API/EI Research Report 545-A

Verification of lightning protection requirements for above ground hydrocarbon storage tanks

First edition, October 2009

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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 lighting 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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