

**PROCESS SAFETY LEADERSHIP GROUP
WORKING GROUP 6 - MECHANICAL INTEGRITY**

**FINAL REPORT - WG6 PROPOSALS
23 JUNE 2009**

WG6 MEMBERSHIP (INCLUDE IN APPENDIX TO PSLG REPORT)

Pauline Hughes	HSE (WG6 Chair)
David Wilkins	Exxon Mobil, Engineering Equipment Materials User Association (EEMUA) representative
Mike Cook	Simon Storage, Tank Storage Association (TSA) representative
George Reeves	NuStar Eastham Ltd
Stephen Dray	Chevron Ltd
Nick Wells	SABIC UK Petrochemicals
Robert Baird	BP Oil UK
Mike Nicholas	EA
Jim Fairbairn	Ineos Manufacturing, Scotland
Brian Hewlett	Vopak
Steve Taylor	Total (replaced Alan Andrew from Total in Jan 09)
Norman Woodward	Vopak (WG6 member from May-Dec 08)

WG6 PROPOSALS

Response to MIIB Recommendation 2.2

Operators of Buncefield-type sites should, as a priority, review and amend as necessary their management systems for maintenance of equipment and systems to ensure their continuing integrity in operation. This should include, but not be limited to, reviews of the following:

- the procedures for implementing changes to equipment and systems to ensure any such changes do not impair the effectiveness of equipment and systems in preventing loss of containment or in providing emergency response

- EEMUA 159⁽¹⁾ Probabilistic Preventative Maintenance (PPM) approach, when referenced together with the standards signposted for integrity management of atmospheric bulk storage tanks, is the benchmark standard which will help ensure that operators have a suitable maintenance strategy and policy underpinning their systems and procedures.

Response to MIIB Recommendation 14

(Rec 14) Operators of new Buncefield-type sites or those making major modifications to existing sites (such as installing a new storage tank) should introduce further measures including, but not limited to, preventing the formation of flammable vapour in the event of tank overflow. Consideration should be given to modifications of tank top design and to the safe re-routing of overflowing liquids

- It cannot be shown, without further research, whether significant modifications to tank top design would have the desired mitigating effect in practice. **Where new**

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research or revised design codes indicate that modification of tank tops may reduce the formation of vapour clouds, then these should be adopted.

3. New tanks should be designed to BS EN 14015⁽²⁾ or API 650⁽³⁾ (or equivalent) as these offer up-to-date standards providing in-depth guidance on design and construction elements for vertical cylindrical atmospheric storage tanks.

4. New tanks should be of single-skinned design, which can be supported by suitable inspection arrangements providing the optimum configuration for ensuring continuing integrity. This will facilitate full Non-Destructive Examination (NDE) of floor-plate welds.

BS EN 14015 offers an alternative double bottom configuration. Provided robust integrity management arrangements are in place, in line with guidance set out in EEMUA publication nos 159 and 183⁽⁴⁾, such a configuration, although not preferred, would also be acceptable. EEMUA publication no 183 sets out the technical disadvantages of this option. Arrangements for inspection and maintenance shall be carefully considered for such configurations to secure containment integrity.

5. Consideration should be given to the overflow route from vent to bund, with the objective of ensuring that within the constraints of the design code, obstacles in the overflow route are minimised.

6. Tanks should either be of 'frangible roof' construction, or should be equipped with an emergency vent of adequate area to prevent over-pressure under all likely relief conditions. Emergency vent should comply with an appropriate design standard (API 2000 or equivalent).

Response to MIIB Recommendation 16

(Rec 16) Operators of existing sites, if their risk assessments show it is not practicable to introduce measures to the same extent as for new ones, should introduce measures as close to those recommended by Recommendation 14 as is reasonably practicable. The outcomes of the assessment should be incorporated into the safety report submitted to the Competent Authority.

7. Existing tanks should comply with a relevant recognised design code at their date of manufacture. Where this is not the case, tanks should be assessed against an appropriate current standard. Remedial action should then be taken, as necessary, informed by the resulting gap analysis to reduce risks ALARP.

8. Ensuring risks are ALARP is a continuous improvement process. Good practice therefore requires a periodic assessment of existing tanks against current standards, BS EN14015 or EEMUA 159.

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- 9. Where major modifications or repair are undertaken on existing tanks these should comply with a suitable recognised standard, BS EN14015 or EEMUA 159.
- 10. A single floor arrangement is preferred as this best supports thorough inspection and ongoing integrity management to prevent loss of containment. Tanks with a replacement floor fitted above a failed single floor are still deemed single bottom tanks, reliant on the integrity of a single floor.
- 11. A tank with a double bottom arrangement which does not comply with a recognised standard should be assessed against a recognised standard and any appropriate remedial action taken.
- 12. Tank top modification should be considered where appropriate to eliminate any obstructions present in the overflow route from vent to bund.
- 13. Emergency vents that do not comply with a suitable, recognised design standard at date of manufacture should be subject to a design gap analysis, and remedial action taken.

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Response to MIIB Recommendation 15

The sector should begin to develop guidance without delay to incorporate the latest knowledge on preventing loss of primary containment and on inhibiting escalation if loss occurs. This is likely to require the sector to collaborate with the professional institutions and trade associations.

- 14. EEMUA 159⁽¹⁾ and API 653⁽⁴⁾ represent relevant good practice and should form the basis of minimum industry standards for tank integrity management and repair to prevent loss of primary containment.
- 15. Industry should also adopt EMMUA 183⁽⁵⁾ - guidance to aid the prevention of bottom leakage, and particularly with regard to the maintenance and repair aspects for tanks with a double bottom configuration
- 16. When assessing storage tanks, users should use competent personnel who are aware of and able to apply relevant tank design codes where necessary. Tank assessors should be qualified to EEMUA 159⁽¹⁾ Tank Integrity Assessor level 1 (minimum) or equivalent. The API 653⁽⁴⁾ Tank Inspector qualification is also acceptable.
- 17. Supporting guidance on the implementation of recommendation 15 can be found in annex 4.

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References

1. Engineering Equipment Materials Users Association - Publication No. 189 ~ Users Guide To The Inspection Maintenance And Repair Of Aboveground Vertical Cylindrical Steel Storage Tanks, (3rd edition) Volumes 1 and 2.
2. BS EN 14015:2004 ~ Specification for the design and manufacture of site built, vertical, cylindrical, flat bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above
3. American Petroleum Institute - API Std 650 ~ Welded steel tanks for Oil Storage, 11th Edition
4. American Petroleum Institute - API Std 653 ~ Tank Inspection, Repair, Alteration and Reconstruction
5. Engineering Equipment Materials Users Association - Publication No. 183 ~ Guide for the Prevention of Bottom leakage from Vertical Cylindrical Steel Storage Tanks

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Annex 4

Supporting Guidance for the Implementation of MIIB Recommendation 15

The sector should begin to develop guidance without delay to incorporate the latest knowledge on preventing loss of primary containment and on inhibiting escalation if loss occurs. This is likely to require the sector to collaborate with the professional institutions and trade associations.

HSE guidance “Integrity of Atmospheric Storage Tanks”, SPC/Tech/Gen/35, (9) **highlights** the factors to consider when operating storage tanks containing hazardous substances and includes reference to EEMUA 159 and API 653.

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Internal/Out of Service Inspections

The scope of inspections, detailed in EEMUA 159 and API 653, acknowledge the typical tank failure modes including corrosion, settlement and structural integrity and provide good guidance for early detection and measurement of symptoms that could lead to failure.

A written scheme of examination is required for internal/out of service inspections. EEMUA 159, Appendix B.2. provides an example of such a checklist.

EEMUA 159 and API 653 provide guidance on inspection intervals by either fixed periodicity or by a risk based methodology. The tables of fixed inspection intervals can be used where there is little or uncertain tank history available. The Risk Based Inspection [RBI] approach allows the use of actual corrosion rates and performance data to influence the most appropriate inspection interval. An example of such a risk assessment is also shown in CIRIA 598(4), page 185.

Many companies have their own technical guidance on tank inspection, maintenance, and engineering best practices, in addition to established RBI programmes. Such operators are best placed to determine inspection frequencies informed by inspection history. HSE research report (**Establishing the Requirements for Internal Examination Of High Hazard Process Plant - RR???? - to be confirmed when published next year**) establishes relevant good practice covering RBI assessment of hazardous equipment.

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The frequency of internal/out of service inspections should be routinely reviewed and in the light of new information, inspections, may become more frequent if active degradation mechanisms are found.

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Particular attention should be given to insulated storage tanks in which corrosion under insulation (CUI) can have significant affects on tank integrity, along with external coating prior to insulation. For corrosive products protective coatings may be applied internally. This may lengthen the inspection interval. To ensure quality control, particular attention should be paid, during the application of coatings.

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Thorough internal inspections can only be carried out by removing the tank from service and cleaning. As a minimum, a full floor scan is considered good practice. This should be implemented along with internal examination of the shell to annular/floor weld, annular plate and shell nozzles through NDT and visual inspection.

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Operators of floating roof tanks should be aware of the HSE document SPC/Enforcement/163, (10), "Drainage of floating roof tanks". This guidance requires operators to have a system in place to manage water drains appropriately to ensure precautions have been taken to prevent loss of containment incidents.

External /In Service Inspections

A written scheme of examination is required for external/in service inspections. EEMUA 159 provides an example of such a checklist.

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Thorough internal inspections must be supplemented by external/in service inspections. These inspections must be completed periodically, as this forms a part of obtaining the overall tank history and assessing fitness for future service. In service inspection frequency may be determined through RBI assessment or may be based on fixed intervals, (see EEMUA 159), based on the type of product stored. Frequency of in-service inspections should be subject to review and may become more frequent if active degradation mechanisms are found.

Full guidance for routine operational checks is provided in EEMUA 159 and API 653. These documents also provide guidance on internal and external mechanical inspections to be undertaken by a trained and competent tank inspector. All inspections and routine checks should be documented. Evaluation should include fixed roof venting, floating roof drainage and general operation.

Deferring Internal Examinations

Deferral of the required inspection date must be risk assessed by a competent person. Where necessary, deferral decisions should be supported by targeted NDT. This additional testing can be carried out to the shell, roof and in many cases annular plate. Deferral decisions must also consider previous inspection history and other relevant information including changes in operating conditions, etc.

Particular attention should be given to tanks without any previous internal examination as the probability of floor failure will increase with every year that the recommended interval is exceeded. In such cases it is unlikely that a deferral could be justified. It is the duty holder's responsibility to ensure that the risk of loss of containment is properly managed.

Competency

When assessing storage tanks, users should use competent personnel who are aware of and able to apply relevant tank design codes where necessary. Tank assessors should be qualified to EEMUA 159⁽¹⁾ Tank Integrity Assessor level 1 (minimum) or equivalent. The API 653⁽⁴⁾ Tank Inspector qualification is also acceptable.

EEMUA 159 takes into account the requirements of both BS2654,(5) (now succeeded by BS EN 14015), and API 653.

Regular on-line operational checks can be undertaken by suitably trained personnel with the competencies required to carry out such checks properly.

Remedial Work

Tank repair is a specialised activity, and should be performed only by those competent in tank design, re-construction and repair works. NDT should be carried out by personnel qualified to CSWIP(7), PCN(8) or equivalent.

Repair options are detailed in API 653 (3). For floor plate repairs, if local overplating or plate replacement is not deemed appropriate, the original floor plates should be removed and a new floor installed.

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The disadvantages of double bottom designs (including, settlement, product entrapment and modification to nozzle compensating plates), are detailed in EEMUA 183.

BS EN 14015 requires that a loss of vacuum in a double bottom tank should alarm to alert the operator that either the upper or lower floor has failed (effectively reverting to a single layer of protection). Remedial action should be carried out within one year. Continued operation in the interim period pending repair should be supported by a technical justification confirming ongoing fitness for service.

Having completed a tank inspection, repair and any additional testing, a new risk or time based inspection frequency should be determined, taking into account all relevant factors including the condition of the tank, future service requirements, potential degradation mechanisms and failure consequences.

References

1. BSTG: Buncefield Standards Task Group. 2008
2. EEMUA 159: Users guide to the inspection, maintenance and repair of aboveground vertical cylindrical steel storage tanks (3rd edition) Volumes 1 and 2. 2003
3. API 653 Tank Inspection, Repair, Alteration and Reconstruction, 3rd edition incorporating addendum 1 and 2. 2005
4. CIRIA 598 Chemical Storage Tank Systems – Good Practice. 2003
5. BS2654 Specification for manufacture of vertical steel welded non-refrigerated storage tanks with butt-welded shells for the petroleum industry. 2005
6. BS EN 14015 Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above. 2004.
7. CSWIP. Certification Scheme for Welding and Inspection Personnel. (TWI)
8. PCN. Personnel Certificate of Non-Destructive Testing. (TWI)
9. SPC/Tech/Gen/35 Integrity of Atmospheric Storage Tanks
10. SPC/Enforcement/163 Drainage of Floating Roof Tanks
11. EEMUA 183 (2nd Edition.Sept 2009). Guide for the prevention of bottom leakage from vertical cylindrical steel storage tanks.

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