Go For the Gold Medal in your Chemical Engineering Career

Todd J. Willman, PE, MBA
Director of Engineering - EPI Engineering
Director of Development - EPCON International

EPI Engineering™

EPCON SOFTWARE
It's time to upgrade to the latest technology

EPI Engineering

Chemical Engineering Disciplines

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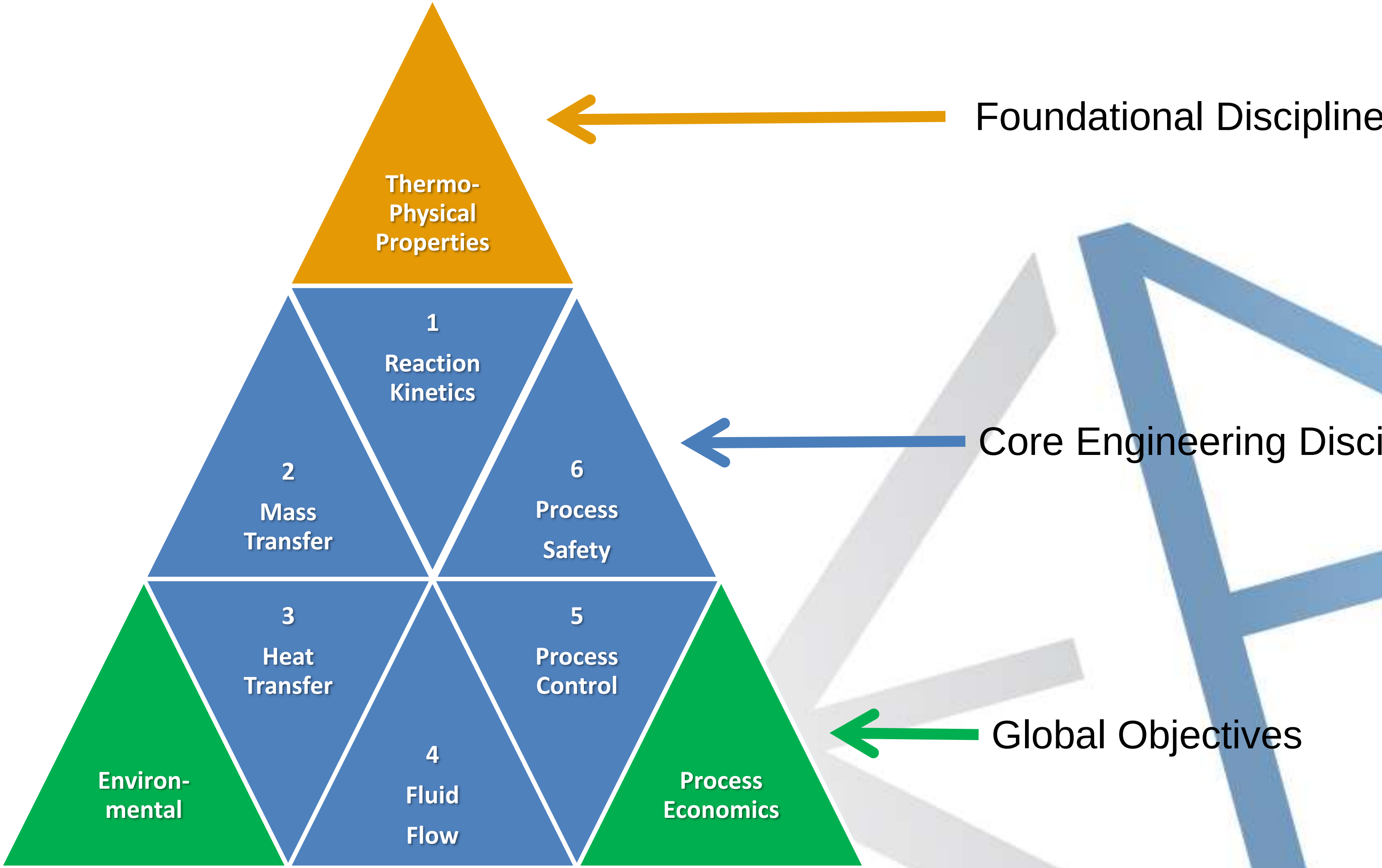

How to Obtain the Gold Medal

- Choose your Event
  - What is your passion in Chemical Engineering?
  - Work on this passion even if it's on your own time
  - Choose mentors who have experience in your passion
- Practice Hard
  - Focus on the fundamentals
  - Choose your mentors
- Have a Vision!
  - Develop short and long term visions
  - Don't listen to the wrong voices (ear plugs sometimes required)
- Go for the Gold!
  - Usually at least 4 years of hard work
  - Sometimes it will take several Olympics to realize Gold
  - Stay with it – you are in the race until you step off the track

Practical Application of Fluid Flow

- Process Systems – *Increased Throughput*
- Energy Systems – *Reduced Fuel, Electrical, Chemical and Water Costs + Increased Throughput*
  - Steam Networks, Letdown Valves/Turbines
  - Condensate and BFW Systems
- Water Systems – *Reduced Electrical, Chemical and Water Costs + Increased Throughput*
  - Cooling Water Distribution Systems
  - Process Water Distribution Systems
- Safety Systems – *Personnel and Asset Protection*
  - Fire Water Distribution Systems
  - Flare Header Gathering Systems
  - Pressure Relief Valves

Background of EPCON & EPI

EPCON SOFTWARE™

Engineer's Aide SiNET
Fluid Flow Analysis, Equipment Sizing and Costing Software

In 1984, EPCON Software developed the first ever suite of engineering software applications and have overtime molded its software into industry leading solutions.

- Over the past 28 years, EPCON Software has accumulated multiple patents that protect its award-winning technology
- EPCON's flagship product Engineer's Aide SiNET is the most widely used pipe flow analysis software in the world
- EPCON Software is also technology partners with the American Petroleum Institute and the Gas Processors Association

- Over the past decade many EPCON Software clients such as Dow Chemical, 3M, Eastman Chemical, Shell Chemicals LP, ConocoPhillips, Chevron, BP, Citgo, Texas Petrochemicals and Lyondell have requested that our team of experts model, simulate, analyze, and optimize their respective utility systems using our software technology.

- Due to high demand of our service, EPCON Software created EPI Engineering in 2002 and expanded into specialized services specifically for utility systems

EPI Engineering Study Types

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Energy

Steam Systems

Condensate

Fuel Systems

Water

Cooling Water

Boiler Feedwater

Clarified Water

Safety

Flare Headers

Firewater

Safety Showers

Mental Model vs. Simulation Model

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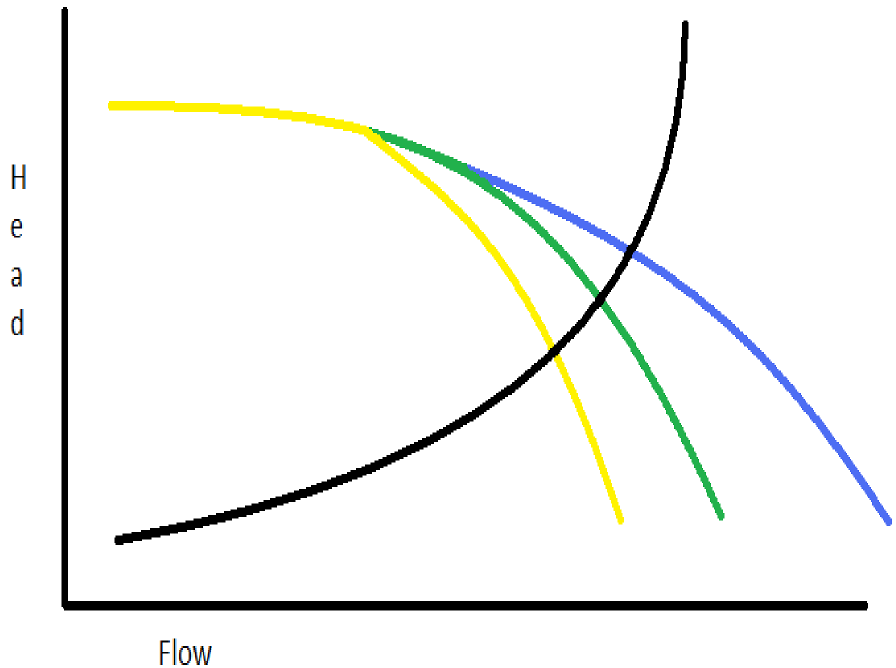

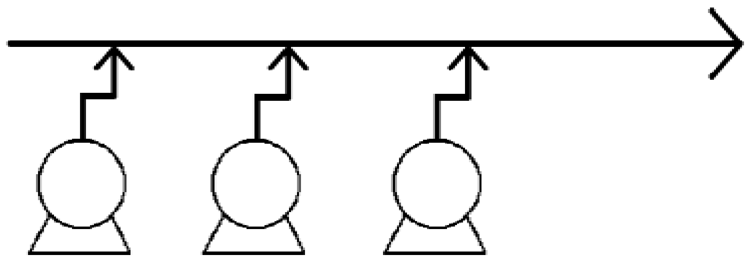

X2 Capacity?

X3 Capacity?

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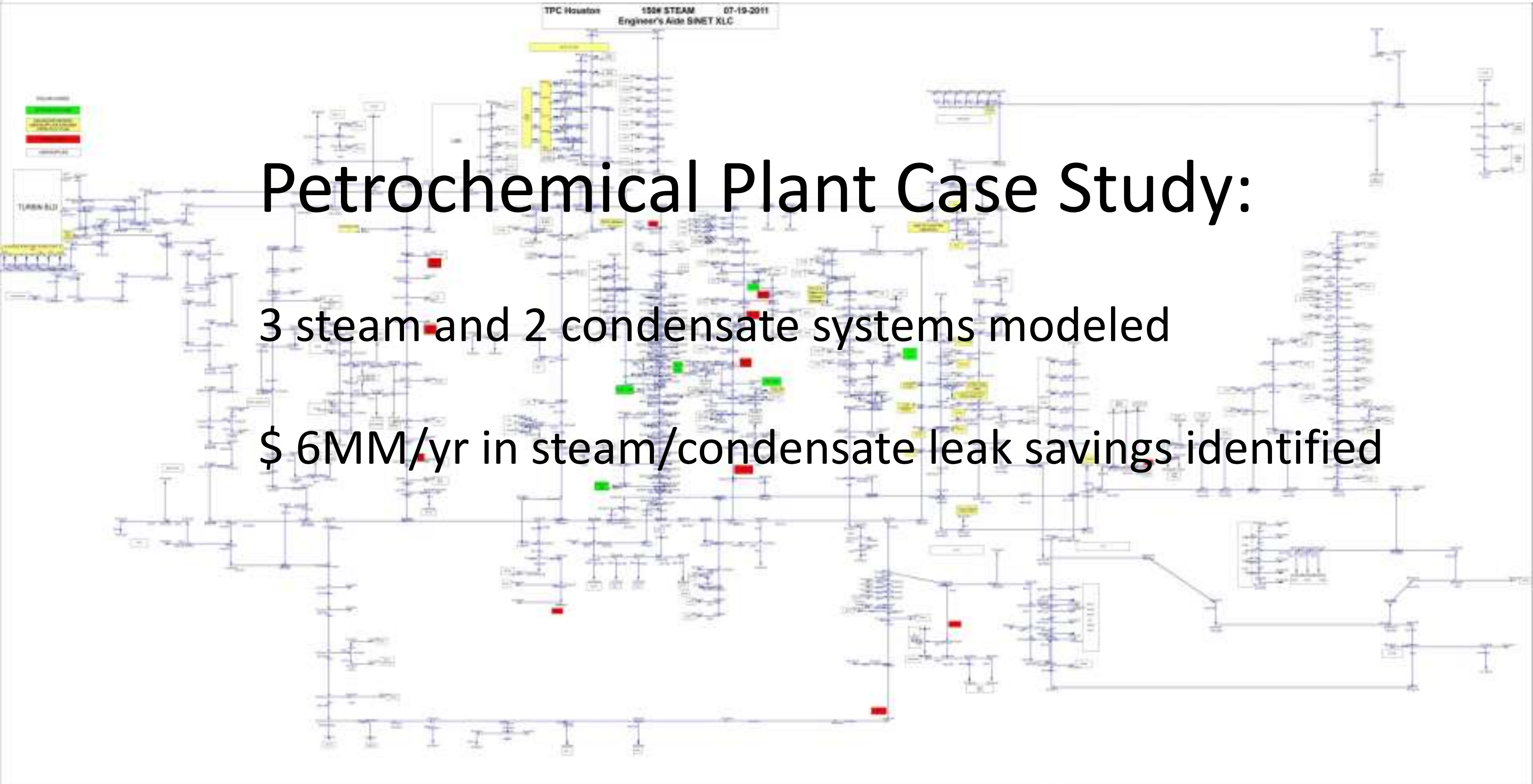
Petrochemical Plant Case Study:

3 steam and 2 condensate systems modeled

$ 6MM/yr in steam/condensate leak savings identified



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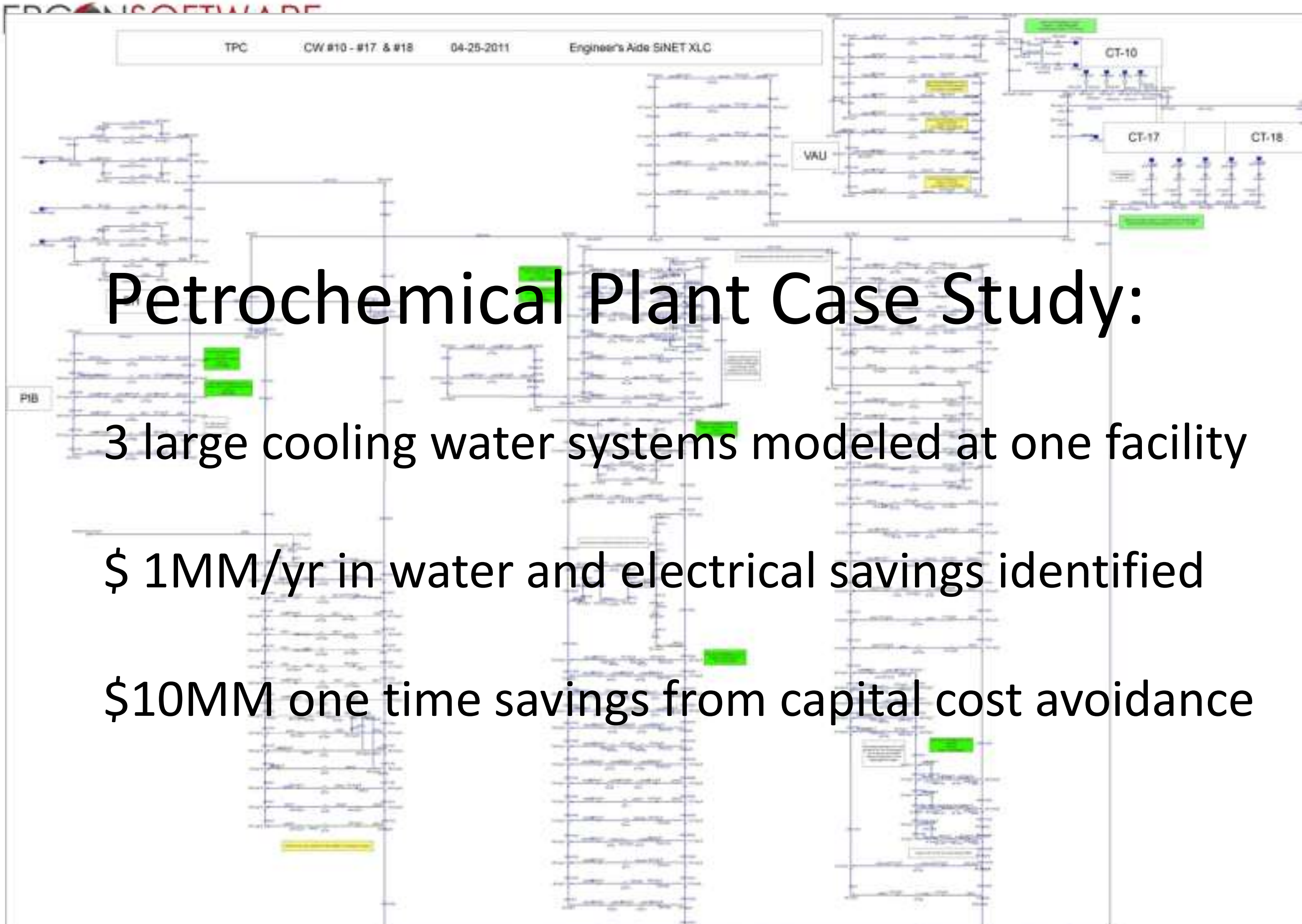
Cooling Water System Analysis



Petrochemical Plant Case Study:

3 large cooling water systems modeled at one facility

$ 1MM/yr in water and electrical savings identified

$10MM one time savings from capital cost avoidance

The Extended Bernoulli Equation

$$P_1 + \frac{\frac{\rho v_1^2}{2g_c}}{144} + \frac{\rho Z_1}{144} = P_2 + \frac{\frac{\rho v_2^2}{2g_c}}{144} + \frac{\rho Z_2}{144} - \sum_{1,2} F + W$$

For determining pressure drop from pipe inlet (1) to pipe outlet (2)

P=Pressure (lbf/in²)

v= Kinetic Energy (ft/sec)

Z=Potential Energy (ft)

W= Work done on or by the fluid (lbf/in²)

ρ= Fluid Density (lbf/ft³)

g_c=Acceleration of Gravity (32 ft/sec²)

144 in² = 1 ft²

Energy Balance for Flow in Pipes

$$P_1 - P_2 = \left(\frac{\frac{\rho v_2^2}{2g_c}}{144} - \frac{\frac{\rho v_1^2}{2g_c}}{144} \right) + \left(\frac{\rho Z_2}{144} - \frac{\rho Z_1}{144} \right) - \sum_{1,2} F + W$$

PRESSURE ENERGY = KINETIC ENERGY + POTENTIAL ENERGY + FRICTION ENERGY + WORK ENERGY

+ Kinetic Energy Change

+ Potential Energy Change

+ Frictional Energy Change

<u>+ Work Energy Change</u>

= Pressure Energy Change (what we are solving for!)

Frictional Energy Loss

$$F = \rho/144\left(\frac{fL}{D} + \sum K\right)\frac{v^2}{2g_c} \qquad K = \frac{fL}{D}$$

To calculate pressure drop from pipe friction and minor losses

F=Frictional Energy Loss in Pipes (lbf/in^2)

f= Moody or Darcy Friction Factor (dimensionless)

L= Pipe Length (ft)

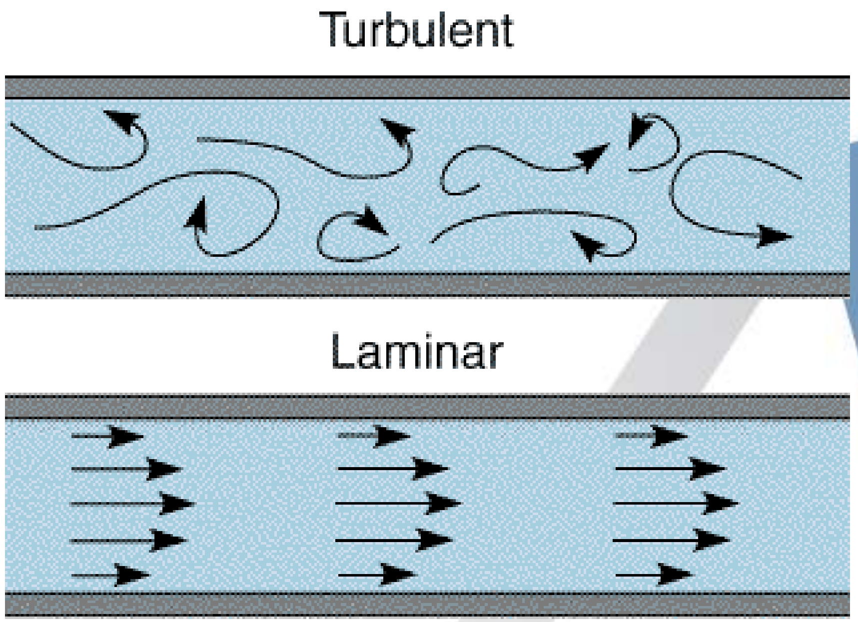
D= Pipe Diameter (ft)

K= K Value for Flow Resistance (dimensionless)

v= Average Velocity (ft/sec)

g_C= Acceleration of Gravity (32 ft/sec^2)

Turbulent vs. Laminar Flow



Moody Friction Factor

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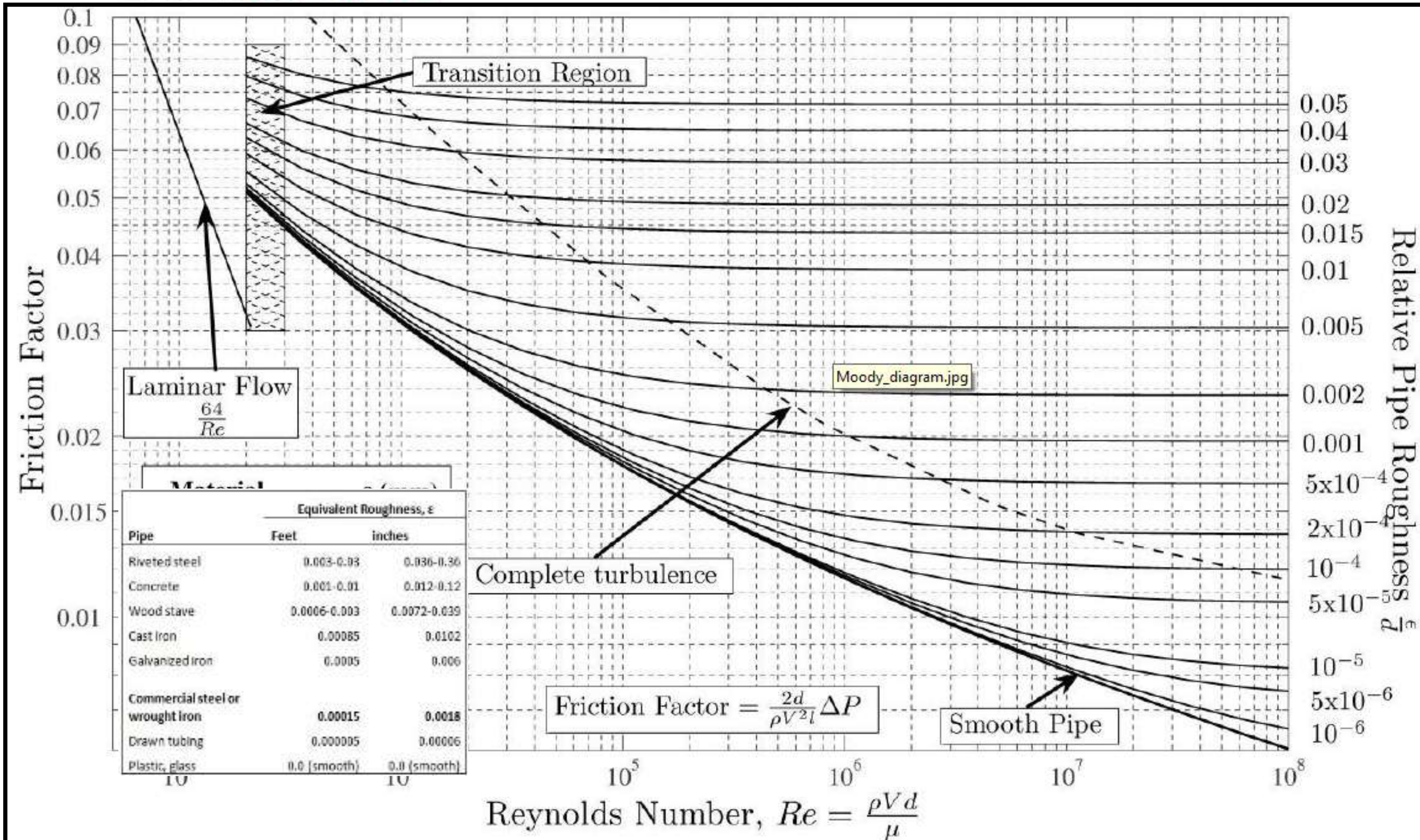

Pipe	Equivalent Roughness, ε Feet	inches
Riveted steel	0.003-0.03	0.036-0.36
Concrete	0.001-0.01	0.012-0.12
Wood stave	0.0006-0.003	0.0072-0.039
Cast iron	0.00085	0.0102
Galvanized iron	0.0005	0.006
Commercial steel or wrought iron	0.00015	0.0018
Drawn tubing	0.000005	0.00006
Plastic, glass	0.0 (smooth)	0.0 (smooth)

K- Values for Fittings and Hand Valves

Fitting, Hand Valve	*K Value*
Short Radius 90 Deg. Elbow (r/d=1)	20 F_t
Long Radius 90 Deg. Elbow (r/d=1.5)	14 F_t
Tee Thru	20 F_t
Tee Branch	60 F_t
Pipe Entrance	0.5
Pipe Exit	1
Gate Valve	8 F_t
Ball Valve	3 F_t
Butterfly Valve	45 F_t
Globe Valve	340 F_t
Swing Check Valve	50 F_t

Pipe Dia	F_t
0.5 inch	0.027
0.75 inch	0.025
1 inch	0.023
2 inch	0.019
3 inch	0.018
4 inch	0.017
6 inch	0.015
8-10 inch	0.014
12-16 inch	0.013
18-24 inch	0.012
26-48 inch	0.011

TPC Group Case Study

- TPC Group Houston Operations was evaluating the potential expansion of several existing production units as well as building new production units.
- The need was identified to assess the capacity of existing utility systems including steam, condensate, compressed air, nitrogen, natural gas, fuel gas, cooling water, and firewater systems.
- Detailed simulation models of each utility system were developed and tuned to match existing plant data in order to identify available capacity of each system and understand current limitations.

Benefits of this Study

- The analysis also provided significant insight into energy savings opportunities throughout the current plant operations.
- All plant utility systems were modeled and evaluated which have not been looked at in detail since their original design
- The end result of the studies provided identified cost reduction opportunities of >$5MM, of which some have already been implemented.
- This presentation will discuss specific examples of the analysis and show corresponding results in both the steam and water systems.

Steam System Savings

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- 750# Steam Leaks (estimated) – 10,000 lb/hr
- 150# Steam Leaks (quantified) – 69,930 lb/hr
- 15# Steam Leaks (quantified) – 44,668 lb/hr
- Total Steam Leaks - $124,598 lb/hr
- Estimated total cost of steam leaks - $6,300,000/yr
- Estimated savings with 80% reduction - $5,000,000/yr

Cooling Water System Energy Savings

Type	**Basis**	**$ Amount**	**Type**
Cooling Water Pump HP	2500 HP	$483,000	Annual
Fire Water Pump HP	200 HP	$38,000	Annual
Total Savings		**$521,000**	**Annual**

Cooling Water System Water Savings

Type	Basis	$ Amount	Type
CIWA Raw Water	800 gal/min	$227,000	Annual
Clarified/Filtered Water	600 gal/min	($62,000)	Annual
Total Savings		**$165,000**	**Annual**

Steam System Modeling

EPCON SOFTWARE

- Detailed walk-down of system piping required to build simulation models.
- All flowmeters and users identified and quantified using data historian.
- Detailed steam balance accomplished for one point in time on the data historian under typical operations.
- Additional flows required to validate the model to match field data represent steam leaks.
- Detailed flow simulation models built and validated to plant data by EPI Engineering using EPCON's industry leading Flow Simulation Software, Engineer's Aide SiNET.

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750 # Steam System

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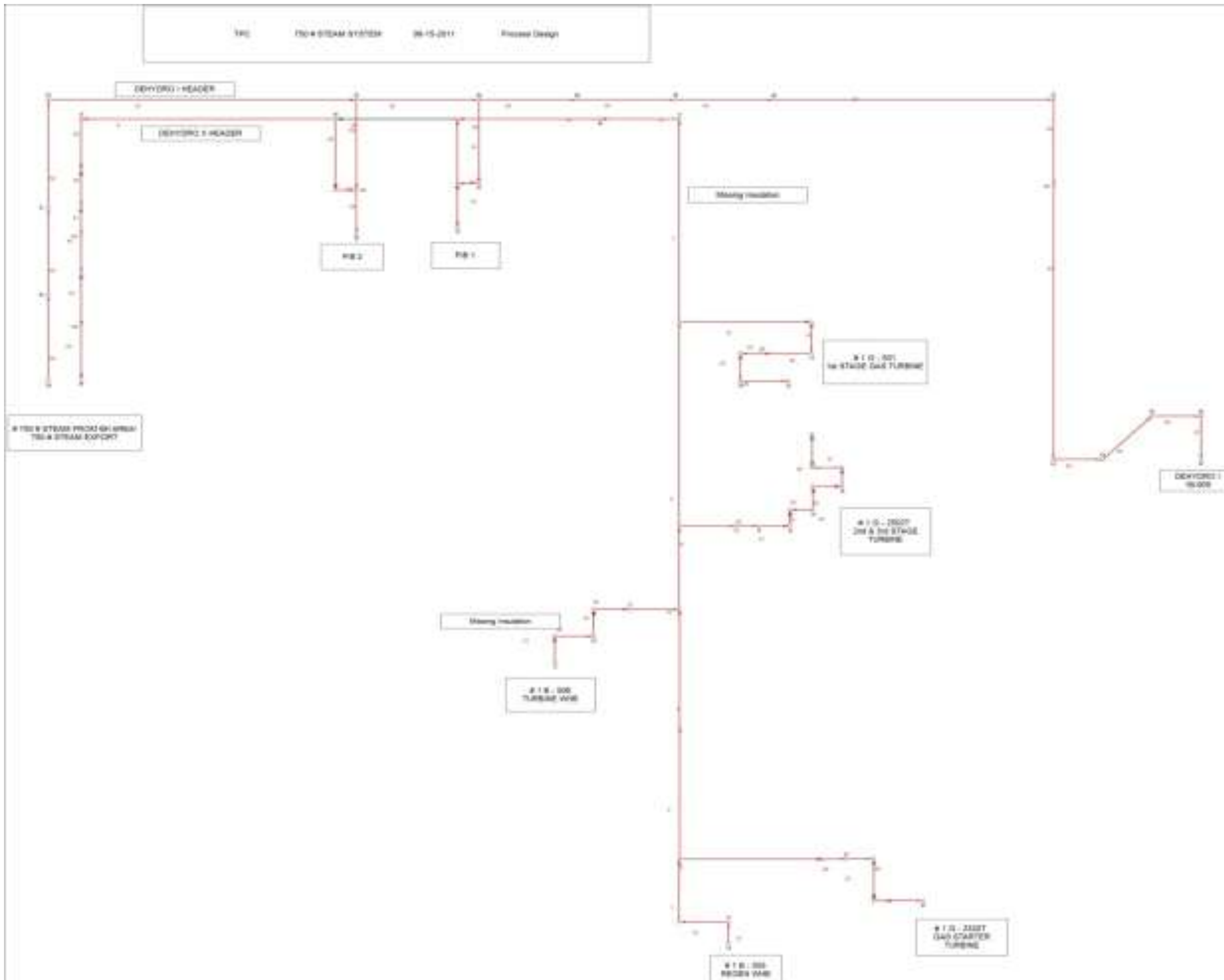

Design. Analyze. Optimize. Implement.©

150 # Steam System

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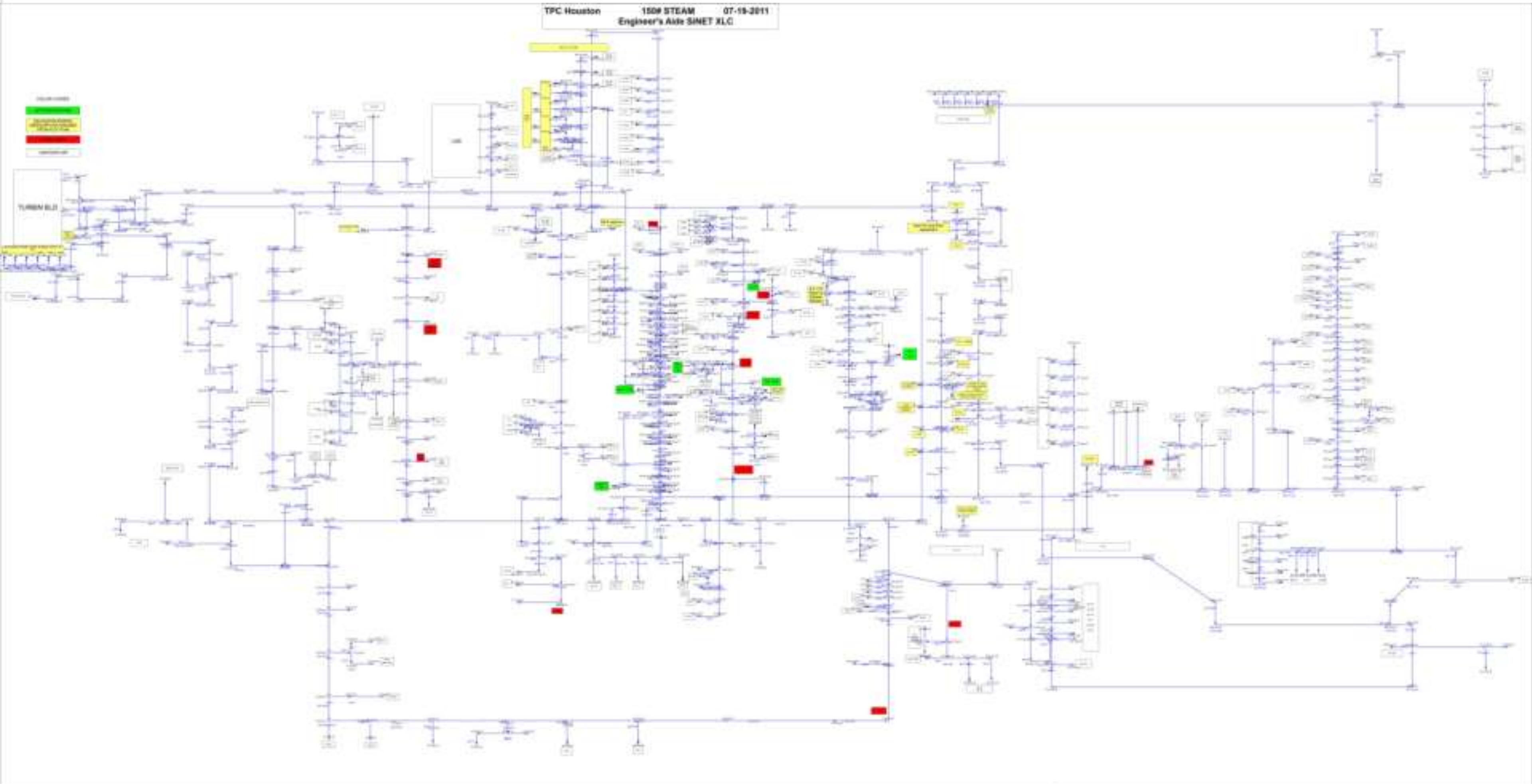

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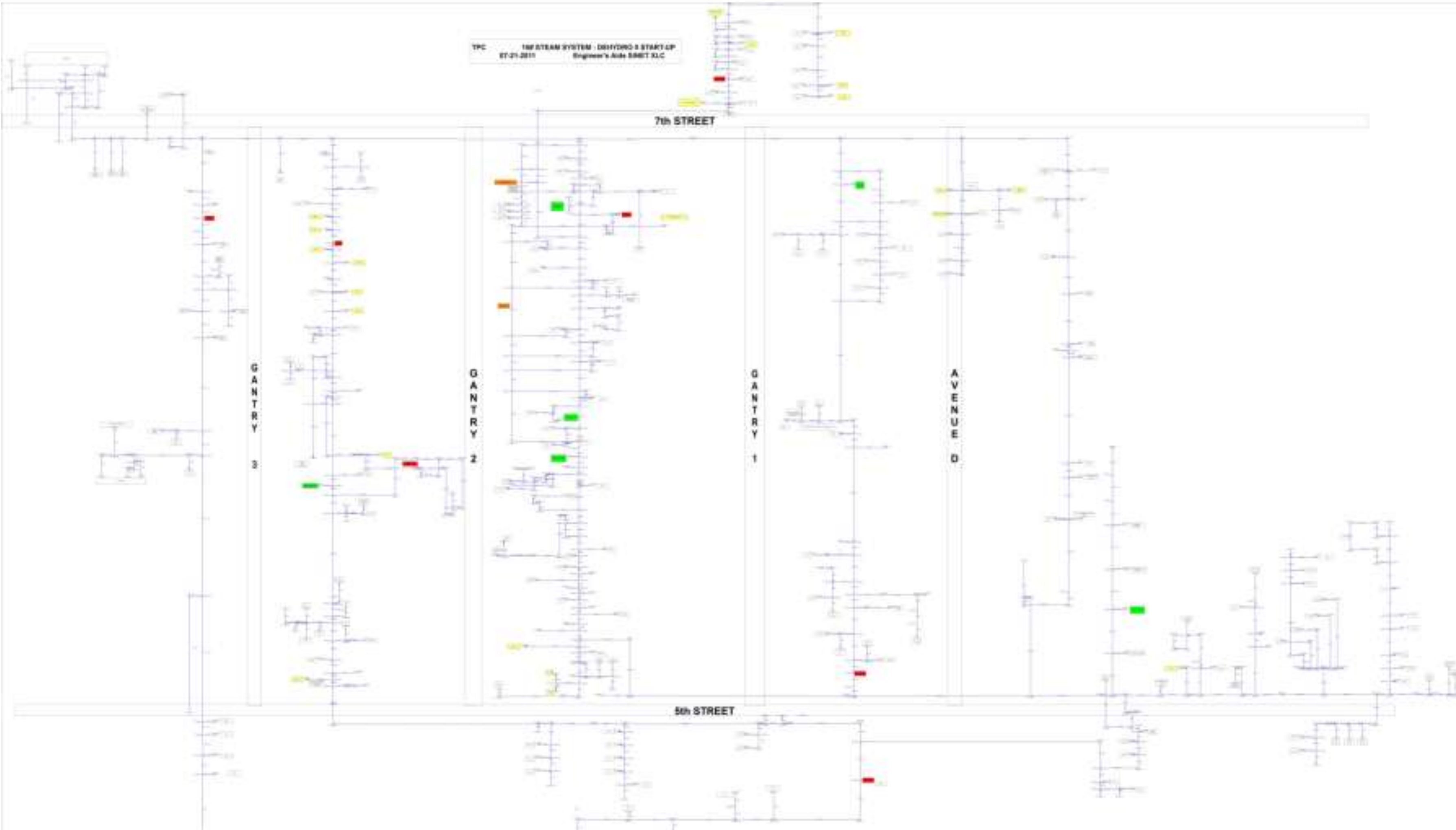
15# Steam System



Cooling Water System Modeling

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- Detailed walk-down of system piping required to build simulation models
- Collected field data on pressures and flowrates using new pressure gauges and ultrasonic flowmeters
- Additional resistances added in model are used to match the real-world data and quantifies system fouling
- Pump curves de-rated in models to match field performance data
- Detailed flow simulation models built and validated to plant data by EPI Engineering using EPCON's industry leading Flow Simulation Software, Engineer's Aide SiNET.

CT-10-17-18 Cooling Water Systems

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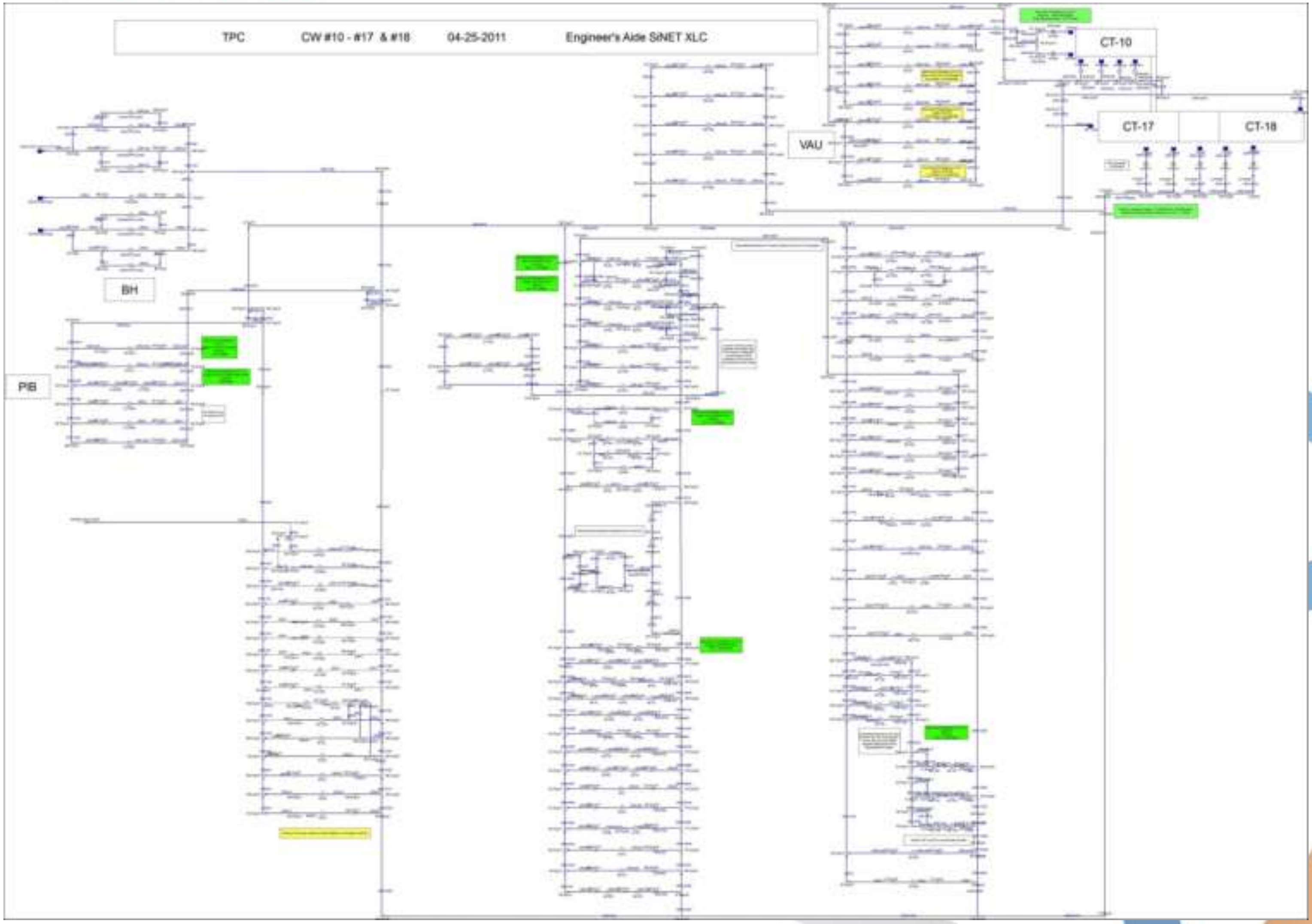

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CT-3-7-14 Cooling Water Systems

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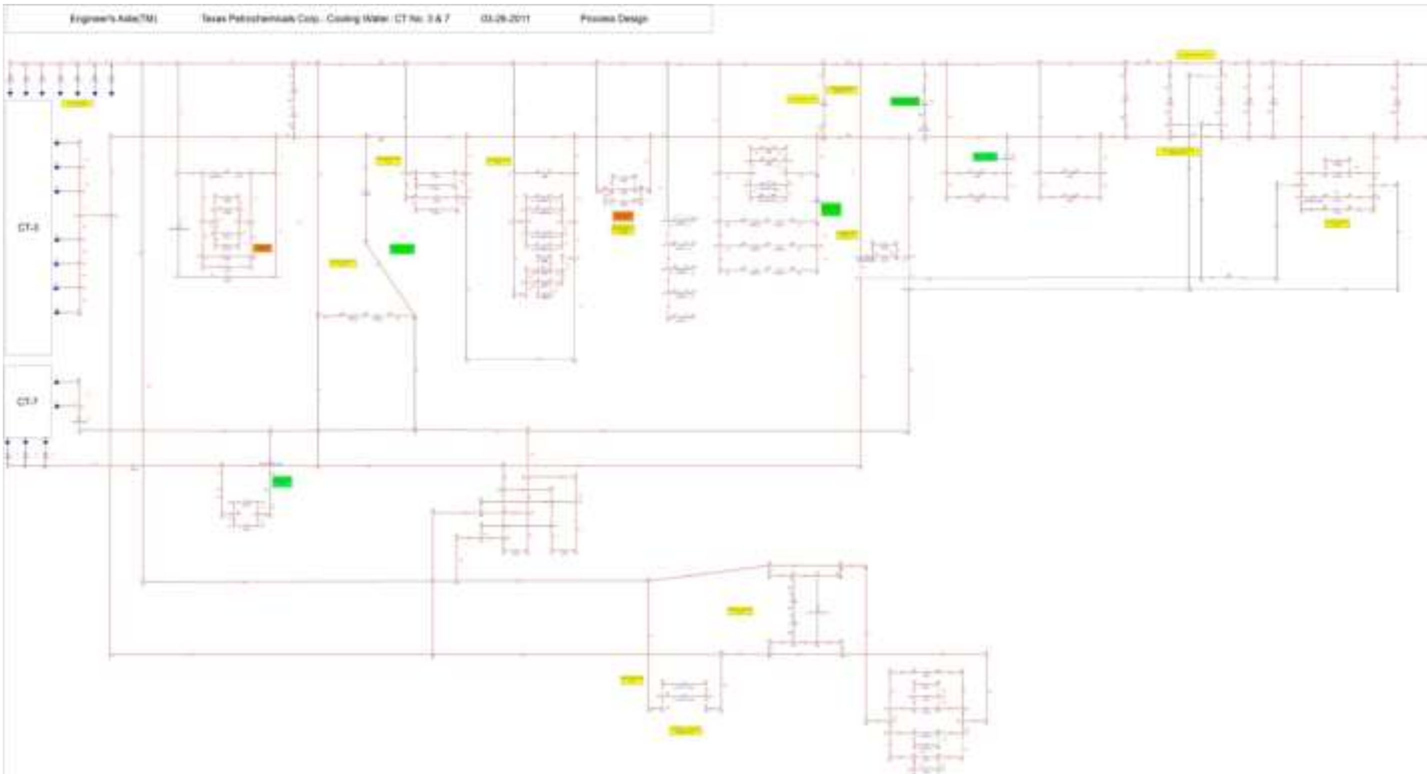

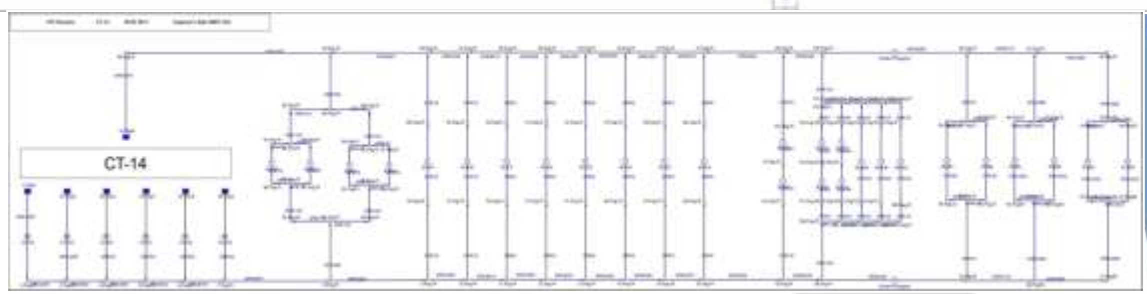

Clarified-Utility Water System

- A new clarified-utility water system was proposed to achieve the water savings and provide improved water quality for cooling water make-up
- Piping was routed to follow an existing underground HDPE firewater pipe now being installed around the facility
- Existing, clarified-utility water pumps were utilized to minimize capital costs
- Will allow for lowering flowrates to exchangers with the majority receiving 50-100% above their design flow to alleviate fouling from CIWA water used as cooling water make-up and avoid the major capital expense of a new cooling tower

Clarified-Utility Water System

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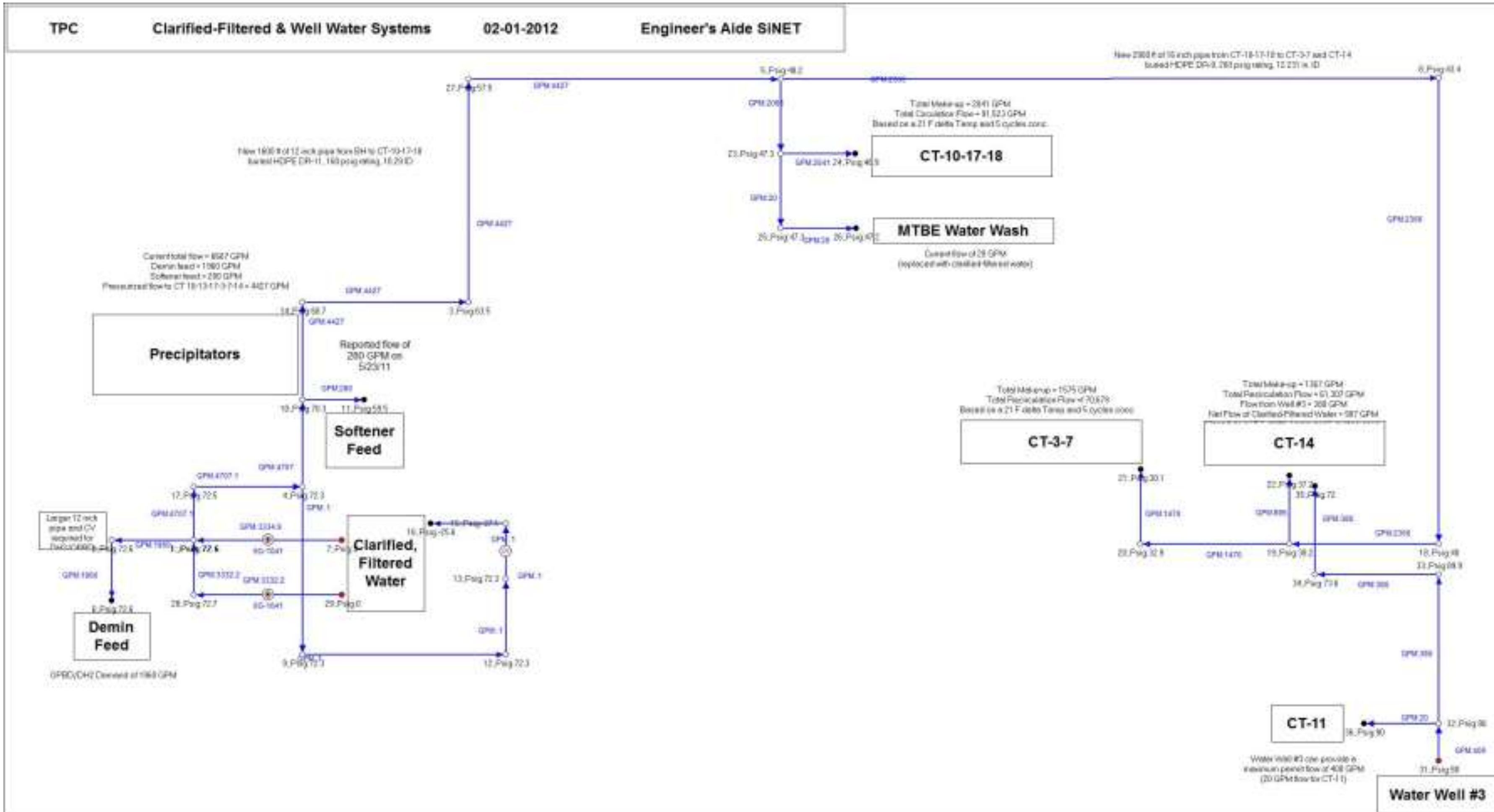

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Flow Simulation Benefits

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- Quantified steam/condensate leaks ($5MM+) for justification of repair
- Identified cooling water pump energy savings and capital cost avoidance savings to quickly justify and pay for the study
- Identified water savings to justify converting cooling water make-up from CIWA to clarified water
- Reduced exchanger fouling and improved process performance from use of clarified water as cooling tower make-up.
- Reduction in planned capital costs ($500,000 in earlier study and recently $10MM in avoidance of a new cooling tower)

Total Facility Energy Study

High Pressure Steam System

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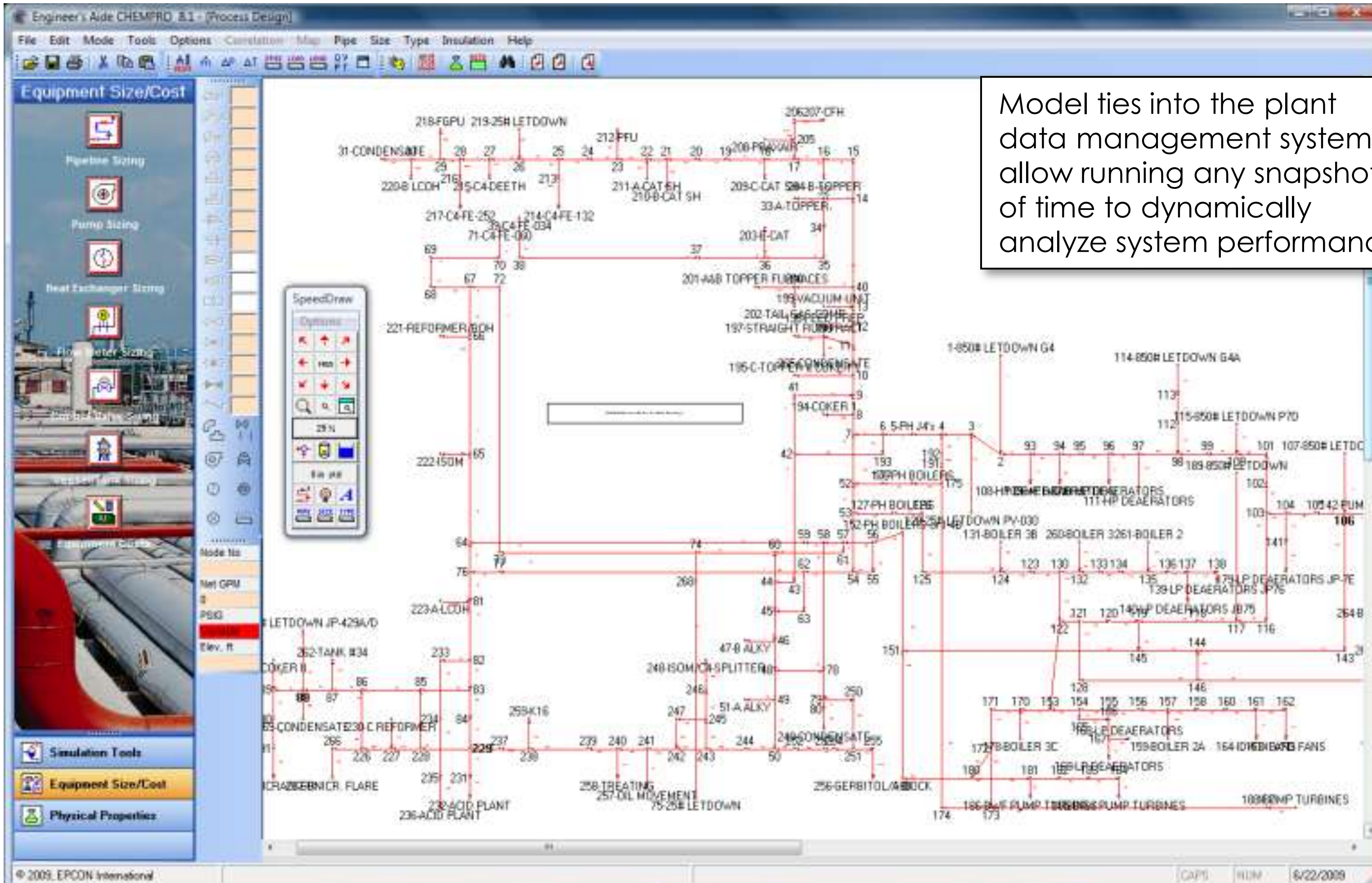

Model ties into the plant data management system to allow running any snapshot of time to dynamically analyze system performance

Total Facility Energy Study

Low Pressure Steam System

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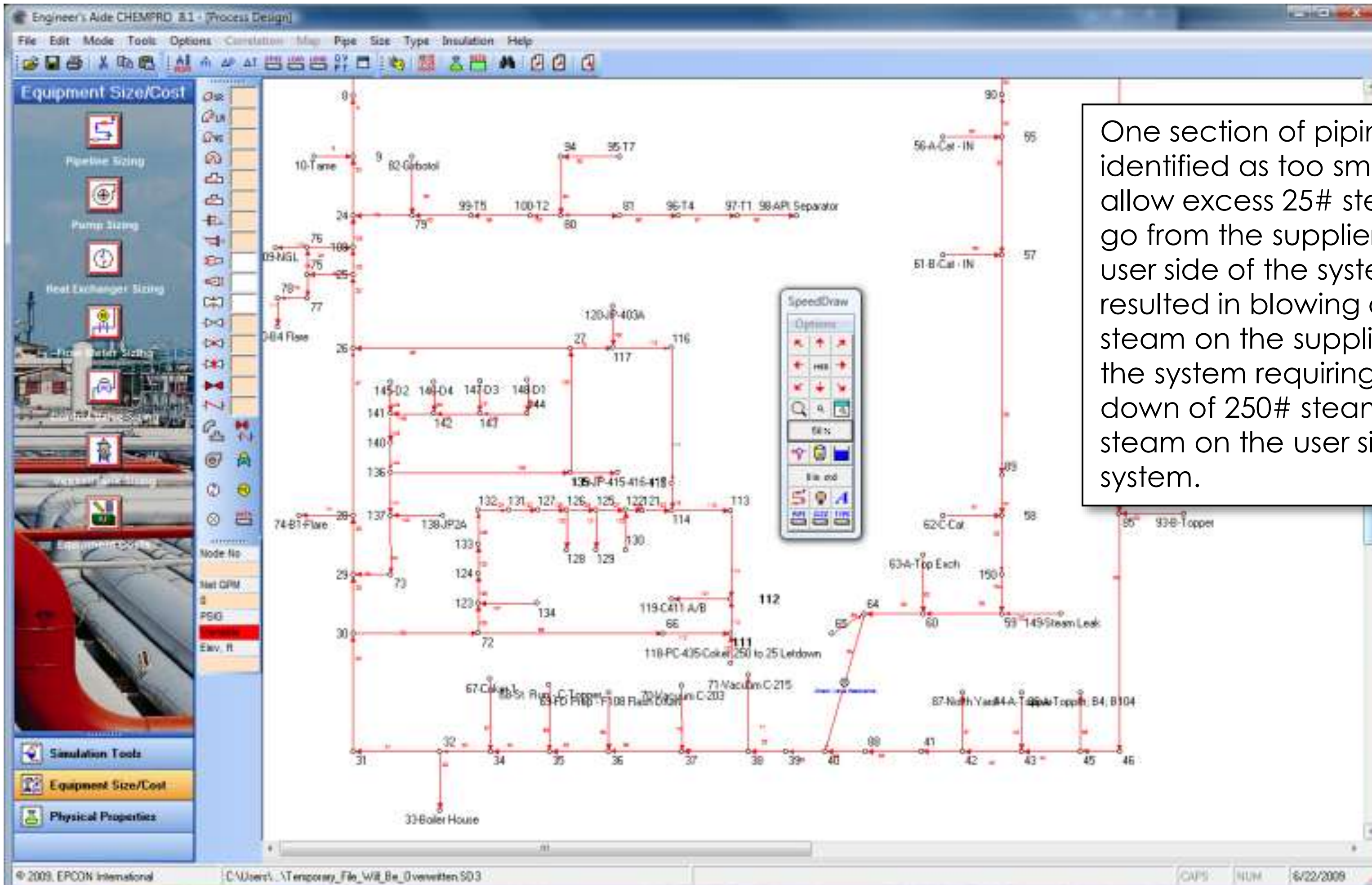

One section of piping was identified as too small to allow excess 25# steam to go from the supplier to the user side of the system. This resulted in blowing off of 25# steam on the supplier side of the system requiring letting down of 250# steam to 25# steam on the user side of the system.

Total Facility Energy Study
Compressed Air System

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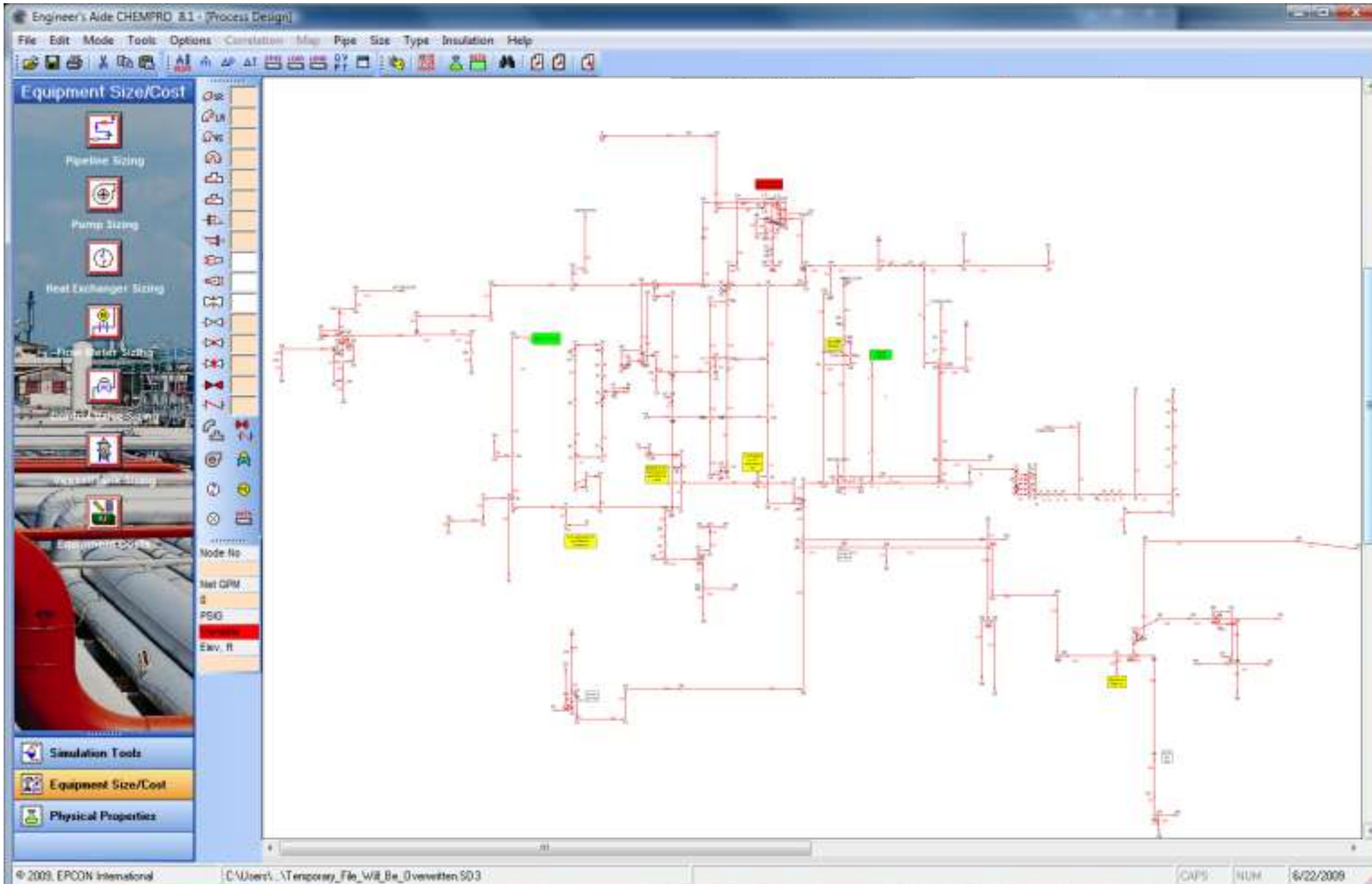

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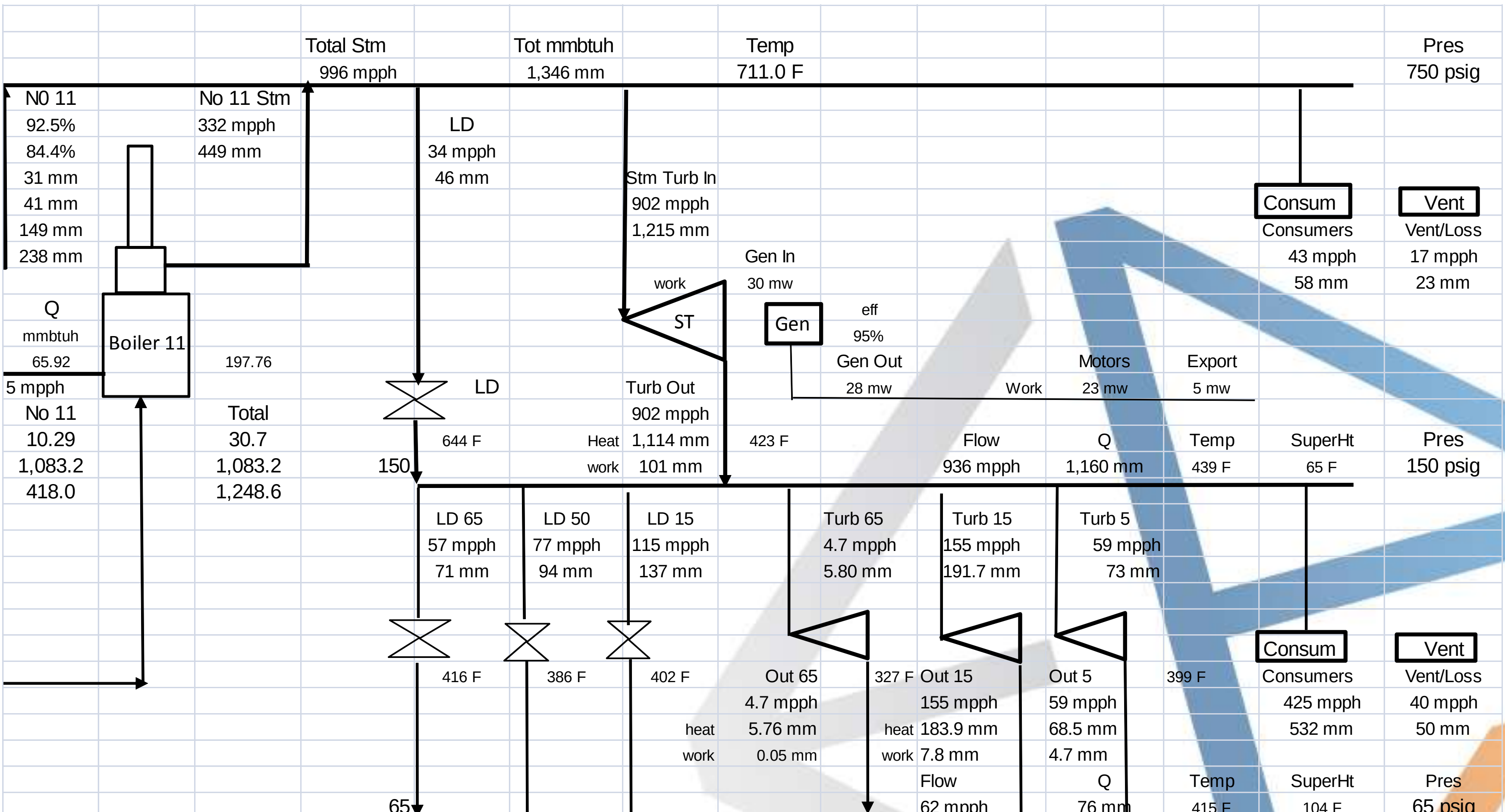
P			Energy Units		mmbtu/h	Turb	Turb	Turb	Turb	Turb			Total	Total					
Generation			**Steam Network Matrix**			LD	LD	LD	LD	LD	LD	**C**	**Heat**	**Work**	**Total**	**Total**	**Consumption**		
Boiler	**Process**	**Import**	**Pres**		**750**	**150**	**65**	**50**	**15**	**5**	**vent**	**Consum**	**Use**	**Use**	**Use**	**Prod**	**delta**		
1,341.9			**750**		1,341.9	1,114.3	0.0	0.0	0.0	0.0		57.9	1,241.0	101.0	1,342.0	1,341.9	-0.1		
					work	101.0	0.0	0.0	0.0	0.0			mmbtu/h	101.0					
			LD		LD	45.9	0.0	0.0	0.0	0.0	22.9		HP	39,698.3					
			150			0.0	5.8	0.0	183.9	68.5		532.2	1,142.3	12.5	1,154.8	1,160.1	5.3		
						work	0.0	0.0	7.8	4.7			mmbtu/h	12.5					
			LD			LD	70.7	94.5	137.2	0.0	49.6		HP	4,932.2					
			65				0.0	0.0	0.0	0.0		29.5	66.7	0.0	66.7	76.4	9.7		
							work	0.0	0.0	0.0			mmbtu/h	0.0					
			LD				LD	0.0	37.2	0.0			HP	0.0					
			50					0.0	0.0	0.0		89.0	108.7	0.0	108.7	94.5	-14.2		
								work	0.0	0.0			mmbtu/h	0.0					
			LD					LD	19.8	0.0		0	HP	0.0					
			15						0.0	0.0		347.5	397.8	0.0	397.8	378.1	-19.7		
									work	0.0			mmbtu/h	0.0					
			LD						LD	0	50.2	0	HP	0.0					
			5									69.5	69.5		69.5	68.5	-1.0		
			LD							LD									
			Total	mmbtu/h	1,341.9	1,160.1	76.4	94.5	378.1	68.5	122.7	1,125.6	2,956.5	113.6	3,070.0	3,119.6	-20.0		
			H	btu/lb	1,347.5	1,239.5	1,238.3	1,226.1	1,200.3	1,159.3		Total Wor	mmbtu/h	113.6					
				psia	764.7	164.7	79.7	64.7	29.7	19.7			HP	44,630.5					
				temp F	**711.0**	**438.9**	**414.6**	**386.2**	**322.2**	**233.9**		Consump	Heat	Work	Vent	Total Cons	Generation		
												Gross	1,125.6	113.6	122.7	1,361.9	1,341.9	-20.0	



Total Stm
996 mpph
Tot mmbtuh
1,346 mm
Temp
711.0 F
Pres
750 psig
N0 11
92.5%
84.4%
31 mm
41 mm
149 mm
238 mm
No 11 Stm
332 mpph
449 mm
LD
34 mpph
46 mm
Stm Turb In
902 mpph
1,215 mm
Consum
Consumers
43 mpph
58 mm
Vent
Vent/Loss
17 mpph
23 mm
Gen In
30 mw
work
ST
Gen
eff
95%
Q
mmbtuh
65.92
Boiler 11
197.76
5 mpph
Gen Out
28 mw
Work
Motors
23 mw
Export
5 mw
LD
Turb Out
902 mpph
Heat
1,114 mm
work
101 mm
No 11
10.29
1,083.2
418.0
Total
30.7
1,083.2
1,248.6
644 F
150
423 F
Flow
936 mpph
Q
1,160 mm
Temp
439 F
SuperHt
65 F
Pres
150 psig
LD 65
57 mpph
71 mm
LD 50
77 mpph
94 mm
LD 15
115 mpph
137 mm
Turb 65
4.7 mpph
5.80 mm
Turb 15
155 mpph
191.7 mm
Turb 5
59 mpph
73 mm
416 F
386 F
402 F
Out 65
4.7 mpph
heat
5.76 mm
work
0.05 mm
327 F
Out 15
155 mpph
heat
183.9 mm
work
7.8 mm
Out 5
59 mpph
68.5 mm
4.7 mm
399 F
Consum
Consumers
425 mpph
532 mm
Vent
Vent/Loss
40 mpph
50 mm
65
Flow
62 mpph
Q
76 mm
Temp
415 F
SuperHt
104 F
Pres
65 psig

Total Facility Water Study

Boiler Feed Water System

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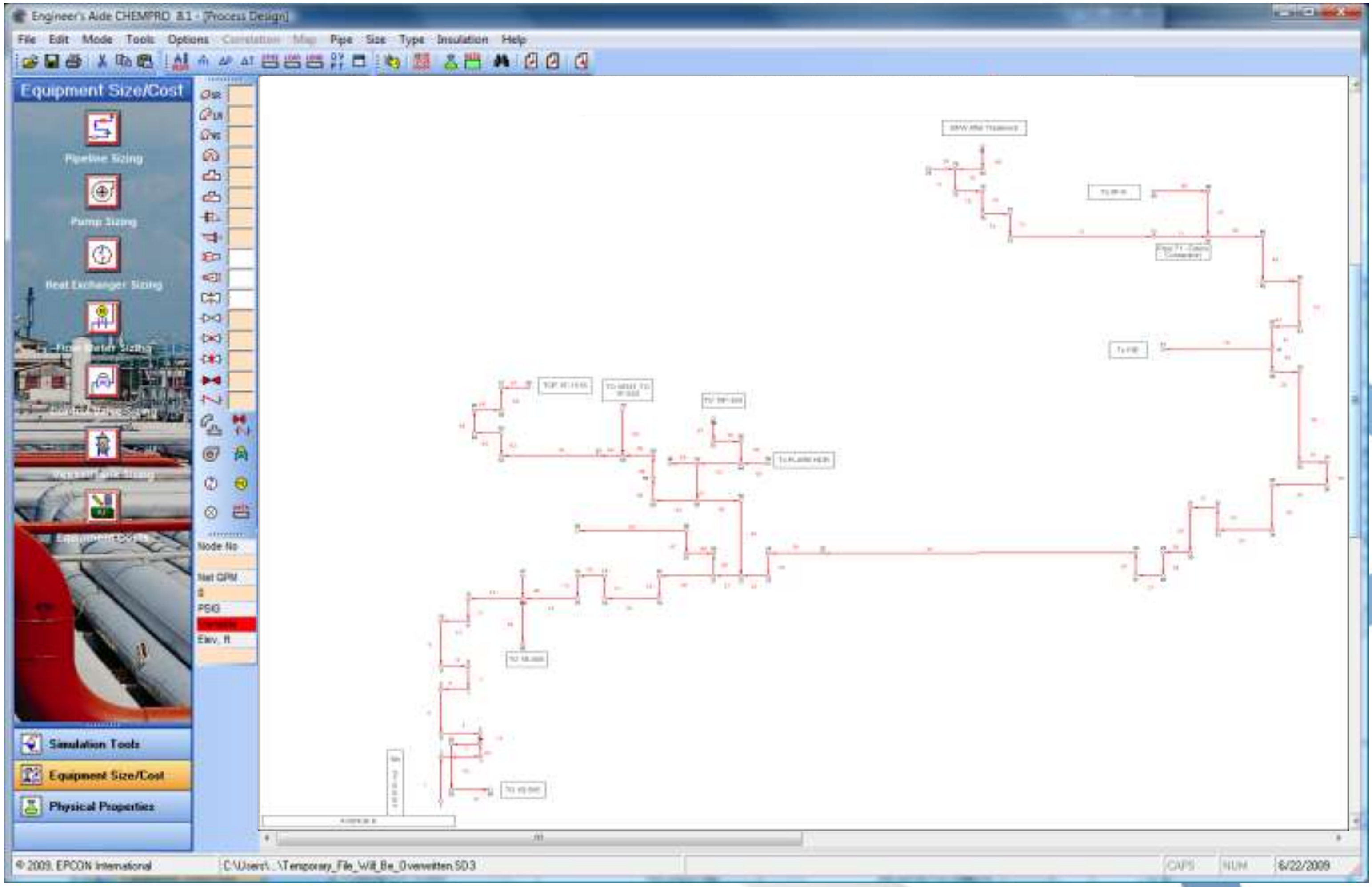

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Total Facility Water Study

Condensate System

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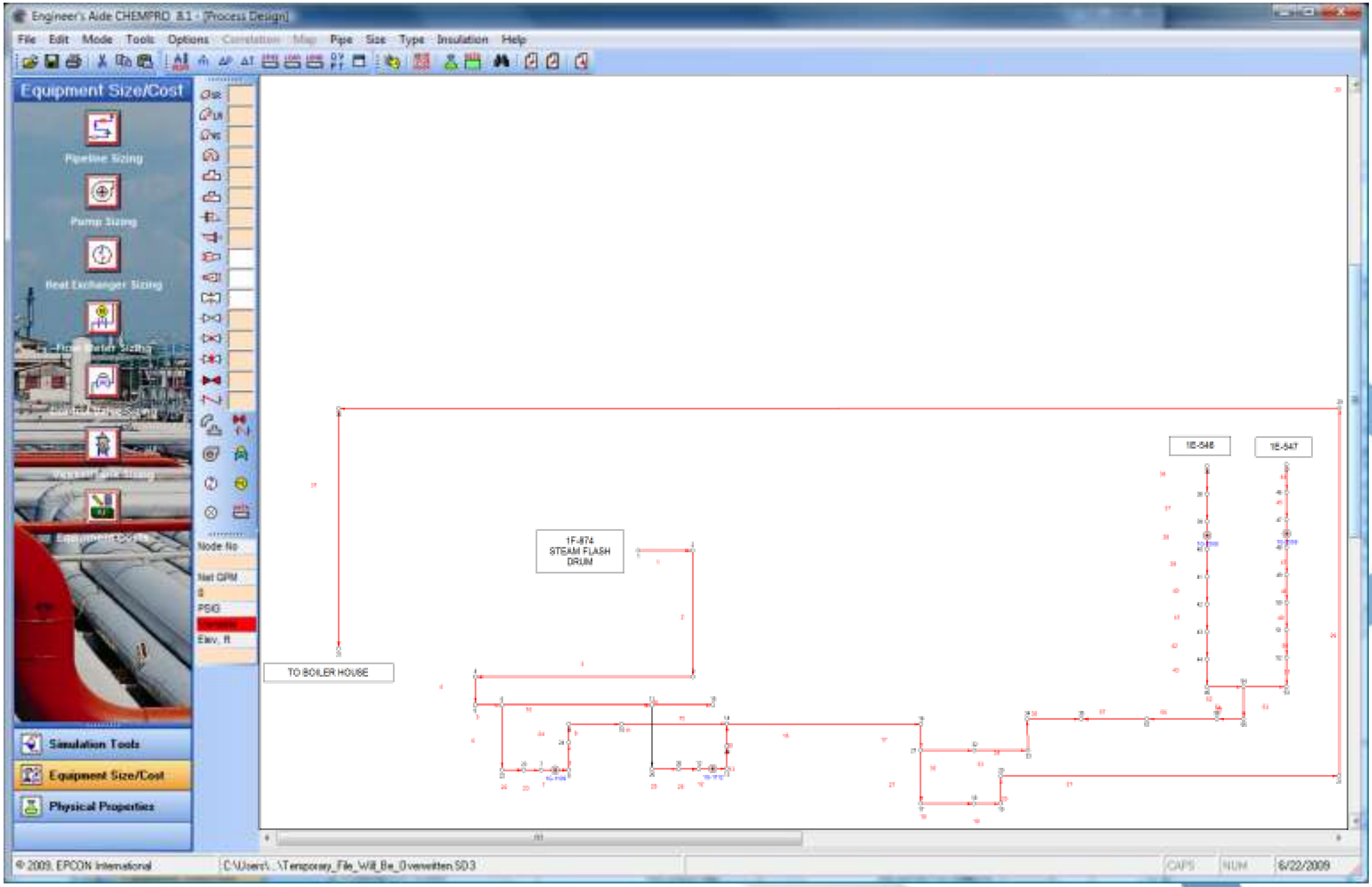

Total Facility Safety Study

Flare System

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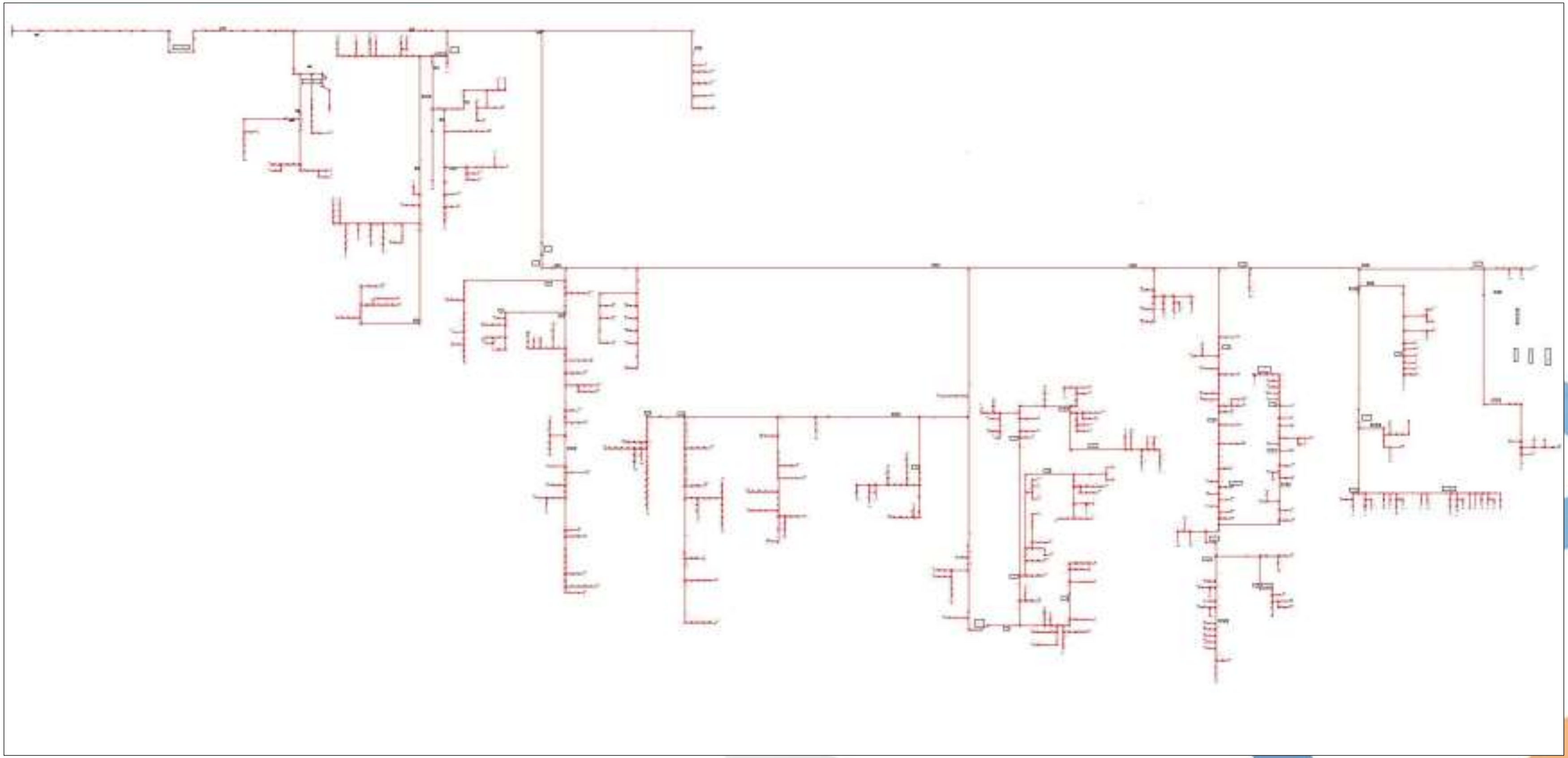

Total Facility Safety Study

Fire Water System

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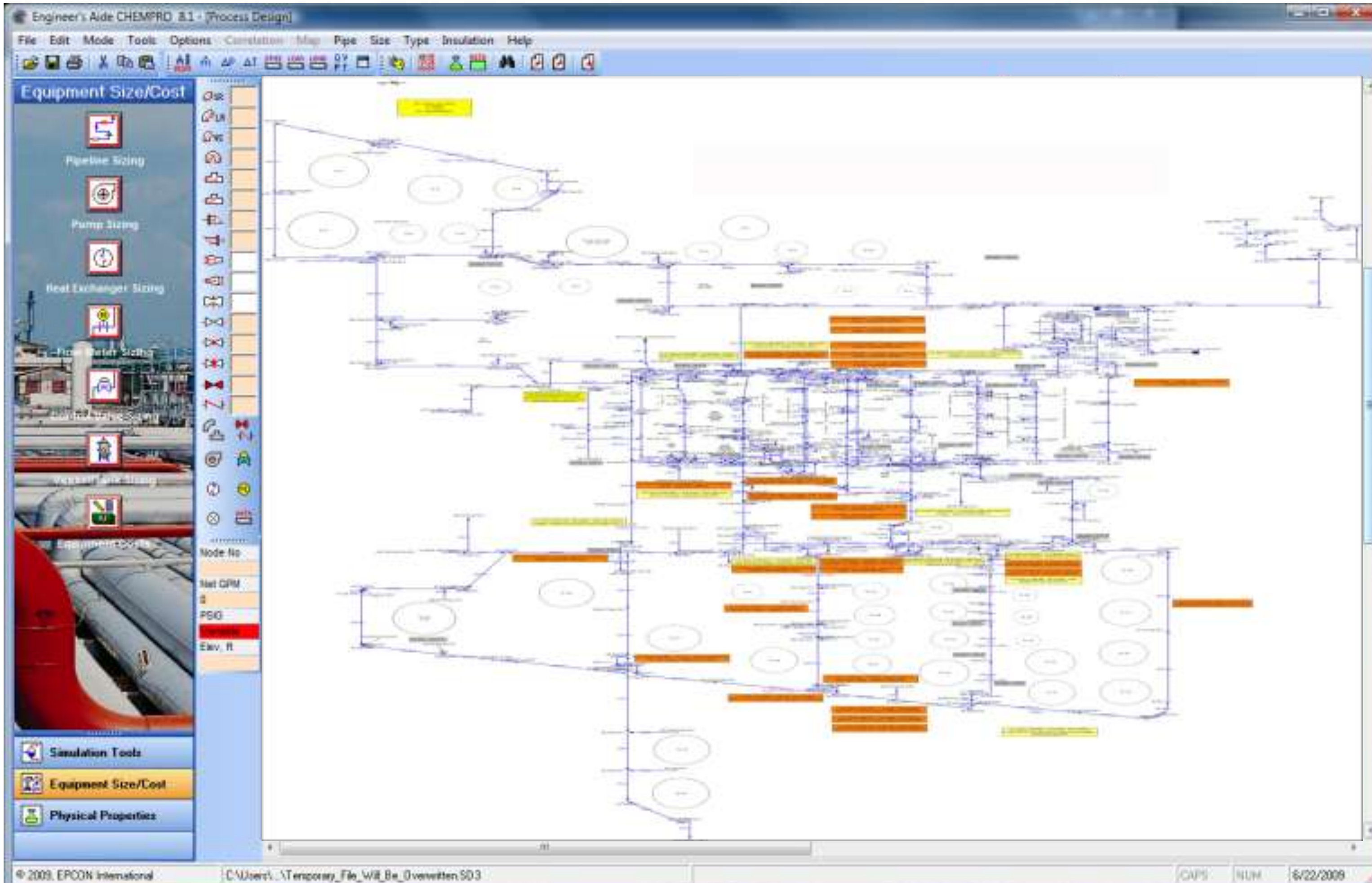

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