Commissioning the Data Center
The Integrated Systems Test

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Overview of the Integrated Systems Test (IST)
Testing protocols performed during the IST.
Trend logs to demonstrate results of testing protocols over multiple test days including
- Electrical/thermal load capacitance
- Equipment staging
- Simulated mechanical failures
- Electrical failure scenarios.

Case studies to illustrate the value of the IST
- Potential facility failures
- Catastrophic breakdown of the facility systems
Current 2012 Beyond

**GLENMOUNT GLOBAL SOLUTIONS LINE CARD**

**ENERGY, AUTOMATION & INDUSTRIAL INFORMATION SERVICES**

**CONSULTING, ENGINEERING**
- Industrial Information (Balanced IT)
- IT
- Cyber Security
- Professional Engineering
- L & T SCADA Services
- Plant Imaging
- FRP Development
- Engineering Studies

**Automation & Control**
- Process Control
- System Design
- System Integration
- System Engineering
- System Startup
- System Testing

**Maintenance & Support**
- Ongoing Services
- Start-Up Support
- System Maintenance
- Plant Operation
- Collaborative Work
- On-Site Support
- Training Services
- Asset Management
- Software Test, Support
- Plant Operation

**Program Management**
- Technical, Schedule, and Cost Estimato Management
- Budget and Cost Estimation
- P/R Revised Development

**ENERGY EXPERTISE**

- Program Development
- Effectiveness Benchmarking
- Procurement Analysis
- Technology Assessments
- Enterprise Energy Management
- Plant, Site EMS/AMR
- ADR/DR Systems
- Metering Systems

**ENERGY INTELLIGENCE, MANAGEMENT SYSTEMS**

- Central Plant Implementation
- Production/Process Improvement
- BOP, Utilities Optimization

**ENERGY EFFECTIVENESS SOLUTIONS**

- Measurement & Verification

**GLENMOUNT GLOBAL – ENERGY SOLUTIONS**

**Central Plant Implementation**
- Production/Process Improvement
- BOP, Utilities Optimization

**Measurement & Verification**

**Segment Specific Solutions**

**Technologist**
- Automation & Controls Specialist

**Expertise**
- Engineering, Procurement & Construction

**Offerings**
- Segment Specific Solutions
Critical Systems Testing

• Founded in 1998 the Company has established itself as one of the premier mission critical facilities testing companies.
• Conducted over 200 data center and high performance facility commissioning, retro-commissioning or energy projects
• Specialists in High Performance Building Controls
• Focused on assuring, maintaining and improving the reliability of critical facilities.
• Provider of NETA, NIST unbiased testing
• Provider of Energy efficiency services, consulting, commissioning and design and construction services
Commissioning Process for Data Centers

- Pre-Construction Activities
  - Design Reviews (drawings and specifications)
  - Prepare Commissioning Specifications
  - Submittal Reviews
- Provide quality assurance/ quality control
- Review contractor test procedures
- Verify functionality of systems and equipment
  - Loop checks/ point to point
  - Controls sequences
  - Modes of operation
  - Failure and safety modes
  - Alarm verification
- Trend control variables for stable operation
- Assist in solving problems and resolving issues
- Manage the Integrated Systems Test (IST)
Integrated Systems Testing Protocol

- Fully coordinated test over a 3-4 day period
- Mechanical and Electrical testing while under thermal load
- Mechanical systems operation under several modes of operation
  - Normal operations
  - Economizer mode
  - Thermal energy (TES) discharge mode
  - Validation of operations at N (design) and N + 1 (redundancy modes)
- Validation under normal power and during emergency power conditions
- Simulated equipment, system and critical device failures
- Trending multiple variables to validate process, energy and interactions
Heat Load Capacitance Test

- Validate thermal conditions of data center under design load
- Thermal and electrical capacitance test under multiple load steps
- Validate design conditions.
- Disable redundant equipment.
- Set design conditions
  - In data center set equipment to maintain SLA conditions
  - Design conditions in electrical spaces and central plant
- Validate multiple design related operating modes, examples
  - Set a fixed design condenser water setpoint
  - Set a reduced condenser water setpoint if reset is a basis of design and conditions permit
  - Validate operations under economizer mode of control
Central plant loading Heat Load Capacitance Test Results

- Validate basis of design
- Validate operational conditions at each load step
  - Temperature differential
  - Plant Flow
  - Plant Tonnage
- Validate staging of central plant
- Validate system ability to maintain functional processes
  - Bypass control
  - Individual chiller staging
• Over head air distribution system
• Damper torque issue
• Dampers manually forced open
• Design of air diffusers was improper
  o Improper diffuser placement
  o High Velocity
  o Low Static
• Diffusers were re-engineered
Under floor system control based on return air temperature

**Observations**
- Under floor air distribution system
- Control set-up resulted in oscillatory control of VFDs and valves
- Uneven control between adjacent CRAH units
- Oscillatory control of chilled water pumps, bypass valves and chiller surging

**Solutions**
- CRAH unit teaming
- Convert to discharge air temperature
Specialized Testing: Central Plant waterside economization verification under load

- Central plant with 2,000 ton design load
- Tested under load in three modes of operation
  - Full mechanical chillers
  - Partial free cooling
  - Full free cooling
- Chillers stage properly during transitions
- Colocation temperature remain stable
Specialized Testing: Facility Energy Impact of Economization Under Load

- 20,000 tons of refrigerant.
- 2,500 hp compressor power
- Air handler fan power, 770 hp
- Direct expansion AHUs
- Direct economization AHUs
- Test validated performance under
  - Full refrigerant cooling
  - Full economization
- Test validated load and PUE reductions
- Test validated load switch
Specialized Testing: Temperature distribution

- Basis of design:
  - 53°F chilled water temperature
  - 60°F discharge air temperature.
  - Maintain sensible cooling range.
  - Avoid latent cooling
  - Avoid humidification
- Data loggers placed at multiple locations along the air pathway
- Coincident relative humidity distribution
- Constant dewpoint temperature
- Validated sensible cooling process
Specialized Testing: Cold aisle test with simulated AHU failures

- Test to demonstrate load capacitance of a single cold aisle at varying load steps
  - 50% design
  - 80% design
  - 100% design
  - 120% design
- Test to demonstrate to alternate modes of operation
  - Wireless aisle sensors
  - AHU return air sensors
- Test to demonstrate capacity during air handler failures.
**Mechanical Failures**

- Validate pump failures and alarms through multiple means
- Validate chiller failures and alarms through multiple means
  - Fail chiller at local disconnect
  - Fail chillers at MCC disconnect
  - Fail chillers by disconnecting internal flow switch
  - Fail chillers by overriding isolation valve(s) closed
- Additional failure scenarios
  - Air handlers and CRAH units
  - Cooling towers
  - Process critical monitoring devices
    - Static pressure
    - Chilled water differential
    - Temperature
    - Flow
  - Panel/ network communications

**Electrical Failures**

- Full utility power failure, transfer to generator, “Pull the Plug”
- MSB Failures (Transfer and Retransfer)
Central plant control during electrical failures

- Simulated loss of utility power
- Retransfer of power from generator to utility
- Simulated failure of MSB panels and recovery
- Validate facility operations under UPS power
- Verify Colocation/ data center temperature and humidity conditions during all events
Englewood, CO Data Center Case Study

**Project Description**
- Data Center located in Englewood, Colorado
- Housing primary servers serving the internet auction functions
- Mechanical systems serving the data floor were comprised of 30 ton split DX Liebert computer room air conditioning (CRAC) units, with pad mounted condensing units in a secure yard.
- IST scenario highlights the critical need for Integrated Systems Testing utilizing load banks on the data floor to simulate a fully occupied and operational data center prior to occupancy.

**Issues & Solution**
- Functional tests and subsequent capacitance tests with load banks revealed that the refrigerant charges in the CRAC units were low.
- After additional refrigerant was added, the tested cooling capacity of the CRAC units was well below the engineers design.
- Limited the number of servers that this facility could host.
- During the simulated utility loss test under full electrical load, multiple CRAC unit failures were experienced.
  - Emergency power generators started, heat plumes onto the condensers
  - CRAC units failed on high head pressure.
Los Angeles Data Center Case Study

Project Description

• High profile data center, with over 75,000 square feet of conditioned data floor area.
• Shortly after completing the project in mid 2006, the Los Angeles metro area suffered a significant ‘brown-out’
• Multiple failures in many of the local data centers.
• Data Center with the IST performed flawlessly, with no interruption to services experienced.

Issues & Solution

• Functional testing revealed many critical flaws which could have caused this facility to fail had they not been identified and remediate.
• During the failure testing under load it was noted that the chillers would shut down in a cascading failure causing complete loss of cooling to the data floor.
• Building automation system was shutting the chillers off during the restart sequence after the simulated loss of utility power test.
Questions?

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