GTI ENERGY

solutions that transform

REPORT

GTI ENERGY PROJECT NUMBER 21279.7.32 & 22662

Venturi Steam Trap – Field Evaluation Study

Reporting Period:

August 2019 through June 2023

Report Issued:

July 17, 2024

Prepared For:

The Peoples Gas and North Shore Gas Energy Efficiency Programs

GTI Energy Technical Contact:

Hardik Shah,

hshah@gti.energy

Arjun Thirumaran

athirumaran@gti.energy

GTI Energy

1700 S. Mount Prospect Rd.

Des Plaines, Illinois 60018

www.gti.energy

Signature Page

Print or typed First M. Last	***Signature***	***Date***
AUTHOR:		
ARJUN THIRUMARAN		10/24/2023
	Title: ENGINEER	
REVIEWED BY:		
HARDIK SHAH		07/10/2024
	Title: Manager, Technical Programs	

Legal Notice

GTI Energy prepared this information for Nicor Gas and Peoples Gas and North Shore Gas (Collectively, "Sponsors").

Neither GTI Energy, the members of GTI Energy, the Sponsor(s), nor any person acting on behalf of any of them:

a. Makes any warranty or representation, express or implied with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights. Inasmuch as this project is experimental in nature, the technical information, results, or conclusions cannot be predicted. Conclusions and analysis of results by GTI Energy represent GTI Energy's opinion based on inferences from measurements and empirical relationships, which inferences and assumptions are not infallible, and with respect to which competent specialists may differ.

b. Assumes any liability with respect to the use of, or for any and all damages resulting from the use of, any information, apparatus, method, or process disclosed in this report; any other use of, or reliance on, this report by any third party is at the third party's sole risk.

c. The results within this report relate only to the items tested.

Table of Contents

Table of Figures

List of Tables

Abstract

This study focused on an extensive evaluation of the Venturi steam traps in field applications to validate their performance and effective useful life.

GTI Energy had previously performed a laboratory study and evaluated the performance of Venturi steam traps. Through the functional laboratory study of Venturi steam traps[1] completed in 2019, it was demonstrated that Venturi steam traps have the ability to discharge varying condensate loads safely across a range of steam pressures, in line with industry requirements, comparable to that of traditional steam traps.[2] Thus it was established that Venturi steam trap technology has the potential to reduce steam waste though lower failure rates, compared to traditional steam traps.

This field evaluation study further validated the Venturi steam trap performance in real-world applications through field installations and in-depth feedback from end-users.

Background on Steam Traps

Steam traps are defined as "self-contained valves which automatically drain the condensate from steam containing enclosure while remaining tight to live steam, or if necessary, allowing steam to flow at a controlled or adjusted rate. Most steam traps will also pass non-condensable gases while remaining tight to live steam." [3]

The performance and safe operation of the steam system is dependent on effective removal of condensate from the system. A steam trap can fail in an open or closed position. If a steam trap is failed-open, steam is lost through the trap, and this reduces the capacity of the heating system. If a steam trap fails-closed, it leads to condensate buildup in the steam system. If the condensate is not removed from the system, it reduces the flow capacity of steam lines and the thermal capacity and efficiency of the end-use heat transfer equipment. In addition, excess condensate can lead to "water hammers," with potentially destructive and dangerous results.

Traditional steam traps like Mechanical, Thermostatic, and Thermodynamic steam traps utilize moving parts to remove condensate from the steam system, and they have an effective useful life of 6 years[4] with an annual failure rate of 8% to 17%.[5]

Venturi steam traps consist of an orifice and a fixed port Venturi nozzle. A Venturi is a piece of narrow tube between wider sections, so named because it creates the Venturi effect where the velocity of a fluid passing through it increases as the cross-sectional area decreases, with the static pressure correspondingly decreasing. Fluid condensate accelerates to pass through the orifice and

[1] Venturi Steam Trap – Functional Laboratory study by GTI Energy for Nicor Gas, Peoples Gas and North Shore Gas, and SoCal Gas, 2019.

[2] Traditional steam traps include inverted bucket traps, float and thermostatic steam traps and thermodynamic disc traps.

[3] The American National Standards Institute (ANSI) definition for a Steam Trap.

[4] Illinois Statewide Technical Reference Manual Version 11.0 – 4.4.16 Steam Trap Replacement or Repair.

[5] Venturi Steam Trap Market Characterization by Resource Innovations for Nicor Gas, 2022.

drops in pressure, partially filling the orifice with condensate. Flash steam, which is produced from saturated water under decreasing pressure in the Venturi, expands in volume to limit the amount of fluid that may subsequently discharge through the orifice. Steam flash is the thermodynamic phenomenon that prevents substantial amounts of steam from leaking out of the trap when the orifice is not full of condensate. In the event an orifice is occupied by less than 68% condensate,[6] a small amount of steam will pass through the orifice. When steam passes through a Venturi orifice, the back pressure created by the flash steam will prevent steam from escaping the piping system but will allow the release of condensate.

Due to the Venturi nozzle design, Venturi steam traps can self-regulate a pre-determined range of condensate loads based on their sizing. Because Venturi steam traps do not have any moving parts, they have lower failure rates and longer effective useful life compared to traditional steam traps.

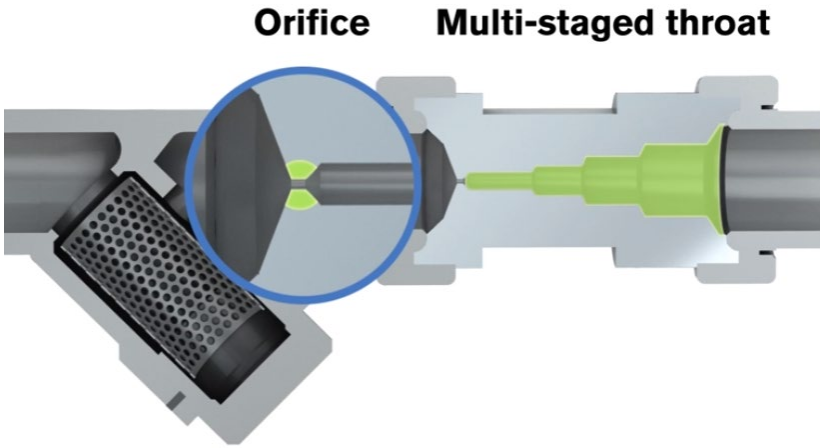


Figure 1. Venturi Steam Trap

[6] Venturi Steam Trap – Functional Laboratory study by GTI Energy for Nicor Gas, Peoples Gas and North Shore Gas, and SoCal Gas, March 26, 2019.

Executive Summary

As a part of this study to evaluate Venturi steam traps in real-life field applications, GTI Energy undertook a two-faceted approach.

1. Sizing and selection of Venturi steam traps
2. Evaluation of effective useful life

Venturi steam traps sold by two different manufacturers were planned and installed at 4 different sites in Illinois during the years 2019 and 2020. Pre-installation inspections were performed by the respective Venturi steam trap manufacturer in all site locations. Infra-red thermal imaging analysis was performed on the existing steam traps to examine their existing conditions and performance. Applicable existing steam traps were selected and replaced with properly sized Venturi steam traps based on the pre-installation inspection results, which included but was not limited to, existing steam trap operating conditions, performance, and type of application. Refer to Appendix A for detailed information from one of the field installations. All the Venturi steam traps installed at field sites as a part of this study were commissioned to work properly as per their design intent.

To evaluate the performance and effective useful life of Venturi steam traps in the field, a detailed questionnaire requesting information on the existing steam system, steam traps, and specifically Venturi steam traps, was developed for a end-user in-depth survey. More detailed information on the survey is provided in Appendix B. End-user survey responses were compiled and summarized to establish preferred application types, effective useful life, and sizing and selection procedures for Venturi steam traps.

Results

Field installations and end-user surveys illustrated that Venturi steam trap technology is well suited for steam systems with non-fluctuating or low-fluctuating condensate loads, which are commonly found in industrial and large commercial buildings. It was also established that Venturi steam traps, properly sized for an operating range of line pressures and condensate loads, provided optimal performance.

Based on information from over 1,000 fully functional Venturi steam traps in the field, an effective useful life of 20 years is established.

Introduction

Methodology

This study validated the performance and effective useful life of Venturi steam traps through installation and evaluation in actual field applications. Building on the laboratory study,[7] the field evaluation focused on:

1) Right-sizing and selection of Venturi steam traps to demonstrate their successful implementation, including identification of preferred built-environments, desirable target application types, and removal of any potential barriers.
2) Effective useful life validation through an end-user in-depth survey to establish the increased useful life of Venturi steam trap technology.

Right-Sizing and Selection of Venturi Steam Traps

Venturi steam trap technology was installed in four different field sites in Illinois from 2019 through 2020. Table 1 lists the field sites, quantity of steam traps inspected, and quantity of Venturi steam traps installed as part of this study.

Table 1. Venturi Steam Trap Field Installations

Facility Name	Built-Environment type	Quantity of Steam traps examined	Quantity of Venturi steam traps installed	Venturi steam trap manufacturer
Site 1, Bridgeview, IL	Food Processing Plant	41	33	Vendor # 1
Site 2*, Chicago, IL	Laundromat	30	30	Vendor # 2
Site 3, Chicago, IL	Laundromat	13	13	Vendor # 2
Site 4, Chicago, IL	Laundromat	18	18	Vendor # 2
*Facility went out of business during the study, and the state of the Venturi steam traps installed in that facility was therefore inconclusive.				

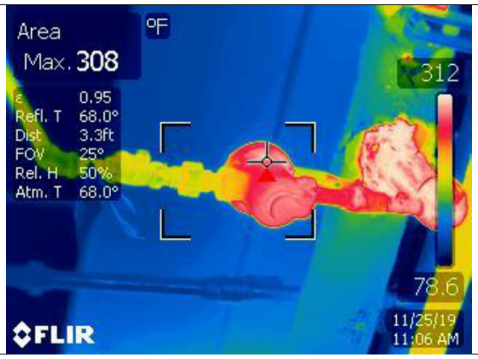
As a first step toward the installation of Venturi steam traps, the respective manufacturer performed a facility inspection that included, but was not limited to, recording the following information:

i. Existing steam trap type, location, and end-use application.
ii. Steam system pressure.
iii. Temperature at the inlet, outlet of the traps, and ambient temperature around the trap.
iv. Piping information – materials, lengths, and surface areas.
v. Heat exchanger capacities.

[7] Venturi Steam Trap – Functional Laboratory study by GTI Energy for Nicor Gas, Peoples Gas and North Shore Gas, and SoCal Gas, March 26, 2019.

Based on the above information and other application specific factors, the respective manufacturer estimated the condensate load for each trap based on engineering calculations,[8] and this information is utilized for sizing Venturi steam traps. Temperature measurements were collected through infrared thermal imaging. Figure 2 shows a snapshot of the thermal imaging result. The temperature differential between the inlet and outlet of the steam traps was also utilized to identify failed and unused traps. After assessment of all potential existing steam traps, traps with preferred application types with non-fluctuating condensate loads were selected for Venturi steam trap replacement.

Refer to Appendix A for attachments containing detailed information from field installations.



psig: 100 / IR: 2641	**Trap Type:** 1/2" IB AG 890 / **Application:** DRIP	
Location: MAIN HEADER, **SG Tag #1**	**Inlet Temperature**	**Outlet Temperature**
Temperature (°F):	314°F	200°F
ΔT (°F):	114°F	
Conclusion:	OK	

Figure 2. Pre-Installation Inspection Report by Vendor # 2

All Venturi steam traps were selected, engineered, and sized by the respective manufacturer based on pre-installation inspection results, drawing on their industry knowledge and subject matter expertise. Figure 3 shows the successful installation of a Venturi steam trap as part of this study.

[8] Based on pre-installation site assessment, Venturi steam trap manufacturer's technical team performed condensate load sizing engineering calculations unique to each application type. The following reference outlines general procedures and guidelines for estimating the condensate load in different steam applications.
Steam conservation guidelines for condensate drainage by Armstrong.
https://www.armstronginternational.com/wp-content/uploads/Broch_SteamConservationGuidelines_P101D_EN_20-20190501.pdf

Figure 3. Venturi Steam Trap Installed

All Venturi steam traps installed as a part of this study were commissioned to work properly to further validate the sizing and selection considerations for different applications. Positive feedback was received from the food processing facility and two laundromat facilities that their Venturi steam traps were fully operational as of 2023. One of the three laundromat facilities went out of business during the study, and the state of the Venturi steam traps in that facility was therefore inconclusive.

It was recommended by both manufacturers to have a strainer and blowdown valve, or a drip-leg, included upstream of the Venturi nozzle to clean and remove the dirt and scale buildup over time.

Validation of Effective Useful life

Effective useful life is defined as the duration that an equipment is expected to be in normal safe operation as per its original design specification. It is validated based on the technical lifetime as indicated by the manufacturers and an estimate of the median number of years based on actively functioning equipment currently in place.

Venturi steam trap vendors have indicated that their traps have been in operation for over 20 years.[9] A detailed end-user survey requesting in-depth information regarding their steam system, steam traps, and specifically Venturi steam traps, was created and shared with personnel in charge of facilities with long-standing, functional Venturi steam traps.

In addition to the survey, performance validation conducted by Venturi steam trap manufacturer Vendor #2 on existing functional traps in field was also analyzed as a part of the study, with results presented in Table 2.

[9] Venturi Steam Trap – Functional Laboratory study by GTI Energy for Nicor Gas, Peoples Gas and North Shore Gas, and SoCal Gas, March 26, 2019.

Table 2. Long-lasting Active Venturi Steam Traps in the Field

Facility Name	Built-Environment type	Year of Installation	Quantity of Venturi Steam Traps (Currently active)	Life (Years)	Notes
University 1, Philadelphia, PA	University	2000	500	23	Feedback from facility as of 2023
		2002	500	21	
		2006	200	17	
University 2, Bethesda, MD	University	2010	60	13	Feedback from facility as of 2023
University 3, New York, NY	University	2005	50	18	Feedback from facility as of 2023
Hospital 1, Chicago, IL	Hospital	1989	21	31	Performance validation completed in 2020 (Vendor 2)
Industrial 1, Channahon, IL	Food Processing Plant	2019	176	4	Feedback from facility as of 2023

Based on end-user survey responses from industrial and large commercial facilities, Venturi steam traps have been preferred in applications with steady, non-fluctuating condensate loads. It was determined that over 1,000 Venturi steam traps have been fully operational for over 20 years, with several more on track to last that long as well.

From a sample size of over 2,500 Venturi steam traps, it was determined that their annual failure rate was 1% or lower, as shown in Table 3. Lower failure rates of Venturi steam traps were attributed to the absence of moving parts. The primary reason for their failure was mainly attributed to a clogged strainer leading to the orifice, which can be significantly reduced through regular maintenance as outlined in the key findings section.

Feedback also validated lower maintenance requirements for Venturi steam traps compared to traditional steam traps, which contributed to reduced maintenance costs, including labor and time. Further information on the end-user survey is detailed in Appendix B.

Table 3. Venturi Steam Traps – Annual Failure Rate from In-depth Survey

Facility Name	Built-Environment type	Total active Venturi Steam Traps	Annual failure rate
University 1, Philadelphia, PA	University	1222	1% or less
University 2, Bethesda, MD	University	225	1% or less
University 3, New York, NY	University	1239	1% or less
Industrial 1, Channahon, IL	Food Processing Plant	176	0%

To validate the performance of Venturi steam traps installed in 1989, infrared thermal imaging was performed at the Hospital in Chicago, where it was found that 21 Venturi steam traps were functional at the time. Figure 4 shows the Venturi steam trap on the left and thermal imaging on the right. The difference in temperatures between the inlet and outlet of the steam traps was analyzed by the manufacturer to validate the trap's functionality.

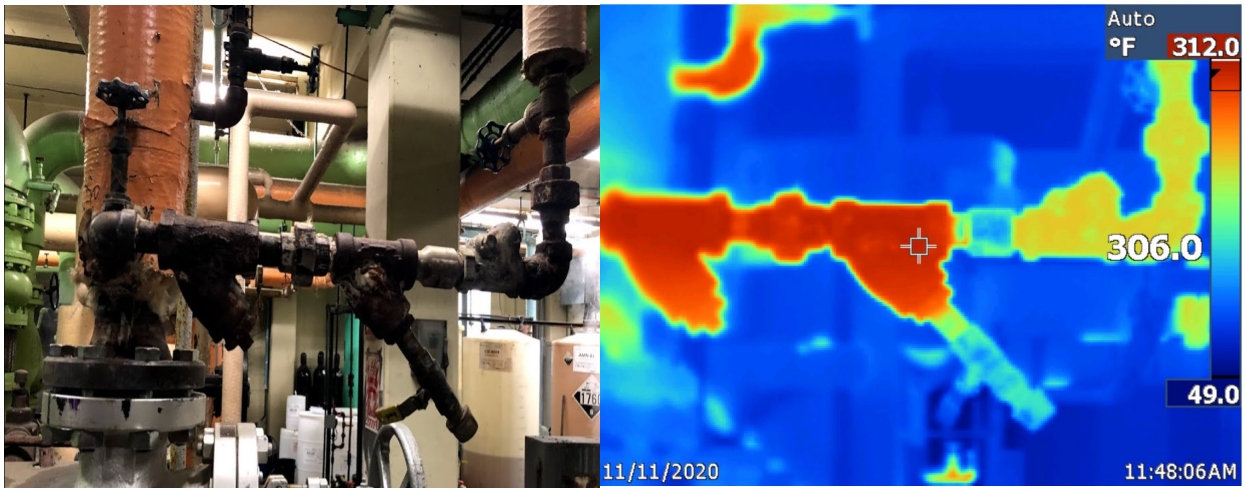


Figure 4. Venturi Steam Trap Performance Validation Using Thermal Imaging

While validating effective useful life, end-user application preferences, challenges, maintenance procedures and recommendations were also recorded as part of the study**.** It was determined that the Venturi steam trap technology is suited for drip-leg, process heating heat exchanger, and other applications with non-fluctuating condensate loads. It was also discovered that it can remain in effective operation for over 20 years, if appropriately sized for a target condensate load and operating pressure, combined with regular cleaning/blowdown of the strainer per manufacturer's recommendation.

Key Findings

Application

Venturi steam traps need to be sized appropriately for target condensate loads and operating pressures, which makes them best suited for steam systems with non-fluctuating loads and steady continuous operation that are typically found in industrial and large commercial facilities. Within these facilities, non-fluctuating condensate loads can be found in drip-leg and certain process heat exchanger applications, and these are preferred locations for Venturi steam traps.

Highly fluctuating condensate load applications like face and bypass coils in space heating applications and other modulating loads pose a significant constraint in Venturi steam trap sizing and thus are not considered a good fit. Table 4 summarizes facility types with target applications and applications to be avoided.

Table 4. Venturi Stem Trap – Target Built Environments

Preferred Built Environments	Target Applications	Applications to avoid
Food processing facilities	Drip-leg, process heating heat exchanger and other applications with nonfluctuating condensate loads. Steam applications with stable 24x7 operation are preferred for Venturi steam traps.	Steam radiator heating applications, face and by-pass space heating heat exchanger applications, and other applications with highly fluctuating condensate loads.
Laundromats		
Hospitals		
Manufacturing facilities		
Pharmaceutical facilities		
Research Laboratories		
Universities		
Other Industrial facilities		

While Venturi steam traps are recommended to be engineered for specific target pressures and condensate loads for their effective performance, the function laboratory study[10] demonstrated that even when testing outside the specified operational range of the Venturi orifice traps, they were found to operate effectively, discharging condensate with measured steam loss values comparable to mechanical steam traps, within experimental error. The direct effects on the performance of Venturi steam traps under fluctuating condensate loads and pressures were not analyzed as a part of this field evaluation study. However, consultation with the manufacturer is recommended to determine if the operating parameters are suitable for the Venturi steam traps.

[10] Venturi Steam Trap – Functional Laboratory study by GTI Energy for Nicor Gas, Peoples Gas and North Shore Gas, and SoCal Gas, March 26, 2019.

Installation and Maintenance

The Venturi steam trap installation process involves pre-installation site assessment performed by a vendor technical representative. Based on assessment results and engineering analysis, a technical proposal to replace existing steam traps will be provided by the manufacturer, which will include sizing and selection of Venturi steam traps for each application. Flushing of the existing steam pipe system is recommended before the installation of Venturi steam traps in a facility, to clear out all the scale and debris from the piping system.

Regular maintenance involves periodic cleaning or blowdown of strainers upstream of the Venturi steam traps. Vendor 1 recommends maintenance on an annual basis while Vendor 2's maintenance frequency recommendation is based on the requirements of each facility. Consultation with the respective Venturi steam trap manufacturers is recommended.

Venturi steam traps cost roughly 1.5 to 3 times more than the cost of a traditional steam trap depending on the manufacturer and application type. Once the Venturi steam traps are installed, they require very minimal maintenance compared to a traditional steam trap. As Venturi steam trap technology matures in the marketplace, the cost premium is expected to decrease. Even with an increased premium cost, Venturi steam traps have the potential for an effective payback due to their increased useful life of 20 years and their capability to limit steam loss from the system.

Results and Discussions

As a part of this field evaluation, Venturi steam traps were appropriately sized and installed in multiple built environments for different applications, and all the traps were observed to be fully operational as per their design intention. This validated the sizing and selection procedure of Venturi steam traps for different applications to facilitate effective functioning of the technology.

Sizing and selection procedure involved pre-installation site assessment and engineering input from the respective manufacturer to identify potential applications and to implement rightsizing of Venturi steam traps.

The effective useful life of the Venturi steam trap technology is evaluated to be 20 years, based on in-depth end-user feedback and completed field assessments. That span might vary depending on the operating conditions of the facility where they are installed. It was also determined that Venturi steam traps have an annual failure rate of 1% or lower and that failures are mainly caused by dirty strainers which led to clogging of the trap orifice. Hence, cleaning the strainer to remove accumulated particulates, on an annual, a bi-annual basis, or as otherwise recommended by the manufacturer, would help protect the life span of the Venturi traps

Conclusions

Benefits

The field evaluations demonstrated that Venturi steam traps can discharge condensate loads safely for specifically engineered applications and that their performance is comparable to a traditional steam trap.

Benefits through the Venturi steam trap technology are derived from:

Increased useful life

Traditional steam traps including inverted bucket traps, float and thermostatic traps, and thermodynamic disc traps have a useful life[11] ranging from 1 to 7 years. The longer useful life of 20 years for Venturi steam traps will facilitate a way for effective payback when appropriately sized for a target application.

Lower failure rate

Energy losses from steam traps are caused by leakage of steam through failed open traps. Venturi steam traps have an annual failure rate of 1% or lower compared to traditional steam traps with an annual failure rate of 8-17%.[12] This lower failure rate promotes minimization of energy losses through undetected failed traps.

Lower Maintenance

Lower failure rates also facilitate reduced maintenance requirements. Maintenance of Venturi steam traps only involves blowdown or cleaning of the dirty strainer on an annual or bi-annual basis, as recommended by the manufacturer.

Energy savings

Energy lost through a failed open steam trap can be estimated as per Table 5[13] below. Since facilities usually test and replace failed steam traps as necessary based on their maintenance schedule, all failed-open steam traps continuously contribute to energy loss throughout the year. The amount of energy lost will depend on the size of the leak, steam system pressure, annual operating hours, and maintenance/replacement schedule of the facility.

As noted above, traditional steam traps have an annual failure rate of 8-17% compared to less than 1% for Venturi steam traps, when appropriately sized and maintained.

Table 5. Leaking Steam Trap – Energy Loss Estimate

Leak Orifice Diameter (inches)	Steam Loss (lb/hr)			
	Steam pressure (psig)			
	15	100	150	300
1/32	0.85	3.3	4.8	-
1/16	3.4	13.2	18.9	36.2
1/8	13.7	52.8	75.8	145

[11] Venturi Steam Trap – Functional Laboratory study by GTI Energy for Nicor Gas, Peoples Gas and North Shore Gas, and SoCal Gas, March 26, 2019.

[12] "Steam Traps." Review and Acceptance. Workpaper. T. DeCarlo and E. Kirchhoff. Energy and Environmental Analysis, Inc.; Southern California Gas. December 2006.

[13] A U.S. Department of Energy sourcebook on Improving steam system performance, Appendix B: Steam tip sheets, provides an estimate for steam loss through different leak orifices at different pressures. https://www.nrel.gov/docs/fy02osti/31797.pdf

3/16	30.7	119	170	326
1/4	54.7	211	303	579
3/8	123	475	682	1,303

For a facility operating with saturated steam with continuous annual operation for 8,760 hours, a failed open trap at 100 psig pressure differential with an 1/8-inch leak, annual steam loss equates to 5,500 therms at just one failed trap without factoring in system and transmission losses. Thus, Venturi steam traps provide a substantial opportunity for facilities to reduce energy losses from the failed open traps.

Next Steps and Recommendations

Venturi steam trap technology presents an opportunity for energy savings in industrial and large commercial facilities, such as hospitals, laundromats, manufacturing plants, universities, and other facilities with non-fluctuating condensate load applications. Utilities' Emerging Technology Program (ETP) teams should aim to utilize the findings of this evaluation to facilitate a path forward for the Venturi steam trap technology to energy efficiency offerings.

References

Venturi Steam Trap – Functional Laboratory study by GTI Energy for Nicor Gas, Peoples Gas and North Shore Gas, and SoCal Gas, 2019.

The American National Standards Institute (ANSI) definition for a Steam Trap.

Illinois Statewide Technical Reference Manual Version 11.0 – 4.4.16 Steam Trap Replacement or Repair.

Venturi Steam Trap Market Characterization by Resource Innovations for Nicor Gas, 2022.

Steam system evaluation of Bunge Loders Croklaan by Steamgard for Crowley Carbon, Dallas TX, April 22, 2019.

"Steam Traps." Review and Acceptance. Workpaper. T. DeCarlo and E. Kirchhoff. Energy and Environmental Analysis, Inc.; Southern California Gas. December 2006.

Appendix A: Field Installation Assessment attachments

The pre-installation assessment report included application type and location, existing steam trap information, inlet and outlet temperatures and pressures, and engineered Venturi steam trap information applicable for each case. Table 5 shows sample pre-installation assessment information from one of the field installations.

Table 6. Pre-Installation Assessment Information for the Site: Site 2

Location (Application)	Elevation	Existing Steam Trap Information						Venturi Steam Trap Information – Selected for this application		Notes
		Size	Type	Temp		Pressure		Size	Mfg and Model	
				Tin	Tout	Pin	Pout			
	ft	inches		°F	°F	psig	psig	inches		
Main Header (Drip-leg)	10	½	IB	314	200	100	1 ft lift; Rtank	½	SG HA	IR: 2641/2642
Presses	1	½	IB	313	205	90	Rtank	½	SG HA	IR:2645/2646
Dryer	1	½	IB	77	70	90	10 ft lift	½	SG HA	(2) Check valves after steam trap; Steam trap is failed closed; IR 2697/2698

Notes

1) IB refers to an Inverted bucket trap.
2) Rtank refers to receiver tank.
3) IR refers to infra-red thermal imaging result identification number.

Figures 5, 6 and 7 are infrared thermal imaging results from pre-installation assessment of steam traps listed in Table 5. Figure 5 shows an existing steam trap in a drip-leg application while Figures 6 and 7 represent existing steam traps in a press station and dryer application, respectively. Based on assessment results, existing operating conditions of the steam trap are examined and are utilized for engineering sizing of Venturi steam traps for each application.

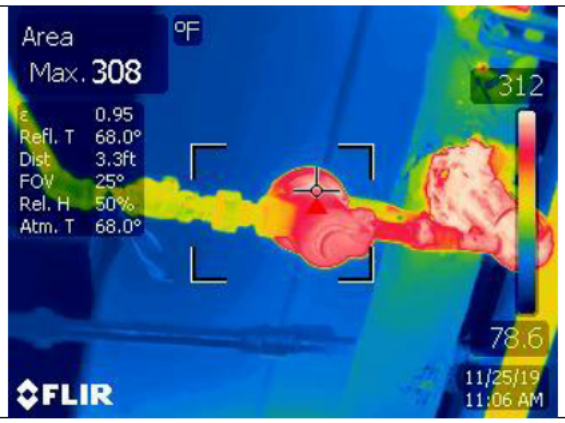
<table>
<tr><td>  </td><td colspan="2"> 
</td></tr>
<tr><td>psig: 100 / IR: 2641</td><td colspan="2">Trap Type: 1/2" IB AG 890 / Application: DRIP</td></tr>
<tr><td>Location: MAIN HEADER, SG Tag #1</td><td>Inlet Temperature</td><td>Outlet Temperature</td></tr>
<tr><td>Temperature (°F):</td><td>314°F</td><td>200°F</td></tr>
<tr><td>ΔT (°F):</td><td colspan="2">114°F</td></tr>
<tr><td>Conclusion:</td><td colspan="2">OK</td></tr>
</table>

Figure 5. Existing Steam Trap Performance Validation Using Thermal Imaging: Drip Leg

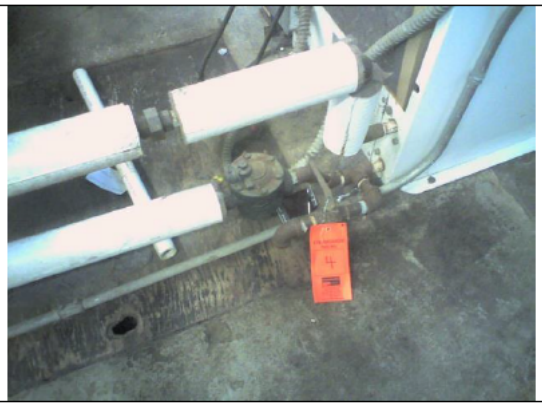
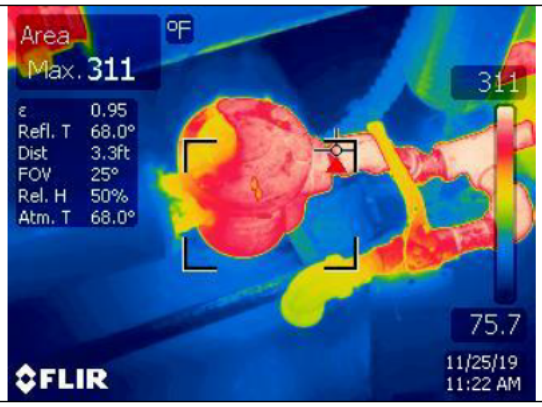
<table>
<tr><td>  </td><td colspan="2"> 
</td></tr>
<tr><td>psig: 100 / IR: 2645</td><td colspan="2">Trap Type: 1/2" IB AG 890 / Application: PRESS</td></tr>
<tr><td>Location: PRESS STATION, SG Tag #4</td><td>Inlet Temperature</td><td>Outlet Temperature</td></tr>
<tr><td>Temperature (°F):</td><td>313°F</td><td>205°F</td></tr>
<tr><td>ΔT (°F):</td><td colspan="2">108°F</td></tr>
<tr><td>Conclusion:</td><td colspan="2">OK</td></tr>
</table>

Figure 6. Existing Steam Trap Performance Validation Using Thermal Imaging: Press Station

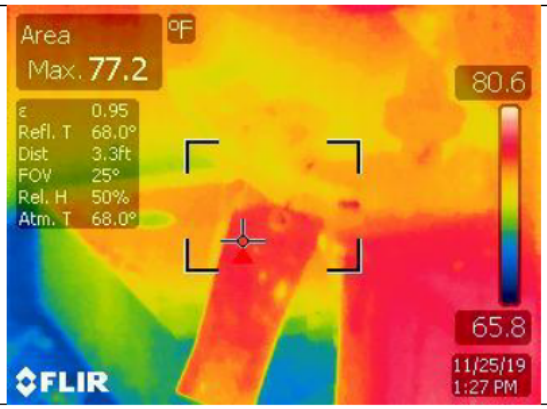
<table>
<tr><td>  </td><td colspan="2"> 
</td></tr>
<tr><td>psig: 100 / IR: 2697</td><td colspan="2">Trap Type: 1/2" TS TRAP / Application: DRYER</td></tr>
<tr><td>Location: DRYER, SG Tag #30</td><td>Inlet Temperature</td><td>Outlet Temperature</td></tr>
<tr><td>Temperature (°F):</td><td>77°F</td><td>70°F (10FT LIFT)</td></tr>
<tr><td>ΔT (°F):</td><td colspan="2">7°F</td></tr>
<tr><td>Conclusion:</td><td colspan="2">FAILED CLOSED (2 CHECK VALVES AFTER TS TRAP)</td></tr>
</table>

Figure 7. Existing Steam Trap Performance Validation Using Thermal Imaging: Dryer

Appendix B: Effective useful life evaluation attachments

Site Assessments

120 Venturi steam traps were installed in Hospital in Chicago, IL, in the year 1989. A site assessment was performed as a part of the study in 2020 to validate the performance of the traps. Figures 4 and 8 show the infrared thermal imaging results from the traps.

Figure 8. Venturi Steam Trap Performance Validation Using Thermal Imaging

During the assessment, it was determined that only 21 Venturi steam traps were in accessible locations and all 21 traps were still operational based on evaluation.

End-user Survey

Figure 9 shows a snapshot of the in-depth end-user survey, and a weblink is provided below. The survey link is still online, and responses are being collected as of June 2023. Table 6 contains some responses. This information was utilized to establish and validate the 20-year effective useful life for the Venturi steam trap technology.

It should be noted that the failure of Venturi steam traps was primarily due to clogged orifices with dirty strainers. Once a clogged orifice is identified, debris clog can be cleaned to put the Venturi steam traps back into effective operation, instead of fully replacing the trap.

Survey Web link: https://forms.office.com/r/r6Jg3JCmYw

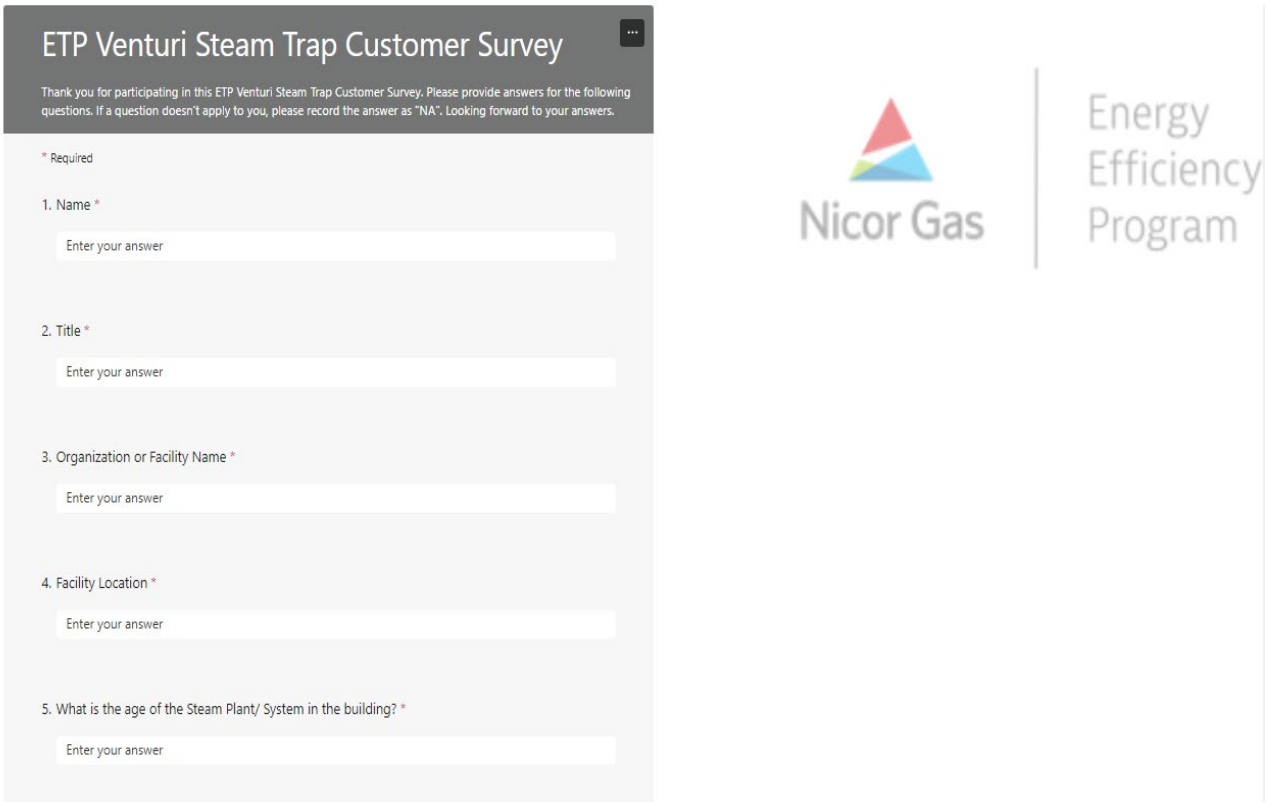


Figure 9. Snapshot of Venturi Steam Trap In-depth End-user Survey

END OF REPORT