

Fundamental Support Types for Vertical and Horizontal Pressure Vessels

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Disclaimer: This document is meant for educational and interview preparation purposes and represents general engineering judgment. It is not an official ASME Code interpretation. Always refer to the most current edition of the applicable design code for your specific project requirements.

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1 Hook / Intro

A pressure vessel is only as reliable as its foundation—an improperly supported vessel can easily buckle under its own immense weight or fail catastrophically during a seismic event. Choosing the correct structural support is a critical first step in static equipment design to ensure safe load transfer to the foundation without compromising the integrity of the pressure boundary.

2 The Core Concept Explained

Pressure vessels require structural supports to carry the dead weight of the steel, the operating fluids, and environmental loads (like wind and earthquakes) while resisting the localized stresses these loads create. For **vertical vessels**, engineers typically select between skirts, legs, or lugs depending on the equipment's height, weight, and operational temperature. For **horizontal vessels**, saddle supports are the universal industry standard. Design codes stipulate that all external loads acting on these supports must be evaluated, though they rely heavily on established engineering mechanics and empirical formulas to determine exact sizing and stress limits.

3 Code Insight (Where to Look)

In ASME Section VIII, Division 1, the general requirements for supports are found in UG-54, while Nonmandatory Appendix G provides suggested good practices for evaluating piping reactions and support attachments. ASME Section VIII, Division 2 provides much more specific design rules and stress evaluation methods for structural supports—including detailed sections on saddles, skirts, and lug/leg supports—located in Part 4.15.

4 The “Why” Behind the Code (Engineering Mechanics)

- **Load Path:** Forces (weight, internal fluid, wind, seismic) travel from the pressure-retaining shell, through the attachment weld, down into the support structure (skirt, leg, lug, or saddle), through the base plate, and finally into the concrete foundation.
- **Stress Distribution:** The type of support dictates the stress distribution. A continuous cylindrical skirt distributes the load evenly around the vessel's circumference, minimizing local bending stresses. Conversely, discrete supports like legs or lugs concentrate the load at specific attachment points, generating high localized shear and bending moments in the shell wall. Horizontal saddles distribute loads over a specific contact arc (usually 120 degrees or more) to prevent the shell from crushing.
- **Failure Modes:** Critical failure mechanisms include compressive buckling of the vessel shell, local yielding at discrete attachment points, shear failure of the anchor bolts, and fatigue failure caused by restrained thermal expansion.

5 Key Design Checks / Governing Logic

- **Important Parameters:** The vessel's operating and empty weights, wind and seismic overturning moments, design temperature, shell thickness, and base plate bearing area.
- **Governing Load Cases:** The design is typically governed by either the full operating weight combined with maximum wind/seismic overturning moments, or the heavy water-filled condition during the field hydrostatic test.

- **Critical Checks:** Engineers must evaluate the support members for buckling and bending, the base plates for safe concrete bearing pressure, the anchor bolts for tension due to uplift, and the vessel shell itself for localized primary and secondary stresses at the support junction.

6 Design Decision Insight

Selecting a support type involves practical engineering trade-offs. For tall, heavy vertical process columns, a cylindrical or conical skirt is almost exclusively used because it distributes heavy loads uniformly and accommodates thermal expansion by allowing a temperature gradient along the height of the skirt. For smaller, short vertical vessels, braced or unbraced legs (made from pipe or structural steel) are highly economical but introduce localized stresses that thin shells may not be able to handle. Lugs are typically chosen when a medium-sized vessel is being supported from the middle by structural steel framing. For horizontal vessels, designers strictly prefer using exactly *two* saddles; adding more saddles creates a statically indeterminate beam, where minor foundation settling could drastically overload one saddle and puncture the shell.

7 Engineering Analogy

Think of supporting a vertical vessel on a skirt like resting a heavy drinking glass flat on a table—the weight is perfectly distributed around the continuous rim, making it incredibly stable. Supporting that same heavy vessel on legs is like resting the glass on three or four toothpicks; the load is highly concentrated at discrete points, which requires a much thicker “glass” (vessel shell) to prevent it from cracking under pressure.

8 Real-World Scenario & Common Failure

A classic practical failure occurs in high-temperature horizontal vessels when inexperienced installers bolt *both* saddles tightly to the concrete foundation. As the vessel heats up, the metal expands linearly. If both saddles are fixed, this thermal growth acts as a massive hydraulic ram, which can shear the anchor bolts, crack the concrete, or tear the saddle completely off the vessel shell.

Prevention logic: Engineers always design one saddle as “fixed” (to resist longitudinal wind/seismic loads) and the other as “sliding” (using slotted anchor bolt holes and low-friction slide plates like Teflon or Lubrite) to allow the vessel to breathe and expand freely.

9 Interview Perspective

How this is asked: “Why do we limit horizontal vessels to only two saddles, even for very long tanks?” or “How do you decide between using a skirt versus legs for a vertical vessel?”

Common mistakes: Suggesting that a very long horizontal vessel should have three or four saddles “to spread the weight better.” This ignores the risk of foundation settlement and structural stiffness.

What a strong answer includes: Explicitly mentioning Zick’s analysis for saddle design, differentiating between uniform load distribution (skirts) versus concentrated point loads (legs/lugs), and explaining how thermal expansion drives support design (fixed vs. sliding saddles, skirt thermal gradients).

One follow-up question: “How do you manage the local stresses in a thin-walled vertical vessel if you *must* use discrete leg supports?” (Strong answer: By adding internal reinforcing rings or external reinforcing pads at the leg attachment points to distribute the load).

10 Long-Term Takeaway

The core principle of static equipment support design is successfully managing the transition from uniform, pressure-retaining shells to discrete foundational tie-downs. The selected support must be robust enough to safely transfer massive static and dynamic loads into the ground, yet flexible enough to accommodate natural thermal expansion without tearing the vessel apart.

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This explanation synthesizes principles from the ASME Boiler and Pressure Vessel Code (Section VIII, Divisions 1 and 2), alongside established procedures from standard industry pressure vessel design handbooks.