity and to filter the air, while the Liebert XD system "supplements" those functions by dissipating extreme heat at its source.

The Computational Fluid Dynamics (CFD) shown in Figure 1 illustrates the concentration of high density heat in the critical space. It also shows the heat is being removed by the Liebert XD cooling modules located on the racks, providing a cool supply of air down into the cold aisle where the server air inlets are located.

Liebert XD refrigerant-based cooling modules work as a system to support hot aisle/cold aisle equipment configurations the industry's most highly recommended method for dealing with extreme heat loads. The pumped refrigerant used in the system is ideal for use around electronic equipment, operating at low pressure in the piping circuit and becoming a gas at room conditions in the unlikely case of a leak.

The following Liebert XD equipment will be discussed in this technical note:

- Cooling modules: Liebert XDH, Liebert XDO, Liebert XDV
- Central units: Liebert XDC, Liebert XDP

Each cooling module is available in different capacities and they are all supported by the Liebert XDC chiller or the Liebert XDP pumping unit. The chiller and pumping unit connect directly to the modules. These components are shown in Figure 2 and are discussed in more detail beginning on page 9.

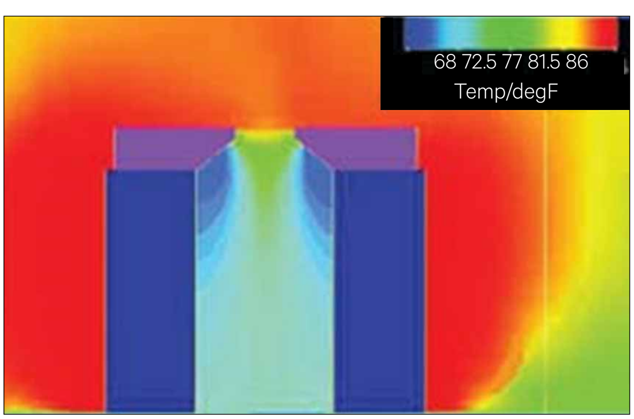

Figure 1: *Computational fluid dynamics model of Liebert XDV*

Figure 2: *Primary components of Liebert XD systems*

Liebert® XD™ Basics

Liebert XD systems consist of two cooling loops. The primary loop uses chilled water or the refrigerant R407C and the secondary loop uses pumped R134a, as illustrated in Figure 3. The fluid in the primary loop is used to maintain the temperature of the refrigerant in the secondary loop above the actual dew point of the conditioned space at all times, preventing the formation of condensation on the piping. The factory setting of the margin between the supply fluid temperature and the calculated dew point is 4 degrees F, but it can be changed by the user.

A high-precision pump circulates liquid R134a refrigerant through the secondary loop. As the refrigerant travels through the coils of the cooling module, heat is transferred from the passing warm air, causing the refrigerant to boil and change phase. Now a gas, the R134a continues to the condenser where it condenses and once again becomes a liquid.

Because Liebert XD systems use phase changing pumped refrigerant technology, they have a built-in, automatic capacity/temperature control. The self-regulating capacity function is achieved through the phase-changing of the fluid as it passes through the cooling module. If there is a low heat load and low entering air temperature to the cooling module, the capacity goes down. A high heat load and higher entering temperature to the cooling module causes the capacity to go up. In addition, the controls in the pumping unit – Liebert XDP (and the refrigerant chiller, Liebert XDC), which supplies pumped refrigerant to the modules – can be set so the room is not over-cooled.

This unique pumped refrigerant technology has a number of advantages over water. There are no water lines in the conditioned space and no condensation is formed on the coils or the refrigerant lines. Pumped refrigerant allows the modules to be mounted overhead, the piping to be routed above the racks without drip pans, does not interfere with the electronic equipment in case of a leak, and is more space efficient and energy efficient than water based cooling technologies.

The energy efficiency of the Liebert XD system warrants special mention. Properly spaced cooling modules and the Liebert XD system's fluid phase change technology combine to reduce a Liebert XD system's energy consumption to at least 30 percent less than a traditional cooling system.

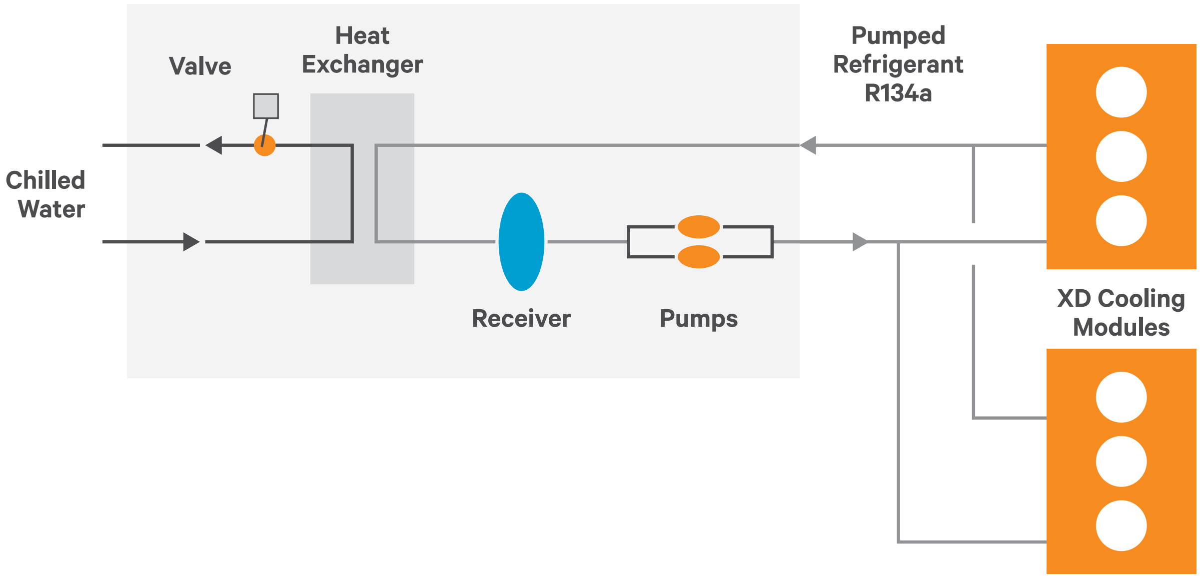

Figure 3: *Liebert XDP component layout.*

The Liebert® XD™ family maintains this energy efficiency by employing the heat absorption properties of a liquid (pumped refrigerant) through a phase change. Refrigerant is pumped as a liquid, becomes a gas within the heat exchangers of the cooling modules and then is returned to the pumping unit where it condenses to a liquid (Figure 4). If a leak were to occur, the environmentally friendly refrigerant would escape as a gas, causing no harm to critical equipment. Because no compressor is used, oil is not used in the Liebert XD pumped refrigerant loop.

Figure 5 shows typical temperatures of the R134a refrigerant as it travels through the secondary loop. The room relative humidity in this example is 55 percent. The refrigerant begins the cycle at point A with a temperature of 56 degrees F. It leaves the pump at point B, with a temperature of 57 degrees F, having picked up a small amount of heat generated by the pump motor. At point C, the refrigerant enters the first cooling module; the temperature is approximately 57 degrees F. At point D, the temperature of the refrigerant is 60 degrees F, but it is now a gas and has absorbed the heat necessary to change phase, the latent heat of vaporization. The refrigerant enters the condenser with a temperature of 58 degrees F. It leaves the condenser with a temperature of 54 degrees F ready to start another cycle.

Liebert XD systems are operating at low pressure in the pumped refrigerant circuit. Figure 6 illustrates the pressure of the refrigerant as it travels through the secondary cooling loop. The pressure of the liquid R134a refrigerant entering the pump at point A is approximately 54 psig. It exits the pump at point B at a pressure of 82 psig. The refrigerant arrives at the cooling modules, point C, with a pressure of 77 psig. It leaves the cooling module at point D, its pressure having dropped to 58 psig. The refrigerant arrives at the condenser, part liquid, but mostly gas with a pressure of 55 psig.

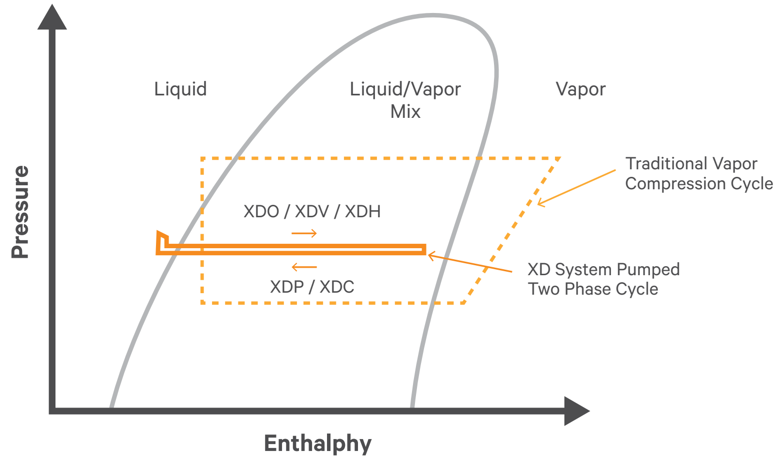

Figure 4: *Liebert XD pumped refrigerant, pressure – enthalphy.*

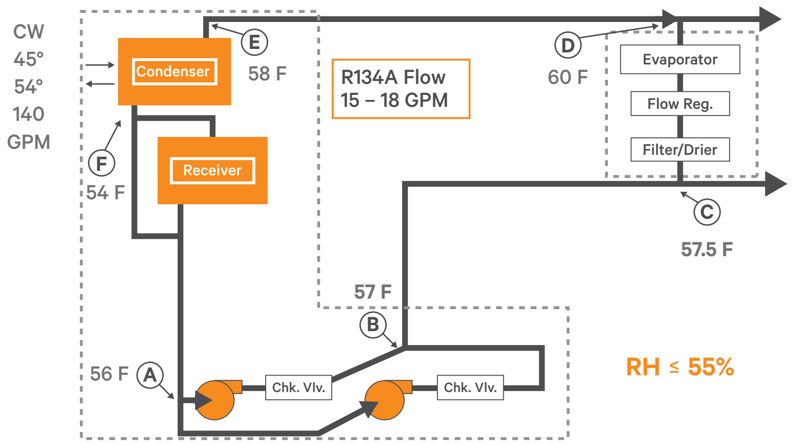

Figure 5: *Liebert XDP secondary piping schematic showing temperatures of R134a refrigerant as it travels through the circuit*

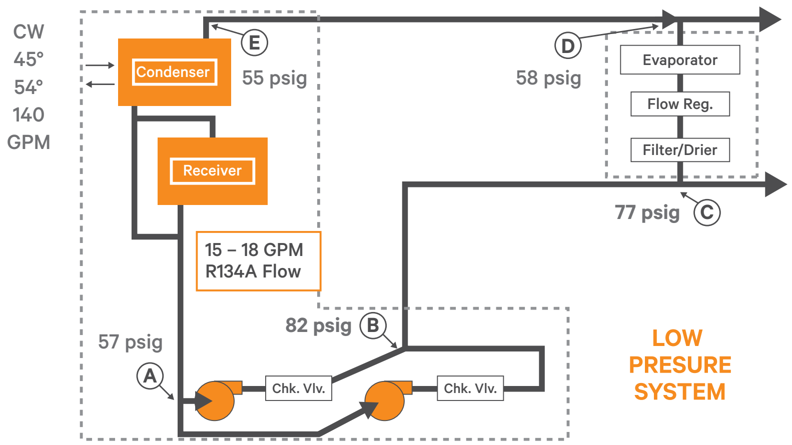

Figure 6: *Liebert XDP secondary piping schematic showing pressures of R134a refrigerant as it travels through the circuit.*

Liebert® XD™ Design Simplicity

Liebert XD products offer the flexibility to tailor easily to most critical space requirements. The components required for an efficient supplemental cooling system are so deliberately simple, a system could almost be designed on a napkin.

Three guidelines should be followed to effectively incorporate the Liebert XD system into a cooling plan:

1. Incorporate redundancy 1. and plan for growth.
2. Use computer room precision air conditioning (base level cooling and humidity control) for heat densities up to 5 kW per rack. (The 5 kW level depends on site specific factors such as raised floor height/duct sizes, room layout, etc.)
3. Use the appropriate Liebert XD cooling modules (supplemental cooling) for heat densities of 5 kW per rack and greater.

Figures 7 through 15 illustrate how these guidelines are met in designing a medium sized server room with a heat load of 10 kW per rack. For this example, it is assumed building chilled water is available (Figure 7).

To design the system we first need to calculate the total load and heat density (Figure 8). A total of 30 racks – two rows of five racks each and two rows of 10 racks each – comprise the critical system. At 10 kW per rack, the total heat load is 300 kW. Other heat load sources such as people, solar gain, etc., are not included in this example.

By dividing 300,000 (300 kW converted to watts) by 1,156 (the square footage of the server room), we get a heat density of 260 watts per square foot.

As noted previously, up to 5 kW per rack can typically be handled by the computer room precision air conditioning, such as the Liebert CW051 chilled water unit, selected for the purposes of this example.

Each unit provides 70 kW of cooling. This design incorporates one operating Liebert CW051, with another unit in standby for redundancy.

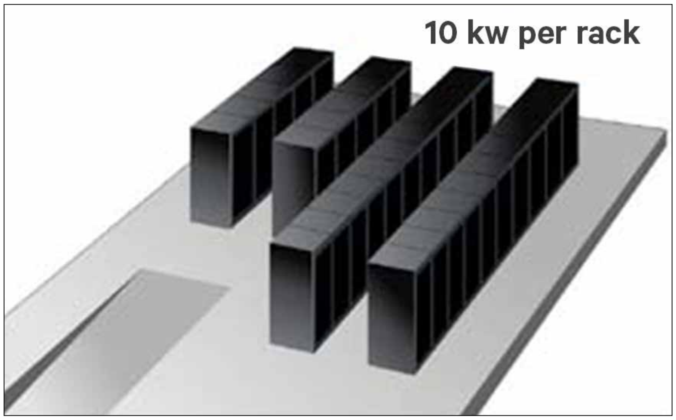

Figure 7: *Server room with 10 kW per rack and available building chilled water.*

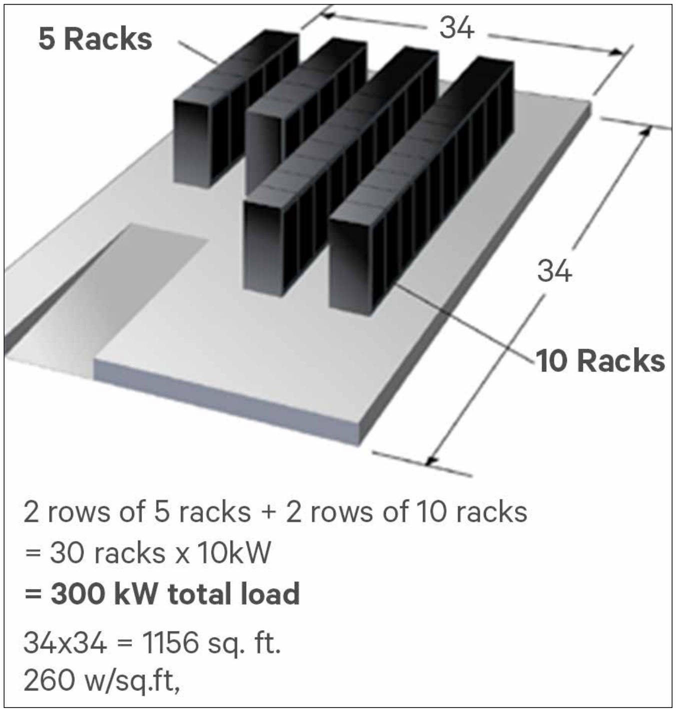

Figure 8: *Calculate total load and heat density.*

With 70 kW provided by the Liebert CW051 base cooling, 230 kW is required from the Liebert XD systems, each of which provides 160 kW. Two Liebert XD systems are required, loaded at only 70 to 75 percent of their full capacity to allow reserve capacity for future growth.

Now, consider whether enough redundancy has been built into this design (Figure 9). Each of two Liebert XD systems provides 160 kW of cooling, and each of two Liebert CW051 units provides 70 kW. No matter which unit is stand-by or shut down for maintenance, the remaining three systems will carry the load.

A plan view of the room is shown in Figure 10. It illustrates the two pumping units (Liebert XDP) centered on one wall. The Liebert CW051 units are located on either side, aligned with the hot aisles, following best practices. The Liebert XD system takes up very little floor space.

The overhead space in the room is an important part of the design. Looking at the floor plan alone is not enough. The overhead space must be checked for obstructions, such as lighting, beams, cable trays, and fire suppression, as shown in Figure 11. Developing an overhead piping plan is critical to avoid difficult surprises during installation.

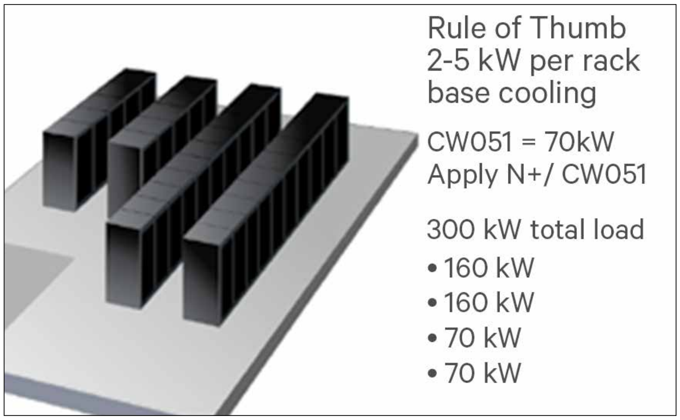

Figure 9: *Plan for redundancy.*

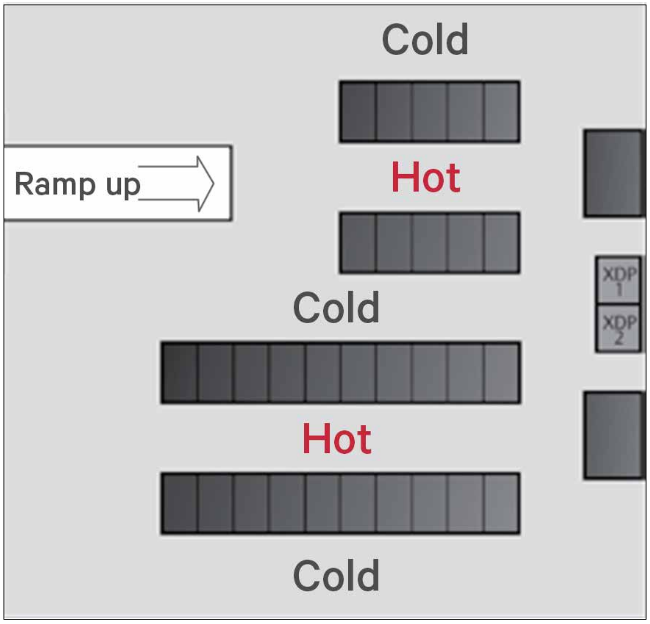

Figure 10: *Server room plan view.*

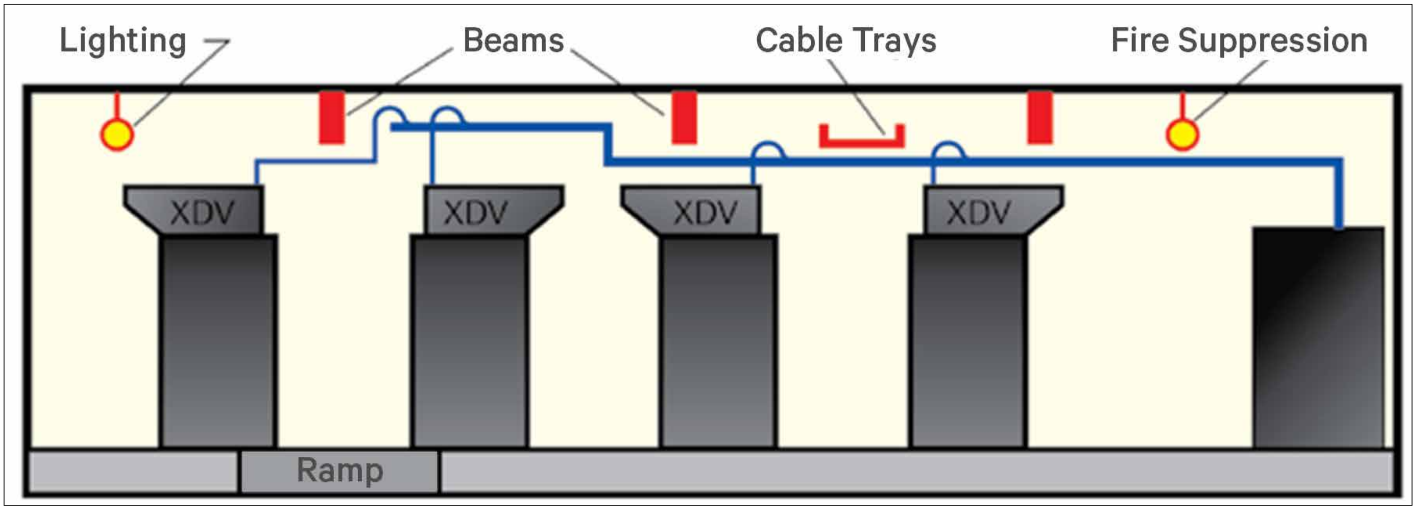

Figure 11: *Check overhead space.*

Interlacing is another important factor to consider when designing the supplemental cooling system, because it improves reliability. Figure 12 shows the Liebert cooling modules (Liebert XDV in this case) are supplied from alternating pumping units. If one pumping unit is shut down for maintenance, the remaining Liebert® XD systems can pick up heat load from all areas. Use interlacing to provide the best availability whenever possible.

At this point the cooling solution design is complete; however, a different approach may be needed should plans change. Following are some "what if" scenarios that demonstrate the flexibility of the Liebert XD system in typical situations encountered during the design process.

1. What if the hot and cold aisles are reversed, as shown in Figure 13? You can simply turn the XDV cooling modules around. Or Liebert XDO cooling modules may be more appropriate than the Liebert XDV. You can also mix and match cooling modules as needed.

2. What if the load is uneven? Figure 14 shows the original 10 kW per rack on the yellow racks only, with quite a few 5 kW heat load racks in blue, and one area having 20 kW heat load racks shown in red. Uneven load is not a problem with the Liebert XD. Spread out the Liebert XDV where the load is light, and double stack them where the load is heavy. Problem solved.

3. Figure 15 shows the elevation view with the double-stacked Liebert XDV solving 20 kW or more per rack. But what if the ceiling is too low to double-stack the modules? That problem is solved by keeping the single Liebert XDV modules, and adding a few Liebert XDH cooling modules between racks to pick up the added heat from those 20 kW heat load racks.

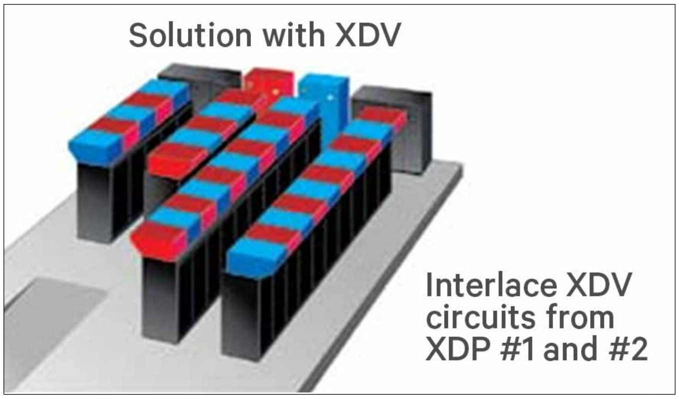

Figure 12: Interlace system.

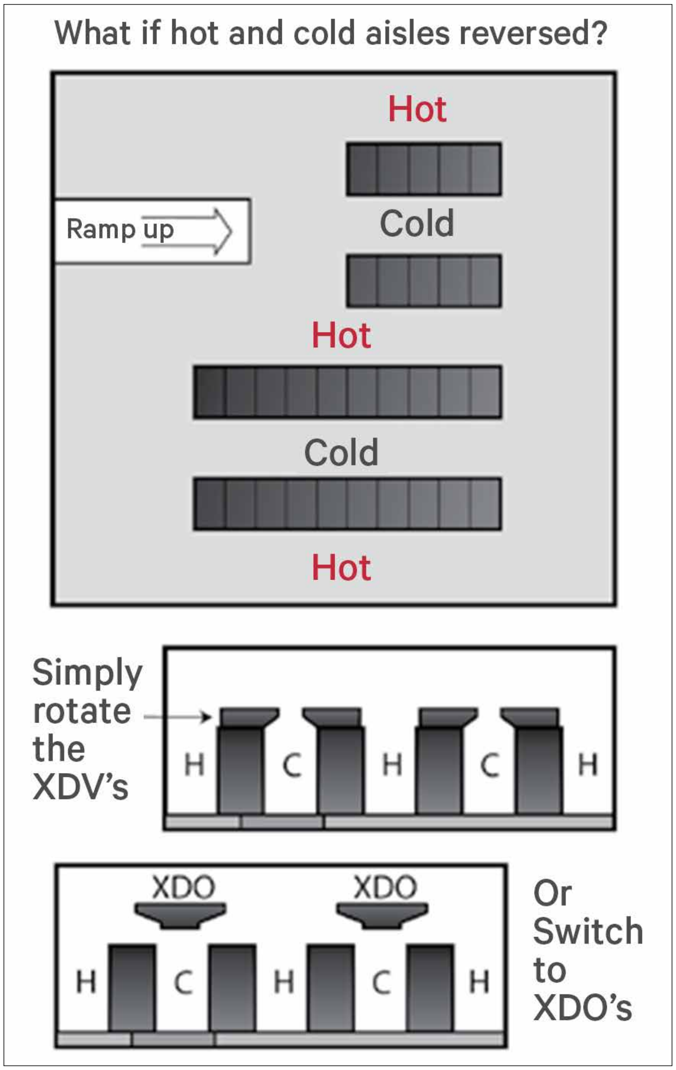

Figure 13: Adapting to change in hot and cold aisles.

Liebert® XD Components

As previously noted, two types of central units (Liebert XDC and Liebert XDP) and three types of cooling modules (Liebert XDH, Liebert XDO, Liebert XDV) with different capacities are available and may be selected based on the application.

Liebert XDP

The Liebert XDP pumping unit isolates the building chilled water circuit from the Liebert XD secondary loop. It cools and circulates the pumped R134a fluid used by the Liebert XD cooling modules. The pumping unit can be mounted against the wall or in a corner.

Liebert XDC

When chilled water is not available, the Liebert XDC chiller is the answer. Primary cooling is provided by four scroll compressors arranged in two tandem circuits. The combination of staged control augmented by electronic hot gas bypass valves provides a smooth linear output for precision control of the secondary loop temperature. The Liebert XDC is available in an air-cooled configuration with a remote condenser or with a water-cooled condenser.

Liebert XDO

The XDO cooling module consists of two cooling coils, two flow control valves, one filter dryer, and one fan. The simplicity of its design contributes to the low maintenance and high reliability of the Liebert XD system. Proper spacing between racks is important for the efficient operation of the Liebert XDO system. Depending on the cooling capacity to be achieved, spacing between Liebert XDO modules in a row may vary from zero to as much as 6 feet. Large distances between the top of the racks and the cooling module can result in the short cycling of air between the hot aisles and cold aisles. Therefore, blocker panels may also be required to direct the air from the Liebert XDO cooling modules to the equipment being cooled in some cases.

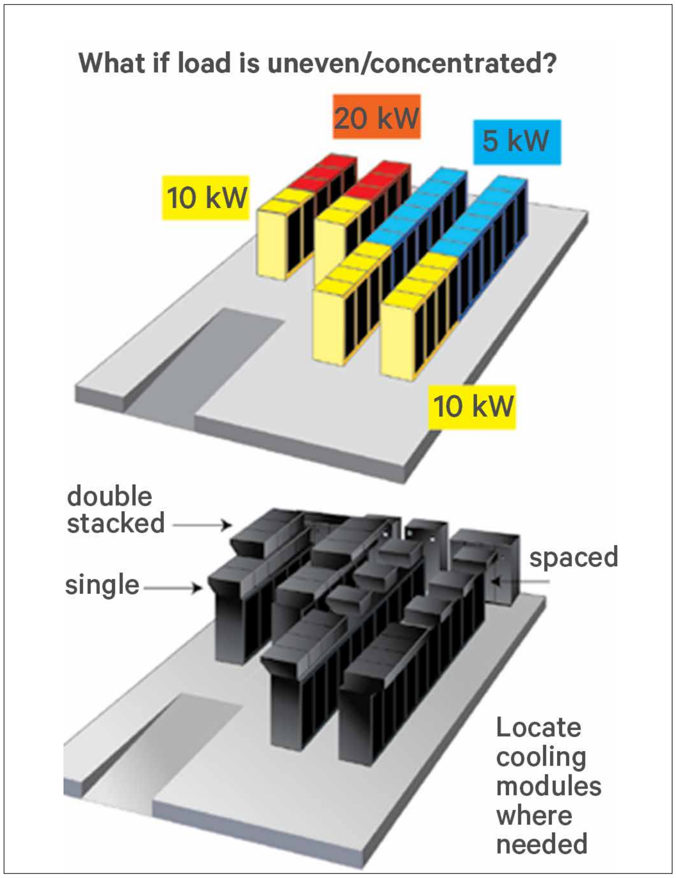

Figure 14: *Adapting to uneven load.*

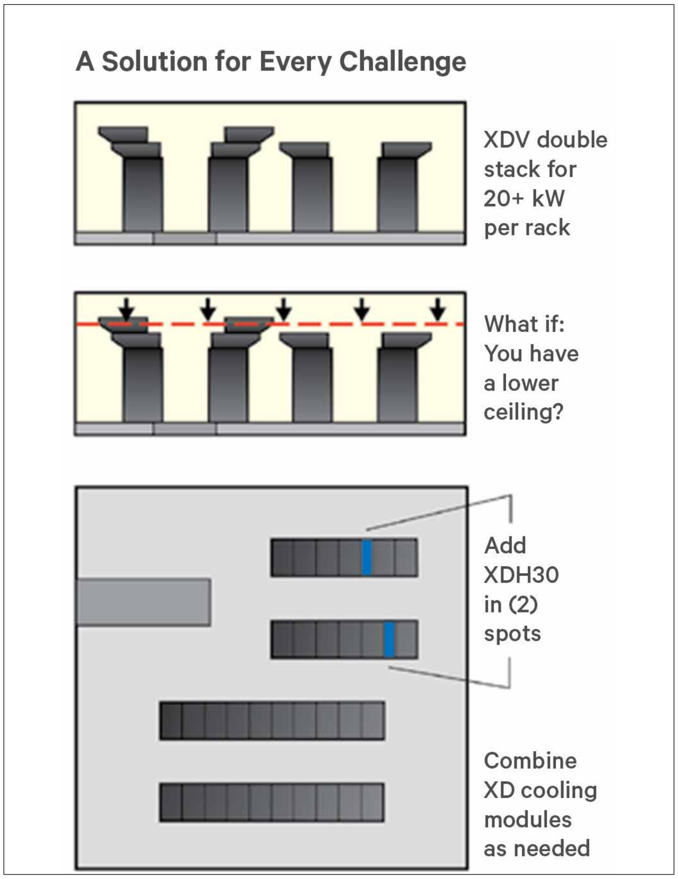

Figure 15: *Adapting to ceiling height.*

Liebert® XDV

Liebert XDV cooling modules can be directly mounted on top of the racks or suspended from the ceiling above. When suspending modules above the rack, a blocking plate between the bottom of the XDV and the top of the rack is recommended.

The Liebert XDV also is simple and reliable. The refrigerant passes through a filter dryer, a flow control valve, and into the cooling coil. Two fans draw the heated air through the coil.

Air can be drawn into the Liebert XDV either through the bottom or back of the cooling module by the positioning of adjustable panels. The modules can be double-stacked, again demonstrating the flexibility of the Liebert XD system.

With higher heat loads, under-floor air delivery may be optimized and space gained for double stacking of the Liebert XDV. This configuration can allow for cooling of more than 20 kW for each rack location.

Liebert XDH

The Liebert XDH is effective in critical spaces where overhead distribution cooling modules are not an option. This cooling module mounts in the row, drawing from the hot aisle and feeding the cold aisle. Only very little overhead space is required for the refrigerant piping system. The floor space required for the Liebert XDH is one-half of a normal rack footprint.

The Liebert XDH is available for 22 or 30 kW of cooling. With such a large capacity, the Liebert XDH is divided into two separate fluid circuits. Two supply and two return piping connections are built in. The upper and lower coils can be fed from separate Liebert XDC or Liebert XDP units to interlace the circuits internally for the best redundancy.

Refer to the Liebert XD System Design Manual, available at www.liebert.com, for additional application guidelines for these components.

System Design Highlights

The Liebert XD System Design Manual also details important considerations for designing a Liebert XD system. Below are several of the most critical to keep in mind.

Number of cooling modules

There is a minimum and maximum number of cooling modules that may be applied with each combination of equipment. For instance, if you have a Liebert XDP pumping unit supplying Liebert XDV10 cooling modules, the number of cooling modules must be between 4 and 16.

Liebert XDC and XDP minimum load

The Liebert XDC's minimum recommended operating load is 40 percent of system nominal capacity. The Liebert XDP's minimum recommended operating load is 20 percent of system nominal capacity. Consult factory for any loading below this recommendation.

Spacing of cooling modules

For any piping run more than 175 feet, consult your Liebert application engineer for factory assistance. At 175 feet or less, the cooling modules may be positioned at any location and allow additional ports for future growth. Apply shutoff valves to allow maintenance and expansion with minimum downtime.

Pipe sizes

Refer to the line sizing chart in the Liebert XD System Design Manual for the supply and return main pipe sizing, as well as to size individual piping drops to each cooling module.

Calculating refrigerant charge

Use the example shown in the design manual to calculate the refrigerant charge. Fill the system with the calculated charge only; do not overfill. This caution is discussed in more detail on page 13.

Refrigerant detection and ventilation system

ASHRAE Standard 34-2007 allows up to 13 pounds of R134a per circuit per 1,000 cubic feet of room volume. (Local codes can have other values.) Above this value, an automatic refrigerant detection and ventilation system must be installed in case of a refrigerant leak. For example, in a 2,500 square foot room with an 18-inch raised floor and 8.6-foot ceiling height, the maximum allowable charge of R134a for any one circuit is 325 pounds, which would accept most Liebert® XD systems. But if this room was much smaller, then automatic refrigerant detection and ventilation would be required according to the ASHRAE Standard. Check each space with Liebert XD equipment and piping to ensure it complies. This requirement applies to any refrigeration system.

Installation Rules

When installing a Liebert XD system, special attention must be given to the piping, controls and charging techniques.

Piping Considerations

Return line slope

The number one installation rule is that the Liebert XD return piping must slope continuously down, all the way back to the Liebert XDP or Liebert XDC. This is because the return piping carries a mixture of liquid and vapor R134a refrigerant. Do not allow any dips or traps that could accumulate liquid refrigerant, blocking gas return and causing reduced efficiency or erratic performance. On the other hand, the supply line is filled 100 percent with liquid refrigerant only, so there are no restrictions for it.

Cooling module height

The 9-foot maximum piping rise from the cooling modules allows headers into the ceiling space. The 20-foot maximum piping rise from the Liebert XDC chiller or Liebert XDP pumping unit allows this equipment to be placed one floor below. The return piping main must slope back to the Liebert XDC or Liebert XDP at a minimum of 1 inch per 20 feet, as illustrated in Figure 16.

Bypass flow controllers

Bypass control valves are used to maintain the optimal refrigerant supply to all the cooling modules. To ensure the Liebert XDP/ Liebert XDC pumps operate within the optimum range, some installations require bypass flow controllers (BFC). It is recommended to install sufficient quantity of BFCs to allow for future flexibility in the number of Lieberty XD modules. Each BFC should be installed with one shutoff valve to allow the controller to be disabled when cooling modules are added to the Liebert XD system.

If BFCs are required, they should be connected between the main supply and the main return lines of the field piping. The connection points to the main supply and return lines should be in a convenient and accessible location between the Liebert XDP/Liebert XDC and the first Liebert XD module in the circuit. See the Liebert XD System Design Manual for piping details as well as the number of BFCs required based on the total nominal capacity of the cooling modules in each Liebert XD system.

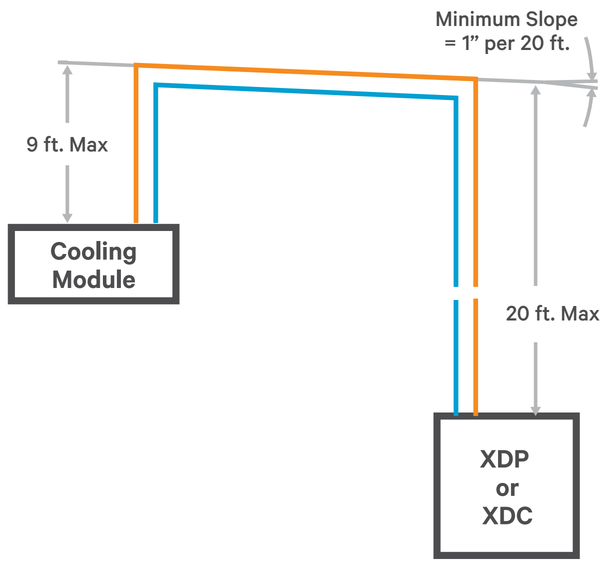

Figure 16: *Cooling module height and slope from module to chiller or pumping unit.*

Flexible piping arrangement

The Liebert XD pumping modules can be connected to the cooling modules using hard or flexible piping. As heat loads increase in the space, a flexible piping system can keep up with the growing demand for cooling. Installation times can be reduced using prefabricated header kits or individual port kits. All port assemblies consist of a mounting bracket, quick disconnect and isolation valve. However, connection ports should only be attached to the upper half of the return line to ensure the unrestricted flow of refrigerant gas to the Liebert XD condenser. A constant downward slope is required. The return line should be free of any traps or dips where liquid refrigerant may collect and impede the flow of the refrigerant gas back to the condenser.

Although easy to install, the bending radius of flexible piping is limited. To avoid on-site modifications, piping lengths and bending radius limits should be considered during the design phase.

Hard piping arrangement

The Liebert XD user can also elect to install a hard pipe system. Tighter radiuses are possible with hard piping, allowing the installer to easily maneuver the piping around fixed obstacles in the room.

Isolation valves are recommended for each Liebert XD component and each branch of supply and return piping in a hard piping arrangement. This allows the operator to isolate a component or branch and perform needed repairs or expand the systems without totally shutting down the Liebert XD system.

Figure 17 shows the inverted trap on the return line of the hard-piped Liebert XDO. Depending on the location, any condensation of the refrigerant gas in the return line will travel back to the cooling module where it will be converted into a gaseous state, or into the return line where it will flow to the condenser in the pumped refrigerant circuit.

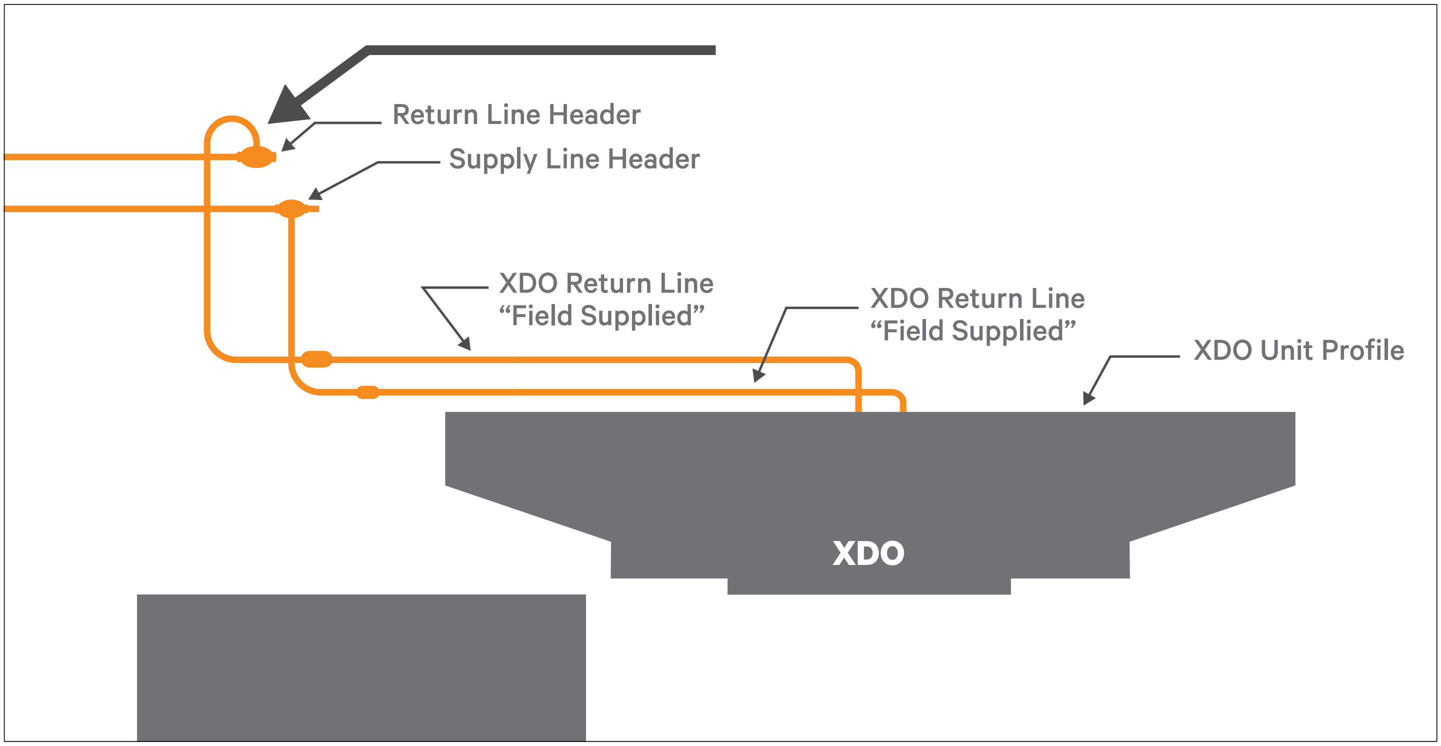

Figure 17: *Liebert XDO hard piping arrangement showing inverted trap at return line connections.*

The supply line is 100 percent liquid, so traps and dips do not interfere with the flow of refrigerant. Isolation valves on the return and supply lines allow the cooling module to be isolated for maintenance, repair or relocation without shutting down the Liebert XD cooling system.

Filter dryers

Filter dryers are used to remove moisture from the R134a refrigerant. Replacing the replaceable filter dryer at the Liebert XDP/ XDC three months after start up and any time the piping system is opened or new components are added is recommend.

Thermal insulation

When located in the conditioned space, thermal insulation of the refrigerant piping is not required. However, if the piping is located outside of the conditioned space, thermal insulation is necessary to prevent the formation of condensation on the refrigerant lines.

Refrigeration piping good practices

When installing a refrigeration piping system, good practices need to be followed. Refer to the ASHRAE refrigeration handbook for general good-practice refrigeration piping.

Liebert XD Controls

The Liebert XD control systems use two temperature and humidity sensors. The local sensors are located in the display panel, normally found on the Liebert XDP/ Liebert XDC unit. If the unit is located outside the conditioned space, the display panel should be relocated to the conditioned area. The remote sensors are mounted in a location within the conditioned space where the highest humidity levels that can cause condensation might occur.

To prevent the formation of condensation, the sensor reporting the highest humidity level is used to control the supply temperature of the pumped refrigerant in the secondary loop. If one sensor fails, the second sensor will take over and an alarm will activate.

Liebert XD units are self regulating. While the controller offers many of the same features found in other Liebert control systems, the amount of programming required to operate the system is much less. Figure 18 shows the control display and its menu.

Charging Techniques

Charging the Liebert XD system is simple. The charge can be added using a standard recovery machine, or the Liebert XD pumps can be operated using the "test output" mode of the diagnostics program. When using the Liebert XD pumps to charge, it is necessary to elevate the refrigerant bottle to maintain a positive suction head and prevent cavitation in the pumps.

Menu

Set points	Service Password
Status	Calibrate Sensor
Active Alarms	Alarm Enable
Alarm History	Alarm Time Delay
Time	Common Alarm Enable
Date	Custom Alarms
Setup Operation	Custom Text
Set-point Password	Diagnostics

Figure 18: *Liebert XD standard LCD controller*

Startup Procedure

The Liebert® XDP and Liebert XDC User Manuals list a few easy steps for start up that should be carefully reviewed. The start up step that will be the focus of this document is:

"If constant flow is established, wait until the Liebert XDP has been operating for 10 to 15 minutes, then verify that the refrigerant level in the receiver sight glass is between the second and third level (see Figure 19). Add or remove charge, if necessary."

Following the easy-to-use guide in the *Liebert XD System Design Manual*, the Liebert XD system's charge is calculated and added to the unit. When operating the Liebert XD system with a normal load, the refrigerant enters the cooling coil in the cooling module. Hot air blowing through the coil transfers its heat to the refrigerant, causing the refrigerant to boil at the transition level.

If the heat load in the space is reduced, it will take a longer period of time to transfer enough heat into the refrigerant to result in a phase change. As a result, the transition level will rise. The additional refrigerant in the cooling coils will result in a lower level in the Liebert XDP/Liebert XDC unit's reservoir tank.

As the heat load in the space increases, boiling of the refrigerant takes place much sooner. As the transition point moves lower in the coil, less liquid refrigerant is needed. The excess liquid will cause an increase in the reservoir. Operation of the Liebert XD systems without a load will result in a low suction head to the Liebert XD pump, causing cavitation. To prevent overcharging the system, only the calculated charge should be added to the Liebert XD system during the installation phase of the project.

Refrigerant levels should be adjusted only after a normal load is available in the conditioned space. Figure 20 indicates the levels at normal, low and high heat loads for the module.

Figure 20: *Refrigerant transition points.*

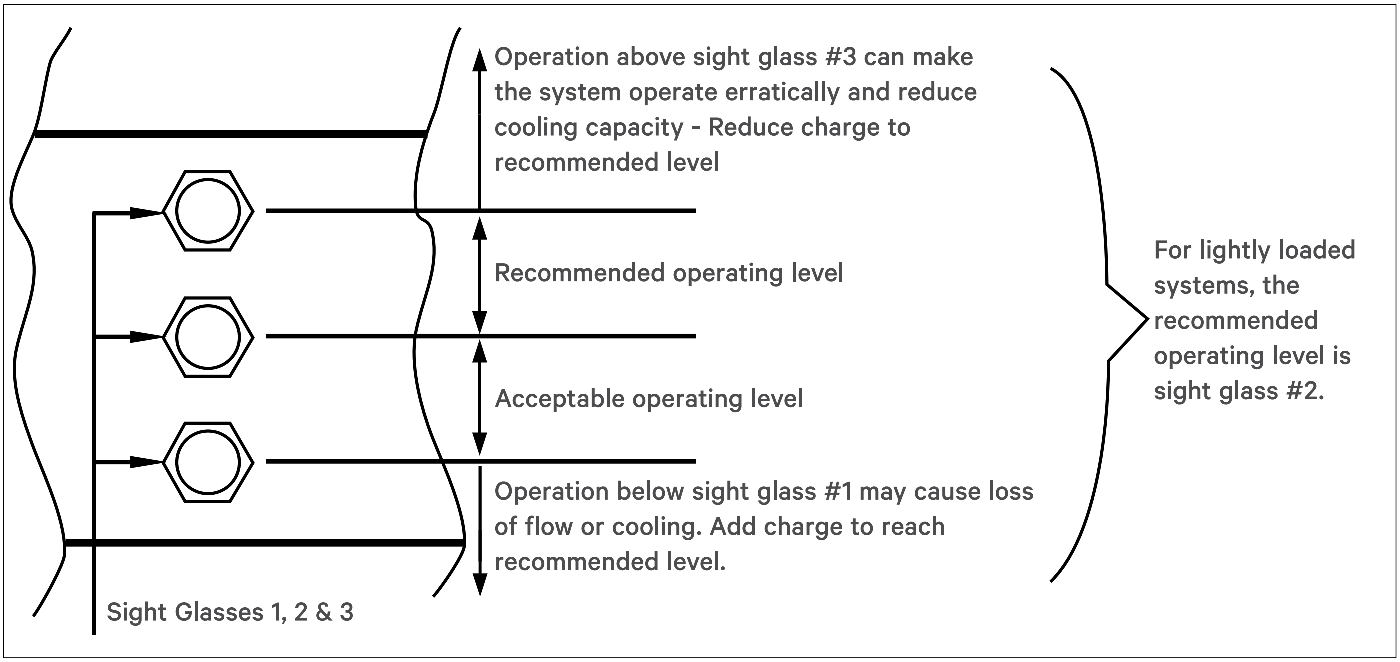

Figure 19: *System R134a liquid level.*

Maintenance

Minimal but regular maintenance checks as specified in the user manuals will keep the Liebert XD system operating at optimal levels.

Visual inspections should be conducted to note any leaks. Check receiver levels to ensure proper operation of the system. Fan coils and cooling fins also should be inspected for cleanliness. To ensure correct and efficient operation of the cooling system, verify that the vapor barrier is good.

In addition to the visual inspection, a tactical inspection should be made to check:

- Air flow in the cooling modules
- Temperature drop across the filter dryer (the replaceable filter dryer at the Liebert XDP/XDC should be changed after the initial three months of operation, then annually)
- Chilled water temperatures and flow, if possible
- Refrigerant temperatures
- Delta/T across cooling module coils, which will vary with area load.

Electrical checks that should be made include:

- Amp draw on the refrigerant pumps
- Abnormal pump noise or vibration
- Amp draw on cooling module fans
- Abnormal fan noise or vibration
- Chilled water valve/transducer operation (test outputs in run diagnostics)

Finally, note that it is critical to read and record all operational parameters when at steady state condition to establish a baseline. Compare readings taken during routine maintenance against this baseline. Changes in computer room loads will result in changes to the steady state reading, so be sure to update them as required.

Conclusion

In summary, the following points are critical to properly configuring a Liebert® XD system:

- Liebert XD systems provide supplemental removal of sensible heat only! They must be used in conjunction with properly sized computer room precision air conditioning systems that handle the humidity control, fresh air supply and air filtering
- The area being cooled must be sealed for proper operation of the Liebert XD system. Too high levels of room humidity will reduce the system's capacity
- Carefully inspect overhead conditions for obstructions prior to installation
- Avoid traps in the hard or flexible piping connecting the cooling module and refrigerant return line
- The refrigerant return line must be sloped downward toward the Liebert XDP/Liebert XDC at a rate of 1 inch per 20 feet of pipe run
- According to ASHRAE, the minimum requirement for a R134a circuit is 1,000 cubic feet room volume for each 13 pounds of refrigerant in the circuit
- Maintain a current record of operational parameters

See also the *Liebert XD System Design Manual* and appropriate users manuals for complete details.

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