



Leak Testing Sealed Packages

Helium leak testing open packages is pretty straight forward as one side of the part is under vacuum (leak detector side) and the other is open to atmosphere (where helium is sprayed).

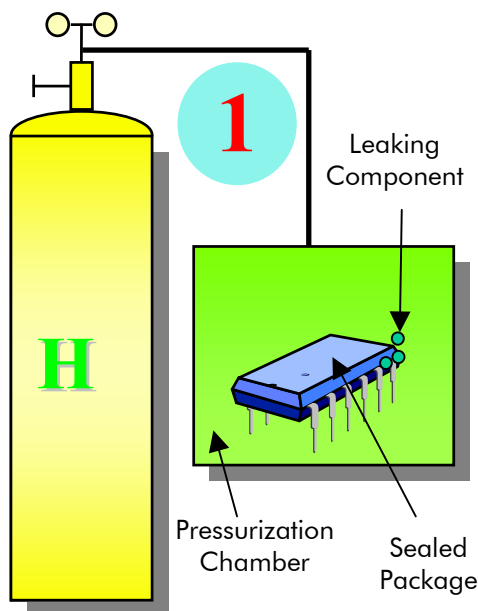
On the other hand, helium leak testing sealed packages present some challenges. These obstacles have been resolved using the “bombing” helium leak testing.

The method involves several phases.

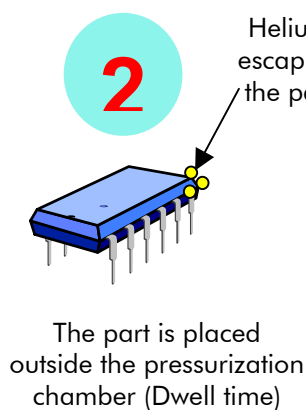
1. Helium pressurization. This phase consists of placing a sealed package in a chamber where it will get pressurized with helium (also called the bombing time). Given the pressure differential between the outside and the inside of the part, should the part leak, helium will be forced inside the part, through the “crack”, during the time of pressurization. Helium will eventually fill the part over time.
2. The second phase consists of removing the part from the pressurization chamber and bringing it to the HLD.
3. Then, the part is placed inside a test chamber that is connected to a helium leak detector (HLD). In case of a leaker, the helium that was forced in the part will come out through the crack. The HLD will detect and measure the helium leak rate coming out of the part.

The three steps of helium leak testing a sealed component:

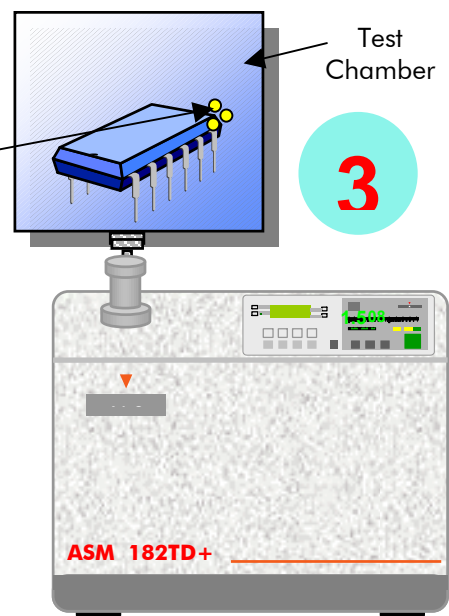
1: The pressurization process



2: The dwell time



3: The helium leak test





Leak Testing Sealed Packages (continued)

The Mil Spec 883-E defines the critical parameters that impact the value of the real leak escaping the part. The spec describes the computation involved to determine the real leak rate that is present after the pressurization phase. The following parameters are required to run the calculation:

- R: is the helium leak rate measured with the HLD (in Atm.cc/sec).
- L: is the real air leak rate that will be computed (in Atm.cc/sec).
- P_E: is the helium pressure inside the pressurization chamber (in Atmosphere)
- P₀: is the atmospheric pressure (in Atmosphere)
- M_A: is the air molecular mass (in gram).
- M: is the tracer gas molecular mass (in this case, helium) – (in gram).
- T₁: Pressurization time (in seconds).
- T₂: is the dwell time, time where the component is removed from the pressurization chamber before being brought to the HLD to be leak tested. The leak test time is included in the dwell time (in seconds).
- V: is the internal dead volume of the sealed package.

$$R = \frac{L P_E}{P_0} \left(\frac{M_A}{M} \right)^{1/2} \left\{ 1 - e^{- \left[\frac{L T_1}{V P_0} \left(\frac{M_A}{M} \right)^{1/2} \right]} \right\} \left\{ \frac{L T_2}{V P_0} \left(\frac{M_A}{M} \right)^{1/2} \right\}$$

Example of test conditions:

The helium pressure is at least 5 atmospheres (75 psi), the pressurization time (T1) is at least 1 hour and the dwell time (T2) is 30 minutes maximum.

For components with internal volume smaller or equal to 0.1 cc, the components will be considered leaking if the helium signal **measured by the HLD** is greater than 5E-08 Atm.cc/sec. (for an acceptable leak rate greater than 5.10⁻⁷ Atm.cc/s).

For components with an internal dead volume between 0.1 and 10cc, the component will be considered leaking if the helium leak rate **measured by the HLD** is greater than 5E-07 Atm.cc/sec (for an acceptable leak rate of 5E-06 Atm.cc/sec).





Leak Testing Sealed Packages (continued)

Practical limitations of the leak test method:

There are three physical limits to this leak test method.

1. The internal dead volume of the part. If the latter is too small, it cannot keep a sufficient quantity of helium that can be detected by the HLD.
2. The sensitivity of the HLD that cannot accommodate the measurement of ultra small leaks.
3. Parts that have a huge leak and that get pumped out during the pump down phase of the leak test. Helium gets removed before the HLD can detect it. Such leaks require a different leak test method to be caught, such as visual tests.

Determination of the pressurization and dwell times:

The pressurization time is determined based on the desirable leak rate value.

Practically, due to production throughput requirements and cost control, there is maximal acceptable pressurization time allowed. The dwell time has to remain within an acceptable value too. It would be unrealistic to set it less than one second as this would be impossible to achieve. Indeed, it would take more than one second to transfer the part from the pressurization chamber to the test chamber.





Leak Testing Sealed Packages (continued)

The following chart shows the pressurization time guide line values:
 These values are based on a pressurization value of 5 Atmospheres.

Calculation of the pressurization time to fill the internal volume of the part. Example, for a pressure of 5 Atm.

Time in hours	Internal volume in cc						
	0,001	0,01	0,1	1	10	100	1000
1,0E-10							
5,0E-10							
1,0E-09							
5,0E-09	39 h						
1,0E-08	19 h						
5,0E-08	4 h	39 h					
1,0E-07	2 h	19 h					
5,0E-07	23 mn	4 h	39 h				
1,0E-06	12 mn	2h	19 h				
5,0E-06	2 mn	23 mn	4 h	39 h			
1,0E-05	1 mn	12 mn	2 h	19 h			
5,0E-05	14 s	2 mn	23 mn	4 h	39 h		
1,0E-04	7 s	1 mn	12 mn	2 h	19 h		
5,0E-04	1 s	14 s	2 mn	23 mn	4 h	39 h	
1,0E-03	1 s	7 s	1 mn	12 mn	2 h	19 h	
5,0E-03		1 s	14 s	2 mn	23 mn	4 h	39 h
1,0E-02		1 s	7 s	1 mn	12 mn	2h	19 h
5,0E-02			1 s	14 s	2 mn	23 mn	4 mn
1,0E-01			1 s	7 s	1 mn	12 mn	2 mn

Only the area shown in light blue on the chart represents realistic leak rate measurements. Outside the blue area, the leak test will not be doable.





Leak Testing Sealed Packages (continued)

Practical method to define a leak test:

After defining the maximum allowable leak rate limit value: R, one needs then to determine the test conditions and the leak rate value measured by the HLD beyond which the part is considered as a reject.

The charts below allow, without complex calculations, to determine these equivalent helium leak rate set points for the HLD.

Test conditions		Pressurization value (in Atm): 5			Pressurization Time (in sec): 3600		Maximum dwell Time (in sec): 600	
Internal volume (cc):	0,001	0,01	0,1	1	10	100	1000	
Leak rate value read on the HLD (in Atm.cc/s)	Maximum allowable leak rate for an internal volume of: V= 0,001 cc	Maximum allowable leak rate for an internal volume of: V= 0, 01 cc	Maximum allowable leak rate for an internal volume of: V= 0,1 cc	Maximum allowable leak rate for an internal volume of: V= 1 cc	Maximum allowable leak rate for an internal volume of: V= 10 cc	Maximum allowable leak rate for an internal volume of: V= 100 cc	Maximum allowable leak rate for an internal volume of: V= 1,000 cc	
1,0E-11								
5,0E-11								
1,0E-10								
5,0E-10								
1,0E-09								
5,0E-09								
1,0E-08	1,2E-08							
5,0E-08	2,4E-07							
1,0E-07	7,1E-07	1,2E-07						
5,0E-07	3,0E-06	2,4E-06						
1,0E-06	2,7E-06	7,1E-06	1,2E-06					
5,0E-06		3,0E-05	2,4E-05					
1,0E-05		2,7E-05	7,1E-05	1,2E-05				
5,0E-05			3,0E-04	2,4E-04				
1,0E-04			2,7E-04	7,1E-04	1,2E-04			
5,0E-04				3,0E-03	2,4E-03			
1,0E-03				2,7E-03	7,1E-03	1,2E-03		
5,0E-03					3,0E-02	2,4E-02		
1,0E-02					2,7E-02	7,1E-02	1,2E-02	
5,0E-02						3,0E-01	2,4E-01	
1,0E-01						2,7E-01	7,1E-01	
5,0E-01							3,0E+00	

Example of application: Test conditions are as follow: Helium pressure = 5 Atm, Pressurization time = 1 hour and dwell time = 10 minutes.





Determination of the leak rate reject level set on the HLD based on a part with an internal volume of 1 cc, acceptable leak rate = 2.4E-04 Atm.cc/sec. The reject point on the HLD shall be set at: 5E-05 Atm.cc/sec.

Leak Testing Sealed Packages (continued)

Test conditions		Pressurization value (in Atm):	5	Pressurization Time (in sec):	18000	Maximum dwell Time (in sec):	600
Internal volume (cc):	0,001	0,01	0,1	1	10	100	1000

Leak rate value read on the HLD (in Atm.cc/s)	Maximum allowable leak rate for an internal volume of: V= 0,001 cc	Maximum allowable leak rate for an internal volume of: V= 0, 01 cc	Maximum allowable leak rate for an internal volume of: V= 0,1 cc	Maximum allowable leak rate for an internal volume of: V= 1 cc	Maximum allowable leak rate for an internal volume of: V= 10 cc	Maximum allowable leak rate for an internal volume of: V= 100 cc	Maximum allowable leak rate for an internal volume of: V= 1,000 cc
1,0E-11							
5,0E-11							
1,0E-10							
5,0E-10							
1,0E-09							
5,0E-09	1,4E-08						
1,0E-08	5,1E-08						
5,0E-08	5,7E-07	1,4E-07					
1,0E-07	1,1E-06	5,1E-07					
5,0E-07	3,0E-06	5,7E-06	1,4E-06				
1,0E-06	2,7E-06	1,1E-05	5,1E-06				
5,0E-06		3,0E-05	5,7E-05	1,4E-05			
1,0E-05		2,7E-05	1,1E-04	5,1E-05			
5,0E-05			3,0E-04	5,7E-04	1,4E-04		
1,0E-04			2,7E-04	1,1E-03	5,1E-04		
5,0E-04				3,0E-03	5,7E-03		
1,0E-03				2,7E-03	1,1E-02	5,1E-03	
5,0E-03					3,0E-02	5,7E-02	1,4E-02
1,0E-02					2,7E-02	1,1E-01	5,1E-02
5,0E-02						3,0E-01	5,7E-01
1,0E-01						2,7E-01	1,1E+00
5,0E-01							3,0E+00

Example of application:

Test conditions are: Helium pressurization = 5 Atm, pressurization time = 5 hours and 10 minutes of dwell time. Determination of the leak rate reject level set on the HLD based on a part with an internal volume of 0.01 cc, acceptable leak rate = 5.1E-07 Atm.cc/sec. The reject point on the HLD shall be set at: 1E-07 Atm.cc/sec.





Leak Testing Sealed Packages (continued)

Test conditions

Pressurization value (in Atm):	5	Pressurization Time (in sec):	18000	Maximum dwell Time (in sec):	600
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Internal volume (cc):

0,001 0,01 0,1 1 10 100 1000

Leak rate value read on the HLD (in Atm.cc/s)	Maximum allowable leak rate for an internal volume of: V= 0,001 cc	Maximum allowable leak rate an internal volume of: V= 0,01 cc	Maximum allowable leak rate for an internal volume of: V= 0,1 cc	Maximum allowable leak rate for an internal volume of: V= 1 cc	Maximum allowable leak rate for an internal volume of: V= 10 cc	Maximum allowable leak rate for an internal volume of: V= 100 cc	Maximum allowable leak rate for an internal volume of: V= 1,000 cc
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1,0E-11							
5,0E-11							
1,0E-10							
5,0E-10							
1,0E-09							
5,0E-09	1,4E-08						
1,0E-08	5,2E-08						
5,0E-08	6,1E-07	1,4E-07					
1,0E-07	1,3E-06	5,2E-07					
5,0E-07	6,2E-06	6,1E-06	1,4E-06				
1,0E-06	1,1E-05	1,3E-05	5,2E-06				
5,0E-06	3,0E-05	6,2E-05	6,1E-05	1,4E-05			
1,0E-05	2,7E-05	1,1E-04	1,3E-04	5,2E-05			
5,0E-05		3,0E-04	6,2E-04	6,1E-04	1,4E-04		
1,0E-04		2,7E-04	1,1E-03	1,3E-03	5,2E-04		
5,0E-04			3,0E-03	6,2E-03	6,1E-03	1,4E-03	
1,0E-03			2,7E-03	1,1E-02	1,3E-02	5,2E-03	
5,0E-03				3,0E-02	6,2E-02	6,1E-02	1,4E-02
1,0E-02				2,7E-02	1,1E-01	1,3E-01	5,2E-02
5,0E-02					3,0E-01	6,2E-01	6,1E-01
1,0E-01					2,7E-01	1,1E+00	1,3E+00
5,0E-01						3,0E+00	6,2E+00

Example of application:

Test conditions are: Helium pressurization = 5 Atm, pressurization time = 5 hours and 1 minutes of dwell time. Determination of the leak rate reject level set on the HLD based on a part with an internal volume of 0.1 cc, acceptable leak rate = 5.2E-06 Atm.cc/sec. The reject point on the HLD shall be set at: 1E-06 Atm.cc/sec.



Alcatel Vacuum Technology France – 98 Avenue de Brogny – BP 2069 – 74009 Annecy – France

Tel : 33 (0) 4 50 65 77 77 - Fax : 33 (0) 4 50 65 77 89

Web site : www.adixen.com



Leak Testing Sealed Packages (continued)

Conclusions:

Based on the formula shown above and based on test conditions, the following rules apply:

- The smallest detectable leak rate for components with an internal volume smaller than 0.001 cc is 5E-09 Atm.cc/sec. Smaller leaks will not be detected.
- The smallest detectable leak rate for components with an internal volume greater than 100 cc is 1E-03 Atm.cc/sec.
- Gross leaks greater than 1E-04 Atm.cc/sec cannot be detected when the internal volume is smaller than 0.001 cc.
- The greater the internal volume, the longer the pressurization time (see below chart).

	Pressurization time	Internal volume in cc						
		0,001	0,01	0,1	1	10	100	1000
Component leak rate (Atm.cc/s)	5,0E-09	39 h						
	1,0E-08	19 h						
	5,0E-08	4 h	39 h					
	1,0E-07	2 h	19 h					
	5,0E-07	23 mn	4 h	39 h				
	1,0E-06	12 mn	2h	19 h				
	5,0E-06	2 mn	23 mn	4 h	39 h			
	1,0E-05	1 mn	12 mn	2 h	19 h			
	5,0E-05	14 s	2 mn	23 mn	4 h	39 h		
	1,0E-04	7 s	1 mn	12 mn	2 h	19 h		
	5,0E-04	1 s	14 s	2 mn	23 mn	4 h	39 h	
	1,0E-03	1 s	7 s	1 mn	12 mn	2 h	19 h	
	5,0E-03		1 s	14 s	2 mn	23 mn	4 h	39 h
	1,0E-02		1 s	7 s	1 mn	12 mn	2h	19 h
	5,0E-02			1 s	14 s	2 mn	23 mn	4 mn
	1,0E-01			1 s	7 s	1 mn	12 mn	2 mn

