Chiller Plant Commissioning

Joseph Lorino, PE, LEED AP
Senior Partner
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Introduction

Presentation:

• Applicable to the commissioning of new chiller plant installations or expansions

• Concentrate on key Cx elements to address and CA responsibilities during:
  • Pre-Design Phase
  • Design Phase
  • Construction Phase
  • Occupancy & Operations Phase
Introduction

• Encourages the need for a “team effort” throughout the project
• Includes Owner, Design Professionals, Contractors, Manufactures, etc.
• **NOT** a step-by-step procedure on how to Cx a chiller plant!
Long Term Issues

Failure to introduce Cx early in the project may lead to:

• Low plant efficiencies
• Higher than anticipated construction costs
• Higher long term operating & maintenance costs
• Excessive plant downtime
• Low availability factors
• Increased crisis repairs
• Untrained plant personnel
• End user complaints!
Commissioning Process:

• A quality focused process for enhancing the delivery of a project.

• Process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated & maintained to meet the Owner’s Project Requirements (OPR).
OPR

- **Written document that details the functional requirements of a project and the expectations on how it will be used & operated**
- **Includes project goals, measurable performance criteria, cost considerations, benchmarks, success criteria & supporting information.**

*Considered the most important document in Cx process!*
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**OPR**

*Should include amongst others:*

- Owner directives
- Restrictions
- User requirements
- Occupancy requirements & schedules
- Training requirements
- O&M criteria
- Equipment maintainability expectations
- Energy efficiency goals
- Adaptability to future expansion
- Existing systems integration
- Accessibility requirements
OPR

- CA’s responsibility to facilitate the development & documentation of the OPR.
- Work closely with project team to develop
- Must be updated throughout the project
- Should be echoing in the back of team member’s minds!
Pre-Design Phase

• Ideal time to select & introduce Commissioning Authority (CA) to project
• Allows project team to familiar with Cx process
• Otherwise, CA may be viewed as “outsider”
• CA plays advisory role in conceptual process
• Issues identified early before affecting later stages
CHW User Needs

• Chiller plant designed to meet various occupants and building needs
• Must be clearly defined in OPR!
• CA should assist project team to ensure plant performance meets user requirements
• Leads to Basis of Design
• Otherwise does not make sense to build it in the first place!
Pre-Design Data

• Cooling coil performance characteristics
  • Plant must be designed to meet these requirements
  • High efficiency DELTA T plant must be capable of properly supplying these coils
  • May require lower CHW supply temperatures, flow balancing or coil replacement

• Historical CHW load profile
  • Peak days
  • Used to properly size chillers
  • Load variations may lead to different chiller capacities
  • Higher efficiencies above 50% load
Pre-Design Data

• CHW end user schedule, pressure, temperature, etc.
  • Process vs. comfort loads
  • Water-side free cooling options?
  • Drastic load drops may require pony chiller

• Future CHW system growth
  • Plant size & related piping
  • Rigging paths, future valves & connections
  • Future equipment locations, spare electrical connections, etc.
Pre-Design Data

• Parallel vs. Series configurations
  • Affects plant layout

• CHW load reduction analysis considered
  • Leads to smaller equipment, lower costs!

• Chiller prime mover options may be limited
  • Steam, electric, diesel or gas engine, etc.
  • Utility availability
  • Elimination leads to a simpler LCA
  • Allowable emissions levels
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Pre-Design Data

• Redundancy requirements (OPR)
• Cooling tower capacity if lower ECWT is being considered to increase efficiency
• Plant efficiency goals
  • Full load efficiency, IPLV, etc.
• Feasibility of water-side free cooling
  • Central plant PFHX or local air cooled unit?
Pre-Design Data

• Hybrid plant for peak load shaving
• O&M staff training
  • Sophisticated equipment may require detailed training
  • May also require costly outside service for future maintenance for items such as engines, turbines, VSD’s, etc.
Design Phase

CA responsibilities:
• Attend design meetings
• Formally review & comment on various stages of design
• Update OPR
• Develop & update Cx Plan
• Include Cx requirements in CD’s
• Define training requirements
• Integrate Cx in project schedule
• Begin developing test procedure
Design Phase

• Assist in chiller selection based on load profile
• Advise on plant layout. Ensure adequate space for:
  • Routine maintenance
  • Tube cleaning
  • Re-tubing condenser & evaporator bundles
  • Rigging of motors, compressors, turbines, etc.
  • Proper heat rejection
  • Future equipment
Design Phase

• Review & verify pump manufacturer curves. Ensure pumps operate at point of peak efficiency

• Premium efficiency motors chosen

• Ensure redundancy requirements are met for maintenance & repair
Design Phase

- Cooling tower (CT) wet bulb conditions prevalent to plant area must be understood & utilized
- Most important when lowering ECWT to increase chiller efficiency
- Under sizing CT results in reduced chiller capacity & lowered efficiency
Design Phase

• CHW temperature reset must be coordinated with BMS. May lead to higher energy consumption
• Suggestion of temporary bypass across chiller sections to protect tubes during chemical cleaning & flushing
• Installation of metering devices to future monitoring of plant performance
• Review of valve amount & locations for proper operation
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Design Phase

• Variable flow primary CHW systems require a bypass to maintain minimum flow
• Sequence of operation review conforms with OPR
• Factory test requirements
  • Chiller – ARI Standard 550/590-98
  • Pumps – Hydraulic Institute ANSI/HI 1.6
  • Cooling Tower – CTI Manual
Design Phase

Plant training requirements must be clearly conveyed in CD’s. Include:

- Classroom location
- Instructor qualifications
- Classroom time vs. field time
- Number of sessions
- Multiple shifts
- Length of each session
- Training syllabus
- Handout requirements

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Construction Phase

CA responsibilities:

• Installation, field inspections & testing meet OPR
• Review submittals for adherence to OPR
• Perform field observation inspections
• Develop & witness equipment factory testing
• Develop commissioning checklists
• Develop test procedures
• Witness testing
• Identify & track issues
• Develop Systems Manual
• Verify O&M training

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Construction Phase

• Compare field installations to shop drawing for additional bends and fittings. May affect pump performance
• Compare pump submittals to design schedules
• Variable flow pumps should include curves at different speeds
• Chiller submittals should include specified performance data
• Review valve installations for operations
• Valves 7 FT AFF should include chain operators
Construction Phase

- Minimum CHW flows through evaporator must be tested and noted. VSD’s output must not go below this value.
- Evaporator flow switch must be set & tested to trip chiller below minimum flow.
- Proper duty balancing valves should be installed.
Construction Phase

• Chemical cleaning and flushing should occur after hydrostatic testing. Corrosion inhibitor immediately afterwards

• Proper floor drain installation
  • Tube cleaning or “punching” areas
  • Pump seal drains
  • Chemical shot feeder tanks
  • Steam turbine blow down drains
Tube Cleaning

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Construction Phase

• Pump performance testing: individual & parallel scenarios
• Chiller performance testing off-season does not constitute acceptance
• Ensure future equipment spaces are kept clear
• Functional testing of equipment should progress from individual components to overall system
• Chiller head removal systems should be considered
Case Study

- 7,500 ton Chiller Plant in NYC
- 4 Chiller of various capacities
- 4 PCHWP
- 4 CWP
- 3 SCHWP
- 8 Cooling Tower Cells
- 1 Water-side free cooling PFHX
- 2 Secondary PFHX
Issues

• CA was contracted late in the game
  • No design review
  • No installation inspections

• Chiller barrels high DELTA P
  • Tube sheets covered with chip scale
  • Did not bypass during cleaning & flushing

• 3 Primary CHW & CW pumps running for 1 chiller
  • Flow not balanced
  • DPT not field calibrated

• 3 SCHWP running
  • DPT not field calibrated

• CWP cavitating
  • $\text{NPSH}_A < \text{NPSH}_R$

• PFHX’s & Cooling Towers not balanced
Actions

- Clean chiller barrels
- Balance flow through chillers
- Calibrate all field DPT
- Balance flow through PFHX’s & CT’s
- Reduced CW pump speed, raised CT level
Results

• Less pumps operating
• Higher chiller efficiency
• Less tower fans operating
• Extended free-cooling season

• ANNUAL SAVINGS:

$150,000
Occupy & Operations Phase

CA responsibilities include:

- Facilitating warranty period
- Coordinating contractor callbacks
- Continue personnel training
- Verify systems meet OPR
- Conduct periodic performance evaluations
- Complete Systems Manual
- Complete Final Cx Report
Occupancy & Operations Phase

• Utilize plant kW meters or BMS to evaluate plant performance during partial & peak load conditions

• Seasonal water-side free cooling testing & training

• Warranty items tabulated & facilitated by CA
Final Commissioning Report

- Final OPR
- Plant Basis of Design
- Plant systems & narratives
- Design review comments
- Submittal review comments
- Final sequence of operations
- Cx Process & Plan
- Completed Cx checklist
- Test Data
Final Commissioning Report

- Training materials
- Systems Manual
- Meeting minutes
- Warranty review information
- Issues or deficiency log

Environmentally Conscience Method

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Conclusion

- Chiller, Cooling Tower & Pump Commissioning Checklists
- Draft Chiller Plant Acceptance Procedure

Available on NCBC 2008 Proceedings
Chiller Plant Commissioning

Joseph Lorino, PE, LEED AP
Senior Partner
30 Broad Street, 15th Floor
New York, NY 10004
212.400.3700
jlorino@horizon-engineering.com

www.horizon-engineering.com