Technical Requirements for Supplemental Cooling Systems
In Network Equipment Environments

This practice provides guidelines and requirements for engineering a supplemental cooling system for high heat equipment environments in AT&T buildings.

Audience: All network, video, internet services, mobility, data center employees

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1. INTRODUCTION

This technical practice defines and establishes requirements for the design and installation of a high heat density cooling system in AT&T equipment environments. A high density cooling system provides supplemental cooling capacity where required to accommodate high heat loads of equipment that cannot be handled with traditional space cooling systems.

2. GENERAL

2.1 Description

2.1.1 To accommodate the greater heat density demands of current and future equipment technologies, a supplemental cooling design may be required beyond traditional overhead ducted room cooling systems or perimeter Computer Room Air Conditioner (CRAC/CRAH) units. Heat densities exceeding 15 KW per cabinet are being deployed with the latest generation of products in AT&T equipment space. These higher heat densities become a challenge for traditional space cooling designs. Supplemental/hybrid cooling designs discussed in this practice shall be deployed when equipment heat loads exceed traditional room cooling system capabilities.

2.1.2 Cooling system designs in this practice provide pumped refrigerant-based remote cooling units immediately adjacent to the source of heat. Cooling units may be in-row units integrated into equipment lineups, located above equipment lineups or installed as a rear door attached to an equipment cabinet. This interim standard provides approval to plan and deploy BOC technology with the proviso that designs are approved prior to awarding contracts. Required approvals are authors. Contact information is listed on the cover page – Points of Contacts – Authors.

2.1.3 In systems recommended by this standard, remote cooling units use a refrigerant loop to move heat from the equipment space to a refrigerant pumping unit. Pumping unit(s) shall be placed away from equipment line-ups and designed to pump liquid refrigerant to the remote cooling units. The circulating refrigerant turns partially into gas as it absorbs heat within the heat exchangers of the remote units. The refrigerant is pumped back to the pumping unit where the heat is transferred to either the building chilled water system or outside air via air cooled condenser(s).

2.1.4 The refrigerant used in these units becomes a harmless and non-ozone depleting gas if a leak should occur in the plumbing. Exposure to the gas will not harm electronic equipment or occupants in the room unless skin comes in direct contact with escaping gas which may result in frostbite.
2.1.5 Remote cooling units integrated in network equipment lineups or placed immediately above equipment lineups shall not use or contain water, liquid coolant and condensate drainage or require the removal of any of these fluids.

2.1.6 Some supplemental cooling systems (e.g., Liebert XD system) provide only sensible cooling. In cases where these units are deployed, the building central plant or CRAC/CRAH’s located in the equipment area shall be used to remove latent heat (e.g., humidity) in line with AT&T standards.

2.1.7 Cooling design shall be used in conjunction with hot aisle/cold aisle equipment configuration as shown in illustrative Figure 1/1a. Equipment framework shall be configured in continuous lineups with front-to-front and back-to-back layout. All efforts to reduce air mixing between hot and cold aisles shall be made by use of blanking plates and equipment cooling airflow from front to the back of the cabinet/frame.

2.1.8 Deployment of remote cooling units requires close coordination between CRE, Common Systems/COLD Engineers and MEI’s because cooling units are either integrated into or placed above equipment lineups. It is recommended that an elevation or section cut-out drawings showing both Network and CRE infrastructure (e.g., AutoCAD) be constructed to assure clearances and identify obstructions between projected overhead structures.

2.1.9 Aisle containment typically improves performance of these cooling designs and should be incorporated where possible. Installations where heat load per cabinet exceeds 10KW shall require appropriate aisle containment to avoid air mixture within and between aisles (Back of Cabinet systems do not typically require containment).

3. DEPLOYMENT STRATEGY

3.1 Design Approach Network Equipment Space

3.1.1 Space cooling in existing equipment buildings is typically provided by overhead ducts and air handling equipment with actual building cooling capacity designed for 40 to 50 Watts per square foot (i.e., upwards of 425 watts per frame using an 8.5 sq. ft. footprint). In floor areas where 50% of the frames produce no heat, the remaining 50% of frames may have loads up to 850 watts per frame (i.e., average of 50 watts per square foot across the floor). Heat loads greater than 850 Watts in a frame may require added floor space for distributing heat across a larger floor footprint.

3.1.2 More recent equipment space, such as Next Generation Network (NGN) space, may have perimeter CRAC/CRAH units and cooling air distributed by a raised access floor and perforated floor panels. Heat density limits for these spaces may be extended above 100 Watts per square foot.
3.1.3 Preparing existing equipment space for higher heat densities may be difficult or not possible due to inability to provide cooling air to locations of high heat equipment. Overhead duct size and runs may be restricted by cable racks and cables over equipment frames. Air handling units may not have the capacity for added heat load.

3.1.4 Supplemental cooling systems may provide the only pathway towards higher heat density limits in existing equipment space. Extra cooling capacity applied to a specific space in the equipment room can be provided with remote cooling units. Cooling units are connected by refrigerant tubing that will occupy very little space and flexible enough to be routed around cable racks.

3.1.5 In general, heat loads above 4 KW per frame are difficult to cool using conventional space cooling techniques. Supplemental cooling methods may provide additional capacity to handle these high heat loads. Precise cool air supply directed to equipment becomes key to cooling such concentrated heat loads.

3.1.6 When designing supplemental cooling designs, heat density in equipment space should be viewed as total Watts per frame rather than Watts per square feet. Supplemental cooling designs provide cooling in localized area of high heat equipment. Adjacent equipment frames housing equipment with total heat load of 20 KW may be served by a single remote cooling unit with a 20 KW capacity. Developing a Thermal Management Plan including the location of remote cooling units as well as cooling infrastructure paths should be planned for current and future heat loads. Great care should be taken to lay out the electronic equipment with the air inlets and outlets designed to take full advantage of the alternating cold and hot aisle design to maximize efficiency of heat removal and enhance network reliability.

3.1.7 CRE shall obtain permits for the installation of the pump unit, chiller and associated remote units for the ultimate installation planned for the space based on Common Systems/COLD Engineers ultimate forecast and equipment/cable racking layout. The CRE project manager/consultant in cooperation with the Common Systems/COLD Engineer shall select the specific type of remote unit(s) required. The CRE contractor shall install pump unit, chiller and remote units to meet either the minimum operational efficiency threshold (i.e., 48kW for XDP or 64kWXDC) or the three year forecast whichever is greater. For subsequent remote cooling unit installations, CRE shall assist with the coordination of the installation of remote cooling units via their mechanical contractor.

Note: The 48kW minimum XDP load requirement as identified by Liebert is based on a system with a typical length of feed pipe. As identified by Liebert technical staff, there may be a site specific lower minimum load based on the length of the feed piping. The 48kW minimum is a standard design criterion. A low load design unit is available. Should a site specific minimum need be required, contact the authors for review support.
3.2 Primary Cooling

3.2.1 The building central air handler units (AHU) may be used to provide a base level (typically 50 watts/sq. ft. in traditional Central Office equipment areas) of cooling of the planned space being considered for supplemental cooling. This is a practice that is being increasingly adopted by owners and operators of Data Centers and Telecommunications facilities due to its inherent energy saving and redundancy advantages. The use of building central air handlers as part of a hybrid cooling solution may provide the following advantages:

- Substantial energy savings through the use of outside air (free cooling) in cooler periods of the year.
- By design, the Liebert XD system does not have the ability to control humidity (i.e., dehumidification) in order to avoid condensation over and around live servers and other equipment. The building central plant may provide this capability. In addition, a supplemental system is required to handle building envelope loads, infiltration, etc.
- Current Liebert XD system requires approximately 40% load (as percentage of capacity) to function. In many cases, the initial loads in the space may be less than this threshold. Having this base level of cooling in place allows the space to be cooled until the loads in the space grow to over this 40% threshold.
- Provides redundancy from a system other the XD in-row coolers resulting in added diversity, lower risks and reduced costs.
- Most of AT&T Central Offices have existing primary cooling of roughly 50 watts per square foot. This plant has already been paid for (sunk costs) and therefore leads to a savings in first capital costs.

3.2.2 In rare cases where the building central air handlers are not available or insufficient for primary cooling or use of outside air is limited by local conditions (e.g., high humidity), consideration should be given to the use of CRAC/CRAH’s for base cooling. This option has many of the same advantages of the building central plant but lacks the energy efficiency and redundancy advantage that results from the use of outside air as well as the lower first cost from redeployment of existing plant. Consideration may also include use of a hybrid cooling solution utilizing a combination of distributed refrigerant based cooling elements and CRAC/H units.

3.2.3 Supplemental cooling designs do not require raised access floors and can allow sharing of overhead space with cable management systems and cooling air ducts in the same space. Overhead ducts may not be as large since the bulk of cooling is provided by supplemental cooling units.
3.2.4 In very high humidity locations, air handlers or CRAC/CRAH units may be required to reduce humidity in equipment space in order to permit proper functioning of refrigerant cooling systems. The refrigerant pumps are designed to control refrigerant temperatures and flow rate to avoid condensation on pipes and remote cooling coils. High humidity in room may cause refrigerant pump to reduce flow and increase refrigerant temperatures thereby reducing sensible cooling capacity of system.

3.3 Supplemental Cooling

3.3.1 Supplemental cooling designs are intended for applications where localized cooling is required for a lineup of high heat products or an individual cabinet of high heat. Heat loads over 850W and up to 4kW per cabinet are considered high heat. Heat loads per cabinet above 4kW are considered extreme heat.

3.3.2 Remote cooling units of a supplemental cooling design allow for the placement of additional cooling capacity directly where high heat load cabinets are located. In-row or above cabinet remote cooling units draw heat from the hot aisle, cooling the air before discharging cool air into the cold aisle and the intake of equipment in cabinets. Back of cabinet transfer heat directly from the equipment cooling it before it has a chance to discharge into the hot aisle.

3.3.3 Supplemental cooling is intended to be applied in conjunction with existing base space cooling system of a room. For sites with overhead duct diffusers or under access floor air distribution, diffusers or perforated floor panels may remain in place aided by the supplemental cooling units. Consideration of the cooling provided by them may improve overall efficiencies.

3.3.4 Remote cooling units should be placed within the equipment lineup, above cabinets or as an adjunct to an individual cabinet generating the greatest amount of heat.

3.3.5 Remote cooling units in the Liebert XD system connect to a central refrigerant pumping unit that removes heat from equipment space by way of the refrigerant loop.

3.3.6 Reduction of floor space use is another benefit with supplemental cooling because thermal management spacing of network equipment would not apply. Thermal management spacing rules are established to spread high heat equipment across a larger floor footprint to stay within heat density limits (usually 100 Watts/square feet). Supplemental cooling systems allow for higher heat density within each equipment cabinet and/or in certain area(s) on the floor than previously permitted.
4. REFrigerant Pumping Unit

4.1 Chilled Water Refrigerant Pumping Unit

4.1.1 In buildings with available chilled water capacity, the chilled water pumping unit is often the most convenient and economical solution. The pumping unit interfaces between the building chilled water system and the remote cooling units. It circulates and controls refrigerant to the remote cooling units placed in network equipment lineups. The pumping unit contains a heat exchanger, redundant circulating pumps, control valve, receiver, controls, valves and piping. Each pumping unit is rated at 160KW (~45 Tons sensible cooling).

Note: Chilled water supplemental cooling systems such as Liebert XDP pumping units shall not be specified for spaces where the initial heat load is expected to be less than 48 kW as the units will not run under these conditions.

4.1.2 As stated in paragraph 3.2.1, by design the Liebert XD refrigerant pump does not have the ability to control humidity (i.e., dehumidification) in order to avoid condensation over and around live servers and other equipment. The refrigerant pumping unit avoids condensation by raising the refrigerant temperature as the relative humidity level in the space increases. This will in turn cause the refrigerant pumping unit to go into alarm and reduce cooling capacity.

Note: In order to avoid this lower capacity and alarm condition, relative humidity (RH) levels in spaces with supplemental cooling (e.g., Liebert XD system) shall not be allowed to exceed 40% RH.

4.1.3 Once the Common Systems/COLD Engineer has completed the equipment line-up floor plan (including forecasted growth), the CRE D&C Project Manager and consultant shall coordinate the number and location of refrigerant pumping units in said space. Pumping units shall be located against walls near building chilled water sources. Ideally, each unit shall be installed perpendicular to the cold aisle it is intended to support in order to minimize refrigerant pipe runs and bends. Additionally, 36 inches of maintenance access clearance shall be provided in front of each unit. CRE shall design and install supply and return pipes to pumping unit(s) tapped off of the closest chilled water lines.

4.1.4 Pumping units come standard with a two-way chilled water control valve. As such, a pressure activated bypass valve shall always be specified and installed by CRE when the units are added to constant volume (i.e., primary pumping only) chilled water systems in order to prevent dead-heading of the chilled water pump. Also, chilled water temperature reset control methods shall not be exercised in buildings using chilled water based refrigerant pumping units (e.g., XDP’s). Isolation valves shall be provided in supply and return pipes between the pumping unit and building chilled water headers.
4.1.5 In slab deployments, pumping unit cabinets shall be secured to the building floor slab with concrete expansion anchors in accordance with building code requirements.

4.1.6 In raised floor deployments, pumping unit cabinets shall be secured to a structural frame in accordance to AT&T standard requirements.

4.1.7 CRE Design & Construction shall design and install power feeds for each pumping unit rated at either 460V/3ph/60Hz 2.1 Full Load Amps or 208V/3ph/60Hz, 4 Full Load Amps (depending on available building distribution panel (MCC) voltage rating).

4.1.8 Refrigerant supply and return lines routed to the remote units are located at the top center of the pumping unit, 1-1/8 inch diameter for supply and 2-1/8 inch diameter for return for runs up to 60 feet or 1-3/8 inch and 2-5/8 inch over 60 feet but less than 175 feet (equivalent pipe length).

4.2 Air Cooled Refrigerant Pumping Unit

4.2.1 In buildings where chilled water capacity or supply is not available or where diversity is desired, air or water-cooled refrigerant chiller units (XDC) shall be installed. Refrigerant chiller units have two distinct circuits each utilizing different refrigerants and mechanical parts. As of the date of this standard, the R-134a circuit is the pumped circuit between the network equipment remote cooling units and the chiller. The R-407c circuit of an XDC is a dual direct expansion (DX) circuit connected to an outdoor condenser. Either an air-cooled condenser or water/glycol condenser for colder climates is available to match each of these units. Each pumping unit is rated at 160KW, ~45 Tons sensible cooling.

Note: Air cooled supplemental cooling systems such as Liebert XDC units shall not be specified for spaces where the initial heat load is expected to be less than 64 KW as the units will not run under these conditions. There is no low load version available.

4.2.2 As stated in paragraph 3.2.1, by design the Liebert XD refrigerant pump does not have the ability to control humidity (i.e., dehumidification) in order to avoid condensation over and around live servers and other equipment. The refrigerant pumping unit avoids condensation by raising the refrigerant temperature as the relative humidity level in the space increases. This in turn causes the refrigerant pumping unit to go into alarm and reduce cooling capacity.

Note: In order to avoid this lower capacity and alarm condition, relative humidity (RH) levels in spaces with supplemental cooling (e.g., Liebert XD system) shall not be allowed to exceed 40% RH.
4.2.3 Once the Common Systems/COLD Engineer has completed the equipment line-up floor plan (including forecasted growth), the CRE D&C Project Manager and consultant shall coordinate the number and location of pumping units in said space. Pumping units shall be located against walls near building chilled water sources. Ideally, each unit shall be installed perpendicular to the cold aisle it is intended to support in order to minimize refrigerant pipe runs and bends. Additionally, 36 inches of maintenance access clearance shall be provided in front of each unit. For air-cooled condensers, CRE shall design and install a 1-3/8 inch diameter hot gas refrigerant line and 1-1/8 inch diameter liquid line. Pipe runs cannot exceed 200 feet equivalent piping length. Shorter runs shall always be considered a preference in system layout. The CRE Contractor must install 400 psig pressure relief valves in the R-407c refrigerant circuit. Shutoff valves shall not be installed between the compressor and the pressure relief valve.

4.2.3 Condenser units cannot be placed in locations lower than 15 feet below the pumping unit. Condenser units shall be secured in accordance to building code requirements.

5 REMOTE COOLING UNITS

5.1 Network Equipment Lineups

5.1.1 In extreme heat density environments, network equipment shall be housed in consistent height, width and depth frameworks such as data cabinets configured in continuous lineups as shown in Figure 1/1a. The lineups shall be arranged in “Cold” and “Hot” aisle configurations with every effort made to contain as much of the cold air in the front aisle and preventing hot exhaust air in the rear from mixing. Blanking panels, side panels and equipment airflow directed from front to back shall be maintained to reduce mixing of air.

5.1.2 Extreme heat density equipment housed in individual cabinets and not intended to be in continuous lineups shall also be configured for “Hot” and “Cold” aisles leaving space between cabinets. Cooling air intake shall be from one aisle and warm air exhaust to other aisle for all cabinets. Isolation of hot and cold aisles may be required to provide integrity to the cooling design/structure.

5.1.3 In-row and overhead remote cooling units of the supplemental cooling system are designed for “Hot/Cold” aisle environments with cool air introduced to the front “Cold” aisles and exhausted warm air returning from rear “Hot” aisles.

5.1.4 Equipment lineups may require reserved space (12 ¼”) between equipment cabinets for the insertion of remote cooling units within the lineup. Planning of equipment lineups where supplemental cooling designs are deployed requires
coordination between the COLD Engineer and CRE D&C project manager on placement of remote cooling units. Blanking plates/structures shall be provided in reserved but not filled space to assure integrity of the hot and cold aisles.

5.1.5 Remote cooling units are integrated into network lineups either with in-row horizontal cabinets, suspended overhead above network equipment or installed as a rear door to the equipment cabinet. In-row cooling units shall be secured to adjacent equipment frames with brackets at each top corner, using self tapping screws. Cooling unit shall be anchored to floor at front and back. Securing of in-row cooling units may require external brackets.

5.1.6 Back of cabinet door cooling units may add approximately six inches to cabinet depth. Where BOC cooling units are utilized, Common Systems/COLD shall maintain aisle spacing standards by taking into consideration the additional 6” depth of the cooling unit frame (12” overall additional depth in common hot aisle).

6. REFRIGERANT LINE INSTALLATION

6.1 Locating Refrigerant Pipes

6.1.1 From the refrigerant pumping unit, CRE shall design and install refrigerant header distribution assemblies along either the cold or hot aisle (depending on the most efficient configuration). Figure 6 shows header distribution assembly refrigerant piping run in the hot aisle on a combined power/cooling structure. The header distribution assembly shall be equipped with quick-connects and valves to allow for the connection of current/future remote cooling units and extension of the refrigerant piping to adjacent aisles as capacity permits. Future unit location(s) shall be based on the ultimate equipment layout provided by the Common Systems/COLD Engineer.

6.1.2 Refrigerant lines may be run up to a maximum of 175 feet equivalent pipe lengths between the pumping unit and remote cooling units. Supply refrigerant piping shall be 1-3/8 inch diameter and return pipe 2-5/8 inch diameter. For runs of less than 60 feet equivalent pipe length, 1-1/8 inch diameter supply and 2-1/8 inch diameter return pipes may be used. (Equivalent pipe length includes pressure loss across bends, valves, joints, and tees in each pipe run). The main supply and return lines must be installed sloping downward toward the pumping unit at a rate of 1"-2" per 20 feet of pipe run. Horizontal connector lines should also be sloped downward from the remote cooling units toward the main supply and return lines. The pipes shall be ASTM Type “L” copper pipe intended for refrigerant service at maximum operating pressure of 90 psi.

6.1.3 All refrigerant pipes shall be assembled with high temperature brazed joints. The lines being brazed must be filled with flowing dry nitrogen during brazing to prevent oxidation and scale formation inside of pipe. Brazing operations shall be very limited in
equipment space with in-service equipment and shall comply with all AT&T TP 76300/76301 installation requirements (e.g., bagging or shut-off of smoke detectors and associated fire watch, detailed MOP’s, etc).

6.1.4 Bypass flow controllers and shut off refrigerant grade ball valves shall be provided in pipe runs for servicing and emergency shutdown.

6.1.5 In the case of Liebert’s current design, a header distribution assembly with quick-connect fittings and valves shall be provided in the piping run where remote cooling units are to be installed. The header distribution assembly provides a connection port to remote cooling units for all current or future units via quick connect couplings without disrupting refrigerant flow. Header distribution assembly are available in 10 feet segment, with 5 or 10 ports, or 8 feet segment with 2 or 4 ports, or custom headers may be assembled on site to meet specific field requirements. Note: Said design detail is provided as an example only and will likely change as Liebert and other manufacturers further develop their product lines.

6.1.6 In the case of Liebert’s current design, runs between the remote cooling units and the connection port of the distribution assembly shall be with flexible pipe with quick-connect fittings. Flexible pipes are available in 4, 6, 8 or 10 feet lengths. In central office environments, refrigerant pipe runs will be located above cable racks and require flexible pipe to reach header distribution assembly at that height. Support methods will vary depending on specific site conditions. Note: Said design detail is provided as an example only and will likely change as Liebert and other manufacturers further develop their product lines.

6.1.8 In the case of Liebert’s current design, refrigerant pipe runs should be located between 11’-7” and building ceiling clear of all cable rack runs. Pipes shall not be located where they will interfere with cable piles extending 12 inches above cable rack. Refrigerant pipe runs are allowed between 9’-4” and 11’-7” level only if cable racks are not placed in that vertical space. Site coordination with Common Systems/MEI and CRE is required to minimize conflicting structures. Note: Said design detail is provided as an example only and will likely change as Liebert and other manufacturers further develop their product lines.

6.1.9 In the case of Liebert’s current design, flexible refrigerant pipes between remote cooling units and connection port shall be run vertically up to distribution assembly with support provided at approximately every 3 feet. The longest unsupported run of flexible pipe shall not exceed 4 feet. Support may be provided by securing a pipe clamp to side of auxiliary framing channels or cable rack stringers for sites where auxiliary framing channels do not exist. See Figures 8 and 9 for pipe support details. Note: Said design detail is provided as an example only and will likely change as Liebert and other manufacturers further develop their product lines.
6.1.10 In the case of Liebert’s current design, the flexible pipe supply line is ½” diameter and the return line is 1” diameter. Due to a protective covering, the overall outside diameter of flex pipe will be greater for both lines. Flexible pipe is available with straight connector or 90 degree connector if needed on the pipe end connected to remote cooling unit. Due to reduced headroom clearance, it is recommended that designs specify straight fitting only for the top attachments to the XDH units. Use of 90 degree hose fitting when attached to the top of XDH in-row cooling unit(s), direct the flexible hosing over the walk area of the hot aisle. This results in significant reduction in head room clearance and should be avoided. Note: Said design detail is provided as an example only and will likely change as Liebert and other manufacturers further develop their product lines.

6.1.11 A tag shall be affixed to each end of the flexible connecting pipe advising of refrigerant content, the need for eye protection when servicing and warning of gas discharge / low temperature risks when disconnecting.

7 REMOTE COOLING UNITS

7.1 In-Row Horizontal Units

7.1.1 Freestanding in-row remote cooling units are best utilized when placed among the equipment cabinets within lineups in a hot aisle-cold aisle arrangement. Cooling units draw air from the hot aisle, cool it and then discharge the cool air into the cold aisle. In-row units should be installed between equipment cabinets as shown in illustrative Figure 3.

7.1.2 In-row cooling units are slightly larger than 12 inches wide (use 12 ¼” to provided minimal clearance), 42 inches deep and 78 inches high (80 inches including pipe connections). Empty weight of cooling unit is 246 pounds. In-row horizontal cooling units are equipped with casters for general transport and movement to the assigned position. These casters are mounted outboard of the unit and need to be removed before final positioning.

7.1.3 In-row cooling units (XDH’s) are available as 20 KW or 32 KW cooling capacity with both capacity units housed in similar dimensioned cabinet. Each unit is supplied with two cooling loops, each providing ½ of the total unit’s designed capacity.

7.1.4 In-row cooling units must be attached to adjacent equipment cabinets when installed in equipment lineup. Cooling unit cabinets are to be attached to equipment cabinets using brackets provided with each unit at each top corner. Secure cooling unit(s) to floor with anchors using a locally sourced external bracket.
7.1.5 The front face of in-row cooling unit(s) shall be placed so as to extend past the front face of equipment cabinets by approximately 1 ½” to allow for unobstructed airflow from the front air flow director grill. The rear of the cooling units may not align and extend beyond depth of equipment cabinets if equipment frames are less than 42 inch depth. Cooling shall be configured so cold air is introduced into front/cold aisle and return air into remote cooling unit drawn in from rear/hot aisle.

7.1.6 In-row cooling units are to be placed at a minimum of every two or typically at a maximum of every third equipment cabinet in lineups depending on the heat mitigation plan. Cooling units in opposing lineups should be staggered with cooling unit of the opposing lineup as shown in Figure 3. Greater effectiveness may be achieved with an in-row cooling unit located at end of lineup to reduce warm air recirculation to front of cabinet by way of air moving around end of cabinet. End of row units should incorporate unidirectional air director grills – ordered through the same Liebert source as the XDHs.

7.1.7 In-row cooling units may be applied to cool standalone equipment cabinets by locating cooling unit beside the equipment so warm discharged air of equipment can be recovered from the rear and cold air directed to front of equipment. The in-row cooling unit should not be more than 3 feet from equipment cabinet.

7.2 Overhead Cooling Units

7.2.1 Remote overhead located cooling units are available to be placed to support equipment aisles when overhead space is available. Cooling units draw heat from hot aisles, cool it and then discharge the cooled air downward into the cold aisle.

7.2.2 Overhead cooling units are available in a version that hangs over center of the “Cold” aisle or in a version that attaches directly to the top of an individual equipment cabinet. Suspended cooling units are designed with cooling capacity for multiple equipment cabinets while cabinet top units cool serve a single cabinet.

7.2.3 Overhead cooling units are applied only where cooling unit will not create interference with cable rack runs or cable entrance into top of cabinets. Network equipment overhead space is reserved for one to three levels of cable racks from 7’-5” up to 11’-8” height. Cable racks may be planned for parallel runs directly over equipment frames, in front or rear aisles. Cross aisle cable runs may be installed perpendicular to lineup runs at 6 feet intervals.

7.2.4 Suspended cooling units should be placed in rows directly above the cold aisle with sides facing perpendicular to hot aisle. Each cooling unit can serve an area equal in width to the cold aisle spacing, typically 12 to 16 feet. Return air is drawn from the sides of unit and cold air discharged down into the cold aisle.
7.2.5 Suspended cooling units shall not be installed above equipment cabinets at a height greater than 30 inches when measured from bottom of cooling unit to top of cabinet.

7.2.6 Suspended cooling units shall be supported by threaded rod hangers from building ceiling anchors. Hanger rod lengths longer than 2 feet requires diagonal bracing cooling unit against sway. Diagonal bracing may be provided by rigid structural steel braces or wire rope cables in two directions. Cooling units shall be braced for side-to-side movement and front-to-back displacement. In high seismic risk locations, building code requirements shall be followed for bracing designs.

7.2.7 Suspended cooling units have four 7/8” diameter mounting on top of each unit. Minimum 5/8” diameter threaded rod hanger shall be used to support each cooling unit to ceiling anchors or surface mounted Unistrut channel. Empty weight of a suspended cooling unit is 150 pounds.

7.2.9 Suspended cooling units are available in 17.2 KW and 20 KW cooling capacity. Cabinet mounted cooling units are available in 8.8 KW and 10 KW cooling capacity. Cooling capacity shall be chosen in accordance to heat load of equipment in cabinets. Multiple cooling units are required for greater heat loads than an individual unit can provide.

7.3 Cabinet Top Remote Cooling Units

7.3.1 Cabinet top mounted cooling units function similar to overhead suspended units except they are installed directly on top of equipment cabinets. Cabinet top cooling units may interfere with cable management systems and access of cables in and out of equipment cabinet. Cabinet top cooling units shall only be applied where cable access is not an issue.

7.3.2 Cabinet top mounted cooling units shall be secured to cabinet by through-bolts. Mounting clips supplied by cooling unit manufacturer permits attachment to cabinets to field drilled holes in cabinet top. Cooling units shall be secured to cabinet with a minimum of four through-bolts of at least ¼” diameter. Cabinets must be verified to have the capability to carry an 80 pound cooling unit in addition to mounted equipment weight prior to installing cooling unit.

7.4 Back of Cabinet Door Cooling Units

7.4.1 The back of cabinet door cooling unit, see Figure 16, is a fan-less heat exchanger module or refrigerant coil that installs as a rear door of an equipment cabinet providing 10 KW, 20 KW or 32 KW of room-neutral cooling. The 10kW system has a single 10KW coolant loop, the 20kW has two internal cooling loops, and the 32kW (40kW) door has four cooling loops – all with a single attachment points. Room neutral
cooling means the air leaving the cabinet is at equal to or lower temperature than the intake air servers draw from the room. Air movement across the BOC door refrigerant coil is provided by the fans of servers mounted in the cabinet.

7.4.2 Cabinets using back of cabinet door cooling units should be sealed to avoid escape of warm air through paths other than the rear door. Some leakage cannot be avoided, but the lower the amount of warm air escaping the cabinet; the more effective the heat exchanger will be in removing heat from the room.

7.4.3 Back of cabinet door cooling units do not require power connections. There is one supply and one return refrigerant pipe connection at the top of the door frame. Refrigerant to the heat exchanger coil passes through sealed hinge joints with no exposed hose connections. These seals have been designed for several thousand cycles of operation.

7.4.4 Back of cabinet door cooling units may be fitted to a variety of data cabinets with door adapter kits supplied by either Liebert or the specific cabinet manufacturer. The cooling units may be field installed as a retrofit or as part of a new installation. Existing cabinets may require modifications to limit openings from air escape such as open base, tops, sides, and front.

7.4.5 A front-to-back device airflow path within a cabinet is required for the most effective movement of air across cooling door. Fan volume of mounted devices should be great enough to move air across coils in door. Fan-less devices will not move air out of cabinet or across rear door for removal of heat. Airflow resistance (approx 33%) of a back of cabinet door cooling unit is not more than standard perforated cabinet door. Consideration should be given to how well the heat load is spread across the cooling surface of the door. The cooling door may be less effective in overall cooling if there is a high concentration of heat in a limited surface of the door.

7.4.7 Back of cabinet door cooling units may provide some minimal sensible cooling to devices in adjacent cabinets without door cooling units when those cabinets are in the flow path of cooling door units and heat loads do not exceed cooling door rated capacity.

7.5 Deploying a Combination of Remote Cooling Units

7.5.1 Different remote cooling units may be intermixed within a single refrigerant system and the total heat load capacities of all the units do not exceed the capacity of the refrigerant pump unit. For example, three in-row cooling units of 20KW each may be installed with two back of cabinet cooling units of 20KW each and three overhead cooling units of 20 KW each in one 160KW refrigerant pumping system. The overall
design shall take into account the minimum heat requirement of 48kW per standard XDP / 64kW XDC.

7.5.2 One precaution to be aware of is that the return air path and discharge air path of the remote cooling units should follow the hot aisle/cold aisle layouts. Back of Cabinet cooling units have a unique heat signature as the heat generated by the equipment is contained – and cooled by the panel. Hot exhausted air is not distributed into the “hot” aisle

8. SYSTEM REDUNDANCY

8.1 Building Space Cooling

8.1.1 Building central air handlers or perimeter CRAC/CRAH units may provide base cooling for the space of around 50 watts per square foot of base cooling. Air handlers may also be designed with an economizer feature. Due to the availability of cool outside air, these systems provide an additional level of efficiency as well as an extra level of redundancy in case of failure of the supplemental cooling system. Ideally, the central air handlers supplying the space shall be equipped with multiple fans or have a cross-connected air handler configuration to provide redundancy for the base 50 w/sq.ft. load. In case of supplemental cooling system failure, the building space cooling system will provide some relief until supplemental systems recover.

8.1.2 In cases where CRAC/CRAH units are used to provide the base capacity for the space (such as when uses of building central air handlers are not feasible due to cost of upgrades), the capacity of these units may pick up all or part of the redundancy for the space.

8.2 Supplemental Cooling System

8.2.1 Refrigerant based cooling systems are designed with two pumps as part of the pumping units. If one pump fails, a backup pump comes on to continue refrigerant flow to the remote cooling units.

8.2.2 When one pumping unit is installed in an equipment room, the remote cooling units shall be connected to refrigerant pipes in a non-interlaced configuration as shown in Figure 4. The pipe connections will be made to common supply and return pipe.

8.2.3 Interconnection of pumping units to remote cooling units may be provisioned with two pairs of pipes as coils in remote units are separated into two circuits. Horizontal in-row cooling units, have a top coil and bottom coil with each coil having supply and return lines.
8.3.4 In equipment rooms where two pumping units and two sets of refrigerant pipes are placed, the remote cooling units may be configured for interlaced piping as shown in Figure 5. Remote cooling units will be connected with one half of the remote cooling units to one pump and the other half to another pump. Interlacing the connection piping will keep one of the circuits operating should one of the pump units fail.

8.3.5 Supplemental cooling systems rely on base cooling systems for humidity control and cooling of lower heat equipment lineups in room. In case of failure of a supplemental cooling system, the base cooling system can temporarily handle cooling until the problem is corrected. However, the time available before room temperatures rise to the point of affecting network service (i.e., ride-through) will depend on a number of factors including: capacity of base cooling system, provisions available for removing hot air from the space (e.g., failure-mode triggered exhaust fans) and the amount of heat generated by network equipment.

8.3.6 Back of cabinet door cooling units have one set of refrigerant connections and cannot be configured to multiple pumping units. Alternating connections to different pumps of every other cooling door within a lineup may provide some protection for loss of one pumping unit. Use of cold and hot aisle alignment minimizes contamination of the cool air input.

9. ELECTRICAL REQUIREMENTS

9.1 General

9.1.1 Power to all supplemental cooling equipment (i.e. refrigerant pumping units, air cooled refrigerant chiller units, and the different remote cooling units) as well as any auxiliary equipment shall be in accordance with the requirements identified in this section.

9.1.2 Power to equipment will generally be from an electrical panel protected by a stand-by engine power source in case of commercial power failure. There is no requirement that supplemental cooling equipment be powered by essential or UPS power source. This is based on cooling system’s redundant design stated in other paragraphs of this document. Connections to the units themselves may be hardwired to a terminal block within a power equipment enclosure but they may be plug- in type receptacles in the remote units. Power connections shall be made/retrofit through locking style NEMA (e.g., L5-20) connectors at the power receptacle and plug end.

9.1.3 All protective devices such as breakers and fuses, conduits, raceways and junction boxes, enclosures and cabinets, and conductors and cables shall be installed in accordance with the latest adopted version of NFPA 70: National Electrical Code (NEC). They shall also comply with all applicable state and local codes and ordinances, and to be in accordance with recognized industry practices.
9.1.4 Protective devices shall be suitably sized for the device being powered in accordance with the manufacturer’s voltage and current load data.

9.1.5 All conductors, wires, cables and connectors shall be constructed of copper and be no less than 98% conductivity unless otherwise specified.

9.1.6 Location of power wire/cable and raceways shall be coordinated with other disciplines to avoid interference with piping and telecommunications cabling for electronic equipment.

9.1.7 All conductors used for this purpose must be #12AWG or larger in accordance with the device being powered and must be stranded.

9.1.8 All connections and terminals shall be tightened in accordance with the manufacturer’s recommended torque values.

9.1.9 All electrical raceway or conduit supporting equipment such as hangers, angle iron, straps, brackets, clamps etc., shall be directly attached to the overhead concrete ceiling structure or building walls and not be supported or attached to network overhead cable racks, cable rack supporting structure or other ironwork intended for network equipment use only. All conduit runs to remote cooling equipment shall be run under the raised floor or the overhead space depending on the site conditions and the type of unit. Self supported and cabinet mounted units such as the Liebert XDO’s and XDV’s respectively may be more suitable for overhead power distribution. Aisle mounted units such as the Liebert XDH may be suitable for overhead or under floor power distribution. Designer shall choose most appropriate method based on site conditions. Installation shall provide the maximum length of flexible conduit feeds for the end runs as allowed by the NEC and AHJ based on site conditions.

9.1.10 Alarm and control cabling associated with the supplemental cooling devices shall be in accordance with the manufacturer’s recommendations or as defined in the drawings and specifications for the specific project. Consideration should be made to place the control lines in a protective flexible conduit.

9.1.11 Electrical grounding of all cooling equipment and enclosures shall be in accordance with the latest adopted version of NFPA 70: National Electrical Code.

9.2 Air Cooled Refrigerant Chiller Units

9.2.1 In general, all air cooled refrigerant units have a higher current load than most of the other supplemental cooling equipment. This is due to the larger motor required to compress the refrigerant into liquid form. As such, the Alternating Current (AC) voltage required for these units will usually be 460V-3-phase-60 Hz. In general, this voltage is
not available within the raised floor environment, so a separate circuit may be required from an MCC in order to provide this type of voltage. In this case, the power to the units shall still be from a circuit protected by a stand-by power engine source.

9.2.2 The typical load associated with these units will be around 80 Amps (@ 460V-3Phase-60Hz), and a 100 Amp circuit should be appropriate for the intended use. However, the designer should verify loads with the manufacturer, and size protective devices in accordance with the latest adopted version of the NEC.

9.2.3 Control wiring for associated control and alarming points must be installed as required to achieve the desired sequence of operations. In general, terminal strip connections are available for temperature and humidity sensor inputs, remote cooling unit alarm and condensation detection inputs, and remote general alarm and shutdown outputs. It is recommended that the remote general alarm output be tied in with the general environmental alarms as defined in the NGN Space: Design and Construction Standard, **ATT-TELCO-812-000-155**

9.3 Chilled Water Refrigerant Pumping Units

9.3.1 Refrigerant pumping units do not have the compressors associated with Air Cooled Chiller units. As such, their load characteristics are significantly lower. The units may be purchased in either 460V-3phase-60Hz configuration, or 208V-3phase-60Hz configuration. The CRE Mechanical Consultant should specify the units based on the voltage and capacity available within the facility.

9.3.2 In general, the full load amperage at 460V-3 phase will be in the 2-3 Amp range, and in the 4-5 Amp range when supplied by 208V-3phase. The CRE Mechanical Consultant should verify the estimated loads with the manufacturer selected and size the protective devices and wiring for the circuit according to the latest version of the NEC.

9.3.3 Control wiring for the pumping units is similar to the Air Cooled Chiller units described in Section 9.2.3. Control wiring for associated control and alarming points must be installed as required to achieve the desired sequence of operations. In general, terminal strip connections are available for temperature and humidity sensor inputs, remote cooling unit alarm and condensation detection inputs, and remote general alarm and shutdown outputs. It is recommended that the remote general alarm output be tied in with the general environmental alarms as defined in the NGN Design and Construction Standard, **ATT-TELCO-812-000-155**.
9.4 Remote Cooling Units

9.4.1 Remote cooling units have very small loads resulting mostly from the small motors powering the fan units to circulate air flow from the cold isles through the equipment, and back through the hot aisles to the cooling coils within the units. Power to units is provided via a single phase circuit. The voltage requirement may be specified as 120V, 208V, or 220V/230V/240V depending on the model specified.

9.4.2 Power to overhead mounted units (XDO) shall be supplied from a hard wired single phase 120V, 60Hz source. Each unit draws an approximate total full load current of 2.7 Amps. A 20 Amp standard circuit should be sufficient to power the fan units.

9.4.3 Power to cabinet mounted units (XDV) shall be supplied from a 120V, 60Hz, 20 Amp standard power outlet and an IEC Power cord (XDH end). These units come equipped with two IEC power inlets, and are intended for two redundant power sources, however, we recommend only one inlet port be energized from a stand-by engine protected power source. These units shall not be powered from the UPS A & B power sources. The full load current for these units is approximately 2.0 Amps.

9.4.4 Power to the in-row horizontal cooling units (XDH) shall be supplied from a 120V, 15 Amp NEMA L5-15R standard power outlet. The supplementary cooling units come equipped with two IEC power cords, and are intended for two redundant power sources, however, we recommend only one inlet port be energized from a stand-by engine protected power source. These units shall not be powered from the UPS A & B power sources. The plug end of the IEC cable shall be updated locally by a qualified electrician with a locally provided locking NEMA style L5-20P plug module. The full load current for these units is approximately 5.0 Amps for the XDH-20 Model and 10 Amps for the XDH-32 Model.

9.4.5 Control wiring for all the remote cooling units (XDO, XDV and XDH) consists of only wiring through a dry contact to be used for condensate alarm sensing and signaling to either an air cooled chiller unit or the central pumping unit. The alarm transmissions to a central station may be further provided via the alarming terminals. The dry contact is rated for 1 Amp capacity at a standard 24VAC control voltage.

9.4.6 Back of cabinet door cooling units do not have powered fans or controls. No power connections are required.

9.5 DC Powered Remote Cooling Units

9.5.1 Job sites requiring remote cooling units to be powered by DC power source shall obtain power from network BDFB or secondary power distribution unit supplying power to the lineups. Fuse assignments shall be obtained by the Common Systems/COLD planner for remote cooling units.
9.5.2 Power cables shall be routed to remote cooling units following similar practices as power for AC network equipment. Cable racks established for secondary power cables of network equipment may be used for routing power cables of remote cooling units.

9.5.3 Power load expected for remote cooling unit will be approximately 1240 Watts or around 30 amps at worst case voltage of 42.6 Volts. Fuse size should be 40 Amps at the secondary power distribution for these loads.

9.5.4 Power installation to DC version remote cooling units shall be responsibility of network installation contractors. The scope of the work includes: running and securing power cables between secondary power distribution unit and remote cooling unit, connecting power cables to remote cooling unit, connecting power cables to secondary power distribution unit, install fuses to secondary power unit and providing ground connection to remote cooling unit.

10. COORDINATION BETWEEN CRE/NETWORK

10.1 Engineering System

10.1.1 Following a request from Common Systems/COLD engineers for deployment of high heat equipment (including project equipment lay-out and associated heat loads), the CRE D&C project manager shall coordinate space cooling requirements to accommodate the high heat products. If Supplemental Cooling is the best solution for the site, the CRE D&C project manager shall coordinate with the Common Systems/COLD Engineer of the design direction.

10.1.2 The COLD Engineer shall design the equipment layout with space for remote cooling unit and if using in-row cooling unit, provide 12 ¼” inch space within lineup for each cooling unit. One 12 ¼” inch wide cooling unit will be required between every 3 equipment cabinets.

10.1.3 When Supplemental Cooling is utilized, CRE will design and initially procure all cooling components including the remote cooling unit for the specific application.

10.1.4 Initial installation of remote cooling(s) unit will be accomplished by a contractor hired by CRE. All electrical and plumbing requirements will be handled by the contractor. An exception would be for remote cooling units that will be DC powered. For DC powered units, the initial refrigerant hose installation will be performed by the CRE hired contractors. Power cabling and fuse assignment from BDFB will be accomplished by network equipment installation contractors.
10.1.5 Physical installation of the initial remote cooling units will be performed by the CRE contractor in coordination with network installation contractors. Space shall be left for the cooling unit when network equipment lineups are installed or the cooling unit may be installed initially and equipment cabinets installed around the cooling unit. Securing of the remote cooling unit to adjacent equipment cabinets would be accomplished by CRE contractors. Network equipment vendors may utilize templates made from unistrut cut to 12 ¼" length. At minimum, two pieces are required one for the front and the other for the back. The spacers are placed between cabinets; the cabinets mounting positions are then marked. The pieces may then be removed and inserted in the next required opening.

10.1.6 In-depth coordination shall be required between CRE contractors and network contractors when running pipe from cooling units overhead to refrigerant distribution header. Flexible pipe runs and electrical connections should not interfere with cable racks and cables. Pipe runs and electrical connections should be accomplished following completion of cable runs unless pipe runs and electrical runs have been planned in areas away from cable racks.

10.1.7 CRE’s consultant shall show future remote units in plans for permit submission (designated as future) to avoid future permits for each new remote unit installation. On the initial project, CRE’s contractor shall only install refrigerant pumping and remote units to meet either the minimum operational efficiency threshold or the three year forecast whichever is greater. Where feasible, ports should be installed for all projected cooling unit deployments as part of the initial installation. This will minimize the disruption to working service required by shutting down the system to add ports in the future.

10.1.8 For subsequently added equipment cabinets, the responsible Network engineer shall contact the Common Systems/COLD Engineer at least four months in advance of the required equipment in-service date and provide specific information regarding the space, power and heat load requirements of the equipment to be deployed into the space. The Common Systems/COLD Engineer shall use this information to determine if the request may be accommodated. If the Common Systems/COLD Engineer concurs with the request he or she shall then update the floor plan showing the new equipment cabinets, associated power drain and heat load (next to each cabinet) in bold red text. This information shall then be sent to the CRE D&C Project Manager at least three months prior to the equipment required in-service date.

10.1.9 All work performed overhead of equipment space shall be conducted to TP76300/TP76301 requirements with all precautions taken to avoid service outage when working over live equipment.
11. SYSTEM MAINTENANCE

11.1 CRE Property Management shall be responsible for performing all preventative maintenance (PM) and repairs on the pumping units (XDP), chiller (XDC) and remote cooling units (e.g., XDO, XDH) as well as related plumbing, piping and electrical systems related to the supplemental cooling system.

11.2 Maintenance requirements of refrigerant pumping unit and remote cooling units should be minimal. Fans in remote cooling units are direct drive. Refrigerant pumping unit do not use belts or have fans. Chilled water versions of pumping unit may use strainers for water in and out requiring periodic cleaning.

12. ALARMS AND MONITORING

12.1 All alarms required for monitoring performance of supplemental cooling system shall comply with procedures described in document IOP (Internal Operating Procedure) CRE Alarm Management Strategy - CRE-50-09-01-IOP-001.

13. CODE COMPLIANCE

13.1 All designs for supplemental cooling system and work to install system described in this document shall be performed in compliance with applicable codes.

14. FIGURES
Figure 1
Hot Aisle/Cold Aisle Configuration
Figure 1a
Typical Integrated Cooling System Utilizing a Back Of Cabinet Cooling Configuration

This design may be utilized for slab of raised floor environments
Figure 2
Equipment Lineups Configured For Hot/Cold Aisles
With Overhead Remote Cool
Figure 3

Equipment Lineups Configured in Hot/Cold Aisle
With In-Row Horizontal Remote Cooling Units
Figure 4
Refrigerant Piping Scheme
Pumping Unit to Remote Cooling Units
Figure 5
Interlaced Refrigerant Piping Scheme
Figure 6
Header Distribution Assembly
Quick Connect Ports

Figure 7
Flexible Piping Connected To Header Distribution Ports
Manufacturer: Part Number CCUDPX4CR2, Cooling Hose Support
Custom Cabinets & Rack
Topeka, Kansas
785 862-2271

Figure 8
Support Bracket For Flexible Pipes
Attached To Cable Rack Stringer
Manufacturer: Part Number CCUDCPX4, Cooling Hose Support
Custom Cabinets & Rack
Topeka, Kansas
785 862-2271

Figure 9
Support Bracket For Flexible Pipes
Attached To Auxiliary Framing Channel
Figure 10
Pumping Unit
Building Chilled Water
Figure 11
Pumping Unit
Remote Condenser Cooled
Figure 12
Outdoor Air Cooled Condenser
Figure 13
Horizontal In-Row Remote Cooling Unit

Figure 14
Overhead Suspended Remote Cooling Unit
Figure 15
Top of Cabinet Remote Cooling Unit

Figure 16
Back of Cabinet Door Cooling Unit
Appendix 1

Vendor Documentation References:

**Emerson Liebert Xtreme Density System, Design Manual**
Download document from Emerson Liebert website