Emission measurements of industrial valves according to TA Luft and EN ISO 15848-1

As the title suggests, in this article Professor Dr.-Ing Alexander Riedl looks into the implications of measuring emissions according to TA Luft and EN ISO 15848-1 and points out some important conclusions.

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TA Luft

Inasmuch as they relate to Germany, the "Technische Anleitung zur Reinhaltung der Luft" (Technical Guidelines for Air Pollution Control, or TA Luft for short and referred to hereinafter as TA Luft) [1] are like a law in character. Among other things, they pursue the objective of reducing emissions with gasket systems as normally used in the chemicals and petrochemical industries. TA Luft only gives guidelines in respect of compliance with permissible leakage limits and refers to regulations which define basic conditions for inspections. For shutoff and regulating valves, this affects VDI (Association of German Engineers) Guideline 2440 [2], which may be regarded as state-of-the-art from a legal perspective.

VDI 2440

Guideline VDI 2440 refers to average gas-like emissions for differing gasket systems but these are not upper limits (see Table 1).

Table 1 – Average gaseous emissions (leakage) and valve gaskets [1]	
Gasket system	**Leakage related to the average size of the gasket [mg/(s x m)]**
Stuffing box with packing	1.0
Stuffing box with cup leather, O-ring	0.1
Stuffing box with packing, stuffing box with cup leather, O-Ring (with "TA Air Certificate" according to VDI 2440, Section 3.3.1.3)	0.01
Metallic bellows, sealed	0.01
Metallic bellows, sealed (with flat gasket possessing a TA Luft Certificate according to VDI 2440)	0.001
Stuffing box with packing and sealing medium/suction, metallic bellows, welded on both sides	No emission (technically leak-proof)

VDI 2440 refers to the use of high-quality metallic bellows with a downstream safety stuffing box or equivalent gasket systems as a particularly effective means of reducing emissions. In other words, metallic bellows and so-called "equivalent gasket systems" are established as conforming to TA Luft. This means that only these kinds of gasket systems may be used in Germany on shutoff and regulating valves when a TA Luft medium is subsidised.

Gasket systems may be regarded as equivalent if they fulfil the following conditions:

(1) The construction of the gasket system can be expected to permit its regulation function under operating conditions.

(2) Compliance with specific leakage rate with reference to the average size of the gasket, from 10^{-4} mbar x l/(s x m) at temperatures of less than 250°C and from 10^{-2} mbar x l/(s x m) at temperatures on the gasket system of greater than 250°C is proven at the first inspection.

No specific explanation is given on construction under (1) as to why this guideline is difficult to understand. On the other hand, the determination of a leakage rate to be complied with under (2) for all gaskets except metallic bellows is crucial in order to get valves that fulfil the conditions of this certificate onto the market.

Guideline VDI 2440 describes a testing procedure with which the above-mentioned certificate can be shown. The ancillary conditions here are:

(1) testing medium: helium;
(2) testing pressure: nominal pressure;
(3) testing temperature: permissible operating temperature;
(4) before the test, a representative number of switching cycles is carried out depending on the operating conditions (switching rate);
(5) test: with static and moving spindle/shaft;
(6) leak rate: leakage resulting after at least 24-hour admission flow with helium under the given testing conditions.

If the leak in (6) is less than 10^{-4} mbar x l/(s x m) (up to 250°C) or 10^{-2} mbar x l/(s x m) (over/the same as 250°C), the valve may be regarded as TA Luft compliant and may be used with TA Luft media.

EN ISO 15848-1

ISO norm EN ISO 15848-1 [3] has been valid since 2006. It refers exclusively to valves and describes, independent of the guidelines of TA Luft and VDI 2440 respectively, detailed tests for determining leakage and the creep behaviour of valves. The norm was developed under the overall control of the CEN/TC 69 "Industrial Valves" Committee. The norm distinguishes between the following parameters:

(1) 3 grades of imperviousness for the spindle/shaft;
(2) a grade of imperviousness for the body gasket;
(3) 2 testing media (helium and methane);
(4) 3 grades of firmness;
(5) 5 grades of temperature; and
1 distinction between shutoff and regulating valves.

Table 2 [3] shows the following grades of imperviousness for die spindle and the shaft:

Table 2 – Grade of imperviousness/leakage areas		
Grade	**Measured leakage rate mg/(s x m)**	**Remarks**
A (helium only)	$\leq 10^{-6}$	Typically achieved with bellows gaskets or an equivalent spindle/shaft gasket system for swivel valves.
B	$\leq 10^{-4}$	Typically achieved with packing on a PTFE basis or elastomer packing.
C	$\leq 10^{-2}$	Typically achieved with packing on the basis of flexible graphite.

The required imperviousness for the body gasket, measured using the sniffing method, may not exceed 50 ppmv (1 ppmv = 1cm^3 x /m^3). In respect of the media, the norm is not intended to achieve any comparability, but less leakage may be expected than with helium. However, this statement requires testing. The leakage tests are conducted both at room temperature and at maximum operating temperature, taking cycles of differing lengths. The gasket connection may only be re-tightened to a limited extent.

At the moment the author does not know whether any European country or the EU has adopted the norm in order to convert the limits described here into national or European law. Through the precise guidelines, however, it is expected that this will be carried out within the foreseeable future. The same applies to the stability and temperature grades described below.

The shutoff and regulating valves differ by stability grades, but the classification to a grade of stability is given by the number of cycles in which a certain grade of imperviousness (see Table 1) has not been exceeded. With the shutoff valves the norm assumes a maximum cycle of 2500 and with the regulating valves, a maximum cycle of 105 cycles. Differences are described in three grades of firmness shown in Table 3 below.

Table 3 – Stability grade for shutoff and regulating valves			
Type	**Stability grade**	**Cycle**	**Temperature cycles**
Regulating valve	C01	500	2
	C02	1,500	3
	C03	2,500	4
Regulating valve	CC1	20,000	2
	CC2	60,000	3
	CC3	100,000	4

The testing temperatures are subdivided into five grades and an area of -29°C x 40°C is given for room temperature (see Table 4).

Table 4 – Grade of temperature					
Grade of temperature	(t-196°C)	(t-46°C)	(tRT)	(t 200°C)	(t 400°C)
Temperature	-196°C	-46°C	Atmospheric temperature	200°C	400°C

Comparison of regulations

The guidelines in EN ISO 15848-1 are very precise and easy to understand. It is important to note here that clear guidelines are given in respect of the testing procedure. As well, the subdivision into grades of stability, imperviousness and temperature are significant in order to also enable the users of valves to differentiate between them. The same applies to the subdivision into shutoff (low number of expected cycles) and regulating valves (high number of expected cycles).

The TA Luft and Guideline VDI 2440 give a maximum permissible leakage as the only criterion which may not be exceeded; however, the marginal conditions (cycle etc.) are not clearly defined. In addition, the construction requirement which allows it to function according to the purpose for which it was built, is not really a clear guideline. But what is important is the question of the usefulness of EN ISO 15848-1 for verifying TA Luft. If we compare the degree of leakage in the ISO norm with the guidelines of TA Luft/VDI 2440, we arrive at the following interrelationship [4]:

$$Y = \frac{M \cdot f}{R \cdot T \cdot \pi \cdot D} \, X \quad \textbf{(1)}$$

where:

D = average gasket diameter (m)
f = conversion factor (=100) (mg x Pa x m³/g x mbar x l)
M = molecular mass (g/mol)
R = general gas constant (8,314) (J/mol x K)
T = temperature of the gases (K)
X = leakage rate (mbar x l/s)
Y = leakage rate (mg/m x s)

Note: the dependence of the leakage on the temperature of the gas is not taken into account in EN ISO 15848-1.

Accordingly, the conversion factor for leaks at room temperature, taking into account the relationship to the size of the spindle/shaft, is:

$$Y = 0{,}164 \cdot X \quad \textbf{(2)}$$

Y = leakage [mg/(s x m)]
X = leakage [mbar x l/(s x m)]

If one takes into account the fact that, according to TA Luft, the average size of the sealing material for inspecting the leakage is the determining factor and that, by contrast, EN ISO 15848-1 includes the size of the spindle/shaft, we arrive at the following interrelationship:

$$Y_{dm} = 0{,}164 \, \frac{D + d}{2d} \, X_d \quad \textbf{(3)}$$

Y_{dm} = leakage according to VDI 2440, in relation to the average size of the gasket [mg/(s x m)]
X_d = leakage according to EN ISO 15848-1, in relation to the diameter of the spindle/shaft [mbar x l/(s x m)]
D = outside diameter of the sealing element (corresponds to the interior diameter of the body) [mm]
D = exterior diameter of the spindle/shaft [mm].

In most cases this probably means that, on achieving grade B imperviousness according to EN ISO 15848-1, the guidelines of TA Luft are probably also fulfilled. The same applies to imperviousness grade C at temperatures of over 250°C.

Essentially, it may be assumed that EN ISO 15848-1 constitutes a tightening of the criteria in contrast to TA Luft/VDI2440, as more temperature cycles can be carried out with the ISO-Norm.

Literature

[1] TA Luft: Technical Guidelines for Air Pollution Control (TA Luft). Heymanns Verlag, Cologne, 2002.

[2]VDI 2440: Reducing Emissions from Mineral Oil Refineries. Beuth Verlag, Berlin, 2000.

[3] DIN EN ISO 15848-1: Industrial Valves - Measuring, Testing and Qualification Procedures for Escaping Emissions - Part 1: A Classification System and Qualification Procedures for the Testing the Design of Valves. Beuth Verlag, Berlin, 2006.

[4] D. Bathen, C. Hummelt, J. Meisel: Emissions on Flanged Joints. Vulkan Verlag, Essen, 2000.