# Resolution of Low Delta T Issues at the Etihad Towers in Abu Dhabi

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# Intro and Due Credit

- Low delta T (high chilled water flow per ton) is a very big district cooling problem
- Most typical problems are related to building comfort, available capacity, and energy consumption
- FVB Energy was engaged after initial construction to help broadly resolve outstanding problems
- Sheikh Surror Projects Department (SSPD) agreed to allow this presentation to share knowledge with the industry about the challenges addressed during design, construction, and commissioning.

# Background and Issues

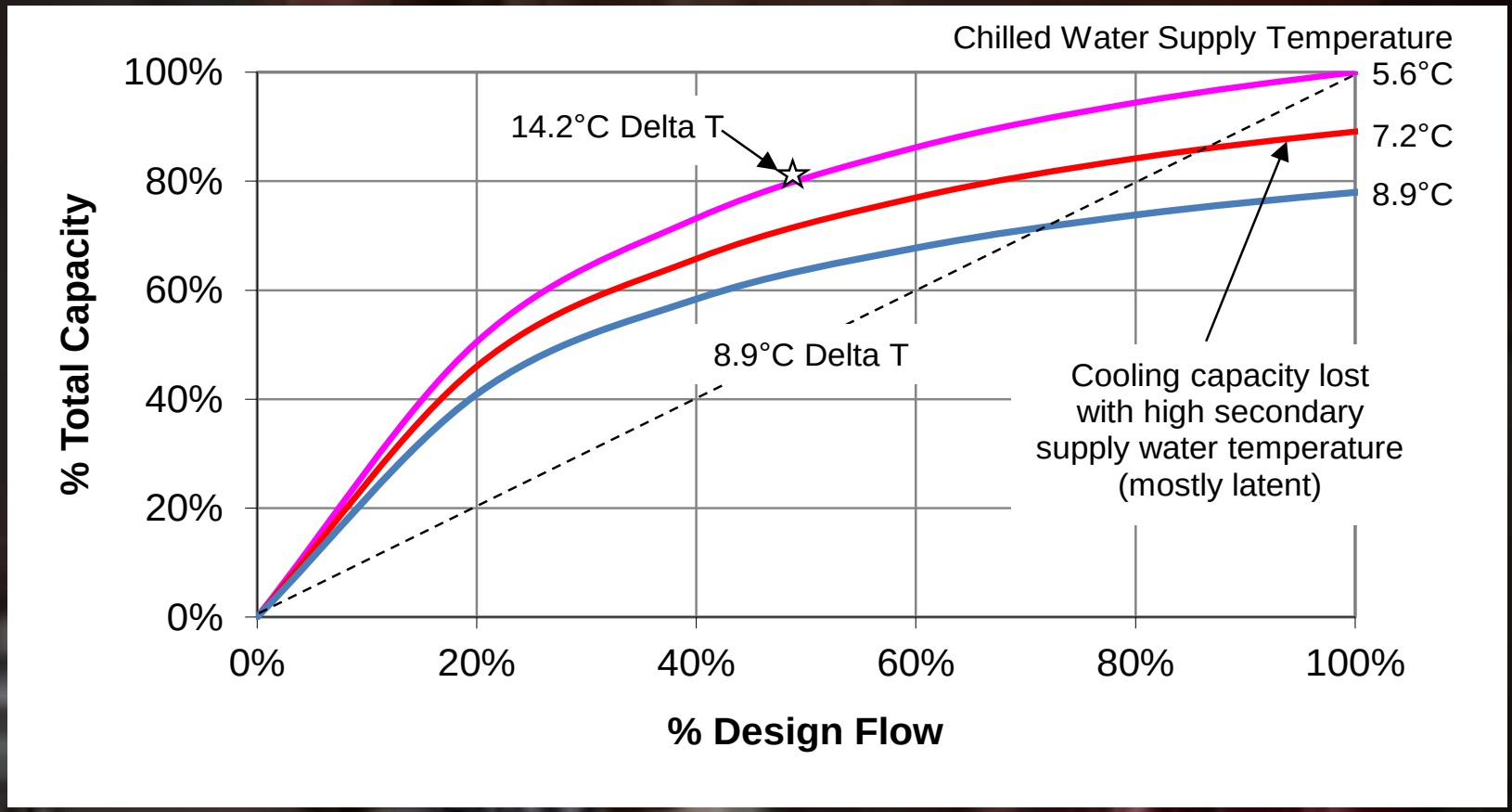
Etihad Towers is a high profile development in Abu Dhabi that contracted for chilled water service from Tabreed in 2010

- Developed by the private office of H.H. Sheikh Suroor Bin Mohd Al Nahyan
- 530,000 square meters mixed use development
- 5 iconic towers with the tallest tower at 300 meters
- World class residential, retail, hotel, office, restaurants
- 12,500 ton Tabreed Baynoona plant  chilled water customer

# High profile development comes with demanding expectations for comfort and humidity control

- Before project completion there were various issues to resolve related to chilled water distribution in the building integrated with service from Tabreed
  - Occasional occupant, guest, and staff comfort complaints
  - Hot zones, moisture, spaces to hot and humid to rent
  - Areas with negative pressurization and air infiltration
  - Warped doors, delaminated wallpaper, curling papers

# Rising building supply temperature reduces coil capacity, lowers delta T and increases the flow rate per ton cooling at terminal loads



# Low district return temperature can adversely affect the available plant capacity or chilled water service to other customers

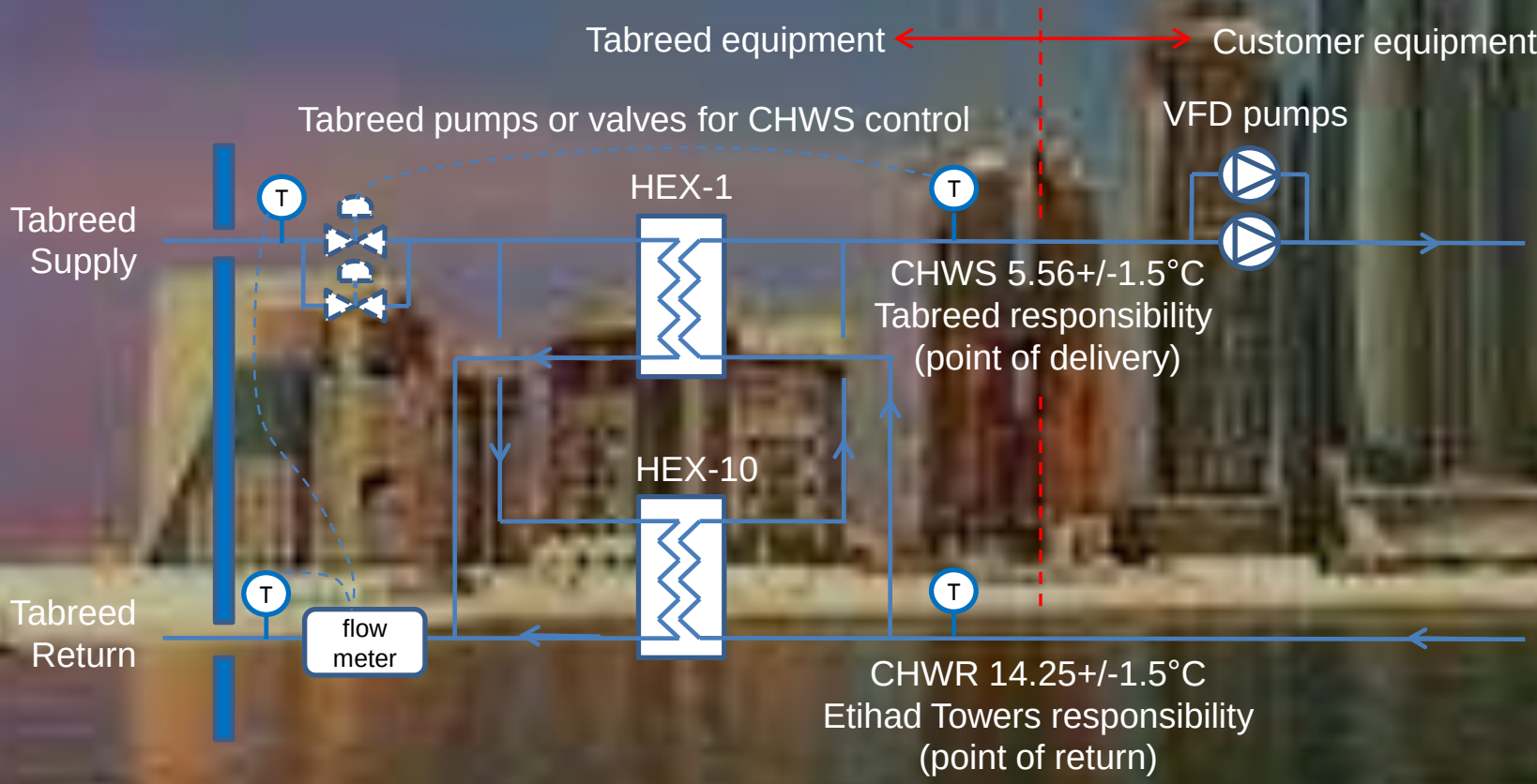
- Low delta T (high flow per ton) can create available capacity and energy issues for the district energy utility
  - Low delta T requires more chillers to run at part load, overflow or running chillers, or blending of return water with supply
  - Low delta T can limit available plant and distribution capacity and adversely affect the utilities ability to serve all customers.
  - Low delta T can create excessive differential pressure for customers near the district cooling plant

# Chiller plants require high return temperature to minimize running equipment, maximize efficiency, and maintain available capacity

With low delta T (high flow per ton) a chilled water plant must process the extra flow. There are only three choices, each with its own limits and issues:

1) Overflow running chillers
2) Turn on additional chillers to maintain chilled water supply temperature
3) Blend return with supply through bypass or non-operating chillers

# This means that the customer and district cooling utility must work together to achieve expected performance at the building interface




Etihad Towers 12,500 tons capacity with 10 HEX's plus space provisions and option for an additional 2,500 tons

# Project Approach

- Establish Project Objectives
- Define Measures of Technical Success
- Figure Out Who Pays to Correct Issues
- Evaluate Broad System Design and Operation
- Propose and Implement Changes
- Assess System Performance
- Address Remaining Issues

# Establish Project Objectives

1. A fundamental understanding of the root causes of comfort, capacity, and energy issues

2. A clear path toward correction of remaining problems to support long term operation and maintenance of the system

# Define Measures of Technical Success

1. 14.25°C ±1.5°C at the point of return
2. 5.56°C ±1.5°C at the point of delivery
3. Design CHWST above pressure break HEX's
   - or 1°C supply side approach
4. Automatic pump control at hydraulically remote point
5. Positive pressurization and control of outside air

# Hold Building Contractors Accountable

- Contractor pays cost of changes necessary to fix chilled water hydronic system design and installation issues to achieve higher return water temperature (at point of return)
  - Incomplete valve installations
  - Butterfly valves at heat exchanger pressure breaks
  - Sensors for pump control in the ETS room
  - Flushing bypasses at air handlers and HEXs
  - Two large bypasses in main header
  - No control of domestic chilled water
  - Inadequate pump control strategy
  - Entrained air

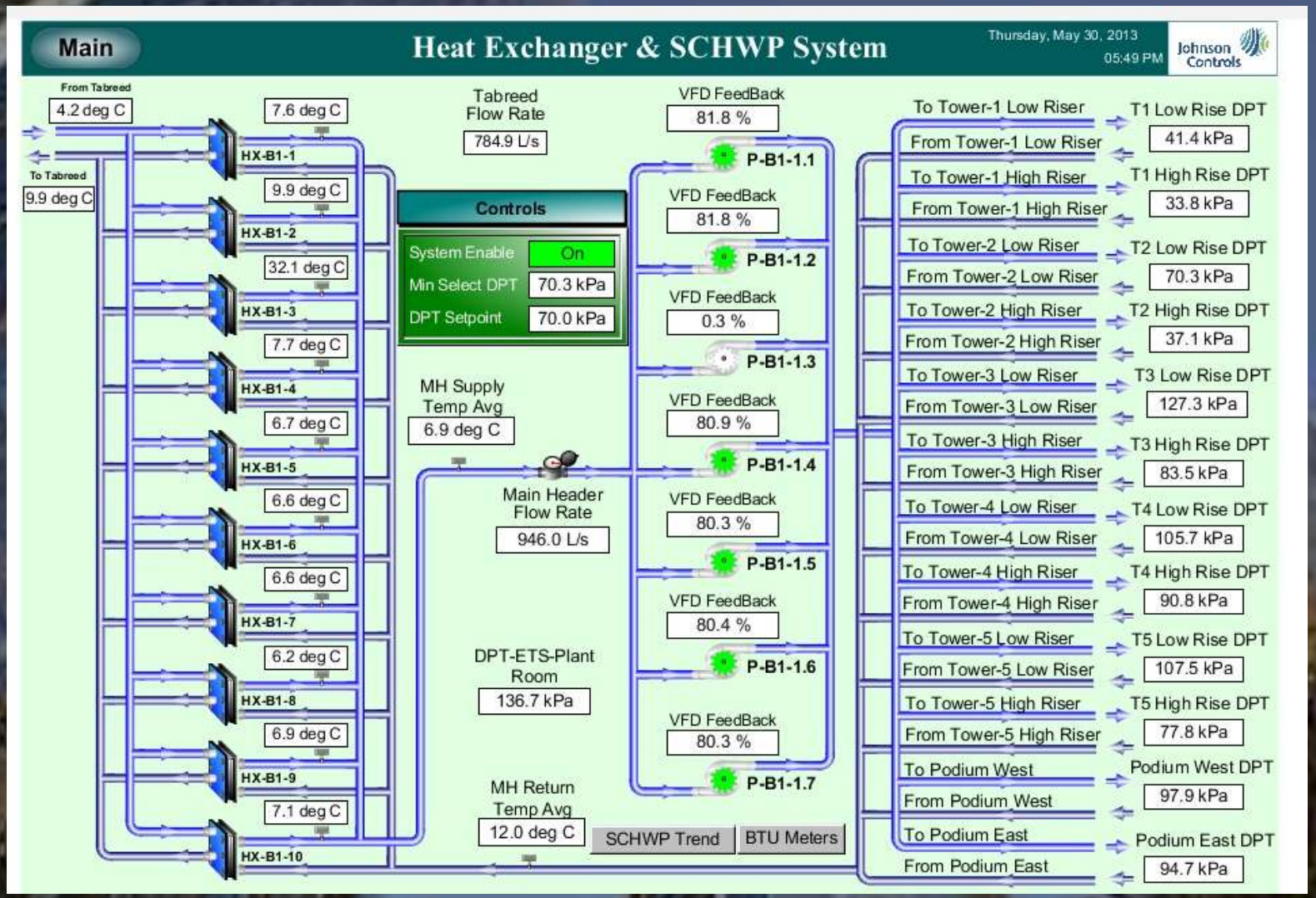
# Work with the District Cooling Utility to Address Service Issues

- Utility works to provide chilled water supply temperature (at point of delivery) and to support customer in their efforts to achieve high return temperature
  - Silt and debris in ETS heat exchangers at end of line
  - Single large strainer installed for 12,500 ton customer
  - Deviation in supply water temperature from HEX to HEX
  - Plant pump control not producing adequate customer chilled water supply temperature
  - Communication

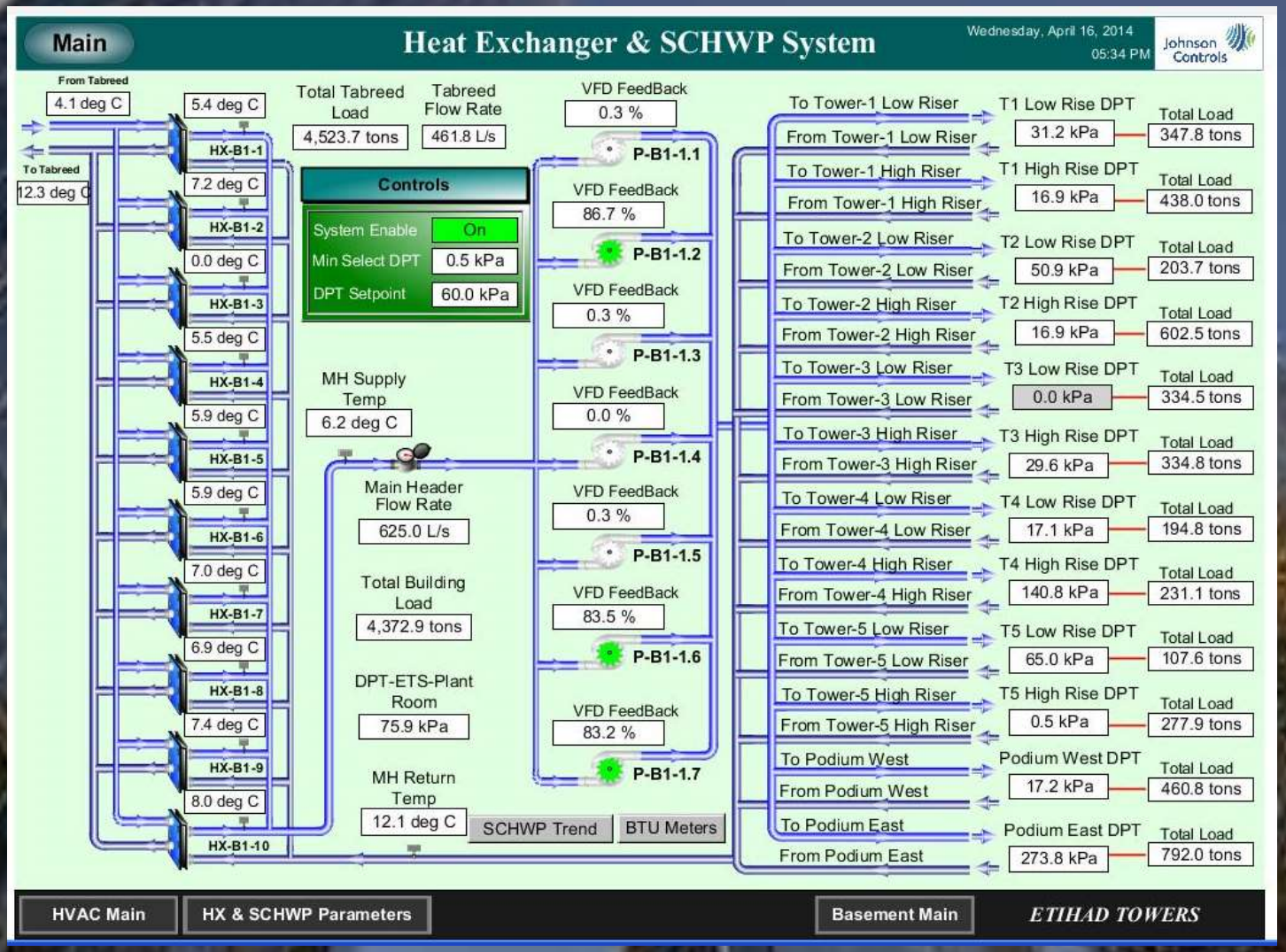
# Evaluate Broad System Design and Operation
(the following charts reflect current configuration)

- 12,500 ton Tabreed service
  - Indirect energy transfer station with ten plate and frame heat exchangers
  - Supply temperature control with Tabreed plant pumps and not control valves
- Pressure break heat exchangers in each tower
  - Two pressure breaks in the tallest tower
- Pressure independent control of terminal units
  - HEX's had no control or large butterfly valves

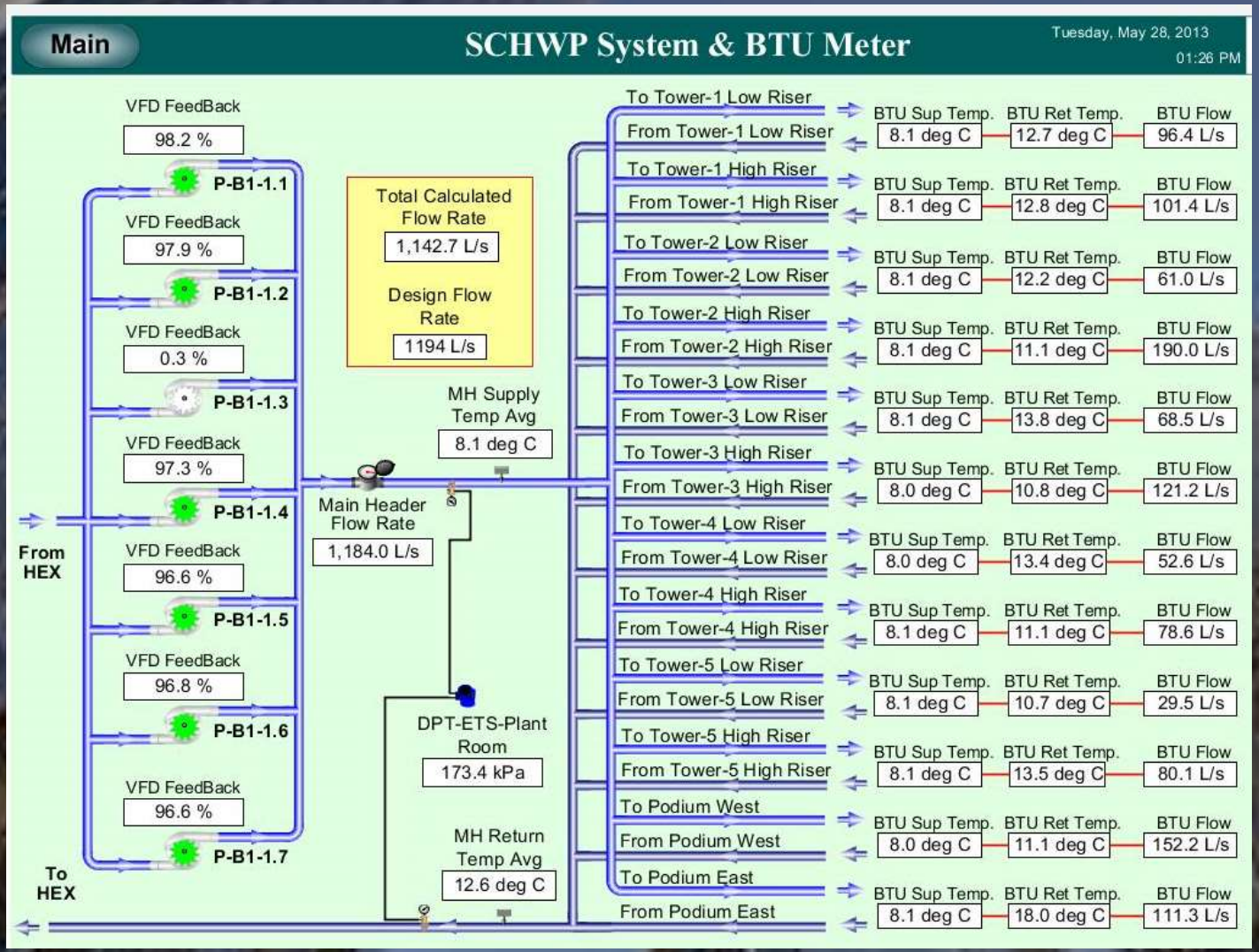
# Automatic Pump Control with Minimum Signal Select (minimum differential pressure at remote location)



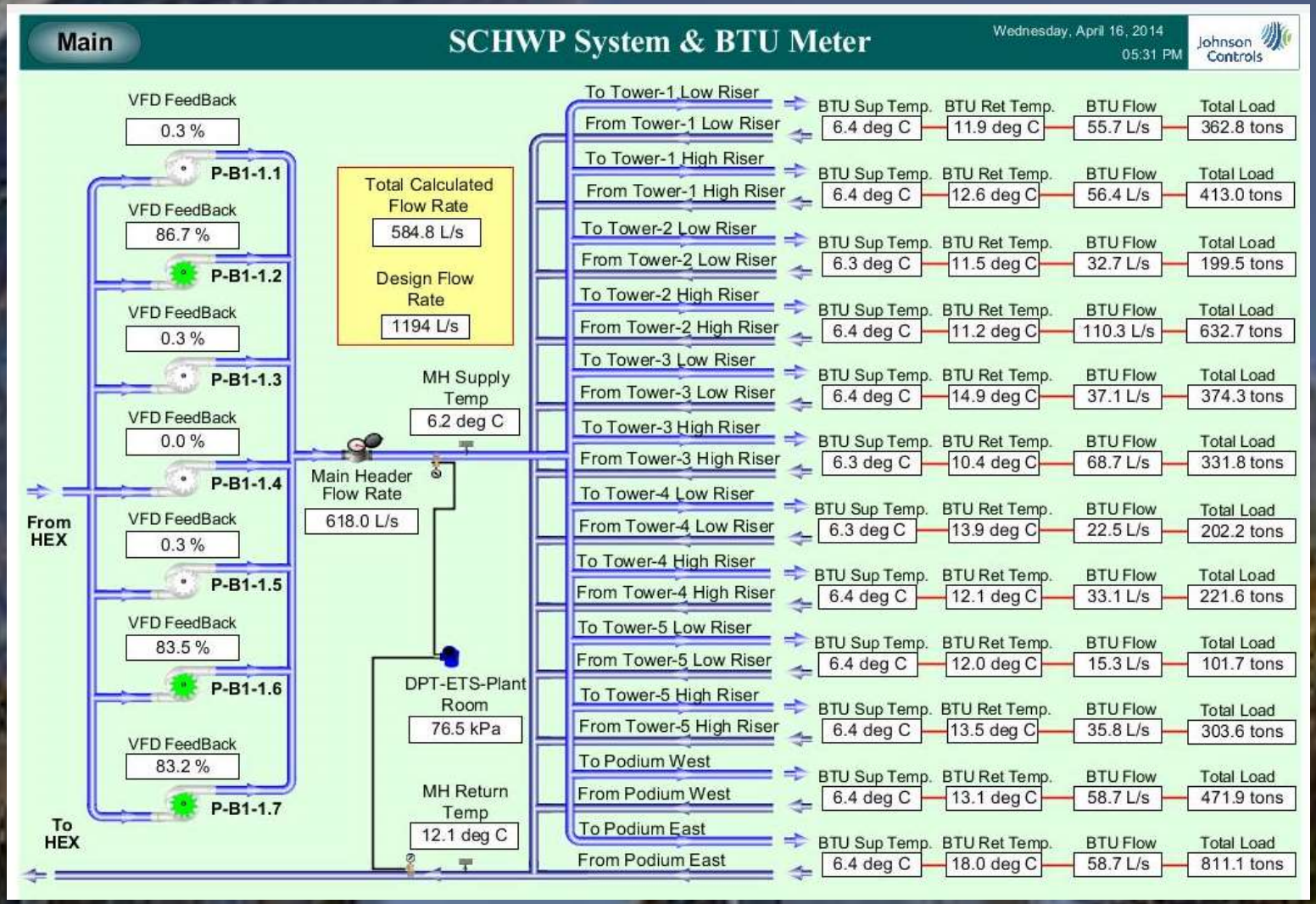
# Experiment with “Slowing Down the Pumps” (temporary manual control to try to raise return temperature)



# Performance Before Bypass Removal
# (high supply temperature and flow, low delta T)

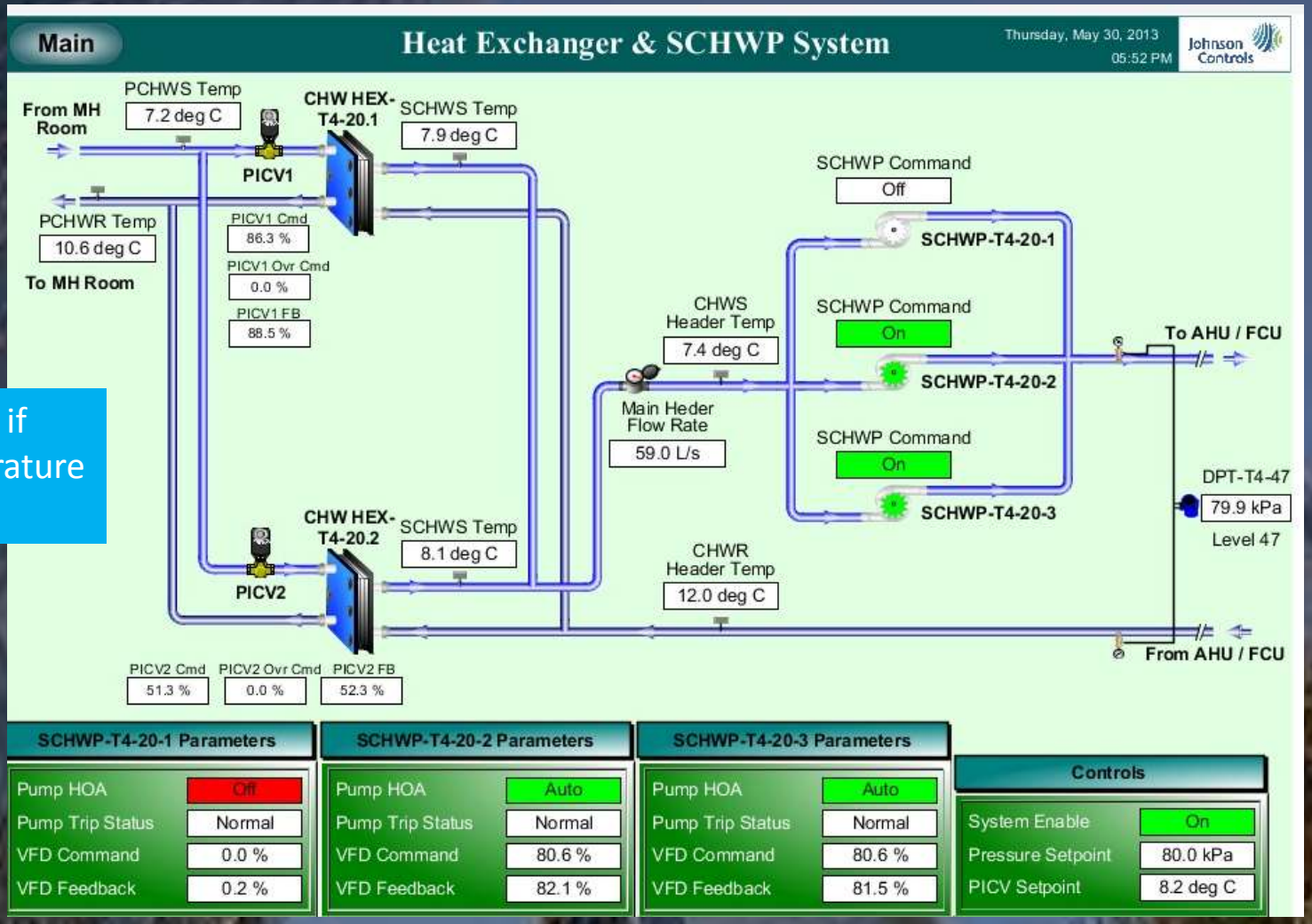


# Performance After Bypass Removal and Additional Changes (lower supply temperature and flow, higher delta T)

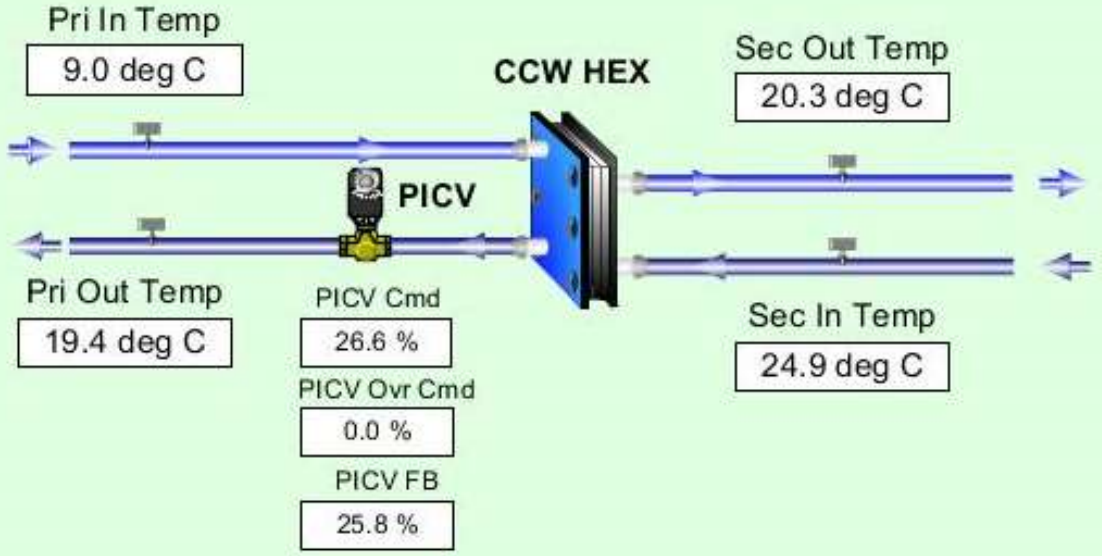


# Pressure Break Heat Exchangers in Each Tower (valves control supply water temperature above HEX)

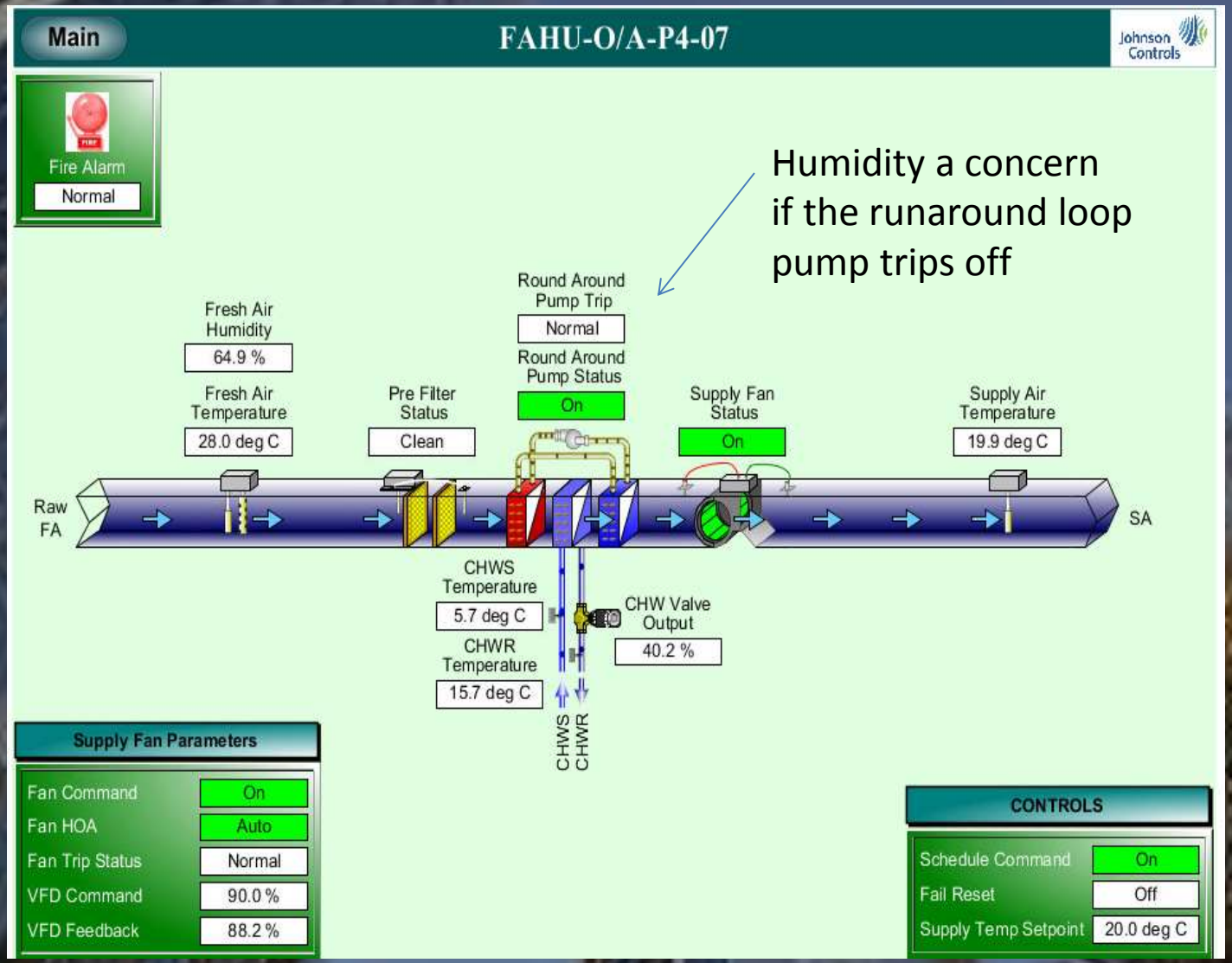
Virtual bypass if supply temperature rises



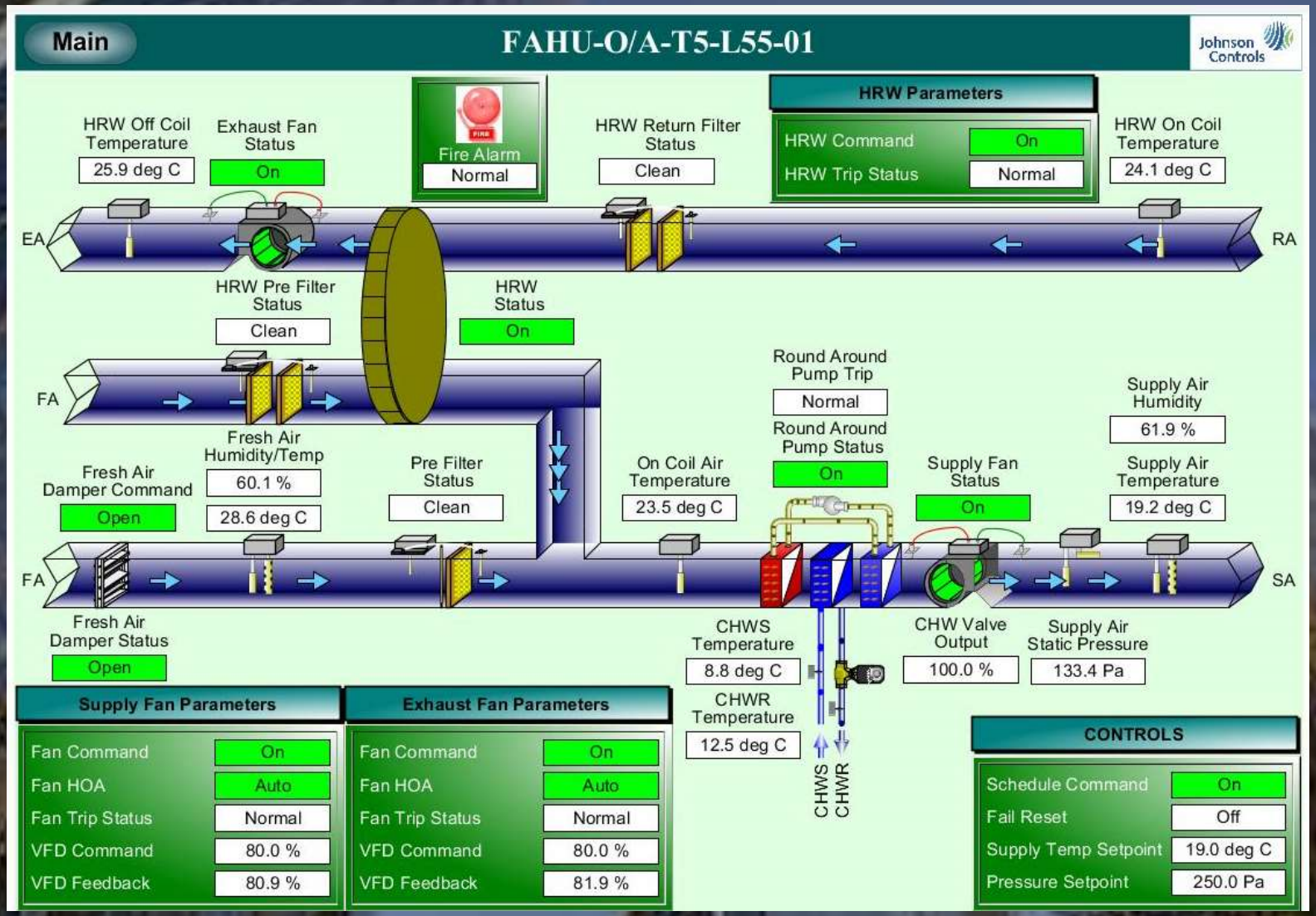
# Domestic Chilled Water
# (valve controls supply water temperature)



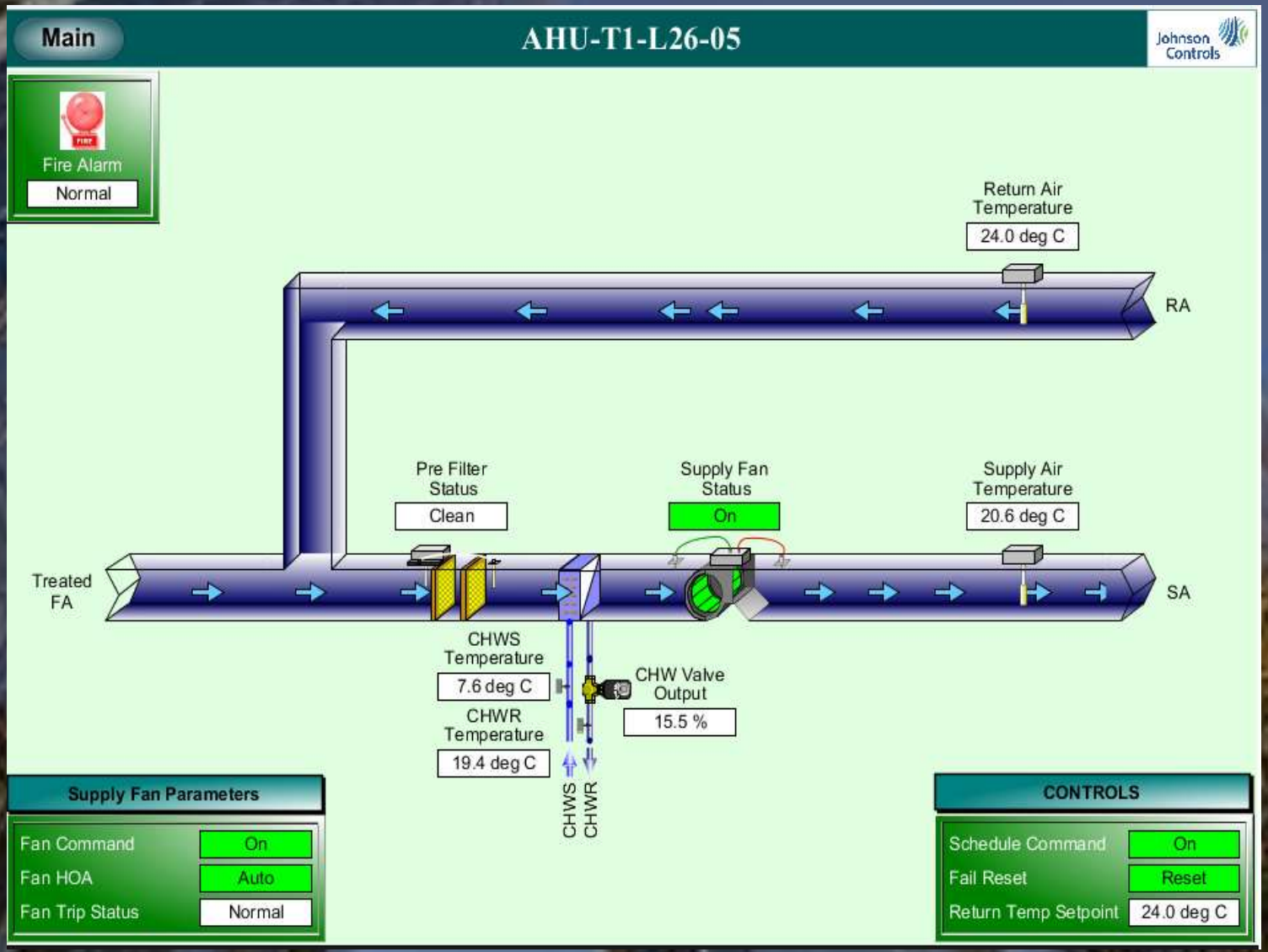

# Fresh Air Handler designed with Preheat and Reheat (valve controls supply air temperature)



# Heat Wheel Used to Pre-Cool Fresh Air (fans control static pressure in supply duct)



# Air Handler Used to Control Space Temperature (valves control space temperature)

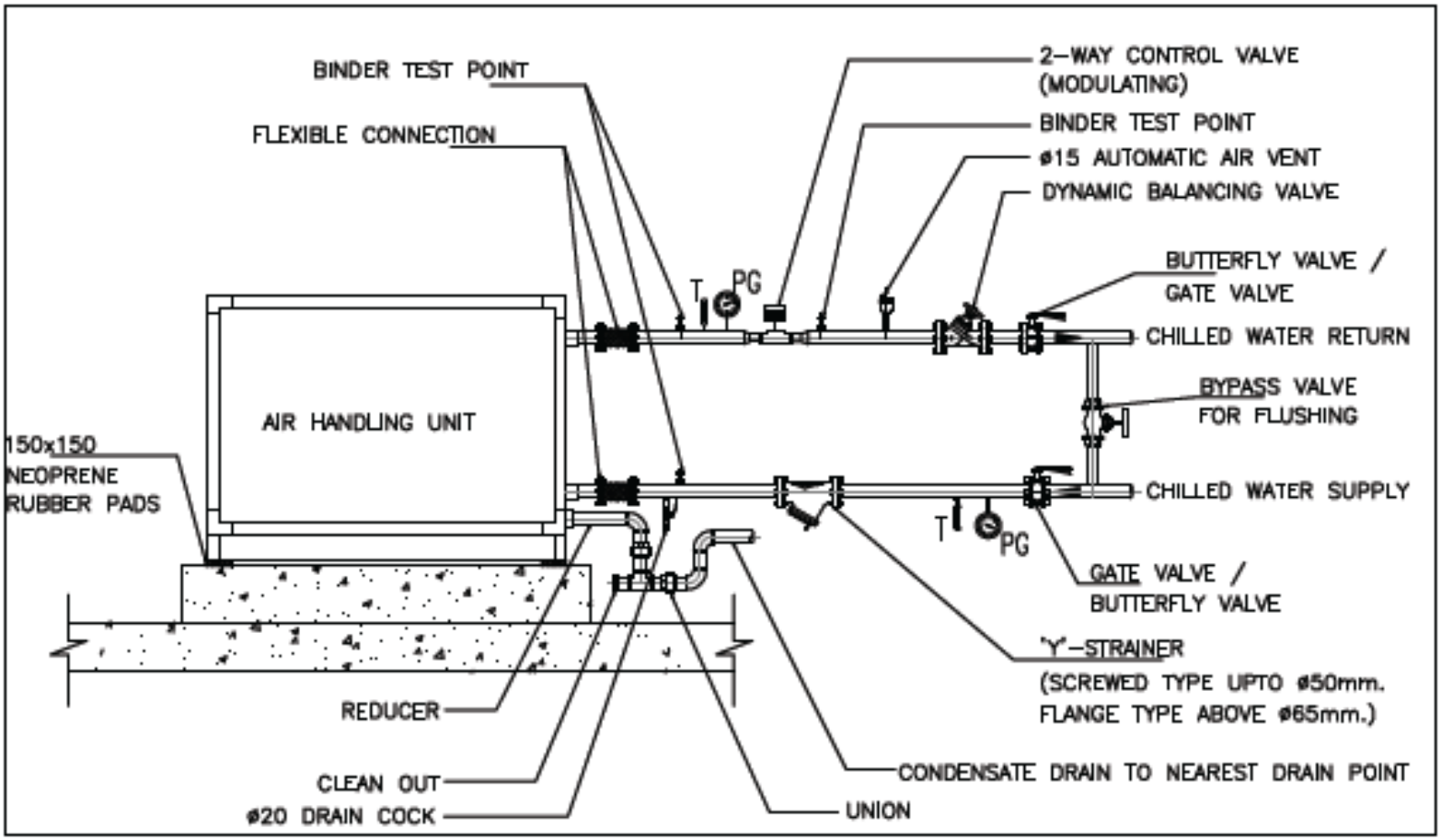


# Change Implemented (Customer)

- Complete valve installations
- Maintenance - clean HEXs, bleed air, fill CHW
- Revise building pump control (to remote DP)
- Remove bypasses in main header (that increase supply)
- Remove flushing bypasses (that decrease return)
- Install PICVs on pressure break heat exchangers
- Install PICVs on “wild” domestic chilled water HEXs
- Facilitate communication with utility
- Train staff

# Removed Bypasses in Header
# (that increase supply temperature)

# Removed Flushing Bypasses
# (that decrease return temperature)




TYPICAL COIL CONNECTION DETAIL FOR AHU
NOT TO SCALE

# Installed Pressure Independent Control on Pressure Break and Domestic Chilled Water Heat Exchangers

# Changes Implemented (District Cooling Utility)

- Backflushed energy transfer station heat exchangers
  - To reduce HEX to HEX supply temperature variations
- Changed flow control to produce customer side CHWST
  - To lower supply temperature
  - To address customer contract requirements
  - To help with troubleshooting of building issues
- Added instrumentation to enable better operational view
  - To facilitate customer and utility communication
- Increased resistance at customers close to plant
  - To enable more chilled water to flow to the Etihad Towers

# Performance Result

- Dramatic improvement in comfort and humidity control in the Etihad Towers
- Clear understanding of customer and utility requirements associated with temperatures on the building side of the energy transfer station
- Far less flow per ton required to maintain comfort conditions (higher delta T)

# Remaining Issues

- On-off actuators on fan coil units limit overall delta T performance
- Chilled water supply temperature instability on building side creates “virtual bypasses” above pressure break HEXs
- Too much variation in building side chilled water supply temperature from HEX to HEX
- Higher delta T performance required to enable district system growth

# Thank You

For More Information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