STEAM TRAP HEALTH MONITORING SERVICE

A PERVASIVE SENSING™ STRATEGY

ECONOMIC STUDY

EMERSON
Process Management

STEAM TRAP HEALTH MONITORING SERVICE BENEFITS

Increases yield and product quality by assuring optimal temperature control and transfer of steam enthalpy

Improves plant reliability by reducing damage to equipment caused by water impingement, water hammer, corrosion & freezing

Reduces risk of safety incidents by minimizing water hammer, manual rounds and foot traffic in high risk areas

Optimizes productivity by enabling plant resources to focus on more critical activities

Reduces environmental impact by minimizing carbon emissions and water usage

Improves energy efficiency by expediently addressing steam leaks and blow-thru failures to reduce boiler load & fuel use

SITE ANALYSIS

STEAM TRAP COUNT	ENERGY	EMISSIONS	CASH FLOW	UPFRONT CAPITAL
Critical 96	$84,401	349 tons	$35,201	$0
Critical & High Value 172	$106,983	439 tons	$18,833	$0

Critical Traps have potential energy savings that quickly contribute to overall plant efficiency and produce positive cash flow. Similarly, High Value Traps contribute to overall plant efficiency and produce positive cash flow but at a lower rate relative to Critical Traps.

INPUTS *used for analysis*			
Total Trap Count	172	Annual Operating Hours	8,760
Steam Cost	$30.00 /ton	Boiler Fuel Type	Natural Gas
Trap Failure Rate*	15.0%	Manual Audit Cost	$20.00 /trap

**Average-quality traps may have just a 4-year life expectancy (which implies a 25% failure rate), while higher-quality steam traps may have an 8-yr life expectancy (12.5% average failure rate).* – Risko, J., Understanding Steam Traps, Chemical Engineering Progress, Feb 2011

EMERSON Process Management

BEST PRACTICE RECOMMENDATION

Remote Monitor for 5 Years	172 steam traps
Upfront Capital Investment	$0
Annual Contract	$66,048
Annual Repair / Replacement	$19,350
Annual Energy Savings	$106,983
Annual Manual Audit Savings	$3,440
Annual Emissions Savings	439 tons
Annual Cash Flow	$25,025

- High Value Steam Traps
- 5 Year Contract
- Local Access Network

$35/mo/trap

ALTERNATIVE OPTIONS

CELLULAR NETWORK *instead of Local Network (VLAN)* — 5 YEAR CONTRACT

Remote Monitor Service	172 steam traps
Upfront Capital Investment	$0
Annual Contract	$103,200
Annual Cash Flow	($12,127)

Add $15/mo/trap each

$50/mo/trap

CELLULAR NETWORK *instead of Local Network (VLAN)* AND 3 YEAR CONTRACT *instead of 5 Year Contract*

Remote Monitor for 3 Years	172 steam traps
Upfront Capital Investment	$0
Annual Contract	$134,160
Annual Cash Flow	($43,087)

Add $30/mo/trap each

$65/mo/trap

EMERSON
Process Management

REDUCED SCOPE OPTION

Remote Monitor for 5 Years	96 steam traps
Upfront Capital Investment	$0
Annual Contract	$36,864
Annual Repair / Replacement	$10,800
Annual Energy Savings	$84,401
Annual Manual Audit Savings	$1,920
Annual Emissions Savings	349 tons
Annual Cash Flow	$38,657

- Critical Steam Traps
- 5 Year Contract
- Local Access Network

$35/mo/trap

ALTERNATIVE OPTIONS

CELLULAR NETWORK *instead of Local Network (VLAN)* — 5 YEAR CONTRACT

Remote Monitor Service	96 steam traps
Upfront Capital Investment	$0
Annual Contract	$54,144
Annual Cash Flow	$21,377

Add $15/mo/trap each

$50/mo/trap

CELLULAR NETWORK *instead of Local Network (VLAN)* AND 3 YEAR CONTRACT *instead of 5 Year Contract*

Remote Monitor for 3 Years	96 steam traps
Upfront Capital Investment	$0
Annual Contract	$71,424
Annual Cash Flow	$4,097

Add $30/mo/trap each

$65/mo/trap

EMERSON
Process Management

SERVICE DETAIL ▸ TOTAL SAVINGS

	High Value	Critical
Steam Traps to be Monitored	**172**	**96**
Average Annual Energy Loss /trap in Blow-Thru	$8,293	$11,722
Failure Identified at Midpoint between Audits	50%	
Average Energy Savings /trap	$4,147	$5,861
Annual Failure Rate	15%	
Annual Energy Savings	**$106,983**	**$84,401**
Annual Manual Audit Cost Savings	**$3,440**	**$1,920**
Total Projected Annual Savings	**$110,423**	**$86,321**

SERVICE DETAIL ▸ ENVIRONMENTAL IMPACT

	High Value	Critical
Steam Traps to be Monitored	**172**	**96**
Average Annual CO_2 Emissions /trap in Blow-Thru	34 tons	49 tons
Failure Identified at Midpoint between Audits	50%	
Average Emissions Reduced /trap	17 tons	24 tons
Annual Failure Rate	15%	
Annual Reduction of CO_2 (85% boiler efficiency)	**439 tons**	**349 tons**
Annual Reduction of CO_2 in Passenger Cars	92.4 cars	73.5 cars
Annual Reduction of CO_2 in Trees Planted	1,062 trees	845 trees
Annual Water Savings	**3,566,000 L**	**2,813,000 L**
Annual Water Savings in Olympic Pools	1.4 pools	1.1 pools

STEAM TRAP POPULATION COUNT

Orifice Diameter (mm)	Pressure (barg)													
	1	1.5	2	2.2	2.5	3	3.2	3.5	3.8	4	4.5	6	8	10
3						1				1				74
3.5													1	
4												3		
5								1	1	12	8			3
7		2	6		4	12	4				1			6
9									2	15	4			
10														1
11			1				3							
12											2			
13	1	1		2										

Critical *High Value* *Remaining*

ANNUAL POTENTIAL ENERGY LOSS

Orifice Diameter (mm)	Pressure (barg)													
	1	1.5	2	2.2	2.5	3	3.2	3.5	3.8	4	4.5	6	8	10
3						$1,466				$1,832				$4,024
3.5													$4,483	
4												$4,556		
5								$4,581	$4,885	$5,088	$5,596			$11,178
7		$5,000	$5,994		$6,989	$7,984	$8,382				$10,968			$21,909
9									$15,829	$16,486	$18,131			
10														$44,713
11			$14,803				$20,698							
12											$32,232			
13	$13,813	$17,244		$22,047										

EMERSON Process Management

PRIORITIZED TRAP LIST SUMMARY

Area	Location	Trap Tag	Line Size (mm)	Pressure (barg)	Orifice Diameter (mm)	Blow-Thru Cost (€/yr)
LLM. UHT Room	APT on ausiheat	463	40	10	10	$44,713
DPF. CIP area at eastern end	On vertical shell and tube hx, near condensate pump	253	40	4.5	12	$32,232
DPF. CIP area at eastern end	On vertical shell and tube hx, near condensate pump	254	40	4.5	12	$32,232
MPF. Mix Room	On lower Heat Exchanger	300	50	2.2	13	$22,047
MPF. Mix Room	On upper heat exchanger	301	50	2.2	13	$22,047
DPF Process	Under Service Tunnel, line drain	222	25	10	7	$21,909
DPF PACKAGING	Micro MC, for spiral hx near ceiling.	234	25	10	7	$21,909
DPF. CIP area at eastern end	Under PRV station, on separator	251	25	10	7	$21,909
MPF. Upstairs	In Pasteuriser 2 room, on plate heat exchanger	374	25	10	7	$21,909
MPF. ESL2	Separator on far wall under windows	377	25	10	7	$21,909
LLM. UHT Room	Separator drain on ausiheat steam supply	460	25	10	7	$21,909
MPF	A Tank No 1, under tank, product steam flush.	306	25	3.2	11	$20,698
MPF	A Tank No 1, on spiral hx to left of tank	307	25	3.2	11	$20,698
MPF	A Tank No 2, vertical shell and tube hx.	315	25	3.2	11	$20,698
DPF. CIP area at eastern end	On vertical spiral hx, near condensate pump	255	25	4.5	9	$18,131
DPF. CIP area at eastern end	On vertical spiral hx, near condensate pump	256	25	4.5	9	$18,131
MPF	A Tank No 2, product pipe steam flush	316	25	4.5	9	$18,131
MPF	A Tank No 3, product pipe steam flush	318	25	4.5	9	$18,131
MPF ESL2 Pasteuriser room	Near pump 901 to the left of office	332	25	1.5	13	$17,244
DPF Process	Natural Set at HT117, line drain	211	25	4	9	$16,486
DPF Process	Natural Set, steam jacketed pipe	213	25	4	9	$16,486
DPF Process	On steam line to dip room	218	25	4	9	$16,486
DPF Process	Dessert Pasteurisers, bottom traps	224	25	4	9	$16,486
MPF ESL2 Pasteuriser room	Pasturiser, above trap 344a	334.1	25	4	9	$16,486
MPF ESL2 Pasteuriser room	Pasteuriser, to right of pump.	335	25	4	9	$16,486
MPF ESL2 Pasteuriser room	On ESL2 Pasteuriser, to left of pump.	336	25	4	9	$16,486
MPF. Tank Farm CIP	CIP 1 heat exchanger	340	25	4	9	$16,486
MPF. Tank Farm CIP	CIP 2 heat exchanger	341	25	4	9	$16,486
MPF. Tank Farm CIP	CIP 3 heat exchanger	342	25	4	9	$16,486
MPF Bottle Hall	CIP Panel above Splatts filler	352	25	4	9	$16,486
MPF Bottle Hall	CIP Panel above Splatts filler	353	25	4	9	$16,486
MPF Bottle Hall	CIP Panel above Splatts filler	354	25	4	9	$16,486
MPF Bottle Hall	Under conveyor behind Fibre King filler on plate heat exchanger.	361	25	4	9	$16,486
MPF ESL2 Pasteuriser room	Pasteuriser, at bottom of column	0334a	25	4	9	$16,486
MPF	Pasteuriser No 3	321	25	3.8	9	$15,829
MPF	Pasteuriser No 3 auxillary heating spiral heat exchangers	322	25	3.8	9	$15,829
MPF. Slops area at two white tanks	Between tanks, on vertical spiral flow hx at rear.	131	25	2	11	$14,803
ENG. At ice tanks	Instantaneous Hot Water Unit	104	25	1	13	$13,813
ENG CIP Milk recivals	Supply to milk tanker wash tank heating.	110	20	10	5	$11,178
DPF Process	In front of Tank FT901	216	20	10	5	$11,178
MPF Bottle Hall	Centre of building near post line drain before heat exchanger	369	20	10	5	$11,178
MPF. Cheese room	Under Vat 5, on spiral flow hx	325	20	4.5	7	$10,968
MPF	A Tank No 1, under tank product pipe steam flush	305	15	3.2	7	$8,382
MPF	A Tank No 1, line drain before Hipex HX	307.1	15	3.2	7	$8,382
MPF	A Tank No 1, supply to tank 1 steam flush.	308	15	3.2	7	$8,382
MPF	On wall, main line drainage near tank No 1	309	15	3.2	7	$8,382
DPF Process	Dessert Pasteurisers, middle trap.	226	15	3	7	$7,984
DPF Process	Dessert Pasteurisers, upper trap	227	15	3	7	$7,984
MPF Bottle Hall	Behind Scholle, on steam filter	349	15	3	7	$7,984
MPF Bottle Hall	Behind Scholle, line drain after BRV2S	350	15	3	7	$7,984
MPF Bottle Hall	On supply to Scholle, line drain	351	15	3	7	$7,984
LLM. UHT Room	Condensate Pump line drain	400	15	3	7	$7,984
LLM. CIP room near icecream process through door	H/X under CIP tank drain	431	15	3	7	$7,984
LLM. CIP room for icecream process through main door from	Clean steam filter drain	470	15	3	7	$7,984
LLM. CIP room for icecream process through main door from	Line drain before control valve on small line	471	15	3	7	$7,984
LLM. CIP room for icecream process through main door from	Line drain after solenoid valve	472	15	3	7	$7,984
LLM. CIP room for icecream process through main door from	Drain line off filter on front supply line	473	15	3	7	$7,984
LLM. CIP room for icecream process through main door from	Line drain after control valve	474	15	3	7	$7,984

Assumed 15mm Connection Line Size

PRIORITIZED TRAP LIST SUMMARY

Area	Location	Trap Tag	Line Size (mm)	Pressure (barg)	Orifice Diameter (mm)	Blow-Thru Cost (€/yr)	CO_2 (ton/yr)
MPF.Cream tanks	On top of cream tanks outside on clean steam filter.	380	15	2.5	7	$6,989	29.7
MPF.Cream tanks	On steam supply line after clean steam filter.	381	15	2.5	7	$6,989	29.7
MPF.Cream tanks	On steam supply line after clean steam filter.	382	15	2.5	7	$6,989	29.7
MPF.Cream tanks	Vacuum breaker above trap 382	383	15	2.5	7	$6,989	29.7
MPF. Slops area at two white tanks	Between tanks, on vertical spiral flow hx at front	130	15	2	7	$5,994	25.6
DPF PACKAGING	Trepko machine, line drain	236	15	2	7	$5,994	25.6
MPF. Tank farm No. 42	Flavored milk tank #42	338	15	2	7	$5,994	25.6
MPF Tank farm on roof	Between tank 39 and 42	338.1	15	2	7	$5,994	25.6
MPF Tank farm on roof	Between tank 39 and 42	338.3	15	2	7	$5,994	25.6
MPF. Tank Farm CIP	Behind suresan tank	346	15	2	7	$5,994	25.6
DPF. CIP area at eastern end	Condensate pump motive steam line	252	15	4.5	5	$5,596	23.1
DPF. CIP area at eastern end	Near condensate pump, on separator near CV2355	257	15	4.5	5	$5,596	23.1
DPF. CIP area at eastern end	Near condensate pump, separator near CV2385	258	15	4.5	5	$5,596	23.1
MPF	A Tank No 2, under tank, product pipe steam flush	317	15	4.5	5	$5,596	23.1
MPF	A Tank No 3, under tank, product pipe steam flush	319	15	4.5	5	$5,596	23.1
MPF. Upstairs	Under Vat 2, on spiral flow hx	326	15	4.5	5	$5,596	23.1
MPF. Tank farm No. 42	Between tank 39 and 42	338.2	15	4.5	5	$5,596	23.1
MPF. Tank farm No. 42	Between tank 39 and 42	338.4	15	4.5	5	$5,596	23.1
ENG. At ice tanks	Instantaneous Hot Water Unit	106	15	4	5	$5,088	21.1
DPF Process	Dip Room Heaters, line drain after prv.	205	15	4	5	$5,088	21.1
DPF Process	Natural Set at HT117	210	15	4	5	$5,088	21.1
DPF Process	Natural Set under tank Ft 102 as cip steam flush	214	15	4	5	$5,088	21.1
DPF Process	Natural Set,at tank FT10, cip steam flush	215	15	4	5	$5,088	21.1
DPF Process	Above tanks on walkway, on steam filter	217	15	4	5	$5,088	21.1
DPF Process	At Ferment Tank 109, line drain	221	15	4	5	$5,088	21.1
DPF Process	Dessert Pasteurisers, bottom traps	225	15	4	5	$5,088	21.1
DPF Process	Dessert Pasteurisers line drain on supply to bottom spiral hx steam supply	229	15	4	5	$5,088	21.1
DPF PACKAGING	ERCA B line filter drain	237	15	4	5	$5,088	21.1
DPF PACKAGING	ERCA A line drain	238	15	4	5	$5,088	21.1
MPF Bottle Hall	On plate Heat Exchanger, next to trap 361	361.1	15	4	5	$5,088	21.1
MPF	Tetra Aldose, below control Panel	313	15	1.5	7	$5,000	21.6
MPF. Tetra Aldose	Under control panel, on lower steam filter	314	15	1.5	7	$5,000	21.6
MPF Bottle Hall	On Splatts filler hot water hx, near TR18	376	15	3.8	5	$4,885	20.3
MPF. Tank Farm CIP	Behind caustic CIP solution tank	345	15	3.5	5	$4,581	19.2
DPF Process	At Ferment Tank 109, CIP steam flush	221.1	15	6	4	$4,556	18.5
DPF Process	Dessert Pasteruisers, top spiral hx	232	15	6	4	$4,556	18.5
MPF Bottle Hall	Near Federal Filler, on horizontal spiral hx above filler	360	15	6	4	$4,556	18.5
MPF Bottle Hall	Above TR18 on platform, line drain before BRV2S	357	15	8	3.5	$4,483	17.9
ENG. Sihi Pump	Dirt Leg Behind Pump	100	15	10	3	$4,024	15.9
ENG. Sihi Pump	Supply to bottle hall, Dirt Leg Behind Pump	101	15	10	3	$4,024	15.9
ENG. Sihi Pump	Behind condensate pump on dirt leg, trap high on outside wall	102	15	10	3	$4,024	15.9
ENG. At ice tanks	On supply to bottle hall, near machining workshop	103	15	10	3	$4,024	15.9
ENG. At ice tanks	Instantaneous Hot Water Unit, separator drain	105	15	10	3	$4,024	15.9
ENG. At ice tanks	Above Instantaneous Hot Water Unit	107	15	10	3	$4,024	15.9
ENG. At ice tanks	In walk way to Instantaneous Hot Water Unit	108	15	10	3	$4,024	15.9
ENG. Main line behind tank farm CIP	At SW end of truck wash area	109	15	10	3	$4,024	15.9
ENG. Engine Room	On roof above milk receivals, behind MPF ELS2 tank farm.	119	15	10	3	$4,024	15.9
ENG. Engine Room	Trevor Boiler, line drain under crown valve.	120	15	10	3	$4,024	15.9
ENG. Engine Room	Trevor Boiler, above crown valve.	121	15	10	3	$4,024	15.9
ENG. Engine Room	Maxitherm Boiler, line drain after crown valve.	122	15	10	3	$4,024	15.9
ENG. Engine Room	Near Feed Tank, on steam main	123	15	10	3	$4,024	15.9
ENG. Entrance to service tunnel for DPF	Near door of service tunnel	124	15	10	3	$4,024	15.9
MPF. Slops Area Outside	Between white tanks	125	15	10	3	$4,024	15.9
MPF. Slops Area Outside	Between to white tanks	126	15	10	3	$4,024	15.9
MPF. Slops area at water meter	Between brick walls, near water meter.	129	15	10	3	$4,024	15.9
MPF. Slops area at two white tanks	left of tanks, on wall	132	15	10	3	$4,024	15.9

Assumed 15mm Connection Line Size

PRIORITIZED TRAP LIST SUMMARY

Area	Location	Trap Tag	Line Size (mm)	Pressure (barg)	Orifice Diameter (mm)	Blow-Thru Cost (€/yr)	CO_2 (ton/yr)
DPF Process	In services tunnel Access from roof	201	15	10	3	$4,024	15.9
DPF Process	In services tunnel, on 2.5" separator	202	15	10	3	$4,024	15.9
DPF Process	In services tunnel, on top steam line at far end.	203.1	15	10	3	$4,024	15.9
DPF Process	Dip Room Heaters, line drain	206	15	10	3	$4,024	15.9
DPF Process	Main 10 bar Line to dip room, line drain	219	15	10	3	$4,024	15.9
DPF Process	HP steam main line on far wall	220	15	10	3	$4,024	15.9
DPF Process	Main line drain, on platform near pasteurisers	223	15	10	3	$4,024	15.9
DPF Process	Dessert Pasteurisers, separator drain before control valves	228	15	10	3	$4,024	15.9
DPF Process	Dessert Pasteurisers, near back wall after separator	230	15	10	3	$4,024	15.9
DPF Process	Line to Desert Pasteurisers, line drain	233	15	10	3	$4,024	15.9
DPF PACKAGING	Micro MC, line drain	235	15	10	3	$4,024	15.9
DPF PACKAGING	Main PRV No 18 on far wall	239	15	10	3	$4,024	15.9
DPF. CIP area at eastern end	On steam main to CIP heat exchangers on drain leg near ammonia tank.	250	15	10	3	$4,024	15.9
MPF. Mix Room	Separator drain before Heat Exchanger	302	15	10	3	$4,024	15.9
MPF. Mix Room	Before Heat Exchangers, line drain	303	15	10	3	$4,024	15.9
MPF. Tetra Aldose	Above panel, on separator before PRV	310	15	10	3	$4,024	15.9
MPF. Tetra Aldose	Above panel, on steam filter	311	15	10	3	$4,024	15.9
MPF. Tetra Aldose	Behind panel, near wall, supply to Tetra Aldose	312	15	10	3	$4,024	15.9
MPF	On spiral flow hx near Tank 38	320	15	10	3	$4,024	15.9
MPF	A Tanks PRV , above tanks on walkway on DN50 separator	323	15	10	3	$4,024	15.9
MPF	Above A Tank on walkway, on DN15 separator	324	15	10	3	$4,024	15.9
MPF Upstairs	Above Vat 2, on main line in corner	326.1	15	10	3	$4,024	15.9
MPF Upstairs	On steam line to pasteuriser 3, near blue panel.	327	15	10	3	$4,024	15.9
MPF	PRV Station near office and emergency shower	329	15	10	3	$4,024	15.9
MPF ESL2 Pasteuriser room	Above door, on main line drain leg	330	15	10	3	$4,024	15.9
MPF ESL2 Pasteuriser room	PRV station on wall	331	15	10	3	$4,024	15.9
MPF ESL2 Pasteuriser room	Dirt Leg on wall near pasteuriser	333	15	10	3	$4,024	15.9
MPF. Tank Farm CIP	Line drainage on CIP shell and tube heat exchanger supply	339	15	10	3	$4,024	15.9
MPF. Tank Farm CIP	Behind tanks on BRV	343	15	10	3	$4,024	15.9
MPF. Tank Farm CIP	Behind tanks on BRV	344	15	10	3	$4,024	15.9
MPF Bottle Hall	Behind scholle, line drain on wall	348	15	10	3	$4,024	15.9
MPF Bottle Hall	Above TR18 on platform, line drain	356	15	10	3	$4,024	15.9
MPF Bottle Hall	At end of line on wall near loudspeaker	358	15	10	3	$4,024	15.9
MPF Bottle Hall	Near Federal Filler, supply to horizontal spiral hx above walkway	359	15	10	3	$4,024	15.9
MPF Bottle Hall	Near Fibre King filler, supply to plate heat exchanger	362	15	10	3	$4,024	15.9
MPF Bottle Hall	Near Fogg filler, next to crate packer	363	15	10	3	$4,024	15.9
MPF Bottle Hall	Upstairs in hall way, near office.	364	15	10	3	$4,024	15.9
MPF. Tank Farm CIP	Under tank farm, above chiller pumps	366	15	10	3	$4,024	15.9
MPF Bottle Hall	Centre of building near exhaust vent	367	15	10	3	$4,024	15.9
MPF Bottle Hall	Centre of building Near post on heat exchanger	368	15	10	3	$4,024	15.9
MPF Bottle Hall	Above TR 18, air vent on steam main	370	15	10	3	$4,024	15.9
MPF Bottle Hall	Above Tetra Pak TR18 hot water unit steam supply	371	15	10	3	$4,024	15.9
MPF Bottle Hall	Above Tetra Pak TR18 hot water unit, line drain	371.1	15	10	3	$4,024	15.9
MPF Bottle Hall	On steam supply to Splatts filler hot water hx, near TR18	375	15	10	3	$4,024	15.9
MPF. ESL2	On header before Pasteuriser.	378	15	10	3	$4,024	15.9
MPF.Cream tanks	On top of cream tanks outside on clean steam set.	379	15	10	3	$4,024	15.9
MPF.Cream tanks	Supply line to separator on clean steam set on bottom of riser	384	15	10	3	$4,024	15.9
LLM. UHT Room	Below Separator for condensate pump supply	404	15	10	3	$4,024	15.9
LLM. UHT Room	Motive drain for apt on ausiheat steam supply	461	15	10	3	$4,024	15.9
LLM. UHT Room	Air vent off reciever on ausiheat	462	15	10	3	$4,024	15.9
LLM. Icecream room northern end of truck bay last door on	Far wall before BSA valve.	464	15	10	3	$4,024	15.9
LLM. Icecream room northern end of truck bay last door on	Separator drain before clean steam filter on wall	465	15	10	3	$4,024	15.9
LLM. Icecream room northern end of truck bay last door on	In corner of room line drain	466	15	10	3	$4,024	15.9
LLM. Icecream room northern end of truck bay last door on	Clean steam filter on wall	467	15	10	3	$4,024	15.9
LLM. Icecream room northern end of truck bay last door on	On rear wall line drain trap	468	15	10	3	$4,024	15.9
LLM. CIP room for icecream process through main door from	LLM. CIP room for icecream process through main door from	469	15	10	3	$4,024	15.9
DPF Process	In services tunnel, on steam filter	200	6	4	3	$1,832	7.6
DPF Process	In services tunnel, on steam filter at far end.	203	6	3	3	$1,466	6.2
MPF Tank farm	At end of line near sink.	337	15	0.5	0	$0	0.0

STEAM TRAP FAILURE MODE

CLOSED

Risk	Reliability Impact	Process Impact	HSSE Impact	Energy Impact	Business Impact
Water Hammer	Piping & Equipment Repairs / Replacement	Unscheduled Shutdown	Increased Risk to Personnel Safety due to Event and Remediation	Increased Steam Production	Personnel Injury, Lawsuits, Lost Production, Capital Equipment Repair Costs
Reduced Heat Transfer	Reduced Heat Exchanger Efficiency	Throughput Slow Down	Excessive Carbon Emissions for Increased Steam Production	Increased Steam Production	Increased Fuel Cost
Poor Temperature Control	Reduced Heat Exchanger Efficiency	Poor Quality, Lost Batches, or Throughput Slow Down	Excessive Carbon Emissions for Increased Steam Production	Increased Steam Production	Lost Batches, Increased Scrap, Increased Rework Costs
Water Impingement	Damage to Steam Turbines and Drives	Unscheduled Shutdown	Increased Risk to Personnel Safety due to Increased Maintenance	Increased Steam Production	Capital Equipment Repairs Purchase More Electricity
Corrosion	Reduced Life of System Components, Pipe Scaling, Plugging Issues	Reduced Heat Transfer Throughput Slow Down Unscheduled Shutdown	Increased Risk to Personnel Safety due to Increased Maintenance	Increased Steam Production	Increased Maintenance and Equipment Costs
Freezing	Steam Coils, Heat Plates Damaged by Condensate Freezing	Line Plugging Throughput Slow Down	Increased Risk to Personnel Safety due to Increased Maintenance	Increased Steam Production	Capital Equipment Repair and Higher Energy Costs
Erosion	Premature Piping Failure	Reduced Heat Transfer Throughput Slowdown Unscheduled Shutdown	Increased Risk to Personnel Safety due to Increased Maintenance	Increased Steam Production due to Leaks	Potential Fines and Energy Expenses

OPEN

Leaking / Blowing Steam	Increased Condensate Return Pressure Lowers Trap Capacity & Risks Water Hammer	More Energy Required Increased Boiler Load	Excessive Carbon Emissions for Increased Steam Production	Increased Steam Production	Potential Fines and Energy Expenses

NOTES

1) Excluded steam traps consist of those with inlet (or differential) pressures below 20 psi (1.5 bar). At low inlet pressures, the acoustic energy generated from steam & condensate passing through the orifice is very low and can be difficult to distinguish from background noise. For this reason, we remove these from being considered for real-time monitoring.

2) Napier's equation was used to estimate the flow through the steam trap orifice:

$$24.24 \times P_a \times D^2 \times F$$

P_a = Absolute Inlet Pressure (psi)
D = Orifice Diameter (inches)
F = Correction Factor (typically 62.5%) to statistically model blowing & leaking traps

3) Orifice size was estimated using statistical averages using inlet pressure & line size.

		Pressure @ Trap (psig)								
		20	25	50	75	100	125	150	200	250
Pipe Size	3/8	0.188	0.188	0.125	0.125	0.125	0.094	0.094	0.094	0.094
	1/2	0.250	0.250	0.188	0.156	0.156	0.125	0.125	0.094	0.094
	3/4	0.375	0.313	0.250	0.219	0.188	0.156	0.125	0.125	0.125
	1	0.500	0.438	0.344	0.313	0.281	0.250	0.219	0.188	0.188
	1 1/2	0.500	0.500	0.469	0.438	0.375	0.375	0.344	0.313	0.281
	1 3/4	0.500	0.500	0.500	0.469	0.438	0.438	0.375	0.344	0.344
	2	0.500	0.500	0.500	0.500	0.500	0.500	0.469	0.438	0.375

4) CO_2 losses were estimated using 85% boiler efficiency and the US EPA's 117.08lbm of CO_2 per million BTU estimate when using Natural Gas boiler fuel.

Global Headquarters
Emerson Process Management
6021 Innovation Blvd
Shakopee, MN 55379, USA
. 800 999 9307 or +1 952 906 8888
952 949 7001
FQ.RMD-RCC@EmersonProcess.com

North America Regional Office **Emerson Process Management**
8200 Market Blvd.
Chanhassen, MN 55317, USA
. 800 999 9307 or +1 952 906 8888
952 949 7001
/IT-NA.RCCRFQ@Emerson.com

Latin America Regional Office **Emerson Process Management** 1300 Concord Terrace, Suite 400 Sunrise, FL 33323, USA
+1 954 846 5030
1 954 846 5121
FQ.RMD-RCC@EmersonProcess.com

Europe Regional Office
Emerson Process Management Europe GmbH
Neuhofstrasse 19a P.O. Box 1046 CH 6340 Baar, Switzerland
41 (0) 41 768 6111
41 (0) 41 768 6300
FQ.RMD-RCC@EmersonProcess.com

Asia Pacific Regional Office
Emerson Process Management Asia Pacific Pte Ltd
1 Pandan Crescent
Singapore 128461
+65 6777 8211
+65 6777 0947
nquiries@AP.EmersonProcess.com

Middle East and Africa Regional Office **Emerson Process Management**
Emerson FZE
P.O. Box 17033, Jebel Ali Free Zone - South 2
Dubai, United Arab Emirates
971 4 8118100
971 4 8865465
FQ.RMTMEA@Emerson.com

EMERSON
Process Management