Recommended Practice for Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids

Downstream Segment

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API/EI Research Report 545-A

Verification of lightning protection requirements for above ground hydrocarbon storage tanks

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FOREWORD

This publication has been produced at the request of the API RP 545 Task Force and the EI Electrical Committee.

It collates a number of research reports produced by Culham Electromagnetics and Lightning Limited (Culham) who were commissioned to investigate the lightning phenomena and the adequacy of lightning protection measures on above ground hydrocarbon storage tanks.

Currently international, British and United States standards contain requirements relating to lightning protection; however, these have not been verified through practical, scientific testing. As a result of the work commissioned by the API and EI, a new Recommended Practice (RP) is being developed which will incorporate the results of this investigation.

Suggested revisions are invited and should be submitted to the director of standards, API, 1220 L Street, N.W., Washington, D.C. 20005 or The Technical Department, Energy Institute, 61 New Cavendish Street, London, W1G 7AR.

API/EI RESEARCH REPORT

VERIFICATION OF LIGHTNING PROTECTION REQUIREMENTS FOR ABOVE GROUND HYDROCARBON STORAGE TANKS

PHASE 1

EXECUTIVE SUMMARY

CUL/LT-0234

REVIEW OF LIGHTNING PHENOMENA AND THE INTERACTION WITH ABOVE GROUND STORAGE TANKS

This document describes the phenomena of lightning, and how it is expected to interact with various types of tank designs, in particular with respect to the problems of hydrocarbon fires. It draws on the experience of refinery and tank farm visits by the author, including those reported in EI-Vis1-01 *Visit to oil refinery A* and EI-Vis2-02 *Visit to oil refinery B*, and other sources. The likely strike points on all types of tanks are described, and the current routes over tanks are shown for the fast and slow lightning components. The shunt/rim seal region for an open top FRT is shown to be the most susceptible to ignitions. Aluminium roof geodesic tanks appear to be the most likely type to suffer hot spots and burn through. The electrical properties of steel as a material for tanks is described along with descriptions of thermal and voltage sparking. Protection strategies for open FRTs, for roofed over tanks, and LPG tanks are described. Comments are made on the problems associated with petroleum product within the pontoons or on the surface of a floating roof. An analysis of the operation of the shunt/shell bonding cable suggests that it would play a vital part in suppressing sparking from the continuing current component of lightning, although it would play only a minor role in suppressing sparking from the fast component. The principal USA/UK lightning protection and oil industry documents are reviewed for their content on lightning protection of tanks.

CUL/LT-0235

REVIEW OF TANK BASE EARTHING AND TEST CURRENT RECOMMENDATIONS

The earthing of a storage tank may have important considerations for safety, and protection of instrumentation on the tank, but in practice the tank is likely to be intrinsically well earthed simply by its construction. Even so earthing rods should be (and are) generally used as recommended by international standards. Quality of earthing has little or no significance in storage tank fire protection. The document also discusses the likely currents which shunts may have to carry (up to 11 kA).

EI-EN2-04

LIGHTNING TESTS TO TANK SHELL/SHUNT SAMPLES

Tests at Culham replicated shunt/shell interfaces and subjected them to conducted lightning-type currents. Even clean steel shunt/shell interfaces sparked. Fast current components produce relatively small sparks, whereas long duration currents produce copious spark showers that are believed to be more hazardous. (In practice good protection against the latter currents can be achieved using a roof bonding cable.) Different shunt materials could also present less of a hazard. Currents in immersed shunts tended to cause an eruption of fluid, due to the arc pressure.

EI-VIS1-01
VISIT TO OIL REFINERY A

EI-VIS2-02
VISIT TO OIL REFINERY B

Describe the features seen during two visits to refineries. Some of the practical difficulties of providing and maintaining lightning protection in the field and over many years are observed and discussed, and some photographs are included.

EI-TN1-03
REVIEW OF BURN-THROUGH AND HOT-SPOT EFFECTS ON METALLIC TANK SKINS FROM LIGHTNING STRIKES

Discusses the threat of lightning strikes puncturing steel or aluminium tanks, or of causing internal hot-spots. Aluminium is easily punctured, and so geodesic roofs which use aluminium skins < 2 mm thick would be a hazard if they contained vapours within the flammable range. Steel skins 5 mm thick would not be expected to be punctured by a lightning attachment. Hot-spot hazards for such thick skins have not been investigated, but could be a hazard for severe strikes.

MAIN CONCLUSIONS AND RECOMMENDATIONS

1. Potential ignition hazards exist particularly at shunt/shell interfaces (for open top FRT) and geodesic roofs. The nature of the hydrocarbon, as well as temperature and ventilation, determines whether the vapour could be within a flammable range.
2. Sparking at shunts is inevitable, and is more severe for the long duration currents. Such sparks tend to fall downwards into the seal region, and any gaps between the seal and the shell would increase the likelihood of flammable vapour ignition. Therefore maintenance of the seal is important.
3. The severity of sparking can be significantly reduced, by using earth cables from the floating roof to the shell, or bonding via the ladder.
4. Immersed shunts should present a good solution to hazardous shunt sparking.

CUL/LT-0234

REVIEW OF LIGHTNING PHENOMENA AND THE INTERACTION WITH ABOVE GROUND STORAGE TANKS

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Where applicable, authorities having jurisdiction should be consulted.

Work sites and equipment operations may differ. Users are solely responsible for assessing their specific equipment and premises in determining the appropriateness of applying the Recommended Practice. At all times users should employ sound business, scientific, engineering, and judgment safety when using this Recommended Practice.

Foreword

This Recommended Practice (RP) is based on the accumulated knowledge and experience of purchasers and manufacturers of welded steel oil storage tanks of various sizes and capacities for internal pressures not more than 17.2 kPa (2 1/2 psi) gauge. This RP is meant to be a purchase specification to facilitate the manufacture and procurement of storage tanks for the petroleum industry. If the tanks are purchased in accordance with this RP, the purchaser is required to specify certain basic requirements. The purchaser may want to modify, delete, or amplify sections of this RP, but reference to this RP shall not be made on the nameplates of or on the manufacturer's certification for tanks that do not fulfill the minimum requirements of this RP or that exceed its limitations. It is strongly recommended that any modifications, deletions, or amplifications be made by supplementing this RP rather than by rewriting or incorporating sections of it into another complete RP. The design rules given in this RP are minimum requirements. More stringent design rules specified by the purchaser or furnished by the manufacturer are acceptable when mutually agreed upon by the purchaser and the manufacturer. This RP is not to be interpreted as approving, recommending, or endorsing any specific design or as limiting the method of design or construction.

Shall: As used in a RP, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a RP, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

This RP is not intended to cover storage tanks that are to be erected in areas subject to regulations more stringent than the specifications in this RP. When this RP is specified for such tanks, it should be followed insofar as it does not conflict with local requirements. The purchaser is responsible for specifying any jurisdictional requirements applicable to the design and construction of the tank. After revisions to this RP have been issued, they may be applied to tanks that are to be completed after the date of issue. The tank nameplate shall state the date of the edition of the RP and any revision to that edition to which the tank has been designed and constructed. Each edition, revision, or addendum to this RP may be used beginning with the date of issuance shown on the cover page for that edition, revision, or addendum. Each edition, revision, or addendum to this RP becomes effective six months after the date of issuance for equipment that is certified as being constructed, and tested per this RP. During the six-month time between the date of issuance of the edition, revision, or addendum and the effective date, the purchaser and the manufacturer shall specify to which edition, revision, or addendum the equipment is to be constructed and tested. API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org .

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Recommended Practice for Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids

1 Scope

API RP 545, First Edition, *Recommended Practice for Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids*, replaces the requirements of API 2003 regarding lightning protection for preventing fires in storage tanks with flammable or combustible contents. This recommended practice (RP) provides guidance and information to assist owners/operators with lightning protection for tanks. This RP does not provide complete protection for all possible lightning stroke occurrences.

1.1 Applicability

This RP is applicable to tanks as described in API 650.

1.2 Application of Requirements to New and Existing Tanks

The requirements of this RP shall apply to new or reconstructed tanks. The requirements may be applied to existing tanks at the discretion of the owner/operator.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API/EI Technical Report 545-A, *Verification of lightning protection requirements for above ground hydrocarbon storage tanks*

API Standard 650, *Welded Tanks for Oil Storage*

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

API Standard 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

ASTM D3453 [1], *Standard Specification for Flexible Cellular Materials*

BS EN 14015 [2], *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*

EMMUA 159 [3], *Users' Guide to the Inspection, Maintenance and Repair of Aboveground Vertical Cylindrical Steel Storage Tanks*

NFPA 780 [4], *Standard for the Installation of Lightning Protection Systems*

SAE ARP 5412 [5], *Aircraft Lightning Environment and Related Test Waveforms*

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1 ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.
2 European Committee for Standardization, Avenue Marnix 17, B-1000, Brussels, Belgium, www.cen.eu.
3 The Engineering Equipment and Material Users' Association, 10-12 Lovat Lane, London, EC3R 8DN, United Kingdom, www.eemua.org.
4 National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.
5 Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.