

System Diagram Workshop

Basic Concepts

Tools and Techniques for Developing your System Diagrams



Instructor:

David Sellers

Senior Engineer

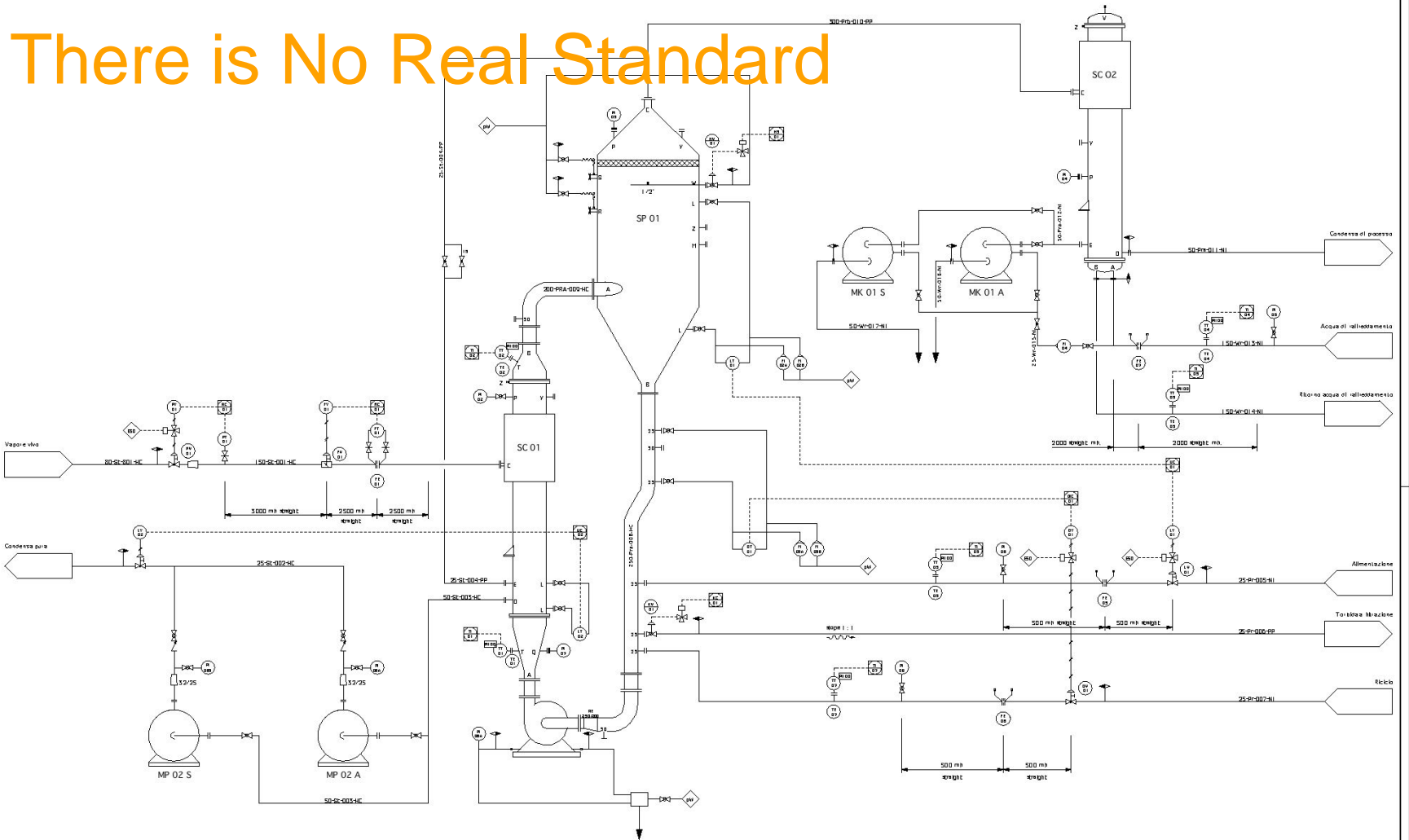
Facility Dynamics Engineering

Resource for Details Behind this Content

www.Av8rdas.Wordpress.com

Posts with the heading “System Diagrams: ...”

There is No Real Standard



P&ID (Process and Instrumentation Diagrams) are a similar concept as is a PFD (Process Flow Diagram)

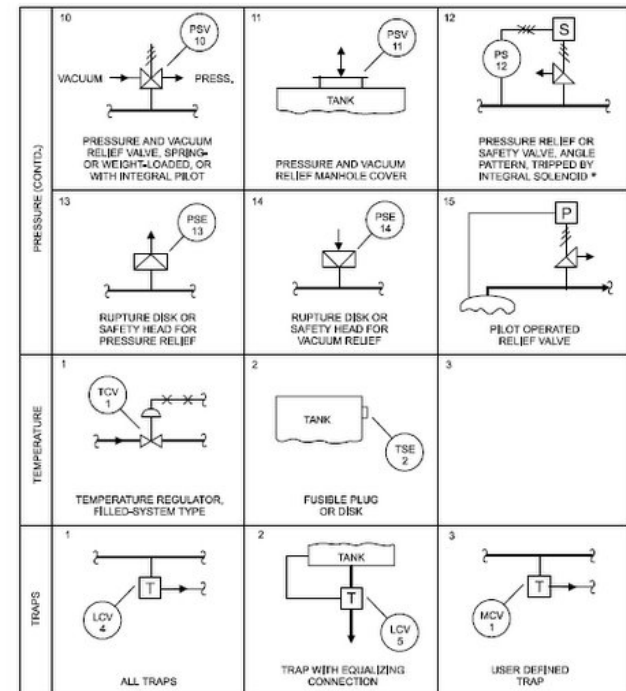
Rev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Rev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Rev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Rev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

http://en.wikipedia.org/wiki/Piping_and_instrumentation_diagram - From the author's own work - Creative Commons Share Alike

Starting Points for Symbols

ISA-5.1-1984 Instrumentation Symbols and Identification

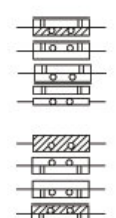

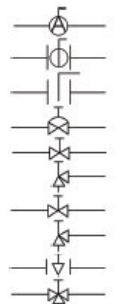
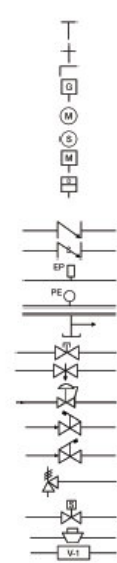
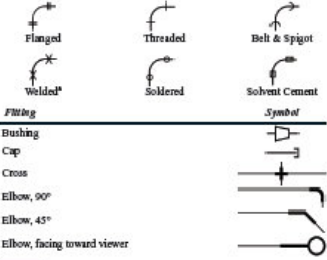
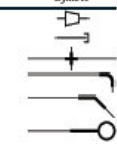
6.6 Symbols for self-actuated regulators, valves, and other devices (contd.)



* The solenoid-tripped pressure relief valve is one of the class of power-actuated relief valves and is grouped with the other types of relief valves even though it is not entirely a self-actuated device.

Starting Points for Symbols

2009 (or earlier) ASHRAE Handbook of Fundamentals, Chapter 37

37.6		2009 ASHRAE Handbook—Fundamentals	
Radiant Ceiling Panels Embedded Above ceiling Surface mounted Suspended Radiant Floor Panels Slab on grade Above subfloor Below subfloor Slab above subfloor Radiant Wall Panels			
Coils Cooling coil Heating coil Electrical coil Humidifier			
Valves Valves for Selective Actuators Air line Ball Butterfly Diaphragm Gate Gate, angle Globe Globe, angle Plug valve Three way			
		Valves, Actuators Manual Non-rising stem Outside stem & yoke Lever Gear Electric Motor Solenoid Pneumatic Motor Diaphragm Valves, Special Duty Check, swing gate Check, spring Control, electric-pneumatic Control, pneumatic-electric Hose end drain Lock shield Needle Pressure-reducing regulator Quick-opening Quick-closing Safety or relief Solenoid Square-head cock Unclassified (number and specify)	
			
		Fittings The following fittings are shown without connection notations. This reflects current practice. The symbol for the body of a fitting is the same for all types of connections, unless otherwise specified. The types of connections are often specified for a range of pipe sizes, but are shown with the fitting symbol where required. For example, an elbow would be:	
			
		Fittings Bushing Cap Cross Elbow, 90° Elbow, 45° Elbow, facing toward viewer	
			

*Includes flange; specify type.

C:\Documents and Settings\David Sellers\My Documents\PECI Tools\AutoCAD Lite Stuff\PECI Symbols

File Edit View Favorites Tools Help
Back Forward Stop Home Folders
Address C:\Documents and Settings\David Sellers\My Documents\PECI Tools\AutoCAD Lite Stuff\PECI Symbols\Simple Flow Diagram Symbols

Starting Points for Symbols

Your Own Creativity

2 way butterfly control valve - electric.dwg
2 way butterfly control valve.dwg
2 way reheat coil.dwg
2 way valve with manual over ride.bak
2 way valve with manual over ride.dwg
2 way valve.dwg
3 way butterfly control valve.dwg
3 way reheat coil.dwg
3 way valve.bak
3 way valve.dwg
12-07-07 Simple Flow Diagram Symbols.zip
acad1t.err

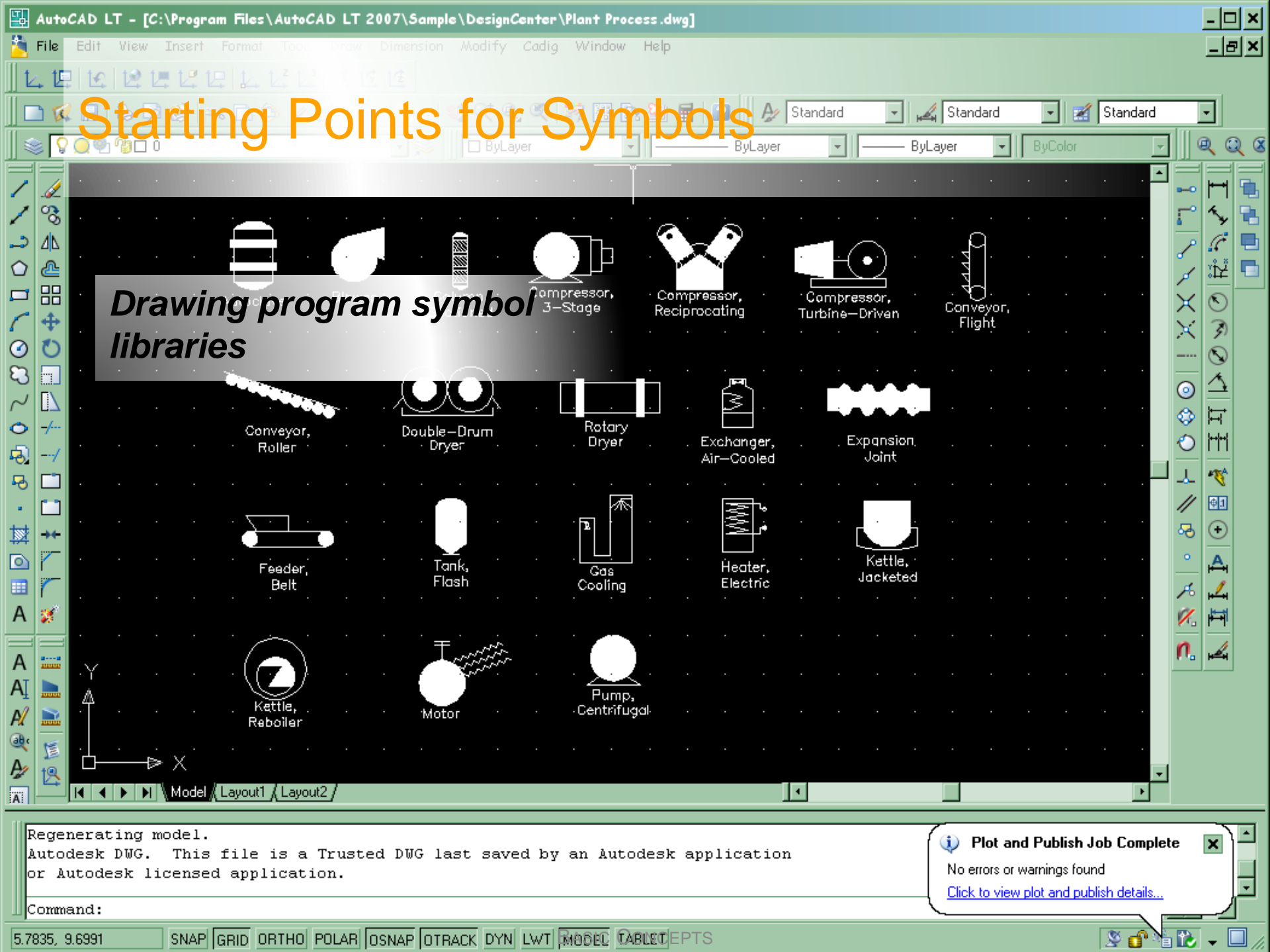
AHU coil bank
Air to air heat exchanger.dwg
Auto air vent.bak
Auto air vent.dwg
Automatic air vent with service valve.dwg
Back pressure regulator.dwg
Balance valve.dwg
Ball valve - instrument.dwg
Ball valve - hydraulically actuated.bak
Ball valve - hydraulically actuated.dwg
Ball valve.dwg
Barometric damper.dwg
Basket Strainer.dwg
Break HHWR.dwg
Break HHWS.dwg
Break.dwg
Butterfly valve - small.dwg
Butterfly valve.dwg
Ceiling diffuser.dwg
Ceiling.dwg
Centrifugal Separator.bak
Centrifugal Separator.dwg
Check valve.bak
Check valve.dwg
Chilled water coil with 2 way valve.bak
Chilled water coil with 2 way valve.dwg
Chiller - Modular.dwg
Chiller with Auto Iso Vlv and Bypass.bak
Chiller with Auto Iso Vlv and Bypass.dwg
Chiller.dwg
Concentric reducer.dwg
Condensing Boiler.dwg
Conductivity Sensor.dwg
Control - Averaging temperature.dwg
Control - Combination duct temp and humidity.dwg
Control - Differential pressure sensor.dwg
Control - Differential pressure.dwg
Control - Duct Humidity.dwg
Control - Freezestat.bak
Control - Freezestat.dwg
Control - Insertion temperature.dwg
Control - Limit switch.dwg
Control - Make up meter.dwg
Control - Space humidity.bak
Control - Space humidity.dwg
Control - Space temperature.bak
Control - Space temperature.dwg
Control - Surface Temperature Sensor - Horizontal.dwg
Control - Surface temperature sensor.dwg

Control - Switch.bak
Control - Switch.dwg
Control - Temperature sensor with well - Vertical.dwg
Control - Temperature sensor with well.bak
Control - Temperature sensor with well.dwg
Control - Turbine flow meter 1.dwg
Control - Turbine flow meter.dwg
Controls - Air Flow.dwg
Controls - Averaging temperature sensor.bak
Controls - Averaging temperature sensor.dwg
Controls - Current relay.dwg
Controls - Filter DP.dwg
Controls - Filter DP.dwg
Controls - Filter DP.dwg
Controls - Starter or VFD with control points - No Fire.bak
Controls - Starter or VFD with control points - No Fire.dwg
Controls - Starter or VFD with control points.dwg
Controls - Starter or VFD.dwg
Cooling Tower Additional Cell.bak
Cooling Tower Additional Cell.dwg
Cooling Tower Base Cell.bak
Cooling Tower Base Cell.dwg
Cooling Tower Make Up Set Up - Float.bak
Cooling Tower Make Up Set Up - Float.dwg
Cooling Tower Single Cell.dwg
Cooling tower.dwg
Damper - vertical - manual.dwg
Damper actuator.dwg
Differential pressure switch.dwg
Double break line.dwg
Drain.dwg
DX Coil with Hot Gas Bypass.bak
DX Coil with Hot Gas Bypass.dwg
Eccentric reducer.dwg
Economizer section - No MOA - Opposed blade.bak
Economizer section - No MOA - Opposed blade.dwg
Economizer section.dwg
Electric Heating Coil.dwg
Enthalpy wheel.dwg
Evaporative cooler.dwg
Expansion Loop.dwg
Expansion tank diaphragm type.dwg
Expansion tank open type.dwg
Fan Powered Terminal Unit - Series.bak
Fan Powered Terminal Unit - Series.dwg
Fan.dwg
Final Filter.dwg
Flange Cap Right.dwg
Flex.dwg
Float Valve.dwg
FloSet Strainer.dwg
FloSet Union.dwg
FloSet valve.dwg
Flow arrow - curved.dwg
Flow arrow - straight.dwg
Flow arrow.dwg
Flow control valve.dwg
Flow meter - Annubar Type.dwg
Flow meter - Turbine.dwg
Flow Switch.bak
Flow Switch.dwg

FPTU - Parallel.bak
FPTU - Parallel.dwg
FTR Element - No Valve.dwg
Gate Valve - small.dwg
Gate Valve.dwg
Gauge and gauge cock.dwg
Gauge cock.dwg
Gauge with cock.dwg
Gauge.bak
Gauge.dwg
Horizontal damper.bak
Horizontal damper.dwg
Hot water coil - 2 way valve - pumped.dwg
Hot water coil with 2 way valve.bak
Hot water coil with 2 way valve.dwg
Hot water coil with 3 way valve.dwg
Humidifier - Trim.bak
Humidifier - Trim.dwg
Humidifier with shut-off.bak
Humidifier with shut-off.dwg
Humidifier.dwg
In Line Pump Strainer Ball Valves Check Valve.dwg
Incraser.dwg
Injection fitting.dwg
Instrumentation Valve.dwg
Jet diffuser box.dwg
Ladder - Feed thru terminal.dwg
Ladder - Fused terminal.dwg
Ladder - Grounding terminal.dwg
Ladder - NO Contact.dwg
Ladder - Switch terminal.dwg
Line size bottom.dwg
Line size right.dwg
Load or equipment block.bak
Load or equipment block.dwg
Load with 2-way valve.bak
Load with 2-way valve.dwg
Load with 3 way valve.dwg
Louver.dwg
Make up meter.bak
Make up meter.dwg
Mechanical Coupling.dwg
Needle Valve.dwg
new block.dwg
Node Number Left Bottom.dwg
Node Number Left Top.dwg
Node Number Right Bottom.dwg
Node Number Right Top.dwg
NYWEX AHU CHW Coil Bank.dwg
One break line.dwg
Petes plug.bak
Petes plug.dwg
Pipe size leader.bak
Pipe size leader.dwg
Plate and Frame Heat Exchanger with Auto Iso Valve.dwg
plot.log
Plug Valve.dwg
Prefilter with Bag Filter.dwg
Prefilter with Final filter.dwg
Pre-filters.dwg
Pressure - temperature test port.dwg
Pressure reducing valve.dwg
Pressure relief door - Labeled.dwg

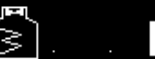
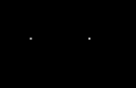
Pressure relief door - Negative - Labeled.bak
Pressure relief door - Negative - Labeled.dwg
Pressure relief door - Negative - No label.dwg
Pressure relief door - no label.dwg
Pressure relief door - Positive - Labeled.bak
Pressure relief door - Positive - Labeled.dwg
Pressure relief door - Positive - No label.dwg
Pressure relief valve.dwg
Pressure switch.dwg
Prop fan.dwg
Pump - ball valve suction diffuser check.bak
Pump - ball valve suction diffuser check.dwg
Pump DP Switch.dwg
Pump Gauge Set (no strainer).bak
Pump Gauge Set (no strainer).dwg
Pump Gauge Set (with strainer).dwg
Pump set with 2 BF Strainer Flex and Check.bak
Pump set with 2 BF Strainer Flex and Check.dwg
Pump set with SD Flex and TDV.dwg
Pump times 2.dwg
Pump with 2 BF mech flex and check no note.dwg
Pump with 2 BF mech flex and check.bak
Pump with 2 BF mech flex and check.dwg
Pump with 2 BFs check and flex.dwg
Pump with check and 2 butterfly valves.dwg
Pump with check service and plug valve.dwg
Pump with check valve.bak
Pump with check valve.dwg
Pumped Preheat Coil.dwg
Radiant panel.dwg
RAG with filter.dwg
Reheat coil with 2way valve.dwg
Riser - Conduit Body.dwg
Riser - Junction Box.dwg
Roll up garage door.dwg
Ron's Valve.dwg
SEN_2WCY.DWG
SEN_3WCY.DWG
SEN_CRLY.DWG
SEN_DMPA.DWG
SEN_DP.DWG
SEN_FISD.DWG
SEN_SMKD.DWG
SEN_STRT.DWG
SEN_TAV.DWG
Sensor - Air Flow.bak
Sensor - Averaging temperature.bak
Sensor - Duct Humidity.bak
Shell and tube Hx.dwg
Shot feeder.dwg
Size lead - Horizontal - Bottom.bak
Size lead - Horizontal - Bottom.dwg
Size lead - Horizontal - Top.bak
Size lead - Horizontal - Top.dwg
Size lead - Vertical - Left.bak
Size lead - Vertical - Left.dwg
Size lead - Vertical - Right.bak
Size lead - Vertical - Right.dwg
Sound Attenuator.dwg
Steam Heat Exchanger.bak
Steam Heat Exchanger.dwg
Strainer with blow down.dwg

Strainer.dwg
Suction Diffuser - 90.dwg
Suction diffuser.bak
Suction diffuser.dwg
Sump pump with check valve.dwg
Tank.dwg
Temperature transmitter with calibration thermometer.dwg
Temperature transmitter with calibration well.dwg
Temperature transmitter.dwg
Thermometer well.bak
Thermometer well.dwg
Thermometer with 2nd well.dwg
Thermometer.bak
Thermometer.dwg
Three way valve.dwg
Triple duty valve.dwg
Turbine Flow Meter.dwg
TurFl.dwg
Two way valve.dwg
Typical pump assembly.dwg
Typical Zone.dwg
Union.dwg
UV Array.dwg
Vane meter.dwg
VAV reheat terminal with two way hot water coil.bak
VAV reheat terminal with two way hot water coil.dwg
Vent.dwg
Vertical damper medium.dwg
Vertical damper small.dwg
Vertical damper.dwg
Vertical opposed blade damper - closed.dwg
Vertical opposed blade damper - open.dwg
Vertical opposed blade damper with actuator - short.dwg
Vertical opposed blade damper with actuator.dwg
VFD.dwg
Vicfaulic Flex.dwg
Water Meter.dwg
Zone damper.dwg



Starting Points for Symbols

Drawing program symbol libraries



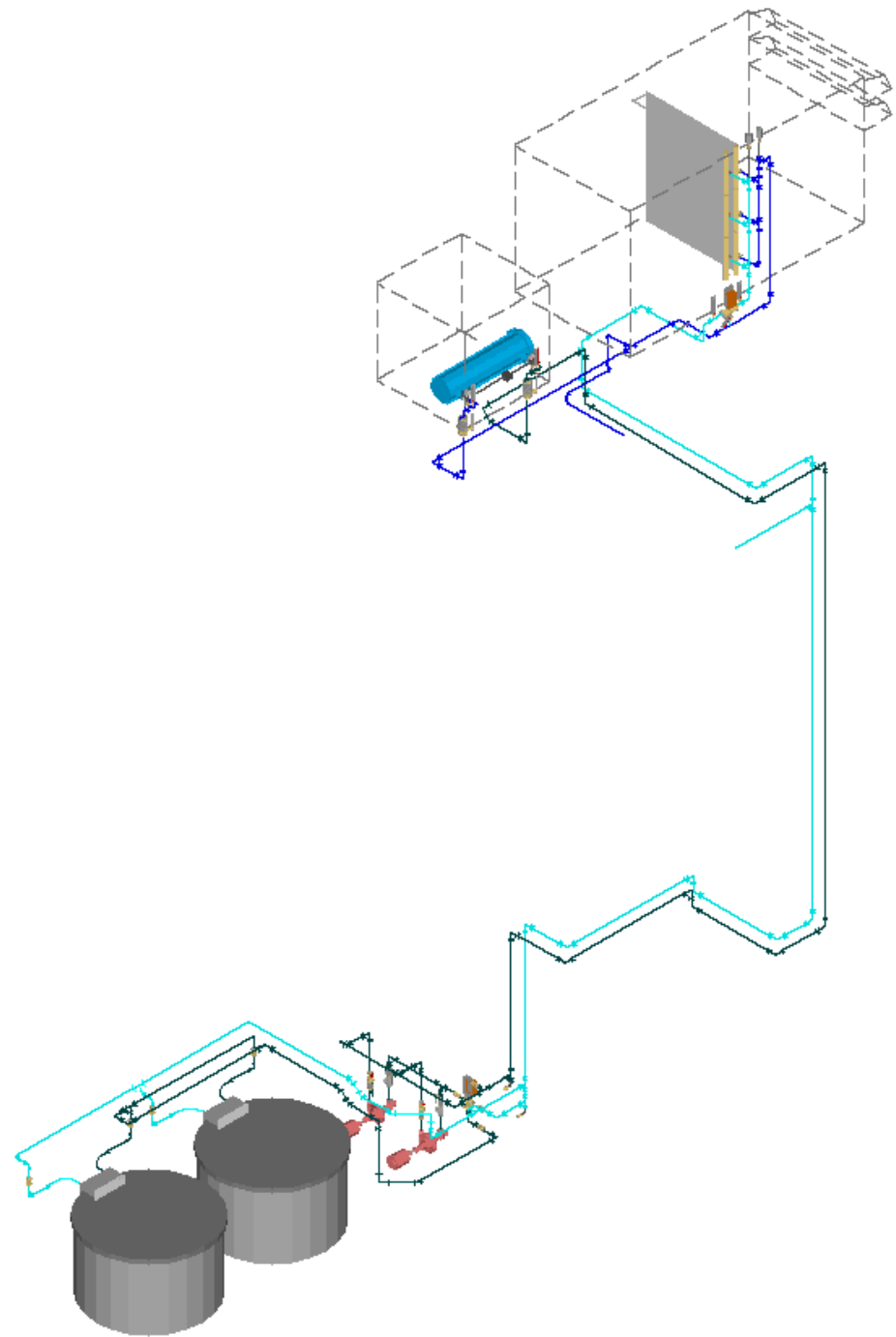
Regenerating model.
Autodesk DWG. This file is a Trusted DWG last saved by an Autodesk application
or Autodesk licensed application.

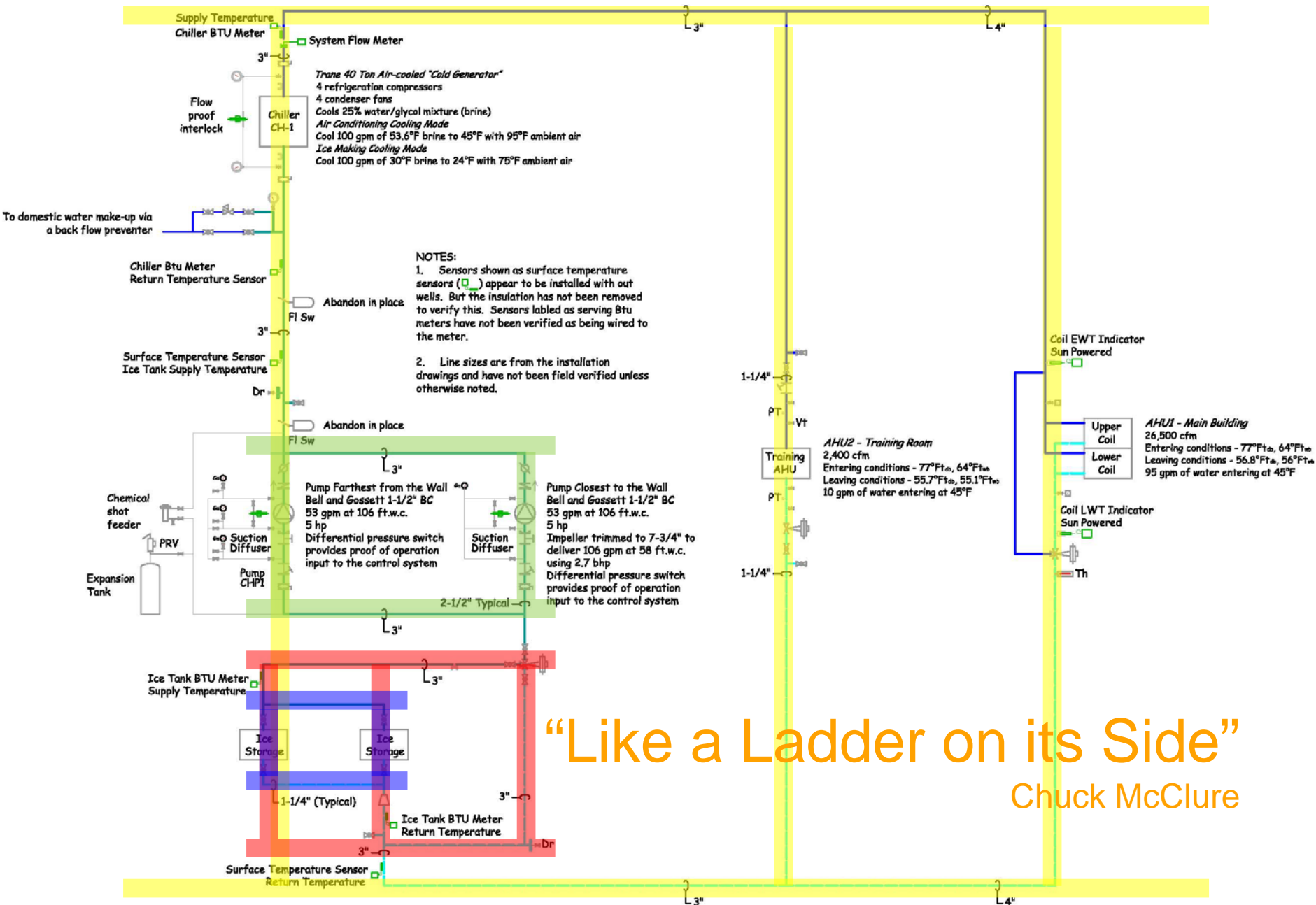
Command:

Plot and Publish Job Complete
No errors or warnings found
[Click to view plot and publish details...](#)

5.7835, 9.6991 SNAP GRID ORTHO POLAR OSNAP OTRACK DYN LWT MODEL TABLET EPTS

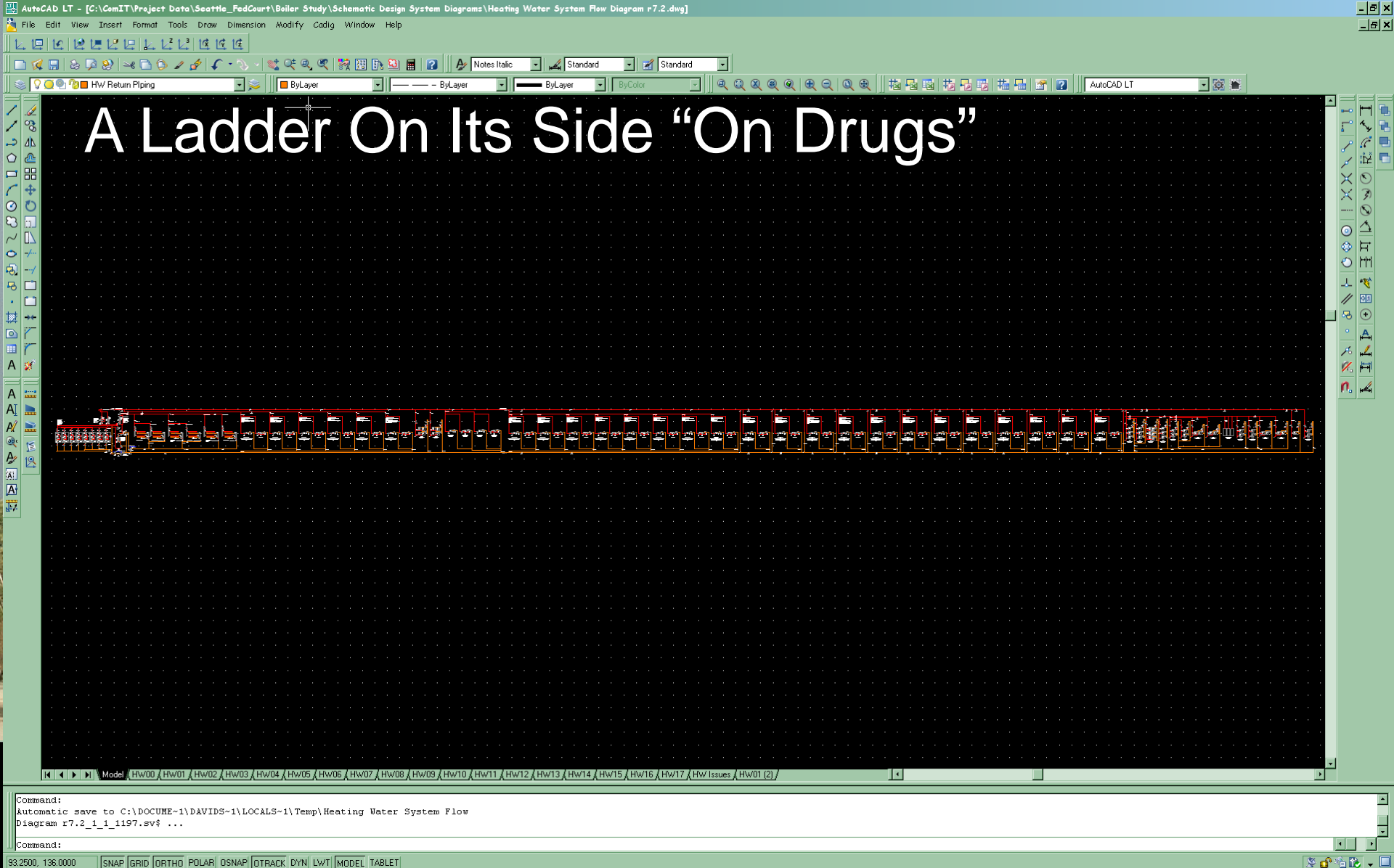
Physically Complex,





“Like a Ladder on its Side”

Chuck McClure



A Ladder On Its Side in Japanese

横にはしごのように

Yoko ni hashigo no yō ni

We're doing that Japan training this week Just thought you'd want to know that the phrase "Ladder on its side" has officially been translated into another language!!

Brian Clark

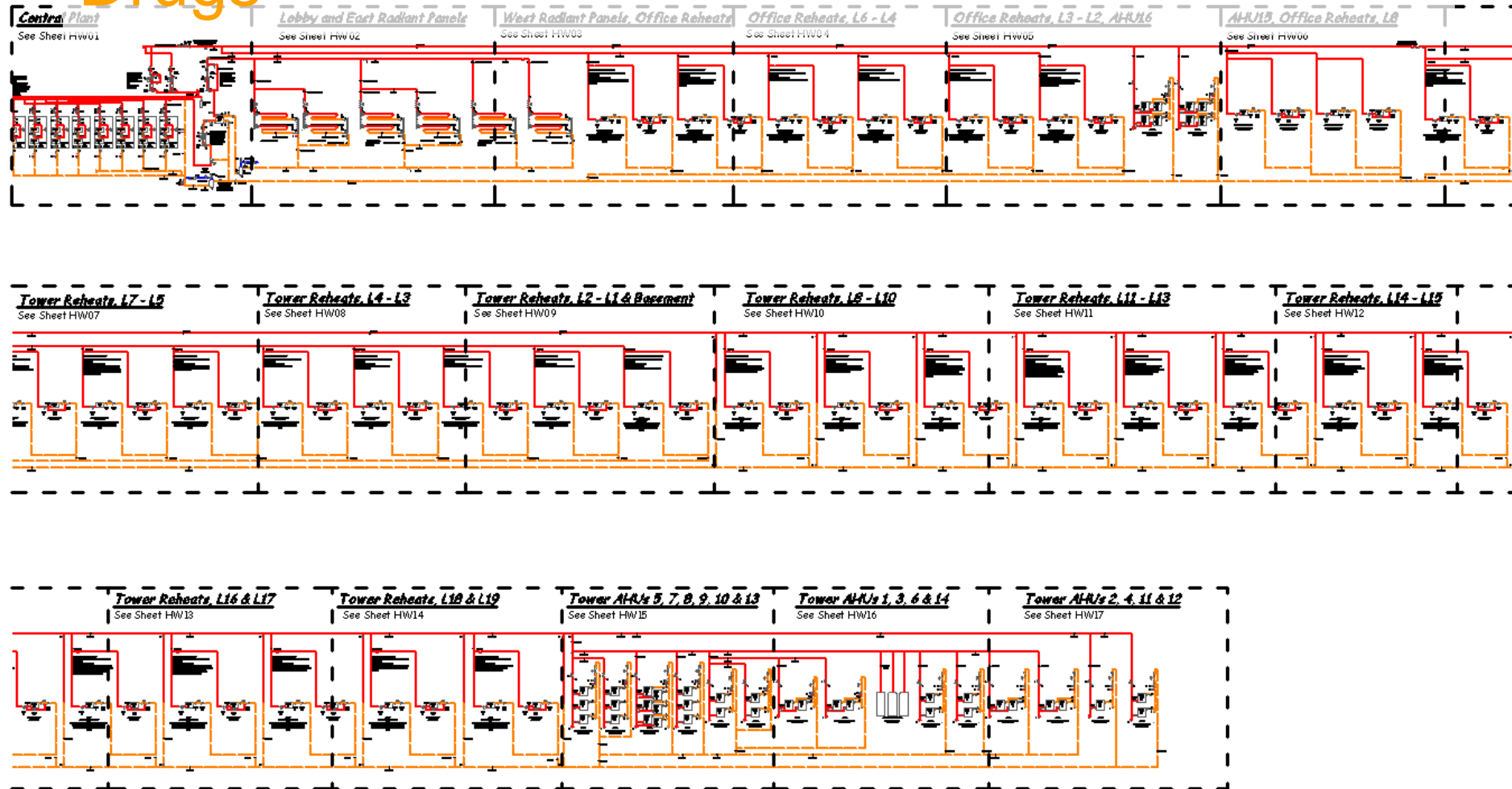
Mechanical Engineer, Energy Branch

Construction Engineering Research Laboratory

US Corps of Engineers

Former EBCx Workshop Student

Dealing With a Ladder On Its Side “On Drugs”



New Seattle Court House Heating Water System Flow Diagram

Revisions: 1 - Revised boiler piping to match actual factory piping.
 Revisions: 2 - 1-24-02 - Modified arrangement of factory piping to make it clearer
 Revisions: 3 - 12-15-03 - Updated and detailed to include radiant panel heat exchanger and HP12.
 Revisions: 4 - Release 3/23/04

Revisions: 5 - Corrected return piping at boiler return headers

Drawn by: DAS

Date: April 29, 2002

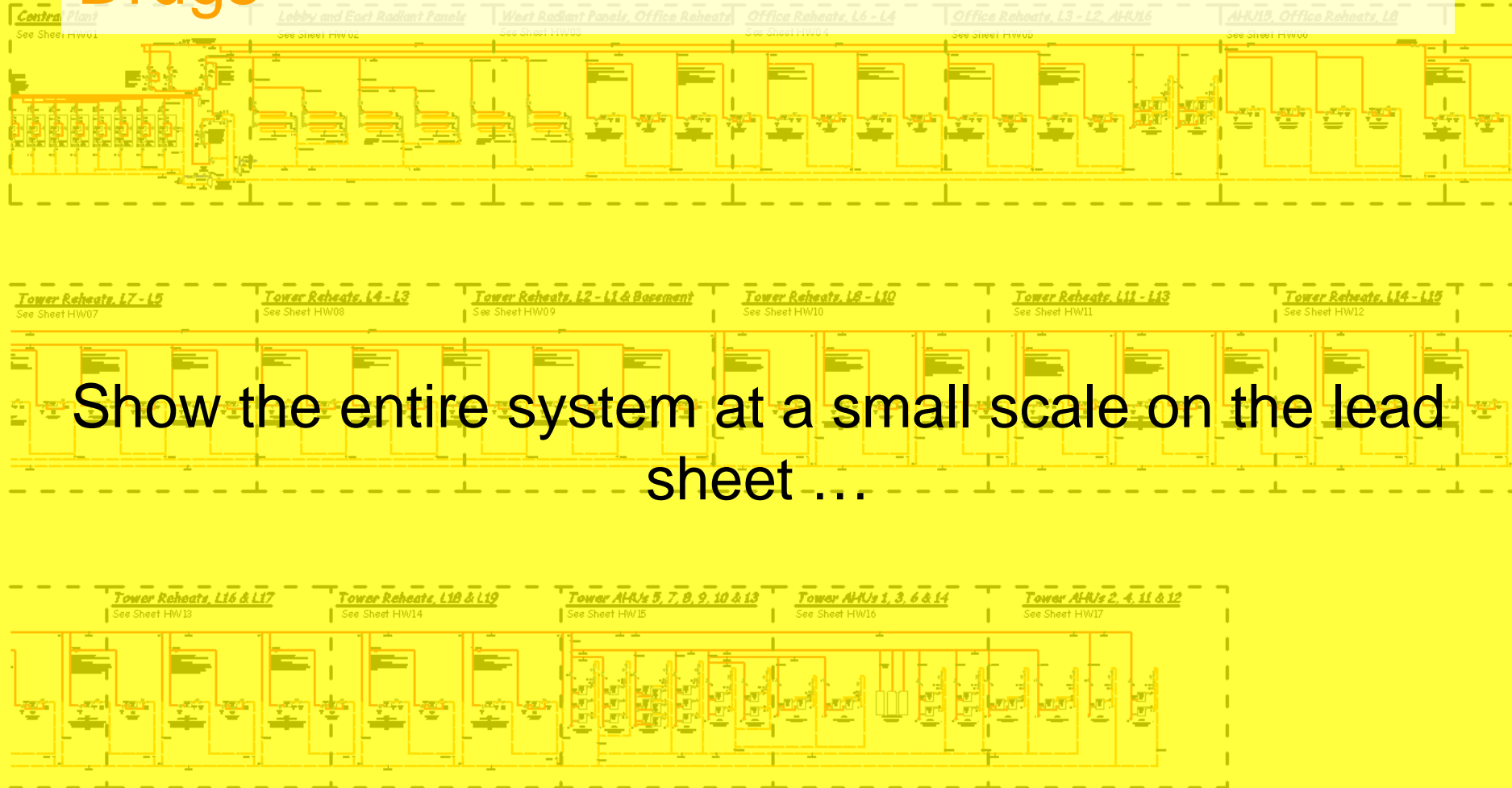
HW00

Checked by:

Plot date: December 09, 2003

BASIC CONCEPTS

Dealing With a Ladder On Its Side “On Drugs”



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Date: April 29, 2002

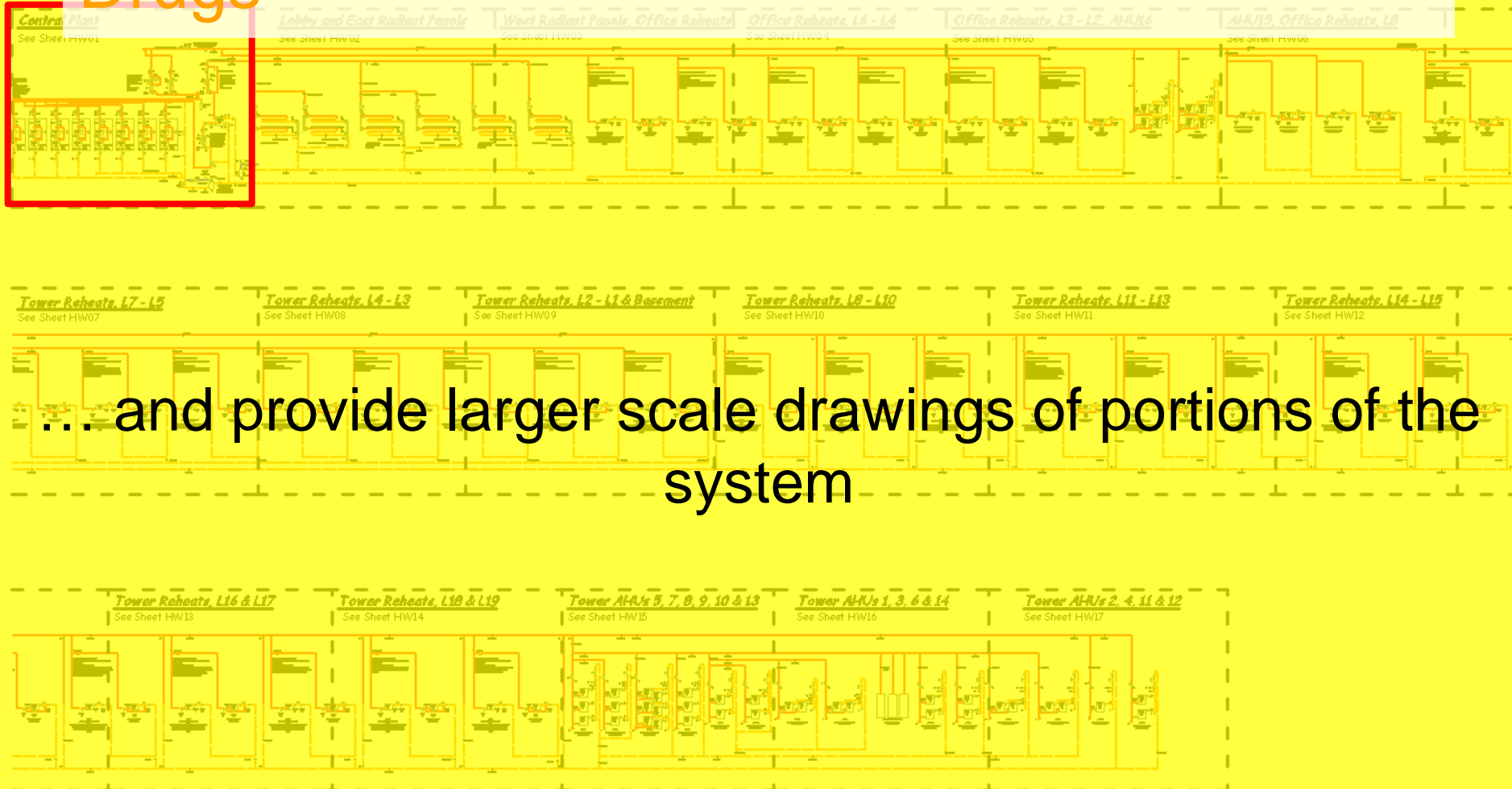
HW00

Checked by:

Plot date: December 09, 2003

BASIC CONCEPTS

Dealing With a Ladder On Its Side “On Drugs”



... and provide larger scale drawings of portions of the system

New Seattle Court House Heating Water System Flow Diagram

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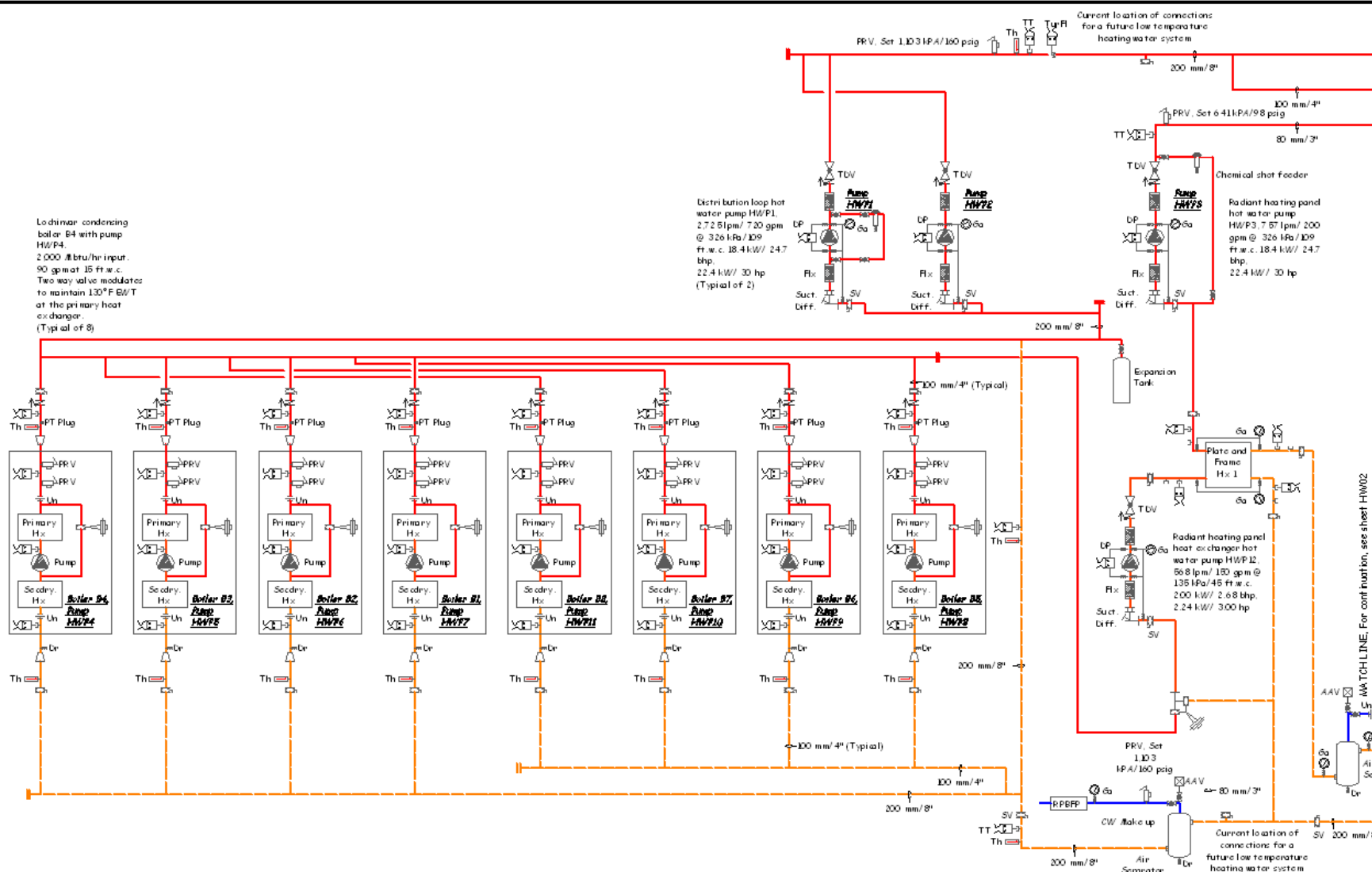
Date: April 29, 2002

HW00

Checked by:

Plot date: December 09, 2003

BASIC CONCEPTS



AWATCH LINE. For continuation, see sheet HW02

New Seattle Court House Heating Water System Flow Diagram

Revisions: 1- Revised boiler piping to match actual factory piping.
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 Revisions: 3- 12-15-03 - Updated and detailed to include radiant panel heat exchanger and HP12.
 Revisions: 4- Release 3/23/04

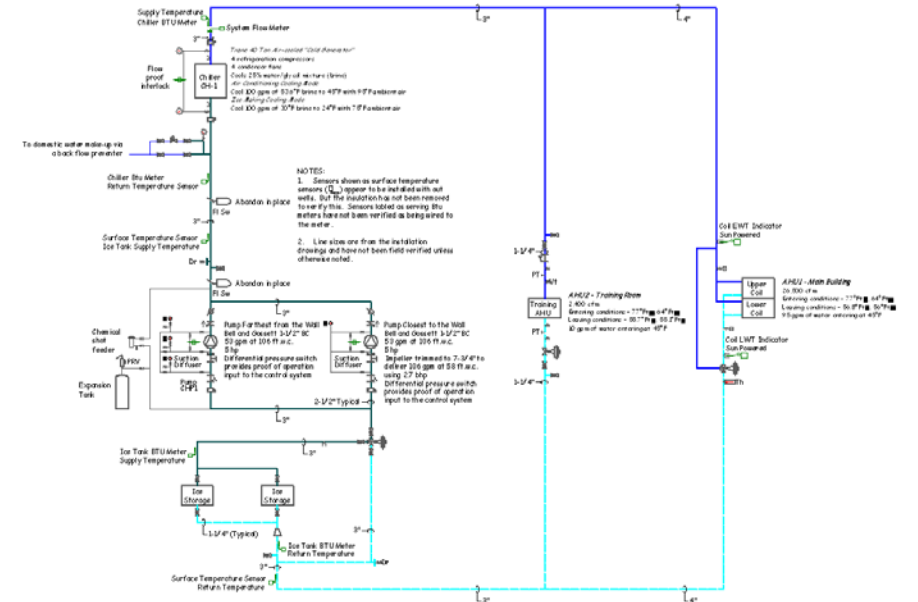
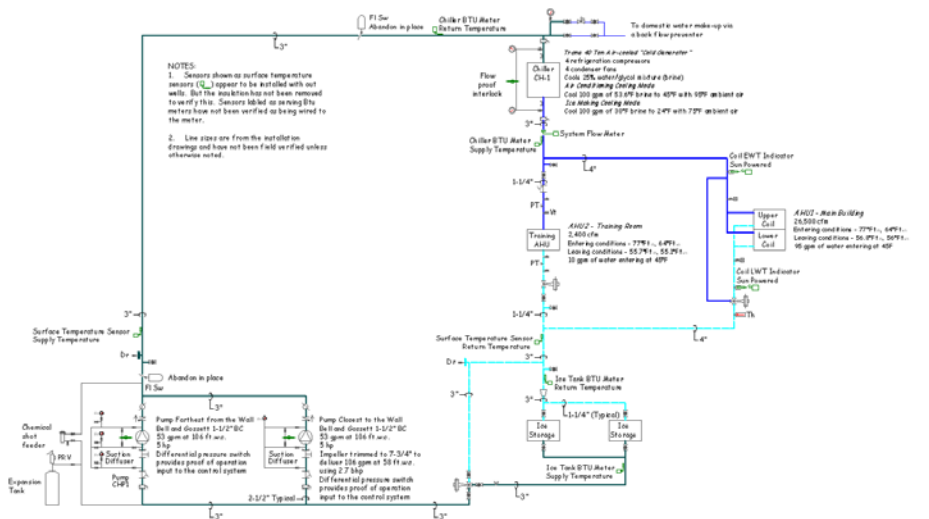
Revisions: 5- 7-6-04 - Revised radiant panel pump connections.
 Revisions: 5.1- 7-7-04 - Revised radiant panel connection to the boiler header.

Drawn by: DAS	Date: April 29, 2002	HW01
Checked by:	Plot date: December 16, 2003	

What's on the Ladder Rungs and What's on the Ladder Rails Can Vary

“What’s using up the pump head?” focus

“What’s making and using cold glycol?” focus



“Untangled” versus “Tangled”

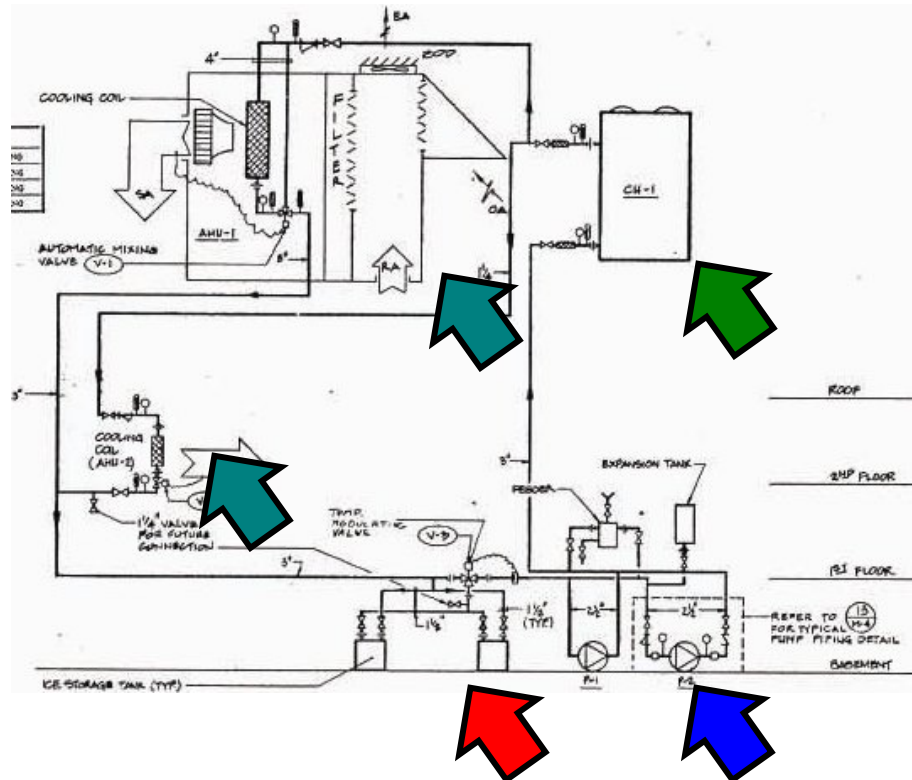


tangled *adj*

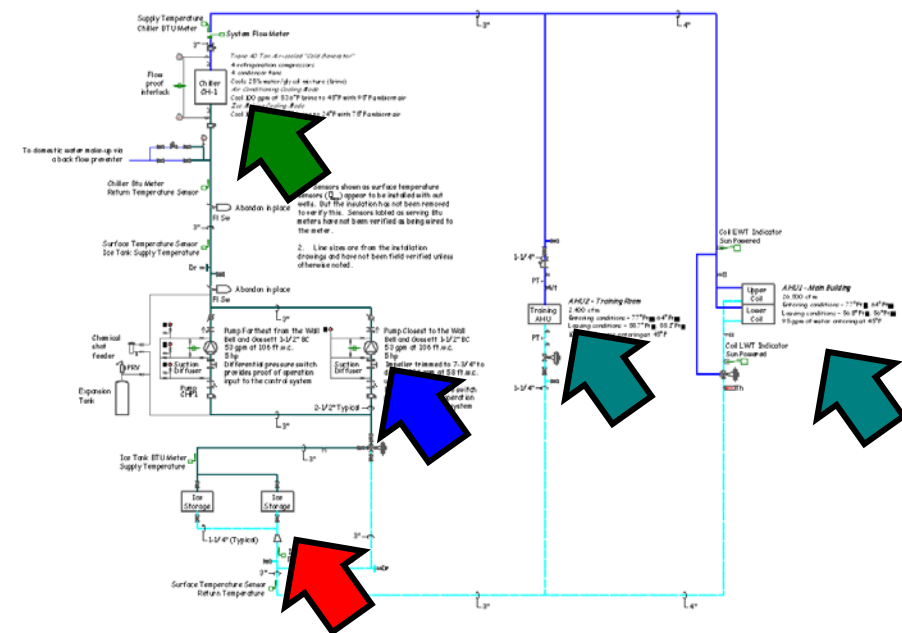
1. existing in or giving the appearance of a state of utter disorder
2. very involved : exceedingly complex

“Untangled” versus “Tangled”

Tangled



Untangled



“Untangled” versus “Tangled”

Keep simplifying things to minimize line crossings and head towards a “ladder on its side”

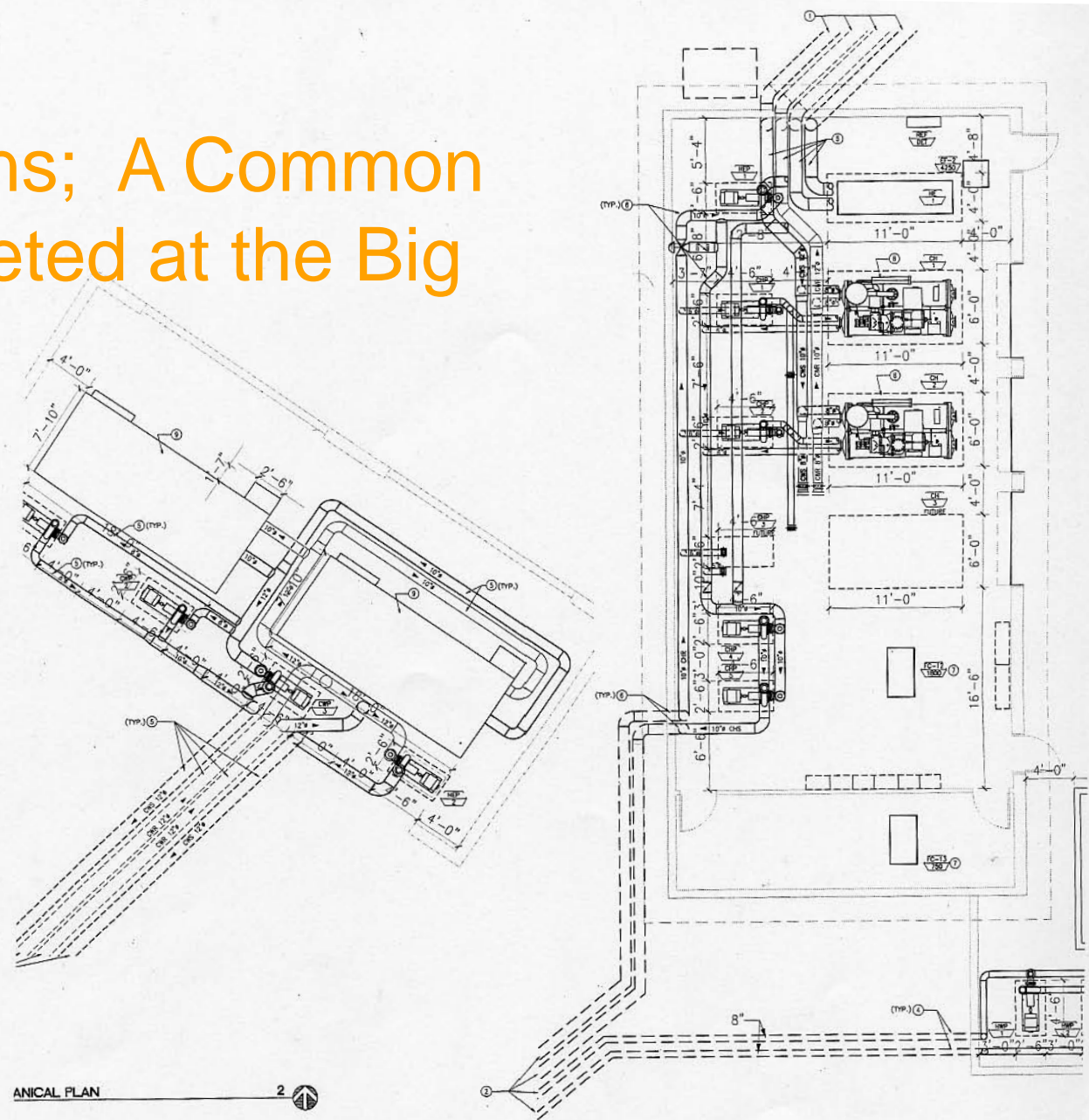
But remember:

Things should be made as simple as possible, but not any simpler.

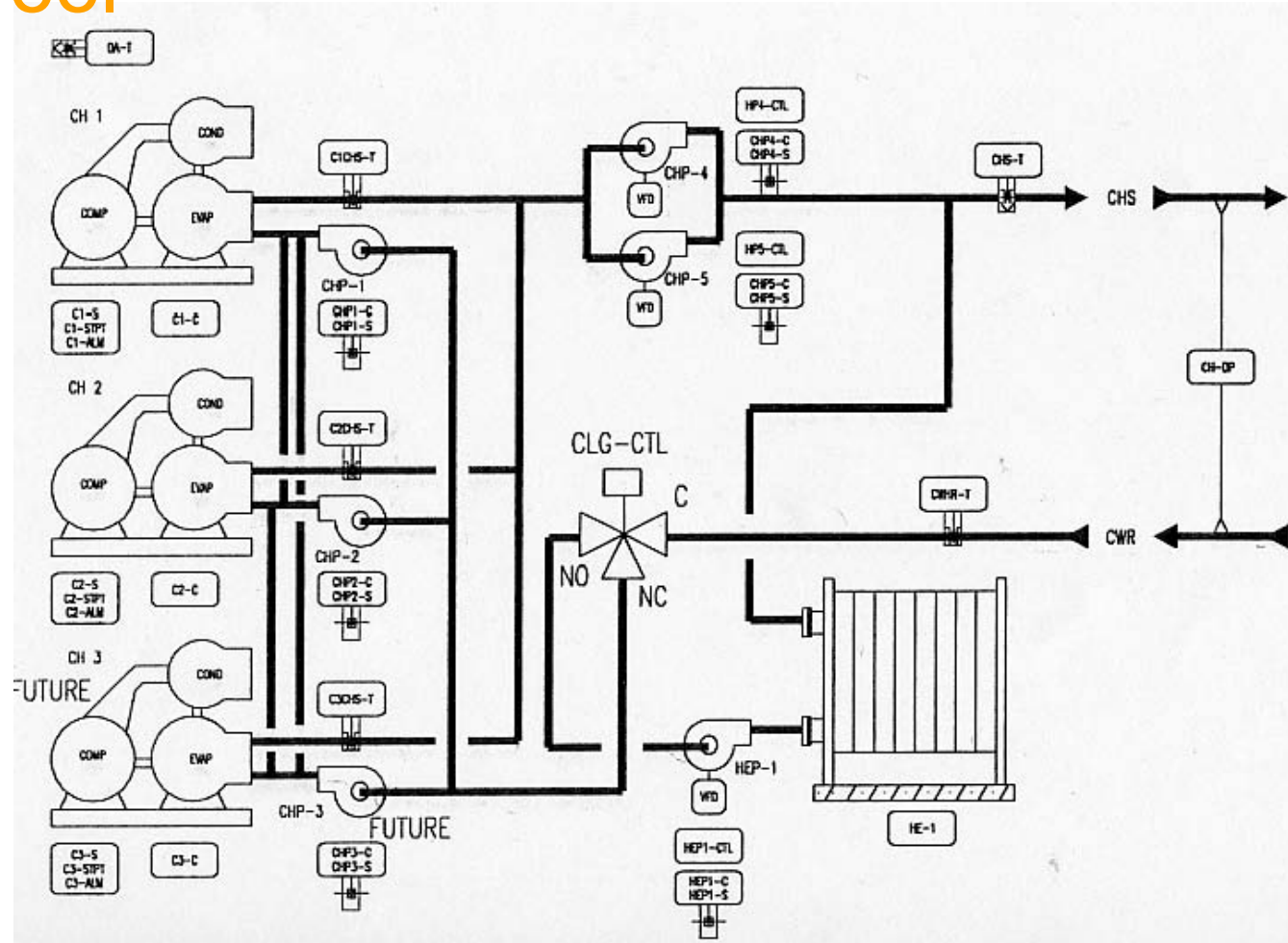
Albert Einstein

That means for a system diagram, order of connection “trumps” untangled

Floor Plans; A Common Tool Targeted at the Big Picture



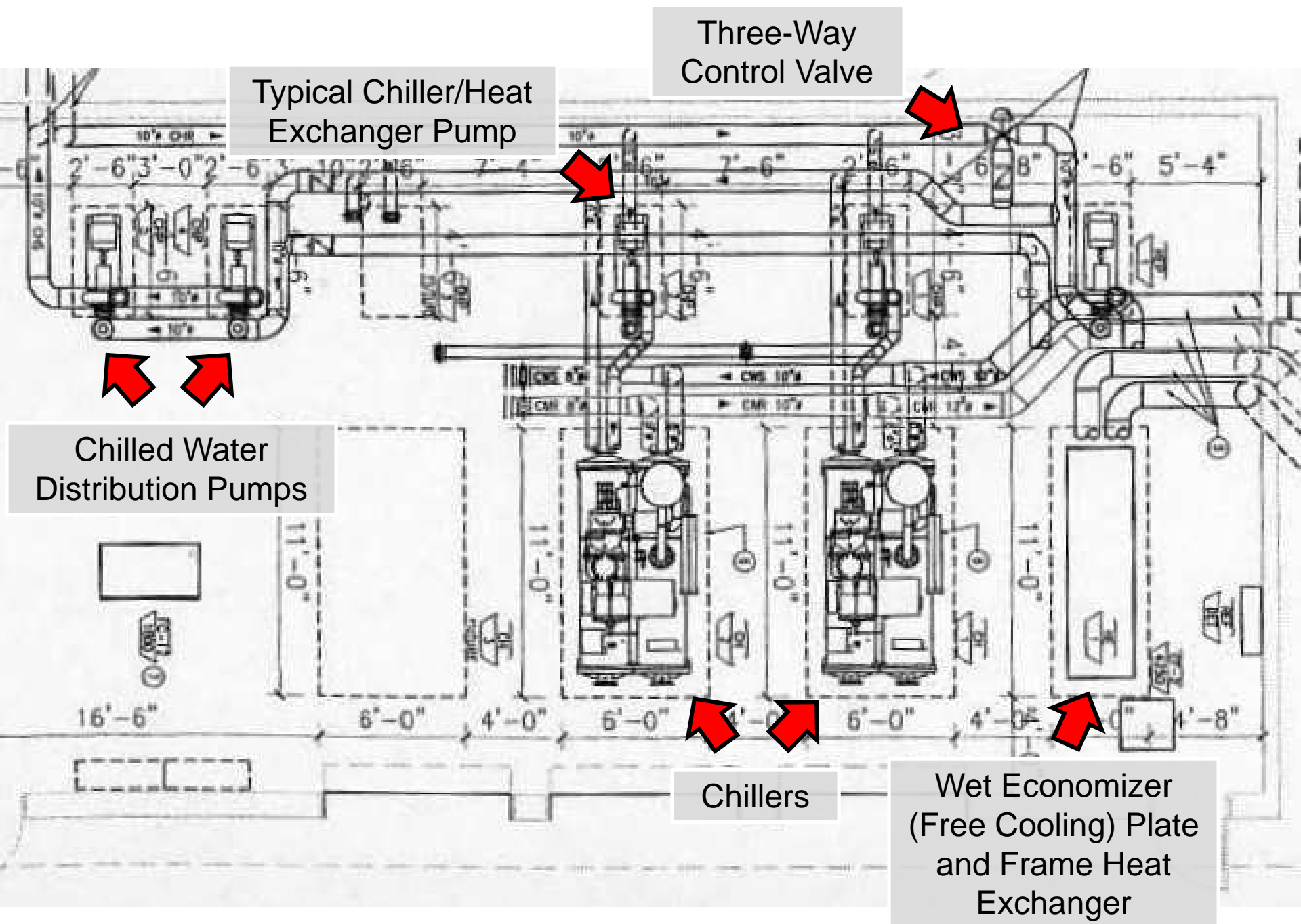
Schematics; Another Common Tool

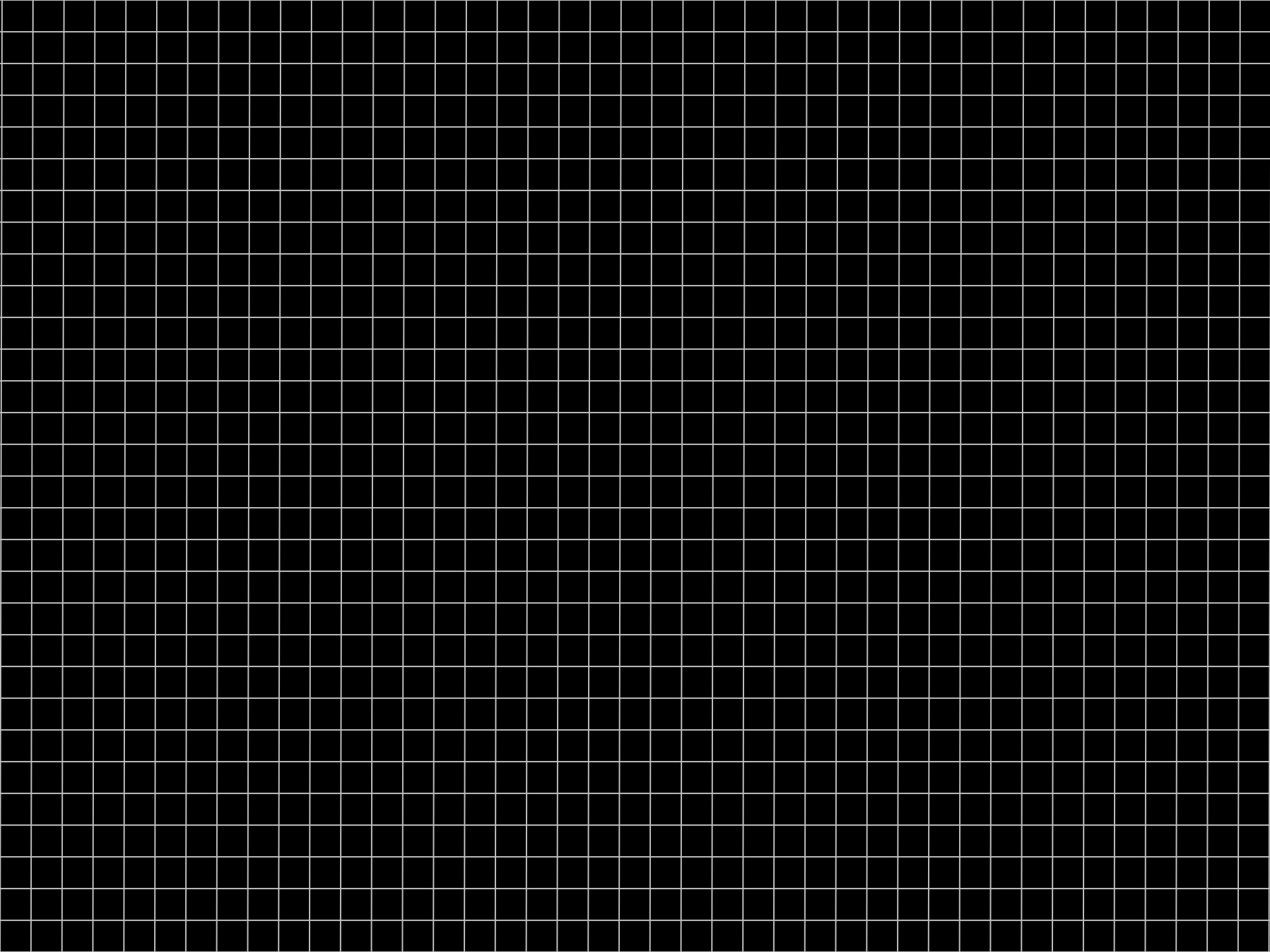




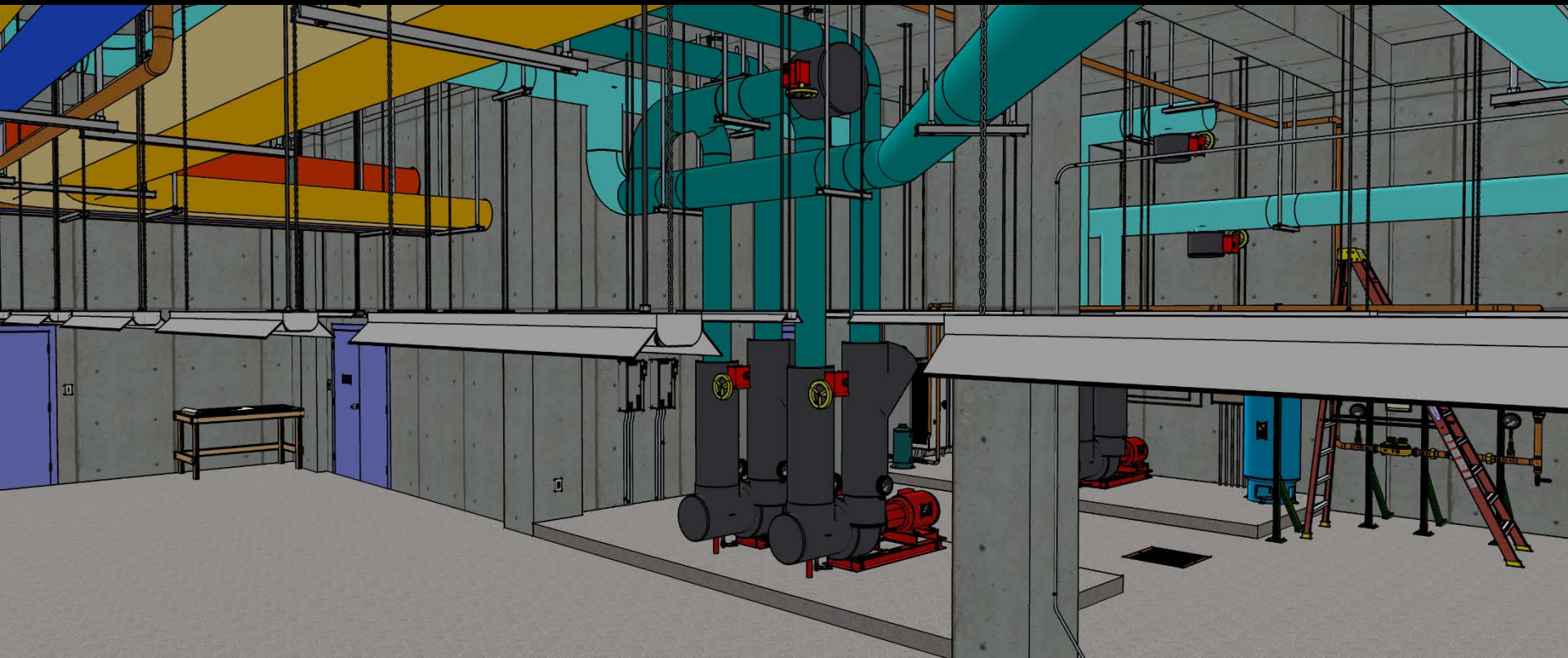
An Exercise Applying What You've Learned So Far

- *Half the class take the piping plan in the next slide and make a system diagram from it*
- *The other half of the class take the schematic in the previous slide and make a system diagram from it*
- *See if there are any problems that jump out at you from your system diagrams*
- *Did you recognize/understand them before you did the system diagram?*





Order of Connection Matters



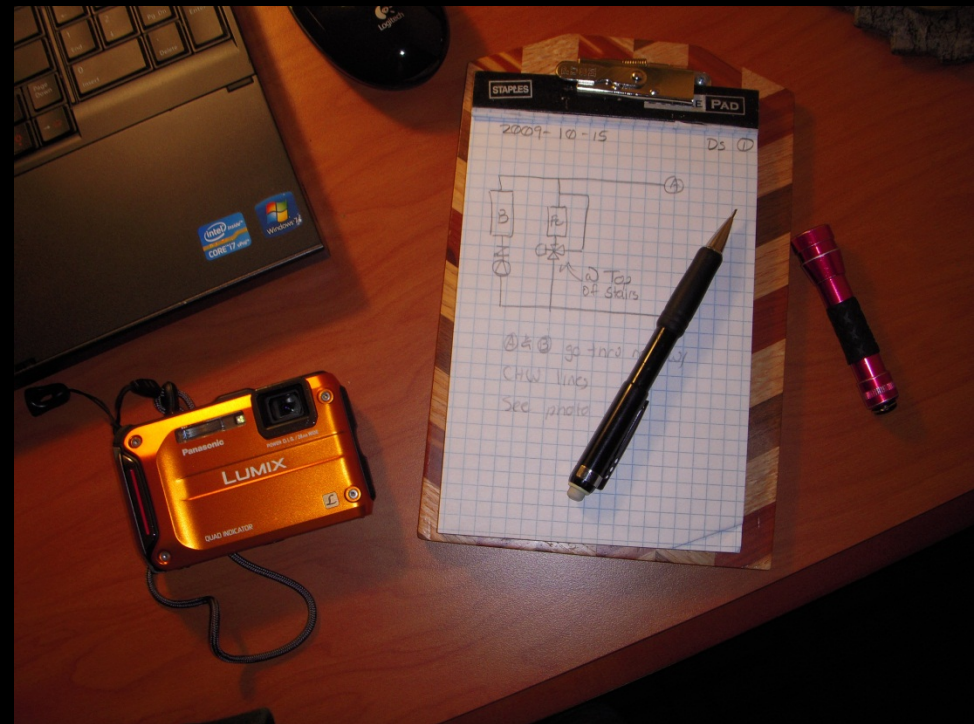
Getting Ready to Go Out in the Field

Study existing drawings if they exist

- May include a schematic
- May reveal issues
- Provides a first draft

Be ready for reality

- Clipboard
- Paper
- Flashlight
- Camera



Getting Started

Find something you can identify

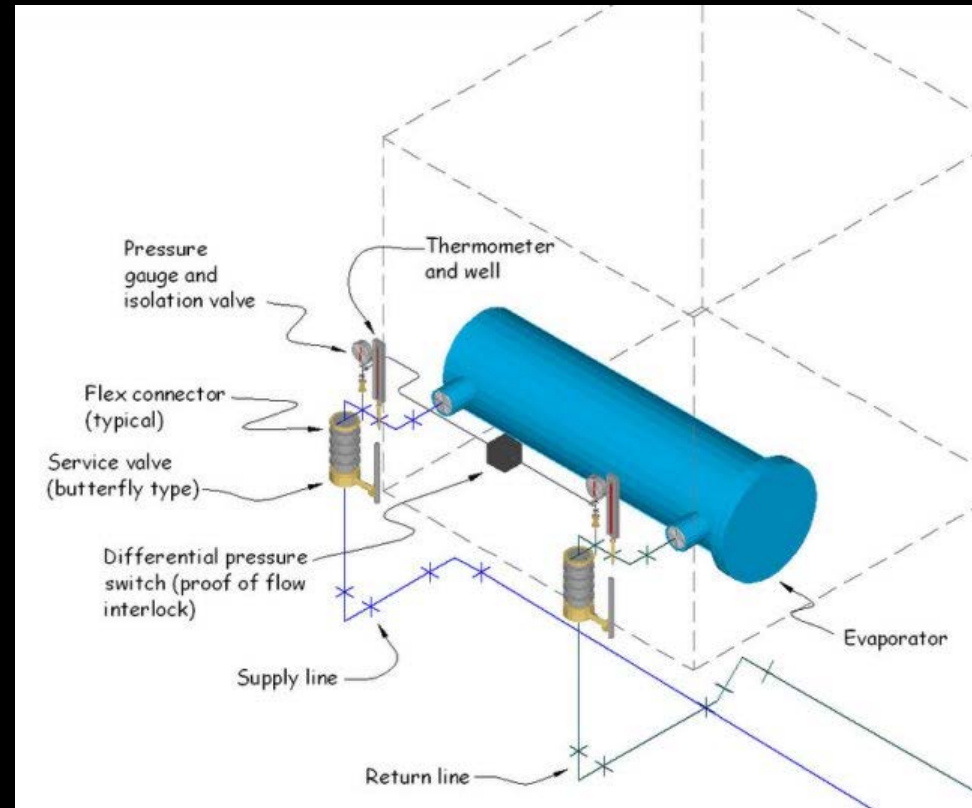
- Nameplate data
- Labels
- Past experience



Getting Started

Find something you can identify

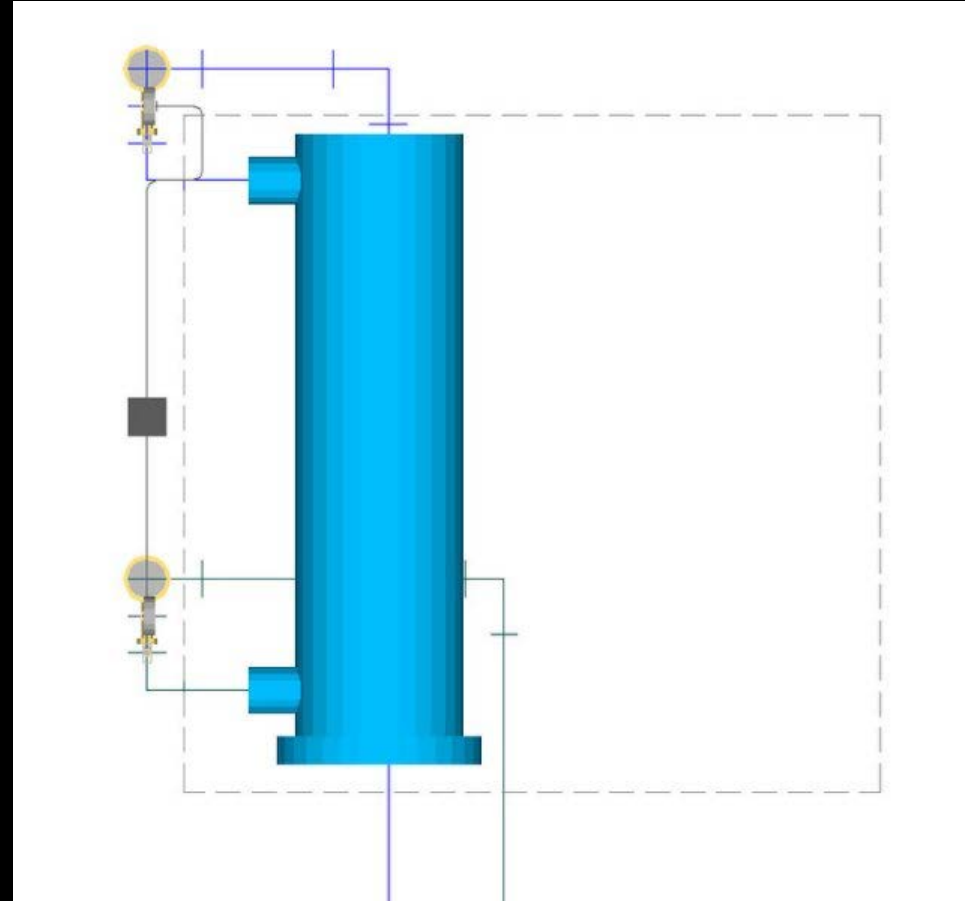
- Nameplate data
- Labels
- Past experience



Getting Started

Find something you can identify

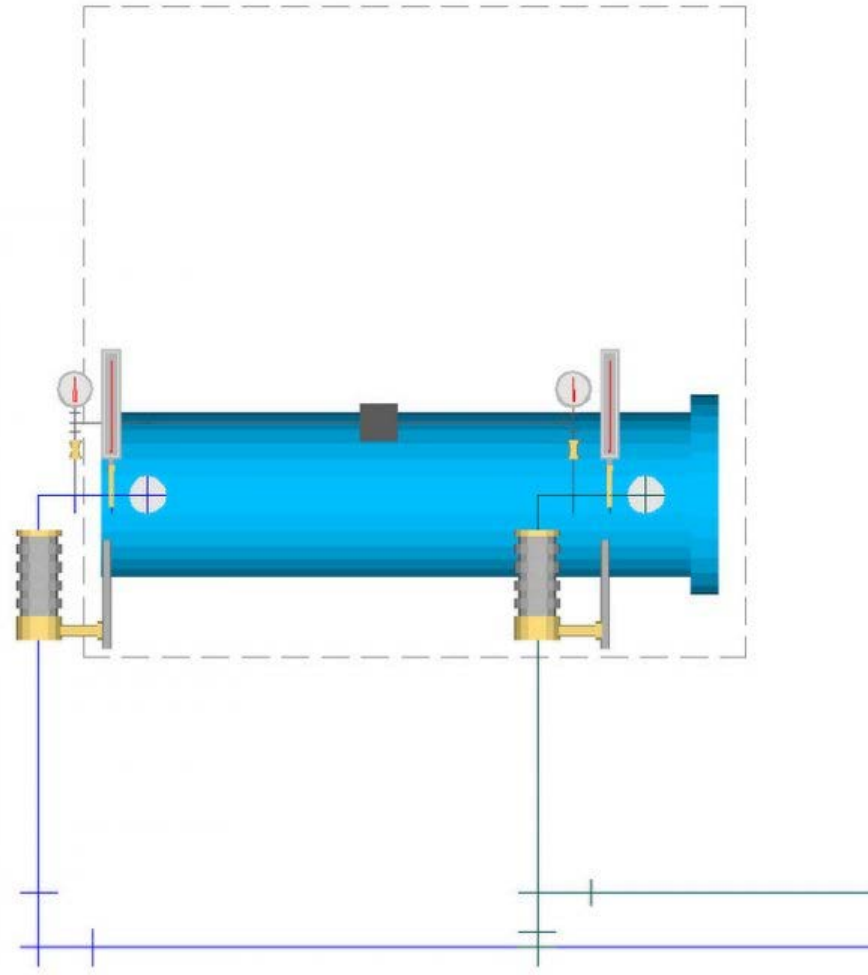
- Nameplate data
- Labels
- Past experience



Getting Started

Find something you can identify

- Nameplate data
- Labels
- Past experience



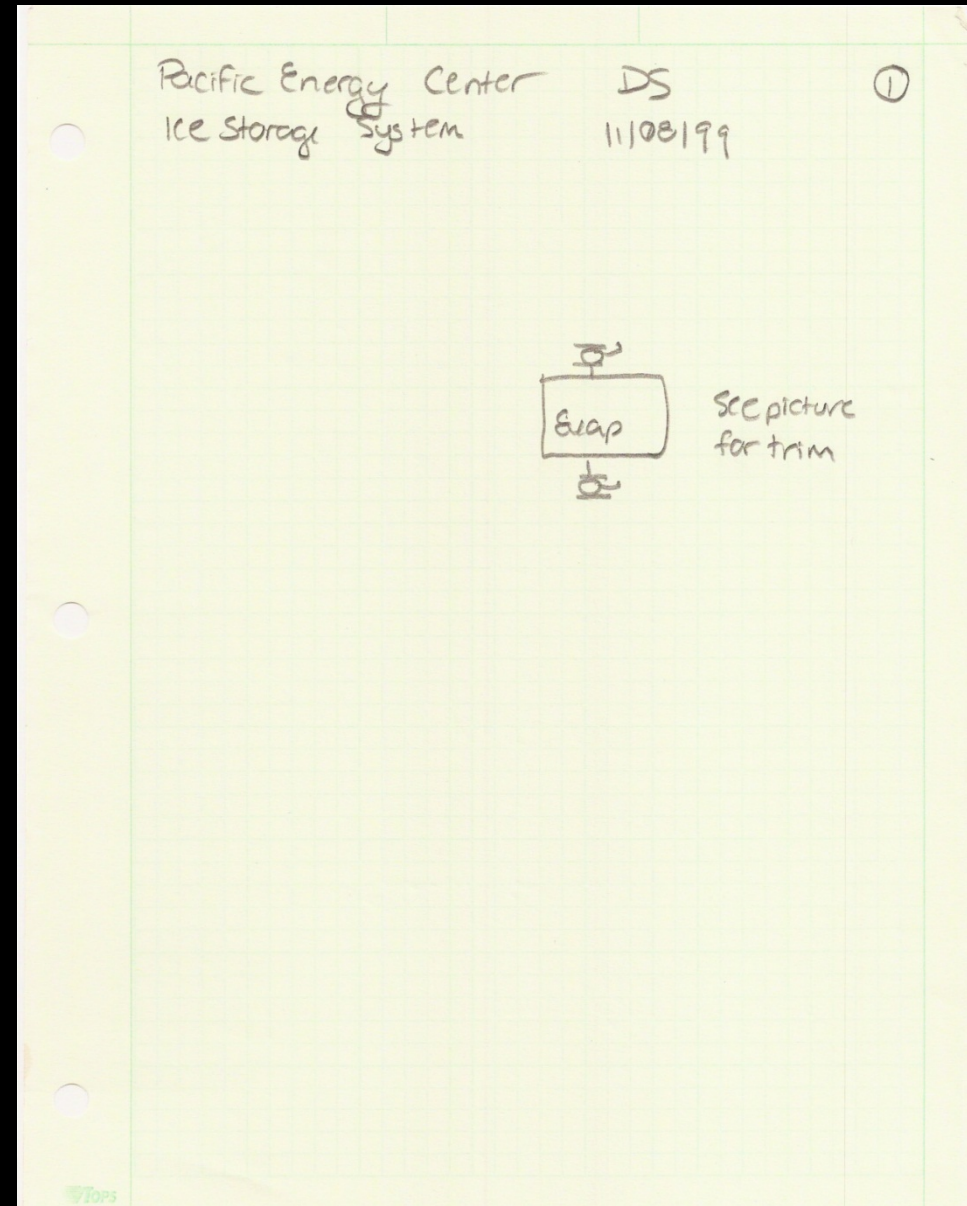
Getting Started

Find something you can identify

- Nameplate data
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- Past experience

Start following the system of interest

- Your first effort will likely not be your last effort



Getting Started

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Start following the system of interest

- Your first effort will likely not be your last effort
- “Follow your nose”



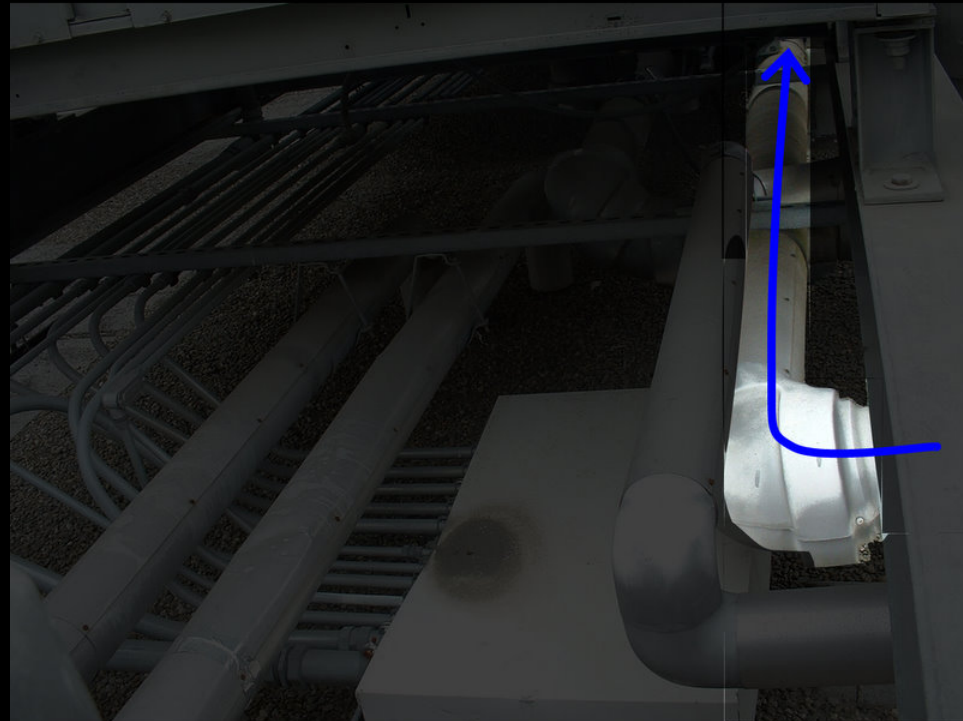
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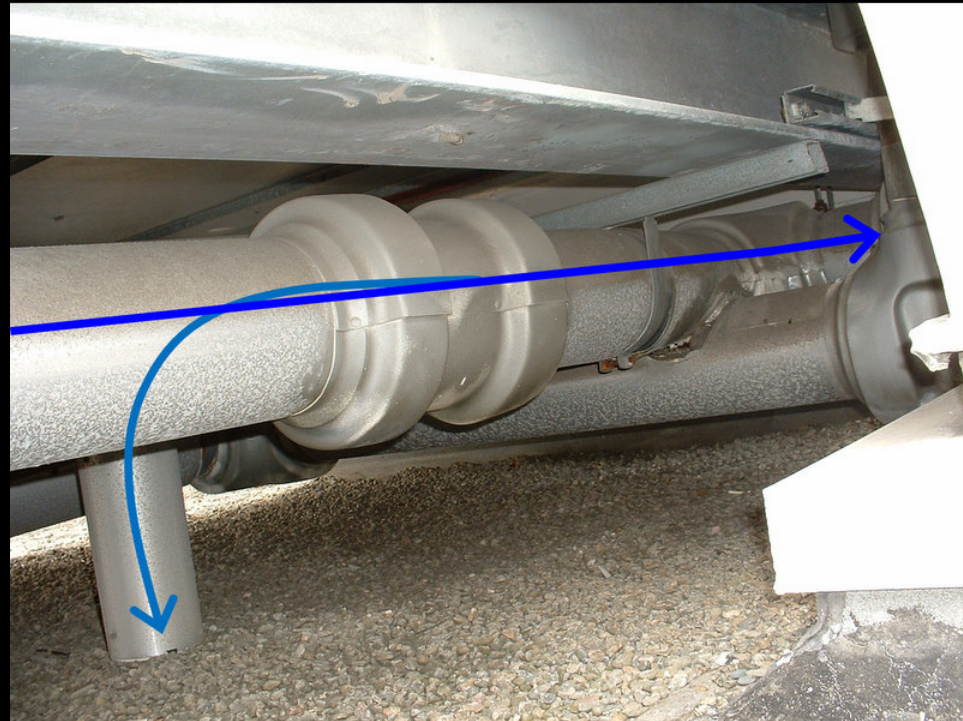
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- Your first effort will likely not be your last effort
- “Follow your nose”
- Make decisions at tees



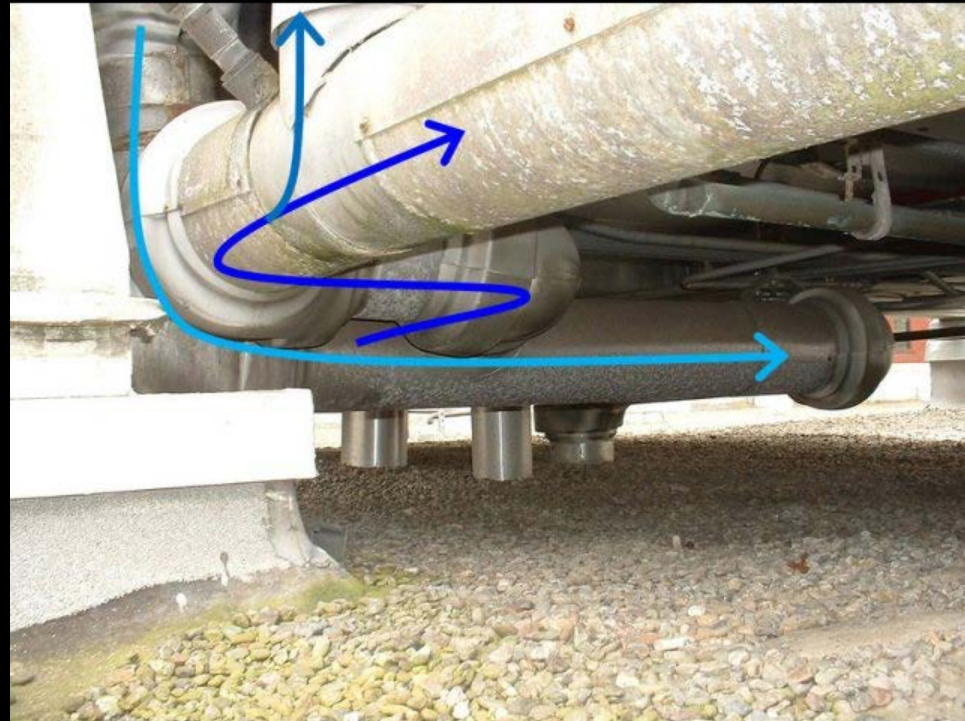
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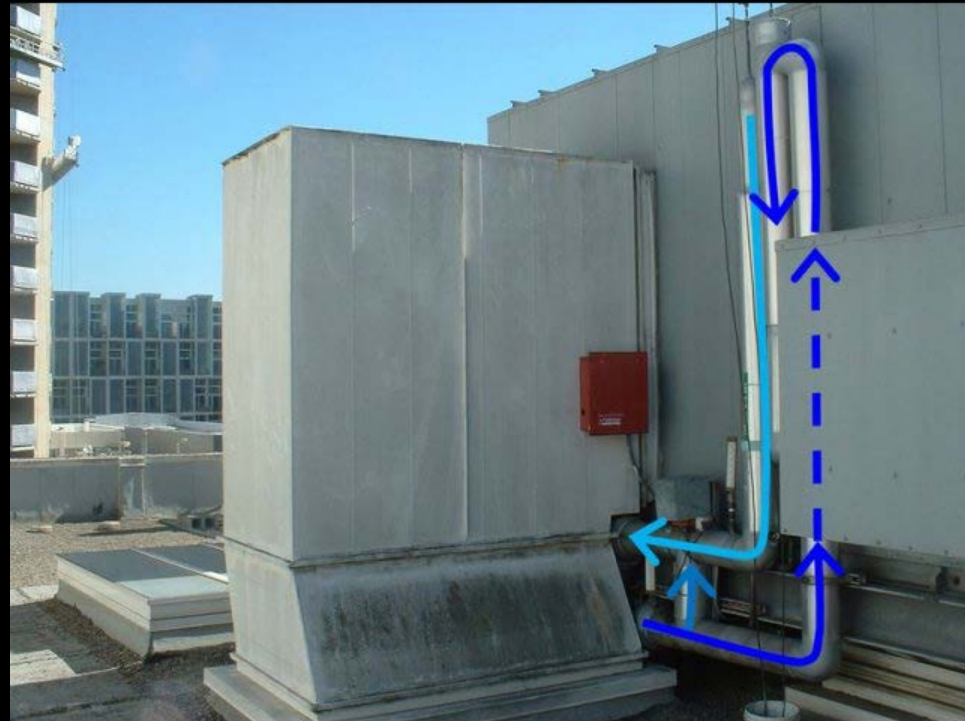
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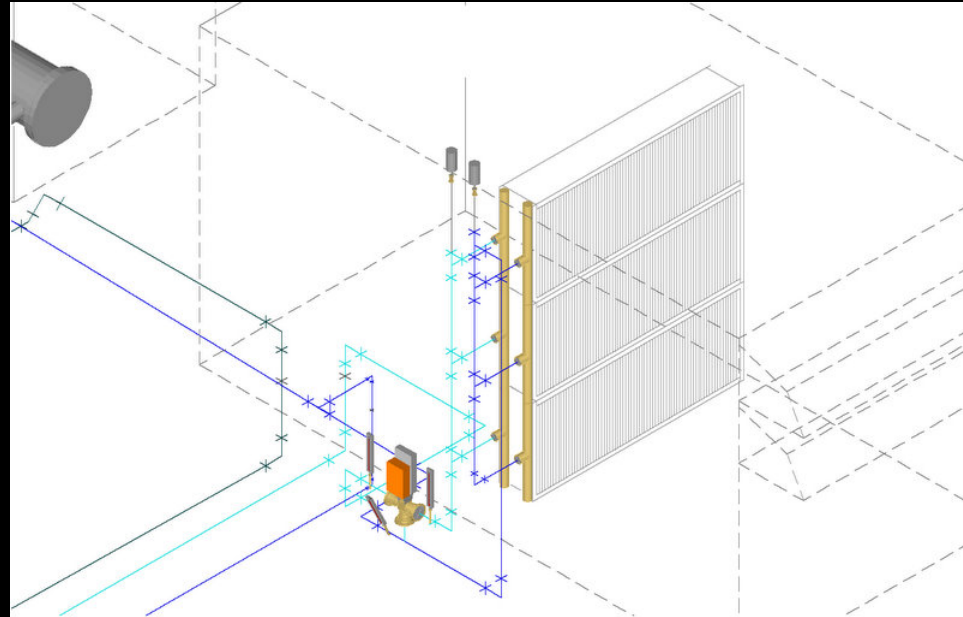
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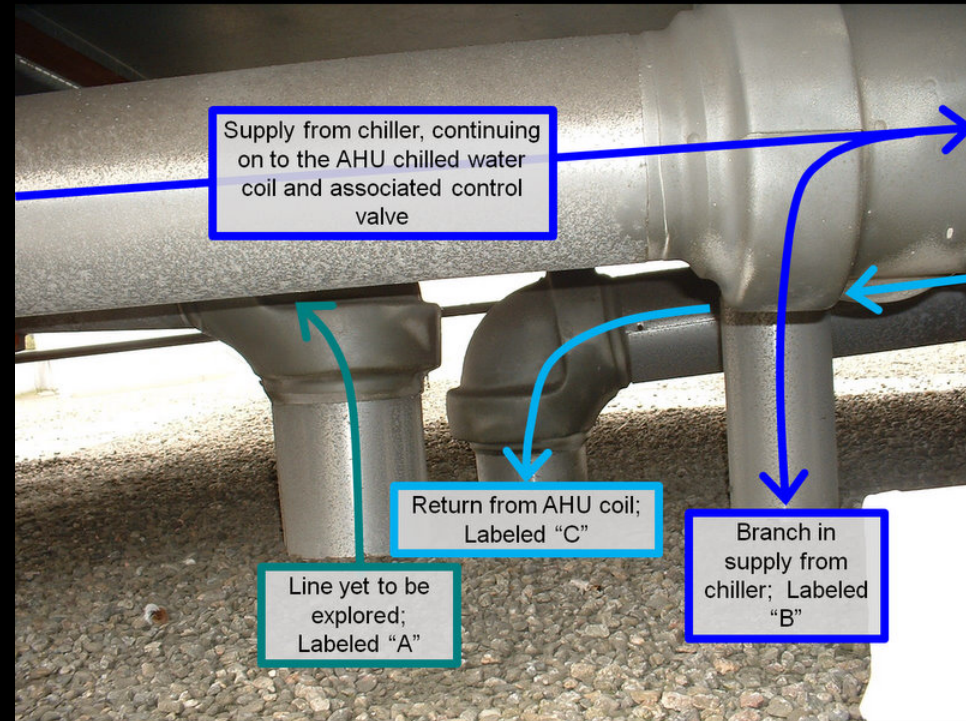
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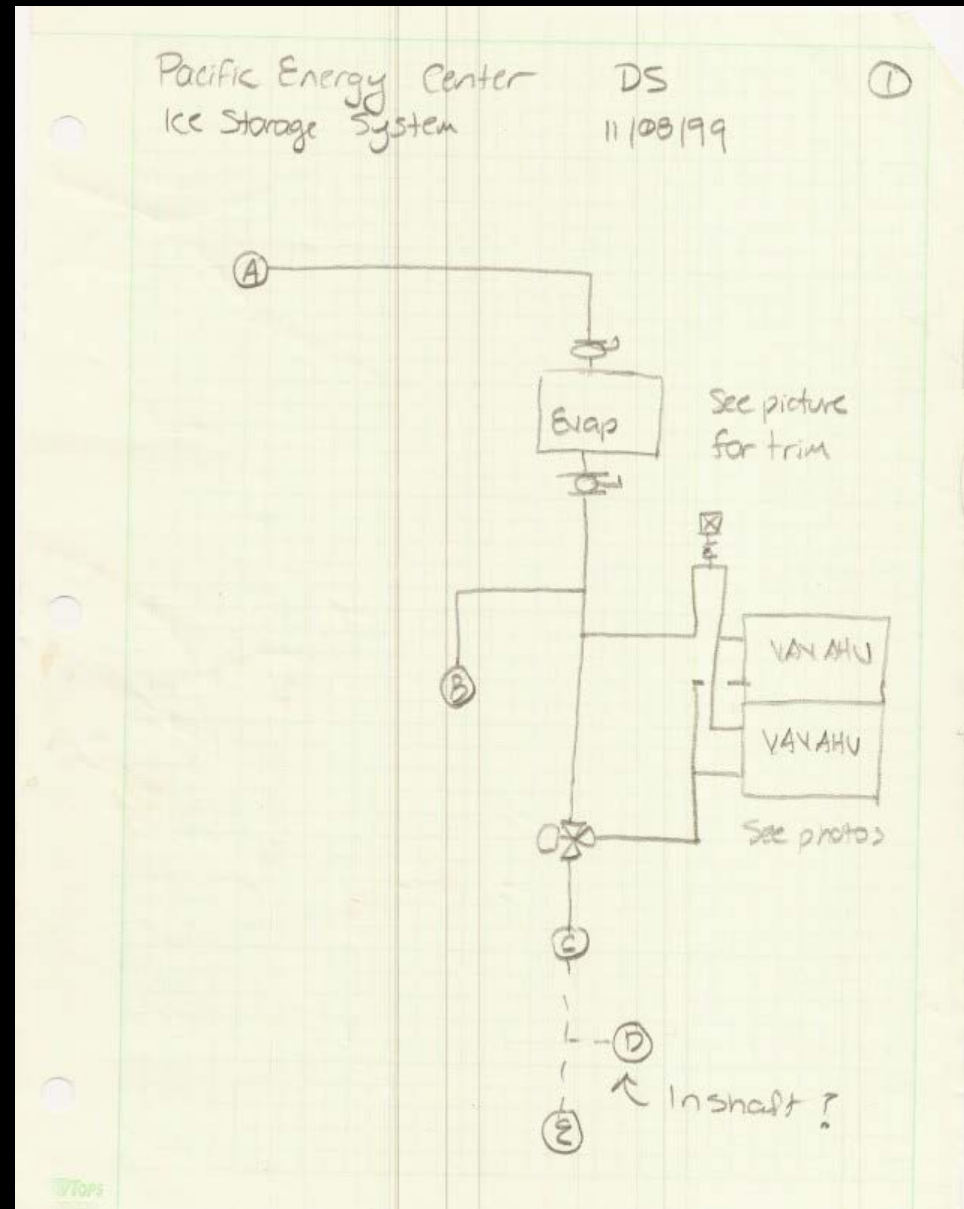
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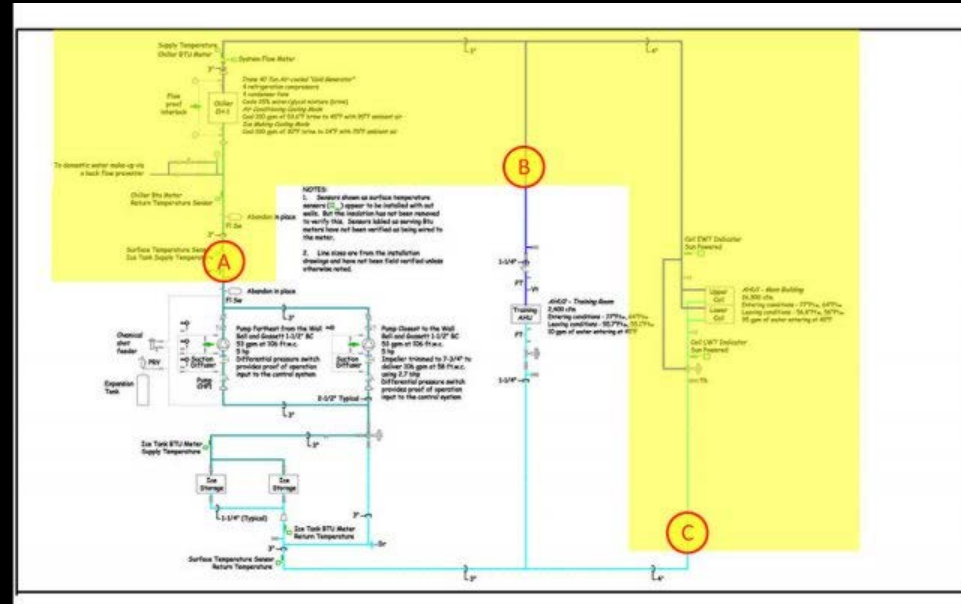
Getting Started

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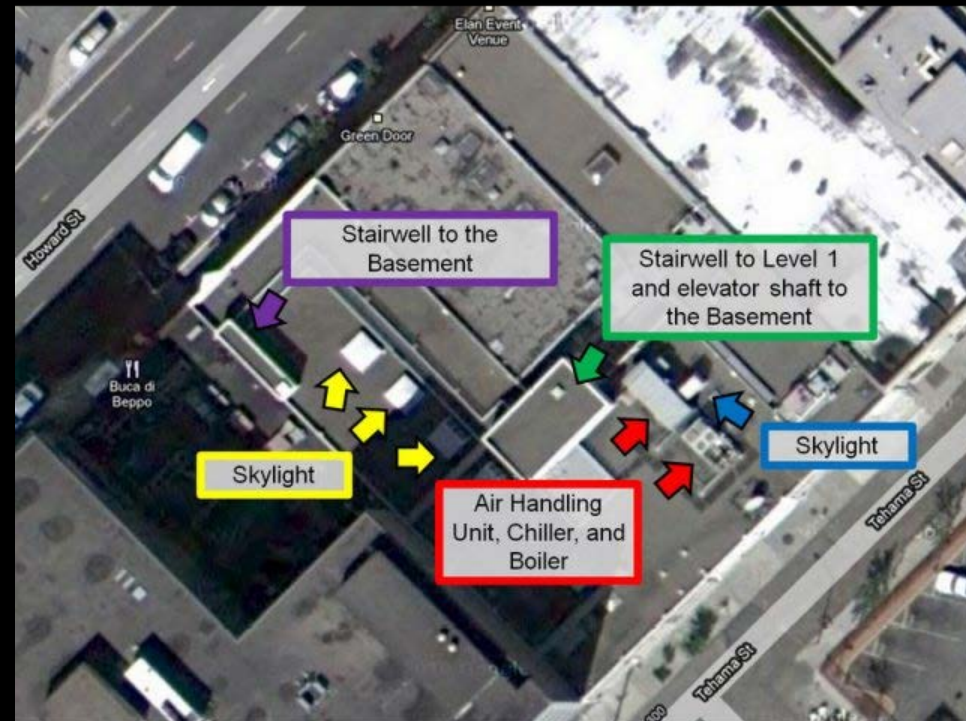
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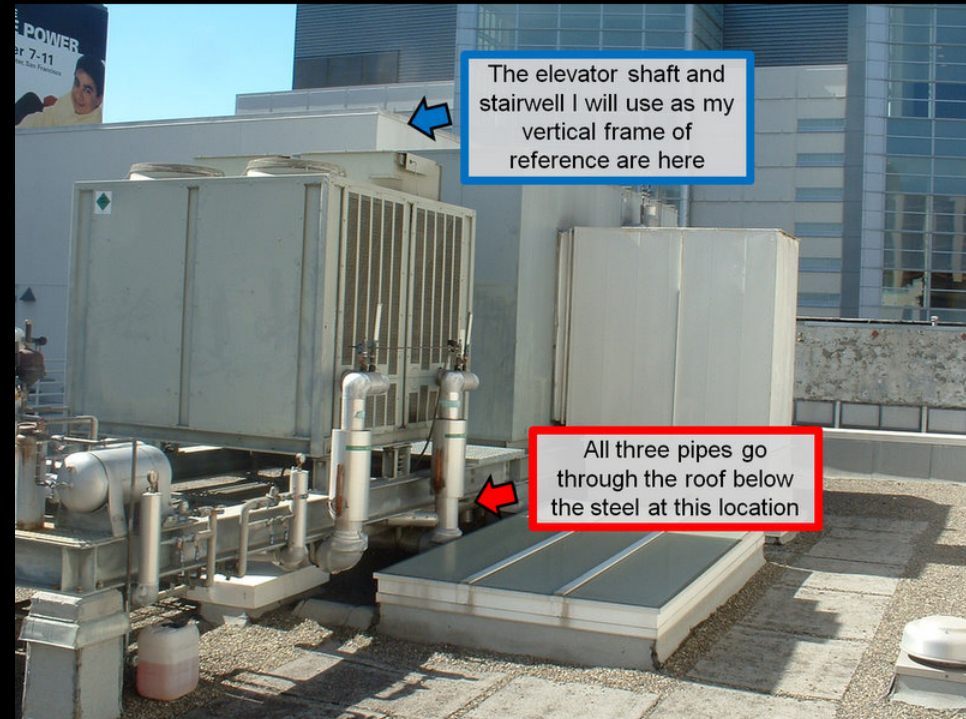
Getting Off the Roof

- Identify a Point of Reference



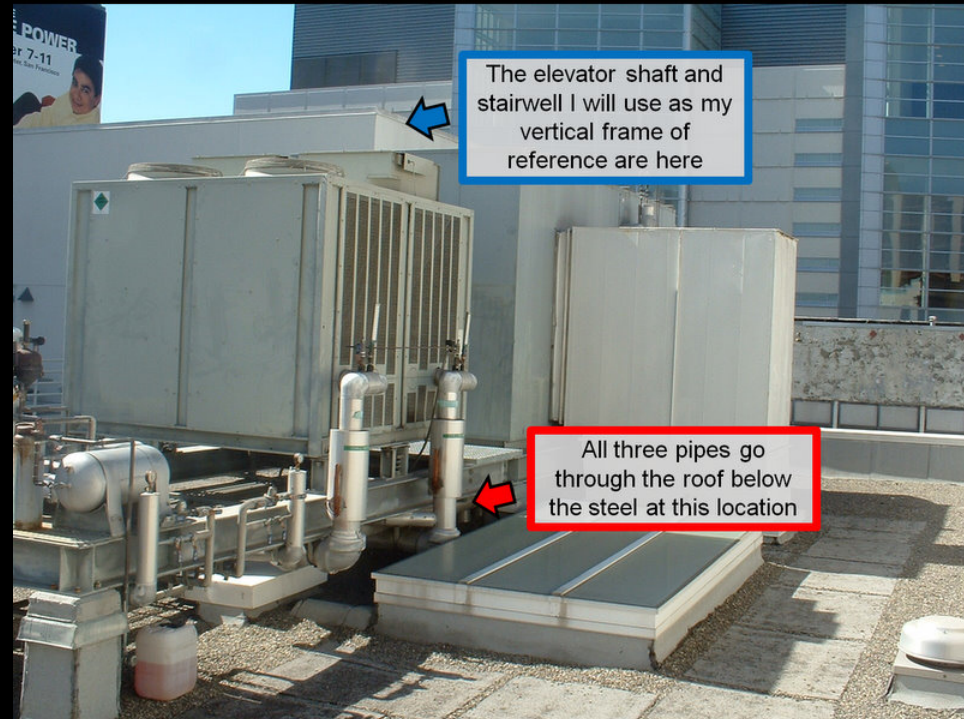
Getting Off the Roof

- Identify a Point of Reference



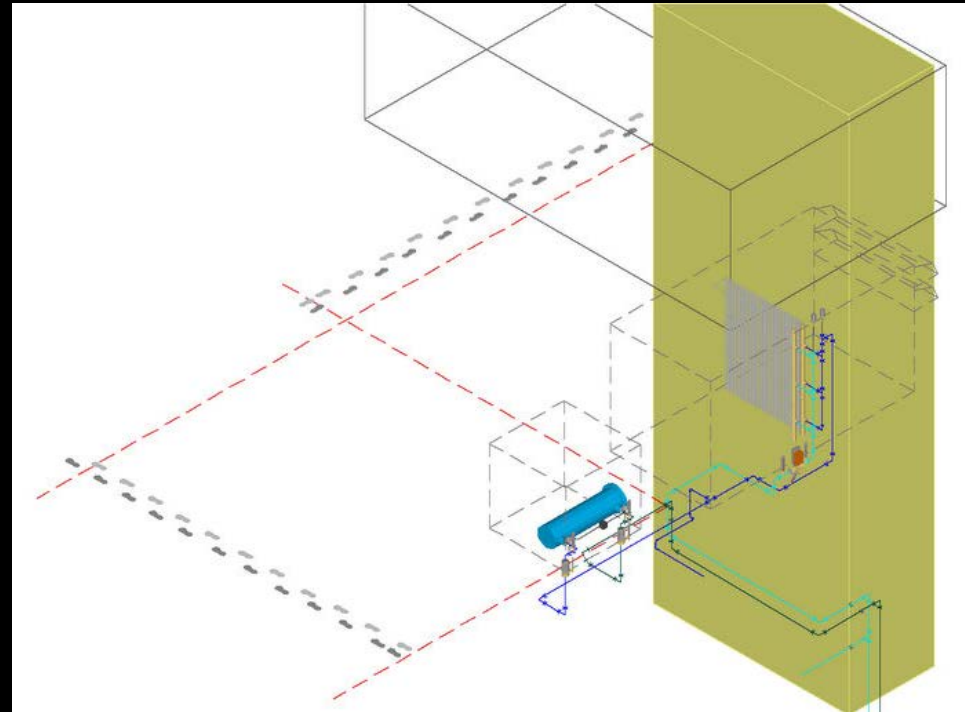
Getting Off the Roof

- Identify a Point of Reference
- Identify Your “Pace”
- Use Your “Pace” to Develop Coordinates Relative to the Point of Reference



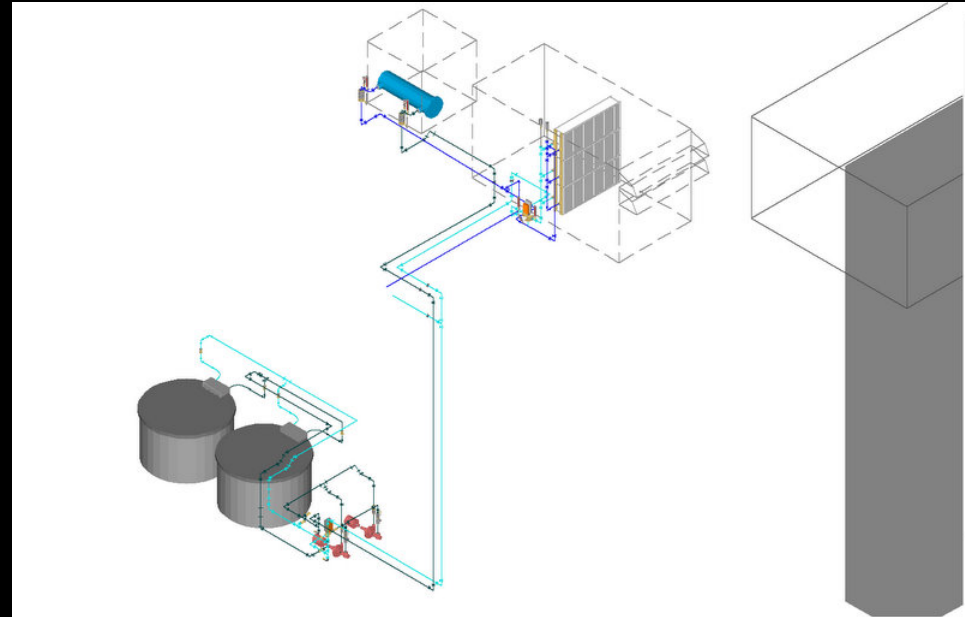
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Getting Off the Roof

- Identify a Point of Reference
- Identify Your “Pace”
- Use Your “Pace” to Develop Coordinates Relative to the Point of Reference
- Apply Your Coordinates on a Different Floor
- Leverage Existing Labels (Maybe)
 - Cutting a hole in the wall or shaft may or may not be warranted
 - Leverage other clues
 - Some of them may be misleading



What About Drawing Programs?

AutoCAD and AutoCAD LT

- Quasi-standard in the industry
- Full version \$3 – \$4K
- Factor of 4 price difference between full and LT version
- LT probably sufficient for most Cx providers
- Steep learning curve
- Can do more than diagrams
 - Drafting
 - Some 3-D
 - Automation

Visio

- Microsoft family
- Full version about \$1K
- Factor of 4 price difference between low end and high end versions
- Geared toward diagrams
 - Not as universally applicable
 - Faster to pick up
- Basic wire-frame capabilities in higher end products
- Interfaces with other Microsoft products directly

What About Drawing Programs?

Draw – OpenOffice.org

- Free
- Limited page size (about 12" x 12")
- Basic diagramming features
- 3D capabilities

Word/PowerPoint Drawing Utilities

- Part of the Office package
- Difficult to use for complex drawings
- Relatively easy to pick up for basic shapes
- Some issues with alignment in 2007 versions

What About Drawing Programs?

Sketch-up

- Google/Trimble
- Free
- Using 3D model to convey 2D information

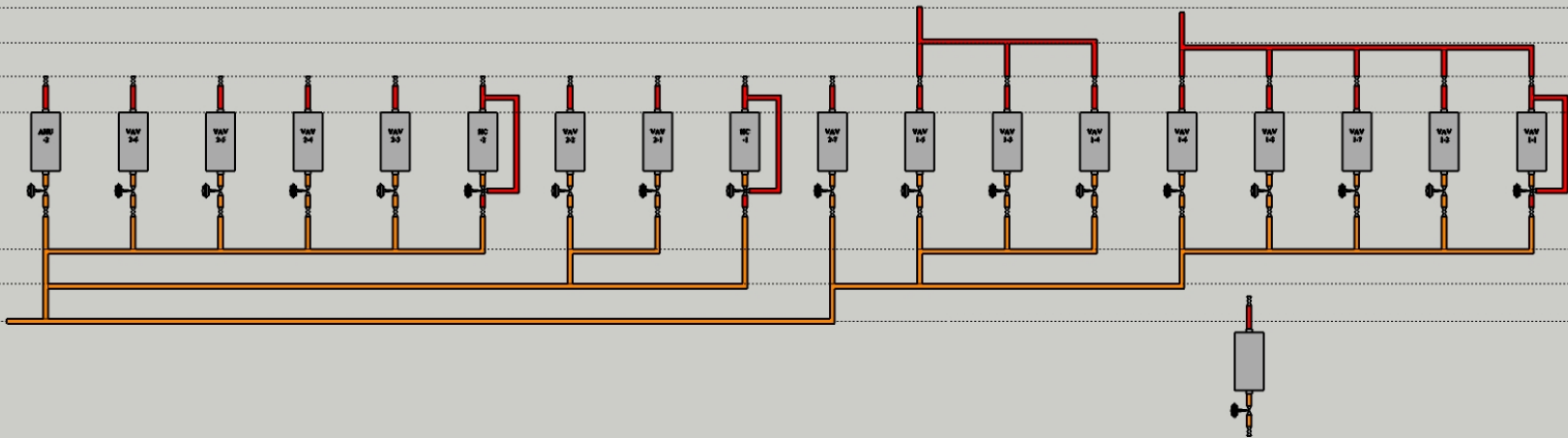


Diagram Drawing 101

Get in the habit of drawing on a grid

- “Electronic graph paper”
- Orderly drawings
- Alignment is easier
- Can be “on” or “off” for printing

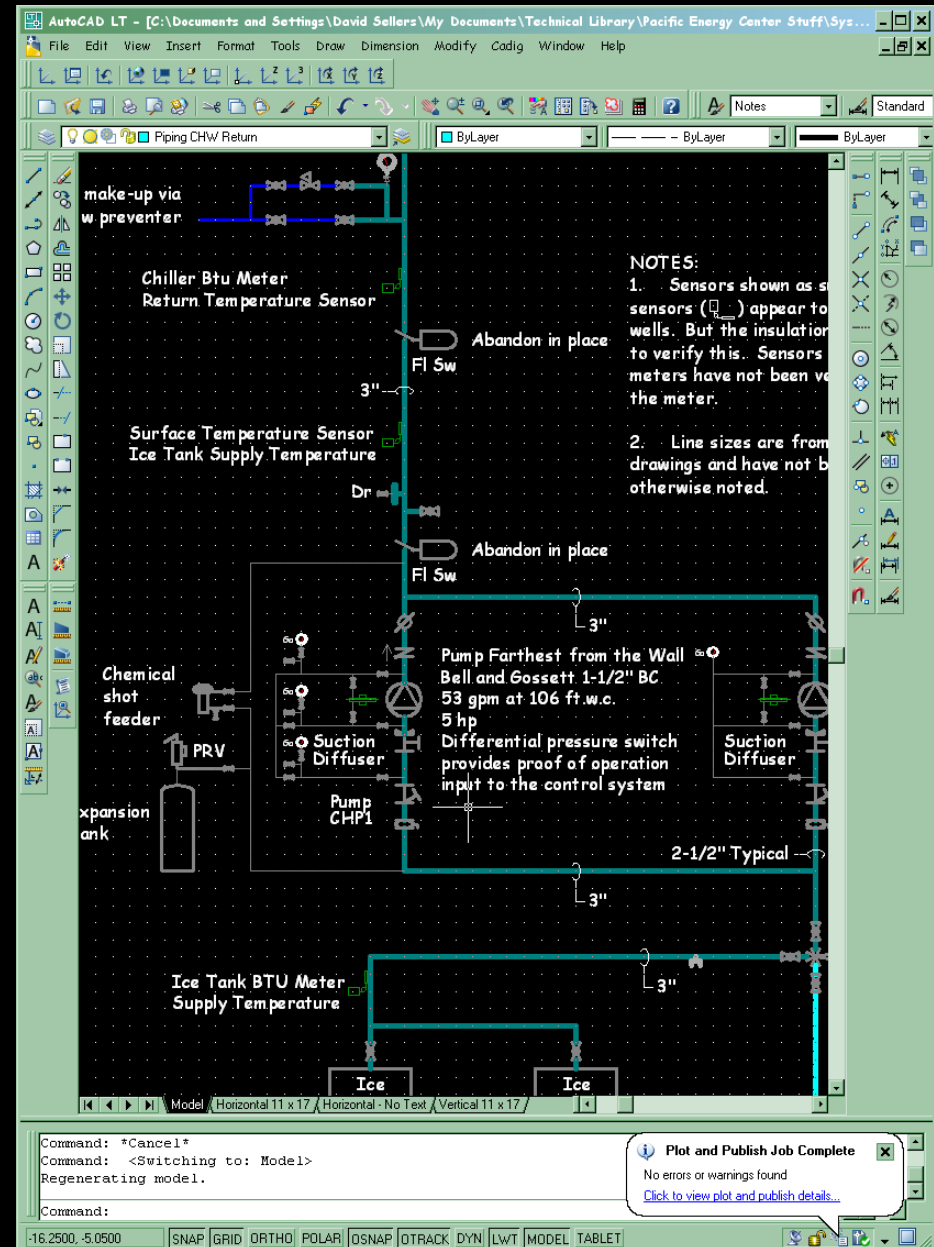


Diagram Drawing 101

Colors can be used to advantage

- Distinguish different types of fluids (chilled water, hot water, condenser water)
- Distinguish hot from cold, warmer from cooler, supply from return

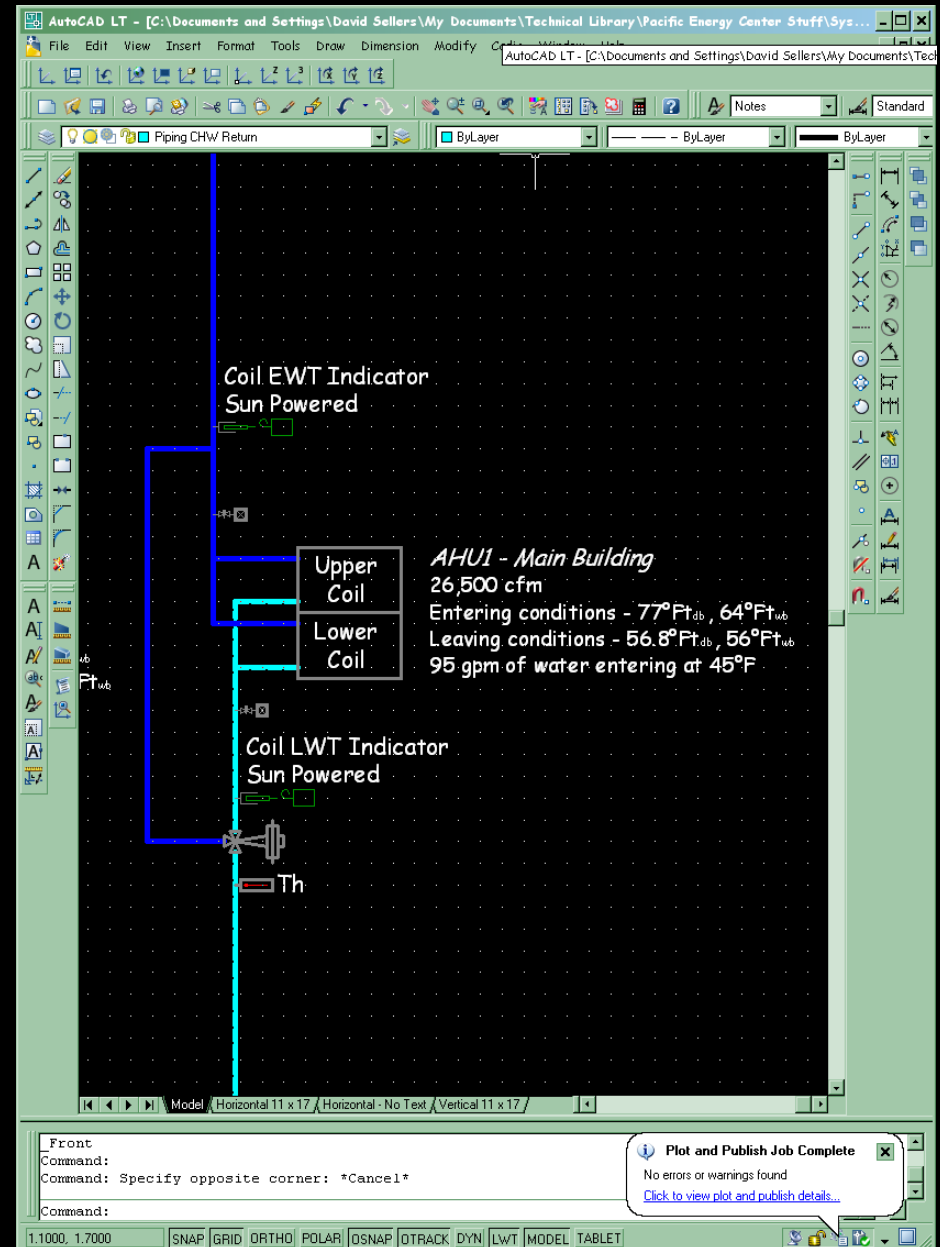


Diagram Drawing 101

Colors can be used to advantage

- Distinguish different types of fluids (chilled water, hot water, condenser water)
- Distinguish hot from cold, warmer from cooler, supply from return
- Enhance understanding

Outside Air mixing with Return Air makes Mixed Air

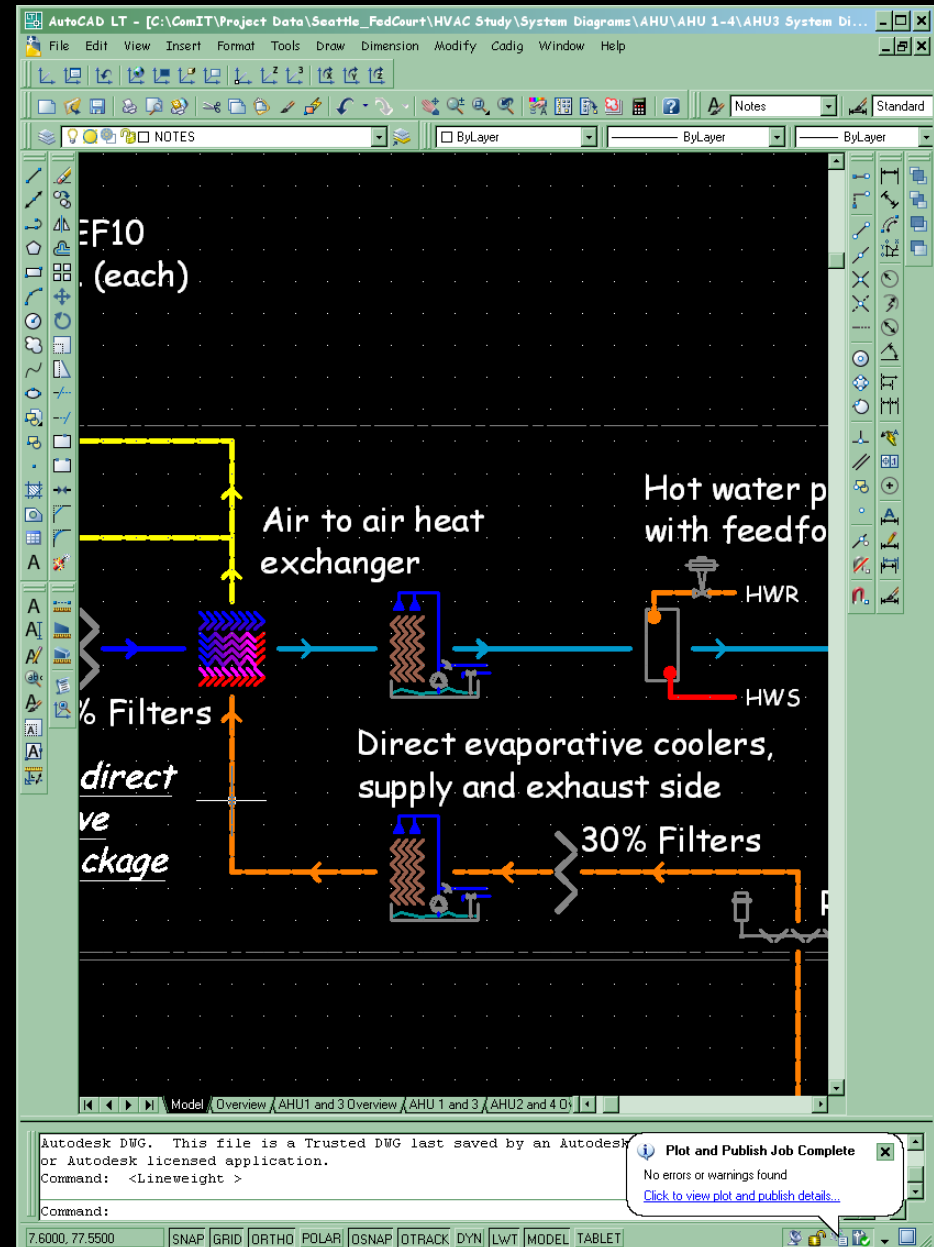
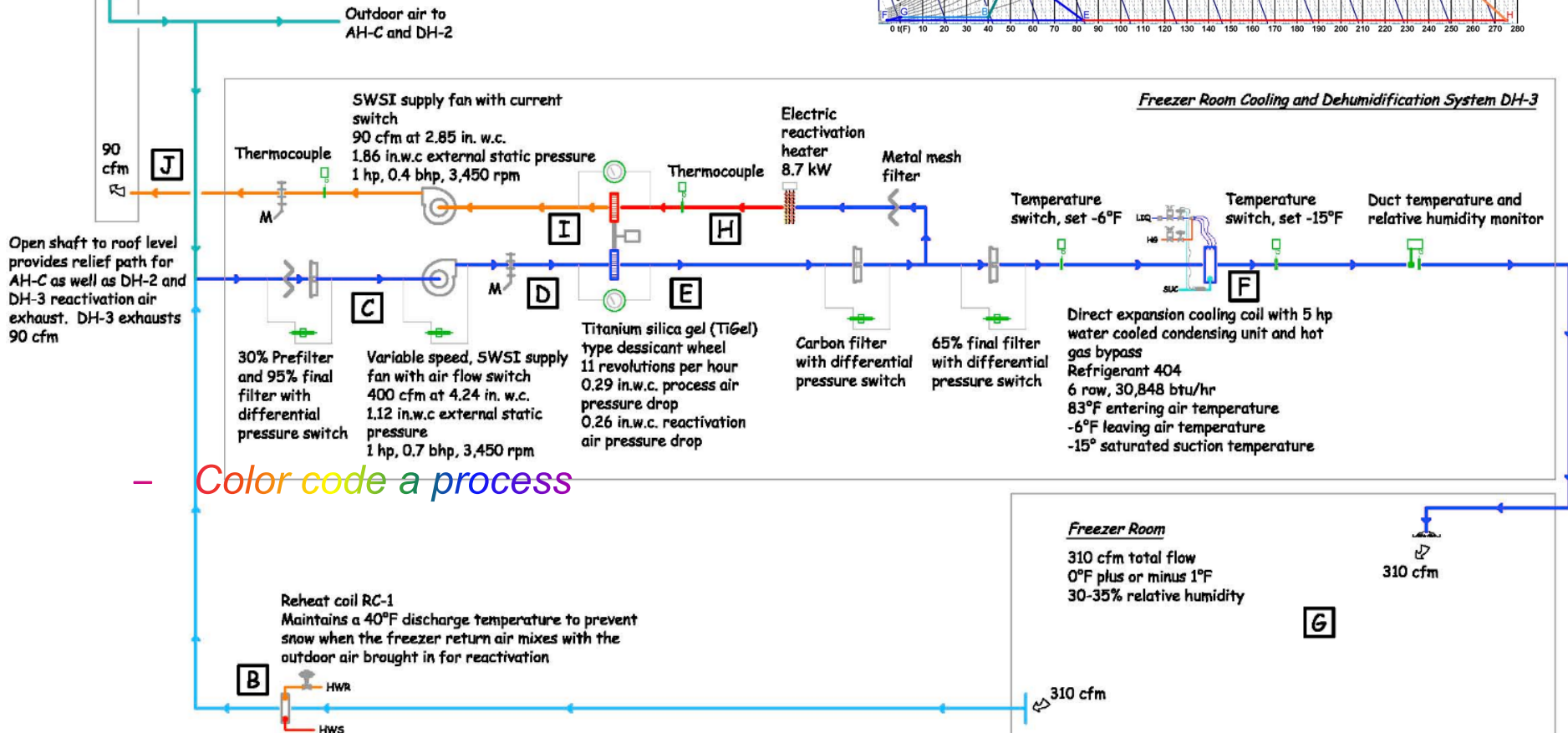
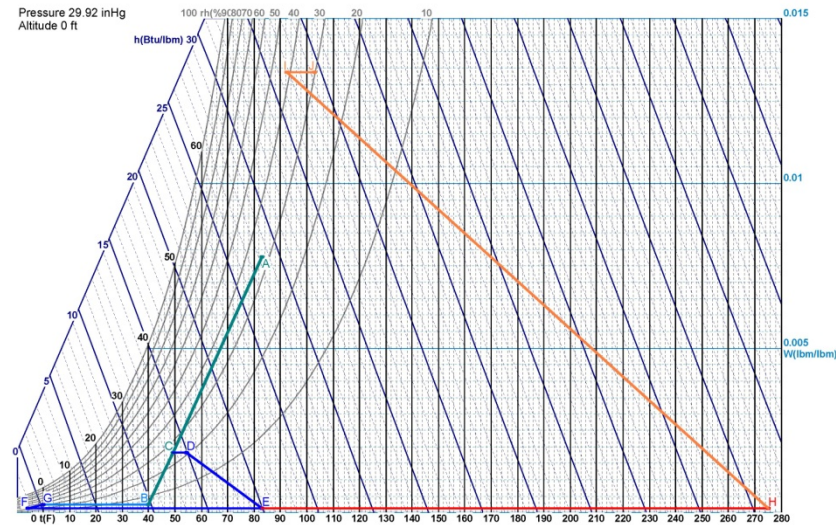


Diagram Drawing

101

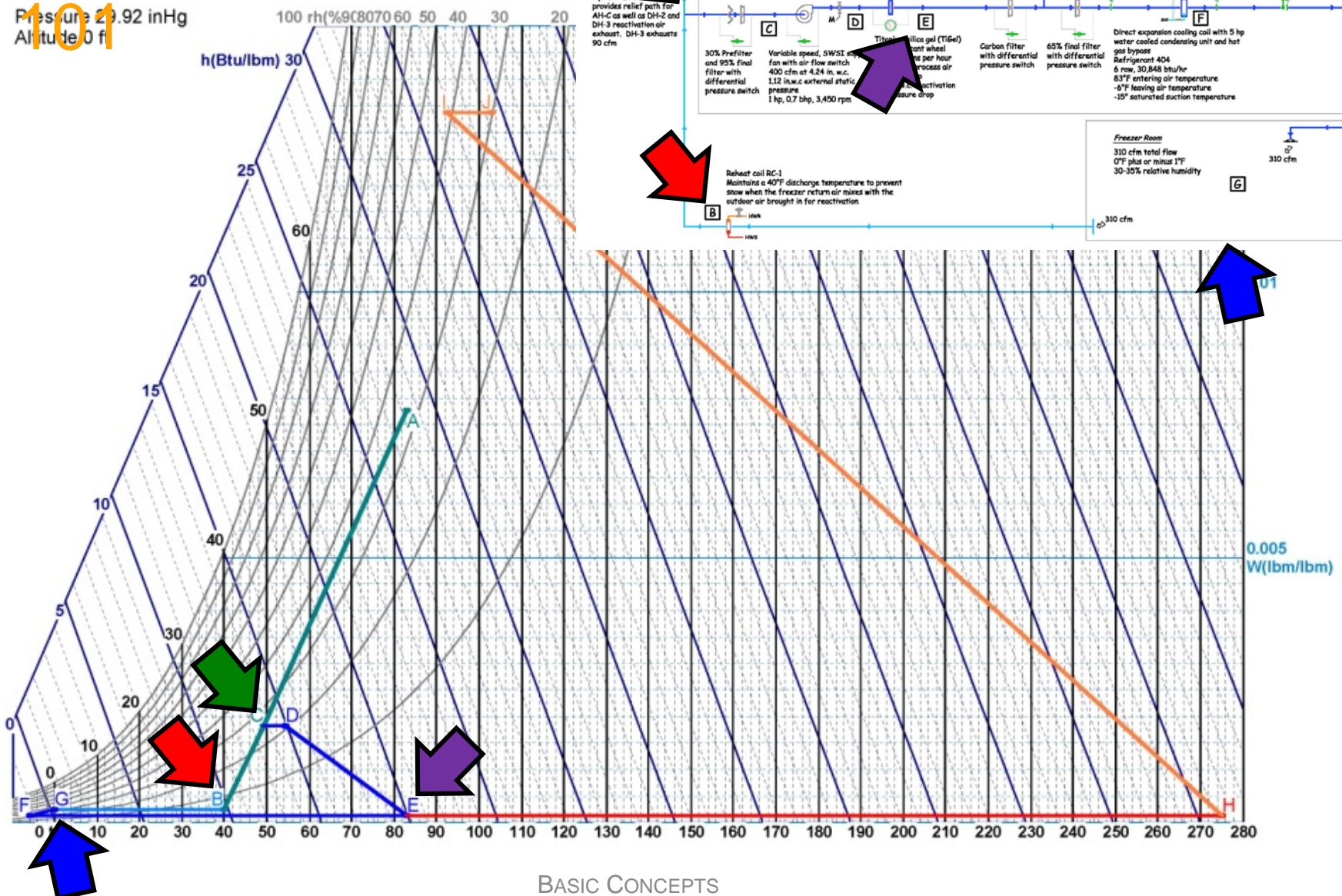
90 cfm
[A] Outdoor air intake at 1st floor roof level serving AH-C, DH2, and DH-3. 90 cfm taken in for DH-1 reactivation air

Colors can be used to advantage



101

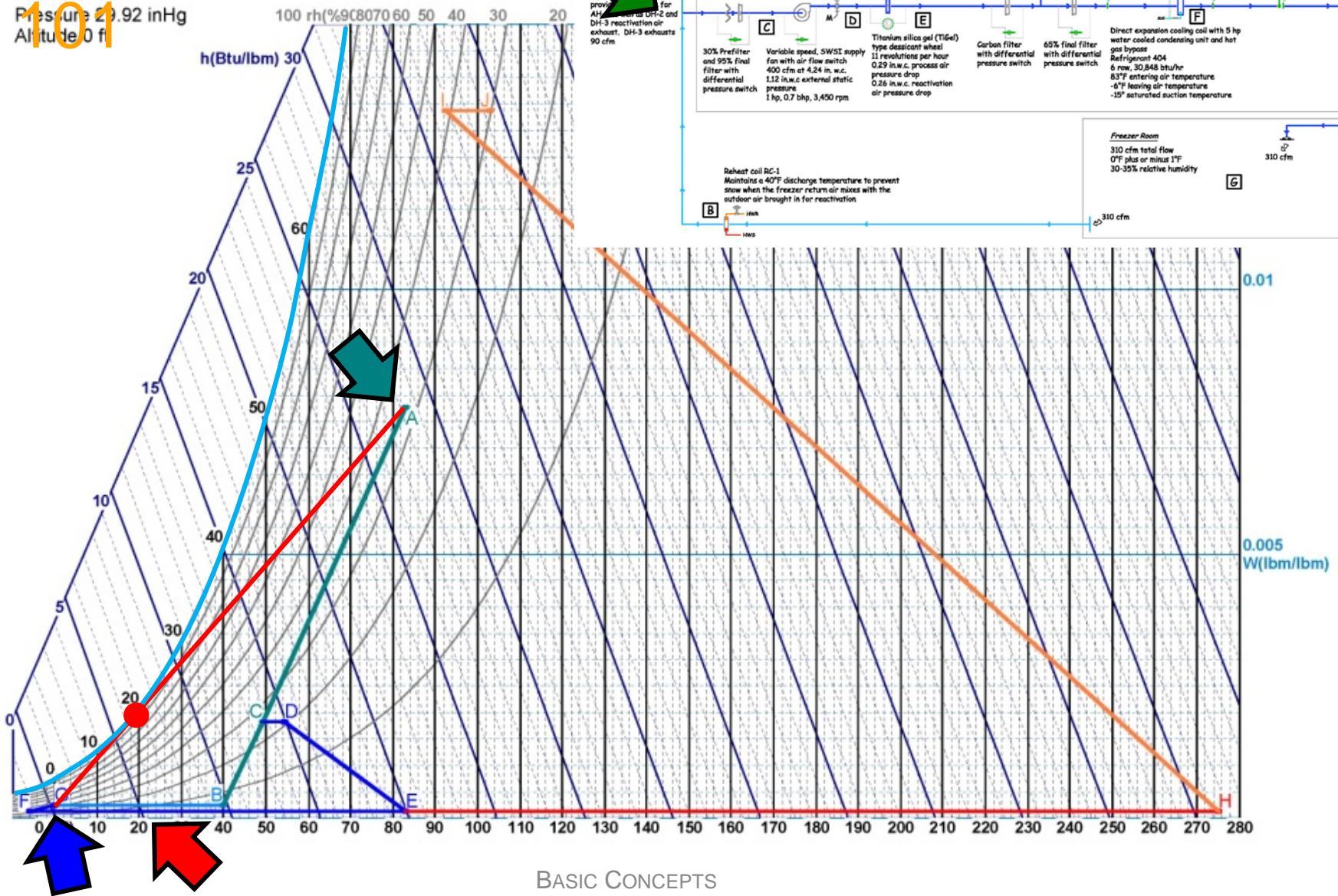
h(Btu/lb



BASIC CONCEPTS

Diagram Drawing

Pressure 29.92 inHg
Altitude 0 ft



BASIC CONCEPTS

Diagram Drawing 101

Line weights can be important

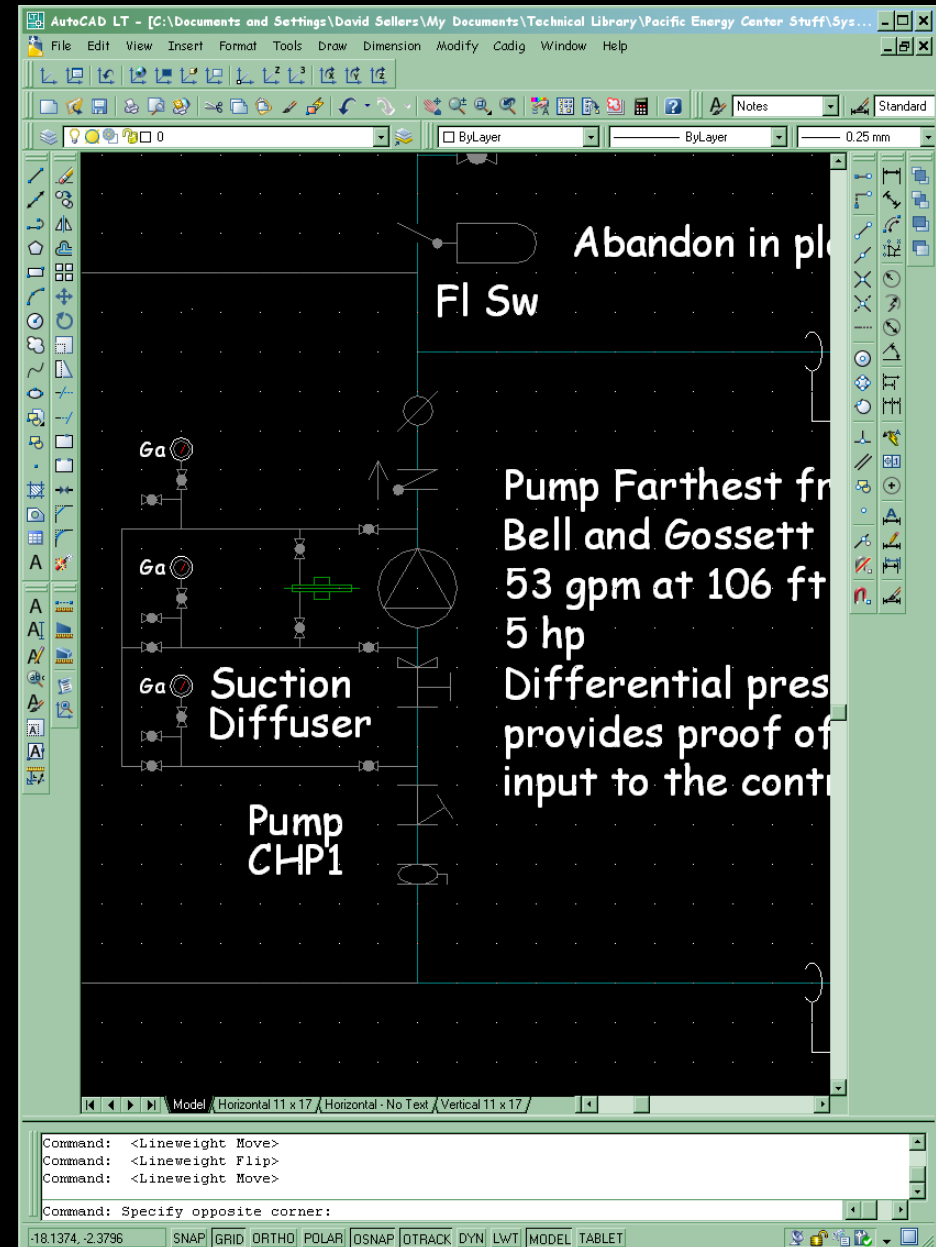


Diagram Drawing 101

Line weights can be important

- Heavier lines draw the eye towards the major system elements
- Lighter line weights show related equipment that is auxiliary to the main system elements

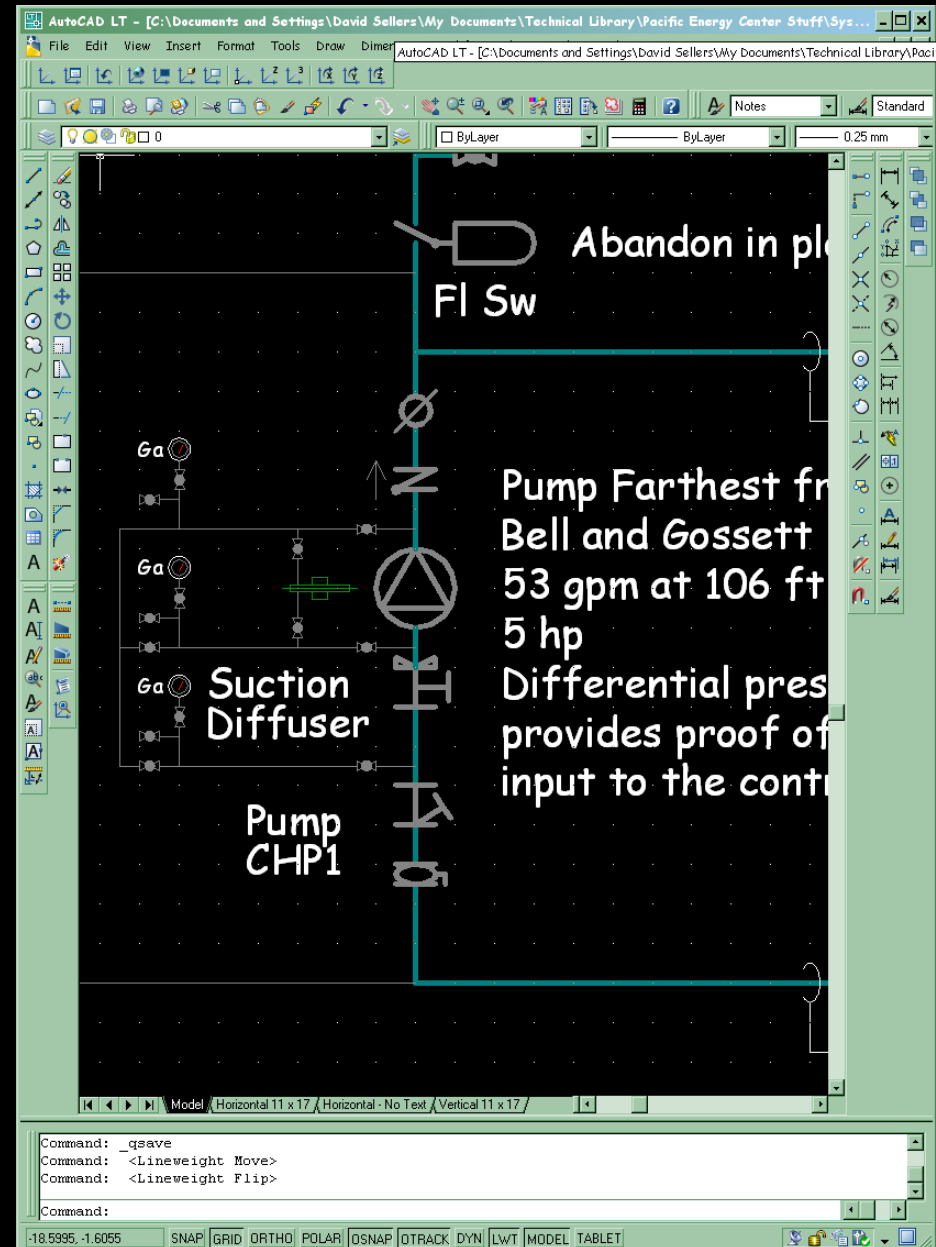


Diagram Drawing 101

Points where lines cross vs. connect
should be clear

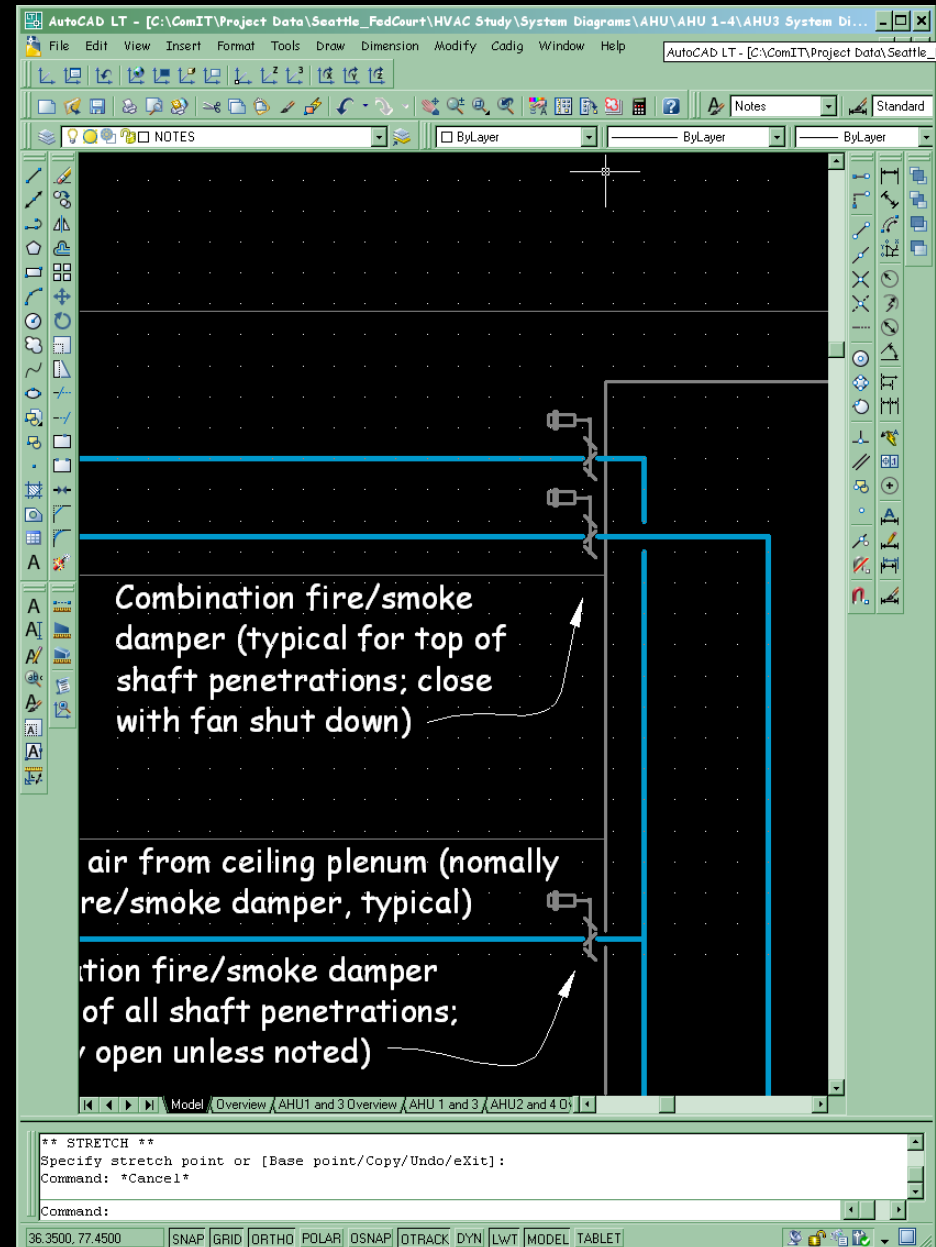


Diagram Drawing 101

Points where lines cross vs. connect should be clear

- Gaps where lines cross need to consider the plot scale relative to the line weight

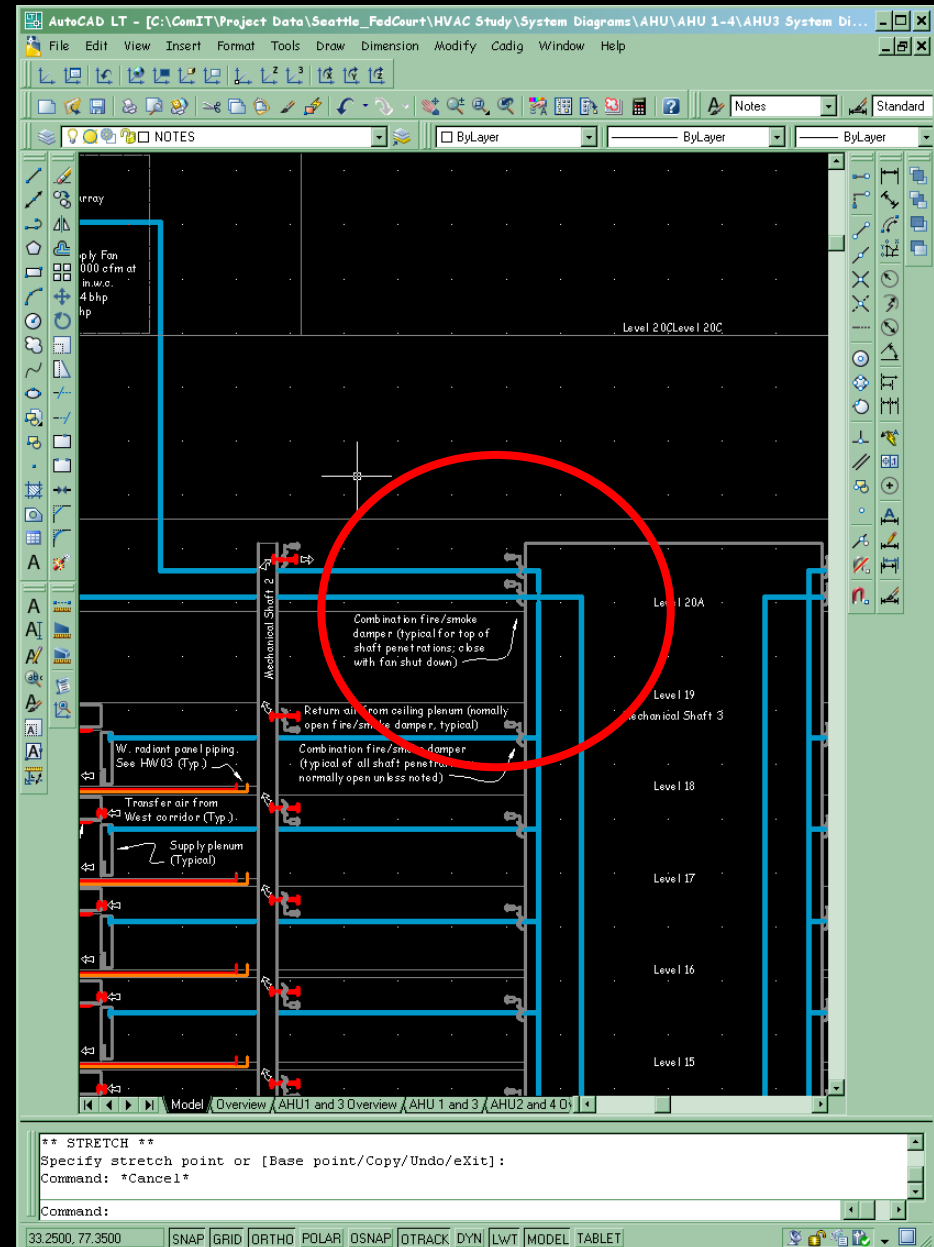


Diagram Drawing 101

Points where lines cross vs. connect should be clear

- Gaps where lines cross need to consider the plot scale relative to the line weight
- “Bumps” can be used to clarify line crossings but can become tedious to draw

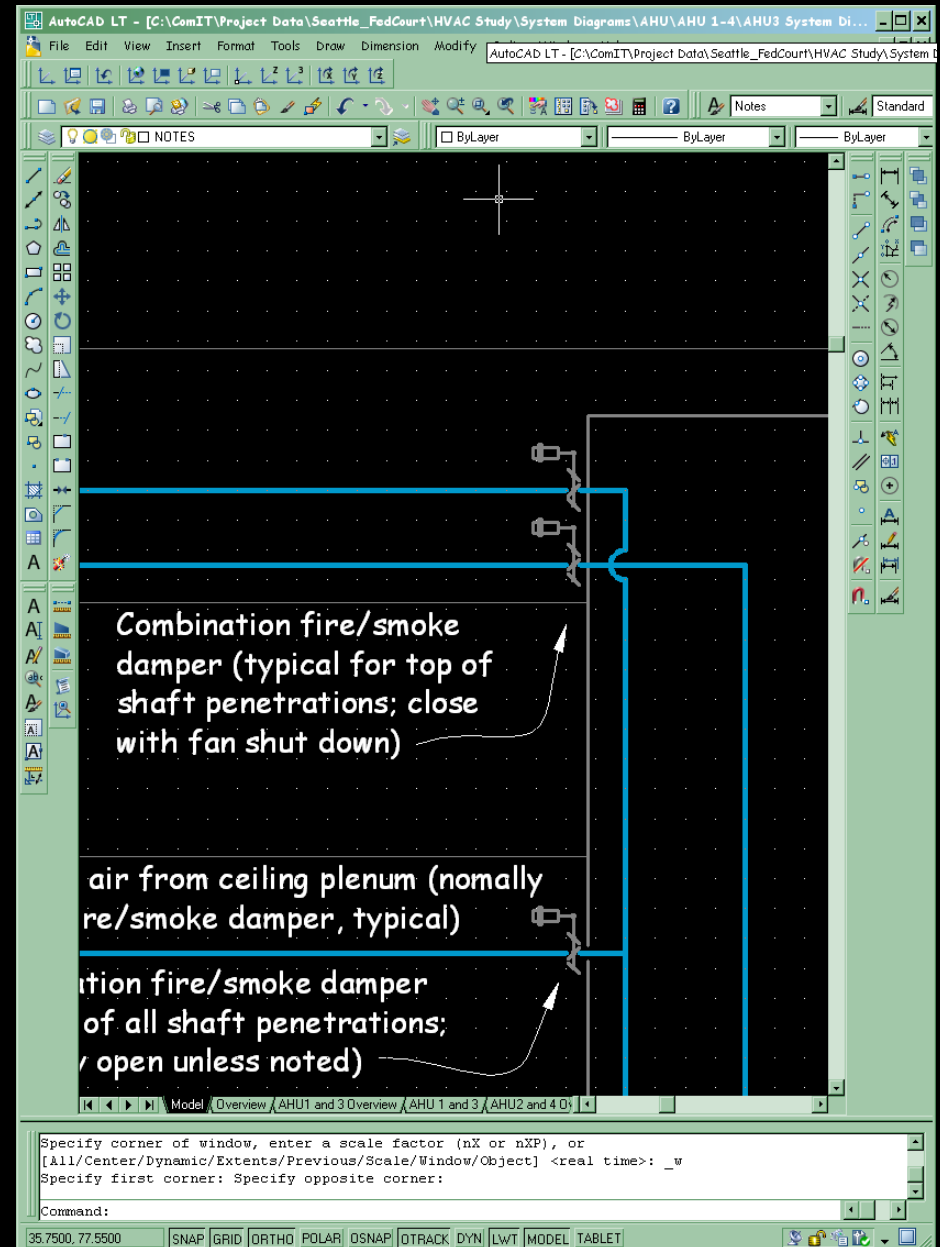


Diagram Drawing 101

Create symbols

- Most programs allow you to take collections of objects, given them a name, and save them as a more complex object
- AutoCAD blocks are an example

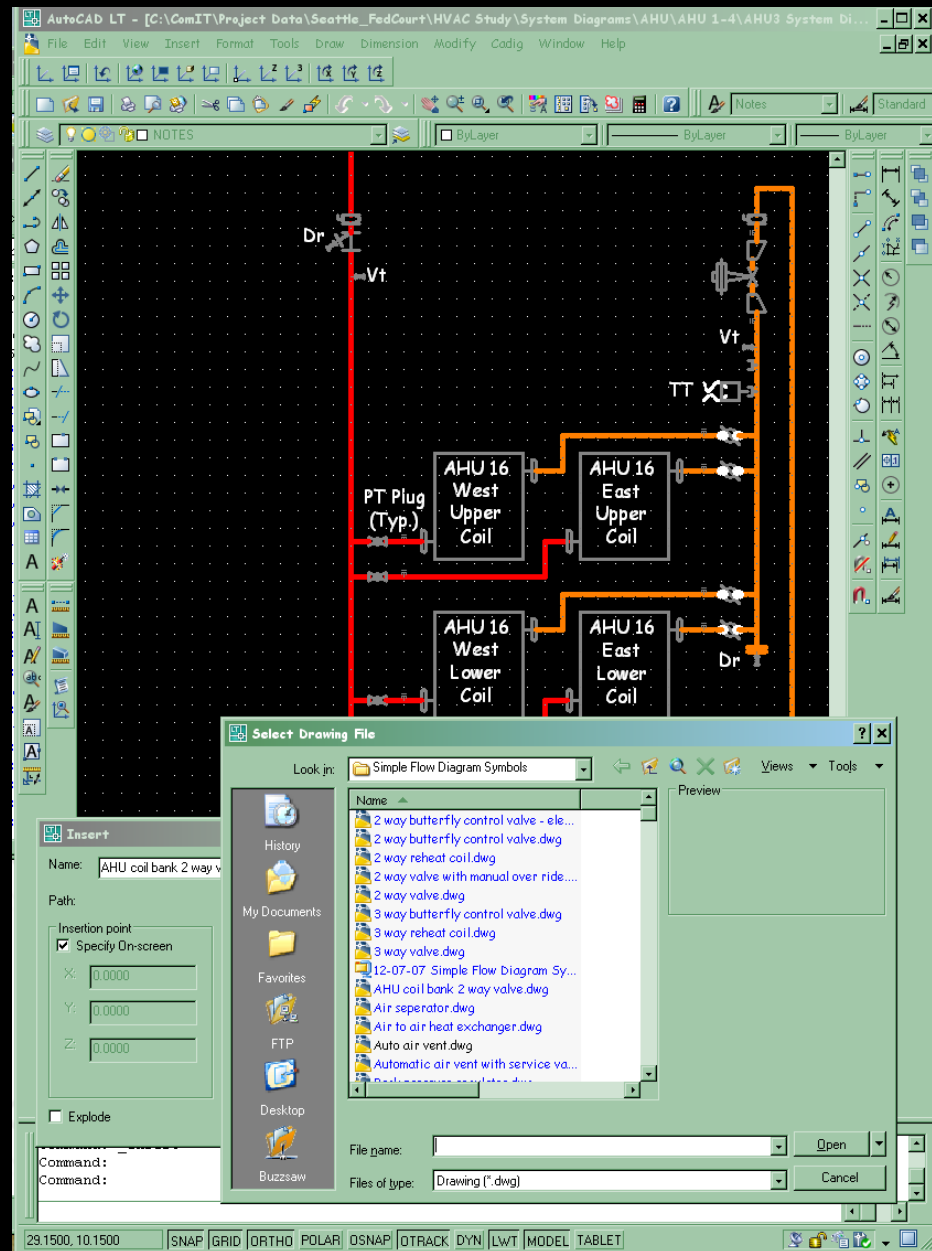


Diagram Drawing 101

Create symbols

- Most programs allow you to take collections of objects, given them a name, and save them as a more complex object
- AutoCAD blocks are an example
- AutoCAD allows you to assign “fill in the blank” field for data associated with the block
- This data can then be extrapolated to generate equipment schedules, point lists, etc.

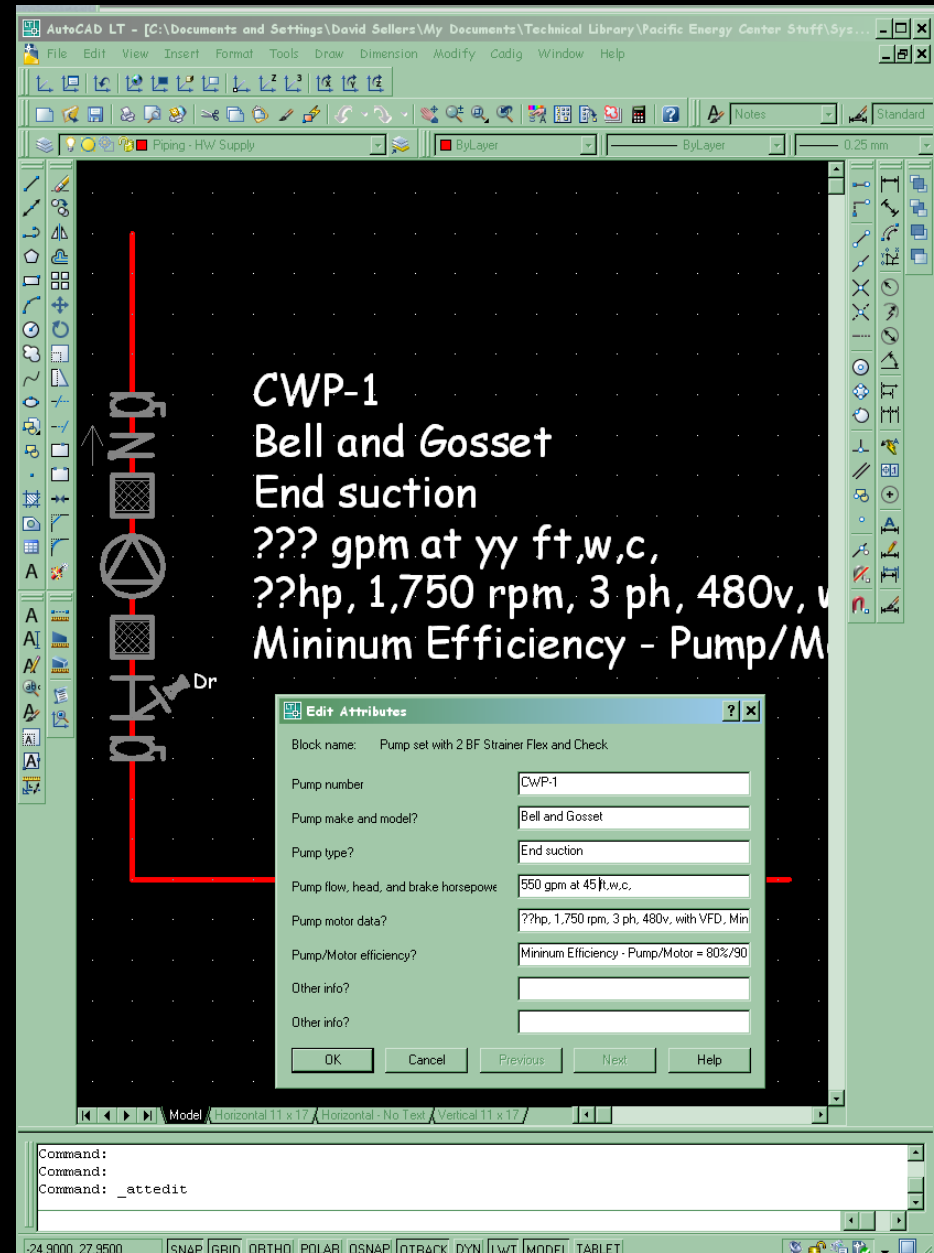


Diagram Drawing 101

Create symbols

- Most programs allow you to take collections of objects, given them a name, and save them as a more complex object
- AutoCAD blocks are an example
- AutoCAD allows you to assign “fill in the blank” field for data associated with the block
- This data can then be extrapolated to generate equipment schedules, point lists, etc.
- You can also edit blocks after they are inserted

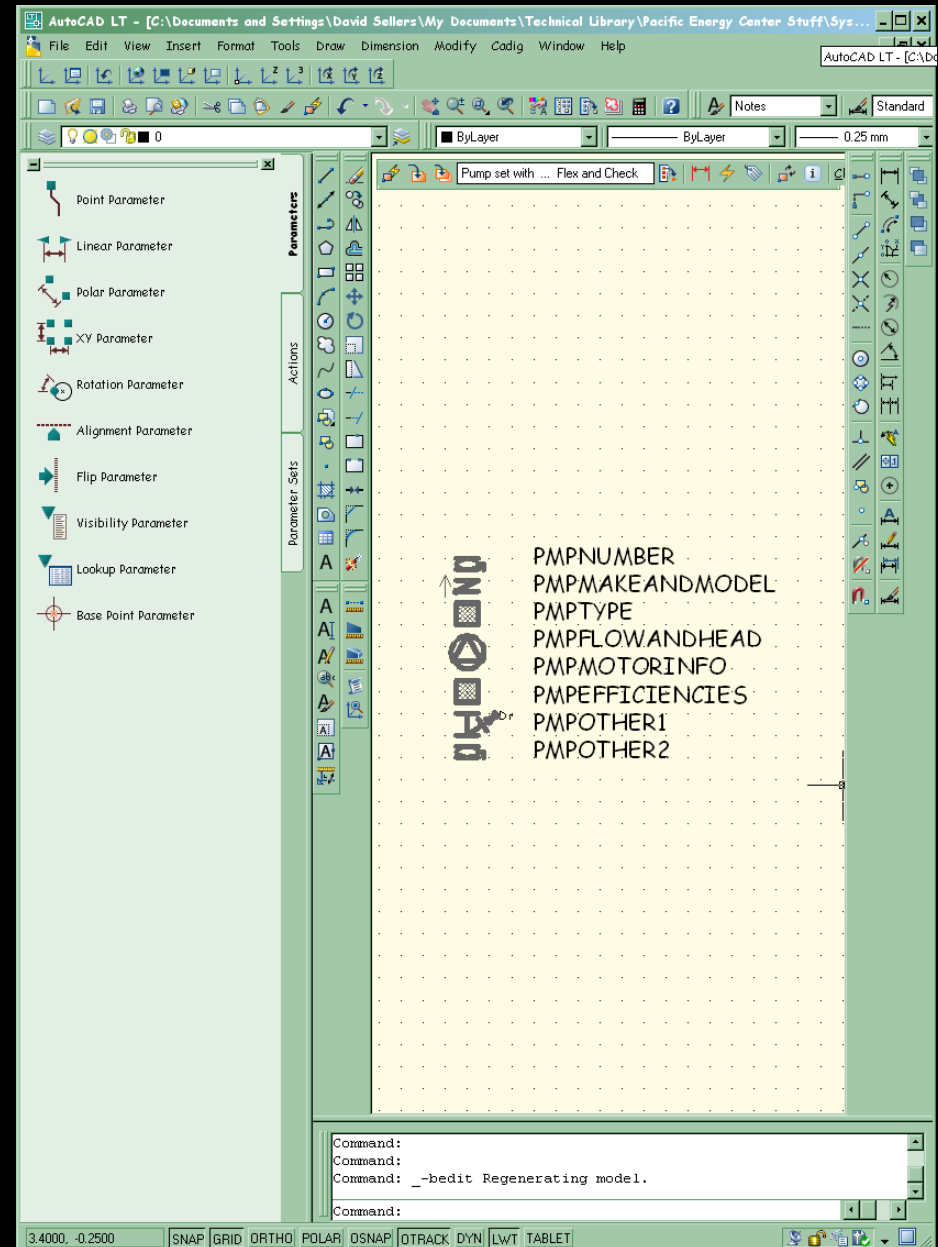
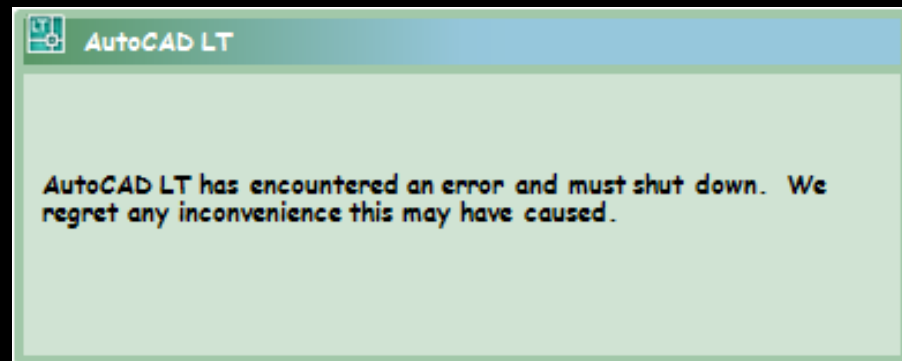


Diagram Drawing 101

Desirable habits/features

- Frequent “saves”
- Enable “auto-save”
- Regular back-ups



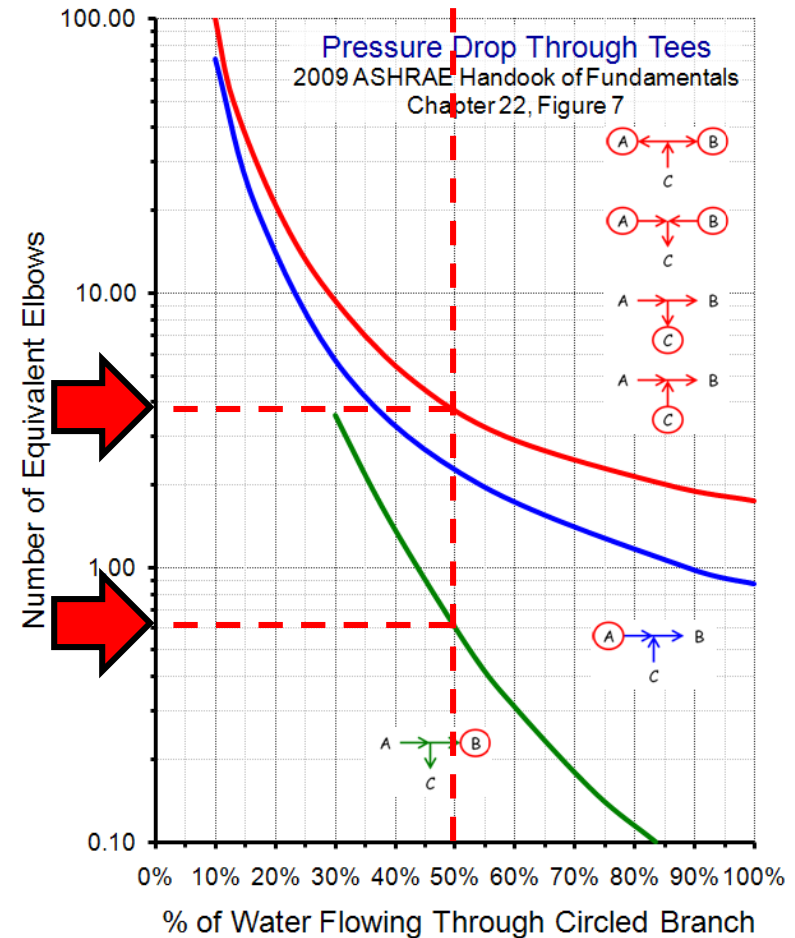
Tee's are Important

For both the physical system and the system diagram:

- Divergence or convergence of flow
- An opportunity to introduce a problem if the order of connection is not correct

For the physical system, they represent a pressure drop

- Significant
- Highly variable with configuration



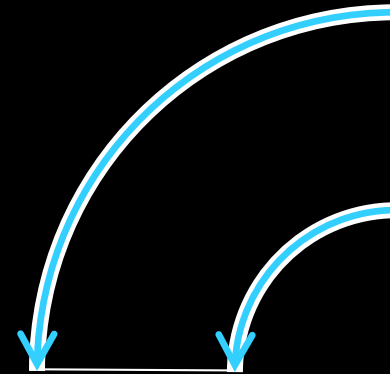
Notes:

1. Chart is based on straight tees (i.e., branches A, B, and C are the same size).
2. Pressure loss in desired circuit is obtained by selecting the proper curve according to illustrations, determining the flow at the circled branch, and multiplying the pressure loss for the same size elbow at the flow rate in the circled branch by the equivalent elbows indicated.
3. When the size of an outlet is reduced, the equivalent elbows shown in the chart do not apply. Therefore, the maximum loss for any circuit for any flow will not exceed 2 elbow equivalents at the maximum flow occurring in any branch of the tee.
4. Top curve is average of 4 curves, one for each circuit shown.
5. Data from Giesecke and Badgett 1931, 1932.

Elbows; Not So Much Maybe

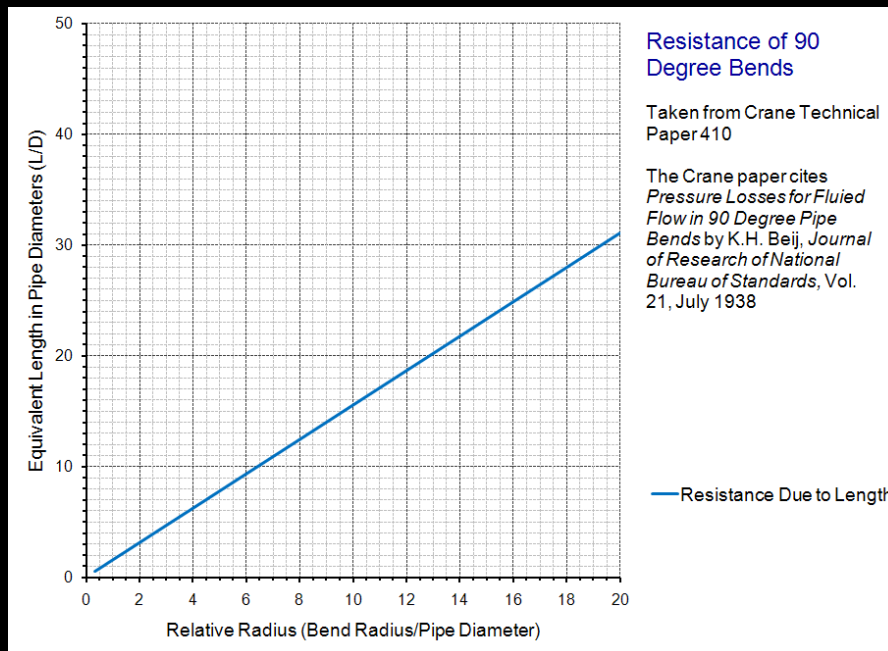
From the perspective of the system diagram:

- Just a bent piece of straight pipe
- Water in = Water out



One way to think of elbow resistance is to consider it as composed of:

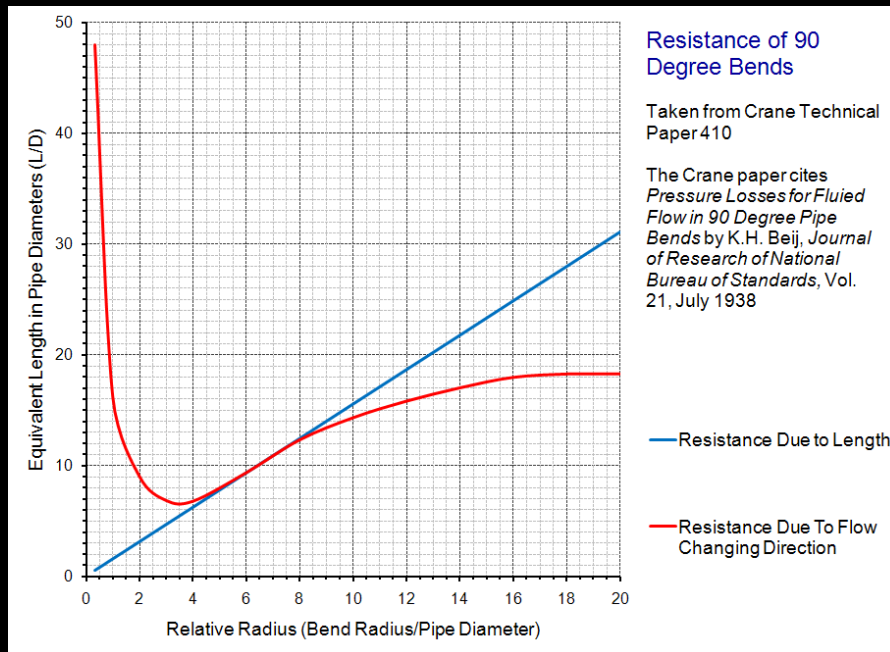
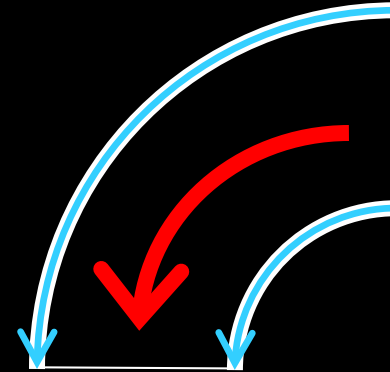
Resistance due to interaction with the pipe wall



Elbows; Not So Much Maybe

From the perspective of the system diagram:

- Just a bent piece of straight pipe
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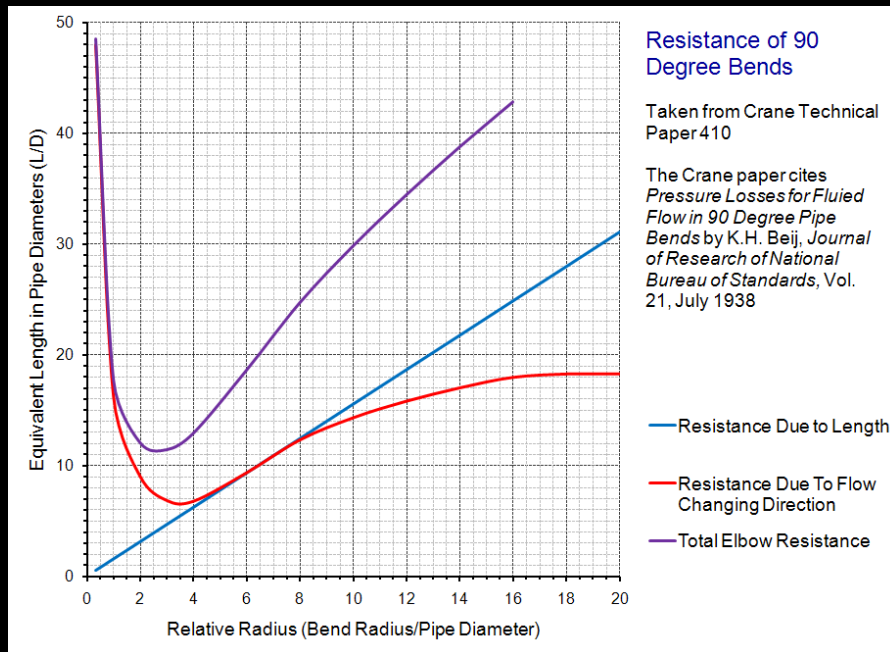
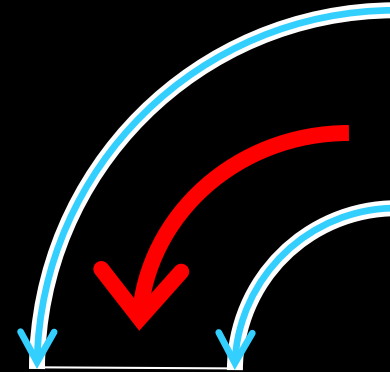
One way to think of elbow resistance is to consider it as composed of:

- + Resistance due to interaction with the pipe wall
- + Resistance due to a change in direction

Elbows; Not So Much Maybe

From the perspective of the system diagram:

- Just a bent piece of straight pipe
- Water in = Water out



One way to think of elbow resistance is to consider it as composed of:

Resistance due to interaction with the pipe wall

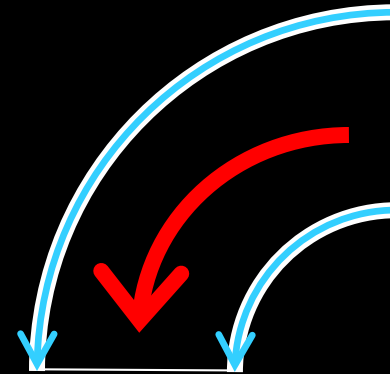
+ Resistance due to a change in direction

Total Resistance for the Elbow

Elbows; Not So Much Maybe

From the perspective of the physical system:

- Pump energy required
- Long radius = optimized loss = energy savings

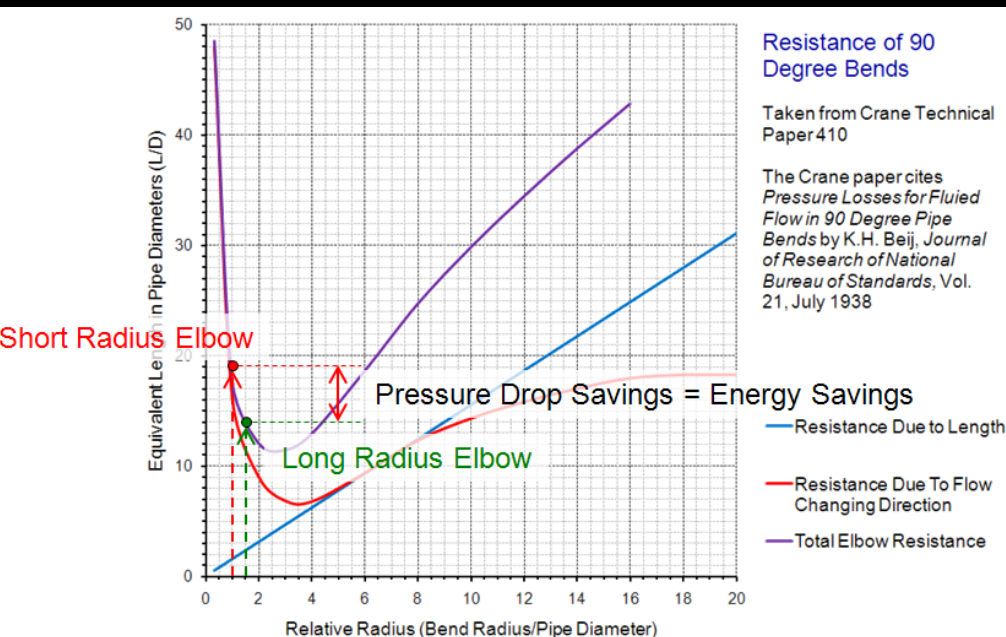


One way to think of elbow resistance is to consider it as composed of:

Resistance due to interaction with the pipe wall

+ Resistance due to a change in direction

Total Resistance for the Elbow



System Diagram Rules for Elbows and Tees



Show all tees

- Verify order of connection
- Order of connection “trumps” drawing organization
- Drawing organization “trumps” matching branch and main configuration in the field

Don't show elbows

- Turns on the system diagram should be made for drawing organization purposes, not to reflect real elbows

Sometimes Rules are Made to be Broken

Elbows that form traps or inverted traps in open systems

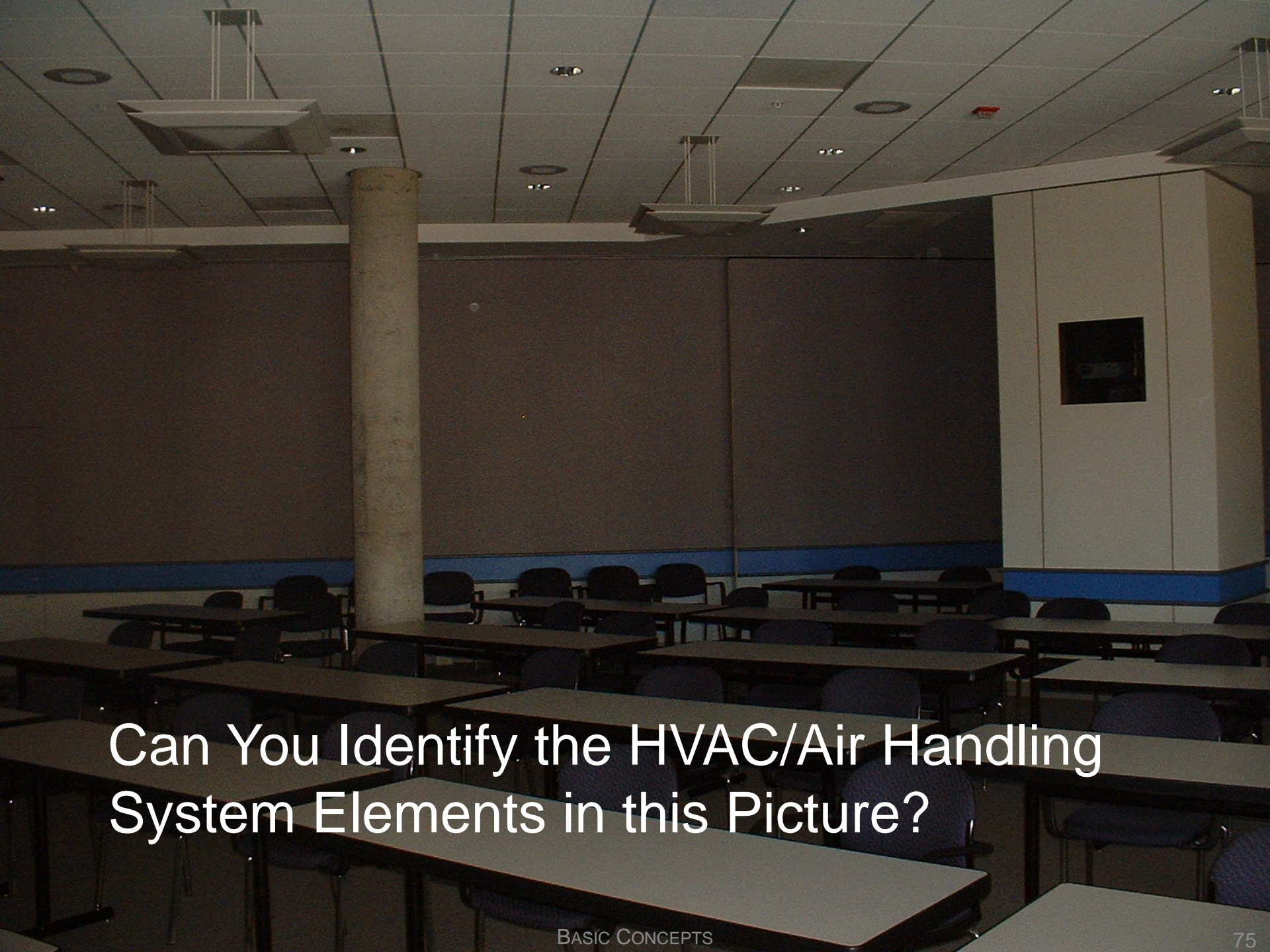
Pipes that run above basin level in open systems

Pipe runs with an relatively excessive number of elbows

Tees where the pressure drop created by the installed configuration could cause an operational issue



So Far, Our Focus Has Been Hydronic Systems; What About Air Systems?



Can You Identify the HVAC/Air Handling System Elements in this Picture?

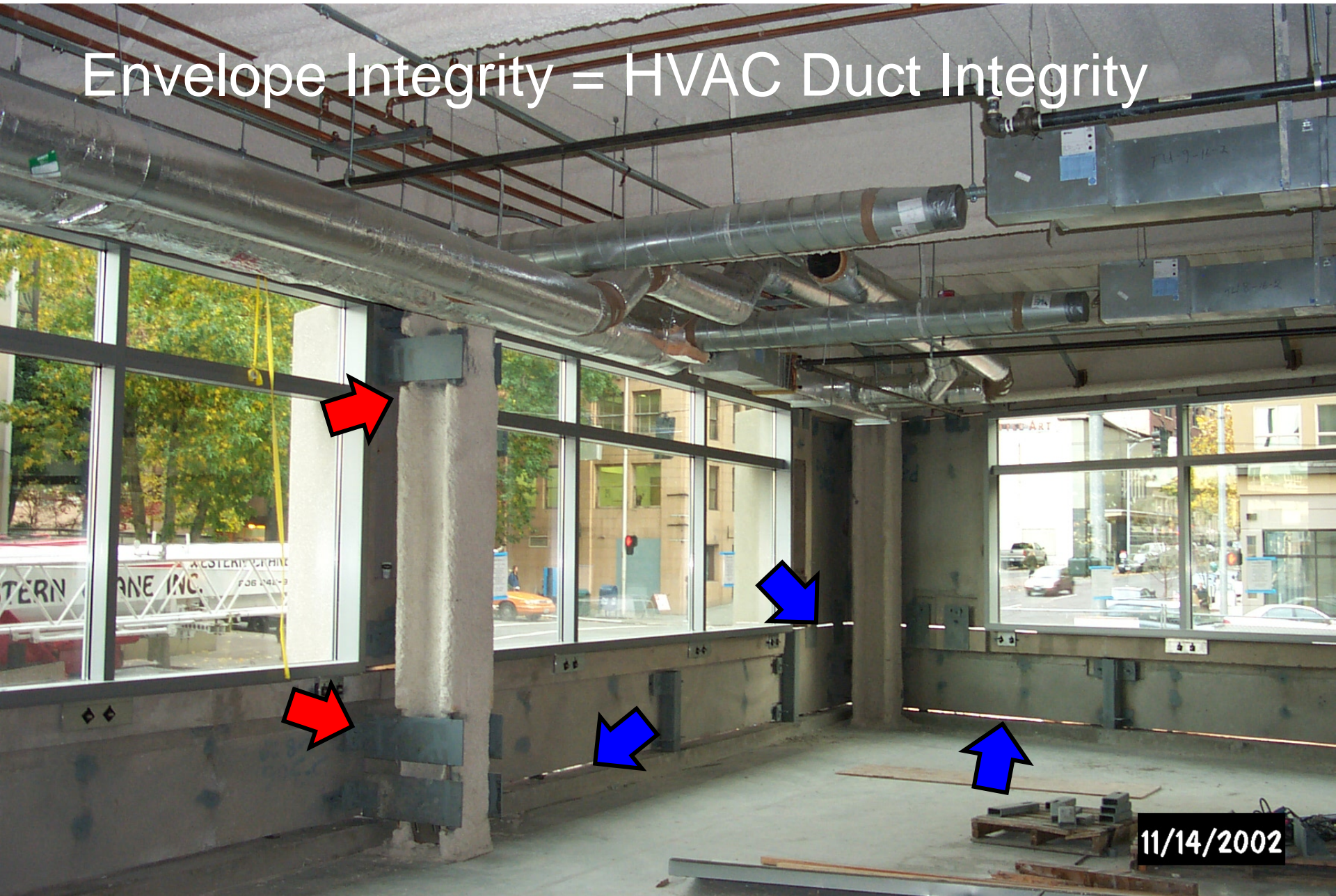
Air Handling Systems and System Diagrams

The same general rules apply

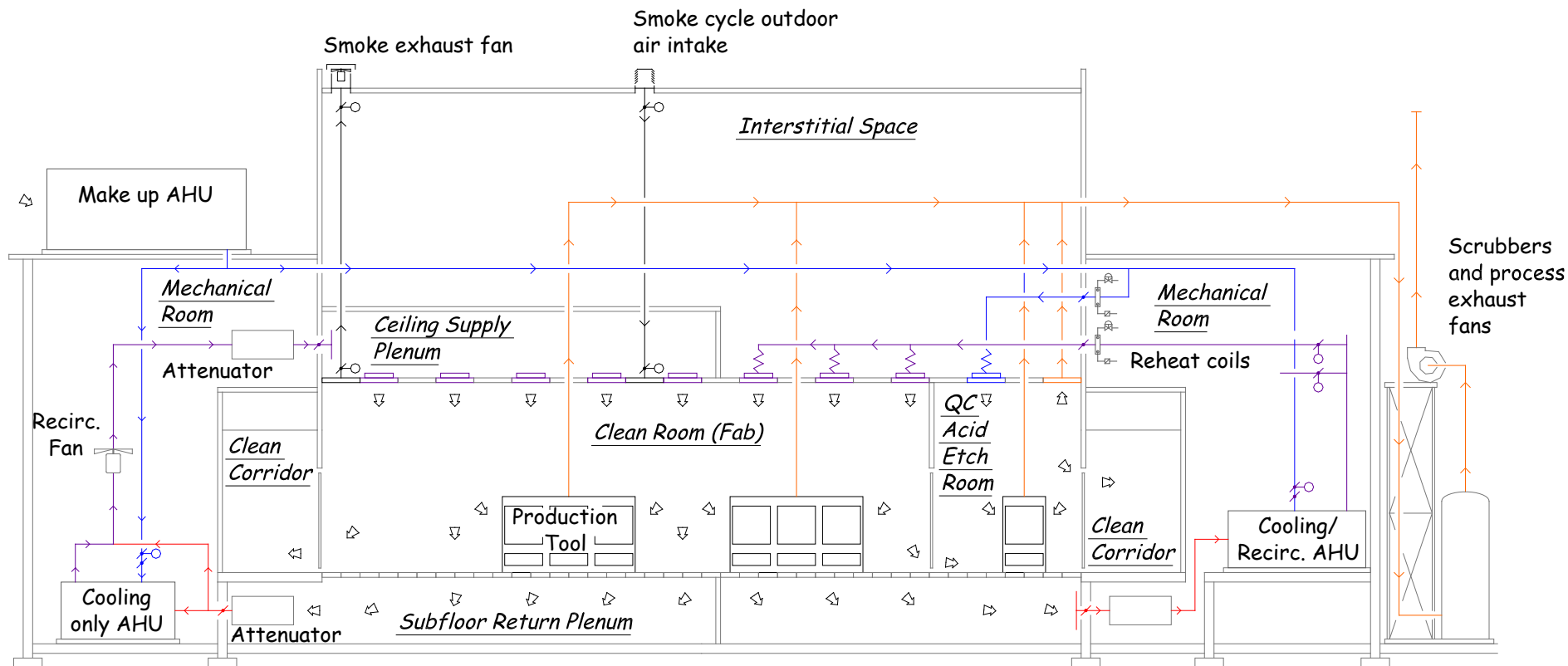
Significant differences from piping systems

- Envelope is a part of the system
- Mass (air and water vapor) are actively moved across the system boundary by the operation of the system
- The water vapor can change state in the system
- People move around inside the systems
- Building processes occur inside the system

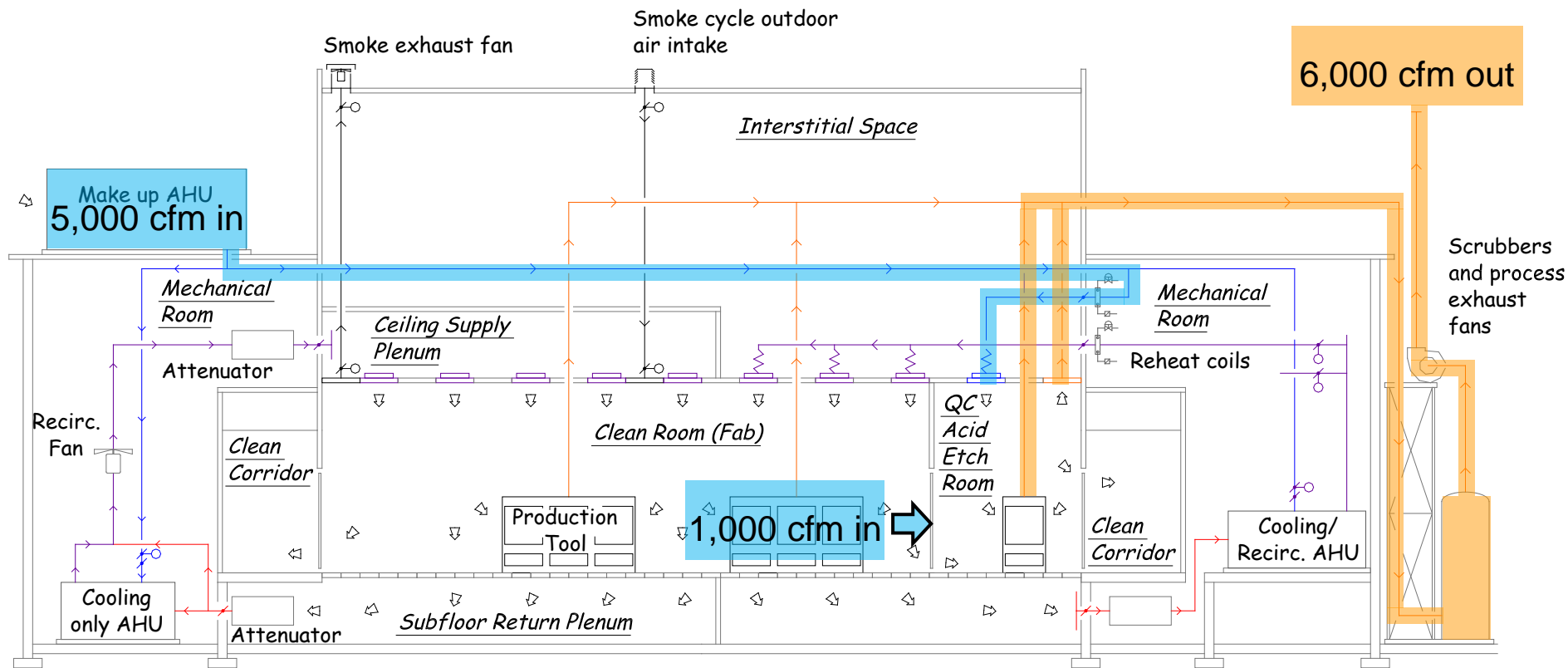
Envelope Integrity = HVAC Duct Integrity



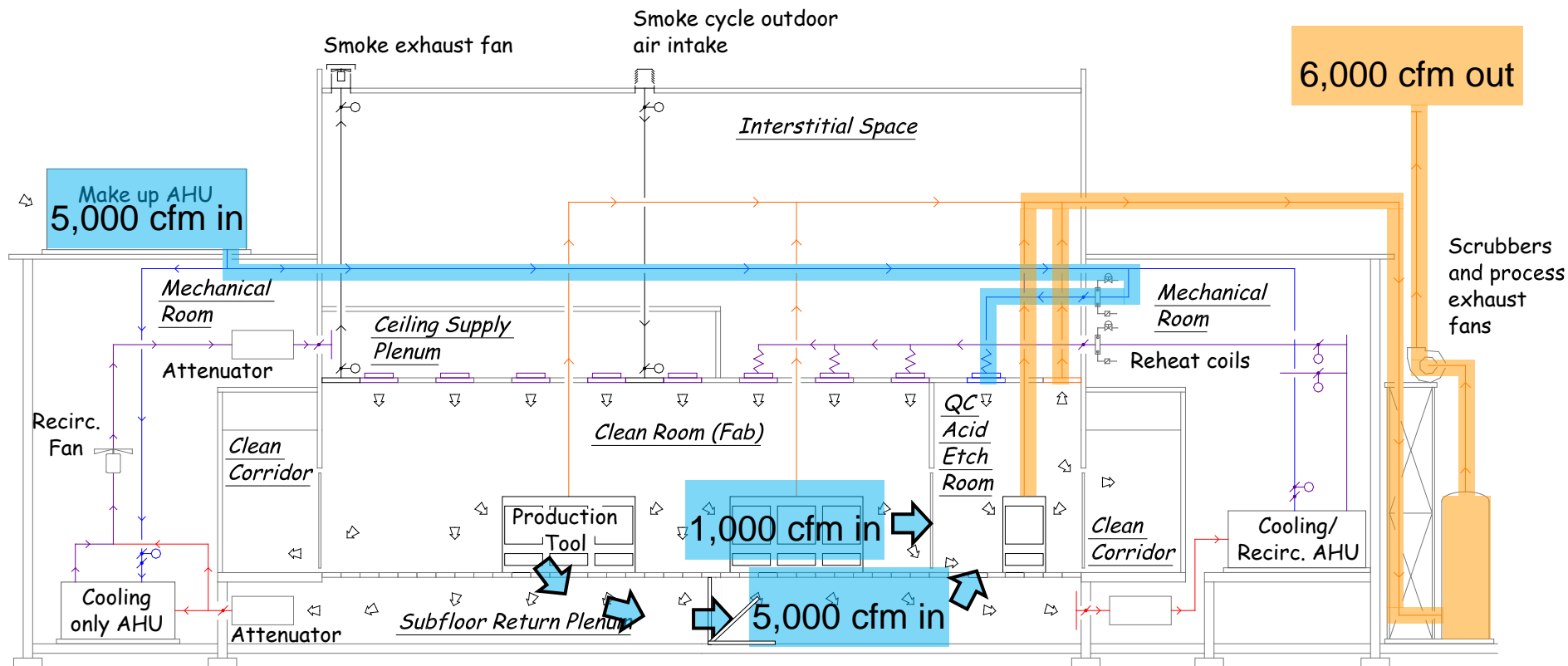
Envelope Integrity = Process Integrity = Cash Flow Integrity



A Demonstration of Fundamental Principles



Conservation of Mass; A.K.A *The Goes Intas gotta equal the Goes Outa's*



The Envelope is Significant(I

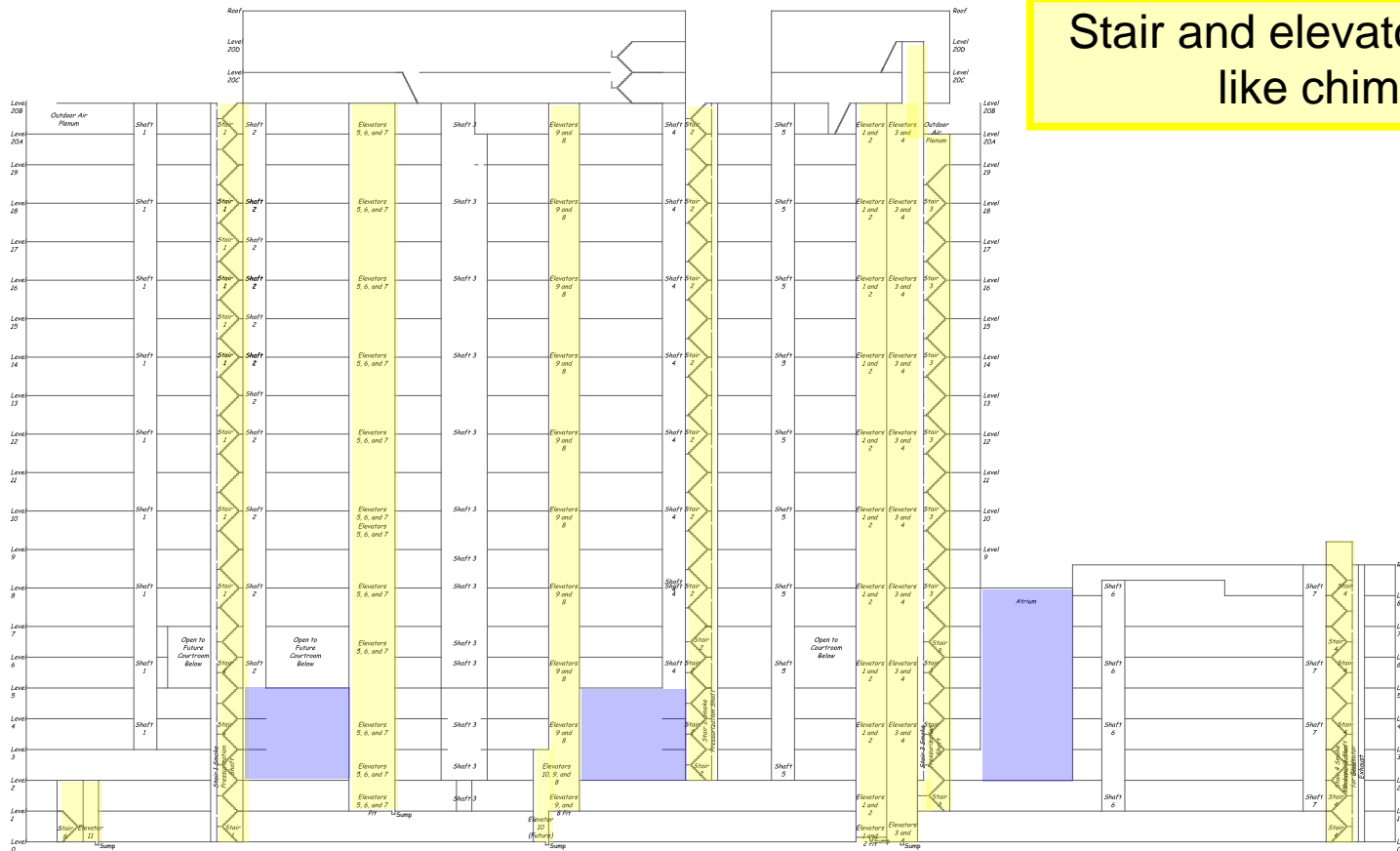
Atriums interconnect floors



The Envelope is Significantly Complex

Atriums interconnect floors

Stair and elevator shafts act like chimneys

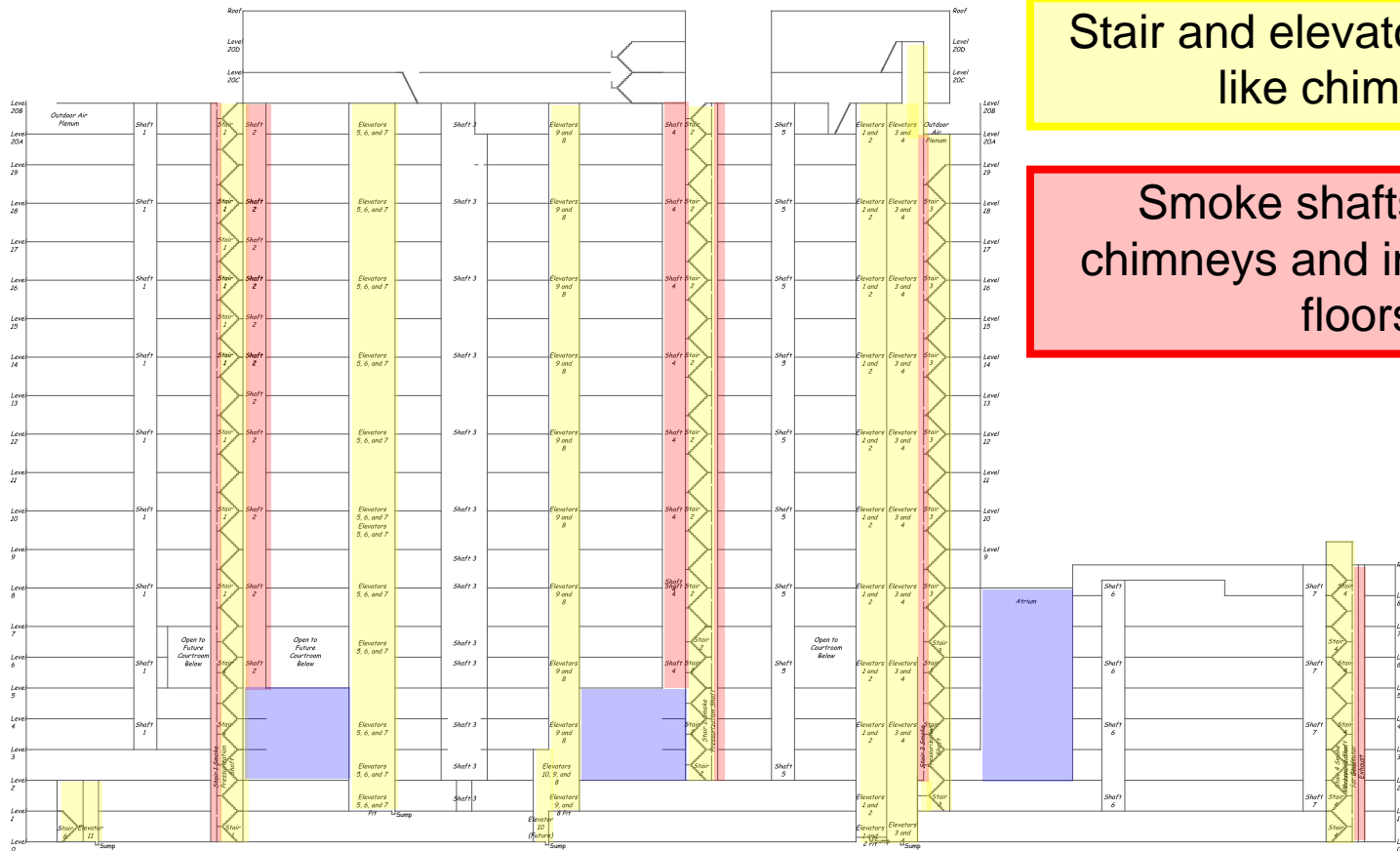


The Envelope is Significantly Complex

Atriums interconnect floors

Stair and elevator shafts act like chimneys

Smoke shafts act like chimneys and interconnect floors



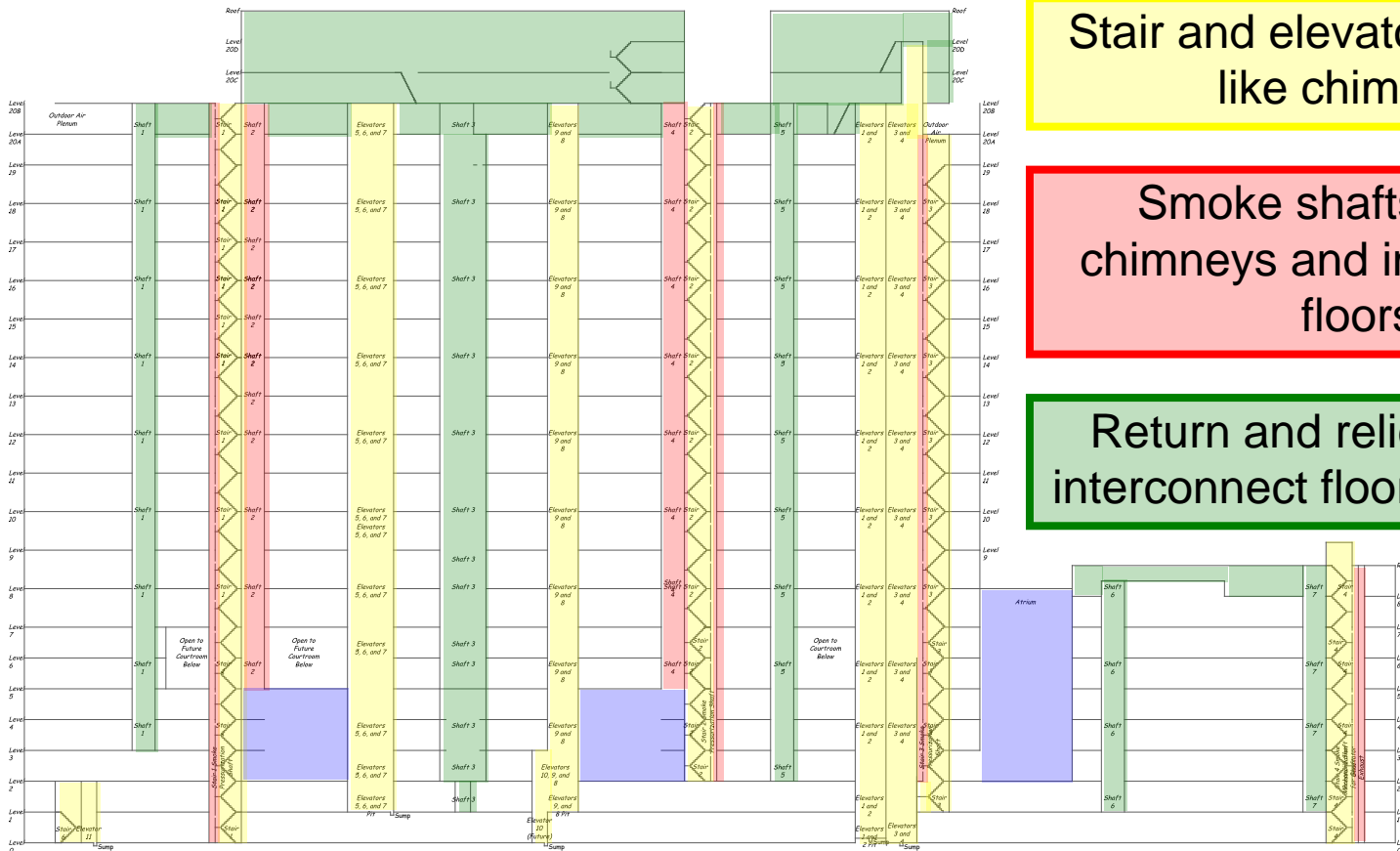
The Envelope is Significantly Complex

Atriums interconnect floors

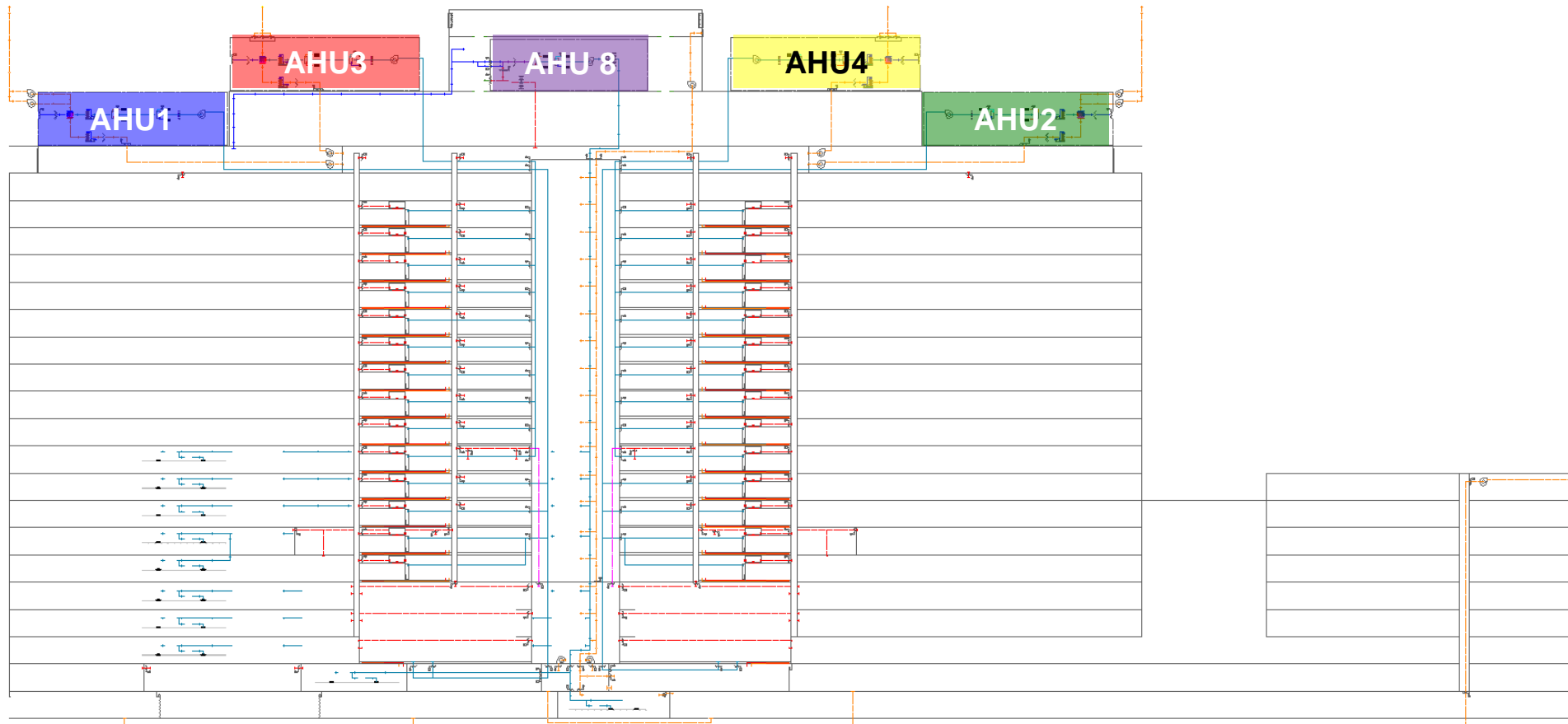
Stair and elevator shafts act like chimneys

Smoke shafts act like chimneys and interconnect floors

Return and relief plenums interconnect floors and shafts

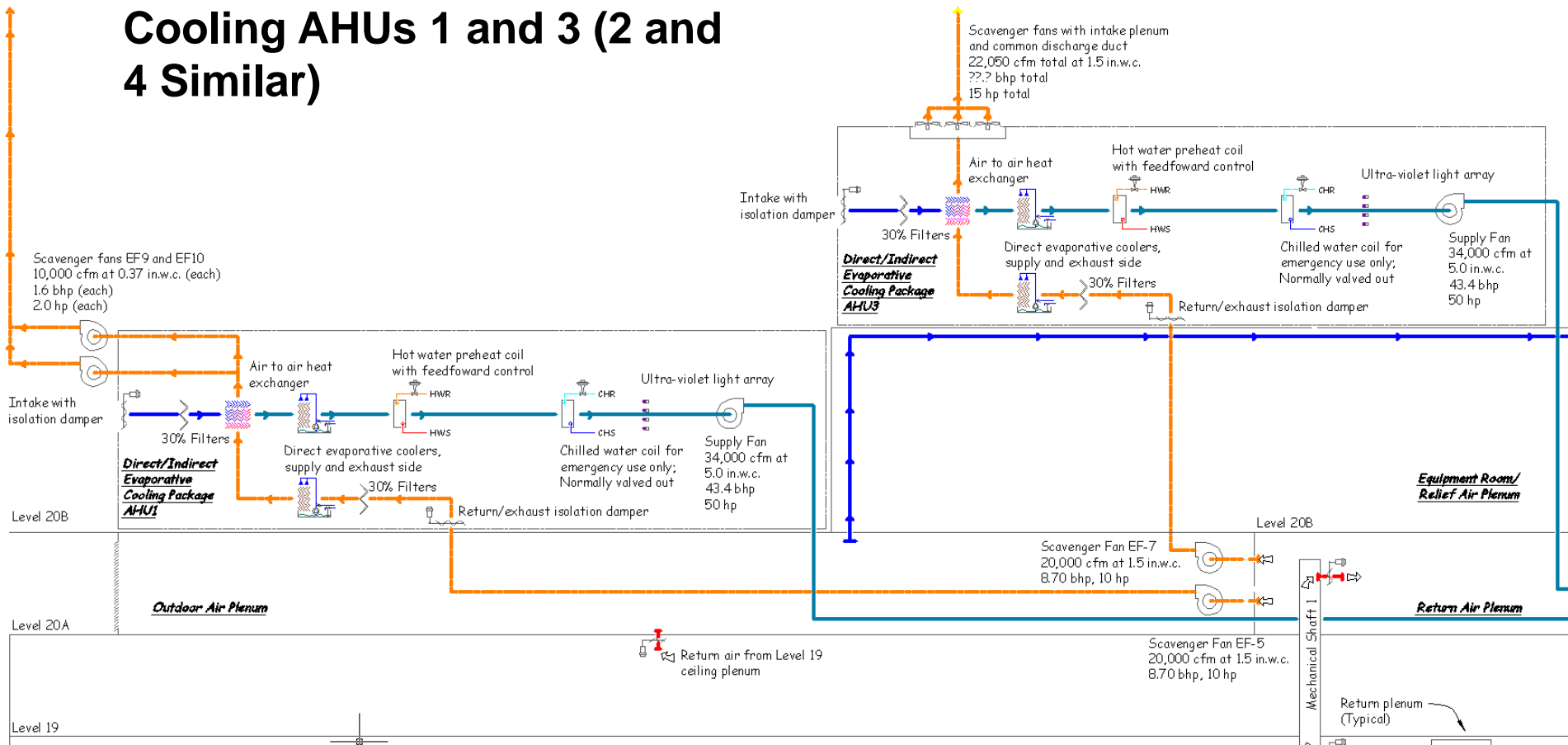


The Envelope as the Framework for the Air Handling System Diagram

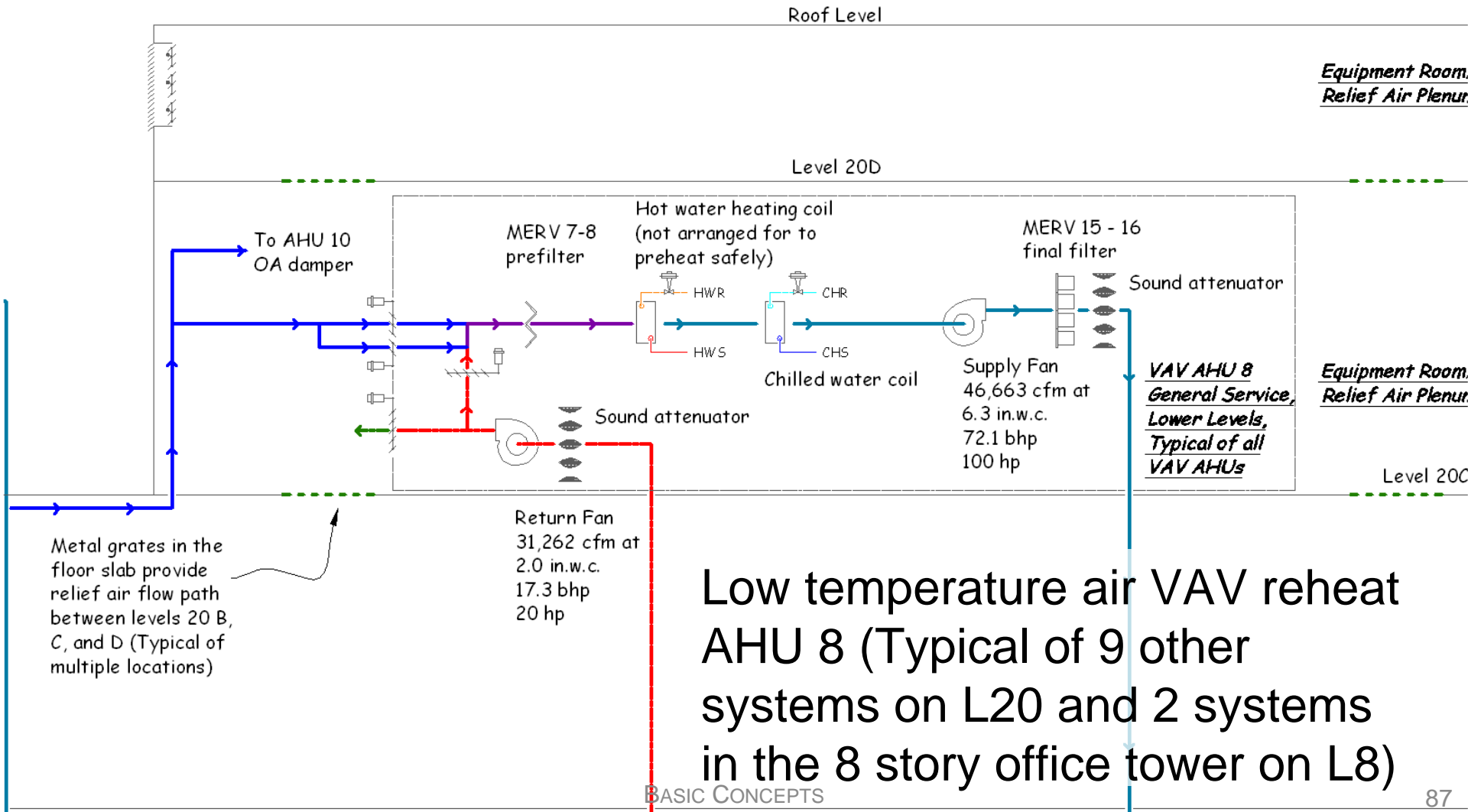


The Envelope as the Framework for the Air Handling System Diagram

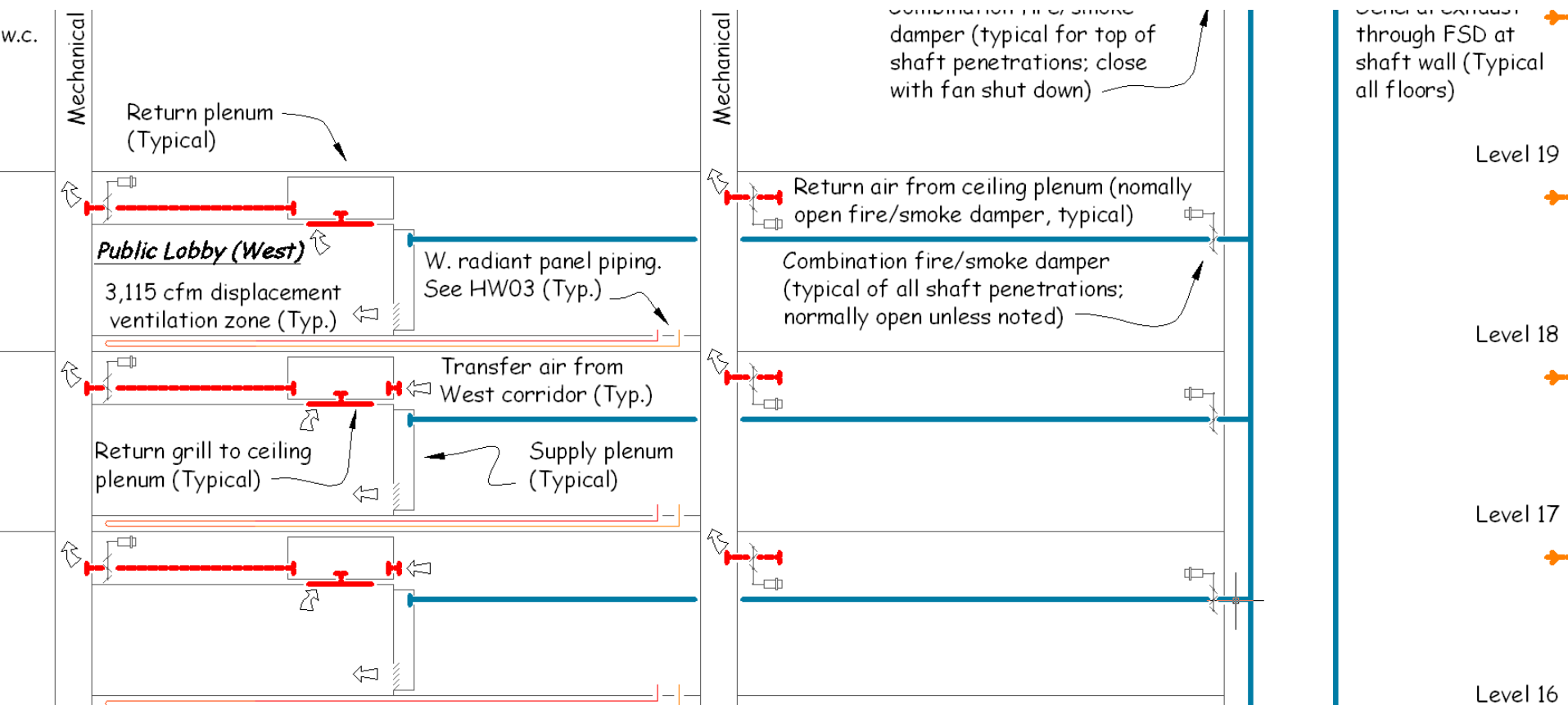
Direct/Indirect Evaporative Cooling AHUs 1 and 3 (2 and 4 Similar)



The Envelope as the Framework for the Air Handling System Diagram

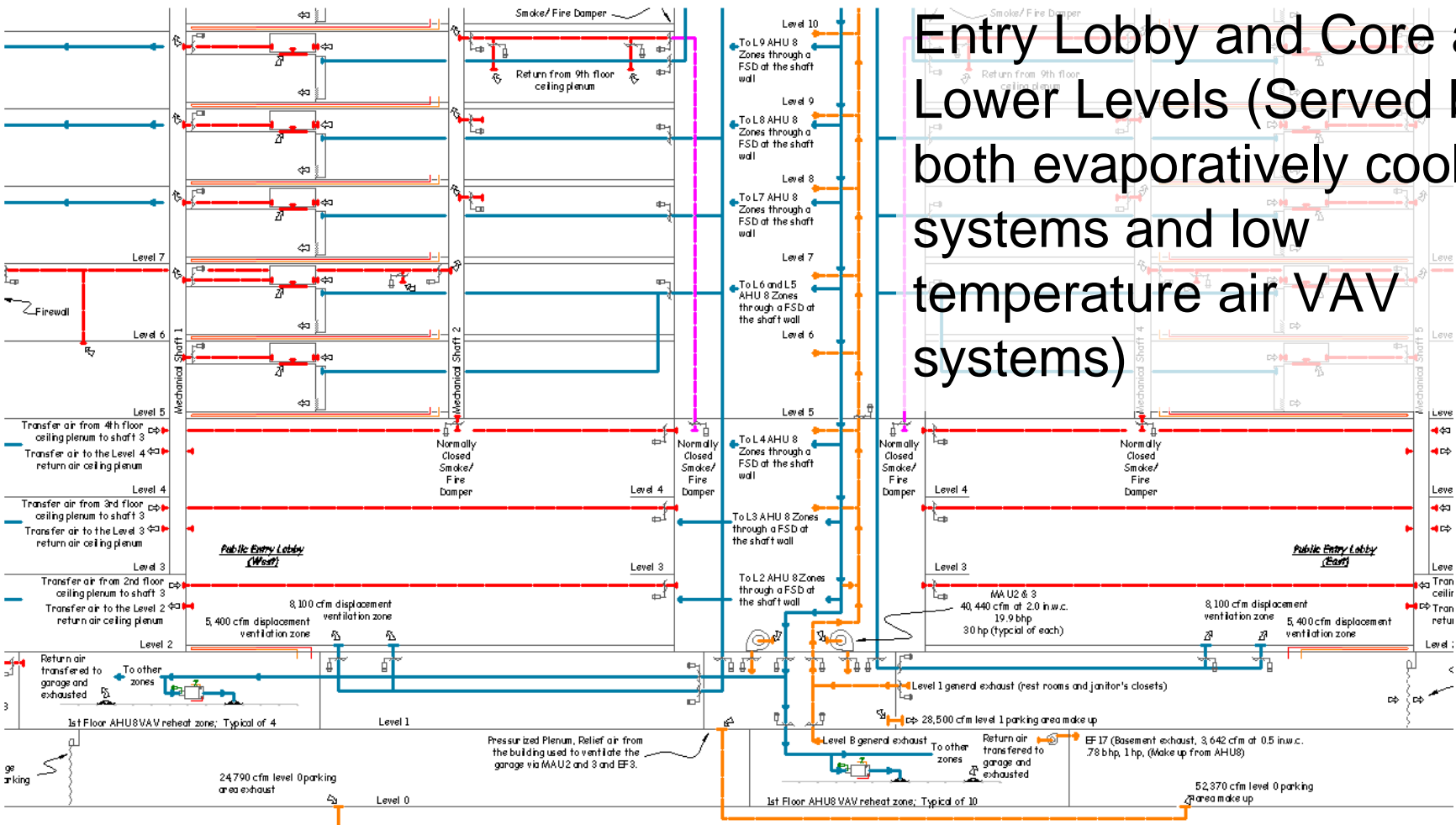


The Envelope as the Framework for the Air Handling System Diagram



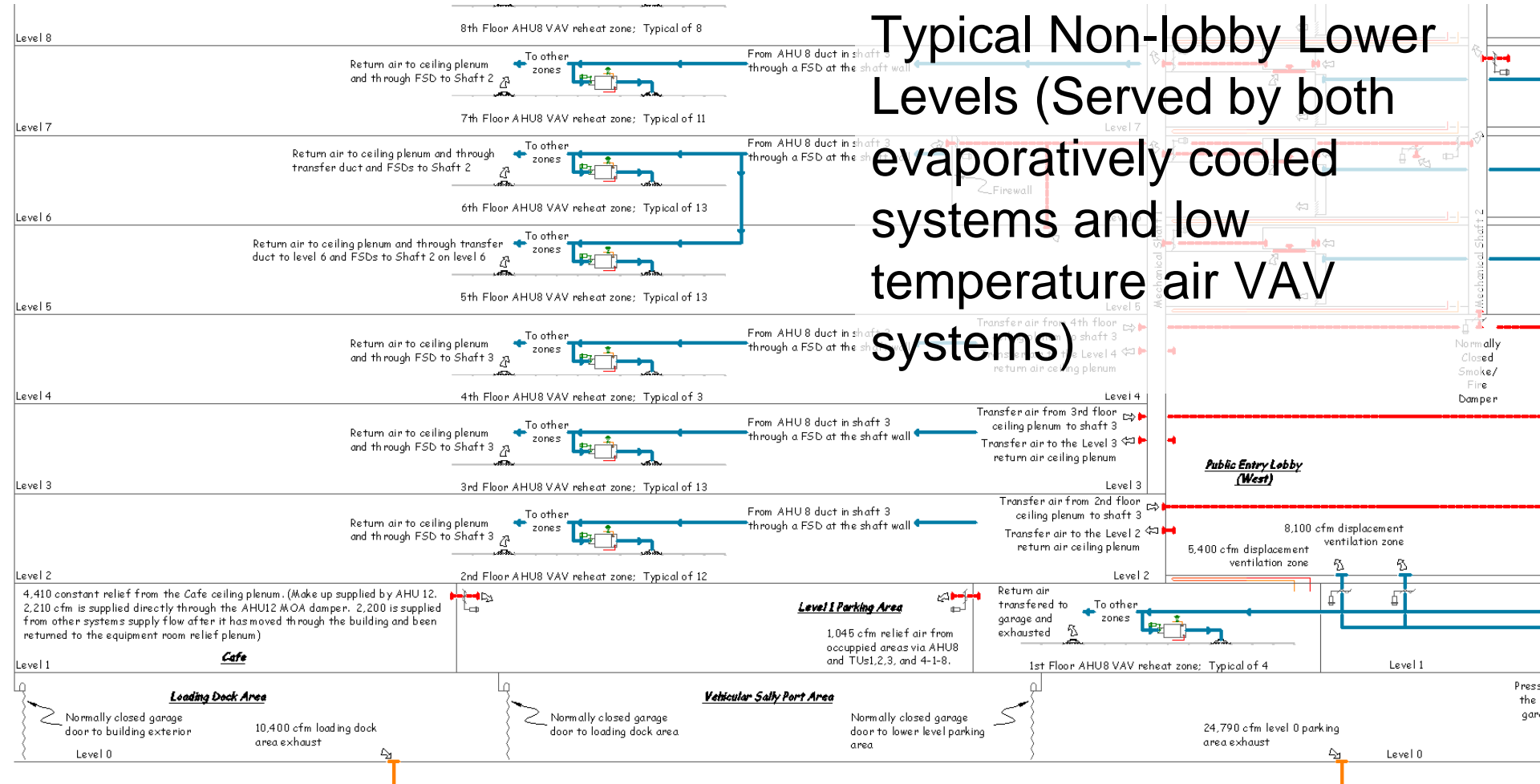
Typical Public Lobby Area (Served Direct/Indirect Evaporative Cooled AHU)

The Envelope as the Framework for the Air Handling System Diagram

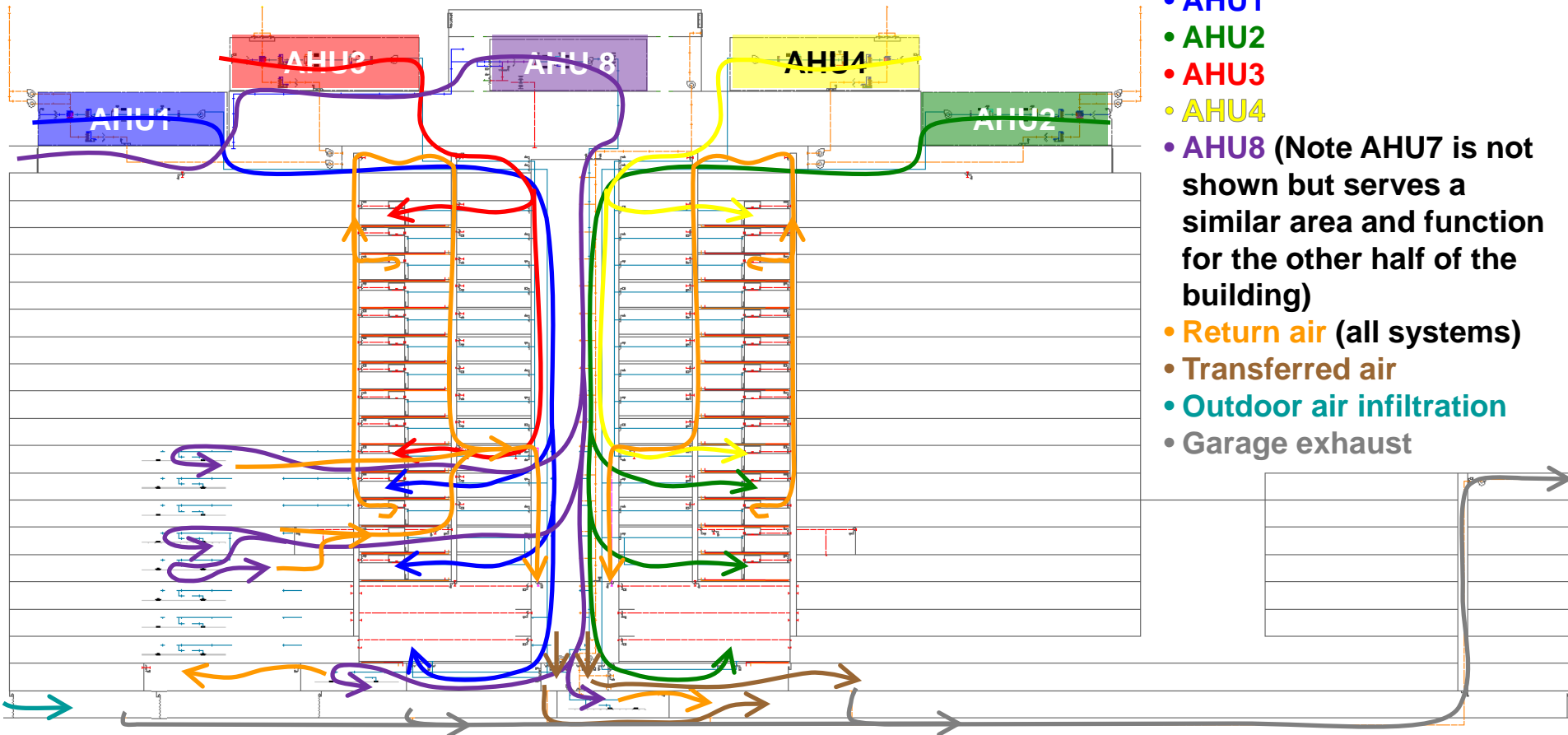


The Envelope as the Framework for the Air Handling System Diagram

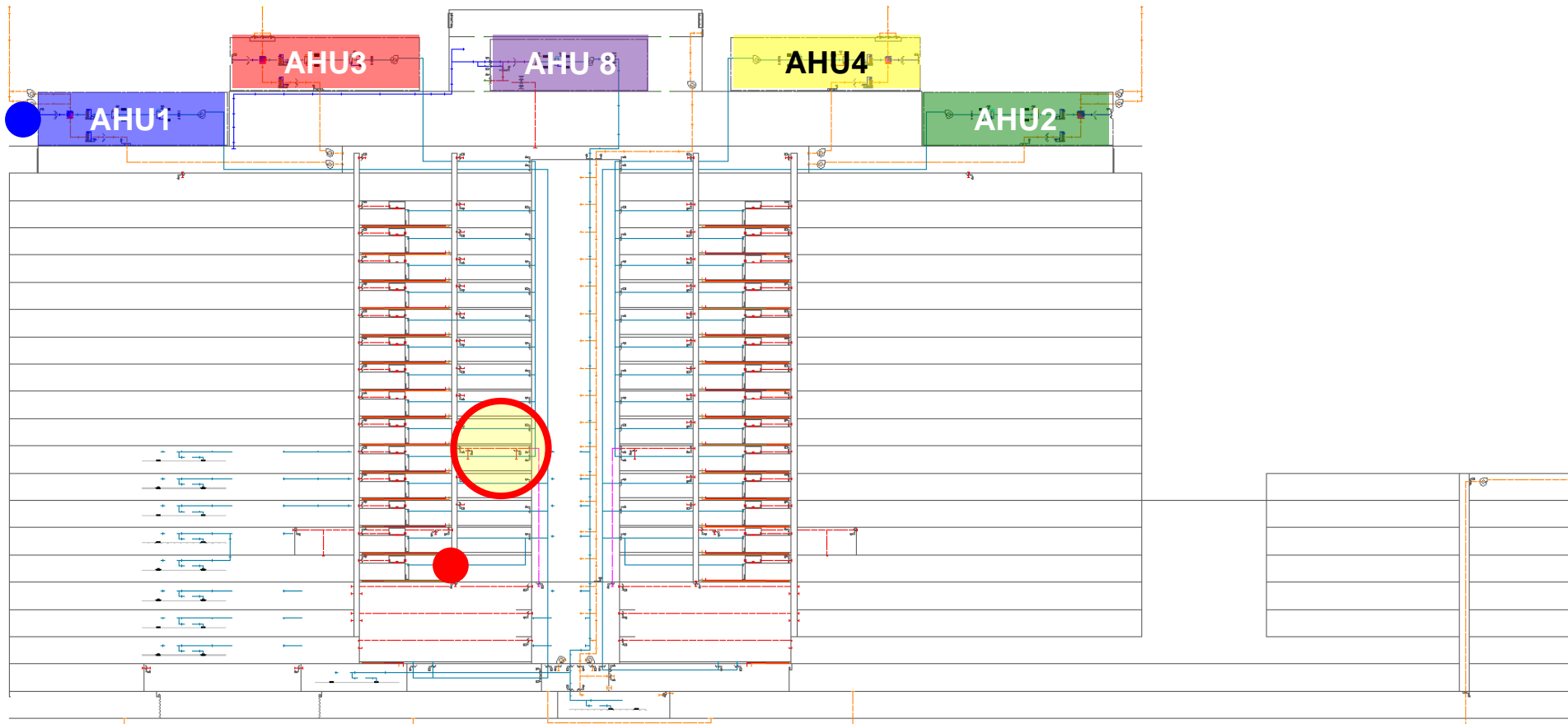
Typical Non-lobby Lower Levels (Served by both evaporatively cooled systems and low temperature air VAV systems)



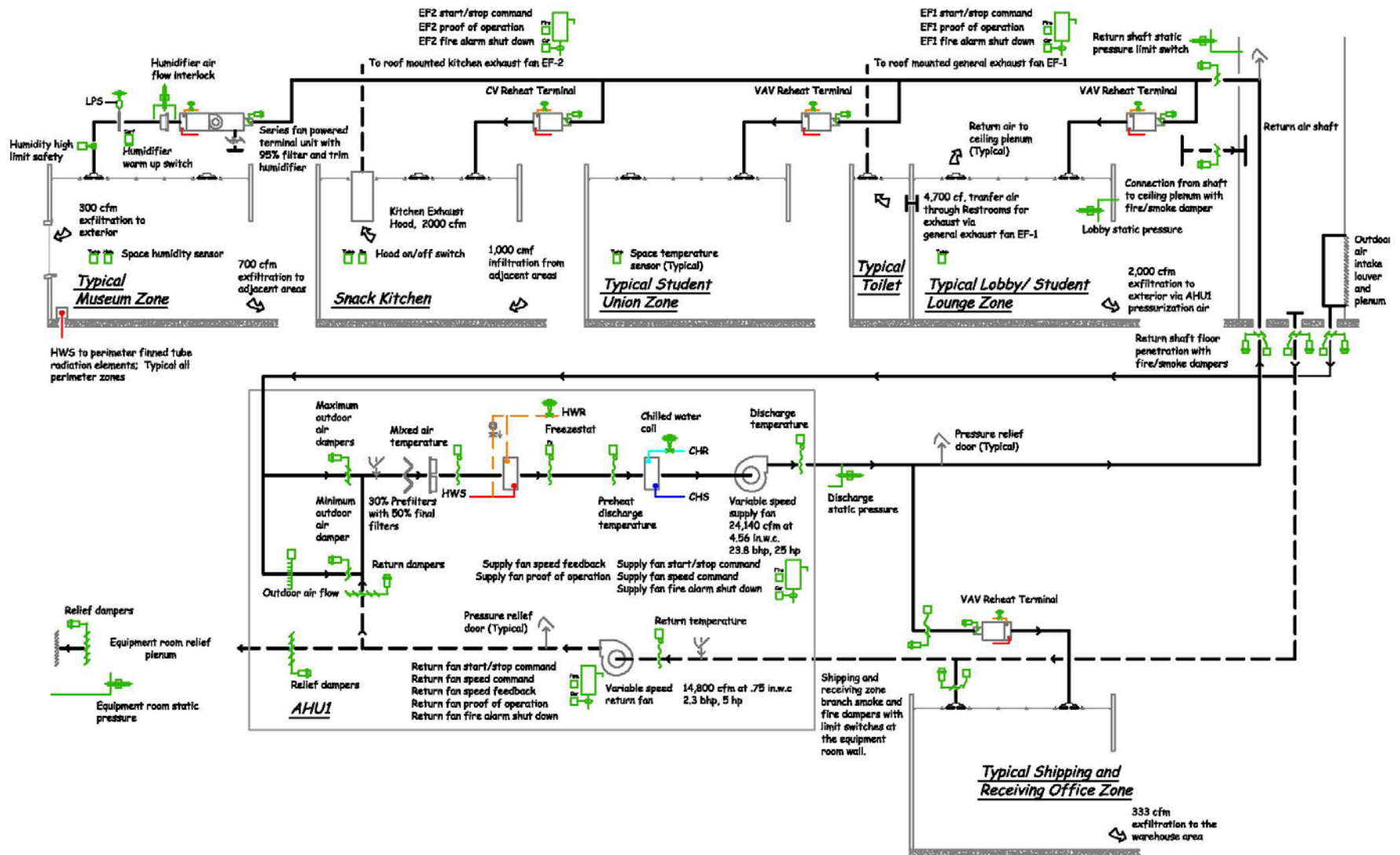
The Envelope as the Framework for the Air Handling System Diagnostics



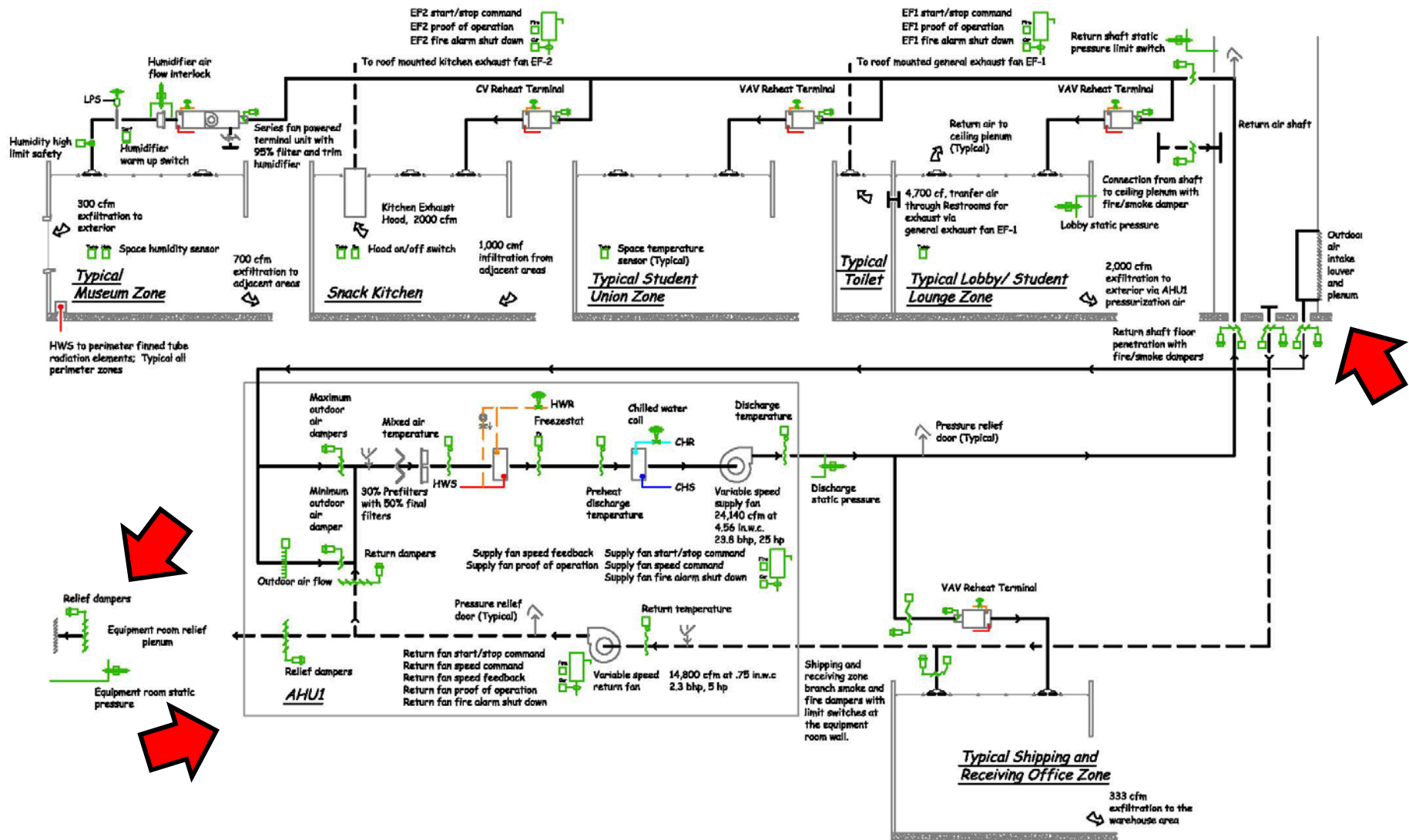
The Envelope as the Framework for the Air Handling System Diagnostics



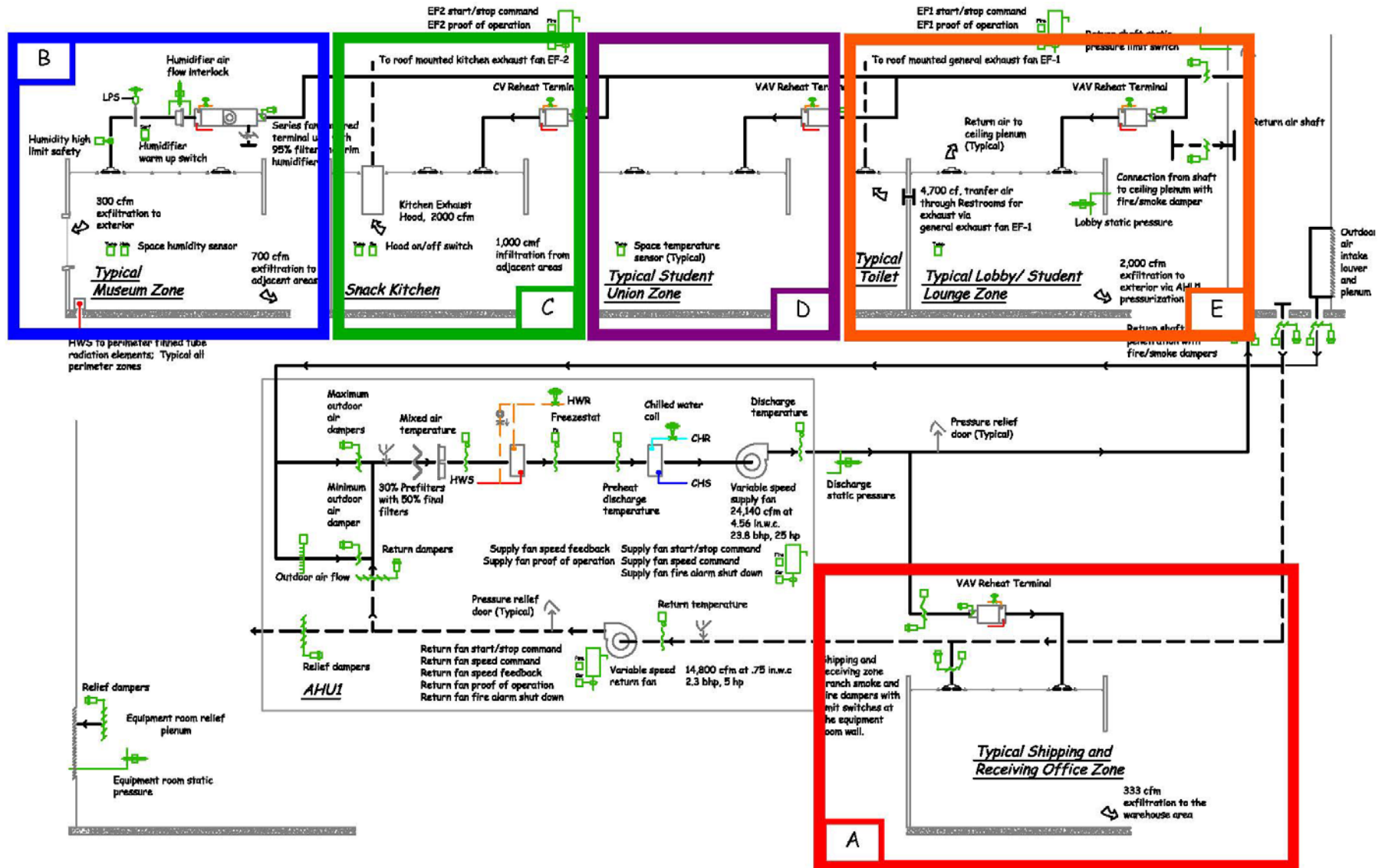
Air Handling System Diagram Characteristics



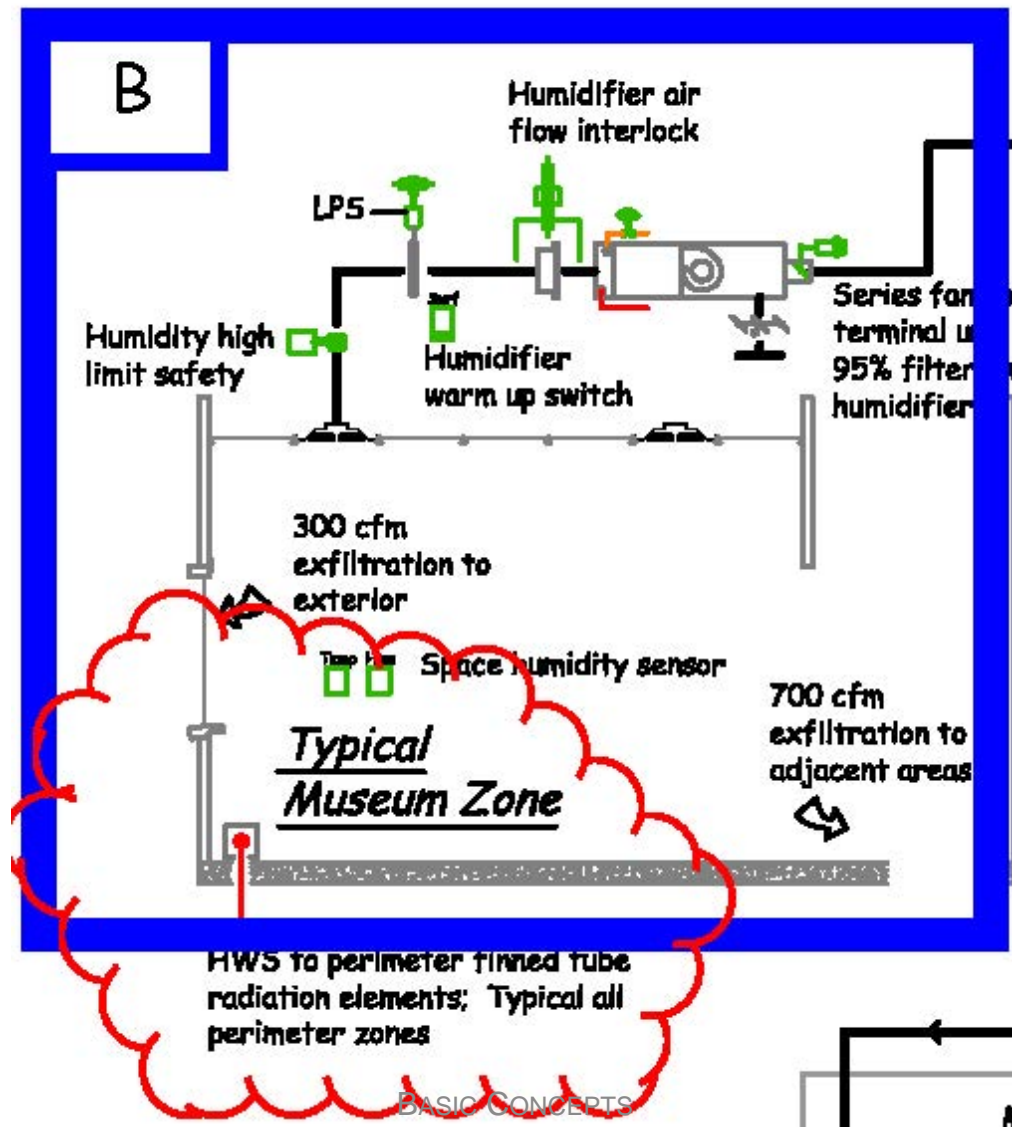
Reflect the Building Physical Arrangement



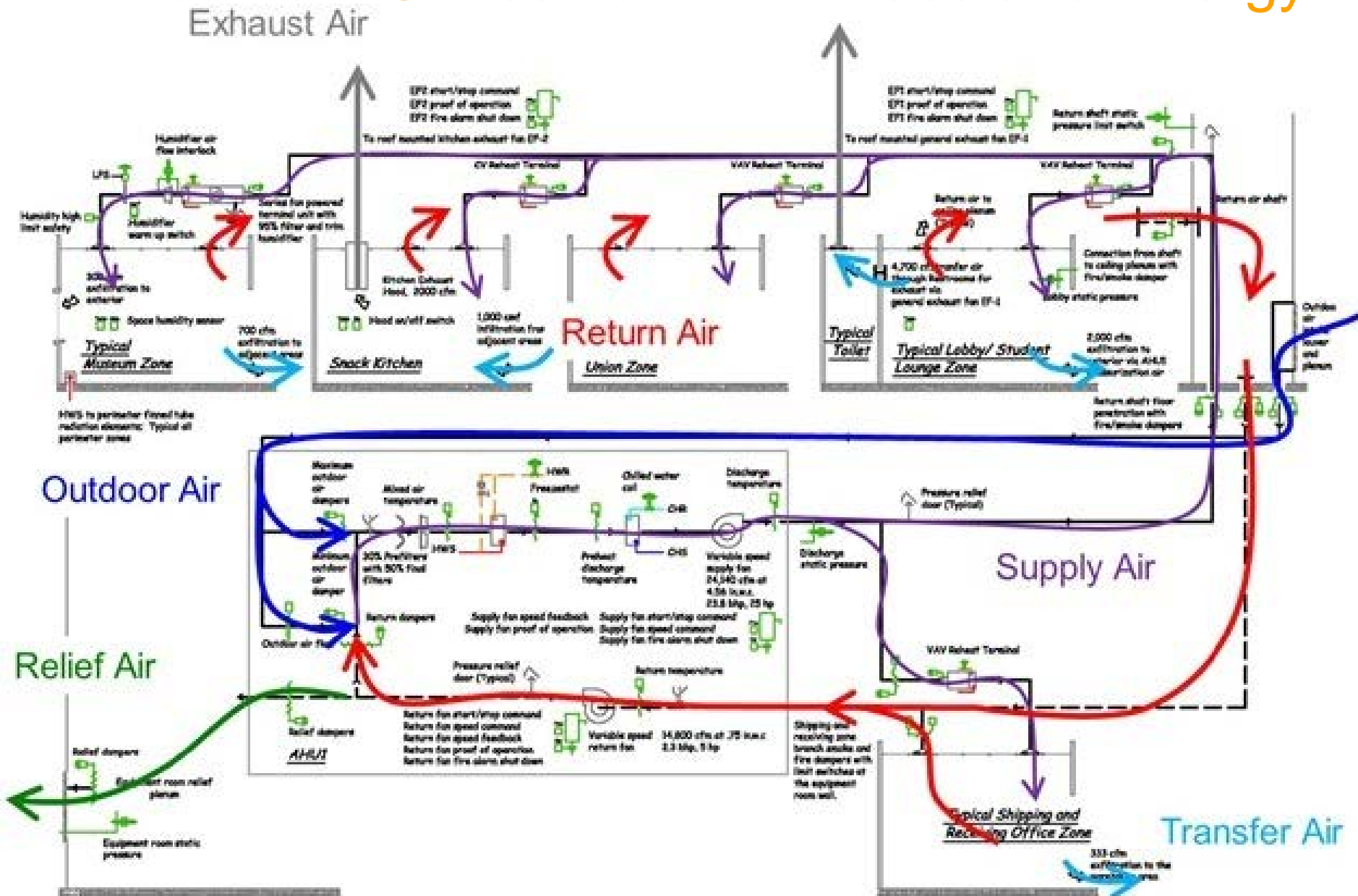
Include Examples of Each Zone Type



Include the Impacts of Other Systems



Document Conservation of Mass and Energy



Let's Try Applying What We've Learned

