2009 Compressed Air Leak Surveyor Handbook

Forward and Permissions

As the indisputable leader in its field, SDT designs and produces a large range of measuring instruments for the ultrasonic detection and evaluation of various other physical parameters. The company's expertise covers a vast array of applications: large and small capacity tightness tests and for underground tanks, the detection of leaks in any pressure system, production quality control and the detection of wear and faults in the predictive maintenance of mechanical equipment. Our company's success is based on our philosophy and our willingness always to respond to our customers' problems with the most effective, money-saving solutions.

This book was written to serve the needs of not only our customers in the field, but any ultrasound inspector engaged in the detection of compressed air leaks. It is the combined effort of our global SDT Team and represents our 35 year history as a solutions provider to industry. We invite you to use the information in this book to make your ultrasound inspections better, and to help ensure your ultrasonic leak management program is successful and enduring. You may distribute electronic copies of this book ONLY IN ITS COMPLETE FORM and only so long as credit is given to the authors, SDT North America and SDT International. You are not permitted to make or distribute partial copies, nor are you permitted to alter the content in any way. This book may not be used for commercial gain through reselling it, or using it as course material for any training purposes. Its intended and sole purpose is to help ultrasound leak surveyors do their job better.

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SDT International n.v. s.a.
Bd. de l'Humanité 415,
B – 1190 Brussels (BELGIUM)
Tel: ++32.2.332.32.25
Fax: ++32.2.376.27.07
info@sdt.be
www.sdt.be

SDT North America, ltd
PO Box 682, 1532 Ontario St
Cobourg, ON (CANADA) K9A 4R5
Tel: (905) 377-1313
Fax: (905) 377-1402
info@sdtnorthamerica.com
www.sdtnorthamerica.com

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1. Detecting compressed air leaks: a double-edged issue

Detecting leaks in compressed air systems is a double-edged issue: an environmental one for each one of us and an economic one for every business. Is it because it's an environmental issue that so few business managers feel worried about the topic? Then let's deal with this issue based on the substantial savings that can be made by eliminating this tremendous waste.

A proactive, ultrasonic leak detection campaign quantifying the amount of compressed air lost can be used to easily calculate the amount of benefit generated. The figures then speak for themselves and will convince you to implement a better energy efficiency management programme.

When people talk about energy saving prospects the idea of protecting the environment is, however, never very far removed. Detecting leaks in your compressed air systems addresses these two concerns.

An environmental and an economic issue.

Energy is, and will increasingly become, an important, priority issue because of its price, because supplies are running out and because of the constant fight against climate change etc. In such conditions, why not eliminate completely worthless consumption caused by leaks from compressed air systems? Isn't it time to limit the damage? Especially in view of the fact that the pledges made under the Kyoto Protocol, ratified in February 2005, require us to reduce toxic emissions into the atmosphere by better energy efficiency management.

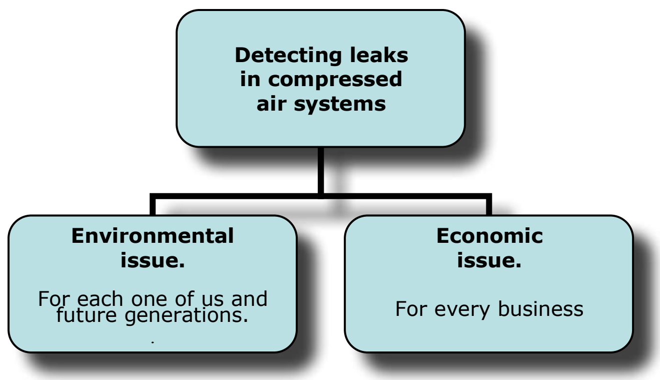
By 2012, 35 industrialised countries have made a commitment to reduce greenhouse gas emissions by 5% compared with their 1990 levels. They represent 35% of global emissions. As such this target is far from being enough. In addition to this no commitment has been made for after 2012. If you listen to Stephen Dion, the retiring President of the United Nations' conference on climate changes, "We would need ten Kyoto agreements to be able to reduce the effects of climate change. Scientists are saying that there must be a 60% reduction in greenhouse gas emissions within the next fifty years to stabilise global warming. Well, if nothing's done, these emissions themselves will increase by 60 %". How much will industry contribute to this?

While you're watching your energy bills rise, not a day goes by without new commitments to reduce CO2 emissions' quotas being tackled. A double challenge to be taken up by any manufacturer

Compressed air leaks are very costly in terms of excess consumption of energy.

Some awareness, skills within everyone's reach and, above all, good reactions are all that is needed to incorporate energy concerns into one's production tool management. Contrary to what you might think, managing energy better and/ or investing in energy efficiency can be very profitable. And, this doesn't happen very often, a solution that involves eliminating leaks has immediate benefits both for the environment and for your finances. More generally, admittedly, measures aimed at protecting the environment will incur some costs. In this case, on the other hand, this is balanced out by the benefits. And what is more motivating than combining this with the future of generations to come!

The detection of leaks in compressed air systems, a measure that is within the grasp of any company, is an important step in its commitment to an active energy management policy.



2. Pay for the air you use, not for leaks!

Compressed air is the most used energy fluid in industry but also the most expensive. Based on 5 years' consumption at a rate of 6,000 production hours a year, it is generally accepted that compressed air production costs are divided into 75% for the provision of energy, 13 % investment and 12% maintenance costs.

> ***Leaks may represent 30-40% of total demand***

Compressed air is expensive for an overall thermodynamic yield (use efficiency) of hardly 10%, even in the best of circumstances.

Compressed air production takes 2nd or 3rd place in a company's energy costs. It is therefore natural to take its improvement potential into consideration. It is important and is based essentially on the ideal balance between actual production requirements and pressure levels, on reducing energy losses, on maintaining components, on checking air quality and eliminating leaks in the network.

In some companies, rather than thinking about these improvements, they bring in a compressor to compensate for these losses. This is not an unusual situation as Leaks may represent 30 - 40 % of the amount consumed.

Size of Leak	Loss of air at 90PSI (SCFM)	Loss of air at 120PSI (SCFM)	Loss of energy in kW/h at 90PSI	Loss of energy in kW/h at 120PSI	Cost/year at 90PSI in USD$	Cost/year at 120PSI in USD$
1/32	1.28	1.4	0.18	1.21	75	83
1/16	5.10	5.60	0.75	0.82	302	332
3/32	11.48	12.60	1.7	1.87	679	746
1/8	20.40	22.41	3.0	3.31	1,208	1,327
3/16	45.90	50.41	6.8	7.45	2,718	2,985
Costs are to be multiplied by the number of leaks Values shown are based on $0.10/kWh x 4,000 operating hours per year.						

You must realise that leaks may occur anywhere in the network; online connections, bleed valves, filters, pressure regulators, slide gates, quick release connections, rubber pipes etc. And there are still lots more places in spots that are the most hidden as well as in the most inaccessible places. A real proactive programme to seek out this type of waste is more than vital to reduce the loss to a reasonable amount; for example, Reducing compressed air losses to 5 % of the amount consumed.

It's all the more true that if losses prevent minimum service pressure being reached, you very often tend to increase pressure. Which increase the percentage of losses. Taking into account the number of components in any compressed air system, it is easy to imagine the potential for leaks and the financial benefits of a detection campaign. This can be calculated very quickly using the cost of the smallest leaks and by simple multiplication:

A single 1/16 inch leak at 90 psi is already costing you $302 per year. At 150 PSI, it will cost you $480 per year

3. Detecting leaks by listening to the ultrasounds that they produce.

Leaks emit ultrasounds.

It is therefore vital to understand what ultrasounds are and how they relate to leaks in order to understand how to detect them properly.

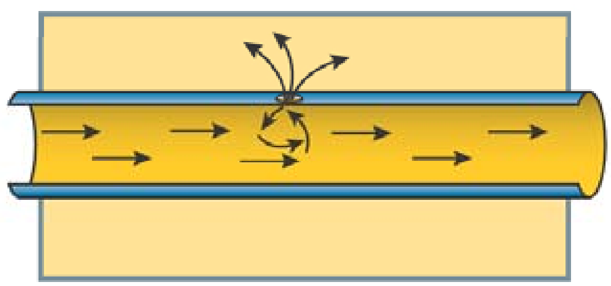
Sounds and ultrasounds are mechanical vibrations of matter. Ultrasound is the same type of vibration as sound but at a frequency higher than 20 kHz, which is inaudible to the human ear, which has a range of between 15Hz and 20Hz.

Compared with the diffuse emission of sounds, ultrasounds spread in a concentrated fashion in one direction. They can be compared with a beam of light whose intensity decreases depending on the distance.

Ultrasounds are generated naturally by fluid turbulence phenomena caused by pneumatic or hydraulic problems (leaks) or by friction phenomena caused by mechanical problems. Electrical problems, such as arcs, corona effects, etc. also generate ultrasounds.

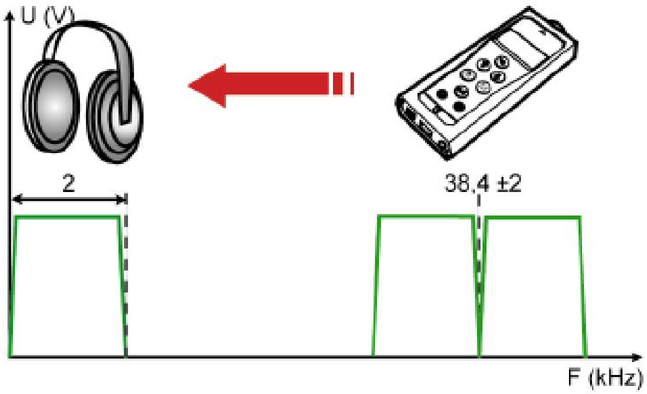
In the event of a leak from a compressed air system, the air friction that escapes generates ultrasounds on the sides of the perforation. And it does this whatever the size of the leak, its flow rate and the dimension of the hole, however small it is.

Ultrasounds can also be produced artificially using a transmitter to perform tightness tests, for example.



As the acuity of the human ear is limited, it is vital to use a detection instrument to listen to ultrasounds, to detect where they are coming from and consequently to locate the leak accurately.

The SDT 170 ultrasound detector operating principle
The SDT 170 detects ultrasound signals, converts them into audible frequencies and amplifies them. The aim is to transpose the signal received into an interpretable audible signal using heterodyne technology. This solution extends human hearing capacity beyond the audible range into the ultrasound band.



It must be noted that the detector's central frequency band can be adjusted to a specific frequency between 15.1 and 190.7 kHz; the default frequency is 38.4 kHz.

For the purposes of detection, the SDT 170 detector is only sensitive to ultrasonic pressure waves. It restores the turbulence effects, i.e. the actual sound of the leak and it quantifies this leak in dBµV.

4. Implementing an Ultrasonic Leak Management Program.
A proactive campaign for looking for leaks requires devising a schedule for performing services repeatedly over time.

This is completely different from the prompt, unforeseen reactions required by leaks that appear suddenly. This proactive campaign involves using the most appropriate tool and attachments for each location, observing an appropriate methodology, managing the data relating to each leak, documented, validated repair measures and, finally, as far as possible, quantifying leaks and doing the calculation resulting from the campaign.

4.1 Devising an effective strategy
The proper management and success of a maintenance programme for your compressed air network is based essentially on the quality of your strategic plan.

DEFINE THE OBJECTIVES
Defining what the objectives are apart from the main one which is to drastically reduce energy costs by only agreeing to a small investment in a detector is vital.

Any effective maintenance strategy is necessarily based on a well defined goal. Thus the first question to ask yourself is, quite logically, "What objectives must be achieved by applying a maintenance plan to my compressed air network?"

Here are some examples:
- Drastically reduce your energy costs with just a small investment.
- Detect, quantify the amount and repair any compressed air leak in the existing system.
- Restrict the overall amount of losses to 5% of the amount consumed.
- Take the strain off your compressors and prolong their lifespan.
- Make all the staff in your company aware of the high cost price of compressed air.
- Train the users involved in the most effective methods for maintaining the compressed air network.

MAKE ALL STAFF AWARE
To achieve maximum efficiency it is important to make all staff aware of this by posting permanent notices about the objectives. These objectives must be spread around the whole company so that each member of staff comes up against them all the time.

RECONSIDER THE WHOLE NETWORK
Managing a maintenance programme for your network is much more than looking for leaks and making repairs. It's also thinking about the network as a whole and making the improvements that are vital for greater efficiency.

4.2 Devising the procedure

Your procedure must be devised so that it achieves three results: the safety, reliability and effectiveness of your programme for looking for leaks. For optimum management of your compressed air network, some procedural steps deserve special attention:

SAFETY

This means compiling a procedural manual. Particular attention must be paid to this document. It will specify the frequency of inspections for each control point as well as the most appropriate sensor and attachments for each of these points.

The checking procedure will be detailed in five phases: detecting, locating, quantifying, repairing and checking the repair. It will also describe how each person involved must record that he has observed the procedure for each phase and also record information about the leak.

FREQUENCY

An effective annual maintenance plan requires 3 - 4 inspections of all the points of the network. Moving parts or those in a hazardous environment will be checked every month. You will then ensure that you have detected all new leaks as early as possible after they appeared and that you have checked the repairs required by previous inspections.

KNOWING ALL ABOUT THE NETWORK

for yourself and the people involved, knowledge of the network, compressors, the various pressure levels necessary are vital to devising the maintenance plan and observing it.

UPDATING THE CONTROL PLANS

Keeping the installation diagrams up to date will enable you to devise the most appropriate plan of all the points to be checked. All leaks will be recorded there progressively, with their precise location, their frequency, how big they are, the type of repair carried out and the check on this.

CHOICE OF EQUIPMENT

It is important to determine precisely the most appropriate sensors and attachments that must be used for each detection point.

TRAINING

All users of the ultrasound leak detector will have received practical and theoretical training from an experienced person before starting his job.

OBSERVING THE 4 STAGES OF THE PROCEDURE

The four stages of the programme for looking for leaks must be observed; identify, locate, repair, check again.

CHECKING REPAIRS

To be incorporated into the procedure: an ultrasound check of each leak repaired. On the one hand, the person who checks is not always the one who repairs, and, on the other hand, you have to check that another leak hasn't been created accidentally when working on the network.

DATA MANAGEMENT

Quantifying how much is leaking is a difficult matter. From feedback from major users and its specialist expertise, SDT provides you with a unique approach to quantification. Recording such figures with the history of each leak will allow you to compile an annual table of savings generated by your network maintenance. They will also encourage the transfer of skills within your business.

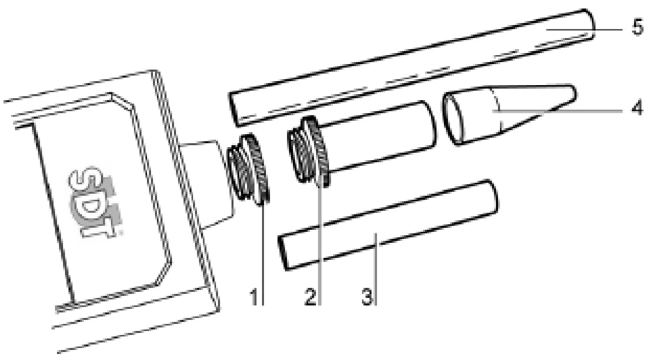
4.3 Choosing appropriate detection equipment

As specified in the procedure, each check point requires the use of a sensor or the most appropriate fitting. Let us always bear in mind that the ultrasound frequency is low energy and that is spreads in a concentrated way and in a single direction.

The most effective ultrasound sensor corresponds to each control and locating situation:

The Internal Sensor

All SDT 170 ultrasound detectors are fitted with an open internal sensor to detect compressed air, gas and vacuum leaks. It's the ideal sensor for daily searches and for a quick check of easily accessible places opposite the operator. Sev-



eral precision attachments may help to locate exactly where the leak is. Use this sensor for easy to reach inspections. When the SDT170 is switched on the internal leak sensor is immediately activated, and remains the active sensor until another sensor is plugged into the sensor input port (located to the left of the sensor).

Image - The Internal Sensor is used here to find an easily accessible leak on a clamped air line.

The Flexible Sensor

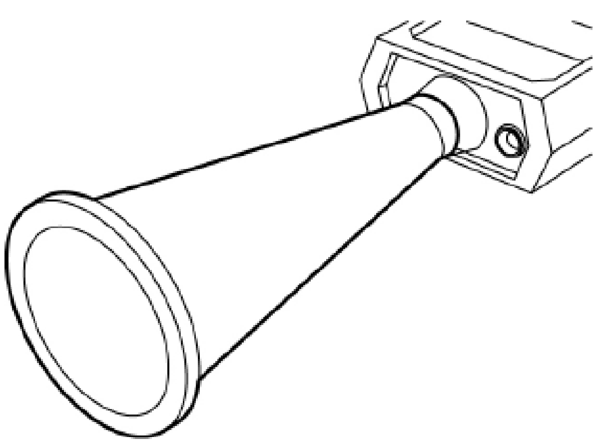
The flexible sensor with replaceable sensor has been designed to detect leaks in hard to reach places and to get around the parts to be checked. In fact, it can be bent, turned and pointed in any direction. The flexible sensor should be strongly considered in areas where safety is concerned, for instance, while looking for leaks near other moving parts such as couplers, belts, pulleys, and conveyors. Two lengths available: 21 and 32 inches. The sensor is equipped with a comfortable and ergonomical rubber grip. Use this sensor for inspections that are less than 10' from the leak source.

The EDS (Extended Distance Sensor)

For detection on average distance (up to 32 ft).

The EDS (Extended Distance Sensor) adapter.

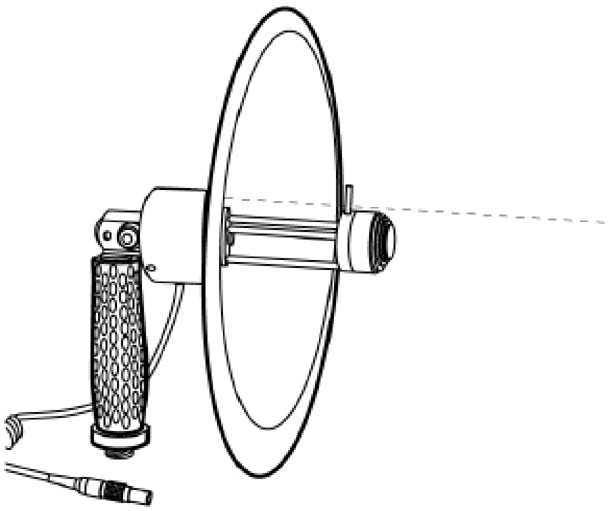
Generally, a large part of the compressed air system is located at ceiling level. You need to use a ladder or lifter to inspect it. There is an easier way… The EDS (Extended Distance Sensor) allows you to inspect it while keeping your feet on the ground. This conical shaped adapter is fitted with a threaded tip. It is screwed onto the SDT 170's internal sensor and concentrates the ultra¬sonic frequencies. It enables better detection at a medium distance and it improves the accuracy of the approach.



The Parabolic Sensor.

For long distance (up to 82 - 98 ft.

If the place to be inspected or the leak to be located is out of range of the detector in spite of using the EDS, you can use this parabolic sensor. This is a high precision signal concentrator which enables detection at very long distances. This transparent Plexiglas parabola is fitted with a particularly sensitive sensor. It has two sights for extremely accurate location: one is a “rifle” sight and the other a powerful laser sight.

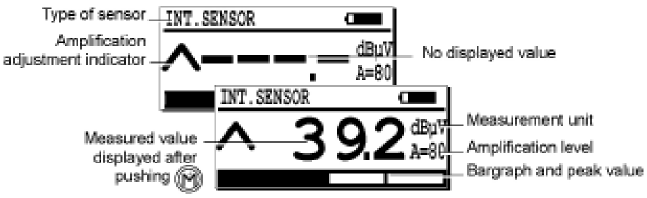


4.4 Using the SDT 170 detector properly*

1. If you don’t use the SDT 170 detector’s internal sensor, connect the selected sensor to the connection for the external sensor. Then connect the headphones to the unit’s audio output. You must use these to search for the leak, to locate it and to be able to quantify it. You will also be protected from surrounding parasitic noises.

2. Start the apparatus.

3. Ensure that the sensor connected is automatically recognised by the SDT 170 unit. The sensor ID is displayed in the top left corner of the screen



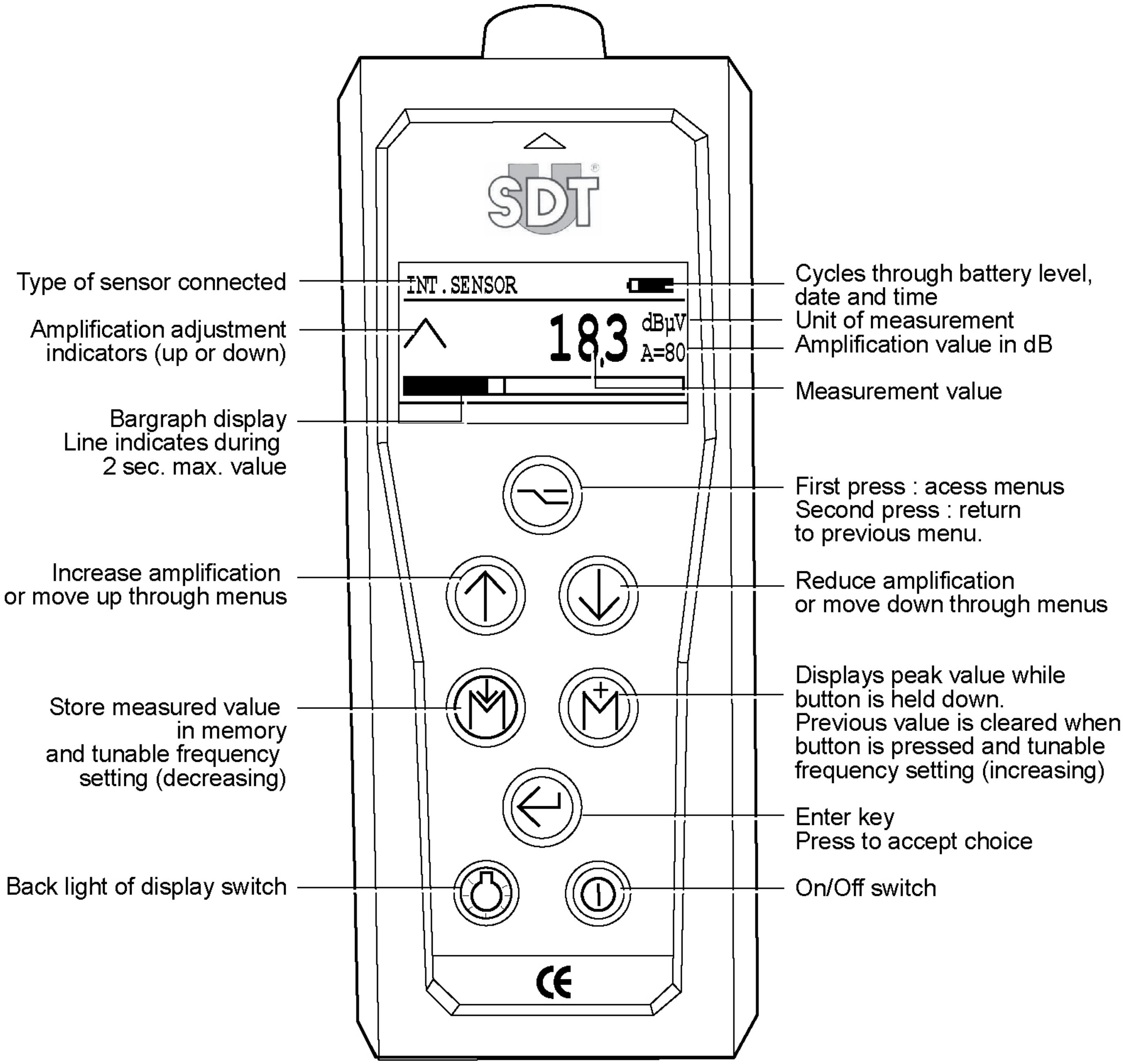
4. Check the battery level on the icon in the upper right corner of the screen.

5. After the company safety procedures have been performed, you start detecting leaks as described in Chapter 5.

*All details can be found in the user manual supplied with the unit.

The Importance of the Digital Display

Your SDT detector may be fitted with a screen with a bar graph display or a digital display. The bar graph can give an approximate indication of the decibel level of the leak. More precisely, the digital display is vital for quantifying leaks through means of the correlation formulae which takes into consideration the loudness of the leak at a set distance (dBuV) and the pressure of the air system and correlates those values into SCCM or SCFM. Using the SDT Leak Calculator the dBuV value of the SDT170’s digital display is entered to assist in estimating the potential $$ savings from your leak management program.



The basic funtions of the SDT170

4.5 Lots of Leaks....But Where to Search First?

Leaks may occur anywhere in your compressed air system! A look at the top twelve most common leak areas:

1. Connections on the supply line	7. Rubber pipes
2. Quick coupler	8. Regulator/lubricator assembly
3. Filters	9. Isolation valves
4. Pneumatic cylinders.	10. Control valves
5. Regulator/dryer assembly	11. Automatic drain traps
6. Pressure regulators	12. Various pipes

As a rough guide, the table below gives you the distribution of compressed air used in industry where there is absolutely no proactive predictive network maintenance program.

Distribution of the amounts of compressed air used in industry (international averages)	
Consumption by equipment	43 %
Leaks into the atmosphere	34 %
Inappropriate uses	16%
Purged Air	5%
Failed Drain Traps	2%`
Data Source: US DOE (Department of Energy)	

5. Procedure for Detecting a Leak

Any implemented procedures should be designed with basic principles aimed primarily at making the task of finding leaks efficient and fun. Some rules to be observed should include:

1. For repeatability and accuracy of inspections, especially where the compressed air leak calculator will be employed, always use the same sensor or sensor attachment.

2. Set the ultrasonic detector's amplification level depending on the working environment. Full explanations for setting amplification are found in the user's manual.

3. The exact location of a found leak is determined by sweeping the ultrasound sensor in a back/forth/up/down motion while always listening with the headphones for the strongest ultrasound signal. This is confirmed on the digital or bar graph display as the highest measured value. The sound heard in the headphone matches the expected sound of hissing turbulent flow from the headphones.

4. If the leak is not to be repaired on-the-spot it is necessary to provide an exact location of the leak. This can be done through a tagging system, whereby a two part tag is used to mark the location. One part of the tag remains on the leak, the other matching section is removed with descriptions noted.

5. Each leak that is repaired must be rechecked using an ultrasound detector. In addition, the surrounding area should be rechecked for other leaks that could have been masked prior to repair.

Procedure:

1. Start searching with maximum amplification, sweeping from the top to the bottom and from left to right with the unit or the sensor that you have connected to the unit, in order to locate the leak accurately.

Detecting the hissing sound that is typical of ultrasounds indicates that there is a compressed air or vacuum leak. If the signal detected is too powerful, reduce the amplification level to make it more comfortable to work.

2. As soon as you detect the hissing sound, move the sensor closer to the source to locate the leak. Press the down arrow to reduce the signal level given that it will increase as you approach the precise location of the leak.

3. This will be at the place where the signal is most powerful and when the highest value is displayed on the screen.

4. Select the amplification level depending on your working environment so that you do not have either of the two indicator arrows on the screen of the SDT 170. They may, still be there when the amplification level is at its maximum (A=80) or at its minimum (A=10).

5. Record the leak measurement (dBµV) displayed on the screen. This can be done to a note pad with pen and paper, or, if your detector has an internal data collector simply store it to memory.

6. Report this precise spot if the leak is to be repaired immediately or mark it with a locating mark if it is to be repaired later.

7. Record as much information as possible about the leak: the place, the type of leak, how big it is, the inspector's name and who repaired the leak.

6. Recording Your Leak Survey Data

Keeping record of every found leak is a vital step in your managed compressed air leak survey program. It must be incorporated into your strategy allowing for the options to add records appropriate and necessary for benchmarking the overall success of the initiative.

Here is an example of an internal data record sheet for your leak inspection program::

COMPANY LOGO

Detecting compressed air leaks:

DEPARTMENT: ....
MACHINE (or premises): ....
INSPECTOR: ……………………………………
SENSOR: …………………………………………
MEASURING DISTANCE: ………………………

Date and inspector	Department	Leak number	Description and location	Size of the leak in dBµV	Loss of air in L/h	Air loss /y	Person responsible and date of repair	Person responsible and date of second check

Data Recorded for the Leak

1. Date and inspector

Date and name of the person responsible for checking leaks.

2. Department

Part of the plant in which the inspection took place (e.g. production workshop, packaging unit etc.).

3. Leak number

Number on the leak locating mark. If you are using serial numbered leak tags enter the number of the leak tag here.

4. Description/location

Description and location of the leak (e.g. on the left side of the T at the outlet of boiler no. XXX or at the inlet to pump no. YYYY, see diagram Z).

5. Size of the leak in dBµV

The value measured and displayed on the detector screen.

6. Air loss in SCFM

See tables from page 28 "Quantifying a compressed air loss".

7. Air loss in $/year

If you have the cost prices of compressed air in your company you can easily estimate the annual financial loss resulting from this leak.

8. Person responsible and date of repair

Actual date the repair was finished and the name of the person who carried it out.

9. Person responsible and date of re-check

Date the repaired leak underwent a second ultrasound check and the name of the inspector.

7. Quantifying Compressed Air Loss

Quantifying a leak by converting the leak's measured dBµV value into L/y or into SCCM/SCFM is to be planned with the greatest care. It should only be undertaken by competent people who have been trained properly on the use of the ultrasound detection instrument. As a minimum requirement we suggest a one-day leak surveyor training session.

Given that a large number of factors influence the gathering of measurements in dBµV, it goes without saying that the inspector must include all of these factors so that he can take account of them when he makes his conclusions on quantifying a detected leak

When detecting leaks in an industrial environment certain factors may influence the measurements:
The leak orivice size, its shape, and its configuration
The surrounding environment and competing ultrasound signals
The distance between the leak and the sensor (attenuation of signal)
The position and the working angle of the sensor in relation to the leak axis
The features of the ultrasound sensor and the conditions under which is it used
The temperature and humidity level of the air escaping from the leak
... and very many more.

Quantifying compressed air losses also means evaluating the savings made.

The big question that's asked most often is "Looking for leaks is all very well. But what good is it going to do me? Is it really worth the effort?"

Under certain conditions the method enables each leak detected to be quantified, and the potential savings from it's repair to be calculated. It is very rewarding to be able to compile a quarterly or annual table of savings made by your network maintenance services, in the certainty that energy efficiency is being managed better and there will be a rapid return on investment.

In the following tables you will find the values in dBµV measured for a determined compressed air leak whatever the pressure up to 10 bars (150 PSI) inclusive.

Some important details that you know about these tables, and how the data was compiled, include:

• The dBµV measurements in the first two tables are the results of detecting with the internal sensor or the flexible sensor using an SDT 170 S+, M, M+ or MD unit. Considering that the 170S Standard model does not provide a digital display of the measured value, we do not inlcude it here. Nonetheless, if you are using the 170S for your survey you may make use of the bar graph measurement which still provides an approximation of the dBµV value.

• The dBµV measurements in the third and fourth tables are the results of detecting with the parabolic sensor, using one of the units mentioned in the previous paragraph.

• All SDT detectors have been used in the default 38.4 kHz central frequency band.

• The dBµV values were recorded at the loudest level of the leak. They are, therefore, maximum values. You will note that when using the SDT detector in an industrial environment, this noisiest level is rarely detected perpendicular to the leak, but most often at an angle of about 30° to the axis of the leak.

An increase in pressure automatically causes an increase in flow. And, at the same time, the ultrasound signals measured in dBµV by the SDT detector also increase.

You can, therefore, favourably deduce from this that quantifying leaks based on the SDT measurements is independent of the level of pressure used (not always known).

Details About the Leak Used
Leak orifice: from 0.2 - 1 mm
Area: from 0.033 - 0.822 mm^2
Important Note
The values in these tables are given as a rough guide and may only be used as guidelines to make the task easier.

8. Table and Charts for Quantifying Compressed Air Loss

Measurements with the internal SDT 170 sensor or the flexible sensor

Pressure 14.5 to 87 psi

1.3 ft

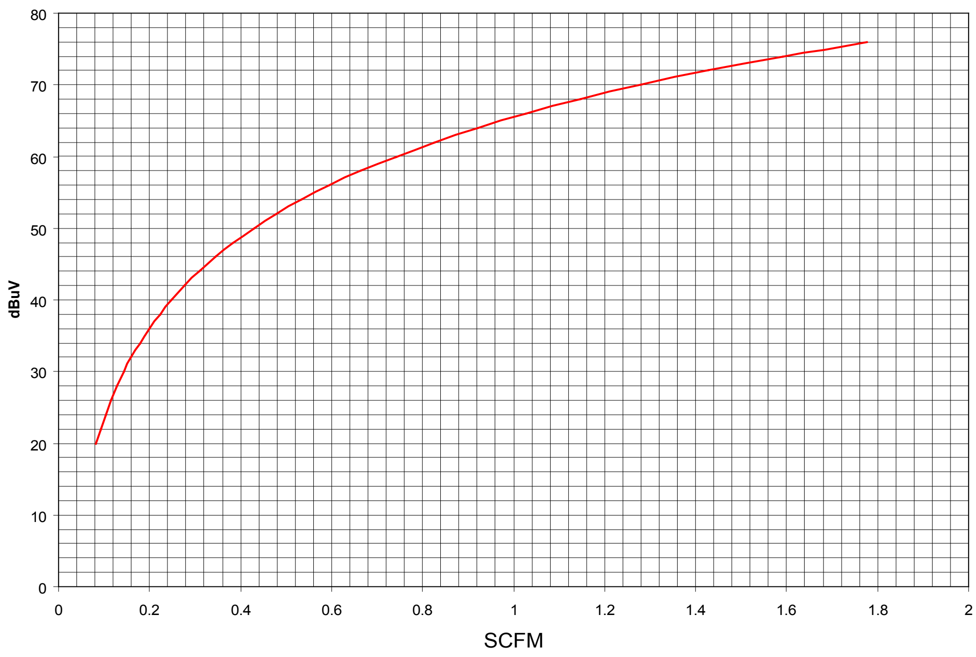
DbµV	L/H	SCCM	SCFM
20	141	2,355	0.083
22	158	2,627	0.093
24	176	2,931	0.104
26	196	3,270	0.115
28	219	3,647	0.129
30	244	4,069	0.144
32	272	4,539	0.16
34	304	5,063	0.179
36	339	5,648	0.199
38	378	6,301	0.223
40	422	7,029	0.248
42	470	7,841	0.277
44	525	8,747	0.309
46	585	9,758	0.345
48	653	10,885	0.348
50	729	12,143	0.429
52	813	13,546	0.478
54	907	15,111	0.534
56	1,011	16,858	0.595
58	1,128	18,805	0.664
60	1,259	20,978	0.741
62	1,404	23,402	0.826
64	1,566	26,106	0.922
66	1,747	29,123	1.028
68	1,949	32,488	1.147
70	2,174	36,241	1.28
72	2,426	40,429	1.428
74	2,706	45,100	1.593
76	3,019	50,311	1.777

Pressure 14.5 to 145 psi

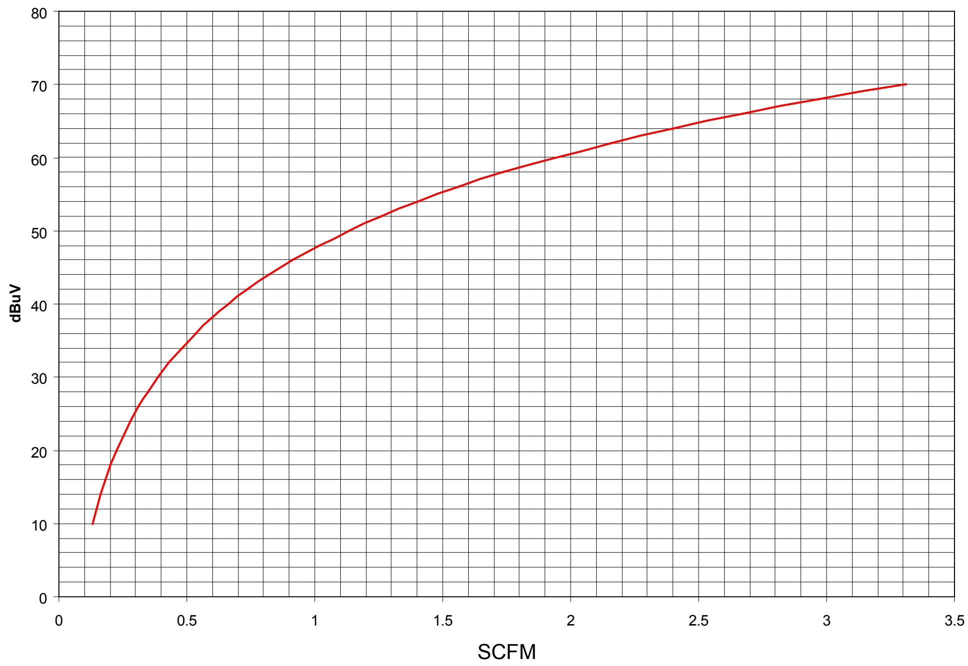
6.6 ft

DbµV	L/H	SCCM	SCFM
10	225	3,745	0.132
12	250	4,169	0.147
14	278	4,641	0.164
16	310	5,167	0.182
18	345	5,753	0.203
20	384	6,404	0.226
22	428	7,130	0.252
24	476	7,938	0.280
26	530	8,837	0.312
28	590	9,838	0.347
30	657	10,953	0.387
32	732	12,194	0.431
34	815	13,575	0.479
36	907	15,113	0.534
38	1,010	16,826	0.594
40	1,124	18,732	0.662
42	1,251	20,854	0.736
44	1,393	23,217	0.82
46	1,551	25,847	0.913
48	1,727	28,776	1.016
50	1,922	32,036	1.131
52	2,140	35,665	1.26
54	2,382	39,706	1.402
56	2,652	44,205	1.561
58	2,953	49,213	1.738
60	3,287	54,789	1.935
62	3,660	60,996	2.154
64	4,074	67,907	2.398
66	4,536	75,600	2.67
68	5,050	84,165	2.972
70	5,622	93,701	3.309

Internal and flexible sensor (14.5 to 87 psi at 1.3 ft)



Internal and flexible sensor (14.5 to 145 psi at 6.6 ft)



Measurements with the SDT 170 and parabolic sensor

Pressure 72.5 to 145 psi

6.6 ft

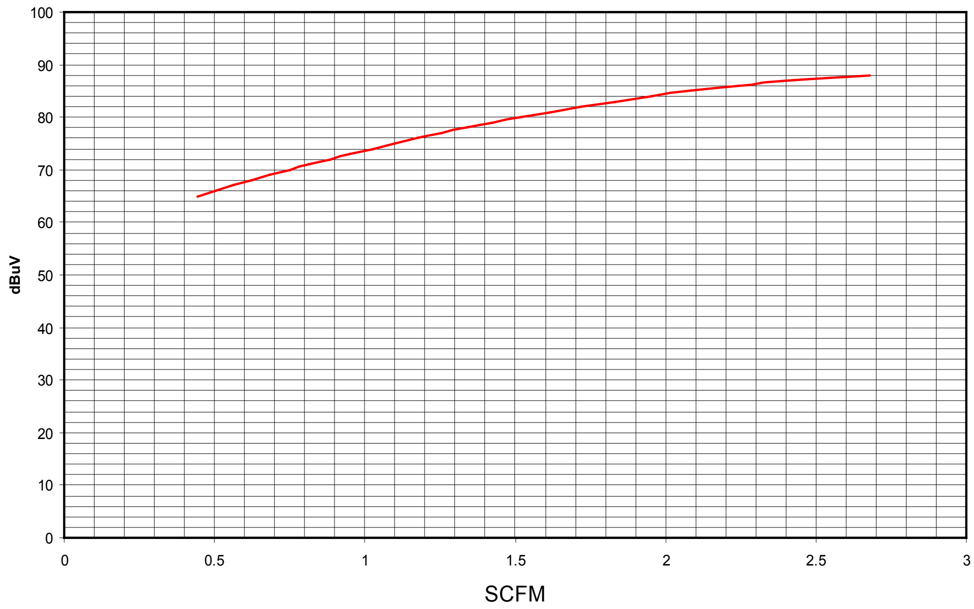
DbµV	L/H	SCCM	SCFM
65	756	12,600	0.445
66	855	14,250	0.503
67	956	15,933	0.563
68	1,059	17,650	0.623
69	1,165	19,417	0.686
70	1,274	21,233	0.75
71	1,385	23,083	0.815
72	1,500	25,000	0.883
73	1,618	26,967	0.952
74	1,740	29,000	1.024
75	1,866	31,100	1.098
76	1,996	33,267	1.175
77	2,132	35,533	1.255
78	2,274	37,900	1.338
79	2,422	40,367	1.426
80	2,580	4,300	1.519
81	2,744	45,733	1.615
82	2,920	48,667	1.719
83	3,110	51,833	1.831
84	3,318	55,300	1.953
85	3,548	59,133	2.088
86	3,810	63,500	2.243
87	4,125	68,750	2.428
88	4,550	75,833	2.678

Pressure 72.5 to 145 psi

16.4 ft

DbµV	L/H	SCCM	SCFM
56	944	15,733	0.556
57	1,052	17,533	0.619
58	1,164	19,400	0.685
59	1,280	21,333	0.753
60	1,400	23,333	0.824
61	1,516	25,267	0.89
62	1,632	27,200	0.961
63	1,770	29,500	1.042
64	1,902	31,700	1.12
65	2,040	34,000	1.201
66	2,186	36,433	1.287
67	2,333	38,883	1.373
68	2,490	41,500	1.466
69	2,656	44,267	1.563
70	2,830	47,167	1.666
71	3,016	50,267	1.775
72	3,217	53,617	1.894
73	3,438	57,300	2.024
74	3,682	61,367	2.167
75	3,964	66,067	2.333
76	4,305	71,750	2.534
77	4,776	79,600	2.811

SDT 170 and parabolic sensor (72.5 to 145 psi at 6.6 ft)



SDT 170 with parabolic dish (72.5 to 145 psi at 16.4 ft)

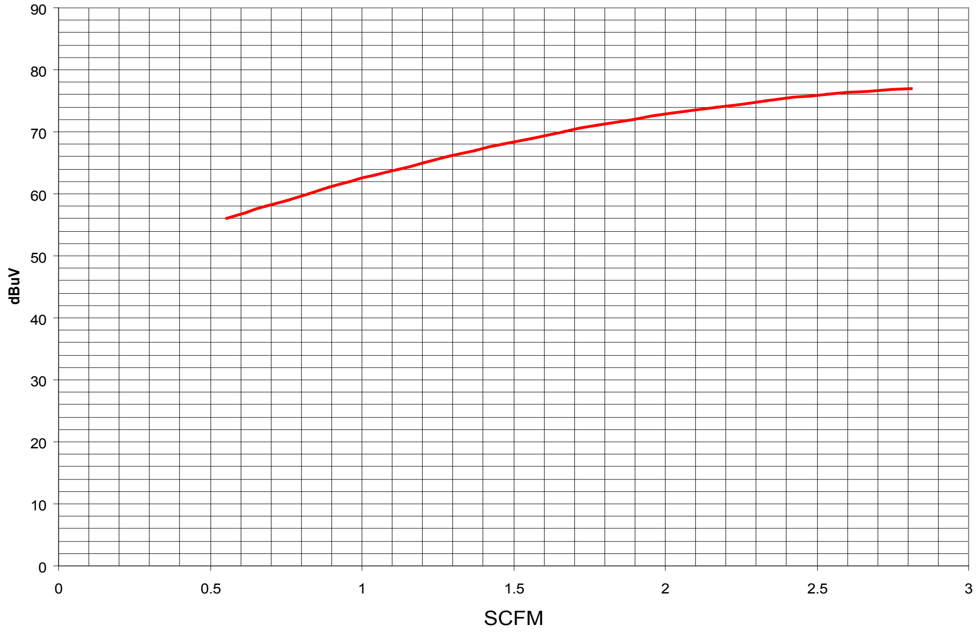


Table Correlating Leak Diameter, Volume, and Energy Loss					
Diameter of the Leak		Volume of Air Lost at 90 PSI			Power Required
mm	inch	l/h	sccm	scfm	kW
1.6	1/16	3,570	59,466	2.1	0.3
3.2	1/8	36,040	600,320	21.2	3.1
6.4	1/4	97,240	1,619,732	57.2	8.3
9.5	3/8	378,250	6,300,533	222.5	33
Information soure for this table: Atlas Copco Compressed Air					

Annual Electricity Cost for Compressor Power Supply			
Pk	kWh	Cost (Euro)	Cost (USD)
5	*3.7*	*1,196*	*1,415*
10	*7.4*	*2,391*	*2,830*
20	*14.7*	*4,712*	*5,576*
30	*22.1*	*7,102*	*8,405*
60	*44.2*	*14,134*	*16,727*
100	*73.6*	*23,628*	*27,962*
150	*110.4*	*35,442*	*41,943*
300	*220.8*	*70,814*	*83,803*
500	*368.0*	*117,998*	*139,643*
700	*515.2*	*165,254*	*195,567*
1000	*736.0*	*236,068*	*279,370*
Base 24h/24h=8,760 h/year Price: $0.044/kWh			

Pictured above, a shimple glove is used to shield a leak

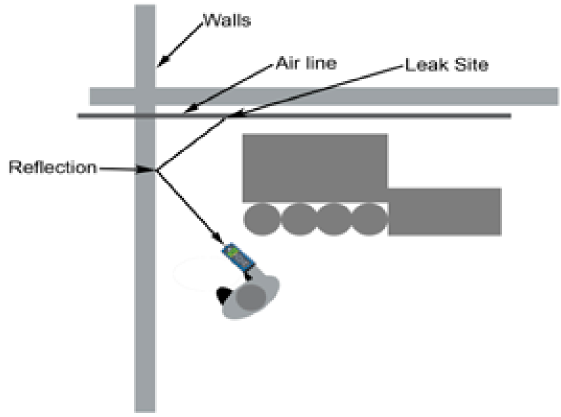
9. Some practical advice

9.1 Use shielding techniques in order to eliminate any parasitic noise.

Ultrasounds are directional. In other words, they propogate through the medium (air) in one direction. Use your body or a piece of cardboard to shield the detector from sources of competing ultrasound. For instance, from a bleed valve. Shielding towels are a great and inexpensive tool for shielding the sensor of the detector from multiple leaks in one zone.

9.2 Be careful of reflection phenomena.

While performing a quarterly ultrasonic leak inspection on the plant's compressed air system, our inspector picked up what sounded like a leak coming from a brick wall. He was miffed. How could a brick wall have a compressed air



leak? The Answer… Play the bounce.

Ultrasound is a low energy wave that is partially absorbed when it contacts a surface. The composite of a surface determines the amount of absorption. A carpeted floor will absorb most of an ultrasonic wave while a harder surface such as steel or brick will absorb less and reflect more of the wave. What appeared to be a leak coming from a brick wall was in fact ultrasonic energy from a pipe leak around the corner, reflecting off the brick wall.

When faced with our inspector's dilemma, play the bounce as though it were a billiard shot.

9.2.1. Walk your ultrasonic detector toward the brick wall where the leak sound is detected.

9.2.2. Now turn the detector away from the brick wall on angles that would represent a reflection or "ricochet". Do this until the leak sound is heard again.

9.2.3. Like a billiards shot, the angle toward the source will be equal to the angle of reflection off the brick wall.

9.2.4. If you are on the right path to the source of the leak, the ultrasound in the headphones should be more intense as you've just eliminated absorption from the brick wall and additional attenuation through the medium of transport.

9.2.5. If your detector has digital readout the intensity can be confirmed by taking a dBuV measurement before and after the ricochet.

9.2.6. Adjust the amplification of the detector to a comfortable level in the headset.

9.2.7. Follow the directional nature of the ultrasound until you pinpoint the leak

9.3 Absorption of ultrasound.

As we have already described in the tip above, part of the ultrasound signal is absorbed by the object on which the ultrasounds are reflected. This absorption factor depends entirely on the material of the object on which the ultrasound signals are reflected. A fabric-covered surface absorbs the sound much more or reflects it much less than a concrete or metal surface.

9.4. Locating a leak precisely.

It isn't normally enough to stop detecting a leak a few centimetres away from the assumed leak. In order to locate the leak precisely you must always check the area surrounding it because the precise location of the leak may be in the same direction as the one you were looking for. All the more so if a compressed air system is behind a pipe or a flange. This is why it is advisable to carry out an inspection of the area all around the suspected leak.

9.5. Quantifying leaks.

To quantify leaks as accurately as possible you must always start from the maximum dBµV value.

This is equivalent to the highest leak sound detected.

Only the highest value can be considered, recorded in the internal memory and then transferred to the computer. By inserting these values in the appropriate Excel lists, it becomes easy to calculate the total air loss (loss in €).

9.6. Leaks produce ultrasound that is very directional

When looking for leaks in compressed air piping, be sure to inspect all sides of a pipe or you the leak may be missed. Airborne ultrasound is directional. Therefore it is vital to inspect all sides of a pipe or fitting. Use a flexible wand sensor for difficult access areas and to reach behind piping that is close to a wall or ceiling corner. For overhead ceiling piping use an extended distance sensor or parabolic dish with laser sighting.

9.7. Learn the sounds of your testing environment

Listen to your plant through the headphones of your ultrasonic detector and you will hear an entirely different world… one you may not realize existed. Your factory floor sounds very different when audible noise is filtered out and ultrasound dominates. To the uninitiated, ambient ultrasounds may disturb an ultrasound inspection often breaking concentration. But most already possess the skills to overcome this and don't realize it. The listening skills learned from real life apply to the ultrasound world and learning the sounds of your test environment will go a long way toward successful inspections.

For example, recall the last time you had a conversation with a friend in a noisy café or bar. Chances are there was a baseline din caused by other conversations; people coming and going, a television, and who knows what else. Before you could successfully converse your subconscious familiarized itself with the clamour in the background and quickly found a way to filter it out, allowing you to concentrate exclusively on your friend. The same theory applies to a successful ultrasound inspection.

The ultrasound detector filters out audible sounds allowing you to hear pure ultrasound. Now you must concentrate on hearing only the ultrasounds you want. For instance, while performing a leak survey in a snack foods plant you clearly hear the characteristic sounds of an air leak, but you hear other ultrasounds too; irregular whooshing and swishing noises from a packaging line where blow-off valves and steam are at work. Familiarize yourself first with the plant's "parasite" ultrasounds just as you would the conversation at the café, and then ignore them and listen only to the ultrasound you want to hear. A more successful inspection is guaranteed.

8. Respecting personal safety

Ultrasonic detectors are super sensitive devices capable of hearing extremely low energy high-frequency sound pressure waves. In some cases the source of ultrasound is quite weak and so the electronics must apply tremendous amplification to the signal. Otherwise, it would remain undetectable.

When performing a leak survey our tendency is to continually increase the gain of the detector so that even micro leaks are discovered. The peril that confronts our own personal hearing is when we enter a zone of the plant where sudden bursts of high energy ultrasound are present. One such zone is the compressor room where blow-off valves open and close at unpredictable intervals. If the detector is set to amplify that signal to the max the resulting audible signal heard in the headset can be quite loud and uncomfortable.

As a precaution, always keep the amplifiers set to low and bring them up gradually to the level required for the inspection.

9. Extend Your Distance and Efficiency

How can overhead piping and air lines that are hard to reach be included in a compressed air leak survey without continuously going up and down scissor lifts and ladders? The use of Extended Distance Sensors and Parabolic Dishes has grown in popularity to improve efficiency and safety of any ultrasonic inspection. Instead of climbing ladders all day, which introduces fatigue and safety concerns, draw out a map of your overhead system and find the leaks from the floor.

Extended Distance Sensors (EDS) are designed specifically to receive and focus low energy ultrasound pressure waves created by compressed air leaks. These sensors are low cost and easy to use while extending normal leak detection beyond 50'. Parabolic sensors that are designed for receiving ultrasound signals are quite small; as small as 10' diameter. Because ultrasound waves can be as small as 3/8" there is no need to use huge dishes. The parabolic shape captures more signals which are focused onto a super sensitive piezo-electric transducer. Laser sights project a small red dot when a leak is found.

10. 2-stage compressed air leak survey

Are you just starting a compressed air leak reduction program? Or perhaps you had a program in place some time ago but it's been months, or even years since the last ultrasound survey. Whatever the case, a new or revitalized program will get immediate and long lasting results by applying a 2-stage approach to leak detection.

A 2-stage approach involves an initial tour of the compressed air system to identify large leaks that are easy to fix, and can often be repaired on-the-spot. Smaller leaks in a complex system of piping are difficult to find and are often masked by larger leaks. A second tour is conducted after the gross leaks are fixed to locate tiny leaks that one day will become more problematic large leaks.

10. Case Study: Compressed Air Leak Detection

By, Allan Rienstra, SDT North America

Compared to water, electricity, and gas, pneumatic processes are a necessary utility and an important source of converted energy, in use long before the Industrial Revolution. In fact the word pneumatics derives from the Greek word pneumatikos, which translates to English as "coming from the wind".

In today's modern industrial operations few processes rank higher in terms of importance than compressed air and no process places a higher demand on energy consumption. As a key utility its uses include running machinery, conveyance in handling systems, and switching for instrumentation and electrical systems to name just a few. But energy demand is negatively impacted when poor maintenance practices allow inefficiencies to spiral out of control; and the single biggest culprit is system leaks. Today's compressed air systems are obviously more complex than those from ancient times and hopefully more efficient. It makes me to wonder how the Greeks dealt with leaks.

Look at this simple breakdown of a typical investment a company would need to make for a simple compressed air system. The chart reveals that energy account for as much as 75% of the total system cost. It's a surprising statistic as conventional logic would have us believe that up front capital costs and ongoing maintenance costs should dominate. True, capital costs for compressors and delivery systems are significant but not ongoing. If a system is specified correctly and maintained well over time its capital costs can be depreciated. A poorly maintained and leaking system will never fulfill demand, continually drain resources, and have a negative impact on energy. An inefficient energy wasting system further hurts our environment through additional and unnecessary greenhouse gas emissions.

The fact we don't always think of compressed air in terms of energy consumption explains why so little attention is given to finding and fixing leaks. Leaks are expensive. According to the US Department of Energy average systems waste between 25% and 35% of its air to leaks alone. In a 1,000 SCFM system 30% leakage translates to 300 SCFM. Eliminating that leak is the equivalent of saving more than $ 45,000 annually (depending on where your plant is located, and that region's energy costs, the amount saved can be three to four times higher).

A better understanding of leak complacency is needed if we are to get to the core of the problem. Why do we pay more attention to energy efficiency lighting (agreed, there are gains to be had with good lighting and efficient uses) and continue to ignore inefficient compressed air systems? One explanation is that compressed air leaks are not seen. I grew up listening to my parents say, "don't leave the lights on" so efficient lighting was ingrained at an early age for me. They never said much about leaks yet I can still recall leaking airlines in my father's workshop.

In the factory setting a steam leak is obvious and an oil leak even more so but air leaks don't create a visible plume nor do they make a dangerous and slippery mess on the floor. They don't have an unpleasant odor and mostly we ignore, or can't hear their continual hissing.

So is it truly a case of "out of sight, out of mind"? Is energy waste and system inefficiency still a low priority for manufacturers? Could it be that compressed air is a background process taken for granted? Consider your compressed air system and all the areas where pneumatics are employed at your facility. Expand your thinking beyond the factory walls where compressed air makes possible many things in science, technology, and everyday living. From jackhammers for road repairs to drills in the dentist's chair; from the tires that roll us too and from work, school, and play, to our children's inflated soccer and basketballs , compressed air is all around us… and yes, taken for granted.

A culture change is occurring in industry where it's needed most. Industry represents the biggest consumer and therefore largest potential gain. It is a dual challenge, and a dual opportunity. The challenge is to invest in more efficient energy and environmentally conscious practices. The opportunity is to improve profitability and slow the effects of global warming. We have an insatiable thirst for electricity and the fossil fuels necessary to quench our thirst are being used up at rates we cannot afford. Two side effects concerning everybody are the diminished supply of non-renewable fuel sources and the effect that increased levels of CO2 have on global climate change. Diminished supply means continued higher energy costs while global climate change represents something much more expensive.

Not all companies are sitting idly by waiting for others to take action. Many have already begun programs that address energy efficiency and specifically target the compressed air system. AFG Glass is the second largest flat glass manufacturer in North America, and the largest supplier to the construction and specialty glass market. Founded in 1978, AFG is headquartered in Kingsport, Tennessee. With its three divisions it is a fully integrated supplier. One division is responsible for flat glass manufacturing, another for advanced energy efficient coatings, and a third fabrication division that adds value to their finished product through tempering, laminating, and insulating. In total AFG has nine glass production operations, 34 fabrication/distribution centers, 4 sputter coating lines, 5 insulating plants, and one laminating facility. They have more than 4800 employees working in their North American operations.

Some of AFG's manufacturing divisions implemented airborne ultrasound programs in 2006. Mainly, ultrasound was considered for its reputation as an overall predictive maintenance and trouble shooting tool. When several technicians attended ultrasound certification training they learned the technology they invested in would be used for much more than trouble shooting.

Ultrasonic Leak detectors work like simple microphones that are sensitive to high frequency sounds ranging beyond the human ear. Early detectors enabled us to hear problems with machinery on the factory floor regardless of background noise. As the technology has grown up so has its form and function. Today's ultrasound detectors can be simple leak detectors or advanced data collectors capable of trending and diagnosing machine failures and plant inefficiencies.

Ultrasound detectors use a sensitive piezoelectric crystal element as a sensing element. Small high frequency sound waves excite or "flex" the crystal creating an electrical pulse which is amplified and then translated into an audible frequency that an ultrasound inspector can hear through high quality noise attenuating headphones.

As a leak passes from a high pressure to a low pressure, it creates turbulence. The turbulence generates a high frequency sound component, which is detected by the crystal element. Higher frequency sounds are directional by nature. By detecting only the ultrasound component of a turbulent leak the technician is able to quickly guide the instrument to the loudest point and pinpoint the leak. A typical compressed air system can be surveyed for leaks in one or two days. Larger plants may take longer, but the benefits to finding and fixing leaks are well worth the investment in time.

Several ultrasonic detectors use parabolic reflectors or elliptical reflectors to enhance and concentrate the leak signal, which can be useful when detecting small leaks or scanning at a great distance. Imagine scanning all the overhead piping without ever climbing a ladder or scissor lift. Parabolic accessories are key to enhanced productivity, and operator safety.

Douglas Bowker is the Plant Maintenance Superintendent at AFG Industries Greenland, TN plant. He has been instrumental in the implementation of ultrasound testing to improve the well being of their plant's equipment.

"Compressed air is not free," writes Mr. Bowker. "It costs Greenland approximately $137,000 per year to supply compressed air to the plant. Air leaks therefore cost us money. A small leak that is undetected by the human ear can typically contribute to $3,000 of cost per year. The Ultrasonic equipment can now be utilized in a cost saving manner to detect such leaks and fix them proactively."

Douglas is quick to add that an air leak having the size of a pinhole can be detected from a distance of 40 feet. In addition, his technicians can detect Natural Gas, Nitrogen, and Hydrogen leaks. The ultrasound equipment is also useful in detecting leaky or malfunctioning valves, and can help detect flow in pipelines from a distance. Maintenance Foreman Randy Treadway was recently certified in Ultrasonic Analysis by SDT North America. Here he demonstrates the use of the SDT 170MD to detect air leaks.

AFG Industries is in the early stages of their compressed air efficiency journey. We will definitely be checking back with them to learn about other ultrasound wins at the Greenland, Tennessee plant.

SDT North America
PO Box 682
Cobourg, ON K9A4R5
Canada
www.sdtnorthamerica.com
Toll Free: 1-800-667-5325
International 1-905-377-1313
Fax: 1-905-377-1402
info@sdtnorthamerica.com