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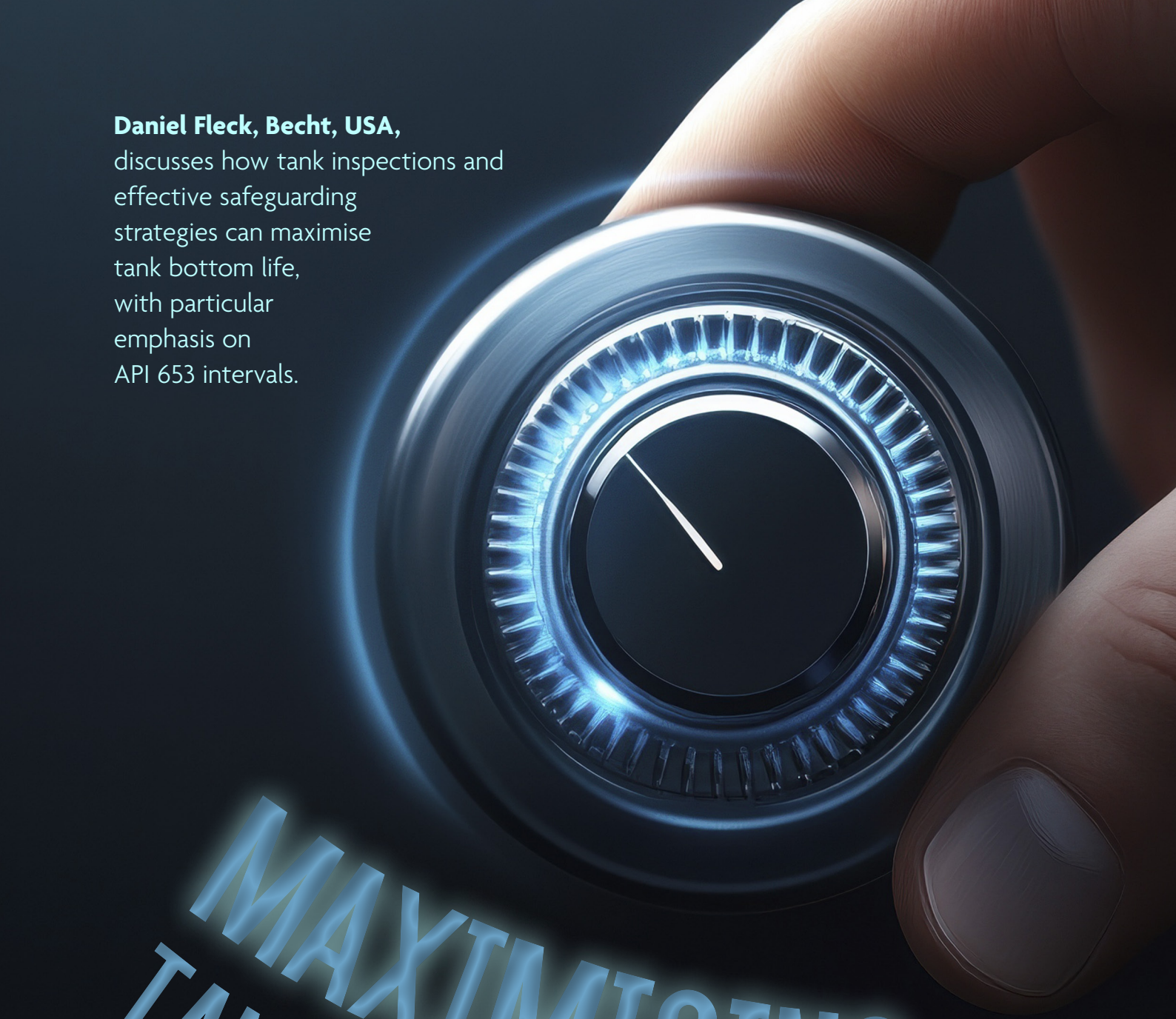
discusses how tank inspections and effective safeguarding strategies can maximise tank bottom life, with particular emphasis on API 653 intervals.



MAXIMISING TANK BOTTOM LIFE

A new tank bottom is not born into a utopia because it is subject to many damage mechanisms and risks. It is difficult to know from the outset how severe the damage will be. Even the most well designed and perfectly constructed tank bottom will degrade to some extent.

Setting an initial interval

API 653 has long prescribed a 10-year interval for the first internal inspection after the installation of a new bottom. This interval has been present since the 1st Edition of the standard. 10 years was likely chosen as a conservative, round-number baseline and historical data suggests this 10-year period generally suffices to prevent leaks caused by corrosion when bare steel is in contact with the ground. While there are exceptions, the majority of tanks following this standard have lasted through the initial decade. More recent editions of the standard have not decreased this base recommendation.

Since the 4th Edition of API 653 was released in 2009, the 10-year initial interval added options for extensions with certain safeguards for the bottom. The current 5th Edition

includes even more safeguarding options, and it is likely that the list will continue to grow as improvements in data, inspections, and technology allow for safer tank operations.

Reinforced linings

Since the 1st Edition, an extra allowance has been granted for the minimum remaining thickness (MRT) of a tank bottom if a reinforced lining is installed, as per API RP 652. However, no extra credit was given for this for new bottom intervals. That being said, installing a reinforced lining on a new tank bottom was not common. In practice, reinforced linings were typically installed to prevent leaks in existing bottoms and to extend the life of an existing floor that was uneconomical or impractical to repair with patch plates. However, there are cases when a reinforced lining is desired for other reasons and newer editions of API 653 allow a credit to the inspection interval of a new floor where one is installed.

From an initial interval perspective, this extension makes sense since a properly installed liner will prevent internal corrosion and also provide extra protection against perforation from soil side corrosion. In the 4th Edition, this safeguard granted three extra years; in the 5th Edition, it increased to five.

Unreinforced linings

Unreinforced linings can prevent corrosion on the product side of a tank bottom when installed properly. However, they do not gain any additional allowance for the retirement thickness of the bottom plates. Consequently, while it makes sense to consider such linings for extending the initial inspection interval, they do not justify as significant of an extension as a reinforced lining. API 653 allows for a two year extension to the initial interval for unreinforced linings.

Cathodic protection

Cathodic protection of the bottom is one of the earliest forms of corrosion mitigation still used on tanks. There are several methods available, ranging from galvanic systems, bottom-specific impressed current to large area deep impressed current systems. API 653 does not differentiate between designs, methodologies, or management for the safeguard allowances. API RP 651 provides guidance on options for cathodic protection, but there is variability in the effectiveness of such systems. Even though API 653 allows utilising a zero-corrosion rate for 'effective cathodic protection,' determining the effectiveness of cathodic protection is a challenge, and caution should be taken before considering this allowance.

Even optimally designed and installed systems can have localised corrosion due to contamination in the fill material under the tank, even when electrical potential measurements show effective protection. Galvanic systems in particular can be problematic as the corrosion rate can change drastically when the sacrificial anodes are depleted and there is rarely a way to accurately monitor remaining life. The 4th Edition allowed for an extra two years of initial interval for any cathodic system, while the 5th Edition raised this to five years.

Vapour corrosion inhibitor (VCI)

The use of VCIs is a relatively new technology for tanks. API TR 655 was released in 2021 and covers practices of using VCIs to protect tank bottoms from soil side corrosion. API 653 does not currently include any allowances for the use of VCIs, but it is likely to be added to future revisions of the standard.

Release prevention barrier (RPB)

Many newer tanks and replacement bottoms are constructed with a liner intended to contain and detect any release through the tank bottom. These are typically a high-density polyethylene (HDPE) or clay-based liner system placed in the foundation under a tank. Many double bottom tanks and tanks on concrete pads are also designed with an RPB. While an RPB does not typically mitigate corrosion of the bottom, this additional safety layer provides protection against a release to the environment. There are also risks of using an RPB that may interfere or limit the use of cathodic protection systems. HDPE and concrete do not allow electrical current to pass and may require compromises or omitting cathodic protection.

With an RPB, API 653 allows a lower minimum remaining thickness on the bottom and a 10-year addition to the initial interval. Additionally, having an RPB allows tanks to go up to a 30-year internal inspection interval rather than the standard 20-year limit on initial and subsequent inspections. However, this additional extension may not be optimal to take; while an RPB will contain a release under the tank, a release into the foundation contained by the RPB may still present safety and environmental issues for the tank. Making repairs to a bottom with contaminated soils is often a challenge. Contamination under the tank bottom can also affect the corrosion rate of the bottom moving forward.

Extra corrosion allowance

5/16 in. (or 8 mm) plates are quickly becoming a common installation for new tank bottoms to provide additional corrosion allowance. Thicker plates can be more labour-intensive to weld as it takes specialised welding practices for thicker single pass-welds. Tank floor thickness should be evaluated to balance material, installation, and future maintenance costs and benefits. API 653 includes a formula to determine the additional credits depending on the thickness. A 5/16 in. bottom adds 4.2 years, and 8 mm adds 5.2 years to the initial interval (there are slight differences due to metric/imperial plate sizes). Thicker bottoms can increase this linearly with the API 653 provided initial corrosion rate.

Stainless bottoms

Stainless materials can be found in some chemical storage tank bottoms and other high-corrosivity environments. There are also some less common cases when these materials may be found to mitigate corrosion concerns from the soil side. While API 653 does allow an additional 10-year credit for stainless materials, there is a caveat requiring a corrosion specialist to evaluate cracking and corrosivity concerns before the credit can be taken.

Interval considerations

It is important to look at many factors when developing the schedule for taking a tank out of service for an initial inspection. The compliance deadline determined from API 653 is the absolute latest a tank bottom should be inspected, but there could be other criteria which makes it more practical and efficient to inspect earlier.

Some examples include operational downtime, coordination with other projects, change of service, floating roof or seal inspections, budget, or availability of labour. This can be especially important when multiple tanks were built together, and it may be impractical to complete inspections and repairs on all tanks near the interval deadline. It is highly recommended to look at a wider inspection and integrity plan when scheduling out-of-service inspections.

Alternatives

API-653 offers two primary routes for deferring the initial inspection:

- Risk-based inspection (RBI): if regulations allow, an RBI assessment compliant with API RP 580 can help define an appropriate interval. Engineers experienced with storage tanks, along with qualified corrosion professionals, should be integral to any RBI team. They must periodically revisit the assumptions and determine if the assigned intervals remain valid and within acceptable risk.
  - Under RBI, the initial interval still cannot exceed 20 years without an RPB or 30 years with one, unless the tank is storing a highly viscous substance that solidifies at ambient temperatures, does not contain hazardous/regulated materials, or will not adversely impact water, human health, or the environment.
- Standard deferral: the latest revision of API-653 allows a short deferral (up to one year) under specific conditions, pending certain reviews and approvals. An experienced storage tank engineer and corrosion professional should evaluate whether this deferral is appropriate.

Figure 1. New tank bottom installation.

If circumstances allow, another alternative is to carry out an in-service internal inspection using available technologies to determine the condition and corrosion rate of the bottom while the tank contains product. There are numerous options on the market with varying levels of success and applicability depending on the tank configuration and the type of product stored.

Pitfalls

While it can be attractive to run tanks to the longest interval allowed by API 653, this can be suboptimal. Tanks constructed in locations with no history of soil corrosiveness, that were subject to insufficient quality control, or with poor operations and maintenance practices have led to tanks being taken out of service earlier than their initial interval might allow. Additionally, while the initial interval is based only on bottom criteria, there are often other drivers for initial inspections such as product quality, floating roofs, and seals.

For some tanks with higher corrosion rates, owners may find that there are extensive repairs needed or even full bottom replacements required at the initial inspection, even if there is no release. If inspections can be done sooner, some of these high corrosion rate issues can be caught early and potentially mitigated to lengthen the life of the tank bottom while minimising the need for future repairs.

Another issue to consider: if there are events that may impact a tank, it may be a good idea to take the tank out of service early to identify any potential damage or unforeseen risks. Some of these events include weather (floods and hurricanes), natural events (earthquakes, wildfires, and settlement), or even abnormal upsets (water slugs, nitrogen bubbles, and product contamination). These events can change the corrosion conditions inside and outside the tank, or can cause mechanical damage that should be identified as early as possible to make repairs.

The final pitfall is that all these initial intervals are based on the premise that corrosion is the limiting factor on the bottom leaking. If there are cracking risks, few of these safeguards provide an extension to the time to failure. Reinforced coatings and RPBs can provide some protection in the case of bottom cracking, but they are no guarantee of maintaining bottom integrity. For tank configurations and materials where cracking is a concern, more frequent inspections should be considered than a corrosion rate basis would recommend.

Conclusion

While the API 653 initial interval for tank internal inspections seems simple at a glance, it is becoming more complex with each new revision to the standard. Additionally, there are many considerations that should be applied beyond the safeguard credits when determining when to schedule a first inspection on a new bottom. A good tank integrity programme should address these safeguards, recommend the safeguards to use for new tank bottoms, and include the expertise to schedule initial inspections within the maximum interval permitted by the API standard. T&T