Recent Developments in API Storage Tank Standards to Improve Spill Prevention and Leak Detection/Prevention

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

Tank Industry Consultants

INTRODUCTION:

American Petroleum Institute (API) Standards 650, 653 and 620 are the primary industry standards by which most aboveground welded storage tanks are designed, constructed and maintained. These standards address both newly constructed and existing aboveground storage tanks used in the petroleum, petrochemical and chemical industries. This paper discusses changes to API Standards 650, 653, 620, and some related Recommended Practices that have been made over the years or are being developed to improve the standards with respect to leak detection and spill prevention. The paper references API and other standards and practices that should be followed to reduce the risk of spills and leaks.

API has published standards for the construction of aboveground storage tanks since the mid-1930's. This paper focuses on the API Standards for aboveground storage tanks designed for atmospheric pressures, up to a maximum of 2.5 psig. API Standard 620 is applicable to tanks and vessels designed for low-pressure storage, ranging from about 2.5 psig to 15 psig. The provisions of (and changes to) API 620 with regard to leak and spill prevention are essentially the same as those of API 650 and so will not be separately addressed in this paper.

The First Edition of API 650 was published in 1961, but its predecessor, API 12C, had been in use since 1936, when welding began to replace riveting as the preferred construction method. Both API 12C and API 650 address only newly constructed tanks. It was not until the late 1980's that API began development of a new standard to address specific maintenance and inspection issues for existing aboveground storage tanks. This standard is API 653, "Tank Inspection, Repair, Alteration and Reconstruction." Since the publication of API Standard 653 in 1991, the tank inspection, repair, alteration and reconstruction methods prescribed therein have - when properly applied – significantly improved the safety and reliability of existing tanks. This standard and other API standards are continuously being improved to incorporate new technology and to reflect the actual experiences of owners and operators of aboveground storage tanks. This paper discusses some of the milestone developments in the API industry standards with regard to leak and spill prevention. And it highlights recent and imminent changes to the aboveground tank standards to further improve the prevention of leaks and spills.

BACKGROUND ON FEDERAL REGULATIONS:

In December of 1973, the federal government promulgated regulations addressing spill prevention and control for petroleum storage tanks under the Federal Water Pollution Control Act (FWPCA). The Clean Water Act (CWA), enacted in 1977, amended the earlier FWPCA regulations, which together authorized the federal government to establish procedures, methods, equipment and other requirements to prevent or control the discharge of oil from vessels and facilities into or upon the navigable waters of the United States. These regulations were published in the form of the Spill Prevention, Control and Countermeasures (SPCC) Plans, and the authority for the enforcement of the regulations was delegated to the Environmental Protection Agency (EPA). While the SPCC regulations established the authority and

enforcement for spill prevention and control countermeasures, they did not establish specific procedures, methods or equipment for the prevention or control of spills. And although leak detection technology was available and in use prior to enactment of the SPCC regulations, it was not until the development of a standard for existing tanks, namely API 653, that specific measures to detect leaks were formulated and adopted by the petroleum industry at-large.

LEAK PREVENTION VS LEAK DETECTION VS LEAK CONTAINMENT:

The petroleum industry's approach to protection of the environment is multi-faceted. Numerous standards have been developed to address protection of the environment from potential escapes of both liquid and gaseous substances. With respect to the risk of liquid escaping the confines of the tank itself, API standards prescribe provisions for leak prevention, leak detection, and leak containment. It is useful to distinguish between leak prevention, leak detection and leak containment to better understand the changes that have occurred in tank standards over the years. In simple terms, leak prevention is any process that is designed to deter a leak from occurring in the first place. Leak detection is any process or system that is designed to find a leak after one has occurred. And leak containment is any process or system that is designed to contain a leak and to isolate the contained liquid from contaminating groundwater or surface water. The petroleum tank industry's primary focus for new tank construction has been primarily on leak and spill prevention rather than on leak or spill detection or containment. As common sense would predict, experience has shown that as tanks age and deteriorate, the likelihood of a leak increases, particularly when tanks are not well maintained or when the tank service is particularly aggressive. Most tank owners long ago recognized and addressed the reality that tanks are more likely to leak when they grow old and implemented measures and technology to

detect leaks before they became an environmental threat. More recently, industry standards have been updated to publish minimum requirements and recommended practices in this regard.

COMMON CAUSES OF LEAKS AND SPILLS:

The most common causes of leaks and spills in aboveground storage tanks are typically classified in seven basic categories. These are:

1) Leaks due to corrosion: The risk of this type of leak is virtually nil when the tank is first constructed but typically increases as the tank ages. This type of leak is generally characterized by a slow rate and, when quickly detected, a small amount of total discharge. However, large total amounts of discharge can occur when the leak is not quickly detected, as in the case of tank bottom plates that are hidden from view and not equipped with leak detection devices or systems.
2) Leaks or spills due to operation: The risk of this type of spill or leak is generally not dependent on the age of the tank although the consequences can be more severe if the tank is in poor condition. Examples include such events as overfilling, leaks in piping connections, valves or pumps and leaks during transfer of product due to operator error or equipment failure. The quantity of product leaked or spilled can vary depending on the nature of the leak or spill.
3) Spills or leaks due to failure of the tank: The risk of this type of spill or leak is dependent primarily on the quality of design and construction of the tank. Brittle fractures of tanks in cold climates have occurred when the materials of construction did not have adequate toughness and ductility. Though exceptionally rare, when this type of failure has occurred, it has generally resulted in catastrophic failure of the tank, total spillage of the stored product, extensive property damage and significant environmental damage. Seismic loadings can

cause tanks and/or associated piping systems to rupture, resulting in significant or total spillage of tank product.

4) Improper maintenance or lack of maintenance: Lack of proper maintenance can lead to leaks resulting from undetected corrosion or other damage.
5) Sabotage or vandalism: Spills and leaks may result from intentional attacks on the tank. The risks of such events are usually mitigated by increased security measures rather than by provisions in design or construction standards.
6) Poorly designed and/or maintained piping systems: Piping system component leaks are the major source of leaks and spills in comparison to all other categories.
7) Fire and explosion: Fires and explosions are most often attributable to improper design, improper operation, or a combination of the two. While fires and explosions are more often considered a result of leaks or spills rather than a cause of them, a fire or explosion is likely to result in additional spillage of the affected tank's contents or to spread to adjacent tanks.

HOW INDUSTRY STANDARDS HAVE CHANGED TO ADDRESS LEAKS AND SPILLS:

The API Standards and other documents that directly address leak and spill prevention, detection or containment for aboveground tanks and their associated piping systems are summarized in the following table.

API DOCUMENTS THAT ADDRESS SPILL AND LEAK PREVENTION (L-P), DETECTION (L-D) OR CONTAINMENT (L-C)

API Number	Title	L-P	L-D	L-C	Applicable to:
Standard 650	Welded Steel Tanks for Oil Storage	Yes	Yes	Yes	Aboveground Tanks
Standard 653	Tank Inspection, Repair, Alteration and Reconstruction	Yes	Yes	Yes	Aboveground Tanks
RP 651	Cathodic Protection of Aboveground Storage Tanks	Yes	No	No	Aboveground Tanks
RP 652	Lining of Aboveground Storage Tank Bottoms	Yes	No	No	Aboveground Tanks
RP 2350	Overfill Protection for Storage Tanks in Petroleum Facilities, 1996	Yes	No	No	Aboveground Tanks
Standard 2610	Design, Construction, Operation, Maintenance and Inspection of Terminal & Tank Facilities	Yes	Yes	Yes	Aboveground Tank Facilities
RP 575	Inspection of Atmospheric and Low Pressure Storage Tanks	Yes	Yes	No	Aboveground Tanks
Publication 306	An Engineering Assessment of Volumetric Methods of Leak Detection in Aboveground Storage Tanks, 1991	No	Yes	No	Aboveground Tanks
Publication 307	An Engineering Assessment of Acoustic Methods of Leak Detection in Aboveground Storage Tanks, 1991	No	Yes	No	Aboveground Tanks
Publication 315	Assessment of Tankfield Dike Lining Materials and Methods, 1993	No	No	Yes	Aboveground Tanks
Publication 322	An Engineering Assessment of Acoustic Methods of Leak Detection in Aboveground Storage Tanks, 1994	No	Yes	No	Aboveground Tanks
Publication 323	An Engineering Assessment of Volumetric Methods of Leak Detection in Aboveground Storage Tanks, 1994	No	Yes	No	Aboveground Tanks
Publication 325	An Evaluation of a Methodology for the Detection of Leaks in Aboveground Storage Tanks, 1994	No	Yes	No	Aboveground Tanks
Publication 334	A Guide to Leak Detection for Aboveground Storage Tanks, 1995	No	Yes	No	Aboveground Tanks
Publication 340	Liquid Release Prevention and Detection Measures for Aboveground Storage Facilities, 1997	Yes	Yes	Yes	Aboveground Tanks
Publication 341	A Survey of Diked-Area Liner Use at Aboveground Storage Tank Facilities	No	Yes	Yes	Aboveground Tank Facilities

API Number	Title	L-P	L-D	L-C	Applicable to:
Publication 346	Results of Range-Finding Testing of Leak Detection and Leak Location Technologies for Underground Pipelines, 1998	No	Yes	No	Pipelines
Publication 1149	Pipeline Variable Uncertainties and Their Effects on Leak Detectability 1993	No	Yes	No	Pipelines
Publication 1155	Evaluation Methodology for Software-Based Leak Detection Systems, 1995	No	Yes	No	Pipelines

This is by no means a complete list of the API documents that address preventive measures against leaks and spills. For a complete list of publications, with descriptions of the contents of each publication, consult the current API "Publications, Programs, and Services Catalog."

Specific changes and additions with regard to leak or spill prevention, detection or containment have been made to the API standards most often used for the construction and maintenance of aboveground petroleum and chemical storage tanks, namely API Standards 650, 653, and 2610 and Recommended Practices RP 651, 652, and 2350.

API Standard 650 - Welded Steel Tanks for Oil Storage:

API 650 covers material, design, fabrication, erection and testing requirements for aboveground, vertical, cylindrical, closed and open-top, welded steel storage tanks in various sizes and capacities. This standard applies to tanks with internal pressures approximating atmospheric pressure, but ranging as high as 2.5 psig. This standard applies to newly constructed tanks before they have been placed in service. The most significant changes that have been made to this standard or are currently in committee with respect to leak and spill prevention are summarized in the following table.

API 650 - First Edition Published 1961, Current Edition (Addendum) Published 2000
• Added Appendix I – "Undertank Leak Detection and Subgrade Protection." This appendix provides acceptable construction details for the detection of product leaks through the bottoms of aboveground storage tanks, and provides guidelines for tanks supported by grillage.
• Vacuum box test pressure was required to be a minimum of 3 psig. Vacuum box testing must be performed on tank bottom welds under the standard to verify that there are no leaks.
• Air pressure testing was added as an alternative to vacuum box testing of the corner weld. In this alternative test, pressure is introduced into the space between the inside and outside corner fillet welds and gauged to detect any leakage from either of the welds.
• Tracer gas testing was added as an alternative to vacuum box testing of the welded bottom joints.
• Bottom welding and leak testing requirements of Section 5 are being revised to further reduce the possibility of a leak resulting during construction of the tank bottom. Post weld cleaning requirements are being included, as are additional inspection qualifications.
• Vacuum testing requirement updates are in the works that will relocate the vacuum testing requirements of Section 5.3.3 to a new Section 6.6 and will update the requirements to include specific vacuum test pressures, additional visual inspector qualifications and mandatory record-keeping provisions.
• Tank welding requirements were clarified to specifically require use of welding procedure specifications described in ASME Section IX.
• Manway flange gasket requirements were revised to specifically address the conditions under which the use of hard gasket materials is acceptable. This item was intended to eliminate the very rare cases in which flange leaks have occurred because of the use of hard manway gaskets.
• New Appendix T will be added to summarize inspection requirements, methods of examination and acceptance criteria, inspector qualifications and procedures.
• The definition and documentation of tank capacity and maximum filling height has been clarified and made consistent with API RP 2350 in an effort to further reduce the risk of accidental overfilling of the tank.
• An index of decisions and actions that may be required of the tank purchaser has been added, along with bulleted identification of each section requiring a purchaser decision or action. This change is designed to ensure that the finished product meets all purchaser expectations. It should also reduce the risk of misoperation or misuse of the tank.

API Standard 653 - Tank Inspection, Repair, Alteration and Reconstruction

API 653 covers the inspection, repair, alteration and reconstruction of existing steel aboveground storage tanks used in the petroleum and chemical industries. It provides the minimum requirements for maintaining the integrity of welded or riveted, nonrefrigerated, atmospheric

pressure, aboveground storage tanks after they have been placed in service. The most significant changes that have been made to this standard or are currently in committee with respect to leak and spill prevention are summarized in the following table.

API 653 - First Edition Published 1991, Current Edition (Addendum) Published 2001
• Robotic inspection provisions were incorporated to allow the use of robotic inspections in lieu of taking a tank out of service to perform periodic inspections required by the standard.
• Bottom plate repairs in the critical zone were permitted, subject to certain restrictions, as an alternative to complete replacement of bottom plates in the critical zone.
• Edge settlement criteria was re-evaluated and changed to more accurately define acceptable settlements in terms of structural and leak integrity as a function of tank size and bottom weld joint orientation.
• Minimum remaining thickness (MRT) acceptance criteria for the bottom plate was reduced, providing advanced inspection techniques were used. This change provided an incentive for using more thorough and more advanced inspection techniques for tank bottoms.
• Qualification requirements for floor scanners and scanner operators were added. These requirements were designed to establish a qualifying method for verifying that floor scanner equipment is operating properly to produce valid information, and to require operator testing to ensure the equipment was being operated properly and within its capabilities.
• Liner attachment details of Appendix I were clarified to permit alternative methods to attachment by a bolting bar and welded studs.
• Lap welded cover or patch plates were permitted as an alternative to butt-welded insert plates for certain types of repairs. If used, lap welded patch plates must be examined by either the magnetic particle or liquid penetrant method in addition to visual examination.
• Add detailed inspection requirements for sumps to Appendix C checklists to ensure that these important components are given appropriate attention in an inspection.
• Roof repair weld examination requirements will be revised to mandate the same examination as is required for newly constructed tanks under API 650.
• Tracer gas test requirements are under study to incorporate a minimum rate of leak to detect and to require calibration before a test by means of a calibrated leak.
• Incorporation of a reference to API RP 579, "Fitness-for-Service" will be included in the standard to explicitly allow the evaluation criteria of RP 579 to be applied in certain cases.
• Minimum weld spacing between the shell-to-bottom weld and the nearest penetration attachment weld has been thoroughly researched and will be redefined to clarify requirements for the case where new bottoms are installed above existing bottoms by the slotted shell method.

API RP 651 - Cathodic Protection of Aboveground Storage Tanks

This Recommended Practice describes corrosion problems characteristic to aboveground steel storage tanks and associated piping systems. The intent of this recommended practice is to

provide information and guidance specific to aboveground steel storage tanks in hydrocarbon service. It does not prescribe specific cathodic protection system designs but rather is intended as a guide to persons interested in cathodic protection as a leak prevention measure. It provides a general description of the two methods currently used to provide cathodic protection against corrosion. These methods are the galvanic cathodic protection method using sacrificial anodes and the impressed current cathodic protection method. This recommended practice references several NACE standards, including RP-01-93, "External Cathodic Protection of On-Grade Metallic Storage Tank Bottoms." The NACE RP provides more specific or "how to" information about cathodic protection. The first edition of API RP 651 was published at about the same time as, and as a "companion" document to the first edition of API Standard 653. The current edition is the second edition, published in 1997. Since API RP 651 provides guidance and information of a general nature, it has not been necessary to make significant revisions since the initial publication of this practice.

API RP 652 - Lining of Aboveground Storage Tank Bottoms

This Recommended Practice describes procedures and practices for the application of tank bottom linings to existing and new aboveground storage tanks to achieve effective corrosion control. It does not prescribe specific tank bottom linings but rather is intended as a guide to persons interested in lining of tank bottoms as a leak prevention measure. Similar to API RP 651, the first edition of this recommended practice was published at about the same time as and is a "companion" document to the first edition of API Standard 653. The current edition is the second edition, published in 1997. Like API RP 651, API RP 652 references an extensive list of publications and "how to" specifications. The referenced publications provide the details necessary to design and apply an effective coating system. Since API RP 652 provides guidance

and information of a general nature, it has not been necessary to make significant revisions since the initial publication of this practice.

API RP 2350 - Overfill Protection for Storage Tanks in Petroleum Facilities, 1996

This Recommended Practice provides information designed to prevent petroleum storage tanks from being overfilled. The basis of the provisions of this practice is that tank overfills can be effectively reduced by developing and implementing practical and safe operating procedures and by providing for careful selection and application of equipment, scheduled maintenance programs, and employee training. It covers overfill protection for all aboveground storage tanks in petroleum facilities that receive flammable liquids from mainline pipelines or marine vessels. Currently, the API Safety and Fire Protection Subcommittee are reviewing it and making improvements to it. Work is underway to develop new language in several areas to improve the effectiveness of the standard. Specific forthcoming changes are not yet publicly available but should be in the near future.

API Standard 2610 - Design, Construction, Operation, Maintenance and Inspection of Terminal & Tank Facilities, 1994

This Standard covers the design, construction, operation, inspection and maintenance of petroleum terminal and tank facilities associated with marketing, refining, pipeline, and other similar activities. It covers site selection and spacing, pollution prevention and waste management, safe operations, fire prevention and protection, tanks, dikes and berms, mechanical systems (pipe, valves, pumps and piping systems), product transfer, corrosion protection, structures, utilities and yard, and removals and decommissioning. The most significant changes that have been made to this standard or are currently in committee with respect to leak and spill prevention are summarized in the following table.

API 2610 - First Edition Published 1994, Current Edition Published 1994
• List of referenced publications has been updated and will now include several related to leak prevention, detection and containment.
• Definitions of release prevention barriers and release prevention systems will be added.
• Section on Release Prevention will be updated to include references to API 650, Appendix I.
• Section on Leak Detection will be updated to include references to API 650, Appendix I, Publication 334 and Recommended Practice 575.
• Section on Tank Alarms will include additional provisions designed to reduce the risk of spills due to overfilling the tank.
• Section on Liners will include additional provisions to require consideration of the permeability of the dike material and to reference API Publications 315 and 341.
• Section on Pressure Testing of piping will be revised to address the negative aspects of testing piping at pressures higher than normal operating pressures.

SUMMARY

There are numerous industry standards designed to prevent leaks and spills from aboveground storage tanks, piping and associated components. This paper summarizes the most significant changes to the American Petroleum Institute industry standards and recommended practices for aboveground storage tanks with respect to leak and spill prevention, detection and containment. It illustrates that these standards are not static documents but are continuously being improved to reflect industry experience and to incorporate new and improved technology to protect the environment from leaks, spills and emissions from tanks and associated components.

REFERENCES:

1) "Aboveground Storage Tanks", Philip E. Myers, Chevron Research and Technology, McGraw-Hill, 1997.

2) "Aboveground Storage Tank Guide", Thompson Publishing Group, 1998.

3) American Petroleum Institute "Publications, Programs, and Services Catalog 2001"

4) API Standard 650 - Welded Steel Tanks for Oil Storage, 10th Edition, 1998

5) API Standard 653 - Tank Inspection, Repair, Alteration and Reconstruction, 2nd Edition, 1995

6) API RP 651 - Cathodic Protection of Aboveground Storage Tanks, 2nd Edition, 1997

7) API RP 652 - Lining of Aboveground Storage Tank Bottoms, 2nd Edition, 1997

8) API RP 2350 - Overfill Protection for Storage Tanks in Petroleum Facilities, 2nd Edition, 1996

9) API Standard 2610 – Design, Construction, Operation, Maintenance, and Inspection of Terminal & Tank Facilities, 1994 (Draft #1 of Second Edition, 2000)

10) Miscellaneous API Refining Meeting Minutes, 1997 through 2001.