Twin Cone Expansion

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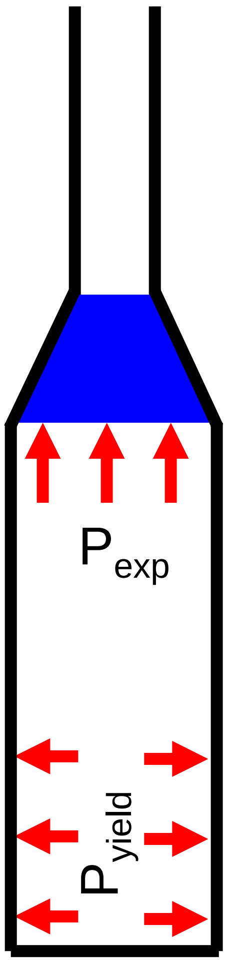
Why twin cone expansion ??

- Expandable technology has had limitations –
  - High Expansion ratios.
  - Limited wall thickness.
  - Thin wall connectors.
- This limits the applications of such a pervasive technology in the areas for hydraulic cone expansion -
  - High pressure clads.
  - High torque environments.
  - Long length liners.
- The following development addresses these by introducing a technique of reducing the expansion pressure.

Launcher System Limitations [Exp. Ratio]



- Maximum expansion pressure condition -

$$P\exp \leq Pyield$$

- Estimating the internal yield pressure [API 5C3] -

$$P_{yield} = 0.875 \cdot \left[\frac{2 \cdot t_{\exp}}{D_{ID.\exp}} \right] \cdot \sigma_y$$

- Estimating the expansion pressure -

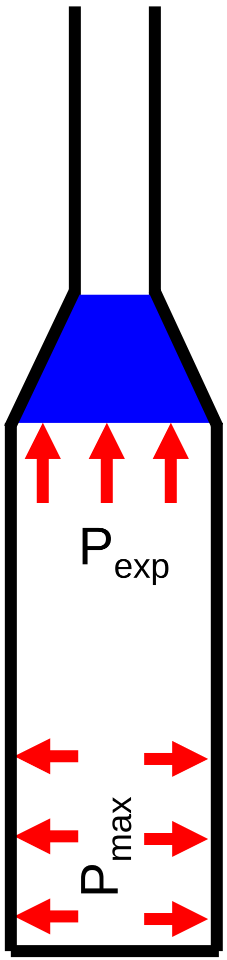
$$P_{\exp} = 4 \cdot 1.85 \cdot \sigma_y \cdot \frac{t_{orig}}{D_{orig}} \cdot \frac{\varepsilon}{(1+\varepsilon)^2}$$

Solving the above for expansion ratio, the maximum expansion ratio regardless of tubular geometry -

$$\varepsilon \leq 22.5\%$$

mohawk energy
expanding the limits

Launcher System Limitations [Collapse]



- Maximum expansion pressure condition -

$$P_{exp} \leq P_{max}$$

- Maximum D/t tubular that can be expanded, for a given pressure -

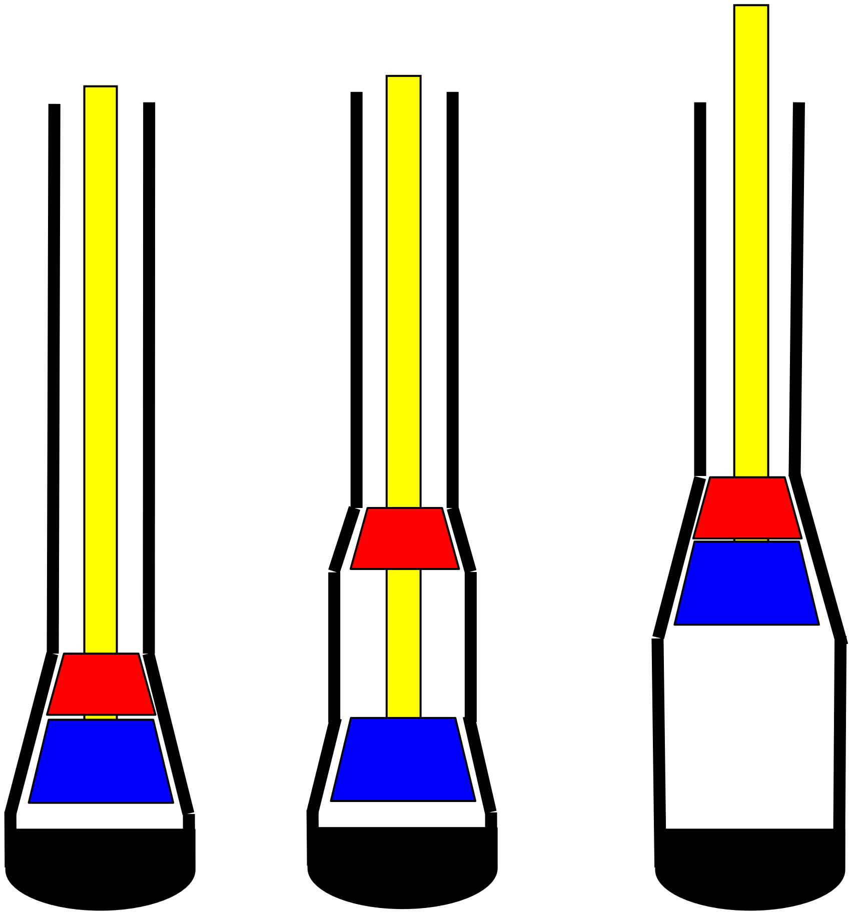
$$\frac{OD_{exp}}{t_{exp}} \geq \frac{Y_p}{P_{max}} \cdot 4 \cdot 1.85 \cdot \frac{\varepsilon}{(1-\varepsilon^2)} + 2$$

- Example - P_{max}=5,000 psi, σ_y=80,000psi and ε=20%

$$\frac{OD_{exp}}{t_{exp}} \geq 26.7$$

Therefore, using API 5C3 for collapse resistance of the expanded tubular - the limit is 2,500psi for this example.

Twin Cone Operation

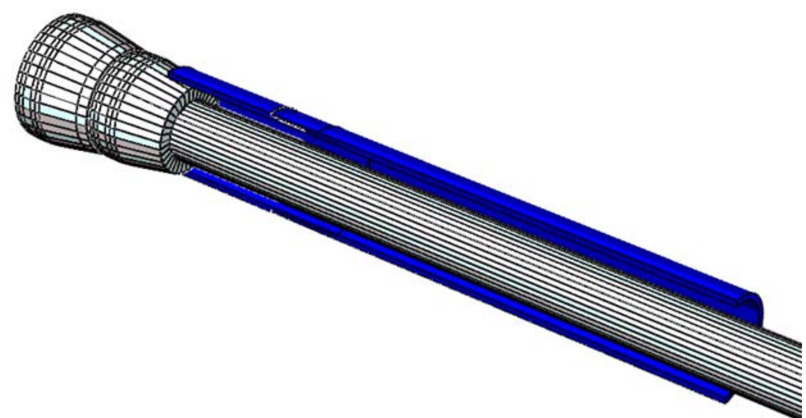


System is deployed, cone adjacent

Force applied to smaller diameter expansion cone to slide over shaft.

Force applied allow larger diameter expansion cone to lift shaft.

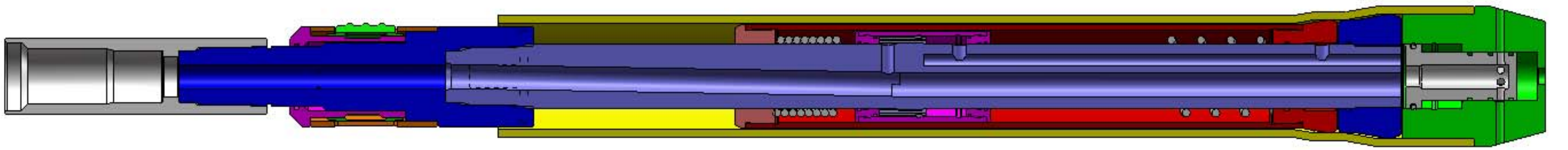
- The key is to use two cones, reducing the expansion force.
- Introducing a sequencing valve into the expansion process, allows this for bottoms up hydraulic systems.
- By reducing the expansion force - increases design possibilities for expandables.

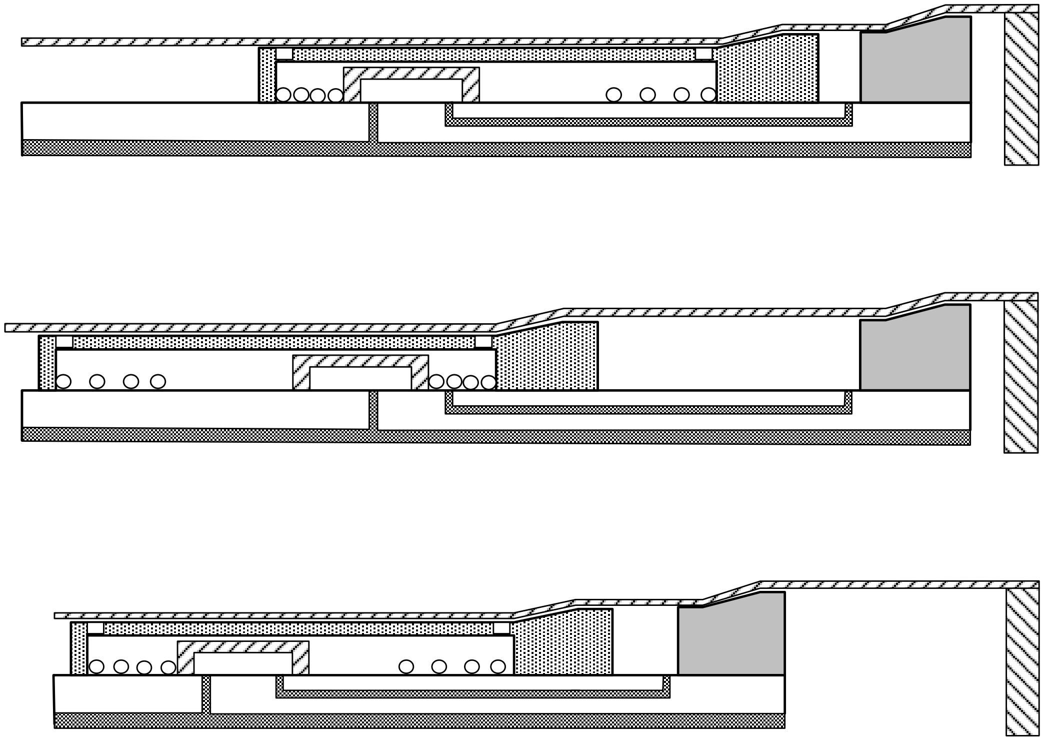


Twin Cone Advantages

- Higher expansion ratios.
  - Due to the reduction in expansion force, greater expansion ratios can be achieved.
  - For a bottoms up hydraulic system ~ 32% is possible.
- Expansion of thicker casing, at a given pressure.
  - In high pressure areas where a low D\t, or high collapse tubular is required.
- More robust connectors.
  - Great load capabilities for tension, compression, torque.
  - More resistance to damage during running in hole i.e. scratching.

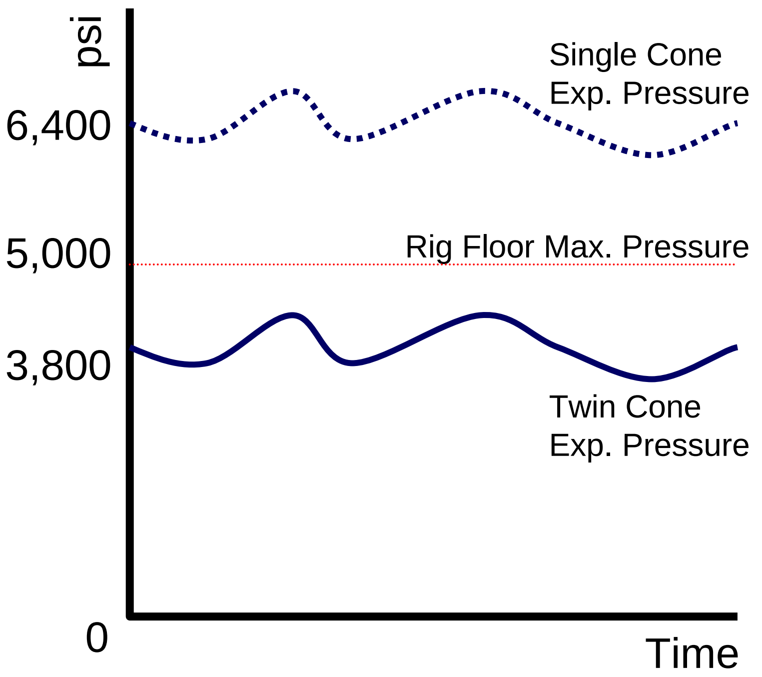
Twin Cone System Overview





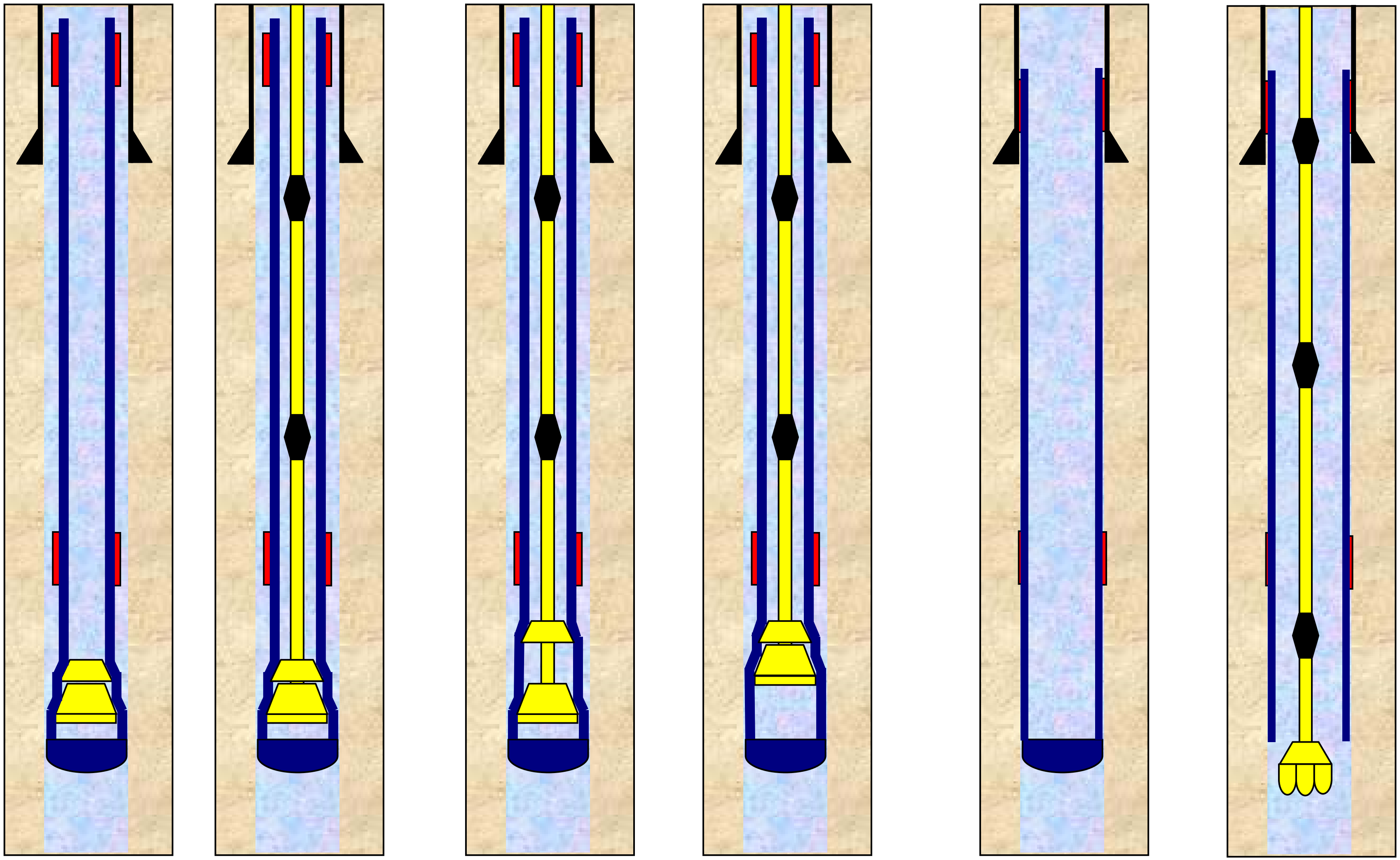
1. Deployment Configuration – Drill string pressure diverted to small cone
2. Small expansion cone progresses until valve is cycled, pressure is diverted to Large cone
3. Large expansion cone progresses until valve is cycled, pressure diverted to Small cone

Twin Cone Application



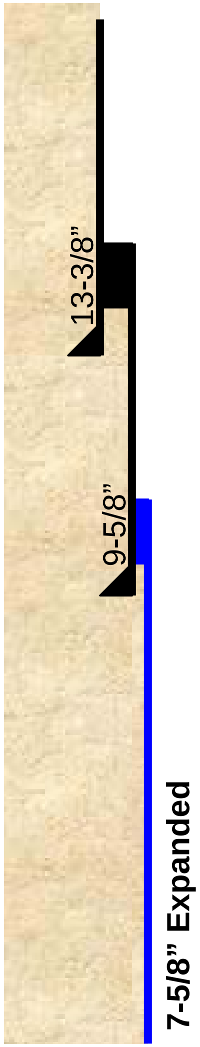
- Where the rig has limited pump pressure available, dual cone expansion brings advantages over single cone expansion.
- Lower pressures greater factor’s of safety for the expansion process.
- Opening possibilities for
  - Thru tubing applications.
  - High Collapse Casing clads.
  - Drill down expandables.

Twin Cone Deployment



Make-Up Expandable Casing	Stab-in anchor & Run to Depth	Apply constant pressure, small cone expands	Valve cycles, apply contact pressure to large cone	Pop-Out Leaving Open Hole Liner	Drill-out Shoe

High Pressure Open Hole Liner Example 1



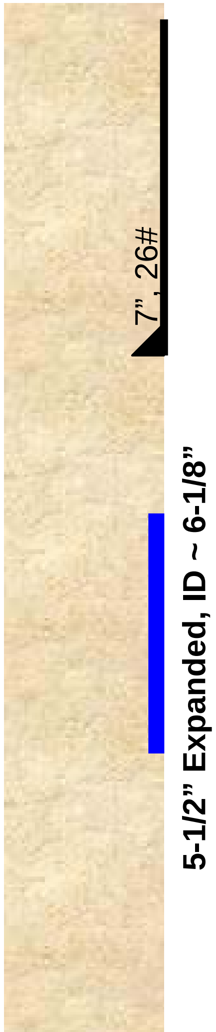
- The following example shows an openhole liner below the 9-5/8” casing. The 7-5/8” expandable has been selected to match the performance characteristics of the API string.

- Existing Casing
  - API 9-5/8”, 47#, L-80
  - ID ~ 8.681”
  - API Burst 6,870psi \ API Collapse 4,760psi

- Openhole Liner Post Expansion
  - 7-5/8”, 39#, 0.500”, 80Ksi
  - ID ~ 7.70”, Ratio ~ 16%
  - Burst 7,902psi \ $Collapse_f$ 5,507psi
  - Twin Expansion Pressure 3,575psi
  - Single cone expansion pressure 6,500psi

- From the above data it can be seen that the performance has been matched but with expansion pressure of only 3,575psi.

OpenHole MonoClad Example 2



- The following example demonstrates an Open Hole Monoclad application. 5-1/2” expandable is run in open hole drilled to 6-1/8” diameter, with an under reamed section. The liner is then expanded to give drift diameter of 6-1/8”.

- Existing Casing
  - API 7”, 26#, L-80
  - ID ~ 6.276”
  - API Burst 7,900psi \ API Collapse 6,560psi

- Openhole Liner Post Expansion
  - 5-1/2”, 17#, MTX-60
  - ID ~ 6.200”, Ratio ~ 27%
  - Burst 3,915psi \ Collapse$_f$ 2,199psi
  - Twin Cone Expansion Pressure 3,250psi
  - Single cone expansion 6,252psi

- The example shows that to-do 27% expansion with a hydraulic cone system, two cones are required due to the internal yield capabilities of the post expanded tubular.

Summary

1. Twin Cone expansion up to 32% can be hydraulically expanded in the in the wellbore.
2. Thicker tubulars and thus high collapse expandable tubulars can expanded at acceptable rig floor pressures.
3. Expandable tubular systems with high efficiency connectors can be expanded to give more reliable expansion.

THANK YOU

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