

**11 – Heating, Ventilation, Air Conditioning and Refrigeration (HVAC) Standards**

354th Civil Engineering Squadron

OPR: CES/CEOIH

ISSUED: 25 August 2017

**Purpose**

These standards will serve as the primary heating, ventilation and air conditions (HVAC) design criteria reference documents for services provided by architectural and engineering (A&E) firms and consultants in the development of both design-bid-build and design-build contracts. This document is not intended to be used in lieu of detailed design documents in the procurement of facility construction. No part of this document should be considered inclusive to all government requirements.

**1. General**

1.1. Design

1.1.1. Designs shall be in accordance with applicable codes and per the Memorandum by AFIMSC Detachment 2/CEO titled, “*HVAC Design Criteria for Eielson AFB*” which is included in Appendix A of this document.

1.1.2. All specified equipment shall be in mid-range of cataloged performance to allow for adjustment. This includes, but is not limited to, all pumps and air moving equipment.

1.1.3. Use heat recovery in applications where feasible. Evaluate all HVAC systems for use of heat recovery system to conserve energy. See heat recovery section of this guide for details.

1.2. Any rooftop equipment shall be in a heated environment and accessed from inside the building.

1.3. Compressors shall not be located on the roof or on top of cooler boxes.

1.4. Buildings shall be heated by hydronic baseboard heat with hydronic unit heaters or cabinet unit heaters in some designated spaces. Exceptions to this must be approved by 354th CES project manager and CES HVAC Shop. Ventilation shall be provided by approved air handlers or approved heat recovery units.

1.5. Heating systems for remote facilities shall be oil-fired, forced air (not hydronic or steam) unless approved by 354 CES HVAC Shop for specific applications.

1.6. Operation and Maintenance (O&M)

1.6.1. O&M training shall be provided by the contractor.

1.6.2. 20 hours of training on controls shall be provided (includes startup/ shutdown, maintenance/calibration).

1.6.3. Contractor shall provide 100% submittal of O&M Manuals, and 95% submittal of corrected contract drawings indicating as-built conditions, 15 calendar days prior to scheduled O&M training.

1.6.4. Deficiencies found during O&M training shall be corrected by the contractor and updated drawings shall be submitted within 15 days of training completion.

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- 1.6.5. O&M training shall be specified as part of the contractor's commissioning responsibility. ASHRAE Type "0" commissioning shall be performed.
- 1.6.6. Two (2) sets of all specialized tools, instruments, and equipment needed to calibrate and maintain the controls and variable frequency drive units shall be provided by the contractor.

**1.7. As-Built Drawings**

- 1.7.1. Separate "as-built" full sheet drawing of each mechanical room shall be laminated and provided for operations personnel. Drawings shall show layout of all equipment (especially numbered valves, etc.) and clearly indicate clearances between equipment.
- 1.7.2. As-built drawings for controls shall be complete, showing point-to-point controls with the sequence of operation, and shall be laminated for storage in the mechanical rooms.
- 1.7.3. Separate piping diagram for each pipe system shall be provided showing location of all valves.
- 1.7.4. Valves shall be numbered on drawings, shall be listed in the valve schedule, and shall be tagged to match.
- 1.7.5. A large scale floor plan shall be provided indicating all zone boundaries.

1.8. All equipment shall be protected from corrosion. For products with protective coatings, specifications shall be written to require the products' corrosion protection bond to pass one of the industry standard adhesion tests.

1.9. Components shall be labeled with attached engraved metal or plastic name plates (not embossed tape).

1.10. All HVAC equipment shall be served by a full sized, lockable disconnect located in readily accessible location adjacent to equipment.

1.11. Use ring gaskets, spiral wound with centering ring, for all flanged connections.

**2. Mechanical Rooms (Including Fan/Air Handling Unit Rooms)**

2.1. Entrance shall be large enough to allow movement of large equipment into the mechanical room. Double doors with a separate access outside the facility are preferred.

2.2. Hot and cold water hose bib connections shall be provided, including in air handler rooms (ensure that back flow prevention devices are provided).

2.3. Shall have a minimum of one (1) interior floor drain with floors sloped toward it.

2.4. Electrical power outlets shall be provided (115/120 VAC).

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- 2.5. Sufficient clearance shall be provided to remove/replace/maintain the following devices:
  - 2.5.1. Air filters and AHU coils
  - 2.5.2. Heat exchanger coils
  - 2.5.3. Water heater coils
  - 2.5.4. Water filters
  - 2.5.5. Glycol
- 2.6. Ergonomic access shall be provided to all mechanical components (i.e., worker does not have to climb over ducts to access an air filter).
- 2.7. Catwalks and ladders or steps, as decided by HVAC Shop, shall be provided to allow access to all elevated units over four feet. All platforms, mezzanines, must have guard rails and kick plates.
- 2.8. Mechanical room temperature shall be maintainable below 90°F.
- 2.9. Combustion and mechanical room ventilation air systems shall be designed so the gravity combustion air inlet prevents cold air from “dumping” into the room. The outside air ventilation fan shall include motorized mixing dampers arranged to mix outside air and return air to 55°F. Inlet openings shall have hoods and filters.
- 2.10. Intake air openings for facilities shall have hoods with wire mesh or screen and with access to remove frost where openings penetrate an exterior facility wall. All intakes shall be a minimum of 10 feet above grade. Exhaust openings may have louvers or hoods. Ensure proper sizing to prevent air flow restriction.
- 2.11. Exhaust fans shall be provided with hand-off-auto (HOA) switch readily accessible.
- 2.12. Adequate lighting shall be provided to all work areas.
- 2.13. Frame walls shall be cement board or a water-resistant gypsum board instead of common gypsum board and all walls shall be finished with water-resistant paint.
- 2.14. Mechanical rooms shall not be used as a return air plenum.
- 2.15. Copies of the following drawings/documents shall be non-fading and laminated in clear plastic and placed in a built-in cabinet in all Mechanical Rooms:
  - 2.15.1. O&M manuals
  - 2.15.2. Duct work layout drawing(s)
  - 2.15.3. Piping layout drawing(s)
  - 2.15.4. Valve Schedules

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2.15.5. Control Schematics

2.15.6. One-Line Electrical Drawing (Mechanical Room & Associated Panels, etc.)

**3. Air Handling Units**

3.1. Air handling units (AHUs) shall be York, Innovent, or approved equal.

3.1.1. AHUs shall be factory manufactured units with insulated double wall construction, with the inner wall being sealed, and integral drain pans in all sections to allow full wash-down of interior. The AHU internal liner shall be suitable for washing with pressure washer or steam cleaned without compromising casing seals and risk of wetting the insulation. Drain lines shall be provided for all drain pans with individual isolation valves and piped to an indirect waste line or floor drain with isolation valves for each AHU section. If drain lines are piped to a floor drain then drain lines must not constitute a tripping hazard.

3.2. Preheat and reheat coils shall be installed with the preheat coil being installed in the outside airstream, before the mixed air section. Maximum air velocity through preheat and reheat coils is 500 feet per minute during all modes of operation, including economizer. Maximum fin spacing is 8 fins per inch.

3.3. Filters shall be installed before all coils, except where heating and cooling coils are adjacent to one another, in which case filters shall be placed before the leading coil, and good access shall be provided for cleaning both coils. Frames shall be of a standard size, and filters shall be minimum 30% efficient. Fiberglass filters shall not be used. Maximum air velocity shall be 500 feet per minute. Dwyer Magnahelic or approved equal pressure gauge shall be installed at each filter bank. Proper space shall be provided to remove all coils/filters for cleaning/replacement (access doors open fully).

3.4. Servicing Platform

3.4.1. AHUs located more than 4 feet above floor level or above suspended ceilings shall have a servicing platform with OSHA approved appropriate guard rails, kick plates, ladders or steps, as determined by the 354<sup>th</sup> CES HVAC Shop for access and maintenance.

3.4.2. Platform shall extend a minimum 36 inches from the edge of the equipment.

3.5. A clear working space of at least 36 inches above the equipment shall be located on the control side.

3.6. Grease (zerk) fittings shall be tube-extended to a single, readily accessible, lubrication block point.

3.7. Thermometers

3.7.1. A thermometer shall be installed in all discharge air ductwork, and

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- 3.7.2. In all mixed air sections
- 3.7.3. Shall be installed adjacent to coils for reading temperature differential across coil on entering and leaving sides of fluid lines for all coils.
- 3.8. AHU shall be identified/labeled/numbered using attached engraved metal or plastic name plates; not embossed plastic tape.
- 3.9. No plastic components shall be exposed to unheated outside air (i.e. damper brackets).
- 3.10. Access openings shall be provided in fan guards for checking fan speed (expose end of shaft for tachometer use) and for cleaning of all coils.
- 3.11. Inside LED lights with external switches shall be provided in all AHUs.
- 3.12. Control valves shall be three-way and installed outside the units in a readily accessible location. Some two-way valves may be used in conjunction with variable speed pumping pending 354<sup>th</sup> CES HVAC Shop review and approval.
- 3.13. Variable Air Volume (VAV) systems shall use Variable Frequency Drive (VFD) motor speed control and shall only be used when system has mechanical cooling. VFDs shall contain 100% by-pass capability.
- 3.14. Full sized lockable electrical disconnects shall be installed in readily accessible location adjacent to equipment.
- 3.15. Minimum distance of 3 times the equivalent fan discharge duct diameter shall be provided between the return air fan and the return air / exhaust air dampers, and 6 times if outlet velocities are >6000 fpm.
- 3.16. Exhaust/return fans shall be equipped with VFD motor speed control, if system uses economizer controls. Installation shall not rely on relief vents.

**4. Louvers, Dampers, and Mixing Boxes**

- 4.1. Pressure independent balancing dampers downstream of VAV terminals shall be installed.
- 4.2. Full quadrant balancing dampers for all fresh air and return air ductwork to all AHUs shall be provided as well as dampers located immediately after branch ducts leave main duct.
- 4.3. Duct access doors shall be installed on both sides of all dampers, when possible.
- 4.4. High efficiency dampers shall be used on fresh air dampers and mixing boxes, TAMCO 9000 series or equal (linkage and construction are key factors).
- 4.5. Air intakes and exhausts shall be designed where the point of zero water penetration corresponds to the point on the air intake or exhaust curve at which water penetration, as defined by the Air Movement and Control Association (AMCA)

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Standard 500, begins. Air intakes shall be at this point or lower velocities. Exhaust louvers shall be at this point or higher velocities. Hoods shall be color matched to building and extend to 90 degrees from vertical.

**5. Ductwork**

- 5.1. Fiberglass ductwork shall not be used.
- 5.2. Sheet metal ductwork shall be specified to be constructed IAW “Low Pressure Duct Construction Standards” or “High Pressure Duct Construction Standards” of SMACNA as applicable.
- 5.3. Ductwork leakage limits shall be 2% for round and 5% for rectangular.
- 5.4. Vapor barrier material shall be specified for all insulation around air conditioning ductwork.
- 5.5. Access doors/panels shall be provided to both sides of the following areas needing periodic cleaning/ servicing:
  - 5.5.1. Reheat coils
  - 5.5.2. VAV terminals
  - 5.5.3. Cooling coils
- 5.6. Branch ducts shall be offset from the main trunk duct (not opposite each other) to allow for better system balance.
- 5.7. Lighting shall be provided in all large ducts, plenums and duct chases, with switches available at the entry points.
- 5.8. Design of supply/return ductwork shall prevent stratification (use baffles as needed).
- 5.9. Each branch duct take off immediately after leaving the main duct shall have a manually operated blade damper and each terminal device/diffuser shall have an opposed blade or quadrant damper as follows:
  - 5.9.1. Manually operated, opposed blade damper
  - 5.9.2. Manually operated, single blade damper
  - 5.9.3. Quadrant-type volume damper
- 5.10. Extended edge turning vanes shall be installed in rectangular elbows.
- 5.11. Manual volume dampers shall be installed at branch duct connections upstream of registers/diffusers and opposed blade dampers at the registers/diffusers. Diffuser-damper combinations are acceptable only in addition, not in lieu of. (Register/diffuser-dampers cannot reduce high volumes w/o high noise levels).

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- 5.12. Volume dampers shall be located at least two (2) diameters from a fitting and as far as possible from diffusers/outlets.
- 5.13. Straight duct sections shall have at least three (3) duct diameters from fan discharge, elbows, or open duct ends to insure accurate traverse reading (industry standard); use more when possible (i.e., 7 or 8 duct diameters of straight sections would be preferred).
- 5.14. Duct drops to diffusers shall have a minimum of two (2) duct diameters to assure uniform/even distribution from the outlet where space permits. Check with the 354<sup>th</sup> CES Project Manager and/or Mechanical Systems/HVAC Supervisor before incorporating in design and/or construction.
- 5.15. Diffuser registers and/or light troffers shall not be located on the same branch duct (causes unbalanced conditions).
- 5.16. Ductwork containing terminal units for VAV systems shall be installed as a header or manifold with units in line and serviceable via a work platform with adequate spacing for installation and servicing.
- 5.17. Ducts shall not be constructed exterior to the building space. Check with the 354<sup>th</sup> CES Project Manager and/or Mechanical Systems/HVAC Supervisor before incorporating in design and/or construction.

**6. Terminal Devices**

- 6.1. Pressure independent terminals shall be used.
- 6.2. Reheat coils shall be used in all VAV boxes and adequate access for cleaning/ servicing shall be provided.
- 6.3. VAV or dual-duct terminals having distribution/orifice plates are not susceptible to dirt entrapment.
- 6.4. All terminal devices shall be placed in accessible locations no more than two (2) feet above ceilings. This could result in the need to lower ductwork, without forming a trap area, or placing VAV devices in a common location such as a header off the main ductwork with work platform access as required for all elevated equipment. A common location for devices is preferred. Placement of individual units in other locations shall only be allowed with approval of the 354th CES HVAC Shop Foreman.
- 6.5. Include an "exclusion zone" around VAV devices to prevent the installation of light fixtures, piping, fire sprinklers, or other such material which would block access.

**7. Testing, Adjusting & Balancing (TAB)**

- 7.1. TAB, General

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- 7.1.1. Commissioning specifications shall be an integral part of the TAB procedures/specifications. Commissioning shall govern TAB.
- 7.1.2. All mechanical systems shall be balanced.
- 7.1.3. If only part of a system is installed/constructed in the immediate contract, the entire mechanical system(s) to which the new equipment connects shall be tested, adjusted and balanced.
- 7.1.4. The appropriate type and quantity of balancing devices (valves, dampers, etc.) shall be incorporated in the design, in accordance with good industry standards.

7.2. Hydronic Balancing

- 7.2.1. Hydronic systems shall have adjustable “flow/circuit setter” type balancing devices; contractor shall provide balancing equipment to the government upon completion of the contract. Preferred brands are B&G and T/A.
- 7.2.2. Balancing valves shall not be used as isolation valves.
- 7.2.3. Combination (multi-function) valves shall not be used and fixed flow control valves will not be allowed.
- 7.2.4. Balance valves shall be installed downstream of all circulating pumps.

7.3. Air Balancing

- 7.3.1. Volume dampers in branch ducts and opposed blade dampers (OBD) shall be provided at all air terminal devices.
- 7.3.2. Terminal devices for all air supply shall be balanced with new balancing equipment and this equipment shall be provided to the government as part of the contract (for contracts exceeding \$1 million).

**8. Control Systems**

- 8.1. Buildings selected by the 354<sup>th</sup> CES HVAC Shop shall have Delta Direct Digital Control (DDC) systems, which communicate directly with the proprietary front end program located in the HVAC Shop as part of an overall system. All major components and functions will be monitored and controlled by this system and the contractor shall provide communications, programming, including connection to the Orcaview front end program, and graphics development consistent with existing appearance and function. Entering and leaving fluid and air temperatures on each coil and heat exchanger, occupied space, outside air, return air, mixed air, discharge air, equipment run status, associated alarms, and controller outputs shall be covered by DDC systems. DDC controls shall be installed by a qualified, licensed, dealer of the above brand.
- 8.2. Buildings which do not utilize DDC (determined by HVAC Shop) will have electronic controls.



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- 8.3. All control valves (low pressure steam) for heat exchangers shall be staged in 1/3, 2/3 configuration with the smaller valve opening first and closing last. Heating medium temperature shall be reset by outside air temperature from 70°F to 190°F. Circulation pumps shall be cycled off at outside air temperature of 70°F and alternated for lead/lag operation.
- 8.4. Control valves on heating and cooling coils in air-handling equipment shall be proportional, three-way valves. Some two-way valves may be used in conjunction with variable speed pumping with approval from the 354<sup>th</sup> CES HVAC Shop Supervisor.
- 8.5. Room zone valves must have a manual bypass or override.
- 8.6. System will not have any automatic reset low limit switches.
- 8.7. Manual overrides shall be installed for all actuators, preferably on the actuator itself.
- 8.8. Stand-alone, equipment air conditioners (for computers, etc.) shall be Liebert or approved equal, and shall have advanced microprocessor controls. Units shall communicate with and be controlled by DDC via Liebert communication system.
- 8.9. Steel channel structural supports shall be provided for any actuators installed on less than 16 gauge sheet metal.
- 8.10. Over-current protection shall be provided for requested input/output circuits of DDC.

**9. Heat Exchangers**

- 9.1. Thermometers shall be to be installed at inlet/outlet of fluid side.
- 9.2. Pressure gauge with isolation valve shall be installed on steam supply after control valves.
- 9.3. Due to Eielson AFB's extreme maintenance challenges, shell & tube (u-tube) heat exchangers shall be used.
- 9.4. Control valves for heat exchangers shall be configured in a 1/3 – 2/3 arrangement with the smaller valve opening fully before the larger valve begins to open. Smaller valve shall be the first to open and last to close.
- 9.5. Glycol heating fluid temperature shall be reset according to the outside air temperature.
- 9.6. Glycol heating fluid temperature shall not exceed 190°F.
- 9.7. Steam supplied to heat exchanger control valves shall be 15 PSIG or lower.
- 9.8. Condensate must gravity drain from exchanger facilitated by a vacuum breaker installed on the exchanger.
- 9.9. Size heat exchanger for no more than 3 psi.

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- 9.10. A structurally sound rail or multiple pick points shall be provided for removal of the tube bundle where tube bundle weight exceeds 100 pounds.

**10. Heat Recovery Units**

- 10.1. Heat Recovery units shall be utilized with ventilation where possible. Required brand is Innovent or approved equal.
- 10.2. Access shall be provided on both sides of coils for cleaning.
- 10.3. Manually activated internal wash-down shall be installed with water piped to unit.
- 10.4. Preheat coils shall be used before outside air enters unit and coils shall be normally operated at 0°F, except for defrost, when they go to at least 35°F. Heating coils shall be sized at full capacity without regard for heat recovery. Defrost requirement shall be decided by pressure differential across the recovery unit.
- 10.5. Defrost shall be accomplished by running preheat coil at sufficient temperature to melt frost while unit functions normally.
- 10.6. Outside air shall be filtered prior to entering heat recovery unit.
- 10.7. Exhaust air shall be filtered prior to entering heat recovery unit.
- 10.8. Fin density shall be 8 fins per inch (or less, if efficiency is not compromised) (demonstrated fin density range capable of being cleaned by HVAC personnel).
- 10.9. Control valves and damper linkages/actuators shall be installed outside the units in a readily accessible location.
- 10.10. No plastic components shall be exposed to un-heated outside air (i.e. damper brackets).
- 10.11. Drains shall be piped to an indirect waste line or floor drain.
- 10.12. Unit shall be labeled using attached engraved metal or plastic name plates (not embossed plastic tape).
- 10.13. All requirements listed for AHUs shall be applicable for heat recovery units.

**11. Condensate Stations**

- 11.1. Condensate pumps shall be non-motorized steam pressure powered pumps with motive steam pressure of 25-35 psi. (Spirax/Sarco or approved equal). Motive steam shall be supplied through a vertical drop placed as close to station inlet as possible to minimize final horizontal run; drip leg trap shall discharge into flash tank.
  - 11.1.1. Alternate, upon approval by 354th CES HVAC Shop Supervisor prior to procurement: condensate pumps shall be electric duplex units with high temp seals and motors.

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- 11.2. Proper filling head shall be provided to the condensate pumps by the condensing equipment feeding the pump and required reservoir.
- 11.3. Pressure gauge with snubber shall be installed on the discharge line with full flow gate valves located on both sides of the pressure gauge port.
- 11.4. All stations shall be fitted with a sight glass and factory provided insulated cover.
- 11.5. Station shall be installed with stainless check valves provided with unit.

**12. Flash Tanks**

- 12.1. All traps serving lines over 15 PSIG shall discharge into a properly sized, vented to atmosphere, flash tank. Discharge of tank shall be served by F&T steam trap before entering reservoir.

**13. Coils**

13.1. General

- 13.1.1. Sufficient space shall be provided with access between cooling and heating coils to allow cleaning.
- 13.1.2. All coils shall be freeze-proof (steam) or burst-resistant (water or glycol mixture; basis of design: Sentry-Guard by USA Coil & Air).
- 13.1.3. All coils shall be easy to drain and clean.
- 13.1.4. All coils shall have only copper tubing.
- 13.1.5. Coils shall be equipped with air bleed valves.
- 13.1.6. Thermometers shall be installed on entering and leaving fluid lines.
- 13.1.7. Cooling coils shall have a minimum 1" diameter condensate drain.
- 13.1.8. Preheat coils shall be used with all ventilation/make-up air introduced into a heated space.
- 13.1.9. Reheat coils shall be to be sized for full capacity, disregarding heat recovery equipment.

13.2. Steam Coils

- 13.2.1. Condensate drain piping shall be sloped a minimum of ¼" per foot in direction of the flow.
- 13.2.2. Steam distributing tube type steam coils shall be of freeze-proof design.
- 13.2.3. Reduce steam pressure to 50 psig or less for all coils – coil wall thickness for 25 psig or less shall be a minimum of 0.035-in., and a minimum coil wall thickness of 0.049-in. for pressures up to 50 psig.

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13.2.4. Accessories included in all steam coil/piping installations shall include at a minimum: automatic air vent, vacuum breaker, float and thermostatic trap (located 12" – 24" below the coil condensate outlet; sized to 3 or 4 times the required condensate lb. /hr. rate).

13.2.5. Coils shall be accessible for cleaning.

13.2.6. Steam coils shall not be used where contact with outside air is possible.

**14. Filters**

14.1. Magnehelic (Dwyer-type) differential pressure indicators shall be installed across all filters.

14.2. Filters shall be to be of standard frame size and no less than 30% efficiency.

**15. Steam Traps**

15.1. Traps shall be located in a readily accessible location for maintenance.

15.2. Traps shall be mounted 12" to 24" below steam coil outlet to provide adequate condensate head on the trap.

15.3. Minimum of 6" dirt leg shall be provided before the trap inlet.

15.4. Traps shall be to be labeled with a 2" round/square numbered brass tag with stamped lettering which is connected by a brass chain.

15.5. F&T traps shall be used for most applications. Bucket traps are not used.

15.6. Traps shall be installed as shown in diagram, with isolation valves, strainer, check valve, unions, and test tee.

**16. Strainers**

16.1. Strainers shall be provided upstream of all of the following:

16.1.1. Steam traps

16.1.2. Control valves

16.1.3. Meters

16.1.4. Pumps

16.2. Strainer housings shall be equipped with drain valves.

16.3. Strainers over two inch, used in steam piping must be covered with removable insulation blankets. This requirement applies to all installed steam components.

16.4. Cast iron strainers shall not be installed in high pressure steam lines.

**17. Valves**

17.1. Ball valves shall be used in lieu of gate or butterfly valves, except for steam systems.

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- 17.2. Multi-duty valves shall not be used.
- 17.3. Balancing valves shall not serve as isolation valves and shall not be of the fixed, flow control type (B&G or T&A are preferred).
- 17.4. Bronze or brass valves, including check valves shall not be used in steam/ condensate systems.
- 17.5. Control valves for heating and cooling coils shall to be three-way configuration. For heating applications with two heating coils in the AHU, one coil control valve may be two-way configuration if approved by the 354th CES HVAC Shop Supervisor.
- 17.6. Valves over 7' to centerline shall be equipped with chain drives.

**18. Pressure Reducing Valves**

- 18.1. Pressure gauges with “pigtailed” or snubbers, and isolation valves, shall be installed on high and low pressure sides.
- 18.2. Pressure Reducing Valves shall be configured in a 1/3 – 2/3 arrangement with the smaller valve opening fully before the larger valve begins to open. Smaller valve is the first to open and last to close.
- 18.3. Bypass piping with isolation and throttling capability (globe valves) must be installed.
- 18.4. Moisture eliminating devices must be properly installed upstream of pressure reducing valves with condensate trapped, piped to flash tank, and returned to system. Tanks shall be vented to atmosphere.

**19. Pumps**

- 19.1. This section applies to pump replacement projects as well as new construction.
- 19.2. Water/Glycol Heating Medium/Fluid
  - 19.2.1. System lubricated (wet rotor) pumps shall be used in most applications.
  - 19.2.2. B&G or approved equal pumps shall be used for any pumps having mechanical seals. The seals must designed specifically for use with a very high percentage of glycol; not just the material used.
  - 19.2.3. Horizontal split case pumps shall be used for large floor mounted pumps.
  - 19.2.4. Pumps shall be to be sized to operate in the mid-range of performance curves.
  - 19.2.5. Circulating pumps shall have piped-in back-up pumps.
  - 19.2.6. Manual switching shall be used to power backup circulating pumps.
  - 19.2.7. Isolation valves and pressure gauges shall be installed on suction and discharge sides of pumps and pressure gauge ports shall be in pump flanges, where possible, suction side between pump and suction diffuser.

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19.2.8. Balancing valves shall be installed on discharge side of pumps. B&G and T/A valves shall be used due to pressure taps location providing greater accuracy

19.2.9. Circulating pumps and piping shall be sized so as not to require booster pumps. Auxiliary pumps on coils shall not be used.

19.2.10. All pumps shall have readily accessible and lockable electrical disconnect switches.

19.2.11. Pumps shall be sized to operate in the mid-range of their performance curves within maximum efficiency range.

19.2.12. A 60/40 ethylene glycol/water mix with phosphate based inhibitors (matching those existing throughout the base), with no silicates (produced specifically for heating and cooling systems) shall be utilized as a heat transfer medium. Ensure pump sizing and selection take this into account.

**19.3. Steam**

19.3.1. Pressure powered pumps shall be used for condensate return. If it is impossible to use a pressure powered pump, then approval may be given for a dual electric condensate pump. (See Condensate Stations above.)

19.3.2. Steel moisture separators shall be installed in all systems and piped as described elsewhere in this document.

19.3.3. Steam from CHPP ranges from 80-100 PSI entering buildings and is then reduced to 15 PSI or less.

19.3.4. Sound piping practices as stated and shown elsewhere in this document shall be practiced.

**19.4. Motors**

19.4.1. Motor starter contactors shall be rated for cyclic loading. Solid state starters are preferred.

19.4.2. Motors shall be “premium efficiency motors”.

19.4.3. All motors 5 horsepower and larger shall be provided phase and over/under voltage protection.

**20. Water Heaters**

20.1. Water heater shall be semi-instantaneous, helical self-cleaning steam coils.

20.2. Aerco units shall be specified with electric controls (not pneumatic).

20.3. Water heaters shall be piped to a minimum 200 gallon storage tank, built for that purpose, and have a pumped circulation system to maintain tank water at set

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- temperature. If multiple tanks are required to obtain required volume, they shall be piped in series to fully utilize storage space.
- 20.4. Temperature leaving the water heater shall be 140°F and a mixing valve shall be utilized to maintain distribution temperature.
  - 20.5. Operate on low pressure steam (less than 15 PSIG).
  - 20.6. Pipe blowdown with full size ball valve to indirect waste receptor tank with separator/strainer for solid debris. Discharge of tanks shall have ball valve to control discharge rate.

**21. Piping**

- 21.1. Standard color coded labels (ANSI A13.1) shall be used for all piping at 10' intervals.
- 21.2. Colored pipe labels shall be printed to indicate the type of fluid carried in the pipe and direction of fluid flow (arrows).
- 21.3. All hydronic heating systems shall be piped with Type L copper, using lead-free solder, 95/5 or better.
- 21.4. Fittings shall be used for offsets. Pipes shall not be bent for offsets.
- 21.5. Pipes shall not be taped to prevent contact between dissimilar metals. Use proper hangers and clearances.
- 21.6. Piping for heat systems shall be run in a reverse return configuration. Mono-flow or any single pipe system shall not be allowed.
- 21.7. Dielectric nipples or flanges shall be used at all connections between dissimilar metals. Do not use dielectric unions.
- 21.8. Isolation valves shall be located in very close proximity to all mechanical units, to include control valves, served by piping.
- 21.9. Steam piping shall be Schedule 40 black steel or heavier. Galvanized pipes/ fittings are not allowed.
- 21.10. Condensate piping shall be Schedule 80 black steel or heavier with extra heavy fittings.
- 21.11. Bronze or Brass fittings, including check valves shall not be used in the steam/ condensate system.
- 21.12. Install moisture eliminating devices (Sarco or approved equal) before pressure reducing valves in steam supplies.
- 21.13. Cast iron fittings shall not be allowed in steam systems above 15 PSI.
- 21.14. Heating system shall be isolatable between individual floors and wings of a facility.

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- 21.15. Air vents with isolation valves shall be provided at all high points in the heating system.
- 21.16. Adjustable balancing valves shall be installed for each heating unit, cooling unit, and pump; not fixed flow devices.
- 21.17. Balancing valves shall be installed on all bypass and return lines serving a 3-way control valve. Preferred balancing valves: Bell & Gossett or Taco.
- 21.18. Balancing valves shall not serve as isolation valves anywhere in the system.
- 21.19. Condensate return lines shall be sloped in direction of flow.
- 21.20. Vapor barrier material shall be installed on all chilled water piping insulation.
- 21.21. All exterior piping shall be protected from freezing. Locate piping in utilidor. Insulate piping with heat tape along its full length, or use another method approved by the 354 CES Mechanical Superintendent, and direct bury below the frost line.

**22. Air Conditioning**

- 22.1. Air conditioning (AC) shall be used in support of critical equipment where the need is justified by technical order (TO), Air Force Instruction (AFI), or manufacturer's specification. The need must be verified. Comfort cooling in rare cases is allowed upon approval of the Base Civil Engineer. Eielson's typical summer includes a few days or weeks when the 78 degree indoor design temperature may be exceeded.
- 22.2. Humidifiers shall be bottle or infrared type; not immersion type.
- 22.3. Equipment cooling units shall be Liebert (base standard), or approved equal. Utilize free cooling coils whenever feasible (piped as described below). Condensers shall be sized for 105°F.
- 22.4. R-134a, or R-404a shall be the refrigerants used.
- 22.5. Phase and low/high voltage protection shall be provided for all AC units.
- 22.6. Glycol cooled units with external "dry-cooler" located at ground level, designed at 105°F, shall be used (base standard). Water-cooled condensers whereby cooling water is wasted to a drain are not acceptable for new installations on Eielson. Dual circulation pumps shall be installed inside with 3-way tempering valve located inside, to supply 42-54°F free cooling and not less than 60°F condensing water to the indoor cooling unit. Size all units for 60% ethylene glycol usage.
- 22.7. Large chilled water cooling systems utilize helical rotary chillers, Trane or approved equal, with dry coolers and free cooling. Condensing/cooling water shall be tempered in the same manner described earlier. Chillers shall have fully independent circuits with 100% redundancy. Piping and pumping requirements shall be as stated elsewhere in this document.



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**23. Refrigeration Piping**

- 23.1. Suction gas lines shall be sized for minimum gas velocities of 900 fpm per ASHRAE.
- 23.2. Discharge gas lines shall be sized for minimum gas velocities of 2000 fpm per ASHRAE.
- 23.3. P-traps shall be located at the bottom of all gas risers with more than 8' of vertical run.
- 23.4. All horizontal refrigerant lines shall be sloped 0.5-in. per 100' in direction of flow.
- 23.5. Isolation valves shall be located at the inlet/outlet of all major system components.
- 23.6. Isolation valves shall be located at each end of all long refrigeration lines.
- 23.7. Each component of the refrigeration system shall have provision for localized evacuation.
- 23.8. Bypass lines shall be provided around all filter dryers.

**24. Water Cooled Condensers**

- 24.1. Space shall be provided to inspect/clean condenser tubes.
- 24.2. Flanges and isolation valves shall be provided/located to allow removal of piping and headers immediately in front of tubes.
- 24.3. Taps, with hose bibs, shall be provided to allow chemical feeding for cleaning purposes and thermometers shall be mounted on fluid inlet and outlets.
- 24.4. Water-cooled condensers whereby the cooling water is wasted to a drain shall not be utilized on Eielson. Water cooled condensers shall be used in conjunction with a dry-cooler (gly-cooler) as described in Air Conditioning section of this document.

**25. Air Cooled Condensers**

- 25.1. Selected condenser shall have a maximum condensing temperature of 20°F above design ambient.
- 25.2. Condenser shall be used only for summer operation and must have low ambient temperature lockouts for unit.
- 25.3. Ensure adequate air flow for proper heat removal. Special consideration should be given if the unit is inside the building where ventilation must be provided to move heat outside, and with outside applications where adjacent walls may prevent adequate air flow.

**26. Refrigeration Compressor Equipment**

- 26.1. R-134a, or R-404a shall be the refrigerants used.
- 26.2. The following devices shall be located on the equipment room wall; not on equipment:

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26.2.1. Suction discharge

26.2.2. Oil pressure gauges

26.2.3. Isolation valves

**27. Insulation**

27.1. General

27.1.1. All valves, strainers, fittings, regulators, expansion joints, uneven surfaces over 2" to be covered with valve blankets, with Velcro or wire ties.

27.1.2. All insulation products that are affected by UV light to be covered with metal jacketing to prevent damage.

27.1.3. Calcium silicate with aluminum jacketing and stainless steel bands shall be used to insulate pipes in high traffic areas, where it is likely to be stepped or walked on.

27.1.4. All mechanical systems insulation values to be doubled where there is not sufficient ventilation or make up air, in mechanical rooms to maintain 90 degrees F.

27.1.5. Paper jacketing will be covered with Fiberglass cloth and sealed with a heavy sealer in all high traffic areas, where contact is made other than stepping or walking on. Aluminum jacketing can be an alternative.

27.1.6. All pipes lying on or near a floor will be covered with calcium silicate with metal jacketing.

27.1.7. All pipes that are near blowdowns or could be damaged by splashing water, steam will be covered with calcium silicate and metal jacketing.

27.1.8. All flanges and heads will be covered with valve blankets on heat exchangers, with Velcro or buckles.

27.1.9. All valves are considered to be minimum unless noted otherwise.

27.2. Steam Lines

27.2.1. High pressure

a. 2" Fiberglass

27.2.2. Medium pressure

a. 1 ½" Fiberglass

27.2.3. Low pressure

a. 1 ½" Fiberglass

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27.3. Condensate Lines

27.3.1. High pressure

- a. 2" Fiberglass

27.3.2. Medium pressure

- a. 1 ½" Fiberglass

27.3.3. Low pressure

- a. 1 ½" Fiberglass

27.4. Hydronic systems

27.4.1. High temperature

- a. 2" Fiberglass, with all joints and fittings insulated and sealed for vapor barrier

27.4.2. Low temperature

- a. 1 ½" Fiberglass, with all joints and fittings insulated and sealed for vapor barrier

27.5. Heat Exchangers

27.5.1. Under 4" in diameter and under 24" in length

- a. 2" Fiberglass

27.5.2. Over 4" in diameter and over 24" in length

- a. 2" calcium silicate, with metal jacketing

27.6. Chilled Water Lines

27.6.1. 1" Fiberglass, with all joints painted and sealed for vapor barrier

27.7. Domestic Water Lines

27.7.1. 1" Fiberglass with all joints painted and sealed for vapor barrier

27.8. Tanks

27.8.1. Low Temperature

- a. 1" Fiberglass, with all joints sealed for vapor barrier

27.8.2. High Temperature

- a. 2" Fiberglass or calcium silicate

27.9. Supply Ducts

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27.9.1. 2” Fiberglass, with all fasteners welded or screwed to ducts

**28. Appendix A - Memorandum by AFIMSC Detachment 2/CEO titled,  
“HVAC Design Criteria for Eielson AFB”**

28.1. See attached



**DEPARTMENT OF THE AIR FORCE**  
DETACHMENT 2, AIR FORCE INSTALLATION AND MISSION SUPPORT CENTER  
JOINT BASE PEARL HARBOR-HICKAM, HAWAII



MEMORANDUM FOR 354 CES/CD

FROM: AFIMSC Detachment 2/CEO

SUBJECT: HVAC Design Criteria for Eielson AFB

References: (a) 354 CES Memorandum Request for UFC Exceptions on Eielson AFB F-35 Projects dtd 19 June 2016  
(b) AFCEC/COSM Memorandum F-35 Projects at Eielson AFB and UFC 3-410-01 HVAC Systems Evaluation dtd 8 August 2016

1. During design for the F-35 Field Training Detachment Facility (FTD), Eielson AFB requested exemptions to existing HVAC design criteria from AFCEC/COSM via reference a). AFCEC/COSM responded with non-concurrence of exemption request via reference b). The main items of concern include the following:

2. Life Cycle Cost Analysis: AFCEC/COSM response stated that the need for an LCCA cannot be waived, since it is required per 10 CFR Part 436. However, studies and life cycle cost analyses have been previously performed for the Central Heat and Power Plant (CHPP) and heating systems at Eielson AFB. We recommend that Eielson should reference and utilize these as much as possible to fulfill the requirement, rather than perform an entirely new LCCA effort each time. Unless significant changes occur which would greatly affect the prior LCCA findings or recommended courses of action, (e.g., sharp increase in coal price), we would expect that the current coal fired CHPP with district heating system should remain the most life cycle cost effective method as has been already determined in the past.

3. Outdoor Design Temperature and Safety Factor: AFCEC/COSM response was that the published Eielson weather data must be used vs. local design temperatures. AFCEC/COSM provided a memorandum for record (Attachment 1) in which they performed a heating load calculation for an example building. Their analysis is based on 2012 weather data, which they found to be the coldest year for the past 11 years at the Eielson weather station. The memo outlines their conclusion that a system designed for a -40 °F outdoor design temperature, with a 15% safety factor in accordance with UFC 3-410-01, would meet the indoor setpoint of +68 °F every day, except for the one coldest day of the year in 2012. On that one day (with an outdoor low temperature of ~ -52 °F), the system could only be able to bring the indoor temperature up to +64 °F (versus +68 °F setpoint).

In parallel, AFIMSC/Det 2 extracted weather data for the Eielson weather station (Station ID ICAO PAEI, WMO #70265) from [www.climate.af.mil](http://www.climate.af.mil). Results showed an extreme minimum temperature of -64 °F on 13 Jan 1971, and an extreme maximum temperature of 93 °F on 15 Jun 1961, for the period of record from 1944 – 2016 (see Attachment 2). Published engineering

weather data shows no hours above 90 °F in an average year. Additional weather data was requested from the 14<sup>th</sup> Weather Squadron to see how temperatures have changed from the past, and according to the information provided, temperatures at or below -60 °F were recorded at an average of 1 to 2 hours per year for 3 different periods of record (see Attachment 3). We could not substantiate to AFCEC with weather data that there is a significant temperature difference from the Eielson weather station to the South Loop area; that Eielson experiences temperature highs in the 100+ °F range; or that the extreme low temperatures last for extended periods of time.

4. Redundant Components: Discussions with AFCEC/COSM indicated that they would consider an exemption request for certain redundant equipment (e.g., heat exchangers), with justification, due to the remote location of the base and recognized difficulty in replacement during winter. A blanket exemption for redundant components (e.g., chillers) would not be supported due to lack of recorded data showing extended periods of extreme temperatures. Note that UFC 3-410-01 for HVAC does already allow some redundant components in certain situations (specific reference in paragraph 7 below), or if specified by other criteria.

5. VAVs and safety factor: AFCEC/COSM will not support an exemption request for an increased safety factor of 120% due to concerns with system over-sizing. Paragraph 3-4.1 of the HVAC UFC does allow designers to use a 15% safety factor. To compensate for uncertainty in designers calculations, and build in an additional safety margin other than the specified 15%, we provide some recommendations in paragraph 7 below.

6. CO2 Monitors: AFCEC/COSM will not support exemption requests for CO2 monitor use, due to historical issues with accuracy and precision. However, paragraph 3-5.4 of the HVAC UFC does allow designers to evaluate use of demand controlled ventilation by occupancy sensors.

7. For future designs, we recommend the following to help compensate for current UFC restrictions and alleviate problems and concerns with HVAC system capacity and reliability.

a) Utilize conservative design assumptions when performing building load calculations, to help compensate for possible differences between design calculations and actual construction methods. Some examples are; assumed R values for building construction, internal/external heat loads, damper leakage, pipe and fitting losses, duct losses, or outdoor air infiltration rates. Design calculations should also assume likely future system degradation, such as an increase in friction losses due to pipe corrosion or scaling, and upsize systems accordingly.

b) Component selection – Verify that the capacity of selected component models also takes into account any factors which could reduce the rated capacity of the heating or cooling equipment, such as glycol concentration to be used (affects the fluid specific heat), base elevation (potential altitude corrections), fouling factors, or any other factors identified by the manufacturer or designer. Incorporating de-rating factors such as these could require selection of a model with a higher capacity range, which then can provide an additional “built-in” capacity safety margin.

c) Leverage the currently allowed base level adjustments to HVAC system setpoints and schedules to best maintain facility space temperatures:

1) An EMCS (Energy Management and Control Systems) playbook has been published on the CE Portal, and it provides some allowances on the use of heating/cooling setpoints. The EMCS playbook can be located at:

<https://cs1.eis.af.mil/sites/ceportal/CEPlaybooks/EMCS/Pages/overview.aspx>.

2) EMCS playbook - "Set Point/Setback Temperatures" section states; "HVAC control systems will be set to maintain space temperatures that will not exceed the conditions in Table 1 during occupied and unoccupied hours". For example, Table 1 of the playbook provides a Maximum heating temperature of 70 degrees F (occupied) and 55 degrees F (unoccupied) for Administrative areas. The installation is authorized to establish policy more stringent than shown in Table 1 of the playbook.

3) EMCS playbook - "Temperature Change Scheduling" section states; "The Civil Engineer squadron establishes formal procedures to annually review temperature set points/setbacks, temporarily changes set point/set back schedules, and establishes prolonged set point/setback deviations. The Base Civil Engineer (BCE) is authorized to allow temporary deviations from the set points for spaces with broken systems, exterior envelop (sic) issues, temporary changes in occupancy and *dramatic temperature variations*.

d) Maximize use of design allowances already in UFC 3-410-01 Heating, Ventilating, and Air Conditioning Systems (change 3, dtd 25 January 2017)

1) Paragraph 4-2.12.1 – IMC Supplements; Addition – Sections 1201.2 "Sizing":

The UFC specifies use of backup pumps for hydronic systems to ensure that the total system capacity is always available, and states: "Provide back-up or standby pumps with lead/lag controls so that the total system capacity is available with any one pump out of service."

2) Paragraph 4-2.12.2 – IMC Supplements; Addition – Sections D1201.4 – D1201.7

The UFC specifies to provide freeze protection as an addition to the International Mechanical Code (IMC), and states: "D1201.6 Freeze protection. Freeze protection must be provided by automatic circulation of hydronic pumps when the outside temperature drops below 35 °F (2 °C), or by the addition of an appropriate antifreeze solution, or design of a pipe temperature maintenance systems (i.e., heat trace) based on *the lowest recorded temperature in UFC 3-400-02*". Therefore, the UFC does specify the use of the lowest recorded temperature for Eielson AFB iaw UFC 3-400-02 as the basis for freeze protection.

The UFC also specifies in the same paragraph to provide a dedicated primary pump and a backup or standby pump for each chiller. The UFC states: "D1201.7 Chilled water systems. Provide a dedicated primary pump and condenser water pump for each

chiller. Provide backup or standby pump for each chiller. Provide piping and valve configuration that allows each chiller to operate with any condenser water pump.”

3) Paragraph 3-4.2.2 - Spaces Conditioned for Specialized Technical Requirements:

The UFC allows use of the 0.4 percent dry bulb temperature to size systems for specialized requirements; “Size equipment and all system components to maintain and control indoor design conditions at each of the following: (1) the 0.4 percent dry bulb temperature and the corresponding MCWB temperature and (2) the 1.0 percent humidity ratio and corresponding MCDB.”

4) Paragraph 3-5.4 – Intermittent Occupancy Facilities

The UFC allows use of demand controlled ventilation with occupancy sensors (versus CO2 sensors) for intermittently occupied facilities such as auditoriums and theatres. The UFC states; “Facilities such as reserve centers, chapels, auditoriums, and theatres are occupied at irregular or infrequent intervals.” ”Evaluate opportunities such as thermal storage systems and demand controlled ventilation by occupancy sensors for these facility types.”

5) Paragraph 3-6.4 – Redundant Systems

Determine if a redundant capability is already allowed or specified in another UFC, Facilities Criteria (FC), Technical Order, Air Force Instruction, or other criteria. The UFC states: “No exemption is required where redundant HVAC systems are specified by other applicable criteria.”

6) Consider use of a lead/lag arrangement of components for system resiliency. The use of multiple smaller units in a lead/lag component arrangement is not prohibited by UFC 3-410-01. Although this arrangement does not provide full system redundancy, it can provide partial system function should a component fail or otherwise be out of service. This type of arrangement is also provided as a “Best Practice” for Data processing and Electronic Office areas per paragraph B-9 of UFC 3-410-01.

8. In summary, we have reviewed Eielson’s requests for exemptions and have re-engaged with AFCEC/COSM on whether they would consider granting such exemptions. We could not provide them with sufficient documented data which supports the local conditions at Eielson AFB. In lieu of exemptions being provided by AFCEC, the recommendations in paragraph 7 can help provide some additional safety margin in facility design and construction. For situations requiring use of redundant equipment not otherwise already allowed, AFCEC will require an exemption request.

9. If you or your staff have any questions, or for further discussions, please contact our POC, Mr. Alden Katano, at dsn 315-448-2548 or [alden.katano@us.af.mil](mailto:alden.katano@us.af.mil). We are also available to assist with design reviews if requested.



Louis J. Schiffel, P.E., GS-14, DAF  
Chief, Engineering and Emergency Services  
HQ AFIMSC Detachment 2

3 Attachments:

Attachment 1 – AFCEC/COSM Memo for Record Eielson Htg Syst

Attachment 2 – Climactic Data Summary from 14<sup>th</sup> Weather Squadron

Attachment 3 – Eielson temp distribution slides (14<sup>th</sup> Weather Squadron)



**HQ AFCEC/COSM**  
**139 Barnes Drive, Suite 1**  
**Tyndall AFB, FL 32403-5319**



MEMORANDUM FOR RECORD

30 Jan 2017

SUBJECT: Facility Heating System Design and Performance Example @ Eielson AFB, AK

1. The purpose of this memo is to show how to specify a facility heating system using the mandatory methods prescribed by UFC 3-410-01, Heating, Ventilation, and Air Conditioning Systems. First, follow the prescribed method in Sec. 3-4, Heating and Cooling Load Calculations:

i) Assume the following bldg parameters:

- (1) Indoor Area: 93,275 ft<sup>2</sup>
- (2) Stories: 2
- (3) Footprint: 48,095 ft<sup>2</sup>
- (4) Length: 486.67 ft
- (5) Width: 98.82 ft
- (6) Height: 31.77 ft
- (7) Exterior Surface Area: 85,298 ft<sup>2</sup>
- (8) Window/Wall Ratio: 21 %
- (9) Wall Type: Mass
- (10) Insulation: ASHRAE 90.1-2013

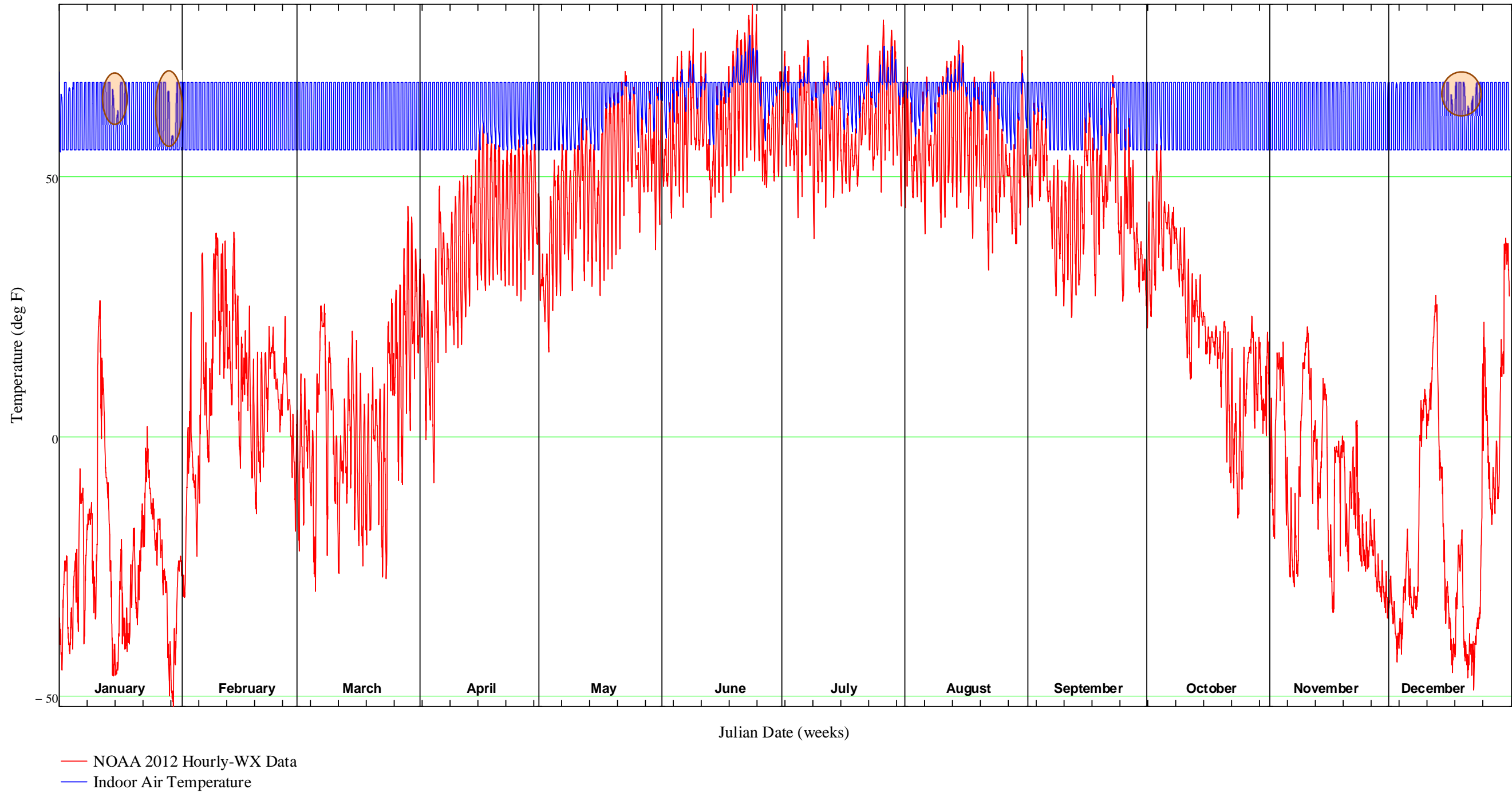
ii) Calculate the overall facility U-value:  $0.0655 \frac{\text{BTU}}{\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F}}$

iii) Calculate required heating system size using 15% recovery factor (RF):  $RF \cdot UA \cdot \Delta T = (1.15\%) \cdot \left(0.0655 \frac{\text{BTU}}{\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F}} \cdot 85298 \text{ ft}^2\right) \cdot [68 - (-40)] = 693.9 \frac{\text{BTU}}{\text{hr}}$

iv) Find heating system to match required size. I.e., Lochnivar FTX725N boiler rated at 705 MBH output. However, it is de-rated 4% per 1,000 ft altitude. Eielson is 548 ft MSL. Therefore, de-rate  $4\% \cdot \frac{548}{1000} = 2.2\%$ .  
 $705 \cdot (1 - 2.2\%) = 689.5$ . Since  $689.5 < 693.9$ , choose next larger size – FTX 850N --  $825 \cdot 97.8\% = 806.85 \frac{\text{BTU}}{\text{hr}}$

2. Now, to determine if we have the proper size heating system, we can run our facility through an energy simulation algorithm and check the inside set point temperatures against actual Eielson WX. Let's choose the WX profile in 2012 – the coldest year in the past 11-years. If the heating system for this facility was sized at exactly  $108^{\circ}\text{F } \Delta T$  (68 - (-40)), the facility's heating system would be sized at 603.4 MBTUH output. A simulation would show the following temperature profile for the facility:

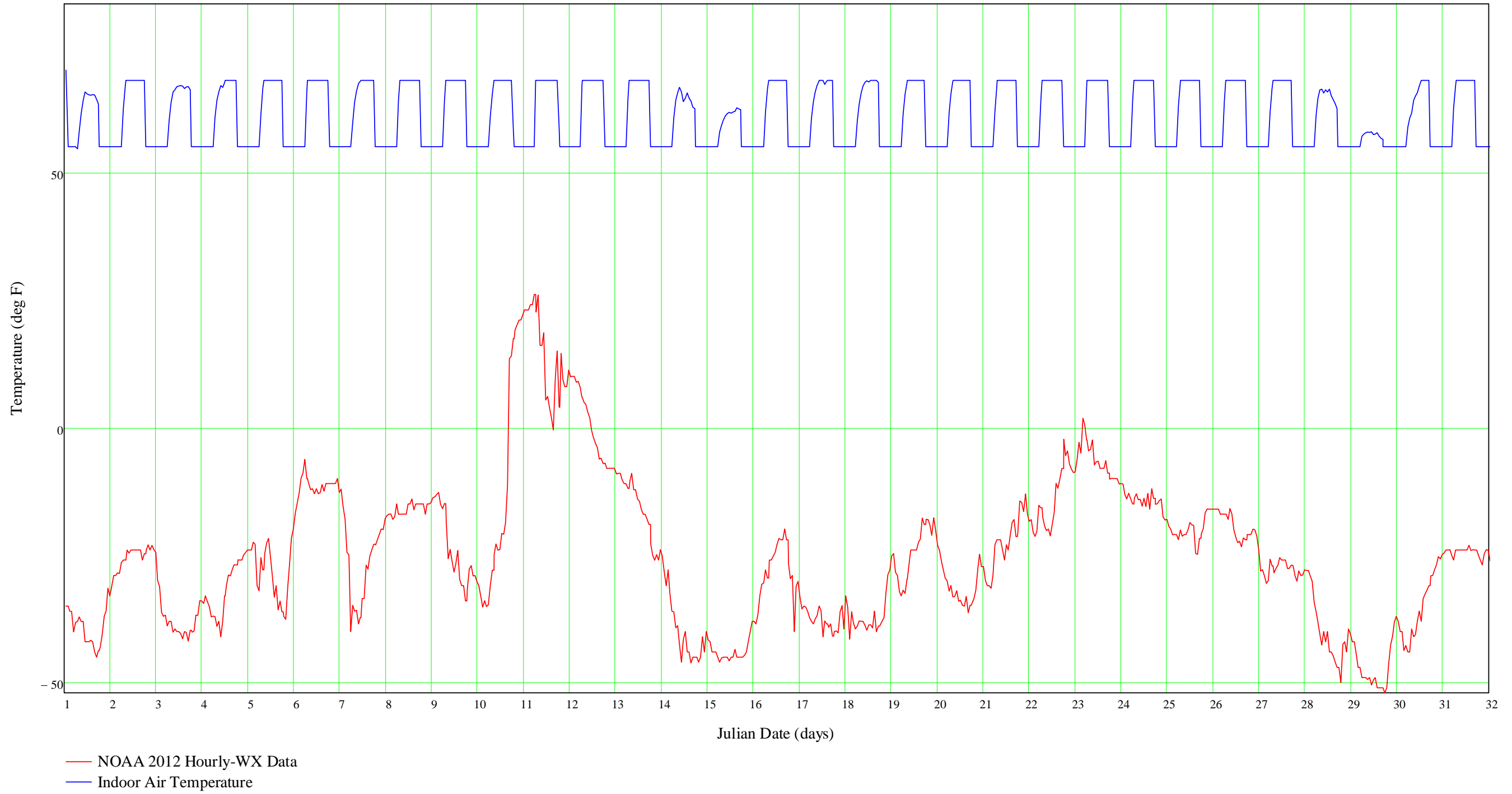
Eielson AFB: 93,000 SF General Admin Building



We notice three areas (highlighted in orange on the chart above) that do not reach set point – two areas in January and one in December. Taking a closer look, we see that the heating system struggles to bring the space temperature above 55 °F setback.

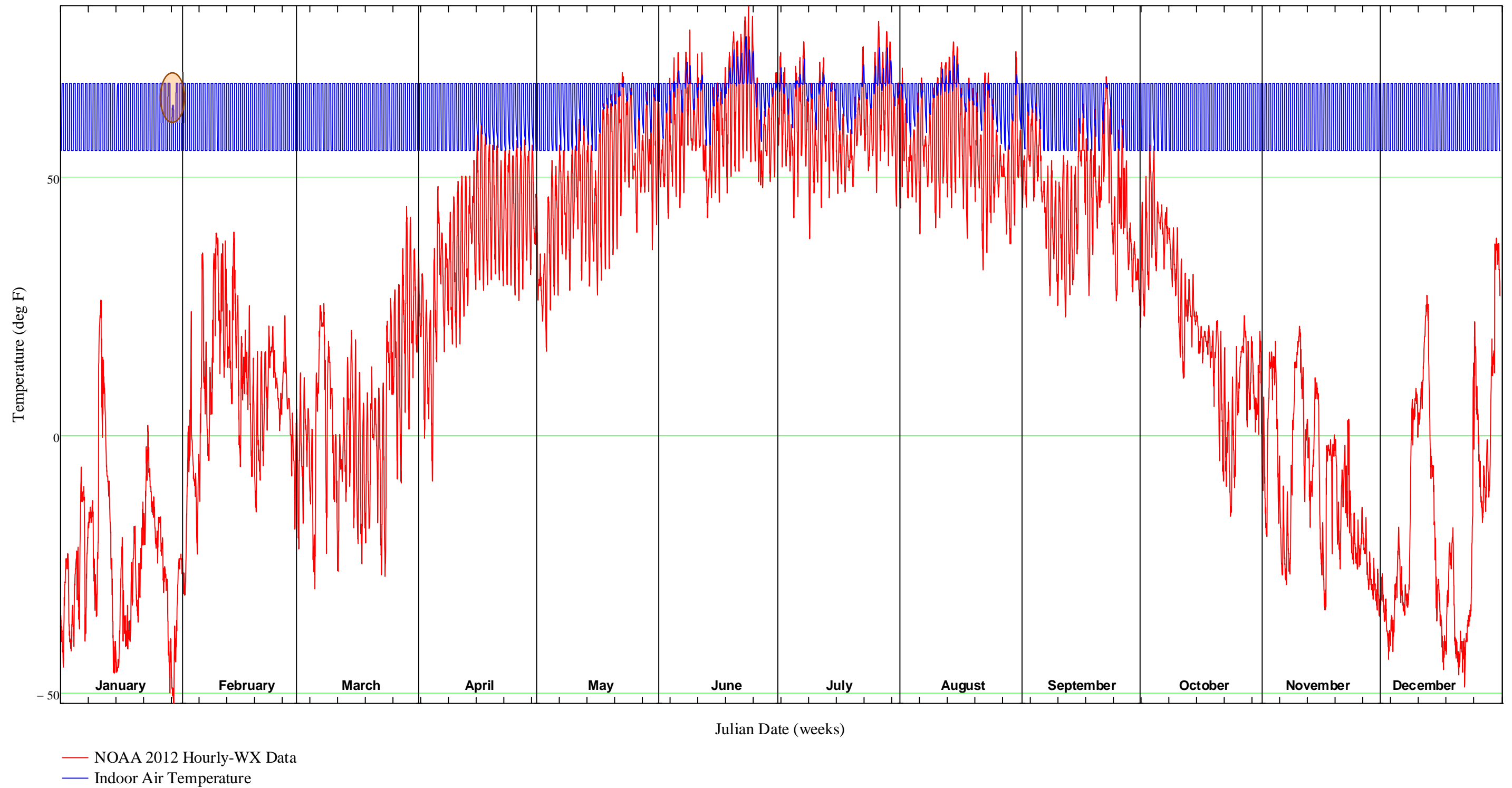
Looking at the graph below, the system cannot reach the 68 °F set point on January 1<sup>st</sup>, 3<sup>rd</sup>, 14<sup>th</sup>, 15<sup>th</sup>, 28<sup>th</sup>, & 29<sup>th</sup>. It struggles to reach and maintain set point on several other dates as indicated by the jagged indoor temperature profile.

Eielson AFB: 93,000 SF General Admin Building



If we up size the heating system by 15%, as allowed by UFC 3-410-01, Sec 3-4.1, our heating system is upsized to 693.9 MBTUH. The temperature profile below documents its ability to reach and maintain set point.

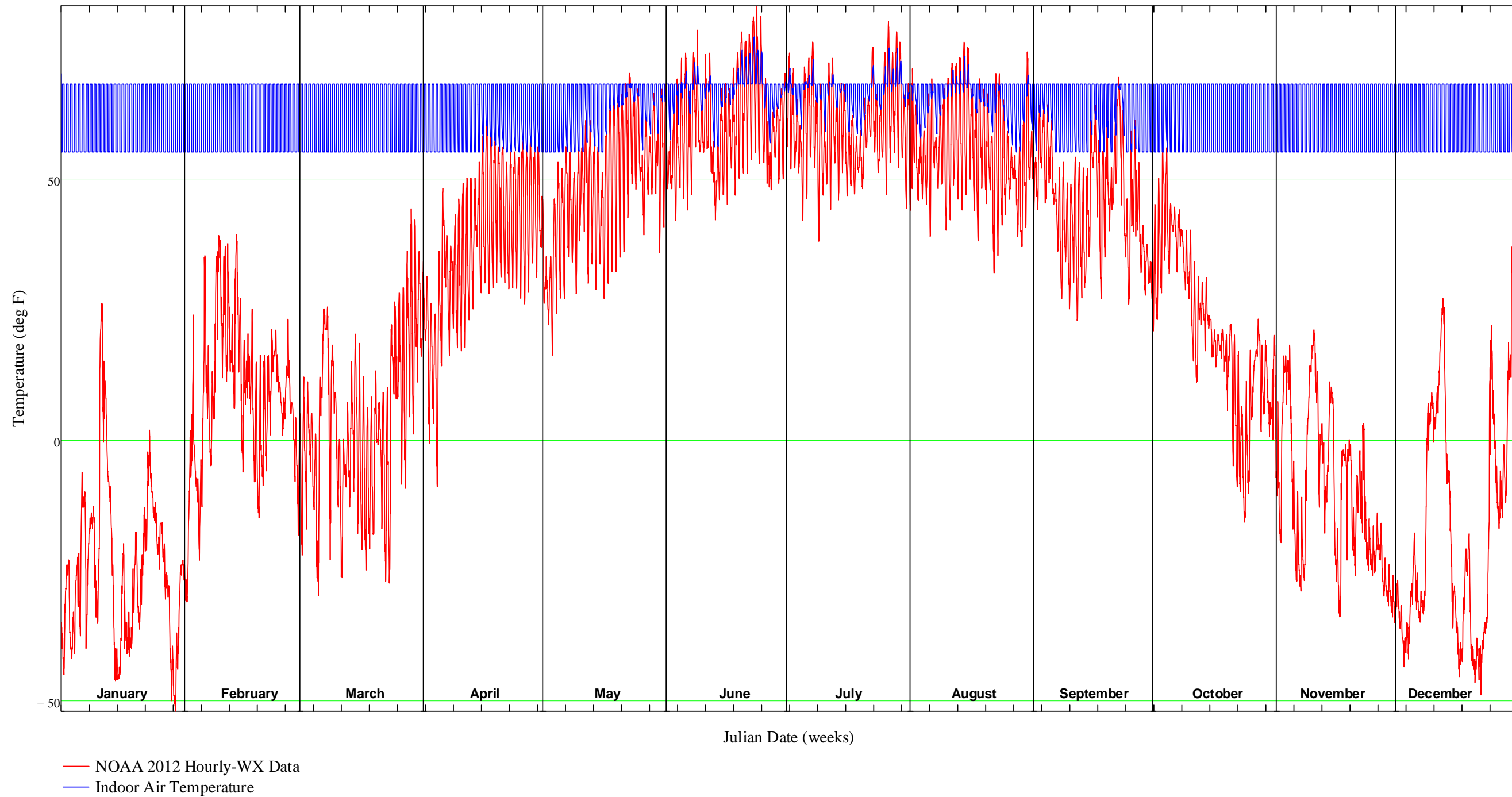
### Eielson AFB: 93,000 SF General Admin Building



The Design + 15% heating system meets set point every day except on 29 January – the coldest day in the coldest year of the past 11-years. On this day, the indoor temperature reaches 64 °F (set point is 68 °F).

But let's assume that you cannot purchase a 693.9 MBTUH output heating system. The Lochinvar example, shown in paragraph #1 above, shows how the system must be upsized from 693.9 MMBTUH to 806.8 MBTUH. This upsizing effectively provides an additional safety factor. The 806 MBTUH profile is shown below:

Eielson AFB: 93,000 SF General Admin Building



Now, the heating system is able to reach set point for every day of the year.

**CONCLUSION:** Using the 99%-tile design temperature of -40 °F is adequate to meet mission requirements.



OPERATIONAL CLIMATIC DATA SUMMARY (OCDS-II)

<b>LOCATION ID</b> ICAO_PAEI	<b>STATION NAME</b> FAIRBANKS/EIELSON A, AK	<b>PERIOD OF RECORD</b> Mean: 2000/01/01 - 2014/12/31 Extreme: 1944/11/11 - 2016/12/31	<b>UTC TO LST</b> -9
<b>LOCATION(DEGREES)</b> N 64.665 W 147.101		<b>ELEVATION(FEET)</b> 548	<b>PREPARED BY</b> 557WW /14WS
<b>YEAR(S)</b> Period of Record (see detailed POR >>>)		<b>DETAILED POR</b> 1944-1970, 1973-2016	

LIMITED ASSESSMENT - SHORT PERIODS OF RECORD AND OR LIMITED HOURS OF OPERATIONS RESULT IN INSUFFICIENT DATA TO ACCURATELY REFLECT TRUE CLIMATOLOGICAL CONDITIONS

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TEMPERATURE

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Temperature Extreme Maximum (°F)	54	50	55	75	92	93	92	91	82	75	50	48	93
Temperature Mean Maximum (°F)	1	14	24	44	61	71	72	67	56	35	11	4	38
Temperature Mean (°F)	-10	1	10	33	49	60	61	56	44	26	3	-5	28
Temperature Mean Minimum (°F)	-14	-7	-2	21	38	50	52	46	35	19	-3	-11	19
Temperature Extreme Minimum (°F)	-64	-60	-50	-26	-1	31	34	25	3	-35	-45	-61	-64
Temperature Maximum Range (°F)	56	59	54	47	43	40	38	40	40	41	47	63	63
Days With Temperature >= 90°F	0	0	0	0	0	0	0	0	0	0	0	0	0
Days With Temperature <= 32°F	31	28	31	27	9	0	0	1	12	28	30	31	229
Days With Temperature <= 0°F	24	20	18	3	0	0	0	0	0	3	19	24	110

\* = No Data T = Trace # = Occurrences rounded to 0

[Go to the top of the page](#)

PRECIPITATION

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Precipitation Period Maximum (In)	4.0	2.5	2.7	4.4	2.3	4.9	6.9	7.5	3.7	3.6	2.7	3.1	24.7
Precipitation Period Mean (In)	0.6	0.5	0.4	0.4	0.8	1.8	2.5	2.3	1.3	0.9	0.7	0.6	12.9
Precipitation Period Minimum (In)	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	5.8
Precipitation Period Daily Maximum (In)	1.2	1.0	0.8	0.8	1.0	1.5	2.2	3.4	1.3	1.2	0.7	1.0	3.4
Snowfall Period Maximum (In)	36.0	34.2	30.9	38.0	17.4	0.0	0.0	0.0	35.2	39.6	48.9	52.4	189.9
Snowfall Period Mean (In)	10.3	8.0	6.9	4.1	0.9	0.0	0.0	0.0	1.9	10.7	12.6	11.3	67.9
Snowfall Period Daily Maximum (In)	12.7	15.0	18.0	13.9	8.4	0.0	0.0	0.0	13.8	11.8	9.3	12.9	18.0
Days with liquid >= Trace	6	5	4	4	8	6	6	4	4	7	6	6	67
Days with liquid >= 0.01"	7	4	4	3	6	11	13	12	9	8	7	7	91
Days with liquid >= 0.5"	#	#	#	0	0	1	1	2	0	#	0	0	5
Days with snow >= Trace	8	6	5	4	2	0	0	#	2	7	7	8	50
Days with snow >= 0.05"	8	7	6	4	1	0	0	0	2	10	10	10	58
Days with snow >= 1.5"	2	2	2	1	#	0	0	0	#	2	3	2	15

\* = No Data T = Trace # = Occurrences rounded to 0

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MOISTURE

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Relative Humidity Mean Maximum (%)	93.7	93.3	86.4	82.6	77.9	83.5	89.3	93.4	93.1	93.4	92.3	92.8	89.3
Relative Humidity Mean Minimum (%)	77.1	69.6	44.0	34.1	28.3	33.6	41.8	45.5	47.2	64.8	77.6	78.7	53.3
Vapor Pressure Mean (In Hg)	0.04	0.05	0.05	0.11	0.18	0.31	0.36	0.33	0.22	0.12	0.05	0.04	0.16
Dew Point Temperature Mean (°F)	-6	-1	2	19	31	45	49	47	36	21	1	-5	20
Dew Point Temperature Extreme Maximum (°F)	39	43	43	53	63	67	73	72	60	53	46	41	73
Dew Point Temperature Extreme Minimum (°F)	-63	-55	-59	-55	-16	10	25	16	-6	-57	-59	-59	-63

\* = No Data T = Trace # = Occurrences rounded to 0

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WIND

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
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Prevailing Wind Direction	\$S	\$N	\$N	\$W	\$W	\$W	\$W	\$W	\$S	\$S	\$S	\$S	\$S
Wind Speed Mean for Prevailing Wind Direction (kts)	3.9	4.1	5.6	7.0	6.8	6.4	6.2	6.2	4.3	4.1	3.9	3.7	4.5
Wind Speed Mean for All Wind Directions (kts)	1.7	2.3	3.7	4.3	4.9	4.3	4.1	3.3	3.3	2.5	1.9	1.7	3.1
Wind Speed Maximum (kts)	32.8	32.1	28.0	29.9	28.0	30.9	29.9	26.0	28.9	32.1	31.1	28.9	32.8
Gust Speed Maximum (kts)	65.1	48.0	42.0	35.9	46.0	42.9	49.9	41.0	46.0	60.0	45.1	64.1	65.1

\* = No Data T = Trace # = Occurrences rounded to 0

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PRESSURE

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Pressure Altitude Extreme Maximum (ft)	1929.1	2066.9	1824.1	1699.5	1614.2	1443.6	1187.7	1460.0	1768.4	1804.5	1998.0	2044.0	2066.9

\* = No Data T = Trace # = Occurrences rounded to 0

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WEATHER OCCURRENCE

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Fog Days Mean (FG/BR)	14	9	4	4	2	3	6	10	9	13	12	14	100
Thunderstorm Days Mean	0	0	0	0	1	4	3	0	#	0	0	0	8
Precipitation Days Mean	*	*	*	*	*	*	*	*	*	*	*	*	*
Rain Days Mean	1	0	#	3	12	17	18	16	13	5	2	1	87
Freezing Rain Days Mean	1	#	#	#	0	0	0	#	0	1	1	1	4

\* = No Data T = Trace # = Occurrences rounded to 0

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CEILING AND VISIBILITY

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Cloud Cover Mean (x/8)	5	5	4	5	5	5	6	6	5	6	6	5	5

\* = No Data T = Trace # = Occurrences rounded to 0

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% FREQUENCY OF WIND > 25 KTS

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	0.6	1.3	1.1	0.1	1.2	0.8	0.4	0.5	0.5	0.2	0.2	0.6	0.6
17-19 LST	0.2	2.0	0.5	0.1	0.9	0.6	0.5	0.0	0.1	0.3	0.2	0.3	0.5
20-22 LST	0.2	1.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.2	0.1	0.4	0.2
23-01 LST	0.1	1.1	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.6	0.3
02-04 LST	0.1	0.7	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.3	0.2
05-07 LST	0.1	0.7	0.2	0.1	0.0	0.0	0.1	0.0	0.1	0.5	0.2	0.4	0.2
08-10 LST	0.3	1.0	0.1	0.4	0.3	0.0	0.0	0.1	0.5	0.7	0.2	1.0	0.4
11-13 LST	0.2	0.4	0.2	0.1	0.6	0.4	0.0	0.1	0.4	0.7	0.2	0.3	0.3
All Hours	0.2	1.0	0.4	0.1	0.5	0.3	0.1	0.1	0.2	0.4	0.2	0.5	0.3

\* = No Data T = Trace # = Occurrences rounded to 0

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% FREQUENCY OF FOG (FG/BR)

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	23.3	6.6	2.1	1.8	2.4	1.0	2.3	3.3	3.2	11.0	14.5	19.6	8.2
17-19 LST	16.3	8.7	3.8	2.4	0.9	1.2	1.7	2.9	3.1	11.6	15.7	16.5	7.6
20-22 LST	17.1	8.2	5.8	5.8	1.4	1.4	3.3	5.3	9.0	18.4	12.2	14.8	9.0
23-01 LST	19.4	14.2	10.9	13.6	9.3	6.6	12.8	17.7	15.5	26.7	17.6	17.9	16.0
02-04 LST	18.0	12.5	9.2	18.2	6.6	13.1	17.2	38.0	29.1	38.5	13.4	14.9	20.3
05-07 LST	18.5	15.7	9.5	12.6	4.4	6.2	11.2	27.8	29.3	29.3	16.5	18.0	17.5
08-10 LST	24.9	15.5	7.1	5.5	2.9	1.9	6.3	16.4	19.0	25.2	19.5	18.8	14.2
11-13 LST	27.1	10.8	2.8	1.9	2.8	2.2	3.0	6.6	6.8	13.0	17.3	21.3	10.3
All Hours	20.6	11.7	6.3	7.2	3.4	3.8	6.8	15.4	14.7	22.3	15.9	17.7	12.8

\* = No Data T = Trace # = Occurrences rounded to 0

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% FREQUENCY OF THUNDERSTORM

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	0.0	0.0	0.0	0.0	0.5	4.7	1.8	0.8	0.1	0.0	0.0	0.0	0.6



17-19 LST	0.0	0.0	0.0	0.0	0.5	2.1	1.1	1.1	0.3	0.0	0.0	0.0	0.4
20-22 LST	0.0	0.0	0.0	0.0	0.2	1.6	1.7	0.1	0.0	0.0	0.0	0.0	0.3
23-01 LST	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.1
02-04 LST	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
05-07 LST	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
08-10 LST	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
11-13 LST	0.0	0.0	0.0	0.0	0.5	1.2	0.4	0.0	0.0	0.0	0.0	0.0	0.2
All Hours	0.0	0.0	0.0	0.0	0.3	1.4	0.8	0.2	0.1	0.0	0.0	0.0	0.2

\* = No Data T = Trace # = Occurrences rounded to 0

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% FREQUENCY OF RAIN

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	0.5	0.3	0.1	3.3	11.8	15.1	16.0	17.8	12.4	2.5	1.4	0.3	6.5
17-19 LST	0.3	0.5	0.1	3.2	10.7	12.3	14.8	16.4	10.2	2.2	1.5	0.2	5.7
20-22 LST	0.5	0.3	0.0	1.7	7.2	13.3	14.7	18.5	11.1	4.2	1.1	0.3	5.8
23-01 LST	0.1	0.2	0.0	0.5	3.5	15.5	24.2	15.0	8.3	1.9	1.1	0.4	4.8
02-04 LST	0.7	0.2	0.2	0.7	3.4	13.4	20.2	16.9	9.3	3.4	2.4	0.1	5.5
05-07 LST	0.4	0.5	0.1	1.9	9.1	14.4	21.6	19.4	11.4	2.7	2.1	0.3	6.7
08-10 LST	0.4	0.6	0.0	2.0	10.0	13.7	17.7	18.7	12.1	2.3	1.6	0.4	6.4
11-13 LST	0.3	0.1	0.1	1.9	9.5	16.0	14.4	18.5	12.9	2.6	0.9	0.9	6.3
All Hours	0.4	0.3	0.1	2.0	8.7	14.2	17.7	17.8	11.1	2.7	1.5	0.4	6.0

\* = No Data T = Trace # = Occurrences rounded to 0

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% FREQUENCY OF SNOW OR ICE PELLET

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	17.8	21.6	14.0	7.1	3.2	0.1	0.0	0.0	2.8	20.7	27.9	21.9	12.0
17-19 LST	19.5	21.0	13.6	7.4	0.7	0.0	0.0	0.0	2.6	15.5	27.2	21.3	11.4
20-22 LST	16.7	16.7	15.7	11.4	1.9	0.0	0.0	0.0	3.5	17.4	25.2	20.2	11.2
23-01 LST	23.4	22.8	23.5	18.4	3.2	0.0	0.0	0.0	4.0	23.7	30.1	24.2	16.7
02-04 LST	26.0	25.1	22.5	18.7	2.8	0.0	0.0	0.0	5.5	21.5	33.0	26.7	16.6
05-07 LST	21.6	20.0	18.1	17.4	4.5	0.0	0.0	0.0	2.9	22.5	29.1	25.3	14.1
08-10 LST	20.6	22.5	18.8	16.3	3.8	0.1	0.0	0.0	2.9	24.9	27.3	21.5	13.7
11-13 LST	17.7	20.4	14.9	8.6	2.9	0.0	0.0	0.0	2.1	20.9	28.5	20.4	11.8
All Hours	20.4	21.3	17.5	12.9	2.9	0.0	0.0	0.0	3.2	21.0	28.5	22.8	13.4

\* = No Data T = Trace # = Occurrences rounded to 0

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% FREQUENCY OF CEILING & VISIBILITY < 100.00 FT / 0.25 MI

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.5	0.1
17-19 LST	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.2	0.1
20-22 LST	0.6	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.2	0.6	0.0	0.2	0.2
23-01 LST	0.3	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1
02-04 LST	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.5	0.1	0.1
05-07 LST	0.0	0.1	0.0	0.2	0.3	0.0	0.2	0.8	0.9	0.3	0.1	0.1	0.3
08-10 LST	0.6	0.4	0.0	0.0	0.0	0.0	0.2	0.2	0.8	0.9	0.5	0.0	0.3
11-13 LST	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.2	0.2	0.2
All Hours	0.4	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.3	0.4	0.2	0.2	0.2

\* = No Data T = Trace # = Occurrences rounded to 0

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% FREQUENCY OF CEILING & VISIBILITY < 200.00 FT / 0.50 MI

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	2.3	0.7	0.1	0.0	0.0	0.0	0.1	0.5	0.1	0.1	0.5	1.1	0.5
17-19 LST	1.7	1.1	0.1	0.0	0.0	0.0	0.2	0.8	0.1	0.5	0.2	0.7	0.5
20-22 LST	1.9	1.3	0.4	0.2	0.0	0.0	0.3	1.0	0.2	1.2	0.0	0.5	0.6
23-01 LST	3.2	3.3	1.5	0.0	0.0	0.1	0.7	0.1	1.2	0.9	0.0	1.5	1.1
02-04 LST	6.4	5.0	2.7	0.1	0.3	0.0	0.5	0.5	1.5	2.0	0.8	2.1	1.8
05-07 LST	4.3	3.7	0.9	0.4	0.4	0.1	0.9	2.4	3.2	1.5	0.6	1.7	1.6

08-10 LST	2.8	2.4	0.0	0.0	0.1	0.0	0.2	1.0	2.2	2.6	0.7	0.5	1.0
11-13 LST	4.1	1.1	0.0	0.1	0.1	0.0	0.0	0.3	0.4	1.1	0.5	0.8	0.7
All Hours	3.3	2.3	0.7	0.1	0.1	0.0	0.4	0.8	1.1	1.2	0.4	1.1	1.0

\* = No Data    T = Trace    # = Occurrences rounded to 0

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**% FREQUENCY OF CEILING & VISIBILITY < 300.00 FT / 1.00 MI**

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	4.7	1.8	0.4	0.3	0.1	0.0	0.5	2.2	0.2	1.5	2.6	3.6	1.5
17-19 LST	4.4	2.2	0.3	0.3	0.0	0.0	0.6	2.0	0.2	1.8	2.4	2.6	1.4
20-22 LST	4.5	1.9	0.4	0.5	0.0	0.2	0.5	3.0	0.5	2.9	2.4	2.4	1.6
23-01 LST	7.1	4.7	2.4	0.4	0.1	0.5	0.7	1.2	2.2	3.7	2.9	4.8	2.7
02-04 LST	11.1	8.2	3.2	0.6	0.4	0.5	1.5	2.3	4.1	6.0	5.0	5.1	3.9
05-07 LST	10.1	6.5	1.5	1.2	0.5	0.7	1.7	6.1	5.6	7.5	4.0	5.2	4.1
08-10 LST	6.8	5.8	0.5	0.6	0.2	0.2	1.1	3.6	4.5	6.8	2.9	2.6	3.0
11-13 LST	8.7	3.1	0.5	0.5	0.1	0.1	0.5	2.0	0.8	2.2	2.1	3.6	2.0
All Hours	7.2	4.3	1.1	0.5	0.2	0.3	0.9	2.8	2.3	4.0	3.0	3.7	2.5

\* = No Data    T = Trace    # = Occurrences rounded to 0

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**% FREQUENCY OF CEILING & VISIBILITY < 500.00 FT / 1.50 MI**

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	8.0	3.0	0.4	0.4	0.2	0.5	0.9	4.1	0.9	3.1	5.7	6.3	2.8
17-19 LST	7.6	3.5	0.6	0.7	0.0	0.5	0.6	4.0	0.6	3.3	5.0	5.1	2.6
20-22 LST	7.6	2.6	0.8	1.3	0.1	0.5	0.8	4.5	1.1	5.6	5.3	5.3	2.9
23-01 LST	12.1	7.5	3.4	1.2	0.4	0.8	0.8	2.6	3.1	6.9	6.7	9.6	4.8
02-04 LST	19.0	11.5	5.4	1.1	0.9	2.1	2.1	5.0	6.2	12.2	10.3	11.3	7.2
05-07 LST	15.8	10.9	2.5	2.0	0.7	2.5	3.5	10.6	8.9	13.7	7.7	9.5	7.2
08-10 LST	11.4	8.1	1.4	0.8	0.6	0.8	1.8	8.3	7.4	13.0	6.8	5.7	5.5
11-13 LST	11.3	5.2	1.0	0.6	0.2	0.8	0.9	4.3	2.7	6.7	6.0	6.8	3.9
All Hours	11.6	6.5	1.9	1.0	0.4	1.1	1.4	5.4	3.9	8.1	6.7	7.4	4.6

\* = No Data    T = Trace    # = Occurrences rounded to 0

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**% FREQUENCY OF CEILING & VISIBILITY < 800.00 FT / 2.00 MI**

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	11.0	4.5	1.0	0.8	0.6	1.3	1.5	6.5	2.8	8.5	8.8	8.4	4.6
17-19 LST	9.9	4.7	0.8	1.1	0.4	1.2	1.6	5.7	1.9	7.4	7.5	7.2	4.1
20-22 LST	9.7	3.9	1.2	1.7	0.4	1.1	1.3	6.9	2.8	10.1	7.3	8.2	4.5
23-01 LST	15.9	9.5	4.4	2.9	0.4	1.9	2.1	4.6	4.9	12.9	10.0	14.1	7.3
02-04 LST	21.6	15.1	6.8	2.1	0.9	3.9	4.0	7.5	10.0	17.2	12.9	16.0	9.8
05-07 LST	18.2	13.5	3.6	3.9	1.4	4.9	6.1	16.3	13.2	19.0	10.8	13.3	10.2
08-10 LST	13.8	10.2	2.4	2.2	1.4	3.3	6.0	14.3	12.6	17.5	9.3	7.7	8.4
11-13 LST	14.6	6.6	1.3	0.9	1.1	1.8	2.2	8.4	6.0	13.6	9.3	9.7	6.3
All Hours	14.3	8.5	2.7	1.9	0.8	2.4	3.1	8.8	6.8	13.3	9.5	10.6	6.9

\* = No Data    T = Trace    # = Occurrences rounded to 0

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**% FREQUENCY OF CEILING & VISIBILITY < 1000.00 FT / 2.00 MI**

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	11.5	4.8	1.0	0.9	1.0	1.4	2.1	6.9	3.6	11.2	9.4	8.8	5.2
17-19 LST	10.5	5.3	0.8	1.2	0.7	1.3	2.2	6.1	2.3	8.3	8.1	7.9	4.5
20-22 LST	9.9	4.3	1.2	1.9	0.8	1.2	1.8	7.3	2.9	11.8	7.8	8.9	5.0
23-01 LST	16.6	9.9	4.8	3.1	0.5	2.1	2.9	5.7	5.9	16.0	11.5	15.0	8.1
02-04 LST	22.2	15.5	7.7	3.1	0.9	4.5	6.3	8.0	10.8	19.3	14.0	17.8	10.8
05-07 LST	19.1	14.0	3.9	5.0	1.5	5.5	7.7	17.6	14.1	20.5	12.2	14.1	11.2
08-10 LST	14.4	10.9	2.8	2.8	1.7	4.1	7.3	16.0	14.3	19.4	9.5	8.3	9.3
11-13 LST	14.9	7.5	1.4	1.3	1.4	2.5	3.4	9.4	7.6	16.0	9.9	10.0	7.1
All Hours	14.9	9.0	2.9	2.4	1.1	2.8	4.2	9.6	7.7	15.3	10.3	11.3	7.6

\* = No Data    T = Trace    # = Occurrences rounded to 0

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**% FREQUENCY OF CEILING & VISIBILITY < 1500.00 FT / 3.00 MI**

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	16.4	7.7	2.6	2.0	1.8	2.5	3.8	10.6	6.7	16.6	13.8	12.4	8.1
17-19 LST	15.8	7.5	3.1	2.2	1.1	1.7	3.2	9.4	3.9	13.9	13.2	10.8	7.1
20-22 LST	14.8	6.7	4.0	2.9	1.0	1.5	3.2	9.2	4.3	18.2	12.9	13.3	7.7
23-01 LST	21.1	12.3	6.7	4.7	1.0	2.7	4.4	7.9	6.9	19.5	15.4	18.2	10.5
02-04 LST	25.2	18.0	9.4	5.1	1.0	6.7	10.0	11.7	12.6	24.9	18.3	21.8	13.7
05-07 LST	23.2	17.8	7.0	8.0	3.0	7.6	12.1	23.4	16.1	25.8	16.1	19.2	14.8
08-10 LST	18.1	13.9	5.9	7.2	3.9	6.7	11.9	23.0	17.2	25.3	14.3	12.7	13.4
11-13 LST	17.9	10.6	3.9	3.4	2.9	4.0	6.7	14.8	12.8	20.8	14.5	14.1	10.5
All Hours	19.1	11.8	5.3	4.4	2.0	4.2	6.9	13.7	10.1	20.6	14.8	15.3	10.7

\* = No Data    T = Trace    # = Occurrences rounded to 0

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**% FREQUENCY OF CEILING & VISIBILITY < 3000.00 FT / 3.00 MI**

HOURS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
14-16 LST	20.6	12.6	6.1	5.3	4.6	5.1	9.5	16.0	11.3	25.8	20.8	17.9	13.0
17-19 LST	20.6	11.5	5.3	4.5	3.3	3.3	6.1	14.4	8.0	21.5	20.0	16.2	11.2
20-22 LST	20.0	11.4	6.7	4.3	2.6	3.3	5.5	12.0	8.1	25.1	19.6	19.1	11.5
23-01 LST	26.3	17.1	11.0	6.5	2.8	4.9	7.3	12.0	9.9	27.8	22.7	22.8	14.8
02-04 LST	32.6	23.6	15.1	7.1	3.2	9.9	13.6	16.0	15.3	30.6	24.7	27.4	18.2
05-07 LST	29.9	23.2	11.4	10.7	5.5	10.4	16.9	27.5	18.1	33.1	23.7	27.6	19.6
08-10 LST	23.9	19.1	8.9	10.5	7.9	10.7	20.0	27.2	20.4	32.8	21.3	20.5	18.6
11-13 LST	22.2	15.4	7.1	8.1	5.7	7.0	15.1	23.4	16.9	28.7	21.4	21.0	16.0
All Hours	24.5	16.7	8.9	7.1	4.4	6.8	11.7	18.6	13.5	28.2	21.8	21.6	15.4

\* = No Data    T = Trace    # = Occurrences rounded to 0

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