NOTE #20-01

Validating a New Leak Test System: The Dual Distribution Technique

GO- / NO-GO LEAK TESTING

A production leak test system is a "go- / no-go" instrument, meaning it is designed to test and sort parts that leak from parts that do not leak in relation to a specified leak rate reject limit. In a production environment, when short cycle times are often desirable, leak test systems are designed to give the highest test reliability in the shortest cycle time. Under these high-speed conditions, it is often not practical to provide highly repeatable measurement results for leaks that are much lower than the leak rate reject limit, nor for gross leaks, which are well above the limit.

Of particular concern is ensuring that the system does not pass leaking parts, and very rarely will reject a "no leak" or good part. There exists a tug and pull between test cycle time and leak test measurement repeatability or process capability.

This document describes one of a few techniques that can be used to set up any leak test system and ensure the equipment and the process are optimized to achieve reliable test results—no false accepts and no false rejects.

OVERVIEW

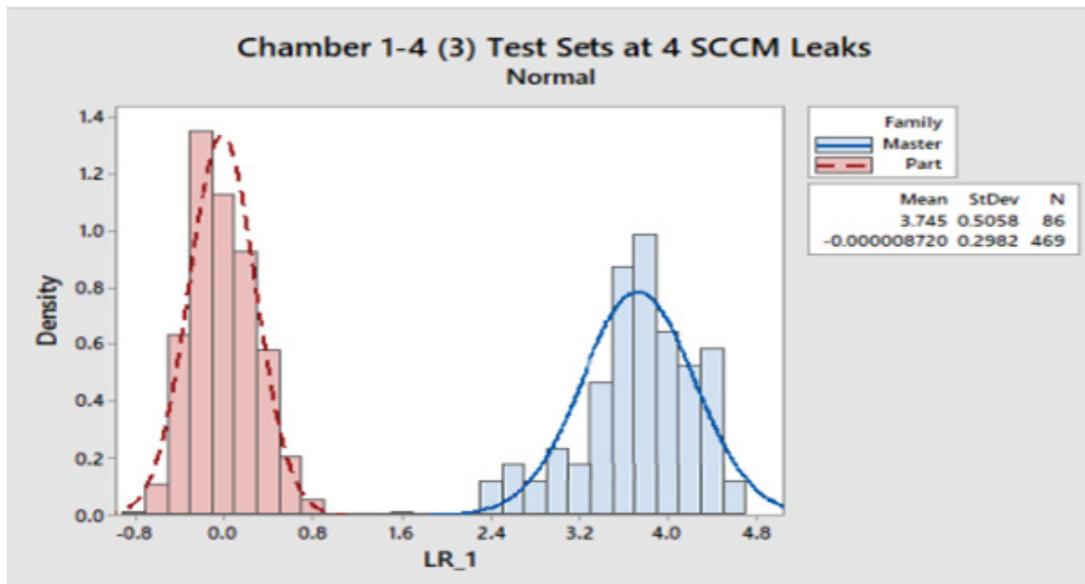The Dual Distribution Technique can be used for any test method including the following.

- Helium Leak Testing – Fill Test Part in Chamber: the test part is placed in the vacuum chamber and the internal volume is connected to a helium source via a hose or fixed tooling.

- Helium Leak Testing - Prefilled Part: The test part has been filled with helium and sealed closed prior to being placed in the vacuum chamber for testing.

- Helium Leak Testing - Bombed Part: The test part has been bombed with helium prior to being placed in the vacuum chamber for testing.

- Air Leak Testing: Any pressure or vacuum decay or mass flow air leak test method.

This document will describe an adaptation to the "Fill Test Part in Chamber" leak test method.

In simple terms, this validation technique requires testing of several "no leak" parts and several "reject leak" parts, creating a set of test data that can be statistically analyzed as two different normal distributions—a distribution of "no leak" parts, and a distribution of "reject leak" parts. If the two distributions are sufficiently separated, then one has an acceptable robust test setup.

The following figure shows a frequency histogram of what the data might look like.

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In order to conduct these tests, the following is required:

- A sample of actual test parts that are known to be non-leaking (a minimum of five).

- A subset of the above test parts that have a port where a calibrated leak can be connected (ideally five or more parts, but one sample part may be used, if necessary).

- An open style calibrated leak with a leak rate value close to the reject limit (within ± 10% approximately).

CONDUCTING THE VALIDATION TESTS

Ideally, the larger the sample of parts the more statistically significant the tests will be. It is common, however, to rotate through and test parts multiple times to obtain sufficient data. If it is not convenient to have more than one reject limit calibrated leak, or if it's not easy to connect the calibrated leak to a known good part, then one part with the calibrated leak attached may be used.

NOTE: In most applications it is critical to have actual test parts in order to conduct the testing. This is because the parts can often have characteristics that can impact the test cycle (For example, a test part may have high surface area and slow down the chamber evacuation step). However, if parts are not available, dummy parts can be fabricated that have similar characteristics to the actual test part.

Prior to beginning data collection of leak test data, set up a test recipe that will meet the desired test cycle time. Perform a calibration run and ensure the system is properly calibrated. Run a few tests with no leak parts and a few tests with parts that have the reject limit calibrated leak connected. Verify that all good parts pass and the leaking parts fail or read very near the failure point (reject limit). Also, verify that the cycle time meets the production needs.

Run between 25 and 50 test cycles (more if practical) randomly selecting leaking and no leak parts, ensuring approximately the same number of test cycles with no leak parts, and leaking parts.

Group the data into the two data sets and plot a frequency histogram as shown in the sample above. Calculate the average and the standard deviation for each sample. Visually verify that the two normal distributions do not overlap. If they overlap, you will need to adjust some recipe parameters, such as test cycle time, to create more separation between the two distributions. Also, verify that there are no outliers of no leak parts that could have indicated a leak due to a tooling or connector issue.

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CONDUCTING THE VALIDATION TESTS (CONTINUED)

For the "Fill Test Part in Chamber" test method, to increase separation of the two sets of data consider adjusting the following parameters (this assumes you are unable to increase the reject limit or helium test pressure):

- **Helium Background Limit.** This limit determines the maximum level of the helium signal prior to filling the test part with helium and taking the measurement. Reducing this parameter requires the system to pump down to a lower helium background signal prior to filling the part with helium. This will create more separation between the no leak and leaking parts by lowering the average reading of the no leak parts. The typical test sequence is as follows:

  1. Evacuate the test chamber (in parallel evacuate in the inside of the test part) Once the chamber pressure is low enough, the helium leak detector is valved into the chamber and the helium signal is monitored.

  2. During this monitoring step the chamber pressure continues to decrease as does the background helium signal. Once the helium signal reaches the Helium Background Limit, the proceed to the next step.

  3. Fill the test part with helium and begin to look for any gross helium leaks. If the signal increases above the gross leak reject limit, then end the test immediately and fail the part. Once the helium pressure is achieved as a result of the fill process, go to the next step

  4. Monitor the helium signal for a period of time, called the Test Time. This timer counts down and ensures the helium signal that appears from the leak has an opportunity to rise and stabilize. Once the Test Time expires record the final leak rate reading and compare to the reject limit. Pass or fail the part accordingly.

- **Test Time.** Adjusting the test time to a longer time frame will ensure that the helium signal reaches full strength and/or stability before making the final pass/fail decision.
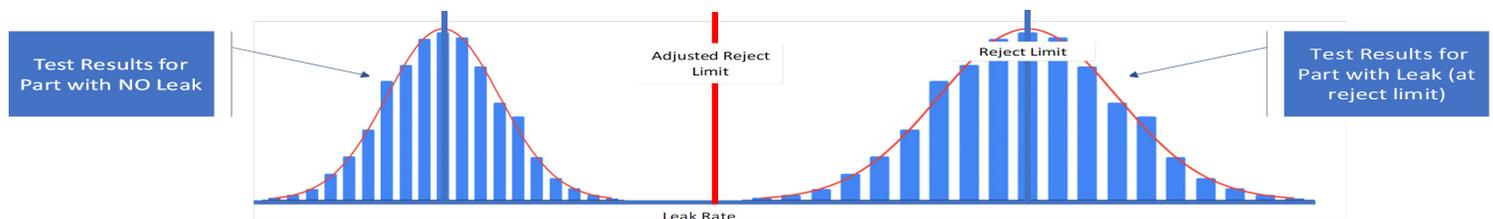
NOTE: For other leak test methods, adjust the recipe parameters that will give more stable test results or cause the test results for non-leaking parts to be reduced closer to zero.

ANALYZING THE RESULTS

A simple way to ensure that the two sets of data do not overlap is to perform the following calculations.

1. Calculate the average and the standard deviation (SD) of each data set.

2. Locate the point on the horizontal axis (leak rate) that is 3 x SD to the right of the average of the no leak data set.

3. Locate the point on the horizontal axis (leak rate) that is 3 x SD to the left of the average of the leaking (reject calibrated leak) data set.

4. Ensure there is still separation between these two points.

To ensure the highest degree of confidence, one should set the reject limit three standard deviations (3 x SD) to the left of the average calibrated leak data set. This provides a 99.7% confidence that the two distributions will not overlap. See the figure below.

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On a LACO leak test system, the Reject Limit Safety Factor can be used to reduce the nominal reject limit. This factor is typically set between 0.5 and 1.0 and is multiplied by the leak rate reject setpoint to lower the actual reject limit used to reject a part. If you perform the above procedure and set the reject limit 2 x SD to the left of the average, then your confidence will be 95%.

The dual distribution method is a simple yet powerful way to ensure you leak test process is statistically robust. Implementing proper daily validation protocols on your production leak test system will ensure that your process remains stable and in control.

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