ISO 10423 revision: Castings vs. Forgings

API SC6 meeting - Houston, 1 Feb 2007
The issue

• ISO 10423 requires forgings for PSL 3 and PSL 4, whereas API 6A allows castings for all PSLs.

• Some principals call for products outside the range of API 6D or API 6A being manufactured to API 6A PSL requirements.

• Under ISO 10423 PSL 3/4, these would have to be forgings, whereas some manufacturers would want to supply castings, or size/complexity/quantity demands castings.

• The problem is also related to products outside the scope of ISO 10423 or API 6A.
API requirements for alignment with ISO

• Persuasive technical and/or safety justification is provided by users, rather than manufacturers

• Justification does not necessarily have to show forgings as clearly superior to, or safer than castings

• It may be sufficient to show that there are sufficient technical differences that the two are not interchangeable in all applications
Product Specification Levels

PSL 3, 3G and 4 currently require forgings in ISO:

- >=15000 psi
- >5000 psi gas applications, or high sour oil

- PSLs are risk mitigation measures for escalating consequences by reducing inherent probability of failure

- Oil
- Gas
- Sweet & mod sour
- High sour
- <=5000 psi
- >5000 psi
- >=15000 psi
Flaws and Defects

• Both castings and forgings can suffer from flaws and defects as a result of the manufacturing process:
  - *Surface discontinuities* (laps, seams, cold shuts, tears, oxides, slivers, chips, foreign materials)
  - *Subsurface discontinuities* (porosity, voids, cracks, bursts, inclusions) often originating from the casting process

• Exposed to in-service conditions, these flaws and defects may affect the expected life of a part
Inherent differences between forgings & castings

- A major problem associated with casting is the development of porosity, cavities and inclusions.
- Forgings improve internal quality due to compressive deformation.
- Forgings tend to eliminate casting porosity and break up macro-segregation patterns.
- The decrease of voids and porosity in forgings is often a function of the reduction ratio. However, fragmentation of hard non-metallic inclusions can be detrimental, whereas more deformable inclusions may contribute to (desired) anisotropic properties.
ASM Metal Handbook:

“Although wrought materials have their own weaknesses, they are free of many of the defects that may be associated with casting”. 
Inspectability for internal defects

• NDE methods to detect defects all have their own characteristic:
  - Detection threshold (lower size of defect not disclosed)
  - Detection hit-rate (% of detectable defects not found)

• This implies:
  - Many defects present = defects may remain after acceptance
  - Few defects present = few defects may remain after acceptance
Does it matter?

• For both castings and forgings:
  - Surface breaking flaws and defects can be detected with sufficient accuracy.
  - For sub-surface flaws and defects:
    - (Semi) coarse grained materials might have problems with inspectability (CRA more so than CS).
    - With increasing thickness, sensitivity for RT becomes lower. On the other hand, for UT surface condition is of prime importance.

• Many services are typically for CO2 and/or H2S containing wells.
• In sour service, H2S enhances corrosion fatigue.
• ISO 15156 almost exclusively calls for forgings in high sour application.
• Therefore, there is a preference to use forgings.
HP low CO2 low H2S services

Allowing castings could be considered
• API 6A NDE amendments are suitable

but...

• May not be a commercially attractive niche
• Complicates the decision tree
• Requires additional information to be submitted
  (NDE quality levels and acceptance criteria)
Proposed solution

- Implicitly allow castings in some PSL3/3G/4 cases:
  - 5.3.2.1 c) Wrought products shall be used for primary parts in all services greater or equal than 15000 psi, or gas services or high H2S concentration oil services greater than 5000 psi
  - 5.4.3.1 c) identical to above

- In line with Figure A.3

- Allows castings for (extended) API 6D valves where principals specify PSL3/3G/4 quality