Today’s Composite Elevated Storage Tanks

Presented at the 2002 AWWA Conference & Exposition - New Orleans, LA

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Abstract: Over the last two decades, composite tanks for water storage—tanks with a steel tank storage container atop a reinforced concrete pedestal—have gained popularity. The challenge for tank owners, engineers, and designers has been that no widely recognized standards were in place to provide guidance for the construction of these types of tanks.

AWWA Standard Committee D170 is working to fill those gaps and provide a comprehensive standard that will supply tank owners and specifiers with the tools needed to design, specify, build, and maintain these structures. It will also aid the tank owner in better determining the type—steel, concrete, composite—tank that will best serve their water system needs now and in the years to come.

This paper reviews the development of the composite tank and includes a state-of-the-art look at what concepts are being built today, the status of the standards process, how composite tanks differ from the AWWA D100 tanks, and how to properly specify a composite elevated tank. Mr. Meier chairs the AWWA Steel Elevated Tanks, Standpipes & Reservoirs Committee and has been a member of the AWWA Composite Tank standard committee since its inception. In addition, he is a member of the ACI 371R Committee; the American Concrete Institute recommended practice for the design of the pedestal.

What is a Composite Elevated Tank?
A composite elevated water tank is comprised of a welded steel tank for watertight containment, a single pedestal concrete support structure, a foundation, and accessories. These tanks are also sometimes referred to as “concrete pedestal elevated tanks.” The steel tank provides a proven, watertight container derived from the AWWA D100 Standard for welded steel tanks which has demonstrated superior performance through decades of use by the water industry. The reinforced concrete support column provides a cost effective, structurally robust pedestal with minimal maintenance.
The basic configurations of the composite elevated storage tanks built in the US and Canada over the last 25 years is shown in Figure 1.

![Figure 1 - Common Composite Tank](image)

The most common composite tank is the domed concrete floor with a carbon steel liner (Style A). The advantages and disadvantages of each style are shown in Table A.

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                 • Reduced dead storage (i.e. water quality) | • Special formwork  
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| B – Suspended Bottom | • Bottom is accessible for coatings and addition or modification | • Tolerances at top of pedestal critical for skirt support  
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| C - Slab       | • Simple forming  
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History

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Figure 2 - 1985 to 1990 New Composite Tank Construction (map point plots)
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The typical construction sequence for the modern composite tank involves the following steps:

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The foundation is usually a spread footing for average soil bearing conditions since the tank footprint is relatively large although deep foundations may be required in some locations. It is important that the wall starter rebar be located within tolerance so the wall construction can start at with correct geometry.
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From the footing, the wall forms are erected and the process of building the wall begins. Form systems are usually proprietary to the tank constructor. The forms typically have strips fastened to the formwork that create rustications in the concrete that hide construction joints and give a pleasing panel-like appearance. Regardless of the formwork details, care should be taken to ensure wall tolerances on thickness and plumbness are met. Additional reinforcement near openings, block outs for the wall openings and embedment installation should be monitored. The concrete mix, placement and vibration should be implemented in such a way to achieve good consolidation and minimal surface defects (fins, bugholes, etc) and shading.

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Jacking
For this erection method supports are erected around base of the tank and the conical sections and vertical shell are fit and welded. Lifting supports are installed on the tank. Radiographic and the coating work may also be completed while the tank is in low position.
Lifting frames and hydraulic cable jacks are supported on the top of the pedestal /dome and used to hoist the tank into final position. When the tank reaches the final position, the tank is pinned in place with proprietary locking systems until the final concrete placement can be made to permanently lock the tank and tower together.

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If specified, the interior of the pedestal can be finished for a variety of uses – storage, office space, training areas and other imaginative uses. If the tank is used for communication antennas, the interior may be sub-divided to provide space for the communication carriers. The interior space also provides a convenient space for controls and valves for the tank. One word of caution, storage of explosive or flammable material is not recommended.

Typically a 1.5 million gallon tank can be completed in approximately 1 year from the issuance of the notice to proceed.
Specifying a Composite Tank
Since no national or AWWA standard exists as yet, specifying a new composite tank is more demanding than a tank type with an AWWA Standard. In the US, the tank builders often perform detail engineering for several of the components based on their proprietary designs, fabrication techniques and erection methods. Therefore, each tank builder has unique design characteristics for their product. Over the past decade, through the development efforts of writing the AWWA Standard for the composite tanks, the major tank builders have reached consensus on some of the design requirements, but areas of disagreement remain.

While detailing a complete specification is beyond the scope of this paper, there are several areas that a specifier should be aware of in preparing the project documents that are different than the typical AWWA welded steel elevated tank. As constructed today, composite elevated tanks and AWWA D100-96 welded steel tanks are not equivalent tanks, even though both serve the intended function.

- **Design Loads** – typically ASCE 7 is used as the design basis for environmental loads (snow, wind and seismic) unless the local building code governs. Any site specific or regional loads such as high winds or snowfall should be specified. ASCE wind category C is usually applied. If future uses (such as intermediate interior floors) are planned specify additional floor loads on the pedestal.

- **Pedestal**
  - Appearance - the typical appearance of the pedestal is a series of rectangular panels that provide relief in the surface. The “grooves” are shaped into the wall when it is formed and is the most economical appearance. Single source of cement and aggregate supply and consistent concrete work practices are important to meet aesthetic requirements.
  - Finish and coating - The industry standard is a brush blast finish. In coastal areas, regions subject to severe freeze-thaw, or in locations where corrosion of reinforced concrete structures is evident, a sealant or coating may be considered. Coloring admixtures are not recommended as it is difficult to get a consistent appearance on a surface area this large with even minor variation in the mix constituents.
  - Interior uses - If the pedestal interior is to be used for storage or other purposes, pre-planning for embedments to support interface and connection elements attached to pedestal (additional floors, ceilings, HVAC, lighting, etc) is vital. Sealing of interior through-ties may also be required for architectural or aesthetic reasons.
  - Access ladders and platforms – In the author’s opinion, these safety-related elements should not be installed with post installed anchors, but securely attached with embedded elements. The long-term adequacy of most post installed anchors in the connection of these critical safety components is unproven.
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  The tank criterion generally follows AWWA D100-96 with a few exceptions:
  - Design method for water-filled conical elements – This is a complex and controversial issue. There is not yet a complete consensus or understanding among tank designers on the design methodology. The experienced, major tank contractors have developed design methods that recognize the beneficial effect of internal water pressure on the critical buckling behavior of the shell (i.e. pressure stability). The effects of pressure stability are not new, but the design techniques for water storage tanks are relatively recent. To properly evaluate this behavior, a complex analysis is required and a thorough understanding of the construction tolerances and boundary conditions for the shell is paramount. Experienced tank contractors have demonstrated that these methods and construction can be used effectively. However, inexperienced designers and contractors that do not understand all of the design and construction issues can err. In the extreme situation, a collapse may result as it did on a composite tank in Newfoundland several years ago.

  The specifier must decide whether to allow the tank contractor to use this benefit which may yield plate thicknesses that are 20% to 30% less than a design that does not include pressure stability. The initial release of the AWWA Standard for composite tanks and the next revision of the AWWA D100 Standard will have guidance and requirements in this area. In this author’s opinion, it is reasonable to permit this design procedure providing the tank contractor can demonstrate experience with this method, can provide complete design calculations and assumptions for review, and the specifier requires the construction tolerances be measured, recorded and verified against the design assumptions.

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Table A – Advantages and Disadvantages of the Styles
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