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Tank Talk

AWWA D100-96 Construction Tolerances for Stability

By: Todd D. Moore, P.E.

The new AWWA D100-96 Standard for Welded Steel Tanks for Water Storage includes many changes from the D100-84 Standard. This article will focus on changes in construction tolerances for shell and cone stability formulas.

The old D100-84 did not address the issue of erection tolerances for double curved, axisymmetrical, conical, and cylindrical sections (referred to as "cones" for simplicity sake). These sections are generally subjected to uniaxial compression or biaxial tension-compression. A member under compressive stress is generally a candidate for buckling, and the buckling stresses must be analyzed and considered in the design. The allowable buckling stresses will generally be much lower than the allowable compressive stresses of a member not permitted to buckle. The new D100-96 provides design criteria in Section 3.4.2, *Double-curved axisymmetrical, conical, and cylindrical sections*, and provides erection tolerances in Section 10.7.6, *Erection tolerances for stability formulas*. To understand the need for the new Section 10.7.6, one must first look at the changes created by Section 3.4.2 which sets the allowable stress levels for cones under compressive stresses.

The heavy blue and black lines in Figure 1 illustrate the allowable compressive stresses for cones as given by the D100-84 and D100-96 standards respectively. The D100-96 Standard has been modified to allow higher stresses in compression than was formerly permitted by the D100-84 standard due in part to more restrictive construction tolerances. Additionally, the maximum allowable compressive stresses in A36 or equivalent material (Class 2) have been raised from 15,000 psi to 18,000 psi.

Local t/R Stability Comparison

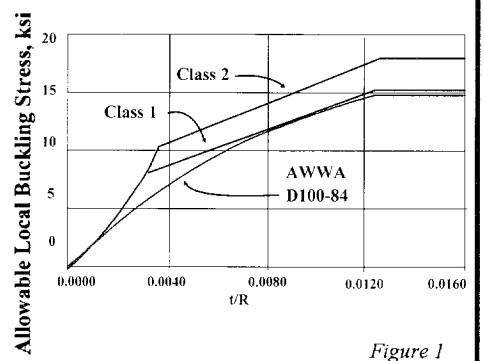

Figure 1

Figure 1 also illustrates the various buckling stages in the new D100-96 Standard. Up to a value of t/R of approximately 0.0035, the buckling is in the elastic range. (t is the thickness of the plate and R is the radius of curvature of the member measured perpendicular to the point under consideration to the axis of rotation.) When t/R is between 0.0035 and 0.125, buckling is in the inelastic range; and for values of t/R greater than 0.125, buckling is in the plastic range.

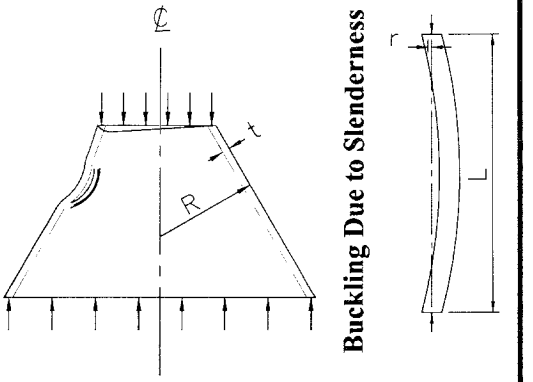

Figure 2

The allowable compressive stresses are further reduced by considering the effects of the slenderness of the member, the KL/r factor, as can be seen in Figure 2. (K is a constant, the value of which depends on the end restraint connections of the member. L is the length of the member, and r is the least radius of gyration of the member.)

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Inside This Issue

Chairman's Corner

By: E. Crone Knoy, P.E., CEO, Tank Industry Consultants

Now I have seen it all!!! The other day I received some junk mail in my e-mail in-basket. Guess what it was? It was an invitation to an **Upsizing Conference**. Several well-known companies were listed as participating in the conference. I printed it and put it aside, thinking it was a joke. My daughter, an engineer at Eli Lilly, one of the participating companies, saw it and said, "No, Dad, this is for real!" Now really! It seems only yesterday that I was writing an editorial poking fun at "re-engineering" and "downsizing," and ridiculing the latest management fad buzz words.

As I read various publications, visit other organizations, and attend various board meetings, I am constantly amazed at the reorganizing, retraining, and other non-productive efforts being expended. No matter what the management fad or buzz word being implemented, the end results come back around to the basics of organization, accountability for one's actions, and placing client service as the number one priority.

As I am involved in strategic planning of the organizations I belong to, I am reminded of two chores I had on the farm. Hammering nails and planting corn. When driving nails, you must always keep your eye on the nail head. If you don't, the nail will invariably start going crooked, then bend over and have to be pulled out and re-driven. The lesson here is, "You must concentrate on what you are doing at the moment, receive immediate feedback, and make corrections to complete the task at hand." My second chore, planting corn, required a different view on the task. As I drove the tractor, I found that my tendency was to just look over the nose of the tractor or at the last row planted. When I did this, the rows of corn I was planting would not be straight and the distance between the rows would vary. This not only made an unsightly field, but made it almost impossible to cultivate and harvest the corn. I soon learned that my father's advice, to concentrate on the fixed point at the end of the field, was the only way to plant a crop of corn that would be spaced with room to grow and to be cultivated and harvested.

I have tried to build Tank Industry Consultants with well-placed, accurately driven nails, focusing on the tasks at hand--creating and maintaining an effective and efficient organization to serve our clients. In between driving the nails, however, I have tried to keep my eye fixed on the end of the row, keeping on the path that would yield the long-term results required to provide meaningful work for our employees and a continuum of service to our clients.

Downsizing, upsizing, re-engineering --they all take energy that could be applied to doing the task at hand. At TIC we have tried to continually keep our eye on the nail **and** the end of the row. Doing so has hopefully kept our organization using its dynamic inertia. To slow down to reorganize means that kinetic energy of the moving organization must be absorbed in order to stop and change directions. In changing directions abruptly, static inertia must be overcome by applying additional energy to get back up to speed. Keeping the organization moving, but constantly correcting to reach the correct point at the end of the field, saves energy (reduces cost) and eliminates the fits and starts of trying on the latest fashions of today's business fads.

I have spoken before of my plans for the perpetuation of Tank Industry Consultants. A major step in an orderly transfer of ownership to the total TIC team was made last spring. This will continue over the next 5 to 10 years, as we keep one eye on the head of the nail...and another on the end of the field.

Thanks for listening. I pledge that the core values of TIC will be here forever.

Crone

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Tank Construction and Maintenance Seminars

This winter, Tank Industry Consultants will host water tank seminars in California and Indiana. These seminars are designed to familiarize attendees with the latest standards, regulations, and technology in water storage tank maintenance. Seminars will be held in:

San Jose, CA - January 12 & 13, 1998
Irvine, CA - January 15 & 16, 1998
Indianapolis, IN - January 27 & 28, 1998

Day 1 of the seminars will be devoted to the basics of corrosion, coating selection and application, and inspection techniques. Day 2 will include evaluation of existing tanks, new tank design and construction, special design and seismic considerations, preparation of specifications, and quality assurance during tank construction and rehabilitation.

Attendees are invited to participate in either one or both of the seminar days. The cost for a one-day seminar is $295, or $495 if the same individual attends both days.

For information call 1-800-TANKSEM.

AWWA Standards

Several tank-related AWWA standards revisions were released in 1997. The effective dates for these standards are:

D100 - Welded Steel Tanks - 3/1/97
D102 - Coating Steel Tanks - 8/1/97
D104 - Impressed Current Cathodic Protection - 8/1/97

The D103 Standard has passed through the appropriate AWWA reviews and submittals, and is currently under review by ANSI. Release date is unknown at this time.

The revisions to these standards will be covered in the 1998 TIC seminars.

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Maintenance Contracts vs. Maintenance Engineering

By: William E. Daugherty, P.E.

Over the years, tank maintenance contracts have become an option when addressing water storage tank maintenance. This is primarily because, on the surface, maintenance contracts appear to answer difficult budgeting concerns. But, when given a closer look, maintenance contracts often fail to solve tank maintenance problems, and in many cases, actually create new ones. Because of this, tank owners should carefully consider maintenance engineering as an alternative.

What is a tank maintenance contract? This type of water tank maintenance allows a tank owner to pay a preset annual fee for a contractor to keep the tank in "good" condition through yearly inspections and by performing any necessary repairs. Sounds like a great idea! But, in reality, few tank owners have the specialized expertise required to determine what are quality inspections, necessary repairs, and good condition. Typically, contracts fail to clarify performance criteria because they are often created by the contractors and do not stipulate performance standards. To make matters worse, repairs may be improperly performed, or in some cases, not performed at all because no one oversees the contractor's work. Since the contractor has a vested interest to find little or nothing wrong during the annual inspection, potential problems could be overlooked or ignored.

What if paint failure occurs? Through proper surface preparation and application, a coating system should fulfill its anticipated design life, typically a minimum of 15 to 20 years. So, on a new or recently painted tank, a ten-year maintenance contract would expire before a quality coating system fails. Even if a coating system fails prematurely, a maintenance contract usually only requires that the contractor perform "touch-up" services on any deteriorated areas. This spot coating can result in a very unsightly water tank that is only marginally protected from corrosion.

What happens if the tank has a serious problem like a leak? In this type of circumstance, a tank owner wants the contractor to repair the leak as quickly as possible. Unfortunately, maintenance contracts often fail to contain a required response time, leaving tank owners guessing when the contractor will arrive to repair the tank. Usually, the contractor arrives when it is convenient for him, regardless of the owner's urgency.

What happens if the contractor goes out of business before the contract expires? If the contractor declares bankruptcy, the owner may have little recourse, and might have to rebid the balance of the contract—probably at a much higher price. And, all of the money spent to date would be lost!

What happens when the ten-year contract expires? If the tank was not properly maintained, the tank owner faces the prospect of a new maintenance contract which will undoubtedly reflect the contractor's lack of performance in the form of a higher annual fee. In fact, there is no guarantee that the current maintenance contractor will bid on an ensuing contract.

Typical responses to these potential problems include: "This contractor is different!" or "This contractor has been in business for years," and a personal favorite, "I checked their references!" (What business person would offer negative references when soliciting work?) Regardless of an owner's faith in a contractor, under a maintenance contract an owner is still paying up-front for services which might not be required or even performed at a later date. Sound financial practices should allow tank owners to invest the anticipated annual maintenance contract fee for use at a later date for planned painting or rehabilitation. Such investing of budgeted funds would likely result in substantial savings to the owner.

The Alternative: Tank Maintenance Engineering

What is tank maintenance engineering? This type of tank maintenance utilizes an independent engineer who evaluates the tank and determines how best to paint or rehabilitate it, if rehabilitation is needed at all. An independent, unbiased third-party engineer has no vested interest in finding or hiding potential problems. This assures the owner that any recommendations for tank maintenance are, in fact, the most prudent and in the best interest of the owner.

Through quality project representation and project administration, a coating system should reach its anticipated design life, therefore reducing dollars spent on unnecessary maintenance contracts. For example, TIC has many projects on which coatings that were applied 18 years ago are still performing extremely well.

In addition to saving money, when

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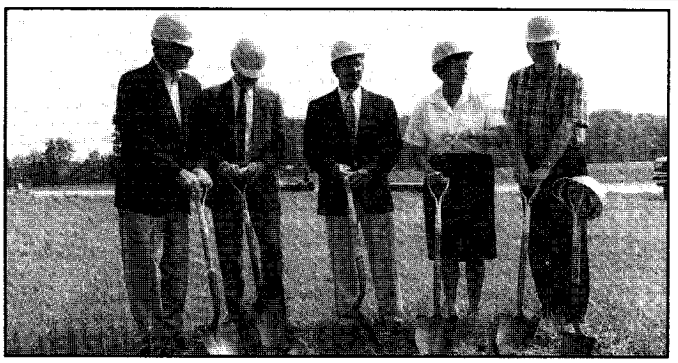

Fort Wayne Ground Breaking

On July 18th, the City of Fort Wayne broke ground for their new 1,500,000 gallon fluted pedestal tank designed by Tank Industry Consultants. Shown in photo at left are: (l-r) Terry Atherton, P.E., Director of Utilities; Greg Purcell of the Fort Wayne Mayor's Office; Steve Roetter, P.E., President, Tank Industry Consultants; Linda Buskirk, Director, Board of Public Works; and David Kohli, President of the Maplewood Terrace and Downs Homeowners Association.

"Construction Tolerances" Continued from Page 1

For those not wanting to get into great detail in the analysis of cones and shells and the use of these formulas, the reader should understand that the D100-96 formulas provide for higher allowable stresses to be utilized in the design of cones in compression. Buckling of compression members occurs when the member is under some critical compressive stress level that causes the member to deflect from its original shape. For perfectly shaped, perfectly loaded members, this allowable buckling stress may be very high. In practice, no member is ever free of defects in contour (perfect) or symmetrically loaded. Buckling of compressive members occurs at lower levels when the members are not properly aligned, leading to eccentric loads; or when the members are not properly formed or assembled and have discontinuities that increase the local stresses. Because of these effects, the D100 Committee included Section 10.7.6 which provides tolerances for discontinuities in shells and cones under compression. Shells and cones which meet these tolerances should be expected to perform in agreement with the formulas in Section 3.4.2. The formulas for allowable deviations in the cones are as follows:

$e_x = 0.04/Rt$

$L_x = 4/Rt$

where:

e_x = the allowable deviation from the theoretical shape

L_x = the gauge length used to measure the local deviation

t = the shell plate thickness

R = the radius of the exterior of the shell surface, normal to the plate at the point under consideration and measured from the exterior surface of the plate to the axis of revolution of the shell or cone.

The above terms are better understood by observing Figure 3.

The AWWA D100-96, Section 3.4.2, requires shells which do not meet the above tolerances must be reworked to meet the tolerances, or stiffeners may be added. Sometimes the precise evaluation of the stresses at the location of the deformity may prove the structure to be adequate.

Local Deviation for t/R Equations

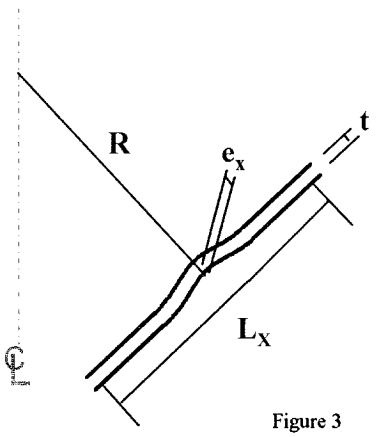

Figure 3

The inclusion of the new criteria will allow tank manufacturers to use thinner plates, thereby saving on material, fabrication, and erection costs. However, the constructor, owner, and engineer should all be aware of the importance of the new erection tolerances. Proper monitoring of the tank members during fabrication and erection is important to verify that the cones meet the new erection tolerances and will perform in accordance with the design.

The use of higher allowable stresses permits the use of thinner steel plates for the cones, but not without assuring that certain construction tolerances are met.

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Todd Moore has been with TIC for over 11 years and is a registered professional engineer in eight states. He has a BSCE from the University of Notre Dame, and an MSCE from Rose-Hulman Institute of Technology. Todd is Chief Engineer for TIC and project manager on many new tank construction projects.

"Maintenance Contracts" Continued from Page 3

maintenance engineering is utilized, the owner controls any decisions regarding tank maintenance without the false sense of security associated with a maintenance contract. If repairs and/or repainting are required, then the engineer or owner can develop design specifications for the rehabilitation project and obtain competitive bids. Because maintenance engineering more precisely defines the scope of work, competitive bids are truly competitive. In fact, TIC, averages more than four bidders per rehabilitation contract! Meanwhile, most owners receive only one bid for a maintenance contract, the bid from the contractor who provided the maintenance contract specifications or criteria.

If a tank's coating system is properly applied it should last in excess of 15 years. Exterior coatings usually do not require reblasting, but can be topcoated multiple times. Instead of diverting funds to a maintenance contract which does not guarantee that services will be required or even performed, an owner should invest budgeted money yearly. Smart investing aides in budgeting and helps alleviate unnecessary problems.

So, what can a tank owner with a maintenance contract expect to happen at the end of their ten-year contract? A new contract at an even higher price!

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Bill Daugherty, P.E., Vice President of Tank Industry Consultants, is a registered professional engineer and a graduate of Rose-Hulman Institute of Technology. Bill has been with TIC for more than 10 years, and is in charge of TIC's marketing and sales activities.

Crone Knoy Named AWWA Committee Chair

Crone Knoy, founder of TIC, has been named chair of the AWWA Steel Elevated Tanks, Standpipes & Reservoirs Committee. This committee develops and maintains standards and related manuals, reports, etc., for the design, manufacture, installation, repair, and painting of steel elevated tanks, standpipes, and reservoirs for water storage. Standards included under the auspices of this committee are AWWA D100, D101, D102, D103, D104, and related manuals. The near-term goals of the committee include the publication of the Steel Tank Manual by mid 1998, and the release of an update to the D102-97 Standard and an addendum to the D100-97 Standard by 1999.