

Cylinder Leaks, Ngai Rule of Thumb

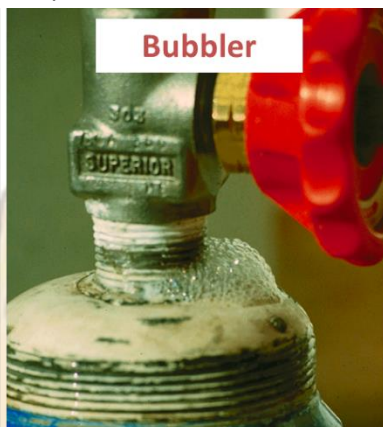
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The Ngai rules of thumb are not exact science that can fit all situations. It was developed to give responders a guesstimate as to what may be going on.

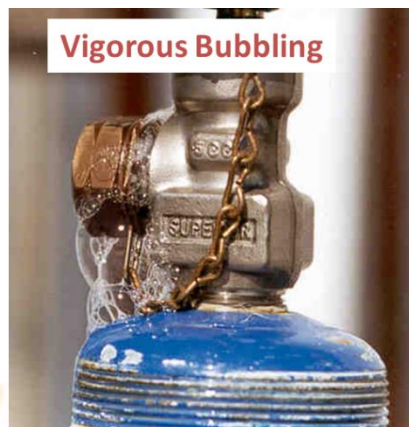
Compressed gas leak rates based on soap solution leak detection:



Foamer
the smallest leak rate detectable by Soap solution is approximately 0.1 cc/min. Can take a few minutes to form after application



Bubbler
0.5 to 10 cc/min
Continuous clear bubbles > 1 cm dia.



Vigorous Bubbling
10-50 cc/min with the formation of large bubbles.

Whistler >50 cc/min can hear the leak

Figs 1-3: Leak Rates

Leak rate is measured at cc/sec which is expressed as a power of ten

0.1 cc/sec	is	1×10^{-1}
0.01 cc/sec	is	1×10^{-2}
0.00003 cc/sec	is	3×10^{-5}

A common cylinder valve thread leaker is 0.1 cc/min (10^{-3} cc/sec)

A cylinder valve seat leaking at 10^{-6} cc/sec will leak 7.8 cc in 3 months and will pressurize a typical diaphragm valve to 110 psig behind the vapor tight outlet cap.

A 12 kg cylinder contains 9,000,000 cc of Silane

Assuming a constant flow and no plugging, a 50 cc/min leak will last for 180,000 minutes! (125 days)

The most likely silane leak will be a small connection leak. This might not ignite and may not be detected. If it ignites, the flames might be intermittent and/or small < 5 cc/min and may not be readily detected by



the UVIR in the cylinder area. This will leak at this rate for weeks or may become plugged from the formation of SiO_2 .

At $10.8 \text{ m}^3/\text{min}$ (381 cfm) exhaust ventilation rate from a single cylinder gas cabinet, a 5 ppm silane detection requires a 54 cc/min leak rate from a pure silane cylinder. This is a huge leak that is not likely to spontaneously occur.

A typical propane leaker is a cylinder valve thread bubbler, Ngai rule of thumb is 10 cc/min. A 20 lb propane cylinder has 4,794,240 cc of gas. At 10 cc/min this would leak for 333 days!

Most likely leak points on a cylinder

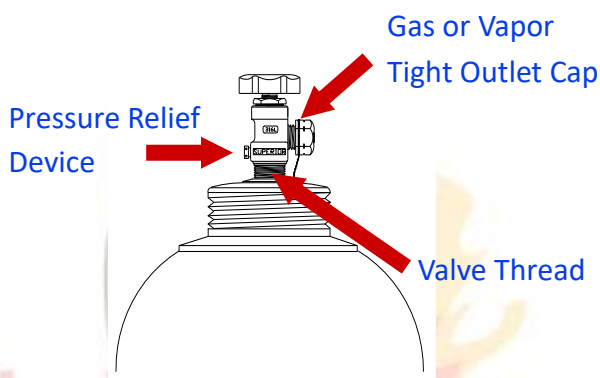


Fig 4: Cylinder Leak Points

Evidence of leaks include:

- Flames
- Charred or bubbled paint
- White, Brown or Green fumes
- Green or Brown liquid dripping down the sides of the cylinder
- Green or Brown Corrosion
- Solids Around Connections
- Black or red deposits
- Hissing sound

A ppt arsine leak was only determined due to a visual inspection in 2001 for a pure arsine shipment to Taiwan. Use of a highly sensitive arsine leak detector did not pick up the leak. See *Metal Hydride Gas Cylinder Leakcheck* for details.



Fig 5: Clean Cylinder Left, Cylinder with PPT leak Right

The black arsenic is due to the hydrolysis of arsine. This leak was not detected using a paper tape detection system at 5 ppb since it was a ppt leak. Since a leak could be from any point as noted above, the only way to detect this leak was to cap the top of the cylinder, wait a short period of time and sample.

Many gas suppliers will use a custom cap to test metal hydride gas cylinders prior to shipment. This policy was practiced by Solkatronic Chemicals for all metal hydride shipments since 2000. Any detection was cause for rejection.

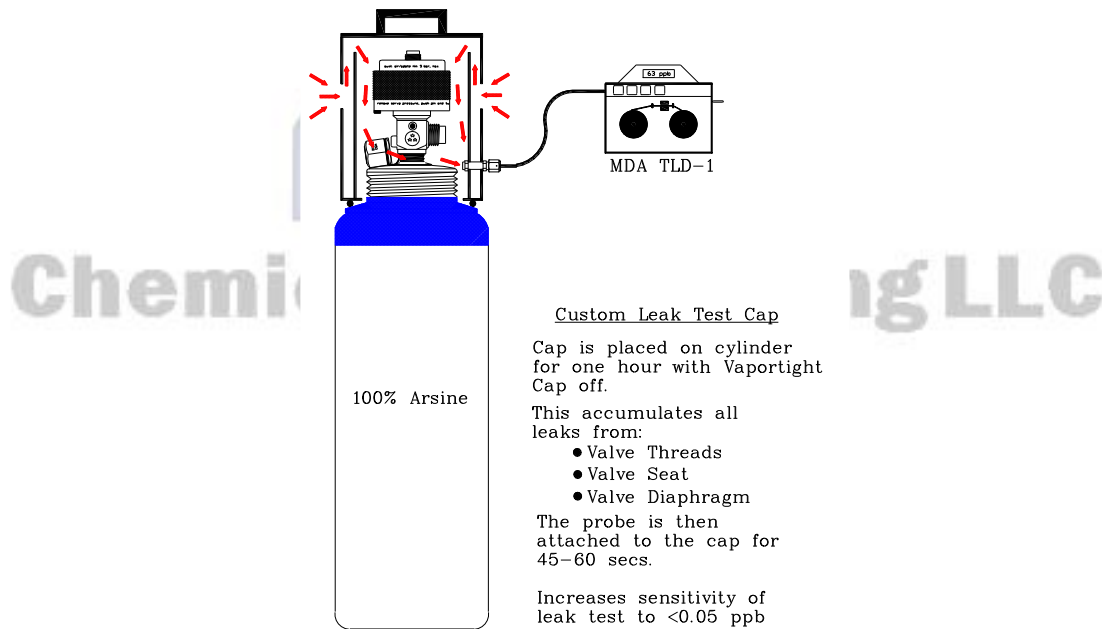


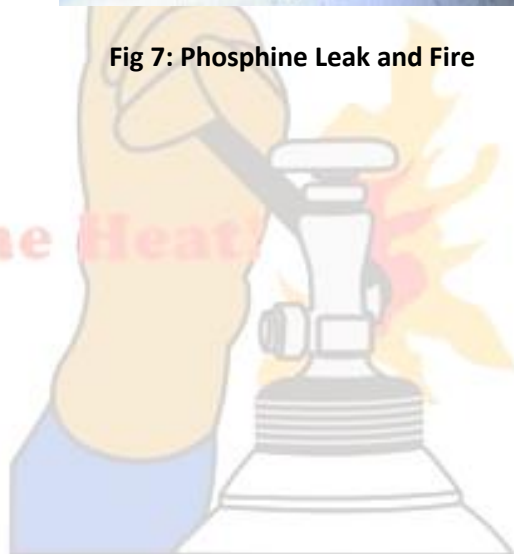
Fig 6: Solkatronic Metal Hydride Gas Leak Test

Phosphine leak and fire forms red phosphorus



Fig 7: Phosphine Leak and Fire

Feel the Heat!



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