Overview of Changes:
API 610 11th Edition (ISO 21049)
API 682 4th Edition (ISO 13709)

Presented by: Scott Svendsen
Engineering Director
Flowserve Seals NA
Agenda

• Changes to API 610 for 11\textsuperscript{th} Edition
  – Released Fall/2010

• Changes to API 682 for 4\textsuperscript{th} Edition
  – Upcoming Release Planned for 2012

• Questions/Discussion
API 610 (ISO 13709) 11th Edition

Significant Changes

• Shaft flexibility  $L^3/D^4$  (9.1.1.3); Annex K.1
• Bearings & Brg. Housings  (6.10); Annex K.2
• Torsional Analysis  Rewritten (6.9.2.1)
Shaft Flexibility Index

- Shaft flexibility calculations using $L^3/D^4$ have long been used to evaluate the stiffness of an overhung pump shaft.
- Annex K.1 standardizes the calculation and provides guidance on acceptable values.
Shaft Flexibility Index

• Uses Pump Sizing Factor and Shaft Flexibility Index
• Blue line defines acceptable level
• Ensures Robust Design
• Seek justification from OEM when >20% above the line
Bearing Life Calculation

• Shall be equivalent to at least 25,000 hrs, continuous operation at rated condition and at least 16,000 hrs at maximum radial & axial loads & rated speed (MCSF... minimum continuous stable flow)

• In the past, this was interpreted as “individual” bearing life

• Now the requirement applies to “system” bearing life using the formula given
Torsional Analysis

• Significantly expanded explanation of requirements
• Three types of analyses:
  • a) undamped natural frequency analysis
  • b) steady-state damped response analysis
  • c) transient torsional analysis
• Flow chart defines the process of determining which type of analysis is required
API 610 11th Ed - Other Changes

• Wording “flammable and hazardous” have been removed from the entire 610 document.

• Welded connections mandatory for all piping welds to casing and rest of drain or seal flush piping (when pipe is used). Only for CAST IRON casings (matl column I-1 and I-2) are screwed connections allowed.

• Spiral-wound gaskets are preferred over o-rings.
API 610 11th Ed - Other Changes

• Customer must specify whether NACE MR0175 or MR0103 applies. MR0103 applies to Petroleum Refining Environments, MR0175 applies to Oilfield Equipment.

• All types of impellers (before was restricted to “enclosed” type only) are allowed

• Electronic Data Sheets – EDE capability and clarity on decision points and allowable entries
API 610 11th Ed - Other Changes

• 3 Inspection Classes designated for casing and nozzle inspection. Based on severity and hazard of service.

• Performance Testing – test tolerances and defined recorded data points have changed

• NPSH₃ – used to be NPSHₗ. “3” designates 3% head drop when conducting NPSH testing

• BEP (best efficiency point) – is basis the rated impeller diameter (for Ns and Nss BEP is basis “max” diameter)
API 610 11th Ed - Other Changes

• Too many to discuss here
• Tutorial Paper from Proceeding of the 27th International Pump Users Symposium (Houston) has more extensive listing and explanation
Review of API 682 First Edition

• Created by industry leaders in rotating equipment
• Designed to capture field experience
• Defaults to proven solutions
• Applies to the most common applications
Mission Statement
from API 682 First Edition

“This standard is designed to default to the equipment types most commonly supplied that have a high probability of meeting the objective of a least three years of uninterrupted service while complying with emissions regulations.”
API 682 Second Edition

- Success of First Edition
- Applications outside of refineries
- Application to non-API 610
- Advancement in sealing technology
- Creation of an International standard
ISO 21049

- Review of API 682 Second Edition by worldwide ISO member countries
- Reorganization of some chapters
- Rewording of some clauses
- Error corrections
- Modified piping plan selection flowchart
- New piping plan
API 682 Third Edition

• Release of ISO 21049 created two standards that were not identical
• Third Edition released to make 682 identical to ISO 21049
Fourth Edition

• Comments on previous editions
• Conflicts within standard from expanded scope
• Capture latest technology
• Task Force began work in 4th Qtr 06
• Release 2012
## Scope of Standard
### Comparison of Editions

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>Seal sizes from 1.50” to 4.50” (30mm to 120mm)</td>
<td>Shaft diameters from 0.75” to 4.30” (20mm to 110mm)</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>-40°F to 500°F (-40°C to 260°C)</td>
<td>-40°F to 750°F (-40°C to 400°C)</td>
</tr>
<tr>
<td><strong>Pressure</strong></td>
<td>0 to 515 PSIA (0 to 34.5 bar)</td>
<td>0 to 615 PSIA (0 to 42 bar)</td>
</tr>
<tr>
<td><strong>Fluids</strong></td>
<td>Water, sour water, caustic, amines, some acids, most HCs</td>
<td>Water, sour water, caustic, amines, some acids, most HCs</td>
</tr>
<tr>
<td><strong>Pumps</strong></td>
<td>API-610, ISO 13709</td>
<td>ANSI/ASME B73.1 and B73.2, ISO 3069 Frame C, API-610, ISO 13709</td>
</tr>
</tbody>
</table>

Removed in API 682 Fourth Edition
New Terminology

- Atmospheric Leakage Collector
- Auxiliary Sleeve
- Barrier/Buffer Fluid Chamber
- Containment Device
- Containment Seal Chamber Leakage Collector
- Dynamic Secondary Seal
- Engineered Seal
- External Circulating Device
- Fixed Bushing
- Fixed Throttle Bushing
- Pumped Fluid/Process Fluid
- Seal Sleeve
- Segmented Floating Bushing
- Strainer
Seal Types

• Type definitions introduced in First Edition
• Captured seal design elements and materials
• No major changes in Fourth Edition
Type A Seal

- Rotating flexible element, multiple springs, O-ring secondaries
- Silicon Carbide versus premium grade blister resistant Carbon
- Fluoroelastomer O-rings (FKM)
- Alloy C276 springs (316 for single spring option)
- Type 316 SS sleeve, gland, and other metal parts
- Throttle bushing in gland
Type B Seal

- Rotating bellows, O-ring secondaries
- Silicon Carbide versus premium grade blister resistant Carbon
- Fluoroelastomer O-rings (FKM)
- Alloy C-276 bellows *(Alloy 718 optional)*
- Type 316 SS sleeve, gland, and other metal parts
- Throttle bushing in gland

*New in API 682 Fourth Edition*
Type C Seal

- Stationary bellows, flexible graphite secondaries
- Silicon Carbide versus premium grade blister resistant Carbon
- Alloy 718 bellows
- Type 316 SS sleeve, gland, and other metal parts
- Premium carbon floating bushing in gland
- Bronze anti-coke device
Rotating vs Stationary

• The Fourth Edition recognizes the need to consider rotating and flexible rotating elements as equals

• Either design can be applied to Type A, Type B, and Type C seals

• High speed application (greater than 4500 ft/min (or 23 m/s) defaults to stationary flexible elements
Mixing Seal Types

- Arrangement 2 and 3 seals contain two seals
- Historically these were the same same seal type (e.g. Type A inner seal with a Type A outer seal)
- Fourth Edition allows mixed types (e.g. Type B inner seal with a Type A outer seal)
Engineered Seal

• The term Engineered Seal refers to a seal outside of the standard
• Not a seal “Type”
• Does not need to follow design requirements of the standard
• Does not require qualification
• Can include coaxial seal
Seal Arrangements

• The seal arrangement defines the number or seals, their orientation, and details about the seal’s operation
• Unchanged from previous editions
Arrangement 1
One seal per cartridge assembly

Contacting single wet seal with a fixed throttle bushing
Configuration 1CW-FX

Contacting single wet seal with a floating throttle bushing
Configuration 1CW-FL

Arrangement 2
Two seals per cartridge assembly with a containment seal chamber which is at a pressure less than the seal chamber pressure

Dual contacting wet seals
Configuration 2CW-CW

Contacting wet inner seal with a containment seal
Configuration 2CW-CS

Non-contacting inner seal with a containment seal
Configuration 2NC-CS

Liquid buffer fluid
Gas buffer fluid or no buffer fluid

Arrangement 3
Two seals per cartridge assembly that utilize an externally supplied barrier fluid

Contacting wet seals in a face-to-face configuration
Configuration 3CW-FB

Contacting wet seals in a back-to-back configuration
Configuration 3CW-BB

Contacting wet seals in a face-to-face configuration
Configuration 3CW-FF

Non-contacting seals in a back-to-back configuration
Configuration 3NC-BB

Non-contacting seals in a face-to-face configuration
Configuration 3NC-FF

Non-contacting seals in a back-to-back configuration
Configuration 3NC-FB
Design Requirements - General

• API 682 First Edition states that the “...standard does not cover the design of the component parts of mechanical seals ...”

• This statement is followed by 16 pages of specifications that directly affect the design of seal components

• The Fourth Edition follow the same direction and contains even more specifications on seal design

• These requirements attempt to capture design features that have proven to be successful in the field
Design Requirements - General

- Seal must handle normal and transient axial motions
- Minimum surface finish for O-rings
- O-ring grooves sized for FFKM
- For vacuum services, components that could be dislodged must be retained (mechanically or hydraulically)
- Minimum clearance between rotating and stationary components 3mm (with some exceptions)
- Major reductions in clearances for specific applications.

New in API 682 Fourth Edition
## Design Requirements - General

<table>
<thead>
<tr>
<th>Inside Diameter</th>
<th>Outside Diameter</th>
<th>Minimal Diametral Clearance</th>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID seal chamber and gland plate</td>
<td>OD rotating seal part</td>
<td>CW seal type, 6 mm (0.25 in)</td>
<td>Figure 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NC seal type, 3 mm (0.125 in)</td>
<td></td>
</tr>
<tr>
<td>ID of stationary seal part</td>
<td>OD rotating seal part</td>
<td>shaft &lt; 60 mm, 1 mm (.039 in)</td>
<td>Figure 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>shaft &gt; 60 mm, 2 mm (.079 in)</td>
<td></td>
</tr>
<tr>
<td>ID stationary gland part</td>
<td>OD internal circulation device</td>
<td>shaft &lt; 60 mm, 1 mm (.039 in)</td>
<td>Figure 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>shaft &gt; 60 mm, 2 mm (.079 in)</td>
<td></td>
</tr>
<tr>
<td>ID containment fixed bushing</td>
<td>OD rotating seal part</td>
<td>shaft &lt; 60 mm, 1 mm (.039 in)</td>
<td>Figure 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>shaft &gt; 60 mm, 2 mm (.079 in)</td>
<td></td>
</tr>
</tbody>
</table>

Clearances Between Rotating and Stationary Components

New in API 682 Fourth Edition
Design Requirements - General

Figure 1

Figure 2

Figure 3
Design Requirements - General

• Glands designed for MAWP of pump
• Glands provided with holes (not slots)
• Shoulder at least 3mm behind face in gland
• Seal designed for seal chamber perpendicularity of 0.0005 in./in. of bore
• Seal chamber pressure must be at least .35 bar (5 PSI)
• Vapor pressure margins must be maintained at 30% pressure margin or 20ºC (36ºF) temperature margin (50 PSI minimum vapor pressure margin)
• Floating throat bushings may be required
• Gland and seal chamber connections must be permanently marked
## Connections

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Symbol</th>
<th>Connection</th>
<th>Location</th>
<th>Type</th>
<th>Size Cat I</th>
<th>Size Cat II and III</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1CW-FX</td>
<td>F</td>
<td>Flush</td>
<td>0</td>
<td>Process</td>
<td>½ (Note 3)</td>
<td>½</td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>FI</td>
<td>Flush In (Plan 23 only)</td>
<td>180</td>
<td>Process</td>
<td>½ (Note 3)</td>
<td>½</td>
<td>WS</td>
</tr>
<tr>
<td></td>
<td>FO</td>
<td>Flush Out (Plan 23 only)</td>
<td>0</td>
<td>Process</td>
<td>½ (Note 3 &amp; 6)</td>
<td>½</td>
<td>WS</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>Drain</td>
<td>180</td>
<td>Atmo</td>
<td>3/8 (Note 5)</td>
<td>3/8</td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>Q</td>
<td>Quench</td>
<td>90</td>
<td>Atmo</td>
<td>3/8 (Note 5)</td>
<td>3/8</td>
<td>WS</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>Heating</td>
<td>-</td>
<td>Utility</td>
<td>½ (Note 3)</td>
<td>½</td>
<td>WS</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Cooling</td>
<td>-</td>
<td>Utility</td>
<td>½ (Note 3)</td>
<td>½</td>
<td>WS</td>
</tr>
<tr>
<td></td>
<td>PIT</td>
<td>Pressure sensing port</td>
<td>90</td>
<td>Instrument</td>
<td>3/8</td>
<td>3/8</td>
<td>WS</td>
</tr>
<tr>
<td>2CW-CW</td>
<td>F</td>
<td>Flush (Inner Seal)</td>
<td>0</td>
<td>Process</td>
<td>½ (Note 3)</td>
<td>½</td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>LBI</td>
<td>Liquid Buffer Fluid In</td>
<td>180</td>
<td>Process</td>
<td>½ (Note 4)</td>
<td>½</td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>LBO</td>
<td>Liquid Buffer Fluid Out</td>
<td>0</td>
<td>Process</td>
<td>½ (Note 4)</td>
<td>½</td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>Drain (Outer Seal)</td>
<td>180</td>
<td>Atmo</td>
<td>3/8 (Note 5)</td>
<td>3/8</td>
<td>WS</td>
</tr>
<tr>
<td></td>
<td>Q</td>
<td>Quench (Outer Seal)</td>
<td>90</td>
<td>Atmo</td>
<td>3/8 (Note 5)</td>
<td>3/8</td>
<td>WS</td>
</tr>
</tbody>
</table>

**Note 3**  
A 3/8 NPT connection may be used if ½NPT not possible due to space constraints.

**Note 4**  
A ½ NPT required for shaft diameters 63.5 mm (2.5 inch) or smaller, ¾ NPT for larger sizes.

**Note 5**  
A ¼ NPT connection may be used if 3/8 NPT is not possible due to space constraints.

New in API 682 Fourth Edition
Design Requirements - General

- Threaded connections shall be plugged with red plastic plugs installed in ports and metal plugs with seal drawing in a bag
- Connections and tubing shall be suitable for max hydrostatic test pressure
- Drill throughs minimum 5mm (3/16”) diameter

Floating carbon throttle bushing diametrical clearances

<table>
<thead>
<tr>
<th>Sleeve Diameter mm</th>
<th>Sleeve Diameter inch</th>
<th>Max diametrical clearance mm</th>
<th>Max diametrical clearance inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 50</td>
<td>0 to 2.00</td>
<td>0.18</td>
<td>0.007</td>
</tr>
<tr>
<td>51 to 80</td>
<td>2.01 to 3.00</td>
<td>0.225</td>
<td>0.009</td>
</tr>
<tr>
<td>81 to 120</td>
<td>3.01 to 4.74</td>
<td>0.28</td>
<td>0.011</td>
</tr>
</tbody>
</table>

New in API 682 Fourth Edition
Design Requirements - General

• Sleeves furnished by the seal OEM
• Sleeve to shaft clearances defined by ISO 286-2 F7/h6
• Rotating components must have a means to be positively located
• Sleeve gasket O-ring shall be located at the impeller end

• Sleeves thickness to be minimum of 2,5 mm (0.100 in)
• Sleeve in areas of set screws defined

<table>
<thead>
<tr>
<th>Shaft Diameter mm</th>
<th>Sleeve Diameter inch</th>
<th>Minimum Sleeve Radial Thickness mm</th>
<th>Minimum Sleeve Radial Thickness Inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 57</td>
<td>&lt; 2.25</td>
<td>2,5</td>
<td>0.100</td>
</tr>
<tr>
<td>57 to 80</td>
<td>2.25 to 3.25</td>
<td>3,8</td>
<td>0.150</td>
</tr>
<tr>
<td>&gt; 80</td>
<td>&gt; 3.25</td>
<td>5,1</td>
<td>0.200</td>
</tr>
</tbody>
</table>

New in API 682 Fourth Edition
Design Requirements - General

• Minimum thickness does not include setting plate groove
• Sleeve OD and ID concentric within 25μm (0.001 in)
• Sleeve piloted on both ends, relieved in the middle
• Drive collar set screws not allowed in piloted area
• Drive collar set screws sufficiently hard to embed shaft
• Use of nine or more set screws only with approval
• Set screws must hold 150% of max load
• Other drive devices (e.g. shrink disk or split ring drive collars) are allowed with approval
• Single spring allowed on Type A seals if specified
• Flexible elements shall not rely on lapped joints for sealing

New in API 682 Fourth Edition
Seal Face Materials

Third Edition
- Category 1 – SSSiC vs C
- Category 2 – RBSiC vs C
- Category 3 – RBSiC vs C
- Hard vs Hard allowed SiC vs SiC

Fourth Edition
- Category 1 – SiC vs C
- Category 2 – SiC vs C
- Category 3 – SiC vs C
- Select the correct SiC for the application
- Other face materials allowed – WC, graphite loaded SiC, coatings allowed to enhance performance
Pumping Rings

• Devices to circulate fluid in Plan 23, 52 or 53 systems
• Actual design not specified
• Allowance for use of
  – Tangential porting
  – Cutwaters
  – Volutes
  – Axial flow designs
Categories

• Different applications may require different levels of seal sophistication
• Current practice of specifying “modified” API-682 seals
• Size restrictions based on pump construction
• Cost impact of seals
• Designated as Category 1, 2, and 3
## Comparison of Categories

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>CATEGORY 1</th>
<th>CATEGORY 2</th>
<th>CATEGORY 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal chamber size</td>
<td>ISO 3069 Type C, ANSI/ASME B73</td>
<td>ISO 13709/API 610</td>
<td>ISO 13709/API 610</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-40°C to 260°C -40°F to 500°F</td>
<td>-40°C to 400°C -40°F to 750°F</td>
<td>-40°C to 400°C -40°F to 750°F</td>
</tr>
<tr>
<td>Pressure range absolute</td>
<td>22 bar 315 PSIA</td>
<td>42 bar 615 PSIA</td>
<td>42 bar 615 PSIA</td>
</tr>
<tr>
<td>Face materials</td>
<td>Carbon vs self-sintered SiC</td>
<td>Carbon vs reaction bonded SiC</td>
<td>Carbon vs reaction bonded SiC</td>
</tr>
<tr>
<td>Distributed flush requirements</td>
<td>When Required or Specified</td>
<td>When Required or Specified</td>
<td>Required</td>
</tr>
<tr>
<td>Gland plate metal to metal contact</td>
<td>Required</td>
<td>Required inside and outside bolt circle diameter</td>
<td>Required inside and outside bolt circle diameter</td>
</tr>
</tbody>
</table>

NEW - Allowances for other seal face materials including SiC with porosity, SiC with graphite, and diamond coating.

Removed in API 682 Fourth Edition
## Comparison of Categories

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>CATEGORY 1</th>
<th>CATEGORY 2</th>
<th>CATEGORY 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal sleeve size increments</td>
<td>None</td>
<td>10mm increments</td>
<td>10mm increments</td>
</tr>
<tr>
<td>Throttle bushing requirements</td>
<td>Fixed carbon, floating carbon optional</td>
<td>Fixed non-sparking metal, floating carbon optional</td>
<td>Floating carbon</td>
</tr>
<tr>
<td>Pumping ring HQ curve required</td>
<td>If specified</td>
<td>If specified</td>
<td>Required</td>
</tr>
<tr>
<td>Scope of vendor qualification test</td>
<td>Test as Category 1 unless core tested as Category 2 or 3</td>
<td>Test as Category 2 unless core tested as Category 3</td>
<td>Test as Category 3 as entire seal assembly</td>
</tr>
<tr>
<td>Proposal document requirements</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Rigorous including qualification tests</td>
</tr>
<tr>
<td>Contract data requirements</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Rigorous</td>
</tr>
</tbody>
</table>

*Removed in API 682 Fourth Edition*
Accessories

• Accessories are components other than the seal that are required to create an acceptable sealing environment. Third Edition included:
  – Auxiliary piping systems
  – Cyclone separators
  – Orifices
  – Seal coolers
  – Reservoirs
  – Pumping rings
  – Condensate collection reservoirs
  – Gas supply panels
Accessories

• Fourth Edition adds:
  – Air cooled seal coolers
  – Strainer
  – Bladder Accumulators
  – Piston Accumulators
  – Collection Reservoirs for Plan 65
Seal Flush Coolers

- Seal flush on tube side of cooler
- Both process and cooling water sides must be able to be completely vented and drained
- Drain valve must be provided on water side
Seal Flush Coolers

• Two sizes of coolers:
  – For shaft sizes over 60mm (2.5 inch) – 0.750 inch diameter tube with 0.095 inch wall thickness
  – For smaller shaft sizes – 0.500 inch diameter tube with 0.065 inch wall thickness

• Size selection now based on application conditions
Seal Flush Coolers

• Air cooling is a supported alternative
• Only solution when high temperatures fluid must be cooled due to the potential of fouling
• Same requirements on water cooled and air cooled seal
• Tubing (minimum 0.500”, 0.065 wall 316 stainless steel, welded)
• Sizing is now based on application
• Fins may be aluminum or stainless steel.

New in API 682 Fourth Edition
Bladder Accumulator

• Pressurization of barrier fluid in Plan 53B systems

• Challenges in selecting a bladder accumulator is selecting a size

• Annex F in the Fourth Edition provides guidance on how to size, pre-charge, and operate Plan 53B
Bladder Accumulator

• Define basic features of an accumulator
• Standard sizes are 20 L [5 gal] and 35 L [9 gal] depending upon shaft size.
• Selected to provide a minimum of 28 days of operation without operator intervention
• Shell of the accumulator shall be carbon steel and the bladder material will be recommended by the manufacturer based on available options and operating conditions
• Tags and labeling requirements are also included.
Piston Accumulator

• Used to provide barrier fluid pressurization in Plan 53C systems.

• Defined in two sizes: maximum 2,8 L [0.7 gal] for shaft sizes 60mm or less and maximum 5,1 L [1.28 gal] for shaft sizes larger than 60mm

• The metallic material should be the same as the seal gland

• Gasketing elements (O-rings, lip seals) shall be suitable for exposure to both the process and barrier fluid.
Leakage Collection Reservoir

- Liquid leakage which leaves the seal gland can be monitored with a Plan 65
- Been used extensively in some industries
- Plan 65 system is considered part of the pressure boundary
- Shall have a capacity of at least 3 L [0.75 gal] and be equipped with a locally indicating level transmitter.
- Constructed from schedule 40 pipe.
Inspection, Testing, and Preparation for Shipment

- General inspection by vendor
- Inspection of seal components
- Qualification testing
- Hydrostatic testing of glands
- Air testing
- Pump manufacturer seal test
Qualification Testing

• Easy for a standard to create a goal of 25,000 hours of service but difficult to prove it
• Concern from users that seals should be tested under real world conditions
• Testing is designed to provide the user with a level of confidence that the seals will perform as required by the standard
Qualification Testing

• Testing will qualify a seal model so testing only needs to be done once for a specific seal
• Not intended as testing for actual job seals
• Two sizes need to be tested: a small size with a balance diameter between 50mm to 75mm (2.0 to 3.0 inch) and a large size with a balance diameter between 100mm to 127mm (4.0 to 5.0 inch)
• Category 1 seal requires 38mm – 75mm (1.5 – 3.0) and 75mm – 127mm (3.0 to 5.0 inch)
Qualification Testing

• Testing requirements are different between the seal categories
• Category 3 seals must be tested in the same configuration as is being offered
• Category 1 and 2 seals may be tested in the same configuration as is offered or it may be designed with seal faces that have been qualified in other testing defined by core components
• Allowance for seal face materials to be qualified as a mating pair to cut down on the number of tests required

New in API 682 Fourth Edition
Qualification Testing

• End users identified typical refinery applications based on process fluids, temperatures and pressures
• Selected five test fluids that are representative of these applications and that were acceptable for lab testing
• Developed a set of steady state and cyclic conditions that would simulate actual field conditions
Test Cycle for Liquid Seals
# Test Qualification Form

## Mechanical Seal Test Qualification Form

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer:</td>
<td></td>
</tr>
<tr>
<td>API 682 Seal Type:</td>
<td>A</td>
</tr>
<tr>
<td>Mat. of construction:</td>
<td></td>
</tr>
<tr>
<td>Secondary Seals:</td>
<td></td>
</tr>
<tr>
<td>Seal Size:</td>
<td></td>
</tr>
<tr>
<td>API Code:</td>
<td></td>
</tr>
<tr>
<td>API Plan:</td>
<td></td>
</tr>
<tr>
<td>Fluid Service:</td>
<td>Non-Hydrocarbon (water, caustic, acid) Non-Flash Hydrocarbon Flashing Hydrocarbon</td>
</tr>
<tr>
<td>Fluid:</td>
<td></td>
</tr>
<tr>
<td>Base Point Temp:</td>
<td></td>
</tr>
<tr>
<td>Base Point Pressure:</td>
<td></td>
</tr>
<tr>
<td>SG:</td>
<td></td>
</tr>
<tr>
<td>V. Pressure:</td>
<td></td>
</tr>
<tr>
<td>Solids:</td>
<td></td>
</tr>
<tr>
<td>Particle Size:</td>
<td></td>
</tr>
</tbody>
</table>

### Dynamic Test

|------|----------------|---------------|---------------|---------------|------------------------|--------------|----------------------|-------------------------|--------------------------|---------------|------------|------------|------------------------|-----------------|

### Static Test

|------|----------------|---------------|---------------|---------------|------------------------|--------------|----------------------|-------------------------|--------------------------|---------------|------------|------------|------------------------|-----------------|

### Cyclic Test

|------|----------------|---------------|---------------|---------------|------------------------|--------------|----------------------|-------------------------|--------------------------|---------------|------------|------------|------------------------|-----------------|

*Dual Seals
Containment Seal Testing

• In the Second Edition, testing requirements were defined for containment seals
• Testing would demonstrate performance under steady state conditions as well as simulated failure of the inner seal
• Recorded data include leakage rate past containment seal
Test Cycle for Containment Seals

- Dynamic test phase
  - 10 PSI Propane
  - Minimum 100 hours
- Static test phase
  - 25 PSI Nitrogen
  - 5 Minutes
- Dynamic test phase
  - 40 PSI Diesel
  - Minimum 100 hours
- Static test phase
  - 250 PSI Diesel
  - 4 Hours
Dual Gas Seal Testing

• Dual gas seal testing is designed to evaluate the seals on the process fluid with an inert barrier gas
• Testing involves steady state testing as well as the cyclic testing procedures defined for liquid seals
• Also involves simulated disruptions of the barrier gas supply
Test Cycle for Dual Gas Seals

Static test phase

Barrier at test pressure

Dynamic test phase

Barrier isolated

Static test phase

Barrier at test pressure

1 Hour

Equilibrium

1 Minute

Equilibrium

10 Minutes
Gas Seal and Containment Seal Test Qualification Form

### Mechanical Seal Test Qualification Form

**2CW-CS, 2NC-CS, 3NC-FF, 3NC-BB, 3NC-FB**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Seal Type/Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrangement</td>
<td>2CW-CS 2NC-CS 3NC-FF 3NC-BB 3NC-FB</td>
</tr>
<tr>
<td>Material of Construction</td>
<td>Rotating Face Stationary Face</td>
</tr>
<tr>
<td>Fluid Service</td>
<td>Non-Hydrocarbon (water, caustic, acid) Non-Flash Hydrocarbon Flash Hydrocarbon</td>
</tr>
<tr>
<td>Shaft Run Out</td>
<td>Sleeve Run Out Face to Sleeve Concentricity</td>
</tr>
<tr>
<td>Test Fluid</td>
<td>Base Point Temperature Base Point Pressure</td>
</tr>
<tr>
<td>Vapor Pressure</td>
<td>Solids Particle Size</td>
</tr>
</tbody>
</table>

**Test Procedure**

- 10.3.1.2.8 (for 2CW-CS, 2NC-CS Arrangements)
- 10.3.1.2.9 (for 3NC-FF, 3NC-BB, 3NC-FB Arrangements)

<table>
<thead>
<tr>
<th>Data</th>
<th>Date</th>
<th>Time</th>
<th>Inner Seal</th>
<th>Buffer/Barrier</th>
<th>Seal Leakage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pressure Bar (PSI)</td>
<td>Temp °C (°F)</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Outer Seal Face Wear | Stationary Face | Rotating Face | mm (in.) |
Inner Seal Face Wear | Stationary Face | Rotating Face | mm (in.) (10.3.1.2.9 only)

Figure I.2 — Mechanical seal test qualification form (2CW-CS, 2NC-CS, 3NC-FF, 3NC-BB, 3NC-FB)
Testing Arrangement 3 Seals

- Test inner seal alone
- Test complete seal
- Established for 3CW-FB orientation
- If applied to test 3CW-BB or 3CW-FB, inner seal becomes ID pressurized
- Difficult to pass test
- May require seal OEMs to design seals for the test and not the application
Arrangement 3 Options
Testing Arrangement 3 Seals

• New test requirements for 3CW-BB and 3CW-FB
• Test complete assembly per test procedure
• Reduce barrier pressure to zero dynamically for one minute
• Repressurize and reach stabilize
• Shut down with base point on inner seal and barrier pressure at zero for one hour

New in API 682 Fourth Edition
Air Testing of Assemblies

- Every seal assembly shall be air tested by the seal OEM
- Dual seals tests must have ability to test each sealing section independently
- Seals tested at 1.8 bar (26 PSI) with a gas volume of a maximum of 28 l (1ft³)
- Maximum pressure drop of 0.14 bar (2 PSI) over a five minute period
- Seals tagged after successful completion
- No changes in Fourth Edition
Overview of Annexes

• Annexes comprise almost exactly half of the pages in API 682 and ISO 21049
• Contain support material for the standard
• Consists of both normative and informative sections
• Normative annexes are enforceable parts of the standard
• Informative annexes are for information only
Annexes Fourth Edition

- Annex A – Recommended seal selection procedure
- Annex B – Typical materials and material specifications for seal chambers and mechanical seal components
- Annex C – Mechanical seal data sheets
- Annex D – Seal codes
- Annex E – Mechanical seal data requirement forms
- Annex F – Technical tutorials and illustrative calculations
- Annex G – Standard piping plans and auxiliary hardware
- Annex H – Inspectors’ checklist for all seals
- Annex I – Seal qualification testing protocol
- Bibliography
Seal Selection Procedure

• First Edition introduced a seal selection procedure
• Procedure was developed to capture selection methods that have proven successful in the field
• Systematic method of selecting a seal type, arrangement, and piping plans for a number of common applications
• Does not cover every service
• Continued into Fourth Edition
New Seal Selection Procedure

- Alternative seal arrangement selection method using Material Safety Data Sheet information
- Chemicals are categorized by risks and hazards in accordance with GHS and EC standards
- R-phrases and H-statements
- Associate higher risk applications to “higher” seal arrangements

New in API 682 Fourth Edition
Piping Plans

• New piping plans introduced in ISO 21049-2011 / API 682 Fourth Edition:
  – General changes
  – Seal flush created by seal chamber design
  – Low pressure buffer fluids systems
  – Alternatives in leakage detection
  – Leakage reduction and detection plans
  – Engineered piping plan
Piping Plans

• Eliminated the term Flush Plan and replaced with Piping Plan
• Consolidated information on one page
• Stressed that seal drawings are typical for illustrating plans only
• Change from “indicator and switch” to transmitter
• Allows minor changes
• Major changes require engineered plan
Plan 03

New in API 682 Fourth Edition
Plan 55

New in API 682 Fourth Edition
Plan 65A
Plan 65B

New in API 682 Fourth Edition
Plan 66A

New in API 682 Fourth Edition
Plan 66B

New in API 682 Fourth Edition
Plan 99

- Engineered piping plan
- Any piping plan not covered by standard piping plans
- Can be modification to existing plan
- Can be completely unique plan
- Described in purchase order or technical specification
- Must be specific
Data Sheets

- Fourth Edition has new sheets
- Two pages
- All categories
- Excel based
- Built in logic
- Unsure of distribution
Historical Seal Code

- Old API 610 still in use (ie. BSTFN)
- Used by engineering contractors and project groups
- Does not cover API 682 requirements
- Does allow for material definitions
Fourth Edition Seal Code

- Revisited reasons for code
- Considered use of old API 610 code
- Carry over some material codes
- Focused on project work
- Created a new seal code

New in API 682 Fourth Edition
## Seal Code – Fourth Edition

<table>
<thead>
<tr>
<th>Seal</th>
<th>Design Options</th>
<th>Size</th>
<th>Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Arrangement</td>
<td>Type</td>
<td>Containment Device</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>A</td>
<td>-</td>
</tr>
</tbody>
</table>

Category designated as 1, 2, or 3

Arrangement designated as 1, 2, or 3

Type designated as A, B, or C
## Seal Code – Fourth Edition

<table>
<thead>
<tr>
<th>Category</th>
<th>Arrangement</th>
<th>Type</th>
<th>Containment Device</th>
<th>Gasket Material</th>
<th>Face Material</th>
<th>Shaft Size mm</th>
<th>Piping Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>A</td>
<td>P</td>
<td>F</td>
<td>O</td>
<td>050</td>
<td>11/52</td>
</tr>
</tbody>
</table>

**Containment device**
- P – plain gland with no bushing (Arrangement 2 or 3 only)
- L – floating throttle bushing
- F – fixed throttle bushing
- C – containment seal
- S – floating, segmented carbon bushing
- X – Unspecified (This will be specified separately)
# Seal Code – Fourth Edition

<table>
<thead>
<tr>
<th>Seal</th>
<th>Design Options</th>
<th>Size</th>
<th>Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Arrangement</td>
<td>Type</td>
<td>Containment Device</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>A</td>
<td>-</td>
</tr>
</tbody>
</table>

Gasket Material

- F – Fluoroelastomer (FKM) gaskets
- G – Polyflouroetraethylene (PTFE) spring energized gaskets
- H – Nitrile gaskets
- I – Perfluoroelastomer (FFKM) gaskets
- R – Flexible graphite
- X - Unspecified (This will be specified separately)
# Seal Code – Fourth Edition

## Table of Seal Code Options

<table>
<thead>
<tr>
<th>Category</th>
<th>Arrangement</th>
<th>Type</th>
<th>Containment Device</th>
<th>Gasket Material</th>
<th>Face Material</th>
<th>Size</th>
<th>Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>A</td>
<td>P</td>
<td>F</td>
<td>O</td>
<td>-</td>
<td>050</td>
</tr>
</tbody>
</table>

### Face Materials
- **M** – Carbon vs nickel bound WC
- **N** – Carbon vs reaction bonded SiC
- **O** – Reaction bonded SiC vs nickel bound WC
- **P** – Reaction bonded SiC vs reaction bonded SiC
- **Q** – Sintered SiC vs sintered SiC
- **R** – Carbon vs sintered SiC
- **S** – Graphite loaded, reaction bonded SiC vs reaction bonded SiC
- **T** – Graphite loaded, sintered SiC vs sintered SiC
- **X** – Unspecified (This will be specified separately)

*New in API 682 Fourth Edition*
### Seal Code – Fourth Edition

<table>
<thead>
<tr>
<th>Seal</th>
<th>Design Options</th>
<th>Size</th>
<th>Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Arrangement</td>
<td>Type</td>
<td>Containment Device</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>A</td>
<td>P</td>
</tr>
</tbody>
</table>

**Shaft size**
- Size in mm rounded up to next whole integer inch size change to mm (1” = 25.4mm = 26)
- Used only for rough sizing and not design

**Piping Plans**
- Plan number
- Multiple plans separated by “/”
- Example: 11/52
API 682 Changes - Review

- Expanded offering
- Remove inconsistencies and clean up conflicts
- New equipment
- Modified test procedures
- New piping plans
- Tutorial Paper from Proceeding of the 27th International Pump Users Symposium (Houston) has more extensive listing and explanation
Comments and Questions