A Basic Guide to Above-Ground Atmospheric Storage Tanks Utilized in the Energy Production Industry

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Introduction to AST Construction

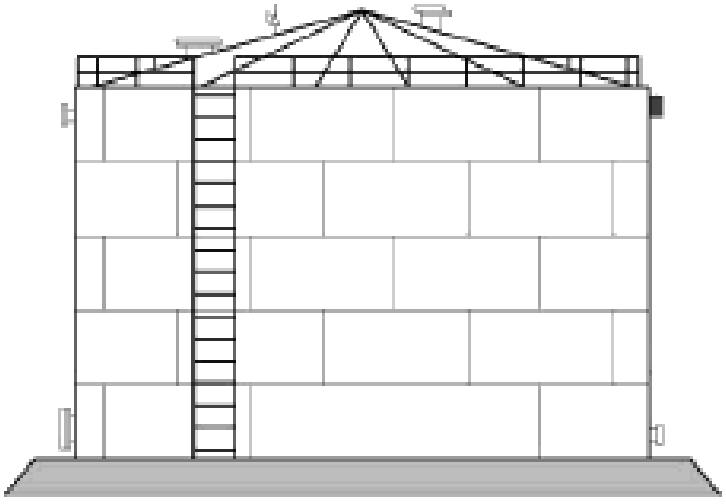
A single Above Ground Storage Tank (AST) in energy production can have numerous codes of construction associated with its design. Although we will not be entering into actual storage tank design calculations in this course, we will provide an overview of common codes.

Storage tanks containing organic liquids, non-organic liquids, and vapors can be found in many industries. Most energy storage tanks are designed and built to the American Petroleum Institute API-650 specification. Other design codes cover everything from the ground preparation, containment area, foundation, nozzles, testing, and inspections. ASTs can be constructed to sizes ranging from 6 to 200 feet or more in diameter. Their heights range from 4 – 50 feet or more.

Energy production utilizes ASTs at refineries, petrochemical, and chemical plants, bulk storage transfer operations, and terminals.

There are basically eight types of tanks used to store petroleum products:

1. Fixed-roof tanks
2. External floating roof tanks
3. Internal floating roof tanks
4. Domed external floating roof tanks
5. Horizontal tanks (not covered in this course)
6. Pressure tanks (not covered in this course)
7. Variable vapor space tanks (not covered in this course)
8. LNG (Liquefied Natural Gas) tanks (not covered in this course)



The first four tank types are cylindrical in shape, with the axis oriented perpendicular to the subgrade. These tanks are almost exclusively above ground. Horizontal tanks can be used above and below ground. Pressure tanks often are horizontally oriented and spherically shaped to maintain structural integrity at high pressures. They are located above ground. Variable vapor space tanks can be cylindrical or spherical in shape. This course will only cover the atmospheric AST styles.

ASTs have five major components to their construction, each one constructed with a purpose. These are:

a. Foundation
b. Bottom - Floor
c. Shell
d. Roof
e. Nozzles

Additionally, there are two major welds that bind the construction into one complete structure.

a. Bottom-to-Shell
b. Shell-to-Roof

Before we dive too deeply into details, we will pause here to set the stage for the next few sections. We will begin with the foundation, working to the floor construction, shell, then end with the roof. We will discuss in more detail the basics of each of these stages. Lastly, we will review the means by which products are transferred in and out through the nozzles. However, first, let's review the primary codes at a high level.

Tank Code Overview

The American Petroleum Institute (API) is responsible for the most common AST codes applied in the energy sector. API storage tank standards were developed by committees of experienced tank designers, fabricators, owners, and operators to bring their wealth of accumulated knowledge and experience together in one trust. Although API standards cover many aspects of AST design and operation, they are not all-inclusive. There are several other organizations that publish standards on tank design, fabrication, installation, inspection, and repair that may be more appropriate in some instances than API standards. Please refer to the following organizations for additional requirements and specifications:

- American Society of Mechanical Engineers (ASME) – www.asme.org
- American Society for Testing and Materials (ASTM) – www.astm.org
- American Water Works Association (AWWA) – www.awwa.org
- Building Officials and Code Administrators International (BOCA) – www.bocai.org
- NACE International (Corrosion Engineers) – www.nace.org
- National Fire Protection Association (NFPA) – www.nfpa.org
- Petroleum Equipment Institute (PEI) – www.pei.org
- Steel Tank Institute (STI) – www.steeltank.com
- Underwriters Laboratories (UL) – ulstandardsinfonet.ul.com
- International Fire Code Institute (Uniform Fire Code) – www.ifci.com

API does not certify tanks constructed under their code. The manufacturer must certify that they have constructed the tank in accordance with API codes. Some older tanks may have nameplates with API certifications on them; however, API continues to maintain its position of no longer certifying tanks or manufacturers. The last known monograms carrying the API symbol were applied in 1977—it is unlikely that you will ever see an API-stamped nameplate on a tank. API does offer certification programs for several of their codes for inspectors, welders, and other functional roles in the tank building process, but not for direct tank construction.

API 650 is considered the gold standard for new steel welded tank construction. API 653 is the standard utilized for the reconstruction and refurbishment of an API 650 tanks or to bring an existing tank into API code standard. API further expanded their specifications to API Specification 12D, covering field welded tanks for storage of production liquids.

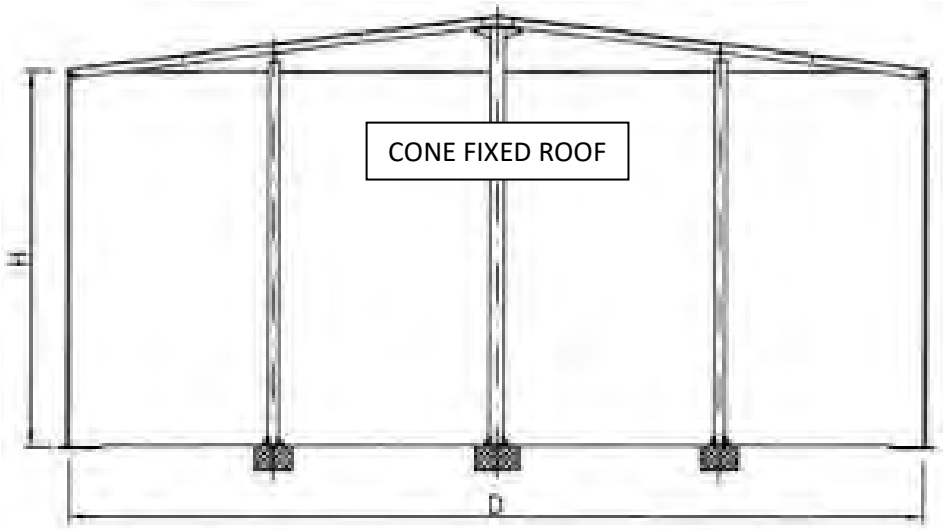
To clarify this course, our work will specifically cover welded steel ASTs. Other API Codes cover fiberglass, bolted, and underground storage tanks (UST). This course will focus on above-ground atmospheric welded steel tanks to ensure there is a focus on API 650 and Specification 12D.

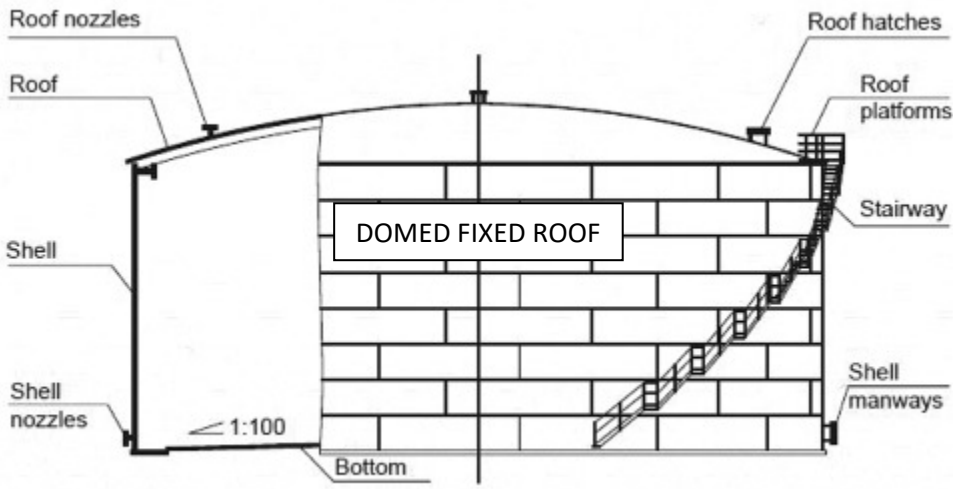
Tank codes, specifically API tank codes, are long, detailed, and technical. Summarizing their meaning and intent in a few paragraphs does not do justice to them, nor to all those engineers that participated in their creation. This course will direct you to investigate and review these codes outside of this training as this is an overview course.

These codes provide details of design and construction. Forgoing detailed design discussions, we will move into the construction of an AST from the ground up in the upcoming sections. Let’s first work through the subtypes of Fixed Roof, Floating Roof, and Domed Roof tanks.

Tank Roof Types

There are several variations of roof types for Fixed Roof tanks. The two primary roof styles are cone and domed. These additionally can accommodate floating roofs as well. The two examples below are without internal floaters.





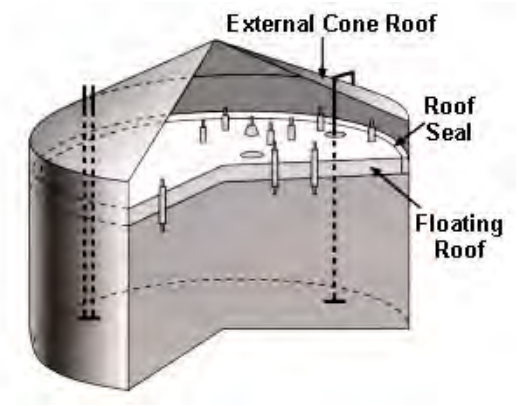
Fixed roof tank

There are two primary types of floating roof tanks: internal floating roof tanks and external floating roof tanks. Internal floating roof tanks have an air gap or space above the floating roof. The space created between the floating roof and the fixed roof is there to reduce VOC (volatile organic compounds) VOC's from entering the atmosphere. These types of emissions can contribute to greenhouse gas volumes.

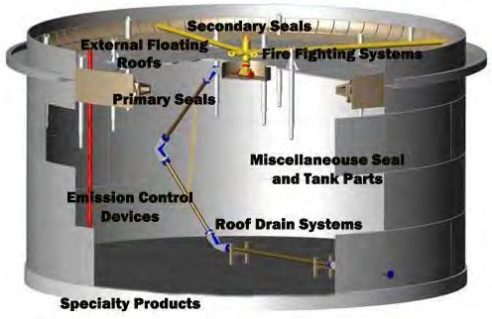
This space, due to the potential buildup of VOCs, which are flammable, can also be pyrophoric (capable of igniting with no external heat source). These are often designed to displace the oxygen with a nitrogen purge and recovery system. These systems prevent gas buildup and the potential for fire and explosion. The emissions are captured and managed with vapor recovery unit (VRU) systems.

Floating roof tanks are constructed with pontoons. Pontoons are cavities, like a barrel or pontoon boat, that float above the liquid contents of the tank. They have guides called legs that keep them aligned. The legs and the area between the roof and the internal wall of the tank have roof seals to reduce vapor leaks.

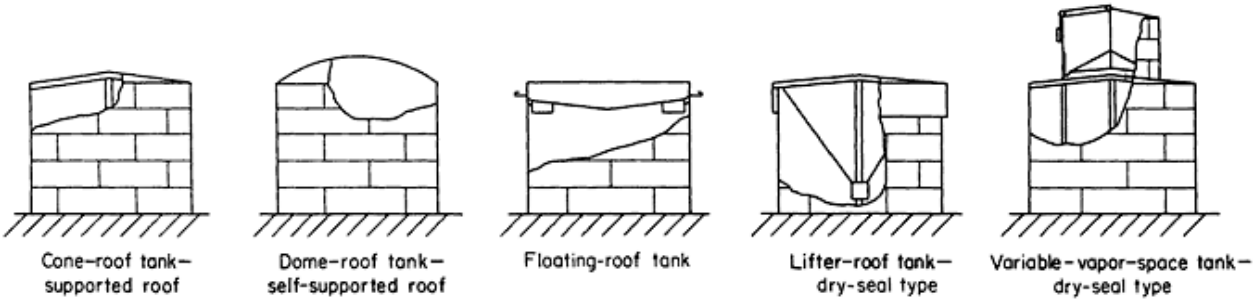
There are two different floating roof tanks shown to the right: an open floater and an external floater. External floaters have additional design considerations, such as precipitation concerns. Heavy rain, snow, and ice have been known to sink the roofs allowing the contents of the tanks to escape around the seals at the legs and the wall, causing the roof to sink. Even worse than sinking, these roofs can sometimes kick sideways, damaging the legs and becoming stuck, wedged between the wall and the legs.



The second graphic shows how roof drainage systems on external floating roof tanks aid in preventing these types of mishaps. During hurricanes, secondary pumps are often placed on top of external roof tanks to provide extra water removal along with coastal areas.



There are as many variations of roof types as there are design engineers practically. Why? Large storage tanks are individually designed. These designs must be unique as the geotechnical conditions, capacity, environment, product, temperature, specific gravity, vapor pressure, and many other design factors change with each tank.

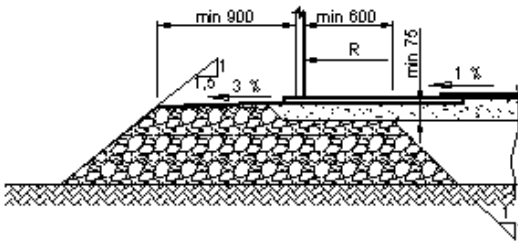


Now that we have a general knowledge of the types of welded energy ASTs covered in this module, we will move into the systematic construction. We will start at the foundation and work a way up and out in the next few sections.

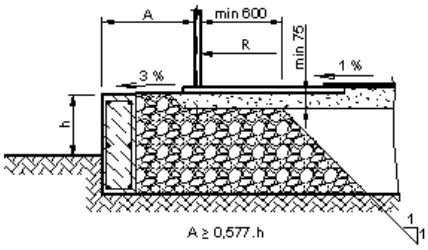
Foundation Construction

A strong foundation with any endeavor sets the stage for everything built upon it. Just as Karate begins with Kata to allow balance, form, and reinforce muscle memory, a tank begins with its foundation.

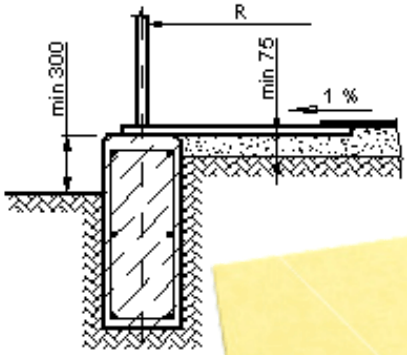
Tanks can and are often built anywhere. They are built in rocky and solid stone environments, swamps, beaches, deserts, and wetland areas. How does the design of the foundation rely on these geotechnical conditions? Tank foundations can be reinforced concrete slabs, reinforced concrete ring walls, and even earth.



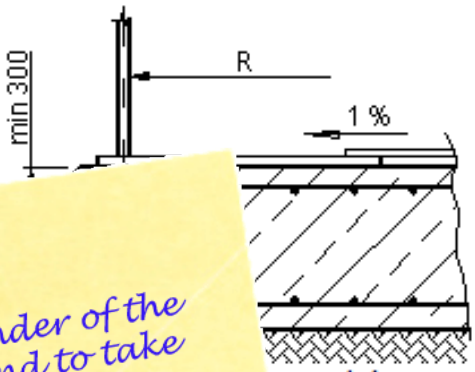
Earth type foundation



Reinforced concrete ringwall foundation which is not placed under the shell



Reinforced concrete



rete slab

Further, slab-style tank f en deep into the earth to bedrock to keep the sl settle or have issues with the tank floor causi nk floors can cause leaks.

Recall that we earlier mer he Bottom-to-shell of these two is the most re important, this particular weld has the m uses fatigue and eventual failure.