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Design Requirements Manual **News to Use**

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The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_j U_i)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho\overline{U}_i\overline{U}_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U}_i}{\partial x_j}-\rho\overline{u_i'u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho\overline{U}_i\overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{H}}{\partial x_i}-\rho\overline{u_i'h'}\right)$ *biomedical research facilities.*

Mechanical Commissioning - Part 2

Commissioning (Cx) is the systematic process for ensuring systems and equipment are designed, installed, and perform according to the design's intent and the NIH's operational needs. Mechanical Cx plays a critical Quality Assurance (QA) role. The "Mechanical Commissioning – Part 1" article described the Cx process and sequence. Part 2 focuses on the various testing requirements for mechanical systems, equipment, and the Building Automation System (BAS).

Mechanical System

The mechanical system provides the equipment necessary to ensure that design requirements, such as space temperature, humidity, air changes, pressurization, and safety consideration for both personnel and equipment, are maintained under various operational scenarios. The Cx of mechanical systems for major laboratory, animal, clinical or Aseptic Processing Facilities (APFs) includes supply and exhaust air handling units (AHUs), preheat and reheat hot water, heat exchangers, distribution pumps, variable frequency drives, distribution piping, distribution ductwork, chilled water systems, humidifiers, heat recovery system, and terminal units.

BAS

The BAS is designed to monitor the conditions within the facility and provide responsive control of the mechanical systems (e.g., chilled water, AHUs, terminal units). The BAS includes operator workstations, programmable controllers, digital /analog input/output modules, field level networks, instrumentation (temperature, relative humidity, differential pressure, flow, and current sensors), actuators (isolation and control valves, air dampers), safety switches/detectors (freeze-stats, smoke detectors, hygrostats, static pressure switches, liquid level detectors), room monitors, Uninterruptible Power Supply (UPS), and 24V DC power supply.

Pre-Functional Checklist (PFC)

During the Cx of the mechanical and BAS, PFCs are generated and executed to confirm that all associated equipment, components, and accessories are supplied and installed in accordance with contract documents (i.e., approved for construction drawings and specifications) and approved construction submittals (i.e., shop drawings, cut sheets, etc.). Component operation verification (dampers, valves, airflow/hydronic monitors), loop check and tuning verification, instrument calibration verification and BAS graphics verification are performed prior to executing the Functional Performance Testing (FPT).

Functional Performance Testing (FPT)

The FPT test script demonstrates that the equipment, components, and accessories associated with the mechanical and BAS operate in accordance with project contract documentation (e.g., manufacturer design specifications, sequence of operations (SOO)). The Cx agent verifies the scripts to confirm that major equipment start/stop sequence, safeties, interlocks, multiple fan operation, duct/piping static pressure, airflow/hydronic flow, VFD control, filter monitoring, temperature control and set point reset, pump control, terminal unit damper, airflow control, reheat valve operation, etc., are in accordance with contract documentation and all alarms are initiated when established limits are exceeded. Loss of communication alarm of BAS controllers and trend report generation is also verified.

Integrated Systems Testing (IST)

The IST is designed to challenge the mechanical system in its entirety under different operational scenarios, with the goal of verifying that the various systems, equipment, and components effectively coordinate with each other during each of these simulated conditions. The IST also ensures that the control of these building systems is robust and capable of maintaining the facility in accordance with design and operational requirements. The prerequisite is successful completion of predecessor PFC and FPT protocols.

The IST includes testing the SOO against loss of normal power; transfer to standby power and restoration of normal power; AHU and exhaust fan start/stop/failure; preheat/reheat, chilled water, humidification, and room terminal unit failure; and reheat coil and branch loop failure. The test verifies if active fans/units maintain duct static pressure on the supply and exhaust system at setpoint. A terminal box failure tests the supply and exhaust equipment and maintains flow requirements in unaffected areas of the facility.

The integrated temperature control and humidification control at system and room level are tested under IST. At the system level, preheat and cooling coil valve modulation, and humidifier enabling andvalve modulation are verified in response to varying demands on the AHUs. At the room level, reheat system pump VFDs, hot water converters, steam valves, and room reheat valve modulation are verified in response to varying heating/cooling requirements. The IST simulates heat recovery response failure and verifies AHU heating/cooling coil and the hot/chilled water system valve modulation to confirm that the AHU discharge set point is maintained.

Endurance/Stability Period

After completion of the IST, the Cx agent generates and reviews facility trend reports to ensure the facility is stable and free of unexpected alarm conditions. In APFs, this period is typically 72 hours. In other facilities, such as a BSL-3, this period can be longer.

Conclusion

Mechanical Cx testing is primarily testing and verification of design specifications and SOO to ensure mechanical systems operate as intended. An essential element of system performance verification is testing under different operating scenarios via the BAS scripts and system trend logs. Every operational mode, including normal, emergency, and failure, needs to be fully analyzed.

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