LEADING THE WAY
CampusEnergy2022
Feb. 15-18 | Westin Boston Seaport District Hotel | Boston, Mass.
INTERNATIONAL DISTRICT ENERGY ASSOCIATION

University of Nebraska-Lincoln Case Study: Tube Fouling Prevention Optimizes Chiller Performance

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UNL Utility Services

Three campuses: City (1929), East (1915), Innovation (2015)

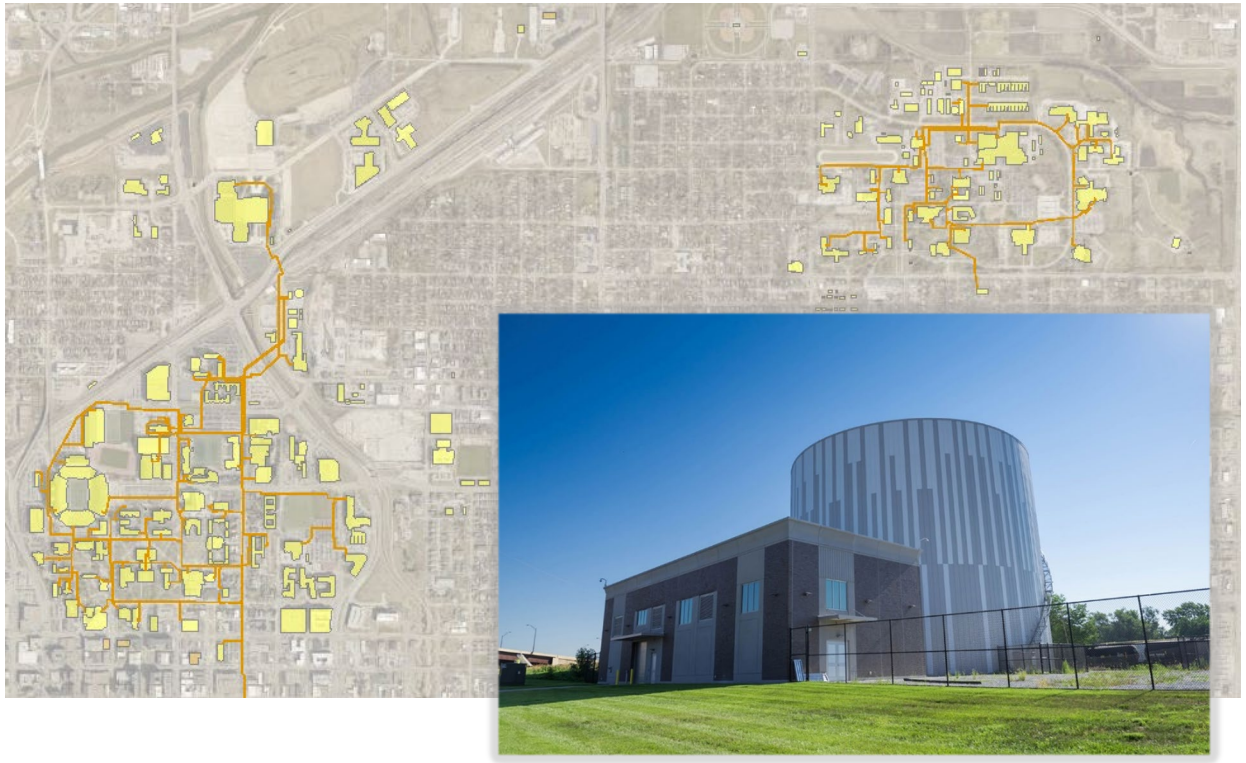
City & East Utility Plants started as powerhouse/steam plants

Chilled water distribution began in the 1960s

UNL Utility Services

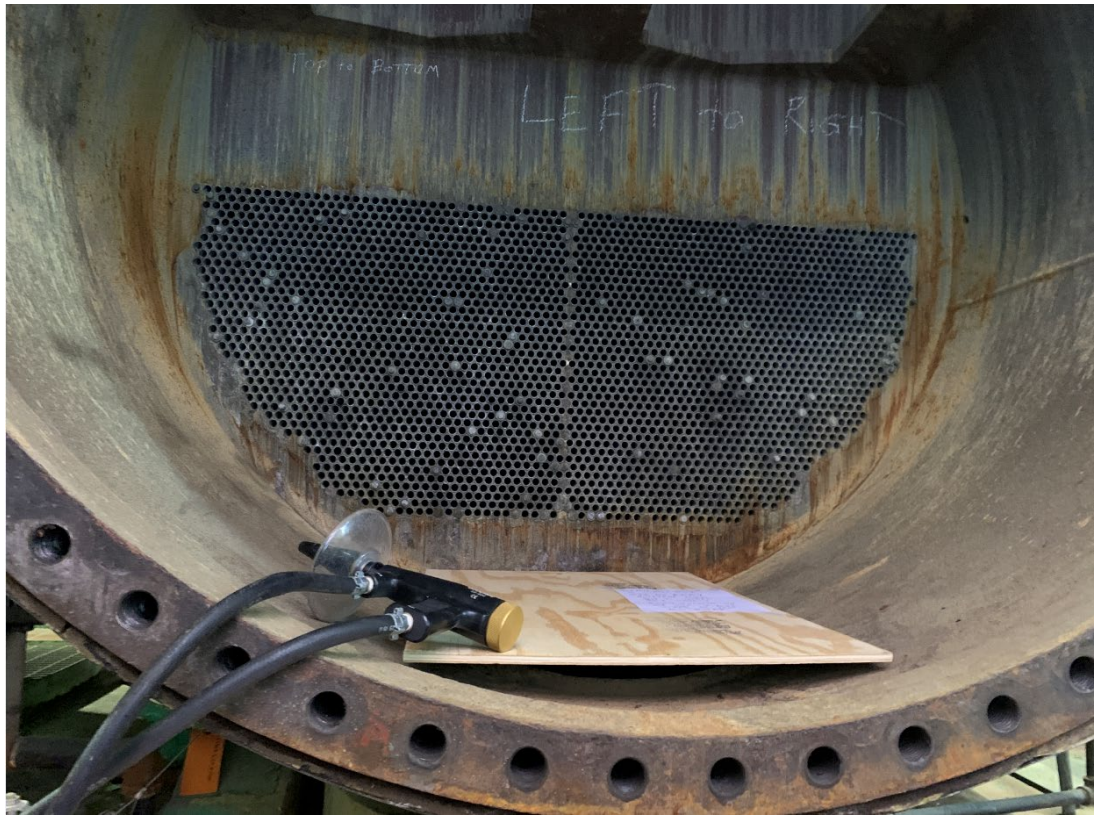
Campus Chilled Water

- 9.7 million ft² of building area
- Variable primary, direct connected*
- 34,000 ton capacity
- 19,600 ton peak load
- 22 miles of distribution piping
- 11 million gallons of TES capacity
- 16 million gallon total volume



Chiller Cleaning

- 11 Total Chillers
  - 2,000 - 4,000 tons
  - 49,600 total tubes
- Cleaned every 1-3 years
- 1.2 minutes per tube to prep machine, clean, test, inspect, and reassemble
- Poor student worker retention



1968 chiller still in operation

Defining the Problem

- Chiller tube fouling is ridiculously *EXPENSIVE*

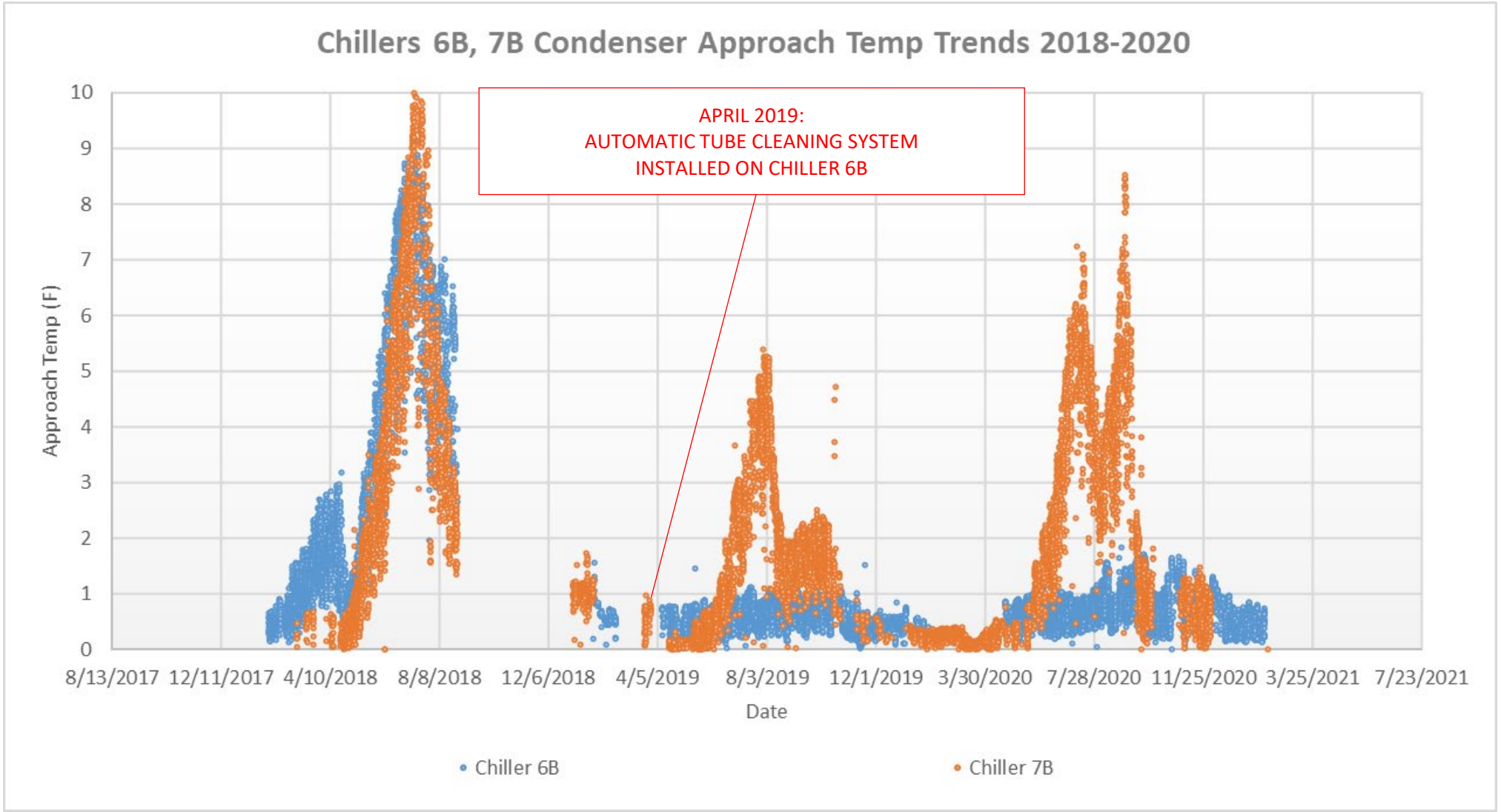
30K RT x 0.44 kW/RT x $0.07/kW-hr x 4500 hrs/yr x 7% = $300,000/yr

- Manual tube brushing is time-consuming, messy, hazardous work

Background Info & Project Setup

- **BACKGROUND INFORMATION:**
  - UNL—CCUP- CHILLERS 6 & 7
  - EACH CHILLER (6/7) ~2,000 TONS
  - MADE UP OF TWIN 1,000 TON CHILLERS (A/B) WITH PARALLEL CONDENSERS
  - COMMON CHILLED WATER & CONDENSER WATER HEADERS
- **PROJECT SET-UP:**
  - APRIL 2019 INSTALL TUBE CLEANING SYSTEM ON CH. 6A & 6B CONDENSER
  - BEFORE/AFTER EVAL OF CH. 6A/B TUBE CLEANING SYSTEM INSTALLATION
  - SIDE-BY-SIDE EVAL OF CHILLER 6 WITH TUBE CLEANING SYSTEM VS. CHILLER 7 WITHOUT TUBE CLEANING SYSTEM

Chiller 6B Condenser Approach Temps Improved Significantly



FIND THE SOURCE OF INEFFICIENCY

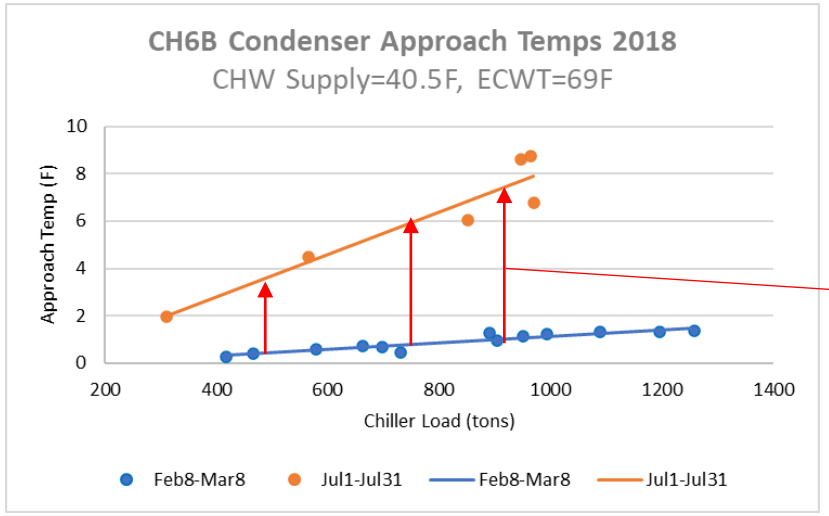
Simultaneously Consider Multiple Factors Impacting Efficiency:

- Chiller Load (L)
- Chilled Water Supply Temperature (CHST)
- Entering Condenser Water Temperature (ECWT)
- Chiller Tube Fouling

Isolate ECWT & CHST → **Plot Chiller Approach Temp Curves** → **Look for Curve Shift Over Time**

Chiller 6B Condenser Approach

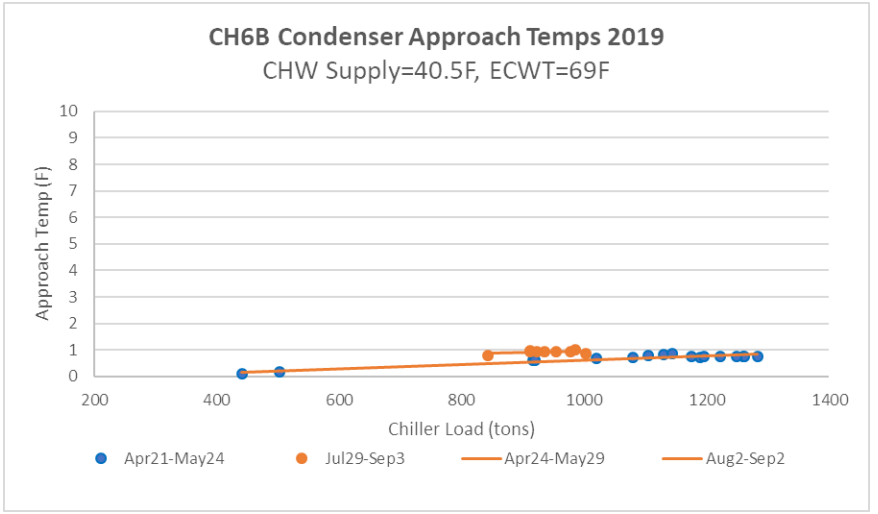
2018 – Without TCS



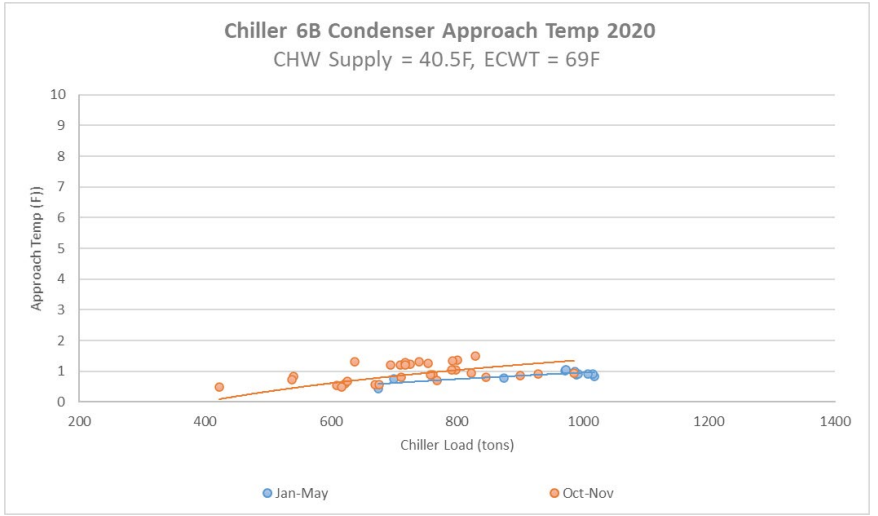
Upward curve shift indicates efficiency loss from fouling.

Avg. Increase in Cond. Approach Temp: 4.3 F

2019 – With TCS:

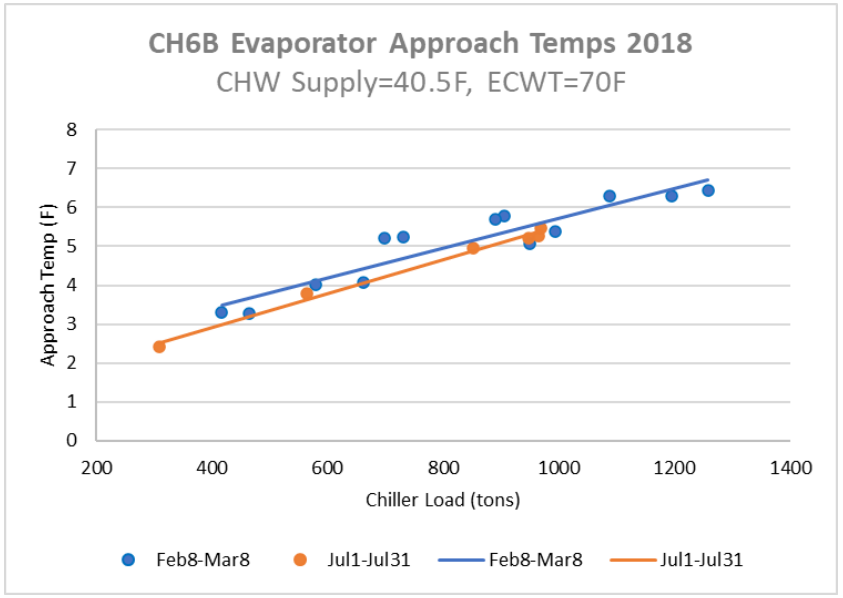


2020 – With TCS:

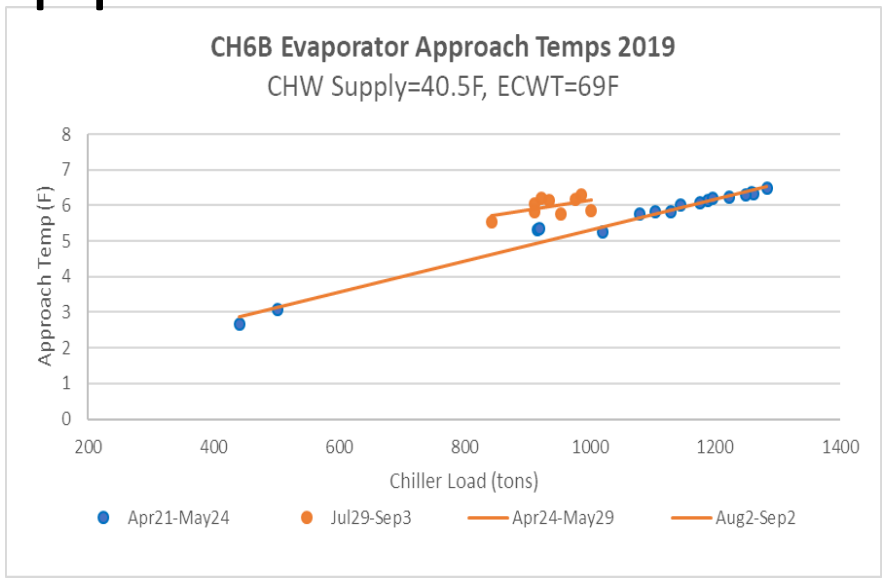


Chiller 6B Evaporator Approach

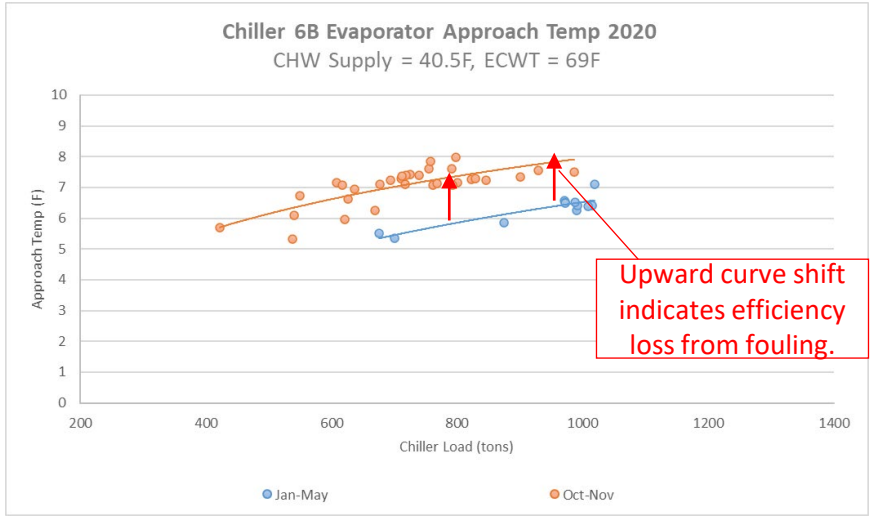
2018



2019



2020



Avg Increase in Evap. Approach Temp: 1.5 F

Efficiency Analysis
Chiller 6 Before/After Tube Cleaning System

Chiller Characteristic	Before TCS (2018)	After TCS (2019)	After TCS (2020)
Chiller 6 Avg. Efficiency Degradation During Season	27%	4%	7%
Chiller 6 Avg. Cond. Approach Temp. Increase During Season	5.3 F	0.1 F	0.1 F
Chiller 6 Avg. Evap. Approach Temp. Increase During Season	0.0 F	0.9 F	1.2 F

KEY OBSERVATIONS:

- Chiller 6A/B maintained efficiency through cooling season much better in 2019 & 2020 after TCS installation.
- After TCS install, Chiller 6A/B condenser approach temperature did not increase through the cooling season.
- Chiller 6A/B exhibited more evaporator approach increase in 2019 and 2020, contributing to efficiency losses.

Efficiency Analysis
Chiller 6 & Chiller 7 Side by Side

Characteristic (2019 Cooling Season)	Chiller 6 With TCS	Chiller 7 Without TCS
Efficiency Degradation During Season	4%	9%
Condenser Approach Temp. Increase During Season	0.1 F	3.5 F
Evaporator Approach Temp. Increase During Season	0.9 F	1.4 F

Characteristic (2020 Cooling Season)	Chiller 6 With TCS	Chiller 7 Without TCS
Efficiency Degradation During Season	7%	13%
Condenser Approach Temp. Increase During Season	0.1 F	3.5 F
Evaporator Approach Temp. Increase During Season	1.1 F	1.7 F

Lessons Learned / Next Steps & Plans?

- **EVAPORATOR** opportunities
- Remove loose scale from waterbox
- Trim divider plate gaskets as needed
- Second installation ready for this spring
- Expanding to other units based on existing performance

HOW IT WORKS

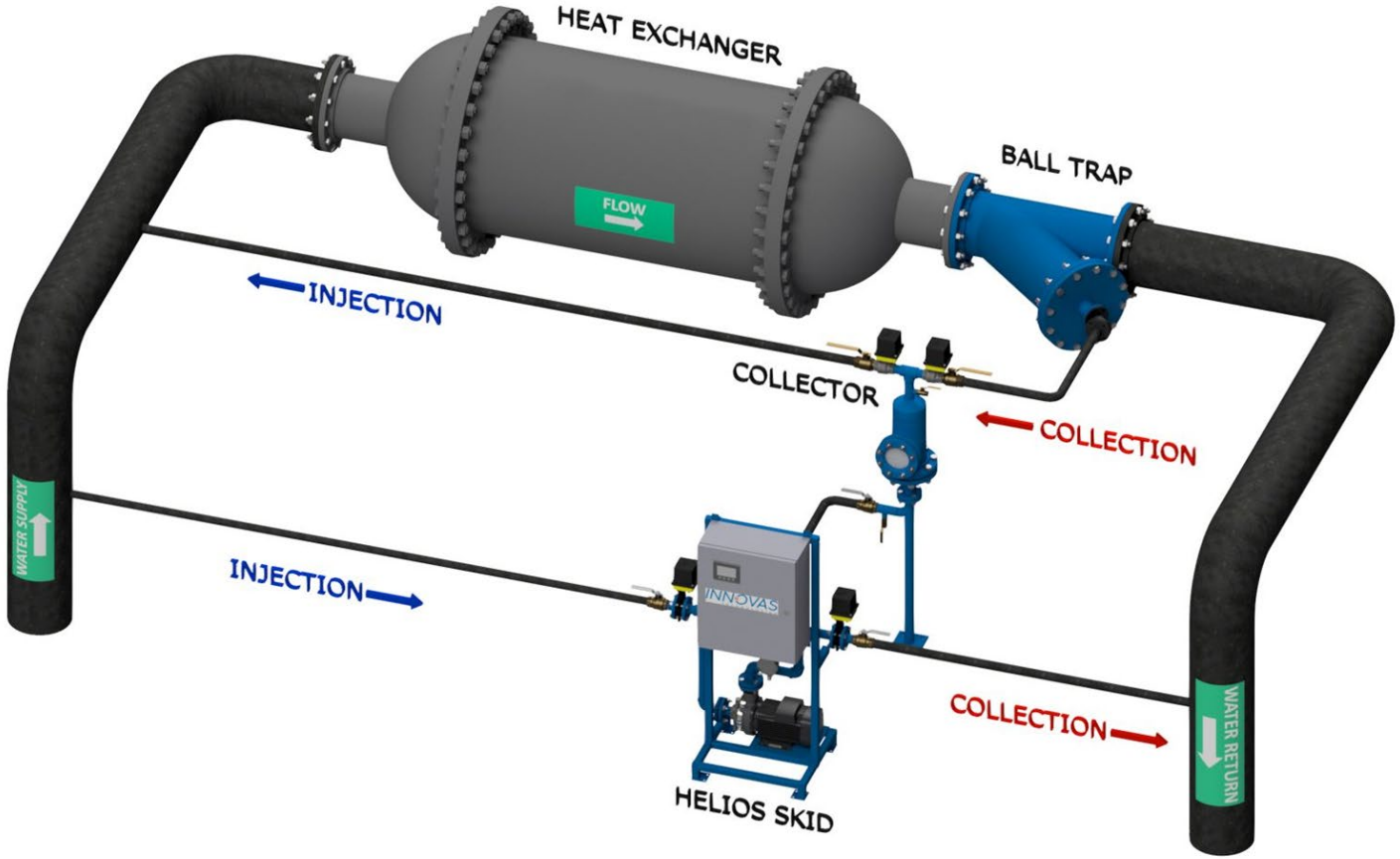
How Tube Cleaning Systems Work

UNL's TCS have run for over 3 years without any increase in condenser approach temperature and no manual tube cleaning.

HOW IT WORKS

How Automatic Tube Cleaning Systems work.

1. The Skid is comprised of the Controls Enclosure, Pump, & Application Controller.
2. The Collector is where balls are staged between injection cycles.
3. The strainer inside the Ball Trap prevents balls from escaping downstream.



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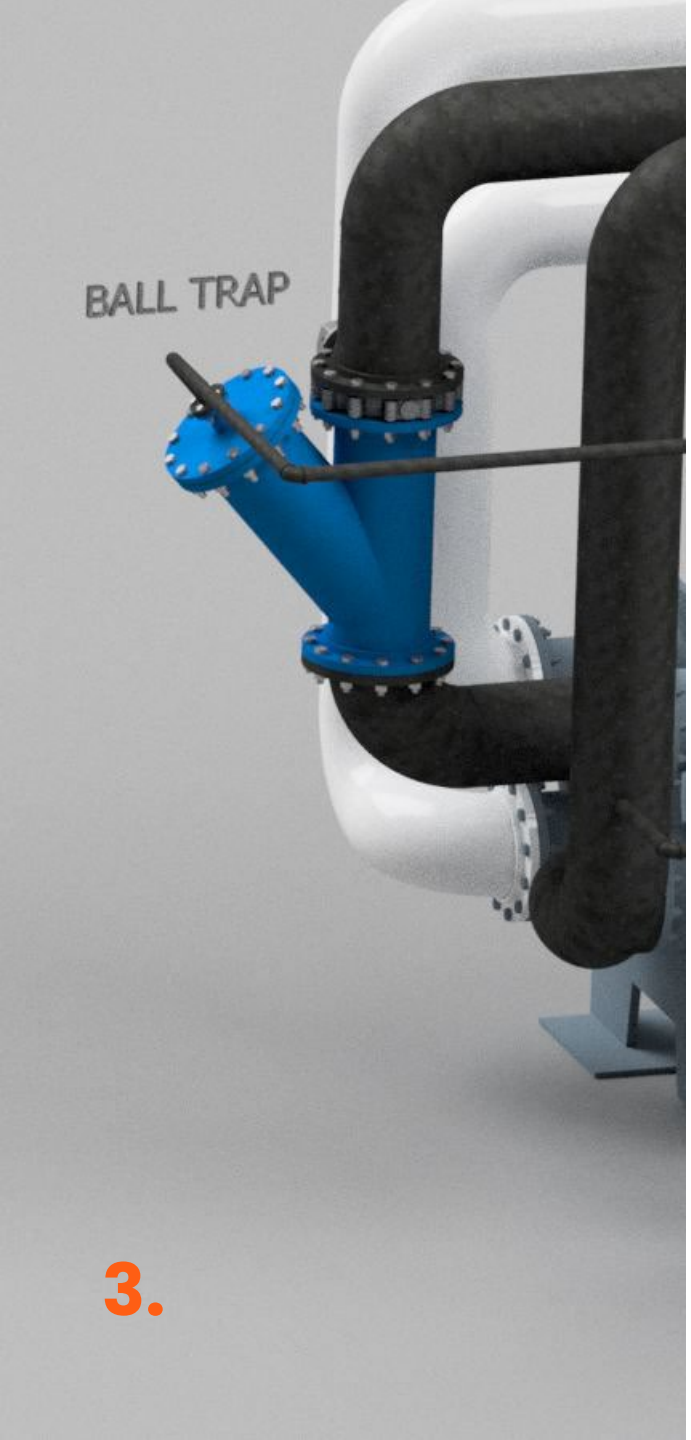

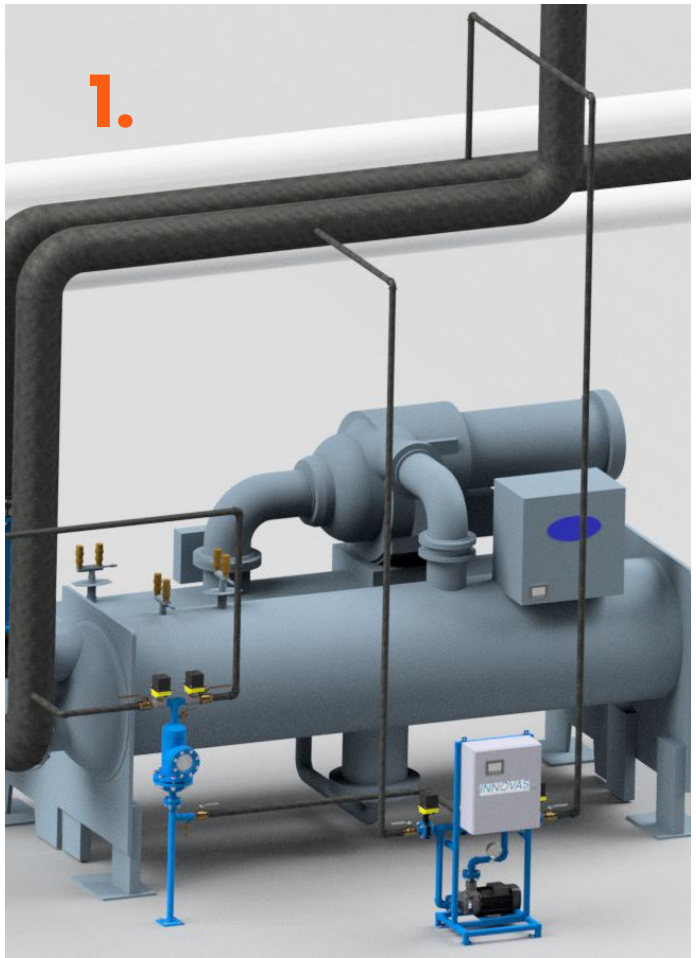

HOW IT WORKS

Example TCS Layout on chiller.

1. The Skid is comprised of the Controls Enclosure, Pump, & Application Controller.
2. The Collector is where balls are staged between injection cycles.
3. The strainer inside the Ball Trap prevents balls from escaping downstream.

RETURN ON INVESTMENT

ATCS Technology: Multiple dimensions of value.

- Chiller energy efficiency improves 5-15%
- Reduce/eliminate manual tube brushing & cleaning
- Increases chiller capacity
- Improves chiller plant availability
- Reduce GHG emissions and environmental impact

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THANK YOU

FOR WATCHING THIS PRESENTATION

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