



AYALA CHILLER PERFORMANCE

Data Analysis Of EcoCOOL® Energy Reduction

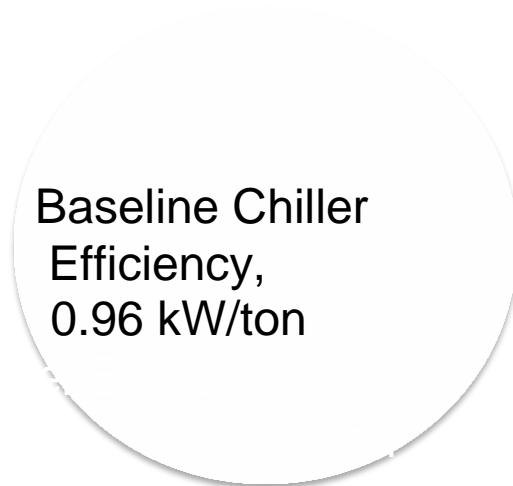
Chiller's Performance Analysis by Dr. Igor Yatskar, Ph.D., CEO

Energy Analytics, LLC

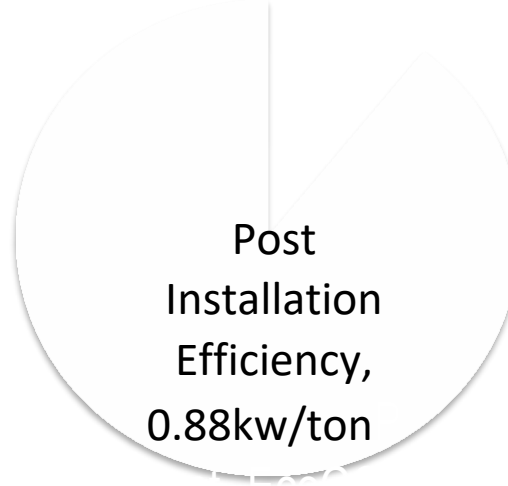
Chiller's Performance – Efficiency Improvement

Pre- and Post-installation chiller's efficiency change

Pre Test



Post Test



**~8.4% chiller's efficiency improvement,
associated with EcoCOOL treatment**

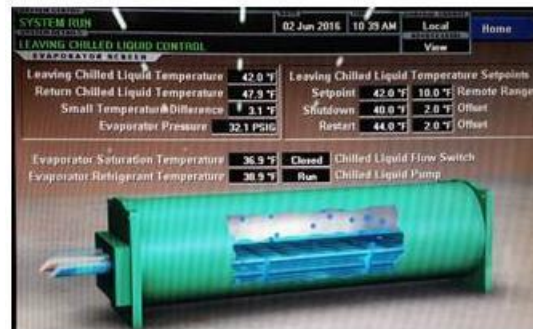
Subject of Analysis – Pilot Chiller#2

Unit : Centrifugal Chiller, 650 Tons capacity

Brand : York

Model: YKEKEP8-CUF

Compressor Model: YDHE 580DD



Data Analyzed and Test Arrangement

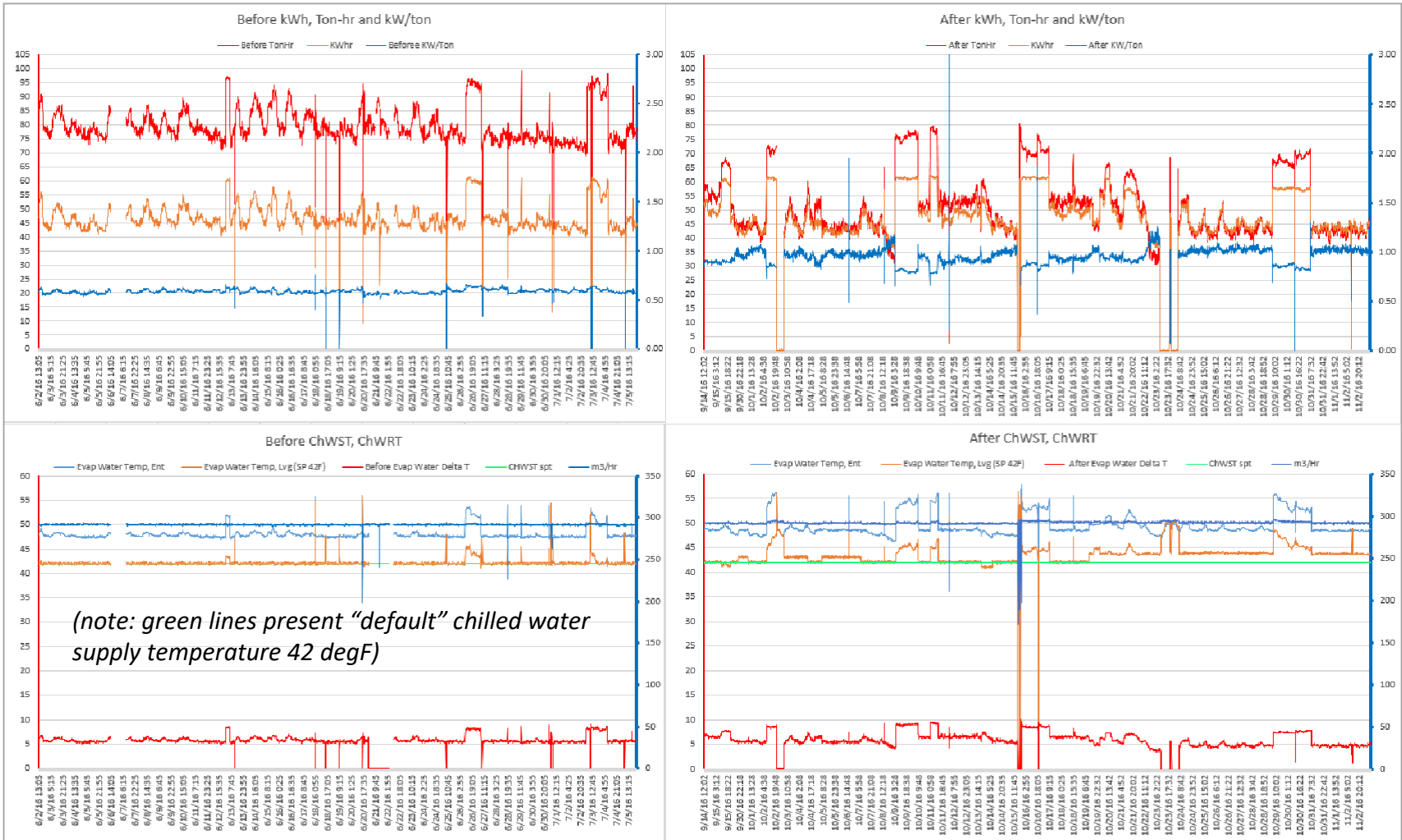
- Pre- and Post- EcoCOOL installation chiller performance parameters were collected by Customer's Building Automation System (BAS) and their Fluke Data Logger in 10-min time intervals for duration of about four weeks (Jun-Jul, 2016) before and about four months (Sep, 2016 – Jan, 2017) after EcoCOOL treatment
- List of parameters monitored is presented below
 - Electric consumption, kWh
 - Cooling Load, Ton-hr
 - Chilled Water Flow, m³/hr – converted to GPM (gallons per minute)
 - Evaporator Water Supply and Return Temperatures, degree (Celsius to Fahrenheit)
 - Chiller Load (% Loading)
 - Chillers Efficiency, kW/ton, EER, COP

Some additional data, collected in Oct, 2016-Jan, 2017 (*.txt files), also included Condenser Water Supply and Return Temperatures, Actual Chilled Water Supply Temperature Set-point, Compressor Pressures and Oil Temperatures

- All available data was utilized in analysis and presented on slides that follow. Time interval Jun-Jul, 2016 was considered as “baseline” pre-installation data; period between EcoCOOL installation date of Sep 11, 2016 till the end of September, 2016 was considered as “transition period” assigned for system relaxation. All data from Oct, 2016 till Jan, 2017 was considered as post-installation data – all this information was “un-folded”, graphically presented and interpreted in analysis, but only Oct-Nov, 2016 records having kWh readings were utilized for calculating average post-installation efficiency kW/ton

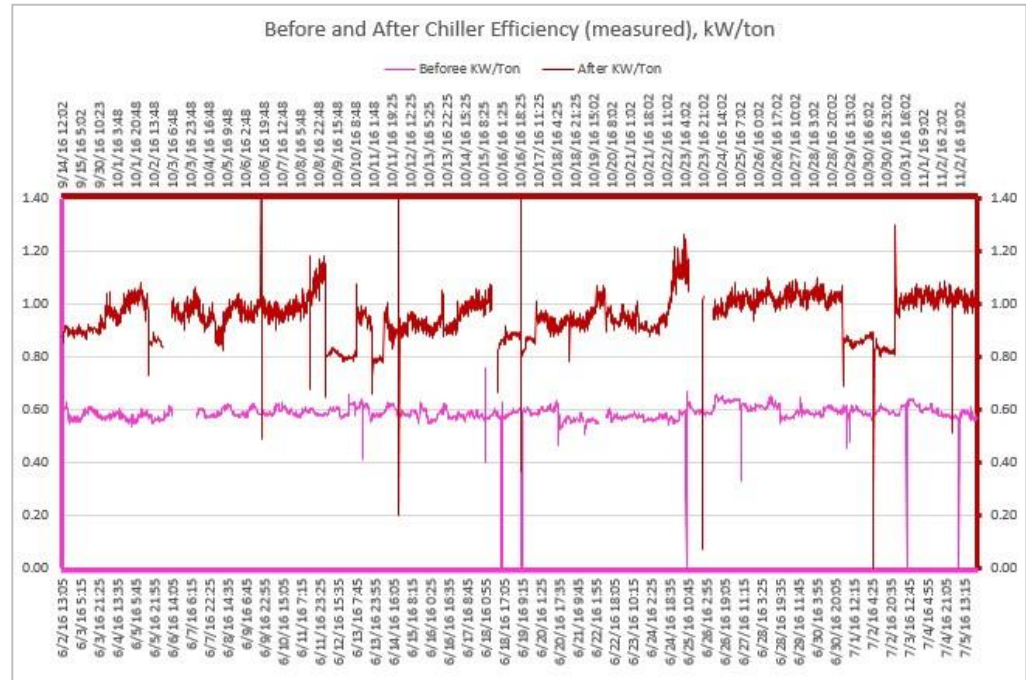
Overview of Chiller's Performance Data

Charts below present chiller's performance parameters, as they measured by Customer's BAS System
 Please note large Cooling Load (~80 ton-hrs/10min, ~480 tons) and low ~0.6 kW/ton in "Before" measurements



The Issue Analyzed and Resolution Proposed

- The main “problem in hand” is discrepancy between expected chiller’s efficiency (less than baseline efficiency ~ 0.6 kW/ton), and actually observed much larger (much worse) post-installation efficiency of ~ 0.9 kW/ton



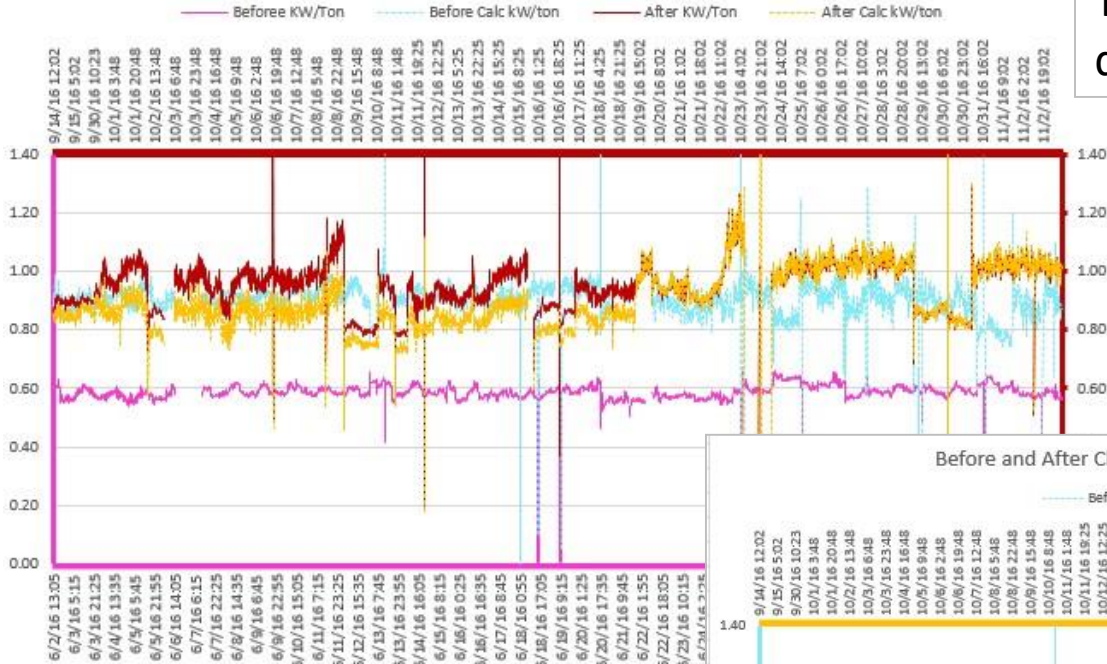
Proposed Resolution

The following three claims were derived from our analysis:

- We came-up with higher than presented by BAS pre-installation efficiency 0.96 kW/ton. This efficiency is result of direct calculation of chiller’s load (tons) from provided chilled water flow and supply/return temperatures. Post-installation efficiency is in the same range, but slightly (8.4%) better – it’s equal in average 0.88 kW/ton
- Claimed by Customer’s BAS %Load (~ 70 - 80% , while max is 95%) can’t be confirmed by existing data neither before, nor after EcoCOOL installation – all available data indicate, that chiller worked at much lower load of 350-400 tons (while chillers capacity is 650 tons), at 40-50% capacity. Accordingly, chiller efficiency is 0.9 kW/ton - much more realistic (than 0.6 kW/ton) value for half-loaded chiller, operating with ~ 5 degF chilled water deltaT only.
- Additional data (*.txt files) for Oct-Nov, 2016 indicate, that Chilled Water Supply Temperature Set-point was changed several times for extended periods time intervals from default value of 42F to 43-44F, which also affected comparison

“Before” and “After” Chiller’s Efficiency – BAS-measured vs Calculated

Before and After Chiller Efficiency (measured and calculated), kW/ton



$$\text{Ton} = 500 * \text{GPM} * \Delta T / 12,000$$

$$\Delta T = \text{ChWRetT} - \text{ChWSupT}$$

Large difference between After (brown line) and Before (magenta line) Chiller Efficiencies is due to incorrect “Before” load (tons) calculation by Fluke meter

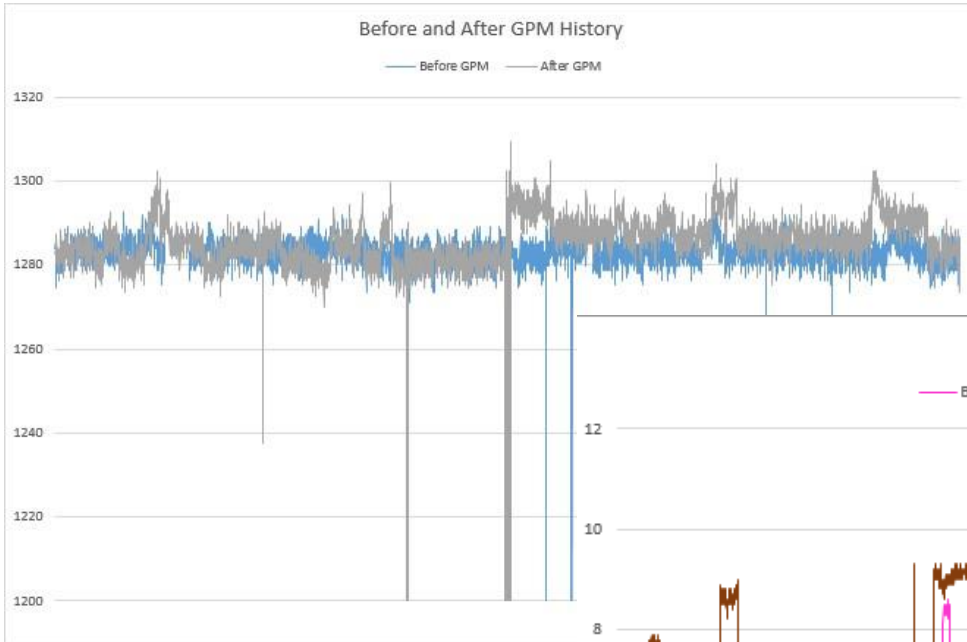
Before and After Chiller Efficiency (calculated only), kW/ton



Large Before - After kW/ton difference is eliminated, when CALCULATED values are compared.

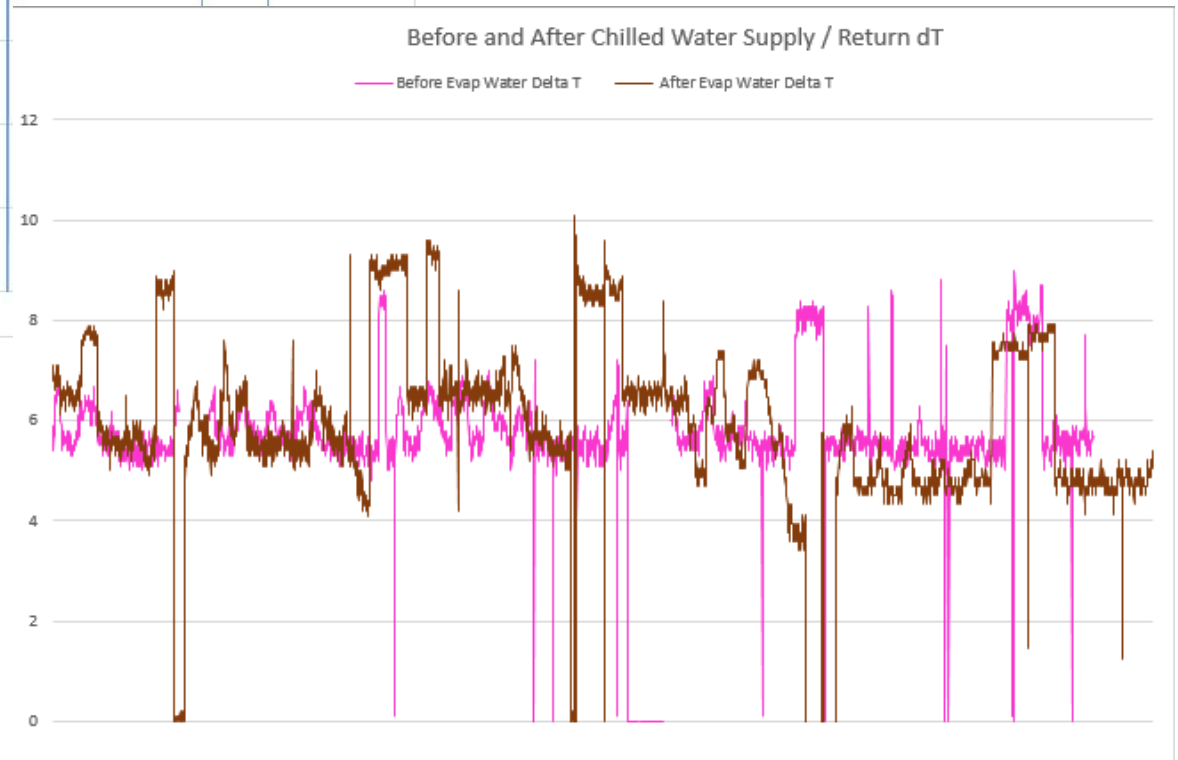
Both calculations were made by the same formula (shown above) using Fluke-provided water flow (GPM) and chilled water supply / return temperatures

Chiller's Load Calculation Details – ChW Flow and Temperatures



Charts demonstrate, that both chilled water flow and chilled water deltaT were close in both Before and After installation. It indicates, that tonnage difference is not due to difference in performance, but rather due to Fluke's calculation error

(Note: the x-axes are not shown, because they are different for Before and After lines)



“After” Tons – BAS-measured, calculated & additionally provided

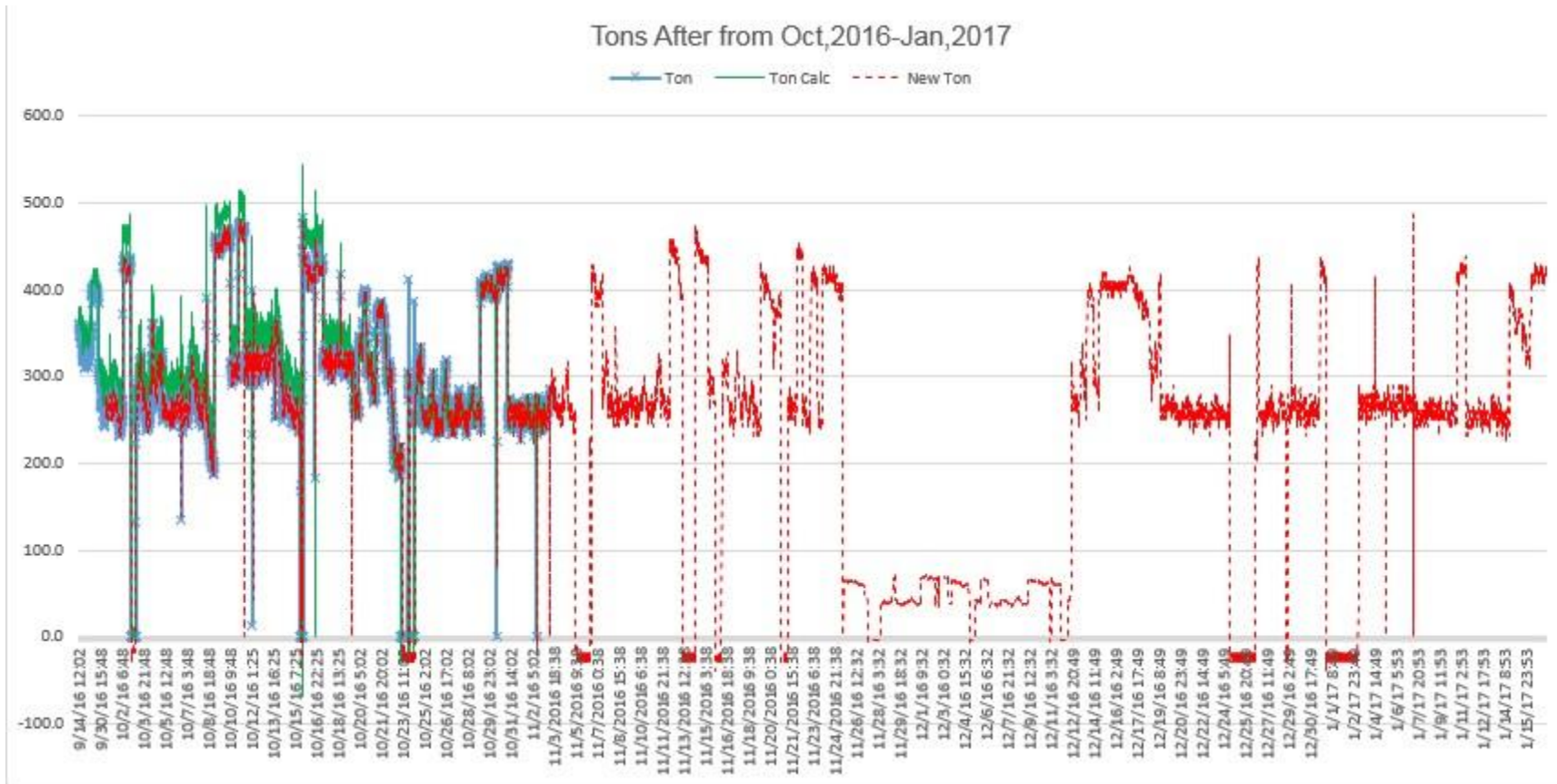
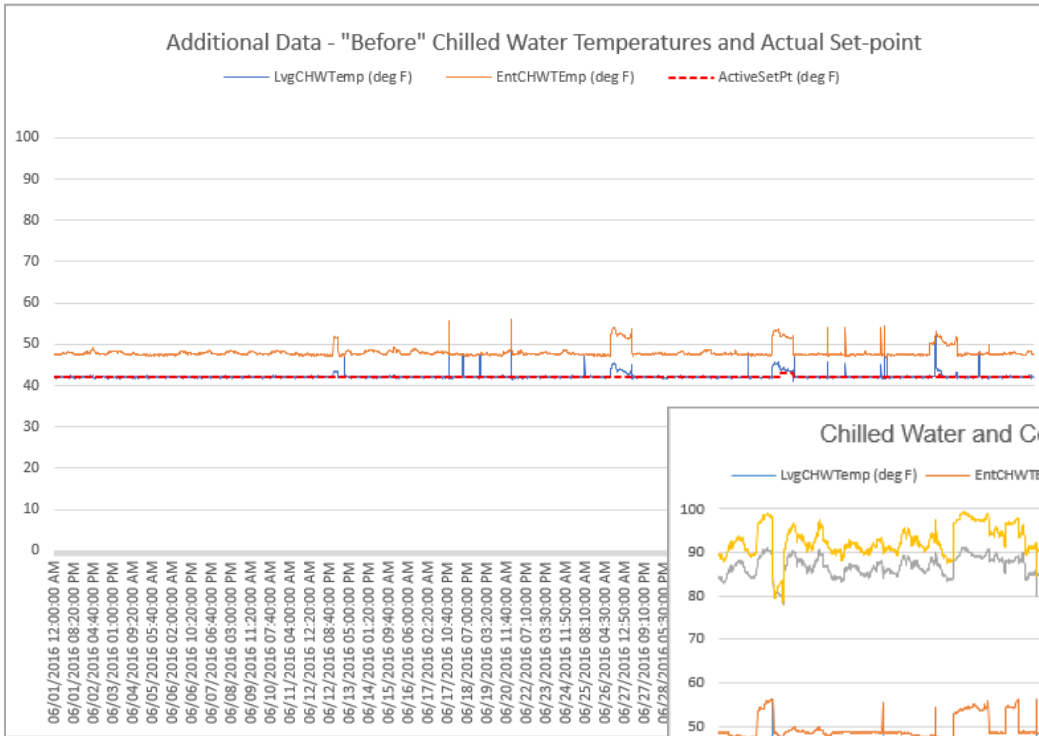
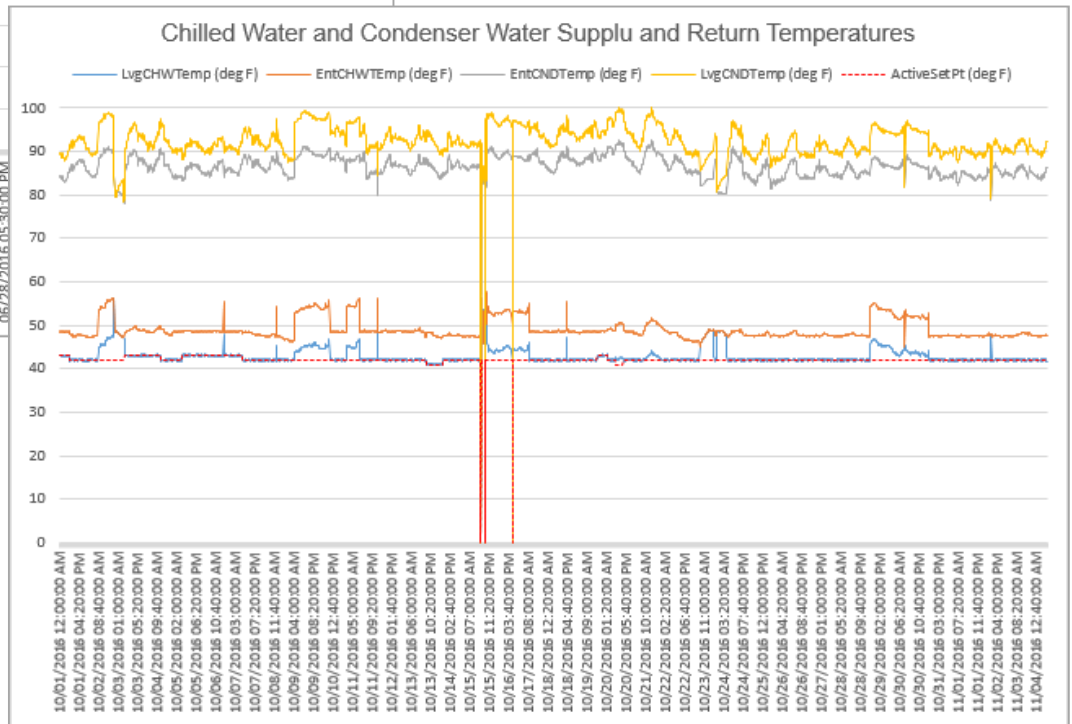


Chart above compares After-installation chiller load (Tons) (from original data set Oct, 2016), from our calculation (slide 6 formula), and from additionally provided *.txt files (Oct, 2016-Jan, 2017) Customer's data. All data are in good correspondence, confirming formula used in calculations and conclusion made regarding ~half-load operation most of the time

Additional Data, "Before" Jun - Jul, 2016 and "After" Oct, 2016



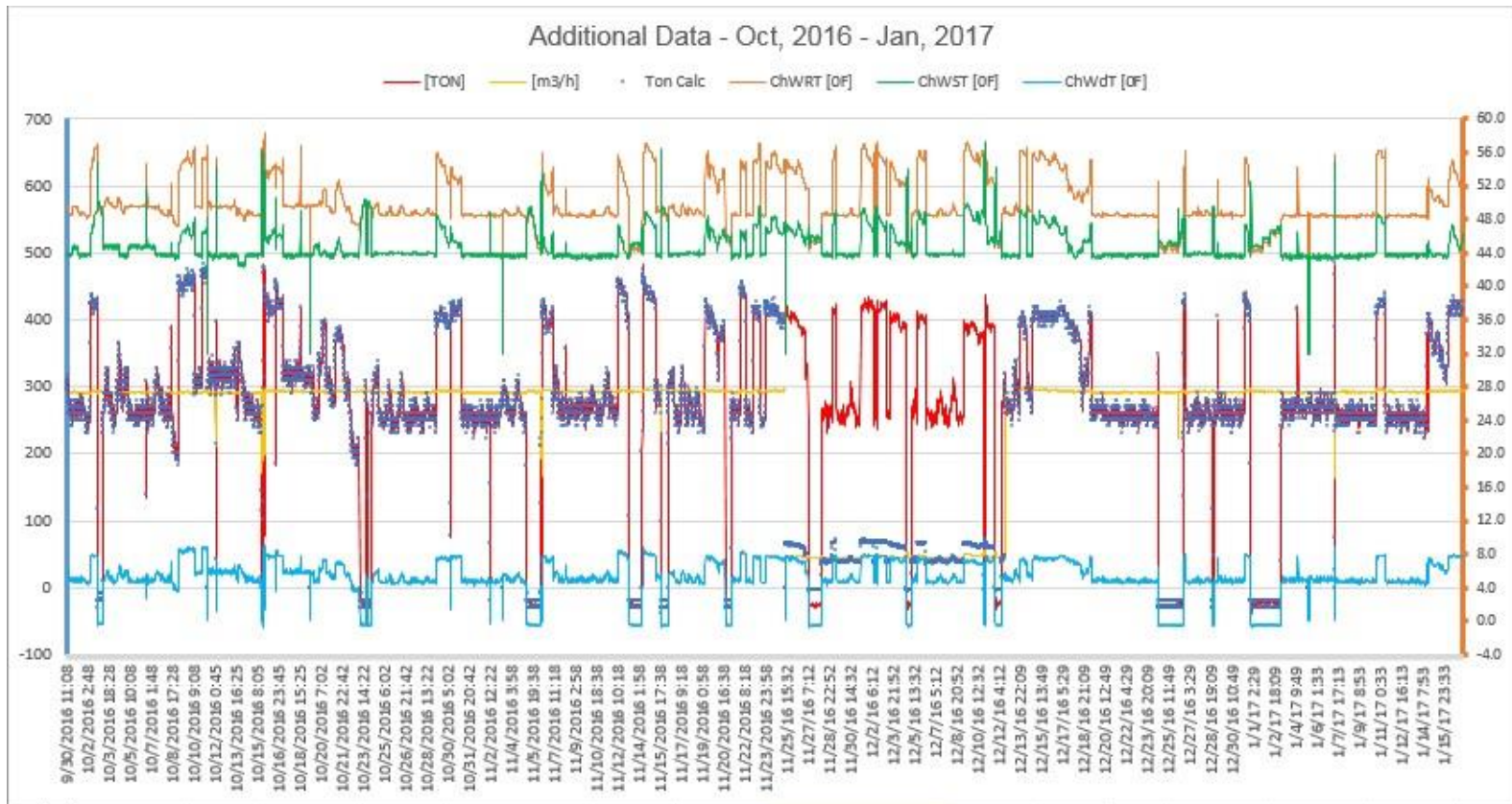
Please note that Active Chilled Water Supply Temperature set-point is fixed at 42F, and most of the time is perfectly maintained



Please note Active Chilled Water Supply Temperature set-point gets reset in interval 40 - 43F, and it were multiple occasions when large deviations of actual supply temperature from it set-points occur

Additional Data, Oct, 2016 – Jan, 2017, cont.

Data indicates, that chiller operates at load ~300-400 tons (or ton-hrs/hr), which is ~50 ton-hrs/10min, with load ~50% of full capacity, with ~5 degF deltaT (most of the time), while providing ~44 degF chilled water supply temperature. That, again, confirms, that cooling load of ~80 ton-hrs/10min, reported in “Before” load data is most probably incorrect.



Please note (almost always) perfect correspondence between calculated and measured Cooling Load (tons)