Enclosed Football Stadium Design History and Lessons Learned

Robert L. Towell, P.E., LEED AP, QCxP
btowell@cxegroup.com
CxE Group LLC
St. Louis, Missouri
314-436-6543

With thanks to the St. Louis Convention & Visitor's Commission and the St. Louis Regional Convention & Sports Complex Authority

Edward Jones Dome at America's Center

- Funded by combination of State, County and City
- Rams agreed to move to St. Louis in April of 1995
- Opened in Nov. of 1995, 6 months ahead of schedule
- Includes 1.7 million ft.^{2} floor area covering 4 city blocks
- 67, 000 spectators + 8,000 more for a floor event
- Added 146,000 ft.^{2} of exhibit floor to America's Center
- Interior of Dome volume is roughly 60,000,000 ft.^{3}
- Conventional roof with top 200 ft. above the floor
- Limited construction phase commissioning effort
- 1998 ASHRAE 1st Place Public Assembly/New

Building Overview

HVAC System Design Data

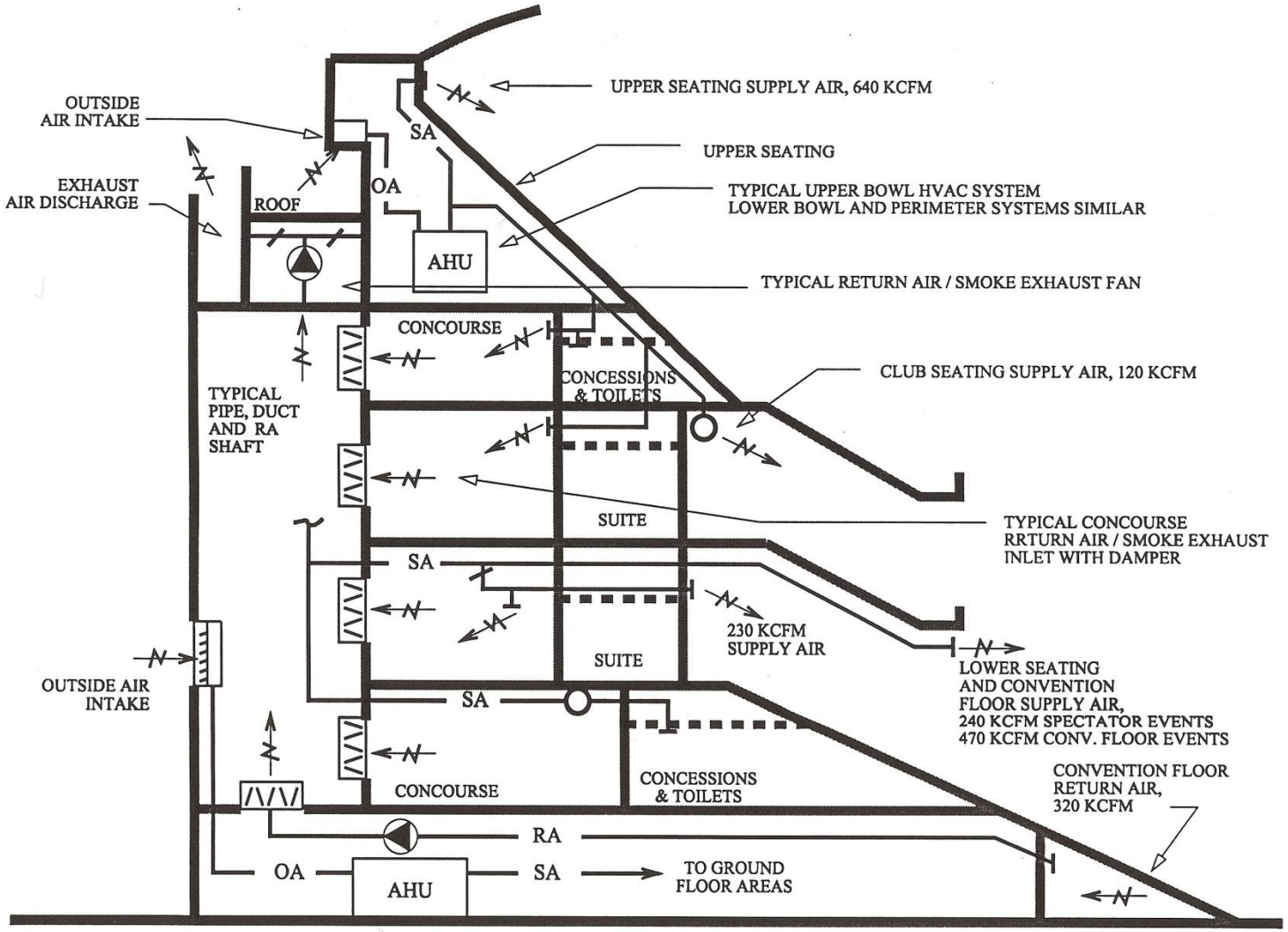
- 68 AHU's with 49,000 CFM maximum size
- Spectator area system airflow totals 2,078,000 CFM
- Ground Floor & Equipment Rooms total 274,000 CFM
- Total exhaust during events totals 374,000 CFM (15%)
- Ventilation based on 15 CFM outside air per person
- CO2 reset of outside air intake, 15% to 52%
- 1,000,000 CFM return/smoke exhaust from concourses
- 1,000,000 CFM relief/smoke exhaust at top of roof
- 100% outside air economizer cycle

HVAC System Breakdown

Upper Level & Club Seating	20 units	914,800 CFM
Lower Level Seating & Conv. Floor	12 units	572,000 CFM
Suite & Club Level Lounges	4 units	136,750 CFM
East & West Exposures	4 units	171,100 CFM
Corner Entries & South Ramps	6 units	217,810 CFM
Press & Broadcast Levels	2 units	20,400 CFM
Ground Floor Offices, Meeting Rooms, Support Areas	10 units	208,800 CFM
Equipment Rooms & Plant Spaces	10 units	64,900 CFM
Totals	68 units	2,351,660 CFM

Mechanical Mezzanine

Building Section



Lower Bowl Air Nozzle

Club Level Air Distribution

AHU Recommissioning

- Approx. 50% of EP devices were unreliable or had failed (heating & cooling valves, OA dampers)
- Moved building static pressure control downward
- Inconsistent control adjustments between units
- Recalibrated CO_2 reset controls & control loops
- 15% of smoke control dampers had problems
- Revised equipment room unit settings
- Incorporated enthalpy or dew point economizer
- Corrected priority settings for smoke control
- Corrected optimal start routines

VAV Unit Recommissioning

- Verified all valves, dampers and other controls
- Replaced inlet vanes with variable speed drives
- Implemented static pressure reset control
- Resolved numerous air terminal unit issues
- Revised operational scheduling from the unit level to the space level
- Established event and non-event operating schemes
- Helped resolve numerous operator issues that simplified system control
- Replaced status DP switches with current sensors

Cooling Plant Data

- 8,000 tons total capacity
- Six 1250 ton and one 500 ton chiller
- Primary only pumping system with pressure regulating discharge valves on pumps
- Eight 1000 ton cooling towers
- Piping flow velocities up to 15 FPS
- Reverse return chilled water piping system
- 42° /58° F. chilled water, 12,000 GPM
- 85° /100° F. condenser water, 16,000 GPM

Cooling Plant

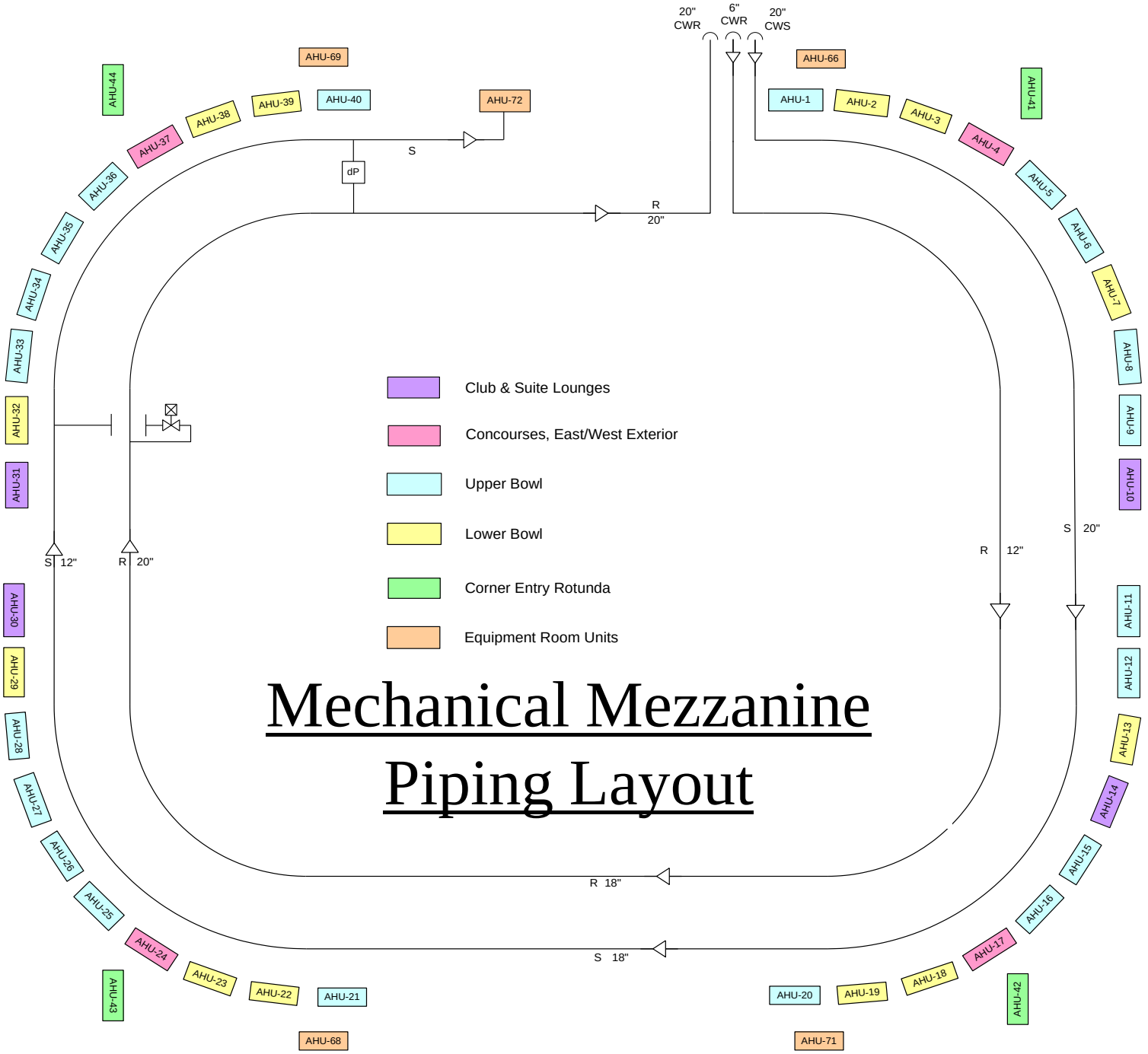
Design Load Profiles

Operating Conditions	Load	Hours
Stadium event w/flr. seating	8,883 tons	Seldom
Stadium type event	8,002 tons	140 hrs
Convention + meeting rms.	2,875 tons	1,600 hrs
Convention setup period	953 tons	2,100 hrs
Base load plus meeting rms.	749 tons	500 hrs
Base load, offices, etc.	343 tons	500 hrs
Unoccupied, equip.rms only	100 tons	3,900 hrs

Cooling Plant Recommissioning

- Added loop pressure control & bypass valve
- Rebuilt all discharge regulating valves
- Abandoned flow sensor control sequence
- Chillers sequenced from end of line DP sensor and bypass valve position
- Slow ramp up and quick ramp down
- Increased flow thru base load chiller
- Added “Chiller Service” point for operator
- Added lead chiller selection point
- Added humidity & mass temperature sensors

Pump Discharge Valves



Mechanical Mezzanine Piping Layout

Cooling Tower Revisions/ReCx

- Added catwalk system for hot water basins
- Installed SS hot water basins with hinged covers
- Coated cold water basins and replaced fill
- Installed weir dams and optimized nozzles
- Grouped towers as four pairs rather than eight individual 1000 ton towers
- Relocated fill valves indoors
- Resolved 2 speed fan short cycling issue
- Added cold water basin cleaning system sized for one pair of towers

Cooling Tower Access

Hot Water Basin Shipping Problem

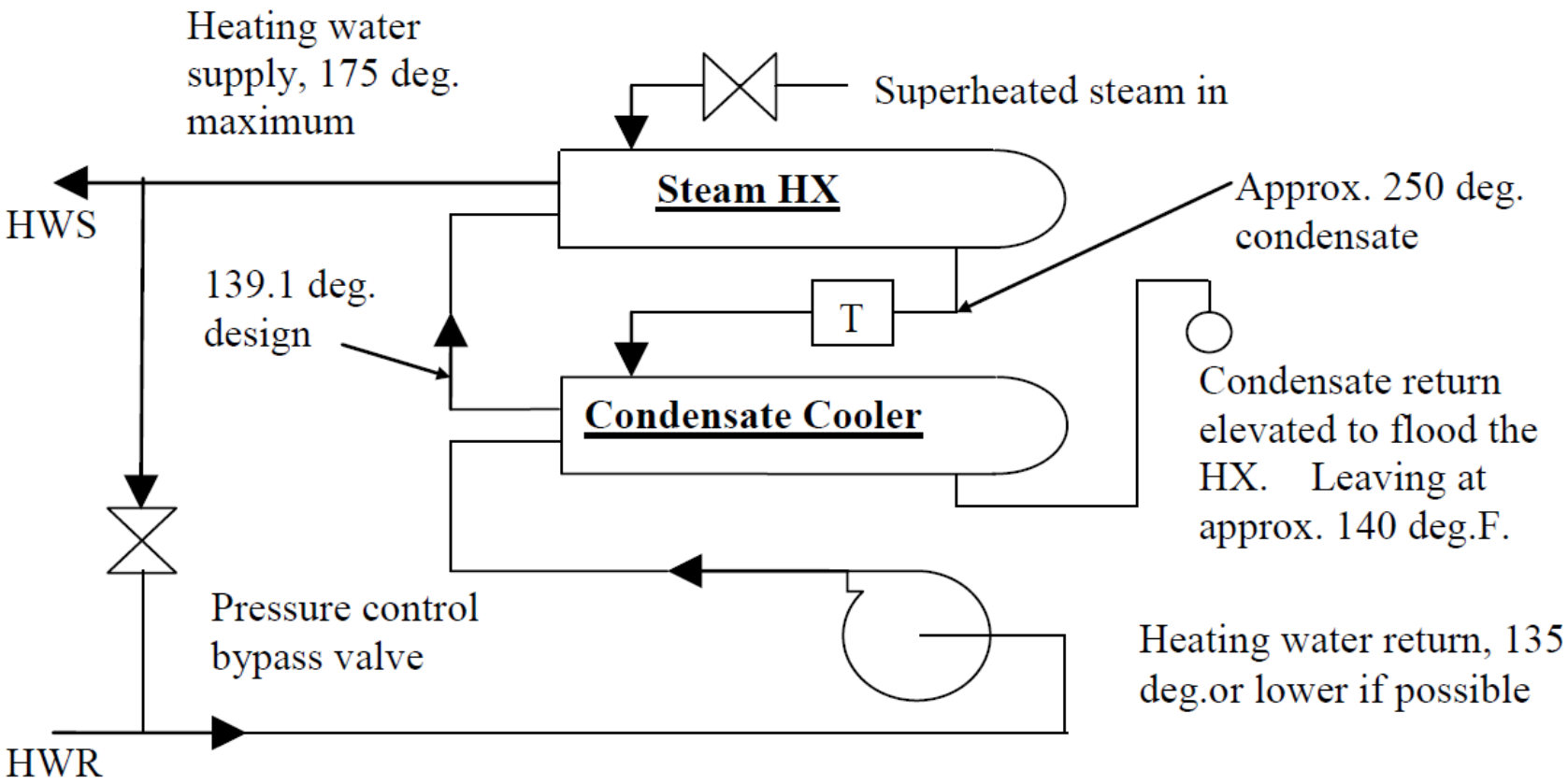
Cooling Tower Weir Dam

Heating Plant Data

- District steam system supplies 150 PSI steam, reduced immediately to 15 PSI
- 109,300 MBH total capacity, split 40/40/20
- Reverse return piping on two levels
- 5,900 GPM from 135° to 175° F.
- 15 FPS distribution system sizing
- Pressure regulating pump discharge valves
- Condensate sub-cooling heat exchanger
- By-pass valve & pressure sensor in Plant
- Supply water temperature reset from OA temp.

Heating Plant

Heating Unit Schematic



Heat Generator Flow Diagram

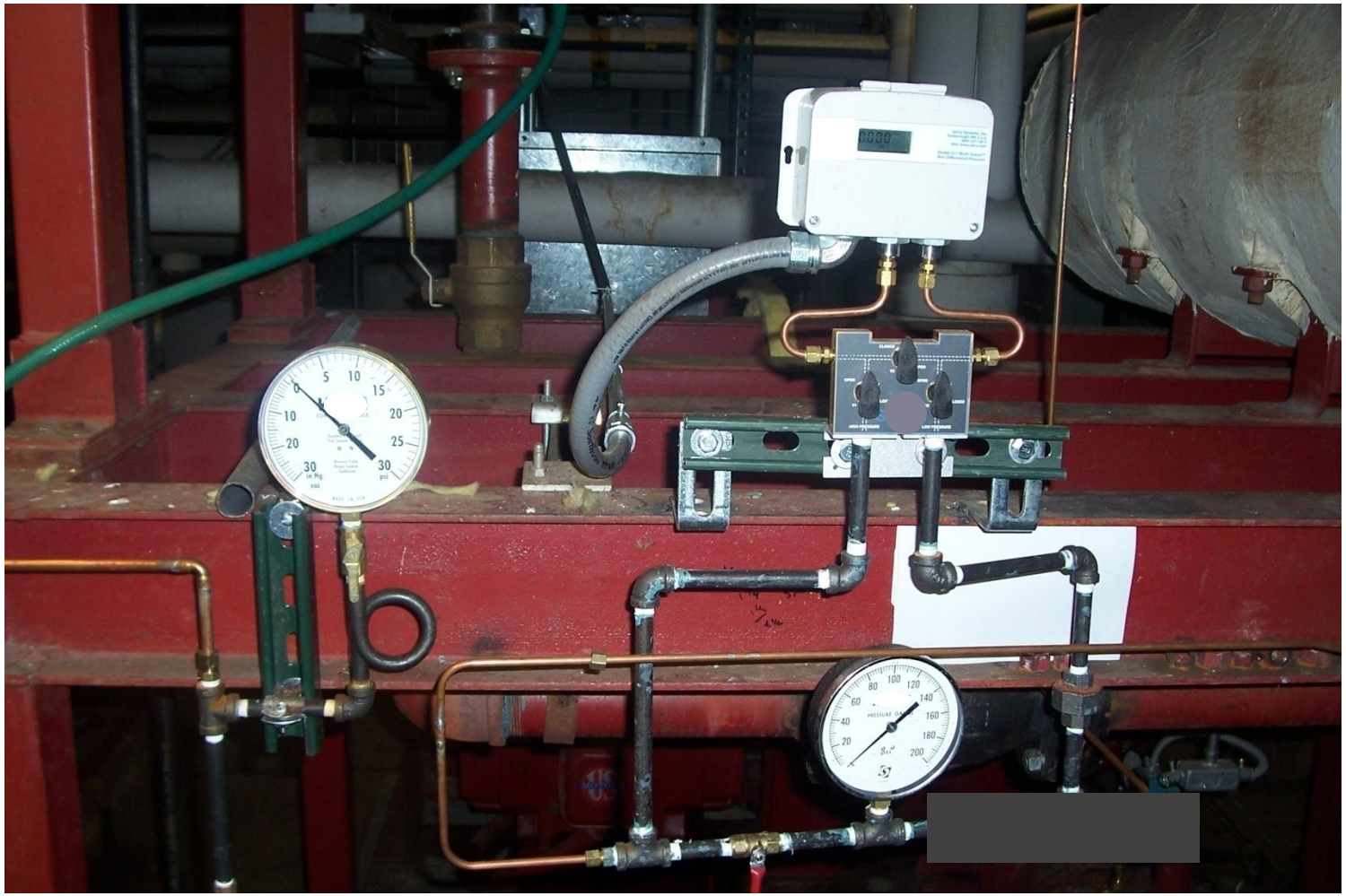
Heating Plant Recommissioning

- Added variable speed drive for base load HX
- Changed discharge valve to check valve
- Added end of loop differential pressure sensors
- Revised supply water temperature reset down to 110° F at 50 ° F outside air temp.
- Added heating exchanger service point
- Automated system sequence with verification during winter event
- Projected savings with 1 to 2 year payback

Steam Heat Exchanger Issues

- Superheated steam increases entrance velocity
- Condensate piping too high
- Insufficient drop between HX and trap
- Air vents & vacuum breakers are critical
- Condensate outlet must allow HX to drain
- Installed unit had undersized HX bundle
- More information for the operator is helpful
- You never want to hear or see the results of steam water hammer

HX Revisions & Vacuum Gage



Failed Domestic HW HX Bundle

Domestic Water Heater Issues

Domestic Water Heater Revision

Summary

- Minimum load operation is major issue from a design and operating cost standpoint
- Periodic control software adjustments without proper oversight can introduce problems, liability & costs
- Separating equipment purchases from installation contracts improves the selection process
- Allow time for material inspection and correction
- Periodic or continuous commissioning offers significant energy and operating savings
- Operator benefits are priceless

Domed Stadium Design & Operation

Questions?

Bob Towell, P.E.