



2012 VMA Technical Seminar

Fugitive Emission Testing
and Certification for Valves

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In addition to safety risks, and product and economic losses, fugitive emissions contribute to air pollution and climate change.

The rate of fugitive emissions in the USA has been estimated to be in excess of 300,000 tons per year.

Rate of fugitive emission from European refineries ranges from 600 to 10,000 tons per year.

According to the ESA (European Sealing Association)

Many different environmental concerns

- EPA is concerned with 42 gaseous emissions
- Greenhouse gases are the significant output from power plants and refineries

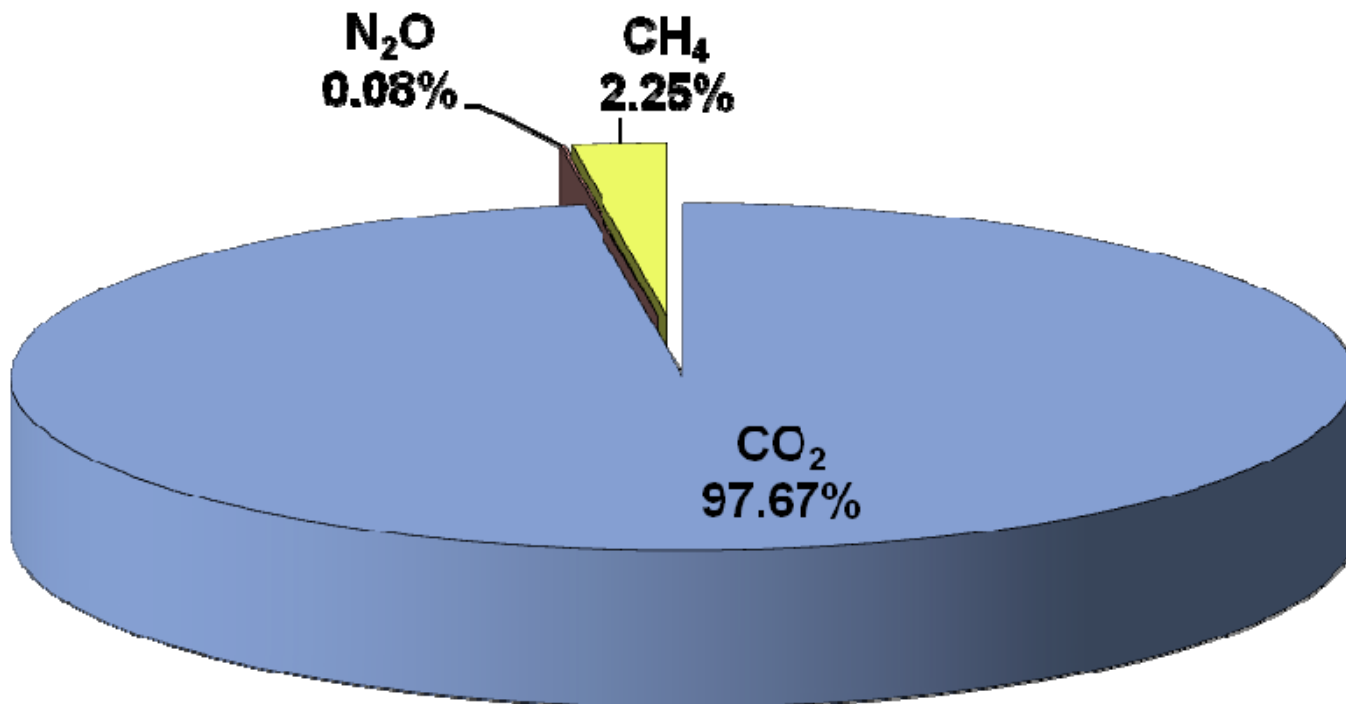
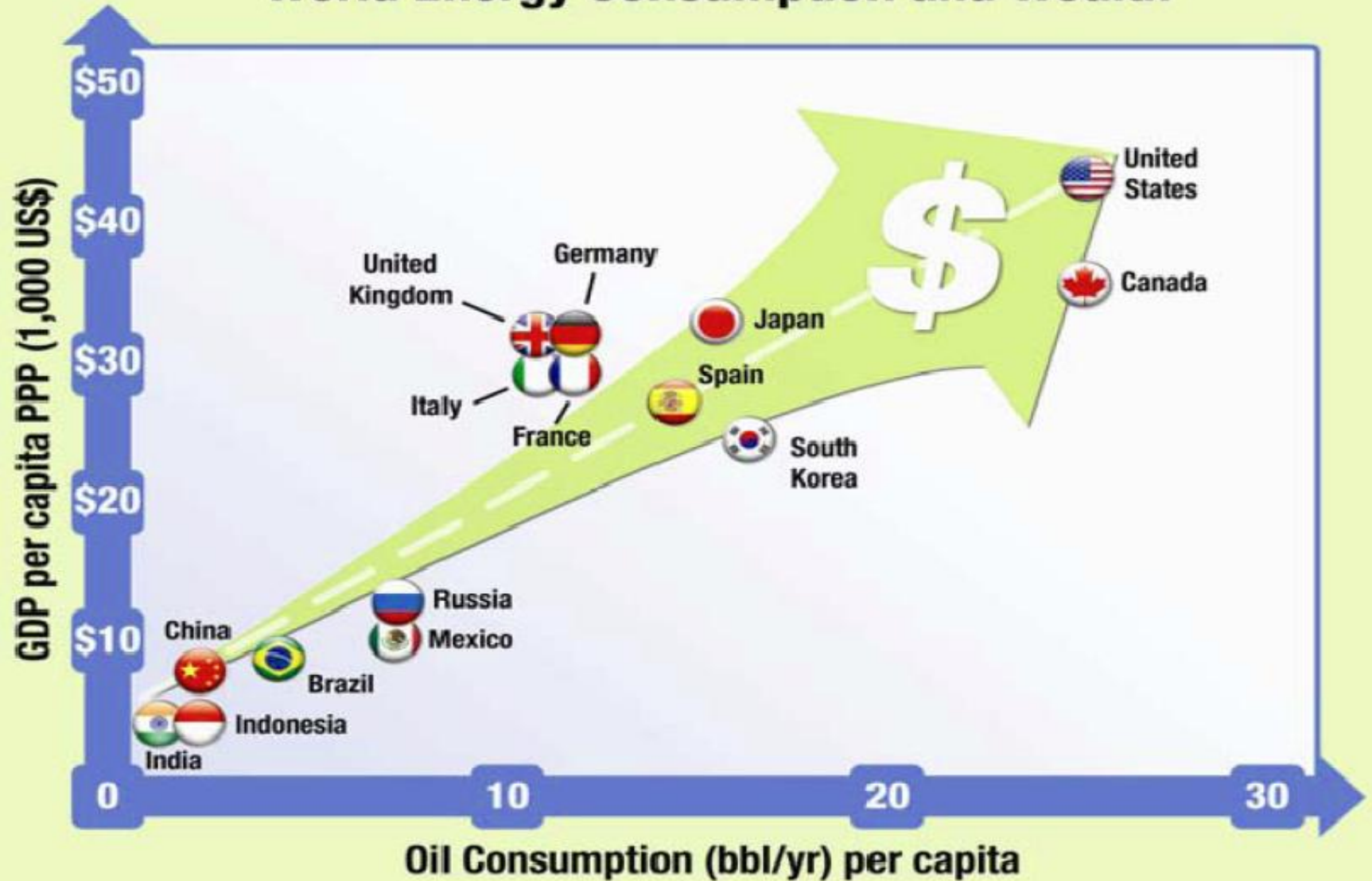


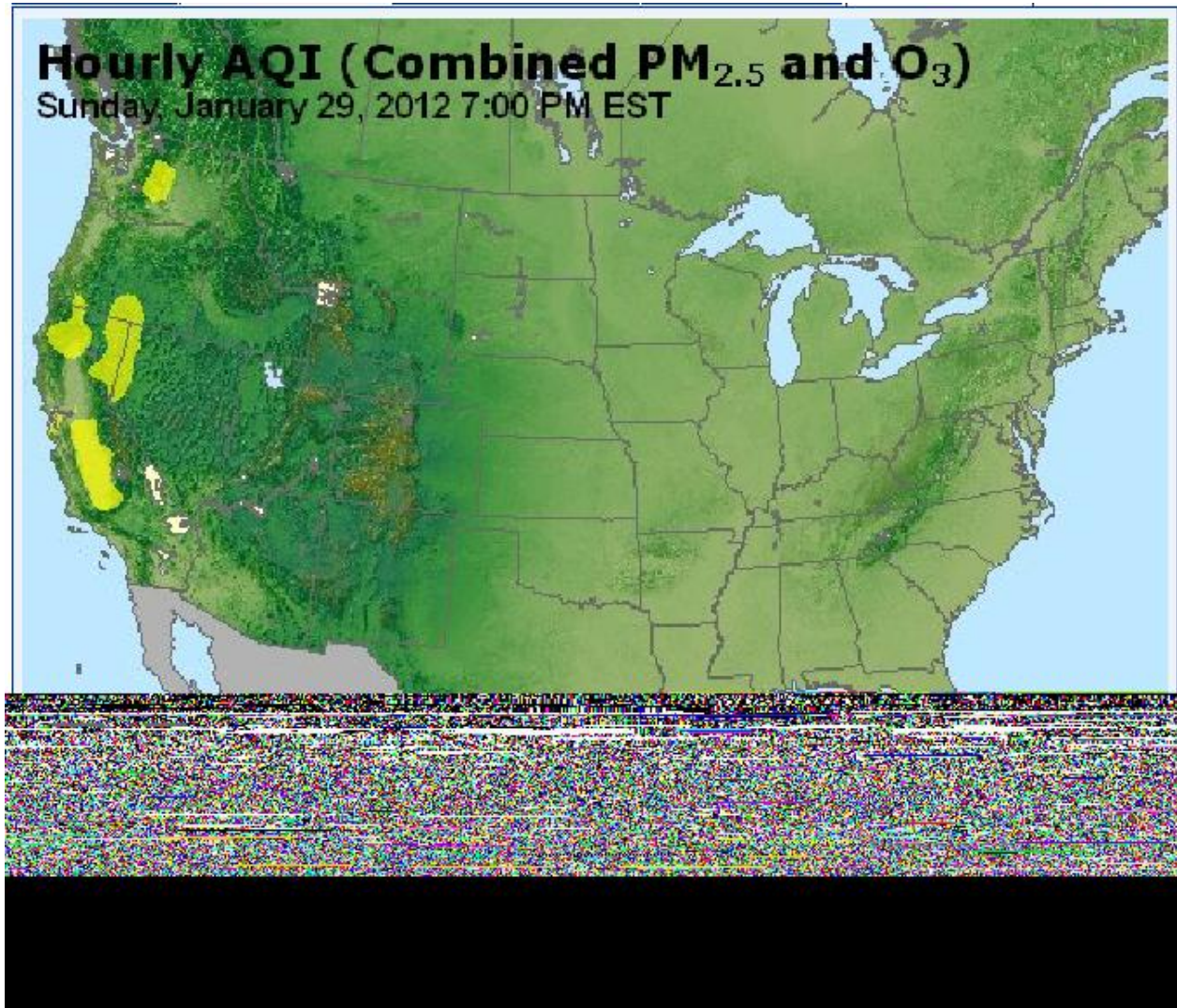
Figure 3. GHG emissions from petroleum refineries.

Is the problem really as bad as we hear?

World Energy Consumption and Wealth



Air Quality Index is reported daily by our EPA



Valve Fugitive Emission Standards

- ANSI/ISA S93.00.01
- ANSI / FCI 91-1
- TA-Luft VDI 2440
- ISO-15848-1 and -2
- Shell SPE 77/300
- Shell SPE 77/312
- API-622
- API-624 (pending)
- ChevronTexaco
- And more to follow...isn't this too much already....why?

History

- Air Pollution Control Act 1955
- Clean Air Act of 1963
- CAA amended in 1970 to include vehicles
- CAA amended again in 1990 to include LDAR program
- Late 1990s, EPA identified that facilities under-reporting emission and non-compliant plants had to assign dedicated management to run formal LDAR programs.
- Lately, EPA attempts to push non-compliant facilities into compliance with enhanced LDAR programs using consent decrees. Low-leak valve and packing technologies are required.
- So far, all emphasis is on the plants to monitor and repair their equipment

History continued

- 1986 - Germany issues “Technische Anleitung zur Reinhaltung der Luft (Technical Guidelines for Air Pollution Control)
- TA-Luft for short
- Association of German Engineers, VDI introduce guideline 2440 to the regulation for on-off and control valves
- Basis for TA-Luft limits are bellows seal valves which have a flat gasket in their construction.
- And, flat gasket leak rate is 10^{-4} mbar.l/s.m
- If leak rate is equal to or less, then the valve sealing is considered to be equivalent to a bellows seal.
- Specific parameters are not defined other than the test shall be representative of actual conditions
- This regulation put the onus of proof on the manufacturer

History continues

- End users around the globe push to satisfy their needs within standards organizations
- Resulting standards vary widely based on the individual experience and perceived needs
- Numerous standards are written
- Result is very high cost in both expense and time to our industry
- Are we anywhere closer to an industry solution?
- What is the root cause of the problem in the first place?

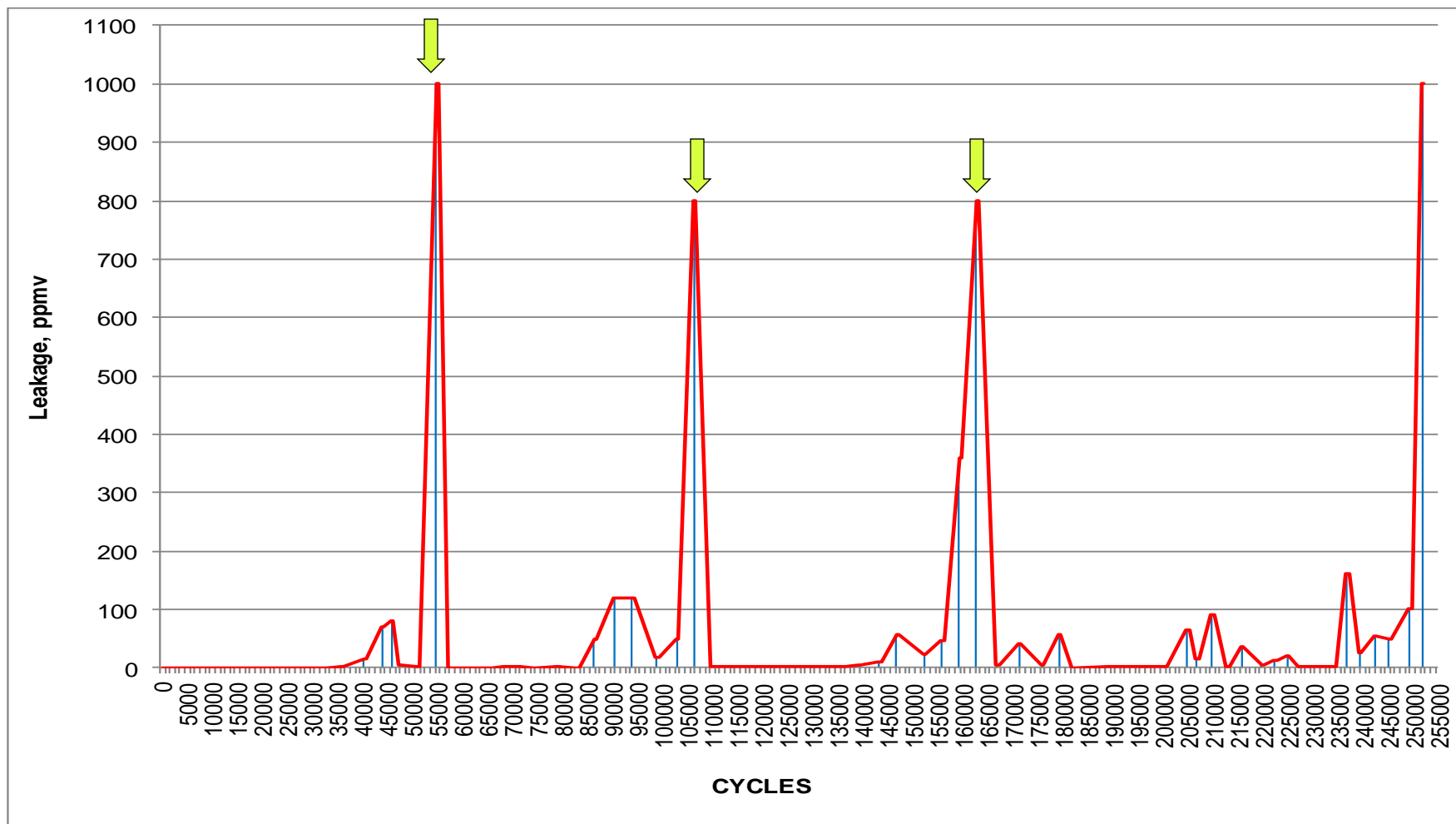
Sources of emission

- In general, overall emissions are attributed to the following primary types of sources:
 - equipment leaks;
 - process venting;
 - evaporation losses;
 - disposal of waste gas streams (e.g., by venting or flaring), and
 - accidents and equipment failures
- Methane (CH₄) is the predominant type of greenhouse gas emitted as a fugitive emission in the oil and gas sector
- Valves are the highest percentage of leakers
 - Valves make up more than 90% of the process components that must be checked for leaks
 - Typically 50 to 60% of emissions from a plant are attributed to valves
 - Approximately 85% of VOC emissions are from valves controlling gas streams

The Test Data shows.....

- Typical breakdown of emissions from valve types
 - Regulating control valve - 70%
 - Automatic gate valve – 27%
 - Gate valve – 26%
 - Globe valve – 20%
 - Plug valve – 20%
 - Ball valve – 1%
- Control valves by far leak the most – difficult choice, accurate control or tight packing
- Linear on-off valves are the second most leakers
- Less than 1% of the valves in gas service account for the majority of emission from a plant

Why do only a few valves contribute to a majority of the emissions?



Other facts to consider

- One successful test is no guarantee of future, consistent results
- Successful results in a laboratory do not translate to success in actual service
- The thermal stresses, vibrations, effects of corrosion (both within the system and from outside atmospheric conditions), and mechanical wear that the components are subjected to account for the development of leaks and the unwanted emissions.
- EPA reports that FE have declined over the last 20 years

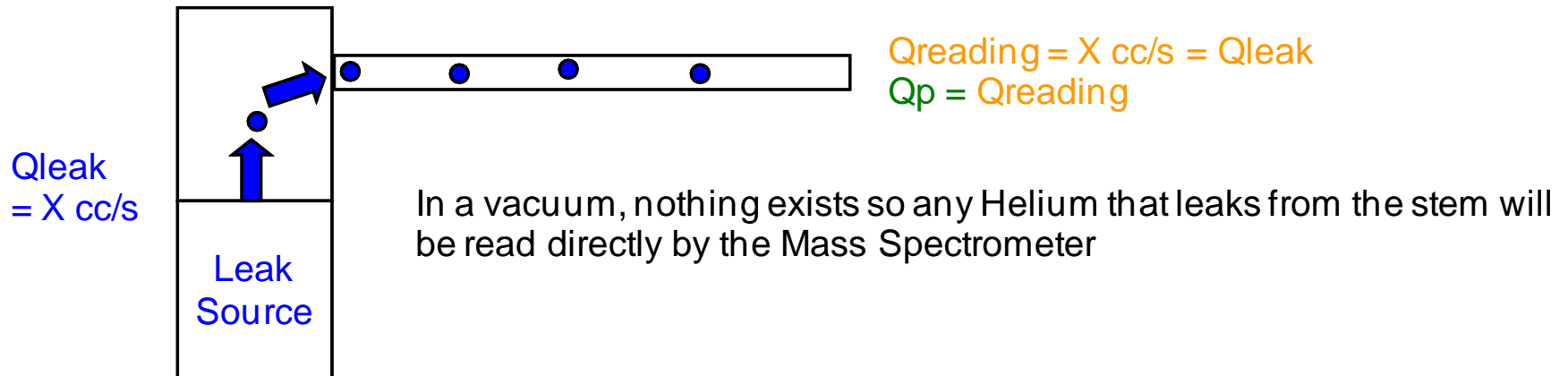
So what are the standards committees trying to accomplish?

- Clearly the overall issue is not known or is not a concern
- Various test for various type of valves
- Much emphasis on the accuracy of the test
- Debates.....or really arguments on what is a appropriate test
 - Measurement methods
 - Helium versus Methane
 - Test temperature
 - Number of thermal cycles
 - Test pressure
 - Etc., etc., etc.....

Debates continue within standards committees

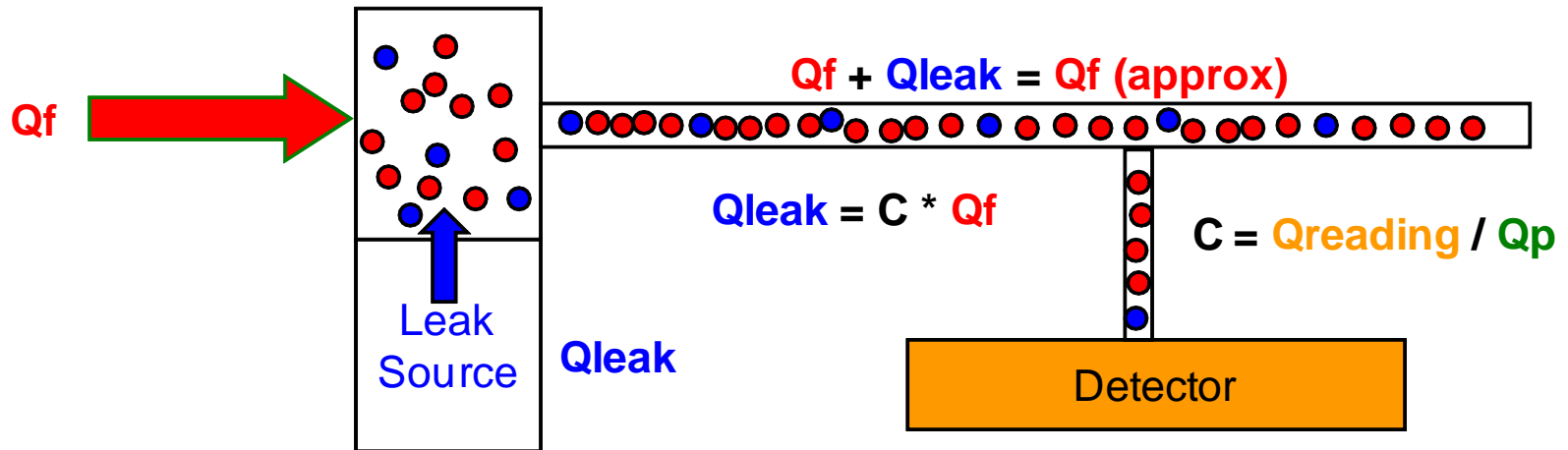
- Global versus local measurement
- Global methods are known as Vacuum, flushing, bagging
- Local method is sniffing

Vacuum Method (Global Method):



Measurement methods

Flush Gas Method (Global Method):



Q_{leak} = leak rate from source = constant, not equal to $Q_{reading}$

$Q_{reading}$ = measured leakage rate from source at Mass Spectrometer, depends on Q_p , Q_{leak} and Q_f

Q_f = flush gas flow rate = variable

Q_p = probe flow rate = variable

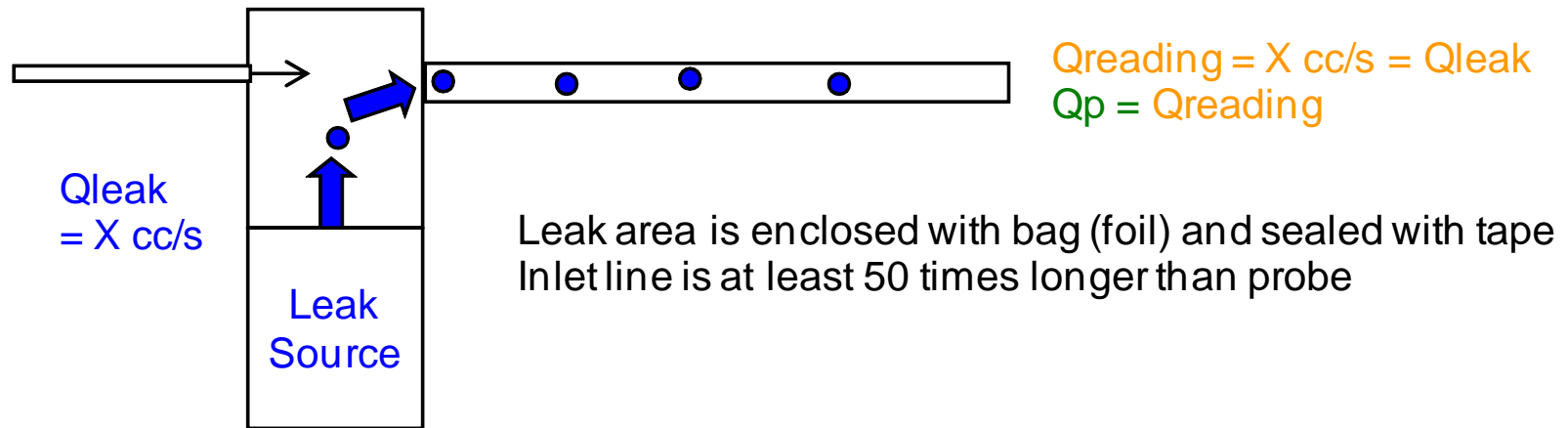
Concentration = $C = Q_{reading} / Q_p$ = variable

$Q_{leak} = C * Q_f$ = constant

Measurement methods

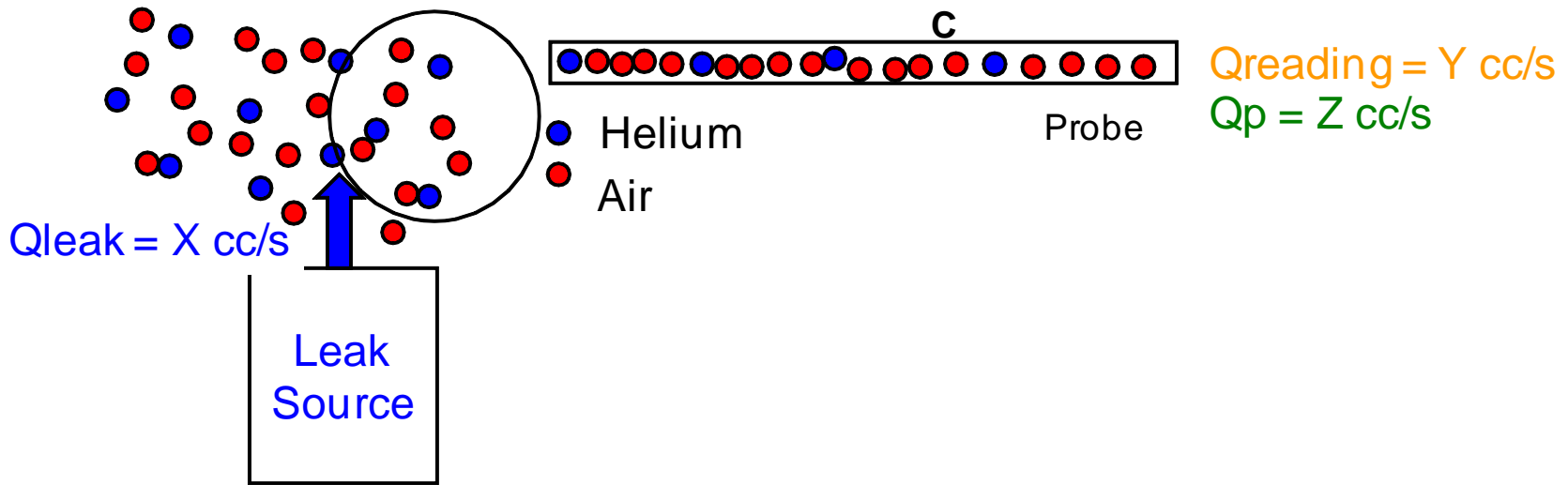
- Accumulation or bagging method

Accumulation (bagging) Method (Global Method):



Measurement methods

Direct sniffing method (local method):



Q_{leak} = leak rate from source = constant, not equal to $Q_{reading}$

$Q_{reading}$ = measured leakage from source at Mass Spectrometer, depends on probe flow rate Q_p and Q_{leak}

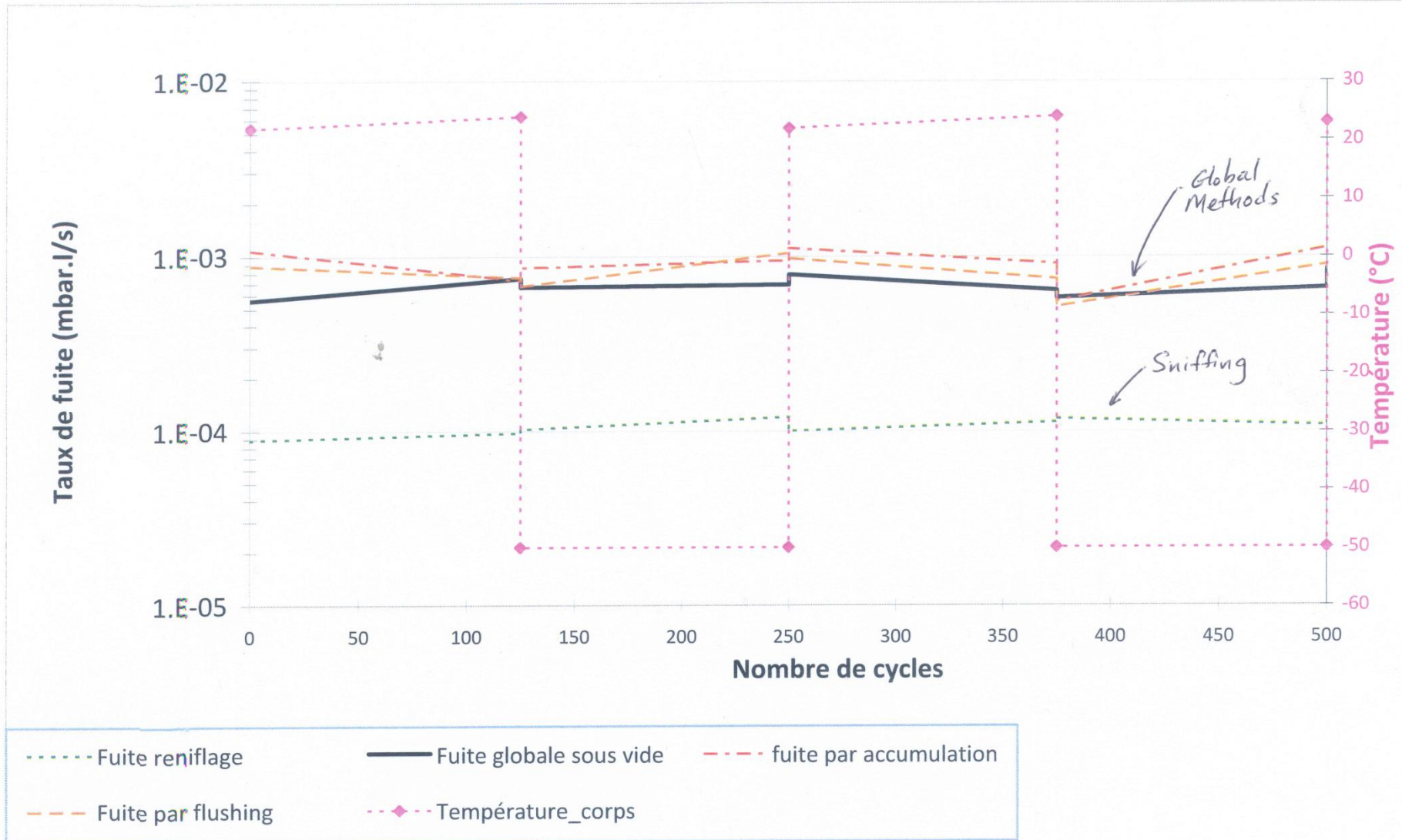
Q_p = probe flow rate = variable

Concentration = $C = Q_{reading}/Q_p = Y/Z = \text{constant}$

No way to directly measure leak rate (Q_{leak})

Volumetric measurement only

Sniffing is not as accurate as global methods



Debates within the standards committees

- Leak rate versus volumetric measurement
 - Leak rates – mg/(s*m), mbar liter/(s*m), std cc/sec
 - Volumetric – ppmv

Conversion based
on 0.5 inch dia.
stem

**Upper Limit
Class AH**



**Upper Limit
Class BH**



**Upper Limit
Class CH**



Helium Leakage Rate (mg/(s*m))	Helium Leakage Rate (cc/s)*	Maximum Environmental ppm
1E-8	2.4E-9	0.03
1E-7	2.4E-8	0.35
1E-6	2.4E-7	3.5
1E-5	2.4E-6	35
1E-4	2.4E-5	346
1E-3	2.4E-4	3459

Leak rates in every day terms

std. cc/sec	N ml/min	SCFH	Reference rate	Comments
0	0	0	"zero leak"	From an Engineering viewpoint, there is no such thing as "zero leak"
1.00E-08	6.00E-07	1.30E-09	Leak rate of 1 cc every 3 years	Diffusion of Helium through glass per square cm of surface area
1.00E-07	6.00E-06	1.30E-08	approximately 3 cc/year	
5.00E-07	3.00E-05	6.40E-08	about 1 cc/month	Average size of leaks at man made joints. Studies indicate that almost all leaks at joints are about 5×10^{-7} std. cc/sec (about 1 cc/month) or larger. This is true of ceramic-to-metal, plastic-to-metal seals, welded, soldered, and brazed joints. Some long leak paths can be slightly less.
1.00E-06	6.00E-05	1.30E-07	approximately 1 cc every 2 weeks	Leaks unintentionally "built in" at joints during manufacture can vary from hour to hour or day to day. Breathing on a 10^{-6} leak provides enough moisture to close it temporarily and for up to several days. Atmospheric particles can close a leak of this size. Leaks of this size do not remain constant.
1.00E-05	6.00E-04	1.30E-06	roughly 1 cc/day	
1.00E-04	6.00E-03	1.30E-05	about 1 cc every 3 hours	Visible bubbles rising in water
1.00E-03	6.00E-02	1.30E-04	4 cc every hour	
1.00E-02	6.00E-01	1.30E-03	less than 1 cc every minute	
0.1	6	0.013	6 cc per minute or 1 pound of air every 6 weeks	

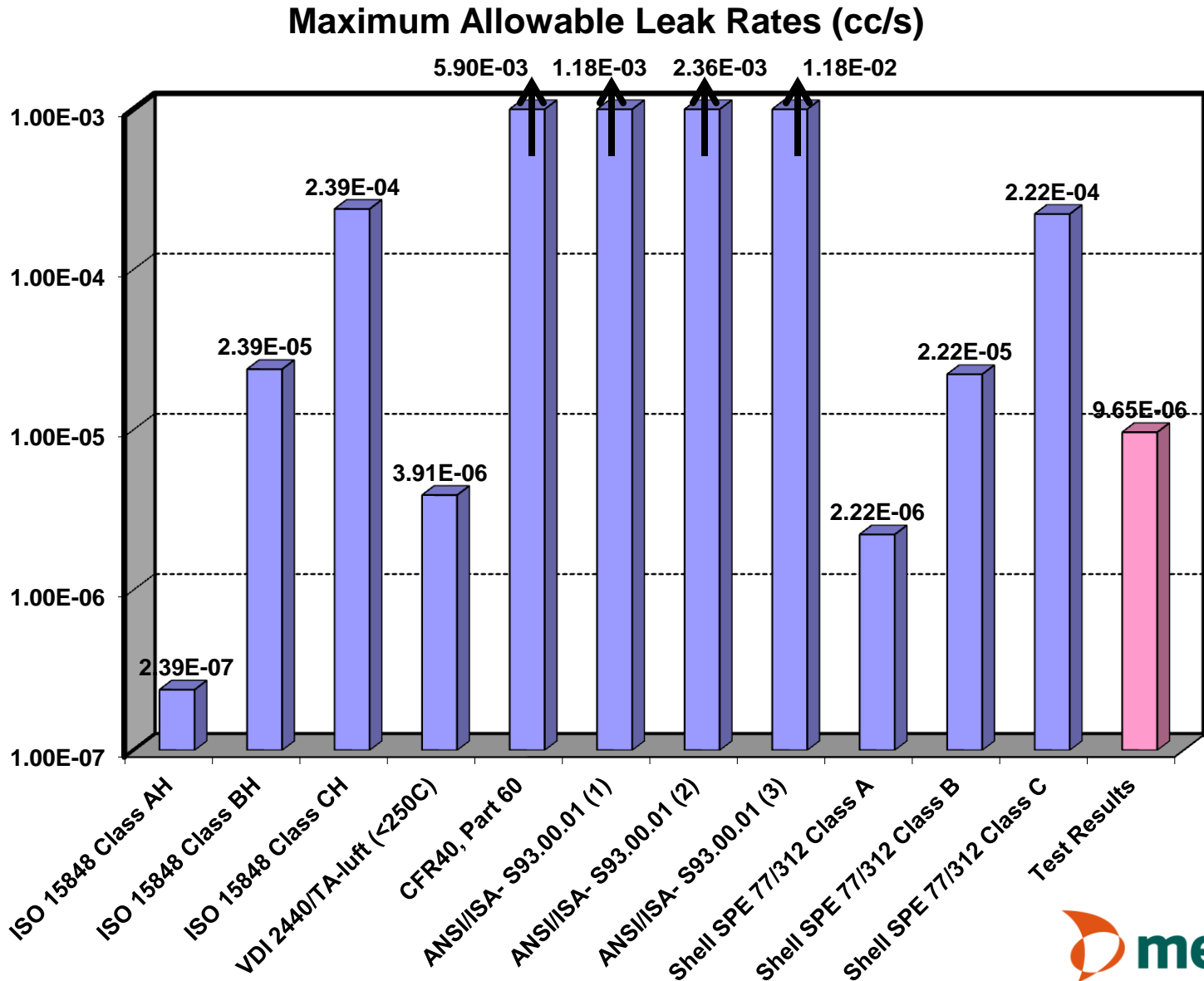
Reference rates: 1 cc is roughly the size of a glass marble or slightly smaller than a typical game dice

1 pound of air at standard conditions (room temperature and pressure) is 13.3 cubic feet. A square box that is just under 2.5' x 2.5' x 2.5'.

Another way to look at the leak rates

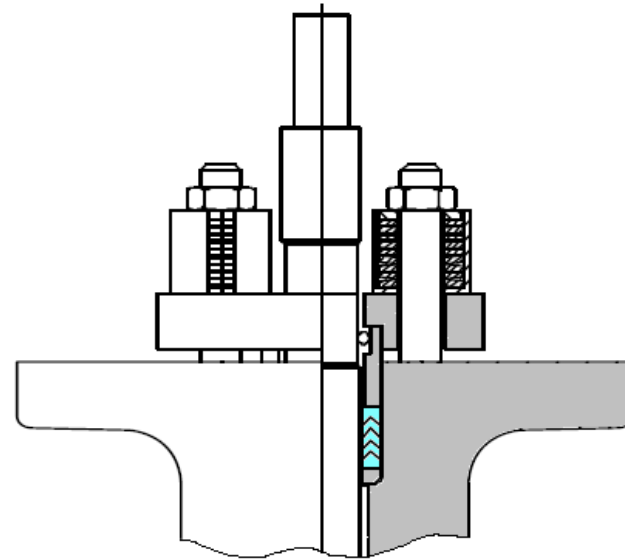
- Take a valve with a 25 mm (1 inch) stem diameter
- And a valve leaking at 0.1 std. cc/sec – which is 6 cc / min or 1 pound of gas every 6 weeks
- Equivalent number of valves:
 - 13,500 TA-Luft valves less than 250 C
 - 23,000 Shell rate A valves
 - 230,000 ISO-15848 rate A valves

A comparison of leak rates between standards



Debates continued

- Helium versus Methane
 - Helium is safer, Methane represents actual plant conditions
 - End Users prefer Methane, test labs prefer Helium
- Operating cycles.....how many?
 - TA-Luft – undefined
 - ISO-15848 – 500 cycles to as many as product can achieve
 - Shell SPE 77/312 – 100 cycles
 - ChevronTexaco – 5,000 cycles
- Temperature cycles...how many?
- Temperature cycles...range?



Debates continued

- Retightening the packing before and during the test.....should it be allowed or not?
- Test pressure...is testing at full rated pressure reasonable?
- Leakage measurement during static and / or dynamic stem movement?

So where do we stand with fugitive emission standards?

- TA-Luft
- ISO
- API
- Shell

TA-Luft

- TA-Luft still mentioned in our industry
- Investment in certifications already made by many
- Cannot be used to compare because test parameters are undefined
- Will live on due to German origin and tied to an overall clean air regulation

ISO-15848-1

- Issues still remain
- The most accurate method for measuring leakage
- Only 1 country adopted as a national standard
- Undergoing revision to simplify....but the 10 resolutions ultimately added more options to the menu
- So many options makes it difficult and expensive to use and nearly impossible to compare results

ISO-15848-1 Resolutions

- Resolution (1) – The test measurement method must be suitable for the leakage class
 - Vacuum method for class A, B, or C
 - Accumulation (bagging) method for class B or C
 - Sniffing for class D
- Resolution (2) – Use the accumulation method for measurement of body seal leakage by applying tape over the body seals
- Resolution (3) – To more closely align with TA-Luft, allowable leakage rate for class A is increased by a factor of 10
- Resolution (4) – CO1 mechanical cycles is reduced from 500 to 205. An optional subsequent low temp. test can be done at the end
- Resolution (5) – Change units for helium leak rate from mbar.l.s^{-1} per mm of stem diameter to $\text{atm cm}^3/\text{sec}$

ISO-15848-1 resolutions continued

- Resolution (6) – Tightness classes for Methane will be ppmv, and US delegation to propose allowable values to WG10 members
- Resolution (7) – Test pressure is to be kept at 6 bar
- Resolution (8) – Flushing test method is removed from the standard
- Resolution (9) – Qualification for CO1 at low temperature is also reduced to 205 mechanical cycles
- Resolution (10) – WG to assign a work group to draft the accumulation (bagging) method procedure

ISO-15848-1 issues remain

- For an API-609 high performance butterfly valve with PTFE packing – tightness class B, Minimum testing is as follows:
 - (1) test for isolating valve CO1, RT to +200°C
 - (1) test for isolating valve CO1, RT to -46°C
 - (1) test for control valve CC1, RT to +200°C
 - (1) test for control valve CC1, RT to -46°C
- What if customer asks for CO2, CO3, CC2 or CC3, etc?
- What if customer wants testing with Methane instead of Helium?
- What if 1 or 2 stem seal adjustments occurred during test where the expectation of some is none?
- What is validity of splitting the test temperature range into 2 groups?
- What is validity of test done with only 6 bar on a class 600 valve?

API-622 & 624 (pending)

- API-622 recently revised back to its original scope
- Confusion about testing in valves is clear
- It is only a packing test in a test fixture which does allow direct comparison of results.....a step in the right direction
- API-624 is intended for gate valves with graphitic packing only
- Makes sense as they are a large contributor to overall emissions
- In development
- No options....a single pass fail test
- Looks like 100 ppm will be the value to achieve
- Rough time frame for publication is early 2013 for release.
- API is considering a separate standard for rotary valves....expect it to quickly develop as 624 nears completion.

Shell SPE 77/300 and 312

- Shell intends to stay with their individual requirements
- These will continue to live
- Main criticism is that sniffing is specified for measuring leak rate
- Shell response is that if it passes the test, then they know it is a good packing design

Summary

- Current standards are not serving our industry & much time and expense has been wasted
- ISO is still going the wrong direction but is widely used because it is the only well known option
- Large end users, frustrated with ISO have developed their own standards
- API is taking a more realistic approach, but has fallen behind and is at risk of losing out to ISO
- Fortunately, the EPA has not taken a firm stance yet in defining a single test method that defines low-leak valve and packing technology
- Ultimately, emissions to the environment are controlled by the plant operators.
- Manufacturers can assist by providing designs that are suitable for the thermal, pressure, and mechanical cycles a valve may experience in service.