Compressed Gas Leak Detection Report

Swagelok Customer

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Anywhere, USA

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Swagelok

SWAGELOK® COMPRESSED GAS LEAK DETECTION SERVICES

Swagelok Compressed Gas Leak Detection Services is a program offered by Swagelok and its global distributor network in which we use our industry expertise in fluid system design to help improve compressed gas performance at your facility.

A Swagelok Compressed Gas Leak Detection Service advisor serves as your partner and trusted advisor to troubleshoot compressed gas-related problem areas that may exist at your facility.

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EXECUTIVE SUMMARY

The Swagelok Compressed Gas Leak Detection Services team conducted a compressed gas leak-detection program at the CUSTOMER facility in Anywhere, USA. Goals of the analysis included determining the compressed gas leak points and leak rates for specified areas of the facility so that we can analyze the condition of the compressed gas system. The report includes detailed comments and recommendations for improving the CUSTOMER facility compressed gas system. The compressed gas leaks are categorized in several ways to assist you in prioritizing the correction of the leak points. The printouts will provide information on component failure, estimated losses, and the cost of each leak. This will allow the CUSTOMER facility to identify the high-priority repairs and make the necessary corrections. All detected compressed gas leaks in the field were tagged with a colored tag, which will allow the facility to quickly and easily locate the appropriate leak location.

Swagelok's investigation determined that the yearly cost of gas leakage is $92,728.49.

Table 1. CUSTOMER Facility Compressed Gas Survey Results

Unit	Number of Leak Points	Identified Leaks Cost Avoidance	Size of Leak (CFM)
Building 1 4th Floor	2	$28,254.59	2.00
Building 2 4th Floor	3	$25,891.82	1.80
Building 2 3rd Floor	4	$28,491.10	4.10
Building 2 2nd Floor	4	$2,157.16	1.50
Building 2 1st Floor	2	$7,933.81	.60
Total	**15**	**$92,728.49**	**10.00**

The loss of compressed gas was largely attributed to the use of threaded connections and standard type valves in the system. The CUSTOMER facility should make necessary changes in design, engineering, purchasing, installation, and operation of the compressed gas system to eliminate compressed gas leakage, which is a large cost to the site operation.

Today's technology supports the use of alternative methods for installation and operation of the compressed gas system, instead of standard pipe threads and valves, to allow facilities to operate leak free. Changes should occur to accomplish this goal.

John Doe, Program Director for the CUSTOMER facility, was the key contact during the evaluation process. We would like to acknowledge and thank him for his time and commitment to this process during our visit.

INTRODUCTION

The Compressed Gas Leak Detection Services team met with John Doe to discuss the compressed gas leak detection survey goals. This report includes comments and recommendations for improving the CUSTOMER facility compressed gas system and operation. The compressed gas leaks are categorized on the printouts by the area of the site where they were detected and their estimated flow (in cubic feet per minute (CFM)) and annual dollar loss. This will allow the CUSTOMER facility to identify high-priority repairs and make the necessary corrections. All detected compressed gas leaks in the field were marked with a colored tag, which will allow the facility to quickly and easily locate the appropriate leak location.

Performing a compressed gas leakage service begins in the hands of a dedicated Swagelok engineering professional working with your lab team. Our expert capabilities encompass design, problem solving, training, and project management. These skills are applicable to both the finite analysis of system components and the assessment of a complete system.

Swagelok® Compressed Gas Leak Detection Team	**Customer Facility Team**
Michael Smith Sarah Jones	John Doe Program Director

BACKGROUND

This report lists and prioritizes opportunities for corrective action and includes the cost savings potential for each improvement. The total costs for achieving energy savings may include expenditures for some of the following items:

- engineering;
- design development and written specifications;
- requests for quotation (RFQ);
- purchasing the needed components;
- installation, mechanical, and electrical;
- commissioning; and
- training.

This report encompasses a total survey of the CUSTOMER facility currently being supplied by an outside compressed gas source.

Estimated Cost of Leakage

This section summarizes the costs arising from the leakage of compressed gas.

Table 2. CUSTOMER facility Compressed Gas Survey Results

Unit	Number of Leak Points	Identified Leaks Cost Avoidance	Size of Leak (CFM)
Building 1 4th Floor	2	$28,254.59	2.0
Building 2 4th Floor	3	$25,891.82	1.8
Building 2 3rd Floor	4	$28,491.10	4.1
Building 2 2nd Floor	4	$2,157.16	1.5
Building 2 1st Floor	2	$7,933.81	.6
Total	**15**	**$92,728.49**	**10.0**

SURVEY GOALS

The following goals were established by CUSTOMER facility and the Swagelok Compressed Gas Leak Detection Services team:

1. Focus on compressed gas during the program.
2. Tag each leak location.
3. Determine the following items:
   - the leakage location,
   - the leaking device, and
   - the estimated volume of the leakage.
4. Evaluate these areas:
   - reliability,
   - safety, and
   - code compliance.
5. Create a final report that covers the following areas:
   - compressed gas leakage printouts,
   - suggested improvements to the compressed gas system to prevent further leakage, and
   - benefits of improving the system:
     - energy,
     - reliability,
     - safety,
     - performance enhancements, and
     - other recommendations for improvement.

PROCESS

A key factor in any program's success is analyzing and validating the compressed gas leakage correction program. Swagelok is committed to ensuring our clients achieve an ongoing and successful compressed gas leakage management program.

Analysis

Root cause analysis should be conducted to determine why the components are failing and to set a road map for correction. The team conducted visual analysis of the following areas for leakage and process improvements:

- National Pipe Thread (NPT) threaded connections,
- fittings that have failed,
- correct fitting installation and consistency in the tube fitting approach, and
- correct component selection.

Validation

Once the changes are made, validation will be necessary to ensure that the changes have reduced or eliminated the leakage. The start date for the validation process is the date the report is delivered to the lab. Compressed leakage scans for validation purposes should be performed on the following schedule:

- every six months if more than 20 leak points are found, or
- every year if fewer than 20 leak points are found.

The Swagelok engineer performs the following validation tasks:

1. reviews the progress on implementing the task list,
2. sets the new benchmarks to be achieved,
3. updates the report to reflect the changes that have occurorange,
4. establishes any new goals if necessary,
5. documents the effects of implementing the opportunities, and
6. provides a report on the site visit.

FINDINGS AND RECOMMENDATIONS

Compressed gas systems without an owner will always tend to have higher leakage levels because responsibility for the problems may not be readily apparent. To improve system performance, designate one person to be responsible for the entire compressed gas leak detection system. That person should coordinate changes in the areas outlined in the table.

Time Frame for Corrections

The recommended time frames for corrective actions are as follows:

Table 3. Recommended Time Frames

Level	Recommendation	Time Frame
S1	Repair severe leaks that have a significant economic impact on the system	As soon as possible
R1	Ensure a leak-free compressed gas operation	0 to 6 months
R2	Medium-priority corrective actions	0 to 12 months
R3	Low-priority corrective actions	0 to 2 years

These time frames are estimates. All objectives should be accomplished within these time frames, contingent upon budget and operational considerations. During the procurement stage, the site should ensure that all components in the compressed gas system are specified to a reliability standard of at least 12 years. No compressed gas system component should fail within a 12-year operational period.

Failure Analysis

Group Name	Area	Location Name	dB Reading	Problem Description	Component	Identified Leaks Cost Avoidance	Size of Leak (CFM)
S1	Bldg 1	4th Floor South Corridor	20	Tube Connection	Connection	$13,185.89	.9
S1	Bldg 1	4th Floor South Corridor	22	NPT Threads	Connection	$15,068.70	1.1
S1	Bldg 1	4th Floor Hall A Nitrogen Tank	21	Packing	Valve	$4,883.11	.3
S1	Bldg 1	4th Floor Hall A Nitrogen Tank	25	NPT Threads	Connection	$10,023.21	.7
S1	BLD 1	3rd Floor Hall B Nitrogen Tank	37	Connection	Valve	$14,474.85	1.0
S1	Bldg 1	3rd Floor Hall B Air Gas Change Over Panel	30	NPT Threads	Connection	$387.55	2.2
R1	Bldg 2	4th Floor Hall A Air Gas Change Over Panel	13	Body	Regulator	$10,985.51	.8
R1	Bldg 2	3rd Floor Hall B Nitrogen Tank	17	Packing	Valve	$10,501.90	.7
R1	Bldg 2	2nd Floor Hall B Air Gas Change Over Panel	14	NPT Threads	Connections	$147.08	.9
R1	Bldg 2	1st Floor Hall A Nitrogen Tank	11	NPT Threads	Connections	$2,510.09	.2
R1	Bldg 2	1st Floor Hall A Nitrogen Tank	13	Packing	Valve	$5,423.72	.4
R2	Bldg 2	3rd Floor Hall A Nitrogen Tank	9	NPT Threads	Connections	$3,126.78	.2
R2	Bldg 2	2nd Floor Hall A 6 Pack Compressed Gas	8	NPT Threads	Connections	$72.21	.4
R2	Bldg 2	2nd Floor Hall A Copper to Swagelok Fitting	7	NPT Threads	Connections	$1,171.22	.1
R2	Bldg 2	2nd Floor Hall B Nitrogen Tank	8	NPT Threads	Connections	$766.65	.1
						$92,728.49	10.0

Failure Points

The results from the compressed gas leak assessment indicate that the leakage points were mostly from the following components or connections:

- pipe threads
- valve packing
- tube fitting connections.

With the high rate of failures with connections, the lab needs to select a different method for connecting components in the compressed gas system. Welding, flanges, or better-quality tube fitting connections need to be implemented in the lab standards.

NPT Connections in the Compressed gas System

Threaded joints are probably the oldest method of joining piping systems. Threaded fittings are mainly used for small bore piping, generally with a nominal diameter of NPS 2 or smaller.

The dimensional standards for taper pipe threads are listed in ASME B1.20.1. That document provides all required dimensions, including the number of threads per inch, pitch diameter, and normal engagement lengths for all pipe diameters.

NPT Connection Leak Points

Pipe thread fittings seal using a metal-to-metal connection. The metal of the male and female fittings deforms during installation to create this seal. As a result, pipe thread connections tend to leak after initial assembly when the connection is disassembled and reassembled. If the connection leaks after reassembly, replacement of one or more of the fittings may be required.

Continuing to tighten the connection will not necessarily eliminate the leak and can easily split the female portion of a pipe thread connection; this is especially an issue when installing male pipe thread fittings into ports on valves, motors, and cylinders.

Leaks can also result from the following:

- vibration,
- thermal cycling, or
- loads being supported by the connection (i.e., using the fittings in the connection to support mechanical loads).

Advantages of Threaded Fittings

- Installation productivity is moderately high, and specialized installation skill requirements are not extensive.
- Leakage integrity is good for low-pressure, low-temperature installations where vibration is not encountered.

Disadvantages of Threaded Fittings

- Rapid temperature changes may lead to leaks due to differential thermal expansion between the pipe and fittings.
- Vibration can result in fatigue failures of screwed pipe joints due to the high stress caused by the sharp notches at the base of the threads.
- In process gas piping systems, threaded connections should be avoided if possible. Their vulnerability to fatigue damage is significant, especially where exposed threads are subject to corrosion.

Tube Fittings vs NPT

Tube fittings have a great advantage over NPT connections, but a selction process must be accomplished before purchasing and installing. A typical tube fitting connection should be a flareless, mechanical grip-type fitting consisting of a body, nut, front ferrule, and back ferrule. All tube connectors (fittings) should be manufactured to exacting tolerances from a high-quality material, providing a tube fitting that will perform reliably in compressed gas service. Tube fittings should have excellent gas-tight seating and tube-gripping action, easily achieved with proper installation, consistent reassemblies, and excellent vibration fatigue resistance and tube support.

Threaded Connection Leak Points

There are several main factors of performance that should be evaluated when selecting tube fitting components:

1. the tube grip, which provides support on the tube and prevents stress;
2. the gas seal, which is achieved by the burnishing or polishing that occurs between the front ferrule and the tube fitting body, and
3. thermal cycling and vibration resistance.

<u>Recommendations:</u>

1. *Where possible, eliminate the use of NPT connections in the compressed gas system.*
2. *Only use NPT connections if no other method can be used.*

Standard Valve Leakage

Other common failure points were the standard (gate or globe) valves used in the compressed gas system. These older technology valves have a high rate of failure with the packing at the valve stem and threaded connections.

The valve stem packing is prone to leakage due to the friction of the stem against the packing. On other applications where leakage is not a concern, the valves will perform very well, but on systems where any leakage is a high cost, better technologies are available.

Valve Choices

Newer valve types feature better technology that provides leak-proof sealing at the valve stem.

1. Ball valves
2. Butterfly valves

<u>Recommendations:</u>

1. *Change site specifications and purchasing to new technology valves for the compressed gas system.*

Gas Change Over Panels

All Gas Change Over Panels in the facility operation have a high leakage level at the connection points.

Corrective action is required to eliminate the leakage points. That may require replacing all the units with new gas change over panels that do not have threaded connections.

<u>Recommendations:</u>

1. *Make corrective actions to the Gas Change Over Panels. Replace fittings that are leaking or replace the entire unit.*

Equipment Installation

A leakage test should be performed on all equipment purchased as a system or as a new installation. Typically, the standard is a pressure decay method, which involves pressurizing the system with a gas to 125 psig or higher and then waiting 24 hours to see whether there is any pressure loss. The pressure loss should not be more than 1 psig in 24 hours. The other method is pressurizing to 125 psig and using high-frequency ultrasound and a liquid leak surfactant when testing every possible leak point.

Root Cause Analysis

All failed components in the compressed gas system should have root cause analysis performed to determine the cause of failure.

1. Review all removed components.
2. Conduct an investigation, analyzing the failures and documenting the changes that need to occur to prevent any further failures.
3. Validate the change has eliminated the leakage problems.

Changes That Need to Be Instituted

The review identified several areas for improvement:

- A number of changes should occur in many areas to accomplish the goal of eliminating compressed gas leakage in the facility within the one-year time frame specified by CUSTOMER facility.
- Several areas have a high level of leakage due to component failures, installation errors, and incorrect product selection. The site should focus on these areas when implementing changes.

Failure Points

Connection Choices

1. Higher-quality tube fittings
2. Welded connections
3. Higher-quality NPT threads

Valves

1. Ball valves with a class VI internal leakage standard
2. Butterfly valves with a class VI internal leakage standard

Standard gate or globe valves should not be used due to their high leakage rates.

Valves in the Pipe Rack

1. Do not install valves in the pipe rack.
2. If valves have to be installed, have leak testing performed every year. Also, add the valves to a database and put them on a preventive maintenance schedule.

APPENDIX A: VALIDATION

CUSTOMER facility has invested the money and time to begin the process of understanding and improving the compressed gas system. This is a major undertaking by the site. A key factor in any program's success is validating the compressed gas leakage correction program. Swagelok is committed to ensuring our clients achieve an ongoing and successful compressed gas leakage management program. The following details the validation process.

Validation Process

Start date for the validation process: 10/26/17

1. Six-month site visit after the report is delivered to the site
   a. Swagelok engineer to review the progress on implementing the task list.
   b. Set the new benchmarks to be achieved.
   c. Update the report to reflect the changes that have occurred.
   d. Establish any new goals if necessary.
   e. Document the effects of implementing the opportunities.
   f. Provide a report on the site visit.

Leak Point with Tag

2. Twelve-month site visit after the report is delivered to the site
   a. Swagelok engineer to review the progress on implementing the task list.
   b. Set the new benchmarks to be achieved.
   c. Update the report to reflect the changes that have occurred.
   d. Establish any new goals if necessary.
   e. Document the effects of implementing the opportunities.
   f. Provide a report on the site visit.

3. Annual site visit
   a. Swagelok engineer to review the progress on implementing the task list.
   b. Set the new benchmarks to be achieved.
   c. Update the report to reflect the changes that have occurred.
   d. Establish any new goals if necessary.
   e. Document the effects of implementing the opportunities.
   f. Provide a report on the site visit.

APPENDIX B: LEAKAGE SUMMARY

Component	Number of Failures (Leaks)
Tube fitting	1
Pipe thread	9
Valve packing	3
Other	2
Total	**15**

APPENDIX C: COST OF COMPRESSED GAS

In calculating the costs of the compressed gas, the following value was used:

Cost of compressed gas: $.33 per 1,000 cfm

APPENDIX D: YEARLY COST OF LEAKAGE

Total Identified Annual Leak Avoidance Cost: $92,728.49

- Connections: $46,459.40
  - *Threaded Connections: $33,273.51*
  - *Tube Fittings: $13,185.89*
- Valves: $35,283.58
- Regulators: $10,985.51

APPENDIX E: LEAKAGE REPAIR PRIORITY

Group Name	Area	Location Name	dB Reading	Problem Description	Component	Identified Leaks Cost Avoidance	Size of Leak (CFM)
S1	Bldg 1	4th Floor South Corridor	20	Tube Connection	Connection	$13,185.89	.9
S1	Bldg 1	4th Floor South Corridor	22	NPT Threads	Connection	$15,068.70	1.1
S1	Bldg 2	4th Floor Hall A Nitrogen Tank	25	NPT Threads	Connection	$10,023.21	.7
S1	Bldg 2	3rd Floor Hall B Nitrogen Tank	37	Connection	Valve	$14,474.85	1.0
R1	Bldg 2	4th Floor Hall A Air Gas Change Over Panel	13	Body	Regulator	$10,985.51	.8
R1	Bldg 2	3rd Floor Hall B Nitrogen Tank	17	Packing	Valve	$10,501.90	.7

When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

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