PENNSTATE

(814) 865-0545
FAX: (814) 865-3737

Manager, Engineering Services

The Pennsylvania State University
101P Office of Physical Plant
University Park, PA 16802-1118

DATE: 6-24-09

RECD JUN 24 2009

FROM: Ian Salada

TO: Telecommunications & Software Support

Completed
JUN 29 2009

RE: Design and Construction Standards Update

DIVISION(S): 23

SECTION(S): 23 21 23

☐ Minor change to correct format problem or typographical errors
No entry in the revision log required

To be entered in "Description" block of Rev. Log

☑ Revision Log Entry Required

Description of Change: Replace current Section in its entirety to include new requirements of general design and installation

☑ Copy of changes sent via email also
clh291
cal9

Delete the following current section in its entirety.

~~23 21 23 Hydronic Pumps~~

~~***.01 Pumps***~~

~~A. General~~
~~1. Standby pumps shall be provided for all hot water heating and chilled water circulating systems.~~
~~2. Pump schedules shall indicate system served, operation (Duty or Standby), gpm, pump head, rpm, motor horsepower, location, make and model number, and electrical characteristics.~~
~~3. A single pressure gauge with gauge cocks and interconnecting piping from the suction to the discharge sides of the pump shall be provided on each pump in order that either pressure can be observed from a single gauge.~~
~~B. Pumps—Closed Coupled~~
~~1. Closed coupled pumps are not permitted.~~
~~C. Pumps—Base Mounted~~
~~1. Pumps shall be electric motor driven, centrifugal, end suction, single stage pumps. Pumps shall be bronze fitted, with bronze impeller, with close grained semi steel split casing (125 psi), provided with mechanical seals designed for operating conditions shown on the plans. Pumps shall be provided with sleeve bearings and oil reservoir.~~
~~2. Pumps shall have sleeve bearing, specially selected for quiet operation at 1750 rpm. Motor size shown on the drawing shall be the minimum acceptable. Nominal horsepower of the pump selected shall not exceed 115 percent of the brake motor hp under any conditions of pump load. Motor shall not exceed the nominal hp at the specified delivery and head.~~
~~3. Discharge increasers shall be concentric and located at pump discharge nozzle. Provide three quarter (3/4) inch drain from each base plate to nearest floor drain.~~
~~4. End suction pumps shall be provided with suction diffusers equipped with strainers.~~
~~5. Pumps shall be selected so that the ratio of impeller diameter used, to the maximum diameter possible in the casing, shall not exceed .85. Provide a purge cock in the casing and gauge tappings in pump suction and discharge.~~
~~6. All piping connections to pumps shall be independently supported so that no strain is imposed on the pump casing.~~
~~7. Pumps to be installed on "slab on grade" shall be mounted on a six (6) inch high concrete pad with anchor bolts. Grout space between pad and base to eliminate all voids. Pumps to be installed on~~

~~supported slabs shall be provided with concrete inertia subbases with isolators.~~

~~8. Refer to Detail [23 xx xx .xx]. Details are not yet available in WEB-based manual.~~

~~D. In-Line Pumps~~

~~1. Pumps shall be centrifugal, single stage complete with motor, mechanical seals, bronze fitted, bronze impellers, dynamically and hydraulically balanced, flexible coupler with safety guard.~~

~~2. Pump motor shall be supported independently.~~

~~3. Refer to Detail [23 xx xx .xx]. Details are not yet available in WEB-based manual.~~

Replace with the following text.

23 21 23 HVAC Pumps

.01 Owner General Requirements

A. H VAC Pumping Systems - Application Requirements

1. Professional shall design each application for optimal operating efficiency, reliability, and flexibility with the lowest life cycle cost.
    A. G eneral: Comply with Hydronic System Design and Control requirements in current ASHRAE Standard 90.1 supplemented by University requirements below.
        i. 01 81 13 Sustainable Design Requirements
        ii. 23 00 01.01 Summary of Design Intent
        iii. 23 00 10 .06 Central Heating and Cooling Plant
        iv. 25 90 00 GUIDE SEQUENCES OF OPERATION
        v. Design Phase Submittal Requirements
    B. Design for efficient and stable system operation: Professional shall determine the anticipated minimum and maximum loads for each pumping system and evaluate most appropriate number, combination and arrangement of pumps for optimal efficiency and stable operation of pumps over entire operating range.
        i. Overall pumping system shall be capable of operating effectively in extreme part load without deadheading or shutting off pumps entirely. For large systems with broad range of loads, evaluate the application of an additional low load pump arrangement if minimum operating point would routinely be less than minimum staged or speed control capabilities of heating/cooling pump(s) sized for full load
            A. P rofessional shall determine this minimum pump flow for each application. As a general guideline, this is often expressed as a percentage (20-25%)

of the best efficiency point (BEP) flow rate, but shall be reviewed to comply with the pump manufacturers' recommendations. On variable speed pump applications, this minimum flow is a function of the pump BEP at the minimum speed which will maintain the system control head, NOT merely based on the BEP flow rate of the full design capacity impeller/speed curve.

ii. Do not use automatic bypass valve installed in mains (directly across the pump) to ensure minimum flow. These are often set up incorrectly or malfunction and contribute to poor system performance and yet are hard to detect as functioning improperly.

A. I f otherwise unavoidable to assure stable operation at very low flows (avoiding deadheading) and/or to maintain temperatures in the loop, small bypass control valves may be located out at the end(s) of the distribution piping system. The sizing of these valves shall be based on the absolute MINIMUM flow requirements of the pump operating at its minimum speed (as described above), not just an arbitrary "rule of thumb" percentage of the full design flow. In these cases, the bypass shall be normally closed and open only when pump/VFD is at minimum speed and DP setpoint is exceeded for a specified minimum period of time (5 minutes (adj.).

C. Reliability: Professional shall determine the consequences of system failure and provide for adequate system redundancy for each application.

i. Install fully redundant (N+1) stand-by pumps for extremely critical applications (such as critical research laboratories and computer centers) and/or as otherwise defined specifically in the Owner's Project Requirements.

ii. Three (3) pumps in parallel, each sized for 50% of maximum load, with two operated in staged lead-lag control with the third in standby, offers the advantages of greater system turndown, three chances to total system failure, duty-standby ability, and smaller individual motors and pumps.

iii. For non-critical applications (such as general office spaces, general purpose classrooms, general commercial type spaces) full redundancy/complete standby is typically not required. In such cases two (2) pumps in parallel, each sized for 50% of maximum load may be considered. This arrangements offers greater

turndown and still provides for approximately 70% of total system capacity in the event of a single pump failure.

D. Flexibility: Consider potential future expansion of pumped systems. Extent of expansion will be determined on a case-by-case basis. Consult with the University Project Leader and Engineering Services.

B. S election Criteria:

1. For HVAC Pump Systems (Chilled Water, Condenser Water, Hot Water Heating):

A. U se end suction, double suction or in-line pumps as described in Equipment Requirements.

i. Typically, use base mounted pumps for all applications over 10HP.

B. Match pump curve characteristics to system application.

i. Flat characteristic pumps - closed systems with modulating two-way control valves.

ii. Steep characteristic pumps - open systems, such as cooling towers where higher head and constant flow are usually desired.

C. Select and specify pumps and motors to be **non-overloading** (not into the motor service factor), as the pump operates throughout any point along its flow/pressure curve.

***i.* This must be carefully considered, particularly in multiple/parallel pump applications to avoid overloading in single pump operation.**

D. Select each pump as closely as possible to its best efficiency range, depending on application:

i. Constant-speed pumps: pick pump such that conservative design conditions are close to and just left of, peak pump efficiency (to allow for safe and efficient operation at actual operating point that are typically at lower head/higher flow).

ii. Variable-speed pumps: pick pump such that conservative design conditions are close to and just right of peak pump efficiency (this allows for the pump to operate closer to the best efficiency curve as the speed is reduced to minimum since the actual system control curve is shifted up and thus to the left.)

E. Select for quiet operation. In order to minimize potential for internal noise generation, pumps shall be selected so that the ratio of impeller radius to cutwater radius shall be no greater than 0.85.

F. Include additional gpm in pump capacity for bypass filter (approximately 10% of system capacity - refer to bypass/sidestream filter requirements in chemical treatment section).

G. Pumps shall be rated for minimum of 175 psi (12 bar) working pressure or higher as otherwise required to provide rated working pressure of at least 1.5 times maximum operating pressure.

H. In general, specify pumps with 1750/1800 rpm motors, unless design condition necessitates alternate motor speed.
   i. Motors shall meet NEMA Premium efficiency levels.
   ii. Comply with other special requirements for motors (shaft grounding) on variable speed drives indicated in 230501.01 Motors and Drives

2. Seals: The Professional shall follow industry best practices and the recommendations of the pump manufacturer to select and specify the most appropriate seals for minimizing long term maintenance and the lowest life cycle cost. Refer to the following general guidelines and review with OPP.

Seal Type	Typical Application	Temperature Range (°F)	Max. Working Pressure (psi)	PH Limits
Standard Mechanical (BUNA)	open or closed clear water systems (heating hot water, chilled water, closed loop condenser water)	–20 to +225	175	7-9
Standard Mechanical (EPT)	open or closed clear water systems (high temp hot water, special process, high temp, high PH)	–20 to +250	175	7-11
FLUSHED SINGLE SEALS (Stuffing Box Design)	closed or open systems where the temperature or pressure requirements exceed the limitations of the standard seal	–20 to +300	175 or 250	7-11
FLUSHED DOUBLE SEALS (Stuffing Box Design)	closed or open low pressure systems which may contain a high concentration of abrasives. An external flush is required.	0 to +250	175	7-9
PACKING (Stuffing Box Design)	open or closed systems which require a large amount of make-up water, as well as systems which are subjected to widely varying chemical conditions and solids buildup (open condenser water)	0 to +190	-	7-9

3. Documentation: The Professional shall schedule all pump performance data and project/application specific requirements on the drawings (not within project specifications). Pump schedules shall indicate identification tag, system served, operation (Duty or Standby), pump type (i.e. end suction, double suction), service fluid (i.e percentage of glycol, operating temperature, etc.) gpm, pump head, rpm, minimum pump efficiency (or maximum brake horsepower), motor horsepower, location, manufacturer and model number (basis of design), and electrical characteristics including starter/speed drive type, and whether on normal/emergency standby power (where applicable).
    A. It is imperative to define minimum pump efficiency/max bhp to ensure final pumps submitted by contractor meet actual optimized design performance, not just within nominal motor horsepower.
    B. Where remote start-stop, or status monitoring is required, use combination magnetic starter or variable speed drive (not manual starter).
    C. Professional shall follow University Equipment Acronym List and Equipment numbering policy defined in Mechanical Identification in developing equipment tags and schedules.
4. Equipment Layout: Comply with all Space Planning Requirements indicated in Div 1 .02 Planning for Engineered Building Systems. Maintain minimum recommended service clearances around pumps of 24".
5. Quality Assurance and Uniformity:
    A. All pumps shall be constructed and tested in accordance with current ANSI/HI Standards for centrifugal pumps.
        i. Small pumps (under 10 hp) shall meet at least level B performance of ANSI/HI 1.6 Standard.
        ii. Large pumps (10 hp and greater) shall be factory tested and certified to level A performance of ANSI/HI 1.6 Standard.
    B. Pump manufacturer shall be ISO-9001 certified. Pumps shall be of U.S. manufacturer.
    C. Provide pumps of same type by same manufacturer.

C. Related Standards Sections
1. 23 00 01 Owner General Requirements and Design Intent
2. 23 00 10 Systems Selection and Application
3. 23 01 00 OPERATION AND MAINTENANCE OF HVAC SYSTEMS
4. 23 05 01 Mechanical General Requirements
5. 23 05 93 Testing, Adjusting, and Balancing for HVAC
6. 25 00 00 INTEGRATED AUTOMATION
7. 25 90 00 GUIDE SEQUENCES OF OPERATION
8. 26 29 23 Variable-Frequency Motor Controllers

.02 Equipment Requirements

A. B ase Mounted End Suction Pumps

1. Base mounted end suction circulating pumps shall be of the centrifugal, single stage type, with back pull-out design.
2. Pump and motor shall be connected through a flexible drive coupling, with safety guard.
3. Pumps shall be bronze fitted, with bronze impeller, statically and hydraulically balanced.
4. A replaceable bronze shaft sleeve shall completely cover the wetted area under the seal.
5. Volute shall have gauge tappings at the suction and discharge nozzles and vent and drain tappings at the top and bottom.
6. Pump bearing housing shall have heavy duty regreasable ball bearings.
7. Pump and motor shall be properly mounted and aligned on a common, welded, rigid structural steel or cast iron base, with an enclosed perimeter with opening for grouting in place. Base shall be grouted in place.

B. B ase Mounted Double Suction Circulating Pumps

1. Base mounted double suction circulating pumps, shall be centrifugal, single-stage type with horizontal split case design for servicing the impeller without disruption of the piping.
2. Pumps shall be bronze fitted, with bronze impeller, statically and hydraulically balanced.
3. A replaceable bronze shaft sleeve shall completely cover the wetted area under the seal.
4. Volute shall have gauge tappings at the suction and discharge nozzles and vent and drain tappings at the top and bottom.
5. Pump bearing housing shall have heavy duty regreasable ball bearings.
6. Vertical split case design is also acceptable, where floor space is at a premium.
7. Provide rigid steel grout base and grout as described for End Suction Pumps section above.

C. In-Line (horizontal or vertical) Circulating Pumps

1. In-line circulating pumps shall be centrifugal, single stage; with cast iron body and bronze impeller and trim construction, unless special fluid handling dictates otherwise. Impeller shall be both hydraulically and dynamically balanced.
2. The motor shaft shall be connected to the pump shaft via a replaceable flexible or split coupler with guard.
    A. Co upler shall permit seal maintenance without disturbing pump or motor.

B. M otors shall be industry standard shaft and mounting for readily available and cost effective replacement, not close-coupled that have special shaft/motor mount requirements.

3. The pump internals shall be capable of being serviced without disturbing piping connections.
4. A replaceable bronze/non-ferrous shaft sleeve shall completely cover the wetted area under the seal.
5. Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts, not press fit components.
6. Comply with manufacturer's installation instructions for supporting pump to maintain proper shaft alignment.

D. Pumps - Close Coupled

1. Close coupled pumps are not permitted.
   A. Al though they may save space and have lower first cost, close-coupled pumps are typically undesirable from a maintenance perspective regarding repairing seals or replacing special order motors with special shaft or base mounting hole requirements.
   B. W ill consider exceptions for very small, in-line, booster pump applications in which it is more economical to replace pumps in entirety rather than service parts.

.03 Execution

A. I nstallation and Start-up/Commissioning

1. Install pumps and accessories in strict accordance with the manufacturer's requirements for maintaining optimum hydraulic performance and lowest accessory pressure drop.
2. Base mounted pumps installed on slab-on grade shall typically be mounted on a concrete housekeeping pad with anchor bolts. Base mounted pumps installed above grade shall be provided with concrete inertia bases with spring vibration isolators.
   A. E xception: For sensitive applications, such as experimental research that could be affected by mechanical system vibrations, provide inertia bases and spring vibration isolation regardless of floor construction.
   B. I n general, the housekeeping pad shall be at least 4 in. thick and 6 in. wider than the pump base plate on each side. Vibration type bases shall also include a minimum 2" pad underneath to prevent water from reaching and corroding vibration spring mountings.
   C. Steel pump frame bases shall be leveled on housekeeping pad or inertia sub-base, rigidly anchored, and **completely filled with non-shrink grout** formulated for equipment

bases in accordance with pump manufacturer's installation instructions. Grout prevents the base from shifting, fills in irregularities, and further stiffens the base to maintain long-term alignment.

D. Sound and Vibration Control Requirements: Comply with the following:
    i. Standard 23 05 01 .05 Sound and Vibration Control. Which also references the *ASHRAE Handbook—HVAC Applications;* Vibration Isolation and Control.

3. All piping connections to pumps shall be independently supported so that no strain is imposed on the pump casing flanges.
    A. S upport suction diffusers and piping directly in contact with pump from housekeeping pad (for slab on grade) or inertia base (above grade).
4. Install line-sized, low pressure drop shutoff valves (typically butterfly) in the suction and discharge piping of each pump to permit servicing the pump and strainer without draining the system. In multiple pump arrangements, install a non-slam check valve in each pump discharge to prevent reverse flow in a non-running pump.
5. Provide low pressure drop, flow-measuring station (venturi, orifice plate) located in the pump discharge. Allow adequate length of straight pipe between the pump discharge and the flow station for measurement accuracy. Install flow measuring devices in strict accordance with manufacturer requirements to ensure proper performance.
    A. **In general, do not use manual balance valves on pump discharge. See Hydronic System Balancing requirements below.**
    B. **Multi-purpose (triple duty) valves are not permitted** because:.
        i. Their pressure drop is usually greater than separate check and butterfly shutoff;
        ii. they are often inaccurate and particularly at lower pressure drops,
        iii. the check valve portion cannot be repaired without draining the system unless an additional shut off valve downstream
6. Provide vibration isolation flexible pipe connectors (reinforced, double spherical neoprene type) between pump and suction and discharge isolation valves. Connectors shall be rated for 2 times normal operating pressure.
    A. E xception: Flexible connectors are typically not required on in-line pumps (allowing pumps to be supported from adjacent piping. However, special noise or vibration

requirements in sensitive applications may overrule and still require the isolators.

B. B raided metal pipe connectors do not provide adequate vibration isolation and are thus not to be use.

7. Pump suction piping shall be kept free of air traps and pockets.
8. Install long-tapered reducers and increasers on suction and discharge lines to smoothly transition the pipe size and pump flanges with minimum pressure drop. Abrupt transitions, bushings and reducing flanges are not permissible.
9. Install a strainer (coarse mesh) in the suction pipe to remove foreign particles that can damage the pump. Final piping connection to pump suction shall be as direct and as smooth as possible to ensure uniform flow distribution. Follow pump manufacturer's installation instructions to ensure performance. Eccentric reducers shall be used at the pump suction flange to reduce the potential formation of air pockets.
    A. O n base mounted pumps, install a long radius elbow and straight section of piping at least 5 pipe diameters long (or as otherwise recommended by pump manufacturer's installation instructions) at the pump inlet to ensure uniform flow distribution. Suction diffusers (combination elbow, flow straightening vanes and strainer) are recommended in lieu of the straight pipe requirement where spacing is a constraint.
    B. D o not use strainers/suction diffusers on pumps for open condenser water systems pulling directly from cooling towers, as they can become quickly blocked, resulting in severely reduce system capacity, pump cavitation and damage.
    C. Be sure to remove any temporary fine mesh start-up screen after cleaning/flushing and commissioning and replace with normal screen to protect the pump and minimize the suction pressure drop in normal operation.
    D. Pump applications with a suction lift shall have an eccentric reducer or a long-sweep reducing elbow at the suction to avoid air pockets.
10. Provide a purge cock on top of the casing, a hose end drain valve on the bottom, and a hose end drain valve on blow-off side of the strainer/suction diffuser.
11. Install a single pressure gauge with ¼" ball valves and interconnecting piping from the suction to the discharge sides of the pump and upstream of the strainer shall be provided on each pump in order that each pressure and/or difference can be observed from a single gauge.
12. For vibration testing requirements, refer to Section 23 05 01 .05 Sound and Vibration Control

A. **Final Alignment: All base-mounted, flexible-coupled pumps shall have final alignment of motors, couplings and pump shafts performed by an independent HVAC Vibration Analyst, using precision laser equipment.**
   i. The Contractor shall coordinate and contract the services of the University's HVAC Vibration Analyst (At University Park, arranged through the Supervisor of Refrigeration and Mechanical Services) whenever available. Otherwise (and at Commonwealth Campus locations) the Contractor shall hire an independent, third party Vibration Analyst meeting the approval of the University.
   ii. Align the pump shaft couplings properly and shim the motor base as required to be within tolerances recommended by pump manufacturer, and/or by specific coupling type, and/or University HVAC Vibration Analyst - whichever is most stringent.
   iii. Measured results of vibration testing and final alignment shall be recorded and coordinated to be entered into University's Preventative Maintenance Software at time of start-up AND included in final report to be submitted as part of TAB/O&M submittals.
   iv. **IMPORTANT: Incorrect alignment causes rapid coupling and bearing failure. This work must be completed to the satisfaction of the University as part of the criteria determining Substantial Completion.**

13. Hydronic System Balancing; Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or maximum pump speed shall be adjusted to meet design flow conditions at actual minimum pressure required to satisfy critical zone(s).
   A. On constant speed pumps, the amount of overpressure shall be determined at time of system balance and the impeller trimmed to eliminate as much of the overpressure as possible.
   B. On variable speed systems, the pump controls shall be adjusted by limiting the maximum speed of the pump.
   C. Exceptions: Impellers need not be trimmed:
      i. For pumps with pump motors 5 hp or less.
      ii. When throttling results in no greater than 5% of the nameplate horsepower draw, or 3 hp, whichever is less, above that required if the impeller was trimmed.
   D. For testing, adjusting and balancing requirements, refer to 23 05 93 Testing, Adjusting, and Balancing for HVAC.

14. For insulation requirements, refer to 23 07 00 HVAC INSULATION.
    A. P rovide removable insulation sections to cover parts of equipment that must be accessed periodically for maintenance (i.e. – strainers, grease filtings, vent/drain plugs or valves, p/t ports) without damaging insulation or compromising vapor barrier; include metal vessel covers, fasteners, flanges, frames and accessories.
    B. E nsure that the bearing assembly grease fittings remain accessible and visible. Any vent slots on the sides and bottom of the bearing assembly should remain uncovered and completely open.
    C. Insulation on pump systems operating below ambient dew point (such as chilled water) shall be insulated with closed cell foam with all joints and penetrations completely sealed to maintain vapor barrier.
15. Provide mechanical identification per University Standards.
    A. .06 Mechanical Identification
16. Refer to Detail [23 21 23 – D01] for typical end suction pump installation. *(Details are not yet available in WEB-based manual.)*
17. Refer to Detail [23 21 23 – D02] for typical in-line pump installation. *(Details are not yet available in WEB-based manual).*

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) To develop and document General Owner Requirements in order to define basic design intent and selection criteria.
    a. Goal – to provide guidelines to promote and achieve Efficiency and Reliability throughout entire operating range
2) To update the Equipment Requirements for the technical details of pump construction
    a. Goal – to improve specifications in order to achieve better and more serviceable pumps.
3) To develop and document the Execution (Installation, Operation and Start-up/Commissioning) requirements.
    a. Goal – to achieve better installations, better operating efficiency and longer life out of pump systems.
    b. Note the following special points:
        i. Manual balancing valves and Triple Duty Valves are not to be used at pump discharges.
        ii. Pump leveling and base grouting requirements.
        iii. Vibration Control and Final Alignment Requirements

iv. Impeller trimming requirements more stringent than ASHRAE 90.1.