

# TankTalk

## Underwater Evaluations of Water Storage Tanks

By Steven P. Roetter, P.E., President and  
George B. "Woody" Warren, Project Coordinator

*As presented at the 1999 American Water Works Association Distribution System Symposium, Reno, NV*

A growing number of water storage tank owners are utilizing underwater inspections of their tanks when they are unable to drain the tank for a complete "dry" evaluation, or when they chose not to. The reasons these owners are opting for underwater inspections are varied. Typically they are unable to completely empty the tank because of the costs associated with draining the tank (cost of water lost and water for refilling the tank). There may also be concerns about the out-of-service time associated with the draining, evaluating, refilling, and disinfecting the tank; and limitations on draining due to consumer or fire protection water supply demands. There are also cases where the tank cannot be drained due to valve, equipment, or piping problems that prevent the owner from draining the tank. For tank owners facing these or other problems, an underwater (or diving) evaluation may provide the information needed to properly rehabilitate and maintain their tanks.

There are limitations and advantages to both dry and wet evaluations. It is important for owners to understand the drawbacks, as well as the advantages, of both.

During diving evaluations, the tank must be isolated from the system and valved off for the safety of the diver. Tanks may need to be off the system for as little as an hour or two while the diver is physically in the tank. However, some states require the tank to be isolated for a specified period of time following the diving evaluation to collect samples and assure water quality.

Both ground storage and elevated storage tanks can be evaluated by diving. With a diving evaluation, the diver is able to access all of the steel surfaces, while with a dry evaluation, the tank evaluation crew is only able to access those surfaces that are adjacent to ladders and that can be accessed by rigging from roof man-holes and vents. The diver has the disadvantage that he/she must evaluate the steel sur-

faces up close, as limited light and visibility do not allow the diver to move away from the tank shell and evaluate the overall corrosion patterns inside the tank.

Some of the physical tests that are normally performed, including adhesion tests and dry film thickness readings, cannot be accomplished on the submerged surfaces. Paint samples gathered to determine the type of coating and the possible presence of hazardous materials in the coating must be taken from the roof and upper shell of the tank interior. While in most cases the coating on the lower shell and bottom of the tank will likely be the same as found on the upper shell, there are occasions when the coatings differ. In these cases, the type and content of the untested coatings will not be known until the surfaces are abrasive blast cleaned.

Silt in the bottom of the tank is a detriment in underwater evaluations. Over time, silt settles out of the water and collects on the tank bottom. It is not unusual for there to be 2 to 3 inches of fine silt on the bottom of a tank. This silt prohibits the diver from being able to observe the tank bottom, one of the areas of greatest corrosion concern. The diver must be careful not to disturb the silt as this turbidity directly affects the quality of the evaluation of the tank bottom and lower portion of the tank shell. There are, however, firms that specialize in cleaning a filled tank prior to an underwater evaluation.

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Evaluation Professional Preparing to Enter Tank

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## Chairman's Corner

**E. Crone Knoy, P.E.**  
**Chairman and Founder**  
**Tank Industry Consultants**



Those of you who have read my Chairman's Corner in the past are probably familiar with my dislike for acronyms and the latest, greatest management "buzzwords." But every once in awhile, a phrase comes along that really seems to mean something...puts a fitting label on a concept or principle. One such term is *intellectual capital*.

When we go to a doctor's office, we know that our bill doesn't only reflect the fifteen minutes we see him or her, but the years of schooling, internship, residency, and continuing education the doctor has undergone. It also includes the cost of trained support personnel and a myriad of other overhead costs. The same is true for most professions, including engineering. Professional expertise has a cost...not just the cost of a given number of hours of work that goes into identifying the problem or writing the specification, but the cost for the days and months and years of training, education, and experience that have gone before.

At Tank Industry Consultants we have invested heavily in intellectual capital. We have the best engineering, field, and support staffs in the business. They have many, many years of education, training, and most importantly, industry experience, and are constantly undergoing update training and education in the latest technology. A recent poll of our personnel showed that collectively, the people at TIC have had more than 500 years in the storage tank and coatings industries. We added some of the most respected names in the industry to TIC's roster in the last few years. We are in a constant state of continual organizational building and training to make sure that Tank Industry Consultants is—and remains—the foremost engineering consultants in the storage tank industry.

Just like your fifteen minutes at the doctor's office, our services aren't the cheapest in the industry. The best is rarely the cheapest. But our clients obviously recognize that

they are getting value for their money as more than 90% of them call on us again and again to do additional work on their structures. That's a fact that we are enormously proud of...as well we should be. And we come to you—we you don't make you cool your heels in our office.

When my wife and I founded TANK INDUSTRY CONSULTANTS more than twenty years ago, we didn't immediately adopt the acronym "TIC." In the late 1970's early 80's, corporate giants like International Business Machines and American Telephone and Telegraph started shortening their names. Somewhere along the line, people started coming up to me and asking how things were going at "TIC." It has been only recently, however, that I have realized what TIC truly stands for...Tremendous Intellectual Capital.

Just as our clients recognize the value of our intellectual capital, so does our management team. We continually "invest" heavily in the education and training of our personnel, and in our efforts to hire the best in the industry. We "re-invest" our intellectual capital by donating countless hours of our time and expertise to code and standards-making committees and organizations, and by assuming leadership roles within these groups. We do this in order to assure that our industry will continue to safeguard and serve the public, and so that our clients are guaranteed the best professional expertise available.

The return on our investment can't always be counted in dollars and cents. More frequently it's demonstrated in the phone calls we receive from former clients asking for our help with yet another tank or structure. This is that type of return on investment that TIC will continue to strive for—providing our clients the best value in the storage tank engineering industry.

TIC...Tremendous Intellectual Capital invested for you.

This edition of the Chairman's Corner was written from notes Crone Knoy jotted down several months ago. As many of you may know, Crone was diagnosed with cancer in September. We have received countless calls from friends and colleagues inquiring about Crone's condition. We are pleased to report that Crone is now at home, is undergoing chemotherapy and other medical treatment, and is doing well.

While Crone's cancer is inoperable and the prognosis is that it will take more than doctors and medical science can do in order for him to beat it, he is confident in the power of positive thinking and prayer. Preliminary tests have indicated that the prognosis is improving. Crone recently remarked that he has overcome many obstacles in his life, and though this is the greatest thus far, he will overcome this one as well. "Cindy and I have been blessed with many valuable friendships within the industry...not just business acquaintances, but true, loyal friends. I enjoy my friends in the industry and I want to be with them...I will be with them."

The Knoys have felt your outpouring of support during this difficult time. They have received literally hundreds of cards and good wishes and find great strength in them. They look forward to hearing from even more friends and colleagues in the industry. Cards and other greetings can be sent to them at the TIC office, 7740 West New York Street, Indianapolis, Indiana 46214.

While Crone is recuperating, be assured that TIC's clients will continue to receive the same professional service and expertise Crone has been noted for. During the past several years, Crone has been putting into place plans to assure continuity of service in the event of his retirement. The management, support staff, and field department have committed themselves to carrying on and improving the fine reputation of TIC during Crone's absence.

Please continue to keep Crone, Cindy, their granddaughter Whitney, and the rest of their family in your thoughts and prayers as they face this greatest challenge of their lives.

## Proper Installation and Retrofitting of Double Bottoms

By John M. Lieb, P.E. Chief Engineer – Industrial

The following is a brief synopsis of a paper presented by Mr. John Lieb at the National Institute for Storage Tank Management, Second Annual National Conference on Aboveground Storage Tanks in May of 1999. John has been invited to present this paper at the 2000 conference also. The work was published in the September/October, 1999 issue of *World Refining*. For the complete paper, please contact John at lieb@tankindustry.com or via fax at 317/271-3300.

Improper design and installation of double bottoms in storage tanks can lead to corrosion, mechanical damage, and ultimately, loss of leak integrity. The results can range from the common slow, sometimes imperceptible leaks, to the rare sudden and catastrophic failure. This paper addresses proper design and installation practices to be used for API 650 and similar (excluding UL 142) tanks supported on grade, to maximize service life and minimize maintenance costs. The steps to a proper double bottom installation, whether for an existing aboveground storage tank or for a new one, begin with engineering design, progress through quality control of the physical installation, and end with a final inspection of the completed work.

The first step, **engineering design**, is critical because in this stage, the optimum configuration and materials of construction for the double bottom are selected for the site-specific conditions. If an improper configuration or incompatible materials are selected for the intended service conditions, there is generally not a lot that can be done to correct the situation during the installation and inspection.

A fundamental premise of all industry standards for flat bottom tanks supported on grade is that, because the bottom is uniformly supported by the grade, the bottom plate is not subject to membrane stress as is the cylindrical shell of the tank. In the case of a double-bottom tank, the filler material between the two bottoms serves the critical purpose of providing uniform support of the bottom of the tank. The degree of uniformity of support depends on the particular material used.

From a structural standpoint, sand provides the most theoretically uniform support, followed by pea gravel, then concrete, and finally, metal structural sections. Sand and pea gravel materials "shift" to maintain uniform support when settlement occurs. To a lesser extent, concrete offers some adjustment, through cracking, to maintain uniform support of settled bottoms. A thorough engineering evaluation should be per-

formed before using wire fabric, grating, or structural shapes as filler material. Of particular concern is the fact that these materials can result in high local bearing stresses (at so-called hard spots) in the bottom plates which, under certain conditions, can lead to accelerated corrosion and premature failure of the bottom. Furthermore, fatigue cracking can occur when bending stresses and/or cycles at or near these hard spots exceed the fatigue limits of the bottom plate material. This is not to say that these materials are not appropriate in some cases.

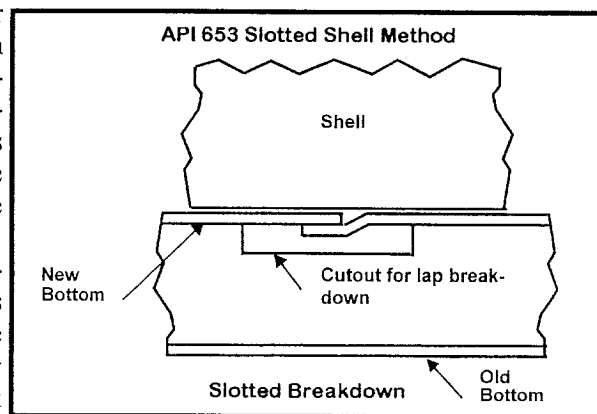
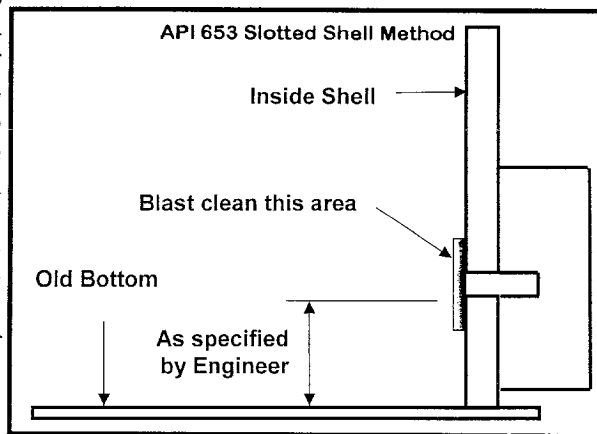
Another factor to consider in using wire fabric, structural sections, or grating in the space between the floors is that they preclude the use of a liner and/or cathodic protection in this space. On the other hand, this system can be designed and constructed to permit injection of inert liquid or gas to form a seal and mitigate potential corrosion.

The second step to proper double bottom installation is **quality-controlled execution** of the physical work. For retrofit situations, the second or primary bottom should be installed using the slotted shell method outlined in API Standard 653. For new double bottom tank construction, the installation procedures are essentially a combination of those for single bottom tank construction with those for retrofit situations. However, there is one area where special care is required. Unlike the slotted shell method for retrofit situations, for new tanks with double bottoms, the shell stub between the two bottoms is installed before and independently of the shell above the upper bottom. This makes it inherently more difficult to ensure that the shell stub and upper shell are properly

aligned when the tank construction is complete.

When liners are incorporated into the design of double bottom tanks, the leak integrity of the liner must not be compromised during the construction process. This means that both the installation of the liner itself and post-liner-installation operations should be carefully conducted and monitored to ensure that any damage that occurs to the liner is repaired.

The risk of bottom leaks is higher at locations of lap weld breakdowns and 3-plate lap welds due to the geometry of these welds. For this reason, special care in the detailing and execution of these breakdowns and welds is prudent. This is true for



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both single and double bottom tanks. As an alternative to lap-welded sketch plates, butt-welded annular plates are commonly used when required by API Standard 650, or when specified by the purchaser. In the case of new double bottom tank construction, the corner weld should be made after the first shell ring is erected and all vertical shell joints are welded. If the corner joint is manually welded, one side of the corner joint should be welded before the sketch plates are fit together.

A sump, when required on a double bottom tank, requires special attention. The location, size, and details of the sump should be in accordance with API Standard 650 or the applicable standard of construction. Furthermore, it is essential that the sump be properly supported by compaction of the surrounding fill material unless the fill is concrete or steel, in which case compaction is not applicable.

Good housekeeping should be maintained continuously throughout the installation of a double bottom. While it is common for construction debris and other expendable materials to collect on the bottom of the tank, it is important that these materials be properly disposed of so that they do not end up under the floor plates - either intentionally or accidentally - where they can lead to corrosion or other structural problems.

How do you ensure that all the good practices described above are being carried out? The four major controls a tank owner or operator can employ to ensure a high quality job are:

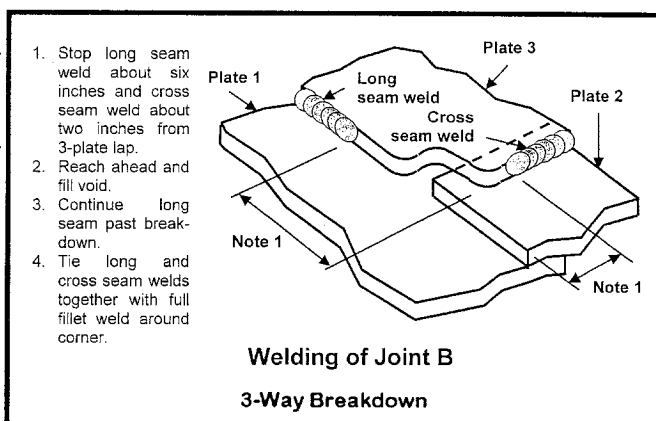
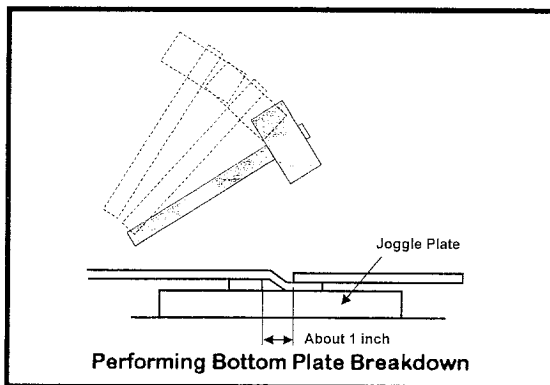
- ◆ **Specifications** – Complete and specific project requirements are essential to the success of a project, both in the bid evaluation stage and in the contract execution stage. Specifications should be prepared under the supervision of a professional engineer with both experience and specialized

training in the design and construction of aboveground storage tanks.

- ◆ **Contractor Selection** – In order to ensure a level of work quality consistent with the requirements of industry standards, it is recommended that the contractor be able to demonstrate that he maintains a documented quality control program for aboveground storage tanks. The program should preferably be patterned after the latest edition of API Specification Q1, “Quality Programs.”

- ◆ **Construction Supervision** – A contractor who can demonstrate by documentation that he maintains a quality program as described above will generally employ competent construction supervision. However, in cases where there is any doubt about the contractor's ability, it is recommended that knowledgeable and experienced construction supervision, (i.e. full-time on-site inspection) whether provided by the owner or a third party, be maintained throughout the the project.

- ◆ **Inspection** – The final step in the proper installation of double bottoms is inspection of the completed work. Inspection should be performed continuously to ensure that any poor practices such as improper disposal of construction debris, or seemingly minor deficiencies such as arc strikes or weld scabs, are corrected before it is too late. When double bottoms are being retrofitted to existing petroleum or chemical storage tanks, inspection activities should be performed under the direction of an API 653 Certified Tank Inspector.



John Lieb has specialized in the design and construction of aboveground storage tanks and pressure vessels for twenty-five years and is a registered professional engineer and an API 653 certified tank inspector.

**Tank Talk®** is published as an informational resource for the storage tank industry. For past issues of Tank Talk, or to learn more about the services offered by TIC, please contact:

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**Offices Nationwide**

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## We've Been Talking about Tanks.... Everywhere!

*To be a leader, you have to lead. To lead, you have to communicate.*

Each year, representatives of TIC travel across the United States talking about tanks, and 1999 was no exception. In addition to **Storage Tank Seminars** in Maryland and Alaska (...yes, we did say "Alaska"), we visited 15 other states where we participated in state, regional, and national conferences.

John Lieb has represented TIC at several API conferences including the **API Storage Tank Management Conference** in San Diego where he took part in a panel discussion of Aboveground Storage Tank Design Questions & Answers. He presented a Report on Minimum Weld Spacing for Aboveground Storage tanks to the **API Joint Subcommittee**. John also presented his paper on the "Proper Installation and Retrofitting of Double Bottoms" at the **National Institute for Storage Tank Management** conference. (A synopsis of the paper can be found in this issue of Tank Talk.) At that same conference, Steve Meier presented his paper on "Upcoming Changes in Seismic Design Criteria."

Chip Stein, Steve Roetter, and Ken Jacobi presented a tutorial on "Advancements in Aboveground Storage Tank Coatings Management" at the **SSPC Annual Conference**, in Houston.

The **American Water Works Association Annual Conference and Exposition** is always a major conference for water storage tank owners and operators. This year's show in Chicago drew record crowds. TIC hosted a breakfast where we discussed cellular antenna installation on water tanks, and shared our vision of the Future of Tank Maintenance with participants. In addition to the ACE in Chicago, Woody Warren and Steve Roetter took part in a workshop where they discussed "Underwater Evaluation of Water Storage Tanks" (a summary of the paper is published in this issue of Tank Talk) at the **AWWA Distribution System Symposium** in Reno, Nevada. At the state level, representatives of TIC participated in **AWWA** and **Rural Water Association** meetings in a number of states. They spoke on such topics as Cellular Antenna Installation on Water Storage Tanks, the Basics of Corrosion, the Future of Tank Maintenance, pre-maintenance evaluations, and a Professional Approach to Tank Maintenance.

Speaking and teaching engagements for the year 2000 are already starting to be planned. Mark your calendars now for a new conference being hosted by AWWA in Baltimore in March. Brian Pohlar and Ken Jacobi will be taking part in this **2000 Infrastructure Conference**. Brian will be presenting a paper on "A Maintenance Prioritization System for Water Storage Tanks," and Ken's topic is "Protecting Your Water Storage Tanks -- An Analysis of Long- and Short-Term Options."

Copies of most of TIC's presentations are available. If you would like to receive a copy of any of these papers, please call, write, or e-mail your request.

## Storage Tank Seminars

Throughout the year, Tank Industry Consultants hosts water storage tank and industrial storage tank seminars at selected sites throughout the United States. These seminars are designed to provide tank owners, engineers, and regulators with the information needed to design, construct, and rehabilitate storage tanks for current and future use.

The next two-day seminar will be held in **Bolingbrook (Chicago), Illinois on February 8 and 9, 2000**. This two-day seminar, lead by the industry's foremost experts, will emphasize the creation and implementation of a comprehensive tank maintenance program. It will provide information about how to develop construction and maintenance programs, plan and budget for the anticipated work, implement inspection programs to gather needed information, and manage the decision-making process. Other topics covered will be special design considerations, the bidding process, contractor selection, quality control, inspection equipment, and lead-paint abatement. Topics to be covered include:

- Tank Failure Modes
- Basics of Corrosion
- Preventing Corrosion in Storage Tanks
- Coatings and Cathodic Protection
- Developing a Tank Management Plan
- Specifying New Tanks
- Planning and Overseeing Tank Repairs and Maintenance
- Environmental Issues
- Cold Weather and Other Special Operating Conditions
- Installation of Cellular Antennas
- Special Design Evaluations
- Structural and Seismic Design Considerations

Throughout the two-day seminar there are many opportunities for participants to network with other owners, operators, and engineers, as well as the seminar leaders, discussing topics of mutual concern and sharing solutions.

If you would like more information about the Bolingbrook seminar or future seminars, please write, fax, or e-mail your mailing information to:

Penni Snodgrass – 7740 West New York Street  
Indianapolis, IN 46214  
Phone: 317 / 271-3100 — FAX: 317 / 271-3300  
snodgrass@tankindustry.com

Continued from Page 1 – *Underwater Evaluations*

Just as two heads are better than one, two sets of eyes can provide a better overall picture of conditions than can one. Perhaps one of the greatest drawbacks to underwater evaluations is that only one diver sees the tank interior. During a dry inspection, at least two members of the tank evaluation crew visually assess the tank interior and evaluate the conditions found. Their joint observations can provide for substantially greater accuracy and a more complete evaluation.

Unanticipated problem areas that were not uncovered during the evaluation phase--whether during an underwater evaluation or a dry evaluation--typically manifest themselves after the coatings are removed from the tank. By that phase of tank rehabilitation, specifications have been prepared based on the condition of the tank as it was observed during the field evaluation. This can cause unexpected delays in the rehabilitation project and costly change orders. This situation puts the tank owner at a severe disadvantage since the repairs required were not competitively bid, and puts the owner at the mercy of the contractor on site.

While dry evaluations allow a more comprehensive evaluation of the tank's overall condition and result in more complete project specifications and fewer change orders, underwater inspections are a valuable evaluation tool when tanks cannot be drained or the tank owner chooses not to. Tank owners need to be aware of all of the implications of each type of inspection, understand what type of information will be derived from the inspection, and make an informed decision about what is best for their particular water system.

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### Please let us know.

We are constantly updating and maintaining our mail list to help assure that the people who want to receive Tank Talk do, and we aren't sending unwanted mail to those who are not interested. Your help is needed.

Please mail or fax us copies of duplicate labels or the labels for individuals who need to be removed from our list. We also welcome new names of those who would like to be added.

### ...and e-mail

We're also working toward being able to send Tank Tips and articles of interest to those in the storage tank industry via e-mail. If you are interested in receiving information over the internet, please send us your e-mail address.  
snodgrass@tankindustry.com

## TANK INDUSTRY CONSULTANTS

*The nation's leading professional engineering firm specializing in the design, maintenance, and rehabilitation of storage tank facilities*  
presents

# Water Storage Tank Design, Construction, & Maintenance Seminar

**Bolingbrook (Chicago), IL  
February 8 & 9, 2000**

Tank Industry Consultants, renowned experts in storage tank engineering, will be presenting a two-day water tank seminar at the Holiday Inn, Bolingbrook, Illinois, February 8 and 9, 2000. This unique seminar is designed to provide attendees with the latest, most up-to-the-minute information concerning water storage tank management.