The What, Why, Who & When of Building Commissioning

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The relationship between mechanical and building envelope commissioning (Cx) is important. The commissioning process should be used to ensure all building systems are installed, calibrated, and perform interactively according to the owner's project requirements (design intent) and operational needs. The whole building commissioning process provides value to building owner(s) and it is important for all members involved in the construction process, as they will all, at some point, play a role in this process, which begins in the concept phase and continues through into the warranty period of the building.

THE WHAT

Commissioning is a systematic process that documents the construction process via a series of construction checklists, issue logs, and functional tests. It is a process developed by the project team to ensure the building is functioning as intended. If this sounds like an obvious requirement for a building, you would be surprised how often this process is missed.

Building commissioning is being embraced by public and private organizations because it benefits the building envelope and provides improved project delivery results.

Traditionally, the mechanical and electrical systems of a building were commissioned. Mechanical systems include ductwork balancing, temperature and relative humidity control, building automation system control valves, steam traps, pumps, boilers, etc. There is currently more emphasis on the commissioning of the building envelope. Building envelope systems, such as, glazing systems, wall assemblies (pre and post construction), roofs, whole building air barriers, and waterproofing systems can also be tested and commissioned. The following are some examples of systems that can be commissioned:

- Window assemblies for air and water leaks;
- HVAC systems, pumps, and air balancing;

- Lighting measurements and controls;
- Wall assembly simulations (will there be condensation under unique indoor / outdoor conditions?);
- HVAC system loads and energy costs (whole building airtightness has a huge effect on these);
- Ongoing measurement tools (i.e., water sub-meters, gas meters, and building automation systems);
- Training and how to properly operate the building; and
- Indoor air quality and filtration systems.

Two blower door fans used for testing the building's air barrier performance.

THE WHY

The Cx process ensures all building systems are installed, calibrated, and perform in synergy according to the owner's project requirements (design intent) and operational needs. It is simple enough to design a building that appears to meet the owner's needs, but the true test is whether it performs as expected. Do the HVAC systems maintain temperature and relative humidity between set-points? Do boilers and pumps switch from lead to lag? Do windows and walls keep the rain out? Is the air barrier system performing as expected? These are all considerations that get confirmed and addressed during the Cx process.

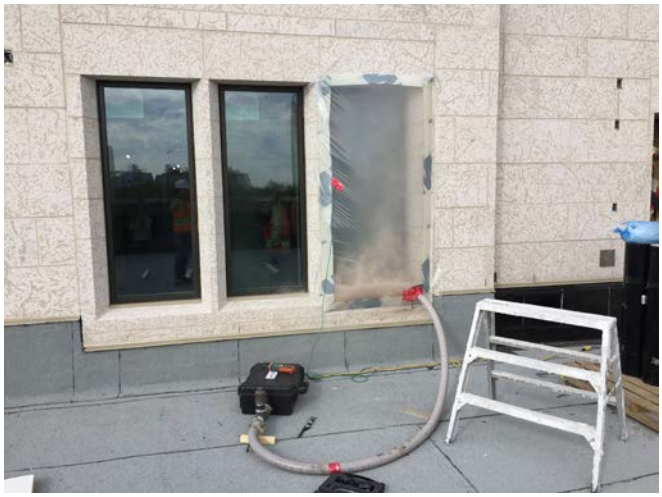
As building owners evolve, and as building code officials—may or may not—become more stringent on energy use for new buildings, the actual performance of a base building system will matter more than ever. The performance of the building systems has a direct relationship with the overall operating costs. Operating costs tend to reoccur every month over the life of the building and must align with the owner's portfolio performance expectations.

The building envelope interacts with the environment to provide the heating or cooling load to the HVAC system. The performance of the building envelope has a direct effect on the HVAC equipment size, operation cost, and the occupants' comfort. The commissioning of the building envelope should also include the review of the overall projected life of the systems and each one of their components. For example, installing a 10-year screw in a 25-year cladding system tends to lead to premature replacement costs and avoidable headaches.

THE WHO

All members involved in the construction process will, at some point, play a role in the Cx process. This includes everyone from the owner(s), to the prime consultant / architect, to structural engineers, to mechanical and electrical consultants, to building envelope consultants and the developer, to general contractors, sub-contractors and maintenance staff. The project's commissioning agent (CxA) does have a role but significantly leans on the designers and installers to complete many of the Cx tasks. The CxA and owner(s) should also strongly consider including an energy manager on the Cx team.

Stakeholders also have a critical role in the Cx process. They need to develop, with the help of the Cx agent and designers,


Exterior view of smoke testing a window assembly to identify gaps in the air barrier.

Interior view of smoke infiltration during testing.

Exterior view of water testing a window assembly.

what is known as the owner's project requirements (OPR), which dictate much of how the building is designed by various consultants.

Based on ASHRAE Guideline 0-2013, the OPR should include:

- Overall project goals.
- Measurable performance criteria for each system. If you cannot measure it, how do you know it is performing? When evaluating the installed system, it must either pass or fail (i.e., lights turn on when someone walks into a room), or meet a threshold of acceptable performance (i.e., maximum acceptable air changes per hour for the building envelope).
- Cost considerations.
- Identify success criteria.
- Supporting information to justify design choices and system performances.

THE WHEN

The Cx process starts in the concept phase and continues beyond the warranty period of the building. The process starts with the CxA and owner(s) developing the OPR prior to the design process. It should be clear to all designers what the owner(s) is expecting from the building before the design process begins.

The designers need to understand what type of performance is expected. Performance requirements vary depending on the owner(s), occupancy, and use. Performance requirements may be based on total energy usage, greenhouse gases (not all energy is created equally and can have different greenhouse gas footprints and costs), occupancy comfort, lighting requirements, indoor air control, etc.

THE PHASES OF A COMMISSIONING PROJECT

- **Phase 1:** Commissioning planning (includes both pre-design and design), construction, occupancy, and operation.
- **Phase 2:** Design (verify the basis of design document with OPR, develop a construction checklist, develop a system manual, define training requirements, and commissioning focused design review).
- **Phase 3:** Testing.
- **Phase 4:** Preventative maintenance and benchmarking performance (creation of a detailed maintenance program; maintenance is key to energy efficiency).
- **Phase 5:** To confirm everything works accordingly, building operations will be reviewed six to 10 months after substantial completion.

COMMISSIONING EXAMPLES

AIR ASSESSMENT:

Air assessment (to verify if the system behaves as intended) is part of the commissioning process. One of the tasks is checking equipment conditions. Verifying that the fans in the rooftop units are correctly installed should be part of the maintenance program. This requires little or zero investment. Proper maintenance of air-handling equipment can prevent energy waste and help ensure the comfort of building occupants.

WHOLE BUILDING AIR LEAKAGE TESTING:

Whole building air leakage testing has gained traction in recent years. It is a great way to test the air barrier system of a building as a whole. The process allows the Cx team and building envelope consultants to test the performance of the air barrier and identify and rectify any deficiencies.

Various standards and performance requirements can be specified for the air barrier and should be determined early in the design process. The owner(s) and prime consultant typically work with the building envelope consultant to determine specific air barrier performance criteria that works for all parties or that have been mandated by a jurisdiction having authority. A tighter air barrier system may require changes to the building envelope design and could potentially increase construction costs.

Roof thermography identifying compromised roofing assembly, otherwise unobservable without cut-tests.

During testing, all intended openings should be sealed. Retesting without seals at these openings can be performed to test performance of the dampers. In high-rise buildings that are already occupied, testing of one floor at a time can be completed if zero pressure difference is maintained between adjacent floors.

ROOFING PREVENTATIVE MAINTENANCE:

Preventative maintenance on the roofing system should be considered during the retrocommissioning or recommissioning of an existing building. As with any Cx, retro and recommissioning are processes to ensure building systems are operating optimally to meet current occupant needs (CanmetEnergy, Natural Resources Canada, 2008). Most roofing issues do not happen overnight and can be addressed if regularly reviewed. Often, issues are easily fixed and caused by blocked roof drains. Typical deficiencies may include membrane blisters, membrane ridges, wind scouring effects, membrane shrinking / tenting, debris, blocked drains, unsealed penetrations, degranulation, "oil-canning" of metal panels, open seams, and

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punctures. Even a simple visual review of the roof with a checklist to note severity of degradation can be part of the Cx process. Reviewing the drying patterns can provide valuable information on the performance of the roof drainage system.

Replacement specifications can include a maintenance protocol and may have been part of the design requirements highlighted early in the process. Frequency of maintenance depends on the age of the roof, building size, usage, and type of roof. A visual review of the roof should be completed at a minimum of twice per year. Thermographic analysis of the roofs should be completed every five years.

The aforementioned should be part of the preventative maintenance plan and also part of the Cx plan because it ensures the roof system is performing as intended. It should also be highlighted that the roof system may consist of many other systems, like air barrier, weather / water barrier, vapour barrier, and thermal barrier.

SUB-SOIL GASES:

Some jurisdictions are now mandating sub-soil gas mitigation systems in new buildings. The design and construction of these systems can be completed with little investment, compared to the overall cost of the building, but can have a huge effect on occupant health. Radon, for example, can be easily mitigated by using a few small fans, perforated piping, and gravel. For more information on radon, take a peek at Pinchin's article, *Recognizing Radon in the Building Envelope: How to Control it & Protect Yourself*, in the Spring 2017 edition of *Pushing the Envelope Canada* (www.obec.on.ca/pte-newsletter). It is no longer acceptable to install the system and assume it is working properly. Testing for radon is required before and after activation of the system to ensure it is actually performing and maintaining radon levels within acceptable levels. Like many other systems, testing should be completed to ensure the system is working as intended, and there is no way of knowing this until the building is constructed and the system is operating.

HVAC / CONTROLS:

The Cx agent will review the overall designs to ensure they meet the OPR. Say, during the review process, the Cx agent observed that the garbage room in the basement of a new mid-rise construction was designed with two independent HVAC systems. Heating was provided by a hydronic unit heater and cooling was provided via an air-handing unit and direct expansion coil. This would not necessarily be an issue, other than the fact that two independent thermostats controlled each system and are not communicating with each other. During the warm summer months, it is conceivable that the building operator

would decrease the temperature set-point for the air conditioning. If the temperature set-point is not readjusted during the winter months, and there is no buffer between the heating and cooling, both systems may be operating at the same time, fighting to maintain their set-points. In this case, the Cx process was able to avoid excess wear and tear on both HVAC systems and likely had a positive impact on the ongoing operating costs, maintenance, premature equipment failure, warranty call-backs, and occupant comfort.

OVERALL PHILOSOPHIES

Earlier in this article, we discussed the current emphasis on commissioning of the building envelope. As the system that keeps the outside out and the inside in, it has the largest influence on the energy use of the building. With technology advancement, condensing boilers and furnaces are reaching higher efficiency ratings and the limits of energy efficiency are within sight. Instead of focusing on efficiency, the construction industry has wisely shifted its priority toward energy conservation.

Focusing on energy conservation from the early stages of design provides benefits throughout the life of the building. With a smaller energy requirement for indoor comfort, HVAC systems can be reduced in size, overall energy costs will be reduced, and equipment will have to cycle less frequently, reducing maintenance costs and extending the overall life of the building.

BENEFITS OF COMMISSIONING

The benefits of a properly commissioned building will last the life of the building, ensuring the owner(s) receive the building that was paid for and allowing it to operate at peak performance. Generally speaking, an issue discovered, resolved, and avoided during the commissioning process pays for the Cx process itself.

As a result of building commissioning, buildings and systems can function as intended, operators are able to know how to operate the building in the most optimal way, occupant comfort can be improved, energy consumption can be reduced, and the life of building systems can be extended. ■

Fume hood testing.

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RESOURCES

ASHRAE offers several resources to help guide your team through this critical phase of a construction project, including:

- *Commissioning Stakeholders' Guide*
- *The Strategic Guide to Commissioning* (FREE)
- *Standard 202-2018 – Commissioning Process for Buildings and Systems*
- *Guideline 0-2013 – The Commissioning Process*
- *Guideline 1.2-2019 – Technical Requirements for the Commissioning Process for Existing HVAC&R Systems and Assemblies* (NEW)