Building Commissioning, Ongoing Commissioning and quality management using BACS

by Stefan Plessner & Ole Teisen

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Meet the speakers:

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Quality Management: Turning Energy Concepts into Building Performance (1/2)

Service concepts – Technical Monitoring and Building Commissioning

Dr. Stefan Plessner
Building Automation

- BACnet Objects
- BACnet Objects per m²

Office 1975, Office 2015, Lab 2015

IoT

www.synavision.de
Building Standards

1973: 15 pages

2018: > 1.000 pages

www.synavision.de
Building Performance needs Quality Management

- Today’s buildings are complex technical systems.

- We have an increasing gap between potential and real building performance.

- For high performance buildings need quality management

- Digitalization allows quality management services to become fast, transparent and cost effective.
Building Performance needs Quality Management

- Todays buildings are complex technical systems.

- We have an increasing gap between potential and real building performance.

- For high performance buildings need quality management

- Digitalization allows quality management services to become fast, transparent and cost effective.
Challenges for buildings’ performance

Owner

- Lack of competence and capacities
- Neglection of early project phases
- No Continuity between construction and operation

Planning

- Lack of precise requirements definition
- No efficient control function of planning implementation
- High dependency on personnel

Construction

- No testing of building automation functions
- Lack of documentation concerning the implemented building control
- High dependency on personnel

Operation

- Premature handing over of incomplete building
- Lack of proper tools to analyze building automation functions
- No time/capacity for frequent in-depth operational analyses
- No service level agreements in place for operation of building equipment with external providers
Quality Management
Quality Management

Recipe

500g Flour
250g Sugar
250g Margarine
100ml Milk
4 Eggs
1 tsp Baking Powder

180°C
60 Minutes
Technical Monitoring as a key to building performance

Quality Control Loop to check for fulfillment of requirements.
Technical Monitoring as a key to building performance

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Quality Control Loop to check for fulfillment of requirements.

- Design
- Construction / Commissioning
- Operation

Feedback into operation

Impact

Design Target Value

Metering Value

Evaluation
Technical Monitoring as a key to building performance

Quality Control Loop to check for fulfillment of requirements.
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Quality Control Loop to check for fulfillment of requirements.
AMEV Recommendation Technical Monitoring

- Official call for quality management in construction projects and for existing buildings in order to ensure that technical and economic potentials are reached in normal operation
- Clear definition of the work packages, services, and results in order to request Technical Monitoring in public tenders
- First to define the role of quality management as a third party service in construction projects

AMEV: Working committee at the German Ministry of Interior, Building and Community
AMEV Recommendation Technical Monitoring

- Derive target values from design
- Recommendations for project setup

- Definition of services of the TMon service provider
- Definition of services of others (e.g. engineer, contractor)
- Requirements for monitoring concepts and reports
- Advice on cost, effort, potential and financing

- Working documents
  - Annex 1: Text modules for TMon services
  - Annex 2: Required services of engineers
  - Annex 3: Required services of contractors
  - Annex 4: Minimum requirements for buildings & systems test parameters
  - Annex 5: Advice on metering devices and data management
Key steps for the implementation of Technical Monitoring

Step 1: Design
- Definition of technical objectives
- Definition of testing procedures

Step 2: Trial operation
- Run trial operation under specified conditions (1-4 weeks)
- Hand over operation data
- Evaluate operation data and report

Step 3: Continuous or repeated testing
- Monitoring
- Quarterly or annual testing
Step 1 (Design): Setpoints & Testing Procedures

- Design review
- Specification of relevant test parameters for the building and the systems
- Specifications for data collection and transfer.
- Specification of testing procedures.

Documents provided by synavision:

- List of Data points for each system to be tested
- Testing Specification for each system to be tested
- Tender document for trial operation
- Tender document for data export
Step 2: Monitoring in trial operation

- Contractor notifies test readiness
- Contractor hands over data export test data
- synavision tests data and notifies test readiness
- Owner notifies ok
- Contractor runs systems as specified ("hands-off operation", but possibly with special load situations)
- Contractor hands over data as specified
- synavision analyses data as specified and reports

Documents provided by synavision:

- Testing Report on each system
- Dashboard (optional)
— Step 3: Monitoring in regular operation

- Building is in regular operation
- O&M Personnel hands over data regularly (or continuous automated hand over)
- **synavision** analyses and reports on system performance (including O&M services)

**Documents provided by synavision:**

- Periodic testing reports on each system, e.g. as
  - monthly report in first years of operation
  - routing slip/checklist for inspections
  - O&M service level check
- Dashboard with continuous data import and visualization (optional)

Example: Dashboard-Template for a chiller
AMEV Technical Monitoring: Organization

3.1.2
The TMon service provider is an independent third party.
AMEV Technical Monitoring – Modular service concept - Design

- Review of design
- Derivation of test parameters and corresponding target values

Annex 4:
- What systems have to be regarded?
- What test parameters have to be specified?

- Additional requirements for metering
- Requirements for data management

Annex 3: Templates for tender documents
- Specification for trial operations
- Specification for data hand over

→ TMon concept
AMEV Technical Monitoring – Modular service concept – Hand over

- Follow up of TMon concept
- Check whether prerequisites for trial operation are given
- Evaluation of operation data
- Reporting on whether target values have been met

Prerequisites for trial operation

- Check plan for trial operation with contractor
- Check for completed installation
- Check test data export
- Systems need to be fully operational in automated mode

- Information to the building owner for test readiness
- Conformation of building owner to carry out trial operation
AMEV Technical Monitoring – Modular service concept – Hand over

Trial operation of the system includes the following services:

- **Operation of the system over a time period of two weeks**
- Two on-site visits (8h each) during trial operation, for adjustment of set values, parameters or time programmes, or other system parameters, according to the specifications of the monitoring arrangement.

**Examples:**
- Increasing a characteristic curve of the heating circuit (e.g. to 5 K)
- Changing a time programme (e.g. of the air conditioning system on work days, 7:00am to 7:00pm)
- Lowering a switching hysteresis (e.g. of the initial temperature for storage charging, to 9°C)
- ...

- During trial operations, systems must be run in automatic operation, if this is provided for in planning. Manual interventions – with the exception of the required changes, e.g. adjustments in set values and time programs on the managing operations level – lead to cancellation of the trial operation.

- Storing required operations data during trial operation.
- Transferring the stored trial data to the client after the completion of trial operation, within 24 hours.

If cross-system functions are involved, trial operations of the affected systems should be executed at the same time, in order to be able to determine their interactions.
Minimum requirements for reports:

- Specification of trial operation schedules
- List of test parameters for buildings, systems and components **including target and measured values**
- Quantitative Evaluation on the fulfillment of requirements:
  Have target values been met?
Digitalization of Technical Monitoring: Metering

Option 1: Design and installation of individual metering devices
Option 2: Use manufacturer gateways and cloud services

Example: Stiebel Eltron Service Welt
Digitalization of Technical Monitoring: Metering
Option 1: Design and installation of individual metering devices
Option 2: Use manufacturer gateways and cloud services
Option 3: Use BMS and data provision cloud services
AMEV Technical Monitoring
Unplausible Ambient Air Temperature
AMEV Technical Monitoring
Incorrect setting of supply temperature
AMEV Technical Monitoring
Incorrect sequence of operation in triple pump
AMEV Technical Monitoring
Disfunctional heat recovery system

Increased temperature after heat recovery system

No increased temperature after heat recovery system
Quality management pays off

Identified savings potential\(^1\) and customer payback times

- **Business model:** Fix price / data point tested (1-3% of total available data points)
- Fits best for new construction projects and existing buildings
- Sustainable improvement of building performance
- Energy savings, climate improvement and less depreciation add up to attractive results
- Detected measures are easy to implement and require no investments

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\(^1\) Cumulative lifecycle savings over 15 years

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Why Technical Monitoring

**Fast payback times in less than one year on average**
- Save on energy consumption and depreciation, improve indoor climate
- Tested building performance increases the value of your real estate

**Save time**
- Faster, better commissioning and handover
- Massive support for technical building management through measurable building performance and automated indication of optimization potential

**Increase productivity and user satisfaction**
- Consistently high quality of indoor climate reduces sick leave and increases productivity

**Easy implementation and fast results**
- Technical Monitoring fits perfectly into existing processes in the building industry
- Low requirements: planning documents and data is all we need.
- No further investments necessary: Results can be easily implemented and sustainably improve building performance
- Complete Transparency for all stakeholders
## Technical Monitoring vs. Commissioning

<table>
<thead>
<tr>
<th></th>
<th>TMon</th>
<th>Cx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nomination of a Cx</td>
<td>Contract service provider</td>
<td>Contract service provider</td>
</tr>
<tr>
<td>service provider</td>
<td></td>
<td></td>
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<tr>
<td>OPR</td>
<td></td>
<td>Write OPR with Building Owner or give guidance to Building Owner</td>
</tr>
<tr>
<td>BoD</td>
<td></td>
<td>Give guidance to Design Engineers for writing BoD and check BoD on compliance with OPR</td>
</tr>
<tr>
<td>Commissioning Plan</td>
<td>Describe TMon Process in the project</td>
<td>Describe Cx Process in the project</td>
</tr>
<tr>
<td>Cx in the Design Phase</td>
<td>Derive target values for building and system operation and specify testing procedures</td>
<td>Check Design on compliance with OPR</td>
</tr>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Cx in the Construction Phase</td>
<td>Check data from trial operation against target values and report</td>
<td>Check Construction on compliance with OPR</td>
</tr>
<tr>
<td>Cx in the Startup Phase</td>
<td></td>
<td>Check startup procedures, prerequisites for testing systems functions and cross system functions and report</td>
</tr>
<tr>
<td>O&amp;M Manual, Systems Manual</td>
<td></td>
<td>Review O&amp;M and system manuals on completeness, timeliness, consistency and plausibility</td>
</tr>
<tr>
<td>Training for O&amp;M Personnal</td>
<td></td>
<td>Check schedule and execution of training</td>
</tr>
<tr>
<td>Training for building occupants during operation</td>
<td></td>
<td>Check schedule and execution of training</td>
</tr>
<tr>
<td>Commissioning In</td>
<td>Check data from ongoing operation against target values and report</td>
<td>Check data from ongoing operation against target values and report</td>
</tr>
<tr>
<td>building operation</td>
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For further information, please contact us anytime.
WEBINAR

Building Commissioning
Ongoing Commissioning
Quality Management using BACS
Building Automation & Control Systems

Ole Teiser
QCxP, CPMP
Sweco A/S

3 Dec 2018 @ 14:00 CET
Learning objectives:

• Basic knowledge of the The Building Commissioning Process, Cx

• Important interactions with Quality Assurance activities in the Building Process

• Roles of different stakeholders in the Quality Management Process
Agenda:

- Why use the Building Commissioning-process, - Cx? - A Case!
- How Cx, - a brief review of a complicated process
- Contractor Quality Assurance, - prerequisites for tests
- Ongoing Cx activities and Monitoring-Based Commissioning
A story from the real world:

In 2012 a new 6000 m² domicile was handed over from the design-build contractor to the owner.

Various media described the construction process as a success and all parties were satisfied with the result.

The designers were particularly satisfied with the technical solutions.

“Everything was tested before the building was put to service”

The building achieved an architectural prize.
Four years later the Sweco Cx-team was invited to verify the indoor Climate Observations and measurements:

- Unhealthy air
- Very varying air velocities in the working areas
- Too little supply of fresh air
- Poor distribution of the fresh air supplied from ventilation system
- Rapid rise of temperatures when the sun hits the facade

The ventilation system is designed as a Constant Air Volume system (CAV) despite meeting rooms operate with Variable Air Volume (VAV)

⇒ Pressure oscillates in the air distribution ducts, the system can’t obtain the values in the balancing report

No measuring points on hydronic systems

⇒ Hydronic balancing is not possible
The story continues:

Exhaust above ceiling without distribution ducts and Chill Beams installed without following the requirements of the producer
⇒ Draft

Architectural solution with windows in aluminium cassettes popping out of the facade
⇒ Temperatures in the Cassettes up to 72 °C, inner surface temperature measured on the glass 35-40 °C

Radiators are heating, also in the summer

Solar screens operate after a control sequence that is not described

The whole cooling system is running constantly – also in the winter – to keep IT-installations cold
Conclusion

• The owners indoor climate requirements are not met
• Indoor conditions are so bad that it is not allowed to have employees working in the building
• 50% dissatisfied employees
• Energy consumption out of control
• Costy renewal of all technical installations and new cooling and ventilation concept necessitating new installations above ceilings and new ceiling system to be implemented in the building in use
The EBC\textsubscript{x} process:

Initiated by indoor climate complaints that didn’t stop no matter what the general contractor provided

Requirements mapped
Building tested
Designers hired to find a solution
Solution is implemented
Cx as usual…
Testing indoor climate:
Choose the right and sufficiently calibrated instrument for each measurement task
Room for service?
WHY Cx?

Where is the key to good indoor environment?

23°C
600 ppm CO₂
WHY Cx?

Where is the key to good indoor environment?

- Sunscreen
- Smoke sensor
- Room Control
- Radiator

Temperature: 23 °C
CO₂: 600 ppm
Where is the key to good indoor environment?
Gaps between disciplines resulting in:

- Poor Coordination
- Lost Details
- Costly Change Orders
- Delays in Schedule

WHY CX?

- Architect
- Mechanical design engineer
- Electrical design engineer
- Contractor
- Data/Security/Div.
- Fire alarm system
- Fire safety
- Automation, BMS
- Electrical contractor
- Mechanical contractor
Commissioning helps fill the gaps in coordination

Commissioning encompasses “All”
Commissioning helps fill the gaps in coordination.

Commissioning encompasses "All"
WHAT CAN GO WRONG?

- Owners Requirements are too fluffy
- Design is not following the requirements
- Construction not according to design
- Communication issues between phases
- New players – different language
- No time for proper QA
- Building programme with intentions instead of measureable requirements
- Calculations and simulations are not supporting technical function
- Details lost in cross disciplinary work with many subcontractors involved
- Documentation not focused on owners O&M
- Staff not trained to operate and maintain the building according to the requirements

Pre-design  ➔  Design  ➔  Construction  ➔  Operations

“quality-oriented process for achieving, verifying and documenting whether the performance of a building’s systems and assemblies meet defined objectives and criteria.”
COMMISSIONING PROCESS FOR NEW CONSTRUCTIONS

Follow-up on issues handed over from one phase to another

 Owners Requirements
- Measureable requirements!
Don’t forget Cx requirements…

Review Design Requirements followed?

Test, train, document Performance according to requirements

Continue testing and monitoring
Does it still work according to requirements?
COMMISSIONING PROCESS FOR EXISTING BUILDINGS

Follow-up on issues handed over from one phase to another

Planning | Investigation | Design | Construction | Operations

Owners Project Requirements
- Measureable requirements!

Examine the documentation
Test the systems
- Where do we need to renovate?

Review Design
Are the requirements followed?

Test, train, Document Performance according to requirements

Continue testing and monitoring
Does it still work according to requirements?
### Commissioning Process documents and activities

<table>
<thead>
<tr>
<th>Document</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owners Project Requirements, OPR</td>
<td>Owners choice of topics to be commissioned</td>
</tr>
<tr>
<td>Commissioning Plan</td>
<td>Description of the Commissioning scope, activities and schedule</td>
</tr>
<tr>
<td>Issues Log</td>
<td>Everything we register or experience that might have influence on the project meeting the OPR</td>
</tr>
<tr>
<td>Accept document</td>
<td>Owners acceptance of Commissioning activities in the particular phase</td>
</tr>
<tr>
<td>Basis Of Design, BCD</td>
<td>Designers early response to each of the requirements in the OPR</td>
</tr>
<tr>
<td>Commissioning review report</td>
<td>The result of operations-focused Commissioning review</td>
</tr>
<tr>
<td>Systems Manual</td>
<td>Library hosting all drawings, design documents, balancing reports, quality- and Cx-documentation</td>
</tr>
<tr>
<td>Training Plan</td>
<td>Plan for how members of the owners staff are trained</td>
</tr>
<tr>
<td>Test Paradigm</td>
<td>Script describing a test in detail</td>
</tr>
<tr>
<td>Test Report</td>
<td>The result of the test</td>
</tr>
<tr>
<td>Commissioning Report</td>
<td>What we experienced when we followed the Commissioning Plan</td>
</tr>
</tbody>
</table>
Commissioning Process Organisation example:

- **Owner**
- **Commissioning steering group**
  - Owners representative
  - Cx Provider (Working for the owner)
  - Design team and/or Contractor
- **Operating personnel, users, suppliers of owner’s supplies**
  - Electrical
  - Data communications
  - Heating & Cooling
  - Ventilation
  - Automation
  - Building Enclosure
- **Cx Specialists** (Cx technical resources design, operations, process)
  - Electrical
  - Data communications
  - Heating & Cooling
  - Ventilation
  - Automation
  - Building Enclosure
- **Construction managers, Designers, Consultants, Contractors, Suppliers**
• COMMISSIONING IS:

QUALITY MANAGEMENT PROCESS TARGETING OWNER PROJECT REQUIREMENTS, LIFE CYCLE COSTS ABOVE CONSTRUCTION COSTS, INDEPENDENT OF DESIGN AND CONSTRUCTION OPERATIONS. FOCUSED REVIEWS, TESTS OF SYSTEMS, FOCUS ON INTERACTION BETWEEN INSTALLATIONS, PLANNING AND CONTROL OF TRAINING, O&M AND DOCUMENTATION, FACILITATING OPEN COMMUNICATION AND DIALOGUE BETWEEN ALL PARTIES.
• COMMISSIONING IS NOT:

STARTUP OF TECHNICAL INSTALLATIONS
APHASE IN THE TIMETABLE
JUST "TESTING IN THE END"
SOLVING DESIGNERS OR CONTRACTORS TECHNICAL PROBLEMS
A QUICK FIX
A POLICE TASK
COMMISSIONING FORCES ALL THE NECESSARY CROSS-DISCIPLINARY CHECKS BEFORE OCCUPANCY

BEFORE WE CAN DO THAT, EACH INDIVIDUAL DELIVERY INCLUDED IN THE CROSS-DISCIPLINARY TESTS OR IN TECHNICAL MONITORING MUST BE FINISHED, DOCUMENTED AND QUALITY ASSURED
PLANNING OF COMING CX-ACTIVITIES

The Cx plan must be updated with activities that occur after-handover.

Highlights:

- Deferred tests
- Seasonal tests
- Review after one year, what should it contain?
- Requirements for maintenance of all documentation
- Ongoing Commissioning Activities
- Monitoring-based Commissioning activities
There should be a plan for Monitoring-based Commissioning, MBCx. Contents, example:

- The building's requirements for monitoring points (and expected optimizations)
- Describe the analysis procedure (limit values, algorithms, etc.) and tools
- Necessary ongoing maintenance to ensure valid data
- Expected actions associated with analysis results
- MBCx operator training
- Requirements for monitoring equipment accuracy
- Evaluation and refresh rate
- Support for process startup, participation in analysis, help with Cx log, update of Systems manual
Why should Cx start early?
Why should Cx start early?

Possibility of impact on the project

Pre-design ➔ Design ➔ Construction ➔ Operations
Why should Cx start early?

- Pre-design
- Design
- Construction
- Operations

Cost of impact on project

Possibility of impact on the project
REMEMBER: GOOD SKILLS ARE NECESSARY TO EVALUATE THE RESULTS!
Who defines Commissioning?
#Commissioned

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