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Advanced metal sealing solution for Triple-Offset butterfly valves

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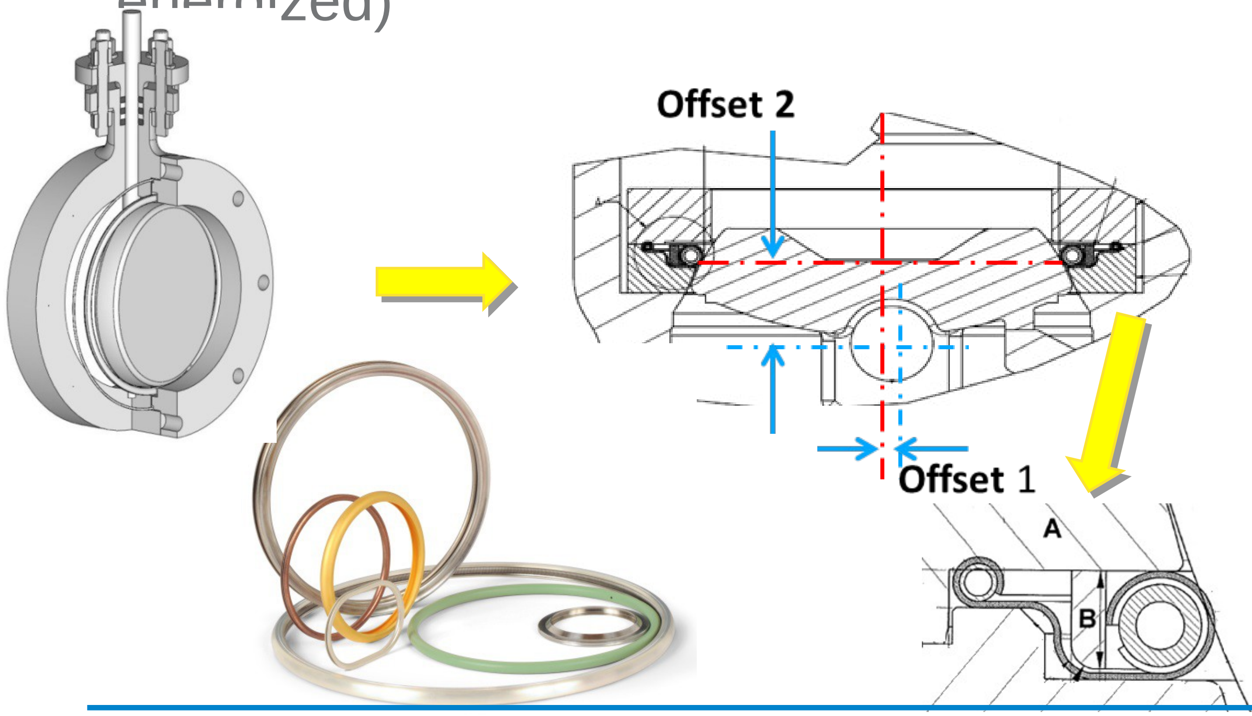
Agenda

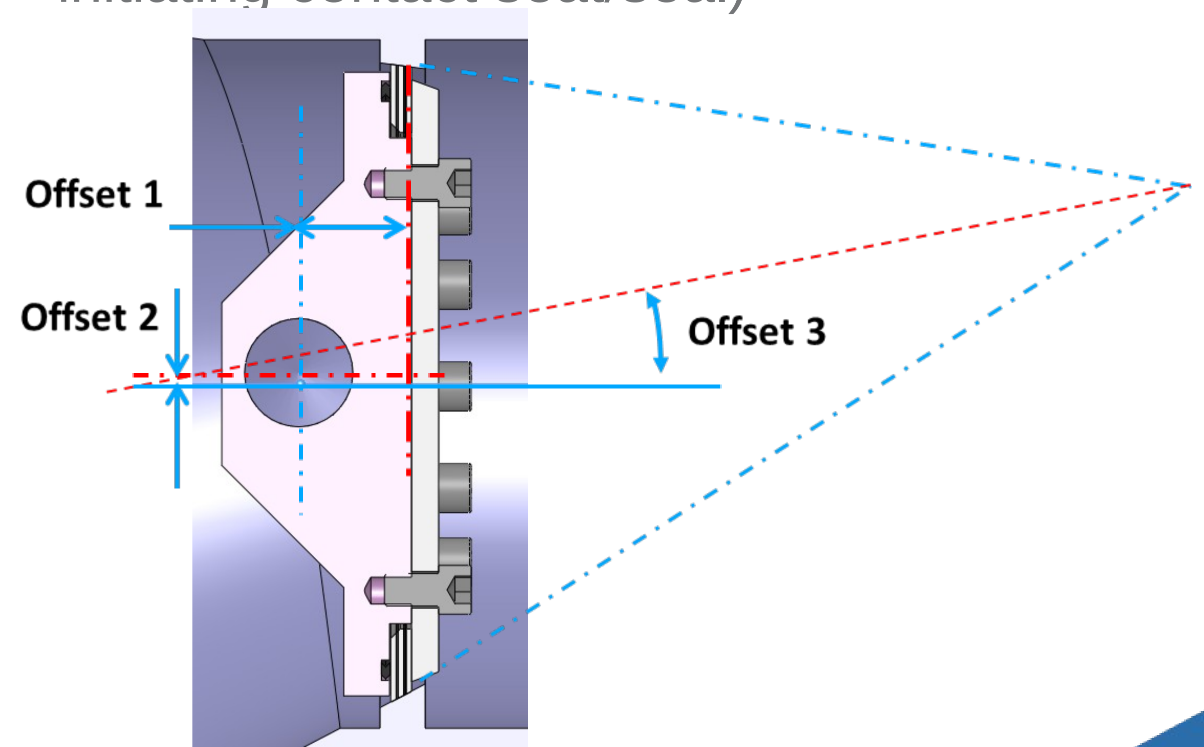
- Type of butterfly valves (DOBV vs. TOBV)
- Main sealing technologies for TOBV
- Lamellar seal principle
- Concept weaknesses
- How to reduce leak paths with lamellar seals?
- Design optimization:
- Lab test examples & results

Type of butterfly valves (DOBV vs. TOBV)

- Double-offset butterfly valve (DOBV)
- Still present on the market
- Reliable and cost-efficient but limited regarding pressure range
- Can be sealed on the seat with a circular metal seal (like spring energized)



- Triple-offset butterfly valve (TOBV)
- Able to achieve higher pressure
- More difficult to machine compared to DOBV
- “Zero-Torque” valve (no torque before initiating contact seat/seal)

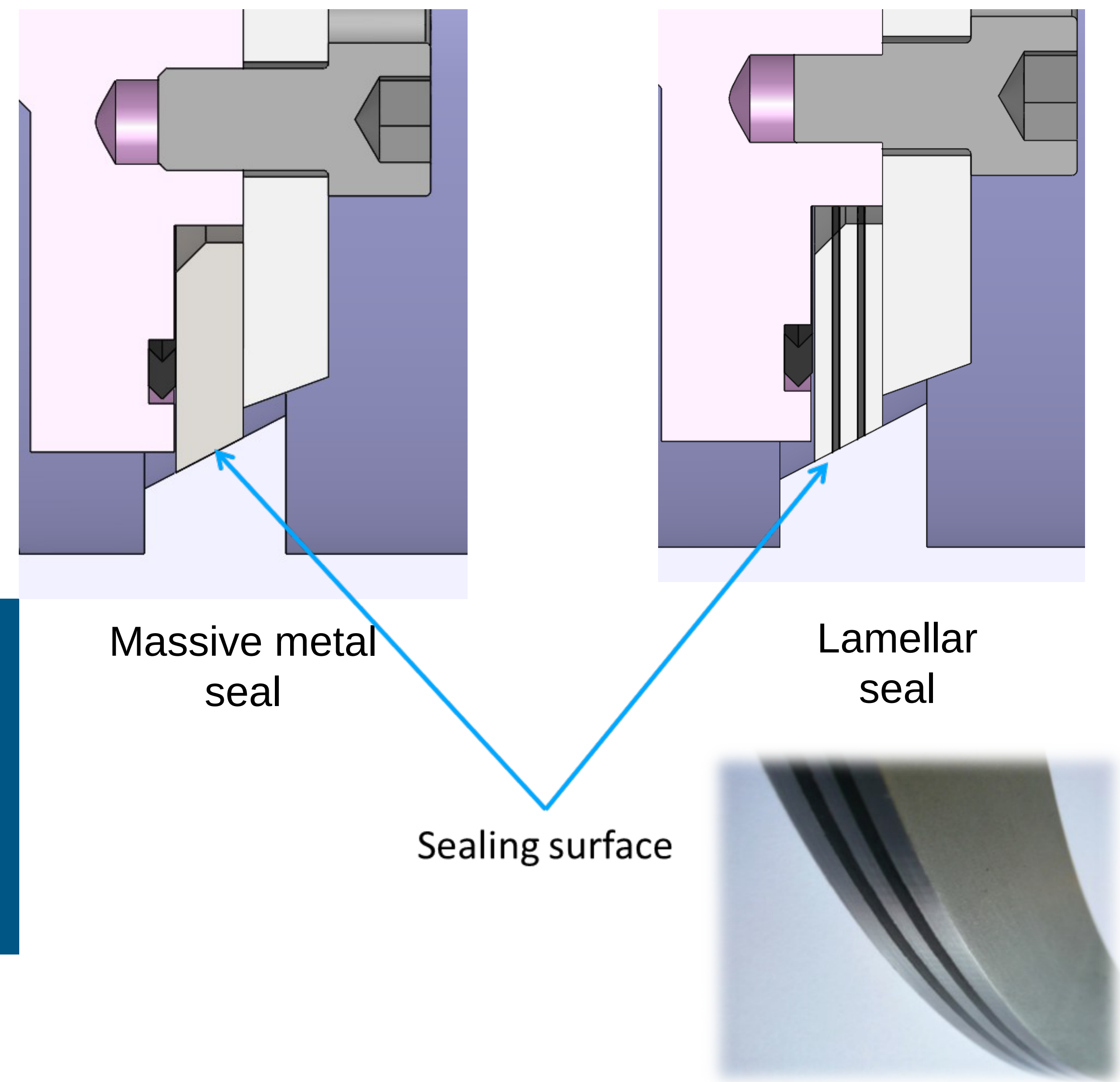


Main sealing technologies for TOBV

- **Massive metal seal**: metal part machined with high accuracy on the sealing surface
- **Lamellar seal**: sandwich of metal and soft layers (usually graphite) machined with high accuracy on the sealing surface
- **For both concepts**: “perfect” conical inclined surface on the seal matching with a “perfect” counter face → surface contact

Lamellar seal preferred as can accommodate deformations

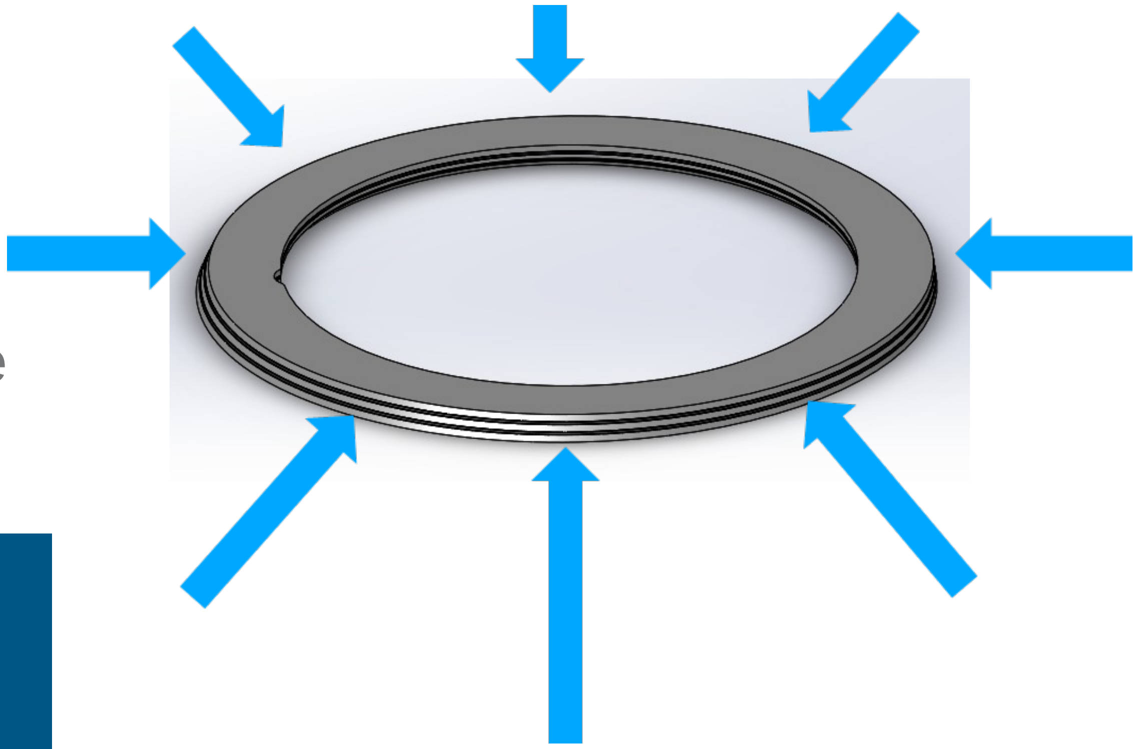
→ enhanced sealing properties



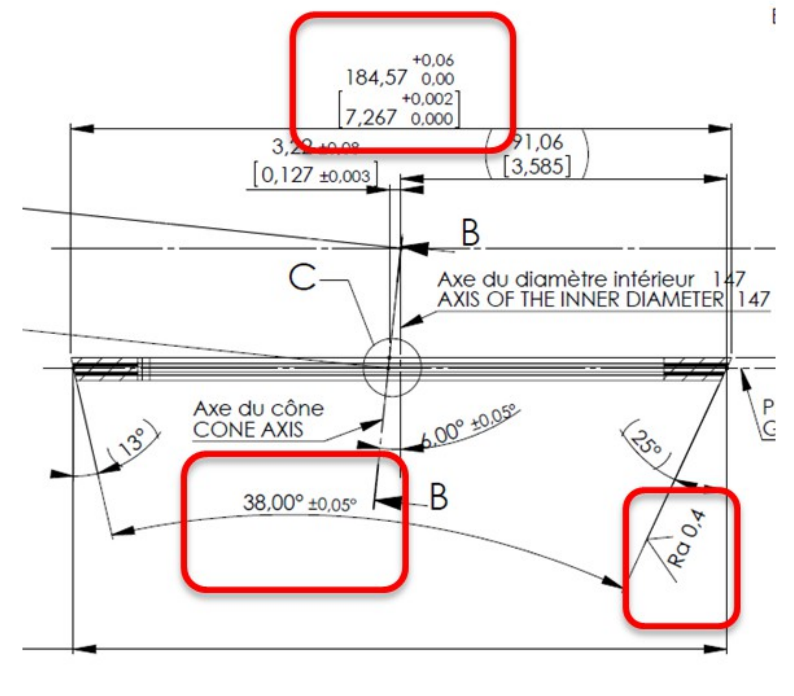
Lamellar seal principle

- Right-angle conical design → sealing by contact
- Torque seating during closing position of the disc → uniform forces equally distributed around the entire circumference of the valve seat
- Closing torque constantly maintained in closed position
- Resilient seal flexes and energizes, assuming the shape of the seat → allows the valve body and disc to contract or to expand

Self-adjusting radial movement between metal layers facilitated by soft layers

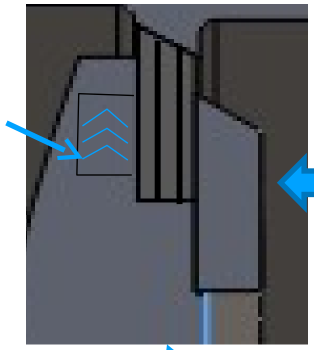


Concept weaknesses

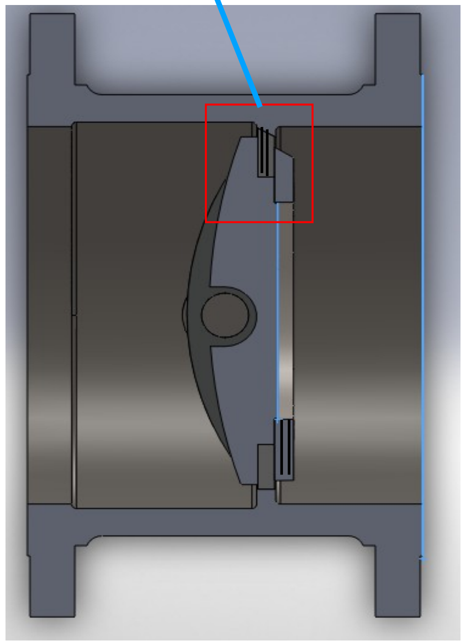


- When fitting the lamellar seal on a valve, compression of a secondary seal
- → **significant deformation of the seal (bending effect)**
- Thickness and density of graphite layers become irregular with an impact on the geometry of the cone

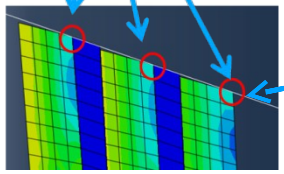
Secondary seal (often Spiral Wound Gasket)



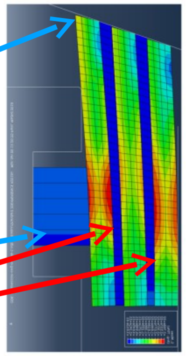
SWG's tightening load



Lineic contacts



Deformation of the machined conical surface



Stiff SWG

Graphite layers

How to reduce leak paths with lamellar seals?

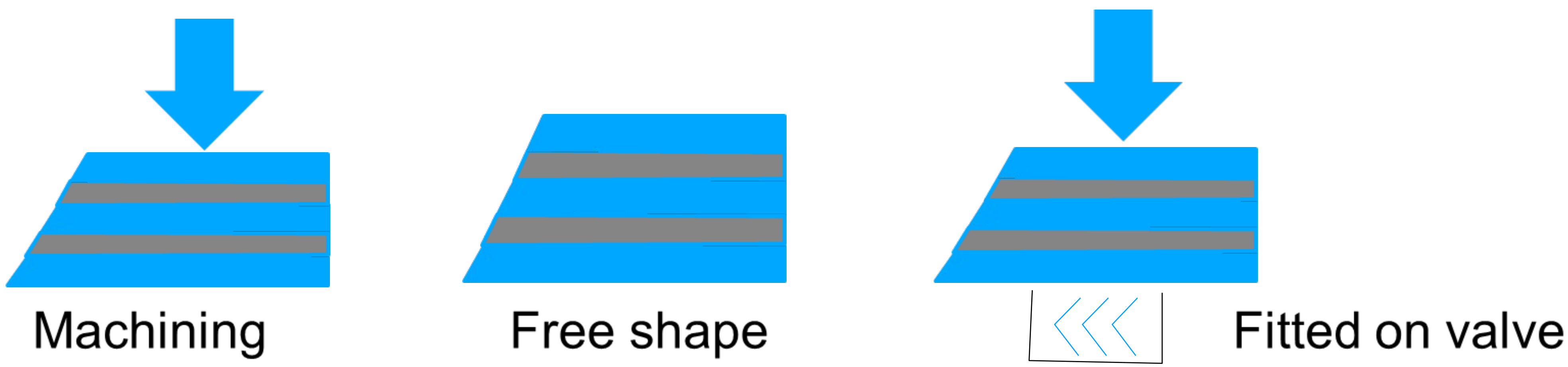
- Optimization of tightness with lamellar seal : result of **combined improvements and choices for**:
  - ☐ Metallic components
  - ☐ Graphite layers
  - ☐ Bonding media
  - ☐ Secondary seal
  - ☐ Machining process
- Strong technical knowledge & understanding of:
  - ☐ **Technical customer requirements** (valve kinematic, how the seal is maintained…)
  - ☐ **Materials interactions** when combined in one component
  - ☐ **Sealing mechanism** to find the best sealing solution

Design optimization | 1
Shape definition & manufacturing

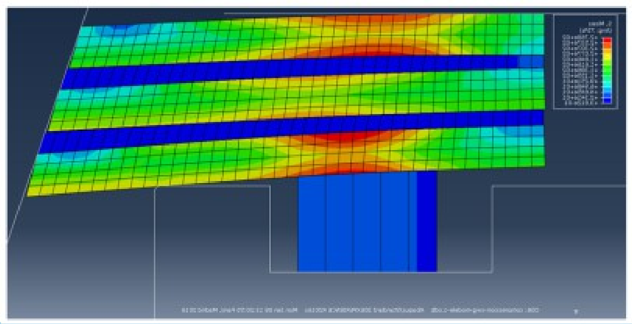
- Definition of precise pre-compression on the seal while machining

  → ideally, **pre-compression load = load applied by the secondary seal** once fitted on the valve

- Choice of **secondary seal** with a **well-known compression curve**
- **Obtain right shape of the seal once fitted on the valve**



- **FEA Support** to anticipate deformations of lamellar seal

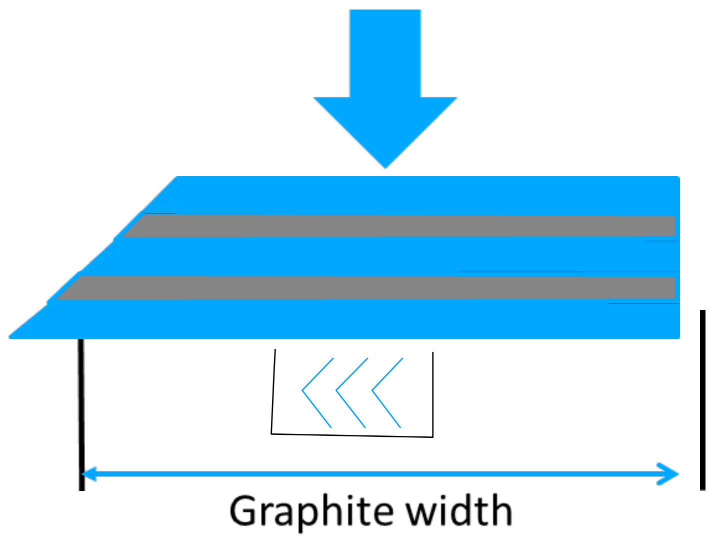


Design optimization | 2
Material choice

- **Metal layers**: importance of choice of material for optimizing blades mechanical behavior

→ Lamellar seal is a metal-to-metal seal

- **Graphite layers**:
  - Optimization graphite width & density to reduce deformations while compressing the secondary seal
  - Tightness improvement due to efficient contact on the seat seal and achievement of leak rate criteria
  - Graphite still in contact with the seat on all circumference of the seal. Expected leak rate facilitated on the test bench (pressure static tests)



Design optimization | 3
Bonding quality

Robust bonding process for lamellar seals:

- **Excellent parallelism** of the seal between external faces due to thin layer of glue
  - Controlled geometry of the seal → optimize the seat contact and leak rate
  - Better compliance with the definition plan of the seal
- **No risk for lack of glue or air bubbles** around all circumference of the seal
  - No graphite blow off during machining operations and good visual control
  - Graphite remains in place at the edge of metal layers to facilitate static leak test
- **Graphite 100% glued to the metal layers**
  - No risk of graphite delamination and leak path between metal layers

Design optimization | 4
Measurement procedure

Dimension control:

- Definition of a robust measurement procedure to control lamellar seals geometry

Design optimization | 5
Secondary seal

Guarantee of global leak results :

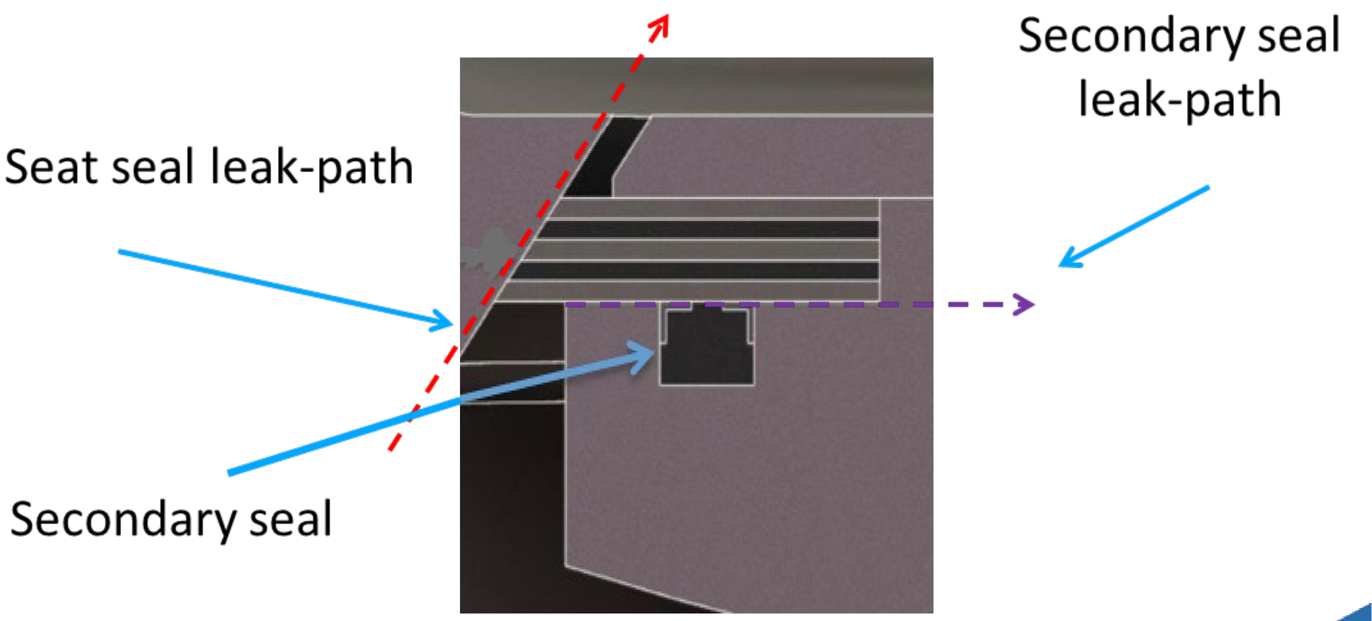
- Leak rate achievement by combining laminated seal and secondary seal

→ sealing assembly package solution

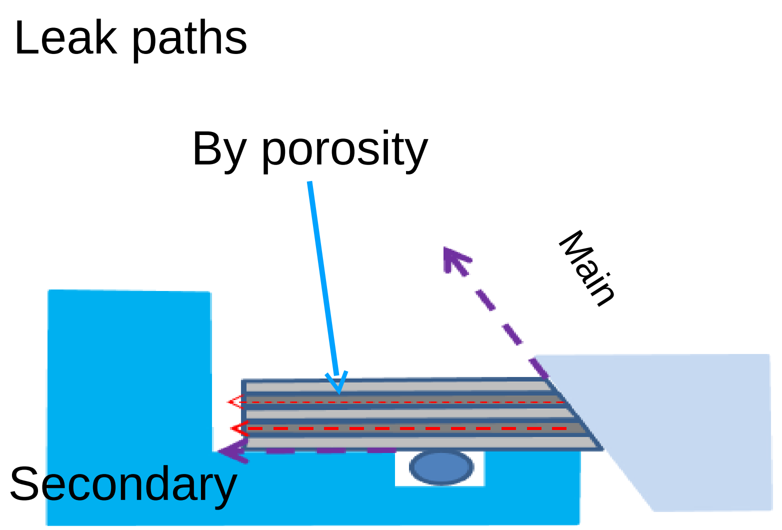
- Consider stiffness **of both lamellar seal and secondary seal**

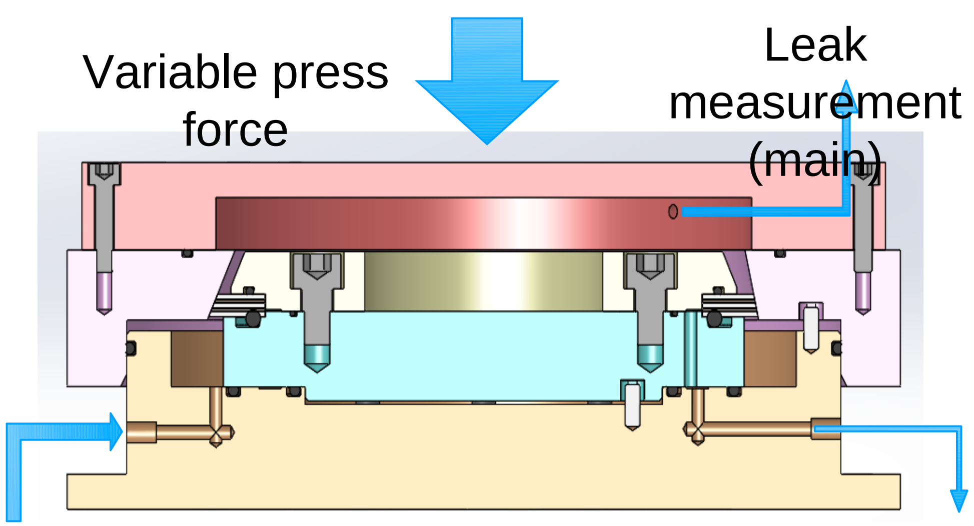
  → master deformations

- Leak path on a poor quality secondary seal can be higher than at seat/seal contact



Lab tests example

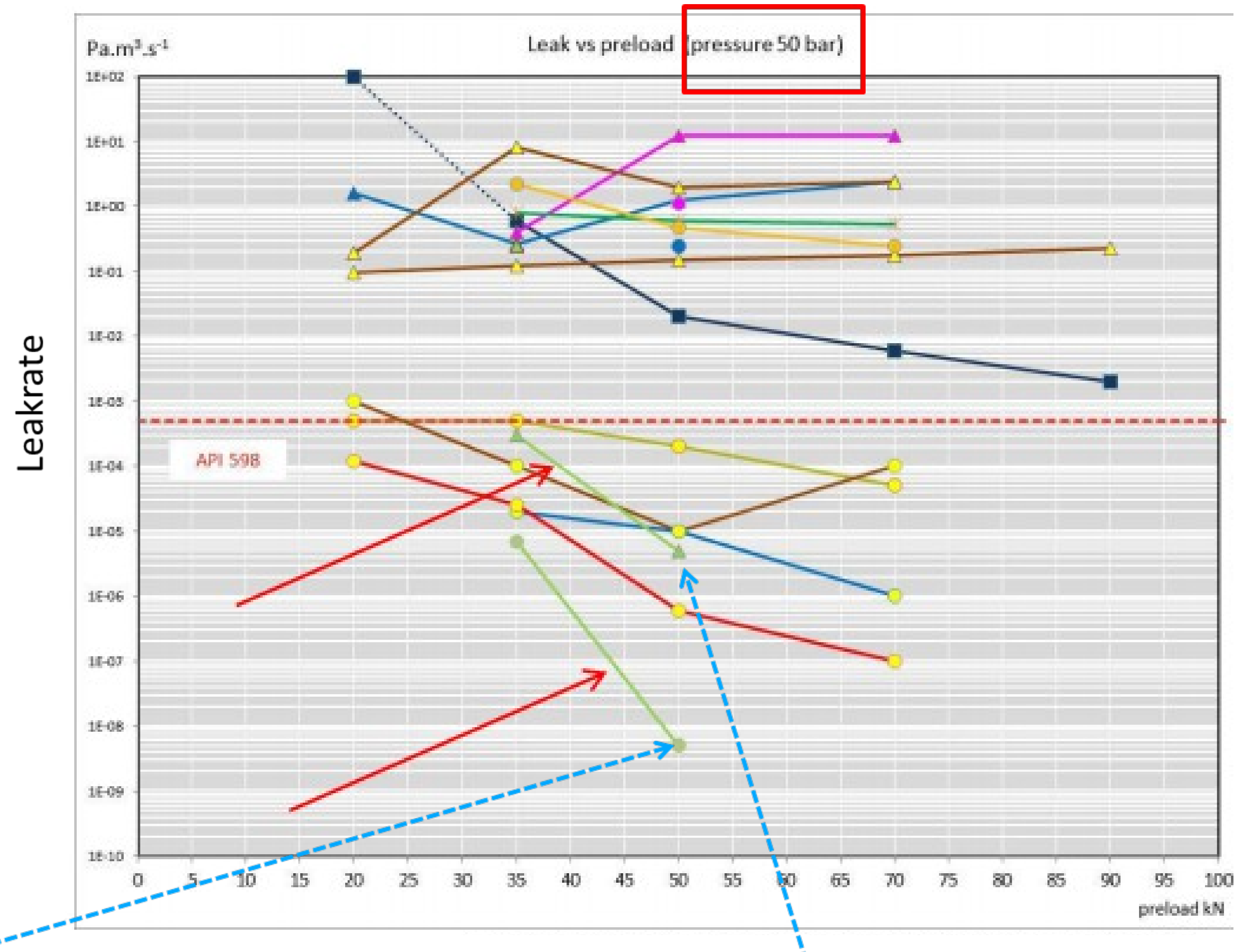




- **Leak results criteria on a dedicated mockup**
- **Strong understanding on how different components interact on mechanism and consequences regarding final tightness performance**
- **Tests performed either with soft O-Ring or stiffer spiral wound gasket as secondary seal**
- **Different leak paths through laminated seal defined by TECHNETICS to achieve expected general leak rate**
  - ☐ On seat seal due to geometry and surface roughness
  - ☐ Through graphite layers (or other soft materials) and glue due to porosity
  - ☐ Through secondary seal working on semi-static position
- **FEA in parallel to make correlations between axial loading and loading on a real butterfly valve**

Results Example

- Test pressure: 50 bar
- Quality criteria: API 598
- Tests of secondary seals (O-Ring or SWG, 8’’ size) from different manufacturers loaded under 35 or 50 kN



O-Ring suitable as a secondary seal

SWG suitable as a secondary seal

Conclusion

Lamellar seal, best sealing solution for TOBV

Why ?

- Achieve **expected leak rates**
- Significantly **reduce leak paths**

How ?

- Strong knowledge on interaction of materials when combined in one component
- Strong technical understanding of **sealing mechanism**

Thank you!

Any Questions ?

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