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A River of Energy Solutions

Steam Systems 101

Jeff Reed – Spirax Sarco

Department of Energy Perspective

Approximately two-thirds of all fuel burned by U.S. Industrial Plants is used to raise steam.

The Alliance to Save Energy estimates that each year U.S. Manufacturers:

- Consume about 9.34 Quadrillion BTU's of energy to produce steam
- Spend approximately $36 billion for fuel to generate steam
- Release more than 10 percent of the total U.S. Industrial emissions, such as NOx and CO2. - Of the 54,000 "Industrial" classified steam boilers in the United States, approximately 196 million metric tons of carbon dioxide is released to the atmosphere.
- Total demand for steam is projected to increase 20% in five major industries by 2015, with demand in food processing and chemicals being even greater.

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Steam Energy Efficiencies

Department of Energy/Office of Industrial Technologies Best Practice Brief History

In 1995 the USDOE created a “Steam Challenge” Program outlining steam efficiency opportunities including;

- Boilers and Controls
- Steam Traps and Condensate Recovery
- Water Treatment
- Flash Heat Recovery
- Combustion and Emissions Monitoring
- Insulation

Department of Energy Potential Definition

The energy efficiency potential is defined as: T*he total of all cost effective efficiency opportunities in steam generation, distribution, and application, as well as in steam system operation and maintenance.*

The DOE estimates that 30-40% savings potential can be realized. If all U.S. manufacturers improved the efficiency of their steam systems by even 20% they would save approximately 2.8 quadrillion BTU's annually ($9.3 Billion)

Steam System Efficiency Potential

Boilers

Boiler Tune-Ups =	1-2%
Heat Recovery Equipment =	2-4%
Emissions Monitoring & Control =	1-2%

System Operation and Maintenance

Water Treatment =	10-12%
Load Control =	3-5%

Distribution System

Steam Leaks and Traps =	3-5%
Condensate Return =	10-15%
Insulation =	5-10%

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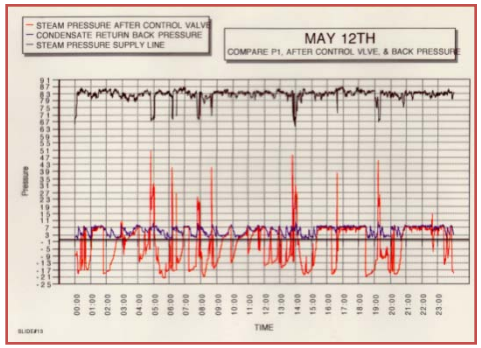
The Low Hanging Fruit

- Steam Traps
- Condensate Return
- Insulation
- Flash Recovery
- Closed-Loop Systems

According to The U.S. Department Of Energy, The Customers Want….

- Proper condensate recovery from all possible steam using processes.
- Stable, repeatable and measureable steam process conditions.
- Reduced maintenance costs of mechanical equipment
- “Flash” and “Condensate Heat Energy” recovery from all possible locations



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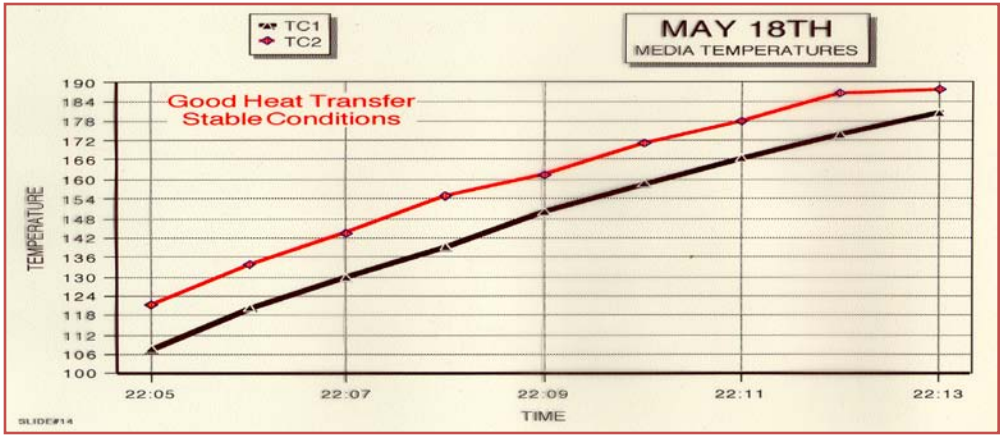
Other notable "Wants"…

- Improved product quality and reduced product spoilage.
- Reduced fuel costs for heating make-up feed water.
- Reduced chemical treatment, water and sewage disposal costs.
- Improved boiler output in lbs./hr.



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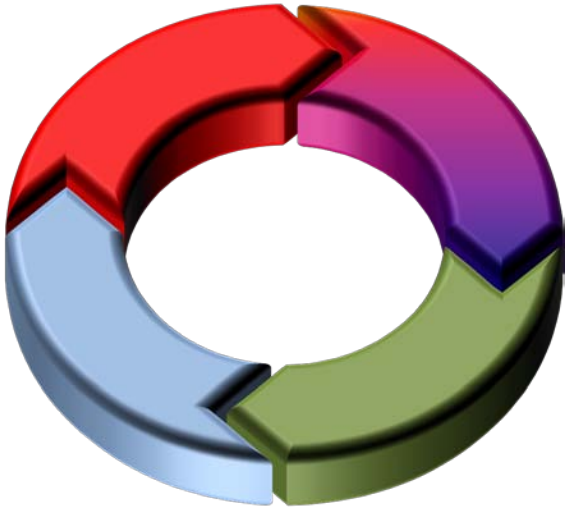
Top Customer “Setbacks”

- Pressure Temperature Relationship
- Effect of Air
- The Economic Impact of Wet Steam
- Condensate Return (“Lift Traps”)
- Specific Volume and Velocity
- Heat Transfer

Let's Get Started

Breaking the Steam System Down Into (4) Parts;

- **Steam Generation**
- **Steam Distribution**
- **Steam and Hot Water Utilization**
- **Condensate Recovery**



Points of Reference

- Pressure/Temperature Relationship
- 1psig = 2.31’ Lift
- Latent heat
- Effects of Air
- Specific Volume
- 70-90 mph Target Velocity
- Fouling Factors

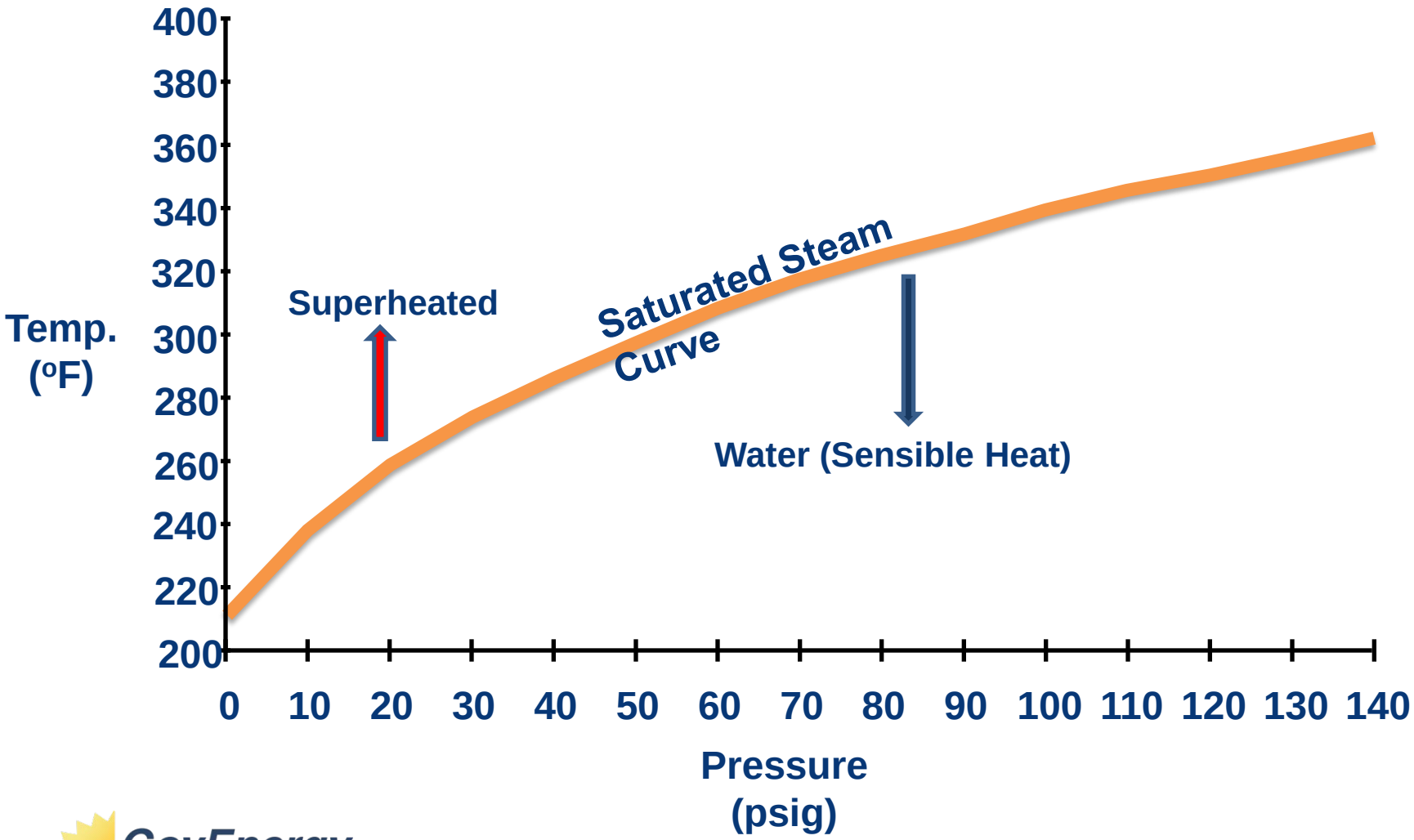
Effects of Wet Steam

- Reduced Enthalpy (energy) due to water particles in suspension.
- Water film will deter heat transfer (equivalent to 60 - 70 times the thickness of iron or steel).
- Water may carry impurities which will promote scale formation again deterring heat transfer.
- Suspended droplets will erode and corrode valves and valve seats and shorten the life of pipeline and fittings due to high velocity.
- May cause water hammer condition damaging system equipment.
- In some processes, product quality will be effected.

What is Steam?

Gauge pressure (psi)	Temp. (ºF)	ENTHALPY (BTU / lb)			Specific Volume. (ft^3 / lb)
		Sensible Heat of Water (h_f)	Latent Heat of evap. (h_g)	Total (h_{fg})	
0	212	180	970	1150	26.8
5	227	195	960	1155	20.1
15	250	218	945	1163	13.8
25	266	234	933	1167	10.5
50	298	267	912	1179	6.68
75	320	290	895	1185	4.91
100	338	309	880	1189	3.89
125	353	325	868	1193	3.23

Temperature-Pressure Diagram



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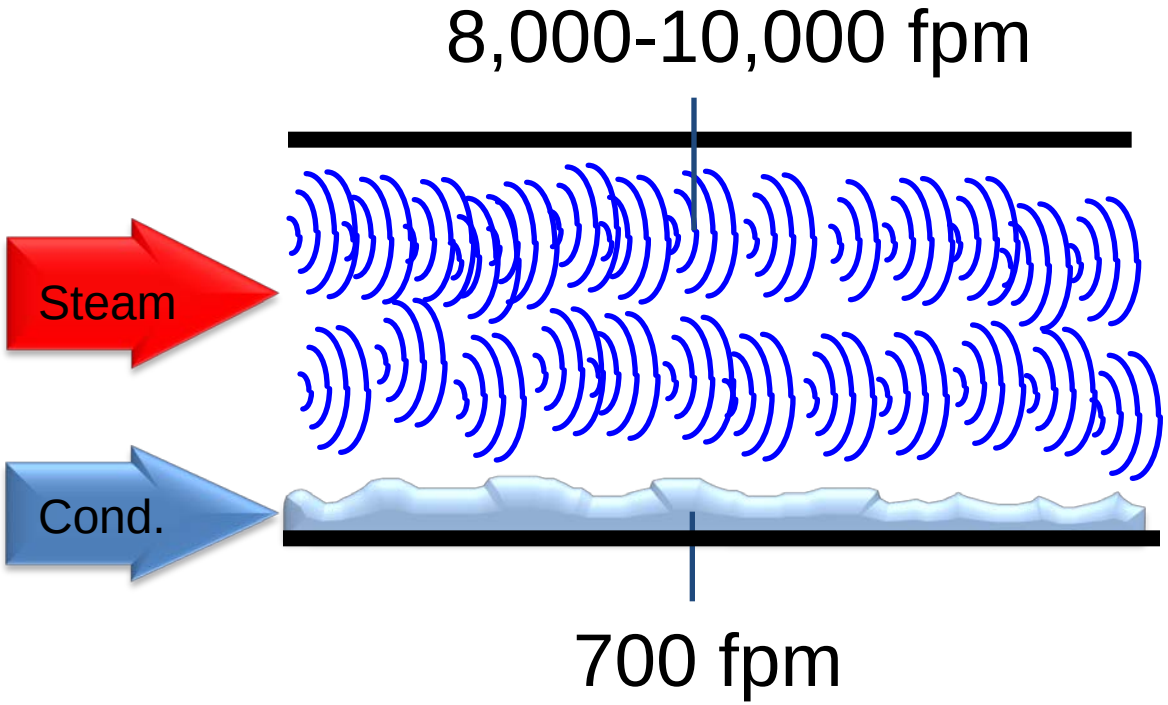
Back To Its Natural State



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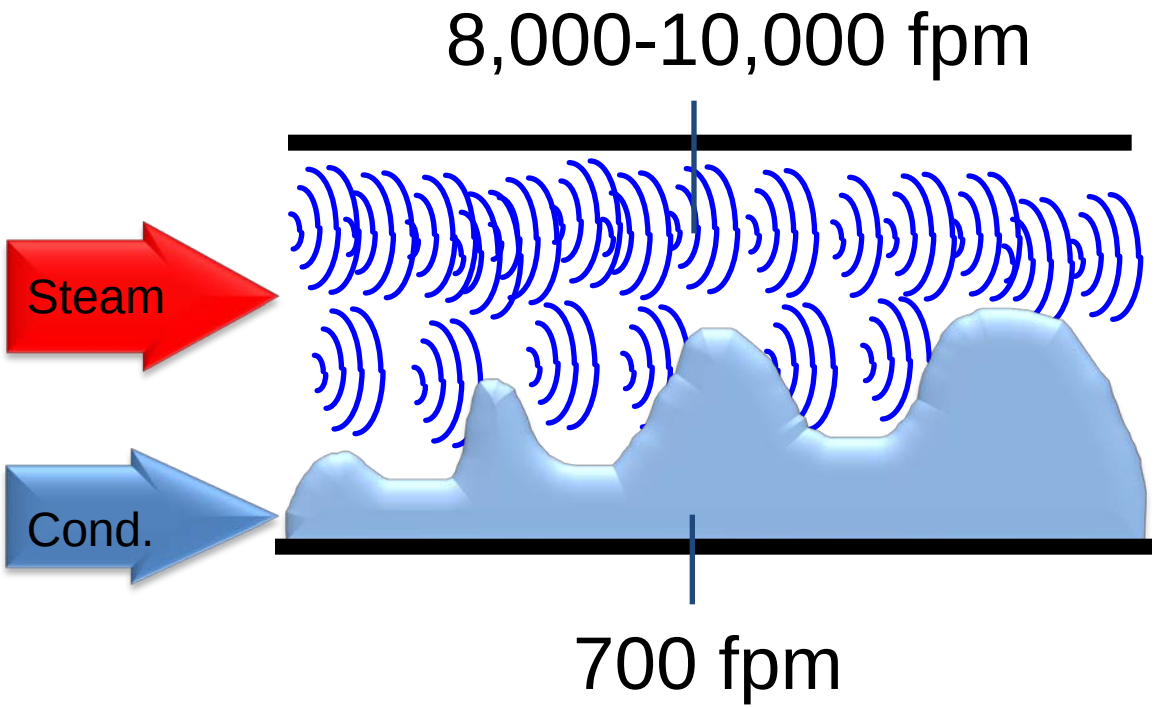
DISTRIBUTION LINES



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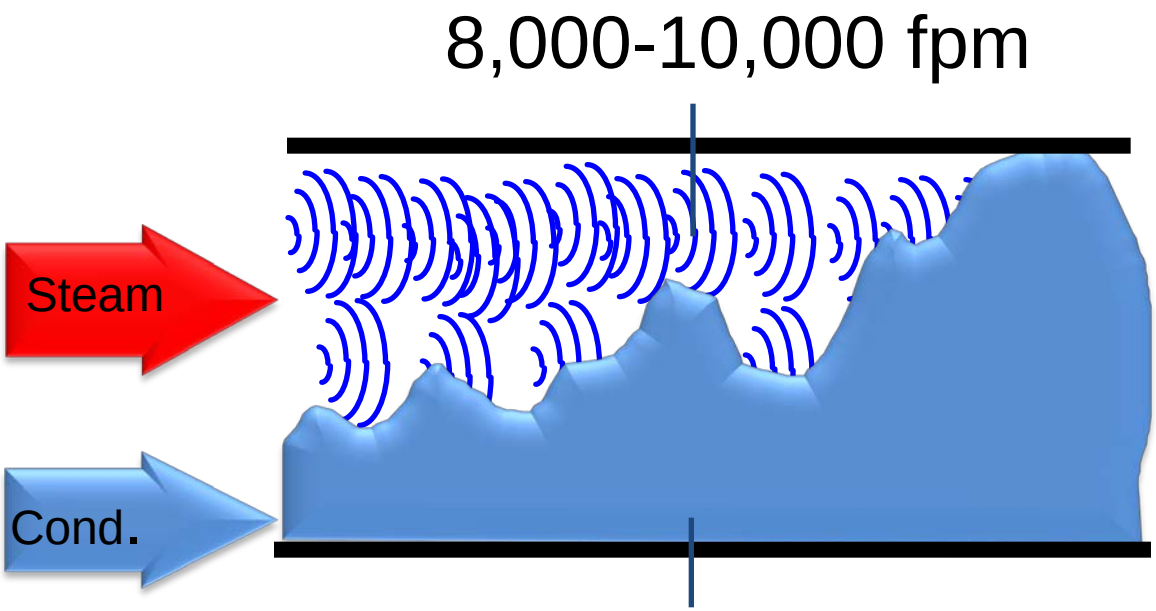
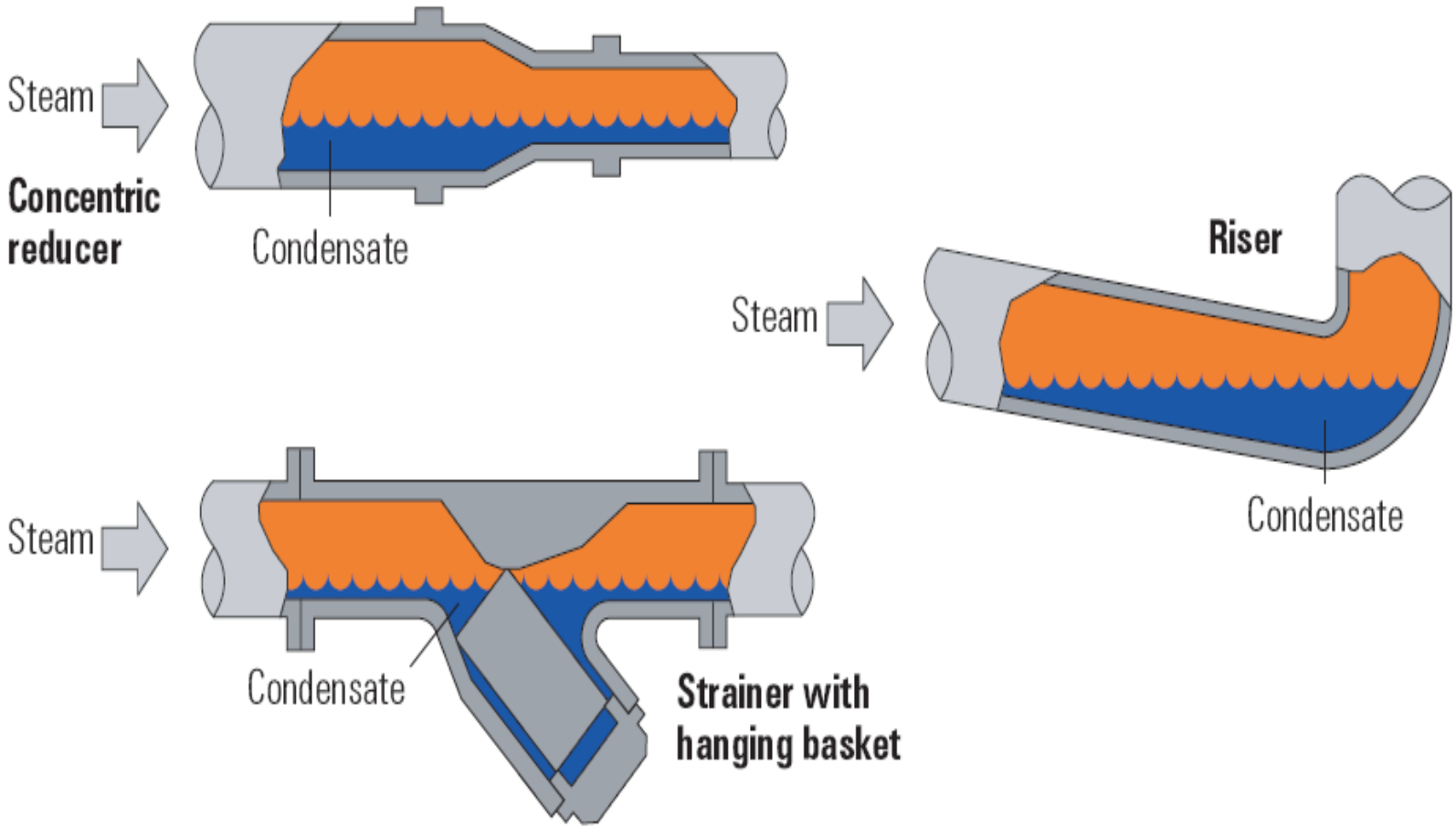


Sources of Waterhammer



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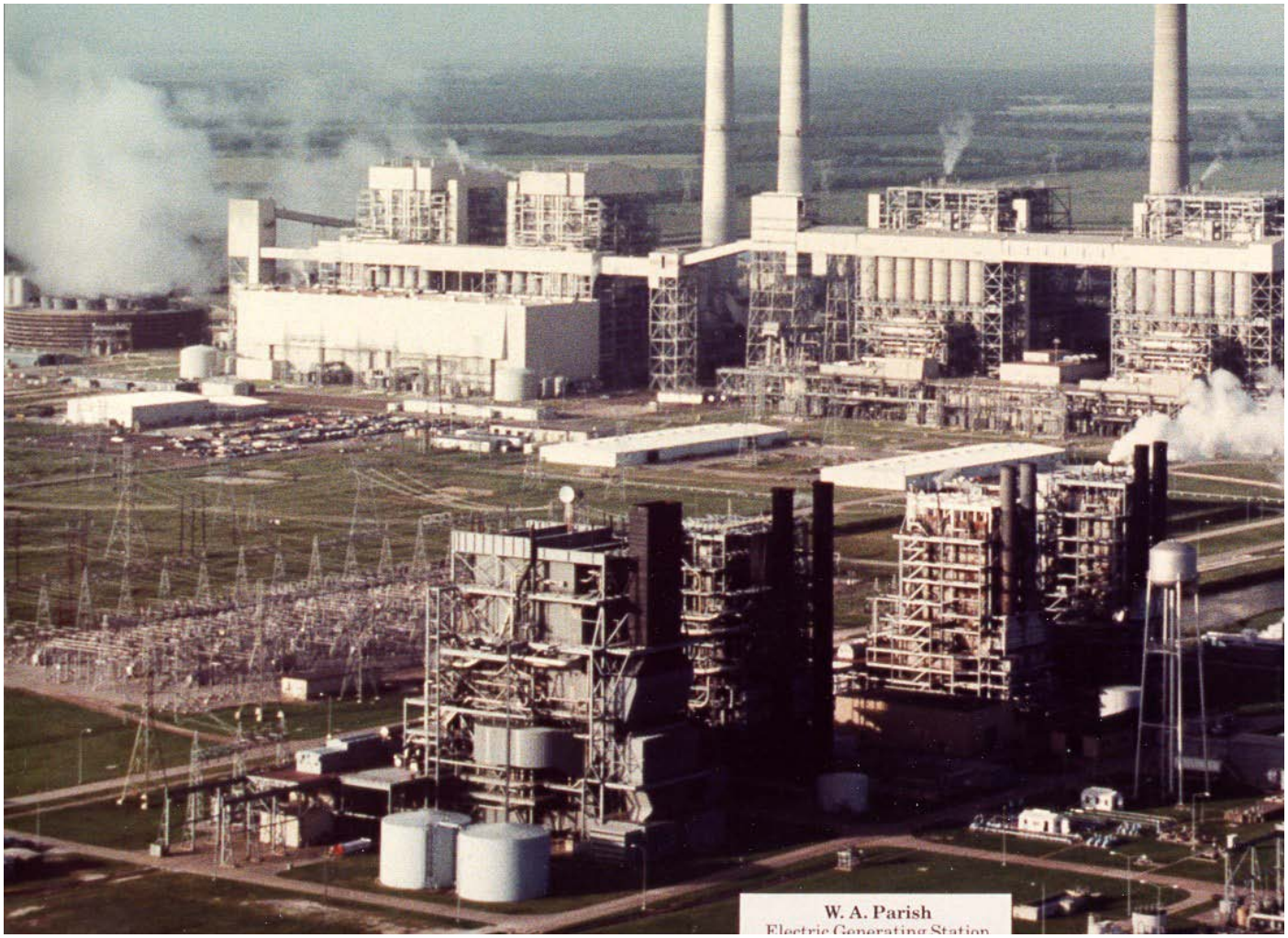
OR……



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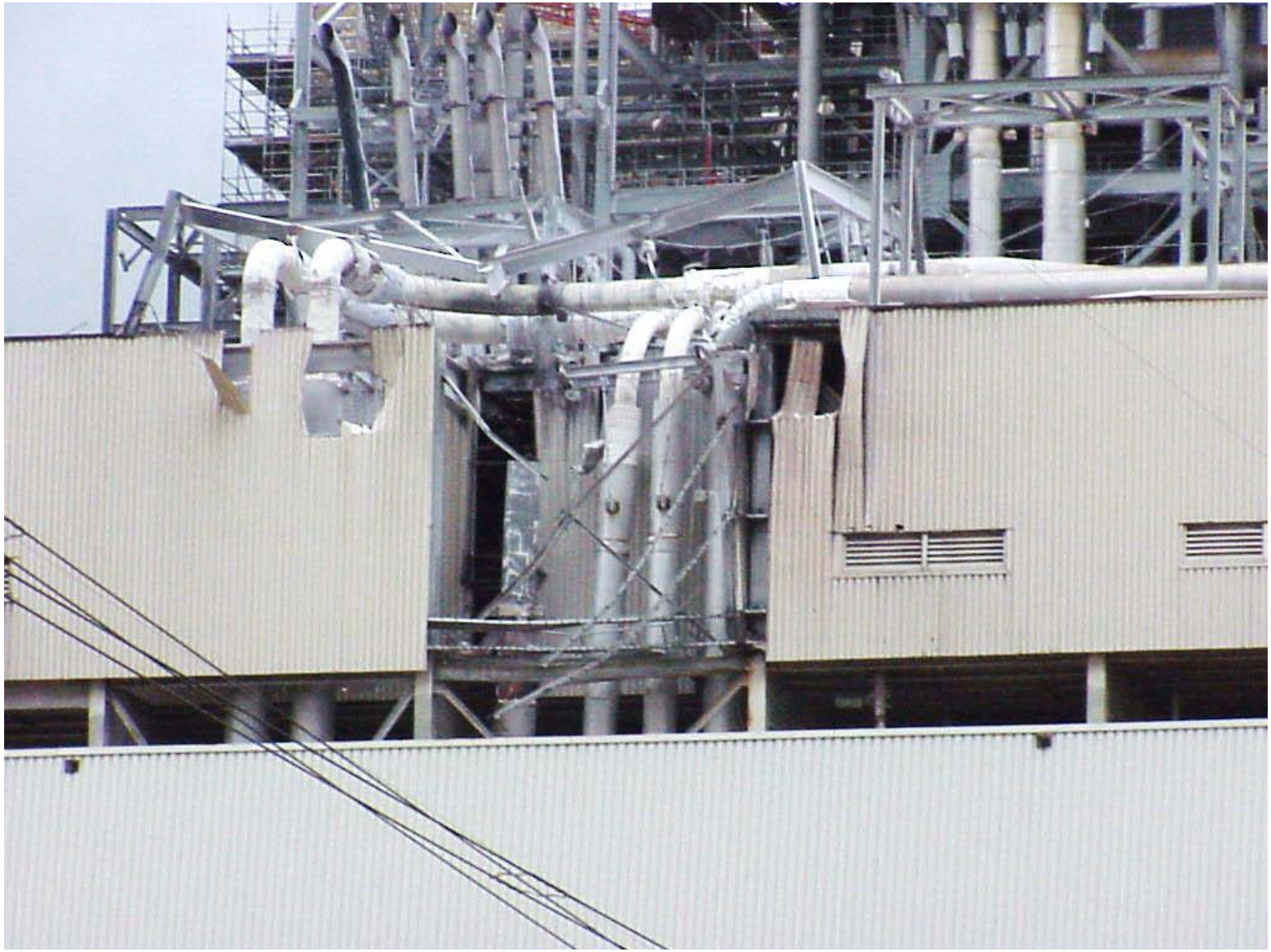
125 psig Saturated Steam Piping



12” Pipe

Piece of pipe traveled over Admin. Building an estimated 400 + yards, before hitting and bringing down two (2) 345 kV transmission lines and falling into this truck in parking lot.

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CHEVROLET

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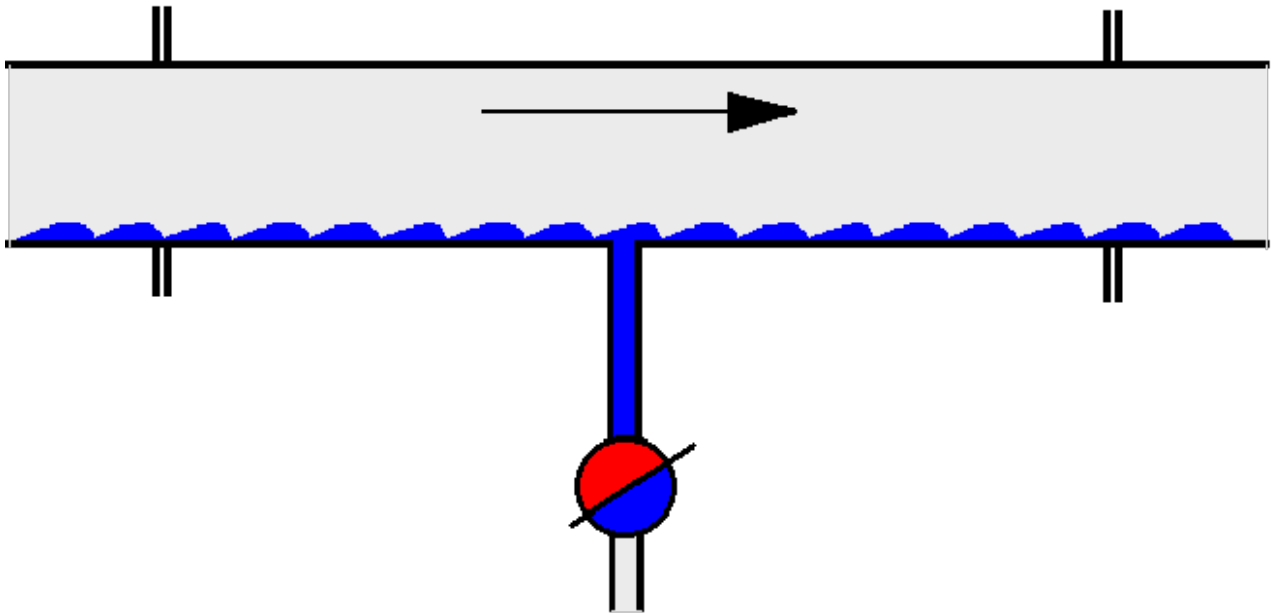
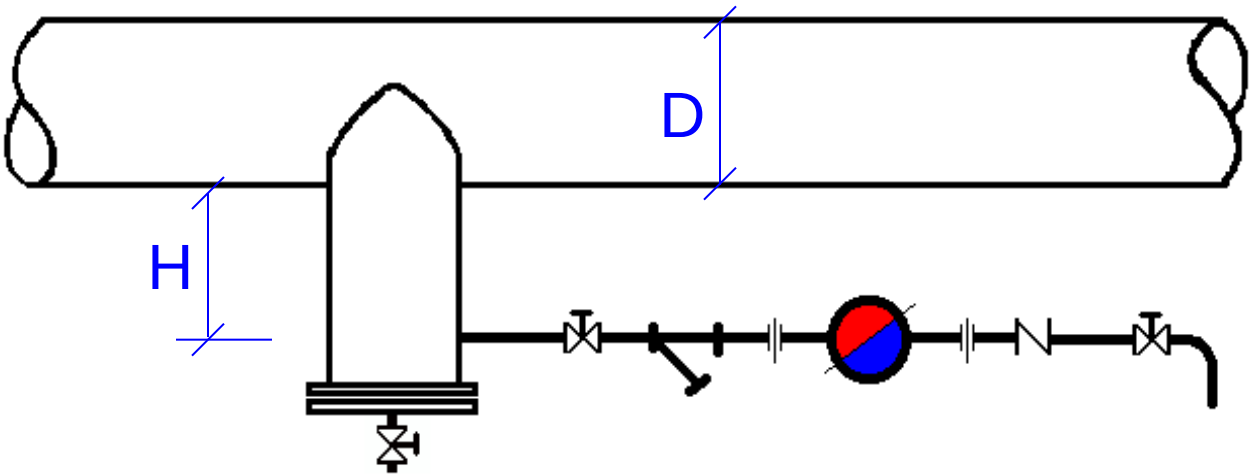
Incorrect Steam Main Drainage



Steam Main Drip Leg Sizing



Length of Collection Leg ‘H’
Automatic Start up: 28” or More
Supervised Start up: 1-1/2 times Main Diameter (min. 8”)

Main Diam. ‘D’	Collection Leg Diameter
1/2” to 4”	Same diameter as main ‘D’
5” & larger	2 to 3 Pipe Sizes Smaller than Main, (But Never Smaller than 4”)

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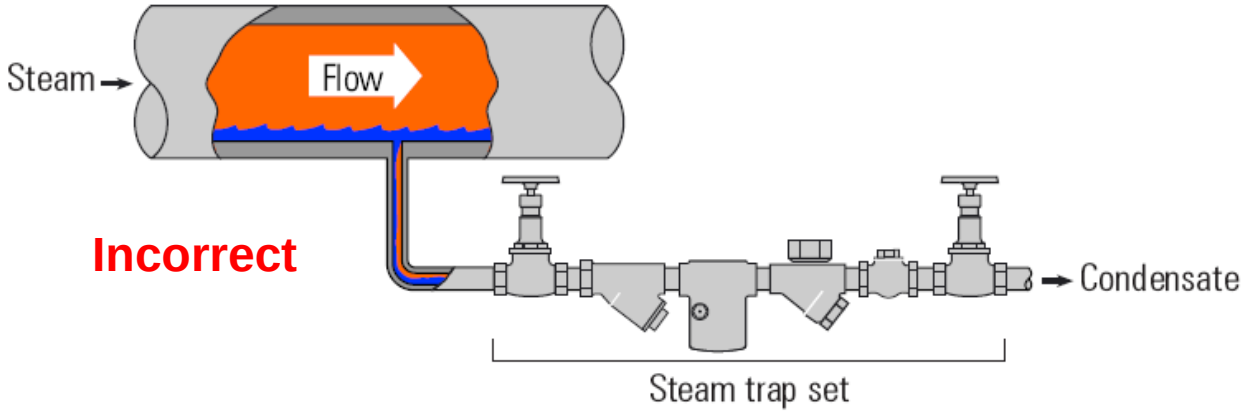
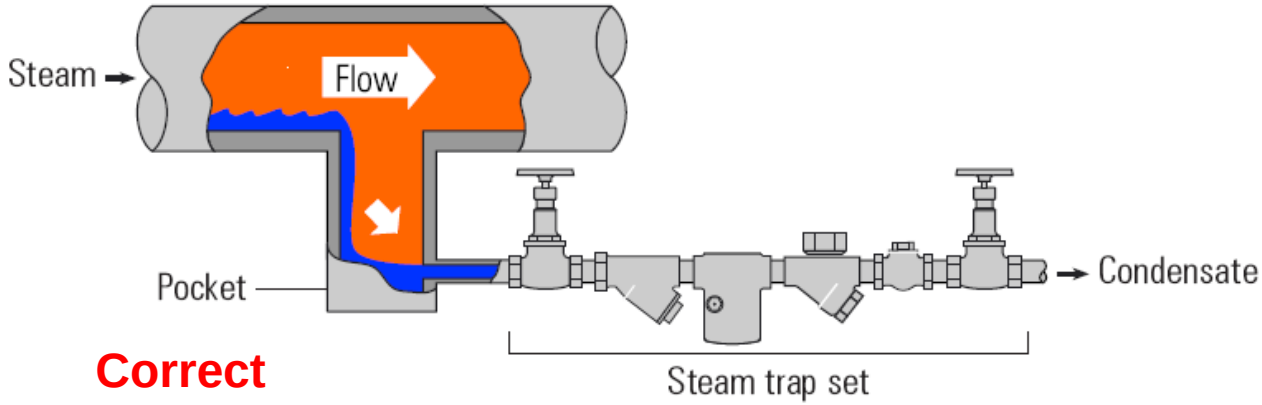
How Do We Get Rid of The Condensate?





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How Large Should My Drip Traps Be?

SYSTEM DESIGN

Table 4: Warm-Up Load in Pounds of Steam per 100 Ft of Steam Main

Ambient Temperature 70°F. Based on Sch. 40 pipe to 250 psi, Sch. 80 above 250 except Sch. 120 5" and larger above 800 psi

Steam Pressure psi	Main Size 2"	2½"	3"	4"	5"	6"	8"	10"	12"	14"	16"	18"	20"	24"	0°F Correction Factor†
0	6•2	9•7	12•8	18•2	24•6	31•9	48	68	90	107	140	176	207	308	1•50
5	6•9	11•0	14•4	20•4	27•7	35•9	48	77	101	120	157	198	233	324	1•44
10	7•5	11•8	15•5	22•0	29•9	38•8	58	83	109	130	169	213	251	350	1•41
20	8•4	13•4	17•5	24•9	33•8	44	66	93	124	146	191	241	284	396	1•37
40	9•9	15•8	20•6	90•3	39•7	52	78	110	145	172	225	284	334	465	1•32
60	11•0	17•5	22•9	32•6	44	57	86	122	162	192	250	316	372	518	1•29
80	12•0	19•0	24•9	35•3	48	62	93	132	175	208	271	342	403	561	1•27
100	12•8	20•3	26•6	37•8	51	67	100	142	188	222	290	366	431	600	1•26
125	~~18•7~~	~~21•7~~	~~28•4~~	40	55	71	107	152	200	238	310	391	461	642	1•25
150	14•5	23•0	30•0	43	58	75	113	160	212	251	328	414	487	679	1•24
175	15•3	24•2	31•7	45	61	79	119	169	224	265	347	437	514	716	1•23
200	16•0	25•3	33•1	47	64	83	125	177	234	277	362	456	537	748	1•22
250	17•2	27•3	35•8	51	69	89	134	191	252	299	390	492	579	807	1•21
300	25•0	38•3	51	75	104	143	217	322	443	531	682	854	1045	1182	1•20
400	27•8	43	57	83	116	159	241	358	493	590	759	971	1163	1650	1•18

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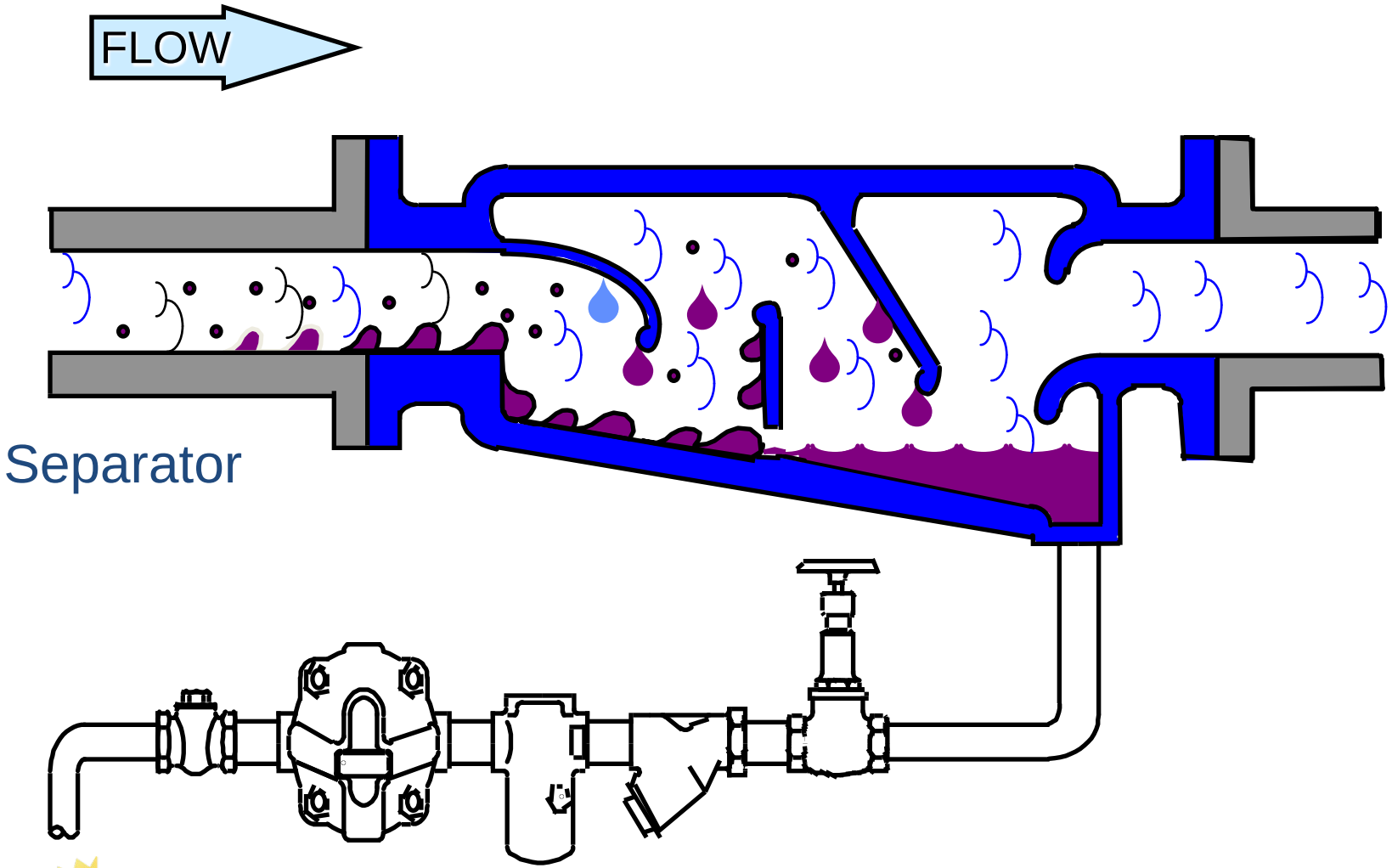
Table 5: Running Load in Pounds per Hour per 100 Ft of Insulated Steam Main

Ambient Temperature 70°F. Insulation 80% efficient. Load due to radiation and convection for saturated steam.

Steam Pressure psi	Main Size 2"	2½"	3"	4"	5"	6"	8"	10"	12"	14"	16"	18"	20"	24"	0°F Correction Factor†
10	6	7	9	11	13	16	20	24	29	32	36	39	44	53	1•58
30	8	9	11	14	17	20	26	32	38	42	48	51	57	68	1•50
60	10	12	14	18	24	27	33	41	49	54	62	67	74	89	1•45
100	12	15	18	22	28	33	41	51	61	67	77	83	93	111	1•41
125	[redacted]	[redacted]	[redacted]	24	30	36	45	56	66	73	84	90	101	121	1•39
175	16	19	23	26	33	38	53	66	78	86	98	107	119	142	1•38
250	18	22	27	34	42	50	62	77	92	101	116	126	140	168	1•36
300	20	25	30	37	46	54	68	85	101	111	126	138	154	184	1•35
400	23	28	34	43	53	63	80	99	118	130	148	162	180	216	1•33

Steam Separator



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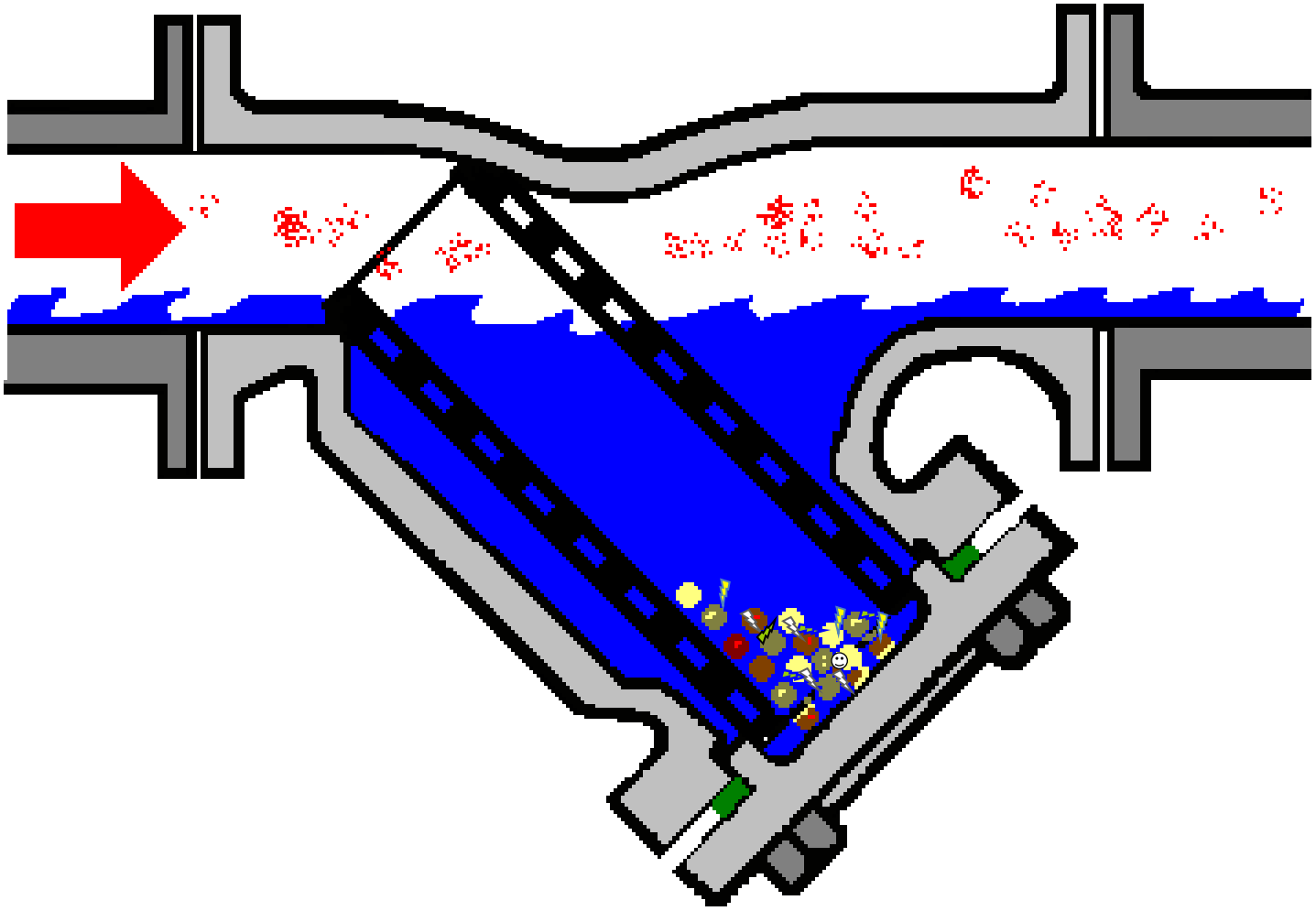
Wye Strainers…What's the use?



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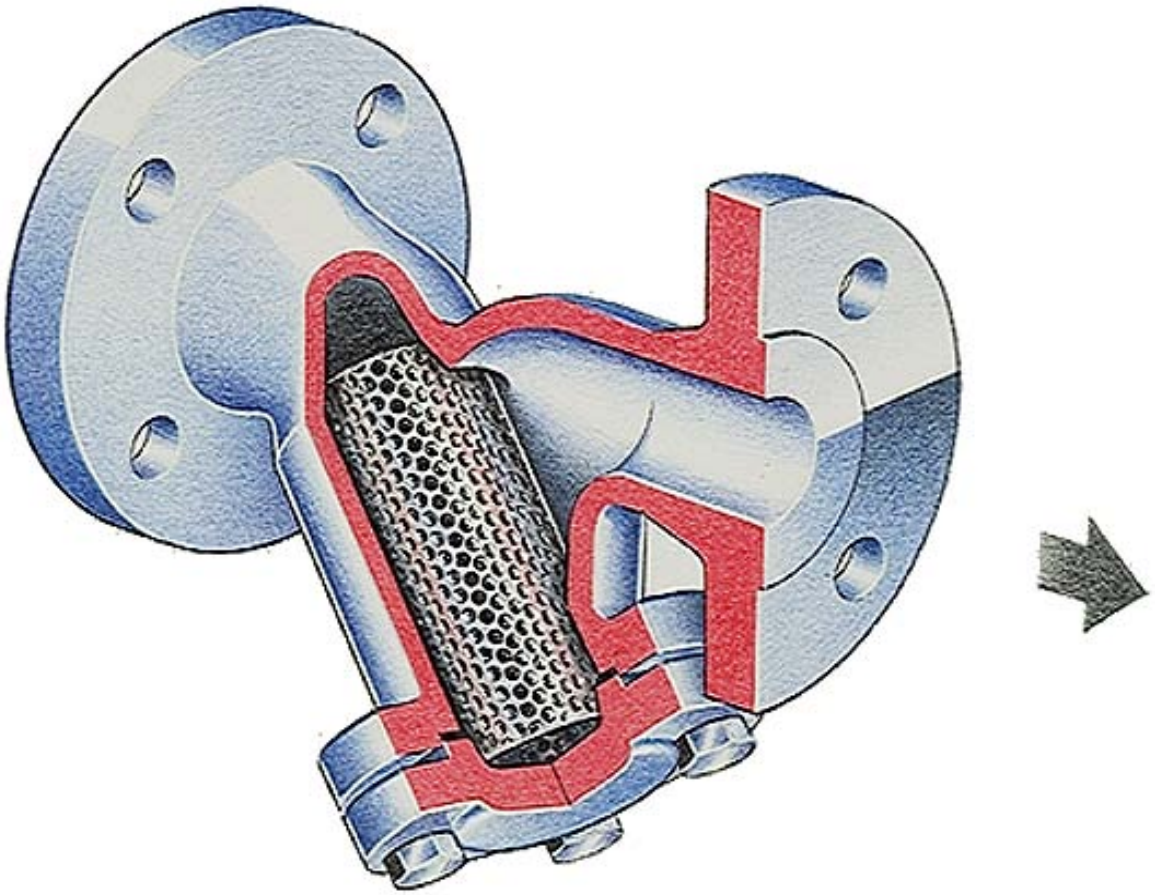
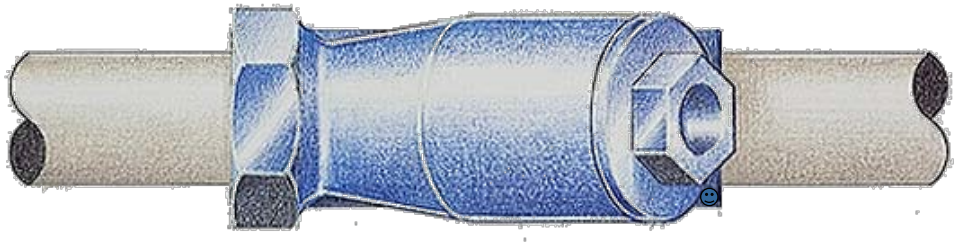
Pipeline Strainers



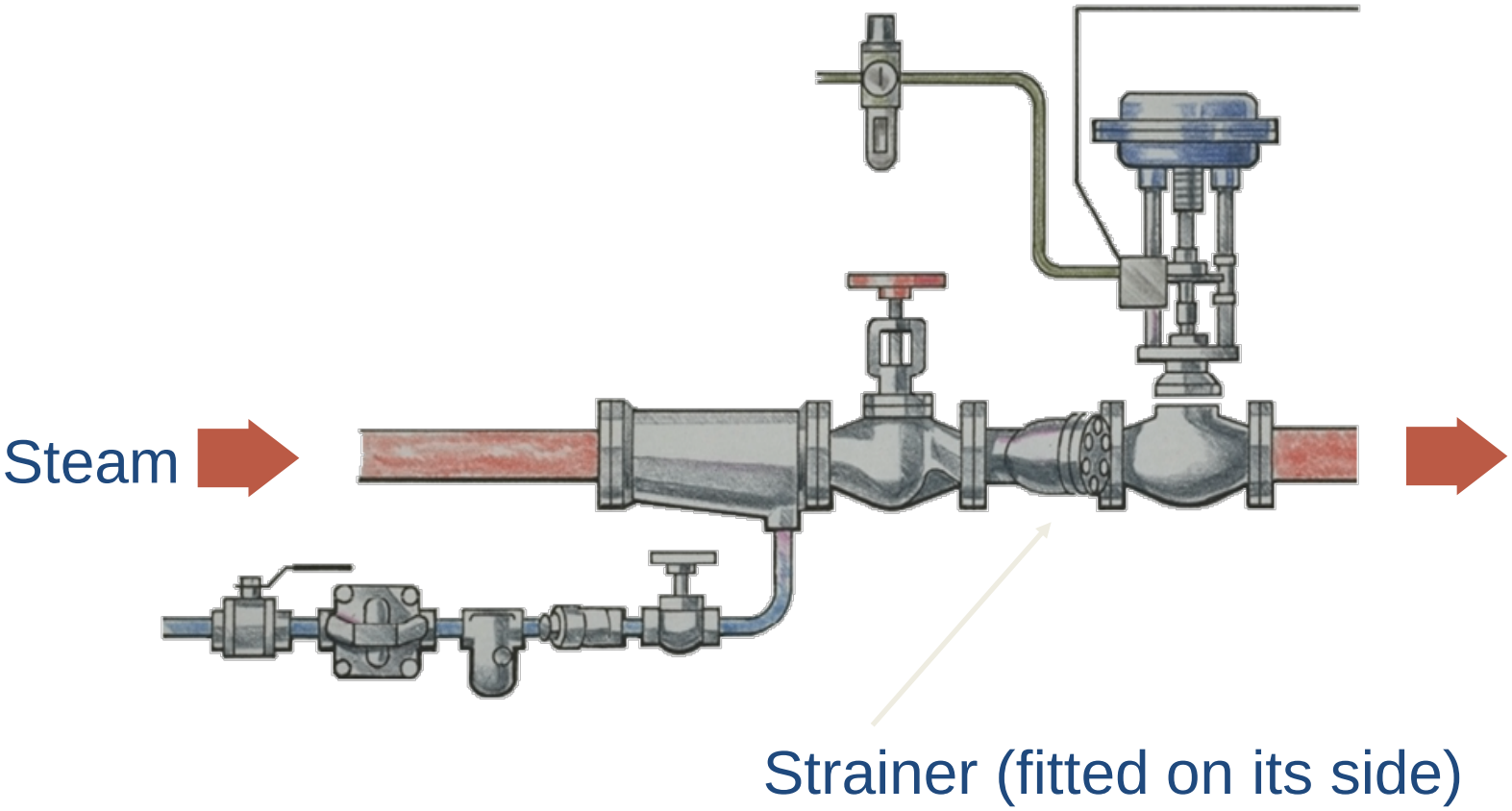
Correct Strainer Position

Vertical



Horizontal

Correct Strainer Installation



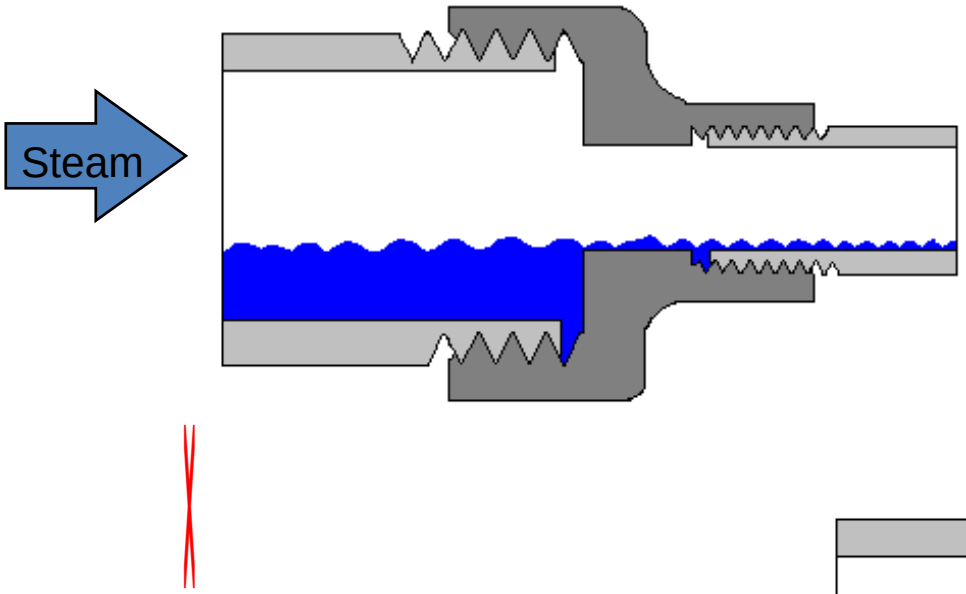
Effects of Air…..

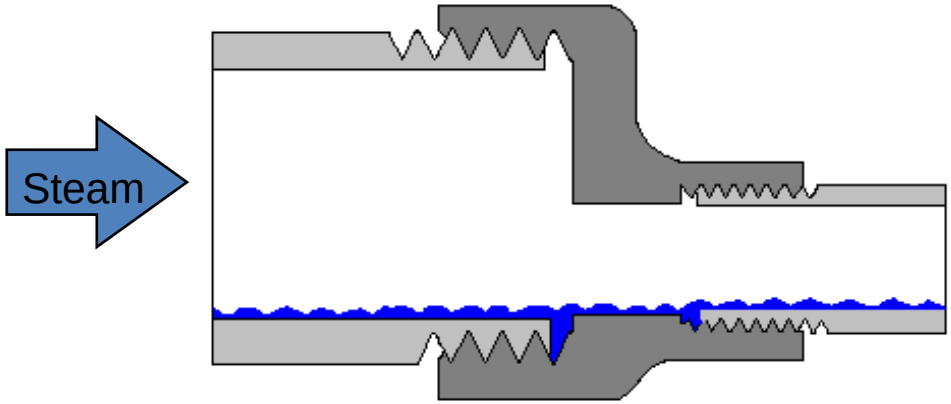
- Prolongs start up
- Lowers steam temperature
- Decreases heat transfer
- Increases corrosion

Sources of Air

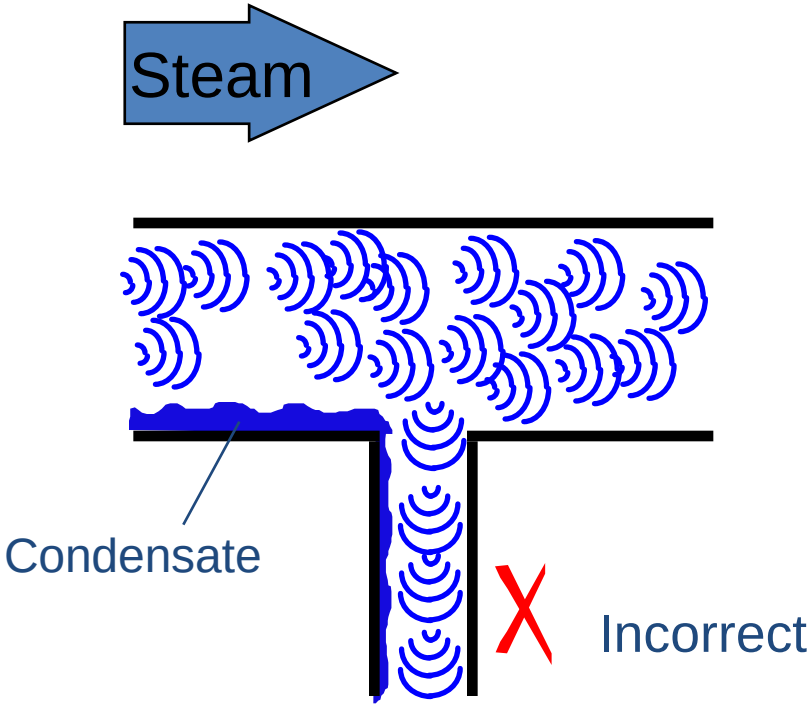
- In boiler feed water
- In makeup condensate exposed to the atmosphere
- Air drawn in at shutdown by resultant vacuum

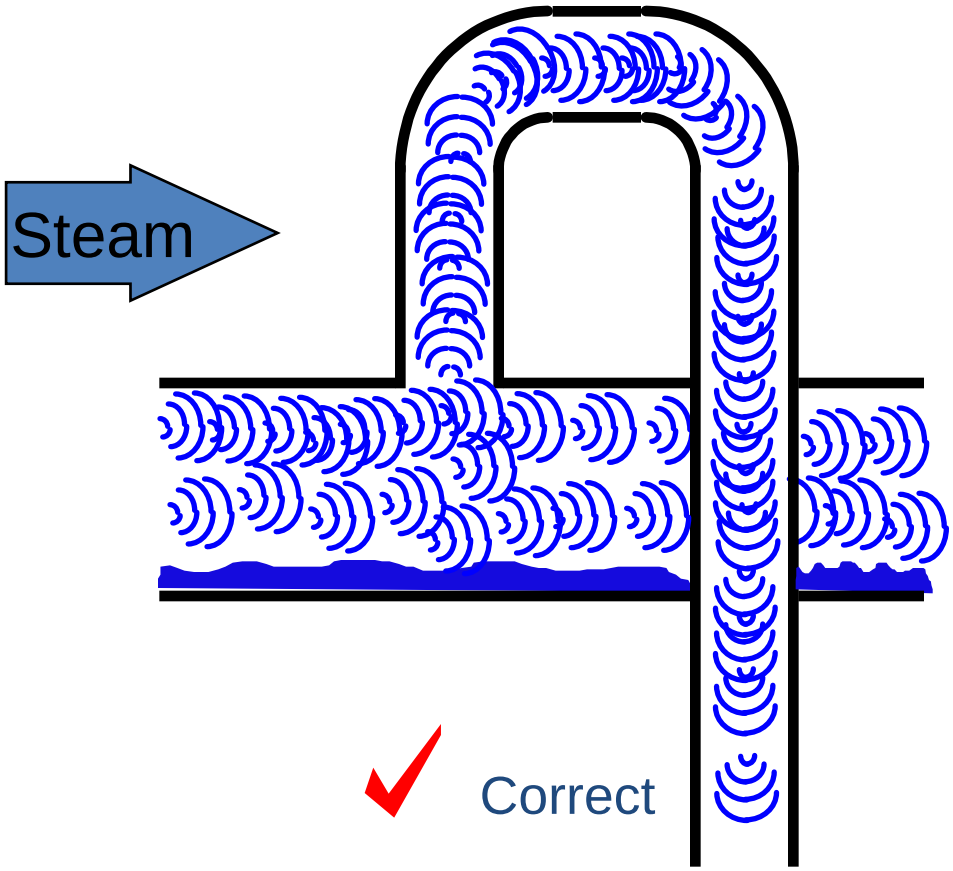
Steam Line Reducers





Branch Connections





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SHCOOL

Regardless of the type of trap……

A Steam Trap has NO Intelligence

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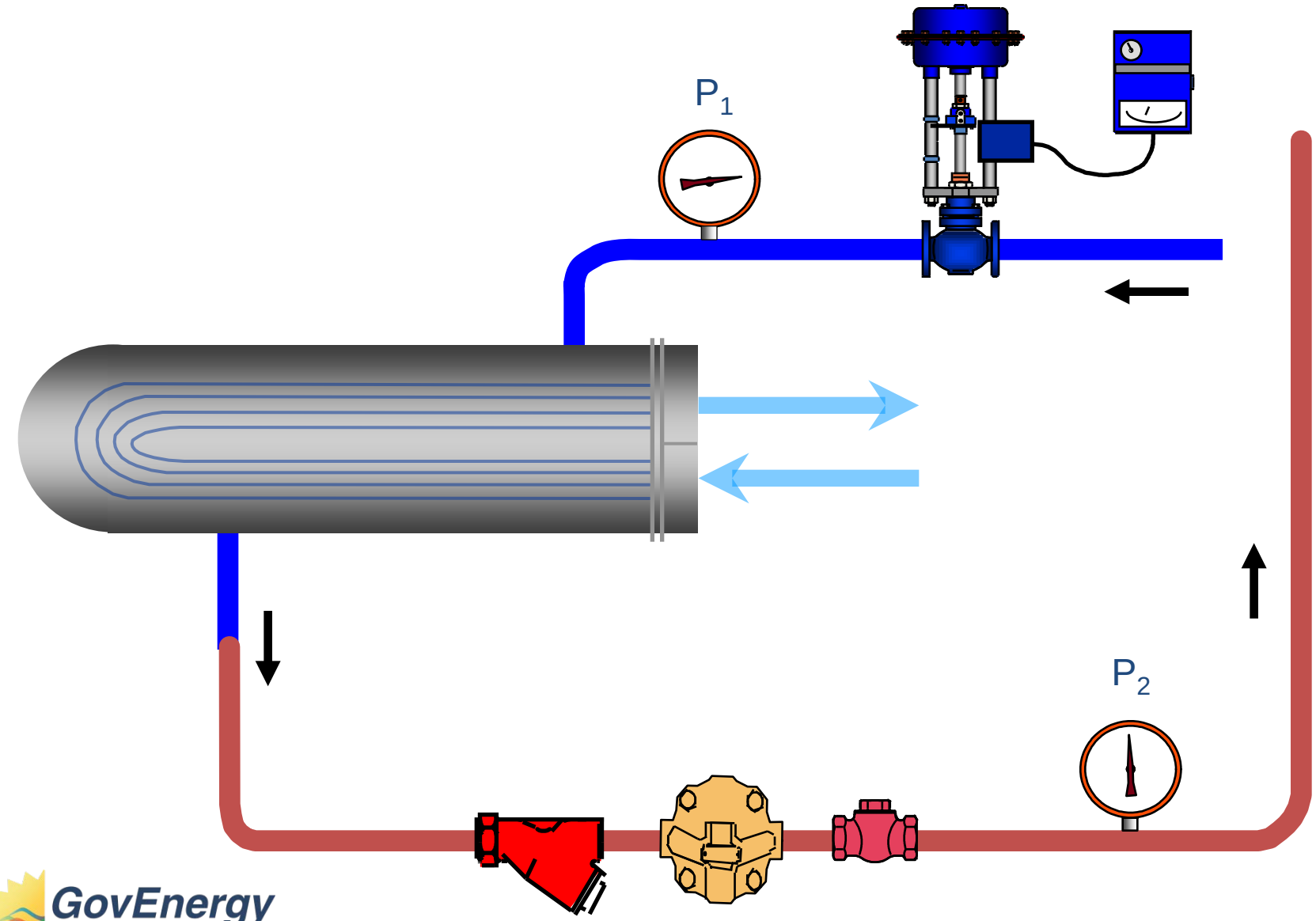
Heat Exchanger – Many Installations



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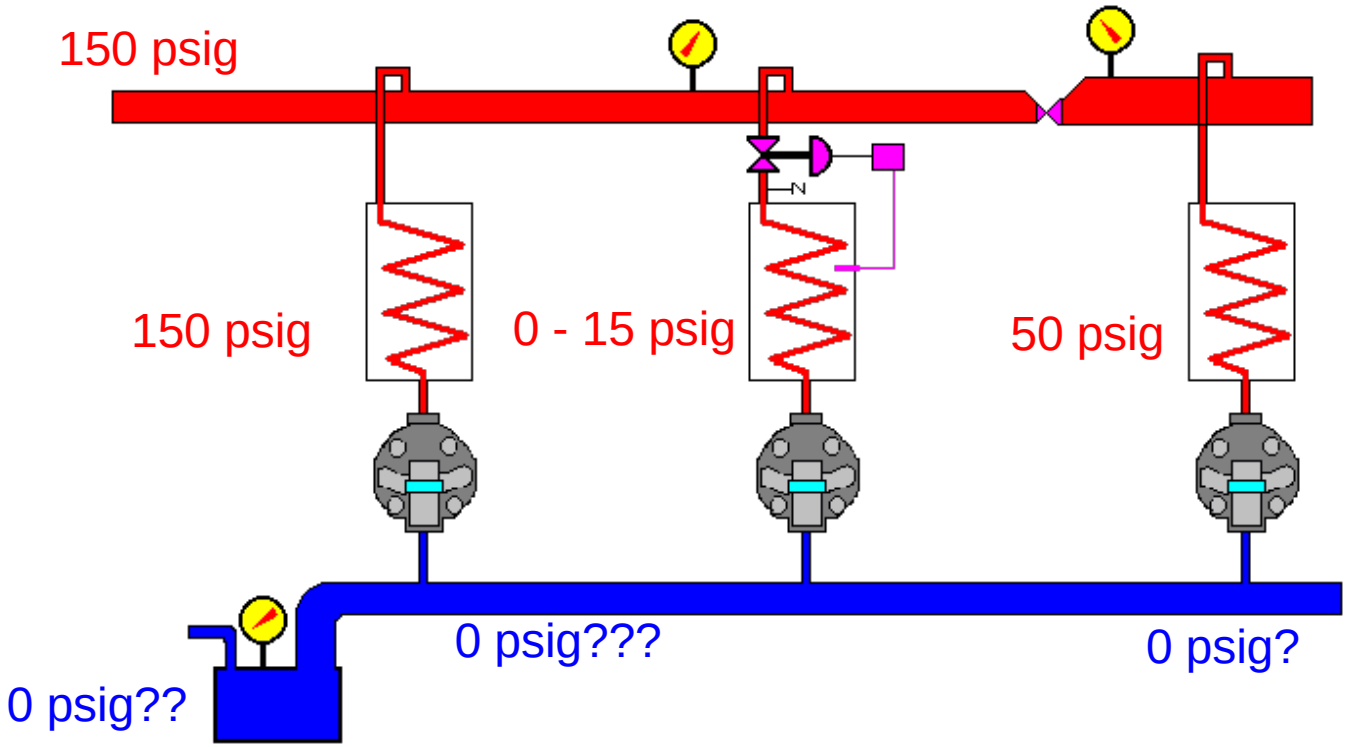
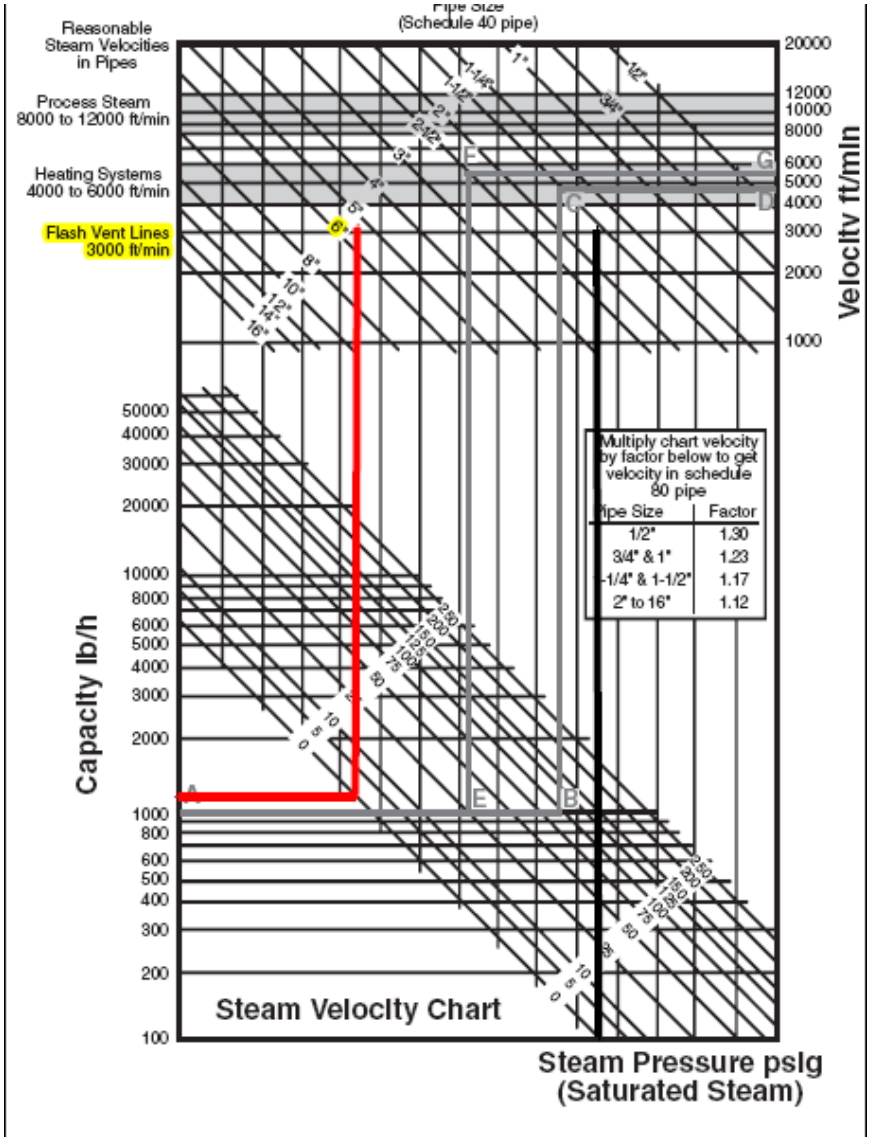
Traps Operating at Different Pressures



Proper Pipe Sizing



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Steam Trap testing

How Many Traps are Failed??...
How Many??

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System Stall

What is it and why should you care?

System stall is one of the largest and most costly industry issues facing facilities today

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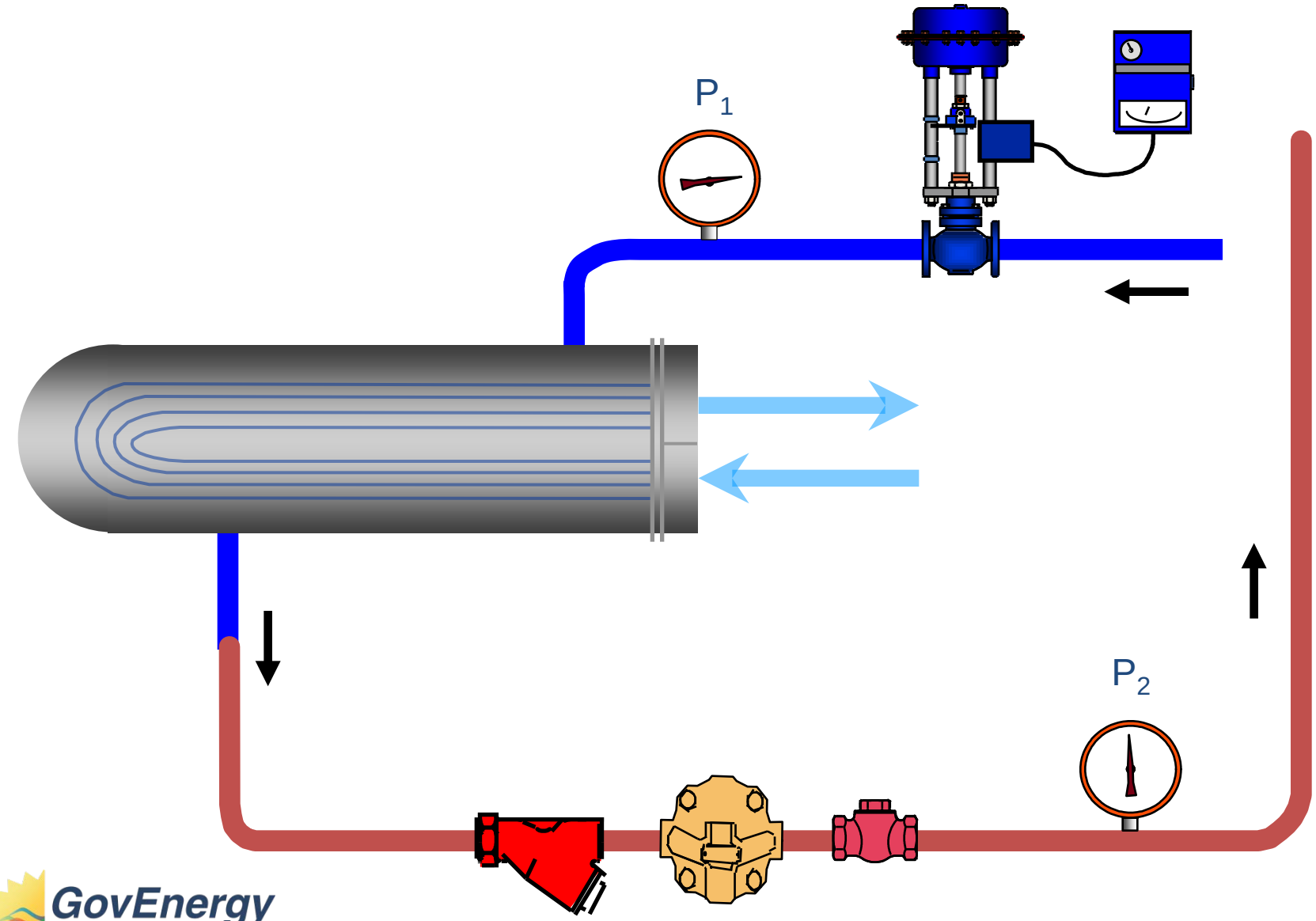
Heat Exchanger - Heavy Load



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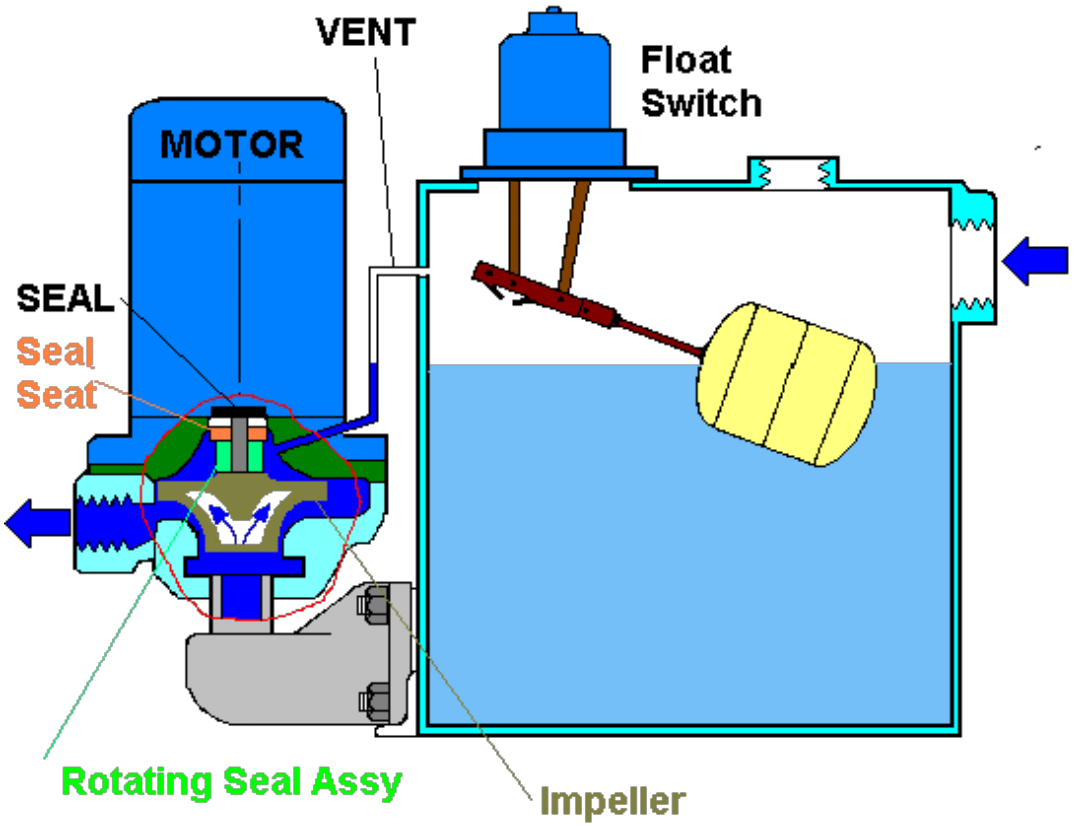
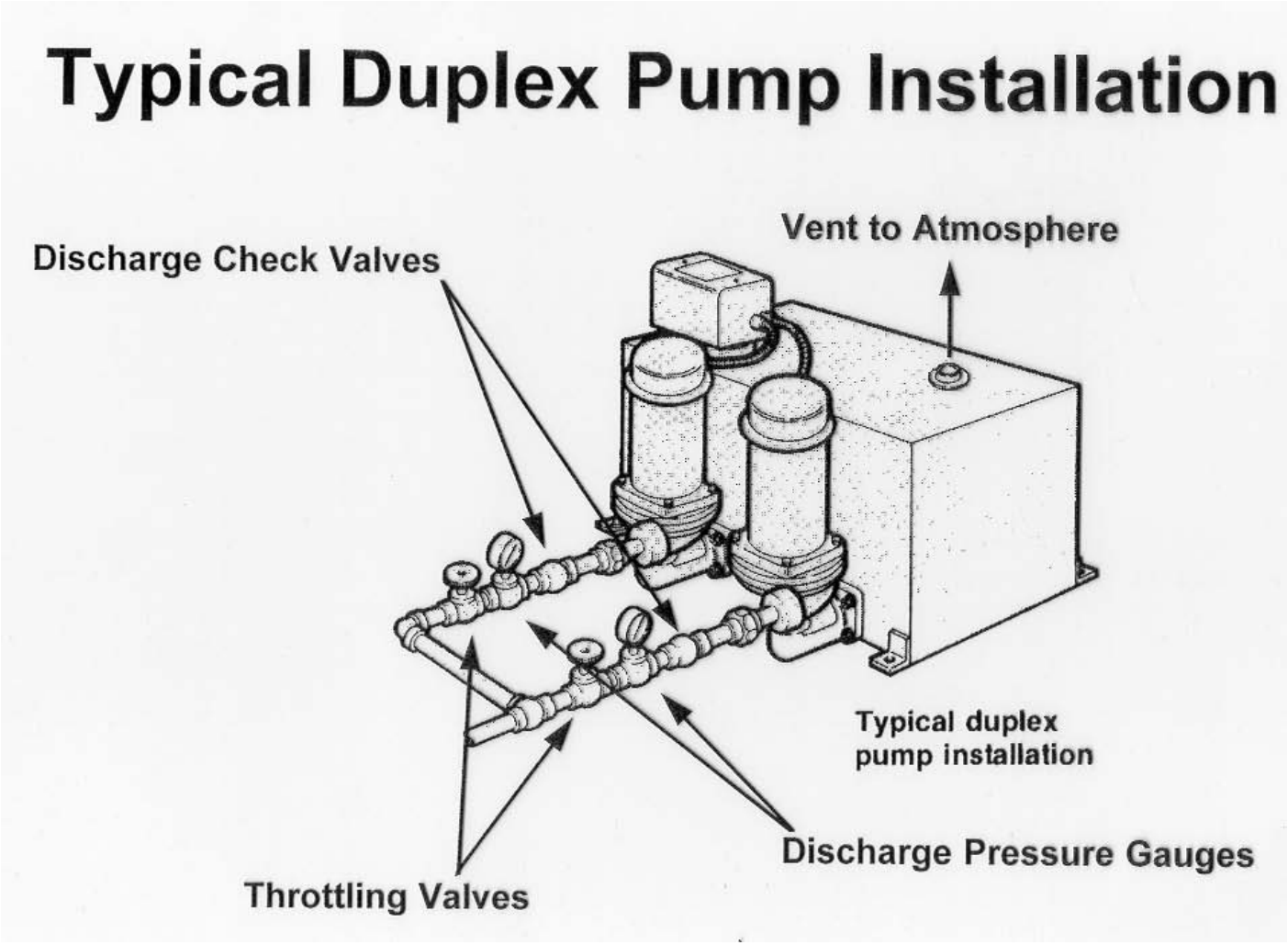

VENT
Float
Switch
MOTOR
SEAL
Seal
Seat
Rotating Seal Assy
Impeller

Condensate Pump - Electric



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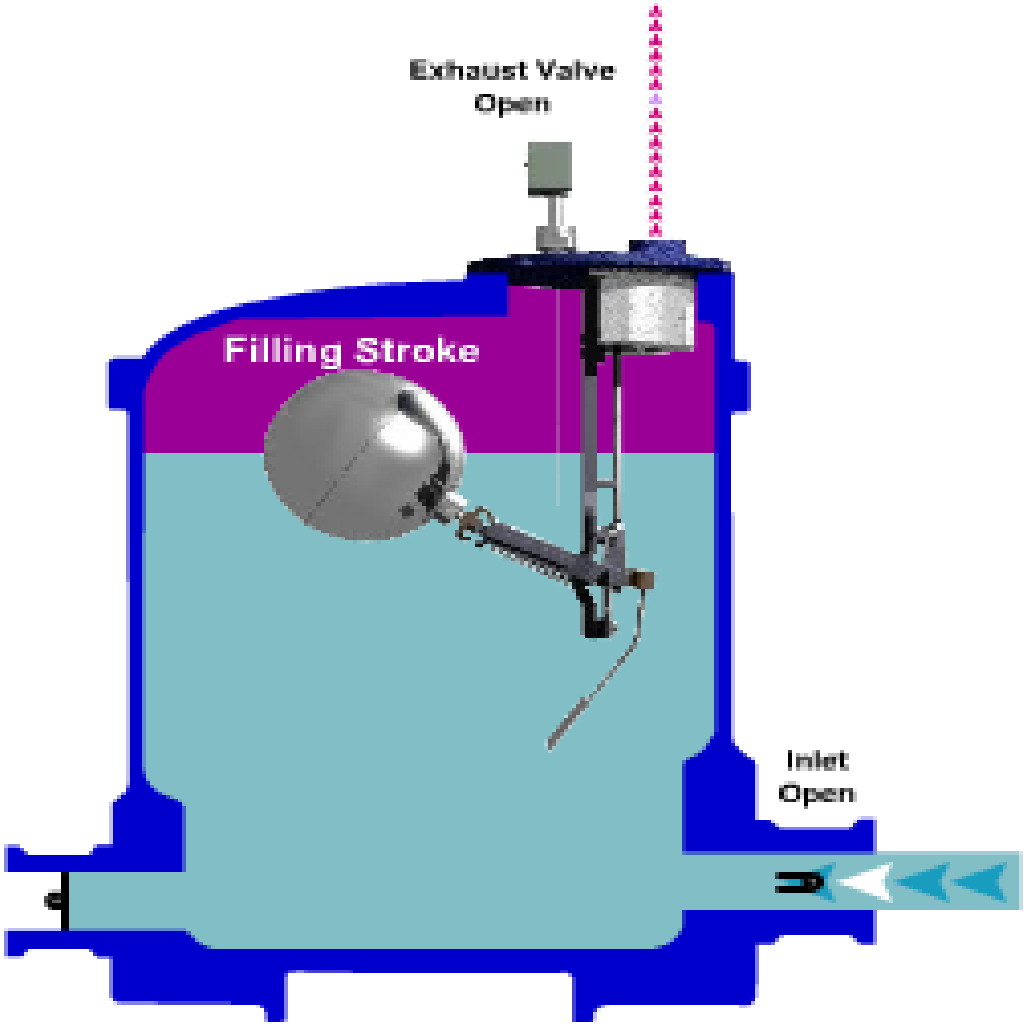
How it Works - Filling Stroke



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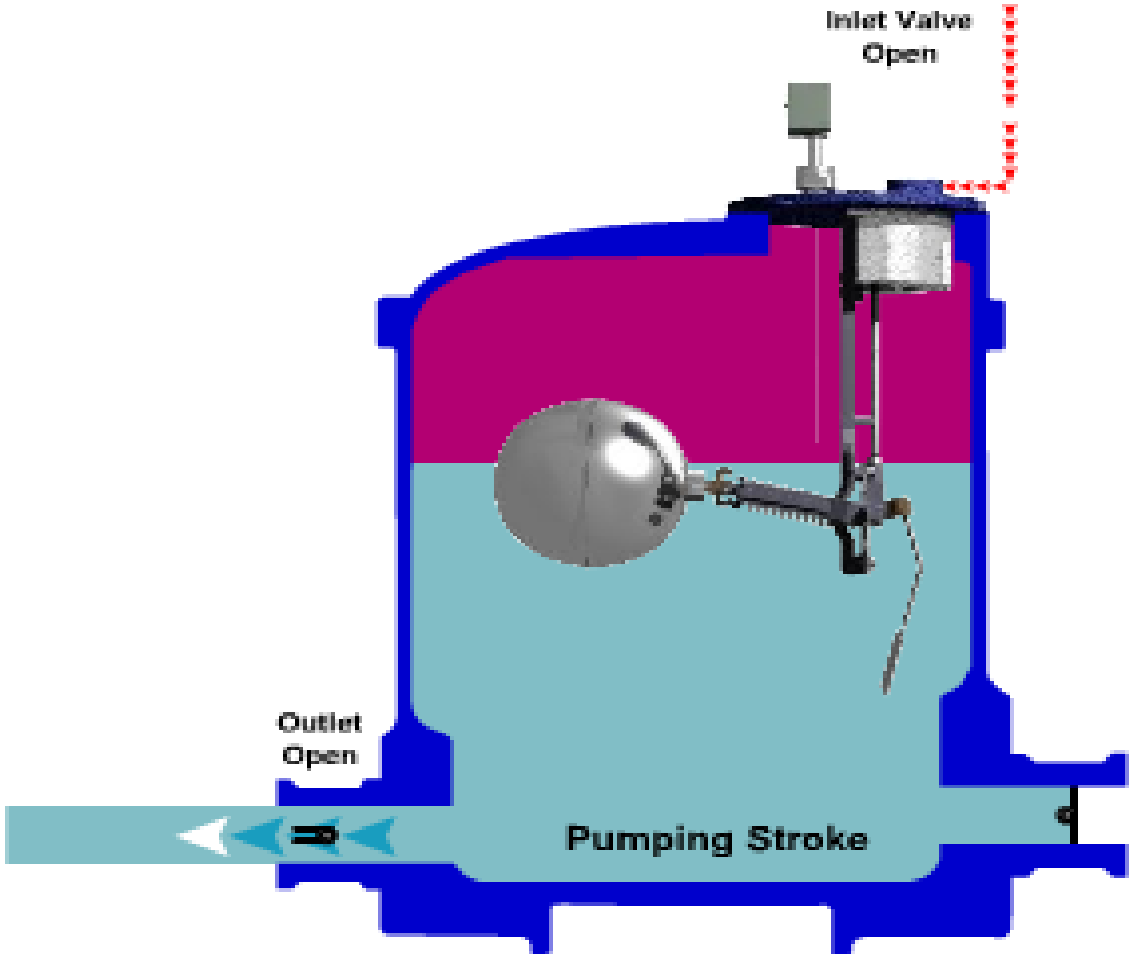
How it Works - Pumping Stroke



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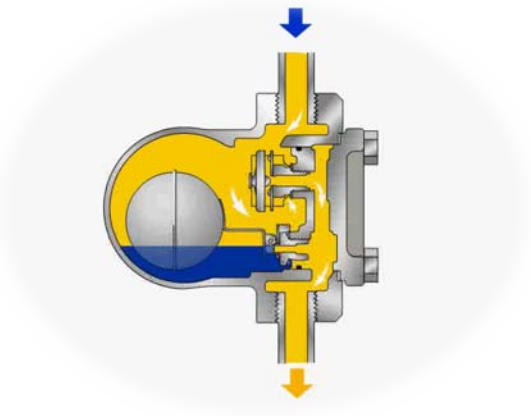
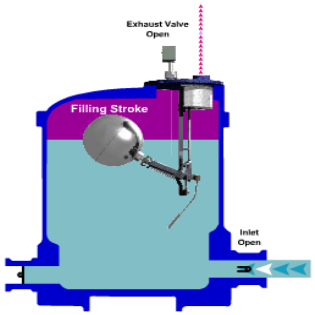
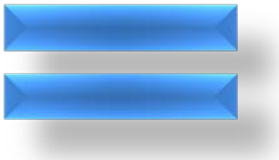
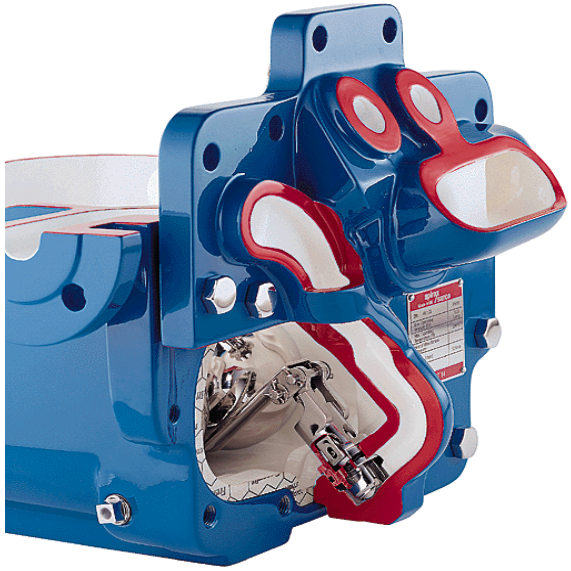
- We Got To Thinking…What If We Combined



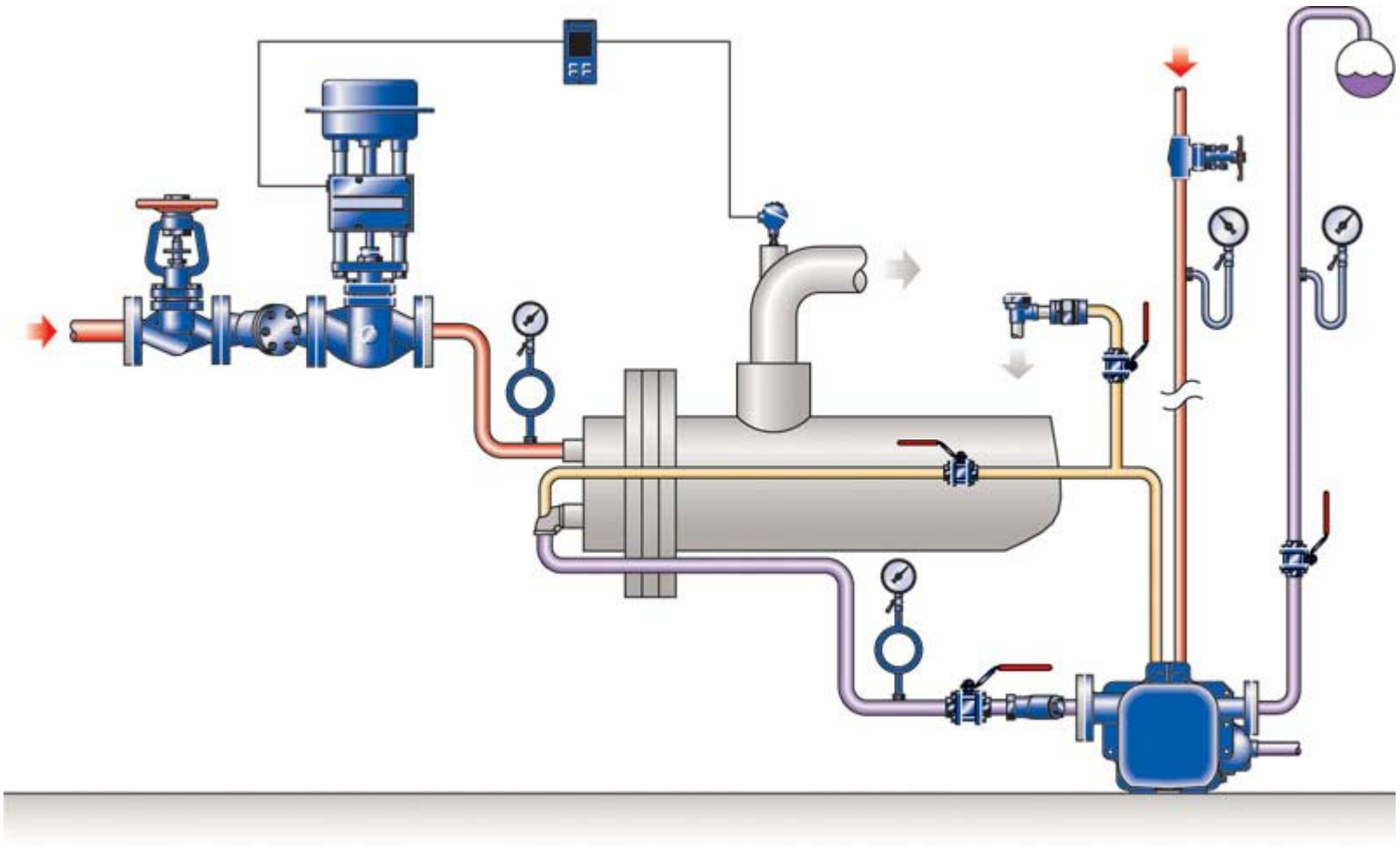




APT – Automatic Pump/Trap Combination



Closed Pumped System



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