THE NATIONAL CONFERENCE ON BUILDING COMMISSIONING

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Commissioning Control Systems: When Good Isn't Good Enough

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What You Will Learn

ATC

DDC

EMS

FMS

BAS

BMS

BMCS

- BMS as Brains
- Focus on Planning and Design Phase
- Dedicated, Redundant Managers
- Broadcast Commands and Real Time Processing
- All Vendors are not "Or Equal"
- The Value of Factory Testing, Vendor Interviews and Bid Leveling

BMS as Brains

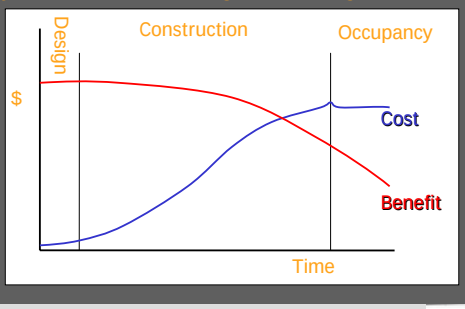
- Like people, some buildings are much smarter than others
- Building control systems are becoming more complicated
- Design professionals are not familiar with or comfortable with the details of control system design
- Will the facility realize the full benefit of the investment in mechanical infrastructure?
- How can the CxA assure the Owner gets as smart a building as he is willing to pay for?

Focus on Planning and Design

- "A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are **planned, designed**, installed, tested, operated, and maintained to meet the Owner's Project Requirements."

ASHRAE Guideline 0-2005
The Commissioning Process

Why Focus on Planning and Design?



What Happens if We Wait Until Testing to Find the BIG Problems?

- Contractors get big extras to change it
- Owner learns to live with it
- Occupants and Operators suffer
- In a Critical Facility Big $$ can be at stake

–A loss of load in a critical facility often results in an immediate reduction in staff by at least one!

Owner's Project Requirements and Basis of Design

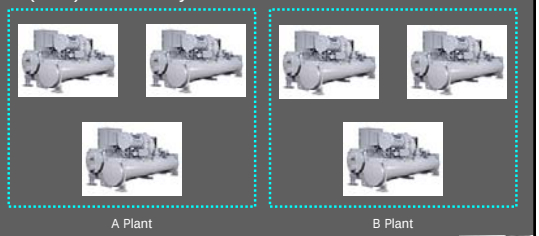
- Make sure the control system is addressed as a stand alone item in both documents
- Controls narrative should include a description of the system architecture
- A controls architecture drawing would be best
- Define control system specific requirements for reliability, availability, maintainability and fault tolerance

OPR and BoD

- For critical facilities, address as appropriate:
  - Uninterrupted cooling
  - Continuous positive building pressurization
  - High altitude electromagnetic pulse (HEMP) survival
  - Other facility specific functions as they relate to controls

Dedicated, Redundant Managers

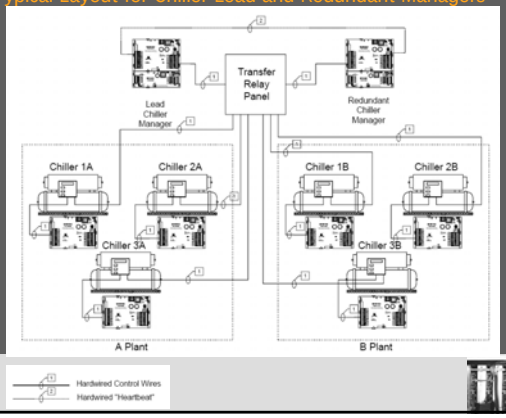
- Chiller Plant Example—Tier 4 Data Center
- 2(N+1) redundancy



Dedicated, Redundant Managers

- Control system redundancy must match mechanical plant redundancy
- Each chiller has it's own local controller—failure of a controller is equivalent to failure of a chiller
- System level control is accomplished by a Lead Manager
- All chillers are controlled by a Lead Chiller Manager

Typical Layout for Chiller Lead and Redundant Managers

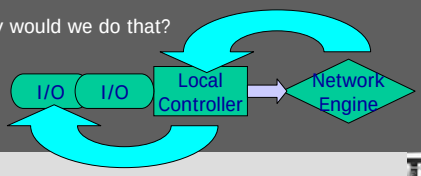


Dedicated, Redundant Managers

- The Lead Chiller Manager is connected to the Redundant Chiller Manager, thru a transfer relay panel in this example
- Programming is mirrored between the two Managers
- Redundant Manager is always on line for an instantaneous changeover on loss of the Lead Manager
- The two Managers are also connected by a hardwired heartbeat signal

Broadcast Commands and Real-Time Processing

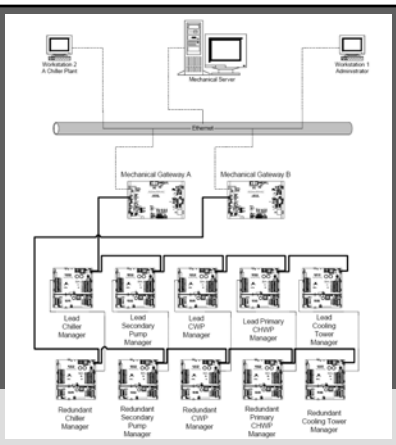
- Where are command decisions made?
- How do they translate back to equipment and actuators?
- Does broadcasting commands over a network create problems?
- Why would we do that?



Low End Processors

- Number of points is limited
- Processing capability is low
- Data can be corrupted if too much processing is attempted
- Partition data onto different gateways and sub networks to reduce traffic on communication buses
- Call for a distributed network architecture drawing in the BoD and CDs to reduce vendor wiggle room

Redundant Chiller Plant Manager Architecture



Consequences of Low End Processors

- The example is maintaining a positive pressure in a hardened facility
- Lead pressurization fan is running and then fails
- Loss of the fan is sensed and sent up the line
- Data is processed and a command is sent down the line to start the Lag fan
- All this time the exhaust fans have been running and the building has been under a negative pressure
- It could be 5 minutes before positive pressure is restored

Consequences of Low End Processors

- Now replace the low end controller with a high end processor with an integrated I/O module
- This processor can handle a high density of physical points
- Time for negative pressure can be reduced to less than one minute
- What if this is still not good enough?

Consequences of Low End Processors

- Now add a Fan Manager to control all the pressurization and exhaust fans together based on building pressure
- Sensors indicate a drop in pressure due to loss of a running pressurization fan
- The Manager reduces the speed of all the exhaust fans (or stops the fans) thru hard-wired connections
- The Lag pressurization fan comes up to speed
- The building remained positively pressurized throughout the event

Preventing the Mechanical Design from Failing When the Controls Vendor is Holding us Hostage

- The Mechanical
  robust and relia
- The speci
  finest in t
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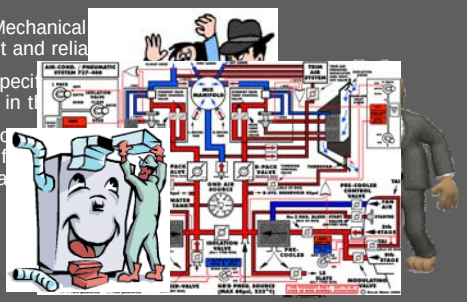

Controls Vendor Comparison

- Controller Comparison Category
  - Communication Protocol
  - Communication Speed
  - Controller RAM
  - Data Samples
  - Point Capacity
  - Input Resolution
  - Module Processor Resolution

Communication Protocol

Vendor S	Vendor J	A1	A2	H
Proprietary ('P2') to primary 'Building Level Network (BLN)' @ 9.6 to 115.2 kbps (peer-to-peer) (3) - Proprietary ('P1') to secondary 'Floor Level Network (FLN)' @ 4.8 kbps (polling) (1) Ethernet Port - 1 Ethernet port for direct BLN communication over Ethernet TCP/IP, at 10/100 BaseT.	"J" N2 over twisted copper	BACnet	BACnet 135-2001b	RS485

Communication Speed

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Proprietary ('P2') to primary 'Building Level Network (BLN)' @ 9.6 to 115.2 kbps (peer-to-peer) (3) - Proprietary ('P1') to secondary 'Floor Level Network (FLN)' @ 4.8 kbps (polling) (1) Ethernet Port - 1 Ethernet port for direct BLN communication over Ethernet TCP/IP, at 10/100 BaseT.	9.6 kbps	156kbps – 2.5Mbps using BACnet over Arcnet Ethernet port for direct communication over Ethernet TCP/IP, at 10/100 BaseT.	Ethernet 10/100Mbps MSTP Trunk – configurable 9.6Kbps - 76.8Kbps EXP(expansion) Trunk – 76.8kbps	9.6kbps, 19.2kbps, 38.4kbps, 76.8kbps

Controller RAM

Vendor S	Vendor J	A1	A2	H
72 MB	32 K	16M RAM 8M RAM Flash	2K EEPROM provides non-volatile, power-independent configuration data storage. 2 MB static RAM provides reliable storage for critical data. 16MB dynamic RAM for program execution. 2 MB flash RAM for nonvolatile program storages.	256 K

Data Samples

Vendor S	Vendor J	A1	A2	H
Trend storage is limited to available RAM	720	1,865,232 stored samples per field controller at 1 min increments. This is a conservative calculation.	200 trend logs	At least 1/Sec

Points Capacity

Vendor S	Vendor J	A1	A2	H
Approx. 300 physical Virtual points limited to available RAM	64 hardwired points	192 points per card for hardwired points. 1000 points per Protocol Translation for soft or virtual points.	Up to 176 total I/O	768 theoretical, 128 of each of 6 types

Input Resolution

Vendor S	Vendor J	A1	A2	H
A/D 12-bit D/A 10-bit	13-bit	14-bit with 40 times scan rate per second.	12-bit inputs	11-bit plus one for sign

Module Processor Resolution

Vendor S	Vendor J	A1	A2	H
Motorola MPC 862T, 48 MHz	NEC 78C10	Motorola PowerPC for execution and separate processor for communications	High-integration Motorola CPU	Toshiba TMP93CS41F
	8-bit	32-bit	32-bit	16-bit

Controls Vendors—What Else Can We Do?

- Specify Factory Simulations (Off-Line Testing)
- This testing requires the vendor to test the software (programming) for in the factory, before it is installed on site
- This forces the vendor to **complete** the programming long before the site is ready for live testing
- Demonstration should address a cross-section of equipment (one AHU, one chiller, etc. in detail plus systems)
- May require test setup with lights, potentiometers, etc.
- This requirement reduces the desire of the CxA to kill the programmer

Controls Vendors—What Else Can We Do?

- Vendor Interviews
  - Not just hardware and software
  - Make sure they agree to meet the approach specified and schedule
  - F2F—3 per day with proper preparation
- Bid Leveling
  - Should be performed by the controls designer
  - Must be knowledgeable of each vendors systems and all the issues addressed in this presentation
  - Keep in mind—the lowest cost system is often the lowest functioning system

Controls Vendors—What Else Can We Do?

- Control Sequences
  - Make sure the sequences are appropriate for the facility
  - Test in normal and failure modes
- Value Engineering
  - OPR may call for a Cadillac, but the budget is for a Chevy
  - CM may see the control system as a golden opportunity to reduce cost and impress the owner with his VE skills
  - Particularly troublesome on GMP projects
  - Don't be defensive! Justify costs from project inception

What Have We Learned?

- During development of the OPR, push for clear statements about reliability, availability, maintainability and fault tolerance, specifically related to the control system.
- Assure there is a section in the BoD dedicated to controls.
- Push for a controls system architecture drawing to be included in the BoD.
- Understand the concepts of dedicated, redundant managers and the heartbeat and how to apply them.
- Understand how broadcast commands affect processing time and reliability.

What Have We Learned?

- Evaluate control system vendors equipment for processing power and the impact on performance and reliability.
- Have the designers include a line-by-line comparison of component and software performance for all vendors being considered as part of the BoD.
- Add a requirement for factory simulation (off-line demonstration) testing of the programming to the specifications.
- Verify control sequences in normal and failure modes are adequate to meet the OPR.

What Have We Learned?

- Have the project team include control system vendor interviews and bid leveling in the evaluation, don't just accept the vendor as the sub the mechanical contractor wants to stick you with.
- Make sure the owner understands the consequences of value engineering on the capability of the control system to meet the OPR.
- Review the controls vendor submittals with a focus on the issues raised herein.

Thank You

- Questions?
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