COMMISSIONING

System commissioning is an integrated process that is carried out progressively to a schedule. The commissioning schedule is structured so that attention builds from the simple to the complex following a testing hierarchy.

Early functional tests focus on components, such as the pumps and connections, and can be carried out in parallel with other component functional tests. Once functional tests are completed, system testing and balancing (TAB) can be carried out. TAB can be carried out in parallel with the TAB and functional testing of other systems. Systems integration tests are carried out after functional and TAB tests confirm the readiness of each individual system. Whole building (or process) tests and tuning tests follow, leading to ongoing monitoring, ongoing tuning and eventual recommissioning tests.

AIRAH Application Manual DA27 provides comprehensive information on system and building commissioning.

Note: System commissioning and fine-tuning are essential for energy efficiency and are recognised as such under the Green Star rating tools.

Pre-commissioning

Pre-commissioning refers to the work that needs to be done or checked prior to the system being tested, adjusted and balanced. Pre-commissioning work on water distribution systems can include things like system flushing and cleaning, system leakage testing, and ensuring that the necessary facilities (power, water drainage) are available for the pump and system commissioning.

Pre-functional checklists

Pre-functional checklists should be completed throughout construction during normal commissioning site visits, as installation of the various components and systems are completed. Sensor and actuator calibration is typically considered to be part of the pre-functional checklist.

System flushing

Before starting up a pumping system, the pipework and any associated reservoirs, sumps or tanks should be cleaned, removing all loose materials and foreign particles. This is particularly important when welding has been used to install pipes and fillings. System flushing is a common approach, with the system progressively flushed until contaminants stop being flushed out of the system.

If the system pump is used for system flushing, it is recommended to change the pump shaft seals, because they will be damaged by the particulates that are being flushed from the pipework. Special system-flushing strainers and filters may reduce this risk, but rarely eliminate the problem.

After flushing, system strainers and filters should always be cleaned and replaced.

Note: BSRIA provides a comprehensive guide to pre-commission cleaning of pipework systems.

Pump commissioning

The pump should be supplied with manufacturer information to assist with commissioning and the following recommendations should be followed:

- Check pump data plate against design requirements and electricity supply
- Check that pump casing and system have been cleaned prior to start-up
- Ensure that pump impeller rotates in the correct direction and pump is installed in correct configuration
- Check for noise and vibration, including evidence of cavitation under system design temperatures (for hot water pumps)
- Check for shaft misalignment
- Check the pump pressure, corresponding flow rate and motor amps.

Functional testing

Pressure and vacuum testing of the pipework distribution system should be carried out as required by the specification. Valve leakage tests and tests that are targeted at verifying valve stroke, spring range, and sequencing should be conducted with the pumping system operating at its peak differential pressure.

Pump VSD testing

The pump should be run-in or exercised while under observation. Ramp the pump speed up and down if control is by VSD, or modulate the motorised valves to assess how the pump and system responds. Modulate any motorised valves during these tests to check system response times and component integration.

Testing, adjusting and balancing (TAB)

Testing, adjusting and balancing (TAB) is the term applied to setting the water distribution system up to deliver the design flow rates. It is a dynamic test where the system is measured and adjusted to deliver the specified measureable performance parameters, such as liquid flow, pressure or temperature, including the current drawn by the motor.

TAB is an appropriate time for system resistance to be reviewed and minimised on the index run. Reducing the system resistance at this stage provides benefits over the life of the system. If significant differences between the installed system resistance and the calculated design resistance occur, the pump selection and control strategy may need to be revisited.
Water-side TAB should be carried out before system testing. Refer to AIRAH DA24 for detailed information on water system balancing.

Centrifugal pump acceptance tests for hydraulic performance should be carried out in accordance with AS 2417 – Rotodynamic pumps – Hydraulic performance acceptance tests – Grades 1 and 2.

System testing
Successful execution of system tests is dependent on the operation of all related system equipment, including air handling units, heat pumps, process loads, chillers, boilers, cooling towers, etc. At a minimum, the pre-functional checklists should be completed on the components/systems served by the water system which should all be capable of safe operation.

Any reset strategies within control algorithms should be disabled and only one control parameter should be varied at a time so that the basic system operation can be verified. Re-establish the resets for other control parameters progressively and verify system operation remains stable.

Verify proper pump staging and VFD control (if applicable) in accordance with the system designer’s sequence of operations.

System performance testing is intended to observe the entire system under normal operating conditions. The plant sequencing, control set-points and resets, control accuracy and stability should all be verified during tests.

Integrated systems testing
Once the system has been fully commissioned, integrated system testing can be carried out. Integrated commissioning tests examine how the pumping system interacts with other building systems and how the system performs in different system operating modes. System integration tests are carried out to ensure systems can interact with each other appropriately. Typical system integration tests would address system performance during:

- System start-up and shut down
- System power loss and restoration
- Fire alarm mode
- System interlocks and control responses (response curves)
- All system control strategies.

Fine-tuning
System tuning forms an important part of final commissioning and should be completed to a documented tuning plan. System tuning typically comprises:

- Monitoring and analysis of system results with respect to the predicted performance and performance benchmarks (energy, flow, pressure, etc)
- System adjustments to suit the actual operational characteristics
- Setting up BMCS trend logs and exception reporting
- Tuning of control loops.

In the first few months of operation it is common to require a significant amount of system tuning as the plant beds down.

System tuning reports should include a review of the tuning activities completed, system performance observations, and recommendations for improving the system design, installation or operation.

Commissioning data
A commissioning checklist should be used for pump and system commissioning to ensure that the pump and system is operating within the specified parameters. All of the data should be recorded during the commissioning tests.

The final commissioning data should be recorded, offered for approval and signed off.

Centrifugal pump data
Record final commissioning data, such as:

- Electrical data: Motor power, amp draw, operating voltage, and efficiency
- Drive data: Belt type, belt size, centreline distances, tension rating and coupling size, type and rating.
- Pump data: Manufacturer, type, size, model, suction and discharge diameter, impeller type and size, and seal type.
- Bearing data: Manufacturer, type, size, and lubrication requirements.
- Design data: NPSH required, design flow rates and design pressure
- Operating data: System final flow rate, pressure, discharge velocity and pump motor amperage, voltage draw, and speed.

Vibration data
Pumps should be tested in accordance with ISO 1940.1 to a balance quality grade of G6.3 or better. After installation, the vibration levels should be checked by personnel experienced with vibration analysis and vibration analysis equipment.

VSD critical frequencies
Centrifugal pumps operating with VSD controllers may be susceptible to excessive vibration at particular system ‘critical frequencies’. Pumps have critical frequencies and the manufacturer should have this data available for any impeller/diameter combination. Centrifugal pumps should be manually run from the minimum to the maximum design speed to check for any frequencies that result in excessive vibration or resonance. Problem frequencies should be noted and the controller should be programmed to bypass these frequencies.

The controller should also be locked to prevent the centrifugal pump from operating beyond the manufacturer stated maximum speed.

Commissioning adjustments
Any adjustments made during the commissioning process such as pump speed, impeller trim and the like should be recorded in operating and maintenance manuals for future information.

OPERATING AND MAINTENANCE MANUALS
Detailed operation and maintenance manuals should be prepared by the installer, approved by the designer and supplied to the owner or operator. The provision, content and format of operating and maintenance manuals is discussed in AIRAH DA19 and these are mandatory for systems that are required to comply with AS/NZS 3666.1 – Air-handling and water systems of
PUMP COMMISSIONING CHECKLIST

The commissioning of HVAC&R systems is a complex process that requires a structured approach. The following checklist highlights some of the areas that need to be verified when commissioning pumping systems:

- Pumps in place and properly grouted, anchoring installed as per specification
- Pump tag and nameplate permanently affixed
- Pump environment clean with adequate access for maintenance
- Distribution piping complete, including pipe fittings and accessories, bleed and makeup water lines and safety reliefs; piping type and flow direction labelled on piping, valves properly tagged
- System flushing complete and strainers cleaned
- Required valves and balancing valves installed and balancing completed; TAB report reviewed for pump flows, pressure or head, electrical data
- Temperature, pressure and flow gauges and sensors installed per specification; test ports installed near all control sensors
- Flow switch and flow meters installed as required and per specification
- Expansion tanks verified to not be air-bound and system completely full of water
- Air vents and bleeds at high points of systems functional
- Vibration isolation devices installed and functional
- Factory alignment/field alignment correct
- No visible leaks
- Pump lubricated
- Automatic valves stroke fully and close tightly
- Pump electrical supply disconnects in place and labelled; all electrical connections tight
- Motor safeties in place and operable
- All control devices, tubing and wiring complete; control system interlocks hooked up and functional
- Water treatment system or plan installed
- VFD commissioned in accordance with manufacturer’s instructions.

Specific commissioning actions will depend on the type and extent of the system to be commissioned.

Pump testing precautions

The following precautions should be taken when testing pumps:

- When pumps are taken out of service, ensure all isolation valves are closed to avoid water leakage
- Exercise care when changing operating modes if the equipment served by the pump is in operation
- Verify that all components between the discharge of the pump and the shut-off valve (including the pump casing) are rated for the peak pressure on the pump curve with the largest impeller installed plus the static pressure on the inlet side of the pump prior to performing a shut-off test
- Avoid sudden flow changes to minimise the potential for water hammer, especially when throttling a large valve for a shut-off test
- Exercise caution when working around live wiring and terminals and taking voltage or amp readings
- Exercise caution while working around the rotating parts of the pump
- Make sure to stop and start the pumps at the motor starter, the VFD, or at a load-rated disconnect switch
- Ensure that all work site jurisdictional requirements are followed (such as WHS, insurance and first aid requirements)
- Try to schedule tests when major equipment – such as chillers and boilers – do not need to be running to avoid creating uncomfortable conditions and equipment damage
- If testing during occupancy is unavoidable, coordinate with those that could be affected.

The information in this month’s Skills Workshop was taken from AIRAH DA01 Centrifugal Pumps, which has been re-released with updated content. It is available for purchase in AIRAH’s online store at www.airah.org.au

Next month: Fans – Operation and maintenance: part one