CINCINNATI TEST SYSTEMS

Your Global Leak and Function Test Solution Experts

Using Pressure Decay to Leak Test Large Volume Part Designs

SEE HOW THE SENTINEL I28 PROVIDES A NEW WAY TO LEAK TEST LARGE PARTS, SOLVING THE TYPICAL CHALLENGES WITH AIR LEAK TESTING TO PROVIDE A REPEATABLE, RELIABLE TEST IN THESE APPLICATIONS.

Click to start

Introduction

Large volume parts are some of the most challenging parts to test in any industry due to their size, handling issues, and the time necessary to conduct testing for any water ingress leak testing requirements.

The most common way to test large parts is to use tracer gas leak testing techniques, especially for high production and low leak rate measurement requirements. However, there is a higher cost associated with tracer gas leak testing due to equipment cost and the ongoing cost of the type of trace gas used for the testing process.

WHAT IS CONSIDERED A LARGE PART?

>15L

Large volume parts include those from 15L to hundreds of litres. These parts are common in commercial machinery, off-highway transportation, eMobility/EV, and more.

FOR MANUFACTURERS CHOOSING TO BYPASS MORE COSTLY TRACE GAS TESTING FOR LOWER PRODUCTION RATE PROGRAMS AND LOWER COST EQUIPMENT, CTS HAS A SOLUTION!

Learn how CTS' Sentinel I28 solves the typical challenges with air leak testing for large parts to provide a repeatable, reliable test.

Continue Reading >

Challenges of Large Part Leak Testing

Problems that are commonly linked with using pressure decay techniques to leak test large volume parts

There are a variety of factors that come into play when designing a large part leak test and you need to carefully balance these contributing factors to ensure a repeatable test.

While many manufacturers could benefit from using pressure decay techniques for testing their large volume leaks, they can be intimidated by the problems linked to using air leak testing technologies for large part volumes, including:

- **Fill time:** This includes instrument-related challenges, restrictions in fill/exhaust valves, part design, including port sizes and seal designs, and more. All of these factors provide restrictions and challenges in bringing a part up to pressure quickly and at a stable, repeatable pressure.
- **Test pressure control:** Test pressure in large volume parts can be inconsistent during the test cycle part to part, due to the complications in test pressure—and adiabatic thermal effects that make it harder for large parts to stabilize. These control factors impact the repeatability of your test from part to part.
- **Low pressure differential:** Due to a variety of factors, including part flex in many large part designs and atmospheric pressure fluctuations, large parts must be testing at low pressures. However, these low pressures are highly affected by atmospheric affects. Atmosphere brings noise into the system, making it very hard to differentiate a small pressure loss in a large surface area part compared to the variability associated with atmospheric pressure changes and environmental drift.
- **Large, flexible areas:** Many large volume parts are designed out of flexible materials, including sheet metal covers, plastic, and other thin wall structures. This creates expansion and contraction effects that amplify atmospheric pressure effects, making it difficult to get a reliable, repeatable leak test.

All of these issues can affect your repeatability test to test and raise the minimum observable leak rates, limiting the specification ranges possible with your test. CTS' Sentinel I28 is built with capabilities that solve these challenges.

See How CTS Solves These Challenges >

CTS Makes it Possible to Use Pressure Decay to Leak Test Large Volume Parts

4 ways the Sentinel I28 solves the typical challenges to provide a repeatable, reliable test

Cincinnati Test Systems has applied 40+ years of experience in leak testing to integrate proven measurement solutions into the Sentinel I28 pressure decay leak test instrument to address these common problems, using:

- Quick Fill Pressurization
- Target Pressure Correction
- Ambient Pressure Correction
- Large Volume Part Calibration

By combining quick fill capabilities, target pressure correction, ambient pressure correction, and a unique calibration process, CTS offers repeatable small pressure loss measurements to be correlated to the low-level volumetric flow rates required for large volume parts. Using this approach, CTS has helped customers across the globe optimize their large volume leak tests with a cost-efficient solution.

ARE YOU USING THE RIGHT INSTRUMENT FOR LARGE VOLUME PART LEAK TESTING?

Learn how the **Sentinel I28 LV** pressure decay leak test instrument has been designed to address each of the factors affected by testing large volume parts.

Continue Reading >

1. Quick Fill Pressurization

There are four main enhancements that have been integrated into the Sentinel I28 LV instrument to meet the quick fill pressurization needs of testing large volume parts:

- Enhanced air flow capacity
- Proportional regulator
- PID feedback loop / PID controller
- PID loop tuning capabilities

To allow for enhanced air flow capacity, CTS has developed a hardware kit as an add-on modular package that integrates easily into the standard Sentinel I28 pneumatic manifold and is controlled by the standard instrumentation. The **Enhanced Fill Kit** connects into the instrument I/O (input/outputs) seamlessly and supplies an unrestricted valve manifold to flow air easily through ½" fill lines that bypass the main instrument manifold.

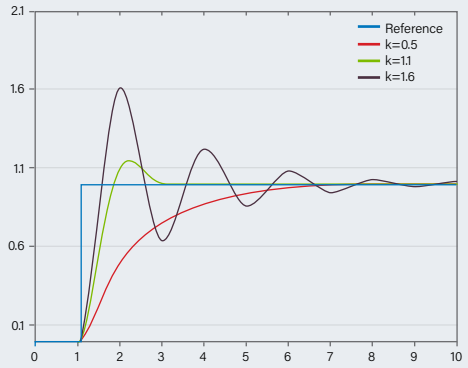
A **proportional regulator** is used to reach target pressure precisely, and a **PID feedback loop / PID controller** (rather than a manual regulator) is used to regulate pressure repeatably. A key benefit to using a PID feedback loop /controller is that it can be tuned (**PID loop tuning**) and filling pressure can be 'programmed' for different parts for better accuracy and repeatability.

The instrument stores different part designs and fill characteristics based on each individual part characteristic so you can program the instrument to react to a certain part size and/or part design and change that as you change over your test parameters from one test design to the next. And it allows for much higher repeatability test to test.

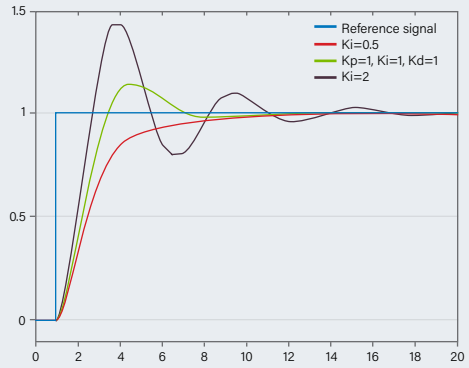
Quick Fill Pressurization continues on the next page

Quick Fill Pressurization (continued)

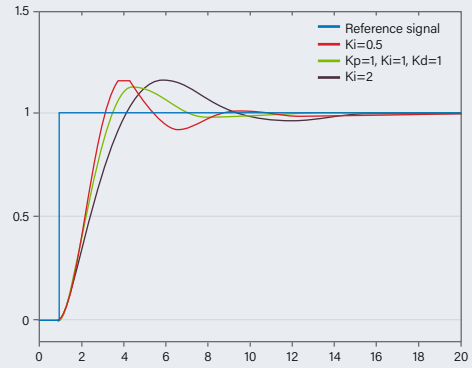
PID loop tuning considers part stability and possible leak characteristics of the part keeping the flow path open to bring the part up to test pressure. There are three control parameters offered to allow different types of parts to be brought up to pressure quickly and in a repeatable, controlled way: Proportional, Integral, Derivative.



Proportional: Affecting the gain of the controller; the larger the error from the setpoint, the larger the proportional effect.



Integral: Affects the acceleration toward the target pressure. This uses the magnitude and duration of the error to determine acceleration.

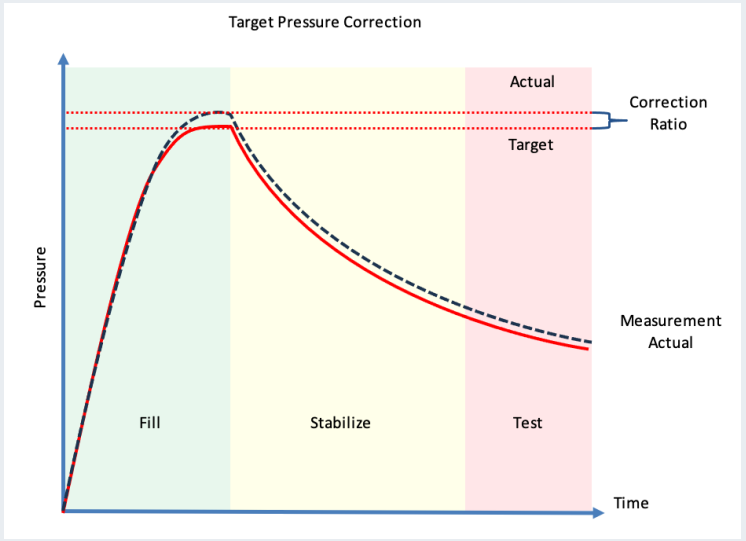


Derivative: Controls the setting time and stability of the system, which is not often used due to other methods of filtration like low pass filters.

2. Target Pressure Correction

Another key to repeatable leak testing of large parts is starting the test cycle at the same test pressure part after part. What makes this challenging is that test pressure in the part after the Fill and Stabilize period will be different based on whether it is a non-leaking part or a leaking part. A leaking part will lose more pressure during the stabilize period (due to the presence of a leak), resulting in a lower pressure used for the test. This results in big problems for part pressure repeatability from test to test.

This is why we have **Target Pressure Correction** built into the Sentinel I28 measurement system for large volume leak testing, to control pressure variance during the Fill and Stabilize periods of the test. Target Pressure Correction compares a programmed test pressure to the actual test pressure measured during the test cycle. The instrument then correlates a comparative measurement output to maintain accuracy accounted for by the two different pressures (calibrated part pressure and tested part pressure). The ratio is used to calculate an offset to loss in pressure.



Target pressure correction paired with a robust calibration cycle allows for a precise and repeatable test measurement. The instrument achieves this by collecting all the data points measured during the test cycle. The calculation of loss uses a linear regression algorithm supplying precision measurements of small pressure changes over a long period of time. By combining target pressure correction into this algorithm, noise commonly measured over long test cycle times is removed.

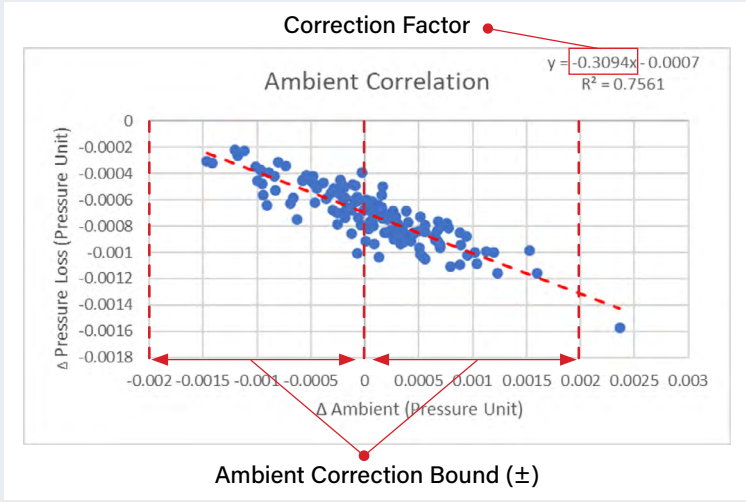
3. Ambient Pressure Correction

When large volume parts are tested at lower pressures (less than 1 psig), there are factors that will affect pressure measurements of the part as it flexes, which is inevitable with many large part designs. These factors include test pressure inside the part, part material design, wall thickness, surface area, leak rates of the part, and atmospheric changes during test caused by factory HVAC systems, etc.

Ambient pressure is one of the biggest influencing factors causing poor test repeatability. These pressure changes, even small, can greatly affect pressure loss measurements in parts with flexing walls that have large surface areas. They can also mask certain leaks.

CTS has integrated Ambient Pressure Correction into the Sentinel I28 LV instrument to help mitigate this influence while collecting test measurements.

Ambient Pressure Correction uses a secondary pressure sensor to measure ambient pressure outside the part while measuring internal part pressure changes. The leak tester automatically brings those two measurements together and includes both in a Correction Factor. The system automatically corrects the pressure changes measured within the part based on the measured ambient pressure changes outside of the part, resulting in significantly higher repeatability.



THE CORRECTION ALGORITHM: HOW IT WORKS

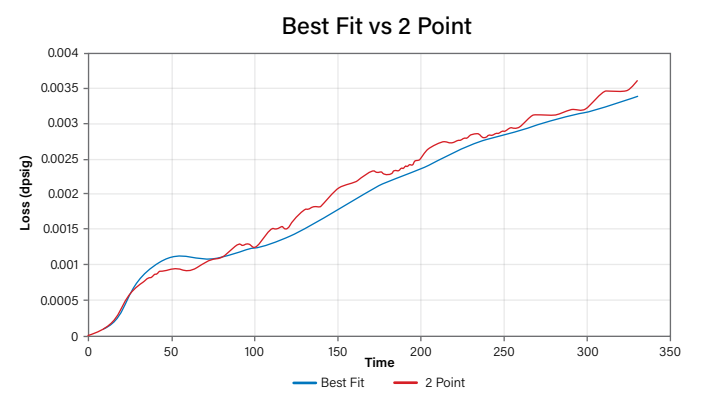
- The part is tested multiple times (30 or more cycles) at its baseline state
- The data is then analyzed, and a correction factor and bounds are determined (using formula to determine correction factor)
- The correction factor and bounds are implemented into the instrument
- If the data during a production cycle is outside of the bounds, correction is not applied and the user can choose to either fail the test or use the uncorrected value

4. Large Volume Part Calibration

A calibration cycle conducted on large volume parts is not the same as a standard two-point calibration cycle used for testing rigid small volume parts. When you are testing part volumes greater than 10L, the calibration cycle is conducted over the period of a day or a normal workday shift. As a day progresses, different environmental variables affect measurements, and a multi-point calibration cycle is utilized to average out variation.

CALCULATING LOSS WITH BATCH CALIBRATION METHOD

The following graph shows the difference between a two-point measurement and a best fit algorithm measurement. You can see how the blue line really smooths out some of the noise we see throughout the process of testing a part. This is with the known leak standard in it and we are measuring a very smooth rate of change as this part loses pressure based on its leak.



Environmental conditions that can impact your test

- Weather / time of year
- Sunshine / heat
- HVAC systems in the plant
- Other machinery on the plant floor
- Etc

The solution to this is using Batch Calibration. This approach is a little different from standard pressure decay calibration, which uses standard two-point calibration. This process calibrates using a master, known non-leaking part and a known leak rate with the leak standard (with a known leak rate) built into it to identify the ΔP.

Benefits of Batch Calibration for large part leak testing

- Eliminates 'bad calibrations'
- Reduces production cycle variances
- Improves testing accuracy

Alternatively, with Batch Calibration, you test the same master part repeatedly throughout the day, with and without a leak standard introduced into it (automated and controlled by the instrument). This characterizes the change in pressure within this known part in relation to different atmospheric pressures, ambient pressures, and corrections that occur throughout the day. **This eliminates the chance of an incorrect calibration, reduces production cycle variances, and improves the accuracy.**

Struggling with Large Part Leak Testing? Contact CTS!

Whether you are looking for an air leak testing solution or a tracer gas leak testing solution, the experts at CTS will help you design an accurate, repeatable leak test. CTS has over 40 years' experience helping manufacturers across the glove overcome the challenges of large part leak testing—and we can help you too!

Our application engineers take the time to understand your part and applications, including leak rates and the variables affecting the part, and then come up with the right technical solution and technology for your application. Using our wide portfolio of leak testers and technology, we can refine your test to reduce any affecting variables to deliver a reliable, repeatable, cost-effective test.

TESTING LARGE PARTS WITH >10L OF FREE AIR SPACE WITH A PRESSURE OF 1 PSIG OR LESS?

You may benefit from the cost-effective Sentinel I28 LV solution!

Contact CTS for a no-obligation consultation >

CINCINNATI TEST SYSTEMS

Your Global Leak and Function Test Solution Experts

Choose the right instrument to leak test your large volume parts for repeatability and accuracy on your production line.

The experts at CTS can assist you in designing the best solution for your manufacturing leak test application.

Contact us today

cincinnati-test.com

© 2024 Cincinnati Test Systems. All rights reserved.