

Process Plant Tent Responses to Vapor Cloud Explosions—Results of the American Petroleum Institute Tent Testing Program

API TECHNICAL REPORT 756-1
SEPTEMBER 2014



AMERICAN PETROLEUM INSTITUTE

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Downstream Segment

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EXECUTIVE SUMMARY

The American Petroleum Institute (API) contracted with Baker Engineering and Risk Consultants, Inc. (BakerRisk) to perform vapor cloud explosion (VCE) tests to determine the response of tents to the potential explosion hazards that may be present at refineries, petrochemical and chemical operations, and natural gas and other onshore process facilities covered by OSHA 29 *CFR* 1910.119. The testing was conducted to provide data for use by the API committee developing API Recommended Practice (RP) 756, "Management of Hazards Associated with Location of Process Plant Tents".

The tests were originally designed to serve multiple purposes:

- provide data on response of tents to a variety of blast loads ranging from 0.6 psi to 1.5 psi,
- identify the failure modes for different types of tents, and
- obtain data on tent response to support estimates on the vulnerability of tent occupants.

As the testing was performed, it became apparent that the tents being tested could withstand higher pressures than originally envisioned. The test program was therefore modified to accommodate the observed behavior. The development and modifications to the scope of the test program are discussed in the report. The following three series of tests were conducted.

- A Series – Three types of non-wind rated tents were tested with the long side of the tents facing the blast source.
- B Series – The same types of tents were rotated 90 degrees and retested at higher loads.
- C Series – Three types of engineered tents (designed for 90 mph 3 second wind gusts) were tested at two different pressures.

Subsequent to the completion of the API-funded tests, BakerRisk performed two additional tests to evaluate the DLG performance, as internal research. The response of the tents in these internal research tests, including the response of contents added to the tents, is discussed in this report.

The Explosion Research Cooperative (ERC) participants voted to release the data from a series of shock tube tests performed under their sponsorship that addressed the potential for the contents of a tent to become airborne. The data, in term of object mass and velocity, are provided in this report.

This report presents data only and does not provide any summary or conclusions on the acceptability of a tent siting approach.

Table of Contents

EXECUTIVE SUMMARY	I
1 INTRODUCTION AND BACKGROUND	1
2 OVERVIEW AND DEVELOPMENT OF THE API TEST PROGRAM	2
2.1 Originally Planned Test Matrix.....	2
2.2 Final Test Matrix.....	4
2.3 Instrumentation and Camera Coverage.....	6
2.3.1 Instrumentation Locations	6
2.3.2 Camera Coverage.....	6
3 A SERIES TESTS	8
3.1 Tents Included.....	8
3.2 Test Bed Layout	8
3.3 Results of Test A02	8
3.3.1 Test Pressures	8
3.3.2 Tent Response.....	13
3.4 Results of Test A03	13
3.4.1 Test Pressures	13
3.4.2 Tent Response.....	13
3.5 Summary and Findings Test Series A	13
4 B SERIES TESTS	20
4.1 Tents Included.....	20
4.2 Test Bed Layout	20
4.3 Results of Test B01	20
4.3.1 Pressures Measured	20
4.3.2 Tent Response.....	20
4.4 Results - Test B06.....	30
4.4.1 Pressures Measured	30
4.4.2 Tent Response.....	30
4.5 Results Test B08	41
4.5.1 Pressure Measured.....	41

4.5.2 Tent Response	41
4.6 Summary and Findings from Test Series B.....	41
5 C SERIES TESTS	50
5.1 Tents Included.....	50
5.2 Test C01 Test Bed Layout.....	54
5.3 Results – Test C01.....	54
5.3.1 Pressures Measured.....	54
5.3.2 Tent Response	54
5.4 Test C02 Test Bed Layout.....	66
5.5 Results of Test C2.....	67
5.5.1 Pressures Measured.....	67
5.5.2 Tent Responses.....	68
5.6 Summary and Findings of the C Series Tests	68
6 FOLLOW-ON TESTS PERFORMED BY BAKER RISK	76
7 RESULTS OF EXPLOSION RESEARCH COOPERATIVE TEST ON TENT CONTENTS	79
7.1 Test Layouts.....	79
7.2 Results	84
8 SUMMARY OF ALL API TEST DATA.....	87

ANNEXES

Annex A. Descriptions of Tents Tested	A-1
Annex B. Test Series A - Full Plots of Pressure Data.....	B-1
Annex C. Test Series B - Full Plots of Test Data.....	C-1
Annex D. Test Series C - Full Plots of Test Data	D-1

LIST OF FIGURES

Figure 1. VCE Deflagration Load Generator Test Rig	1
Figure 2. Typical Test Layout Showing Tent Locations	4
Figure 3. Pressure Gauge Layout – Front View of Tent - Facing Explosion	7
Figure 4. Pressure Gage Layout – Side View of Tent.....	7
Figure 5. Pole Tent with Sides.....	9
Figure 6. Light Framed Tent with Guy Wires	9
Figure 7. Pole Tent without Sides.....	10
Figure 8. Layout of Tents for Test Series A	10
Figure 9. Internal vs. External Pressure, Non-Wind Rated Pole Tent with Sides, Test A02.....	12
Figure 10. Internal vs. External Pressure, Non-Wind Rated Frame Tent, Test A02	12
Figure 11. Internal vs. External Pressure, Non-Wind Rated Pole Tent with Sides, Test A03.....	15
Figure 12. Internal vs. External Pressure, Non-Wind Rated Frame Tent, Test A03	15
Figure 13. Damage to Non-Wind Rated Pole Tent with Sides, Test A03.....	16
Figure 14. Rope to Wall Panel Connection, Non-Wind Rated Pole Tent w/ Sides, Test A03.....	16
Figure 15. Damage to Light Frame Tent, Test A03	17
Figure 16. Damage to Hinge of Roof Frame Member, Light Frame Tent, Test A03	17
Figure 17. Deformations of Light Frame Tent, Test A03.....	18
Figure 18. 3D Rendering of Deformed Light Frame Tent, Test A03	19
Figure 19. Layout of Tents for Test Series B	21
Figure 20. Comparison of Internal and External Pressure – Tent B, Test B01	23
Figure 21. Pole Tent with Sides Post Test B01	23
Figure 22. Interior of Pole Tent with Sides Test B01	24
Figure 23. Light Frame Tent Post Test B01.....	24
Figure 24. Interior of Light Frame Tent Post-Test B01	25
Figure 25. Pole Tent without Sides Post Test B01	25
Figure 26. Deformations of Pole Tent with Sides Test B01	26
Figure 27. Deformation of Light Frame Tent Test B01	27
Figure 28. Deformations of Pole Tent without Sides Test B01	28
Figure 29. 3D Rendering of Frame Deformations Test B01	29
Figure 30. Comparison of Internal and External Pressure – Tent B, Test B06	32
Figure 31. Comparison of Internal and External Pressure – Tent C, Test B06	32

Figure 32. Pole Tent with Sides Post Test B06	33
Figure 33. Interior of Pole Tent with Sides Post-Test B06.....	33
Figure 34. Rear of Light Frame Tent Post-Test B08	34
Figure 35. Exterior of Light Frame Tent Post-Test B06	34
Figure 36. Interior of Light Frame Tent Post-Test B06	35
Figure 37. Bent Frame on Light Frame Tent Post Test B06.....	35
Figure 38. Pole Tent without Sides Post-Test B06.....	36
Figure 39. Deformations of Pole Tent with Sides Test B06	37
Figure 40. Deformations of Light Frame Tent Test B06	38
Figure 41. Deformations of Pole Tent without Sides Test B06.....	39
Figure 42. 3D Rendering of Light Frame Tent Deformations Test B06	40
Figure 43. Comparison of Internal and External Pressure – Tent A, Test B08.....	43
Figure 44. Pole Tent with Sides Post-Test B08.....	43
Figure 45. Interior of Pole Tent with Sides Post-Test B08.....	44
Figure 46. Light Frame Tent Post-Test B08	44
Figure 47. Interior of Light Frame Tent Post-Test B08	45
Figure 48. Pole Tent without Sides Post-Test B08.....	45
Figure 49. Deformations of Pole Tent Test B08	46
Figure 50. Deformations of Light Frame Tent Test B08	47
Figure 51. Deformations of Pole Tent without Sides Test B08.....	48
Figure 52. 3D Rendering of Light Frame Tent Test B08.....	49
Figure 53. Exterior View of 90 mph Pole Tent – Test Bed Location A Pre-Test.....	51
Figure 54. Internal View of 90 mph Rated Pole Tent Pre-Test.....	51
Figure 55. External View of Moment Framed Tent Test Bed Location B Pre-Test.....	52
Figure 56. Internal View of Moment Framed Tent Showing Frames and Cross Bracing.....	52
Figure 57. External View of 90 mph Light Framed Tent Test Bed Location C Pre-Test.....	53
Figure 58. Internal View of Light Framed Tent	53
Figure 59. Layout of Tents for Test C01.....	55
Figure 60. Pressure Gauge Layout – Test C01, C02 – Front View of Tent Facing Explosion	55
Figure 61. Front of Pole Tent – Test C01	57
Figure 62. Rear of Pole Tent Test C01.....	57
Figure 63. Damage to Connector at Top of Perimeter Pole	58

Figure 64. Example of Failed Connector at Top of Side Pole	58
Figure 65. Deformations of Tent A – Test C01	59
Figure 66. Damage to Front of Framed Tent – Test C01	60
Figure 67. Damage to Rear of Framed Tent – Test C01	60
Figure 68. Damage to Framing Joint – Test C01	61
Figure 69. Failed Bolted Connection of Framed Tent – Test C01	61
Figure 70. Detail of Failed Horizontal Member – Test C01	62
Figure 71. Deformations of Framed Tent – Test C01	63
Figure 72. Damage to Front of Light Framed Tent – Test C01	64
Figure 73. Deformations of Light Framed Tent – Test C01	65
Figure 74. Layout of Tents for Test C2	66
Figure 75. Damage to Pole Tent – Test C02	69
Figure 76. Bent Pole on Pole Tent – Test C02	69
Figure 77. Deformations of Pole Tent – Test C02	70
Figure 78. Damage to Side of Framed Tent – Test C2	71
Figure 79. Damage to Rear of Framed Tent – Test C02	71
Figure 80. Deformations of Framed Tent – Test C02	72
Figure 81. Damage to Light Framed Tent – Test C02	73
Figure 82. Bending of Side Frame – Test C02	73
Figure 83. Bending of Roof Frames – Test C02	74
Figure 84. Failure of Roof Frame Connector – Test C02	74
Figure 85. Deformations of Light Framed Tent – Test C02	75
Figure 86. Pre-Test Photo of Tent Contents	77
Figure 87. Close-up View of Materials on Table	77
Figure 88. Post Test View of Pole Tent Tent and Contents	78
Figure 89. Damage to Pole Tent and Displacement of Table and Chairs	78
Figure 90. Test Layout A, Lunch Room with Plastic Table	79
Figure 91. Test Layout A', Lunch Room with Wooden Table	81
Figure 92. Test Layout B, Lunch Room with Plastic Table, Rotated	81
Figure 93. Test Layout C, Lunch Room with Tall Standing Objects	82
Figure 94. Test Layout D, Simulation of Welding Enclosure	82
Figure 95. Test Layout E, Simulation of Warehouse	83
Figure 96. Test 1, Pre- and Post-Test Photographs	85
Figure 97. Test 2, Pre- and Post-Test Photographs	85

Figure 98. Test 3, Pre- and Post-Test Photographs	85
Figure 99. Test 5, Pre- and Post-Test Photographs	86
Figure 100. Test 6, Pre- and Post-Test Photographs	86
Figure 101. Test 8, Pre- and Post-Test Photographs	86
Figure 102. Test 9, Pre- and Post-Test Photographs	87
Figure 103. Test 10, Pre- and Post-Test Photographs	87
Figure 104. All API Test Data Shown in Pressure-Impulse Space	88

LIST OF TABLES

Table 1. Originally Planned Test Matrix.....	3
Table 2. Final Test Matrix.....	5
Table 3. Peak Pressures and Positive Phase Impulses Recorded for Test A02	11
Table 4. Peak Pressures and Positive Phase Impulses Recorded for Test A03	14
Table 5. Peak Pressures and Positive Phase Impulses Recorded for Test B01	22
Table 6. Peak Pressures and Positive Phase Impulses Recorded for Test B06	31
Table 7. Peak Pressures and Positive Phase Impulses Recorded for Test B08	42
Table 8. Peak Pressures and Positive Phase Impulses Recorded for Test C01	56
Table 9. Peak Pressures and Positive Phase Impulses Recorded for Test C02	67
Table 10. Summary of Mass and Velocity for Selected Items	84

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1 INTRODUCTION AND BACKGROUND

The American Petroleum Institute (API) contracted with Baker Engineering and Risk Consultants, Inc. (BakerRisk) to perform vapor cloud explosion (VCE) tests to determine the response of tents to the potential explosion hazards that may be present at refineries, petrochemical and chemical operations, natural gas and other onshore process facilities covered by OSHA 29 *CFR* 1910.119. The testing was conducted to provide data for use by the API committee developing API Recommended Practice (RP) 756, “Management of Hazards Associated with Location of Process Plant Tents”.

BakerRisk designed and constructed the Deflagration Load Generator (DLG) test rig used for these tests. The test rig measures 48 ft. long by 24 ft. deep by 12 ft. tall and has three rigid walls, a rigid roof and floor, and one open wall facing the structure being tested, as shown in Figure 1. The interior of the rig is fitted with congestion. The test rig is filled with a propane/air mixture and ignited, causing a VCE.



Figure 1. VCE Deflagration Load Generator Test Rig

The specific test environment is controlled through selection of fuel concentration, obstacle geometry, and the distance between the test article and the VCE test rig. The tests were deflagrations with moderate flame speeds such that the wave shape of the blast load would include a rise time to the peak pressure. This type of VCE is representative of typical accidental VCEs at industrial facilities.

The VCE deflagrations are set to vent outside the test rig, toward the test articles. The tents were placed at a sufficient range from the test rig such that three test articles could be tested simultaneously on each shot. The test rig was configured such that the blast loading on the tent could be changed by varying the fuel concentration rather than relocating the test articles.

The tests were originally designed to serve multiple purposes: