Design Review for New Construction Commissioning and Beyond

Day 1 of 2

Presented By:

- David Sellers, Facility Dynamics Engineering
- Senior Engineer

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Learning Objectives – Class Series

1. Attendees will be able to list the different phases in the design and construction process and where design review activities are desirable in that process.

Learning Objectives – Class Series

2. Attendees will be able to describe the importance of reviewing the construction documents and which drawings and specification sections to target in order to best address potential commissioning issues.

Learning Objectives – Class Series

3. Attendees will be able to discuss the importance of reviewing equipment submittals and shop drawings emphasizing the items to look for in order to best mitigate potential commissioning issues.

Learning Objectives – Class Series

4. Attendees will be able to explain how construction observation can be applied as a tool to complement the design review process for new construction projects.

Learning Objectives – Class Series

5. Attendees will recognize that the implementation phase of EBCx projects is often a small NCx project and that design review and construction observation are key aspects to the success of that process.

Agenda

1. Introduction
2. The Submittal Review Angle
3. The Construction Observation Angle
4. Pump Assessment Case Study
5. Design Conditions Assessment Case Study

Getting to Know You

Please visit the following like if you have not already while waiting for class to start and complete the form. This will help get us all acquainted with each other and also help the instructors target the content to the audience.

https://tinyurl.com/PECDesRevGet2Know

Introduction

A Bit About Me

A Bit About Me

I intended to be an aircraft maintenance engineer

I'm doing something <u>totally</u> different

A Bit About Me

- HVAC field technician
- Control system designer
- HVAC designer
- MCC Powers system engineer
- Murphy Company controls and start-up engineer
- Project engineer
- Wafer fab facilities engineer and system owner
- A happily married PECI technical support engineer and trainer
- FDE Senior Engineer

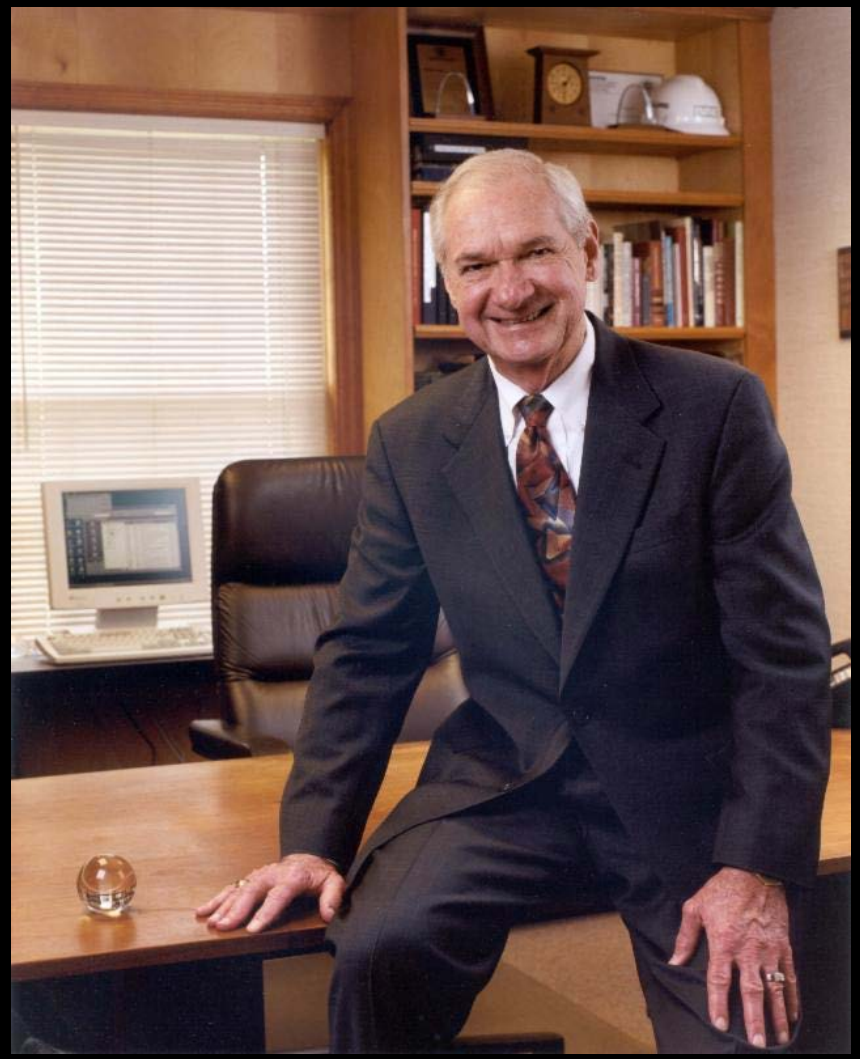
I’ve Had Great Mentors Along the Way

Bill Coad's Thoughts on Energy Conservation

"… that is to practice our profession with an emphasis upon our responsibility to protect the long-range interests of the society we serve and, specifically, to incorporate the ethics of energy conservation and environmental preservation in everything we do."

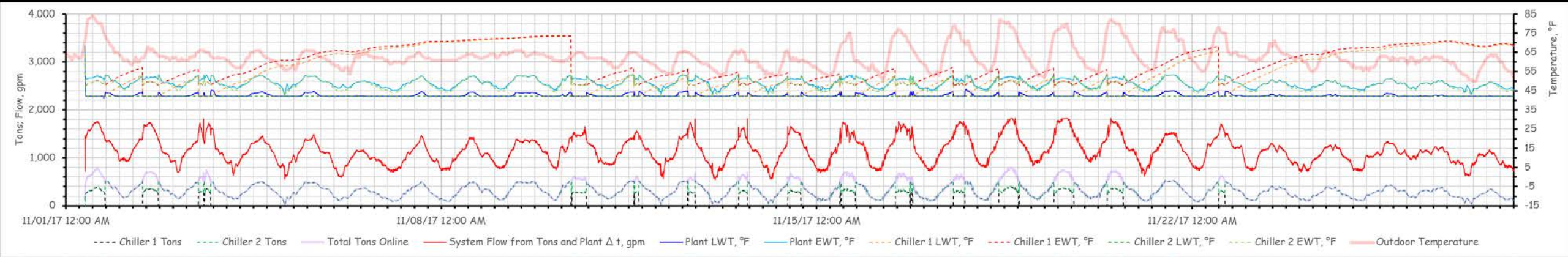
Energy Conservation is an Ethic
ASHRAE Journal, vol. 42, no. 7, p. 16-21

PDF available at
https://tinyurl.com/EnergyConservationEthic



My Most Important Lesson

It’s all about the load profile



A Commissioning Resources Web Site

Google | Facility Dynamics is a consulting | Pacific Northwest Environmental | Map Results | Wind, Forecast, Ra | Home

Not secure | www.av8rdas.com

Apps | 00-Kathy's Calendar | 00 OPB On-Line | 00-Weather | Airplanes | Building Benchmarks | Copy Right | Energy | Financial | Fit Bit | Hawaii Trip | Heart | Heart | Other bookmarks

HOME BLOG RESOURCES TRAINING CONTACT

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What's New? Search

Buildings are Talking to Us

We Just Need to Learn How to Listen

My Goal

Welcome to A Field Perspective on Engineering's commissioning resource website. For those who don't know me from my blog or some other venue, I am a senior engineer for a company named Facility Dynamics Engineering a.k.a FDE, which specializes in commissioning, control system design, and some forensic engineering work.

Facility Dynamics ENGINEERING

http://www.av8rdas.com/

A Blog with a Field Perspective on Building Systems

https://av8rdas.wordpress.com/

A Field Perspective on Engineering

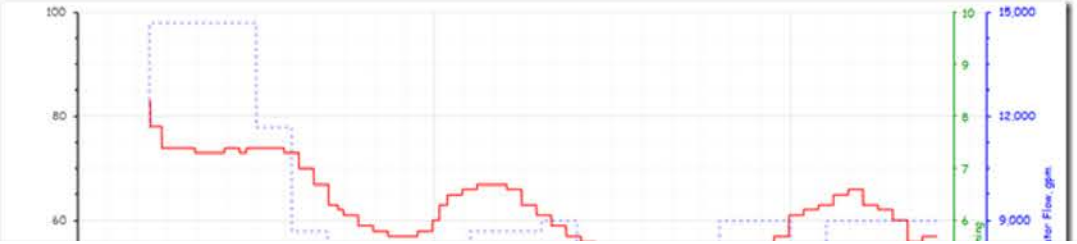
Engineering lessons from the field

Home About

Creating a Third Axis In Excel

Posted on April 19, 2019

One of the challenges that came up when I was creating the time series graph of a 9,000 ton chiller plant load profile that I show in my previous post was that I wanted to plot data series that had numbers in them with very large differences in the order of magnitude.



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Design Review Resources

https://av8rdas.wordpress.com/2013/10/13/design-review-resources/

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← System Diagrams: Practice Making a System Diagram – The Answer

Simulating Small Pressures; My Inch Water Column Simulator →

Design Review Resources

Posted on October 13, 2013 by David Sellers

2023-04-24 Author's Note – This was originally posted in 1028. Some of the links in were broken because sites were modified or shut down. In this repost, I have gone through and fixed them. Otherwise, the post is unchanged from when I first put it up.

In the past, I have written a few posts that bring up the topic of design review including:

- Equipment Replacement Cost Calculations; There's More to it than Simple Payback
- Design Review; Leveraging Opportunities Before Ideas Become Realities
- Design Review – Same Frame Size, Different Fan Sizes – Part 2
- Design Review – Taking a Look at Coil Options

Its not unusual for people to ask me if I can suggest design review resources and that happened just the other day at dinner. So, I thought I would just make a blog post that shared what I know in answer to the request.

Incidentally, some of the posts above were from when the blog first stated on the CSE web site. When the magazine shut down for a while and I decided to continue the blog on my

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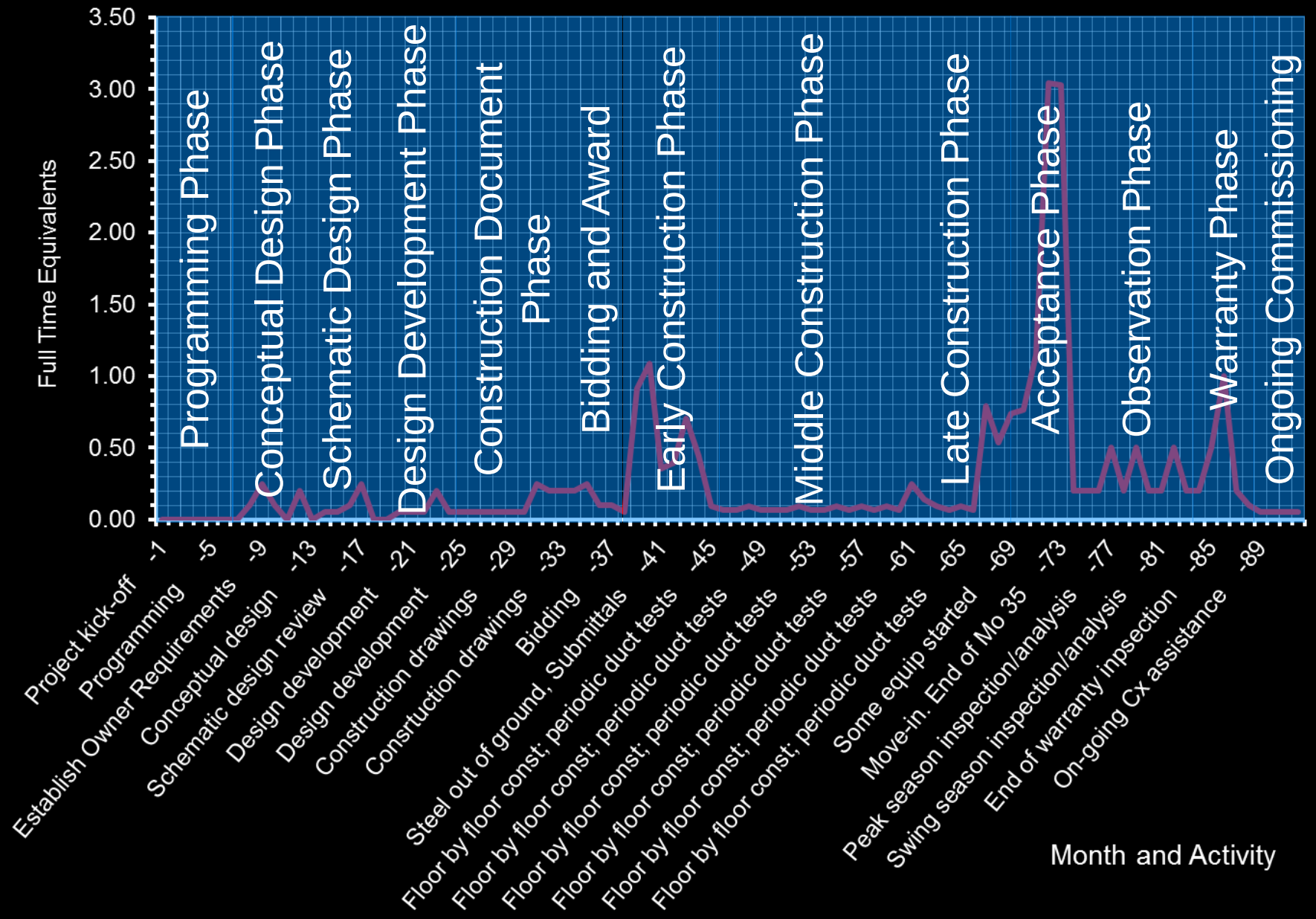
https://tinyurl.com/DesignReviewResources

A Question For You

https://tinyurl.com/PECDesRevWhen2Do

Typical New Construction Commissioning Activity

600,000 sq.ft. High Rise Basis



Design Review During NCx

Design Phase

- Bringing an integration perspective to the drawing board
- Bringing field experience to the drawing board
- Sooner may be better
- Allows the provider to learn the project

Construction Phase

- Takes the form of submittal review
- Some submittals may happen in multiple phases
  - Control system hardware
  - Control system installation
  - Control system database, logic and graphics

Typical New Construction Cx Issues

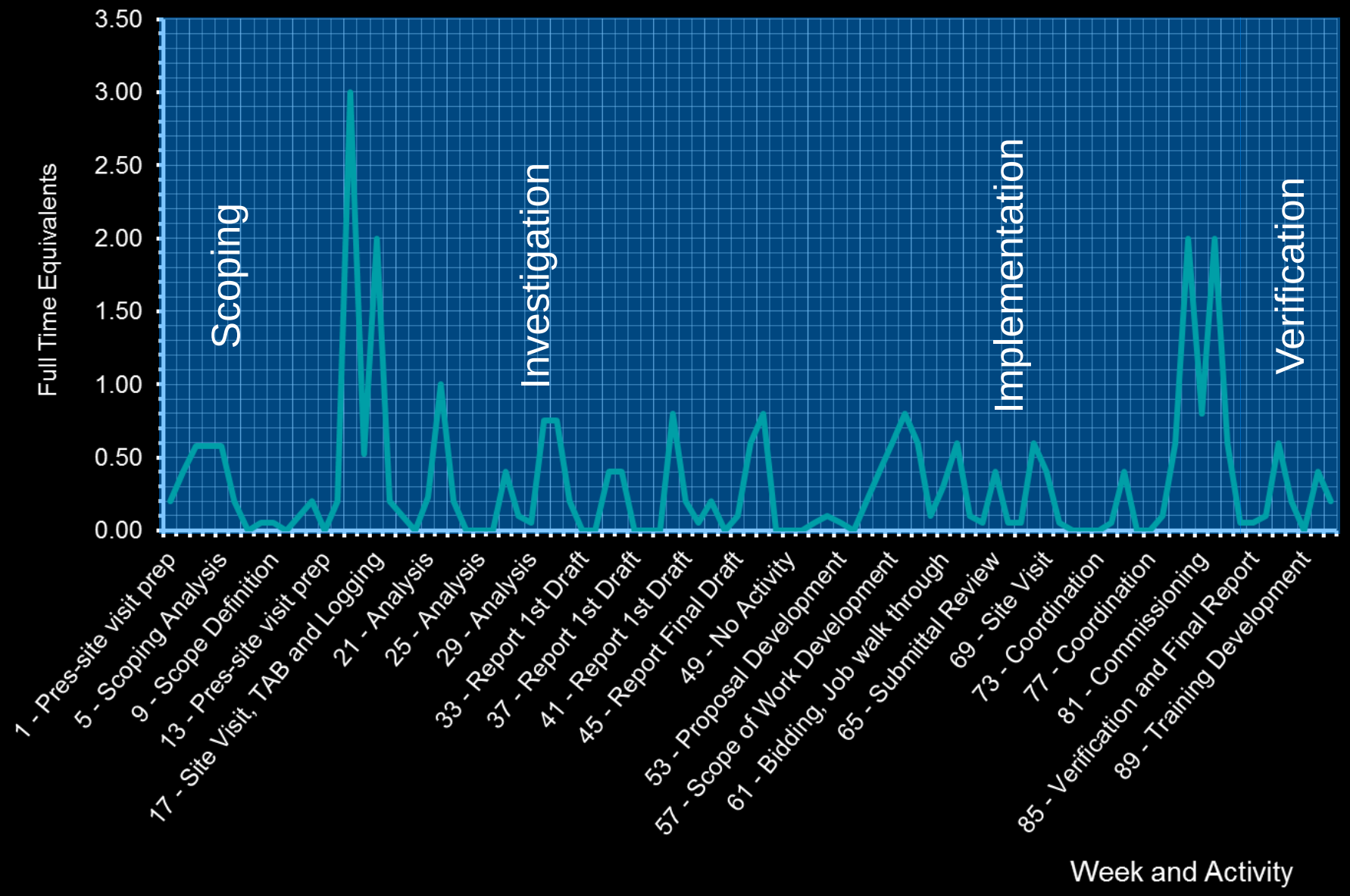
- Poor turn-down capabilities
- Unanticipated interactions
- Pump head is excessive
- Fan static is insufficient
- Rouge zones
- Control sensor calibration
- Control sensor location
- Control system logic
- Control system design
- Schedules missing
- Equipment missing

Typical Existing Building Cx Issues

- Poor turn-down capabilities
- Unanticipated interactions
- Pump head is excessive
- Fan static is insufficient
- Rouge zones
- Control sensor calibration
- Control sensor location
- Control system logic
- Control system design
- Schedules missing
- Equipment missing

Typical Existing Building Construction Commissioning Activity

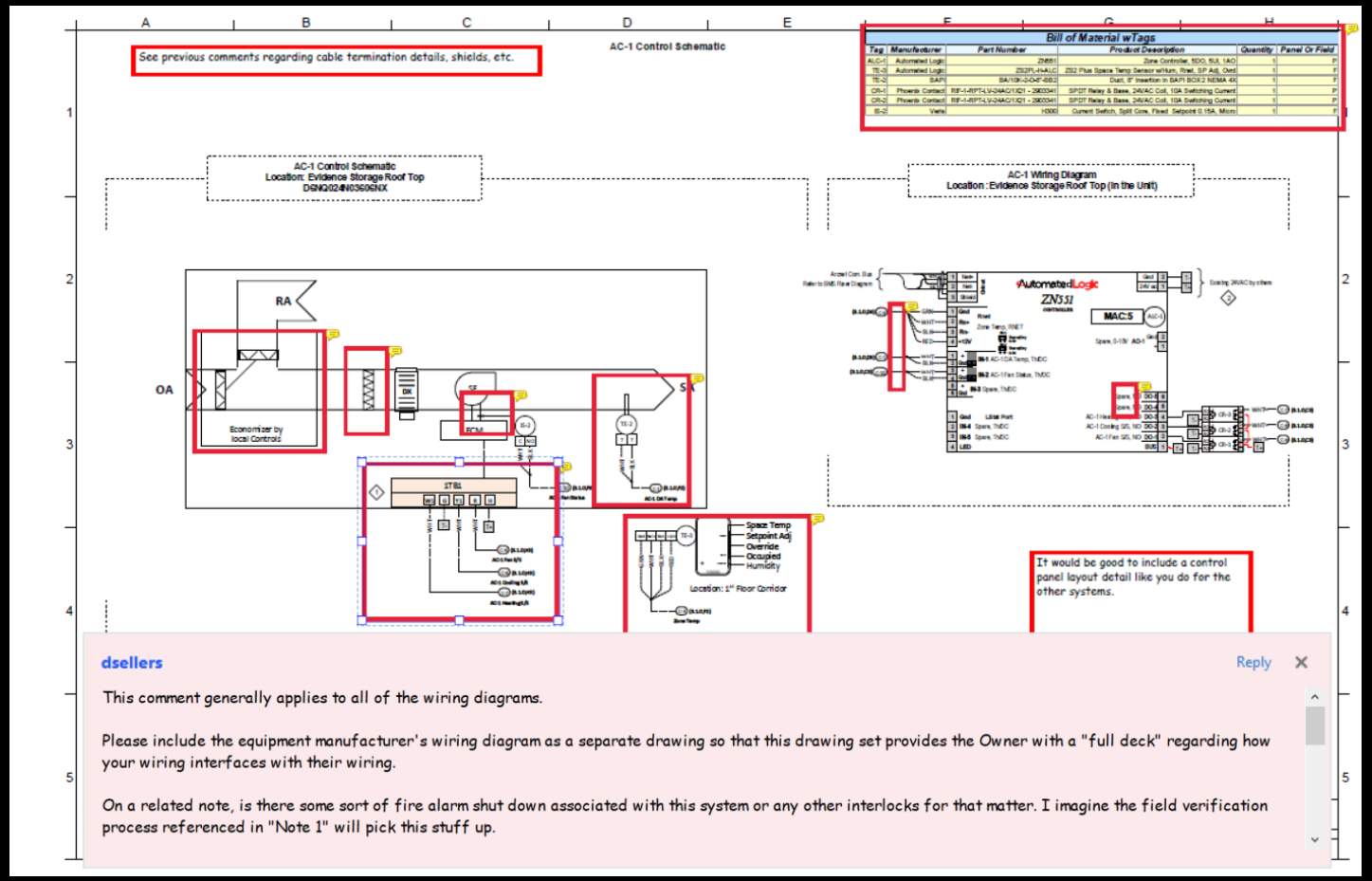
750,000 sq.ft. Hospital Basis



Processes that Complement Design Review

Submittal Review

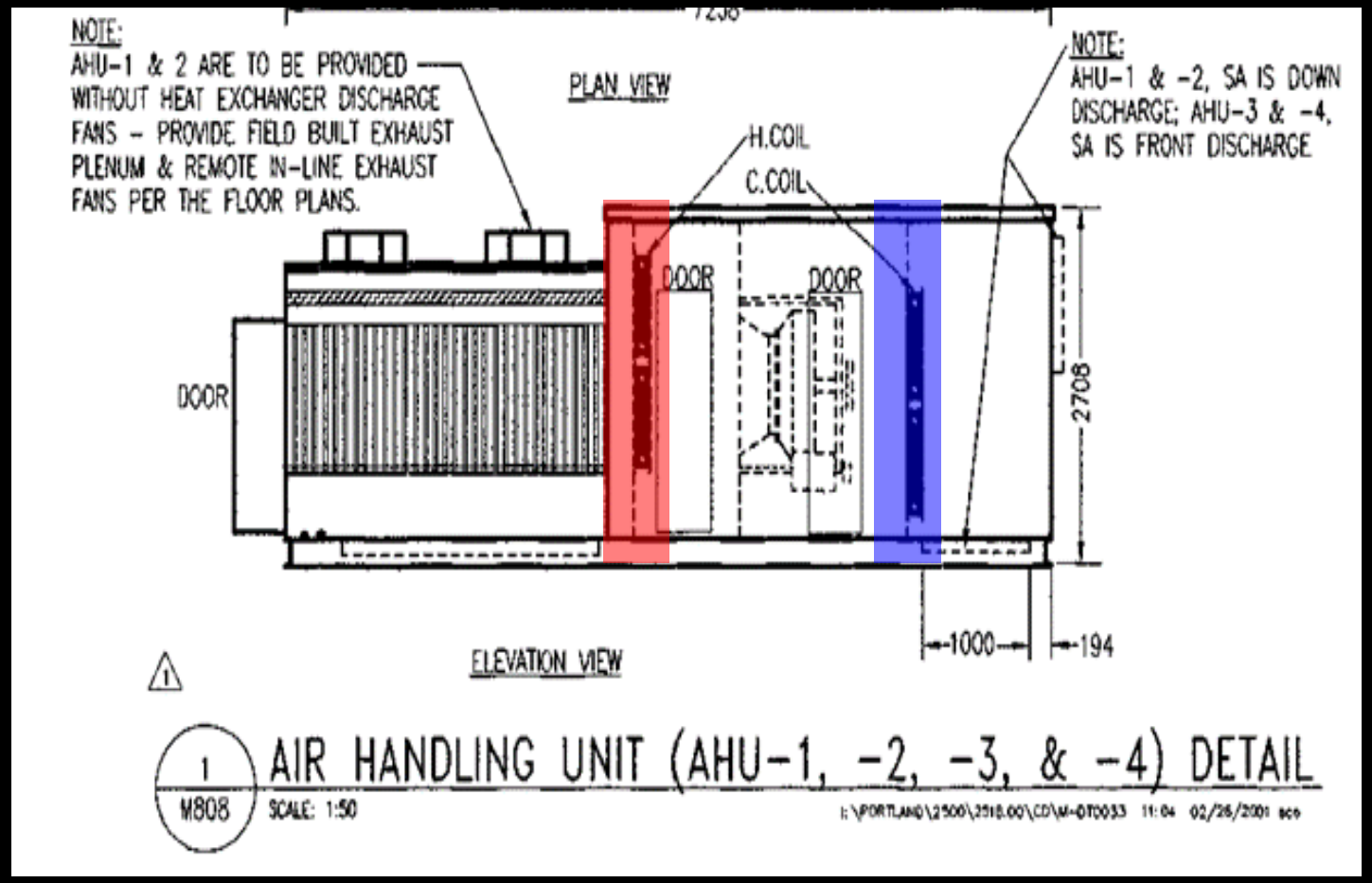
- You are about to transition from concepts on paper to physical, wired, bolted, welded in place reality
- Just because you asked for it does not mean someone read the spec and drawings and thus, you will get it



Processes that Complement Design Review

Construction Observation

- Just because you asked for it and marked up the submittal to reflect that does not mean that the information got to the field

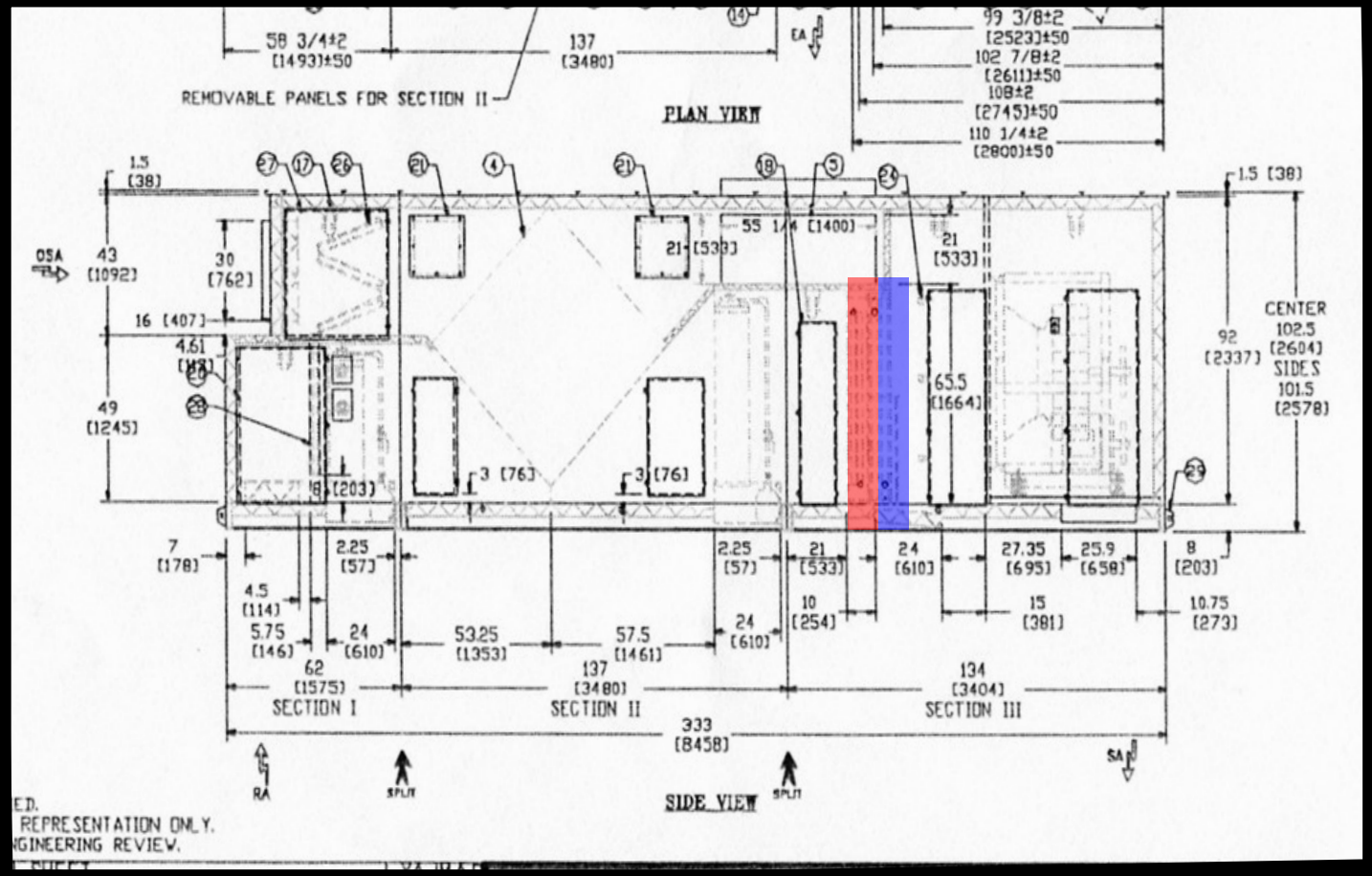


Construction Documents

Processes that Complement Design Review

Construction Observation

- Just because you asked for it and marked up the submittal to reflect that does not mean that the information got to the field

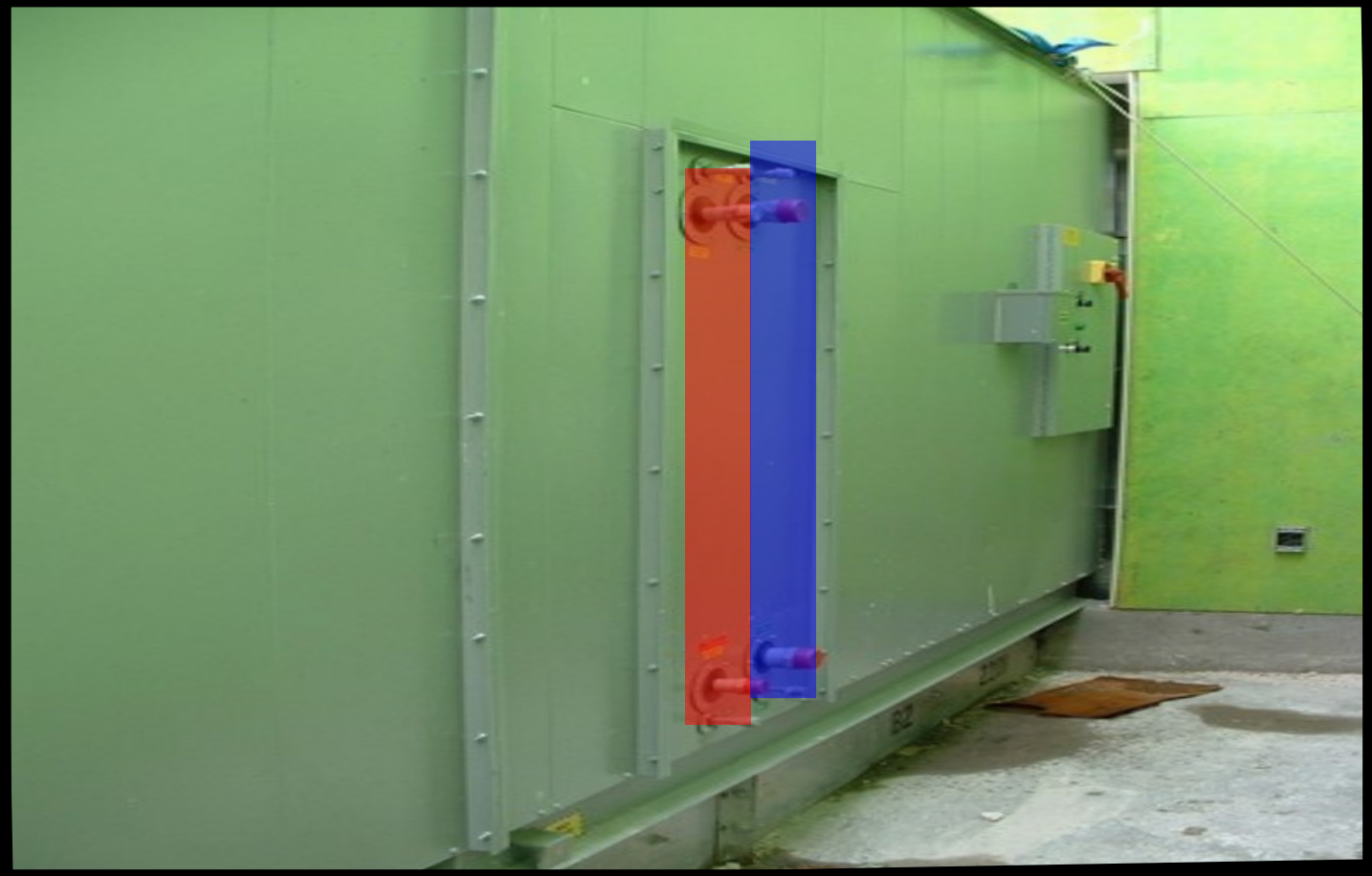


Submittal

Processes that Complement Design Review

Construction Observation

- Just because you asked for it and marked up the submittal to reflect that does not mean that the information got to the field



Reality

Processes that Complement Design Review

Construction Observation

- Just because you asked for it and marked up the submittal to reflect that does not mean that the information got to the field
- Pausing for corrections mid-reality is better than making corrections later

Reality

Design Review Skills

Technical

- Understand systems and equipment
  - Design experience
  - Field experience
  - Mentoring
- O&M interest and perspective
- Recognize the load importance of the load profile and being able to follow it

Non-technical

- Detail oriented
- Integration perspective
- People skills
- Curious
- Willing to learn
- Persistent

Design Review Targets

energydesignresources

EnergyDesignResources.Com

Cx Assistant™

Design Review Tool Module
Master Reference Guide

Developed by
Portland Energy Conservation, Inc.

Under contract to
Pacific Gas and Electric Company

March 2007

Design Review Targets

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Cx Assistant™

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Pacific Gas and Electric Company

March 2007

Table of Contents

Let’s Try It

Given

Fan Power Relationship

$$bhp_{Fan} = \left(\frac{Flow_{cfm} \times Static_{in.w.c.}}{6{,}356 \times \eta_{Fan}} \right)$$

Where:

bhp_{Fan} = Input to the system to produce the flow and static pressure.

$Flow$ = Flow rate in cubic feet per minute.

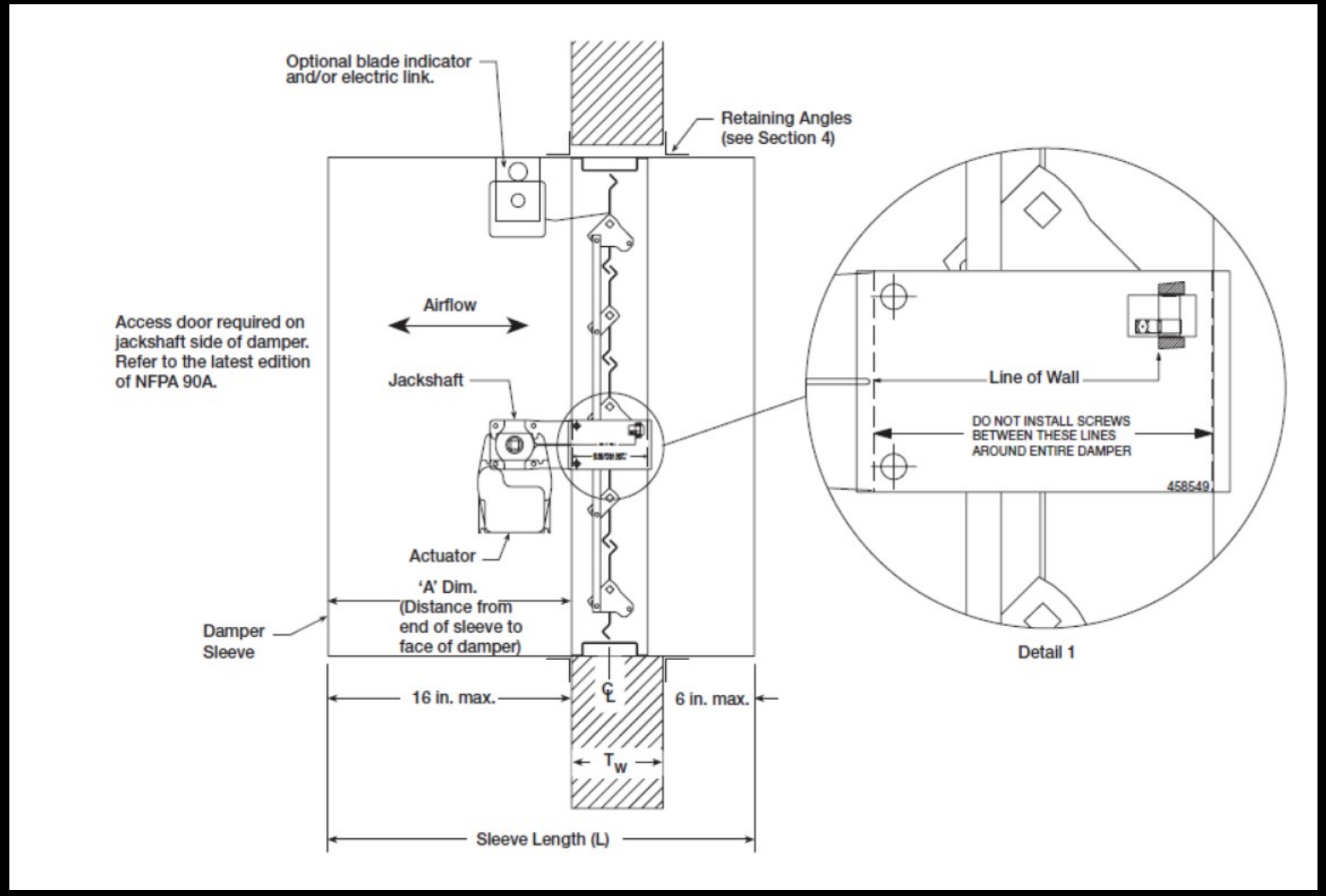
$Static$ = The fan static pressure in inches water column.

6,356 = A units conversion constant that is good for air at approximately 0 - 2,000 $feet_{msl}$ and between -40°F and 120°F.

η_{Fan} = Fan static efficiency.

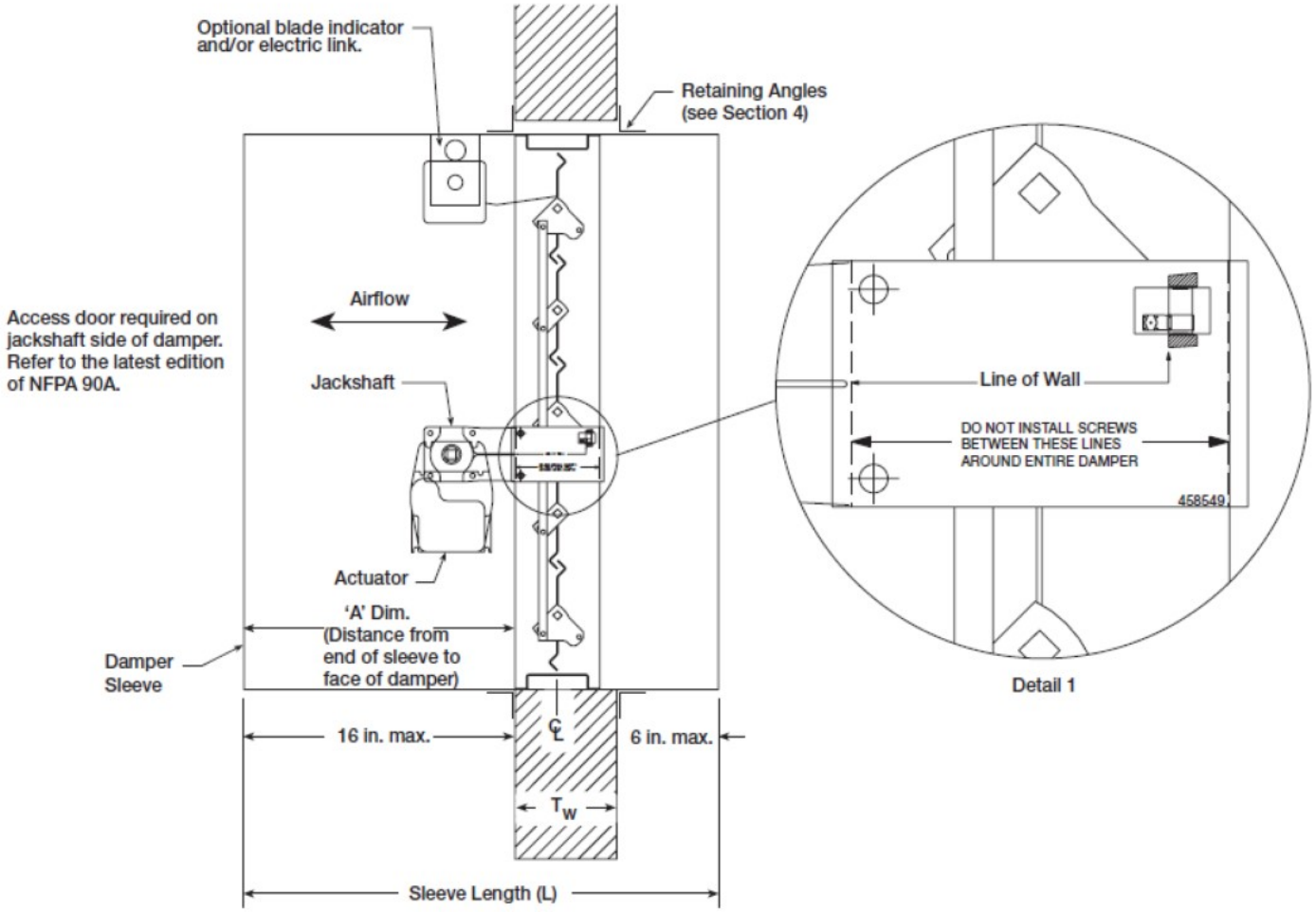
Given

V-Groove Blade Fire/Smoke Damper Detail on the drawings for a project



Given

V-Groove Blade Fire/Smoke Damper Product Data



Given

V-Groove Blade

Given

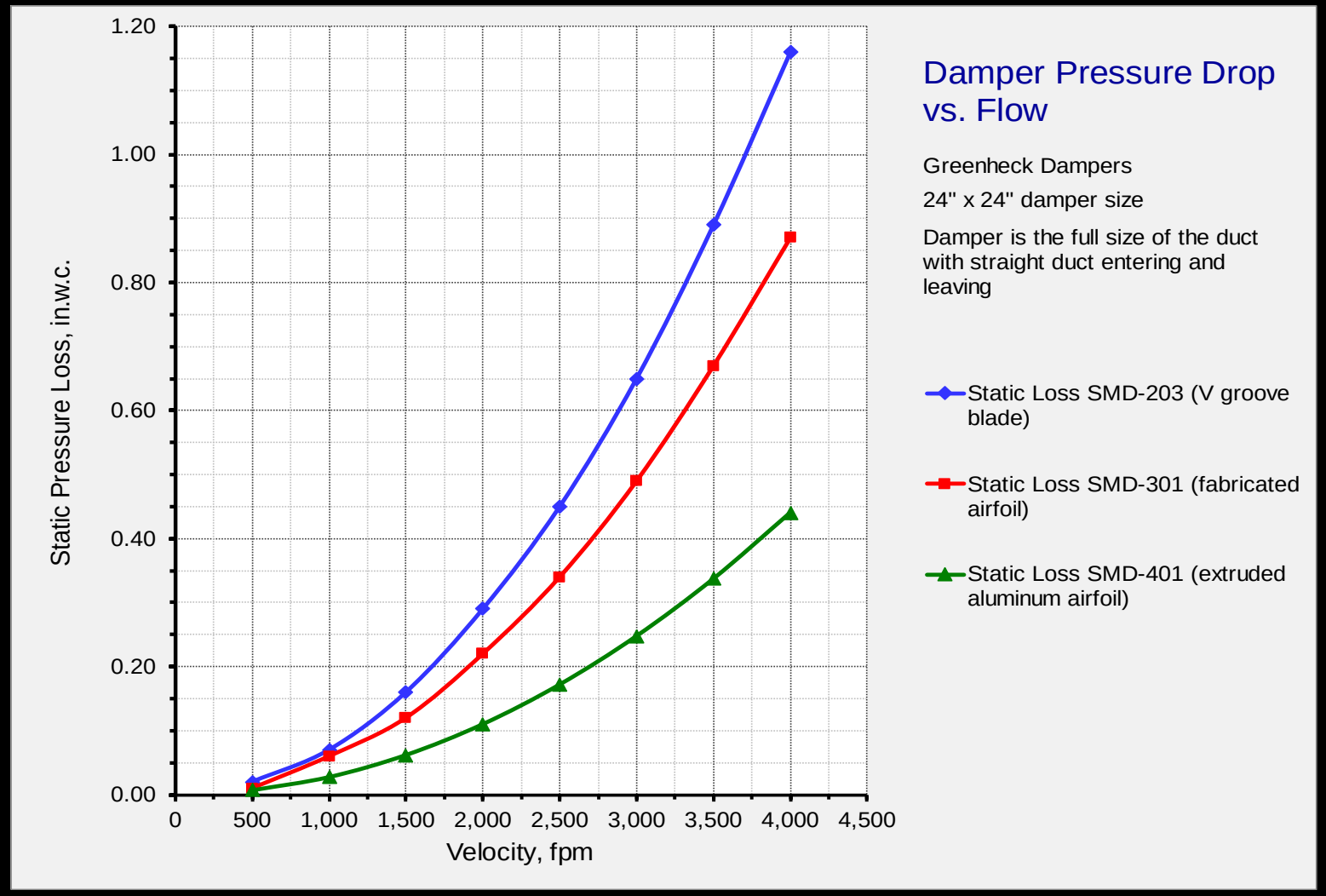
Fabricated Airfoil Blade

Given

Extruded Airfoil Blade

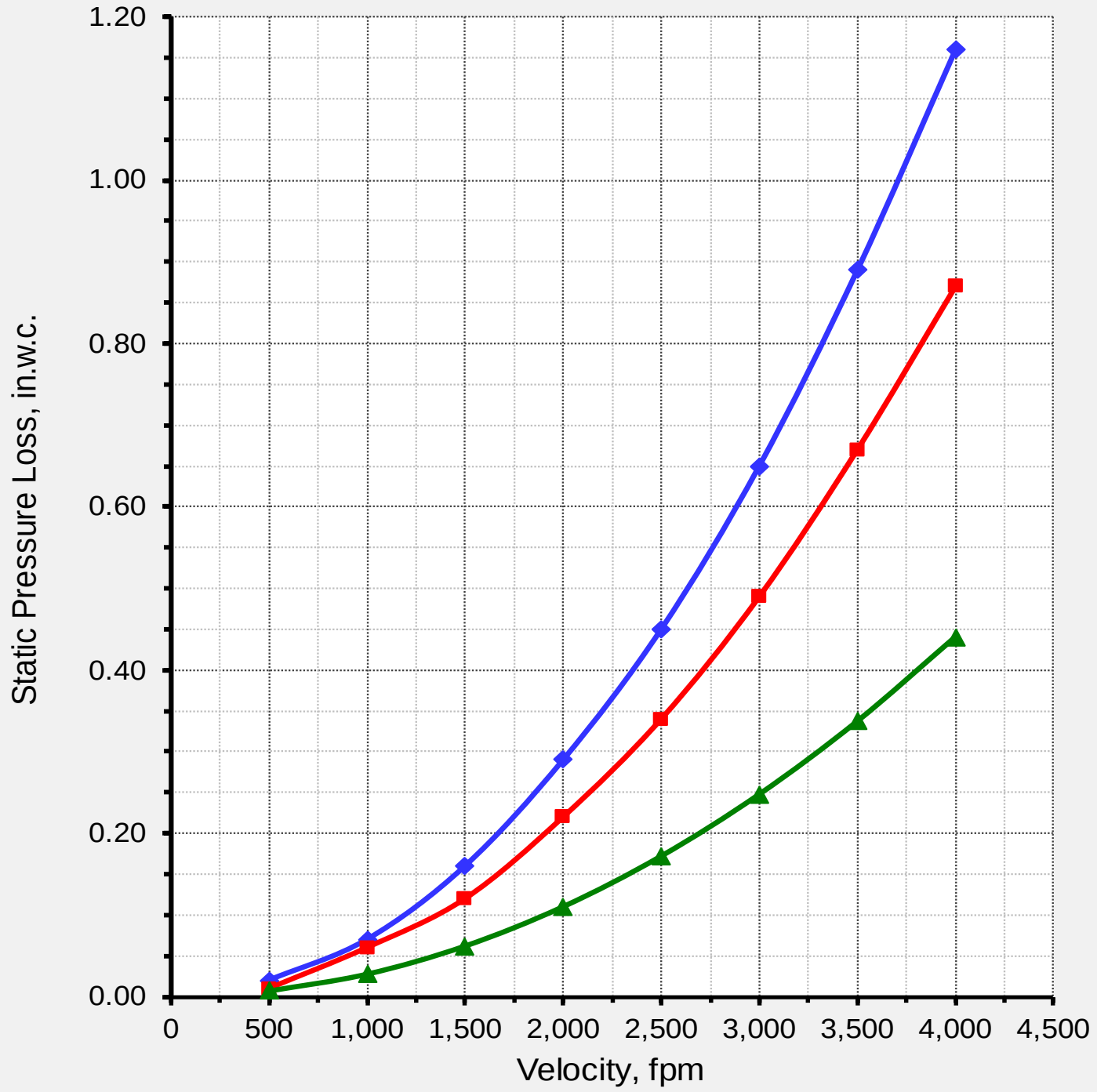
Given

Pressure Drop Curves



A Question For You

https://tinyurl.com/PECDesRevFSD



Damper Pressure Drop vs. Flow

Greenheck Dampers

24" x 24" damper size

Damper is the full size of the duct with straight duct entering and leaving

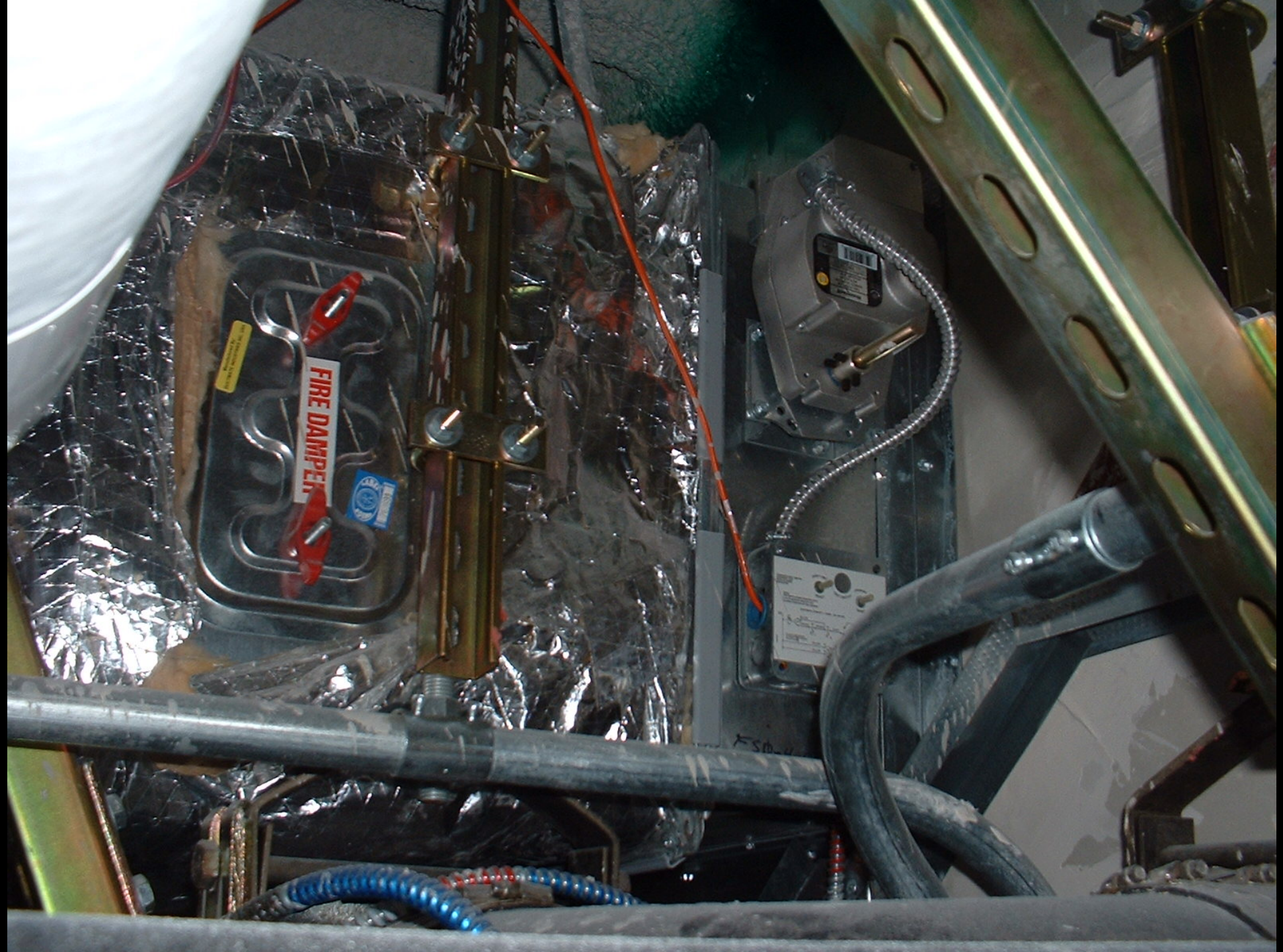
- Static Loss SMD-203 (V groove blade)
- Static Loss SMD-301 (fabricated airfoil)
- Static Loss SMD-401 (extruded aluminum airfoil)

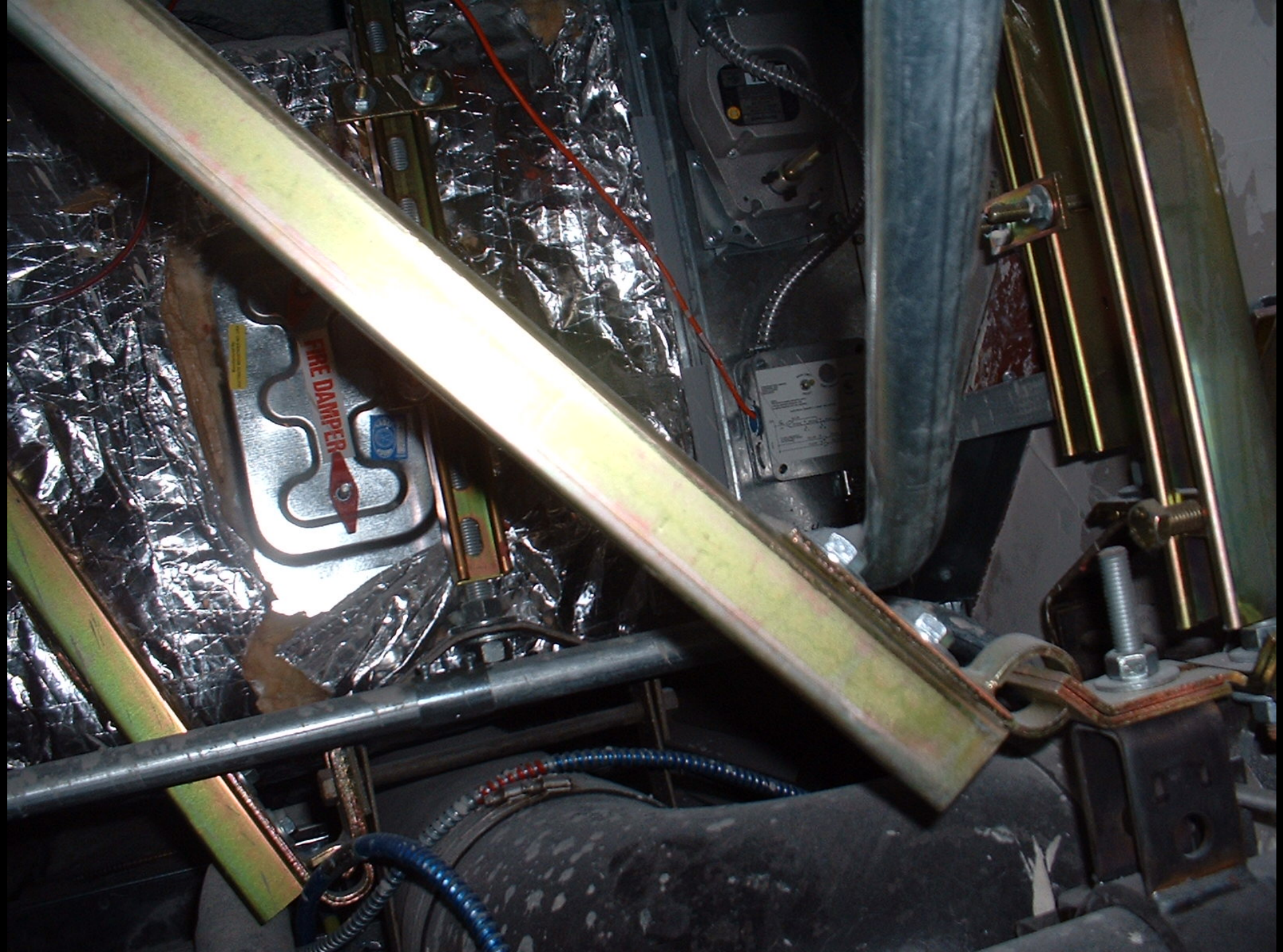

11/14/2002


11/14/2002

G-P 5/8" FIREGUARD

APARTMENTS
EARLY BIRD Specials
11/14/2002

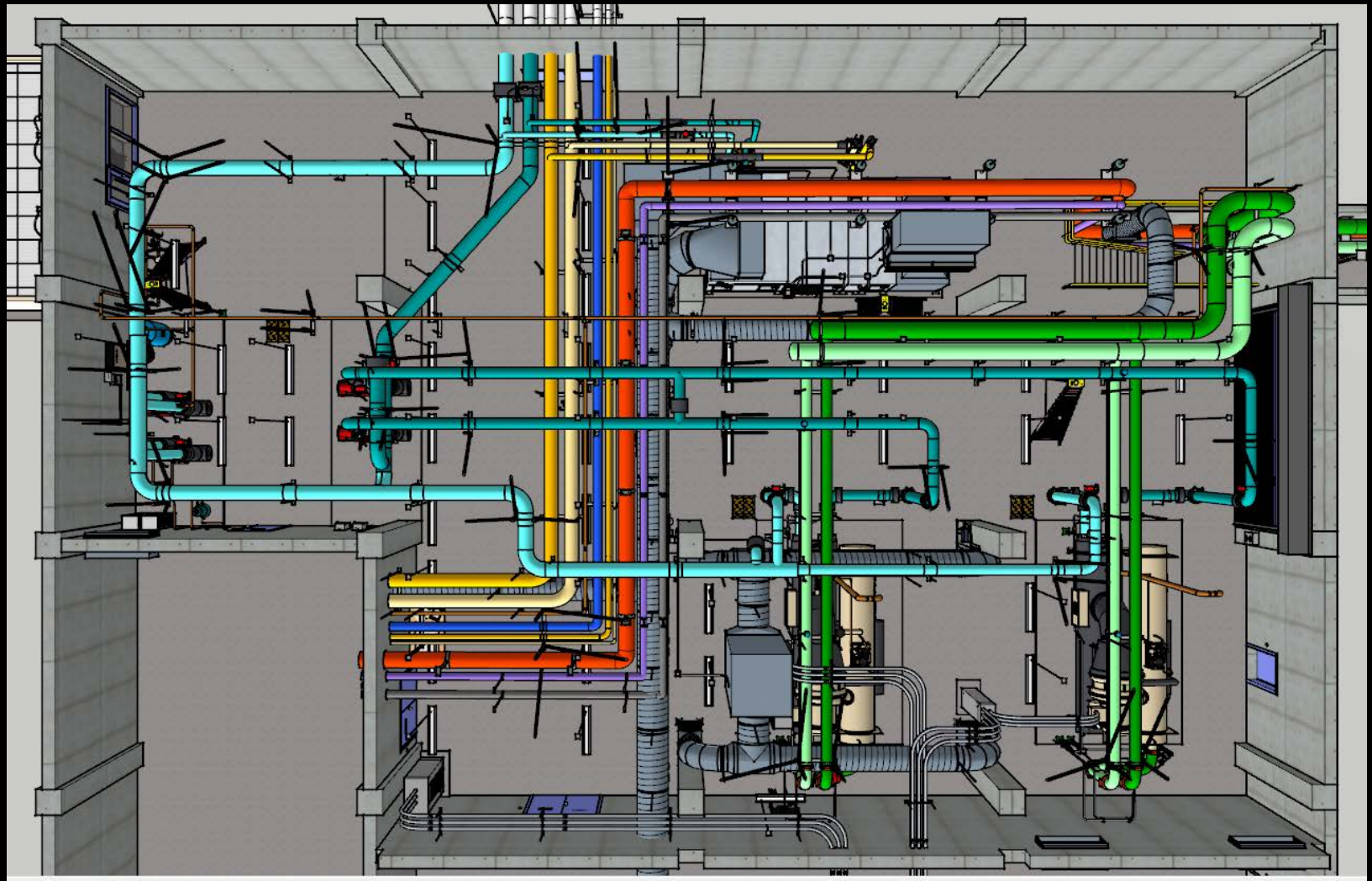

FIRE DAMPER


FIRE DAMPER

Let’s Try Another

Given

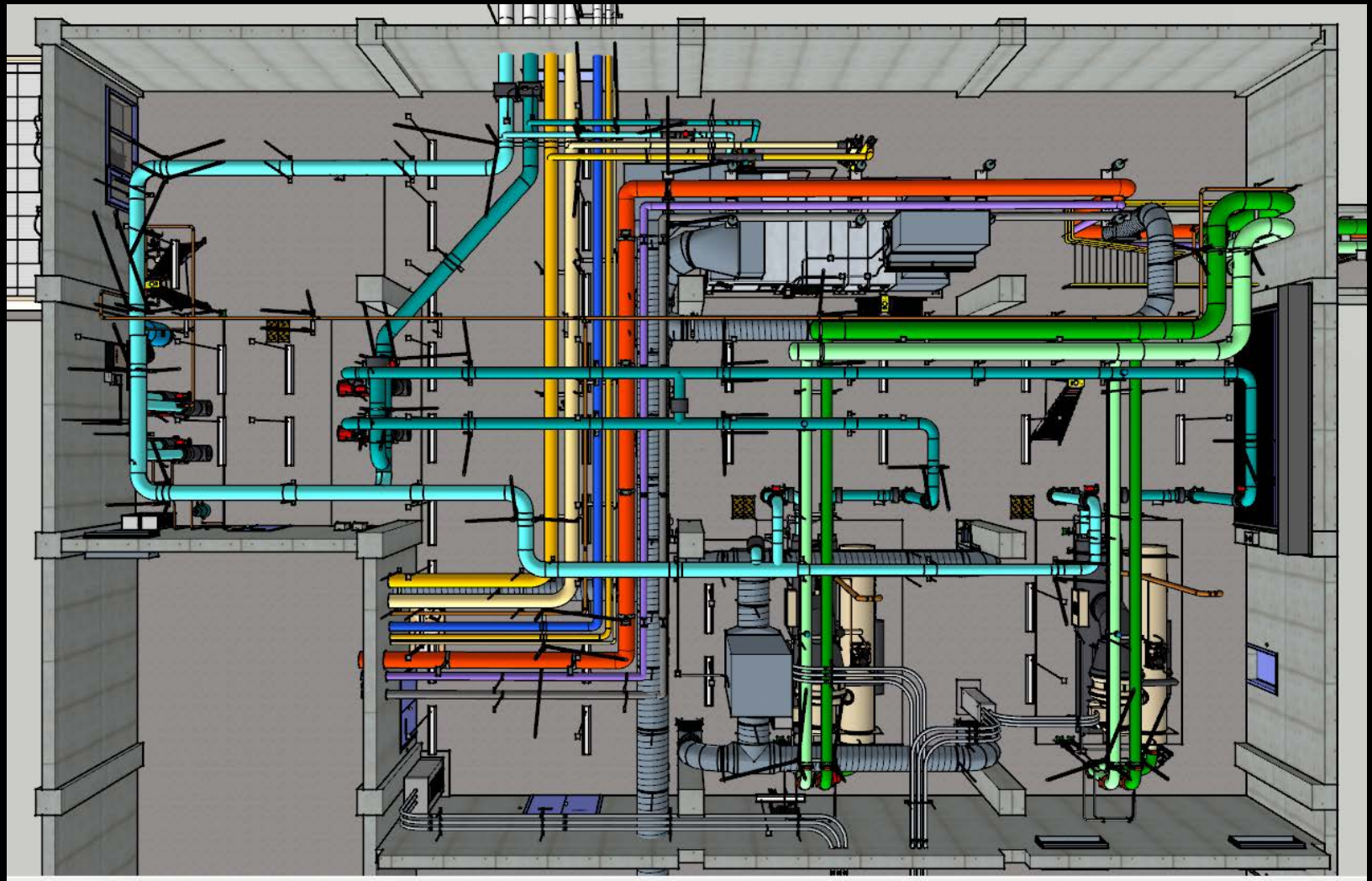
The installed reality



Given

A Few “Rules of Thumb”

1. Designers will go up a line size if the friction rate exceeds 4 ft.w.c. per 100 ft. of pipe
2. The equivalent feet of pipe will be 1.5 to 2 times the linear feet of pipe



Given

The pump portion of the equipment schedule

Pump Schedule

Pump Number	Unit or System Served	Make	Model	Flow, gpm	Head, ft.w.c.	Impeller Diameter, in.	Rpm	Bhp	Minimum Pump Efficiency	Motor Hp	Motor Volts	Motor Phase	Comments
CHWP-01	Chiller 01 Evaporator Pump	Bell and Gossett	1510 6G	1,100	40	10-7/8	1,150	13.6	82.1%	15.0	480.0	3.0	
CHWP-02	Chiller 02 Evaporator Pump	Bell and Gossett	1510 6G	1,100	40	10-7/8	1,150	13.6	82.1%	15.0	480.0	3.0	
CHWP-03	Chilled Water Distribution Pump	Bell and Gossett	1510 5A	1,100	90	6	3,550	34.7	72.0%	40.0	480.0	3.0	Note 1,3
CHWP-04	Chilled Water Distribution Pump	Bell and Gossett	1510 5A	1,100	90	6	3,550	34.7	72.0%	40.0	480.0	3.0	Note 1, 3
CWP-01	Chiller 01 Condenser Pump	Bell and Gossett	1510 6E	1,650	84	10-1/4	1,770	40.7	85.9%	50.0	480.0	3.0	Note 2
CWP-02	Chiller 02 Condenser Pump	Bell and Gossett	1510 6E	1,650	84	10-1/4	1,770	40.7	85.9%	50.0	480.0	3.0	Note 2

Notes

1. VFD Rated Motor
2. Pump selection allows for the head required for the future addition of a 550 ton absorptoin chiller
3. Revision 1, VE Analysis

Given

The cooling coil portion of the equipment schedule

Cooling Coil Schedule

Coil Number	Unit or System Served	Flow, cfm	Maximum Fins per Inch	Rows	Minimum Face Area, sq.ft.	Airside Performance						Waterside Performance					Comments
						Entering Air		Leaving Air		Face Velocity, fpm	Pressure Drop, in.w.c.	Entering Water Temperature, °F	Leaving Water Temperature, °F	Flow Rate, gpm	Pressure Drop, ft.w.c.	Tons	
						Dry bulb, °F	Wet bulb, °F	Dry bulb, °F	Wet bulb, °F								
CC-1	AHU1 - Hotel Lobby and Administration	26,000	8	6	52.0	81.0	63.8	51.0	50.5	433	0.63	42.0	56.0	141.0	8.6	82.2	Note 3
CC-2	Main Ball Room	20,000	9	6	40.0	86.6	66.1	51.4	50.9	500	0.82	42.0	54.0	148.7	11.0	74.4	Note 3
CC-3	Junior Ball Room	15,000	8	6	30.0	80.2	63.5	51.7	51.1	500	0.74	42.0	54.0	88.7	9.2	44.3	Note 3
CC-4	Meeting Rooms	15,000	9	6	30.0	90.3	67.6	52.2	51.6	500	0.83	42.0	54.0	120.1	9.1	60.1	3-way valve, Notes 1, 4
CC-5	Corridor Make-up Air	23,775	8	6	47.6	90.3	67.6	53.7	52.9	495	0.74	42.0	54.0	177.0	4.9	88.5	Note 4
CC-6	Corridor Make-up Air	23,775	8	6	47.6	90.3	67.6	53.7	52.9	495	0.74	42.0	54.0	177.0	4.9	88.5	Note 4
CC-7	Laundry	10,000	8	6	20.0	81.3	65.0	53.9	53.3	500	0.75	42.0	54.0	57.9	3.1	29.0	Note 3
CC-8	Breakfast/Lunch Café	6,500	8	6	13.0	82.7	64.5	50.9	50.4	406	0.56	42.0	54.0	43.9	7.8	21.9	3-way valve, Notes 1,3
CC-9	Restaurant and Lounge	11,500	8	6	23.0	82.7	64.5	51.8	51.2	479	0.70	42.0	54.0	73.7	9.3	36.9	Note 3
CC-10	Main Kitchen	19,000	8	6	38.0	88.5	67.6	51.5	51.0	396	0.56	42.0	54.0	157.2	9.2	78.6	Note3
VF-1	Electrical Room	8,200	8	3	16.4	83.7	67.6	60.7	57.9	410	0.35	42.0	54.0	42.5	9.8	21.2	Note 3
CC-GR01	Typcial North Exposure Guest Room (294 thus)	300	14	3	1.4	72.0	60.0	49.4	49.0	214	0.15	42.0	48.6	2.7	3.5	0.7	Note 2
CC-GR02	Typcial East Exposure Guest Room (22 thus)	400	14	3	1.4	72.0	60.0	51.2	50.5	285	0.22	42.0	49.4	2.8	3.7	0.9	Note 2
CC-GR03	Typcial South Exposure Guest Room (292 thus)	600	14	3	2.2	72.0	60.0	50.4	49.8	275	0.21	42.0	50.1	4.1	9.7	1.4	Note 2
CC-GR04	Typcial West Exposure Guest Room (22 thus)	400	14	3	1.4	72.0	60.0	51.2	50.5	285	0.22	42.0	49.4	2.8	3.7	0.9	Note 2
CC-CR05	Typcial Luxury Guest Room (4 thus)	1,000	14	3	3.2	72.0	60.0	51.2	50.4	313	0.26	42.0	50.3	6.3	8.9	2.2	0

Note 1 Bypass balanced to 5 gpm with the valve positioned to full bypass

Note 2 One fan coil at the top of each riser to have a three way valve with the bypass balanced to the fan coil design flow rate when the valve in full bypass

Note 3 Integrated economizer equipped

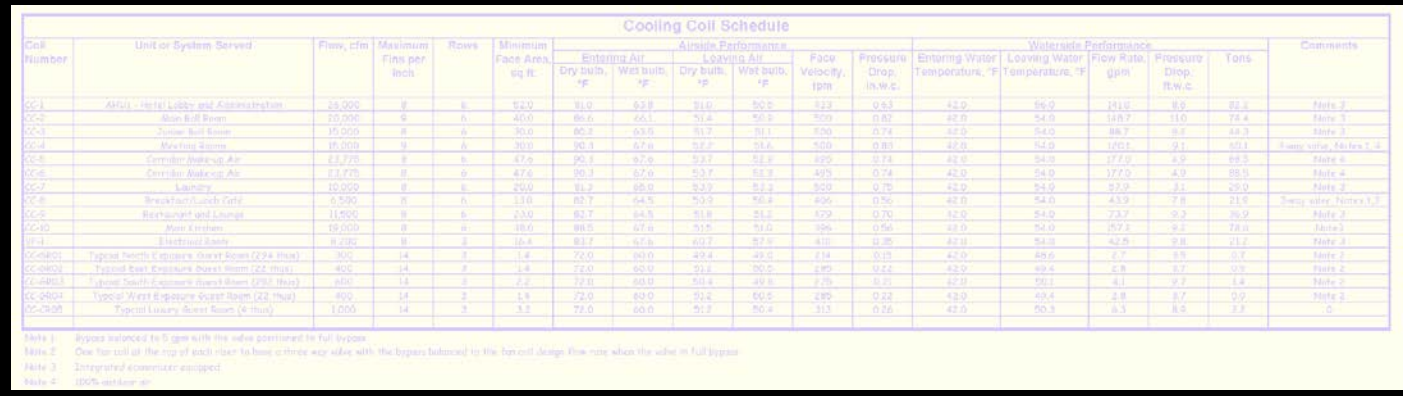
Note 4 100% outdoor air

Assignment

- Assess the diversity designed into the chilled water plant
- Estimate the pump head required for an evaporator pump

A resource:

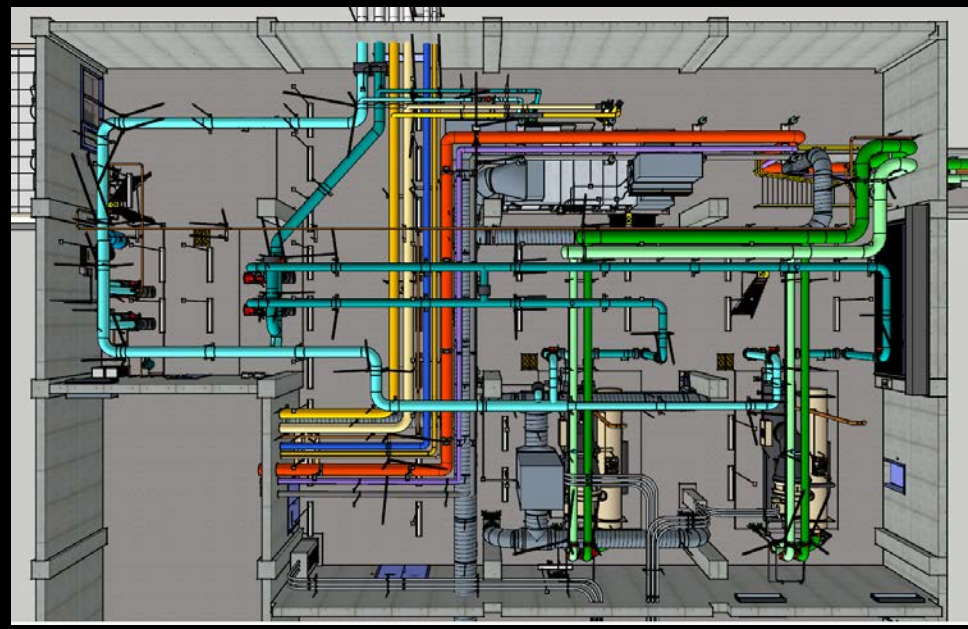
https://tinyurl.com/FieldEstimate

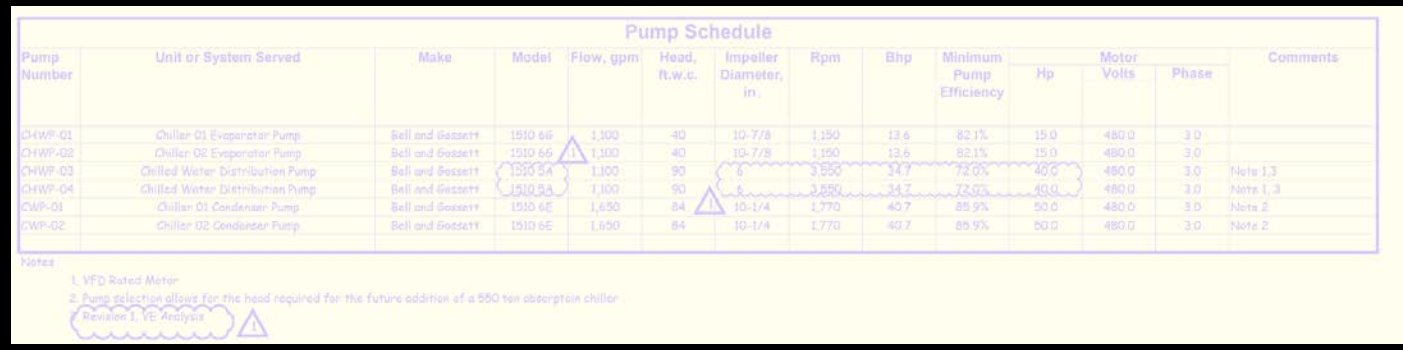


Cooling Coil Schedule

Coil Number	Unit or System Served	Flow, cfm	Maximum Fins per inch	Rows	Minimum Face Area, sq ft	Airside Performance: Entering Air Dry bulb, °F	Entering Air Wet bulb, °F	Leaving Air Dry bulb, °F	Leaving Air Wet bulb, °F	Face Velocity, fpm	Pressure Drop, in.w.c.	Waterside Performance: Entering Water Temperature, °F	Leaving Water Temperature, °F	Flow Rate, gpm	Pressure Drop, ft.w.c.	Tons	Comments
CC-1	AHU1 - Hotel Lobby and Administration	26,000	8	6	52.0	81.0	63.8	51.0	50.5	523	0.63	42.0	56.0	141.6	8.0	82.1	Note 2
CC-2	Ballroom	25,000	8	6	40.0	80.6	66.1	51.4	50.3	625	0.82	42.0	54.0	148.7	11.0	78.4	Note 3
CC-3	Junior Ball Room	15,000	8	6	30.0	80.3	63.5	51.7	51.1	500	0.74	42.0	54.0	88.7	9.3	44.3	Note 2
CC-4	Meeting Rooms	15,000	8	6	30.0	90.3	67.8	52.2	51.6	500	0.83	42.0	54.0	100.1	9.1	50.1	Swing valve, Notes 1, 3
CC-5	Corridor Make-up Air	23,775	8	6	47.6	90.3	67.8	53.7	53.3	499	0.74	42.0	54.0	177.0	4.9	88.5	Note 4
CC-6	Corridor Make-up Air	23,775	8	6	47.6	90.3	67.8	53.7	53.3	499	0.74	42.0	54.0	177.0	4.9	88.5	Note 4
CC-7	Laundry	10,000	8	6	20.0	91.2	68.0	52.9	52.4	500	0.75	42.0	54.0	57.9	3.1	29.0	Note 2
CC-8	Breakfast/Lunch Café	6,500	8	6	13.0	82.7	64.5	50.0	49.4	496	0.56	42.0	54.0	43.9	7.8	21.9	Swing valve, Notes 1, 3
CC-9	Restaurant and Lounge	11,500	8	6	23.0	82.7	64.5	51.8	51.2	499	0.70	42.0	54.0	73.7	9.3	36.9	Note 2
CC-10	Main Kitchen	19,000	8	6	38.0	86.5	67.6	51.5	51.0	496	0.56	42.0	54.0	157.1	9.1	78.6	Note 2
CC-11	Electrical Room	8,200	8	6	16.4	83.7	67.6	60.7	57.9	500	0.35	42.0	54.0	42.5	2.8	21.2	Note 3
CC-GR01	Typical South Exposure Guest Room (224 this)	300	14	3	1.4	72.0	60.0	52.4	49.5	214	0.13	42.0	49.6	6.7	3.5	0.7	Note 2
CC-GR02	Typical East Exposure Guest Room (22 this)	400	14	3	1.9	72.0	60.0	52.4	50.0	285	0.22	42.0	49.4	8.8	3.7	0.9	Note 2
CC-GR03	Typical South Exposure Guest Room (257 this)	450	14	3	2.2	72.0	60.0	50.4	49.6	226	0.21	42.0	50.1	8.1	4.7	1.4	Note 2
CC-GR04	Typical West Exposure Guest Room (22 this)	400	14	3	1.9	72.0	60.0	52.4	50.5	285	0.22	42.0	49.4	8.8	3.7	0.9	Note 2
CC-GR05	Typical Luxury Guest Room (4 this)	1,000	14	3	3.3	72.0	60.0	51.2	50.4	313	0.26	42.0	50.3	9.3	8.5	2.3	0

Note 1 Bypass balanced to 5 gpm with the valve positioned in full bypass
Note 2 One fan coil at the top of each riser to have a three way valve with the bypass balanced to the fan coil design flow rate when the valve in full bypass
Note 3 Integrated economizer equipped
Note 4 100% outdoor air





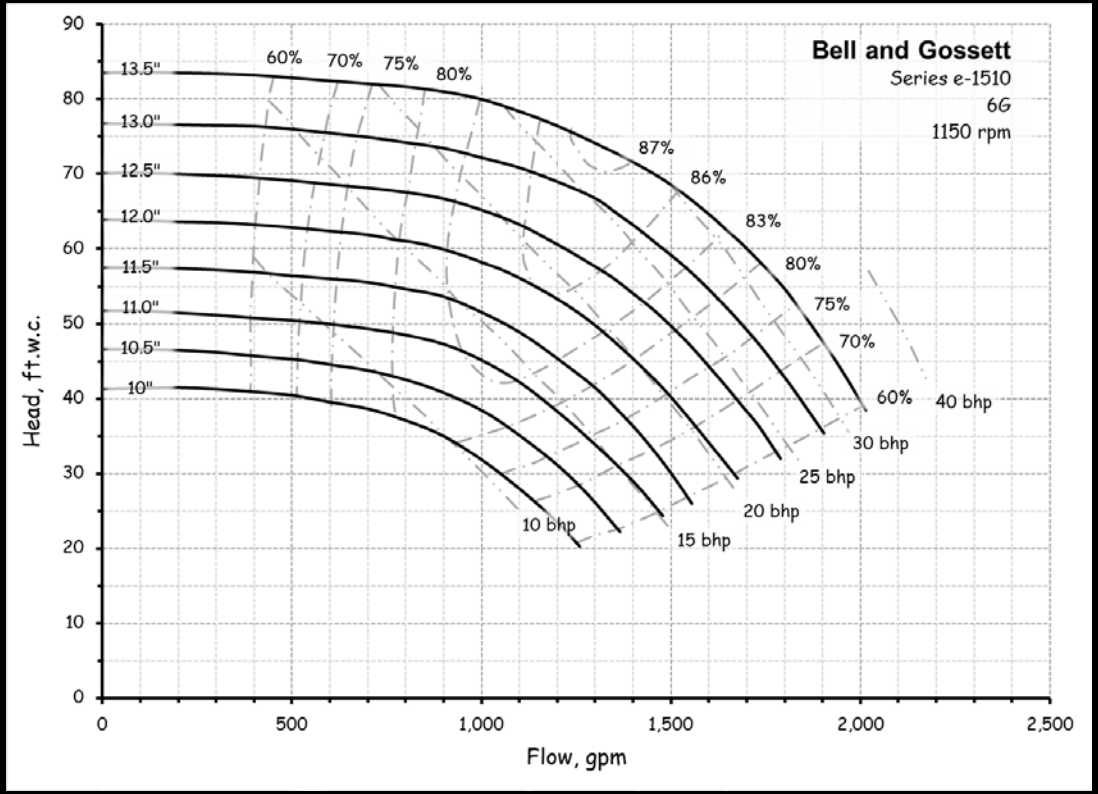
Pump Schedule

Pump Number	Unit or System Served	Make	Model	Flow, gpm	Head, ft.w.c.	Impeller Diameter, in.	Rpm	Bhp	Minimum Pump Efficiency	Motor Hp	Motor Volts	Motor Phase	Comments
CHWP-01	Chiller 01 Evaporator Pump	Bell and Gossett	1510 6G	1,100	40	10-7/8	1,150	13.6	82.1%	15.0	480.0	3.0	
CHWP-02	Chiller 02 Evaporator Pump	Bell and Gossett	1510 6G	1,100	40	10-7/8	1,150	13.6	82.1%	15.0	480.0	3.0	
CHWP-03	Chilled Water Distribution Pump	Bell and Gossett	1510 5A	1,100	90	6	3,550	34.7	72.0%	40.0	480.0	3.0	Note 1,3
CHWP-04	Chilled Water Distribution Pump	Bell and Gossett	1510 5A	1,100	90	6	3,550	34.7	72.0%	40.0	480.0	3.0	Note 1, 3
CWP-01	Chiller 01 Condenser Pump	Bell and Gossett	1510 6E	1,650	64	10-1/4	1,770	40.7	85.9%	50.0	480.0	3.0	Note 2
CWP-02	Chiller 02 Condenser Pump	Bell and Gossett	1510 6E	1,650	64	10-1/4	1,770	40.7	85.9%	50.0	480.0	3.0	Note 2

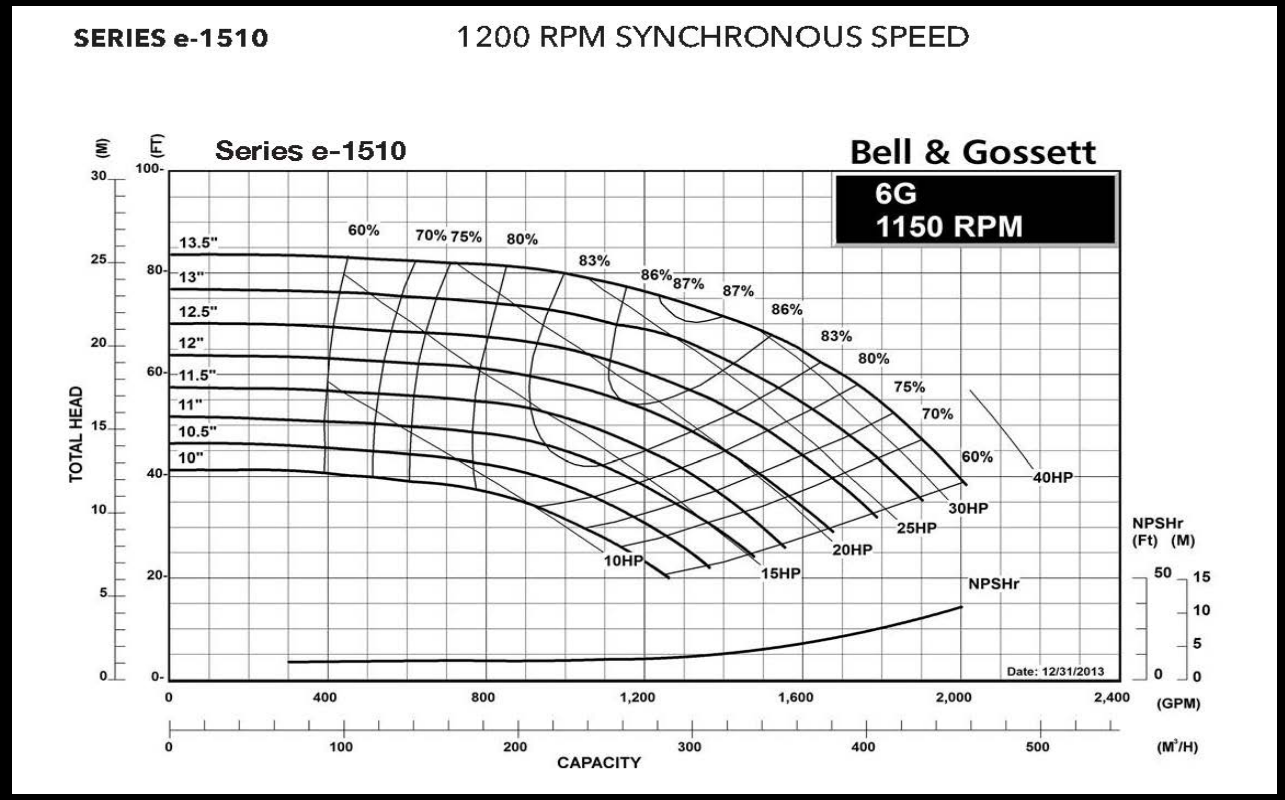
Notes
1. VFD Rated Motor
2. Pump selection allows for the head required for the future addition of a 550 ton absorptein chiller
Revision 1, VE Analysis

Pump Curve Refresher

Digitized Curve



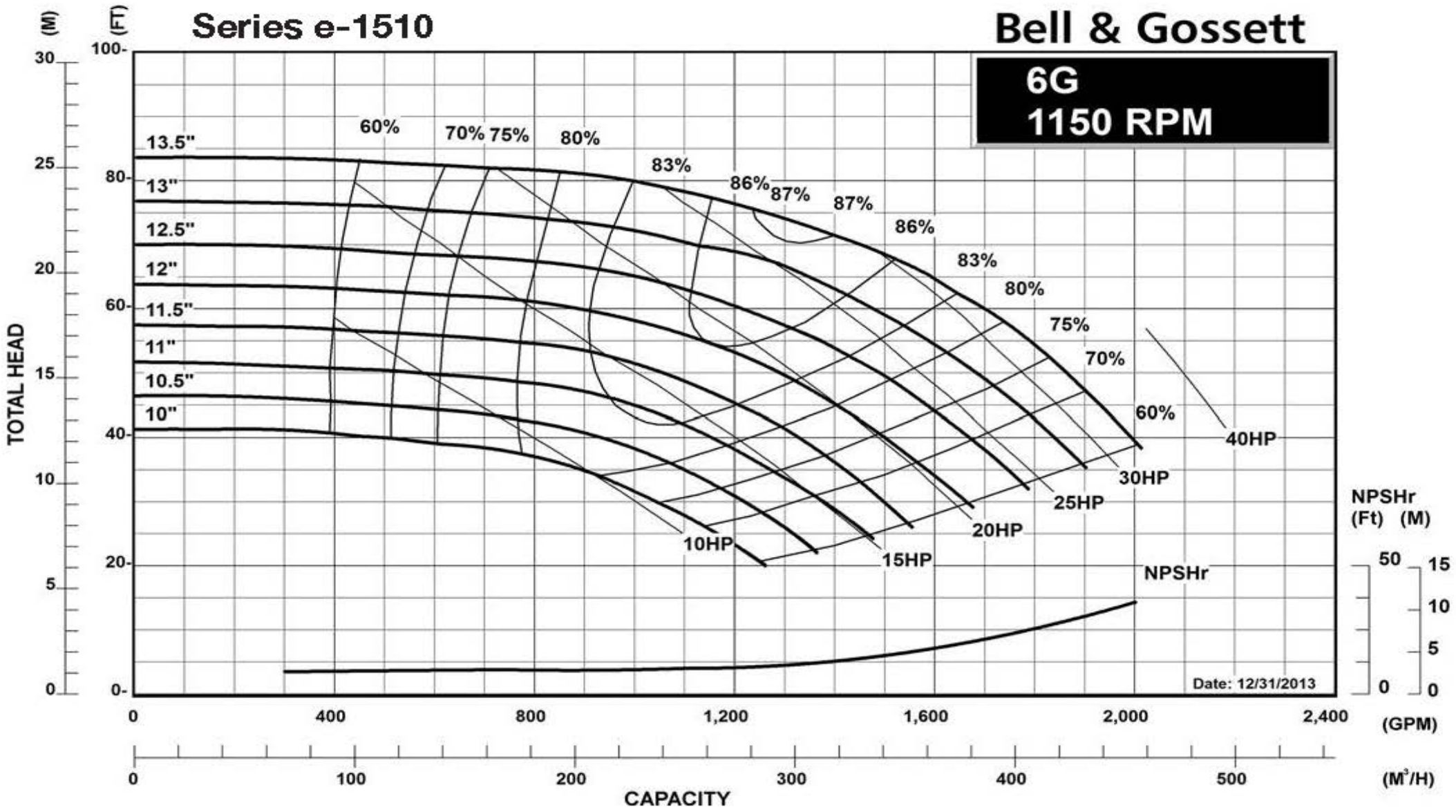
Vendor's Curve

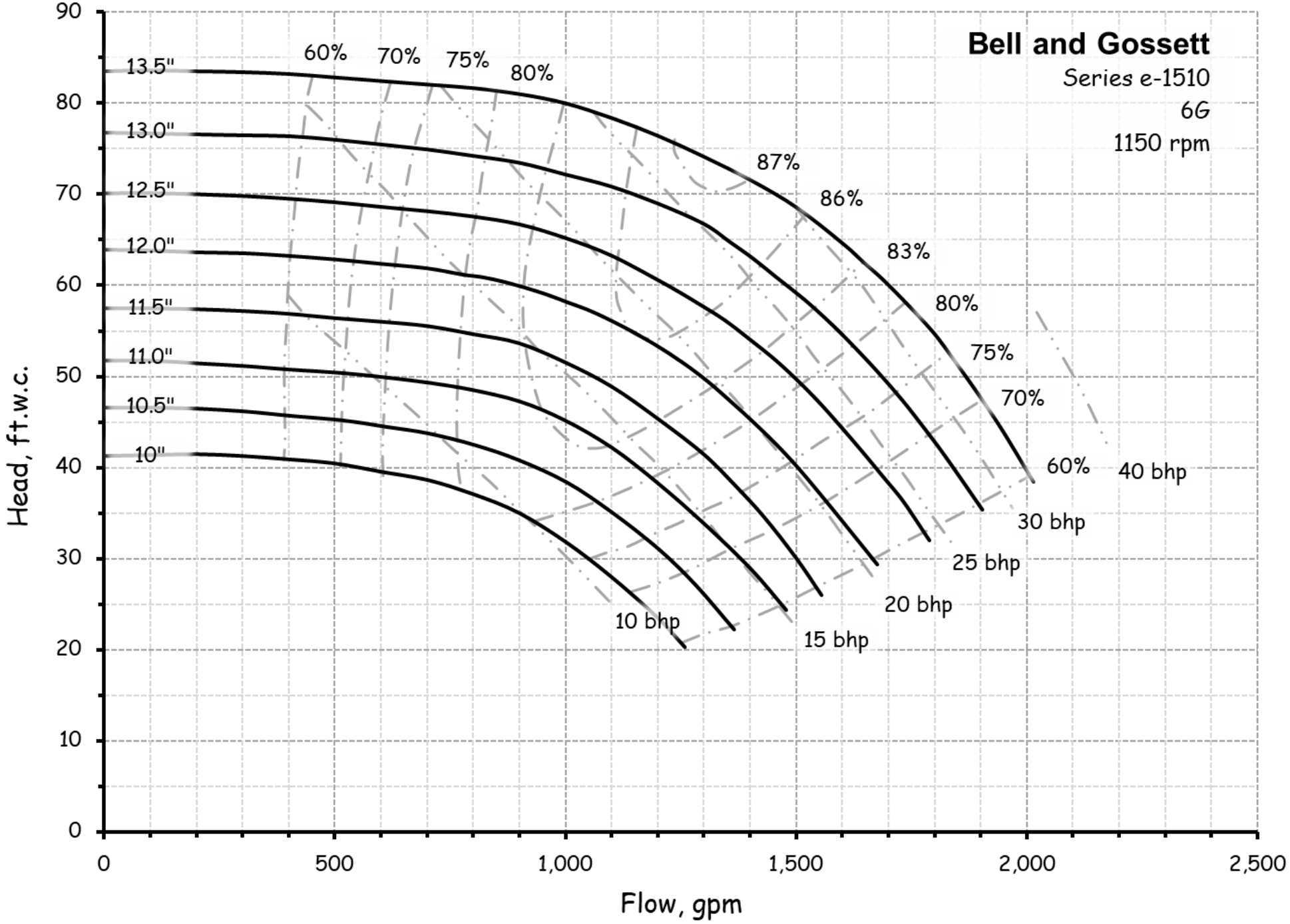


https://tinyurl.com/DigitizeCurves

SERIES e-1510

1200 RPM SYNCHRONOUS SPEED

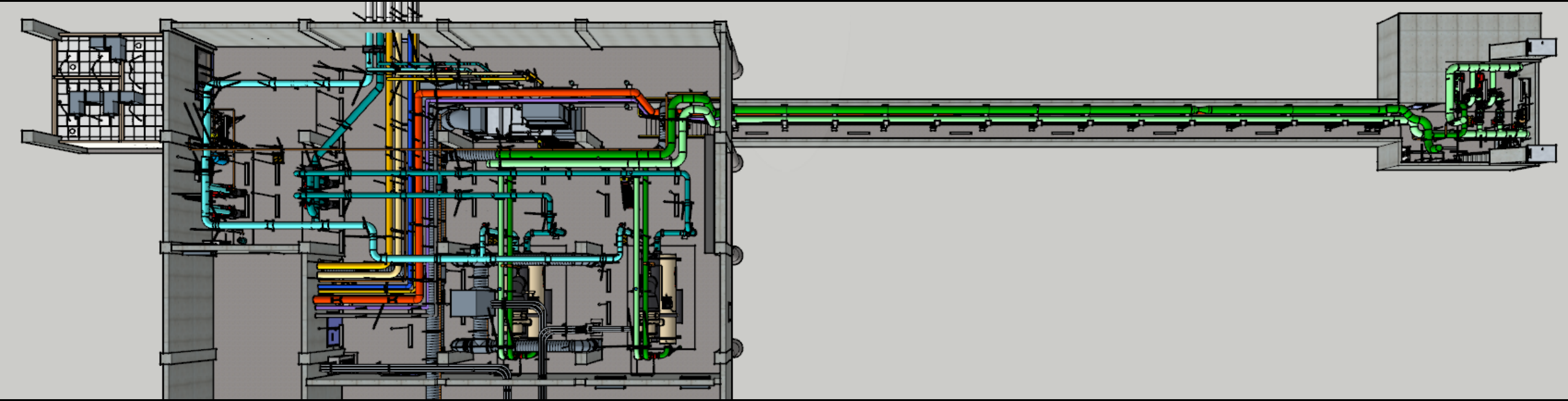



Bell and Gossett
Series e-1510
6G
1150 rpm
13.5"
13.0"
12.5"
12.0"
11.5"
11.0"
10.5"
10"
60%
70%
75%
80%
87%
86%
83%
80%
75%
70%
60%
40 bhp
30 bhp
25 bhp
20 bhp
15 bhp
10 bhp
Head, ft.w.c.
Flow, gpm
0
10
20
30
40
50
60
70
80
90
0
500
1,000
1,500
2,000
2,500

Let’s Try Another

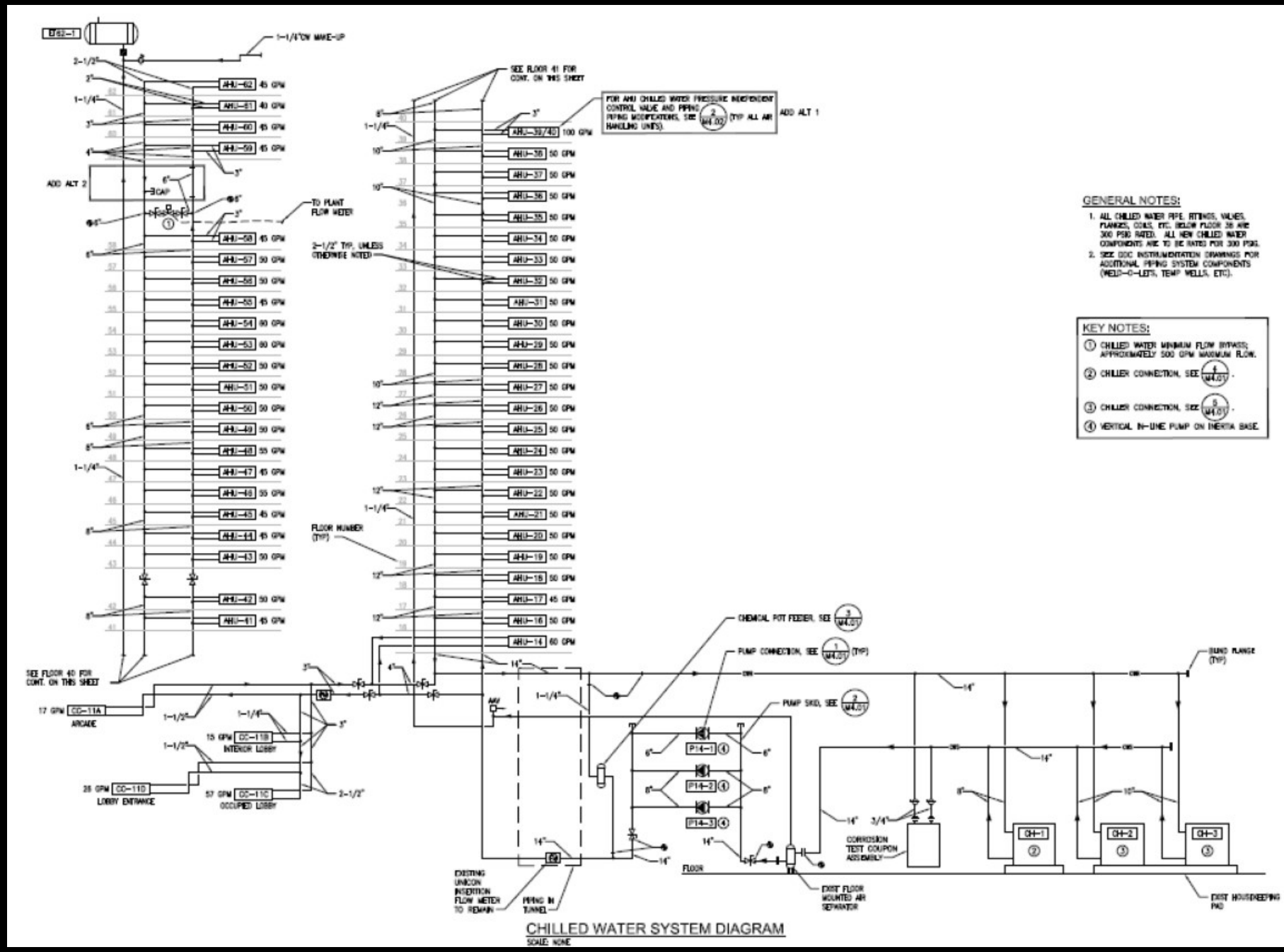
Given

The kW per Ton Concept



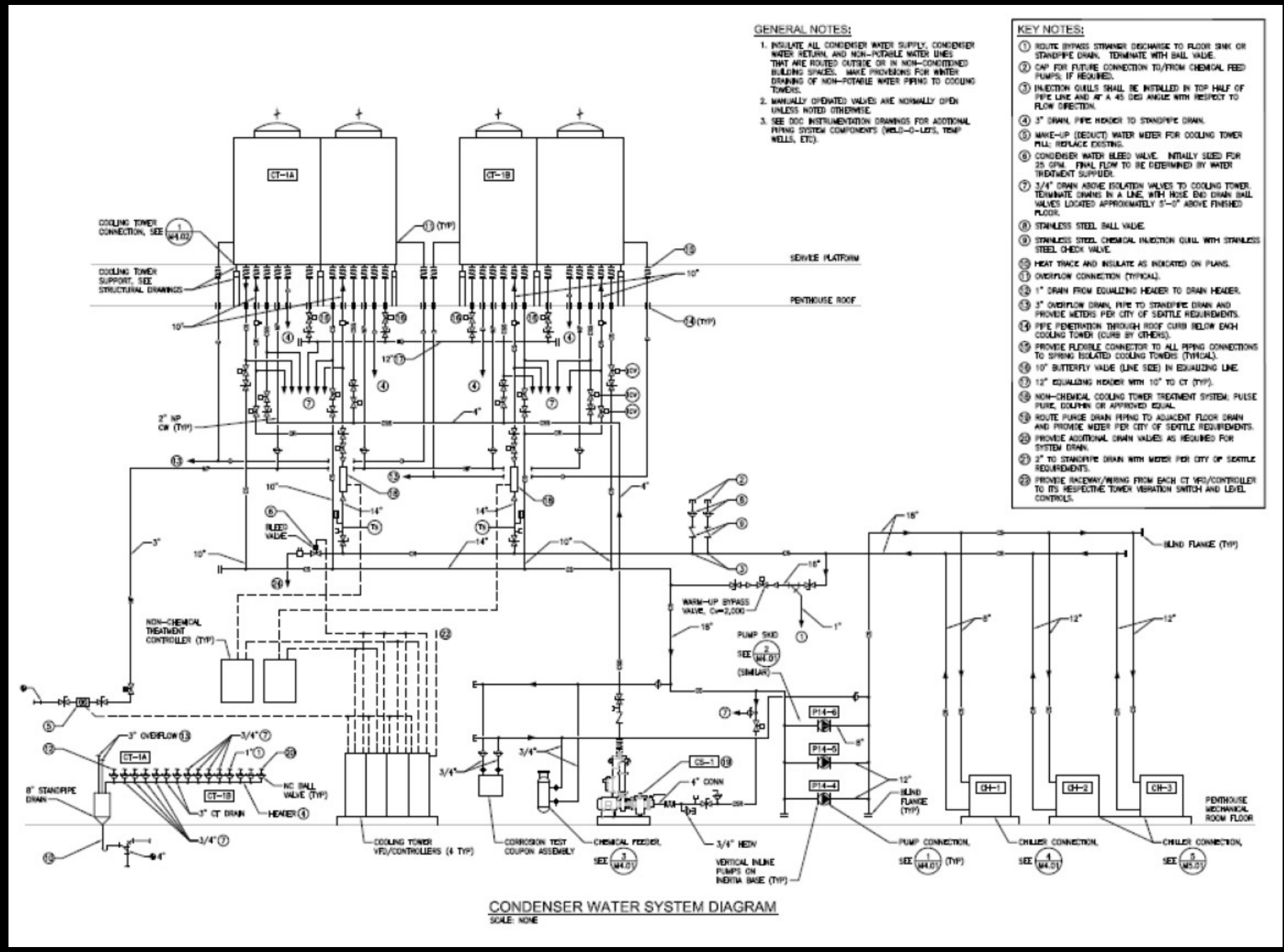
Given

Proposed CHW Schematic



Given

Proposed CW Schematic



Given

Proposed chiller performance

CHILLERS - WATER COOLED

MARK		CH-1	CH-2	CH-3
LOCATION		MECH RM	MECH RM	MECH RM
SERVES		CLG WATER	CLG WATER	CLG WATER
CAPACITY	TONS	300.0	1,000.0	1,000.0
	KW/TON	0.554	0.470	0.470
	COP			
COMPRESSOR	TYPE	CNTFGL	CNTFGL	CNTFGL
	QUANTITY: NO	2	3	3
EVAPORATOR	FLOW: GPM	450	1,500	1,500
	EWT: F	59	59	59
	LWT: F	43	43	43
	PD: FT HD	11	18	18
	FOULING FACTOR	0.00010	0.00010	0.00010
CONDENSER	FLOW: GPM	850	2,800	2,800
	EWT: F	86	86	86
	LWT: F	76	76	76
	PD: FT HD	15	16	16
	FOULING FACTOR	0.00025	0.00025	0.00025
REFRIGERANT	TYPE	R-134A	R-134A	R-134A
	CHARGE: LBS	895	2851	2851
ELECTRICAL	VOLT/PHASE	460/3	460/3	460/3
	TOTAL KW	163.3	470.4	470.4
	MCA	261	518 [3]	518 [3]
	MOP	350	724 [3]	724 [3]
	SCCR: AMPS	100,000	100,000	100,000
OPER WEIGHT	WEIGHT: LBS	10,000	35,000	35,000
BASIS OF DESIGN	MANUFACTURER	SMARDT	SMARDT	SMARDT
	MODEL	WA095.2H	WV400.3U	WV400.3U
	NOTES	[1, 2, 4, 6]	[1, 2, 4, 6]	[1, 2, 4, 6]

PROVIDE ALL CHILLERS FROM ONE MANUFACTURER.

NOTES:

1. SINGLE POINT CONNECTION, REFER TO ELECTRICAL DRAWINGS.
2. MAGNETIC BEARING, OIL-LESS COMPRESSORS.
3. RATINGS PER COMPRESSOR.
4. PROVIDE ONE SPARE COMPRESSOR FOR EACH SIZE USED IN THE NOMINAL 300 TON AND 1000 TON CHILLERS. DELIVER AT END OF WARRANTY PERIOD – ALTERNATE BID ITEM.
5. PROVIDE 5 YEAR WARRANTY – ALTERNATE BID ITEM.
6. PROVIDE MARINE BOXES AT ENDS WITH PIPING CONNECTIONS (300 LB PRESSURE CLASS ON EVAPORATOR) AND HINGED ACCESS AT ALL ENDS.

Given

Proposed pump performance

PUMPS - HYDRONIC

MARK		P14-1	P14-2	P14-3	P14-4	P14-5	P14-6
LOCATION		MECH RM	MECH RM	MECH RM	MECH RM	MECH RM	MECH RM
SERVES		CHILLED WTR	CHILLED WTR	CHILLED WTR	COND WTR	COND WTR	COND WTR
CAPACITY	FLOW: GPM	500	1,500	1,500	900	3,500	3,500
	TDH: FT	120	160	160	60	60	60
	EFFICIENCY: %	75	79	79	67	74	74
TYPE	DESCRIPTION	VIL	VIL	VIL	VIL	VIL	VIL
	MOTOR RPM	1,800	1,800	1,800	1,800	1,800	1,800
	MAX BHP	27.00	87.00	87.00	21.00	70.00	70.00
	SUCT CONN: IN	6	8	8	8	12	12
	DISCH CONN: IN	6	8	8	8	12	12
	IMP DIA: IN	11.20	13.26	13.26	8.34	10.00	10.00
ELECTRICAL	VOLT/PHASE	460/3	460/3	460/3	460/3	460/3	460/3
	MOTOR HP	40	100	100	25	75	75
	SCCR: AMPS	35,000	65,000	65,000	14,000	35,000	35,000
OPER WEIGHT	WEIGHT: LBS	1,050	2,150	2,150	950	2,600	2,600
BASIS OF DESIGN	MANUFACTURER	PACO	PACO	PACO	PACO	PACO	PACO
	MODEL	VLS 6x6x11.5	VLS 8X8X15	VLS 8X8X15	VLS 6x6x11.5	VLS 12x12x13	VLS 12x12x13
	NOTES	[1, 2, 3, 4]	[1, 2, 3, 4]	[1, 2, 3, 4]	[1, 2, 3, 4]	[1, 2, 3, 4]	[1, 2, 3, 4]

PROVIDE ALL PUMPS FROM ONE MANUFACTURER.

NOTES:

1. REFER TO ELECTRICAL DRAWINGS FOR DISCONNECT SWITCH.
2. PROVIDE WITH VARIABLE FREQUENCY DRIVE AND SUCTION DIFFUSER.
3. MOUNT PUMP ON SPRING ISOLATED CONCRETE INERTIA BASE; OPER WEIGHT DOES NOT INCLUDE INERTIA BASE.
4. PROVIDE ALL PUMPS WITH SUCTION DIFFUSERS; 300 LB PRESSURE CLASS ON CHILLED WATER PUMPS.

Given

Proposed cooling tower performance

COOLING TOWERS

MARK		CT-1A	CT-1B
LOCATION		ROOF	ROOF
SERVES		CHILLERS	CHILLERS
TYPE	AIRFLOW CONFIG	IND DRAFT	IND DRAFT
	DISCHARGE	VERTICAL	VERTICAL
	CELLS	2	2
CAPACITY [1]	HEAT REJ: TONS	1,185	1,185
	FLOW: GPM	3,450	3,450
	AMBIENT WB: F	66	66
	EWT: F	86	86
	LWT: F	76	76
	PD: FT HD	12	12
FAN	TYPE	SILENT PROP	SILENT PROP
	FANS: NO	2	2
	AIRFLOW: CFM	268,800	268,800
	ESP: IN WG	–	–
	TOTAL MOTOR HP	60	60
	PONY MOTOR HP	–	–
	VOLT/PHASE	460/3	460/3
BASIN HEATER	HEATERS	–	–
	CAPACITY: KW	–	–
	VOLT/PHASE	460/3	460/3
ELECTRICAL	SCCR: AMPS	14,000	14,000
OPER WEIGHT	WEIGHT: LBS	43,780	43,780
BASIS OF DESIGN	MANUFACTURER	EVAPCO	EVAPCO
	MODEL	UT–224–418	UT–224–418
	NOTES	[2–7]	[2–7]

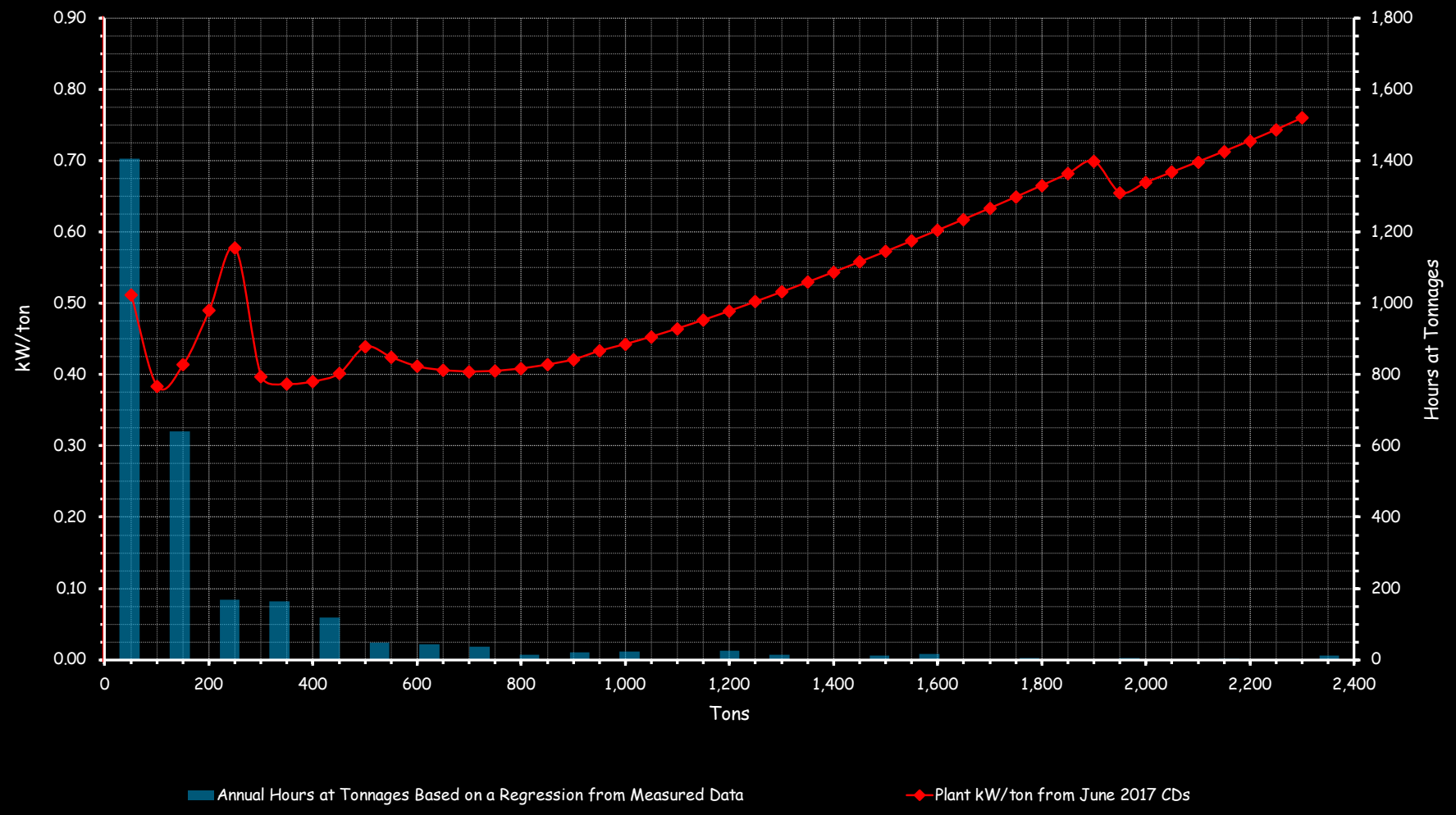
PROVIDE ALL COOLING TOWERS FROM ONE MANUFACTURER.

NOTES:

1. CAPACITIES BASED ON WATER.
2. REFER TO ELECTRICAL DRAWINGS FOR MOTOR STARTER AND DISCONNECT SWITCH.
3. PROVIDE WITH VIBRATION CUTOUT SWITCH.
4. PROVIDE WITH VARIABLE SPEED DRIVE AND FAN MOTORS.
5. PROVIDE WITH VORTEX ELIMINATOR AND BOTTOM PIPING CONNECTIONS.
6. PROVIDE STAINLESS STEEL PAN AND SUMP SWEEP PIPING/NOZZLES.
7. PROVIDE WITH REMOVABLE MOTOR LIFTING DAVIT PER 2–CELL TOWER, AND LIFTING DAVIT MOUNTING CHANNEL ON EACH TOWER CELL.

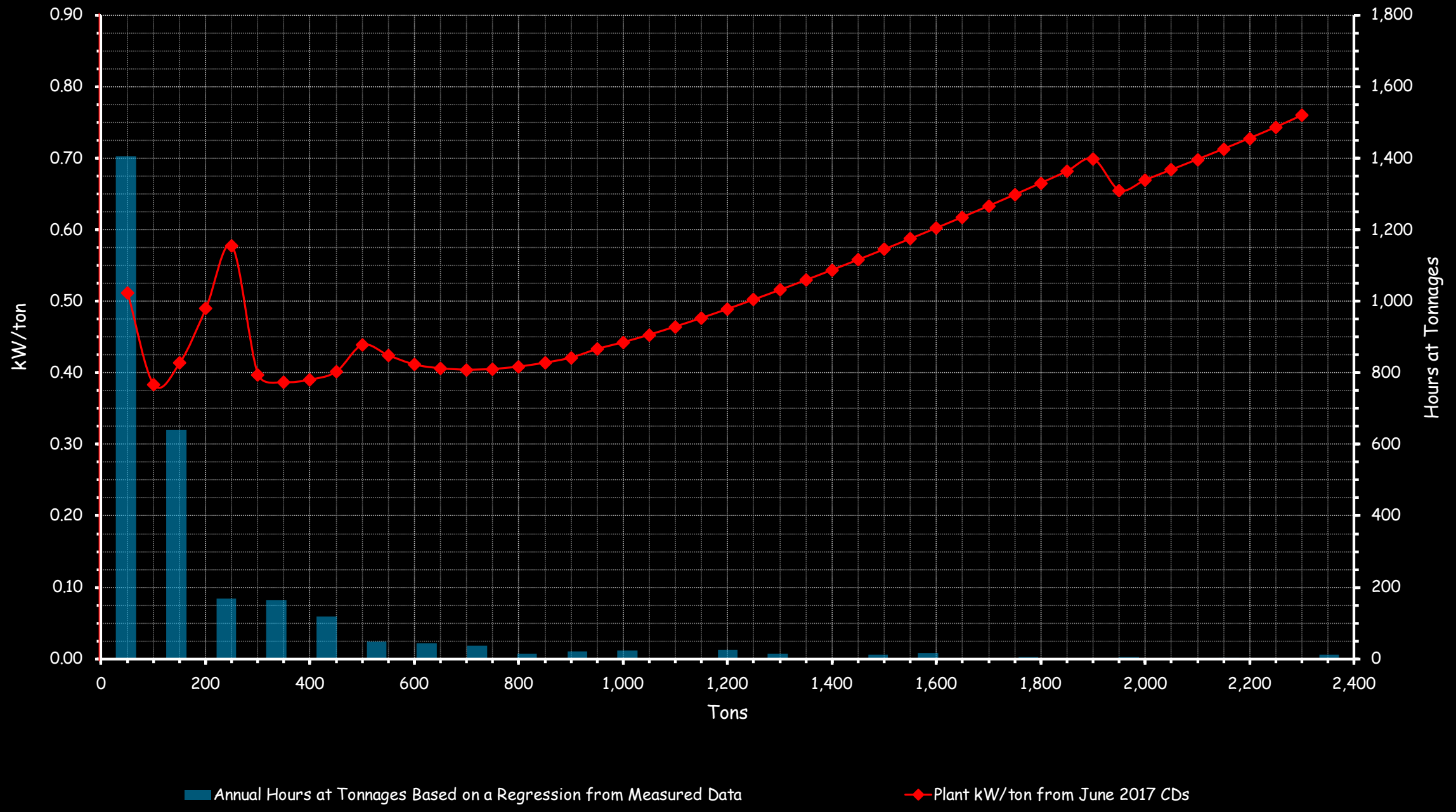
Given

Proposed kW per ton profile



A Question For You

https://tinyurl.com/PECDesRevkWPerTon


0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
kW/ton
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Hours at Tonnages
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Tons
Annual Hours at Tonnages Based on a Regression from Measured Data
Plant kW/ton from June 2017 CDs

Pump Power Relationship

$$bhp = \left(\frac{Flow \times Head}{3{,}960 \times Efficiency_{Pump}} \right)$$

Where:

$Flow$	=	Flow produced by the pump in gpm
$Head$	=	Head produced by the pump in feet water column
3,960	=	A units conversion constant that will work for water at the temperatures and pressures typically encountered in HVAC systems.
$Efficiency_{Pump}$	=	Pump efficiency, read from the pump curve or estimated from past experience; .40 - .70 for small (under 500 gpm) pumps, .70 - .85 for large pumps

$$kW = \left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

ESP-PLUS - [System Requirements]

File Options MyEsp Internet Help

System Configuration

- General
- Pressure Booster

System Parameters

Total Flow Gallons / Minute

Head Feet of Water

Number of Pumps in Parallel 1

Motor Parameters

Any RPM / 60 Hz

- ESP-Optimized™ Motor Selection
- Use Non-Overloading Motors
- Select Motor Using Duty Point

Minimum HP Req. None, Let ESP Determine HP

System Options

Fluid Property

Current Fluid: Water

Max NPSHr: 0

Pump Series

All Pumps Shown
Ecocirc_XL Small Circulator Pumps
Booster Small Circulator Pumps
60-ECM Series 60 With ECM Motor
60 & 60-STOCK In-Line 1" to 2-1/2"
1522 Floor-mounted Booster
e-90-ECM e-90 With ECM motors
90 & e-90 In-Line Close Coupled,1" to 3"
1535 Small Close Coupled
80 In-Line Closed Coupled, 1-1/2" to 8"
80SC In-Line Split Coupled, 1-1/2" to 14"
e-1510 Base-mounted End-suction
1531 & e-1531 & e-1532 Cls-cpld End-suction
VSX-VSC New Dbl-Suction Pump
VSX-VSCS New Dbl-Suction Pump
VSX-VSH New Dbl-Suction Pump

- Show All
- Base-Mounted
- In-Line

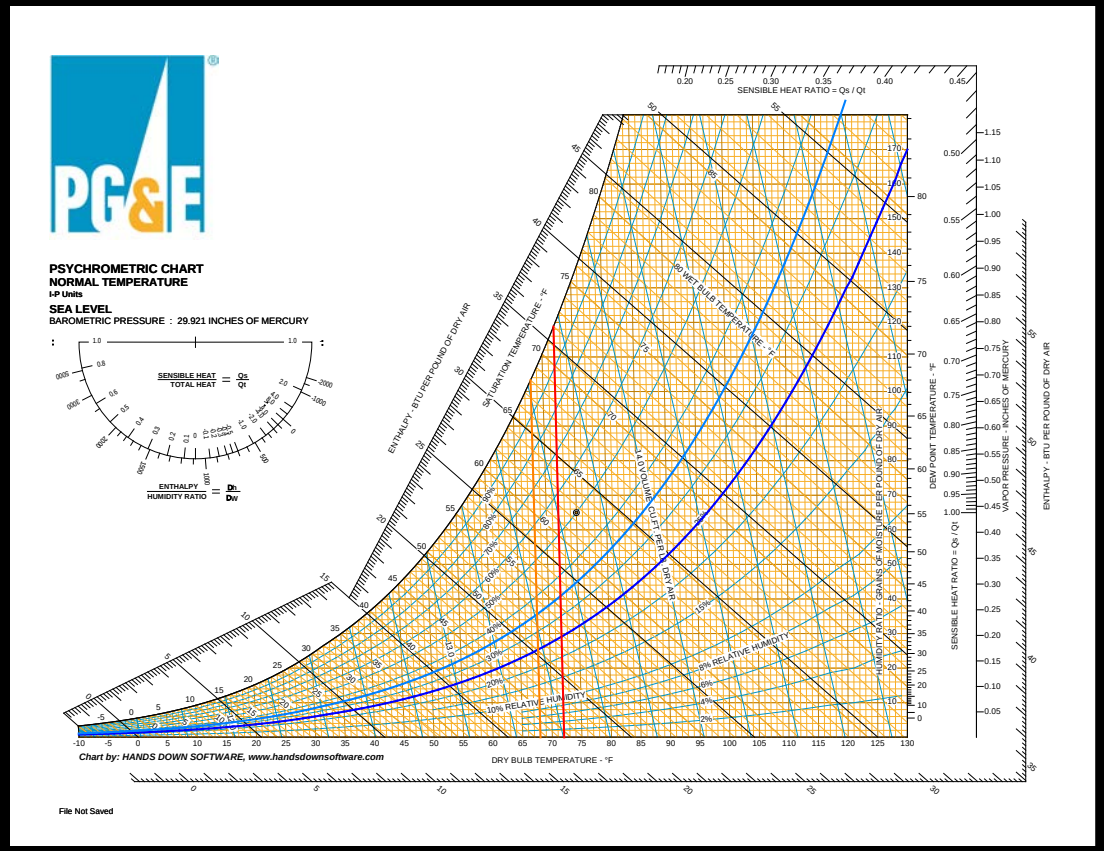
For multiple pumps in parallel, system flow will be split equally among pumps.

Select Pumps

Bell & Gossett
a xylem brand

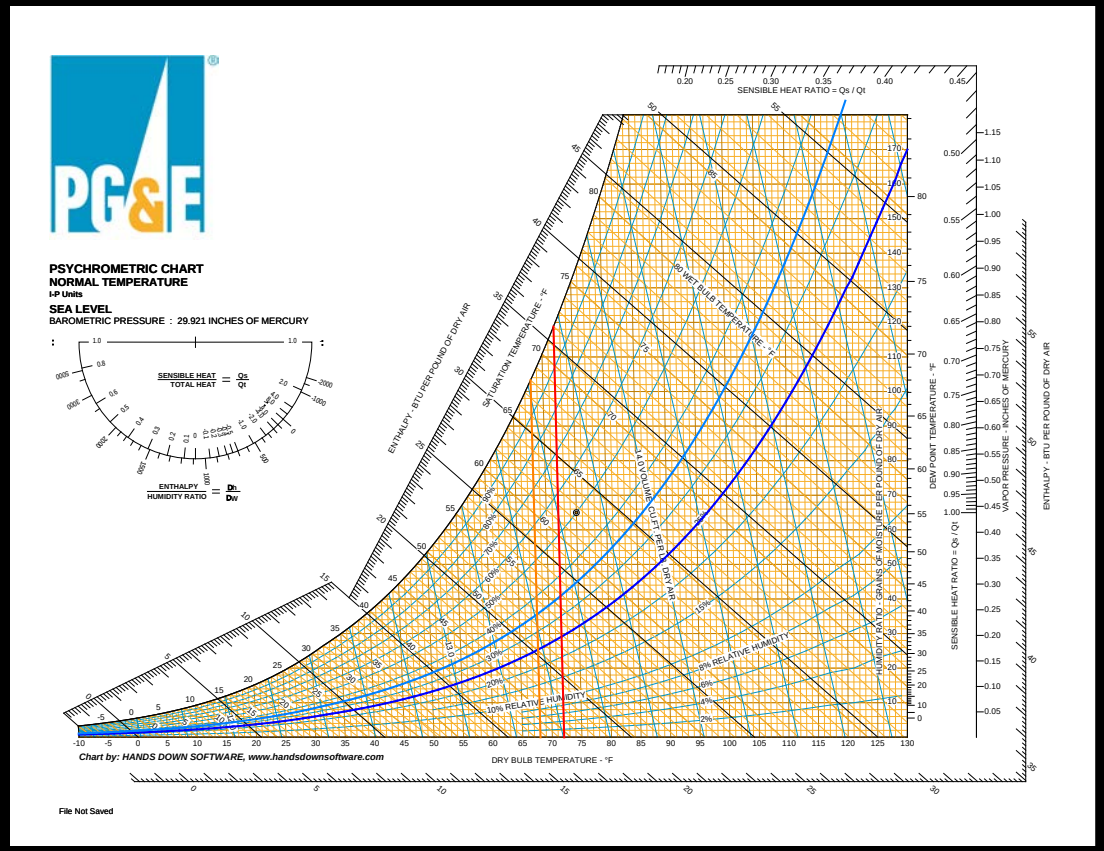
Let’s Work on This One Together

Given an Owners Requirement



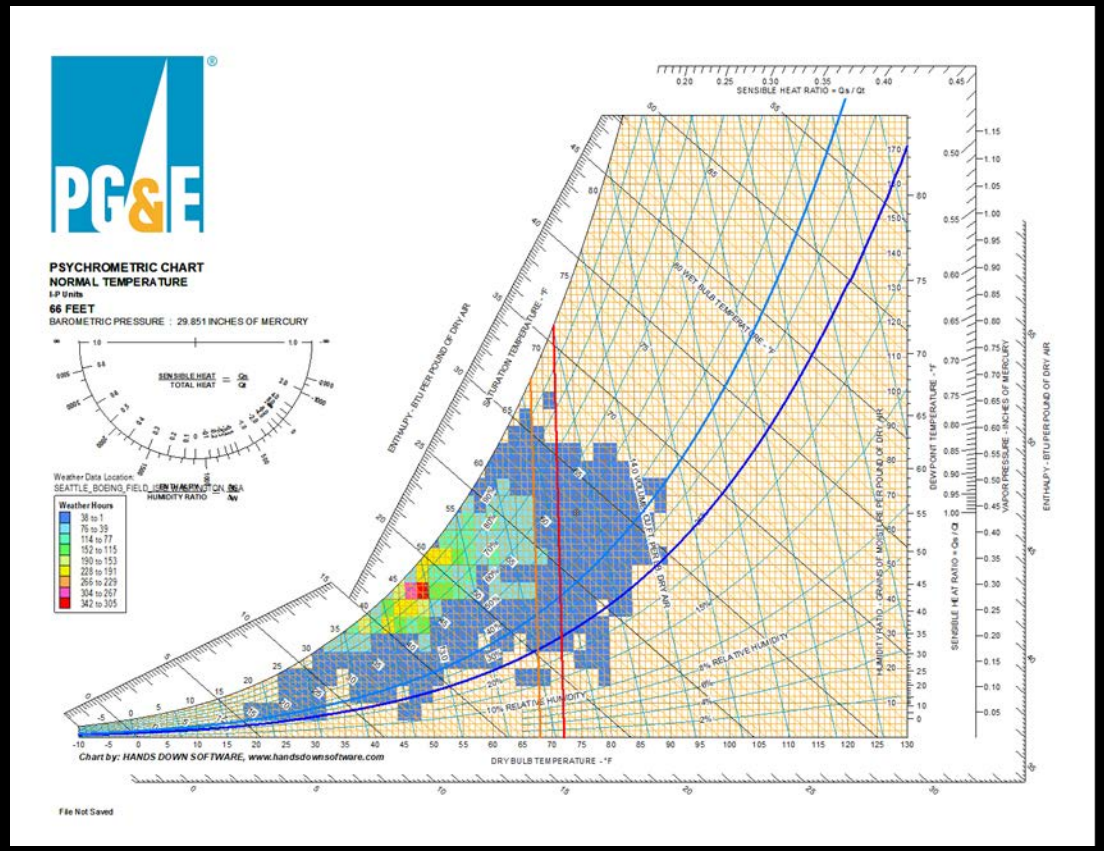
- Winter Indoor Dry Bulb Temperature Target – 68°F – 72°F
- Winter Indoor Relative Humidity Target – 25% - 35%

An Early Design Development Meeting

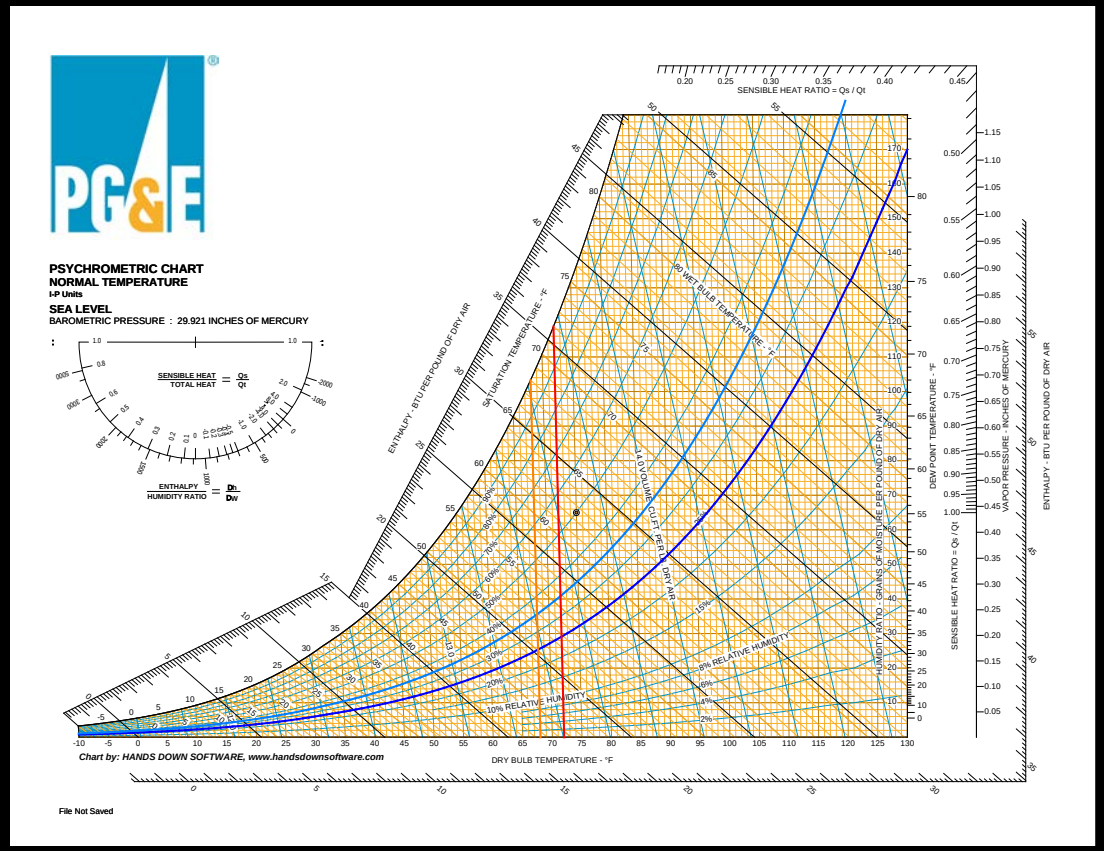


- The project is projecting to be over budget
- It may be necessary to eliminate commissioning from the project

The Pacific NW Climate



Is There Something We Can Do to Keep Commissioning in the Project



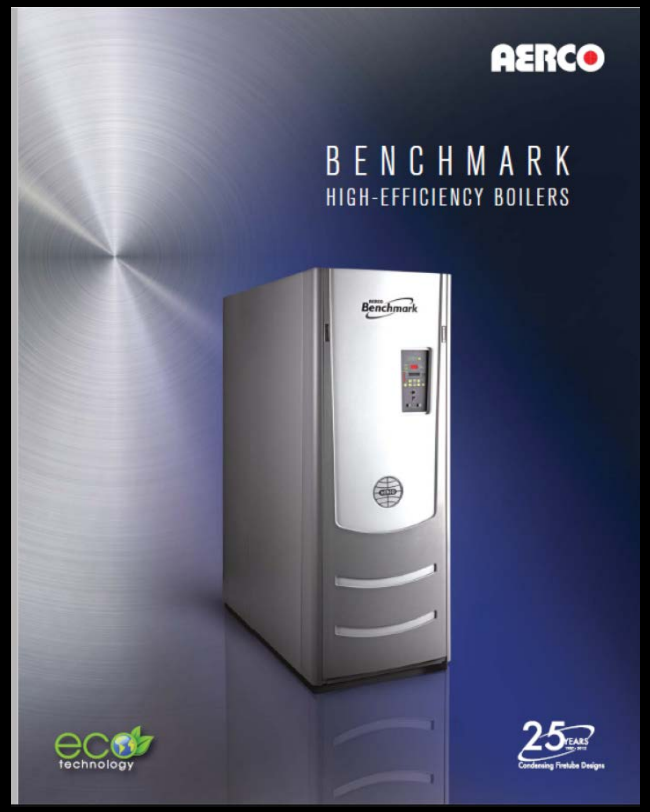
Some psychrometric resources

- https://tinyurl.com/FreePsychChart
- https://tinyurl.com/OlivieriChapters
- https://tinyurl.com/SlfSLoadsPsych

Let’s Try Another Submittal Review

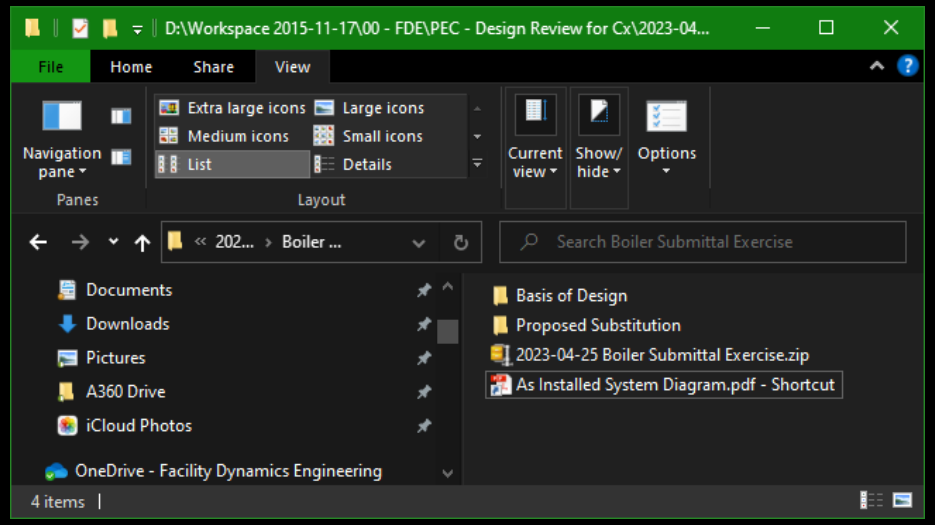
Given Submittal Data

Basis of Design



Submitted

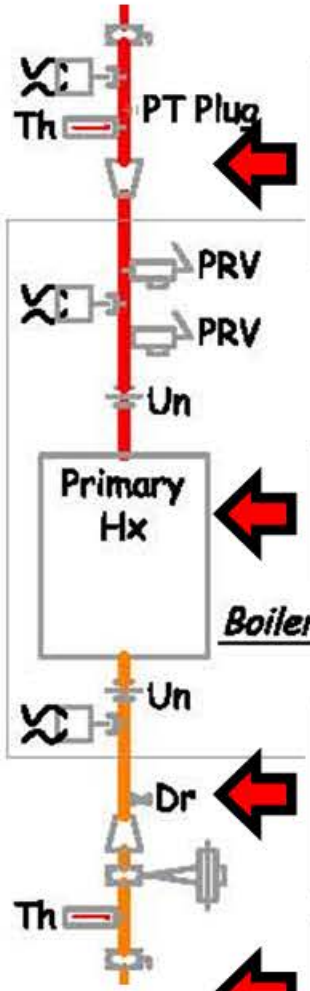
These files in the class materials



Answer the Questions at This Link

https://tinyurl.com/PECDesRevBoiler

Comparing the Boilers



Leaving water temperature range – 85 - 180°F

Single condensing heat exchanger

Entering water temperature range – 80 - 160°F

Constant volume pumping circuit

Leaving water temperature restricted to130°F minimum

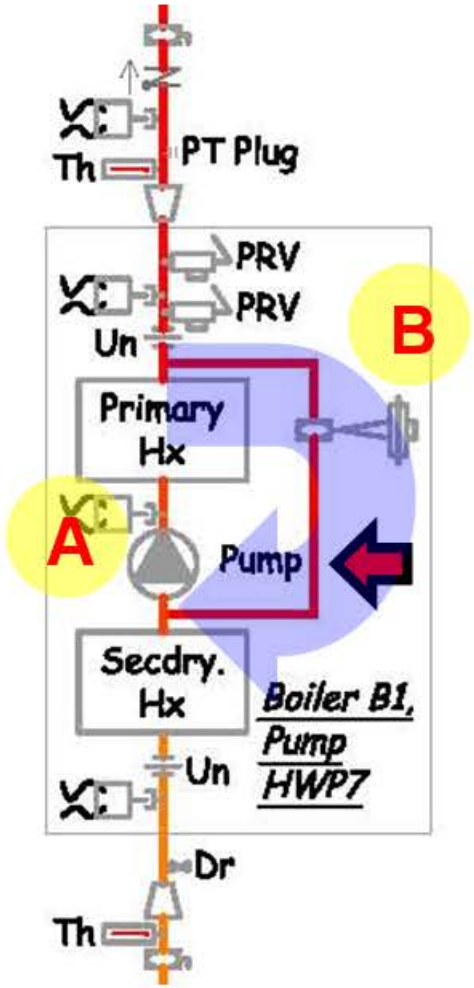
Noncondensing heat exchanger restricted to130°F EWT

Pump and control valve control EWT and make boiler loop variable flow

Condensing heat exchanger

Entering water temperature range – 85 - 160°F

Constant volume pumping circuit



Comparing the Boilers

The primary difference between the Aerco Benchmark BMK2.0 boilers (left illustration) that were the basis of design and the Lochinvar Intellifin IBM2000 boilers (right illustration) that were actually furnished is that the Aerco units employ a single heat exchanger, rated and designed for condensing operation. In contrast, the Lochinvar units employ two heat exchangers, one of which (termed the secondary heat exchanger) is rated and designed for condensing operation and one of which (termed the primary heat exchanger) is not. To protect the primary heat exchanger from damage do to the corrosive by-products associated with condensing operation, the Lochinvar boilers incorporate a circulating pump (A) and a control valve (B), arranged to ensure that the entering water temperature to the primary heat exchanger never drops below 130°F. This is accomplished by recirculating water from the boiler's discharge to the inlet side of the primary heat exchanger as indicated by the blue shaded arrow in the right illustration. For this approach to work, the boiler must be controlled so that the leaving water temperature from the primary heat exchanger is never below 130°F. As a result, a system that employs the Lochinvar units and must directly control for supply water temperatures below 130°F need to incorporate some other mechanism for achieving the supply temperature requirement while protecting the boilers. One common approach for accomplishing this is to provide the system with a three-way valve that allows water from the boiler loop to be mixed with return water from the system to achieve the required supply temperature. Since the Aerco boilers are rated to control directly for any set point from 50-190°F, the basis of design system did not in incorporate such a feature. As a result, when the Lochinvar boilers are applied in the basis of design system configuration, there is no direct method for controlling supply temperature to a set point of 130°F. Rather, the master controller charged with cycling the boilers to maintain a desired system supply temperature must try to find a combination of boiler settings that indirectly produces the desired result by forcing the distribution system into an over-flow condition (distribution flow exceeds boiler loop flow) while the individual boiler controllers work to prevent the entering water temperature to their primary heat exchangers from dropping below 130°F. This is a complex hydraulics problem at best and may be impossible to achieve under some operating conditions with out considerable operator intervention.

Other Issues Identified During Construction Observation

Other Issues Identified During Construction Observation


OWER
CORNI
1 FOC


OWN
CORN

Optional Assignment

Given the Pump Schedule

PUMP SCHEDULE

PLAN MARK	MANUFACTURER & MODEL	LOCATION & SERVICE	GPM	FT. HD.	[1] IMPELLER SIZE	MOTOR SPEED RPM	MOTOR HP	MOTOR VOLTS / Φ	NOTES
MP-D12	B&G HSC-6X8X17M	'D' LEVEL - HEATING WATER	1380	193	15	1750	100	460/3Φ	[2] [3]
MP-D13	B&G HSC-6X8X17M	'D' LEVEL - HEATING WATER	1380	193	15	1750	100	460/3Φ	[2] [3]
MP-D14	GRUNDFOSS #CR16-30U	'D' LEVEL - BOILER FEED	83	140		3500	7 1/2	460/3Φ	[5]
MP-D15	GRUNDFOSS #CR16-30U	'D' LEVEL - BOILER FEED	83	140		3500	7 1/2	460/3Φ	[5]
MP-G1	B&G 60-2 AA	GD.FL.-AHU-G1	50	20	4 3/4	1750	3/4	460/3Φ	
MP-3B	B&G 60-1 1/2 AA	3rd FL.- AHU-3B	40	18	4 3/4	1750	1/2	460/3Φ	
MP-3D	B&G 60-1 1/2 AA	3rd FL.- AHU-3D	40	18	4 3/4	1750	1/2	460/3Φ	
MP-3G	B&G 80-2 1/2 X 2 1/2 X 7	3rd FL.- AHU-3G	120	25	6	1750	1 1/2	460/3Φ	
MP-3-1	B&G 80-3 X 3 X 8 1/2	3rd FL.- TOWER WATER	220	66	8 1/2	1750	7 1/2	460/3Φ	[4] [6]
MP-3-2	B&G 1510-3 BB	3rd FL.- LOOP WATER	220	80	9	1750	10	460/3Φ	
MP-G3	B&G 60-2AA	GRD FL MEZZ-AHU-G3	50	21	4 3/4	1750	3/4	"	[4]

[2] 400 PSIG WORKING PRESSURE.

[3] PROVIDE WITH VARIABLE SPEED PUMPING SYSTEM - SEE SPEC.

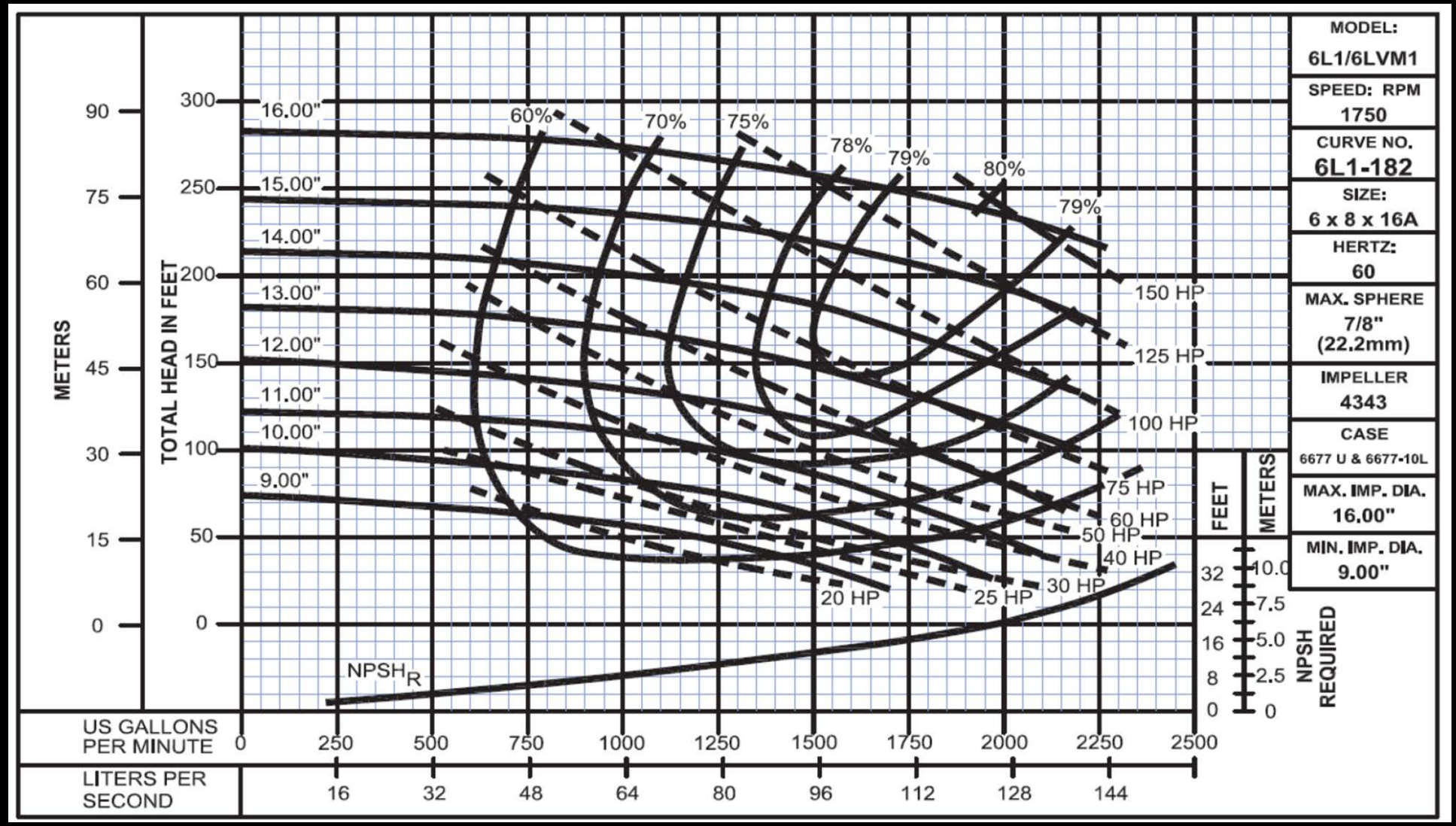
[4] 250 PSIG WORKING PRESSURE.

[5] CONTROL CABINET, C/W STARTERS, CIRCUIT BREAKERS, PILOT LIGHT AND HOA SELECTOR SWITCHES.

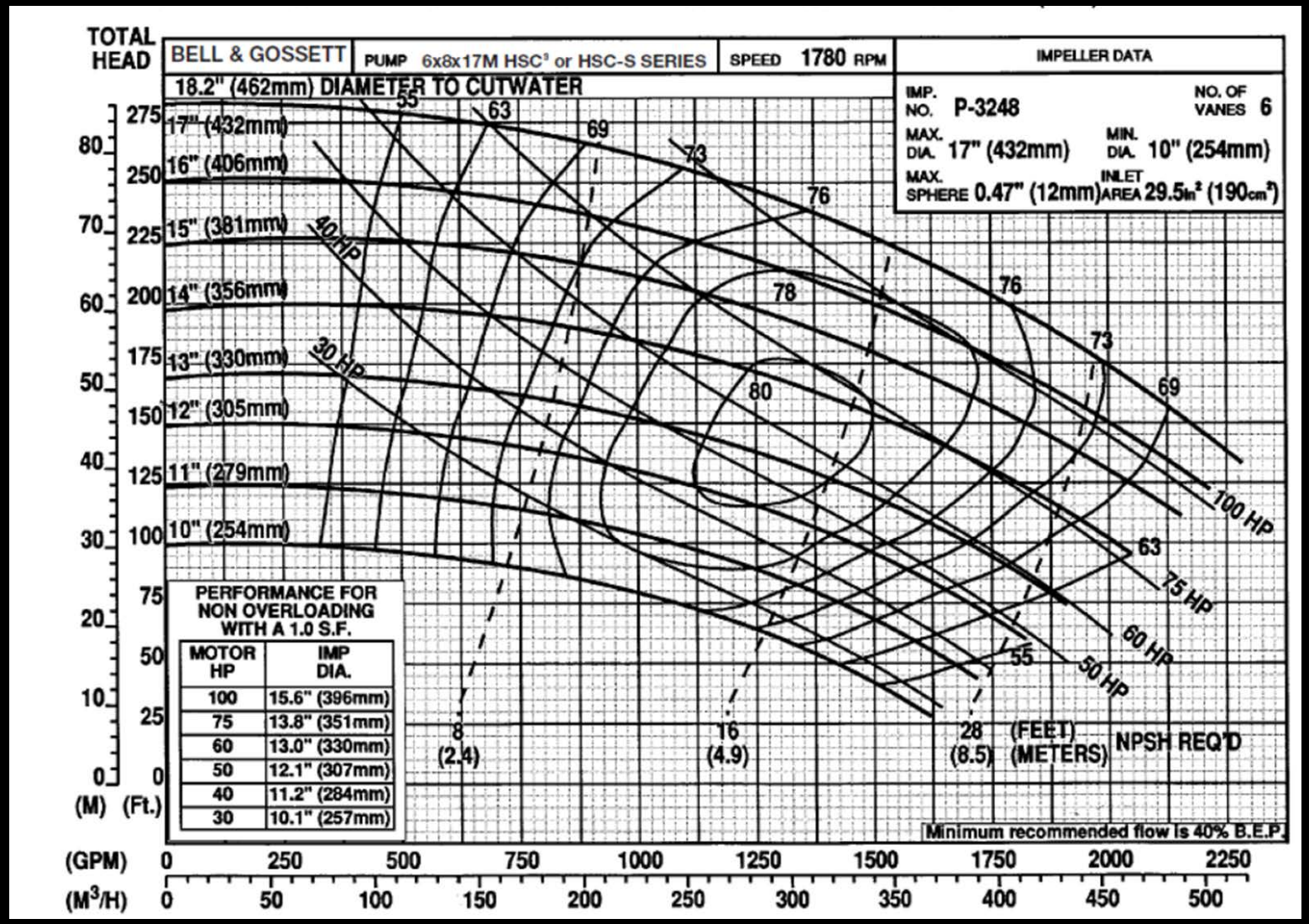
[6] HORIZONTAL MOUNT

[1] PROVIDE FULL SIZE IMPELLER, TRIMMED/SHAVED IMPELLER IS NOT ACCEPTABLE

Given the Basis of Design Pump Curve

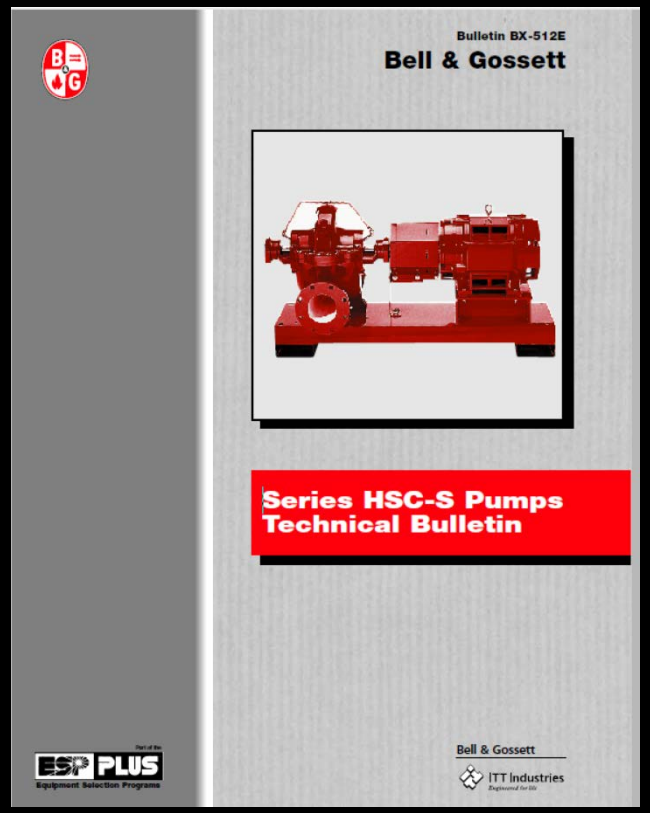


Given the Submittal Pump Curve



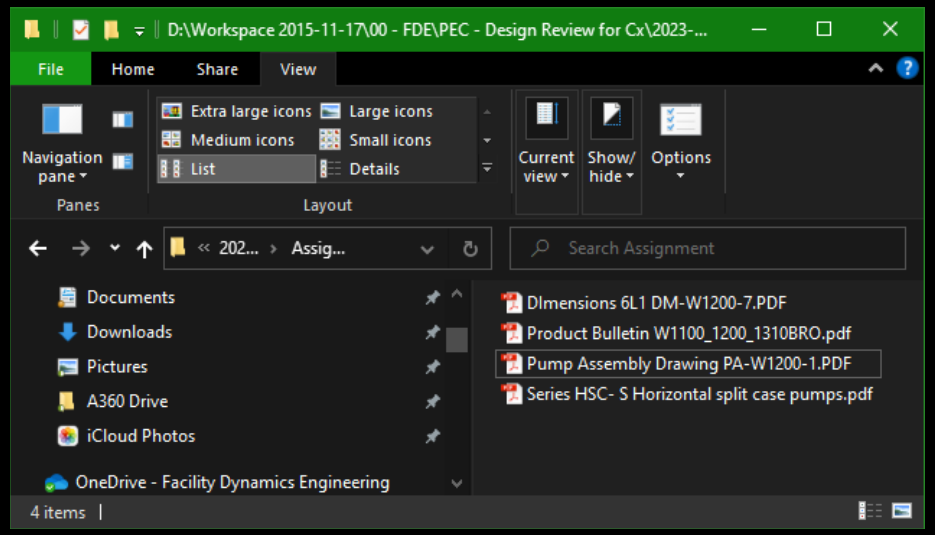
Given the Manufacturers Catalog Data

Basis of Design



Submitted

These files in the class materials



Would You Approve the Substitution

- Why or why not?
- What other things might you comment on?

Facility Dynamics
ENGINEERING

Questions?

Thank you for participating!

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Contact me at Dsellers@FacilityDynamics.com

- David Sellers; Facility Dynamics Engineering
- Senior Engineer

- March 12, 2017

ADVANCED ENGINEERING PROGRAM

AEP 2023