

Spherical Tank Design & Material Selection Guide

Engineering Overview and Main Components

RELIABLE STEEL SOLUTIONS
FOR A SAFER TOMORROW



What is a Spherical Tank?

A spherical tank is a welded steel pressure vessel designed for the storage of compressed gases and liquefied gases under controlled pressure and temperature conditions. Its spherical shape develops approximately equal membrane stresses in all tangential directions, allowing efficient use of shell material for large-capacity pressurized storage.

Main Design Inputs



Storage Medium

LPG, ammonia, propylene, hydrogen, etc.



Design Pressure

Based on operating conditions



Design Temperature

Minimum and maximum design metal temperatures



Tank Capacity

Project-engineered (e.g. 400 – 10,000 m³)



Shell Diameter

Approximately 9,200 – 26,800 mm in selected reference designs



Shell Material

Carbon steel, low-alloy steel, stainless steel, or low-temperature steel

Typical Applications



LPG



Ammonia



Propylene



Hydrogen



Oxygen



CO₂

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Spherical Geometry and Pressure Resistance

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1. Stress Distribution Under Internal Pressure

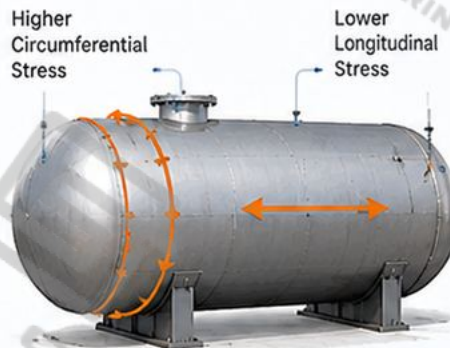
Spherical Tank



Uniform Membrane Stress

Internal pressure acts uniformly in all tangential directions. The spherical shape develops approximately equal membrane stresses in the shell, allowing efficient use of shell material.

Cylindrical Tank



Higher Circumferential Stress

Lower Longitudinal Stress

 Circumferential (Hoop) Stress
 Longitudinal (Axial) Stress

2. Same Volume, Less Surface Area



Spherical Tank



Cylindrical Tank

A spherical tank requires less surface area to enclose the same volume than a cylindrical tank. This can reduce the amount of steel needed for the pressure-retaining shell, subject to design pressure, material properties and code requirements.

3. Membrane Stress Formula (Thin Shell Approximation)

Spherical Tank

$$\sigma = \frac{P \times D}{4 \times t}$$

σ = Membrane stress (MPa)
 P = Internal design pressure (MPa)
 D = Internal diameter (mm)
 t = Shell thickness (mm)

Cylindrical Tank (Hoop Stress)

$$\sigma_h = \frac{P \times D}{2 \times t}$$

σ_h = Hoop (circumferential) stress (MPa)
 P = Internal design pressure (MPa)
 D = Internal diameter (mm)
 t = Shell thickness (mm)

Note: These are simplified thin-shell formulas for illustration only. Actual design shall follow applicable pressure vessel codes such as ASME Section VIII or GB/T 12337, and include corrosion allowance, weld joint efficiency, stress intensification and other factors.

4. Structural Behavior and Advantages



Uniform Stress Distribution
More even membrane stress under internal pressure



Efficient Material Use
Smaller surface area for the same volume



Suitable for High-Pressure Storage
Widely used for LPG, ammonia and industrial gases



Large-Capacity Application
Commonly applied for 400 – 10,000 m³ projects

Design Influencing Factors

Design pressure, tank diameter, material strength, temperature, corrosion allowance, code requirements and construction capability.

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Capacity, Pressure and Shell Thickness

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1. Key Design Parameters



Tank Capacity
400 – 10,000 m³
(project-engineered)



Design Pressure
Based on stored medium
and operating conditions



Design Temperature
Minimum and maximum
design metal temperatures



Shell Material
Q345R, Q370R, 16MnDR,
SA537 Class 2, stainless
steel, etc.



Design Code
ASME Section VIII,
GB/T 12337, or other
applicable standards

2. Shell Thickness and Typical Section



Shell Section Detail



Thickness Influencing Factors

- Design pressure
- Shell diameter
- Allowable material stress
- Design temperature
- Corrosion allowance
- Weld joint efficiency
- Applicable design code
- Service conditions

3. Engineering Reference Specifications for Different Storage Media

Storage Medium	Capacity (m ³)	Design Pressure (MPa)	Design Temperature (°C)	Shell Material	Nominal Shell Thickness (mm)
LPG	3,000	1.77	0 to 60	Q345R	46
Oxygen	2,000	3.15	-19 to 50	07MnMoVR	51
Liquid CO ₂	1,000	2.20	-30 to 50	16MnDR	42
Liquid Ammonia	2,000	2.50	-19 to 50	Q370R	54
Butane	4,000	0.79	-19 to 50	Q370R	24
Propylene	3,000	2.16	-19 to 50	Q370R	54
Hydrogen	400	2.00	-19 to 55	Q345R	34
Nitrogen	2,000	3.15	-20 to 60	SA537 Class 2	56

Note: The data are examples from separate engineering projects, not standardized Octal Steel stock specifications. Thickness values apply to the particular designs shown and should not be transferred to another tank without calculation.



LPG



Oxygen



Liquid CO₂



Liquid Ammonia



Butane



Propylene



Hydrogen



Nitrogen

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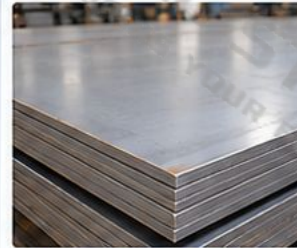
Materials, Fabrication and Design Considerations

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1. Common Shell Materials and Engineering Considerations

Material	Main Characteristics	Typical Application Conditions
Q345R	Pressure-vessel steel with good comprehensive properties	General pressure and temperature applications
Q370R	Higher strength than Q345R	Medium to higher design pressure where permitted
16MnDR	Low-temperature steel with good toughness	Low-temperature service, such as LNG, liquid CO ₂ and cold regions
SA537 Class 2	Heat-treated pressure-vessel steel with improved toughness	Low-temperature and higher-strength requirements
S30408	Austenitic stainless steel with excellent corrosion resistance	Corrosive media or process service applications
07MnNiMoDR	Specialized low-temperature steel with good toughness	Very low temperature service requiring grade-specific design

2. Material Forms and Inspection



Pressure-vessel Steel Plate
Material identification and thickness verification



Formed Spherical Shell Plates
Check material heat number and surface quality



Spherical Shell Segment
Dimensional and curvature inspection

Material Inspection Points



Material certificates and heat number



Thickness measurement

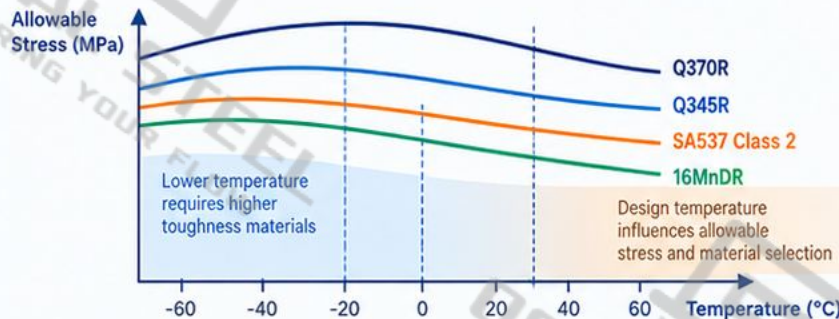


Surface condition and lamination



Mechanical properties as required by code

3. Temperature Effect on Material Selection



Allowable material stress decreases as temperature drops. For low-temperature service, such as LNG, liquid CO₂ or cold regions, materials with verified low-temperature toughness (e.g. 16MnDR, 07MnNiMoDR, SA537 Class 2) are selected based on the design code and project requirements.

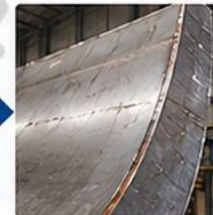
4. Fabrication of Spherical Shell Plates



Plate Cutting
CNC cutting to required size



Cold Forming
Hydraulic press forming to spherical curvature



Edge Preparation
Beveling for full penetration welding



Fit-up and Welding
Segment assembly and welding

Key Fabrication Considerations



Accurate curvature and dimensional control



Qualified welding procedure (WPS)



Post-weld heat treatment (PWHT) where required



Compliance with design code and project specification

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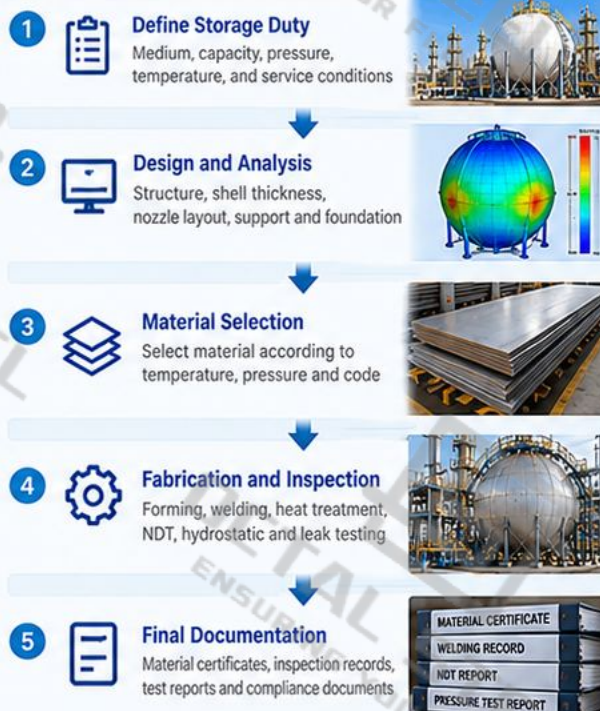
Applicable Standards, Design Process and Applications

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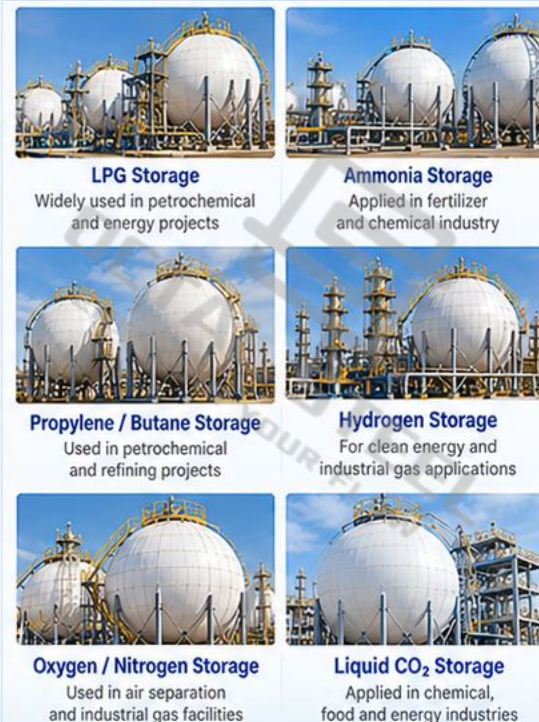
1. Applicable Standards and Regulations

Standard / Regulation	Relevance to Spherical Tanks
ASME BPVC Section VIII, Division 1	Pressure-vessel design, fabrication, examination, and testing under its applicable rules
ASME BPVC Section VIII, Division 2	Alternative pressure-vessel rules including more detailed design and analysis provisions
GB/T 12337	Chinese standard for steel spherical tanks within its applicable scope
GB/T 150 series	General pressure-vessel requirements where invoked by the governing design framework
PED 2014/68/EU	European regulatory conformity requirements for pressure equipment within its scope
ASME Section IX	Qualification of welding procedures and welding personnel
ASME Section V	Nondestructive examination methods when referenced by the applicable construction rules
API 2510	LPG installation requirements relevant to the overall storage facility, rather than a substitute for the pressure-vessel construction code

2. Spherical Tank Design Process



3. Typical Applications



4. Key Design Considerations

Safety	Material Selection	Fabrication Quality	Inspection and Testing	Project Compliance
Design and construct according to applicable codes and service conditions	Consider temperature, pressure, corrosion and toughness requirements	Qualified procedures and controlled welding and forming processes	Material, weld, dimensional, hydrostatic and leak tests as required	Meet design code and regulatory requirements for the target market