ON/OFF BALL VALVES
Engineering, manufacturing and FAT
SDAG Requirements from experience

Technical meeting with Russian valve manufacturers
Moscow 24th June 2010
Essential Background Information

• Block valves are essentially ball valves.
• The specification is built from several standards with some additional requirements:
  – Reliability & Robustness: selected manufacturers
  – Simplicity: for maintenance
  – Safety: Gas service.
  – Specifications have been enriched from engineering, manufacturing, testing outputs, and field experience.

Summary of technical problems
• ‘Flexible’ design
• Stem / ball misalignment
• Stem bearing galling
• Bonnet bolting failure or over stress
• Ball drive insert failure
• Damage of soft seals by solid particles
• Quick decompression effect on elastomer o-rings seals
• Seal pocket corrosion
• ENP coating blistering
• Valve internal distortion
• Valve stem overstress
• Inappropriate testing medium
• Non conforming metallic materials
Engineering: Valve specification requirements

- Main actions on design, main features of International application:
  - Design code selection
  - Definition of “service classes”
  - Anti-blow out design of stems
  - Basic calculation rule for stem
  - Anti-static construction, stem to ball and stem to body
  - Seals category and material selection for ED or specific service conditions (H2S service, chemical additives)
  - Corrosion and wear resistant coatings
  - Specific metallurgical requirements for sour service
  - …and Valve Data Sheet requirement

ASME B 16.34 for:
- pressure and temperature rating
- Minimum wall thickness
- Bolt sizing
- Inner and outer ligament rules

API 6D selected for:
- Internal bore
- Face to face dimensions
Valve specification: ball valve design rules

- All ball valves are of bi-directional type.
- Split body type is the preferred design. Top Entry type is limited to some pipeline applications.
- All welded valves are rarely considered, except in LNG and Loading lines.
- Reduced bore unless otherwise required by requisition (pigging...)
- All actuated ball valves are of trunnion-mounted type
- Material for Pressure retaining parts are matching the generic pipe material. However more and more consideration for carbon steel material with weld overlay on all wetted surfaces for large valves in stainless steel or other CRA materials.
- Anti-extrusion stem design
- Following essentially limited to Class B (soft seat) and E (metal/metal seat) of our specification: HC not for cryogenic service, up to HC service 200°C.

Table 3.1 - Definition of service classes for valves

<table>
<thead>
<tr>
<th>Valve Service Class</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluids</td>
<td></td>
<td>Hydrocarbons (liquid and gas)</td>
<td>Hydrocarbons (gas)</td>
<td>Hydrocarbons (liquid and gas)</td>
<td>Hydrocarbons (liquid and gas)</td>
</tr>
<tr>
<td>Service</td>
<td>Utility or water injection</td>
<td>General Process Production Transport</td>
<td>General Process (Cryogenic)</td>
<td>General Process</td>
<td>(Note 1)</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>T ≤ 75°C</td>
<td>T ≤ 200°C</td>
<td>T &lt; -46°C</td>
<td>T &gt; 200°C</td>
<td>T ≤ 200°C</td>
</tr>
</tbody>
</table>
ED test bench for qualification of elastomer o-rings

Soaking condition: 190 bar @75°C
Five cycles: 72 hours first and four times 48 hours cycles, with one hour stand-by in-between plus 24 hours stand-by before opening the vessel
Groove filling: < 75%
Compression set < 15%
Depress rate 190 bars in 90 seconds post 72 hours
Valve specification requirements: stem design/Tork

Basic rule used for stem: minimum diameter of common valves

The maximum equivalent stress $\sigma_e$ shall not exceed 90% of the nominal yield strength of the stem material: $\sigma_e \leq 0.90 \text{YS}$ (where YS = the nominal yield strength of the stem material).

‘D’ minimum diameter of the stem

‘L’ & ‘a’ dimensions of the stem key

\[
\sigma_c = \text{torsional stress (N/mm}^2) \\
M_c = \frac{\sigma_c \pi D^3}{16000}
\]

One table per actuator / valve type:
all actuated valves are tested with their own actuator and control panel
We do not impose any rule on the seat design, except all valves of service class B and E are of simple piston effect.

Tungsten carbide coating (HVOF process)

Typical aspect

Engineering: removable plugs....
Metal to metal seat valves

Class E valve:

- Metal to metal contact
- Inconel 625 weld overlay on the two matching faces of ‘dynamic seal’ pockets, i.e. seat and stem sealing areas.
- Inconel 625 weld overlay can be replaced by Inconel 625 HVOF in 300 microns when service conditions permit.

Tungsten carbide coating is performed on the following ball and seat materials:

- Carbon steel A105, A 350 LF2, F60 (ball & seats)
- Low alloys, typ. AISI 4140 (ball & seats)
- Stainless steels SS3xx (ball & seats)
- DSS 2205 (ball & seats)
- Inconel 625 (ball & seats)
- Inconel 718 (seats)
- On weld overlay (SS316L or Inconel 625) (ball manufacturing)
Tungsten carbide coating (HVOF process)

Tungsten carbide coating:
- Typical test by the applicator

Tungsten Carbide coating:
- Mini thickness, Hardness, porosity, density, roughness...
- Void and oxides between boundaries, oxides on open surface

Typical aspect

But when that’s wrong....
Valve specification requirements: Testing

Main actions on testing:
- Material certificates, including actuator components
- Code selection for testing, starting from API 598
- Definition of the amount of testing supervision and attendance
- Selection of an appropriate testing medium, high pressure closure test with nitrogen
- Seat relief test requirement: criteria = 10% pressure rating
- Definition of acceptable leakage rates for high pressure gas tests

ACTUATED Valve Testing:
Excessive overlap will reduce dramatically the safety factor initially set between the valve allowable torque and the torque delivered by the actuator...
TYPICAL Incidents from experience

- Despite all these considerations.....
Ball surface defect; Manufacturing defects

SS 316 8” PC900
ball surface, manufacturing issue detected during valve testing.

- Seat failure during line testing.
- Material A705 TP 630 (17.4PH)
- Brittle type fracture
- Large solidification grains
- Interdendritic mode failure
- Seta material correct but not heat treatment
Seat damage, Material failure...

Seat damaged during line testing

Bolt failure during tensioning
Material A193 B7
Bolt Diameter 3 1/2"

Supposed to be dry and clean....but then dismantled since not passing the test.

Crack in the bolt vertical plan
TCC damage

What can happen…
Lessons learnt Ball Valves:

Supplier Side
• Qualification of manufacturers (for identified products), rather than qualification of vendors
• Design appraisal
• Manufacturing and sub-manufacturing facilities
• Sub-supplier chain...and control of it: Performance testing
• Quality assurance audits, despite planning driven EPC

Contractors side (EPC)
• We would like them more “proactive” in that kind of supply
• Not helping that much in detailed engineering, looking at low cost ...
• Generally claiming the list of ‘recommended manufacturers’ is too short, but unable to provide any consistent
  backup for additional ones (qualification dossier)
• They do not really feel concerned by the manufacturing process and potential problems

End user side: COMPANY and operation teams
• Select the appropriate valve service class and type on PID’s
• Involvement in design verification at the manufacturer qualification stage, and during purchase, at random
• Involvement in valves testing
• Supervise storage and handling, witness flushing and lines cleaning (remove valve when feasible).

• Ball valves are important features for gas service and are not sufficiently defined in codes and standards
• Our specification has been built on past experience; it corresponds to some improvement observed on valve
  reliability in our production facilities.
• We still promote such a specification, standards do not suffice.
• But there is still room for improvement in all fields, design, manufacturing and testing