KiK|MPi
Kennis- en innovatiecentrum Maintenance Procesindustrie

BEMAS

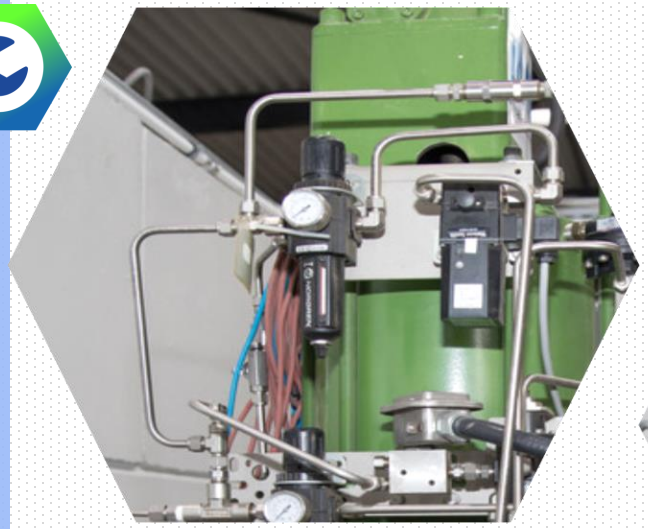
Interreg
EUROPESE UNIE
Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling

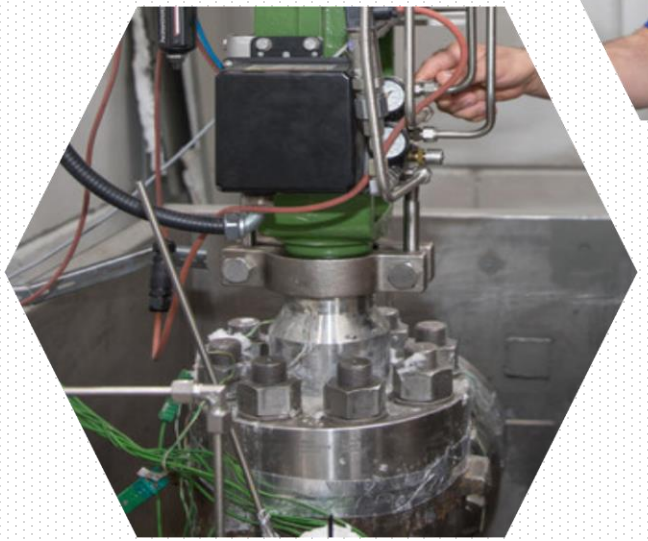
Circulair Onderhoud

Seminar

Voorkomen van fugitive emissies door het correct monteren van de stem-afdichting van afsluiters en regelkleppen

15 September 2022





‘Voorkomen van fugitive emissies door het correct monteren van de stem-afdichting van afsluiters en regelkleppen’

Colin Zegers
ITIS (Industrial Testing & Inspection Services)
Goes (NL)

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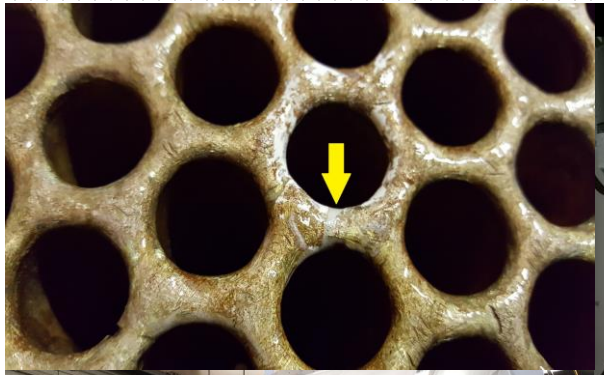
Testing & Inspections of Industrial Installations & Components



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Testing & Inspections of Industrial Installations & Components

- Test temperatures: -196°C - 800°C
- Test pressure: ≤1E-3 mbar
- Test pressure: 1600 bar gas, 3000 bar liquid
- Endurance & Functional testing

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ITIS Industrial Testing & Inspection Services

Company Background

ITIS (Industrial Testing & Inspection Services)

Located in Goes (NL), founded in 2010

Accredited Test Laboratory according to ISO 17025

Conformity Assessment Body (CAB)

Member of International ISO Working Groups:

Team Leader of ISO 12101: Type Approval Testing of stem sealing for Industrial Valves.

Team Leader of CEN TC 69 – Hydrogen Ad- hoc-Group: Working Group Valve Standardization Hydrogen services

ISO 15848-1 & ISO 15848-2 (WG5): Industrial valves – Measurement, test and qualification procedures for Fugitive Emissions - Part 1: Classification system and qualification procedures for type testing of valves & Part 2: Production acceptance test of valves.

ISO 23632 (WG10): “Design Validation Testing of Industrial Valves”.

ISO 28921-1 & 2 (WG12): Industrial valves - Isolating valves for low temperatures application - Part 1: Design, manufacturing and production testing & Part 2: Type testing.

ISO 10497 (WG14): Testing of valves - Fire type-testing requirements.

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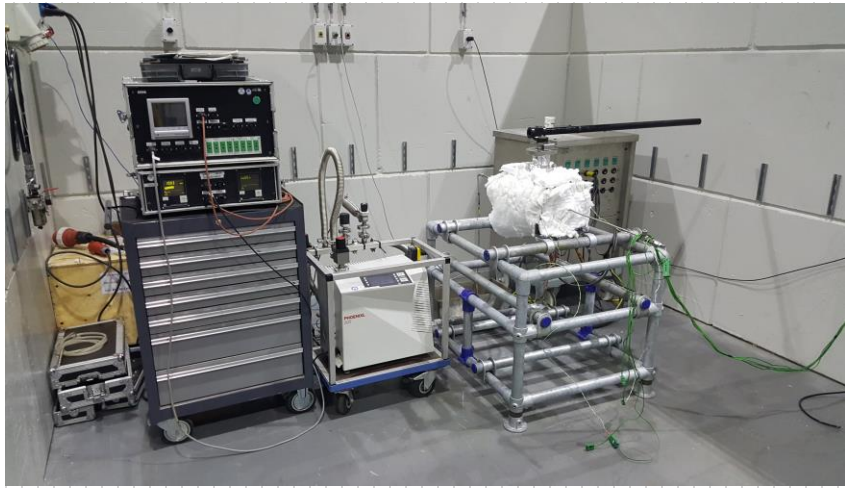
Valve Testing

- ‘Production tests’ (after manufacturing)
  - Hydro test, seat test, FE (ISO 15848-2)
- ‘Fit for use testing’:
  - Fugitive Emission
  - Temperature Testing (LNG, LH2)
- ‘Type Testing’:
  - Fire Safe Testing
  - Fugitive Emission testing (ISO 15848-1, API 624/641)
  - Design Validation Testing (DVT)



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Performance of DVT & Fugitive Emission Testing

Depending valve type and design conditions testing in accordance with standards:

Test Standards for DVT & FE:

- DVT: Shell SPE 77/300, ISO 23632
- FE: ISO 15848-1 (TA-Luft)
- FE: API 624, 641 (methane)

Test:

- Review of documents
- Visual inspection
- Test set up, Testing in according with test requirements specified in the standard
- Strip down
- Test report (certificate) with covering range

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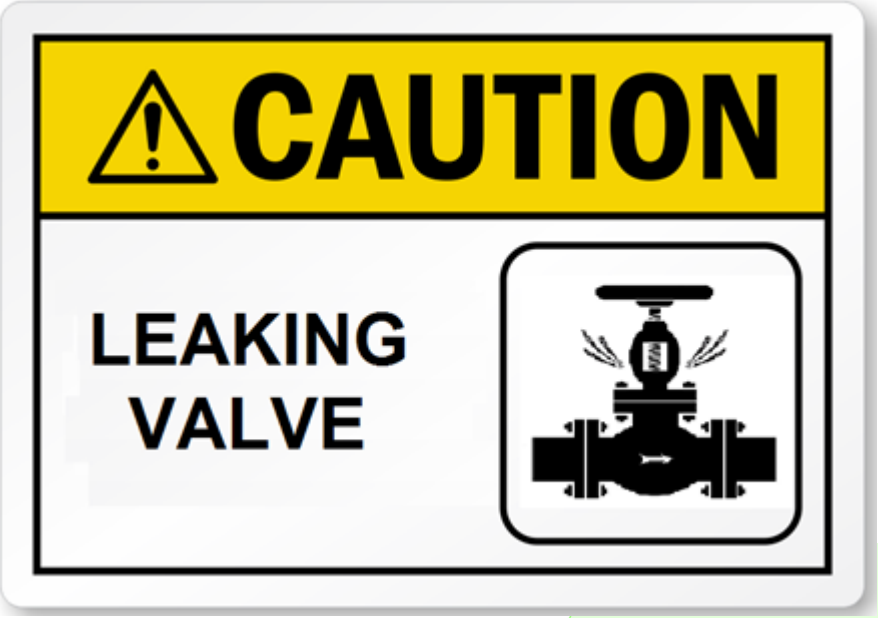
Valves failures during DVT

To prevent failures in practice, major customers already require type tests
Failure percentage is roughly 65%!



Failures:

-Visual inspection and NDT
-Operability
-Seat leakage
-Damages during strip down
-Fugitive Emission

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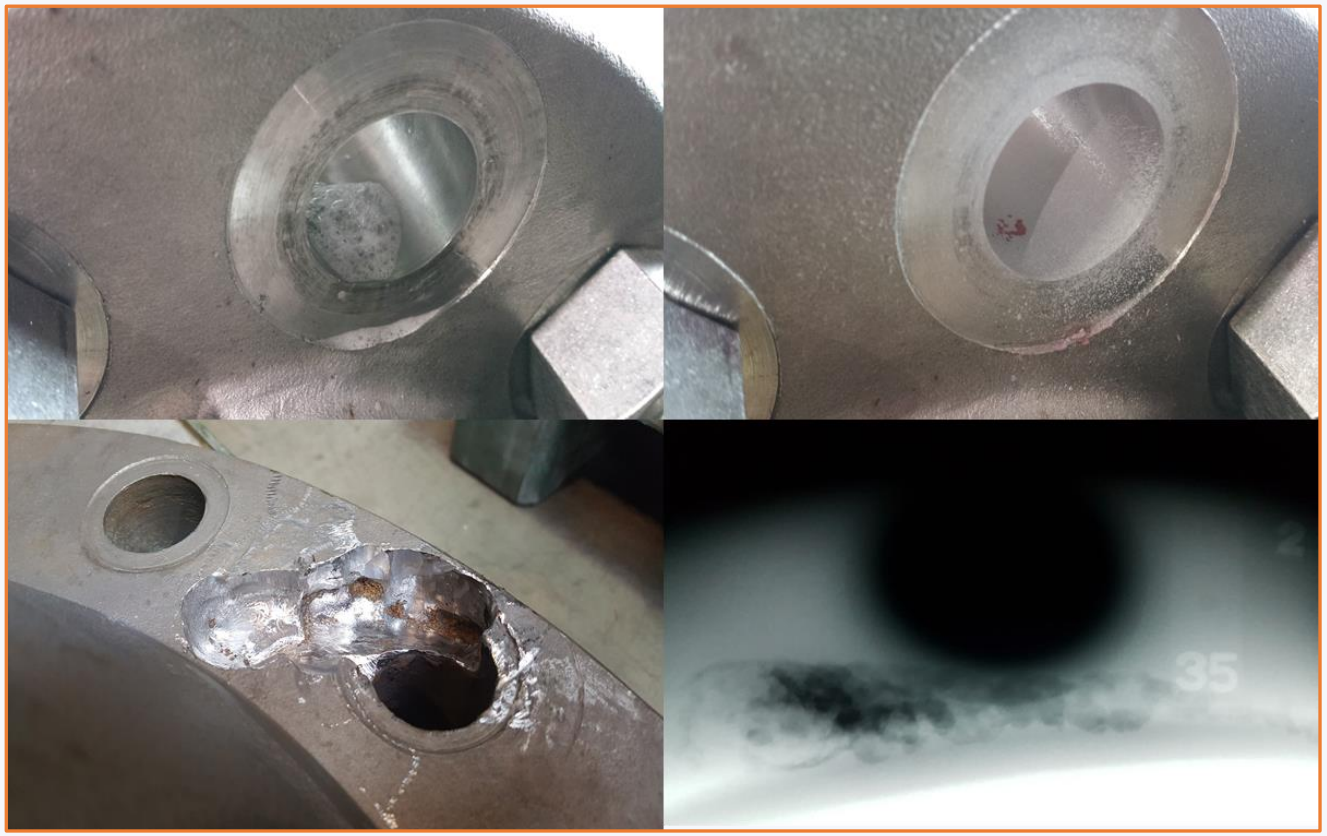
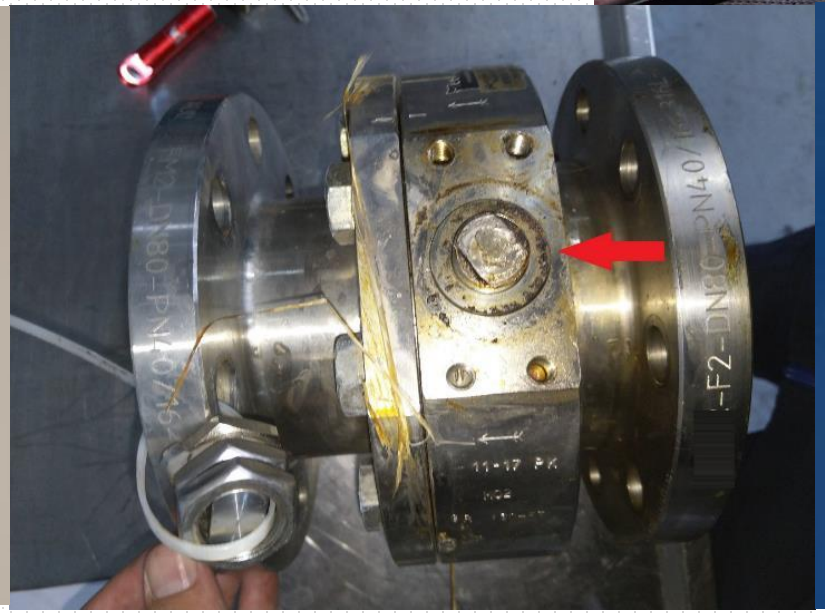
Visual Inspection

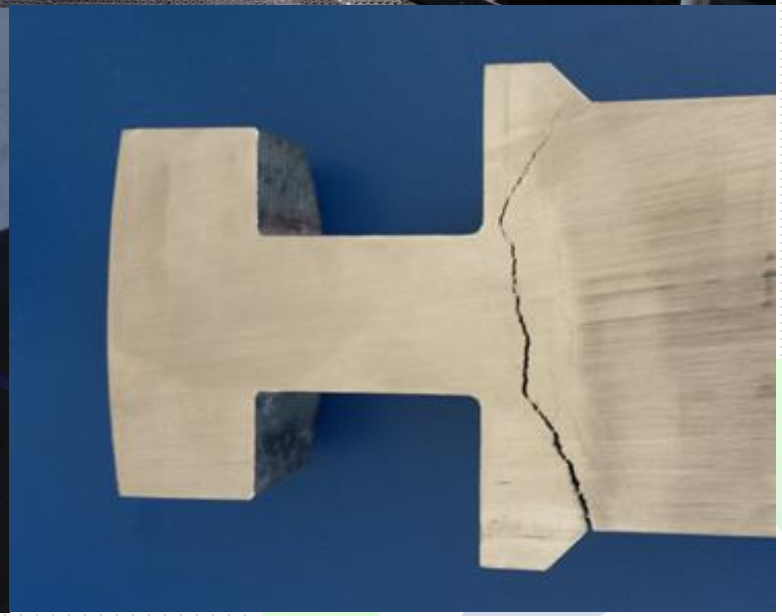
Materials & Machining



Operability of Valves

(MAST: Maximum Allowable Stem Torque)





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Seat leakage

Strip down after test

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Main Cause of Fugitive Emissions: Leakage of Stem Seal

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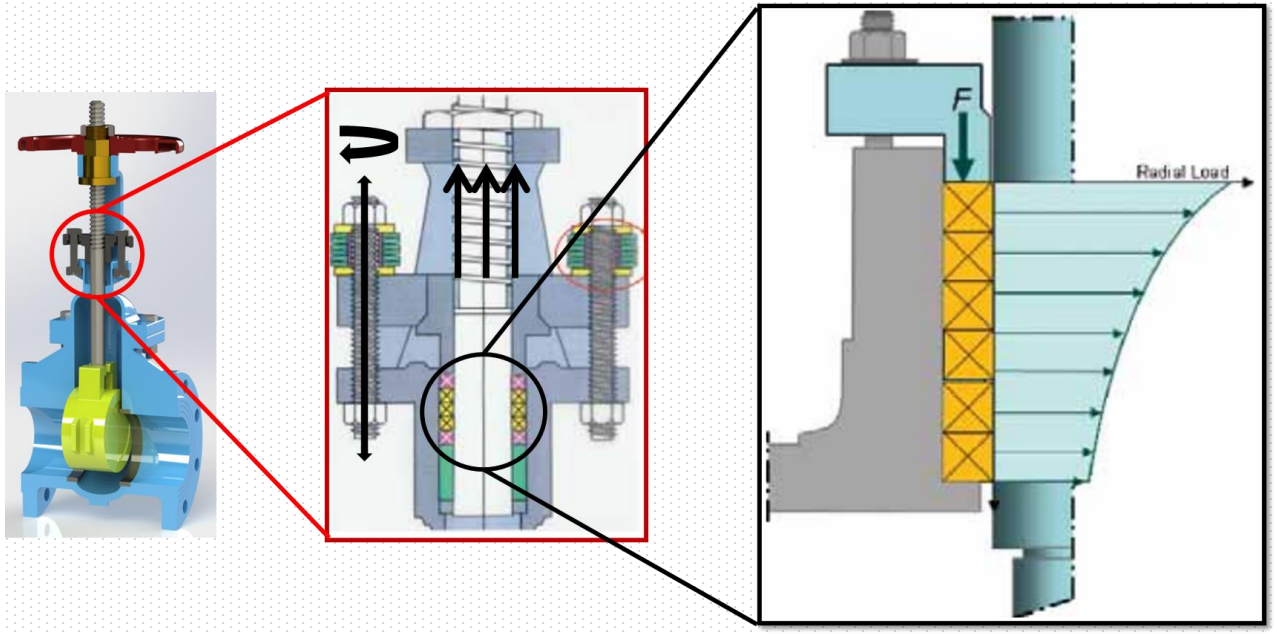
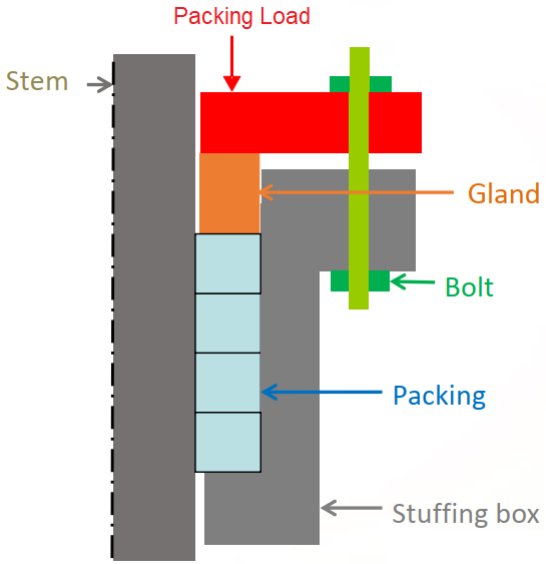
Stem Seal (stopbuspakking)





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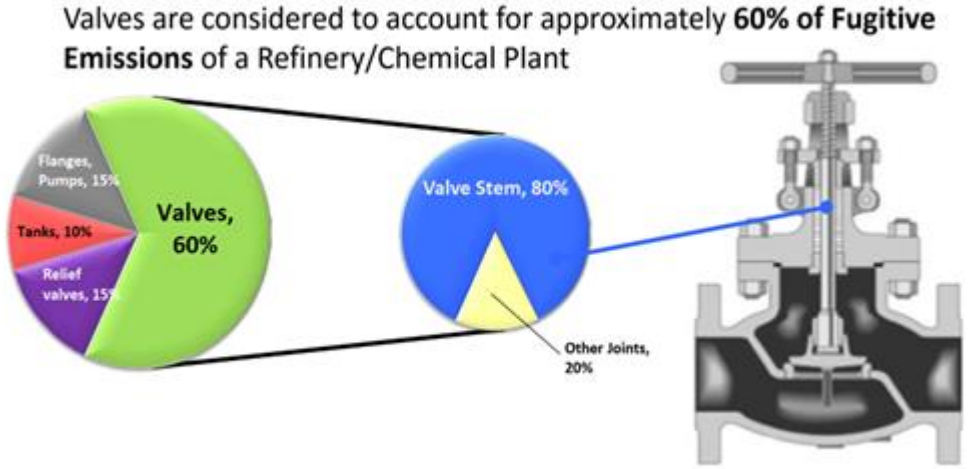
Amount of Fugitive Emission:

Fugitive emissions are leaks that occur from process equipment such as valves, pumps, compressors, and flanges. Fugitive emissions account for over 125,000 metric tones of lost product per year in the United States alone [1,2]. The percentage of fugitive emissions that come from valve stems is estimated to be 60% to 85% [1,2] due to the cumulative effects of large numbers of valves in processing plants.



*Source - Monitoring and Containment of Fugitive Emissions from Valve Stems, University of British Columbia, Vancouver

Amount of Fugitive Emission:

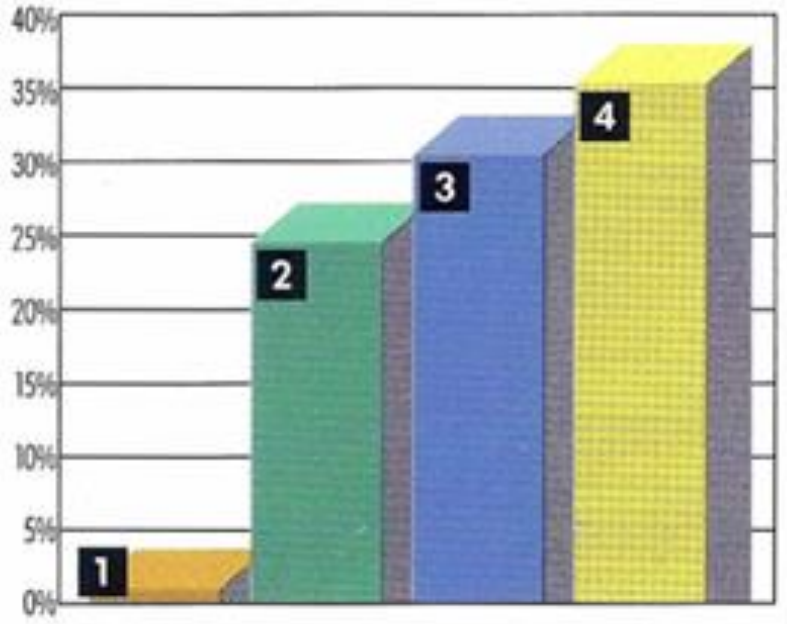
The impact for increased economic efficiency

Important cost saving potential

Various petrochemical companies are committed to improve the environmental performance of their plant and operation. The research and investigation of important petrochemical companies lead to concrete decisions for economical and environmental friendly plants. An emission rate between 10,000 and 100,000 ppm provides up to 1,000 kg of lost product per annum. This number could be caused from a single valve only. E.g. for 500 control valves in an ethylene application with an emission rate above 100,000 ppm a cost saving potential of 1,500 tons or 498,000 Euro has been realised.

Source: Garlock brochure

Percentage of valves with a leakage >10.000 ppm by valve type



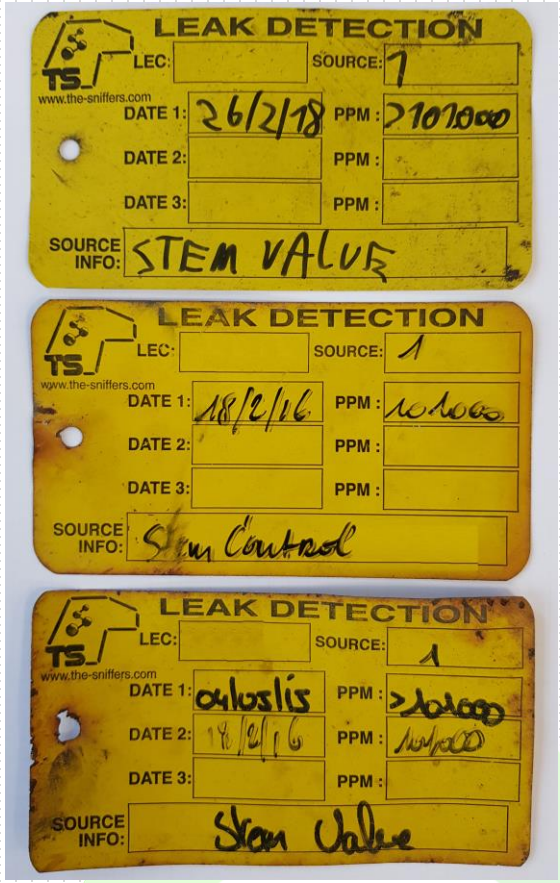
1-Ball valves; 2-Control valves; 3-Gate valves; 4-Globe valves

Regelgeving in Europa, Vlaanderen en Nederland

Europa: PED, RICHTLIJN 2014/68/EU: ontwerp,
fabricage, beproeving of samenstellen van drukapparatuur.
Toepassen van materialen die veilig in gebruik zijn.
Green Deal (2030)

Vlaanderen: Vlarem, omgevingsvergunning?

Nederland: omgevingsvergunning,
Omgaan met Zeer Zorgwekkende Stoffen (ZZS)
in een Circulaire Economie.
RIVM-briefrapport 2019-0186, coalitieakkoord 2021-2025



Different Standard for Valves
No Standard for Stem Seals!

ANSI / FCI 91-1

ANSI / ISA S93.00.01

TA Luft VDI 2440

15848-1 and -2

Shell SPE 77/300

Shell SPE 77/312

API 624

API 641

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Need for an International Standard: Type Testing of Stem Seals for Valves (ISO 12101)

International Organization for Standardization

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Need for an International Standard:

The standardization to include parameters covering interchangeability, mating details for mounting, testing, marking, quality requirements, terminology and other relevant parameters to prevent misunderstandings and failures.

Onderstaande bereiken zijn met onze stopbuspakkingen maximaal haalbaar:

Temperatuursbereik	: -240°C. tot +600°C. In sommige gevallen tot +2500°C.
Drukbestendigheid	: Tot 400 BAR.
Loopsnelheid	: Tot 40 m/sec.
pH bereik	: 0 tot 14.
Dichtheid (s.g.)	: Van 0,9 tot 1,9 g/cm³.
Afmeting	: Vanaf 3 mm t/m 25 mm (1/8" t/m 1").

pH	P bar	t* °C	Bewegung
0-14	1000	-240 +3000	

* 500 °C in Atmosphäre, 650 °C in Dampf, 3000 °C in inerter Umgebung

- Extremely low or high temperatures (-270°C to +980°C)
- Ultra-high vacuum to 6800 bar pressure
- Stick-slip free, slow movement or high speed
- Universal chemical resistance
- Resistance to radioactive environments
- Lowest leakage and highest wear resistance

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Development of ISO standard: ISO 12101

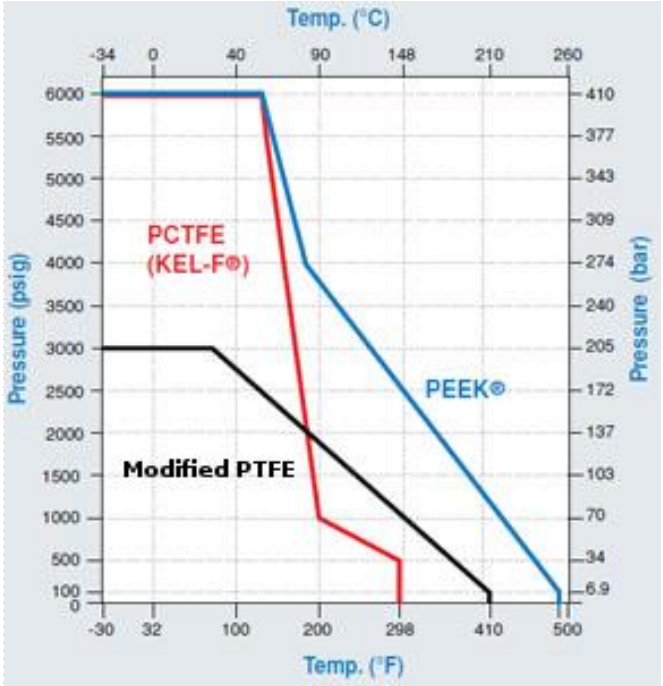
Marking according to: ISO 15848-1 (Type Testing On/Off & Control Valves):

6.6 Marking

In addition to the marking required by relevant standards, production valves qualified by type testing in accordance with this part of ISO 15848 can be marked with “ISO FE”, which stands for ISO fugitive emission, and the information as indicated in 6.5.

EXAMPLE 1 Performance class: ISO FE BH (or BM) — CO1 — SSA 1 — t(−46°C, 200 °C) — PN 16 — ISO 15848-1.

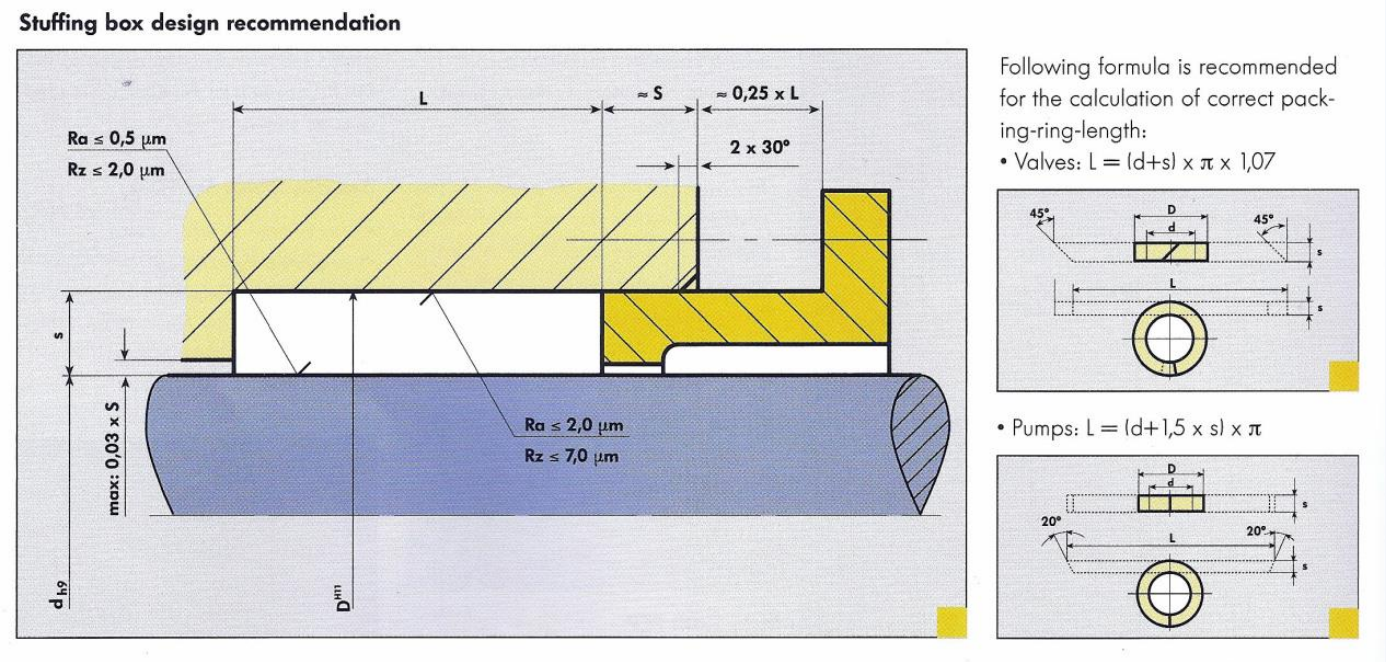
EXAMPLE 2 Performance class: ISO FE BH (or BM) — CO1 — SSA 1 — t(−46°C, 200 °C) — CL150 — ISO 15848-1.



Development of Requirements for Dimensions, Tolerances and Fitting Instructions

The standardization to include parameters covering interchangeability, mating details for mounting, testing, marking, quality requirements, terminology and other relevant parameters to prevent misunderstandings and failures.

- Temperature Ranges
- Pressures
- Medium and applications in practice
- Stem movement type
- Fitting instructions
- Compression Factor: 10 – 100 MPa
  1 MPa = 1 N/mm2



European Sealing Association e.V.

FLUIDSEALING ASSOCIATION℠

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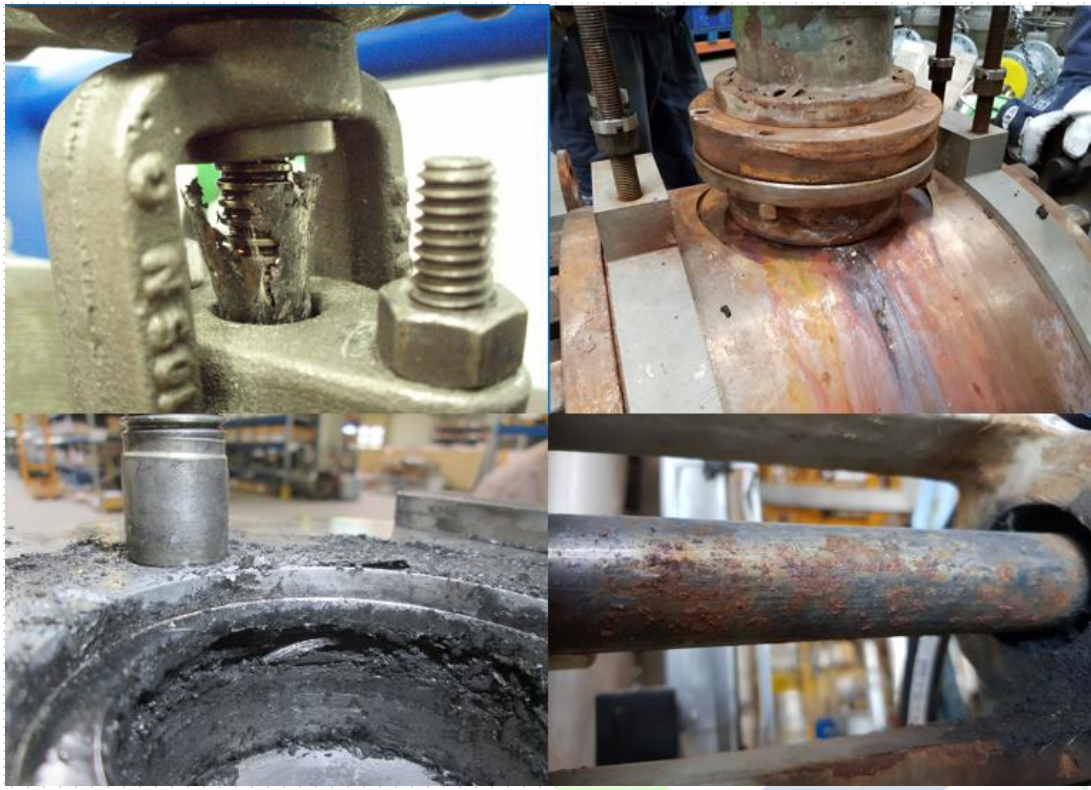
Belangrijke factoren voor keuze stem seal

- Merk en type seal, materiaal: grafiet, PTFE, combinatie sealing
- Test resultaten: b.v. ISO 15848-1, voorbeeld: type klep (on/off, of control), tightness class
- Medium (gas/vloeistof/stoom)
- Chemische bestendigheid (Corrosie testen)
- Temperatuur
- Druk/temperatuur (PT)
- Installeren volgens instructie fabrikant
- (voor)compressie
- Minimum vlaktedruk
- Manier van snijden van pakkingen
- Relaxatie
- Onderhoud (vlaktedruk)



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Belangrijke factoren voor valve bij: fabricage of revisie

- Controle van maatvoering(en) en toleranties (ESA)
- Geschiktheid van materialen (galvanische corrosie)
- Ruwheid spindel (range)
- Ruwheid body
- Allignment (scheefstand)
- Minimum benodigde vlaktedruk
- Extrusie Gaps (grondring juiste materiaal)
- Manier van monteren (ring voor ring, voorcompressie, eventueel tussendoor cyclen voor afzetting grafiet, aanhaalmoment)
- Smering bouten
- Aanhaalmoment: minimum vlaktedruk
- Movement (45°, rotating/rising, non-rotating rising)

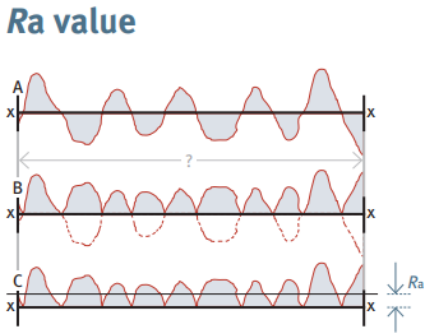


Figure 1. The principle of measuring average roughness (R_a) [3]

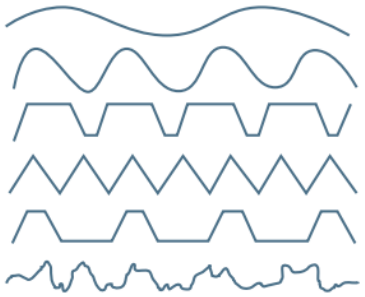
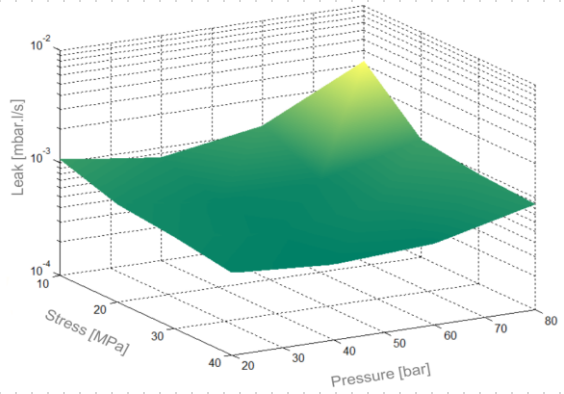


Figure 2. Various surface profiles having the same R_a value [4]

Belangrijke factoren voor valve bij: montage van de stem seal

- Manier van monteren
- voorbeeld: ring voor ring, voorcompressie, tussen iedere ring cyclen voor afzetting grafiet of complete set in één keer?
- Smering bouten en moeren
- Juiste aanhaalmoment, minimum vlaktedruk:

  10 MPa – 100 MPa (volgens opgave fabrikant)



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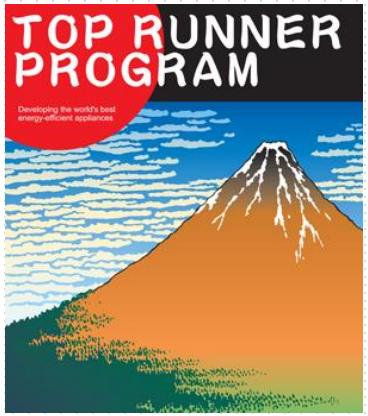
Interreg project
‘Het reduceren van Fugitive Emissions’



- Project gestart als best runner program:

  Wat is de best presterende stem seal?
- Zeer opvallende testresultaten:
- Control valve 700.000 cycles: RT & +200°C, lekwaarde AH
- Zelfde valve, andere stem seal met telkens verlies van vlaktedruk (50% in 24 uur) daardoor zichtbaar lek
  Tot 9x verlies in vlaktedruk!
- Verder onderzoek welke factoren de relaxatie veroorzaken

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Vervolg onderzoek en testen

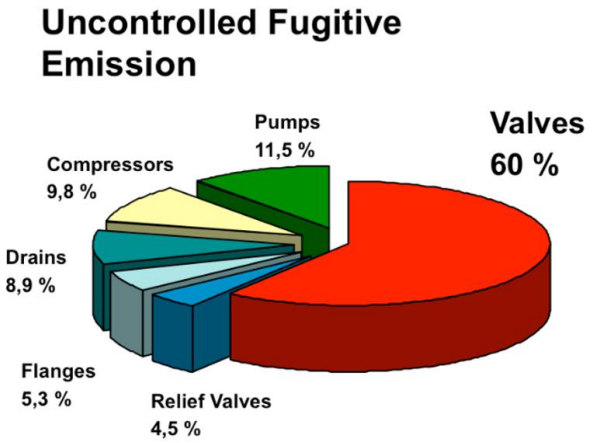

Ventilspindel Packungen

> Zurück zur Produkteübersicht

Technische Daten

Material: reines Graphitexpandat	Imprägnierung: PTFE Filcoat-Verfahren
Temperatur: - 0°C bis + 450°C	Druck: 0 bis 450 bar
Geschwindigkeit:	pH-Wert: 0 - 14
Zulassungen: ISO 15848-3	Abmessungen: vorgepr. auf Anforderung

- Interreg project eindigt najaar 2022
- Verder ontwikkelen van norm ISO 12101
- Budget voor onderzoek en testen?
- Onderzoek naar factoren die zorgen voor relaxatie en daardoor falen van stem sealing:
- Oorzaak van stem seal blow out
- Testen van diverse merken en materialen stem seals
- Functie ‘live loading’
- Ontwikkeling Emissie Monitoring System



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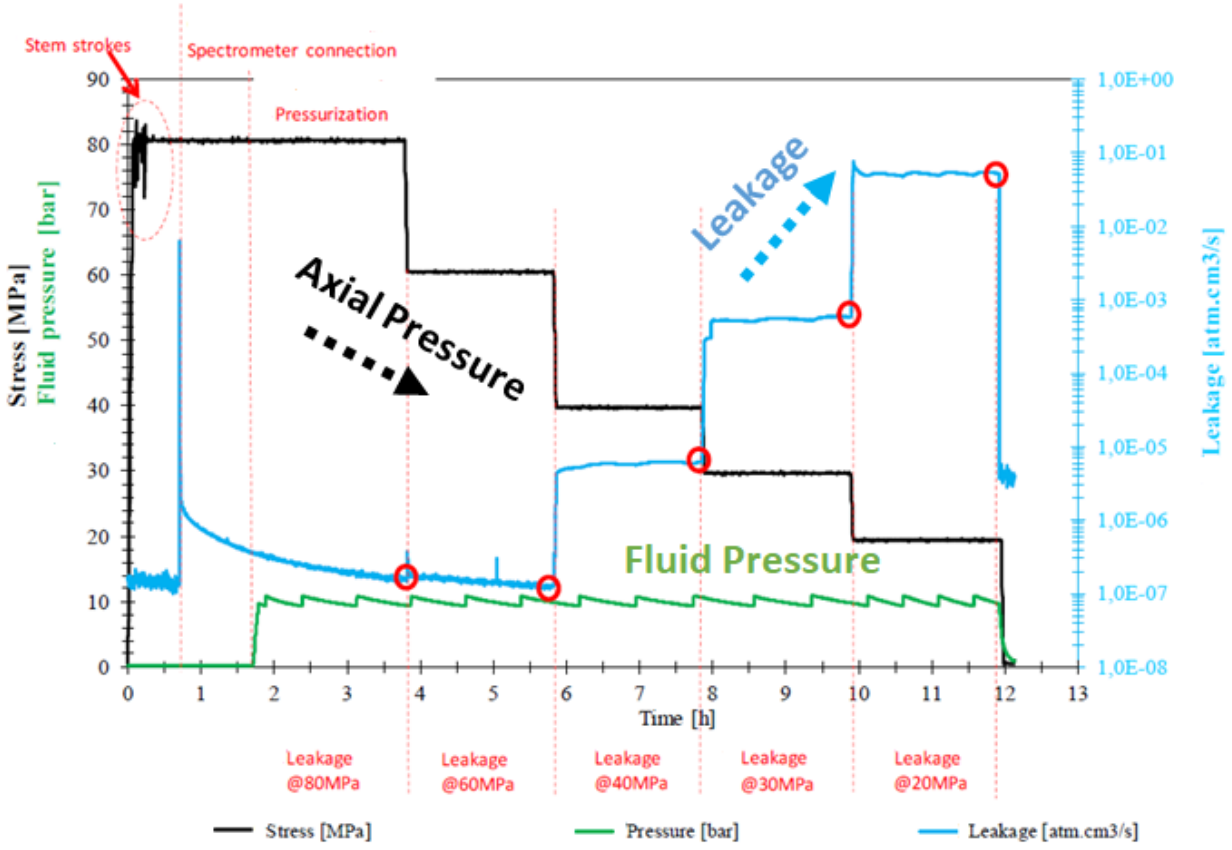
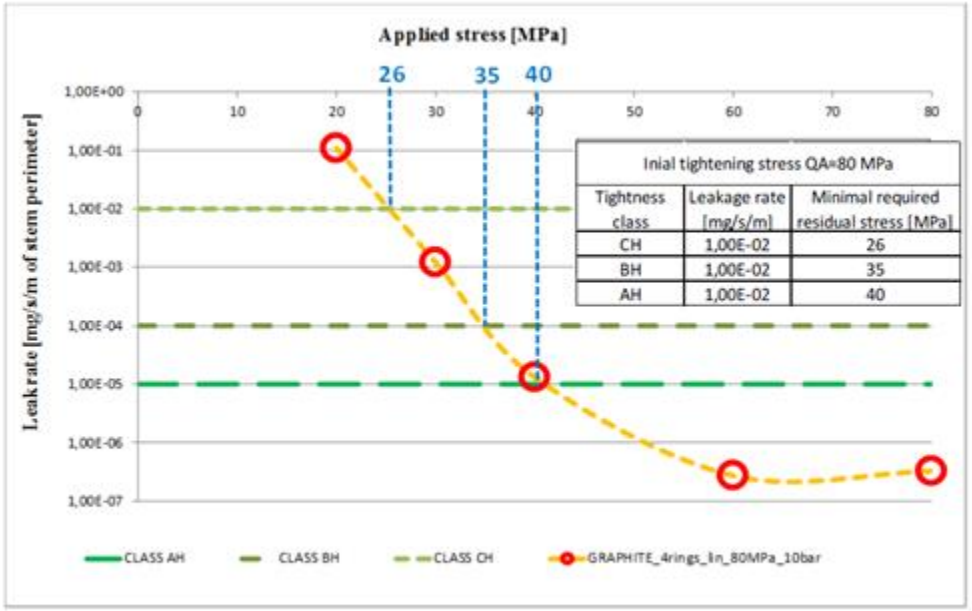
Onderzoek minimum Vlaktedruk per merk/type

Test curve voor stem seal met grafiet ringen en een liniaire beweging, 80 MPa vlaktedruk en 10 bar helium druk





Sealing diagram and table example (graphite packing)

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PACKING: Relaxation

Experiment vs Simulation

Mohammed Diany
Assistant Professor
University Sultan Moulay Slimane,
Faculté des Sciences et Techniques,
BP 523 Beni Mellal 23000,
Beni Mellal Morocco
e-mail: mdiany@yahoo.com

Creep Constitutive Law of Packing Materials Based on Relaxation Tests

The tightness of valves, compressors and pumps is ensured by superposed braided rings installed in a stuffing-box system. The nature of the packing material and structure, which is like a rectangular braided cord, influences the proper stuffing-box assembly behavior. During installation, a minimum compressive load is required to ensure a min-

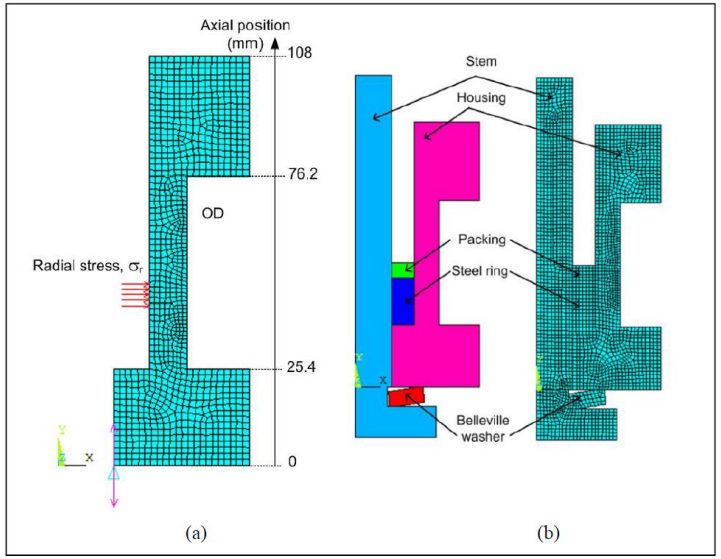


Figure 1.15 Finite element models to study the creep characterization of packing element (Diany and Bouzid, 2012)

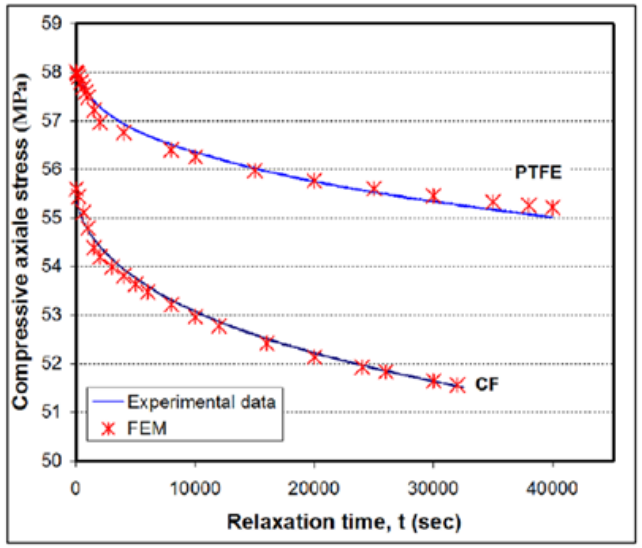
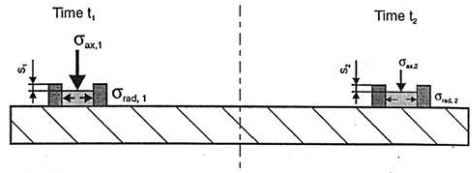


Figure 1.16 The relaxation curve from experiment and characterizing packing (Diany and Bouzid, 2012)

Table 1 Relaxation moduli of the material tested

	κ_0	κ_∞	μ_0	μ_∞
FG	118	105.7	88.5	79.3
CF	82.3	27.4	61.7	20.5
PTFE	144.8	74.2	107.9	55.5



Relaxation ($t_2 > t_1$):
Deformation $s_1 = s_2$
Loss of Pre-Stress ($\sigma_1 > \sigma_2$)

$$R_s = \frac{\sigma_{axial,\,Service}}{\sigma_{axial,\,Assembly}} = \frac{\sigma_{radial,\,Service}}{\sigma_{radial,\,Assembly}}$$

$R_s = f(\sigma_{axial}$; Temperature; Stiffness of Gland, Bolt and Distance Tubes,....)

Fig. 7: Principle of the relaxation test

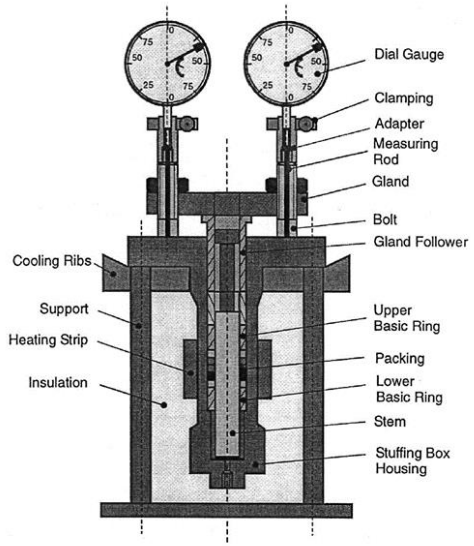


Fig. 8: Test equipment for the relaxation test (schematic)

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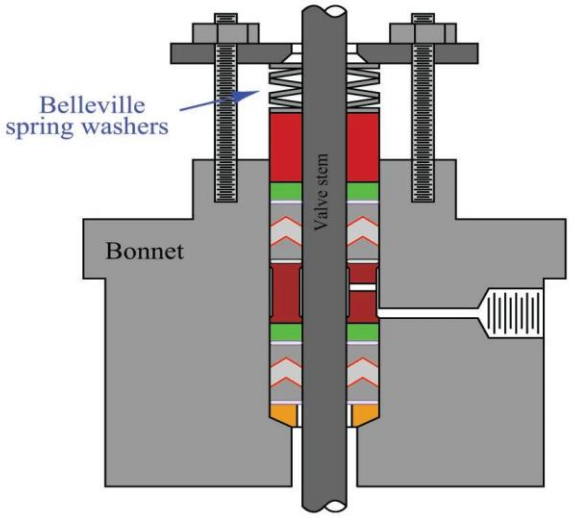
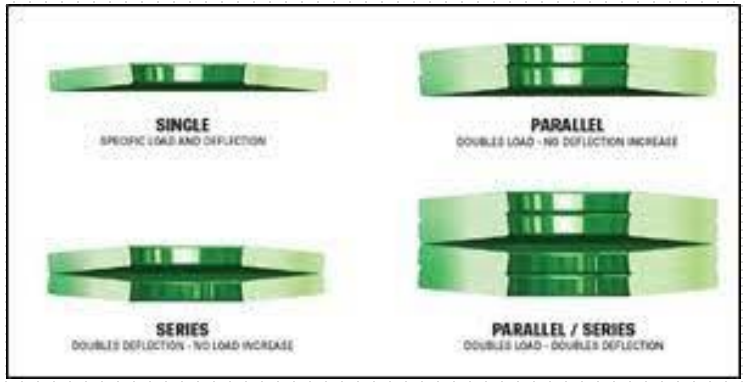
Onderzoek naar werking ‘Live Loading’

Een juiste werking (veerkracht) is niet altijd gegarandeerd

Kracht live loading: >minimum vlaktedruk



Live-loaded valve stem packing



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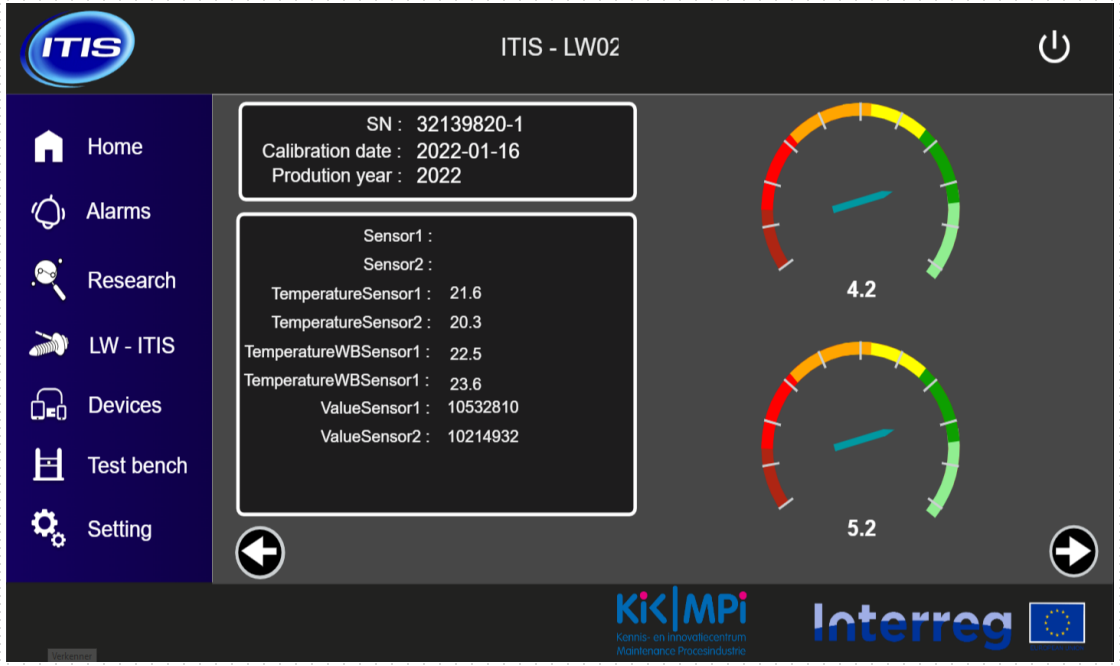
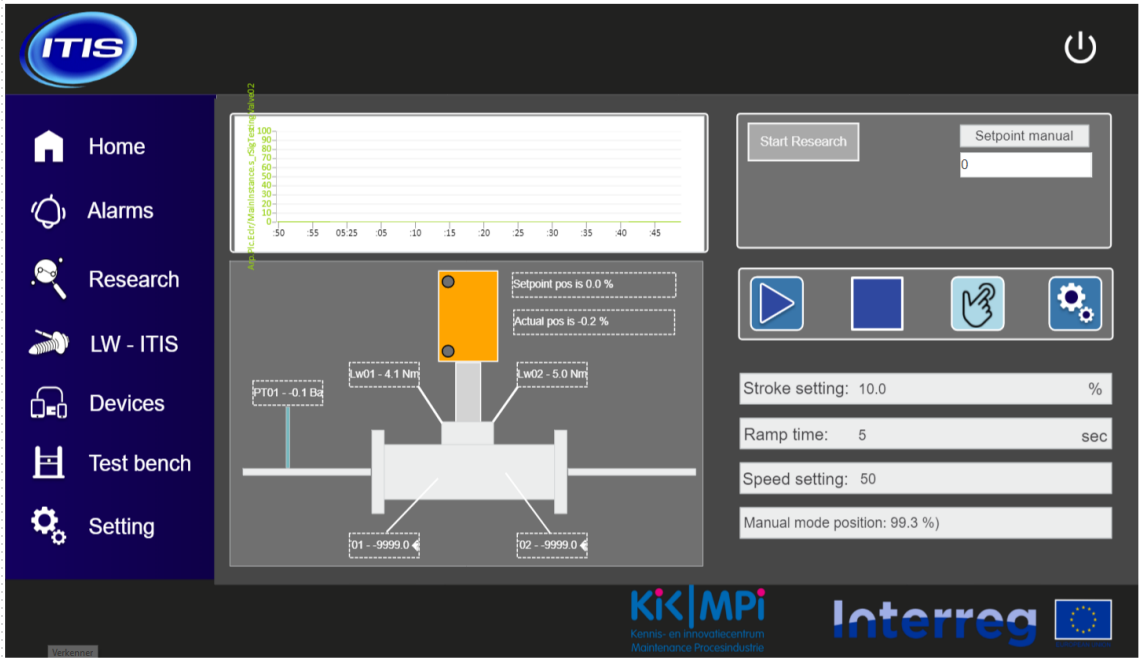
Monitoring System Fugitive Emissions:





Werkend proto type
Aanvraag patent (2022/begin 2023)
Budget zoeken voor doorontwikkeling systeem
Testen in praktijksituaties

ITIS Industrial Testing & Inspection Services

Interreg Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling

Thank you for listening!

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