23 01 00 OPERATION AND MAINTENANCE OF HVAC SYSTEM

23 01 01 GENERAL REQUIREMENTS

General System Design

1. Use air systems in combination with perimeter radiation. Perimeter radiation shall be capable of being operated independent of the air system.
2. Avoid all air systems.
3. Zone mechanical systems by intended occupancy, separate interior and exterior zones.
4. Provide re-heat coils in each interior zone.
5. All air handling units shall have heating or preheat coils even if building load indicate that one is not required.
6. Proposed fan volume control schemes, based on building static pressure, must have prior approval from FMGT.
7. Do not specify variable pitch in motion fans.
8. Design all air handling units with minimum 15% spare volumetric and static pressure capacity.
9. Buildings with no mechanical cooling (typical) shall have cooling circulation air increased by minimum of 25% or have sufficient volume to meet WCB requirements with respect to maximum space temperature, whichever is greater. Consider additional costs of construction and compare to cost of adding and operating mechanical cooling.
10. Radiant heating panels shall not face windows.
11. Provide separate exhaust to all photocopier rooms or areas. Exhaust to outdoors.
12. Ensure sufficient air mixing within the occupied space on VAV systems under all operating conditions.
13. VAV systems shall have reheat coils.
14. Window mounted air conditions and exhaust fans are not acceptable.
15. All exhaust ductwork within the building shall be under negative pressure.
16. Specify separate ventilation and heat recovery systems for mechanical and electrical rooms.
17. Do not specify sidewall supply registers for classroom applications.
18. Laboratory design shall meet best practices of applicable ASHRAE design standards, and/or the equivalent CSA standard recognized by the B.C. Building Code.
19. Return and supply fans requiring volumetric tracking shall have same type devices for volume control (i.e. inlet dampers must be only used with inlet dampers, VFD’s with VFD’s, etc.).

20. If fume hood exhaust systems are located in mechanical penthouses they shall be located in separate self-contained areas within the mechanical penthouse.

21. Where fume hood fans are contained within mechanical penthouses, pressurize the penthouse with supply air from the building from a safe outside source to avoid the possibility of recirculation exhaust air into the service space and to provide flushing of contaminants if a minor duct leak occurs. Fumes from industrial lab process shall be removed from spaces by the use of dedicated exhaust systems (not recirculation permitted).

22. Ventilation systems shall be designed to limit bio-contamination. Spaces containing “like-risks” can share ventilation systems, while bio and chemical ventilation systems shall be separated to avoid cross contamination.

23. Humidification shall be applied to each specific zone which requires local control. Avoid upstream humidification and downstream dehumidification.

Piped Systems Cleaning

1. For the campus heating mains, process water lines or chilled water lines, retain the services of a professional cleaning agency to supervise the chemical cleaning and flushing of the new piping. FMGT Mechanical Shop will provide the subsequent chemical treatment.

23 01 30 OPERATION AND MAINTENANCE OF HVAC AIR DISTRIBUTION

Cleaning Exhaust Systems – General Requirements

1. All new ventilations systems, or those affected by the project shall be cleaned by a professional cleaning Trade Contractor with appropriate equipment and trained personnel.

2. The following air systems shall be cleaned as specified by the Mechanical Consultant:
    i. Supply, return, relief, and exhaust.
    ii. Air conditioning.

3. All components within each new or affected system shall be thoroughly cleaned to the Consultants satisfaction.

4. On new construction, renovation, or retrofit project, the ductwork shall be cleaned before the air systems are balanced or calibrated.

5. All damper positions shall be marked before cleaning and returned to their original position unless the system is to be balanced.

6. Cleaning shall generally include high capacity power vacuum, compressed air or wire brushing. Solvent cleaning is to be avoided.

Filters

1. The Cleaning Contractor shall replace any temporary or existing filters and supply and install new filters as specified by the Consultant after the air system is cleaned.

23 07 19 HVAC PIPING INSULATION

1. Insulation shall be installed by qualified insulation fitters.

2. Insulation shall be installed in accordance with the requirements and recommendation of B.C. Insulation Contractors Association Manual.

Campus Heating Mains

1. This system may operate with up to 116°C (241°F) water.

2. Provide minimum 50mm (2”) thick, mineral fibre insulation on piping (not drains) with vapour barrier jacket and where trenches or manholes provide a generous coating of water-proofing sealer.

3. Mains valves 65mm (NPS 2-1/2) and larger shall have bonnets insulated with removable insulation jackets.

Refrigeration Piping (Including Chilled Water)

1. Where installed outdoors, provide a continuous aluminum jacket finish (to prevent birds removing the insulation).

2. Provide closed-cell insulation and best industry practice to seal surface at all locations including hangers and exposed fittings.

Insulation Finish

1. Provide aluminum jacket over all outdoor insulation.

2. Provide an all service jacket and pre-fitted PVC jacketed elbows and fittings for all indoor insulated pipes with the exception of:
    i. Provide a “Thermocanvas” type finish and pre-fitted PVC jacketed fittings on all piping in mechanical rooms and where exposed to occupant view.

23 10 00 FACILITY FUEL SYSTEMS

23 11 00 FACILITY FUEL PIPING

Campus Heating Mains

1. All piping shall be Schedule 40 steel to ASTM A53 Grade B.

2. All piping shall be welded except manual air vent and drain valves may be screwed and piping downstream of them may be screwed.

3. Manual air vent and drain valves shall be ball valves with wing-type (not lever-type) handles.

4. There shall be no high or low point in the piping between heating mains manholes. If this cannot be avoided then air vents/drains must be provided at the high/low point.

5. Valves (other than air vent and drain valves) shall be class 150 ball valves. 150pisq/400°F. >=1 1/2" must be equipped with gear driven operator to slow speed to open valve. >=4” to have 3/4" gate bypass for warmup.

6. For the most part these mains run underground. Where underground they shall run in a concrete trench typical in design and construction to the existing which are designed for water-tightness and to have removable lids.

7. Mains valves, drain valves, and vents shall be in accessible manholes or in building mechanical rooms.

8. Where possible arrange take-offs for a building to be valved such that future shutdown of a section of the mains will not interrupt service to the building.

Building Heating, Heat Recovery, and Chilled Water Piping and Valves

1. Piping may be steel to ASTM A53 Grade B or type L copper, to ASTM B88M-86.

2. Connections for steel pipe shall be welded and flanged on pipe NPS 2-1/2 (65mm) diameter and larger shall be screwed on pipe NPS 2 (50mm) diameter and smaller.

3. Connections for copper pipe shall be brazed with silver base brazing alloy, 538°C (1000°F) melting point but with soldered to screwed cast bronze fittings (to ANSI B16.18) or wrought copper fittings (to ANSI B16.22).

4. Grooved mechanical couplings are not acceptable.

5. Press-fit type couplings are not acceptable.

6. Valves NPS 2-1/2 (65mm) and larger shall be flanged. Valves NPSD 2-1/2 (65mm) and smaller shall be soldered or screwed.

7. Butterfly valves may only be used on heat recovery systems or chilled water systems or heating water systems where the maximum design temperature does not exceed 180°F (82°C).

8. Balance valves shall be multiple-turn, memory stop, positive shut-off with inlet and outlet pressure connections, calibrated for flow measuring. Acceptable products: Armstrong CBV, Tour & Andersen STA.

23 20 00 HVAC PIPING AND PUMPS

23 21 13 HYDRONIC PIPING

1. All hydronic heating systems within a building must have shutoff valves on each floor, complete with drain valves and ¾ inch hose connections.

23 21 23 HYDRONIC PUMPS

General

1. Where Manufacturer's Specifications are provided, the assembly, installation, alignment, testing, calibration and lubrication, start-up and test run shall conform to the Manufacturer's Specifications, or this specification, whichever is more stringent.

2. In this section the following words shall have the meanings herein assigned to them:
    i. *Primary equipment* shall mean the first item of machinery set into place whether or not it is a pump, a refiner, or the common drive on a multi-vacuum pump assembly.
    ii. *Drives* shall include turbines, motors, couplings of all types, reducers, sheaves, sprockets, V-belts and chains.
    iii. *Equipment* shall include both the driver and driven items.

Care of Equipment Prior to Installation

1. Equipment with openings, such as pumps, fans, refiners, screens and similar equipment, shall have the inside examined, any foreign matter removed, and defects shall be reported to the Engineer. Any temporary or permanent covers removed for inspection shall be replaced.

2. All equipment shall be inspected in the place of storage to ensure that it is in good condition, report any damages or defects to the Engineer prior to transporting the equipment to its prescribed location.

3. If the equipment is not in good condition or requires modification, the repairs and modifications shall be done prior to transporting the equipment to its prescribed location.

General Installation Requirements

1. Washers shall be installed under all nuts and under bolt heads when slotted holes are encountered.

2. Beveled washers shall be used on tapered surfaces such as structural steel flanges.

3. Equipment bolted to frames and structures shall have the bolt heads on top of the connecting components so that the bolts will not drop out of the holes in the event of a nut working loose.

4. After tightening of nuts on bolts or studs, the length of exposed bolt shall be not less than the equivalent of two threads and not more than the thickness of one nut.

5. Machine bolts, nuts and keys shall be coated before being assembled with an Owner approved lubricant, which shall be free of potentially toxic materials and metal compounds.

6. Equipment shall not be altered or repaired, and no burning or welding will be permitted on any parts except with the written permission of the Engineer.

7. Couplings, sheaves and sprockets shall be fitted during Stage 1 "Set in Place". Unless specified otherwise, they shall be fitted as follows:
    i. Couplings shall fit flush with the end of shaft, unless otherwise noted in “Plant Conditions”.
    ii. Sheaves and sprockets shall have a shaft protrusion of ¼”

8. The hubs of couplings, sheaves and sprockets shall have interference fits with the shafts, all in accordance with ANSI B4.1 (imperial) or B4.2 (metric). The interference fits shall be recorded in the presence of the Engineer on a record sheet. Compression type hubs (taper lock) shall be mounted in accordance with manufacturer’s specifications.

9. Sealing and cooling water piping discharges from equipment shall be visible.

10. Couplings shall be aligned following Stage 4 "Alignment". Tolerances shall be as per this specification.

Installation Sequence

1. To ensure that each stage of the sequence is completed by the Contractor and checked by the Engineer before the next stage commences, the Engineer shall attach a Mechanical Equipment Tag to each piece of primary equipment as it is received on site.

2. After the contractor has completed a stage he shall advise the Engineer.

3. When the Engineer is satisfied the stage is complete, both he and the contractor will sign the tag.

4. The Engineer will also maintain a separate record for each piece of equipment in case a tag is lost or damaged. The contractor will be required to sign the Engineer's record for each stage of the installation that has been completed and for which he has signed the tag.

5. On completion of the installation, the Owner's Representative will attach a green Owner Acceptance Tag to the primary equipment to signify the completion of the installation of the equipment.

6. Stage No. 1 "Set in Place"

    i. *Equipment on Concrete Pads:* Before the equipment is placed, the surface of the foundation that is to be in contact with grout shall be cleaned of all dirt, oil, grease and loose materials, and shall be roughened with a bush hammer. When this work is complete the Contractor will notify the Engineer who will check the foundation prior to setting the equipment in place.
    ii. *Equipment on Structural Supports or Steel Floors:* Before the equipment is placed, all surfaces to be covered shall be finish coated as per project paint specification.
    iii. When the equipment has been set in place, the Contractor and Engineer will sign Stage 1, "Set in Place".

7. Stage No. 2 "Levelling of Primary Equipment and Baseplate"

    i. Levelling of equipment to the location and elevation shown on the drawings shall be done with packing plates and pre-cut stainless steel slotted shims. Wedges shall not be used. Jack screws, when supplied with the equipment, may be used for vertical adjustment to achieve the tolerances specified. Jacking screws should not bear directly on concrete. The size of the packing and shims shall be approved by the Engineer and shall be large enough to provide adequate bearing on the concrete. Solid shims should be used where possible and in no case shall shims be built up to more than 3/16". The number of shims shall not be more than four.

ii. Packing and shims shall be placed on both sides of all anchor bolts within ¼" of the bolt, except where the bolt is mounted in a sleeve, then the packing and shims shall be placed as close to the bolts as possible, leaving space, however, for the introduction of grout into the anchor bolt sleeves.
iii. For large soleplates, additional packing and shims shall be placed between the anchor bolts where specified by the Engineer.
iv. Primary equipment alignment shall be within the tolerances specified in this standard. Where process temperatures warrant it, thermal growth of the equipment must be taken into consideration, and proper adjustments to alignment must be done.
v. Jacking screws shall only be used to level the equipment and shall be backed off when the equipment is shimmed and anchor bolts have been tightened.
vi. Pumps - Set the pump without motor in place over the anchor bolts. Level to a machined surface (motor mounting surface, pump discharge flange, etc.), within limits +0.003" or -0.000" and hard shim the pump with the suction piping attached. Stress on pump casing shall be within the allowable recommendation limits specified by the vendor. The stress shall be checked by loosening the suction piping and witnessing the dial indicator, located on pump shaft end or half coupling for movement, until satisfied that the pump stress is within limits (+0.002" or -0.002"). Piping will be reattached for later pump alignment, including the discharge piping.
vii. When the levelling of the primary equipment and baseplate is complete the Contractor shall notify the Engineer and they shall both sign Stage 2 "Levelling of Primary Equipment and Baseplate".

8. Stage No.3 "Grouting"

i. Recheck the concrete surface to ensure it is rough and free from dirt, oil, grease and loose materials and suitable for grouting
ii. The grouted area must be protected and heated when temperatures are less than 4°C.
iii. The concrete surface area to be grouted, shall be saturated with water from 12 to 24 hours. Any free standing water must be removed before placing the grout.
iv. Grout shall be installed so that all voids under a hollow baseplate are filled. Open frame baseplates shall be filled with grout to the top of the frame, or as specified by vendor.
v. When grouting is complete, the contractor shall notify the Engineer and they shall both sign Stage 3 "Grouting".

9. Stage No. 4 "Shaft Alignment"

i. All alignment of drives to equipment shall be done by laser alignment. The laser alignment system shall be the Optalign laser alignment equipment or equivalent, as approved by the Engineer.
ii. All connections of attachments (e.g. piping support systems) must be completed before beginning the alignment. Lugs with jacking screws may be used to assist with alignment.
iii. Any shimming done at this stage shall be in accordance with shim specifications in Section 4.7.1.
iv. When both halves of the coupling are rotated together in the same relative position, the soft foot flatness values, angular and parallel alignment values in both planes shall be within the tolerances specified in this standard.
v. Soft foot correction is to be completed, corrections made and final results recorded on Soft Foot-Check Sheet and or alignment sheet by the contractor.
vi. All alignment of equipment shall be started and completed on the same day. Following the readings, all connections and attachments must be released and readings rechecked for external loads and forces which may cause misalignment.

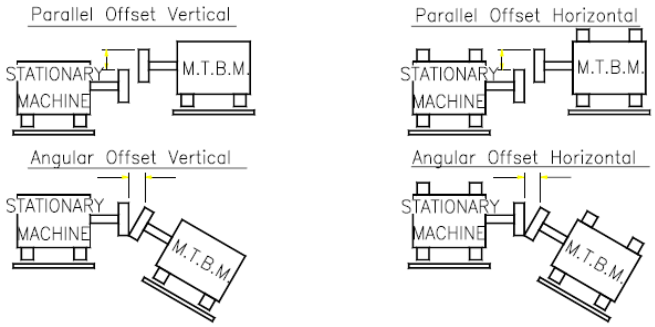
vii. If the attachments cause a deviation from the recorded readings, the attachments shall be adjusted in order to eliminate the forces. (For Tolerances See 4.7.5)
viii. When the alignment of the equipment and drive is complete, an alignment check shall be done in the presence of the Engineer. The Engineer will read and record the final results on the alignment check sheet. Contractor and Engineer shall both sign Stage 4 "Alignment".

Tolerances for Shaft Alignment

1. When aligning pump shafts use the table below to determine the required tolerances. Record alignment values and submit as part of close out submittals, a template form can be provided by FMGT. Have FMGT operations representative witness and approve final alignment.

Parallel Offset		
RPM	Excellent (mils)	Acceptable (mils)
600	0.005	0.009
900	0.003	0.006
1200	0.0025	0.004
1800	0.002	0.003
3600	0.001	0.0015
7200	0.0005	0.001
Angular Offset		
RPM	Excellent (mils)	Acceptable (mils)
600	0.001	0.0015
900	0.0007	0.001
1200	0.0005	0.0008
1800	0.0003	0.0005
3600	0.0002	0.0003
7200	0.0001	0.0002

Notes:
1) Values are expressed in thousands of an inch (mils)
2) These suggested tolerances are the maximum allowable from zero or a targeted offset in each of the four parameters of misalignment illustrated below:



23 30 00 HVAC AIR DISTRIBUTION

23 31 13 METAL DUCTS

Ductwork

1. All ductwork shall be metal, typically galvanized steel. Flexible ductwork is not acceptable.

2. Fume hood duct shall normally be 18 gauge, 316 stainless steel, continuously welded. Exceptionally corrosive situations may require more corrosion resistant materials.

3. Flexible duct of 300mm maximum length is acceptable only on a horizontal branch duct to an individual diffuser to allow alignment with the ceiling grid. It may provide a maximum of 15 degrees change in direction. No flexible duct shall be used for diffuser necks.

4. Ductwork shall be to SMACNA Standards excluding beaded, crimp joints and snaplock seams. Adjustable elbows must be the same gauge as the adjoining duct and only used if all sectional joints are sealed and secured in the installed position.

5. Ducts shall be sealed to SMACNA Seal Classification A or B as appropriate for the rated working pressure.

6. Specify access panel each side of heating coils.

7. Specify filter protection of heat recovery coils.

8. Motorized control dampers are strongly preferred over backdraft dampers.

9. Balance dampers of same material as the ductwork and shall have bushing-type bearings and a quadrant operator capable of locking the damper in a fixed position.

10. Avoid ductwork acoustical liners. Employ other methods acceptable to FMGT.

23 36 16 VARIABLE-AIR-VOLUME UNITS

1. Monitor supply air temperature downstream of every VAV box with a heating coil.

23 37 00 AIR OUTLETS AND INLETS

1. Do not specify balancing dampers at the face of air outlets and inlets. Locate balancing dampers sufficient distance into the ductwork to maintain acceptable sound level within the conditioned space (NC 3035 or less).

2. Coordinate with architectural discipline.

Outside Air Intake Louvers

1. Locate outside air intake louvers as far away as practical from all sources of contamination; avoid locating intakes at loading docks, fume hood exhausts, and generator exhausts. Outside air intake louvers are not to be located on roof tops where fume hood exhausts are located.

2. Locate outside air intake louvers as high as possible above grade and shall not be at grade level.

3. Where below grade intakes are unavoidable install bird/debris screen on outside of the louvers.

4. Where roof top parapets or screening hinder effective cross ventilation exhaust discharges, plumbing stacks and other contaminated discharges shall be elevated above air intakes at a minimum distance proscribed by code/regulation and/or good engineering practices.

Painting

1. Specify corrosion resistant primer paint to ferrous supports and site fabricated work (pewter gray).

Salvage

1. UVic does not have extensive storage facilities for salvaged material. Air conditioners, motors, and variable frequency drives in good condition have previously been considered for salvage. Occasionally a small fan or fume hood in good condition has been salvaged.

2. On renovation projects the Consultant shall submit a list of items to be considered for salvage to FMGT at the start of the design stage. The Consultant shall coordinate with FMGT to determine all materials to be salvaged which shall then be clearly specified.

3. The Mechanical Shop prefers the Contractor to remove the materials and move them to a designated storage place on campus.

4. All materials to be salvaged shall be carefully removed and handled to prevent damage and the Contractor shall obtain a signed receipt from the Mechanical Shop for all salvaged materials.

Photocopier Exhaust

1. Provide exhaust air from photocopier rooms, areas with large photocopiers (larger than a typical office copier) and areas for regular large copy production.

23 40 00 CENTRAL HEATING EQUIPMENT

23 41 00 PARTICULATE AIR FILTRATION

Indoor Air Quality – Filters

1. Filters for service rooms, protection of heat recovery coils or for small air handling units (less than 500 l/s) shall be minimum MERV 8. Standard of acceptance is 50 mm thick AAF AM-AIR 300. Acceptable product is Farr 30/30.

2. Filters for air handling systems over 500 l/s shall be a combination of a MERV 8 pre-filter and a MERV 13 final filter unless user requirements stipulate a higher value. Pre-filter standard of acceptance: 100mm thick AAF AM-AIR 300. Acceptable product is Farr 30/30. Final filter standard of acceptance, 100mm thick AAF AM-AIR Varicell II. Acceptable product is Farr Econocell.

3. Preference for pre-filter bank to be slide-in type. Final filter bank shall be built up from gasketted, individual filter frames with spring clips.

4. Separate filter gauge for each filter bank. Standard of acceptance: Dwyer Series 2000.

5. Design for suitable access for changing filters.

23 50 00 CENTRAL HEATING EQUIPMENT

23 52 00 HEATING BOILERS

1. Main Campus Loop – Industrial type, minimum boiler efficiency of 85%; gas fired.

2. Off Campus Loop – Condensing boiler (if supply water temperature demands permit); minimum life span – 20 years.

3. Minimum life span to exceed 25 years (industrial grade) for greater than 250,000 btu/hr burner rating (input).

23 57 00 HEAT EXCHANGERS FOR HVAC

1. Heat exchangers using campus heating water or any service over 82°C (180°F) shall be brazed plate type (not gasketted, plate-and-frame type).

2. Heat exchangers for domestic hot water heating shall be double-wall brazed plate type.

3. Heat exchangers for hydronic systems with water temperature 80°C (180°F) or below may be plate and frame or brazed plate type.

4. Heat exchangers anticipated to be in year-round service shall be installed as a pair each having 60% of design capacity and each with valves and unions so as to be removable without interfering with the operation of the other. This allows removal for replacement or cleaning. Duplex heat exchangers for domestic water heating shall only be considered where interruption of domestic hot water would be very disruptive (e.g. laboratory use, food services use).

5. Provide a two-way control valve on the campus mains return from the heat exchanger. Provide a 20mm (NPS 3/4) heat exchanger by-pass between the campus mains supply and return with a modulating control valve (c_v between 1.5 and 2.0), a throttling valve and isolation valves.

6. The building heating water pumps shall be designed either with duplex pumps or with valves and piping that can provide back-up in the event of failure of any one pump.

7. The heating coils should be on a separate heating water circuit from radiation to allow for different scheduled temperature control.

8. Provide flexible piping connectors on all piping connections. Standard of acceptance is Flextech Style FB26-TF.

9. Provide isolating valve, pressure gauge, thermometer, temperature sensor on each pipe connection.

10. Standard of acceptance is Alpha Laval Brazed Plate – Model CB200.

23 60 00 CENTRAL COOLING EQUIPMENT

23 61 00 REFRIGERANT COMPRESSORS

Mechanical Cooling

1. Some spaces require mechanical cooling because of equipment heat gain or process driven requirements.

2. Air cooled split systems or evaporating type condensers (closed or open) using treated water for make-up may be used. Systems using municipal water or other portable water (pass through cooling) are not acceptable.

3. Packaged roof-top equipment is generally not acceptable.

4. Unit with modulating cooling capacity are preferred (e.g. Mitsubishi variable refrigerant flow, inverter compressors).

5. Consider heat pump units instead of cooling only. Multi-zone heat pump systems must have master controls that communicate with the BAS.

6. For a new builder consider a centralized cooling system with chilled water if numerous spaces (present or future) are anticipated to require cooling.

7. Refrigerants shall not be CFC or HCFC type. R134a, R407c, and R410a refrigerants are acceptable. For low temperature refrigeration R507 is acceptable.

23 70 00 CENTRAL HVAC EQUIPMENT

23 74 00 PACKAGED OUTDOOR HVAC EQUIPMENT

Outdoor Air Handling Units

1. Select for long-life, weather tightness, and good quality.
2. Standard of acceptance: Haakon, Scott Springfield or equal.
3. On large units include a service corridor or mechanical (non-plenum) room for controls.
4. Include over-head lifting point for motors 7.5 hp and larger.
5. Variable frequency drives are required where variable volume control is required.
6. Pilot lights on plenum light switches.
7. Quality plenum door hardware.
8. Exterior doors lockable and keyed to suit appropriate UVic mechanical access key.
9. Weather louvres preferred to exterior hoods.
10. Electrical power and controls wiring in EMT conduit.
11. Typically locate air handlers in mechanical rooms. When necessary locate outdoors. Coordinate access to equipment with Architect. Typically full stairway access is required to mechanical rooms and to roof top equipment with paver walkways across roof and around equipment to protect roofing. Coordinate railings/fall protection with Architect.

Centrifugal Fans

1. Bearings: Heavy duty pillow-block, grease lubricated ball or roller self-aligning type, minimum life of AFBMA L-10 80k or AFBMA L50 400k.
2. Extend grease nipples to exterior of guards.
3. Sound power levels to AMCA 311.
4. Statically and dynamically balanced, constructed in conformity with AMCA 99.
5. Ratings: based on tests performed in accordance with AMCA 211, and ASHRAE 51.
6. Units shall bear AMCA certified rating seals.