



Hortonsphere[®]

PRESSURE VESSELS

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CB&I pioneered the concept of field-welding spheres in the 1920s and built the world's first field-erected Hortonsphere vessel in 1923. Since then, we have designed and built thousands of spheres around the world, including liquid spheres up to 94 feet (28.6 m) in diameter and gas spheres up to 110 feet (33.5 m) in diameter. We built the world's largest self-supporting sphere, measuring 225 feet (69 m) in diameter nuclear plant containment vessel in New York.

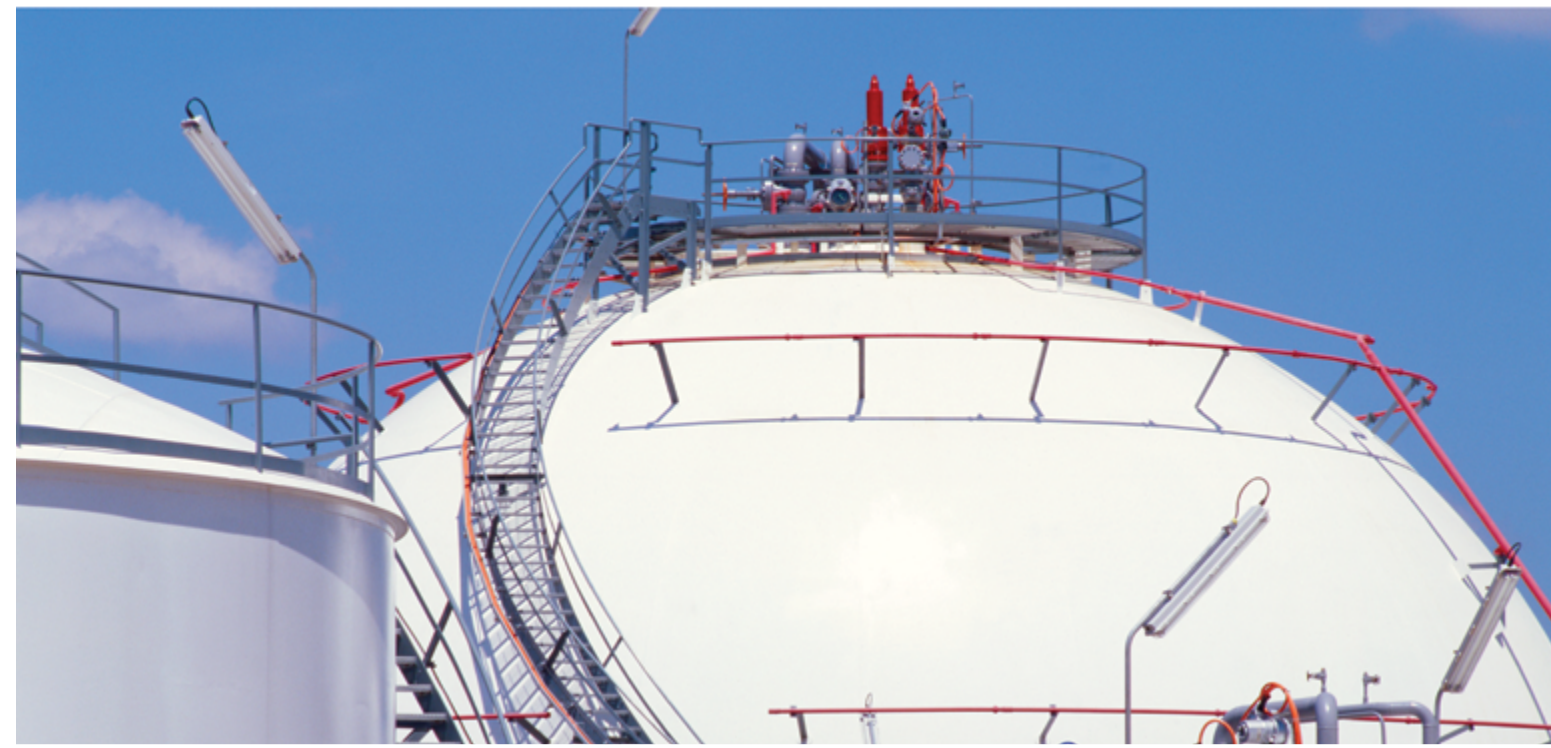
Ensuring the health and safety of our employees, customers and the community is a core value of CB&I. We uphold this value in the same way it ensures the quality of our work—implementing rigorous controls through every phase of our projects. CB&I is firmly committed to operating all of its facilities and projects in a safe, efficient manner and in compliance with applicable safety, health, and environmental laws, rules, and regulations. Many customers seek our input early in project development, enabling us to deliver long-term value with project-specific solutions. We ensure quality throughout the project, from our engineering design to the materials we select and by our expertise in welding and non-destructive testing of weld joints, including x-ray, ultrasonic and others, as necessary.

Our vast experience has given us a strong technical base and a foundation for continuous improvement of spheres and their related systems. Our civil, structural and mechanical engineers, together with our project managers and craftspeople, strive to optimize every component of a project. From a standard storage sphere to a complete turnkey terminal, We have the ability to work with customers to solve their complex and challenging project needs.

Ambient & Low Temperature Liquid Storage

The most common use for the Hortonsphere vessel is ambient temperature liquid storage. This method uses high stress advantages of the spherical shape to minimize wall thickness. Products stored in ambient and low temperature Hortonsphere vessels include:

- Gasoline
- Anhydrous ammonia
- Vinyl Chloride Monomer
- Naphtha
- Propane
- Propylene
- Ethane
- Butane
- Natural Gas Liquids
- Butadiene



Many of these products can also be stored at low temperatures by lowering the design pressure. A balance can be found between ambient temperature storage which uses full pressure with no refrigeration and fully refrigerated storage at atmospheric pressure. The vessel design pressure is lowered by 150 to 200 psig (10.3 to 13.8 barg), translating into lower cost vessels and larger storage capacities. Partially refrigerated Hortonsphere vessels are single-wall vessels with an external insulation system.

Cryogenic Temperature Liquid Storage

Hortonsphere vessels for cryogenic storage are fully refrigerated double-wall spheres with an evacuated, perlite-filled annular space. Cryogenic product storage requires boil-off vapor handling or liquefaction systems that can also be provided. Products stored in cryogenic Hortonsphere vessels include:

- LNG
- Methane
- Ethylene
- Hydrogen
- Oxygen

Gas Storage

Hortonsphere pressure vessels are commonly used by municipalities to store natural or manufactured gas and at sewage treatment plants for digester gas. They are also used in the petroleum, chemical and aerospace industries to store gases such as:

- Hydrogen
- Nitrogen
- Oxygen
- Helium
- Argon



Turnkey Terminal Projects

In addition to the spheres themselves, we furnish turnkey terminal facilities. Over the years, we have provided engineering, procurement and construction services for hundreds of marine, pipeline, rail and highway terminals. We can design and build the entire terminal facility, including infrastructure.

Other Uses

- Space chambers
- Hyperbaric chambers
- Environmental chambers
- Vacuum vessels
- Process vessels
- Test vessels
- Containment vessels
- Surge vessels

Optional Features

In addition to the standard features of a sphere, we can provide optional features such as:

- Water deluge systems
- Firewater spray systems
- Foundations
- Insulation
- Pressure relief and vacuum relief valves

Surface and Volume of Spheres

Diameter in Feet	Surface of Sphere(sq.ft.)	Volume of Sphere			Diameter in Feet	Surface of Sphere(sq.ft.)	Volume of Sphere		
		Cubic Feet	U.S. Gallons	U.S. Bbls.			Cubic Feet	U.S. Gallons	U.S. Bbls.
1	3.14	0.52	3.92	.09	61	11,690	118,847	889,037	21,168
2	12.57	4.19	31.33	.75	62	12,076	124,788	933,481	22,226
3	28.27	14.14	105.75	2.52	63	12,469	130,924	979,382	23,319
4	50.27	33.51	250.67	5.97	64	12,868	137,258	1,026,764	24,447
5	78.54	65.45	489.60	11.66	65	13,273	143,793	1,075,649	25,611
6	113.10	113.10	846.03	20.14	66	13,685	150,533	1,126,062	26,811
7	153.94	179.59	1,343.46	31.99	67	14,103	157,479	1,178,026	28,048
8	201.06	268.08	2,005.40	47.75	68	14,527	164,636	1,231,565	29,323
9	254.47	381.70	2,855.34	67.98	69	14,957	172,007	1,286,701	30,636
10	314.16	523.60	3,916.79	93.26	70	15,394	179,594	1,343,460	31,987
11	380	697	5,213	124	71	15,837	187,402	1,401,863	33,378
12	452	905	6,768	161	72	16,286	195,432	1,461,935	34,808
13	531	1,150	8,605	205	73	16,742	203,689	1,523,699	36,279
14	616	1,437	10,748	256	74	17,203	212,175	1,587,178	37,790
15	707	1,767	13,219	315	75	17,671	220,893	1,652,397	39,343
16	804	2,145	16,043	382	76	18,146	229,847	1,719,378	40,938
17	908	2,572	19,243	458	77	18,627	239,040	1,788,145	42,575
18	1,018	3,054	22,843	544	78	19,113	248,475	1,858,721	44,255
19	1,134	3,591	26,865	640	79	19,607	258,155	1,931,131	45,979
20	1,257	4,189	31,334	746	80	20,106	268,083	2,005,398	47,748
21	1,385	4,849	36,273	864	81	20,612	278,262	2,081,544	49,561
22	1,521	5,575	41,706	993	82	21,124	288,696	2,159,594	51,419
23	1,662	6,371	47,656	1,135	83	21,642	299,387	2,239,571	53,323
24	1,810	7,238	54,146	1,289	84	22,167	310,339	2,321,498	55,274
25	1,963	8,181	61,200	1,457	85	22,698	321,555	2,405,400	57,271
26	2,124	9,203	68,842	1,639	86	23,235	333,038	2,491,299	59,317
27	2,290	10,306	77,094	1,836	87	23,779	344,792	2,579,219	61,410
28	2,463	11,494	85,981	2,047	88	24,328	356,818	2,669,184	63,552
29	2,642	12,770	95,527	2,274	89	24,885	369,121	2,761,217	65,743
30	2,827	14,137	105,753	2,518	90	25,447	381,704	2,855,341	67,984

Diameter in Feet	Surface of Sphere(sq.ft.)	Volume of Sphere			Diameter in Feet	Surface of Sphere(sq.ft.)	Volume of Sphere		
		Cubic Feet	U.S. Gallons	U.S. Bbls.			Cubic Feet	U.S. Gallons	U.S. Bbls.
31	3,019	15,599	116,685	2,778	91	26,016	394,569	2,951,581	70,276
32	3,217	17,157	128,345	3,056	92	26,590	407,720	3,049,959	72,618
33	3,421	18,817	140,758	3,351	93	27,172	421,161	3,150,499	75,012
34	3,632	20,580	153,946	3,665	94	27,759	434,893	3,253,225	77,458
35	3,848	22,449	167,932	3,998	95	28,353	448,921	3,358,160	79,956
36	4,072	24,429	182,742	4,351	96	28,953	463,247	3,465,327	82,508
37	4,301	26,522	198,397	4,724	97	29,559	477,875	3,574,750	85,113
38	4,536	28,731	214,922	5,117	98	30,172	492,807	3,686,453	87,773
39	4,778	31,059	232,340	5,532	99	30,791	508,048	3,800,459	90,487
40	5,027	33,510	250,675	5,968	100	31,416	523,599	3,916,792	93,257
41	5,281	36,087	269,949	6,427	101	32,047	539,465	4,035,475	96,083
42	5,542	38,792	290,187	6,909	102	32,685	555,647	4,156,531	98,965
43	5,809	41,630	311,412	7,415	103	33,329	572,151	4,279,984	101,904
44	6,082	44,602	333,648	7,944	104	33,979	588,978	4,405,585	104,901
45	6,362	47,713	356,918	8,498	105	34,636	606,131	4,534,176	107,957
46	6,648	50,965	381,245	9,077	106	35,299	623,615	4,664,962	111,071
47	6,940	54,362	406,653	9,682	107	35,968	641,431	4,798,239	114,244
48	7,238	57,906	433,166	10,313	108	36,644	659,584	4,934,030	117,477
49	7,543	61,601	460,807	10,972	109	37,325	678,076	5,072,359	120,771
50	7,854	65,450	489,599	11,657	110	38,013	696,910	5,213,250	124,125
51	8,171	69,456	519,566	12,371	111	38,708	716,090	5,356,726	127,541
52	8,495	73,622	550,732	13,113	112	39,408	735,619	5,502,811	131,019
53	8,825	77,952	583,120	13,884	113	40,115	755,499	5,651,527	134,560
54	9,161	82,448	616,754	14,685	114	40,828	775,735	5,802,900	138,164
55	9,503	87,114	651,656	15,516	115	41,548	796,329	5,956,951	141,832
56	9,852	91,952	687,851	16,377	116	42,273	817,284	6,113,705	145,564
57	10,207	96,967	725,362	17,271	117	43,005	838,603	6,273,185	149,362
58	10,568	102,160	764,213	18,196	118	43,744	860,290	6,435,415	153,224
59	10,936	107,536	804,427	19,153	119	44,488	882,348	6,600,417	157,153
60	11,310	113,097	846,027	20,144	120	45,239	904,799	6,768,217	161,148

Notes: If diameters are assumed as meters, values in columns "Surface of Sphere in Square Feet" and "Volume of Sphere in Cubic Feet" will represent Surface of Sphere in Square Meters and Volume of Sphere in Cubic Meters respectively. Surface Area of sphere = $3.141593 D^2$ Square Feet. Volume of sphere = $0.523599 D^3$ Cubic Feet., = $0.093257 D^3$ Barrels of 42 U.S. Gallons. Numbers of barrels of 42 U.S. Gallon at any inch in a true sphere = $(3d-2h)h^2 \times .0000539681$ where d is diameter of sphere and h is depth of liquid in inches.

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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