



Atmospheric

STORAGE SOLUTIONS

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Delivering Results

For more than a century, CB&I has focused on delivering atmospheric storage solutions safely, on time and with the highest quality standards. We specialize in consistently delivering these solutions through our unique, true EPC approach – designing and building projects turnkey and self-performing the work from concept to commissioning.

With more than 46,000 tanks built in more than 100 countries, we have accumulated more atmospheric storage tank design and construction experience than any other organization in the world.

We have designed and constructed the world's first floating-roof tank in 1923 to minimize evaporation, reduce product-side corrosion and decrease the risk and severity of fire or explosion. It has since become a worldwide standard for the storage of many petroleum and chemical products. We pioneered the concept of air raising tank roofs in the 1960s and also introduced the low-profile secondary rim seal in 2005, the VS 400, which is designed to increase usable tank capacity. Through the decades, we have remained a technical leader in the storage industry.

NOMINAL CAPACITY OF STORAGE TANKS

Diameter (feet)	Tank Height 20 ft (6.1 m)		Tank Height 30 ft (9.1 m)		Tank Height 40 ft (12.2 m)		Tank Height 50 ft (15.2 m)		Tank Height 60 ft (18.3 m)		Diameter (meters)
	Mbbbls*	m ^{3**}	Mbbbls*	m ^{3**}	Mbbbls*	m ^{3**}	Mbbbls*	m ^{3**}	Mbbbls*	m ^{3**}	
20	1.1	178	1.7	267	2.2	356	2.8	445	3.4	534	6.1
25	1.7	278	2.6	417	3.5	556	4.4	695	5.2	834	7.6
30	2.5	400	3.8	600	5.0	801	6.3	1001	7.6	1201	9.1
35	3.4	545	5.1	817	6.9	1090	8.6	1362	10.3	1635	10.7
40	4.5	712	6.7	1068	9.0	1423	11.2	1779	13.4	2135	12.2
45	5.7	901	8.5	1351	11.3	1801	14.2	2252	17.0	2702	13.7
50	7.0	1112	10.5	1668	14.0	2224	17.5	2780	21.0	3336	15.2
55	8.5	134	12.7	2018	16.9	2691	21.2	3364	25.4	4037	16.8
60	10.1	1601	15.1	2402	20.1	3203	25.2	4003	30.2	4804	18.3
65	11.8	1879	17.7	2819	23.6	3759	29.5	4698	35.5	5638	19.8
70	13.7	2128	20.6	3269	27.4	4359	34.3	5449	41.1	6539	21.3
80	17.9	2847	26.9	4270	35.8	5693	44.8	7117	53.7	8540	24.4
90	22.7	3603	34.0	5404	45.3	7206	56.6	9007	68.0	10809	27.4
100	28.0	4448	42.0	6672	56.0	8896	69.9	11120	83.9	13344	30.5
110	33.8	5382	50.8	8073	67.7	10764	84.6	13455	101.5	16146	33.5
120	40.3	6405	60.4	9608	80.6	12810	100.7	16013	120.9	19216	36.6
130	47.3	7517	70.9	11276	94.6	15034	118.2	18793	141.8	22552	39.6
140	54.8	8718	82.2	13077	109.7	17436	137.1	21795	164.5	26154	42.7
150	62.9	10008	94.4	15012	125.9	20016	157.4	25020	188.8	30024	45.7
160	71.6	11387	107.4	17080	143.2	22774	179.0	28467	214.8	34161	48.8
180	90.6	14412	136.0	21617	181.3	28823	226.6	36029	271.9	43235	54.9
200	111.9	17792	167.9	26688	223.8	35584	279.8	44480	335.7	53376	61.0
220	135.4	21528	203.1	32293	270.8	43057	338.5	53821	406.2	64585	67.1
240	161.1	25621	241.7	38431	322.3	51241	402.8	64052	483.4	76862	73.2
260	189.1	30069	283.7	45103	378.2	60137	472.8	75172	567.3	90206	79.2
280	219.3	35873	329.0	52309	438.6	69745	548.3	87181	658.0	104618	85.3

*Mbbbls = 1000 API Barrels
**m³ = Cubic Meters
*API BBL = 42 gallons
1m³ = 6.29 bbls



Proven Capabilities

Our capabilities range from single tank design and installation to complete design-build services for storage terminals. For any project we can provide:

- Concept definition
- Design and detail engineering
- Specification writing and material procurement
- Fabrication
- Project management
- Site development
- Foundation construction
- Mechanical and piping installation
- Tank construction
- Painting and coating
- Electrical installation
- Foam deluge and fire protection systems
- Inspection and testing

- Commissioning and startup
- Operator training
- Repairs and modifications

Experience sets us apart from the competition and enables us to quickly deliver the economical atmospheric storage solutions our customers expect. Whether a single fixed-roof or floating-roof storage tank or an entire terminal, our experienced team of civil, structural and construction engineers strives to optimize every tank component on the project.

Our skilled civil engineers analyze and design the most appropriate foundation alternatives. Our structural engineers analyze and evaluate the storage tank through the use of our state-of-the-art design tools and innovative finite element analyses for steel plate design. Our in-house construction engineering team provides specific designs and procedures for unique construction issues.

Complete Solutions

We offer a variety of atmospheric storage systems and terminals that can meet any customer need. Available as standard designs or engineered for specific needs, our storage solutions have ranged in size up to 1.5 million barrels (238,500 m³) and are designed to accommodate such geographic and climatic factors as temperature, wind, seismic and precipitation extremes.

Standard storage tanks

- Fixed-roof tanks
- External floating-roof tanks
- Internal floating-roof tanks

Special atmospheric tanks

- Elevated cone bottom tanks
- Bins
- Silos

Other design considerations

Our unparalleled storage tank expertise contributes to the development of unique and patented design details and construction techniques for a safer, better performing and longer lasting tank. Tank specifics to consider include:

- Product conditions
- Maximum usable capacity configurations
- Minimum product heel
- Environmental code requirements
- Unique loading conditions including seismic, blast or other dynamic loads
- Foundation design
- Welding sequences that control plate deformation of flat bottoms, decks and roofs
- Proven patented emission control devices
- Secondary containment systems
- Floating roof access options

Emission control

We have been a leader in the development and testing of emission control technology and equipment for above-ground storage tanks since our development of the first successful floating-roof storage tank in 1923. The focus of our development efforts is on emission control of storage tanks to meet environmental air quality requirements.

We have developed a wide range of emission control options to help tank owners and operators meet their specific requirements, which are generally very site-specific and dependent upon local regulations. Available emission reduction options range from add-on construction features for rim seals and roof

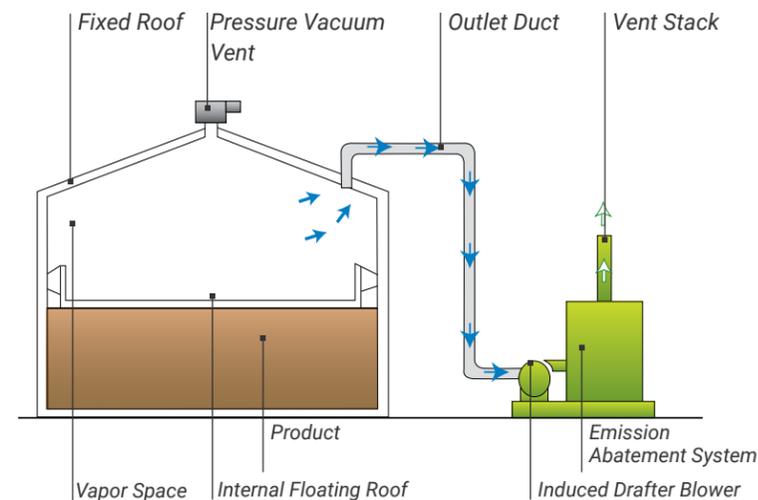
fittings to concepts where all atmospheric emissions are collected and treated, resulting in a Zero Emission Storage Tank facility.

STORAGE TANK EMISSION REDUCTION OPTIONS

Storage Tank Emission Reduction Options	Storage Tank Types			
	Fixed-Roof Tank	External Floating-Roof Tank	Internal Floating-Roof Tank	Closed Floating-Roof Tank
Add a Floating Roof	●			
Add a Fixed Roof		●		
Reduce Rim Seal Loss		●	●	●
Reduce Floating Roof Fitting Loss		●	●	●
Reduce Floating Roof Seam Loss			●	●
Reduce Product Clingage		●	●	●
Reduce Product Vapor Pressure	●	●	●	●
Collect and Treat Emissions	●		●	●



ZERO EMISSION COLLECTION AND TREATMENT FACILITY



OPTIONAL FITTINGS AND ACCESSORIES FOR ATMOSPHERIC STORAGE TANKS

Component	Fixed-Roof Tank	Type 5 Pontoon FRT	Double Deck FRT	Weathermaster FRT
Automatic Bleeder Vent		●	●	●
Automatic Tank Gage and Float Well	●	●	●	●
Circulation Vents - Screened				●
Drains		●	●	
- Pipe Drains		●	●	
- Flexible Hose/Pipe Drains			●	
- Emergency Drains			●	
Gage Hatch	●	●	●	●
Gage Well Pole		●	●	●
Guide Pole		●	●	●
Horton Seal		●	●	
- SR-1A				●
- SR-1S		●	●	
- SR-1		●	●	●
- VS 400		●	●	●
Inside Vertical Ladder		●	●	●
Nozzle	●	●	●	●
Pontoon Manholes		●	●	●
Rim Vent (Metallic Shoe Seal Only)		●	●	●
Rolling Ladder		●	●	
- With Self-Leveling Threads		●	●	
- Without Self-Leveling Threads				
Roof Supports		●	●	●
- Adjustable				●
- Fixed				●
Secondary Seals (Rim Mounted)		●	●	●
Shell Manhole	●	●	●	●
Sole Plates		●	●	●
Spiral Stairway and Platform	●	●	●	●
Swing Lines	●	●	●	●
Through-Roof Manhole	●	●	●	●
Top Windgirder		●	●	●
Wax Scrapers		●	●	●
Wear Plates		●	●	●

Fixed-Roof Tanks

Fixed-roof tanks are designed for low internal pressures. Tanks designed in accordance with API 650 can be designed up to a pressure of 2.5 psig (129 mm Hg).

Fixed-roof tanks may be equipped with either open or pressure-vacuum vents that are mounted on the fixed roof to provide sufficient venting capacity, thus protecting the tank from the damaging effects of overpressure or over vacuum. API 2000 describes the venting requirements for vents on fixed-roof tanks for both normal and emergency venting conditions.

Open type vents should be considered for products with a true vapor pressure less than 1.5 psia (77.6 mm Hg).

For higher vapor pressures, pressure-vacuum vents are normally installed.

A wide variety of fixed-roof styles is available, depending on the storage tank requirements.

- Column-supported cone roofs are generally the most economical option for tanks over 50 feet (15.2 m) in diameter
- Self-supporting dome or cone roofs are generally the most economical choice for tanks under 50 feet (15.2 m) in diameter



Floating-Roof Tanks

Floating-roof tanks have become the worldwide standard for the storage of many petroleum and chemical products. Our floating-roof tanks provide the most effective and practical means of reducing vapor emissions from stored volatile liquids. Floating-roof tanks may have an open (external) design or may include a fixed roof to aid in the protection of the (internal) floating roof. The tanks are generally designed to API 650 and are used to store products with a true vapor pressure up to approximately 11.1 psia (574 mm Hg). The basic features and benefits of a floating-roof tank are:

- Welded roof designed to float in contact with the stored product
- Rim seal system that closes the space between the floating-roof rim and the tank shell
- Floating-roof fittings that are functional and provide effective emission control

The contact-type floating-roof concept reduces the exposed liquid surface and the vapor volume susceptible to emissions to a minimum. Contact-type floating roofs also minimize corrosion on the underside of the floating roof.

Floating-roof tanks have compiled an impressive record of long-term, economical and dependable service. Our extensive experience in designing and constructing

floating-roof tanks ensures that a properly operated and maintained floating-roof tank will provide many years of reliable performance.

External floating-roof tank

An external floating-roof tank is a vertical cylindrical tank that has a roof which floats on the liquid product surface. It significantly reduces evaporative losses and the hazards associated with having a large, possibly combustible, vapor space. The external floating roof, however, is exposed to snow, ice and rain.

Weathermaster® internal floating-roof tank

The internal floating-roof tank was developed to provide protection of the floating roof while keeping the evaporated loss low. The tank space, located above the floating roof and below the fixed roof, is equipped with circulation vents to reduce the potential for product vapor accumulation. The use of the fixed roof virtually eliminates the effect of the wind on emissions from the floating-roof rim seal and deck fittings. Our internal floating roof is of welded construction, eliminating roof seam emissions. Our Weathermaster internal floating-roof tank combines many of the advantages of both fixed and floating-roof tanks. The Weathermaster internal floating-roof tank keeps out snow, ice and rain, effectively controls emissions and protects the internal floating roof from lightning.

Closed floating-roof tank

Similar to an internal floating-roof tank in that it uses both a fixed roof and an internal floating roof, but it does not use circulation vents to provide natural ventilation of the tank. Instead, the closed floating-roof tank is equipped with gas blanketing and pressure-vacuum vents. Emissions are virtually the same as those from an internal floating-roof tank. However, this type of tank permits the emissions to be easily collected for further treatment in an emission abatement system, if additional emission control is necessary.

Floating-Roof Types

Type 5 pontoon floating roofs

Our Type 5 pontoon floating roofs have a compartmented annular ring of pontoons and a center single deck. The design of the floating roof provides sufficient strength and buoyancy to keep the roof floating when the center deck and any two adjacent pontoon compartments are punctured or when the center deck is loaded with the design rainfall. The roof is designed to float directly on the product. The underside of the pontoon slopes upward toward the center of the roof to hold temperature-generated condensable vapor under the center single deck. The top deck of the pontoon slopes downward toward the center to direct rainwater onto the single deck.

Double-deck floating roofs

Double-deck floating roofs have two complete decks joined by a series of concentric rims. The outer annular

bay is compartmented by radial bulkheads. The design of the roof provides sufficient buoyancy to keep the roof floating with any two compartments punctured. Emergency overflow drains are provided to prevent storm water accumulation from exceeding the capacity of the roof. The roof is designed to float directly on the product. The air space between the upper and lower decks reduces the amount of surface product heating from ambient air temperatures and solar radiation. This significantly reduces the formation of temperature-generated condensable vapor under the floating roof. For heated tanks, the insulating effect of the double-deck floating roof reduces heat loss and helps to maintain the desired product temperature.

Internal floating roofs

Our internal floating-roof tank uses a welded steel, single-deck, contact-type internal floating roof, typically of pan-type construction. Pontoons, open or covered, can also be provided for more positive flotation and increased stability. For unusual applications, double-deck floating roofs can also be provided. No rainwater drainage system is required. Elimination of this system may permit operation of the floating roof at lower liquid levels.

Type 6 internal floating roofs

The Type 6 floating roof is our new internal floating roof offering. This configuration uses annular pontoons and also open top central compartments and is classified as a hybrid type floating roof. This combination provides the benefits of a pontoon floating roof and allows a reduced pontoon height to better utilize tank volume. The VS 400 low profile secondary seal will allow even greater tank utilization.

CB&I is the world's leading designer and builder of storage facilities, tanks and terminals. With more than 59,000 structures completed throughout our 130-year history, CB&I has the global expertise and strategically located operations to provide our customers world-class storage solutions for even the most complex energy infrastructure projects.

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