50 Years of Chilled Water Distribution

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- Land grant school founded in 1858
- 410 acres (Central Campus only)
- Cogeneration began in 1891
- Chilled water distribution planning began in 1968

<table>
<thead>
<tr>
<th>Year</th>
<th>Campus Buildings Using Chilled Water</th>
<th>Chilled Water Distribution Cooling Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>19</td>
<td>0 tons</td>
</tr>
<tr>
<td>1972</td>
<td>35</td>
<td>2,000 tons</td>
</tr>
<tr>
<td>2000</td>
<td>82</td>
<td>12,900 tons</td>
</tr>
<tr>
<td>2019</td>
<td>108</td>
<td>18,200 tons</td>
</tr>
</tbody>
</table>
Chilled Water: 1965
Central System:

**Phase 1 (1968 to 1972)**

- Foresighted program to provide central chilled water to campus
- Installed 5,000 tons of chiller capacity at the Power Plant
- First chillers were steam driven
- 31,000 ft of pipe over four years through the heart of campus (diameters up to 30”)
- Hybrid Primary/Secondary
  - Initially setup for 18°F $\Delta T$ at the Plant
Chilled Water: 1972
Central System: Phase 1

• Problems from the start
  • Difficulty with existing pumps and neutral bridges
    • Caused some buildings to “starve”
  • Building coils not designed for 18°F ΔT
  • System ΔT operated near 5°F
  • Chillers overflowed
  • Buildings not able to meet cooling demands
Central System: **Phase 2 (1972-2000)**

- Filled in the gaps in distribution mains
- Connected more buildings
- 3,000 ft of main line piping installed
- In 1993, the system was converted to variable/primary
  - Coils around campus replaced to achieve 20° ΔT
  - Conversion successful! Results increased capacity
- System was advertised as providing 16 psi ΔP at each building
  - Central Plant maintained 20 psi ΔP
Planned Location of Future Load

- Load predictions revealed need for more chiller capacity
- 30-year-old backbone piping no longer sufficient
- North Chilled Water Plant added in 2004
- Site for the plant was based on:
  - Steam availability for 4,000 ton chiller
  - Future (large) building site planned adjacent to the plant
  - Politics
- System modeling updated
  - What piping sections to replace in order to make largest impact?
Central System: Phase 3 Revised

• Targets of opportunity:
  • 2004: 30” connection of new chiller to existing loop (740’).
  • 2007: 24” pipe with Coover Hall remodel (720’)
  • 2010: 36” connector section with Hach Hall utility corridor (740’)
  • 2017: 30” second connection to North Chiller Plant with the north chiller expansion (1,900’)

• Each pipe installation integral to nearby campus projects
Central System: Phase 3 Revised

- Increased load was causing $\Delta P$ to drop on west campus
- Rarely able to maintain the advertised 16 $\Delta P$
  - Plant responded by changing pressure control
  - The increased pressure had the effect of increasing load
- The SW section of campus was still seeing $\Delta P$ drop off
Central System: **Phase 3 Completion**

- As of 2017, system operation proved model predictions
  - Low ΔP on SW corner of campus
- This required upgrade to the distribution system under Bissel Road
- Bissel Road a major arterial through heart of campus
- Disruption to vehicular/pedestrian traffic was imminent
Central System

• The final leg of Phase 3 piping
  • 24” Diameter

• Shive-Hattery hired to design and coordinate the project
Bissel Road: Utility Upgrade

- Storm water study incorporated into design
- Roadway master plan incorporated into design
- Coordination with adjacent project sites
  - Student Innovation Center Construction
  - Union Drive Re-construction Project
Bissel Road: **Utility Upgrade**

- $4M Construction Costs
- 1,300’ Chilled Water Mains – 24”
- 1,000’ Storm Sewer – 24” thru 42”
- 500’ Water Main – 10”
- 100’ Steam Tunnel Under Bissel Road
- (9) Construction Phases
Phasing: Key Plan

NORTH PHASE 1A: MARCH 12 - MARCH 16, 2018
NORTH PHASE 2: MAY 7 - MAY 25, 2018
NORTH PHASE 3: MAY 28 - JUNE 29, 2018
NORTH PHASE 4: JULY 2 - JULY 13, 2018
NORTH PHASE 5: JULY 16 - JULY 20, 2018
NORTH PHASE 6: JULY 23 - AUGUST 3, 2018

SOUTH PHASE 1: MARCH 18 - MAY 10, 2019
SOUTH PHASE 2: MAY 13 - JULY 5, 2019
SOUTH PHASE 3: JULY 8 - AUGUST 9, 2019

STUDENT INNOVATION CENTER: 2017 - 2019

UNION DRIVE RECONSTRUCTION: APRIL 1 - JUNE 17, 2019

CONTRACTOR LAYDOWN NORTH PHASE
CONTRACTOR LAYDOWN FOR SOUTH PHASE
Bissel Road: Utility Upgrade

- The final section of pipe was put in service 7/26/19
- West campus ΔP returned to anticipated values
- Chiller plant reduced output pressure
System Pressure Improvements
Lessons Learned

• On a well-looped system, location of additional loads not critical to overall system modeling
• Unanticipated load locations caused isolated areas of low ΔP for many years
• Forward-thinking modeling avoided capacity constraints
• Coordination with campus projects reduced disruption and costs
• Complex and disruptive projects can be completed with proper planning
Chilled Water Load Projections

New Peak Load of 18,169 tons set in summer 2019

Assumptions:
1. 1% annual load growth plus known new buildings
2. 5000 tons of new capacity available summer 2032
Central System: **Future Plant Location**

• The distant future: Year 2030
  - Load growth predictions suggest campus demand will exceed the current plant capacities
  - North Chiller Plant is out of real estate
  - Piping from MPP at capacity
  - New chiller plant required

• Siting is based on:
  - Electric chillers are now more attractive
  - East Campus location requires several thousand feet of 36” piping
  - West Campus expansion
  - Plans for large West Campus parking ramp
  - Best use of the existing piping infrastructure
Thank you!

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