Leak Detection Report

This report has been prepared by **Ovec Systems Ltd**, leaders in micro-leak testing systems, to help clarify leak detection measurement and terminology. The report covers existing leak testing techniques, standards and features, to assist you in identifying an appropriate system for the control of your manufacturing process, to ensure quality and customer satisfaction.

What is Leak Detection?

A leak can be defined as *"a crack or hole that admits or lets escape, usually with prejudicial effect."*

This definition of a leak can be related to industrial leak detection. **Leak detection** can be defined as a method for the detection of gas or liquid leakage in sealed products or systems, which can occur despite careful manufacturing techniques. Therefore, to ensure product quality and integrity, leaks must be detected, and often measured, in food packaging and other industrial and military sectors. Leak testing is performed for 3 basic reasons:

- **To prevent material loss by leakage.**
- **To prevent contamination, the creation of hazardous conditions, short product life or disfigurement by leakage.**
- **To detect faulty components and control the reliability of the product.**

Leak detection falls into 2 categories

- **Leak Measurement** – measurement of the individual leak rate or total leakage of a system or subsystem.
- **Leak Location** – precisely locating the point of leakage.

In testing a product, the most appropriate sequence is the measurement of total leakage and then, if necessary, the location of individual leaks.

How are leaks measured? What terminology is used?

All leaks into or out of products, involve a flow. The most widely used methods of leak detection depends upon observation of gas flow and therefore, **leaks are typically measured in terms of quantity of gas flow per unit of time**. Quantity can be described as the mass or number of molecules of the gas per unit time.

The most common term used to measure the quantity of the leaking substance (gas) is **Standard cubic centimeters per second (Std. cc/sec)**. This is simply the mass of gas in a cubic centimeter measured at a barometric pressure of 760mm Hg and defined at a standard room temperature of 20° C.

Leak Rates are expressed as Mass per Unit of Time

1 Std. cc/sec :- Defined as amount of gas in 1 cubic centimeter supporting a column of mercury 760mm high at a temperature of 20°C.

cc = cubic centimeters

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What are acceptable leaks?

Leaks which are classified as acceptable will depend upon the nature of the product. In industry, the term **leak-tight** has taken on a variety of meanings and could perhaps be best described as **no detectable leak.** This helps to determine to what type of test the product should be subjected. A water bucket is leak tight if it does not allow easily detectable quantities of water to leak out. A customer may notice that a food can shows signs of staining on the end if liquid had escaped or, when the tab is pulled on a beverage can, he will observe that there is no hiss of the fill gas escaping.

In each situation, the required degree of leak tightness depends on the product. Since the cost of leak detection increases as the specified leak rate decreases, it follows that testing for unnecessarily small leaks can incur unwarranted additional test expense. Therefore, **it is important to measure leaks or define the degree of leak tightness by comparison with a standard or specification**.

Some examples of product leak rate specifications are shown in the table below:

Product or System	Leak Rate Specification	Comment
Chemical Process Equipment	1 cc to 10^{-3} Std cc/sec	Distillation Processes
Torque Converter	10^{-3} to 10^{-4} Std cc/sec	Retention of fluid
Beverage Can End	10^{-6} Std cc/sec	Retention of CO_2
Vacuum Process System	10^{-2} to 10^{-10} Std cc/sec	Dynamic system. Smaller leaks, if present, have negligible effect.
IC Package	10^{-7} to 10^{-9} Std cc/sec	Hermetically sealed package.
Heart pacemaker	10^{-9} Std cc/sec	Implant in human body.
Domestic refrigerator	$4x10^{-6}$ Std cc/sec	Refrigerant retention, sufficient to give a 5 year guarantee on product

A leak amounting to 1 cc per second is a very large and usually an unacceptable leak, particularly if the leaking fluid or gas is toxic, corrosive, explosive, or flammable. There is a need for a universally understood method of stating leak rates which are smaller than 1 cc per second. This can be done by expressing the leak rate using fractions of a cc per second, in decimals, or more commonly in minus powers of the number 10 (exponential).

The following chart expresses the difference in leak rates in various powers of 10, which is the most common method of expression. It shows the leak rate in cubic centimeters at various intervals.

Leak Rate (cc)	1×10^{-2}	1×10^{-3}	1×10^{-4}	1×10^{-5}	1×10^{-6}	1×10^{-7}
	Amount of leakage (cc)					
Per Second	0.01	0.001	0.0001	0.00001	0.000001	0.0000001
Per Minute	0.6	0.06	0.006	0.0006	0.00006	0.000006
Per Hour	36	3.6	0.036	0.0036	0.00036	0.000036
Per 24 Hours	864	86.4	0.864	0.0864	0.00864	0.000864
Per Week	6048	604.8	60.48	6.048	0.6048	0.06048
Per 4 Weeks	24192	2419.2	241.92	24.19	2.419	0.2419
Total Leakage Per Year	314496	31449.6	3145	314.5	31.45	3.145

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Leakage Effects

In certain circumstances the consequences of unacceptable leaks can be serious. Leakage can lead to spoilage, especially in canned food and beverages, which can further lead to infection and food poisoning incidents. The unacceptable leaks can encourage the growth of microorganisms, which are responsible for such incidents, as well as affecting the product freshness and taste. **These incidences cause the industry many millions of pounds in claims each year.**

The following information shows how different types of leakage can affect product performance.

Ingress / admission (leaks in)
Substances entering through leaks can affect product performance. Quenching fluids and bacteria, airborne contaminates. Examples are,

PRODUCT	EXPOSURE	EFFECTS
Sealed packed foods/Canned Foods	*oxygen, water vapour and bacteria*	Spoiled product
Semiconductor IC packages	*oxygen, water vapour*	Product life reduction
Pharmaceuticals	*water vapour*	Loss of potency
Pacemakers, other implants	*corrosive body fluids*	Malfunction / death
Chemical process systems	*oxygen, water vapour*	Product spoilage
Watches (conventional or digital)	*water vapour*	Malfunction
Cryogenic storage and transport units	*air leaking into vacuum vessel*	Reduced product retention

Loss / escape (leaks out**)**
Substances escaping through leaks can affect performance. Operating fluids and gases, Examples are,

PRODUCT	EXPOSURE	EFFECTS
Refrigerant and air conditioning systems	*loss of refrigerant, water*	Efficiency loss
Beverage cans	*loss of carbon dioxide, contents*	Spoiled contents
Shock absorbers, hydraulic systems and torque converters	*loss of oil or compressed gas*	Malfunction of product
Aerosol spray cans	*loss of propellant*	Product stays in the can

Ingress / loss
Some can leaks can fall into both groups, depending on shelf life and temperature variations to which they are exposed.

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Leak detection techniques used in the canning industry

TECHNIQUE & DESCRIPTION	ADVANTAGES	DISADVANTAGES	Minimum Detectable leak
PRESSURE DROP This test is performed on a system pressurized to a recorded pressure. The system is sealed and leakage is monitored by checking the rate at which pressure drops.	Test is relatively simple in principle. Fairly easy to perform in small test systems.	Can be used only for systems capable of being pressurized Difficult to determine location of unacceptable leakage. More suitable for measuring large rates of leakage.	**0.01cc/sec ($1x10^{-2}$)**
LIGHT DETECTION TEST Light is collected through any pin-holes in the end exposed to the light source.	On line 100% test	Faulty products can pass the light test because some leaks cannot be detected due to masking or the geometry of the leakage path.	**0.001cc/sec ($1x10^{-3}$)**
BUBBLE TESTING This technique involves the use of air as the tracer gas. One of the many techniques available under this method involves pressurizing one side of the system to be tested with air (tracer gas) and submerging in water. A stream of bubbles will form at the point of leak.	Bubbles locate leak position Little skill and cost involved. Procedure is safe in combustible atmospheres. Appropriate equipment readily available.	Sometimes bubbles are from sources other than leaks and give false signals. Low reliability as water surface tension or impurities may plug the leaks temporarily. Operator and time dependent. Tested product can't be returned to the line without cleaning.	**0.0001cc/sec ($1x10^{-4}$)**
DYE PENETRATION This test involves applying a penetrating dye to one side of the surface. After a minimum of 15 minutes the other side is visually examined for the presence of dye by using either a developer solution or ultraviolet light.	Materials are relatively low cost. The dye produces a visual indication of the leak.	Method has more sensitivity than water immersion or soap bubbles, but the results can be affected by the geometry of the leakage path. Objects or products tested are defaced. Procedure is very slow The dye may plug the leak temporarily.	**0.000001cc/sec ($1x10^{-6}$)**
HELIUM MASS SPECTROMETER The tracer gas used in this method is inert Helium gas (He). The gas is exposed to one side of the product and the other side is evacuated though the mass spectrometer (detector). If any of the Helium passes through a leak, the spectrometer sensor will detect the presence of Helium atoms. The sensor responds with a signal in proportion to the amount of Helium, and an alarm is triggered.	Not dependent on operator judgement. Method is reliable and consistent. Helium is readily available. Mass spectrometer system can have sensitivity of up to $1x10^{-12}$ cc/sec. Fast and efficient. Non-destructive Reference leaks traceable to international standards	Production-line units involve high initial cost. This is offset by:- • returning the tested product to the production line. • No operator involvement in the testing process • Reduction of costly returns Equipment requires regular maintenance by a qualified person. (Training is provided for customer's engineers)	**0.000001cc/sec ($1x10^{-6}$)**

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Additional Information on Helium Leak Detection

Mass spectrometry is the fastest, most sensitive and reliable form of micro leak detection. The process can be automated, thereby reducing operator costs, and can accurately detect the smallest of leaks.

Helium is the tracer gas used, due to its combination of useful features:

1. It is the lightest inert gas with the smallest molecular size (easily penetrates small leaks).
2. Trace amounts are easily detected (by mass spectrometer)
3. There are only 5 parts per million occurring naturally in the atmosphere (low background during testing).
4. It is readily available.
5. It is non-destructive, non-toxic and non-hazardous.

The helium mass spectrometer can provide an immediate identification of:

- The existence of leakage
- The location of leakage
- The rate of leakage

It is used in the canning industry for end leakage testing and is also used widely for testing industrial and laboratory equipment, high pressure systems, compressor units, glass to metal seals, hermetically sealed components, space hardware, liquid gas storage vessels and valves.

Conclusion

It is important that leak testing of products is carried out to a known standard and by a reliable technique. In this way, there is greater control over the manufacturing process and improved product quality, one of the main driving factors for manufacturing businesses today.
Leak detection is clearly important in maintaining quality, customer satisfaction and public health standards, as well as in avoiding the risk of costly returns.

For further information, contact Ovec Systems Ltd, specialists in helium detection equipment and quality control products.

Helping you to control the process

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