# Tank Inspections Based on Risk to the Environment

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Abstract

Inspection of storage tanks based on the risk to the environment is important to both the owners of tanks and regulators – although for different reasons. To the owner of tanks, reduced inspections by the addition of safeguards which are extensive enough to reduce or simplify expensive tank inspections makes good business sense. Regulators wish to minimize and eliminate releases. The Steel Tank Institute Standard, SP001, "Inspection of Aboveground Storage Tanks" includes a risk-based inspection schedule. Should not tanks that have these safeguards and therefore are less likely to create a problem be inspected with a lower frequency and intensity than tanks without them? This paper discusses how this inspection standard is intended to be used by facility owners, regulators and professional engineers preparing SPCC Plans.


## Risk-based Inspections

By assessing equipment based on relative risk, an inspection program for any type of equipment can optimize resources (time and money). Traditionally, RBI programs use a "risk ranking matrix" that include the two essential elements of risk – likelihood and consequence. In our case, likelihood relates to the uncertainty associated with a release. Consequence relates to the possibility that an unwanted event can occur, i.e., groundwater contamination or spill to nearby body of water; as well as the extent of the unwanted event.

As shown in the diagram below, equipment (such as a tank) is ranked based on the likelihood of its failure along the x-axis and the consequence of the failure along the y-axis.

Risk matrix example

| Consequence of failure \ Likelihood of failure | Not likely | Somewhat likely | Very likely |
|---|---|---|---|
| Small | 1 | 2 | 3 |
| Minor | 2 | 3 | 4 |
| Average | 3 | 4 | 5 |
| Major | 4 | 5 | 6 |

The best scenario is that the likelihood of failure is deemed, "not likely" and the consequence is "small." Conversely, the scenario to avoid is where the likelihood of failure is "very likely" and the consequences would be "major."

The Engineering Equipment and Materials Users Association[1] (EEUMA) Publication No. 159, 3rd Edition, *Users' Guide to the Inspection, Maintenance and Repair of Aboveground Vertical Cylindrical Steel Storage Tanks* includes a discussion of Risk Management as it applies to inspection and maintenance of ASTs.

[1]EEUMA is an established industry Association with an international reputation in engineering, technology and the management of capital assets, typically chemical process plants, refineries, power stations and upstream oil/gas facilities. EEMUA has developed industry guidance, user standards and specifications for the management of technology and to ensure development of competency in the workforce. Its publications and views are now recognized and followed worldwide. For more than 50 years, EEMUA members have built and maintained relationships with government, regulatory agencies, equipment manufacturers and suppliers, formal Standards organizations, the plant inspection and insurance sectors, and many other bodies in the UK, Europe and worldwide.[Information taken from the organization's website www.eemua.co.uk]

In paragraph 6.2.2.2 *Probability of a Specific Failure Mode* of EEUMA Publication No. 159 is the following text,

> "The cornerstone of RBI is the assessment of an item's risk classification, since the RBI methodology is risk-based. Generally, risk is defined as the probability of occurrence (likelihood) of harm (failure) and the consequences of that harm…
>
> Generally, the RBI method takes into account those degradation mechanisms affecting the tank during normal operations (corrosion, fatigue, etc.). However, failures as a result of excursions outside the defined operating window should also be considered.
>
> Many degradation mechanisms are time-dependent (e.g., general corrosion, settlement)…In reality, the degradation rate may vary over time. This aspect should be considered, and 'worst case' assumptions made to provide acceptable safety margins. Through inspection, the average rates of degradation may become better defined.
>
> Some degradation mechanisms are independent of time, and occur when there are specific conditions present. These conditions may not have been predicted in the original assessment. For this reason, RBI should be applied on a single or individual basis, where tank history and specific experiences with the particular tank are taken into account within the whole RBI process."

In paragraph 6.2.2.4 *Risk Rating* of EEUMA Publication No. 159 is the following text,

> "Quantification of the risk is generally assessed in a semi-quantitative way by estimating the probability of a (specific) failure mode and a consequence rating for that failure mode which, combined in a risk matrix, leads to a risk class or rating…
>
> The main purpose of risk rating is to focus attention on the high risk items…"

<u>Risk-based inspections and the SP001 Standard</u>

EEUMA Publication No. 159, as well as API Recommended Practice 580, *Risk-Based Inspection*, and API Publication 581, *Risk-Based Inspection*, provide the steps necessary to establish a risk-based preventive maintenance program. Likewise, these publications include steps needed to assigning numerical values to both likelihoods and consequences (as described in paragraph 6.2.2.4 of EEUMA Publication No. 159). Lastly, it is recommended that users of these publications consult individuals knowledgeable in tank design and RBI methodology in establishing inspection programs based on the RBI principles.

In the development of the 3rd edition of the Steel Tank Institute SP001 Standard (July 2005 edition), an inspection schedule was devised that is based on risk management concepts. However, the SP001 inspection schedule is prescriptive and does not rely on assigning values to various likelihoods and consequences. Rather, a table of types of tank installations and tank sizes is given varying periods between inspections. Single-wall tanks sitting directly on soil without secondary containment or spill control were deemed to pose the greatest risk for an incident and therefore require more frequent inspections. The basis for this assessment was empirical and determined by experts in the field based on good engineering practice.

## SP001 Terminology

Key to understanding the inspection schedule in SP001 is an understanding of the terminology used in SP001. Here are some key concepts:

**CONTINUOUS RELEASE DETECTION METHOD (CRDM) –** a means of detecting a release of liquid through inherent design. It is passive because it does not require sensors or power to operate. Liquid releases are visually detected by facility operators. The system shall be designed in accordance with good engineering practice. Several acceptable and commonly used CRDM systems are as follows:

- Release prevention barrier (RPB) described in definition of release prevention barrier.
- Secondary containment AST including double-wall ASTs, double-bottom ASTs, or other ASTs described in definition of secondary containment.
- Elevated AST with release prevention barrier

**FIELD-ERECTED AST –** a welded metal AST erected on-site where it will be used. For the purpose of this standard, ASTs meeting either of the following descriptions are to be inspected as field-erected ASTs:

a. An AST where the nameplate (or other identifying means such as accurate drawings) indicates that it is a field-erected AST. These are limited to a maximum shell height of 50 feet (15.24 meters) and a maximum diameter of 30 feet (9.14 meters).
b. An AST without a nameplate (or other identifying means such as accurate drawings) that is more than 50,000 U.S. gallons (189,271 liters) and a maximum shell height of 50 feet (15.24 meters) and a maximum diameter of 30 feet (9.14 meters).

**FORMAL EXTERNAL INSPECTION (FEI) –** a documented external inspection conducted by a certified inspector to assess the condition of the AST and determine its suitability for continued service without entry into the AST interior.

**FORMAL INTERNAL INSPECTION (FII)** - a documented internal inspection conducted by a certified inspector to assess the internal and external condition of the AST and determine its suitability for continued service. This includes the inspection requirements of a formal external inspection. A formal internal inspection satisfies the requirements of a formal external inspection and shall be considered equivalent to or better than a formal external inspection for the purposes of scheduling.

**LEAK TESTING METHOD (LTM) –** a point in time test method to determine if an AST is liquid tight. Leak testing is not preventive in the sense that it provides an indication only if the AST integrity has already been breached. Therefore, it may be used as a tank integrity measure or as a supplement to other inspection procedures. LTMs may include the following technologies:

- Gas pressure decay (includes vacuum decay)
- Gas pressure soap bubble testing
- Gas tracers (e.g., helium tracer)
- Soil tracers (chemical marker)
- Mass measurement
- Level measurement
- Hydrostatic test

**PERIODIC AST INSPECTION** - a visual, documented inspection conducted by an owner's inspector, to assess the general AST conditions, as best as possible, without suspending AST operations or removing the AST from service.

**RELEASE PREVENTION BARRIER (RPB) –** a liquid containment barrier that is sufficiently impervious to the liquid being stored and is installed under the AST. Its purpose is to divert leaks toward the perimeter of the AST where they can be easily detected as well as to prevent liquid from contaminating the environment. RPBs are composed of materials compatible with the liquid stored in the AST and meet proper engineering standards. Examples are steel (such as in steel double-bottom tanks), concrete, elastomeric liners, or other suitable materials provided the above criteria are met.

**SECONDARY CONTAINMENT AST –** an AST which is either a double-wall AST, or an AST with an integral secondary containment dike. These integral secondary containment dikes may be pans, boxes or containers and are designed to contain the contents of the primary tank if the primary tank fails. A secondary containment AST may be open or closed to the atmosphere. If precipitation cannot readily enter the integral secondary containment, then the containment need only be sized for the primary tank volume. If precipitation can enter the secondary containment, then the secondary containment is sized to contain the primary tank volume and with sufficient freeboard to contain precipitation.

**SHOP-FABRICATED** – a welded metal AST fabricated in a manufacturing facility or an AST not otherwise identified as field-erected with a volume less than or equal to 50,000 U.S. gallons (189,271 liters).

**SPILL CONTROL** - a means of preventing a release of liquid to the environment including adjoining property and waterways. Methods include the following:

- Remote impounding
- Secondary containment dike/berm
- Secondary containment AST
- Secondary containment system

**SUFFICIENTLY IMPERVIOUS** - Sufficient resistance to diffusion and transport of hydrocarbon or other chemical substances to prevent contamination of the environment until clean-up occurs. Determination of "sufficiently impervious" is a technical consideration that a Professional Engineer or other qualified professional (such as Professional Geologist, Environmental Professional, etc.) must make. This determination is to be based on sound technical considerations, the site specific conditions, as well as risk based considerations, such that ground and groundwater contamination is prevented, using current normally accepted engineering practices and principles. Sufficiently impervious does not necessarily mandate the use of a liner. Additional information about liners is found in API 341, *A Survey of Diked-area Liner Use at Aboveground Storage Tank Facilities.*

Further, SP001 divides ASTs into 3 categories.  Tank installations are classified based on whether they have safeguards to prevent spills from entering the environment.  The determination of which category is applicable for a specific tank is the responsibility of the tank owner, but the owner should consult the SPCC Plan for the facility, if applicable.

Examples of the tank categories follows:

Category 1 - ASTs with spill control, and with CRDM

**Double-wall tank**

**Double-bottom tank in concrete dike**

Category 2 - ASTs with spill control and without CRDM

**Single-wall tanks in earthen berm**

## Category 3 - ASTs without spill control and without CRDM

**Single-wall tank directly on soil and without spill control**

## SP001 Standard Inspection Schedule

Here is the corresponding Table 5.5, “Table of Inspection Schedules” from SP001:

| AST Type and Size (U.S. gallons) | | Category 1 | Category 2 | Category 3 |
|---|---|---|---|---|
| Shop-Fabricated ASTs | 0 – 1100<br>(0-4164 liters) | P | P | P, E&L(10) |
| | 1101 - 5,000<br>(4168-18,927 liters) | P | P, E&L(10) | [P, E&L(5), I(10)]<br>or<br>[P, L(2), E(5)] |
| | 5,001 - 30,000<br>(18,931-113,562 liters) | P, E(20) | [P, E(10), I(20)]<br>or<br>[P, E(5), L(10)] | [P, E&L(5), I(10)]<br>or<br>[P, L(1), E(5)] |
| | 30,001 - 50,000<br>(113,566-189,271 liters) | P, E(20) | P, E&L(5), I(15) | P, E&L(5), I(10) |
| Field-erected AST | | P, E(5), I(10) | P, E&L(5), I(10) | P, E&L(5), I(10) |
| Portable Containers | | P | P | P |

Note the following:
P – Periodic AST inspection
E – Formal External Inspection by certified inspector
I – Formal Internal Inspection by certified inspector
L – leak test by owner or owner’s designee
( ) indicates maximum inspection interval in years.
For example, E (5) indicates formal external inspection every 5 years.
and
Category 1 - ASTs with spill control, and with CRDM
Category 2 - ASTs with spill control and without CRDM
Category 3 - ASTs without spill control and without CRDM

The above table from SP001 shows that Category 3 tanks must have the most complex and most frequent inspections (with the associated costs for inspections), whereas Category 1 tanks have the least inspection complexity.

<u>Tank Examples</u>

These few examples will show how to assign a tank to the various categories which then determines the inspection requirements.

1. 1,100 gallon double-wall tank. Horizontal cylindrical on saddles. In the chart above, this is a Category 1 tank and requires only Periodic AST inspections by the owner.
2. 3,500 gallon single-wall elevated horizontal tank in an earthen dike. In the chart above, this is a Category 2 tank (does not have CRDM, but has secondary containment). The tank requires Periodic AST inspections by the owner as well as both Formal External Inspections by a certified inspector and leak tests by owner or owner's designee at 10 year intervals.
3. 5,000 gallon single-wall tank in an earthen dike. Tank is vertical cylindrical and rests directly on the ground. In the chart above, this is a Category 2 tank and requires Periodic AST inspections by the owner as well as both Formal External Inspections by a certified inspector and leak tests by owner or owner's designee at 10 year intervals.
4. 10,000 gallon single-wall tank without secondary containment of any type. Tank is vertical cylindrical and rests directly on the ground. This is a Category 3 tank. In the chart above two choices are given for inspection schedules.

- *Choice 1* - Periodic AST inspections by the owner are necessary. Also, Formal External Inspections by a certified inspector and leak tests by owner or owner's designee are necessary at 5 year intervals. Lastly, Formal Internal Inspections by certified inspector are necessary at 10 year intervals.
- *Choice 2* - Periodic AST inspections by the owner are necessary. Also, leak tests by owner or owner's designee are necessary at 1 year intervals. Lastly, Formal External Inspections by certified inspector are necessary at 5 year intervals.

Notice that two inspection alternatives or owner choices of types of inspections are given. STI SP001 provides alternatives where warranted in an effort to equalize the risks associated with each alternative. In this case, these two choices were given because entering an AST poses significant risk to the inspector. Also, many shop-fabricated ASTs do not have manways and therefore entry is difficult. Noted though is the fact that Formal Internal Inspections provide more information about the condition of an AST than Formal External Inspections combined with leak tests and therefore the former method is provided with longer intervals between inspections than the latter. Hence, if we can reduce the frequency of internal inspection while also maintaining equivalent protection, we can reduce the risk of harm to human health and the environment.

To the owner of tanks, reduced inspections by the addition of safeguards is money in their pocket. To the regulator, targeting inspections at the tanks that are installed without safeguards prevents leaks. Implied in Table 5.5 in SP001 is the encouragement for a tank owner to improve a tank installation to reduce its risk to the environment. By applying generally accepted good industry and engineering practices, such as those given for Category 1 tanks, the tank owner is rewarded with fewer inspections. While short-term costs may be higher, the long-term total cost of ownership can be much lower due to fewer incidents, environmental cleanup, regulatory citations, new regulations and many other factors. Further, when comparing inspection requirements of underground tanks to aboveground tanks, most tank owner/operators realize that the visual inspection of elevated ASTs is considerably simpler than inspecting an underground tank.

The owner of tanks should clearly consider upgrading of tank installations. This should be accomplished by incorporating CRDM and secondary containment to ASTs or moving underground tanks aboveground at the first available opportunity. This will become quite evident when the next scheduled Formal External or Informal Inspection reveals that missing safeguards require an increased inspection frequency or are needed to comply with regulations.

Numerous tank types are found in the United States. Although Table 5.5 in SP001 includes many tank types and types of installations, including all types is impossible. For example, inspection methods for plastic tanks are not included in SP001. Therefore, a Professional Engineer assessing tank inspection programs must use professional judgment to adapt this standard to specific industries or facilities. Per paragraph 1.3 of SP001,

> "The Professional Engineer must use other standards, recommended practices and other equivalent engineering and best practices that exist and provide alternative inspection requirements for tanks defined within the scope of this standard and for tanks outside the scope of this standard."

The SP001 Standard is intended for use in many contexts, only one of which is part of an EPA-SPCC Plan. To understand how the SP001 Standard is to be used in the context of an SPCC Plan, a review of the USEPA SPCC Rule is needed.

USEPA SPCC Rule

In 2002, the United States Environmental Protection Agency's (USEPA) issued its Final Revised SPCC Rule regarding the storage and handling of oils, both petroleum and non-petroleum (40 CFR Part 112). This Rule requires that facilities covered under the EPA's SPCC regulations develop a Spill Prevention, Control and Countermeasure (SPCC) Plan that is certified by a licensed Professional Engineer. The purpose of the SPCC regulation is to prevent the discharge of oil into the U.S. navigable waters.

- Facilities affected - This Rule impacts a multitude of facilities that have oil in containers of many constructions and sizes. Facilities affected are those with total aboveground (i.e., not completely buried) oil storage capacity greater than 1,320 gallons. Containers of oil, petroleum and non-petroleum, of 55 or more gallons are to be included when determining the total oil storage capacity at a facility. (Refer to further requirements on the type of tank installations, such as partially buried tanks, found in §112.1 of 40 CFR Part 112.)
- Integrity testing – In §112.8(c)(6) [petroleum oils] and §112.12(c)(6) [non-petroleum oils], the Rule states,

> "Test each aboveground container for integrity on a regular schedule, and whenever you make material repairs. The frequency of and type of testing must take into account container size and design (such as floating roof, skid-mounted, elevated, or partially buried). You must combine visual inspection with another testing technique such as hydrostatic testing, radiographic testing, ultrasonic testing, acoustic emissions testing, or another system of non-destructive shell testing. You must keep comparison records and you must also inspect the container's supports and foundations. In addition, you must frequently inspect the outside of the container for signs of deterioration, discharges, or accumulation of oil inside diked areas. Records of inspections and tests kept under usual and customary business practices will suffice for purposes of this paragraph."

Note that the original SPCC Rule did not mandate integrity testing, but rather stated that tanks should undergo periodic integrity testing. This means that a large number of facilities may not have had a tank inspection program, but are now required to do so.

Standard SP001 meets the intent of this "integrity testing" definition. The standard includes the following provisions as mentioned in this SPCC Rule language:

- Testing of ASTs for integrity are shown to be on a regular schedule
- Frequency and type of testing takes into account the container size and design
- Visual inspection is combined with ultrasonic testing
- Comparison records are to be kept
- All tank appurtenances are to be inspected including supports
- Frequent inspections of the AST exterior are required

- <u>Role of Professional Engineer</u> - The owner or operator of an applicable facility must prepare the SPCC Plan in accordance with good engineering practices and the plan must be reviewed and certified by a licensed Professional Engineer (see §112.3(d)). The Professional Engineer is to use both good engineering practice and consideration of applicable industry standards to establish the procedures for required inspections and testing. (see §112.3(d)(1)(iii) and §112.7(e)).

- <u>Industry Standards</u> - The SPCC Final Rule issued in 2002 includes a "Section by Section Analysis" commonly called the Preamble to the Rule. This analysis includes a summary of all public comments and responses to the comments.

  The comments on §112.1(e) includes a reference to Industry standards,

  > "Under this Rule, a facility is required to at least consider the use of all relevant measures, including the use of industry standards, as a way to implement those measures. The requirement comes in the language of revised §112.3(d)(1)(iii) requiring the PE to attest that 'the Plan has been prepared in accordance with good engineering practice, including consideration of applicable industry standards, and with the requirements of this part.' A facility should use industry standards whenever possible in preparing and implementing its SPCC Plan, and should discuss their use in Plans."

Commentary in the Preamble on §112.8(c)(6) also includes a reference to Industry standards,

> "Industry standards that may assist an owner or operator with integrity testing include: (1) API Standard 653…(3) Steel Tank Institute Standard SP001-00…"

- Environmental Equivalence - Information about this concept that is new in the 2002 SPCC Rule is provided at §112.7(a)(2), that states,

> "Comply with all applicable requirements listed in this part. Your Plan may deviate from the requirements in paragraphs (g), (h)(2) and (3), and (i) of this section and the requirements in subparts B and C of this part, except the secondary containment requirements in paragraphs (c) and (h)(1) of this section, and…where applicable to a specific facility, if you provide equivalent environmental protection by some other means of spill prevention, control, or countermeasure. Where your Plan does not conform to the applicable requirements…you must state the reasons for nonconformance in your Plan and describe in detail alternate methods and how you will achieve equivalent environmental protection."

Professional Engineer's Use of Environmental Equivalence

Assembling these key references for the SPCC Rule, a Professional Engineer may use good engineering practices while considering the applicability of industry standards and adapting such standards to specific facilities. The establishment of inspection schedules for tanks that do not strictly fit into the provisions given in a particular industry standard can be problematic. To establish schedules for these situations, a Professional Engineer may recommend an inspection schedule be based on other inspection methods and schedules provided an equivalent environmental protection is achieved. Most Professional Engineers realize that the use of industry standards reduce their liability.

Further, in the preparation of the SPCC Plan, a Professional Engineer must be explicit in concerning where deviations from the SPCC Rule are taken, the reasons why this is necessary, and how equivalent environmental protection is provided (see §112.7(a)(2)).

Conclusion

Did you know that

- Each year about 14,000 oil spills are reported, per the EPA website?
- It is estimated that in the US there are 618,000 facilities that are regulated under EPA-SPCC?
- There may be more “regulated” aboveground storage tanks than underground storage tanks in the United States?
- Tanks under 300,000 gallons likely represent 90% of the actual tank units in operation?
- STI estimates that as many as 4 million shop-fabricated tanks have been produced since the mid-1960’s for purposes of storing oil? It is difficult to assess how many of these tanks are still in use today, but anecdotal evidence suggests that tanks are often used for 40 years or more.

With this significant population of tanks, risk-based inspection schedules become even more important. As discussed above, the use of risk-based inspection schedules benefit tank owners and regulators. SP001 provides a means to accomplish this without the use of outside RBI experts.