Barrel pumps

To BB5 or not to BB5, that is the question.

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2009 Calgary Pump Symposium
Double Case or Barrel Pump BB5

- Heavy duty radially or axially split inner casing with a secondary outer casing or “barrel”.
- Pressure containment joint is metal to metal with a confined gasket.

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Axially Split Multistage
BB3

- Casing is split to allow ease of maintenance
- Pressure containment is achieved at the parting flange with a custom cut gasket
When to specify a barrel pump?

- Barrels generally are considered more reliable than an axially split pump however strong MTBR comparison data is hard to come by
- As we will see later there are many other factors that can impact MTBR
- Experts have estimated that a barrel’s MTBR will be 50% longer than BB3
Para 5.3.9 Unless otherwise specified, pumps with radially split casings are required for any of the following operating conditions:

- a) a pumping temperature of 200 °C (400 °F) or higher (a lower temperature limit should be considered if thermal shock is probable);
- b) a flammable or hazardous pumped liquid with a relative density of less than 0.7 at the specified pumping temperature;
- c) a flammable or hazardous pumped liquid at a rated discharge pressure above 10 000 kPa (100 bar) (1 450 psi).

Axially split casings have been used successfully beyond the limits given above, generally for off-plot applications at higher pressure or lower relative density (specific gravity). The success of such applications depends on the margin between design pressure and rated pressure, the manufacturer’s experience with similar applications, the design and manufacture of the split joint, and the user’s ability to correctly remake the split joint in the field. The purchaser should take these factors into account before specifying an axially split casing for conditions beyond the above limits.
Typical markets and applications for double case barrel pumps

- Refinery
- Pipeline
- Power generation
- Water Injection
- CO2 injection and Sequestration
- De-scaling
When to specify a barrel pump?

- For Refinery Services: Hot, flammable and/or toxic fluids.
- Industry experience (and API recommend) using barrel pumps where rated discharge pressure > 100 bar (1,450 psig) and Pumping temperature > 200°C (400°F) or liquid SG < 0.70.

Barrel’s used when:
- Rated discharge pressure greater than ≈ 100 bar (1,500 psig)
- Additional reliability and maintainability is valued by client.
When to specify a barrel pump?

- For Boiler Feed service temperatures are high but fluid is clean water.
- For Power Generation Industry standard is for ring section style for all combined cycle applications. Barrel pumps used for base load coal and supercritical stations where reliability and availability is valued.
- For Boiler Feed in refinery and SAGD applications selection usually based on discharge pressure, BB3 below 200 bar, BB5 above

Barrel’s used when:
- Rated discharge pressure greater than ≈ 200 bar (3,000 psig)
- Additional reliability and maintainability is valued by client.
When to specify a barrel pump?

- For Pipeline service: Generally temperatures are low and users prefer the axial split multi-stage over barrel style pumps due to their ease of maintainability and lower tolerance of multiple leakage paths.
- Use axially split – BB1 and BB3.

Barrel’s used when:
- Rated discharge pressure greater than ≈ 200 bar (3,000 psig)
- Liquid S.G. lower than ≈ 0.50 (axial split is still acceptable at low pressure).
When to specify a barrel pump?

- For Water injection: Low temperature application with non hazardous or flammable liquids.
  
  Industry experience with axially split – BB3 – for rated discharge pressure up to 250 bar (3,750 psig).

Barrel’s used when:
- Rated discharge pressure greater than ≈ 250 bar (3,750 psig)
- Additional reliability and maintainability is valued by client.
When to specify a barrel pump?

- For CO2 sequestration / injection: Low temperature, non flammable fluid.
- Industry experience from the 1980s with axially split - BB3 to pressures ≈ 200 Bar (3,000 psi).

Barrel’s used when:
  - Rated discharge pressure greater than ≈ 200 bar (3,000 psig)
  - Additional reliability and maintainability is valued by client.
When to specify a barrel pump?

- For Steel mill de-scaling service: Hot, dirty and with frequent stops and starts.
- Often use axially split – BB3 – for rated discharge pressure to 275 bar (4,000 psig). Industry trending towards variable speed Barrel pumps to improve Mean Time Between Planned Maintenance.

Barrel’s used when:
- Rated discharge pressure greater than ≈ 275 bar (4,000 psig)
- Additional reliability and maintainability is valued by client.
When a Barrel is required or Specified
Major Considerations

Hydraulic considerations
- Hydraulic fit
- Efficiency
- Head Rise
- Suction specific speed
- NPSHA
- Minimum flow

Rotor design
- Mechanical stiffness
- Lomakin effect
- Max number of stages

Speed Limit
- Higher speed means fewer stages
- Gearbox
- NPSHA
When a Barrel is required or Specified Major Considerations

Bearing Arrangement

• Ball/ball
• Sleeve/ball
• Sleeve/tilting pad

Balancing axial thrust

• Balancing device (straight drum or flanged drum)
• Opposed impellers

Inner Casing

• Volute
• Diffuser
Operational Considerations – Hydraulic fit and operating range

- Hydraulic fit becomes more important in barrel pumps due to higher energy involved
- A point of efficiency means considerably more power
- Further from BEP results in higher vibration levels and likelihood of failure
- High head rise impacts downstream pressure ratings, low head rise can lead to control issues for parallel operation
- Typically manufacturers have more custom hydraulics available

Final selection of the optimum pump design is always a balance between a number of hydraulic and mechanical factors
Operational Considerations – Hydraulic fit and operating range

- Minimum flow, suction specific speed, NPSH margin

API Para ..5.1.10 ……the purchaser and the vendor should recognize the relationship between minimum continuous stable flow and the pump’s suction-specific speed. In general, minimum continuous stable flow, expressed as a percentage of flow at the pump’s best efficiency point, increases as suction-specific speed increases. However, other factors, such as the pump’s energy level and hydraulic design, the pumped liquid and the NPSH margin, also affect the pump’s ability to operate satisfactorily over a wide flow range.…

Final selection of the optimum pump design is always a balance between a number of hydraulic and mechanical factors.
Mechanical Stiffness and Lomakin Effects

Shaft stiffness criteria for critical service, unspared and other high reliability applications:

- Higher shaft stiffness is an indication of increased mean time between planned maintenance
- Less deflection at seal faces, less rubbing contact
- Very slender shafts rely heavily on liquid effects (Lomakin effect) and are not recommended.

"Duncan Hood Chart"—modified to reflect operating experience.

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Stage Limits and Speed

- Generally fewer stages is better but there is a trade off
- Typical max for most vendors is 14 stages but many experts limit at 10
- Fewer stages can be offered by decreasing the specific speed of the impellers, results in lower efficiencies
- Speeds higher than 3600 are very common on barrel pumps using steam turbines or motor/gearbox drives. Typical speed ranges are 5-8000 RPM
- Higher speed results in fewer stages but must consider the added complexity of a gearbox
- NPSH considerations often set the speed limit
- Consider critical speed issues and shaft stiffness
Bearing Arrangement

API 610 provides guidelines

- Ball/Ball for lower power and speeds
- Sleeve/Ball popular on pipeline applications
- Sleeve Tilting Pad: Most common barrel pump arrangement, requires an external lubrication system
Inner Casing axial split volute

- Dual volute balances radial loads.
- No rotor disassembly after balancing.
- Clearances can be inspected by removing top half casing, no necessity to dismantle bundle.
- Seal chambers are connected with balance line – operate at suction pressure.
- Longer stage length than equivalent diffuser style leading to larger values of L3/d4.
- Hydraulic balance/thrust load is more sensitive to vapor lock.
- Volute casing has 30% larger diameter than comparable flow diffuser casing, requires a larger barrel – extra cost!
Inner Casing Split Radial split diffuser

- Multiple diffuser channels balances radial loads.
- Affords:-
  - Smallest volume.
  - Ability to mill diffusers for excellent surface finish in waterways and accuracy of dimensions.
- Reliable internal sealing
  - Sensitivity to thermal shock during system transients is minimized
- Balance device has to break down full differential pressure.
Rotating Element – Opposed Impellers

- Opposed impeller construction creates hydraulic balance without use of a full differential pressure balance drum.
- Lower thrust loads permit use of low cost bearing arrangements (sleeve/ball) without expensive Force Feed Lube oil system.
- Even wear rate throughout pump life has minimum effect on bearing thrust loads.
- Centre stage piece (bearing effect) reduces effective bearing span leading to more stable rotor conditions.
- Rotor is not disassembled after balancing, rotor integrity is not compromised.
- Clearances can be readily inspected without dismantling the rotor.
- A spare rotor is much lower cost than a diffuser style bundle.

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Rotating Element –
Tandem or In-line Impellers

- Tandem impeller construction requires balance device.
- Even wear rate throughout pump life has minimum effect on bearing thrust loads.
- Close clearance balance device is located at area of minimal deflection.
- Overall length of rotor is minimized improving shaft flexibility factor and reliability.
Comparison in size 8 stage inner casings
(after performance testing)
Axial Thrust

Balancing device

Single diameter (straight) drum:
- Highest residual thrust
- Residual thrust increases with impeller running clearance wear
- High tolerance of partial vaporization

Combined disc-drum (flanged drum):
- Low residual thrust
- Only for medium temperature, clean liquids
- Self compensating for normal wear
- Lower tolerance of partial vaporization
SAGD High Pressure Boilerfeed Pump

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High head Diffuser Barrel for low gravity
Saudi Arabia Water Injection

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Offshore Water Injection
Conclusion

• Double case barrel pumps are applied for the most arduous, heavy duty and demanding pumping applications.
• Various design configurations are available within the industry and each have Pros & Cons associated with them.
• A collaborative dialogue with a friendly pump Sales Engineer will ensure the optimum design and selection for your application.
BB5 Barrel pumps

To be or not to be,
that is the question.

Thank You!