> Maximize Output With TraceBOOST™

TraceBOOST™ COMPARISON TO TUBE TRACING

EXECUTIVE SUMMARY

CSI performed the following case study for the engineering client. **TraceBOOST** and conventional steam tracing were compared for both economic and technical considerations. The piping lines considered are listed in Appendix 1 and 2. A complete list of assumptions is included in Appendix 3.

When all of the lines are considered, **TraceBOOST** offers a total savings in capital expenditures (CapEx) of over $1,196,000 USD for this system. Due to the more efficient thermal design, **TraceBOOST** requires 50% fewer steam circuits; this results in a steam savings of over $89,000 USD per year -primarily due to the reduced utility infrastructure. The long-term maintenance cost is also reduced as there are fewer components to maintain and repair.

Technical benefits of **TraceBOOST** over conventional steam tracing include:

- Improved heat transfer efficiency
- Reduced circuit count
- Reduced steam consumption
- Reduced maintenance

TECHNICAL CONSIDERATIONS

Heat Transfer Calculations

Heat transfer calculations are necessary to determine the effectiveness of steam tracing. Most tracing providers perform this analysis by first calculating the total heat loss from an un-traced pipe; the number of tracers is then specified to offset the calculated heat loss. The heat input from the tracers is calculated based on a pre-determined heat transfer coefficient between the tracer and the pipe. While this type of overall heat-balance calculation is typical of the tracing industry, it is inadequate because it does not assess the temperature distribution in the pipe wall. Rather, it assumes the pipe wall is at a uniform temperature, when, in reality, the pipe wall temperature varies depending on factors such as the heat transfer efficiency of the heating element, distance between heating elements, pipe material, pipe schedule, insulation thickness, and the process convection coefficient. In order to calculate an accurate bulk process temperature, CSI employs a finite-difference model of the piping/tracing system. This model calculates the heat transfer within the pipe wall itself and determines the resulting pipe wall temperature distribution. Using this model and the tracing specifications from the customer, CSI has generated Table 1 below which shows the predicted bulk process temperature maintained for each line size and insulation combination. Table 1 also lists the number of **TraceBOOST** elements required to maintain the process at or above this predicted bulk process temperature. The superior heat transfer efficiency of the **TraceBOOST** means that the performance of the tube tracers can be matched with fewer elements.

*Table 1: Comparison of **TraceBOOST** elements required versus conventional steam tracing*

Pipe Size	Insul. Thick.	Temp. Maint.	# of Tube Tracers	# of TraceBOOST
2”	35 mm	133°C	2	1 enhancer
2”	65 mm	145°C	2	1
2”	80 mm	149°C	2	1
3”	40 mm	131°C	2	1
3”	75 mm	137°C	2	1
4”	45 mm	124°C	2	1
4”	100 mm	136°C	2	1
6”	50 mm	113°C	2	1
6”	135 mm	134°C	2	1
8”	50 mm	122°C	3	1
8”	140 mm	141°C	3	1
10”	55 mm	116°C	3	1
10”	95 mm	127°C	3	1
12”	55 mm	123°C	4	2
12”	100 mm	134°C	4	1
14”	85 mm	132°C	4	2
18”	135 mm	132°C	4	1
20”	135 mm	132°C	4	1

Heat Transfer Efficiency

TraceBOOST has two significant advantages over conventional steam tracing in its fundamental design:

1. The geometry of the **TraceBOOST** cover
2. The use of heat transfer compound (HTC)

Conventional tube tracing only touches the piping intermittently and, when it does, makes contact with a small area. As a result, the majority of the heat transfer occurs through the air space surrounding the tube. As air is a generally poor conductor, the heat transfer between the tubing and the pipe is relatively low. In contrast, the **TraceBOOST** cover is formed to closely match the curvature of the pipe, as shown in Figure
1. **TraceBOOST** is also installed with heat transfer compound in order to provide a direct, conductive path between the **TraceBOOST** and the pipe. This significantly increases the overall heat transfer efficiency between the **TraceBOOST** and the pipe wall. As a result, the heat transfer efficiency is 4 to 8 times greater than that of conventional tube tracing. Consequently, a **TraceBOOST** system can achieve the same thermal objective with fewer elements than a conventional tube tracing system.

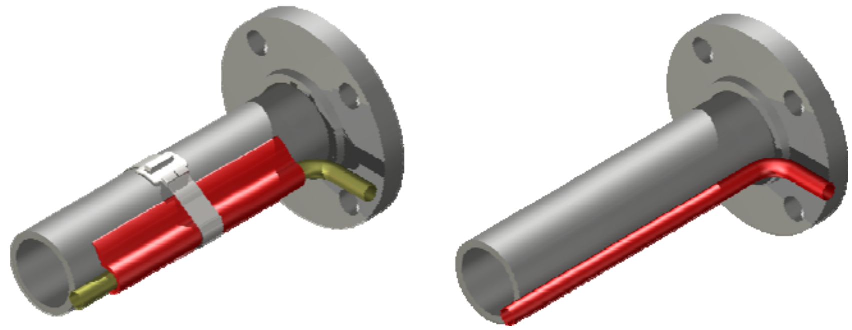

*Figure 1: To-scale drawing of **TraceBOOST** versus conventional steam tracing*

<u>Reduction of Circuits and Steam Consumption</u>

The reduction in the number of heating elements discussed above has a significant impact on the total circuit count and steam consumption of the heating system. Using less heating elements around the circumference of the pipe directly translates into fewer circuits required. Table 2 below shows that using a **TraceBOOST** system reduces the total number of circuits by over 50%. This reduction in circuit count means a reduction in the infrastructure required to operate a tracing system. Each circuit requires not only the tubing that heats the piping, but also a supply and return manifold tap, multiple isolation valves, supply and return tubing, a steam trap, strainer, and blow-down valve as well as various fittings and connections. By reducing the circuit count the cost and maintenance of all the associated infrastructure is reduced.

*Table 2: Comparison of circuit count for **TraceBOOST** versus conventional steam tracing*

	TraceBOOST	Tube Tracing	Δ
Circuit Count	322	768	4

The **TraceBOOST** elements themselves consume approximately the same amount of steam as a conventional steam tracing system that is sized to meet the same thermal objective, however the steam utility infrastructure also consumes a significant amount of steam which is often overlooked when evaluating heating solutions. Table 3 compares the steam consumption of the **TraceBOOST** and conventional steam tracing for all the lines in this project.

*Table 3: Comparison of steam consumption for **TraceBOOST** versus conventional steam tracing*

Steam Consumption	TraceBOOST (kg/hr)	Tube Tracing (kg/hr)	Δ (kg/hr)
Tracing	930	877	-53
Infrastructure	1,382	3,285	1,903
Total:	**2,312**	**4,162**	**1,850**

COMMERCIAL CONSIDERATIONS

TraceBOOST also offers significant capital expenditure savings over conventional steam tracing. Total savings in project capital expenditures for this case study is over $1,196,000 USD as shown in Table 4.

These CapEx costs include the total installed cost of the heating system, as well as the cost of the steam utilities infrastructure (including supply and return manifolds, isolation valves, supply and return tubing, steam traps, strainers, blow-down valves, various fittings and connections, and field labor). This savings might not be expected based on a comparison of the heating system alone; but, the increased infrastructure requirements of a conventional steam tracing system typically overshadow the reduced cost of the heating system itself. As previously discussed, **TraceBOOST**'s reduced infrastructure requirements result from its improved heat transfer and significant reduction in steam circuits (traps).

Table 4: CapEx cost comparison

TraceBOOST	Tube Tracing	Δ $
$ 1,397,964	$ 2,594,614	$ 1,196,650

The reduction in the number of steam circuits results in a lower overall steam consumption. This is because the additional equipment required to supply and return steam to each circuit (reference the list in the previous paragraph) has an associated significant heat load. The combined steam consumption of these items was found to be roughly 4.5 kg/hr for each circuit. CSI calculated the heat load of these items using the assumptions in Appendix 3. When both the tracing and the utility infrastructure are considered, **TraceBOOST** can save over $89,000 USD per year in steam cost, as shown in Table 5. Note that only the cost of steam utilization is considered in this comparison; the cost of maintenance for the additional steam circuits associated with the conventional steam tracing system has not been considered.

Table 4: OpEx cost comparison (25 years)

TraceBOOST	Tube Tracing	Δ $
$ 2,784,804	$ 5,013,129	$ 2,228,325

CONCLUSION

This study shows that over $1,196,000 USD can be saved in CapEx costs by choosing **TraceBOOST** instead of conventional steam tracing for the engineering client plant. Additionally, over $89,000 USD will be saved in energy cost each year due to the 1,850 kg/hr reduction in steam consumption. Over the last decade, superior operational performance and cost savings has allowed CSI products to gain acceptance in a wide spectrum of industries all over the world.

LIST OF APPENDICES AND ATTACHMENTS

More detailed information supporting the Executive Summary is included in the following appendices:

Appendix 1: CapEx cost break-down

Appendix 2: OpEx cost break-down

Appendix 3: General assumptions

APPENDIX 1: CapEx Cost Break-Down

Quote: 49393-00
Client: Confidential Client
Date: 29-May-14

Line Size (NPS)	Pipe Length (m)	Maint. Temp (°C)	Insul. Thick (mm)	Qty of hTT	Total hTT Length	Qty hTT Circuits	hTT Tracing Price	hTT Circuit Price	hTT Tracing Installation Cost	hTT System Price
2	810	100	35	2	1,620	54	$ 25,920	$ 135,000	$ 23,143	$ 184,063
2	1297	160	65	2	2,594	88	$ 41,504	$ 220,000	$ 37,057	$ 298,561
2	196	160	80	2	392	14	$ 6,272	$ 35,000	$ 5,600	$ 46,872
3	713	100	40	2	1,426	48	$ 22,816	$ 120,000	$ 20,371	$ 163,187
3	1210	160	75	2	2,420	82	$ 38,720	$ 205,000	$ 34,571	$ 278,291
4	415	100	45	2	830	28	$ 13,280	$ 70,000	$ 11,857	$ 95,137
4	1357	160	100	2	2,714	92	$ 43,424	$ 230,000	$ 38,771	$ 312,195
6	175	100	50	2	350	12	$ 5,600	$ 30,000	$ 5,000	$ 40,600
6	861	160	135	2	1,722	58	$ 27,552	$ 145,000	$ 24,600	$ 197,152
8	109	100	50	3	327	12	$ 5,232	$ 30,000	$ 4,671	$ 39,903
8	70	160	140	3	210	9	$ 3,360	$ 22,500	$ 3,000	$ 28,860
10	12	100	55	3	36	3	$ 576	$ 7,500	$ 514	$ 8,590
10	98	160	140	3	294	12	$ 4,704	$ 30,000	$ 4,200	$ 38,904
12	160	100	55	4	640	24	$ 10,240	$ 60,000	$ 9,143	$ 79,383
12	1182	160	100	4	4,728	160	$ 75,648	$ 400,000	$ 67,543	$ 543,191
14	51	160	85	4	204	8	$ 3,264	$ 20,000	$ 2,914	$ 26,178
18	164	160	135	4	656	24	$ 10,496	$ 60,000	$ 9,371	$ 79,867
20	278	160	135	4	1,112	40	$ 17,792	$ 100,000	$ 15,886	$ 133,678
	9,158				**22275**	**768**	**$ 356,400**	**$ 1,920,000**	**$ 318,214**	
									Total hTT System Price	**$ 2,594,614**

Notes:

1. Pricing compares traced scope 2" and above only.
2. Price per Meter of hTT includes tubing fittings ($12.50/m), and banding ($3.50/m).
3. Price per Meter of **TraceBOOST** includes tubing with tubing fittings ($12.50/m), **TraceBOOST** Enhancer ($27.88/m), and HTC with banding ($4.16/m).
4. Price per Circuit includes supply/return tubing, steam supply manifold port, condensate return manifold port, steam trap, isolation valves, and connections. Typical circuit price ranges from $2,500-$4,500.
5. Client hTT element coverage based upon client submitted hTT tracer specification.
6. All tubing is priced as 1/2" S/S. Total price savings would increase with copper tubing as the smallest client denoted copper tubing is twice (2x) the price of 1/2" S/S tubing.

Qty of TraceBOOST	Total TraceBOOST Length	Qty TraceBOOST Circuits	TraceBOOST Tracing Price	TraceBOOST Circuit Price	TraceBOOST Tracing Installation Cost	TraceBOOST System Price
1	810	27	$ 36,077	$ 67,500	$ 15,188	$ 118,765
1	1,297	44	$ 57,768	$ 110,000	$ 24,319	$ 192,087
1	196	7	$ 8,730	$ 17,500	$ 3,675	$ 29,905
1	713	24	$ 31,757	$ 60,000	$ 13,369	$ 105,126
1	1,210	41	$ 53,893	$ 102,500	$ 22,688	$ 179,081
1	415	14	$ 18,484	$ 35,000	$ 7,781	$ 61,265
1	1,357	46	$ 60,441	$ 115,000	$ 25,444	$ 200,885
1	175	6	$ 7,795	$ 15,000	$ 3,281	$ 26,076
1	861	29	$ 38,349	$ 72,500	$ 16,144	$ 126,993
1	109	4	$ 4,855	$ 10,000	$ 2,044	$ 16,899
1	70	3	$ 3,118	$ 7,500	$ 1,313	$ 11,930
1	12	1	$ 534	$ 2,500	$ 225	$ 3,259
1	98	4	$ 4,365	$ 10,000	$ 1,838	$ 16,202
2	320	12	$ 14,253	$ 30,000	$ 6,000	$ 50,253
1	1,182	40	$ 52,646	$ 100,000	$ 22,163	$ 174,809
2	102	4	$ 4,543	$ 10,000	$ 1,913	$ 16,456
1	164	6	$ 7,305	$ 15,000	$ 3,075	$ 25,380
1	278	10	$ 12,382	$ 25,000	$ 5,213	$ 42,595
	9,369	**322**	**$ 417,295**	**$ 805,000**	**$ 175,669**	
					Total TraceBOOST System Price	**$ 1,397,964**

Pricing Conditions / Assumptions	
30 m	= Maximum Circuit Length
$16.00	= Price per Meter of hTT
$44.54	= Price per Meter of TraceBoost
2.1 m / hr	= hTT Installation Rate
1.6 m / hr	= TraceBoost Installation Rate
$30 / hr	= Labor Rate
$2,500.00	= Price per Circuit

APPENDIX 2: OpEx Cost Break-Down

Quote:	**49393-00**					
Client:	**Confidential Client**					
Date:	**30-May-14**					

Technology	Trace Steam Consumption (kg/hr)	Infrastructure Steam Consumption (kg/hr)	Total Steam Consumption (kg/hr)	Total Steam Consumption (kg/yr)	Price for Steam (1 Year)	Price for Steam (25 Years)
TraceBOOST	930	1,382	2,312	20,253,120	$ 111,392	$ 2,784,800
Tube Tracing	877	3,285	4,162	36,459,120	$ 200,525	$ 5,013,129
			Price Savings w/ TraceBOOST		**$ 89,133**	**$ 2,228,325**

Pricing Conditions / Assumptions	
$5.50 / 1000 kg	= Cost of Steam

APPENDIX 3: General Assumptions

Pipe Configuration

1. Pipe sizes and lengths are as shown in Appendix 1 and 2.
2. Insulation is mineral wool, thickness as listed in Appendix 1 and 2.
3. Insulation is applied to all piping, fittings, in-line valves and components, flanges, supports, etc.
4. All process piping is schedule STD carbon steel.

Temperatures

1. Ambient design conditions are 0°C with a 40 kph wind.
2. Process enters the piping system at or above the maintenance temperature.
3. The process design flowrate is no-flow (worst case).

Heating System

1. Heating medium is 0.8 MPag (116 psig) saturated steam.
2. The cost of steam is $5.50 per 1000 kg.
3. **TraceBOOST** elements utilize 12 mm OD tubing installed with heat transfer compound within the **TraceBOOST** cover.
4. Conventional steam tracing features 12 mm OD tubing without heat transfer compound.
5. **TraceBOOST** and tube tracing average circuit length is 30 m.

Infrastructure

1. Each circuit requires an independent steam supply port and condensate return port.
2. Each circuit supply and return consists of a supply/return port on the supply/return manifold, isolation valves, supply/return tubing, a steam trap, a strainers, a blow-down valve, and various fittings and connections.
3. Each **TraceBOOST** is supplied and returned with 25 m (50 m total per circuit) of 12 mm OD pre-insulated tubing.
4. Each conventional steam trace circuit is supplied and returned with 25 m (50 m total per circuit) of 12 mm OD pre-insulated tubing.
5. Cost of all material and labor is as listed in Appendix 1.

Other Note for Consideration

1. CSI has currently not included documentation (above CSI standard) for painting, valve jacketing, export packing, insulation, or other NDE which is non-standard in the scope of this study. These can be evaluated and priced at a later date, once a more formal quotation is completed.

12201 Nations Ford Road
Pineville, North Carolina • USA
sales@csiheat.com / www.csiheat.com

1900 Crystal Industrial Court
St. Louis, Missouri • USA
obrien.sales@ametek.com / www.obcorp.com