Gasket sealability test results in accordance to new test setup concerning Air Quality Control control act (“TA-Luft”)

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Summary:

On 1st of December 2021 the new Technical Instruction on Air Quality Control act (German:”TA-Luft”) came into action. After six years of preparation by the German government, the new technical instruction on Air Quality Control act now has approx. 600 pages. The list of changes to previous version does have 144 pages, not only calling out more hazardous substances but also setting new rules for gaskets and flange-connections as well as for stirrers and agitators. Since this Technical Instruction has significant effect to other European Nations as well, because gasketing materials often are specified with regards to this Technical Instruction within customer chemical and petrochemical plants worldwide and across Europe.

1. What is TA-Luft?

TA-Luft can be regarded to be a “rule” for allowed fugitive emissions where a list of medias which are either dangerous to the environment, to human beings, or are expected to be dangerous, for example because they are changing the genetic material or are even intolerable such as dust, smell, and even if they are not directly toxic.

The “list” is 700pages long. For each of the medias, there is a limit given which is considered to be „non-toxic“. Fugitive emissions, transportation, decanting, storage of medias (liquid, gaseous, noise, dust,…) are treated within this technical instruction. This instruction is rated beneath the Air pollution control act, which is legislative, therefore it can be considered like a law.

In Germany only, because of its reference within the control act, it is a MUST HAVE to follow this instruction. From gasketing perspective, chapter 5.2.6 is most interesting, because it is including fugitive emissions, transportation, decanting and storage of medias with its sub-chapters:

- Pumps and Rotators/Agitators, Valves (5.2.6.1)
- Compressors (5.2.6.2)
- Flange joints (5.2.6.3) clamp connections (Tri-Clamp connectors)
- Shut-off devices, Control devices (5.2.6.4), Compression packings

1. New rules for flanged joint connections

Within “old” TA-Luft, previously, a certificate showing the result of a standard test setup could be used for the gasketing material Metallic connections, which are containing a media listed in the TA-Luft, now have to be calculated in accordance to DIN EN 1591-1 using DIN EN 13555 characteristics. The outcome would be a range of possible torque level with a given sealability level (L0,01) where the iterative calculation is done, checking tolerated strength of flanges, screws and gasket as well as bending of flanges, local plastification of materials and recovery using actual (on customer site) given temperature and pressure condition in working and mounting situation, for all components of the bolted connection.

If no numerical iterative calculation or no Finite-Elemente-Method is possible, a test rig setup needs to be done.

2. The “old” test-setup

Up to now, the test setup was always done with a pair of standard steel flanges including standard size of DN40-PN40 related to DIN EN 1092-1 and the gasket geometry was the same size related to DIN EN 1514-1 DN40 PN10.

The measured sealability class was done with 1bar and should meet the criteria of 1,0 x 10E-04 [mbar*l)/(m*s)]

Figure 1: Old test-setup with steel flange pair

3. **The “new” test-setup**

Most likely, all kind of “Low-Load” flange connections, such as PVDF, PE/PP, FRP or glassy connections (enamel) cannot be calculated using above calculation methods, because they do not perform linear on temperature changes.

Especially , if the customer purchases same size components from different producers, he has to do the new test setup for each size and each component he purchases/sources.

For “Low-Load” flanges, each nominal flange size and even each pressure number often are produced with different flange thickness or made in different ways using different production methods from each producer of flanges.

This means: Each producer and each size must be checked with the new given test rig-setup, using:

- Effectively used working conditions like temperature and pressure
- Effectively used clamping components like screws or loose flanges
- Effectively used (different) gaskets and flanges (from different producers)

Figure 2: PP flange

Figure 3: PVDF flange

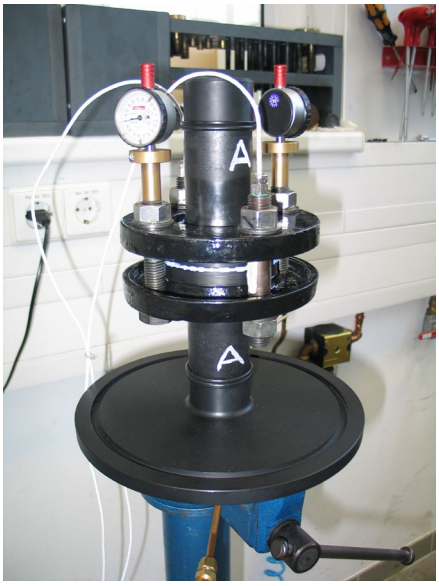

Figure 4:PE flange

Figure 5:DIN 32676 Flange "tri-clamp"

The “new” measurement unit also has changed. Reading the numbers this seems to be easier to fulfill but the truth is different, because the “old” unit has been a

volumetric unit and the new unit now is a “weight based” unit, where single atoms of the test gas helium now are counted using a helium mass-spectrometer.

The NEW CRITERIA is 1,0 x 10E-02 [mg/(m*s)]

This means a gasket of 1m circumference now is allowed to have a “leakage” 0,01mg per second. This is regarded to be Sealability class L0,01.

4. The “new” test-procedure

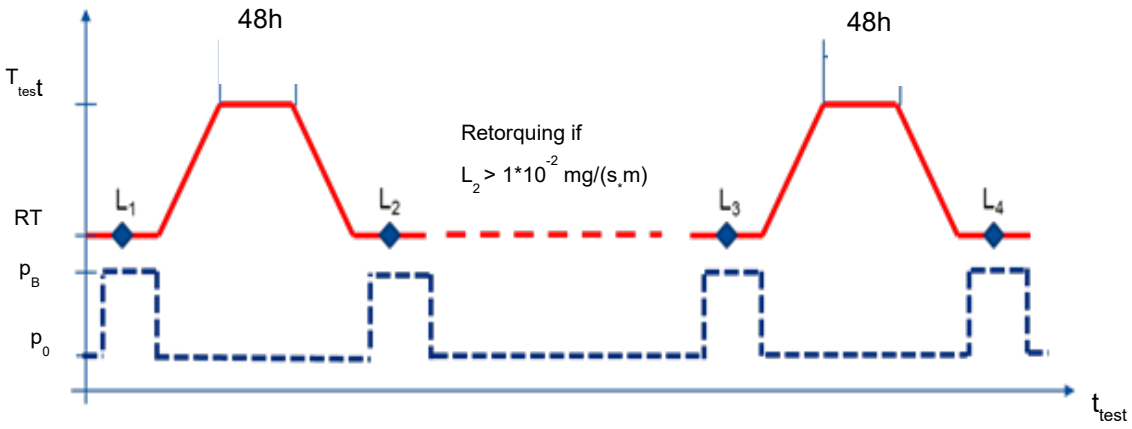

Figure 6: VDI 2290 draft version of new test procedure

T_{test}	Test-Temperature [°C]
t_{test}	elapsed time of test
L_1	Determination of leakrate at Room-Temperature (RT)
L_2	Determination of leakrate at Room-Temperature after temperature storage
L_3	Determination of leakrate at Room-Temperature after retorquing
L_4	Determination of leakrate at Room-Temperature after retorquing and after 2nd temperature storage
p_0	Ambient pressure
p_B	Line pressure (pressure of real condition on customer site)

5. Difficulties of sinking into surface

All gasketing materials used on “Low-Load” flanges (except glassy surfaces) do have the concern of “sinking” into surface. Because materials like FRP (Fiberglass Reinforced Plastic) or PE (Polyethylene) are not tolerant against seating stress or against load in general.

Pictures below do indicate the sinking of each gasket material into the surface under elevated temperature, resulting in loss of tensile strength and/or tension inside the screw material, thus resulting in loss of clamping ability and unloading of the gasket.

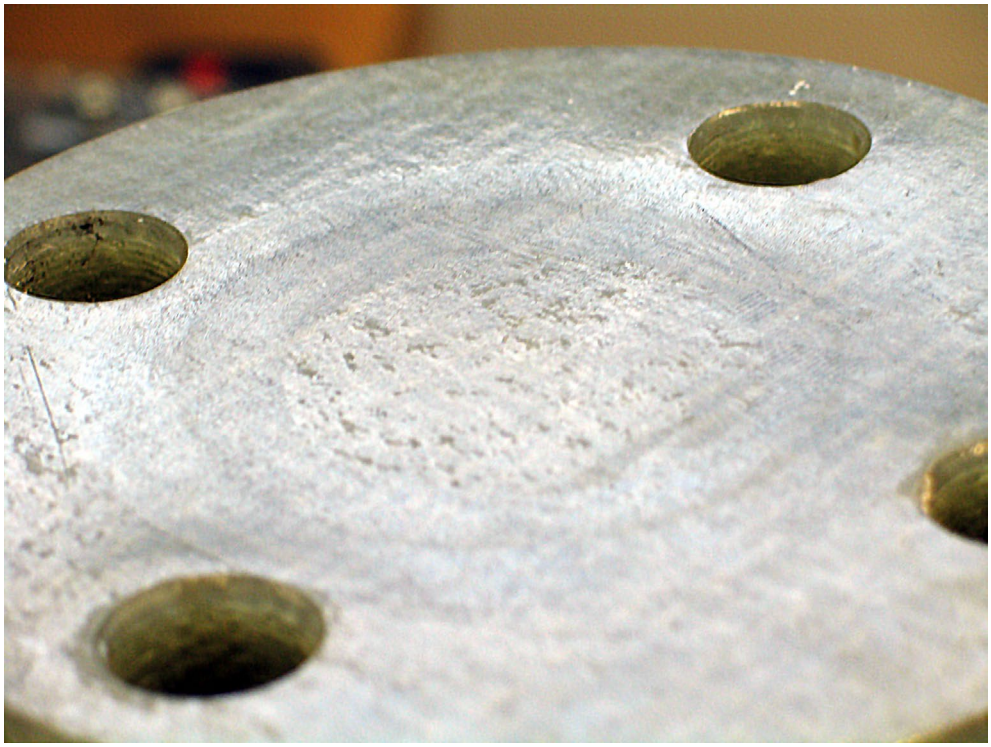

Figure 7: Sinking of gasketing material into surface of FRP flange

6. Materials used on “Low-load”-flange-surfaces and their test results in accordance to the new test setup

The gasketing materials which are to be used on those “Low-Load” flange surfaces all need to be chemical very resistant against aggressive medias (other ways steel-pipelines could be used). In addition to this, the gasket materials all need to have excellent compressibility and excellent recovery.

Typical examples are:

1) Modified PTFE gaskets with microscopic glass microspheres (for example Garlock Style 3504)
2) “STRESS-SAVER” gaskets, where rib-technology allows to concentrate the minimum load available on a small linear surface section (for example Garlock Stress-Saver Style 3504)

Assuming, those gaskets can be tested with minimum surface load of 10MPa under maximum tolerated flange temperature and maximum tolerated line pressure of each below mentioned flange materials the outcome of results is of high interest for petrochemical and chemical customers as well as all plant owners using such kind of flanged systems in Germany (and Europe).

Tested on following flanges:

- PP -R flange, colour grey
- PE100 flange, colour black
- PVDF with welding neck
  all above mentioned with loos flange PP/steel company AGRU

- FRP flange with welding neck
  Loose flange galvanized steel company PLASTICON

...which are regarded to be most commonly used in Chemical/Petrochemical applications.

7. Results for commonly used gasketing materials

In accordance to mentioned gasketing and flange materials (chapter 7 above) within have been tested with below shown results regarding PP-Flanges.

SETUP flange system	Load under assembly [MPa]	Pressure	Temperature storage	Q_{i1} assembly load [MPa]	L_1 [mg/(s*m)]	L_2 [mg/(s*m)]	Q_{R1} residual load [MPa]	Q_{i2} load after retorque [MPa]	L3 [mg/(s*m)]	L_4 [mg/(s*m)]	Q_{R2} residual load [MPa]	Results comment
PP-R flange (light grey)	10MPa	16bar	70 °C									
Whelding neck, SDR11, short, surface grooved, 50x4,6 AGRU												

Test No.	OD -Ø [mm]	ID -Ø [mm]	Thickness [mm]	Gasket used								
PP-R 20_01	87,81	39,84	12,83	**STRESS-SAVER® GYLON® 3504**	10	1,9E-04	4,1E-04	1,7				Fine without re-torque
PP-R 20_02	87,84	40,17	12,82									
PP-R 20_03	87,8	39,87	12,83	**GYLON® 3504**	10	1,5E-04	3,5E-04	1,4				Fine without re-torque
PP-R 20_04	87,82	39,85	12,82									

In accordance to mentioned gasketing and flange materials (chapter 7 above) within have been tested with below shown results regarding PE-Flanges.

SETUP flange system	Load under assembly [MPa]	Pressure	Temperature storage	Q_{i1} assembly load [MPa]	L_1 [mg/(s*m)]	L_2 [mg/(s*m)]	Q_{R1} residual load [MPa]	Q_{i2} load after retorque [MPa]	L3 [mg/(s*m)]	L_4 [mg/(s*m)]	Q_{R2} residual load [MPa]	Results comment
PE100 flanges (black)	10MPa	16bar	70 °C									
Whelding neck, SDR11, short, grooved, 50x4,6 AGRU												

Test No.	OD -Ø [mm]	ID -Ø [mm]	Thickness [mm]	Gasket used									
PE 20_01	87,61	39,6	12,89	**STRESS-SAVER® GYLON® 3504**	10	2,0E-03	1,0E-03	1,6	no retorque needed, if retorqued even better				
PE 20_02	87,66	39,78	12,9										
PE 20_03	87,62	39,67	12,89	**GYLON® 3504**	10	2,0E-04	Not sealant	1,3	10	4,8E-04	4,1E-04	2,6	fine after retorque
PE 20_04	87,65	39,67	12,9										

In accordance to mentioned gasketing and flange materials (chapter 7 above) within have been tested with below shown results regarding PVDF-Flanges.

SETUP flange system	Load under assembly [MPa]	Pressure	Temperature storage	Q_{I1} assembly load [MPa]	L_1 [mg/(s*m)]	L_2 [mg/(s*m)]	Q_{R1} residual load [MPa]	Q_{I2} load after retorque [MPa]	L3 [mg/(s*m)]	L_4 [mg/(s*m)]	Q_{R2} residual load [MPa]	Results comment
PVDF Whelding neck PN 16 50x3mm (Weiß) Whelding neck, SDR21, short, grooved, 50x3,0 AGRU	10MPa	16bar	100°C									

Test No.	OD -Ø [mm]	ID -Ø [mm]	Thickness [mm]	Gasket used								
PVDF 20_01	87,27	42,84	9,29	**STRESS-SAVER® GYLON® 3504**	10	5,1E-02	1,6E-05	0,7				No retorquing needed. If retorqued, even better.
PVDF 20_02	87,29	42,87	9,32									
PVDF 20_03	87,3	42,93	9,31	**GYLON® 3504**	10	2,4E-04	3,2E-05	1,0				
PVDF 20_04	87,31	42,82	9,3									

Also, in accordance to mentioned gasketing and flange materials (chapter 7 above) within have been tested with below shown results regarding FRP-Flanges (FRP=FiberglassReinforcedPlastic).

SETUP flange system	Load under assembly [MPa]	Pressure	Temperature storage	Q_{I1} assembly load [MPa]	L_1 [mg/(s*m)]	L_2 [mg/(s*m)]	Q_{R1} residual load [MPa]	Q_{I2} load after retorque [MPa]	L3 [mg/(s*m)]	L_4 [mg/(s*m)]	Q_{R2} residual load [MPa]	Results comment
GFK Whelding neck (no tempering prior use)	10MPa	16bar	80°C									

Test No.	OD -Ø [mm]	ID -Ø [mm]	Thickness [mm]	Gasket used									
GFK 20_01	88,23	40,49	15,27	**STRESS-SAVER® GYLON® 3504**	10	2,9E-04	not sealant	0,3	10	3,4E-04	still not sealant	0,8	Both Styles not sealant with 10MPa, because of the "soft" flange material where the gasket sinks into the surface.
GFK 20_02	88,1	40,61	15,01										
GFK 20_03	88,25	40,46	15,15	**GYLON® 3504**	10	1,2E-04	not sealant	0,1	10	3,9E-04	still not sealant	0,4	
GFK 20_04	88,32	40,36	15,08										

Test No.	OD [mm]	-Ø ID -Ø [mm]	Thickness [mm]	Gasket used									
GFK 20_05	88,05	40,4	15,07	**STRESS-SAVER® GYLON® 3504**	20	6,8E-05	nicht messbar	1	20	1,3E-04	3,5E-03	3,7	Often, 30MPa load are tolerated by FRP flanges. Here tests with 20MPa load are successfully completed.
GFK 20_06	88,15	40,52	15,20										
GFK 20_07	87,97	40,49	15,07	**GYLON® 3504**	20	1,4E-04	nicht messbar	0,7	20	2,1E-04	1,0E-03	3,3	
GFK 20_08	88,19	40,45	14,95										

Also, Flanges in accordance to DIN 32676 (Tri-clamp connectors) with the given disadvantage of an "non-normatized clamp" can be tested in accordance to new TA-

Luft. Here, “Tri-Clamp-Gaskets” produced of modified PTFE materials (those modified PTFE materials will be included in the next revision of DIN32676 which highly likely would be green-printed in 2022).

The results are depending on the load created by the clamp which is taking care of loading the gasket.

Hint: Any double screw clamp called “High-Pressure-Clamp” has a very beneficial outcome to the test, because the load created on the gasket is more homogeneous. The picture below (Figure 8) is indicating the load with a pressure-sensitive “Fuji-Film Foil”.

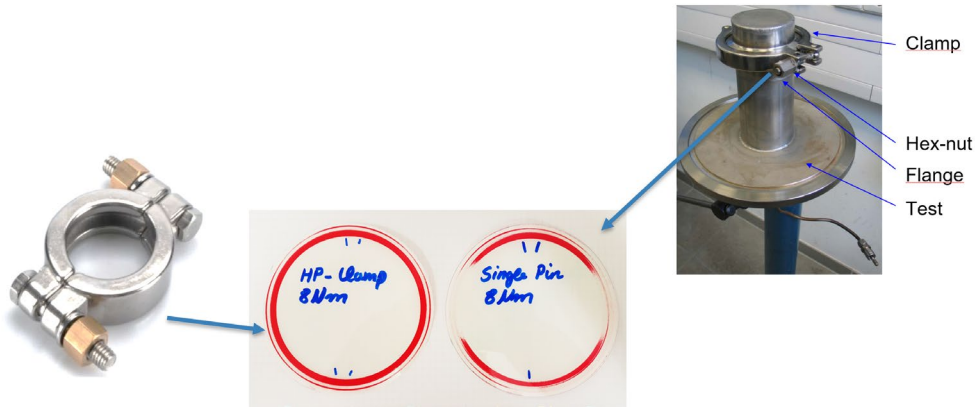

Figure 8: red fuji film showing load on DIN 32676 gasket caused by single-, and double-pin clamp

Using 8Nm torque to simulate a closing by hand, with a given line pressure of 16bar and temperatures up to 130°C, PTFE gaskets in accordance to DIN 32676 standard, providing reduced cold-flow, for example Garlock GYLON® BIO-PRO® which is modified with aluminosilicate microspheres (micro-glass-bubbles) already could reach values of 4,9 $x10^{-3}$ [mg/(s*m)]. Calanderized pure PTFE gaskets like Garlock GYLON BIO-PRO® PLUS, which also is providing reduced coldflow and reduced creep by its production method, already could reach values of 2,4 $x10^{-4}$ [mg/(s*m)]. The given normative value which should not be exceeded for this kind of test and connection is 1,0 $x10^{-2}$ [mg/(s*m)].

8. Summary

Plant owners now have to do their homework.

The previously used “TA-Luft-Certifiacte” which was tested in normative steel flanges with given load using 1bar line pressure cannot be used to fulfil the new German Air Quality Control control act called “TA-Luft” regulation.

Now, commonly used gasketing materials on metallic flanges need to be calculated in accordance to EN 1591-1. The results will indicate the check of minimum load needed to be sealant and of maximum load not to be exceeded for the gasketing material, indication of reached sealability class, indication of used torque and check of all tensile forces, including screw/bolts and flanges as well as rotation of flanges.

If no calculations are possible the new test setup can be used successfully to prove the existing joint connection, even if “low-load” flanges are given, modern gasketing materials can still be used to be in line with the new “TA-Luft” regulation.

References:

- Figure 7: VDI – 2290 (undated), Emission Control – Sealing constants for flange connections, by Verein Deutscher Ingenieure (open public version)
- Figure 2-6: Photos by GAIST GmbH, Am Campus 2, 48565 Steinfurt with all rights to use
- Figure 8 and ff. as well as tables of results: Own Photos and Illustrations by Garlock GmbH

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Figure 9: Ralf Kulessa