

Inspection of Secondary and Tertiary Containment Systems

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Introduction

One of the author's strongest memories when he actually got out to work on a real chemical plant in the early 1970's was of a bund which served a Hydrochloric Acid Stock Tank. There was a condensate leak dripping in to it and it supported a tropical micro environment, including 3 ft long goldfish! Times have changed, and we would hope operating practices have as well. Effective emergency containment systems are needed to enable operations to meet the requirements of legislation worldwide.

The legislation in the United Kingdom will be considered as an example. As with most jurisdictions, the regulations associated with emergency containment is fragmented both in exactly which systems legislation applies to and what component "state" within the country it applies to. In the examples given below, all the legislation applies to England and some applies to other parts of the United Kingdom. Where the stated legislation does not apply to other parts of the United Kingdom, there is other legislation equivalent to the ones mentioned that does. Because most of the United Kingdom legislation brings European Directives in to force in the United Kingdom, there is comparable legislation in all European Union States.

COMAH (Ref 1), Regulation 5 requires operators of establishments subject to COMAH to take all measures necessary to prevent major accidents. This includes the provision of emergency containment systems. The expected standards for effective emergency containment systems evolve over time. They took a significant step forward following the loss of containment, detonations and fire at Buncefield in 2006. The consequent report finished by the Process Safety Leadership Group in 2009 (Ref 2) includes significant guidance on engineering secondary and tertiary containment systems including some detailed guidance on the need to inspect certain components. The COMAH Competent Authority Policy on Containment of Bulk Hazardous Liquids at COMAH Establishments (Ref 3) introduces the requirement that the secondary and tertiary containment systems should be subject to periodic inspection and certification by a competent person regarding their condition and performance. The supporting guidance for this (Ref 4) also mentions the value of other inspections which have traditionally always been undertaken. Although the COMAH Competent Authority Policy on Containment of Bulk Hazardous Liquids at COMAH Establishments only applies to COMAH establishments storing bulk liquid fuels, the principles of it have been incorporated in to wider good practice (Ref 9) and should be applied to all establishments storing dangerous liquids.

The EPR-{Environmental Permitting (England and Wales) Regulations 2010 (as amended) (Ref 5)} covers most of the Process Industry that is not covered by COMAH. The Environment Agency's guidance on how to comply with environmental permits is now web based (Ref 6), and includes a requirement to periodically check bunds for hydraulic integrity and resolve the matter if it is compromised.

The Control of Pollution (Oil Storage) (England) regulations covers oil storage in containers greater than 200 litres, with some exceptions, on all industrial premises. The statutory guidance, now published with the regulations themselves (Ref 7) gives various requirements for inspecting bunds.

As noted above, there are various references to "inspection" in applicable legislation. Business management is ultimately responsible to ensure that the legislation is complied with, but in practice company's interpretations of "inspection" are very different. Inspection is also referred to in various pieces of guidance, but no definition of what it actually involves has been defined anywhere.

The publication CIRIA Report R164 (Ref 8) is referenced in a number of the documents mentioned above. It has been updated and replaced by CIRIA Report C736 (Ref 9). CIRIA C736 is generally regarded as one of the best reference documents for the construction, maintenance, repair, extension and upgrading of containment systems. It sets out to cover detailed technical aspects of inspections. The guidance given on the management of inspections is limited and is adopted from an earlier Energy Institute (EI) publication in 2007 (Ref 10). This element was revised in a more recent update (Ref 11)

From experience in inspecting COMAH Upper Tier sites, there are a number of different designs of inspection regimes which work for the company involved which are not quite as prescriptive as the EI's. This inspection activity can be broadly broken down into the following areas:

- Daily Production Technician routines
- Unqualified operator, Production Technician Routine Inspections
- Operational Management Systems
- Basic engineering Inspections
- Site Engineering and Management Review and Inspection
- Professional Inspection
- Audit

This paper will now discuss the details, the strengths and the weaknesses of each of these, look at the overall objectives of this inspection activity and conclude with some guidance into how to combine them into a cost effective system that meets an operator's needs.

The Site Engineering and Management Review and Inspection described here goes beyond the scope of a type of "pure" inspection. Ultimately, site senior management are responsible for the integrity of the sites facilities, and the methodology described here represents a systematic way for senior management to be able to demonstrate that they have taken this responsibility seriously.

Production Department Inspections

The tasks different organisations require of their production technicians or process operators can vary quite widely. It will depend on a number of factors, including workload, training and ability. Each organisation must make its own decision on what it can reasonably expect of its people.

The maxim "if it has not been recorded, it has not been done" is appropriate for inspections – for quick ones as well as more extensive ones.

Daily Production Technician Routines

Water companies can operate and monitor small water treatment plants remotely and only attend them periodically (weekly) or as required. This is acceptable where the inventories of hazardous substances is zero or extremely low. Small air separation plants are also operated that way. Remote operation and monitoring can have a very important part in running a higher hazard installation, but it is extremely unwise not to inspect the hardware (tanks and bunds) on at least a daily basis and to have people available to rapidly respond to problems indicated by instrumentation.

Table 1: Possible Daily routine inspections by production technicians
Walk round the site, identify and clear up any waste materials.
Check and record how full the bund is.
If it needs draining, check for possible contamination of the water.
Empty it if necessary, choosing an appropriate disposal route for the degree of contamination detected. Record how long the draining took
Check that any tank and bund drain isolation valve is closed and locked off
Check any drip trays and pans. Report any leakage into them
Report any problems associated with the integrity of the bunds

Table 1 above is based on the EI's current recommendations (Ref 11, Section 5.3.1).

The EI guidance suggests that it is possible to check the integrity of bunds and bund lining systems associated with secondary and tertiary containment systems as part of this daily routine. This would mean that the process technician would need, at the very least, to walk round the whole bund looking with some degree of care at the walls, floors and fittings. In the author's experience, it is unlikely that a process technician will be allowed enough time to undertake this task with any degree of rigour and a process technician is possibly the least qualified member of staff able to do it effectively. An organisation should not place any reliance on the integrity of a quick daily integrity check. . However, if a process technician does observe any problem, it should be made very clear that it should be reported. Any new flaw observed should be put in to the site's maintenance management system for attention on initial identification

The EI guidance also suggests that any (Oil/Water) separators should be checked on a daily basis. It is quite reasonable to have an Oil/Water separator on internal effluent streams or appropriately consented continuous discharges to regulated waters and, among other preventative measures, they should be visually checked at least daily. However, it is not appropriate to have continuous runoffs on emergency containment systems – the means of removing water should always be shut off, except when opened for draining under controlled conditions.

Recording bund levels and emptying times can be extremely useful. The following are indications of leaks:

- Bund never registering a liquid level when others around it are
- In dry weather periods, bund losing level faster than others
- Bund emptying times getting shorter relative to other bunds
- Groundwater ingress into bund when groundwater levels are high (unexpected water in bund after no rain).

There should be an operating procedure covering routine inspection and drainage of secondary and tertiary containment systems. It should give guidance on:

- The frequency of checks, including under abnormal weather conditions. It may be appropriate to check more frequently in very wet weather and inappropriate on safety grounds to undertake a check in extremely cold and wet weather.
- The maximum level that the containment system should be allowed to get to before it must be drained. Bunds with limited capacity compared to their potential demand should be emptied more regularly than bunds with more capacity.
- Instructions on what tests to undertake on the containment systems contents – they may be different depending on the contents of the tanks that are protected by the reserve containment system.

- Disposal arrangements for uncontaminated water and contaminated water.
- Pro-forma for recording inspection, or instructions on where to record it on the site's computer system.
- Where and how to report problems

Unqualified Production Technician Routine Inspections

As noted previously, it is not considered realistic for a production technician to actually inspect a bund with any degree of rigour on a daily basis. However, the production technician should know the hardware better than anybody else and it is appropriate to ask him to inspect the system. Various organisations which use this form of inspection do so on quite different frequencies. This frequency will depend on a number of factors, including how much the operators actually do on their daily routines, whether operations are all contained within pipework or associated with frequent vehicle movement in the bund, how much change there is on the establishment etc. For a normally operated bund the UK Ministry of Defence frequency of three monthly (Ref 14) would seem reasonable. Weekly or even twice weekly would be more appropriate where there are frequent vehicle movements in the bund.

Some organisations will ask a member of their day process team to undertake this task every three months. This has the advantage of continuity but the disadvantage of familiarity, increasing the risk of not detecting emerging flaws. Other organisations require shift personnel to undertake the task. In an establishment comprising a significant number of reserve containment systems, there are advantages to splitting them up into a smaller set of bunds per shift, and giving each shift ownership of a group of bunds with the shift supervisor undertaking the three monthly inspection to ensure that that shift's bunds are being kept up adequately. Management needs to decide what system is appropriate for their own establishment.

When undertaking a three monthly "in depth" inspection, it is worthwhile undertaking the daily inspection routine as given in Table 1. Table 2 below gives the extra work associated with the three monthly inspection.

Table 2 - Possible Three Monthly routine inspections by production technicians
Check for signs of plant growth in the bund, and clear it away
Check for signs of leakage from any pipework or equipment. If safe and reasonable, tighten up joints showing signs of distress.
Check for any obvious signs of any potential breach of containment of the bund system - seeing any daylight through bund walls is indicative of a problem
Check the general condition of steelwork, including pipe supports, which should be supporting pipes not the other way round - e.g. see Figure 1
Check that drainage trenches and sumps are clear of debris. This should include lifting up gratings and checking and cleaning inside the smaller contained areas.
Report any concerns or faults to operations and maintenance - attend to them if possible.

Figure 1: An example of a steelwork fault that should have been reported and rectified well before it got to this stage.

"Wet Stock Reconciliation" is not included in Table 2. In this day and age, it is expected that this will be done fairly frequently, quite possibly at a fixed time every day, by the DCS based on telemetry. Otherwise it is expected that it will be done manually on a daily or at least weekly basis for accounting reasons. There are some statutory requirements that need to be respected, e.g. HMRC's requirements to periodically reconcile materials that are stored tax free.

Management's role in production technician inspections

Bunds tend to be the rather unloved part of the operation – and if they are not loved enough, they will turn round and bite! Responsible managers need to ensure that the necessary disciplines are in place to demonstrate compliance, which could include checking that bund routines are being undertaken and any reporting requirements are completed and recorded. In the Author's experience, limited to bulk chemical, bulk petrochemical and fuel establishments, all too often flaws in containment systems have been identified and recorded in process documentation but not taken forward into the maintenance system for attention. It is not expected that a minor flaw in a containment system will be attended to straight away, but it should at least be flagged for maintenance attention to be adequately monitored on an appropriate frequency.

In the author's experience, most operations do record the fact that a bund was emptied on a certain date and some also record how long it took to empty, giving a crude measure of how much liquid is removed. However, very few organisations analyse the data gathered. Even crude analysis, checking that each bund is emptied occasionally, could spot problems with the containment ability of a bund. More in depth analysis, for example looking at the recent average emptying frequency of bunds compared to the average for the establishment as a whole and comparing that to historical values could help spot problems before they get more expensive to manage. Comparing volumes discharged to historical values for a particular bund would be even more sensitive.

Management should see any stock reconciliation reports that indicate a stock inconsistency and ensure that the root cause of this inconsistency is identified and rectified.

Preparation of Bunded Systems for Inspections

Before any reasonable inspection of a bund and its associated provisions, bunds should be prepared for inspection by production personnel. Bunds cannot be inspected if all surfaces cannot be seen - because either they are underwater or the floors are alive with grass, for example see Figure 2. Table 3 below gives a summary of the key actions than must be undertaken prior to a reasonable inspection of a containment system:

Figure 2 – A bund that cannot be inspected because of Grass Growing

Table 3 – Actions required in preparation for a System Inspection
Housekeeping issues have been addressed
The bund has been drained as far as possible
All signs of plant growth and as far as possible any dirt they were growing in are removed
Any bund trench and bund sump covers have been removed and cleaned out

These actions will help reduce the frequency of abortive inspections and hence cut third party inspection costs.

Engineering Inspections

As a general rule, engineering inspections should be risk based. This requires definition of a tolerable degree of risk. This is to some extent establishment specific, and senior management as well as engineers should be involved in defining it.

Again, as a general rule with very few exceptions, senior management are responsible for the safety and environmental integrity of an establishment. Specific elements, for example bund inspection by an appropriately qualified engineer, can be contracted out. However, an inspection only covers those aspects of the establishment which it is defined to cover. It is senior management's responsibility to agree a contract, and hence to make sure any contracted out work is defined appropriately. If the definition of the work is loose, it is unlikely that the work itself will meet senior management's aspirations for it in full. It is extremely unusual for a contract to say the contractor must define the work that needs to be done then go on and do it without any management controls in place. It is also unusual for the same contractor to have the skills to define work and undertake it at a reasonable price. The "Intelligent Customer" who takes an active role in managing his engineering services will benefit greatly over less active customers.

The Oxford English Dictionary defines an "engineer" as "a person who designs, builds, or maintains engines, machines, or structures". This encompasses many different skill levels from the general worker digging holes by hand during ground preparation works though the plumbing and heating engineer to the internationally recognised specialist. Three different levels of Engineering Inspections are identified here – a basic engineering inspection possibly undertaken by maintenance supervisory personnel, the Site Engineering and Management Review and the Professional Engineering Inspection.

Basic Engineering Inspection

The basic engineering inspection is the simplest form of inspection that is undertaken by anybody with engineering skills. The inspector or inspection team should hold some sort of engineering qualification appropriate to his or her role. Ideally, the inspection team would include someone with civil engineering skills but is still potentially useful if it only includes plant engineers and / or supervisors of the plant maintenance team.

If a basic engineering inspection is undertaken, it is possibly appropriate to do it annually. The preparation work mentioned in Section 2.4 should be undertaken prior to the inspection. The inspection would normally be informed by the Schemes of Examination for each asset and the previous inspection report. It should cover 100% of the assets involved in secondary and tertiary containment. It should also cover and record inspection of any recent repair works. As well as considering the

actual condition of the assets, the inspecting team should be considering the Schemes of Examination and recommending changes to them should they feel that this is appropriate.

Some headings for this inspection are included in Table 4 below. More detail and technical guidance is given in the PSLG Final Report (Ref 2)

Table 4 - Basic Engineering Inspection Points
For any holes in the bund wall or bund floor
At concrete in particular for finish, cracks and exposed aggregate
At the condition of any seals of any penetrations of the bund structure
At the condition of the sealing systems in any lined bunds
At the base of the tank for signs of liquid between the tank and the floor, the condition of any tell-tales and possible wall/base corrosion
At pipe penetrations of the walls to check the sealing arrangements
At any underground stock tanks to check that appropriate provisions are made.
Undertake leak tests (Drop Tests) on any underground pipework associated with the containment system. These can be: - Internal bund drainage systems - Connections to remote secondary sections - Transfer systems to tertiary containment provisions

The basic engineering inspection team should produce a report detailing their findings. The report should include a reference to the Schemes of Examination used, their fitness for purpose and photographs to support the observations made. The report should also highlight flaws that were identified on previous inspections that had not been corrected by the time of the latest inspection.

Site Engineering and Management Review

As mentioned previously, site senior management is responsible for the integrity of the site assets and is therefore wise to check that these assets remain appropriate and are adequately maintained.

Table 5 summarises the main activities that it is recommended are undertaken, Even if the inspection itself is only undertaken by engineering personnel, the reviews should include production management as well, both for the values of their input and to gain appreciation of potential engineering restraints. These reviews are the only activity that covers every aspect of the site and should be undertaken by personnel with reasonable technical skills and a deep knowledge of the establishment and current good practice associated with it. They should not just be left to the site engineer to complete.

The overview of the changes on the site should obviously include any changes to operations and hardware that the operator has made and also a check the site is up to date with current good practice

Table 5 below summarises the main activities that should be undertaken.

Table 5 – Site Engineering and Management Reviews and Inspection
Overview of changes on the site
Documentation check
Visual inspection of the facilities
Procedure check
Operating Records check

Detailed written records should be made of any appropriate reviews that have been undertaken and the records kept. This is to enable the next review to concentrate on what has changed. The results of any engineering inspection should be also be recorded and should include photographs of any areas of concern to be included in the inspection report.

CIRIA C736 (Ref 9) recommends that a Site Engineering check – the documentation and facility inspection elements of the above - is done annually. If Basic Engineering Inspections are undertaken annually, this is possibly more frequent than necessary for a full site Engineering and Management Check. In this case, it may be appropriate to undertake a “light” check, reviewing site changes and the adequacy of the documentation annually. A full review should be undertaken at least once between the professional engineering inspections and used to inform the scope of the professional engineering inspection. This latter form of inspection is typically undertaken on a 5 yearly cycle.

It is expected that all secondary and tertiary containment provisions will be covered by a Site Engineering inspection and Management Review.

The overview of the changes on the site should include a check that the addition of any new hardware or changes in production patterns have not affected the containment requirements. It should also include a check that applicable standards have not changed or been updated, or “good practice” has not moved on.

The Site Engineering and Management Review Team's documentation check should ensure that the site possesses an appropriate set of documents to support its containment provisions. As a minimum, it should include checking that appropriate documents can be produced to demonstrate

- The design drawings and appropriate construction certificates are available (including design of secondary containment under tanks). This to include supplier information for any limited life elements, such as joint sealant, which would need to be periodically replaced as per supplier recommendation.
- The design standards of the containment facilities are appropriate for their duty.
- The bund wall strength is adequate
- The tank's spacing meets good practice (e.g. HSG 176 for flammables)
- That incompatible materials are not stored in the same bund
- That the bund capacity is adequate
- That the gaps between the standards that the containment systems were built to and current standards are tolerable. i.e. there is a written formal justification (ALARP demonstration) for any deviation from good practice.
- There is a written formal justification for any bunds which are emptied by gravity drainage
- There is a written formal justification for any pipes that penetrate the bund walls and that appropriate provisions are in place to minimise leakage past the pipe penetration.
- The asset register provides a unique identification of individual assets
- There is an appropriate preventative maintenance regime in place for each asset, including a written Scheme of Examination which has been reviewed and re-approved following the last time the asset was inspected.
- The tertiary containment plan has been reviewed appropriately, in particular since the last change in asset.

Regardless of any other inspections undertaken, the site engineering and management review team should get out and actually inspect the containment systems occasionally. It would be appropriate to use the guidelines in Table 4 for this inspection.

If basic engineering inspections are undertaken, the site engineer should consider the reports of these inspections as they are generated, looking in particular for flaws that have been recognised but not attended to and indications of poor repair work. This review should be documented and, if repair work is not initiated, the reasons for not doing so recorded. The Site Engineering and Management Review Team should review these and confirm that the appropriate philosophy is being adopted

If a basic engineering inspection regime is in place, the site engineering team may decide that it is appropriate to only inspect a sample of the containment systems. If there are no other site based engineering inspections undertaken, the Site Engineering and Management Review Team should inspect 100% of the assets provided for secondary and tertiary containment.

The Site Engineering and Management Review Team's procedure check should ensure that the site has an appropriate set of procedures in place covering operation and maintenance of containment systems. As a minimum, it should include checking that:

- There are appropriate procedures in place for bund inspections and maintenance
- The procedures meet appropriate standards
- The tertiary containment plan, including spill and firewater management, looks reasonable and gives adequate guidance for anybody trying to implement it in earnest.
- Procedures cover wider containment areas (e.g. yards) and ensure transfer systems (drains) are jetted and inspected (video and leakage tests)

A procedure for inspecting bunds should at a minimum specify:

- The minimum frequency of each type of inspection
- The minimum qualifications required by the (lead) inspector for each type of inspection.
- Guidance on what each inspection should comprise
- The level of records to be made during each type of inspection (photographs, NDT testing records, analysis etc.)
- How flaws identified in inspections are followed up
- The inspection report format
- Where inspection records are to be kept (usually copies on and off site) and how long for (usually the life of the plant)
- The ability of an inspector to recommend that an inspection at that level or at a higher level is brought forward.

The Site Engineering and Management Review Team's Operating Records check should ensure that operation and maintenance activity associated with containment systems is being recorded appropriately. As a minimum, the Operating Records Check should include:

- Auditing the reports of lower level routine checks
- Making sure that reported shortfalls are being attended to
- Preventative maintenance routines are being undertaken
- Shortfalls identified in previous inspection have been entered into the maintenance prioritisation system and given appropriate priority. Check that lower priority maintenance work is not continuously pushed back.

Professional Engineering Inspection

The main value of the professional engineering inspection is that it brings in an independent professionally qualified view of the actual condition of a set of containment systems. The professional engineering inspection can also be used to remedy shortfalls in documentation if it is within the scope of the inspection to do so.

The frequency of the professional engineering inspection is set by site management. It will probably be risk based. There are two standard frequencies for higher risk establishments:

- Every three years for sites storing fuels as set by the MOD (Ref 14)
- Every five years for establishments storing fuels as set by the Competent Authority (Ref 3)

It is recommended that the starting point for setting the frequency of professional engineering inspections is 5 yearly. This may be extended if the application does not pose a high environmental risk or the most recent professional engineering inspection does not raise any concerns about the condition of the system. It should, be reduced if the latest professional engineering inspection raises significant concerns. It is unlikely under any circumstances that the professional inspection frequency could reasonably be extended beyond once every 10 years and this only where the environmental risk is low.

The main points of the professional engineering inspection are covered in Table 6

Table 6 – The Professional Engineering Inspection
Scope of Inspection
Qualifications of the inspecting engineer
Adequacy of the documentation
Visual inspection of the facilities
Written report and record

To enable a professional engineer to quote for work and identify the appropriate resources, the scope of work needs to be adequately defined. The professional engineer can help the site by undertaking some of the elements of work identified above for the Site Engineering and Management Review. The main element that needs to be defined is what the main objective of an inspection is. It is assumed that the operator will want the inspection to confirm that the bund is fit for purpose at the time of the inspection and is likely to remain so for a period of time. The scope of the inspection should, therefore include what the purpose of each individual bund is (e.g. fuel and fire resistant, chemically resistant to e.g. strong acids etc.). If a bund has several possible duties, all of these should be listed.

Any additional checks that the operator wants the professional engineer to do also need to be included in the scope of the work. For older concrete bunds (>30 years), the professional engineer should be asked to consider the possible reduction in integrity of the bund due to ageing of the concrete.

There are quite a few references in the literature to an “appropriately qualified engineer”, for example Ref 9, Section 5.2. Ref 4, p 11 qualifies this by saying “who has been adequately trained” and goes on to say “For more complex and/or critical assessments, this may increase the need for inspection by suitably trained personnel and certification by a chartered civil engineer.” Unfortunately, there is no equivalent inspection system in the civil engineering field to the EEMUA 159 Tank Integrity Assessor or the API 653 Tank Inspector qualifications for stock tank integrity assurance.

The Environment Agency has in the past commissioned professional Engineering Inspections of operating bunds. The following has been extracted from the “Requirements” document for that project (Ref 12):

Essential Skills/ Experience:
- Minimum 3 year’s knowledge and experience within the structural engineering sector.
- Specialisation in design, construction and assessment of bunds.
- Knowledge of relevant standards i.e. CIRIA 163 and 164.
- Member of a relevant professional institution.
- Relevant qualifications for a structural engineer.
- Self-motivated.
- Good communication and interpersonal skills.
- Understanding and compliance with health and safety requirements for themselves and others.
- Working knowledge of current legislation
- Ability to perform complex audits.

In the USA, the safety of dams has been subject to regulation since the 1970’s. Chapter 3 of a manual issued by the United States Department of the Interior, Bureau of Reclamation (Ref 13) sets out the qualifications for the full Examination Team inspecting dams. The Team is normally composed of civil engineers, mechanical engineers, and geologists. Engineering members of the Team should be registered professional engineers. Team members should have in-depth experience in the design, construction, and operation of dams and their appurtenant features. Appropriate Team members should have

expertise in the following disciplines: hydraulics, soil and rock mechanics, structural design and slope stability analyses, mechanical design, materials properties evaluation, engineering geology, instrumentation, etc. They should also be knowledgeable of the causes and modes of dam failure.

Bunds are really only small scale dams. The qualifications, knowledge and experience required by a professional bund inspector will be determined by the type of construction of the bunds; the same individual may not have adequate skills and experience to cover all aspects of an establishment's bunding systems. This paper suggests that the skills and experience needed by a bund inspector should be:

- Minimum 3 year's knowledge and experience within the structural engineering sector in the type of structure of the bund(s) being inspected.
- Specialisation in design, construction and assessment of bunds the type of structure of the bund(s) being inspected.
- Knowledge of relevant standards e.g. CIRIA C736 and associated documents
- Member of a relevant professional institution.
- Relevant qualifications for a structural engineer.
- Self motivated.
- Good communication and interpersonal skills.
- Understanding and compliance with health and safety requirements for themselves and others.
- Working knowledge of current legislation
- Ability to perform complex audits.

There are a number of consultancies, small and large, offering bund inspection services. The quality of the consultancy that the operator uses is possibly less important than the quality of the Engineer who actually undertakes the inspection and assessment work.

It is very important to retain records of containment structures – previous inspection reports and especially construction records and design details. Detailed records are important, e.g. the specification of the sealant used to seal cracks in the bund structure and if relevant the preparation work done and weather conditions during application. Design details and construction records should be made available to the inspecting professional engineer as required. They may be required while the engineer is planning the inspection as well as on the day. If the documentation supplied has a shortfall, the professional engineer's final report should state that, what effects these gaps have on the ability to characterise the structure and provide alternatives to get to a more satisfactory assessment.

The scope of the visual inspection of the facilities undertaken by the professional engineer will be at least the same as the basic engineering checks Table 4. The professional engineer is likely to bring a better understanding of what he is looking at than a less experienced one will have. The professional engineer may also bring in instruments to check for the presence and condition of reinforcement and or require certain intrusive tests to be undertaken either immediately or in the future.

It is expected that a report issued following a professional engineering inspection will include

- The name(s), qualifications and experience of the inspecting engineer(s).
- A schedule of the operator's documents reviewed during the inspection.
- An analysis of the adequacy of the documents, including what effects any gaps have on the ability to characterise the structure and alternative means to achieve a more satisfactory assessment.
- A description of the methodology used to inspect the bunds, including the use of any instruments and any intrusive tests undertaken.
- Detailed bund by bund inspection reports including relevant photographs. Where flaws in the bund structure are identified, an indication of the significance of the flaw should be given.
- Options on repair methods for each type of flaw identified.
- An assessment of the current fitness for purpose of each individual system inspected.
- If any system is not considered currently fit for purpose, a list of the shortfalls that need to be addressed before it can be considered fit for purpose should be provided.
- An assessment of the longer term prospects for the system before major engineering work is required on it.
- The recommended time period before the next professional engineering inspection

Double skinned and Underground Storage Systems

Checking and maintaining the integrity of double skinned stock tanks is extremely difficult. There is a risk of common mode failure. Double skinned UST's should be inspected using primary containment methodology. It is usually extremely difficult to inspect conditions of the space between the two tanks but it may be possible - if any liquid is run off, it should be clean! Double skinned tanks are unlikely to be able to cope well with thermal stresses so you will need to try to check that any temperature limitations placed on the tank by the design have been exceeded - ever! If provisions are made to do so, it is possible to check the level of liquid in the space between the inner and outer tank. If a loss of containment is detected, there is usually no other option than to empty the tank and take it out of service. The level of liquid between the inner and outer tank should be checked reasonably frequently, although probably not daily. It could form part of a monthly process technician routine, although it would be better done weekly.

Underground Stock Tanks (UST's) also require particular attention. UST's placed in separate bunds/underground chambers are less intrinsically difficult than multiple tanks placed in a single underground chamber. In particular:

- It is essential that both components of a UST system, the tank and the bund, are inspected appropriately. It is unlikely that this will be possible if the tank is not lifted out of the underground chamber for a full professional inspection, but it may be reasonable to risk assess the need for this and extend the inspection frequency. I would be suspicious if that inspection frequency exceeds once in 12 years.
- USTs shall have any access chambers designed to provide secondary containment
- USTs shall have a primary containment failure monitoring and alarm system (e.g. leak detection) – check that they are working as far as is reasonably practicable.

Repair Priorities

Even in the best run and maintained operation, it would be extremely surprising if shortfalls are not identified by the inspections and reviews discussed above. The question then arises as to how to remedy the flaw(s) and what priority to place on that work. Clearly shortfalls that mean the containment system is not fit for purpose take a higher priority than shortfalls associated with slow deterioration. If a containment system is not fit for purpose and the faults not immediately rectified, the operator should review the environmental risk assessment in order to understand the level of risk reduction lost because the containment system is not functional. The tolerability of this increase of environmental risk should be compared to the site's tolerability thresholds. A record of this work should be made and retained. If senior management consider this increase in environmental risk intolerable and repairs cannot be made in a reasonable timescale, the question of shutting down the assets involved should be considered.

Third Party Audits

The containment provisions of an establishment can be audited by the company that owns the facility, the facilities insurance company or by the Regulator (e.g. if it is subject to EPR or COMAH). Some voluntary schemes, such as BASIS for agrochemical stores, establish specific requirements for third party inspections.

If an auditor has prior knowledge of the site or undertaken a similar audit previously, it is often worth his while considering what has changed since he was last on site. This could be useful when considering what examples to look at during the audit. It is suggested that the sequence given in Table 7 would be appropriate for a third party audit.

Table 7 – Third Party Audit Sequence
Review the operator's notes on his site engineering and management review.
Review a set of appropriate engineering inspection reports and other documentation as appropriate
Visual inspection of the facilities
Procedure check
Operating Records check

Ideally, the operator's site engineering and management reviews will have completely and satisfactorily covered all the ground covered by the audit. It is worth considering starting the audit by at looking at them. However, the Author has never found one that does cover everything. The complete scope of a full third party audit could be essentially the same as the scope of the Site Engineering and Management Review described in Section 3.2 above. Realistically, it is unlikely that a third party audit would cover all that ground in one go and it needs to be selective in what it sets out to do.

If it has not been covered by a local formal management review, a good starting point may be to take a look at the site's latest professional engineering report. This may be of limited use as standards associated with professional engineering inspection reports are very variable. All the work mentioned here may not have been undertaken. It will depend on what the operator asked the inspector to do, how he has followed it up and how good his records of doing so are.

It is generally considered the most important checks that need to be made are those of Bund Wall Strength and Bund Liquid Retention Capacity. If this has not been done previously, these should be looked into in some depth as a matter of priority. On one site, the Author was presented with a set of bund strength calculations to support the operators claim that the bunds were strong enough. The documents were summarily looked at and in two cases individual calculations' stated that the bund walls were not strong enough. Looking at them in more depth the calculations themselves did not support the conclusions. Other "calculation" documents concluded that the bund walls were strong enough with blank supporting calculations pro-formas. On another site, the Author saw a set of bund capacity calculations that did not take into account the fact that there were other tanks in the bund, which rather compromised available capacity!

No containment system audit is complete without including some sort of visual inspection of at least some of the facilities. If the auditor is not familiar with the establishment, it may be worthwhile being quite thorough with this inspection. Ideally, it would be best to look at all the bunds thoroughly, but it is better to do at least a limited number of bunds thoroughly than to do everything skimpily –better standards are set that way and it could assist the operator in setting more appropriate standards in future.

Conclusions

This paper discusses some five forms of inspection of containment systems – the daily operator inspection, the more detailed operator inspection, a basic engineering inspection, the site engineering inspection and review and the professional engineering inspection.

Management has to decide which forms of inspection it wants to undertake. If the storage operations are low risk, protected by separate emergency containment systems which are operated remotely and there is independent instrumentation on the containment system, it may not be necessary to attend the operation daily. In most cases these criteria are not met and daily attendance by a process technician is necessary. It is good practice to have emergency containment systems inspected by a professional engineer periodically. The frequency of such and inspection is discussed above and will normally be around 5 yearly. Realistically, a gap of 5 years is too long not to undertake some sort of intermediate systematic inspection. The exact combination of a more detailed operator inspection, a basic engineering inspection and site engineering inspection used will be set by management who need to satisfy themselves that adequate attention is given to assuring the functionality of the systems.

The scope of any inspection will depend on the technical competence of the individual who undertakes the inspection and the time available for it. It is unreasonable to expect a process technician to systematically inspect a series of emergency containment systems on his daily routines or to understand what minor flaws in them mean. When inspecting structures, be they bunds, yard areas, drains or tanks constructed of concrete, bricks, blocks or earth, it is helpful to fully understand them. Even a single professional engineering inspector may not have the full set of skills and knowledge needed to inspect all types of containment system applications.

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