

This Technical Power Point was prepared by IsoVac Engineering and presented at the JEDEC meeting in January 2007 at the request of DSCC.

Its purpose was to provide an understanding of the influx of outside environments into devices of different cavity sizes with various leak rates, over intervals of time up to 20 years.

This was part of the evaluation of the adequacy of the seal testing requirements called out in the 750E TM 1071.8 & 883G TM 1014.12 Standards.

The Technical Theory used in computing this data may not agree with other's thinking, but it is found to be in close agreement with experimental data, and shows the Standard's leak specs need tightening.

Package Environment Exchange

--Based On--

***Leak Rate vs Cavity
vs Time***

Definition: “HERMETIC DEVICE”

Tables of Air Exchange

Proposed Tightening of Leak Rates

Bomb Pressure vs Device Compatibility

“Radioisotope” Thermal Leak Testing

Bubble Test

Helium Test

Optical Test

“Hermetic Device”

“Hermetic” is related to “Occult-Sciences”

“Magic” “Alchemy”

“Hermetic Device”

- *Is impervious to outside environments*
- *Sealed against entry of outside air*
- *Leak tightness sufficient to assure protection from materials that would prevent successful operational life.*

Note: *Extreme Tightness requirements can be expensive and be difficult to achieve.*

Objectives

Review:

- Current Leak Rate Specification Callouts
- Package Internal Volumes
- % Exchange with External Environments in days, months, 1, 5, 10, 15, 20 Years
- Options for Tighter Leak Rates

External Environmental Concerns:

- External Oxygen: $pp = 159$ torr; 20.9%
- External Water: $pp = 25$ torr; 3.3%

This Data Report is:

- **Not assuming all devices leak at Spec.**
- **Not speculating on effects on Devices**
- **Not recommending Leak Rate Specs.**

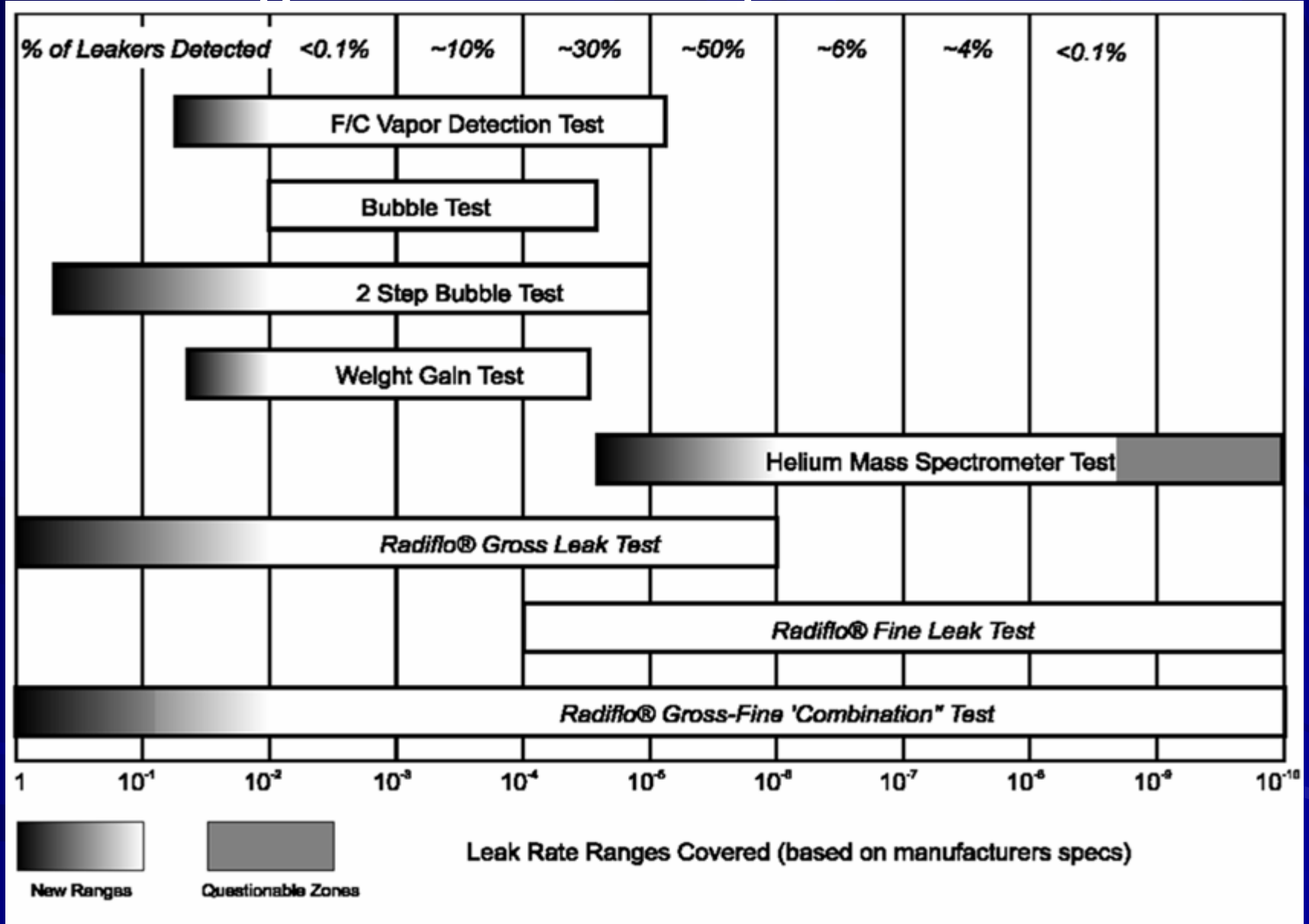
It Is Presenting the Data to show:

**The Exchange Rates of Atmosphere with
Device Internal Environments:**

- **With Devices of Different Internal Volumes.**
- **With Devices of Different Leak Rates.**
- **With Devices over Various Lifetimes.**

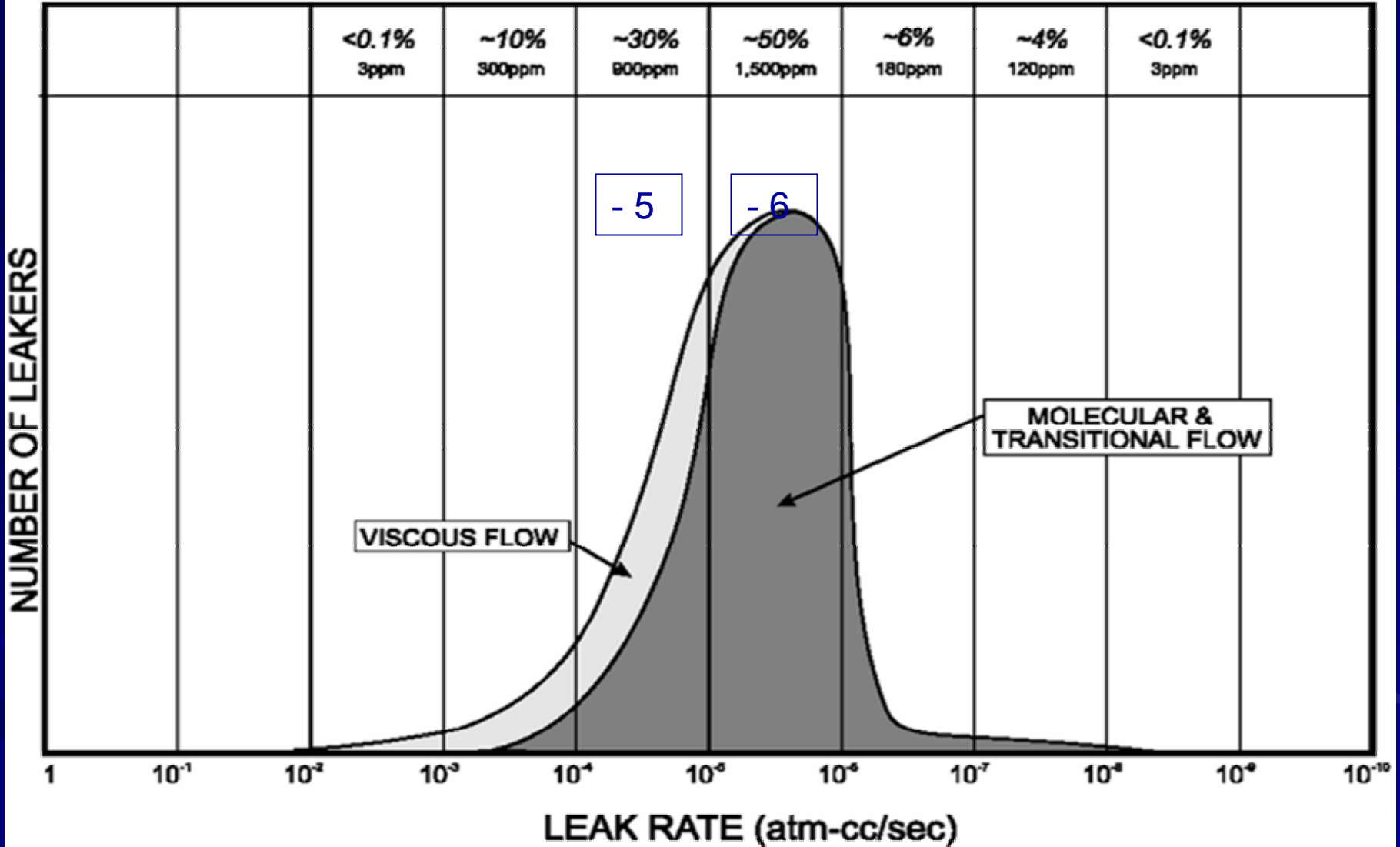
- It is important to realize that most devices that leak, have leak rates much greater than the Specification Callouts.
 - Extensive research has developed data to show that over 96% of leakers have leak rates Greater than 1×10^{-7} atm cc/s, and $<0.1\%$, (3 ppm), are below a 1×10^{-8} atm cc/s leak rate.
- That 0.1%, (3 ppm), is the concern here.

Leak Ranges Covered by Various Methods

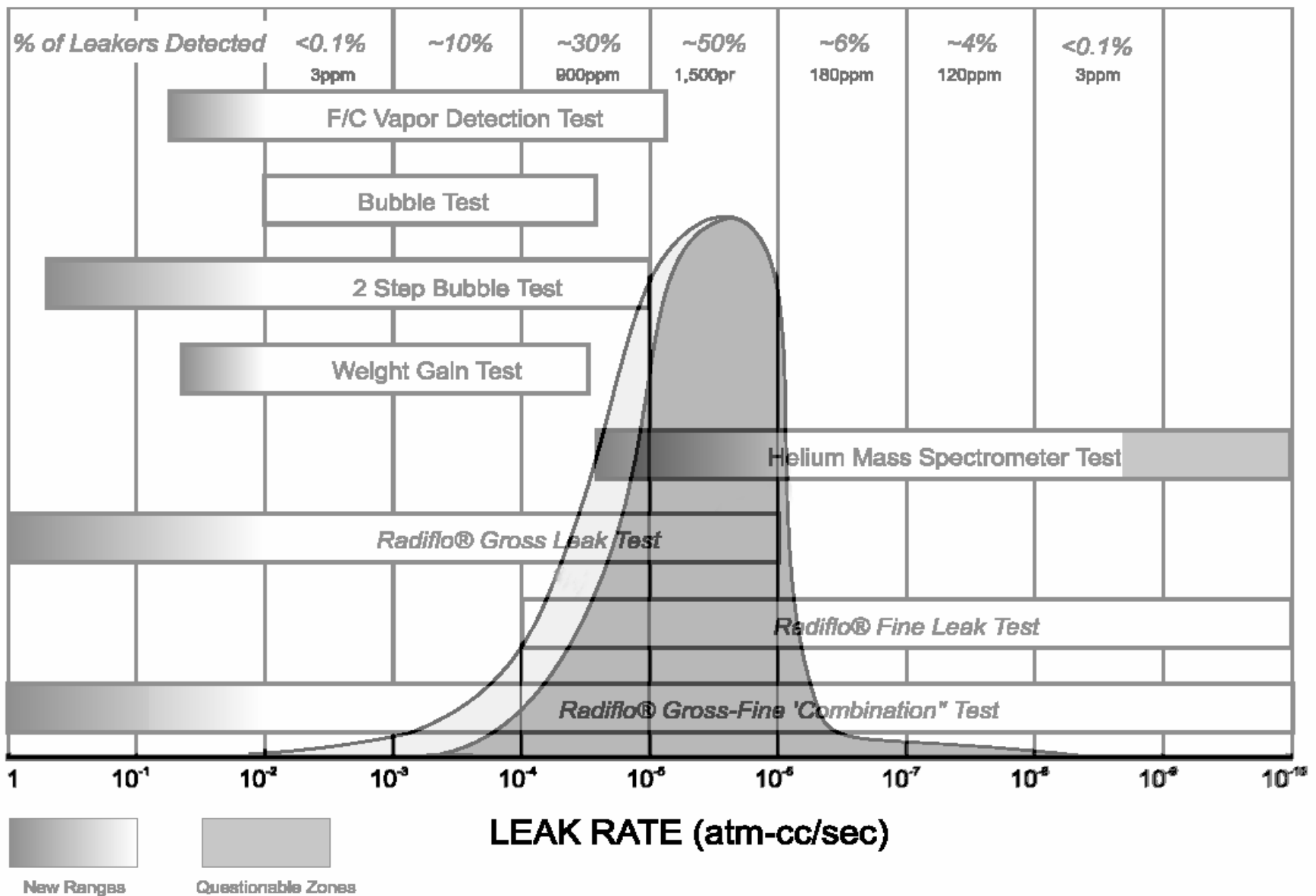


Typical Leak Rate Bell Distribution Curve

NOTE: Assume 'High Rel' devices with an average of 0.3% reject



Typical Leak Rate Bell Distribution Curve



Theory

The theory used here is based on an exponential equation that will show the transfer of one gas through a leak into a cavity, (which is void of that gas), at a rate based on the measured leak rate for that gas.

Since Oxygen and Water are of concern, we will use the leak rates in “Air” atm cc/sec.

Gas Exchange Equation (for O₂)

$$P_t = P_o e^{-kt}$$

Where:

P_t = Partial press O₂ at time “t”

P_o = Original partial press O₂

k = leak rate (std cm³/s)

cavity vol. cm³

t = time in seconds

Package Volume = 20 cc

Spec: 5×10^{-8} (He) 1.8×10^{-8} (Air)

Rate of Exchange:

3% 1 year	= 0.63% O ₂	0.099% H ₂ O
13% 5 years	= 2.7% O ₂	0.43% H ₂ O
25% 10 years	= 5.2% O ₂	0.8% H ₂ O
35% 15 years	= 7.3% O ₂	1.16% H ₂ O
44% 20 years	= 9.2% O ₂	1.5% H ₂ O

Package Volume = 20 cc

Spec: 5×10^{-8} (He) 1.8×10^{-8} (Air)

Options: 1×10^{-8} He = 3.6×10^{-9} Air

1% 1 year	=	0.21% O ₂	0.033% H ₂ O
3% 5 years	=	0.63% O ₂	0.099% H ₂ O
6% 10 years	=	1.3% O ₂	0.2% H ₂ O
9% 15 years	=	1.88% O ₂	0.297% H ₂ O
11% 20 years	=	2.3% O ₂	0.4% H ₂ O

Package Volume = 10cc

Spec: 5×10^{-8} (He) 1.8×10^{-8} (Air)

Rate of Exchange:

6%	1 year	=	1.3% O ₂	0.2% H ₂ O
25%	5 years	=	5.2% O ₂	0.9% H ₂ O
44%	10 years	=	9.2% O ₂	1.5% H ₂ O
58%	15 years	=	12% O ₂	1.9% H ₂ O
68%	20 years	=	14.2% O ₂	2.2% H ₂ O

Package Volume = 10 cc

Spec: 5×10^{-8} (He) 1.8×10^{-8} (Air)

Options: 1×10^{-8} He = 3.6×10^{-9} Air

2% 1 year	=	0.42% O ₂	0.07% H ₂ O
6% 5 years	=	1.3% O ₂	0.2% H ₂ O
11% 10 years	=	2.3% O ₂	0.4% H ₂ O
16% 15 years	=	3.34% O ₂	0.53% H ₂ O
21% 20 years	=	4.4% O ₂	0.7% H ₂ O

Package Volume = 1 cc

Spec: 1×10^{-8} (He) 3.6×10^{-9} (Air)

Rate of Exchange:

11% 1 year	=	2.3% O ₂	0.4% H ₂ O
44% 5 years	=	9.2% O ₂	1.5% H ₂ O
68% 10 years	=	14.2% O ₂	2.2% H ₂ O
82% 15 years	=	17.1 % O ₂	2.7% H ₂ O
90% 20 years	=	18.8% O ₂	3.0% H ₂ O

Spec: 1 x 10⁻⁸ (He) 3.6 x 10⁻⁹ (Air)

1 cc Option: 5 x 10⁻⁹He = 1.8 x 10⁻⁹ Air

6% 1 year	=	1.3% O ₂	0.2% H ₂ O
25% 5 years	=	5.2% O ₂	0.8% H ₂ O
44% 10 years	=	9.2% O ₂	1.5% H ₂ O
58% 15 years	=	12% O ₂	1.9% H ₂ O
68% 20 years	=	14.2% O ₂	2.2% H ₂ O

1 cc Option: 1 x 10⁻⁹He 3.6 x 10⁻¹⁰ Air

2% 1 year	=	0.42% O ₂	0.07% H ₂ O
6% 5 years	=	1.3% O ₂	0.2% H ₂ O
11% 10 years	=	2.3% O ₂	0.4% H ₂ O
16% 15 years	=	3.3% O ₂	0.53% H ₂ O
21% 20 years	=	4.4% O ₂	0.7% H ₂ O

Package Volume 0.5 cc

Spec: 1 x 10⁻⁸ (He) 3.6 x 10⁻⁹ (Air)

21% 1 year	=	4.4% O ₂	0.7% H ₂ O
68% 5 years	=	14.2% O ₂	2.2% H ₂ O
90% 10 years	=	18.8% O ₂	3.0% H ₂ O
97% 15 years	=	20.3% O ₂	3.2% H ₂ O

Option: 5 x 10⁻⁹ He 1.8 x 10⁻⁹ Air

11% 1 year	=	2.3% O ₂	0.4% H ₂ O
44% 5 years	=	9.2% O ₂	1.5% H ₂ O
68% 10 years	=	14.2% O ₂	2.2% H ₂ O
82% 15 years	=	17.1% O ₂	2.7% H ₂ O
90% 20 years	=	18.8% O ₂	3.0% H ₂ O

0.5cc spec: 1 x 10⁻⁸ (He) 3.6 x 10⁻⁹ (Air)

0.5 cc Option: 1 x 10⁻⁹ He 3.6 x 10⁻¹⁰ Air

3%	1 year =	0.6% O ₂	0.099% H ₂ O
11%	5 years =	2.3% O ₂	0.4% H ₂ O
21%	10 years =	4.4% O ₂	0.7% H ₂ O
29%	15 years =	6.1% O ₂	0.96% H ₂ O
37%	20 years =	7.7% O ₂	1.2% H ₂ O

0.5 cc Option: 5 x 10⁻¹⁰ He 1.8 x 10⁻¹⁰ Air

2%	1 year =	0.42% O ₂	0.07% H ₂ O
6%	5 years =	1.3% O ₂	0.2% H ₂ O
11%	10 years =	2.3% O ₂	0.4% H ₂ O
16%	15 years =	3.34% O ₂	0.53% H ₂ O
21%	20 years =	4.4% O ₂	0.7% H ₂ O

Package Volume 0.1 cc

Spec: 1 x 10⁻⁸ (He) 3.6 x 10⁻⁹ (Air)

68% 1 years = 14.2% O ₂	2.2% H ₂ O
99% 4 years = 20.7% O ₂	3.27% H ₂ O

0.1 cc Option: 5 x 10⁻⁹He 1.8 x 10⁻⁹ Air

43% 1 year = 9% O ₂	1.4% H ₂ O
95% 5 years = 19.9% O ₂	3.14% H ₂ O

0.1 cc Option: 1 x 10⁻⁹He 3.6 x 10⁻¹⁰ Air

11% 1 year = 2.3% O ₂	0.4% H ₂ O
44% 5 years = 9.2% O ₂	1.5% H ₂ O
68% 10 years = 14.2% O ₂	2.2% H ₂ O
82% 15 years = 17.1% O ₂	2.7% H ₂ O
90% 20 years = 18.8% O ₂	3.0% H ₂ O

Package Volume 0.1 cc

Spec: 1×10^{-8} (He) 3.6×10^{-9} (Air)

Option: 5×10^{-10} He 1.8×10^{-10} Air

6%	1 year	=	1.3% O ₂	0.2% H ₂ O
25%	5 years	=	5.2% O ₂	0.8% H ₂ O
44%	10 years	=	9.2% O ₂	1.5% H ₂ O
57%	15 years	=	11.9% O ₂	1.9% H ₂ O
68%	20 years	=	14.2% O ₂	2.2% H ₂ O

Package Volume 0.05 cc

Spec: 1×10^{-8} (He) 3.6×10^{-9} (Air)

43% 90 days	=	9% O ₂	1.4% H ₂ O
67% 6 months	=	14% O ₂	2.2% H ₂ O
90% 1 year	=	18.8% O ₂	3.0% H ₂ O
99% 2 years	=	20.7% O ₂	3.27% H ₂ O

Option: 5×10^{-9} He 1.8×10^{-9} Air

68% 1 year	=	14.2% O ₂	2.2% H ₂ O
90% 2 years	=	18.8% O ₂	3.0% H ₂ O
97% 3 years	=	20.3% O ₂	3.2% H ₂ O

0.05 cc Spec: 1×10^{-8} (He) 3.6×10^{-9} (Air)

Option: 1×10^{-9} He 3.6×10^{-10} Air

21% 1 year	=	4.4% O ₂	0.7% H ₂ O
68% 5 years	=	14.2% O ₂	2.2% H ₂ O
90% 10 years	=	18.8% O ₂	3.0% H ₂ O
97% 15 years	=	20.3% O ₂	3.2% H ₂ O

Option: 5×10^{-10} He 1.8×10^{-10} Air

11% 1 year	=	2.3% O ₂	0.4% H ₂ O
44% 5 years	=	9.2% O ₂	1.5% H ₂ O
68% 10 years	=	14.2% O ₂	2.2% H ₂ O
82% 15 years	=	17.1% O ₂	2.7% H ₂ O
90% 20 years	=	18.8% O ₂	3.0% H ₂ O

0.05 cc Spec: 1×10^{-8} (He) 3.6×10^{-9} (Air)

Option: 1×10^{-10} He 3.6×10^{-11} Air

3% 1 year	=	0.63% O ₂	0.0999% H ₂ O
11% 5 years	=	2.3% O ₂	0.4% H ₂ O
21% 10 years	=	4.4% O ₂	0.7% H ₂ O
29% 15 years	=	6.1% O ₂	0.96% H ₂ O
37% 20 years	=	7.7% O ₂	1.2% H ₂ O

Package Volume > 0.01 cc

Spec: 1×10^{-8} (He) 3.6×10^{-9} (Air)

61% 30 days	=	12.7% O ₂	2.0% H ₂ O
85% 60 days	=	17.8% O ₂	2.8% H ₂ O
94% 90 days	=	19.7% O ₂	3.1% H ₂ O

Option: 5×10^{-9} He 1.8×10^{-9} Air

61% 60 days	=	12.7% O ₂	2.0% H ₂ O
75% 90 days	=	15.7% O ₂	2.5% H ₂ O
94% 6 months	=	19.7% O ₂	3.1% H ₂ O

>0.01 cc Spec: 1 x 10⁻⁸ (He) 3.6 x 10⁻⁹ (Air)

Option: 1 x 10⁻⁹He 3.6 x 10⁻¹⁰ Air

25% 90 days	=	5.2% O ₂	0.83% H ₂ O
43% 6 months	=	9% O ₂	1.4% H ₂ O
68% 1 year	=	14.2% O ₂	2.2% H ₂ O
97% 3 years	=	20.3% O ₂	3.2% H ₂ O

Option: 5 x 10⁻¹⁰He 1.8 x 10⁻¹⁰ Air

44% 1 year	=	9.2% O ₂	1.5% H ₂ O
94% 4 years	=	19.7% O ₂	3.1% H ₂ O

Option: 1 x 10⁻¹⁰He 3.6 x 10⁻¹¹ Air

11% 1 year	=	2.3% O ₂	0.4% H ₂ O
44% 5 years	=	9.2% O ₂	1.5% H ₂ O
68% 10 years	=	14.2% O ₂	2.2% H ₂ O
83% 15 years	=	17.4% O ₂	2.7% H ₂ O
90% 20 years	=	18.8% O ₂	3.0% H ₂ O

Package Volume < 0.01 cc

Spec: 5×10^{-9} (He) 1.8×10^{-9} (Air)

15% 10 days = 3.1% O₂ 0.5% H₂O

61% 60 days = 12.7% O₂ 2.0% H₂O

94% 6 months = 19.7% O₂ 3.1% H₂O

Option: 1×10^{-9} He 3.6×10^{-10} Air

43% 6 months = 9% O₂ 1.4% H₂O

68% 1 year = 14.2% O₂ 2.2% H₂O

90% 2 years = 18.8% O₂ 3.0% H₂O

97% 3 years = 20.3% O₂ 3.2% H₂O

<0.01 cc Spec: 1 x 10⁻⁸ (He) 3.6 x 10⁻⁹ (Air)

Option: 5 x 10⁻¹⁰ He 1.8 x 10⁻¹⁰ Air

44% 1 year = 9.2% O₂ 1.5% H₂O

95% 5 years = 19.9% O₂ 3.1% H₂O

Option: 1 x 10⁻¹⁰ He 3.6 x 10⁻¹¹ Air

11% 1 year = 2.3% O₂ 0.4% H₂O

44% 5 years = 9.2% O₂ 1.5% H₂O

68% 10 years = 14.2% O₂ 2.2% H₂O

82% 15 years = 17.1% O₂ 2.7% H₂O

90% 20 years = 18.8% O₂ 3.0% H₂O

<0.01 cc Spec: 1 x 10⁻⁸ (He) 3.6 x 10⁻⁹ (Air)

Option: 5 x 10⁻¹¹ He 1.8 x 10⁻¹¹ Air

6% 1 year	=	1.3% O ₂	0.2% H ₂ O
25% 5 years	=	5.2% O ₂	0.8% H ₂ O
44% 10 years	=	9.2% O ₂	1.5% H ₂ O
57% 15 years	=	11.9% O ₂	1.9% H ₂ O
68% 20 years	=	14.2% O ₂	2.2% H ₂ O

Option: 1 x 10⁻¹¹ He 3.6 x 10⁻¹² Air

2% 1 year	=	0.4% O ₂	0.07% H ₂ O
6% 5 years	=	1.3% O ₂	0.2% H ₂ O
11% 10 years	=	2.3% O ₂	0.4% H ₂ O
16% 15 years	=	3.3% O ₂	0.53% H ₂ O
20% 20 years	=	4.2% O ₂	0.66% H ₂ O

Package Volume 0.005 cc

Spec: 5 x 10⁻⁹ (He) 1.8 x 10⁻⁹ (Air)

61% 30 days = 12.7% O₂ 2.0% H₂O

96% 90 days = 20.1% O₂ 3.2% H₂O

Option: 1 x 10⁻⁹ He 3.6 x 10⁻¹⁰ Air

43% 90 days = 9% O₂ 1.4% H₂O

67% 6 months = 14% O₂ 2.2% H₂O

90% 1 year = 18.8% O₂ 3.0% H₂O

Option: 5 x 10⁻¹⁰ He 1.8 x 10⁻¹⁰ Air

43% 6 months = 9% O₂ 1.4% H₂O

68% 1 year = 14.2% O₂ 2.2% H₂O

97% 3 years = 20.3% O₂ 3.2% H₂O

0.005 cc Spec: 5 x 10⁻⁹ (He) 1.8 x 10⁻⁹ (Air)

Option: 1 x 10⁻¹⁰ He 3.6 x 10⁻¹¹ Air

21% 1 year	=	4.4% O ₂	0.7% H ₂ O
68% 5 years	=	14.2% O ₂	2.2% H ₂ O
90% 10 years	=	18.8% O ₂	3.0% H ₂ O
97% 15 years	=	20.3% O ₂	3.2% H ₂ O

Option: 5 x 10⁻¹¹ He 1.8 x 10⁻¹¹ Air

11% 1 year	=	2.3% O ₂	0.4% H ₂ O
43% 5 years	=	9% O ₂	1.4% H ₂ O
68% 10 years	=	14.2% O ₂	2.2% H ₂ O
82% 15 years	=	17.1% O ₂	2.7% H ₂ O
90% 20 years	=	18.8% O ₂	3.0% H ₂ O

Option: 1 x 10⁻¹¹ He 3.6 x 10⁻¹² Air

3% 1 year	=	0.6% O ₂	0.099% H ₂ O
11% 5 years	=	2.3% O ₂	0.4% H ₂ O
21% 10 years	=	4.4% O ₂	0.7% H ₂ O
29% 15 years	=	6.1% O ₂	0.96% H ₂ O
37% 20 years	=	7.7% O ₂	1.2% H ₂ O

Package Volume = 0.0015cc

Spec: 5 x 10⁻⁹(He) = 1.8 x 10⁻⁹(Air)

65% 10 days = 13.6% O₂ 2.2% H₂O

96% 30 days = 20.1% O₂ 3.2% H₂O

Option: 1 x 10⁻⁹ He 3.6 x 10⁻¹⁰ Air

46% 30 days = 9.6% O₂ 1.5% H₂O

98% 6 months = 20.5% O₂ 3.2% H₂O

Option: 5 x 10⁻¹⁰ He 1.8 x 10⁻¹⁰ Air

85% 6 months = 17.8% O₂ 2.8% H₂O

98% 1 year = 20.5% O₂ 3.2% H₂O

Option: 1 x 10⁻¹⁰ He 3.6 x 10⁻¹¹ Air

53% 1 year = 11.1% O₂ 1.7% H₂O

98% 5 years = 20.5% O₂ 3.2% H₂O

Package Volume = 0.0015cc

Spec: $5 \times 10^{-9}(\text{He}) = 1.8 \times 10^{-9}(\text{Air})$

Option: $5 \times 10^{-11} \text{ He} \quad 1.8 \times 10^{-11} \text{ Air}$

32% 1 year = 6.7% O₂ 1.1% H₂O

85% 5 years = 17.8% O₂ 2.8% H₂O

98% 10 years = 20.5% O₂ 3.2% H₂O

Option: $1 \times 10^{-11} \text{ He} \quad 3.6 \times 10^{-12} \text{ Air}$

7% 1 year = 1.5% O₂ 0.23% H₂O

32% 5 years = 6.7% O₂ 1.1% H₂O

53% 10 years = 11.1% O₂ 1.7% H₂O

68% 15 years = 14.2% O₂ 2.2% H₂O

78% 20 years = 16.3% O₂ 2.6% H₂O