Guide for ultrasonic leak detection in compressed air systems in an industrial environment
SDT’s goal is to provide ultrasound solutions that give its customers a greater understanding about the health of their factory. SDT helps them predict failures, control energy costs and improve product quality while contributing to the overall uptime of their assets.

It's know-how covers a wide range of applications: leak testing, detection of gaseous fluid leaks, monitoring of steam traps, monitoring of rotating machines and follow-up of their lubrication and the inspection of HV electrical equipment.
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1. Some data about compressed air

1.1 COMPRESSED AIR IS WIDELY USED AND ENERGY INTENSIVE

Compressed air is easy to manufacture. Its production does not generate pollution or waste. It uses inexpensive and rugged components. It is easy to transport via cheap network of pipes. There is no risk in case of an accidental leak.

These strong points explain why compressed air is the fourth most commonly used source of energy in industry, following electricity, natural gas and water. On average, it represents 13% of the industrial electricity consumption in France.

However, its use is not without drawbacks. Air is not compressed in its natural state. Energy is therefore required to be able to compress it artificially. Compressing air is extremely energy intensive due to poor performance. The optimisation of compressed air production and distribution is thus crucial. In this context, leak detection and repair remains the operation with the best short-term profitability.

The bulk of the expense to produce this fluid consists of electrical energy consumption. For example, for use of 6,000 hours per year * for 5 years, the energy consumed thus represents 75% of the cost of the compressed air. It reaches 80% during intensive use of 8,000 hours per year for 5 years.

* i.e. operation of the installation 24 hours a day, 5 days a week.

Distribution of costs over 6,000 h/year over 5 years.
1.2 **THE YIELD IS VERY LOW**

This is about the thermodynamic efficiency. Actually, more than 90% of the electrical energy consumed is lost, notably in the form of heat. At best, 10% of this energy is converted into mechanical energy conveyed by the fluid. Routinely, the useful energy barely reaches 8%, especially when no campaign to search out leaks is in place. So you understand why compressed air is so expensive.

![Overall performance of an optimised installation](image)

1.3 **WHAT IS THE COST OF COMPRESSED AIR?**

While everyone knows the price per kWh of electricity, gas or water, few manufacturers are aware of the cost price of a cubic meter of compressed air. The subject is quite complex as many parameters must be considered. Take, for example, the purchase price per kWh, the efficiency of the compressor (variable speed control, heat recovery), processing (drying, conditioner, filter), distribution (pressure losses, looped network), and not to mention a key factor: operating pressure.

There is a simple and quick way to estimate the financial burden of compressed air, knowing that on average, the production of a cubic meter of compressed air at 7 bar requires 200 Wh.

By knowing your average consumption* (m³/h), the number annual number of operating hours and the purchase price per kWh, you can calculate your annual compressed air energy cost.

* If you do not know your average consumption, production of 10 m³/h per kW, compressor installed, is considered.
1.4  **WHAT IS THE COST OF A LEAK?**

Taking an average price of € 0.085/kWh over 8,700 hours of use per year, the table below gives a few examples of annual financial losses:

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Pressure (bar)</th>
<th>Loss (m³/year)</th>
<th>Loss (€/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>29,400</td>
<td>€ 500</td>
</tr>
<tr>
<td>0.5</td>
<td>8</td>
<td>9,900</td>
<td>€ 170</td>
</tr>
<tr>
<td>1.5</td>
<td>10</td>
<td>115,000</td>
<td>€ 1,900</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>115,000</td>
<td>€ 1,900</td>
</tr>
</tbody>
</table>

Of course, these figures are multiplied by the number of leaks ...

1.5  **LEAKS: AN UNACCEPTABLE WASTE**

Generally speaking, leaks do not have an impact on production and do not represent a health hazard. They are odourless, colourless and usually not audible in industrial environments.

However, leaks represent 30-40% of compressed air production. And even more in some cases! They are very expensive and are responsible for the unacceptable waste of energy and financial resources.

The international average (source: Plant Support & Evaluation, Inc.) is 34%.

This means that one out of three compressors operates only to supply the leaks!
1.6 **THE ELIMINATION OF LEAKS IS AN ABSOLUTE PRIORITY**

The elimination of leaks is not the only way to optimise the cost of compressed air. The optimisation of production (control, variable speed and heat recovery) and processing (dryer, filters and condenser) must also not be overlooked.

This action must be given top priority. The investment required is low. Just two hours are needed to become proficient in the use of an SDT device. Searching for leaks is relatively simple. Finally, the savings is substantial for an immediate return on investment. In contrast to other actions aimed at improving the performance of a compressed air system, as this chart shows, taken from the "Compressed Air Systems in the European Union" study conducted by the European SAVE program.
2. Detecting leaks by listening to the ultrasounds that they produce

2.1 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.

2.2 THE SDT ULTRASOUND DETECTOR OPERATING PRINCIPLE

The device 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.
The main function of the SDT detector is to convert high frequency signals into audible signals.

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.

The frequency bands are used depending on the type of sound to be detected.

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

2.3 THE ULTRASONIC SENSOR IS THUS THE BEST TOOL

Searching for the largest leaks by ear, possible only during production shutdowns, and using soapy water, both tedious and inefficient in areas difficult to access, are not profitable in terms of the required number of man-hours.

Only the ultrasonic detector is widely acknowledged as the industrial solution, by compressor and pneumatic equipment manufacturers, and system managers. One must select a rugged device, equipped with sensors adapted to suit every situation, and having quality fabrication and reputable after-sales service.
3. Detecting leaks with an SDT kit

3.1 Sensor selection guide

The sensor is selected based on two parameters: the distance to the equipment to be inspected and ease of access.

**Internal sensor**

Both the SDT200 and SDT270 detectors are equipped with an internal sensor. It is the ideal sensor when the areas to inspect are easily and directly accessible and located opposite the operator. Generally speaking, the sensor/inspection area distance is less than a meter. The precision indicator tip is particularly useful. Leak localisation becomes more precise when the sensor's detection window is reduced. It also acts as a barrier, reducing interfering leaks.

**Flexible sensor**

The flexible sensor can be bent, rotated and oriented in all directions. As with the internal sensor, it is used to inspect elements that are directly accessible and located at distances less than one meter. Its ergonomic design allows it to detect leaks in hard to reach places and to get around obstacles. The flexible sensor is essential when inspecting areas with a high density of pneumatic equipment.

You will note that the flexible sensor is completely separated from the unit. This allows you to comfortably read the information on the screen of your SDT in all situations.

The flexible sensor is available in 3 lengths: 350, 550 and 820 millimetres. The precision indicator tip also fits onto the flexible sensor.
**Acoustic cone or EDS (Extended Distance Sensor)**

The EDS screws onto the internal sensor. The acoustic cone has two properties that are particularly useful to the inspector: it increases the sensitivity of the internal sensor by 12 dB (*) and it is highly directional, meaning that it improves localisation of the leak compared to the internal sensor alone.

(*) 12 dB means that the internal sensor equipped with the EDS is 4 times more sensitive.

This substantial increase in sensitivity allows the operator to be up to 4 to 6 meters from the inspected area. Directivity allows you to accurately determine the direction of the leak.

In short, the EDS should primarily be used to detect small leaks, such as vacuum leaks, located at an average distance from the operator.

**Parabolic sensor**

The parabolic sensor is the ideal tool when the leak is located at a distance beyond 6 meters. Its sensitivity and directivity enable it to locate leaks located more than 30 metres away. Its laser sight also allows you to remotely pinpoint the location of the leak.
Sensor selection guide depending on the distance and pneumatic density

<table>
<thead>
<tr>
<th></th>
<th>Less than 1 m</th>
<th>From 1 to 6 m</th>
<th>More than 6 m</th>
<th>High density</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal sensor</strong></td>
<td>Detection</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td></td>
<td>Localization</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td><strong>Flexible sensor</strong></td>
<td>Detection</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td></td>
<td>Localization</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td><strong>EDS</strong></td>
<td>Detection</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td></td>
<td>Localization</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td><strong>Parabolic sensor</strong></td>
<td>Detection</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td></td>
<td>Localization</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
</tbody>
</table>

3.2 **USING AN SDT DETECTOR**

**Detecting the leak**

Begin by sweeping the area at mid-distance using the EDS or the parabolic sensor. Amplification set to maximum. Sweep from right to left and from bottom to top to locate the characteristic hissing sound of a leak. Search in the direction of the strongest signal to determine where the leak is coming from. For your comfort, the volume in the headphones can be increased or decreased using the left and right arrows. Detection is simple and intuitive as you actually hear the noise of the leak.

**Locating the leak**

If the parabolic sensor is used, the laser indicates the faulty element remotely.

If the EDS, flexible sensor or internal sensor is used, move closer to the leak while continuing to sweep in all directions. It is important to reduce the amplification as you approach the faulty element. Move in the direction of the strongest signal until you are able to determine the leak site.

**Measuring the leak**

This step is required if you want to use the SDT Field Leak Estimator to determine the savings made following your leak detection campaign.
Stand at a distance (*) of 40 centimetres or 2 metres for the flexible sensor, internal sensor with or without EDS. Select a distance (*) of 2 or 5 meters for the parabolic sensor. Search and determine the direction of the strongest signal. Set the amplification using the up and down arrows until the amplification indicator no longer appears on the screen. Finally, note or record the value measured in dBµV.

(*) The distance has an effect on the measurement result. If the distances indicated are not respected, there will be significant error in the resulting measurement.

Practical advice: note that if the distance is doubled, the measurement will be reduced by 6 dBµV. For example, if a measurement of 19 dBµV is obtained at a distance of 20 centimetres, it would be 13 dBµV at a distance of 40 centimetres (19 dBµV - 6 dBµV = 13 dBµV). On the other hand, if the distance divided in two, the measurement will be increased by 6 dBµV. This rule is applicable to SDT detectors and sensors only.

3.3 **A FEW PRACTICAL TIPS**

There are 3 techniques that can facilitate your work in the field: the shielding technique, the covering technique and reflection management.

**Shielding technique**

This technique greatly reduces the influence of interfering leaks. It consists in using a piece of cardboard and a sheet of paper (*)... to create a barrier between the "parasitic" leak noise and the location where you want to detect/locate a leak.

(*) Any material will work. It will reflect approximately 90% of the energy coming from the interfering leak.

Practical advice: the precision indicator tip placed on the internal or flexible sensor acts as a shield. This technique is very useful when leaks are very close to one another.
Covering technique

This technique also greatly reduces the influence of interfering leaks. It consists in:

Either covering an interfering leak with a rag or glove while you inspect an area.

Or covering the sensor with a rag or glove in the zone you want to inspect.

Reflection management

When searching for leaks, we sometimes get the impression that a leak is coming from a place where there is clearly no compressed air, such as a wall or a partition. This is due to the phenomenon of reflection. Ultrasounds from the leak are bouncing off the reflective surface. You will find the leak by following the angle of reflection. The angle of reflection is equal to the leak’s angle of origin relative to the reflection surface.

3.4 SDT kits available in ATEX version

The SDT200 and SDT270 detectors are also available in ATEX version for potentially explosive environments, as are the flexible sensor, parabolic sensor; EDS and headphones. Directive ATEX 94/9/CE (II 1 G / Ex ia IIC T3/T2 Ga).
4. Quantifying a compressed air loss

The big question that arises is "Searching for leaks a good thing, but how will it benefit me? Is it really worth it?" Certainly, what could be more rewarding than being able to prepare the quarterly or annual report showing the savings generated by your maintenance services, being certain to provide better energy efficiency management and a quick return on investment.

To meet this demand, SDT has developed a calculator that is able to estimate the relationship between dBµV and m³/h. It is the result of our three decades of experience and was designed with partners such as Atlas Copco, Electrabel and Laborelec. It allows you to quantify each leak detected, prioritise repairs and calculate the profit generated by each repair.

This calculator works only with our detectors and sensors that are individually factory calibrated at the time of manufacture and after repair.

Our "Field Leak Estimator" can be downloaded from our website www.sdt.eu.

It should be noted that this conversion is only an approximation. In fact, many factors come together to influence the result, such as:

- The leak orifice size and shape,
- The profile leak orifice's wall,
- The perimeter/cross-section ratio of the leak,
- The viscosity of the fluid,
- The ejection speed of the fluid through the leak.

Not to mention the criteria influencing the measurement:

- The sensor used,
- The distance between the source and the sensor,
- The position of the sensor relative to the source.

The result can thus be very different for a given leak. Nevertheless, our experience shows that the result obtained over a sufficiently wide range of leaks has a quite acceptable margin of error.
5. Implementing a leak detection campaign and drawing the most benefit from it

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.

5.1 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.
    - etc.

- **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 OF YOUR 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.

### 5.2 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** – Il est important de déterminer avec précision les capteurs et accessoires les plus adéquats qui devront être utilisés pour chaque point de détection.

- **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.
6. Leaks....but where?

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

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

Recording data relating to each leak inspected is a vital step in your campaign to search out leaks. It must be incorporated into your maintenance plan with the option to add records appropriate for your strategy which will meet the objectives of each campaign.

Example of an internal data record sheet for an inspected leak.
Data recorded for the inspected leak:

**Date and inspector**
Date and name of the person responsible for checking leaks.

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

**Leak number**
Number on the leak locating mark.

**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).

**Size of the leak in dBμV**
The value measured and displayed on the detector screen.

**Air loss in L/hour**
See page 17 "Quantifying a compressed air loss".

**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.

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

**Person responsible and date of re-check**
Date the repaired leak underwent a second ultrasound check and the name of the inspector.

Always identify the defective item with a completed "leak tag". The detachable part of tage is logged to ensure that the repairs are processed.
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 calculate the amount of savings made. The figures then speak for themselves and will convince you to implement a better energy efficiency management programme.

Eliminating compressed air 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.

The solution is there. It is simple and easy to implement. It enables you to make substantial savings and goes well beyond eliminating a great waste of energy.

And however, compressed air is still often forgotten when programmes for reducing production costs are drawn up.

André DEGRAEVE, Manager SDT International