Asymmetric bulkheads are proposed for the ends of vertically oriented cylindrical pressure vessels. These bulkheads, which would feature both convex and concave contours, would offer advantages over purely convex, purely concave, and flat bulkheads (see figure). Intended originally to be applied to large tanks that hold propellant liquids for launching spacecraft, the asymmetric-bulkhead concept may also be attractive for terrestrial pressure vessels for which there are requirements to maximize volumetric and mass efficiencies.

A description of the relative advantages and disadvantages of prior symmetric bulkhead configurations is prerequisite to understanding the advantages of the proposed asymmetric configuration:

• In order to obtain adequate strength, flat bulkheads must be made thicker, relative to concave and convex bulkheads; the difference in thickness is such that, other things being equal, pressure vessels with flat bulkheads must be made heavier than ones with concave or convex bulkheads.
• Convex bulkhead designs increase overall tank lengths, thereby necessitating additional supporting structure for keeping tanks vertical.
• Concave bulkhead configurations increase tank lengths and detract from

These Pressure-Vessel Configurations have the same radius (R) and volume (4πR³/3). The different shapes are shown here to illustrate the advantages and disadvantages of each. This is a representative but not exhaustive set of configurations, and is limited to single, non-nested pressure vessels for the sake of simplicity.
volumetric efficiency, even though they do not necessitate additional supporting structure.

- The shape of a bulkhead affects the proportion of residual fluid in a tank — that is, the portion of fluid that unavoidably remains in the tank during outflow and hence cannot be used. In this regard, a flat bulkhead is disadvantageous in two respects: (1) It lacks a single low point for optimum placement of an outlet and (2) a vortex that forms at the outlet during outflow prevents a relatively large amount of fluid from leaving the tank.
- A concave bulkhead also lacks a single low point for optimum placement of an outlet.

Like purely concave and purely convex bulkhead configurations, the proposed asymmetric bulkhead configurations would be more mass-efficient than is the flat bulkhead configuration. In comparison with both purely convex and purely concave configurations, the proposed asymmetric configurations would offer greater volumetric efficiency. Relative to a purely convex bulkhead configuration, the corresponding asymmetric configuration would result in a shorter tank, thus demanding less supporting structure. An asymmetric configuration provides a low point for optimum location of a drain, and the convex shape at the drain location minimizes the amount of residual fluid.

This work was done by Donald B. Ford of Marshall Space Flight Center.

This is the invention of a NASA employee, and a patent application has been filed. Inquiries concerning license for its commercial development may be addressed to the inventor:

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