

DRAFT

Minnesota Statute § 123B.72 School Facility Commissioning

System Inspection Guidelines

for

Minnesota PK – 12 School Construction Projects

Minnesota Department of Children, Families & Learning

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School Facility Commissioning/System Inspection Guidelines

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Introduction

As the heating, ventilation and air conditioning (HVAC) systems within pre-kindergarten through grade twelve (PK-12) school construction projects become more and more complex it becomes imperative that these systems are properly tested before they are turned over to the owner. Current contractual arrangements between the school district and the architect, and between the architect and the mechanical engineer are generally clear on the required scope of services through physical construction of a project, but are usually silent on services required for a thorough checkout of the operation and performance of the mechanical systems. In addition, the need to provide mechanical systems that are energy efficient and provide proper indoor air quality and comfort to all occupants at all times has resulted in rather complicated systems that may often be run by minimally-trained and under-skilled school district staff.

Problems not uncovered by the end of construction can go unnoticed for years, resulting in higher energy costs, poor conditions for learning, lost faculty and student days due to illness, and many maintenance hours spent searching for the causes and solutions to those problems. This often results in the loss of credibility between school district administrators and the public.

In 1998 the Minnesota legislature recognized this issue and passed a commissioning statute requiring that mechanical HVAC systems undergo an inspection process to uncover and rectify problems before or shortly after the building is occupied.

In non-school construction projects, the systematic process of ascertaining that all building systems and components are installed and function as intended has also been termed commissioning. The construction industry standard for a full commissioning process differs from the state-mandated limited commissioning or HVAC system inspection process in terms of the number and extent that building systems are checked and when a quality assurance expert or system inspector is involved in the construction project.

The full commissioning process necessitates hiring a quality assurance expert or commissioning authority early in the construction planning process, no later than the design development phase, so that the commissioning authority will be involved with the quality assurance aspects of building systems throughout the design and construction phases. In a full commissioning process, all components within all building systems are thoroughly tested.

Although the Minnesota commissioning statute does not state when the system inspector should be hired, it is strongly recommended that a system inspector be hired no later than during the construction document phase of a school construction project. Whereas full commissioning requires all components of all building systems to be verified, the Minnesota commissioning or system inspection process focuses only on all major pieces of HVAC equipment. Hiring a system inspector early on will increase the probability that all key HVAC system components will be verified and all significant problems uncovered at a lower first cost.

Minnesota School Facility Commissioning Statute

123B.72 SCHOOL FACILITY COMMISSIONING

Subdivision 1. **Application.** This section applies to the installation or retrofitting of heating, ventilation, and air conditioning systems for which review and comment of the project under section 123B.71 has been requested after July 1, 1997.

Subdivision 2. **System inspector.** For purposes of this section, system inspector means:
(1) a Minnesota-licensed architect or engineer; or
(2) properly qualified testing and balancing agency or individual.

Subdivision 3. **Certification.** Prior to occupying or reoccupying a school facility affected by this section, a school board or its designee shall submit a document prepared by a system inspector to the building official or to the commissioner, verifying that the facility's heating, ventilation, and air conditioning system has been installed and operates according to design specifications and code, according to section 123B.71, subdivision 10, clause (3). A system inspector shall also verify that the facility's design will provide the ability for monitoring of outdoor airflow and total airflow of ventilation systems in new school facilities and that any heating, ventilation, or air conditioning system that is installed or modified for a project subject to this section must provide a filtration system with a current ASHRAE standard.

Subdivision 4. **Occupancy.** If the document submitted by the school board to the local building official or the commissioner does not demonstrate to that official's satisfaction that the heating, ventilation, and air conditioning system has been installed correctly or that the system is not operating at a level to meet design specifications, the official or commissioner may allow up to one year of occupancy while the heating, ventilation, and air conditioning system is improved to a level that is considered satisfactory by the system inspector.

HIST: 1Sp1997 c 4 art 4 s 8; 1998 c 397 art 4 s 51; art 11 s 3; 2000 c 489 art 5 s 7

NOTE: The amendment to subdivision 3 by Laws 2000, chapter 489, article 5, section 7, is effective July 1, 2002. Laws 2000, chapter 489, article 5, section 7, the effective date.

The Commissioning/System Inspection Process

For all school construction projects in excess of \$500,000, regardless of the funding source, where project dollars are spent for new HVAC systems or for major modifications to the existing HVAC systems, the HVAC system must undergo a commissioning or system inspection process. At a **minimum** the commissioning or system inspection process should consist of the following:

A. The inspector shall be a licensed architect, licensed engineer, qualified test and balance contractor or other qualified individual. The system inspector can be an independent third party or the engineering firm of record, if qualified. The school district must check the qualifications, experience, and track record of applicants.

It is strongly recommended that a system inspector be hired no later than during the construction document phase of a construction project. This would provide adequate time for the system inspector to understand the design intent, determine which tests and procedures are appropriate for the project, and prepare an inspection plan and the necessary specifications that define contractor involvement in the system inspection process. If the system inspector is not retained until after the project is bid, then project documents may not adequately define the contractors' requirements for assisting with the system inspection process, resulting in more change orders and/or a lack of cooperation between the system inspector and contractors.

Again, for the commissioning or system inspection to work properly, it is strongly recommended that the school district must notify the architect, engineer, and construction manager before they are hired that their participation in the commissioning or system inspection process is required in the project, and that fees will be withheld, possibly up to one year after occupancy, until all project work passes the HVAC system inspection process. The architect, engineer, and construction manager need to spend additional time working with and responding to the efforts of the system inspector. Notification prior to hiring allows these professionals time to include dollar amounts for those system inspection efforts in their fee proposal (e.g. schedule of values), payment of which should be withheld by the school district until the professionals complete their system inspection responsibilities and the HVAC system passes the system inspection process. The professionals must also be notified that they will be required to provide to the owner a design intent document outlining what HVAC system design criteria and assumptions are being used on the project and issue specification sections that have been prepared by the system inspector, along with the construction documents.

If the above recommended system inspection process is not followed, there is a much greater probability that all parties may not cooperate as needed, and that the school district will receive numerous requests for additional fees late in the project.

B. Before occupancy, the system inspector shall submit a letter to the school district, which in turn submits a letter to the building code official, with a copy to the commissioner of the Department of Children, Families & Learning (CFL), verifying that the facility's heating, ventilation, and air conditioning system has been installed and operates according to design specifications and applicable ventilation codes. If, in the opinion of the system inspector, the

Commissioning/System Inspection Guidelines

HVAC systems are not complete and/or operating properly, the letter to the district shall indicate the deficiencies. At this point the building code official may issue a temporary certificate of occupancy for up to one year.

During this time the HVAC systems must be completed, provide the amount of outdoor air specified by code, and operate at a level considered satisfactory by the system inspector and the school district. When the HVAC system inspection process has been completed, the system inspector shall issue a second letter to the school district, which in turn submits a letter to the building official, with a copy to the CFL commissioner, indicating the HVAC systems are complete and operate as intended. At this point the building official issues a final certificate of occupancy.

Since system inspection activities are linked to the seasons of the year, it is nearly impossible to complete the inspection process prior to occupancy. Therefore, it is absolutely necessary that a school district withhold adequate dollars from the appropriate contractors (e.g. test and balance, controls, sheet metal, pipe fitters, etc.), and professionals (e.g. system inspector, architect, construction manager, mechanical engineers) until the system inspection process has been completed.

If after one year the project is not completed at a level considered satisfactory by the system inspector, the school district must then take steps to utilize the withheld funds as well as the required performance bonds to hire outside parties to complete the work.

C. For new school construction and extensive remodeling the system inspection process is comprehensive, covering all HVAC work. For small remodeling projects, the focus is on determining that the appropriate amount of outdoor air is supplied to the occupants. For example, if classroom renovation requires new distribution ductwork, but no changes are planned to the air-handling unit, the system inspector shall verify that appropriate quantities of outdoor air are delivered to all occupied spaces served by the unit. At the owner's discretion and direction, the system inspector could check the entire control sequence.

D. The system inspector shall also verify that air filtration has been provided that meets design intent and appropriate code, if any.

E. The system inspector shall verify that there are tools designed into the ventilation system (e.g. flow measuring stations), or provided during the project (e.g. hand held devices), that allow district staff to determine the quantity of outdoor air delivered to an occupied space on an as needed basis. Where practical, systems with < 2,000 cubic feet per minute (cfm) of total air flow can be checked using hand held devices. Above 2,000 cfm of total airflow, whenever possible, utilize flow measuring stations with local readouts or connection to building automation systems.

Optional Full Commissioning Process

The commissioning or HVAC system inspection process described above is that required to meet Minnesota statutory requirements and to provide reasonable assurance that HVAC systems operate as intended. However, this limited commissioning process falls short of providing a full quality assurance program. For larger, more complex projects it is recommended that a full commissioning process be undertaken to provide a higher level of certainty that all HVAC and other building systems (e.g. life safety) are designed, installed and operate properly and that the owner has received proper training and operational manuals.

Advantages of a full commissioning process are:

- Verification that **all** HVAC equipment operates according to design;
- Review of design documents for commissioning process prior to issue;
- Building operators will receive thorough training;
- All documentation will be gathered, organized and reviewed before being turned over to the owner;
- Additional indoor air quality systems such as wall and roofing system design and installation verification can be included;
- Minimize energy consumption of all systems;
- Maximize equipment life expectancy; and
- Increase the productivity of operational staff resulting in higher tenant satisfaction and lower staffing levels.

Full commissioning is a quality assurance process designed and implemented by a person, company or agent that carries the designation of commissioning authority. The process works best when the commissioning authority is brought into the project early, before plans and specifications are prepared. It is imperative that the quality assurance process envisioned by the commissioning authority be adapted to the project and communicated to the contractors through attachments to the construction documents.

Several organizations have developed commissioning guidelines that are gaining in acceptance for use in the private sector throughout the country as follows:

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The American Society of Heating Ventilation and Air Conditioning Engineers (ASHRAE), through Guideline 1-1996 has created guidelines that place the emphasis on commissioning as a process. This provides an owner with a complete and fully functional HVAC system along with complete documentation and appropriately trained operating and maintenance staff. (ASHRAE, 1791 Tulie Circle NE, Atlanta, GA 30329, (404) 636-8400, www.ashrae.org);

The National Environmental Balancing Bureau (NEBB) has also created Procedural Standards For Building Systems Commissioning. This publication provides procedures and methods for documenting and verifying that the performance of the building systems does or does not operate in conformance with designer's intent and project contract documents. (NEBB, 8575 Grovemont Circle, Gaithersburg, MD 20877-4121, (301) 977-3698, www.nebb.org); and

Minneapolis Public Schools has also developed a Master Commissioning Manual. The purpose of the manual is to specify the methods, responsibilities and procedures to assure that Minneapolis Public Schools receive a highly reliable system of equipment and materials installed and maintained in a manner consistent with acceptable standards and practices, and that operate as required. This is a guideline that can be issued to commissioning agents in regards to all phases of a project, from the design phase through commissioning and turnover. (Minneapolis Public Schools, 807 N.E. Broadway, Minneapolis, MN 55413-2398, (612) 627-2050, www.mpls.k12.mn.us).

If a school district has a preference for a commissioning procedure, this preference should be communicated to applicant commissioning authorities before they are hired. If the district does not have a preference, they need to have applicant commissioning authorities indicate which commissioning procedure they will use. School construction projects need to use a recognized commissioning process.

System Inspector – An Independent Firm, Engineering Firm of Record, or Other Provider

When hiring a system inspector, an important question is: who is the best person to perform this inspection, the engineering firm that designed the system or an independent third party? There are advantages and disadvantages to each approach.

Independent System Inspector

Advantages:

- No conflicts of interest – responsible only to the owner.
- Third party may offer additional expertise to the owners in the areas of building system testing, training, and troubleshooting, as well as in facilitating a problem solving process.
- System inspection may be a valid part of the owner's quality assurance process as an independent reviewer of systems for design intent and system testability.

Disadvantages:

- Requires managing an additional contract.
- May be more costly due to a learning curve for understanding the building systems, and the costs in managing the separate contract.
- If the role of the system inspector is not properly defined, it can be confusing as to who is responsible for what.

Engineering Firm of Record as the System Inspector

Advantages:

- The firm is already familiar with the design intent, as well as the project in general, thus reducing first costs.
- An engineer brings theoretical knowledge of how systems are intended to work and may bring expertise in the areas of building system testing, training, and troubleshooting, as well as in facilitating a problem solving process.
- The firm has the expertise to write the required specification sections and oversee the inspection process.
- Reduces the number involved parties, simplifying communications and contract management.
- The firm already has the trust of the owner to provide a building that works. Providing system inspection is a natural progression of that relationship.

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Disadvantages:

- Engineering firm may be reluctant to identify design-related deficiencies, particularly after components have been installed.
- The firm may not have the expertise to conduct a systematic inspection process.
- Firm may have a conflict of working for the owner as system inspector, while at the same time being responsible to the architect of record for the building design.

Other Providers such as the Contractor (General/M/E/TAB)

Advantages:

- Experience in scheduling and the construction process.
- Provides an incentive to cooperate in scheduling and completing the system inspection work

Disadvantages:

- Possibly lack the theoretical technical knowledge to understand or solve system performance problems.
- Possible conflict of interest with a low bid and getting the job done profitably.

Appendix A Roles and Responsibilities

For a system inspection process to be effective, all the involved parties (owners, architects, engineers, construction managers, contractors, and system inspectors) must work well together in this process. This appendix is intended to provide an overall perspective of the typical responsibilities of each party. This information can be used when requests for proposals and/or contracts are prepared for architects, engineers, construction managers, contractors and system inspectors.

Architect

Programming and Conceptual Development Phases

Document the owner's building criteria, needs, etc. for a programming report.

Design Development

Document the design intent for general building design and function.

Construction Documents Phase

1. Coordinate the development of the design intent by all design team members.
2. Document the design intent, design narrative and design parameters.
3. Include appropriate system inspection sections into the specification, including specialty systems such as food service, swimming pool, etc. The system inspector shall prepare sections.

Construction and Acceptance Phase

1. Coordinate resolution of system deficiencies identified during the system inspection process, according to the contract documents.
2. Prepare and submit final as-built design intent documentation for inclusion in the operation and maintenance (O&M) manuals. Review and approve the O&M manuals.
3. Coordinate the review of applications for payment with engineer and system inspector.

One-Year Correction Period

Coordinate resolution of design non-conformance and design deficiencies identified during the one-year correction period.

Commissioning/System Inspection Guidelines

HVAC Mechanical and Electrical Designers/Engineers

Programming and Conceptual Development Phase

Document the owner's mechanical system requirements.

Design Development Phase

Document design intent and general operating parameters.

Construction Documents Phase

1. Complete the documentation of the design intent and operating parameters.
2. Include in the division 15 (HVAC mechanical designer) and division 16 (electrical designer) of the specification, the contractor requirements for system inspections, as prepared by the system inspector or attached as a supplemental document.

Construction and Acceptance Phase

1. The designers shall assist (along with the contractors) in clarifying the operation and control of equipment in areas where the specifications, control drawings, or equipment documentation are not sufficient for writing detailed testing procedures.
3. Participate in the resolution of division 15 and 16 system deficiencies identified during the system inspection process.
4. Prepare and submit the division 15 and 16 final as-built design intent and design and operating parameters documentation for inclusion in the O&M manuals.
5. Review and approve the O&M manuals.
6. Review contractor applications for payment.

One Year Correction Period

Participate in the resolution of respective Division 15 and 16 non-conformance and design efficiencies identified during system inspection process.

Commissioning/System Inspection Guidelines

System Inspector

The primary role of the system inspector is to review the design intent and construction documents, observe that construction is performed according to the design documents, develop and coordinate the execution of a testing plan, and document the testing results in order to be reasonably assured that the installed systems operate according to design intent and in accordance with the contract documents.

Programming and Conceptual Development Phase

—None—

Design Development Phase

—None—

Construction Documents Phase

1. Review the drawings and specifications at appropriate points (e.g., 50% and 95% complete) for testability and consistency with design intent.
2. Review the drawings and specifications to become sufficiently aware of the systems proposed in order to prepare a testing plan and the system inspection sections of the specifications.
3. Review the engineer's design intent and basis of design, at least for ventilation systems. At a minimum these should include the number of occupants for which each space was designed, the volume of outdoor air per occupant (cfm) for each space, whether intermittent occupancy was assumed for any space, whether the ASHRAE 62-89 or most recent version of the multiple space equation was used, and any unusual ventilation requirements.
3. Develop a draft project-specific system inspection plan.
4. Prepare the necessary specification sections to indicate the requirements and responsibilities of the various contractors during the verification process. This work should also include the retesting requirements of each trade during the check out phase of the project.

Construction and Acceptance Phase

1. Coordinate and direct the system inspection activities in a logical, sequential, and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, and frequently updated timelines and schedules and technical expertise.

Commissioning/System Inspection Guidelines

2. Revise, as necessary, the system inspection plan.
3. Request and review additional information required to perform inspection tasks, including O&M materials, contractor start-up, and checkout procedures.
4. Review submittals (shop drawings) for testability of ventilation equipment, temperature controls, and other water and air flow control devices. Review the test and balancing plan/procedures, concurrent with the architect/engineering (A/E) reviews.
5. Observe HVAC installation and its compliance with the plans, specifications and ASHRAE 62-1989 (or most recent version). Attend selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the system inspection process. Assist in resolving any discrepancies.
6. Write and distribute project specific pre-functional tests and checklists.
7. Approve pre-functional tests and checklist completion by reviewing returned checklists and by site observation.
8. Before startup, gather and review the current control sequences and interlocks, and work with contractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.
9. Develop a start-up and initial systems checkout plan with subcontractors.
10. Approve systems startup by reviewing start-up reports and by selected site observation.
11. Review testing, adjusting, and balancing (TAB) execution plan and the draft test and balance report. Validate the test and balance report by: 1) randomly checking (with contractor assistance) 10% of the occupied rooms to determine that the air flow supplied to the rooms matches the test and balance report as well as the engineer's design intent; and 2) checking (with contractor assistance) 100% of the ventilation equipment that supplies outdoor air to the occupants to determine that the quantities of outdoor air brought into the building match the test and balance report as well as the engineer's design intent.
12. With necessary assistance and review from installing contractors, write the functional performance test procedures needed to complete items 15 and 16 below. This may include energy management control system trending, stand-alone data-logger monitoring, or manual functional testing.
13. Validate through witness testing and review of validated test and balance reports, that the specified minimum outdoor air volumes are being provided for all ventilation equipment that introduces outdoor air into the building, throughout the full operational range of the equipment and during all seasonal modes of control. Verification shall occur through a

Commissioning/System Inspection Guidelines

validated test and balance report and functional performance tests. Ventilation equipment includes but shall not be limited to central fan systems, rooftop units, unitary air conditioning equipment, air to air energy recovery units, desiccant dehumidification systems and unit ventilators, etc. Variable air volume systems in particular must be checked for conformance with design intent and appropriate mechanical ventilation codes during all modes of operation.

14. Be responsible for organizing contractor efforts to conduct a visual check to determine that **all** HVAC system components are installed and physically operate as intended. See Appendix C for a sample of a typical Air Handling Unit Pre-Functional Checklist. After the checklists provided under item 6 are returned and reviewed by the system inspector, the system inspector, with assistance from the contractors, shall spot check a minimum of 10% of the equipment to verify contractor results.
15. Direct, witness, and document the verification of the sequence of operation for all key pieces of major equipment and a sample from each group of essentially identical equipment having a unique operational control sequence. The sample rate for equipment with unique control sequences should be influenced by the size and complexity of the project and therefore determined by the owner and system inspector. Verification is performed by the contractor and witnessed by the system inspector and shall be done for all operational and seasonal modes of control. Verification includes a visual determination that all components and systems respond as called for in the sequences and function in accordance with the design requirements. Modes to be tested include all normal modes (e.g. occupied and unoccupied modes, full heating, full cooling and economizer modes), and abnormal modes (e.g. emergency conditions, component failures, alarms, and power failures, etc.). The system inspector shall provide the contractors the necessary functional test forms and procedures for these tests. See Appendix D for a sample of a typical Air Handling Unit Functional Performance Worksheet. The system inspector shall personally witness these tests. Major equipment includes boilers and associated equipment such as chillers, condensers, cooling towers and associated equipment, heat recovery equipment (etc.). Equipment with a unique operational sequence would be air handling units, fan coil units, etc..
16. Develop, direct and document the verification of the sequence of operation for a sample of terminal equipment (suggest 20% of each type of equipment). The system inspector shall provide the contractors the necessary pre-functional and functional test forms as well as the procedures for these tests. The contractors shall complete the pre-functional checks for all equipment. Functional tests shall be performed by the contractors on a sample of the terminal units (suggest 20%) and shall be done for all operational and seasonal modes of control. A sample of the equipment, tested and untested, shall be randomly checked by the system inspector through: 1) witnessing the original contractor tests; 2) retesting with contractor assistance); or 3) by utilizing trend logs, provided that a facility automation system is installed. The sampling rate can be modified upward by the owner and the system inspector, after taking into account project size and complexity.

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17. Provide the project team written progress reports and test results with recommended actions.
18. Coordinate retesting as necessary until satisfactory performance is achieved.
19. Approve water systems balancing by site observation, spot testing, and by reviewing completed balancing reports.
20. Compile and maintain a system inspections report log.
21. Review and approve the preparation of the O&M manuals.
22. Provide a final system inspections report, including an executive summary, list of participants and roles, brief building description, overview of testing scope and a general description of testing and verification methods, along with a summary of the process used and an appendix which includes the final test and balance report, test procedures that include pass/fail notation, and design intent documentation. Each non-compliance issue shall be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented. Appendices shall contain acquired sequence documentation, logs, meeting minutes, progress reports, deficiency lists, site visit reports, findings, unresolved issues, communications, inspection plan, etc.

One Year Correction Period

2. Supervise any seasonal or deferred testing and deficiency corrections required by the specifications.
3. Return to the site during the one-year correction period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal system inspections. Also interview facility staff and identify problems or concerns they have with operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports and documents and requests for services to remedy outstanding problems.

Contractor and Subcontractors

Programming through Construction Documents Phases

—None—

Construction and Acceptance Phase

1. The general contractor and/or construction manager shall ensure that all subcontractors (subs) execute their system inspection responsibilities according to the contract documents in a timely fashion.
2. Subs shall assist, along with the design engineers, in clarifying the operation and control of tested equipment in areas where the specifications, control drawings, or equipment documentation are not sufficient for writing detailed testing procedures.
3. Subs shall provide limited assistance to the system inspector in preparation of the specific functional test procedures. Subs shall review test procedures to ensure feasibility, safety, and equipment protection.
4. Subs shall execute their normal system pre-start-up checkout procedures. In addition, subs will complete pre-functional performance checklists and tests provided to them by the system inspector.
5. Subs shall provide a start-up report copy and a copy of the manufacturer's recommended start-up procedures to the system inspector. Subs shall address all A/E punch list items to date and TAB shall be completed with discrepancies and problems remedied before functional testing. Subs shall perform standard start-up testing and system operational checkouts. System inspection is intended to verify proper performance, not replace the start-up testing and system debugging responsibilities of the subs.
6. Subs shall execute performance testing, as defined in the specifications by the system inspector and as witnessed by the system inspector.
7. Correct deficiencies (i.e., differences between specified and observed performance) as interpreted by the system inspector, construction manager, and A/E.
8. Prepare O&M manuals according to the contract documents.
9. Communicate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Commissioning/System Inspection Guidelines

One Year Correction Period

1. Subs shall execute seasonal and other deferred functional performance testing, witnessed by the system inspector, according to the specifications.
2. Correct deficiencies and make necessary adjustments to deficiencies uncovered during the system inspection process

Construction Manager

Programming through Design Development Phases

Ensure that the system inspection process is appropriately scheduled throughout the project.

Construction Documents Phase

Issue the specifications sections prepared by the system inspector with the construction documents.

Construction and Acceptance Phase

1. Ensure that commissioning activities are being scheduled into the master schedule.
2. Review commissioning progress. Coordinate contractor efforts to correct deficiencies in a timely manner.
3. Coordinate the resolution of non-compliance and design deficiencies identified in all phases of commissioning.
4. Assist the contractor in coordinating the training of owner personnel.

One Year Correction Period

Coordinate contractor efforts to correct deficiencies in a timely manner.

Commissioning/System Inspection Guidelines

Owner

Conceptual Phase

1. Decide if system inspection will be limited to the Minnesota commissioning statute requirement that HVAC systems will work as intended or if the optional full commissioning process that ensures that all building systems will work as intended will be used in the school construction project.
2. Decide whether an independent firm will be used for system inspections or if the engineering firm of record will be responsible for this activity.
3. Provide language in the request for proposal to the architect, engineer, and construction manager that specifies what system inspections will be required in the project, and that their participation is necessary. Indicate that their entire fee will not be paid until the system inspection process has been completed.

Programming through Design Development Phases

Work with the engineers to identify which building systems will undergo the commissioning or system inspection process, (e.g. HVAC as required by statute, or others, such as fire alarm, telephone, data, fire sprinkler, windows, walls, roofs, etc).

Construction Documents Phase

1. Work with the system inspector to identify the sampling rates for system testing.
2. Approve the final system inspection testing plan.
3. Work with architects, engineers, and construction managers and the system inspector to provide language in the specifications that the contractors will provide in their bid a specific dollar amount for their part of the system inspection process. This amount shall be indicated on the schedule of values form, with draws made against this amount throughout the system inspections process.
4. Review and approve the design intent documentation.
5. Review and approve the system inspection specification sections.

Construction and Acceptance Phase

1. Manage the contractor's contracts.
2. Provide final approval for the successful completion of the system inspections.
3. Do not pay down contractor retainage until all work is complete and operates properly.

Commissioning/System Inspection Guidelines

One Year Correction Period

Withhold adequate funds from the contractors, construction manager, architects, engineers, and system inspectors until all system inspection activities have been successfully completed.

Appendix B System Inspector Qualifications

Company Name Title	Contact Person		
Address	City	State	Zip/Postal Code
Telephone	Fax	E-Mail	

Description of Business

Commissioning Activities

Percentage of overall business devoted to system inspections and/or commissioning services. _____ %

How long has the firm offered system inspections and/or commissioning services? _____ Years

Average number of system inspections and/or commissioning projects performed each year? _____ Projects

Systems (technologies) for which firm has provided system inspections or commissioning services (check all that apply):

- | | |
|--|---|
| <input type="checkbox"/> Packaged or Split HVAC | <input type="checkbox"/> Envelope |
| <input type="checkbox"/> Chiller System | <input type="checkbox"/> Fire/Life Safety |
| <input type="checkbox"/> Boiler System | <input type="checkbox"/> Plumbing |
| <input type="checkbox"/> Energy Management System | <input type="checkbox"/> Commercial Refrigeration |
| <input type="checkbox"/> Variable Frequency Drives | <input type="checkbox"/> Telecommunications |
| <input type="checkbox"/> Lighting Controls | <input type="checkbox"/> Thermal Energy Storage |
| <input type="checkbox"/> Day lighting | <input type="checkbox"/> Labs & Clean Rooms |
| <input type="checkbox"/> Electrical, General | <input type="checkbox"/> _____ |
| <input type="checkbox"/> Electrical, Emergency Power | |

Commissioning/System Inspection Guidelines

Number of qualified professionals on staff who have directed commissioning projects: _____

List Qualifications: _____

Prior Projects of a similar nature

Building Name	Location	Type of Project (new, additions or remodeling)	Contact Name	Contact Phone Number

Appendix C Pre-Functional Performance Test Checklist

Project: _____

Test No: _____

Contractor: _____

Discipline: Test & Balance Date: _____

Equipment: Air Handling Unit (Supply) Mark: _____

System: _____ Location: _____

Manufacturer: _____ Serial No: _____

The Installation Contractor certifies the following are complete:

	COMPLETE	
Inspection	Contractor Initials	Date
• Certified balancing reports submitted.	_____	_____
• Test equipment NEBB or ABC certified.	_____	_____
• Thermal overload protection in place and checked.	_____	_____
• Electrical voltage, phase, and current checked and recorded.	_____	_____
• Fan belt tension and set screws tight and checked.	_____	_____
• Duct leakage test certified and submitted.	_____	_____
• Fan vibration, deflection based on VFD low speed, tested, and certified.	_____	_____
• Sound power level tested and certified. See page 2, section 15211.	_____	_____
• Control system installed, tested and operational.	_____	_____
• Flexible connector and boot alignment checked.	_____	_____
• Fan data balanced, tested and recorded at minimum and maximum speed.	_____	_____
Fan Service _____ RPM _____	_____	_____
Actual CFM _____ Total Pressure _____	_____	_____
Actual BHP _____ Drop _____	_____	_____
_____ Sheave Size _____	_____	_____

Commissioning/System Inspection Guidelines

- | | | | |
|-------------------------------|---------------------------------|--|--|
| Actual Suction Pressure _____ | Actual Discharge Pressure _____ | | |
|-------------------------------|---------------------------------|--|--|
- Fire and smoke dampers in place open and checked. _____
 - Air measured at intake and discharge matches design within 5%. _____
 - Servicing valves installed, checked, and tested. _____
 - Clean filter installed and gauge calibration checked. _____
 - System is left in proper working order, normal operating settings, all covers in place and secured, controls in automatic. _____

	COMPLETE													
Inspection	Contractor Initials	Date												
<ul style="list-style-type: none"> • Coils balanced, tested, and data recorded. _____ 														
<table border="0" style="width: 100%;"> <tr> <td style="width: 30%;">Coil Service _____</td> <td style="width: 30%;">Entering Water Temp _____</td> <td style="width: 20%;"></td> <td style="width: 20%;"></td> </tr> <tr> <td>Entering Air Temp _____</td> <td>Leaving Air Temp _____</td> <td></td> <td></td> </tr> <tr> <td>Pressure Drop _____</td> <td>Actual GPM _____</td> <td></td> <td></td> </tr> </table>	Coil Service _____	Entering Water Temp _____			Entering Air Temp _____	Leaving Air Temp _____			Pressure Drop _____	Actual GPM _____				
Coil Service _____	Entering Water Temp _____													
Entering Air Temp _____	Leaving Air Temp _____													
Pressure Drop _____	Actual GPM _____													
<ul style="list-style-type: none"> • Construction filters replaced w/new and differential pressure gauge in place and checked. _____ • Coil thermometer installed and calibrated. _____ • Balancing dampers set and locked in place. _____ • Valve tested and pressure drop at full open checked. _____ • Coil air vents tested. _____ 														

All test completed.

Contractors Signature

Date

Verified

Date

Appendix D Functional Performance Test Sequence Of Control And Record Sheet

Project:

Test No:

	COMPLETE	
	Y / N	Date

1.	<i>Functional Performance Test for AHU</i>		
2.	Verify the pre-functional test checklist is completed.	_____	_____
3.	Begin the functional test with the AHU S and E fans off. Simulate normal mode program to start the AHUs in the normal mode. Verify visually at damper that dampers open and, after proof of status, the fans started. Supply Fan on _____ Exhaust Fan on _____ Supply Duct SC - open _____ Supply Duct D - _ closed _____ Exhaust Duct SD - __ closed _____ Backdraft Dampers closed _____ Distribution System Duct SD's closed _____	_____	_____
4.	Verify DDC monitor status matches above on mode.	_____	_____
5.	Verify fan shutdown. Begin with fans running as above, all dampers in correct open position. Simulate normal shutdown. Verify fans stop and dampers close. Check DDC system for status. Supply Fan on _____ Exhaust Fan on _____ Supply Duct SC - open _____ Supply Duct D - _ closed _____ Exhaust Duct SD - __ closed _____ Backdraft Dampers closed _____ Distribution System Duct SD's closed _____	_____	_____
6.	Measure and record the delta T across all the coils. Inlet air temperature _____ Outlet air temperature _____ Inlet water temperature _____ Outlet water temperature _____ GPM _____	_____	_____

Commissioning/System Inspection Guidelines

		COMPLETE Y / N	Date
7.	Verify DDC system monitor status matches above off modes.	_____	_____
8.	Start the AHU. The AHUs should now be operating in normal mode. Disable zone reset of discharge air temperature. Simulate non-heat recovery mode by setting the outside air signal to HR system between ___°F and ___°F. Verify the signal indicates HR off normal. Verify the HR coil bypass dampers are open and AHU is maintaining discharge air temperature setpoint of between _____°F and ___°F. Record setpoint and actual temperature. _____°F SP, _____°F Actual	_____	_____
9.	From the monitor observe the CAV zone with the highest demand. Enable the reset signal from only that one zone with the highest demand. Record the new AHU discharge air setpoint. _____°F	_____	_____
10.	Manually raise the setpoint of the one CAV zone for the highest demand of cooling (demand = the difference between setpoint and room temperature) until the demand begins to reduce. Observe the zone demand reduce at least 50%. Observe the effect on the reset and the new setpoint. _____°F	_____	_____
11.	Disable this one zone from the reset of the discharge air setpoint, so that the reset is not in effect. Simulate heat recovery heating mode as follows: Enable the HR system pump but don't allow the supplemental heat to energize and disable any other lockouts that may prevent the test. Manually command the supplemental heat HR valves if necessary.	_____	_____
12.	Raise the AHU discharge temperature setpoint above the actual outside air temperature. Simulate the exhaust air temperature is at least 5°F above the outside air temperature. The HR valve should modulate attempting to heat the discharge air. Record HR valve and cooling coil valve output and OSA., DA, and RA temperatures for several minutes. Observe the cooling valve remains closed in the heating mode.	_____	_____
13.	Now enable the supplemental heat at the HR system and raise the setpoint of the HR supply to force the valve open. Observe the HR coil modulation to maintain discharge air setpoint. Record HR valve modulation and DA temperature for several minutes.	_____	_____

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		COMPLETE Y/N	Date
14.	Simulate heat recovery cooling mode as follows: Disable the HR supplemental heat from above and any other lockouts that may prevent the test. Lower AHU discharge temperature setpoint below the actual outside air temperature. Simulate the exhaust air temperature is at least 5°F below the outside air temperature. The HR valve should modulate open first to cool the discharge air with the cooling coil valve in sequence to maintain discharge temperature. Record HR valve and cooling coil valve and OSA, DA, and RA temperature for several minutes.		
15.	Enable all AHU, HR, and temperature control back to the original automatic.		
16.	With AHU in the automatic mode, observe the downstream duct static pressure and the speed of the VFC. Record the data. Decrease the static pressure setpoint to ____" WC and observe the controller modulate the fan speed to maintain ____" setpoint. Increase the static pressure setpoint to original, and observe the controller modulate the fan speed to maintain ____ setpoint.		
17.	Verify the exhaust fan CFM is tracking the supply fan CFM. The exhaust fan AHU VFC shall be controlled to equal the supply CFM minus the dedicated exhaust CFM plus ____ CFM.		
18.	Set the duct static setpoint at ____" WC. Verify the high pressure safety trips and alarms.		
19.	Set the duct static setpoint at ____" WC. Verify the high pressure damper opens and alarms.		
20.	Verify the back-up system properly starts upon failure of the supply and exhaust fan.		
21.	Functional Performance Test for AHU - ____ Smoke Mode		
22.	Begin the functional test according to the matrix on sheet ____ . Start the AHUs and associated exhaust.		
23.	Simulate a smoke condition in the space to trigger the AHU-____ mode for the selected area.		
24.	Verify AHU supply fan on 80% volume, AHU supply outside damper D-____ open, and smoke damper SD-____ open.		
25.	Verify AHU exhaust fan 100 % and exhaust smoke damper SD-____ is open.		
26.	Verify smoke alarm signal sent to fire alarm system as alarm.		
27.	Verify all duct fire/smoke dampers in supply and exhaust of the specific AHUs open. (See Duct Smoke Damper Test below.)		

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		COMPLETE Y/N	Date
28.	Verify vent fans VF-__ and ____ are on.	_____	_____
29.	Verify DDC system monitor status for above equipment is on smoke mode.	_____	_____
30.	Run test long enough to purge smoke from area. Reset all components to automatic test.	_____	_____
31.	<i>Functional Performance Test for AHU Smoke Mode</i>	_____	_____
32.	Begin the functional test according to the matrix on sheet __. To simulate smoke mode program, start the AHUs and associated exhaust.	_____	_____
33.	Simulate a smoke condition in the AHU supply duct upstream of SD to trigger the AHU-__ mode for the selected area.	_____	_____
34.	Verify AHU supply fan trips off, AHU supply outside damper D-_____ closes, smoke dampers in supply SD-_____ close, exhaust SD-____ closes, AHU exhaust fan is off, and associated exhaust fan is on.	_____	_____
35.	Verify smoke dampers in supply and exhaust duct close. (See Duct Damper test).	_____	_____
36.	Verify alarm signal sent to DDC panel to indicate alarm and status of all equipment.	_____	_____
37.	Verify alarm signal sent to fire alarm panel.	_____	_____
38.	Verify all other AHUs and exhaust continue to run.	_____	_____
39.	Verify vent fans VF-__ and ____ are on.	_____	_____
40.	Verify exhaust EX-____ is on.	_____	_____
41.	<i>Functional Performance Test for Exhaust Fans Smoke Mode</i>	_____	_____
42.	Begin the functional test according to the matrix on sheet __ with the AHU S and E off. To simulate smoke mode program, start the AHUs and associated exhaust.	_____	_____
43.	Simulate a smoke condition in the associated exhaust duct upstream of SD-__ to trigger the smoke mode.	_____	_____
44.	Verify AHUs remain in normal mode and associated exhaust fan is off.	_____	_____
45.	Verify alarm signal sent to DDC panel to indicate alarm and status of all equipment.	_____	_____
46.	Verify exhaust duct smoke dampers close. (See Smoke Damper Test below).	_____	_____
47.	Verify alarm signal sent to fire alarm panel and fireman's panel.	_____	_____
48.	Verify vent fans VF-7 and 8 are on.	_____	_____
49.	<i>Negative Isolation Room Exhaust</i>	_____	_____

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		COMPLETE Y/N	Date
50.	Verify sound and alarm at the nurse's station to allow override for 10 minutes, then fan shuts down if no override.		
51.	<i>Fume Hood Exhaust</i>		
52.	Verify sound and alarm at the nurse's station to allow override for 15 minutes, then fan shuts down if no override.		
53.	Functional Performance Test for Supply and Exhaust Smoke Dampers. (See AHU and FCU Smoke Test above).		
54.	Check the electrical as-built drawings to locate smoke dampers and verify smoke dampers are in the correct location, sized for the damper, properly installed without binding, proper wire size, wires tagged, and connected securely. Record actual test results on a clean set of drawings.		
55.	The DDC system smoke damper's indicator point descriptor identifies the correct smoke damper on the DDC system.		
56.	The smoke damper actuator wires are proper size, tagged, and connected securely.		
57.	Simulate a smoke mode or manually command smoke damper to 100% open position, verify the damper actuators open to that position, and the DDC system indicates smoke damper actuator is open to 100%.		
58.	Simulate a smoke mode and manually command smoke damper, verify the open and closed positions, and the software indicates smoke damper SD-1 damper actuator is actually open or closed as shown.		
59.	Disconnect power to damper motor and verify motor spring returns to the normal closed fail position.		
60.	Verify Supply Fan does not run if damper is closed.		
61.	Verify Exhaust Fan does not run if damper is closed.		
62.	Verify a change of state out of normal expected range is displayed as an alarm at the workstation, point descriptor, and the alarm printer.		
63.	<i>Functional Performance Test for General Alarm Smoke Mode</i>		
64.	Begin the functional test according to the matrix on sheet ___ with the AHUs and associated exhaust fans on, and vent fans and ___ off.		
65.	Simulate a general alarm condition on the individual floors ___ and ___ generated from the fire alarm control panel to the DDC.		
66.	Verify the AHU-S volume is at 80-%, the AHU-E volume is 100%, and the associated fans are off.		
67.	Verify the exhaust fans EX-___ is on, and VF ___ and ___ are on.		

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68.	Comments:	
All tests completed.		
	_____	_____
	System Inspector's Signature	Date