SCHOOL FACILITY COMMISSIONING

System-Inspection Guidelines For Minnesota PK – 12 School Construction Projects

Minnesota Statutes, Section 123B.72

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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 the timing of a quality assurance expert or system inspector's involvement 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 that all key HVAC system components will be verified and all significant problems uncovered at a lower first cost.

Minnesota School Facility Commissioning Statute

Subd. 1. ***Application.***

This section applies to the installation or retrofitting of heating, ventilation, and air conditioning systems for projects where the total project cost per site exceeds $1,400,000.

Subd. 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.

Subd. 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 9, clause (6), item (iii) . A systems 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.

Subd. 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.

History:

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; 1Sp2003 c 9 art 12 s 6; 2011 c 76 art 1 s 14; 1Sp2011 c 11 art 4 s 5; 2014 c 312, art 18 s 11 (highlighted yellow to show a change)

The Commissioning/System-Inspection Process

For all school construction projects in excess of $1,400,000, regardless of the funding source, when project dollars are spent for new HVAC systems or for major modifications to the existing HVAC systems, a commissioning or system-inspection process of the HVAC system is required. At a minimum the commissioning/system-inspection process should consist of the following:

- 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 will 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 notify the architect, engineer, and construction manager before they are hired that their participation in the commissioning/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 commissioning/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 these amounts 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.

- 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 sent to the representative of the commissioner of the Minnesota Department of Education (MDE), 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 HVAC systems are not complete and/or operating properly, the letter to the district shall indicate the deficiencies and also state that the overall HVAC system provides the minimum amount of outdoor air as specified by code as indicated in a preliminary testing and balancing report. The building code official may then 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 code official, with a copy to MDE, indicating the HVAC systems are complete and operate as intended. At this point, the building code 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.

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

> The American Society of Heating Ventilation Refrigeration 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);

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); and

The Sheet Metal and Air Conditioning Contractors' National Association , Inc. (SMACNA) published their HVAC Systems Commissioning Manual in 1994. The manual focuses on the HVAC systems and the parties responsible for their proper design and installation. (SMACNA, 4201 Lafayette Center Drive, Chantilly, VA 22021).

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 of 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.

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 interest 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 between 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 together in this process. This appendix provides 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 based upon 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.

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.
2. Participate in the resolution of division 15 and 16 system deficiencies identified during the system-inspection process.
3. 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.
4. Review and approve the O&M manuals.
5. 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.

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 percent and 95 percent 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.

4. Develop a draft project-specific system-inspection plan.
5. 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.
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 check-out 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 check-out plan with subcontractors.
10. Approve systems start-up 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 percent 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 percent 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 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 percent 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 percent 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 percent) 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.
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

1. Supervise any seasonal or deferred testing and deficiency corrections required by the specifications.
2. 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.

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.

Owner

Conceptual Phase

1. Decide if system-inspection will be (a) limited to the Minnesota commissioning statute requirement that HVAC systems will work as intended or (b) 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.

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.

Role of the Building Code Official

Plan Review and Inspections

1. The State of Minnesota, Office of Labor and Industry, Building Codes and Standards Division (BCSD) is responsible for plan review and inspections of school district building projects over $100,000 unless there is an agreement with the local municipality for plan review and/or inspections.
2. The BCSD (or a municipality) will verify that the HVAC system has been designed in accordance with the following mechanical/ventilation code requirements:

- Minnesota State Building Code adopts ASHRAE Standard 62-2004 or the most receive edition, Ventilation for Acceptable Indoor Air Quality;
- ASHRAE Standard 62 requires 15 cfm of outdoor air per person in a classroom and/or auditorium of a school; and
- ASHRAE Standard 62-2004 is scheduled for adoption with the more recent International Mechanical Code.

Prior to Final Inspection

1. Before completion of testing and balancing, a letter is submitted by the system inspector to the building code official (BO) indicating the deficiencies in the HVAC system;
2. Before a temporary certificate of occupancy can be issued, the letter from the system inspector must also state that the overall HVAC system provides the minimum amount of outdoor air as specified by code as indicated in a preliminary testing and balancing report; and
3. The BO then issues a temporary certificate of occupancy, valid for up to one year.

Final Inspection

1. Before occupancy, a letter is submitted to the BO verifying that the HVAC system has been installed and operates according to design specifications; and
2. If all other code requirements are satisfied, the BO issues a certificate of occupancy

Inspection of Small Remodeling Projects

1. The appropriate amount of outdoor air to existing (or new) HVAC systems must be verified; and
2. Air filtration must comply with design-intent.

Enforcement of HVAC System Guidelines

1. BO currently has statutory authority to enforce these HVAC system requirements, but School Facility Commissioning/System-inspection Guidelines (and MS 123B.72) will create more consistent enforcement;
2. All jurisdictions that have adopted the building code will be sent letters referencing the School Facility Commissioning/System-inspection Guidelines and the effective date of commissioning/system-inspection requirements; and
3. Inspection requirements will be included in the administrative chapter of the building code and building code officials will be informed of the requirements at future educational seminars.

Role of the Commissioner of the Minnesota Department of Education

The Division of School Finance represents the commissioner on school facilities matters and on school facility commissioning/system-inspection issues.

Plan Review and Inspections

1. MDE staff normally tour school facilities that will be renovated and/or replaced as part of a major school construction project. Preliminary and final plans are not usually reviewed nor are schools inspected by MDE unless issues necessitate such review or inspection; and
2. A copy of the document prepared by the system inspector before the temporary and/or final certificate of occupancy of the facility is issued should be sent to the Division of School Finance.

Enforcement of HVAC System Guidelines

MDE staff will continue to work with school districts, school architects and engineers, system inspectors, legislators, and other interested persons in helping to interpret and clarify school facility commissioning/system-inspection requirements and guidelines.

Appendix B

System Inspector Qualifications

____

Company Name | Contact Person

____

Address | City | State | Zip Code

____

Telephone Number | Fax Number | E-Mail Address

Description of Business

Commissioning Activities

Percentage of overall business devoted to system-inspections and/or commissioning services. ________________ Percent (%)

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):

- ☐ Packaged or Split HVAC
- ☐ Chiller System
- ☐ Boiler System
- ☐ Energy Management System
- ☐ Variable Frequency Drives
- ☐ Lighting Controls
- ☐ Day Lighting
- ☐ Electrical, General
- ☐ Electrical, Emergency Power
- ☐ Envelope
- ☐ Fire/Life Safety
- ☐ Plumbing
- ☐ Commercial Refrigeration
- ☐ Telecommunications
- ☐ Thermal Energy Storage
- ☐ Labs and Clean Rooms
- ☐ Other: ________________________________

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

List Qualification: ____

____

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 Text Checklist (Sample checklist only)

Project: ______________________________ Test No. ______________

Contractor: ____

Discipline: Test and Balance ______________ Date: ______________________

Equipment: Air Handling Unit (Supply) ________ Mark: ______________________

System: ______________________ Location: ______________________

Manufacturer: ______________________ Serial No. ______________________

The installation contractor certifies the following are complete: (You will initial and date after each inspection item)

Inspection n/a	**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, defection based on VFD low speed, tested and certified.		
Sound power level tested and certified. See page 2, section 15211.		
Control system installed, tested and operations.		
Flexible connector and boot alignment checked.		
Fan data balanced, tested and recorded at minimum and maximum speed.		
Fan Service ________ RPM ________		
Actual CFM ________ Total Pressure Drop ________		
Actual BHP ________ Sheave Size ________		
Actual Suction Pressure ________ Actual Discharge Pressure ________		
Fire and smoke dampers in place open and checked.		
Air measured at intake and discharge matches design within five percent.		
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		

Inspection	COMPLETE	
n/a	Contractor Initials	Date
automatic.		
Coil balanced, tested and data recorded. Coil Service ______ Entering Water Temp ______ Entering Air Temp ______ Leaving Air Temp ______ Pressure Drop ______ Actual GPM ______		
Construction filters replaced with new and differential pressure gauge in place and checked.		
Coil thermometer installed and calibrated.		
Balance dampers set and locked in place.		
Valve tested and pressure drop at full open checked.		
Coil air vents tested.		

All tests completed.

Contractors Signature ______________________________ Date ________________

Verified ______________________________ Date ________________

Appendix D

Functional Performance Test
Sequence of Control and Record Sheet

Project: ____ Test No. ______________________

(You will answer yes or no and date after each inspection item)

n/a		COMPLETE	
n/a		**Y / N**	**Date**
1	*Functional performance test for air handling unit (AHU)*		
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 state the AHUs in the normal mode. Verify visually ad 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 ______________ 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 ______________		
7	Verify DDC system monitor status matches above off modes.		

n/a	n/a	COMPLETE	
		Y / N	**Date**
8	Start the AHU. The AHUs should now be operating in normal mode. Disable zone rest 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 percent. 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 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. Make sure 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.		

n/a	n/a	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 percent volume, AHU supply outside damper D _____open, and smoke damper SD- _____open.		
25	Verify AHU exhaust fan 100 percent 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.)		
28	Verify vents fans VF - _____ and _____ are on.		
29	Verify that 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.		

n/a	n/a	COMPLETE	
		Y / N	Date
31	*Functional Performance Test for AHU Smoke Mode*		
32	Begin the functional test according the matrix on sheet __. To simulate smoke mode program, state 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 continues to run.		
39	Verify vent fans VF-___ and ___ are on.		
40	Verify exhaust EX-___ is on.		
41	*Functional Performance Test for Exhaust Fans Smoke*		
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 fans 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 Text 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	*Negative Isolation Room Exhaust*		
50	Verify sound and alarm at the nurse's station to allow override for 10 minutes, then fan shuts down if no override.		
51	*Fume Hood Exhaust*		
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.		

n/a	n/a	COMPLETE	
		Y / N	**Date**
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 percent open position, verify the damper actuators are open to that position, and the DDC system indicates smoke damper actuator is open to 100 percent.		
58	Simulate a smoke mode and manually command some 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	*Functional Performance Test for General Alarm Smoke Mode*		
64	Begin the functional test according to the matrix on sheet ____ with the AHUs and associated exhaust fans on, and vents 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 percent, the AHU-E volume is 100 percent and the associated fans are off.		
67	Verify the exhaust fans EX-____ is on and VF ____ and ____ are on.		
68	Comments:		

All tests completed:

______________________________ ______________________

System Inspector's Signature Date