Understanding European Flange Design Rules (EN 1591-1) & Gasket Characterization Methods (EN 13555) & Their Application in Reducing Fugitive Emissions

Manfred Schaaf

VSP Technologies - Sealing Conference
November 21, 2013, Prince George VA

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North America, Inc.

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registered 2013

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amtec North America, Inc.

German Parent Company

amtec

Advanced Measurement
Messtechnischer Service GmbH

established 1979

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Sealing Technology

- **Testing Laboratory**
- **Testing Equipment**
- **Measurement Techniques**
- **Calculation Programs**
  (service and software, EN & KTA code, FEA)
- **Bolt Mounting Systems**
  (Hydraulic Tensioners, Measurement Tools)
- **Data Bases Designed**
  (Joint Integrity Management)

TEMES

Advanced Tools for the Reduction of Fugitive Emissions

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TEMES (tm)

TEsting and
Mounting **E**quipment for
Sealings

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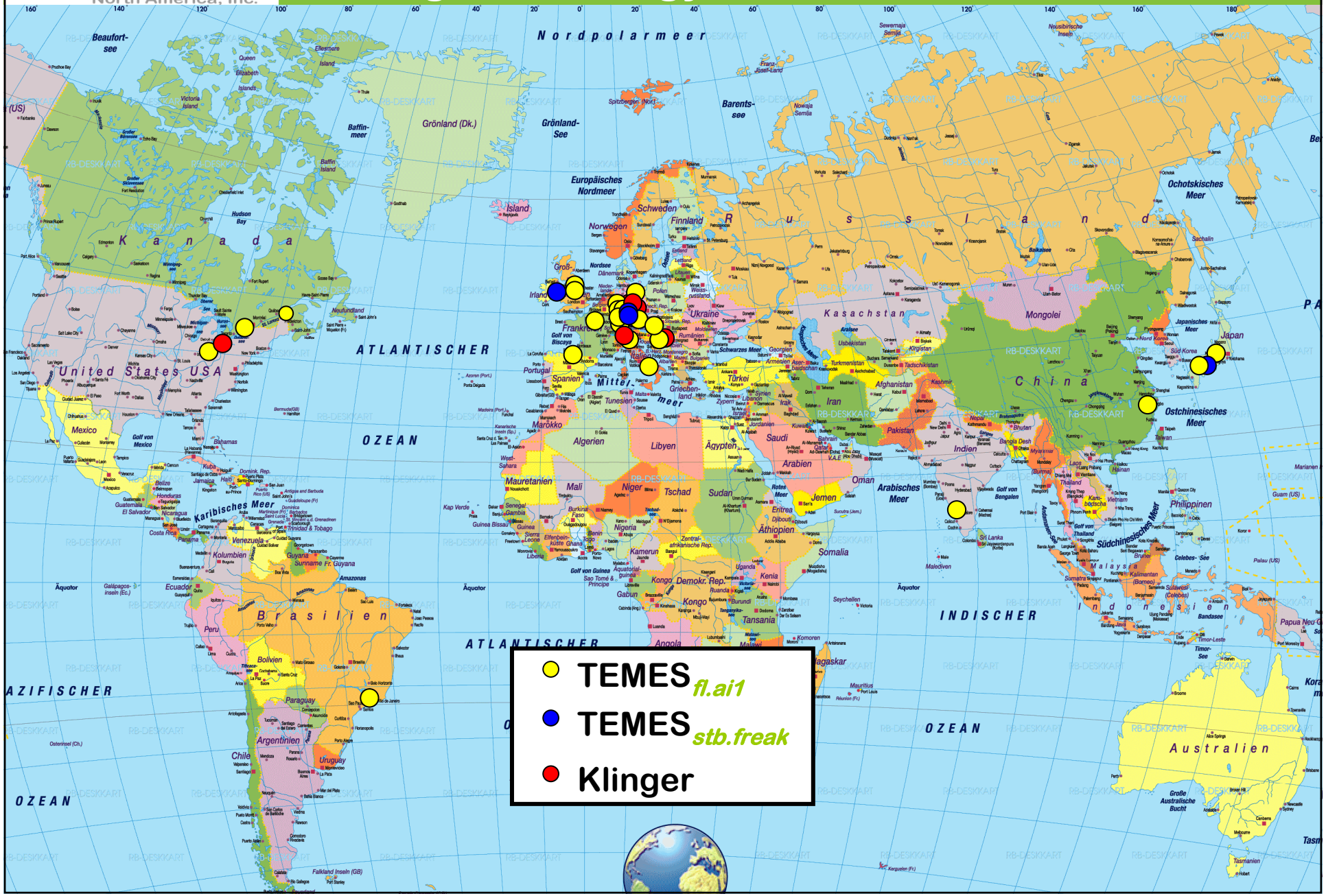
Sealing Technology • References



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Sealing Technology • References

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Motivation

Whoever promises you that he can provide

ZERO LEAKAGE,

don´t trust him, it

is a fairy tale!

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Fire in a Refinery after a Leakage from a BFJ

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Leakage from a Tank Wagon

Origin: Feuerwehr Blieskastel

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Leakage from a Valve Body Seal

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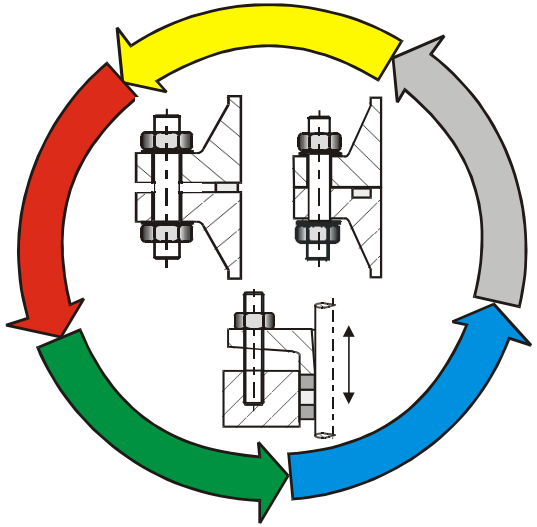
Leak Detection of Volatile Organic Compounds

Origin: LDAR Envolve Ltd.

Content

- Background Information
- European Standards
- Industry Experience
- Outlook



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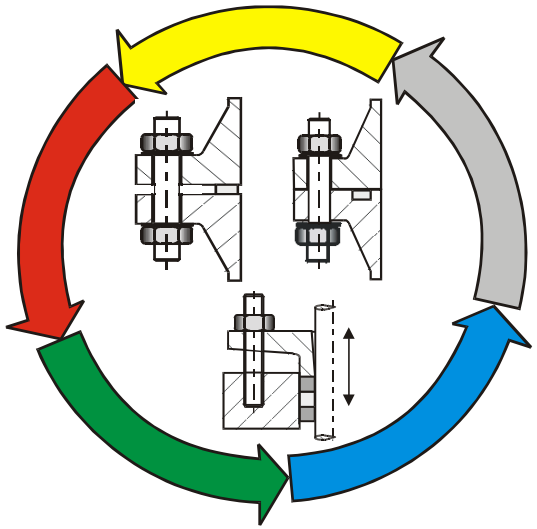
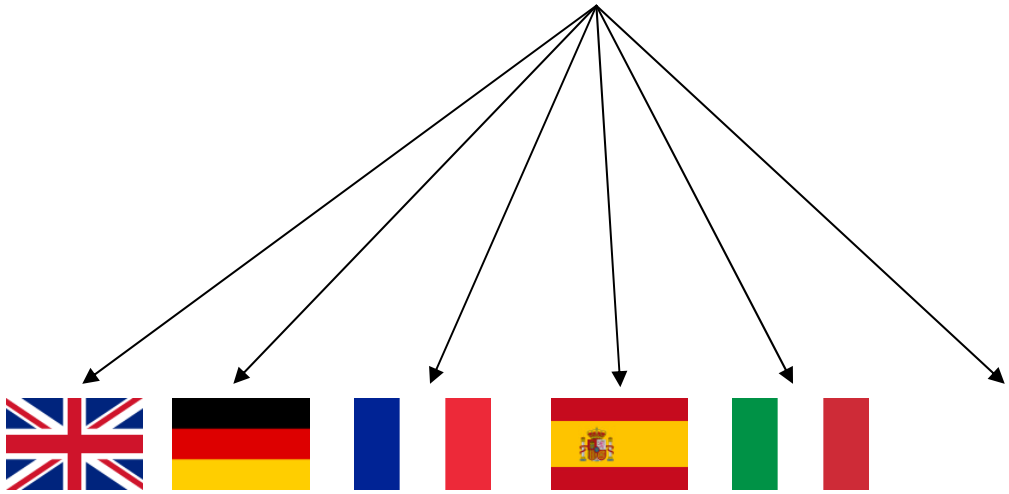


EU and National Legislation (General)

EU Legislation

(Regulations, Directives, etc.)

European Commission/ Parliament/ Council of Ministers



EU Member States

Directives are transposed into National Legislation

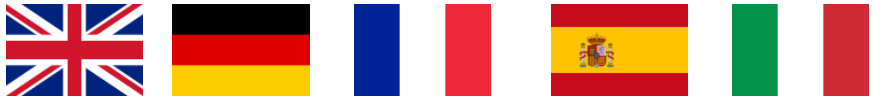
EU and National Legislation (Emissions)

EU Legislation
(Industrial Emission Directive)

European Commission/ Parliament/ Council of Ministers

BREF

Transposition Tools



… **TA-Luft** … … … …

EU Member States

(Technical Instruction on Air Quality Control)

VDI Guidelines

Guideline on Reduction of Emissions

- **EU Legislation:**
  Integrated Pollution Prevention and Control (IPPC) Directive 2008/01/EC
  Industrial Emission Directive (IED) 2010/75/EU
- **German Legislation:**
  Technical Instructions on the Air Quality Contriol - TA-Luft
- **VDI 2440:**
  Approval of gasket materials as high-grade sealing system in a first-time test („TA-Luft approval“)
- **VDI 2200:**
  Additional demands on high-grade sealing systems in respect of the design, the calculation, and the assembly of bolted flanged joints

→ **VDI 2290**
Emission control – Sealing constants for flange connections
2012-06

VDI 2290 – Guideline on reduction of emissions

- **Basics for design and calculation of flanged joints**
  - Applicable calculation rules → **EN1591-1**
  - Gasket characteristics → **EN13555**

- **Explanations on gasket characteristics for the calculation of flange joints**
  - Testing procedure
  - Interpretation of first-time test
  - Selection / interpolation of gasket characteristics

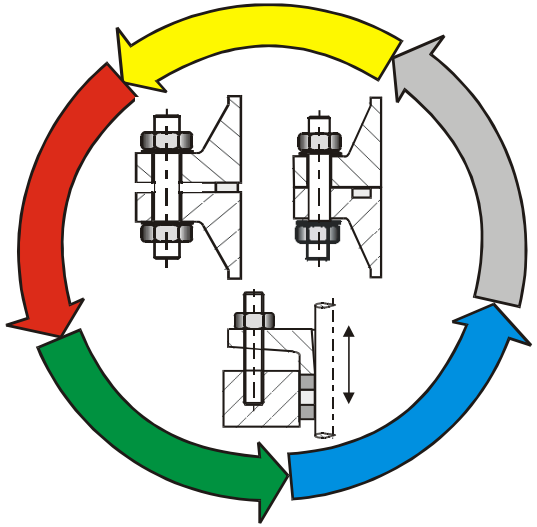
- **Assembly of flanged joints** → **EN1591-4**

- **Tightness demands** → **$L_{0.01}$ (He)**

No LDAR program required!

Content

- Background Information
- **European Standards**
- Industry Experience
- Outlook



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Technical Committee TC 74

“Flanges and their Joints”

- **WG 1** Basic Standards
- **WG 2** Steel Flanges (PN and Class)
- **WG 3** Cast Iron Flanges (PN)
- **WG 4** Copper Alloy Flanges (PN and Class)
- **WG 5** Aluminium Alloy Flanges (PN and Class)
- **WG 8** Gaskets
- **WG 9** Bolting
- **WG 10** Calculation Methods

Business Plan of TC 74

… It is recognised that industry must reduce its impact on the environment in order to ensure global development for the future. Part of industrial emissions occur through unanticipated or spurious leaks in process systems, e.g. from leaking valves, pumps or flanges. These "fugitive emissions" have not only an impact on the environment, but cause also a tremendous financial burden on industry, because it represents a huge loss of potentially valuable materials, and cause of plant inefficiency. …

Business Plan of TC 74

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Business Plan of TC 74 (cont´d)

… The European standards for the determination of the gasket characteristics and for the flange calculation enable the determination of the required assembly bolt forces to fulfil a demanded tightness class. This shall give the industry the possibility to reduce fugitive emissions in a pro-active manner instead of implementing control measures to find leaks on site and to minimize the leaks in this reactive way. It is therefore crucial to have testing standards as well as technical delivery conditions for gaskets and gasket materials, also a calculation procedure is required for the stress and tightness analysis. …

Business Plan of TC 74 (cont´d)

… The European standards for the determination of the gasket characteristics and for the flange

reduce fugitive emissions in a pro-active manner

ired
ess
to

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instead of implementing control measures to find leaks

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TC 74 – Standards under development

- **prEN 13555 rev**
  Flanges and their joints - Gasket parameters and test procedures relevant to the design rules for gasketed circular flange connections
  Formal Vote 2013-11
  2014-03

- **prEN 1591-1 rev**
  Flanges and their joints - Design rules for gasketed circular flange connections - Part 1: Calculation
  2013-11

- **prEN 1591-4 rev**
  Flanges and their joints - Part 4: Qualification of personnel competency in the assembly of the bolted connectionsof critical service pressurized systems
  2013-12

EN 1591-1 - Status quo

EN 1591-1 released as an European Standard in 2001

Amendment A1 of EN 1591-1 released as an European Standard in 2009

New Issue in December 2013

Calculation method for gasketed circular flange connections with gaskets inside the bolt circle and without metal-to-metal contact of the flange faces

- **leak tightness and strength criteria are satisfied**
- **behavior of complete flanges-bolts-gasket system is considered**

EN 1591-1 - Treated parameters

- strength value of flange and bolt materials
- gasket characteristics
- thermal loads
- medium pressure
- external axial forces and bending moments
- nominal bolt load
- possible scatter due to bolting-up procedure
- changes in gasket force due to deformation of all components
- influence of connected shell or pipe

EN 1591-1 - Specifics

- elastic deformation balance
- flange rotation and effective compressed gasket area
- iterative determination of the required bolt force in assembly to fulfill tightness demands
- force balance
  (interaction between all components)
- virtual flange resistance of the flanges
- limit load theory
  (admissibility of plastic deformation)

Gasket characteristics (EN 13555)

Mechanical characteristics		
$Q_{Smax}(RT)$	MPa	Maximum allowable gasket surface pressure at RT
$Q_{Smax}(T)$	MPa	Maximum allowable gasket surface pressure at T
E_G	MPa	Modulus of elasticity
Δe_{GC}	mm	Creep relaxation of the gasket
Tightness characteristics		
$Q_{min(L)}$	MPa	Minimum required gasket surface pressure for tightness class L during assembly
$Q_{Smin(L)}$	MPa	Minimum required gasket surface pressure for tightness class L in operation (in dependence on the gasket surface pressure Q_A applied during assembly)
Additional parameters		
μ_G	-	Friction factor which is necessary for the treatment of shear forces and torsion moments

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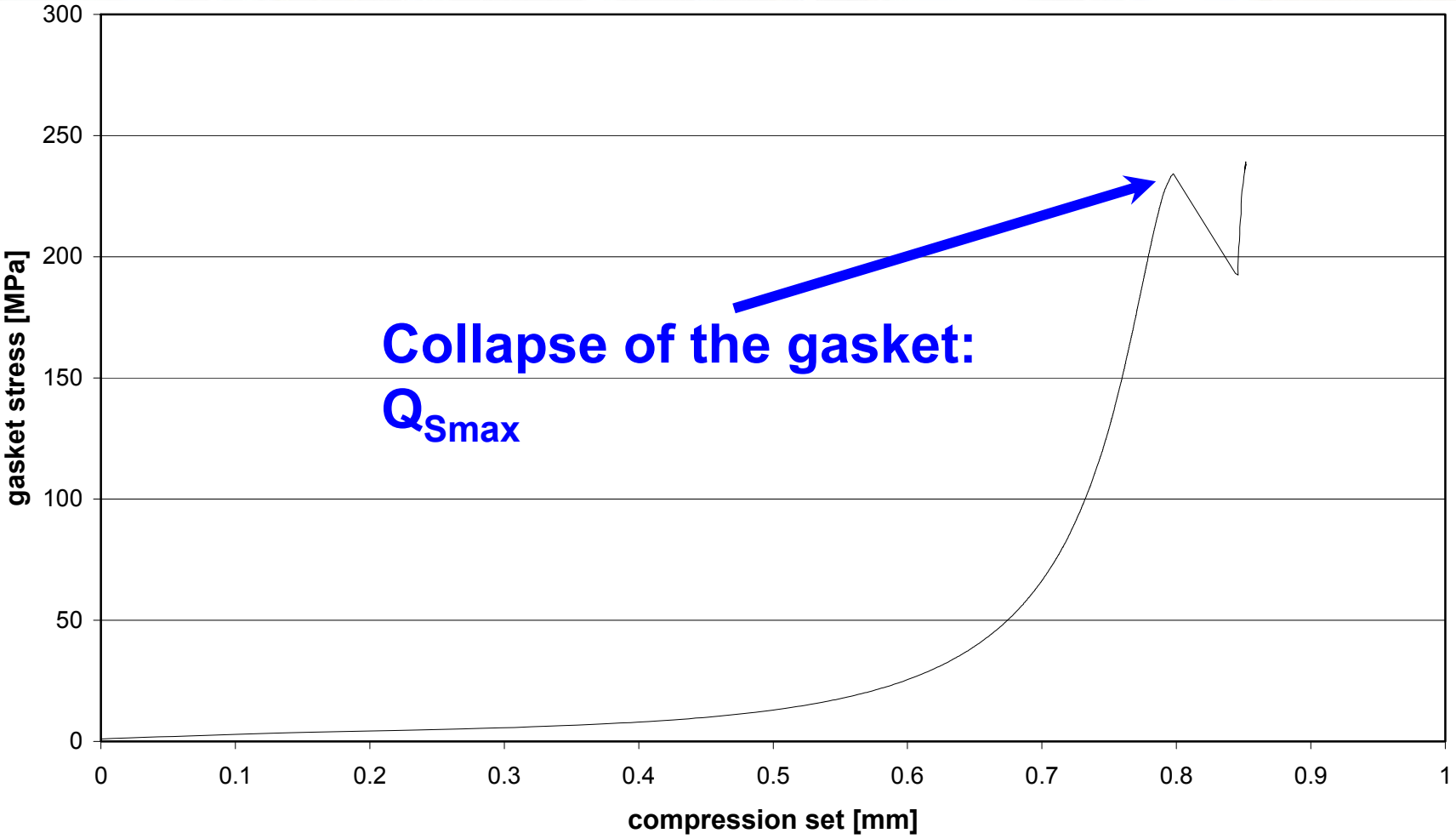
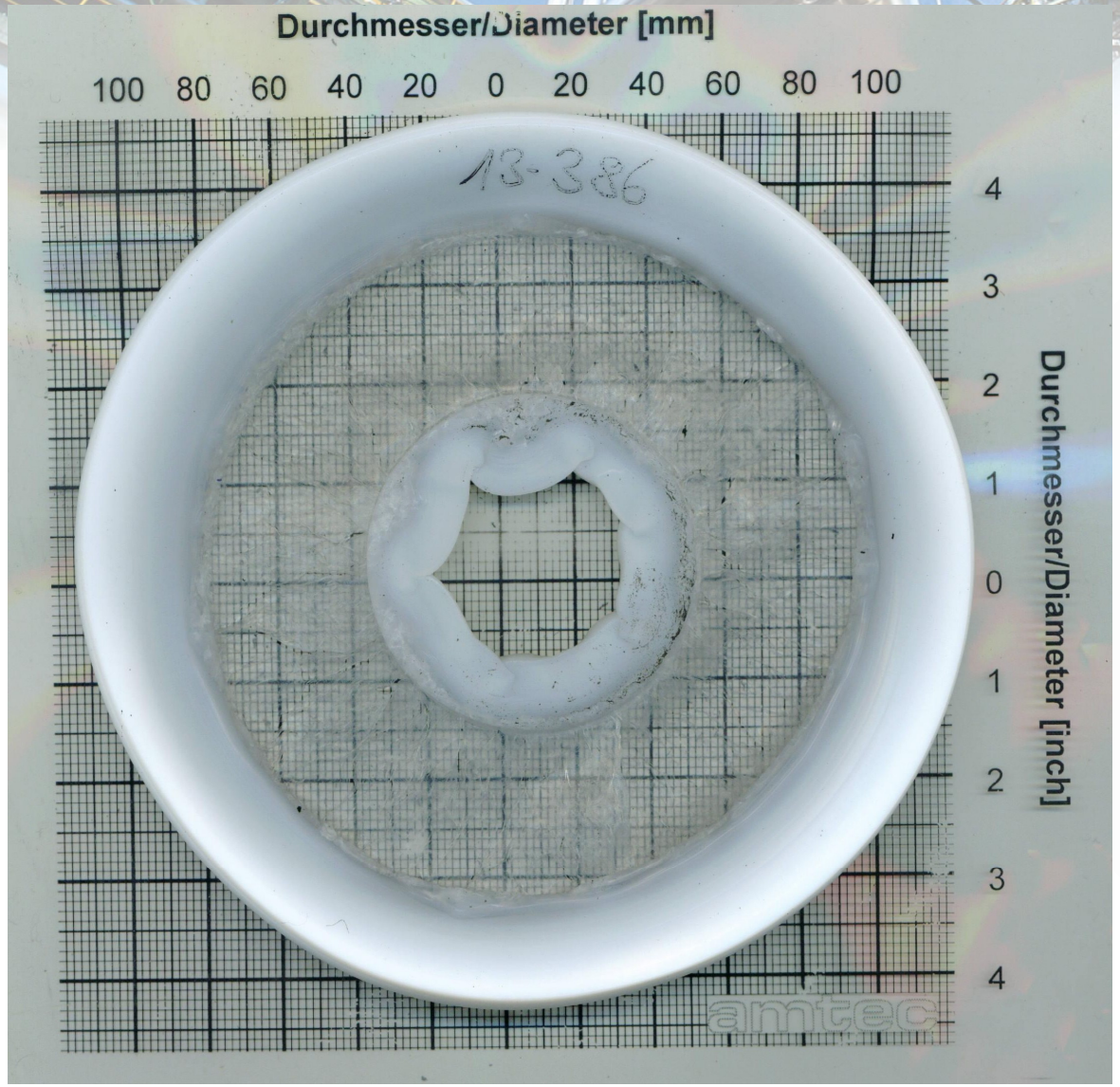
Testing equipment

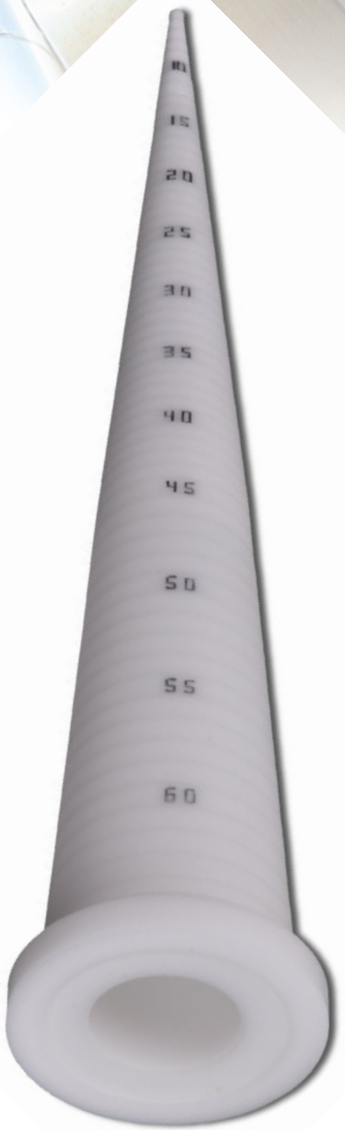
Deformation characteristic

Compression curve
P01-IBC-GR 92x49x1.535 mm
Test number: 10-412



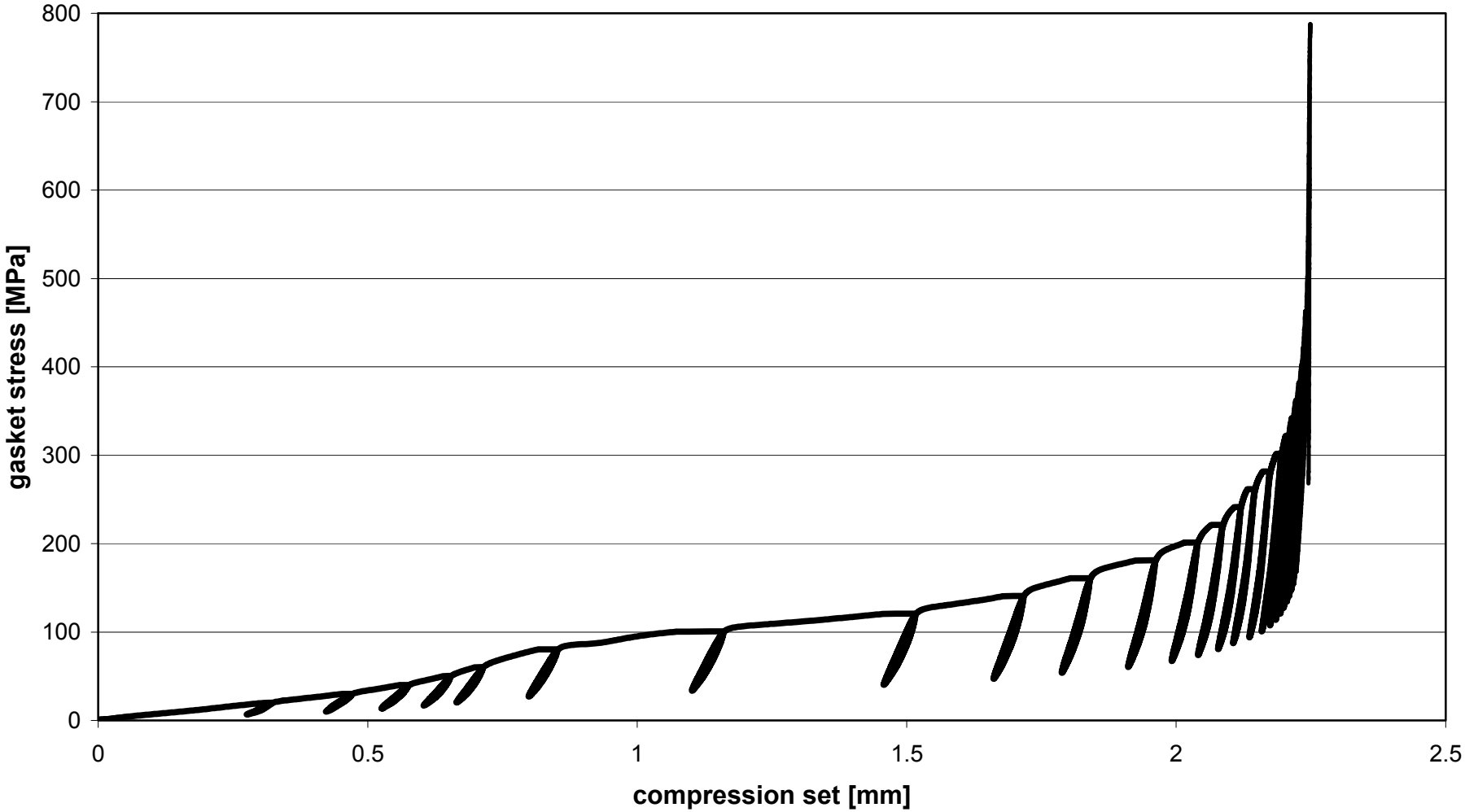
Maximum allowable gasket stress Q_{Smax}





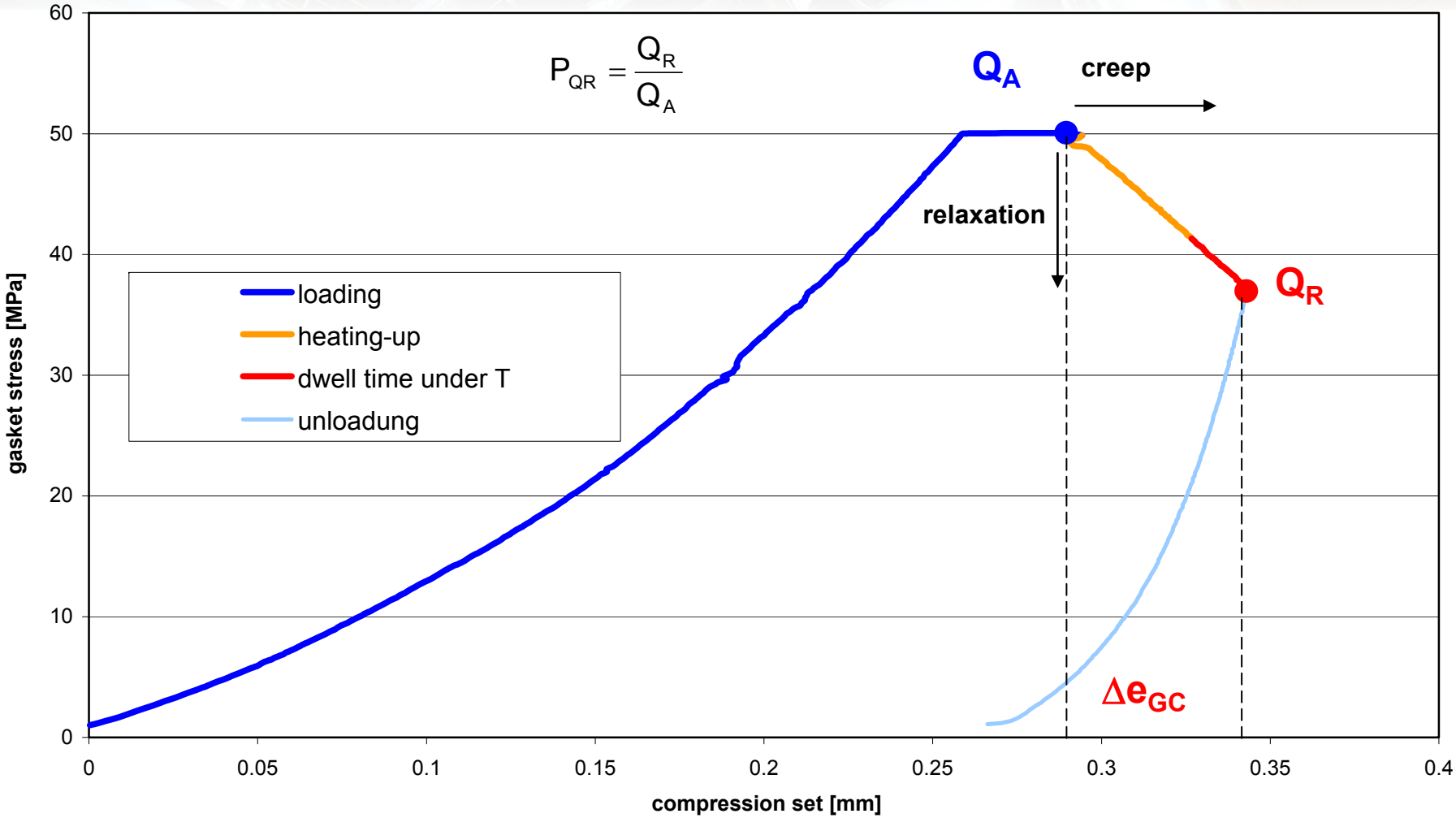
Loading and unloading cycles

Compression curve
B01-SWG-GR 68.95x56.22x5.192 mm
Versuchsnummer: 10-098



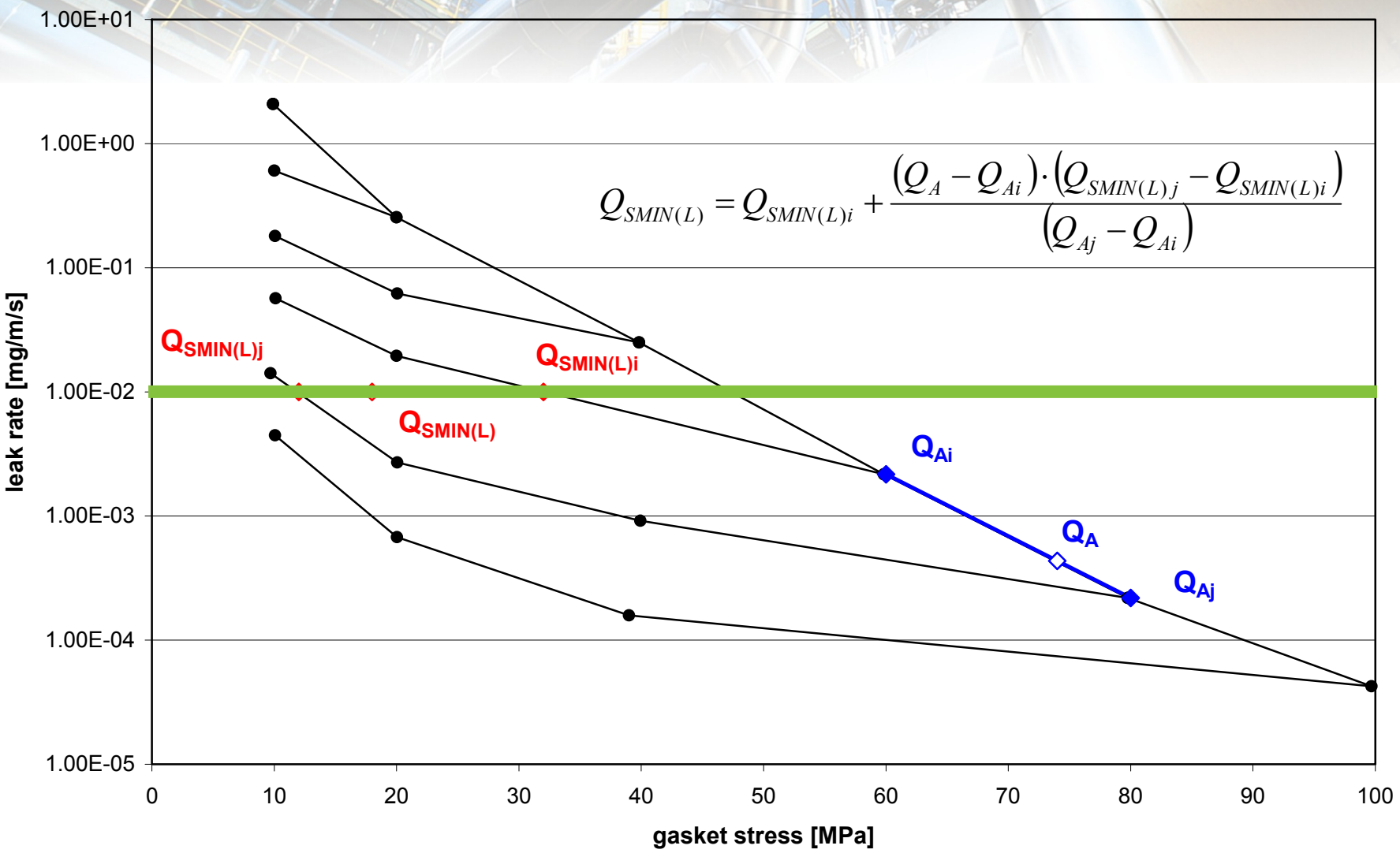
Creep relaxation characteristic

Compression creep curve
D01-IBC-FA 91.7x49.05x2.845 mm
Versuchsnummer: 10-104



Tightness characteristics

Leakage curve



CEN/TS 1591-4 - Status quo

CEN/TS 1591-4 released as an Technical Specification in 2007

Issue as an European Standard in November 2013

Process for training and compentency assessment of personnel in the assembly of bolted flanged joints fitted to equipment subject to PED

- **design codes increasingly require controlled bolt tightening**
- **ensure personnel are competent to assemble and tighten bolted joints for a leak-free status throughout its´ service life**
- **training, experience and assessment of knowledge are required to achieve competency**

CEN/TS 1591-4 - Specifics

- **procedural framework must be included within operator´s quality management system**

- **route for achieving comeptency in the skills**

  - **classroom training and workshop practice**
  - **written test**
  - **period of monitored work site experience**
  - **assessment by a qualified assessor**

Work-site experience	Earliest assessment
Frequent and intense	3 months
Infrequent but with intense periods	6 months
Sporadic	12 months

CEN/TS 1591-4 - General knowledge

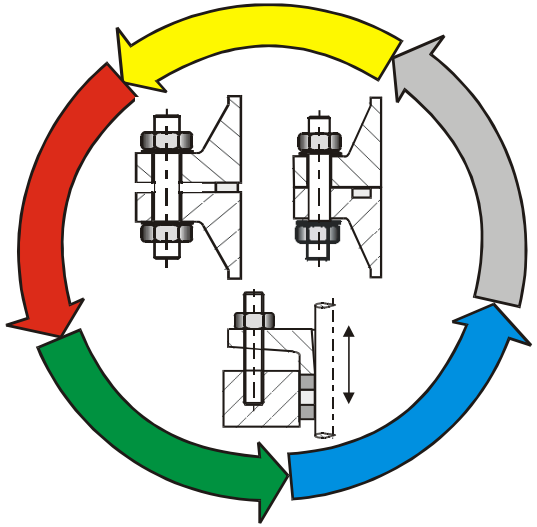
- the principles of bolt elongation (strain), bolt load and stress;
- importance of applied and residual bolt loads;
- bolt load loss and the implications;
- effect of coefficient of friction on bolt load when using torque;
- bolt tightening methods and their relative accuracies;
- joint assembly methods and tightening procedures;
- the requirements to meet a specific class of tightness;
- flange, bolt and gasket types and their limitations;
- functionality of gasket and seal;
- factors affecting the degradation of bolted assemblies, e.g. corrosion;
- common causes of joint failure and leakage;
- specific health or safety requirements associated with joint components;
- maintenance requirements of bolt tightening systems;
- importance of certification and records.

CEN/TS 1591-4 - Specific knowledge

- general health and safety precautions;
- procedure for preparing a joint for closure;
- identification of correct joint components;
- seal face preparation;
- gasket handling, preparation and installation;
- functionality of clamp or engineered joints;
- importance of alignment and gap uniformity;
- importance of using the specified lubricant;
- manual and hydraulic torque joint tightening;
- joint tightening using hydraulic bolt tensioners;
- techniques for measuring bolt strain;
- confirming joint can return to service;
- identifying defects or faults;
- variance or irregularity reporting;
- safe joint disassembly;
- safety requirements when selecting and operating bolt tightening tooling;
- calibration of bolt tightening tooling;
- recording bolted joint activity and maintenance of records.

Content

- Background Information
- European Standards
- **Industry Experience**
- Outlook



First experiences with VDI 2290

Although the VDI 2290 was issued only one year ago, the industry has already experience on the use of this guideline in their plants.

- **Revision of pipe classes**
- **Imperative of EN 1591 (tightness based design)**
- **Greater significance of assembly**
- **Introduction of a quality management circle to assure proper function of BFC´s**
- **Reduction of incidients during start-up after turnaround**

Revision of Pipe Classes

	PIPE CLASSES		
	Code:	Plant:	UAN:	Page 43 of 69

Pipe Class XXXXXXXX

Nominal pressure	PN 250																	ype	Alloy	
Allow. design pressure	MPag	25,0	25,0	25,0	25,0	25,0	25,0											ing	EN 1092, Form E, F	
Design temperature	°C	-10	20	100													250	Corr. Allow.	8,0 mm	
Design Code	AD 2000																equirements			
Medium	Hy														Branch Table			B-2		

Revision required

DN		15	20	25	32	40	50	65	80	100	125	150	200	250	300	350	400	450	500	600
OD	mm	21,3	26,9	33,7	42,4	48,3	60,3	76,1	88,9	114,3	139,7	168,3	219,1	273,0	323,9	355,6	406,4	457,0	508,0	610,0
Wth	mm	–	–	–	–	–	16,0	17,5	17,5	20,0	22,2	25,0	30,0	36,0	40,0	40,0	45,0	50,0	55,0	65,0

Item	DN	Item description	Design DIN / EN	Material see Note 2, 3 Short name	Material see Note 2, 3 Norm	Note	Rev.

Pipe Class Calculation

First studies have shown that the new guideline will cause large-scale changes in the sealing technology in industry facilities:

- **Some popular gasket material cannot fulfill the tightness requirements for all operational conditions and/or for all nominal sizes of one pipe class.**
- **Also commonly used bolt materials (quality 5.6) must be replaced by bolts of higher quality because higher gasket stresses are required.**
- **A positive effect will be the determination of bolt forces, torques or bolt elongations as presetting for the fitters.**

Significance of Assembly

Possible improvements in respect of the assembly of flanged joints :

- **Controlled bolt tightening method**
  (at least torque wrenches / tables with torques)
- **Qualified fitters**
  (individual personnel)
- **Independent check-up of the the assembly quality**
  (basis: risk analysis)
- **Installation of a quality management system in the industry plants**
  (e.g. detailed work instructions)

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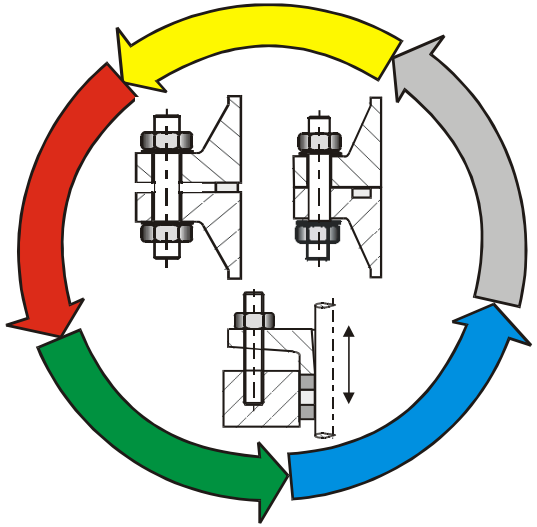
- European Standards
- Industry Experience
- **Outlook**



Quality Management Circle

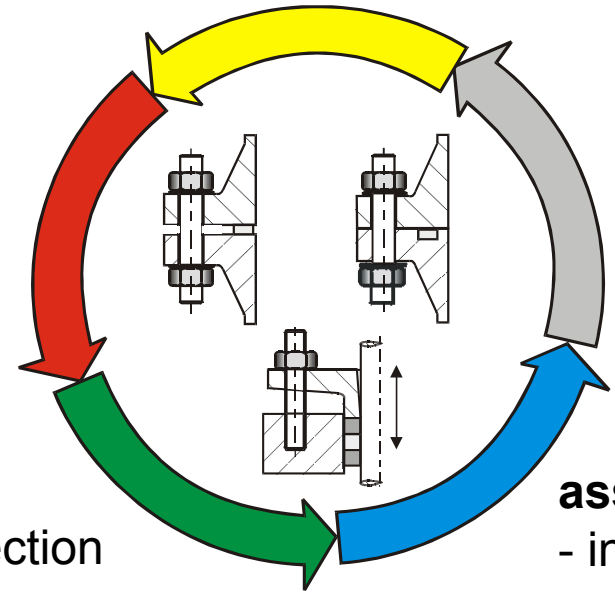
plant engineer → data base

data collection in data base gasket characteristics

loads
- every state of operation

review of the data sheet for BFC´s

design
- geometry (stiffness)
- materials
- gasket



feedback & review
- feedback
- review

calculation
- bolted flange connection
- gasket characteristic
- assembly force, tightness proof, stress analysis

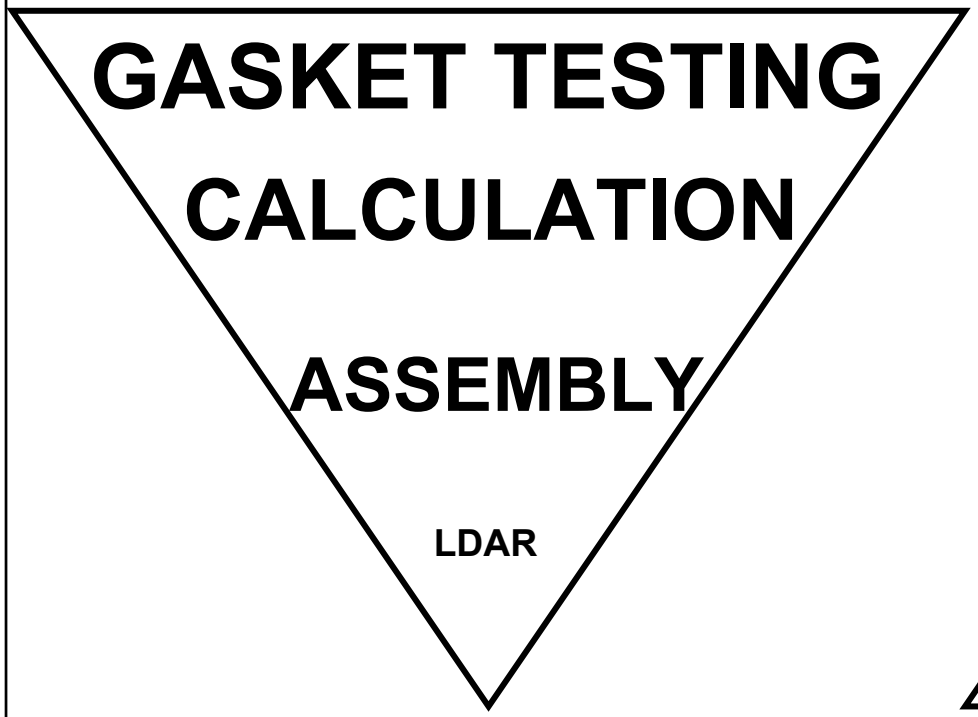
assembly
- in accordance to the requirements
- quality assurance (control)

new calculation according EN 1591-1 → data base

data sheet for BFC

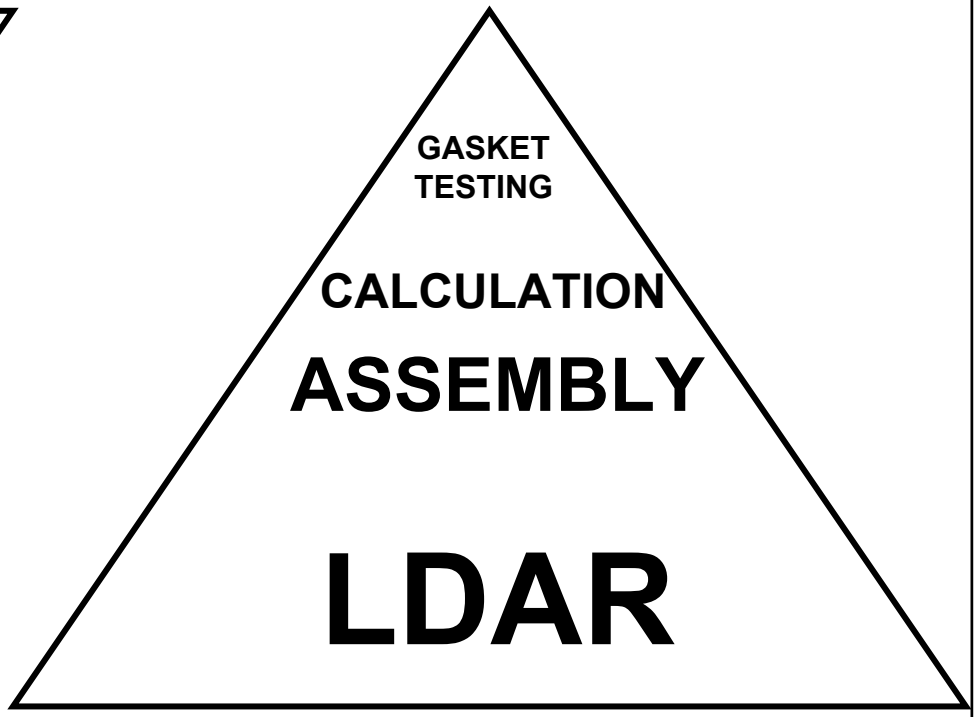
Different procedures to reduce emissions

PROACTIVE APPROACH



Extraordinary Shut-Downs

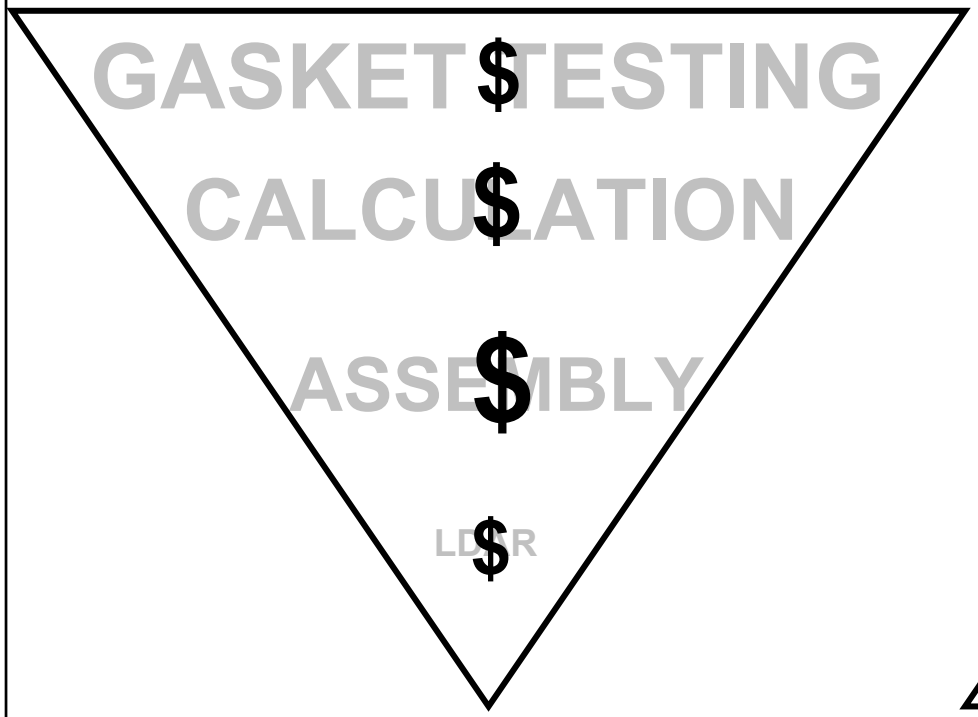
REACTIVE APPROACH



Extraordinary Shut-Downs

Different procedures to reduce emissions

PROACTIVE APPROACH



Extraordinary Shut-Downs

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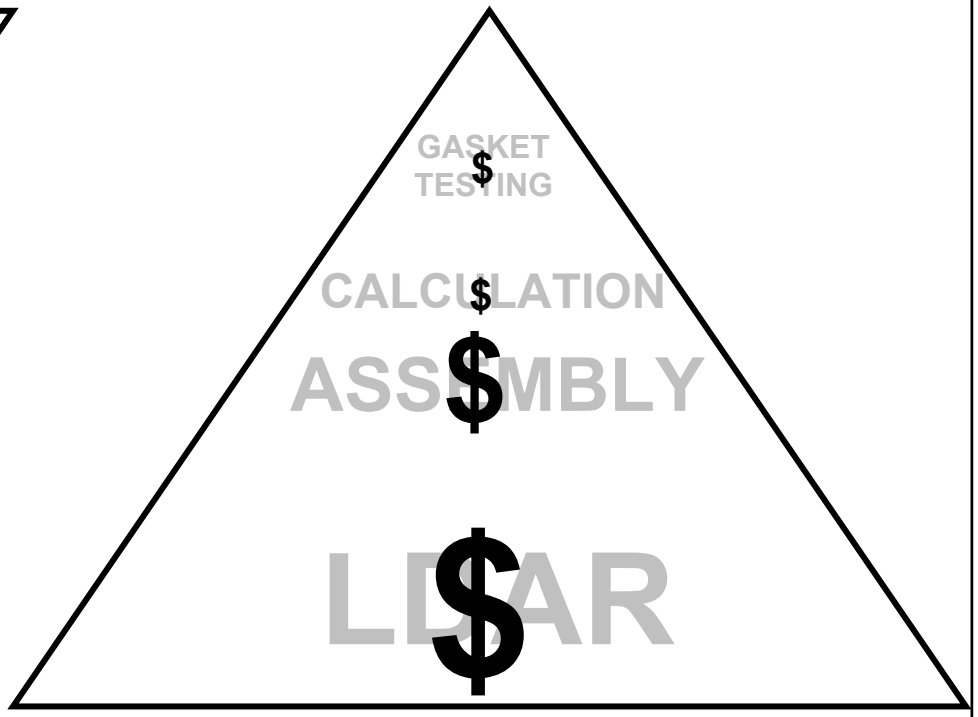
REACTIVE APPROACH



Extraordinary Shut-Downs

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Contact

Please do not hesitate to contact us, if you have any questions on our products and services:

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