Containment Configurations for Low Temperature and Cryogenic Storage

Presented by Brad Veath & Kevin Gallagher

November 13, 2025

Steel Tank Institute
Steel Plate Fabricators Association
944 Donata Court
Lake Zurich, IL 60047

CB&I
1725 Hughes Landing Blvd
The Woodlands, TX 77380

Caldwell Tanks
4000 Tower Road
Louisville, KY 40219

STI/SPFA
Containment Configurations for Low Temperature and Cryogenic Storage

Bradley M. Veath, P.E.
CB&I

- Vice President Business Development – USA
- 32+ years of experience with CB&I holding roles in design, fabrication, and construction of AWWA and API storage tanks and ASME vessels, as well as assignments in marketing and business development
- Graduate of the University of Illinois Urbana-Champaign with a Bachelor of Science in General Engineering
- Licensed professional Civil Engineer
- STI/SPFA Board of Directors

STI SPFA

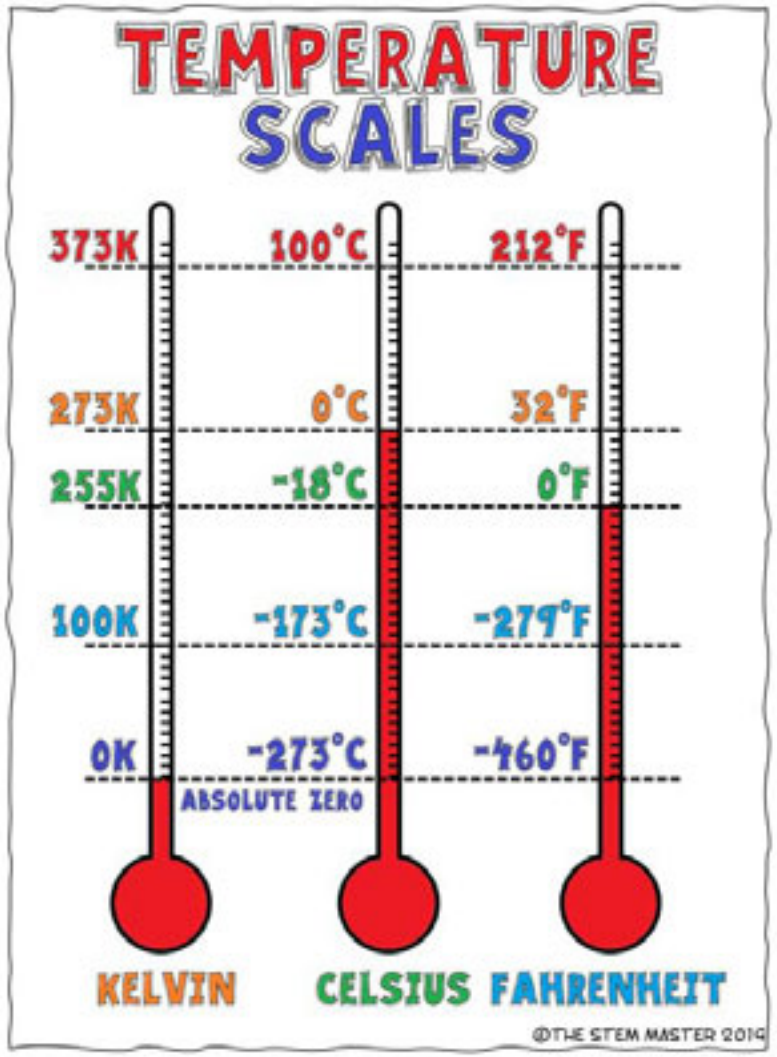
STI/SPFA
Containment Configurations for Low Temperature and Cryogenic Storage

Kevin J. Gallagher, P.E.
Caldwell Tank, Inc.

- Vice President of Caldwell Tanks, Inc.
- 30+ years of industry experience
- Co-author of *Steel Water Storage Tanks*, AWWA's comprehensive book on the design, construction, maintenance, and repair of water storage tanks
- Contributor to *Scientific American*, *Modern Marvels*, and other industry journals
- Active member of: ASCE, AWWA, API, STI/SPFA, ILTA, NISTM, IDEA, NACE, and NRWA
- Past Chairman of STI/SPFA Field Erected Tank Section
- Past STI/SPFA Board of Directors Vice Chairman
- B.S. Civil Engineering – Structural, Purdue University
- MBA – University of Louisville

STI SPFA

PROPERTIES OF VARIOUS LIQUIDS



Boiling Point of Various Gases @ 14.7 psia

Normal Butane: 31 deg F
Isobutane: 11 deg F
Ammonia: -28 deg F
Propane: -44 Deg F
Carbon Dioxide -109 deg F
Ethane: -127 deg F
Ethylene: -154 deg F
Methane: -259 deg F
Oxygen: -297 deg F
Nitrogen: -320 deg F
Hydrogen: -423 deg F
Helium: -452 deg F

STI SPFA

LOW TEMPERATURE VS. CRYOGENIC

API 620 – Cover the design and construction of large, welded, low pressure carbon steel above ground storage tanks (including flat-bottom tanks that have a single vertical axis of revolution.

“Cryogenic Storage”
Annex Q – Covers Low-pressure Storage Tanks for Liquified Gases –325 deg F and Warmer

“Refrigerated Storage”
Annex R – Covers Low-pressure Storage Tanks Operating Between 40 deg F and -60 deg F.

STI SPFA

CONTAINMENT CONFIGURATIONS FROM API 625

SINGLE CONTAINMENT TANK SYSTEMS

Section 5.1.4 “… It can be a liquid- and –vapor-tight single-wall tank or a tank system composed of an inner and outer container, designed and constructed so that only the primary liquid container is required to be liquid-tight and contain the liquid product.”

STI SPFA

CONTAINMENT CONFIGURATIONS FROM API 625

DOUBLE CONTAINMENT TANK SYSTEMS

Section 5.3.1 “ … consists of a liquid- and vapor tight primary tank system, which is itself a single containment tank system built inside a liquid-tight secondary liquid container.”

Section 5.3.2 “The secondary liquid container is designed to hold all the liquid contents of the primary container in the event of leaks from the primary container, but it is not intended to contain or control any vapor resulting from product leakage from the primary container.”

STI SPFA

CONTAINMENT CONFIGURATIONS FROM API 625

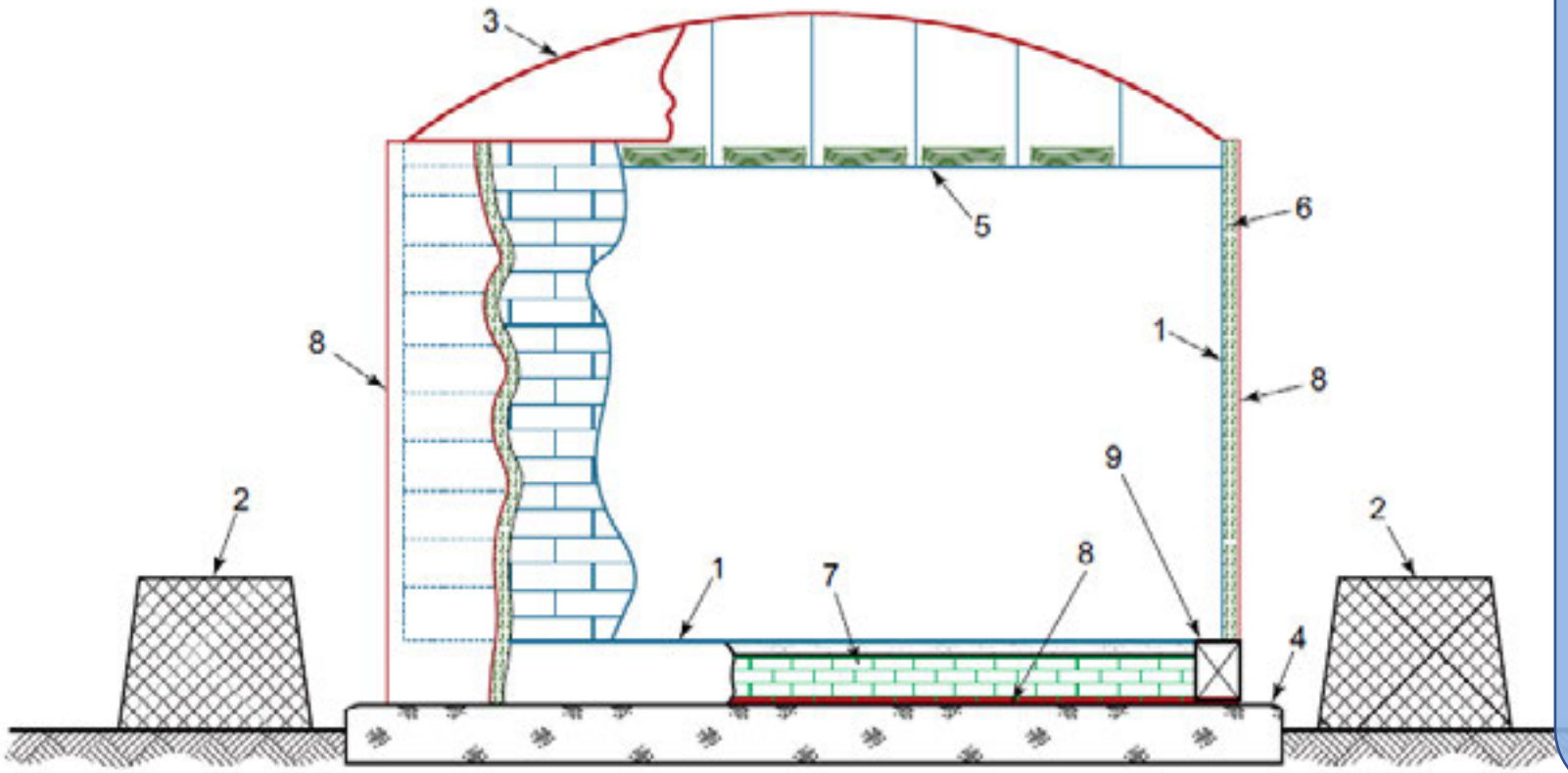
FULL CONTAINMENT TANK SYSTEMS

Section 5.4.1 “… consists of a liquid-tight primary container and a liquid- and vapor-tight secondary liquid container. Both are capable of independently containing the product stored.”

Section 5.4.2 “The secondary liquid container shall be capable of both containing the liquid product and controlling the vapor release in the event of product leakage from the primary liquid container.”

STI SPFA

SINGLE CONTAINMENT / SINGLE WALL



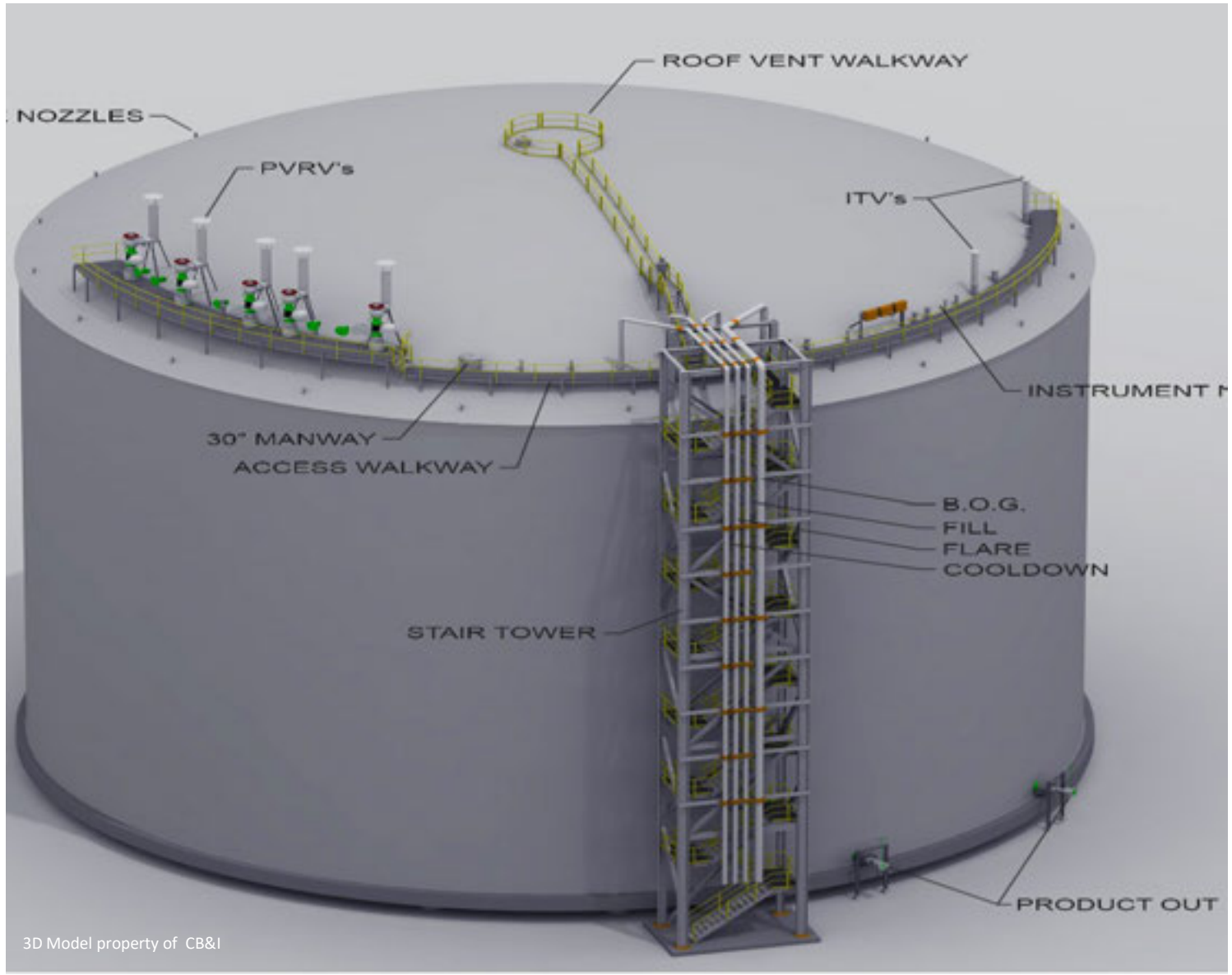
- Single liquid and vapor tight container used to store refrigerated product.
- Remote dike is required to contain leaks/spill.
- Bottom Insulation – Cellular glass.
- Shell Insulation – Polyurethane foam with moisture barrier (aluminum jacket).
- Suspended Deck Insulation – Fiberglass.

Key

1 primary liquid container (low temp steel)
2 secondary containment (dike wall)
3 warm product vapor container (roof)
4 concrete foundation
5 suspended deck with insulation
6 insulation (external)
7 load-bearing insulation (bottom)
8 moisture barrier
9 ring beam

STI SPFA

SINGLE CONTAINMENT



- Single Containment
- Single Walled Steel Tank with External Insulation or Double Walled with Perlite Annular Space or External Insulation
- Side Discharge with External Product Pumps
- Free Standing Stairtower for External Insulation or Shell Supported with Annular Space Insulation

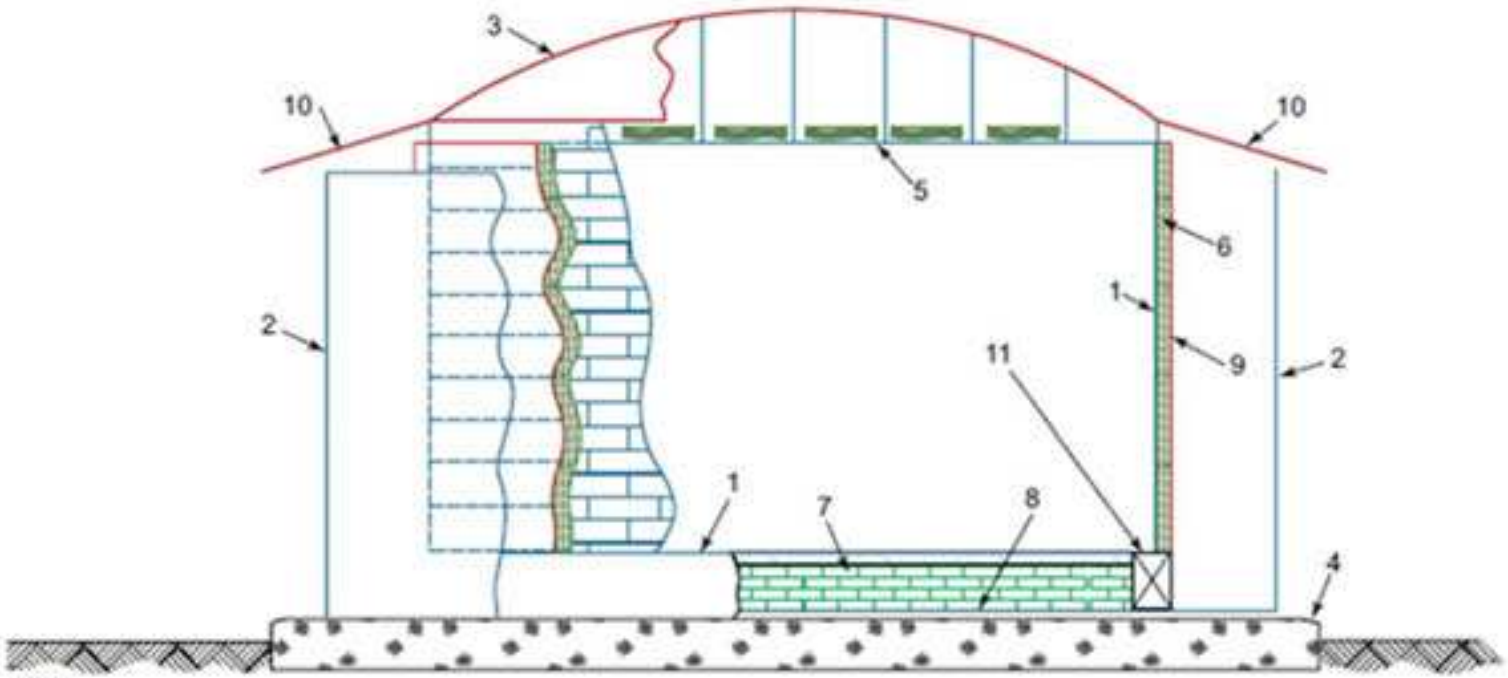
SINGLE CONTAINMENT / SINGLE WALL / EXTERNAL INSULATION

SINGLE CONTAINMENT / DOUBLE WALL / ANNULAR INSULATION / SIDE WITHDRAWAL

STI SPFA

SINGLE CONTAINMENT / DOUBLE WALL / ANNULAR INSULATION / IN-TANK PUMPS

DOUBLE CONTAINMENT



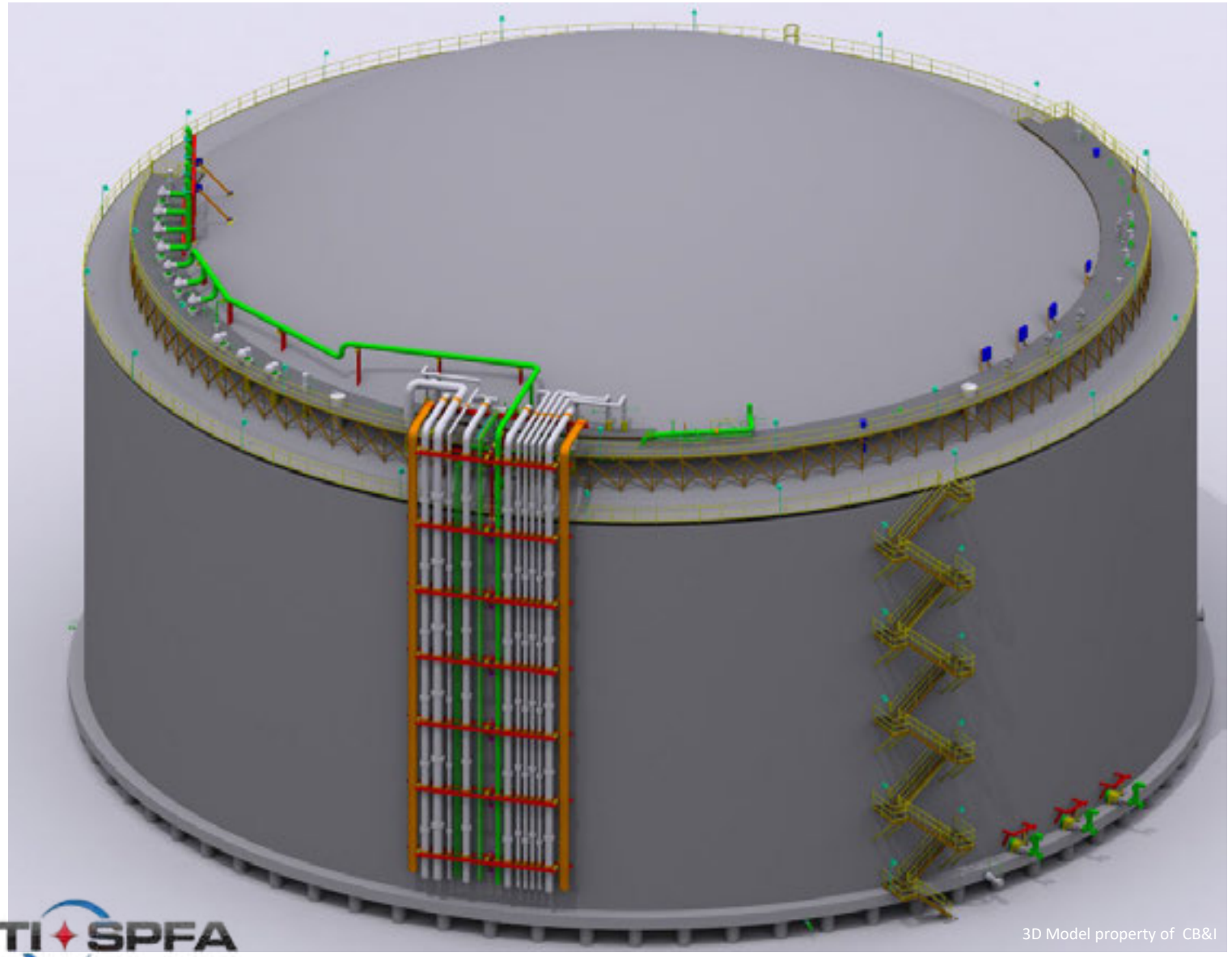
Key

1	primary liquid container (low temp steel)	5	suspended deck with insulation	9	moisture barrier
2	secondary liquid container (low temp steel)	6	insulation (external)	10	rain shield
3	warm product vapor container (roof)	7	load-bearing insulation (bottom)	11	ring beam
4	concrete foundation	8	secondary liquid container (low temp steel)		

- Inner liquid and vapor tight container used to store refrigerated product.
- Secondary containers designed to store refrigerated liquid.
- Secondary container not intended to contain or control any vapor resulting from product leakage from the primary container.
- Secondary container shall be in close proximity to primary container.
- Shed roof over annular space for weather protection.
- Atmospheric moisture condensation in annular space can be an issue.

STI SPFA

DOUBLE CONTAINMENT



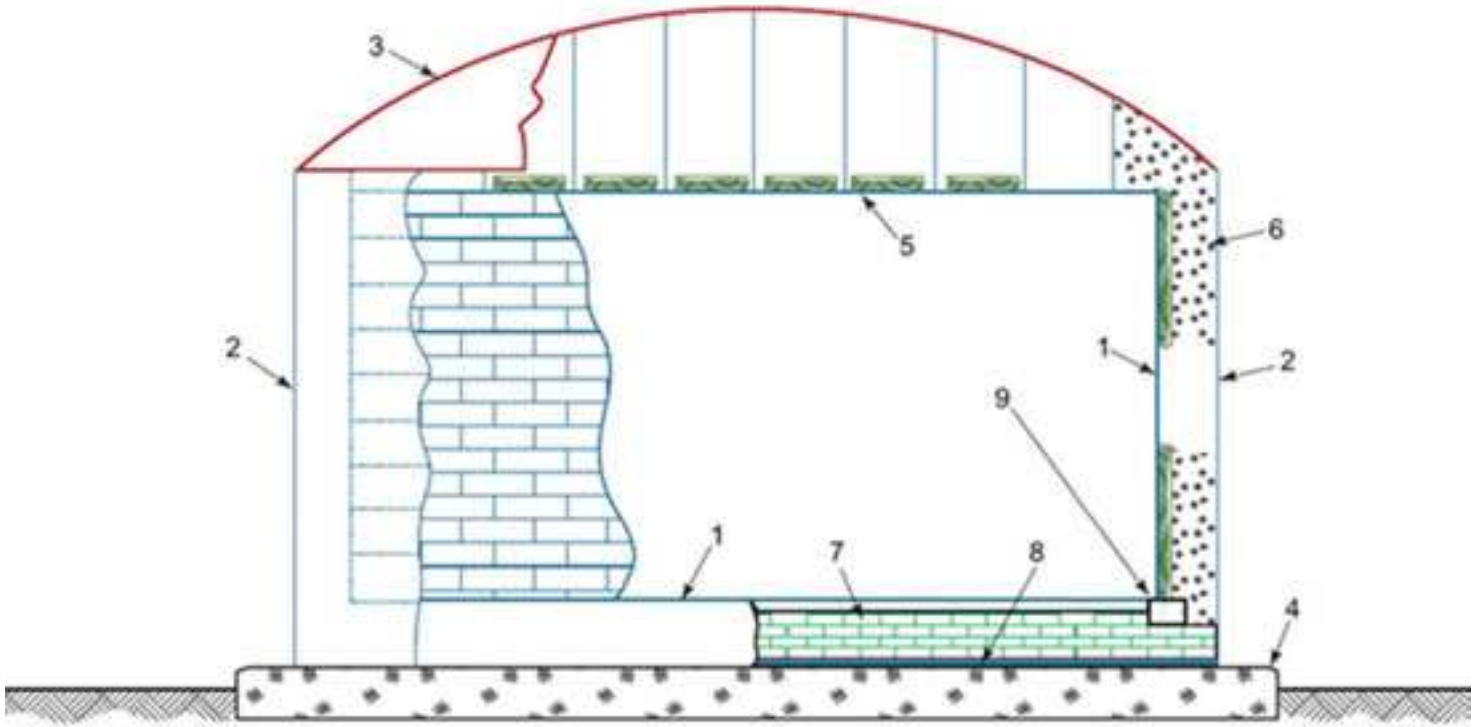
- Double Containment
- Single or Double Wall
  Single Containment Tank with External Close-In Bund Wall
- Can be Side Discharge with ITV with External Tank Pumps or In-Tank Pumps
- No Vapor Containment for a Primary Container Leak

DOUBLE CONTAINMENT TANK / SINGLE WALL W/ CLOSE CONCRETE BUND WALL

DOUBLE CONTAINMENT TANK / DOUBLE WALL W/ SHED ROOF

STI SPFA

FULL CONTAINMENT



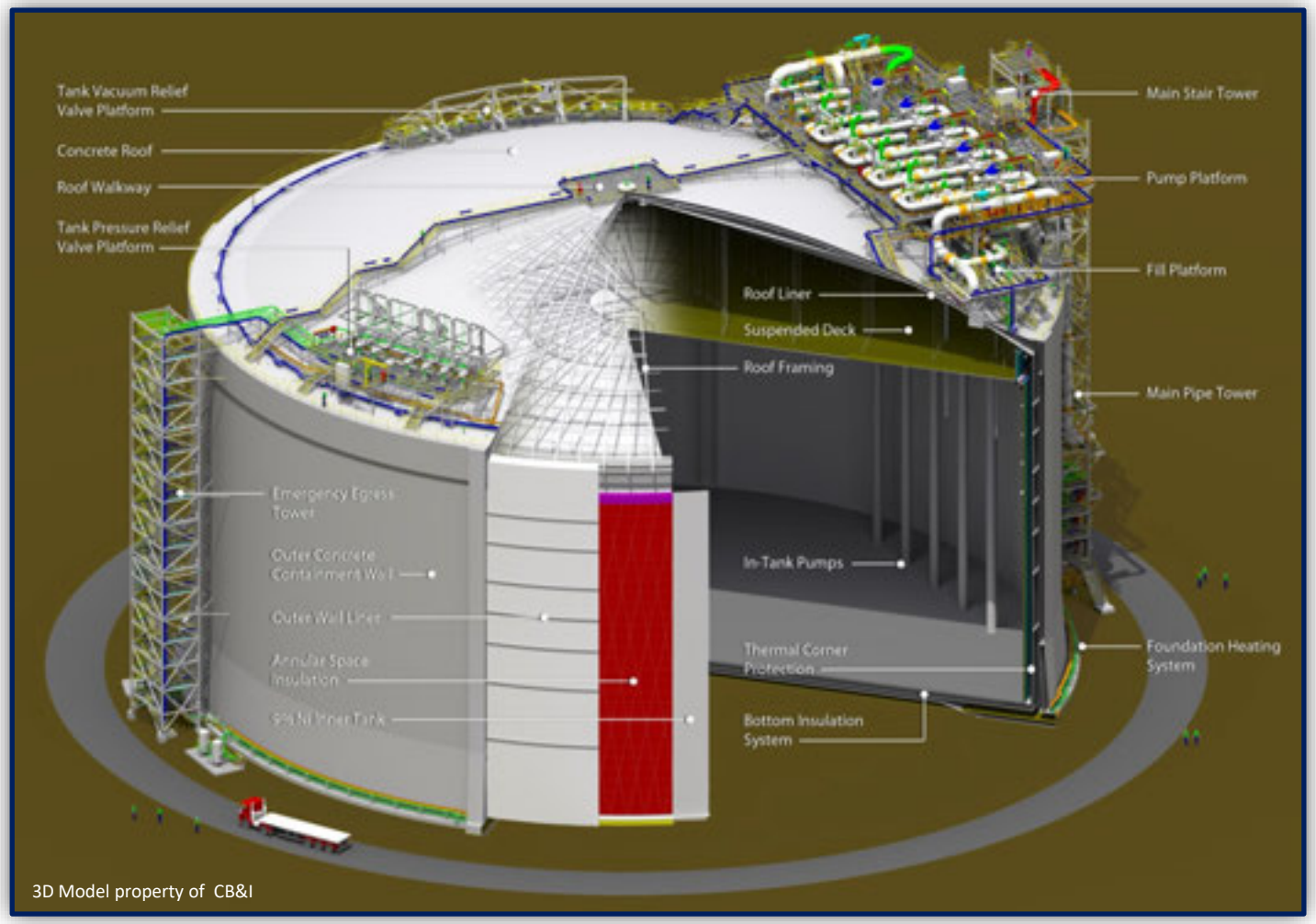
Key

1	primary liquid container (low temp steel)	5	suspended deck with insulation	8	secondary liquid container (low temp steel)
2	secondary liquid container (low temp steel)	6	insulation (annular space)	9	ring beam
3	warm product vapor container (roof)	7	load-bearing insulation (bottom)		
4	concrete foundation				

- Inner liquid tight container used to store refrigerated product.
- Both Primary and Secondary containers designed to contain refrigerated liquid.
- Secondary Container designed to control the vapor release (via venting system) in the event of product leakage from the Primary liquid Container.
- Bottom Insulation – Cellular glass.
- Shell Insulation – Perlite in annular space between inner and outer tank shells.
- Suspended Deck Insulation – Fiberglass.
- Alternative – External Insulation on outside face of secondary container.

STI SPFA

FULL CONTAINMENT



- Full Containment, Double Wall Tank
- Perlite Insulation in the Annular Space
- Can be side discharge with In Tank Valve and External Tank Pumps or In Tank Pumps
- Perimeter Walkway for nozzle and instrument access on roof
- Stairway (switchback or spiral)

STI SPFA

FULL CONTAINMENT STEEL / IN-TANK PUMPS

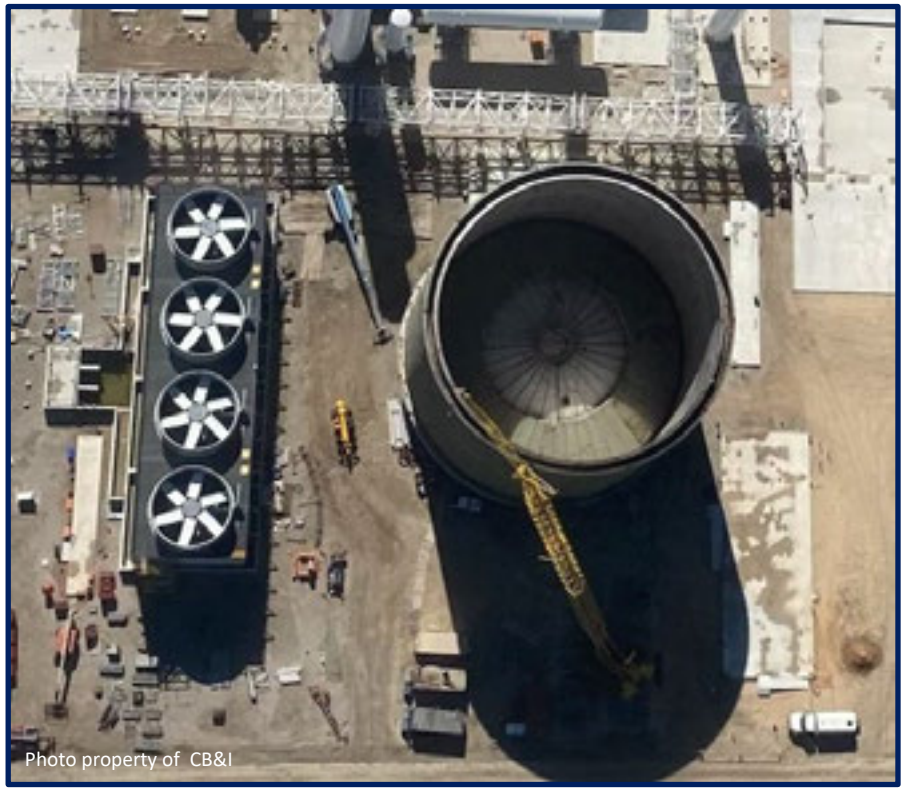
d text

FULL CONTAINMENT TANK / CONCRETE OUTER / IN-TANK PUMPS

STI SPFA

FULL CONTAINMENT TANK / CONCRETE OUTER / IN-TANK PUMPS

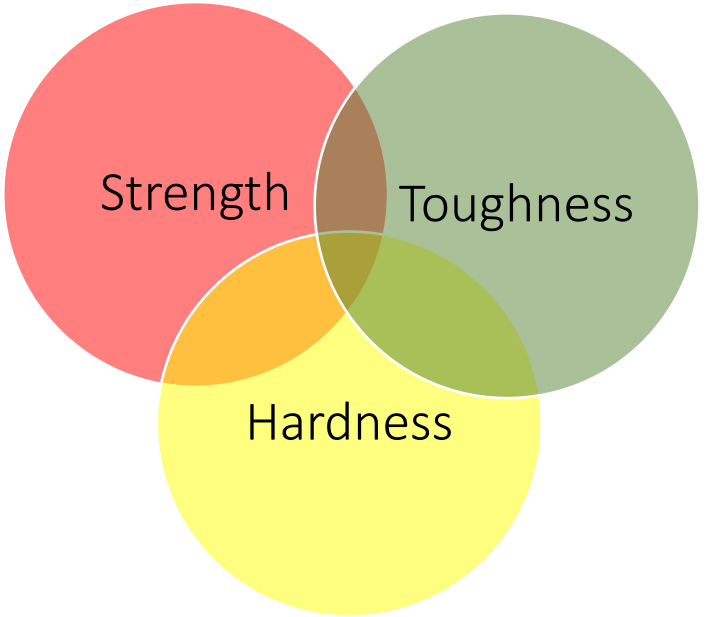
LIQUID NITROGEN / OXYGEN / ARGON TANK CONFIGURATIONS ARE UNIQUE



STI SPFA

MATERIAL SELECTION AND WELDING PROCEDURES ARE CRITICAL AND SPECIALIZED FOR AMMONIA STORAGE

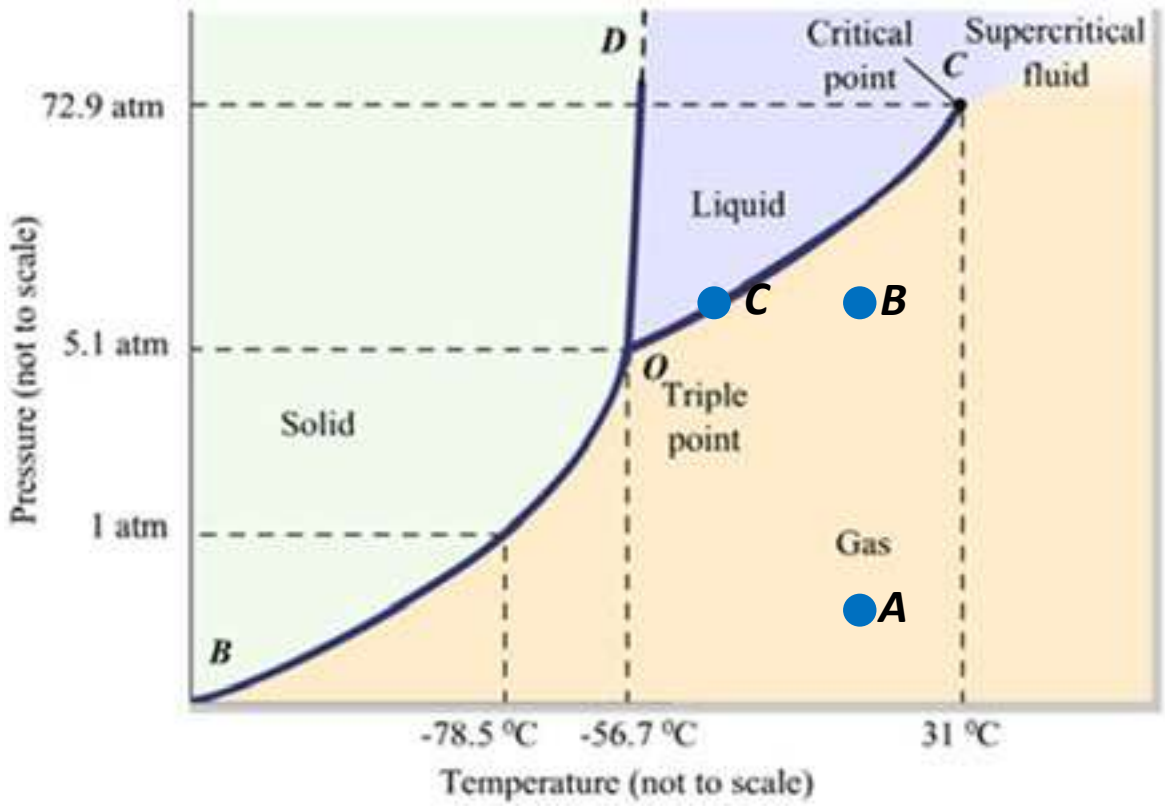
- Plate material shall be low carbon, low carbon equivalent, and of higher toughness with limited strength, to mitigate Stress Corrosion Cracking
- Weld electrode must be low hardness and provide higher toughness
- Refined welding technique, preheat & heat input levels optimize the welding procedure, and with bead sequencing allows control of joint material properties
- Post Weld Heat Treatment (PWHT) can be used to minimize hardness and enhance ductility.



STI SPFA

LIQUID CO2 MUST BE STORED IN A PRESSURE VESSEL

- The unique properties of CO2 requires a combination of pressure and refrigeration for storage
- As such, these structures are designed per ASME Section VIII rather than API 620
- Liquid CO2 can be designed in a single-wall, single-containment insulated sphere above the triple point



CURRENT TECHNOLOGY FOR LIQUID HYDROGEN IS THAT IT ALSO MUST BE STORED IN A PRESSURE VESSEL

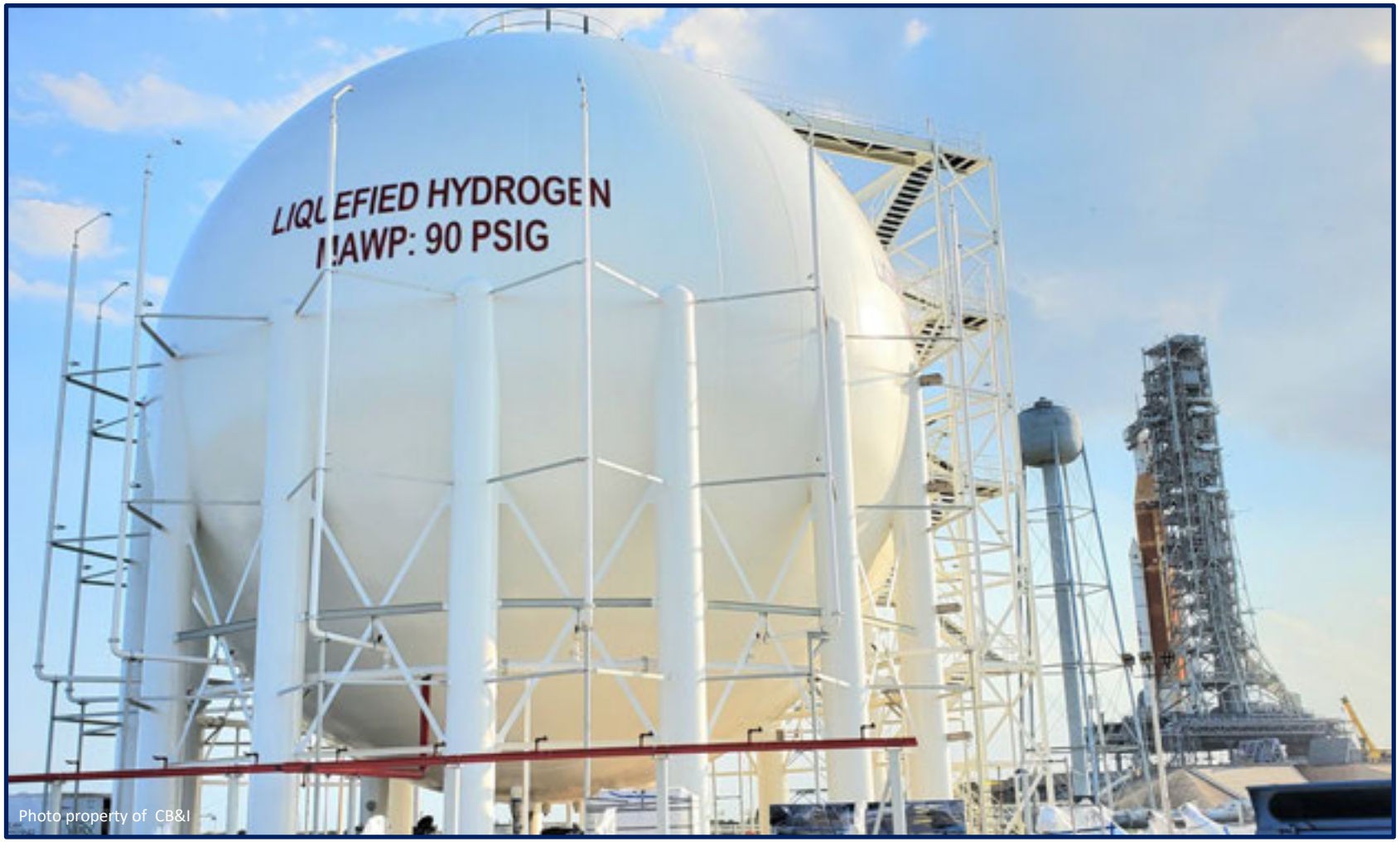


Photo property of CB&I

IN SUMMARY

- There are three general containment classifications defined by API 625
  - Single Containment
  - Double Containment
  - Full Containment

- Within each general containment classification there are variations specific to the product stored

- Rarely does a governmental body define the containment configuration, sometimes the size of the project site will dictate the containment configuration, but many times the containment configuration is based on the risk tolerance of the owner

- Reach out to a tank contractor to best understand the pros and cons of various containment configurations to assist with your next project

All storage projects are unique, site specific, customer specific, highly engineered and constructed structures!!!

STI SPFA

QUESTIONS

Bradley M. Veath, P.E.
Vice President of Sales – USA
1725 Hughes Landing Blvd
The Woodlands, TX 77380

Office +1 (832) 513-4187
Mobile +1 (281) 685-0365
brad.veath@CBI.com
www.cbi.com

Kevin J. Gallagher, P.E.
Vice President
4000 Tower Road
Louisville, KY 40219

Office +1 (502) 964-3361
Mobile +1 (502) 299-0092
kgallagher@caldwelltanks.com
www.caldwelltanks.com