B.L.E.V.E TEST REPORT

Test Description

This Test Report verified by Bureau Veritas demonstrates the results of the large scale external B.L.E.V.E tests carried out on the 23/05/2019, in which there are three tanks filled with 50% fuel and 100% TK3D SAFETY ALLOYS and exposed to temperatures higher than one thousand degrees celsius. Prove how the TK3D SAFETY ALLOYS technology drastically reduces thermal radiation, the volume of flame intensity, preventing and eradicating the risk of explosions from occuring, and especially eradicating the risk of B.L.E.V.E.

Test Explanation

Recreate in the most reliable way possible an explosion which is classified and named in the safety and accident prevention industry as B.L.E.V.E. (Boiling Liquid Expanding Vapor Explosion) based on a traffic incident in Bologna, Italy on August the 6th, 2018. During this accident a tanker truck filled with LPG Propane crashed into the rear end of a stationary freight truck on the motorway.

The Bologna B.L.E.V.E was caused by the LPG road fuel tanker impact and its tractor unit fuel tank rupturing thus creating a fuel leakage and a "fuel fire pool" of hundreds of litres of fuel, therefore creating the thermal radiation source, fuel fire, to create a B.L.E.V.E explosion with its LPG Propane Cargo.

This large scale, live test (21000 litres of volume) is based on the technical reports issued by the UNECE and the Italian Government of said accident and trying to replicate a similar scenario and increasing the risk factor as much as possible to prove the total efficiency and effectiveness of the use of the TK3D Safety Alloys to eradicate the risk of explosions and especially B.L.E.V.E. Therefore, being TK3D an anti-B.L.E.V.E safety technology. Tests were verified by Bureau Veritas Paris HQ and Madrid HQ for total validation of the obtained technical and test data.

Economic Commission for Europe Inland Transport Committee Working Party on the Transport of Dangerous Goods.

- http://www.unece.org/fileadmin/DAM/trans/doc/2019/dgwp15ac1/ECE-TRANS-WP15-AC1-19-BE-inf8e.pdf
- http://www.unece.org/fileadmin/DAM/trans/doc/2018/dgwp15/ECE-TRANS-WP15-105-GE-inf23e.pdf
- http://www.unece.org/fileadmin/DAM/trans/doc/2018/dgwp15/ECE-TRANS-WP15-244e.pdf

The Test

To place three fuel tanks "in line "simulating a truck tractor head unit in the form of a 1,000 litre fuel tank which was filled with 500 litres (50%) of LPG Propane, then a 10,000 litres fuel tank which was filled with 5,000 litres (50%) of diesel and following this, the final fuel tank of 10,000 litres which was loaded with 5,000 litres (50%) of LPG Propane.

The three fuel tanks total volume capacity of 21,000 litres, the total amount of fuel used for this test was 10,500 litres (50%) of liquid fuels and gases between the three units.

The test objective was to simulate the above-mentioned Bologna accident and / or a terrorist attack for example. Hence, each fuel tank had an individual "fuel fire tray" which had been incorporated under each tank, in which the following volumes of liquid fuels (95-octane gasoline and diesel) were ignited to create the maximum thermal radiation load and direct fire/flames as possible.

The first "fuel fire tray" had a volume of 150 litres of 95 octane petrol and is placed under the first tank which is simulating that of the trucks tractor head and is filled with 500 litres (50% capacity) of LPG Propane (Tank C). The second "fire tray" containing 800 litres of 95 octane petrol and 100 litres of diesel (900 litres in total) and was placed under the second tank(Tank A) of 10,000 litres which contained 5000 litres (50%) of diesel and under the last tank of 10,000 litres(Tank B) which contains 5000 litres of LPG Propane the "fire tray" which contained 1,000 litres of 95 octane petrol and 100 litres of diesel (1,100 in total). Therefore, the amount of fuel in total in the "fuel fire trays" was of 2,150 litres.

Fuel Tanks Volume, Fuel and Trays (Fire Trays)

- **Fuel Tank A**
  Volume 10,000L/Diesel 5,000L/ Fuel Fire Tray 900 Litres.
- **Fuel Tank B**
  Volume 10,000L/LPG Propane 5,000L/Fuel Fire Tray 1,100 Litres.
- **Fuel Tank C**
  Volume 1,000L/LPG 500L /Fuel Fire Tray 150 Litres.
- **Total Test Volume**
  21,100 Litres.
- **Total Fuel Test**
  10,500 Litres.
- **Total Fire Tray Fuel**
  2,150 Litres.

INCREMENT THE LEVEL OF RISK WITH THE TEST

Two (2) FUEL DRUMS were placed simulating "tractor head" tyres with a total volume capacity of 50 litres per fuel drum. One fuel drum filled with 25 litres of 95 octane petrol and the other with a 10 litres of 95 octane petrol, so, as to recreate the maximum possibility of an additional lateral explosion and to create additional direct or indirect thermal radiation around and towards the test tank which in this case had a fuel tank capacity of 1000L and containing 500 litres of LPG Propane.(50% liquid/gas ratio).(Tank C).

The other two fuel tanks "B" and "A" had a total twelve (12) fuel drums surrounding both fuel tanks. In this case six (6) fuel drums each had 25 litres of 95 octane petrol and six (6) with 10 litres of gasoline.

The idea was to prove again that seven(7) FUEL DRUMS filled with fuel/gas ratio liquid fuel 50%- gas 50% and seven(7) other fuel drums also with filled with liquid fuel 20%-gas 80% ratio wouldn´t explode or have a B.L.E.V.E. but at the same time increasing as much as possible the lateral thermal radiation for the test.

Fuel Drum Volume and Fuel Used

Fuel Tank "A"

- 6 Fuel Drums X 50 Litres Of Volume Total 300 Litres
- 3 Fuel Drums X 25 Litres= 75 Litres + 3 Fuel Drums X 10 Litres=30 Litres
- 6 Trays/Fuel Drums X 10 Litres Per Tray = 60 Litres
- Subtotal Fuel Drums Of Fuel Tank "A": Volume 300/Fuel 165 Litres.

Fuel Tank "B"

- 6 Fuel Drums X 50 Litres Volume Total 300 Litres
- 3 Fuel Drums X 25 Litres= 75 Litres + 3 Fuel Drums X 10 Litres=30 Litres
- 6 Trays/Fuel Drums X 10 Litres Per Tray = 60 Litres
- Subtotal Fuel Drums Of Fuel Tank "B": Volume 300 Litters/Fuel 165 Litres.

Fuel Tank "C"

- 2 Fuel Drums X 50 Litres Volume Total 100 Litres
- 1 Fuel Drum Of 25 Litres & 1 Fuel Drum Of 10 Litres: 35 Litres
- 2 Tray/ Fuel Drum X 10 Litres Per Tray = 20 Litres
- Subtotal Fuel Drums Of Fuel Tank "C": Volume 100 Litters/Fuel 55 Litres.

All three fuel tanks and fuel drums were protected with the TK3D Safety Alloys according to their technical design and applicable use.

The fourteen (14) fuel drums at the end of the test were opened and underwent both visual and physical inspections. The fourteen (14(fuel drum trays were marked from letters "A" to "M".

Volume 10,000 l
Diesel 5,000 l
Fuel Fire Tray 900 l

Volume 10,000l
LPG Propane 5,000 l
Fuel Fire Tray 1,100 l

Volume 1,000 l
LPG 500 l
Fuel Fire Tray 150 l

Technical Information of the Test

1.	Verification of the physical location of fuel tank "A"	Yes.
2.	Verification of the physical location of fuel tank "B"	Yes.
3.	Verification of the physical location of fuel tank "C"	Yes.
4.	Verification of the serial number of fuel tank "A"	Yes.
5.	Verification of the serial number of fuel tank "B"	Yes.
6.	Verification of the serial number of fuel tank "C"	Yes.
7.	Distance between the three tanks and fuel tanks	4 meters fuel tank "A" 6 meters fuel tank "B" 1,5 meters fuel tank "C".
8.	Fuel volume fire tray "A"	900 litres.
9.	Fuel volume fire tray "B"	1100 litres.
10.	Fuel volume fire tray "C"	150 litres.
11.	Type of fuel in tray "A"	87,5 % 95 octane gasoline & 12.5 % diesel.
12.	Type of fuel in tray "B"	90 % 95 octane gasoline & 10 % diesel.

13. Type of fuel in tray "C"	100% 95 octane gasoline.
14. Ignition system for starting the fire	Manual torch.
15. Verification of the diesel load in tank "A", 5000 litters de diesel	Yes.
16. Verification of the lpg load in fuel tank "B", 5000 litres glp propane	Yes.
17. Verification of the lpg load in fuel tank "C", 500l glp propane: yes	Yes.
18. Start time of the test	13:38
19. Finish time of the test	15:08
20. Time elapsed during the test	90 minutes.
21. Means of extinguishing of the fuels fire	Autonomous combustion of the fuel in an autonomous-combustion form. No external fire fighting assistance.
22. Post test internal fuel tank inspection "A" mesh	Yes.
23. Visual condition of TK3D alloys of fuel tank "A"	Top layer min tarnish/ under intact.
24. Tactile condition of TK3D alloys of fuel tank "A"	Good.
25. Physical integrity of the TK3D alloys of fuel tank "A"	Perfect.
26. Post test internal fuel tank inspection "B" mesh	Yes.
27. Visual condition of the TK3D alloys of fuel tank "B"	Intact-perfect.

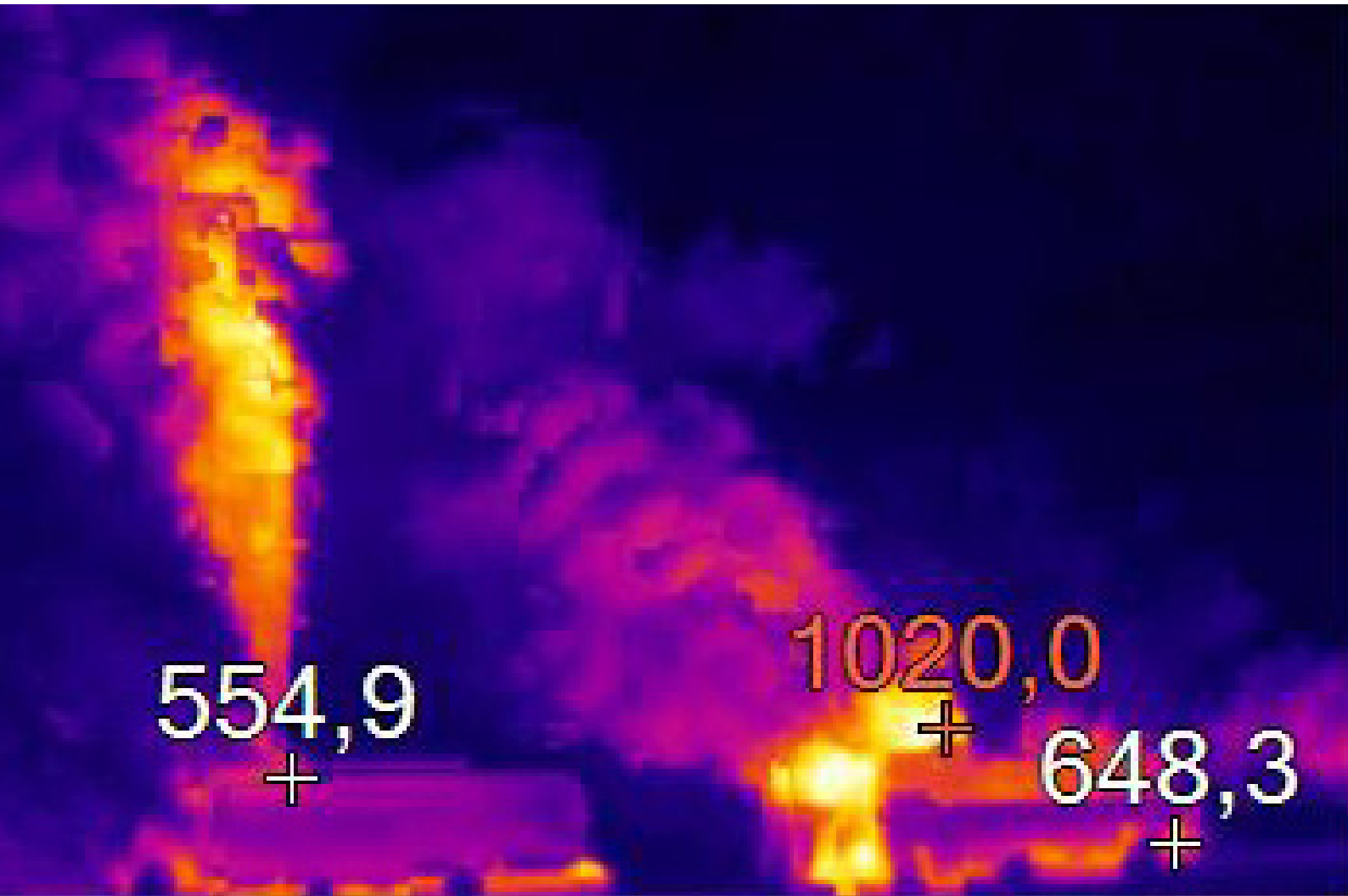
28.	Tactile condition of TK3D alloys of fuel tank "B"	**Intact-perfect.**
29.	Physical integrity of the TK3D alloys of fuel tank "B"	**Intact-perfect.**
30.	Post test internal fuel tank inspection "C" spheres/balls	**Yes.**
31.	Visual condition of TK3D alloys of fuel tank "C"	**Intact-perfect.**
32.	Tactile condition of TK3D alloys of fuel tank "C"	**Intact-perfect.**
33.	Physical integrity of the TK3D alloys of fuel tank "C"	**Intact-perfect.**
34.	The fuel tank security valve "A" active	**Yes.**
35.	Minute of activation of the security valve of the fuel tank "A"	**08:00.**
36.	The safety valve of the fuel tank "B" active	**Yes.**
37.	Minute of activation of the valve of fuel tank "B"	**05:30**
38.	The safety valve of the fuel tank "C" active	**Yes.**
39.	Minute of activation of the fuel tank valve "C"	**04:30**
40.	Some type of secondary explosion of tank "A"	**No.**
41.	Some type of main B.L.E.V.E. Explosion from tank "A"	**No.**
42.	Physical integrity of tank "A"	**Fully operational**
43.	Some type of secondary explosion of fuel tank "B"	**No.**

44. Some type of main B.L.E.V.E. Explosion of fuel tank "B"	**No.**
45. Physical integrity of fuel tank "B"	**Fully operational**
46. Some type of secondary explosion of fuel tank "C"	**No.**
47. Some type of main B.L.E.V.E. Explosion of fuel tank "C"	**No.**
48. Physical integrity of fuel tank "C"	**Fully operational.**
49. Audiovisual evidence and post test checks	**Yes.**
50. Thermal images recordings	**Yes.**

Test

Thermal Images

Photographic sequence of the test, on each page there are 2 columns and in each column, there are three versions of the same photograph. The first is a live image, the second is a mixed image (mixture between the live image and the thermal image) and finally the third is a pure thermal image. Each photograph corresponds to the exact minute of the test caption at that exact moment.



These photographs and full imagery recordings have been taken with a Fluke Ti450 PRO thermal camera, being its main features:

IFOV (spatial resolution) with standard lenses	1,31 mrad, D:S 753:1
Detector resolution	320 x 240 (76.800 pixels)
Super resolution	Capture and combine quadruple data so as to create a 640 x 480 image (307.200 pixels)
MultiSharp™ focus	Provide focus from both near and far in every area.
LaserSharp® automatic focus	Provide focus for images in a uniformed way.
Laser distance meter	It calculates the distance up to the objective and offers correctly focused images on screen, as well as distances.
Advanced manual focus	Yes
High resistance touch screen	LCD panoramic 3,5 inches 640 x 480
Erogomic and resistant design, suitable for one-handed use	Yes
Digital zoom	2x and 4x
Temperature measure range (not calibrated for below -10 °C)	-10 °C to 1500 °C (14 °F to 2732 °F)
Precision	± 2 °C or 2% (at 25 °C nominal, the greater of both)
Thermal sensitivity (NETD)*	≤ 0,025 °C at 30 °C temp. objetive (25 mK)
Emissivity correction on screen	Yes (Value and Table)
Compensation of reflected background temperatura on screen	Yes
Screen transmission correction	Yes

* The best possible

The paramaters used to take these images are the following:

Emissivity	0,95
Transmission	1,00
Camera Model	Ti450P
IR Sensor Size	320 x 240
Serial Number of the camera	Ti450P-19030424
DSP version	6.0.92
Make	Fluke Thermography
Calibration range	-20,0°C a 1500,0°C

PHOTO Nº 1
23/05/2019 13:39:55

PHOTO Nº 2
23/05/2019 13:40:58

PHOTO Nº 1 MIXED
23/05/2019 13:39:55

PHOTO Nº 2 MIXED
23/05/2019 13:40:58

PHOTO Nº 1 TER
23/05/2019 13:39:55

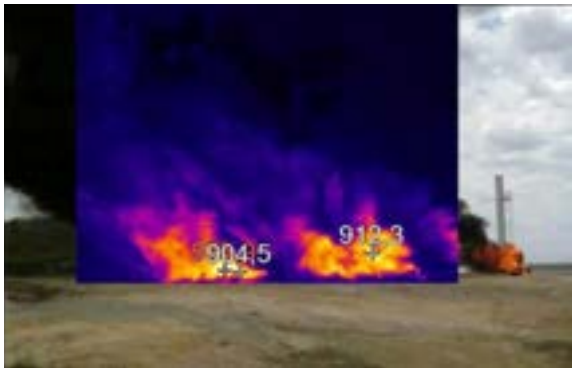


PHOTO Nº 2 TER.IS2
23/05/2019 13:40:58

Max Temp.	~90,0°C
A Fuel Tank Temp.	25,1°C
B Fuel Tank Temp.	25,0°C

Max Temp.	978,9°C
A Fuel Tank Temp.	912,3°C
B Fuel Tank Temp.	904,5°C

PHOTO Nº 3
23/05/2019 13:41:20

PHOTO Nº 4
23/05/2019 13:42:13

PHOTO Nº 3 MIXED
23/05/2019 13:41:20

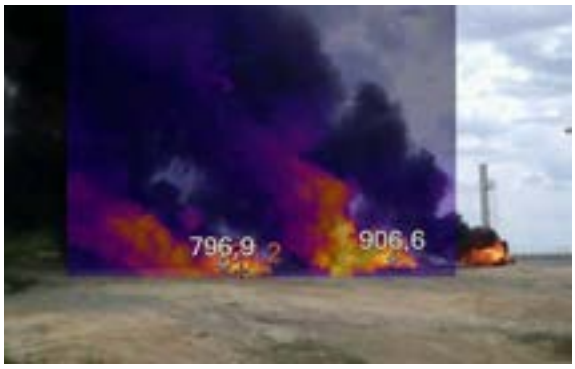


PHOTO Nº 4 MIXED
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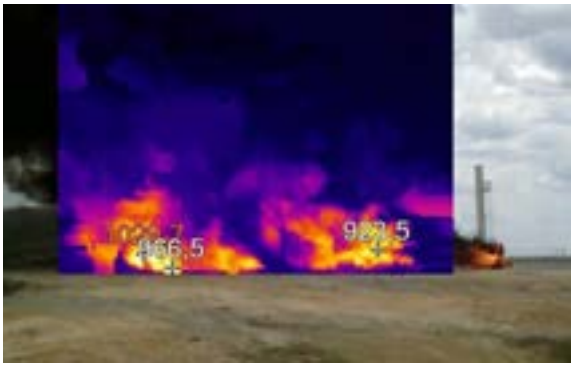

PHOTO Nº 3 TER
23/05/2019 13:41:20

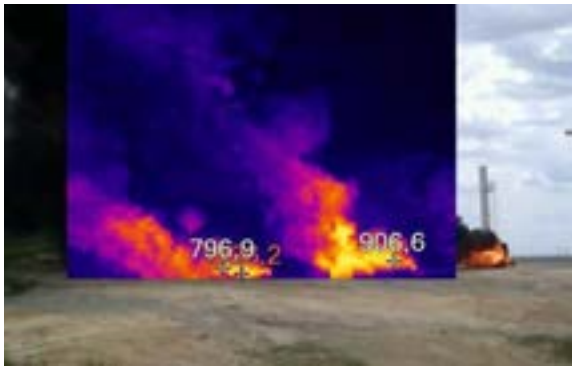

PHOTO Nº 4 TER.IS2
23/05/2019 13:42:13

Max Temp.	1029,7°C
A Fuel Tank Temp.	923,5°C
B Fuel Tank Temp.	966,5°C

Max Temp.	1026,2°C
A Fuel Tank Temp.	906,6°C
B Fuel Tank Temp.	796,9°C

PHOTO Nº 5
23/05/2019 13:43:38

PHOTO Nº 6
23/05/2019 13:44:52

PHOTO Nº 5 MIXED
23/05/2019 13:43:38

PHOTO Nº 6 MIXED
23/05/2019 13:44:52

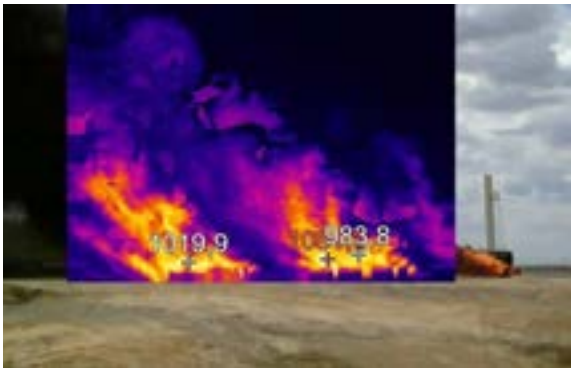

PHOTO Nº 5 TER
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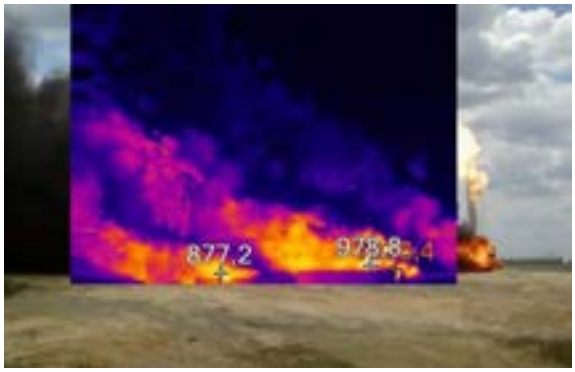

PHOTO Nº 6 TER
23/05/2019 13:44:52

Max Temp.	1081,2°C
A Fuel Tank Temp.	983,8°C
B Fuel Tank Temp.	1019,9°C

Max Temp.	1036,4°C
A Fuel Tank Temp.	978,8°C
B Fuel Tank Temp.	877,2°C

PHOTO Nº 7
23/05/2019 13:45:57

PHOTO Nº 8
23/05/2019 13:46:52

PHOTO Nº 7 MIXED
23/05/2019 13:45:57

PHOTO Nº 8 MIXED
23/05/2019 13:46:52

PHOTO Nº 7 TER
23/05/2019 13:45:57

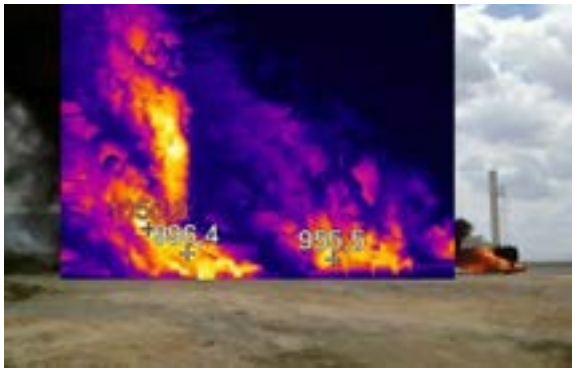

PHOTO Nº 8 TER
23/05/2019 13:46:52

Max Temp.	1082,2°C
A Fuel Tank Temp.	1033,7°C
B Fuel Tank Temp.	978,5°C

Max Temp.	1050,9°C
A Fuel Tank Temp.	955,5°C
B Fuel Tank Temp.	996,4°C

PHOTO Nº 9
23/05/2019 13:47:48

PHOTO Nº 10
23/05/2019 13:48:53

PHOTO Nº 9 MIXED
23/05/2019 13:47:48

PHOTO Nº 10 MIXED
23/05/2019 13:48:53

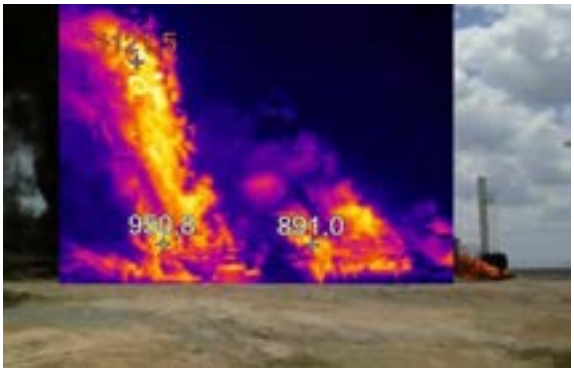

PHOTO Nº 9 TER
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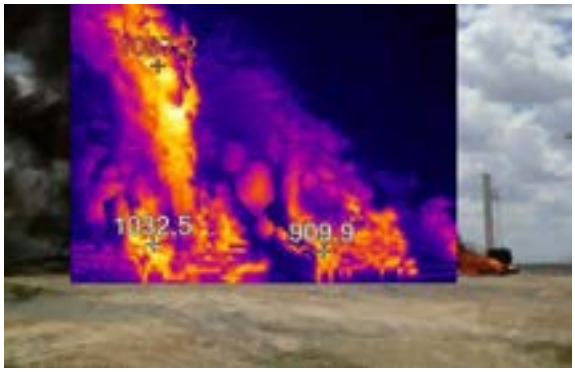


PHOTO Nº 10 TER
23/05/2019 13:48:53

Max Temp.	1121,5°C
A Fuel Tank Temp.	891,0°C
B Fuel Tank Temp.	950,8°C

Max Temp.	1097,2°C
A Fuel Tank Temp.	909,9°C
B Fuel Tank Temp.	1032,5°C

PHOTO Nº 11
23/05/2019 13:49:46

PHOTO Nº 12
23/05/2019 13:50:28

PHOTO Nº 11 MIXED
23/05/2019 13:49:46

PHOTO Nº 12 MIXED
23/05/2019 13:50:28

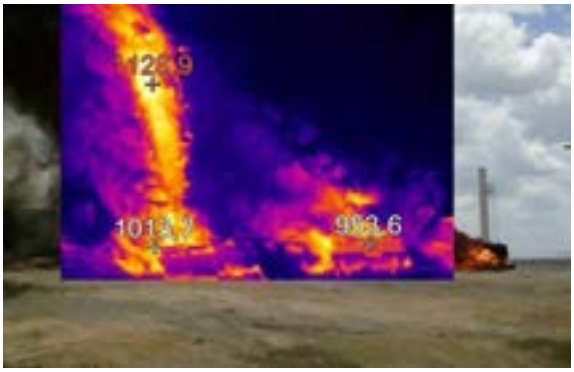


PHOTO Nº 11 TER
23/05/2019 13:49:46

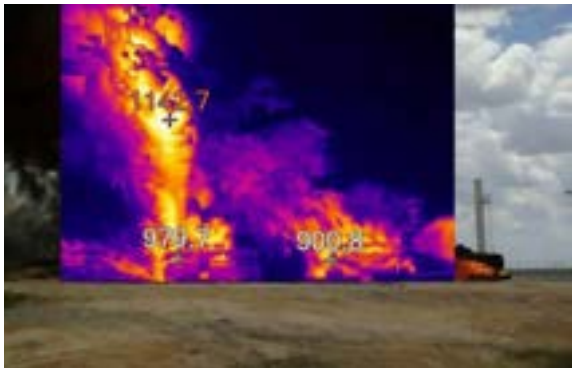


PHOTO Nº 12 TER
23/05/2019 13:50:28

Max Temp.	1128,9°C
A Fuel Tank Temp.	953,6°C
B Fuel Tank Temp.	1013,7°C

Max Temp.	1142,7°C
A Fuel Tank Temp.	900,8°C
B Fuel Tank Temp.	979,7°C

PHOTO Nº 13
23/05/2019 13:51:42

PHOTO Nº 14
23/05/2019 13:52:14

PHOTO Nº 13 MIXED
23/05/2019 13:51:42

PHOTO Nº 14 MIXED
23/05/2019 13:52:14

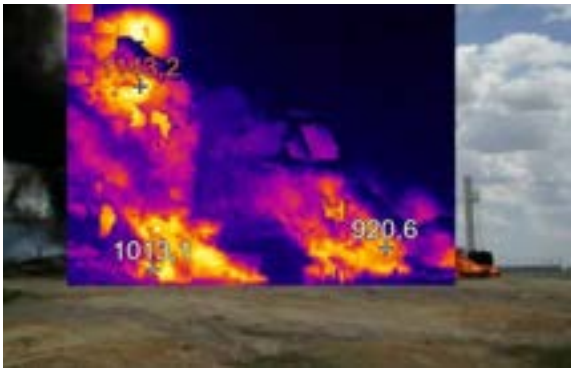


PHOTO Nº 13 TER
23/05/2019 13:51:42

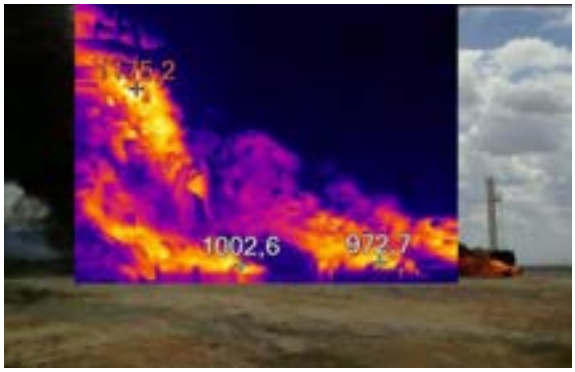


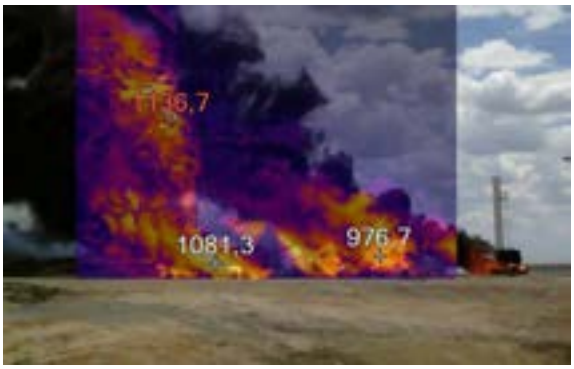
PHOTO Nº 14 TER
23/05/2019 13:52:14

Max Temp.	1143,2°C
A Fuel Tank Temp.	920,6°C
B Fuel Tank Temp.	1013,1°C

Max Temp.	1175,2°C
A Fuel Tank Temp.	972,7°C
B Fuel Tank Temp.	1002,6°C

PHOTO Nº 15
23/05/2019 13:53:28

PHOTO Nº 16
23/05/2019 13:54:10



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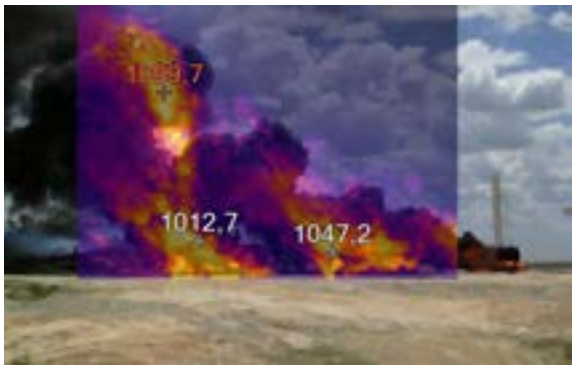

PHOTO Nº 16 MIXED
23/05/2019 13:54:10

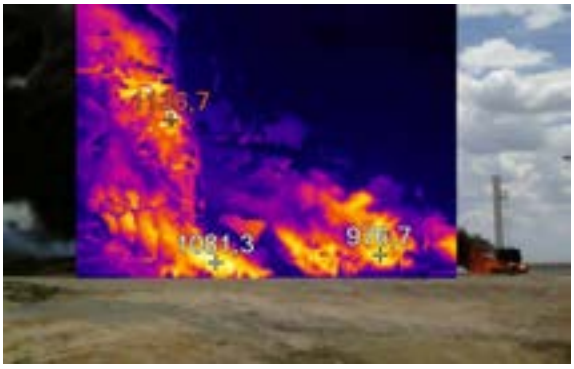

PHOTO Nº 15 TER
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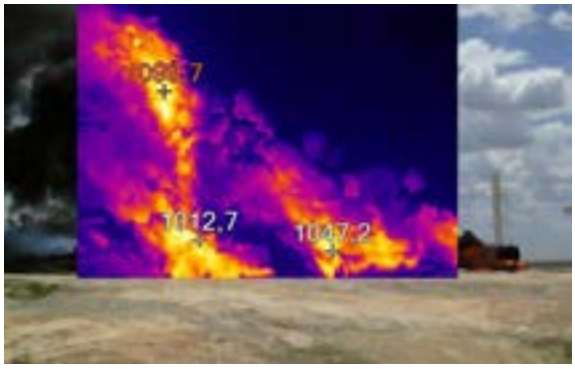

PHOTO Nº 16 TER
23/05/2019 13:54:10

Max Temp.	1136,7°C
A Fuel Tank Temp.	976,7°C
B Fuel Tank Temp.	1081,3°C

Max Temp.	1099,7°C
A Fuel Tank Temp.	1047,2°C
B Fuel Tank Temp.	1012,7°C

PHOTO Nº 17
23/05/2019 13:55:34

PHOTO Nº 18
23/05/2019 13:56:59

PHOTO Nº 17 MIXED
23/05/2019 13:55:34

PHOTO Nº 18 MIXED
23/05/2019 13:56:59

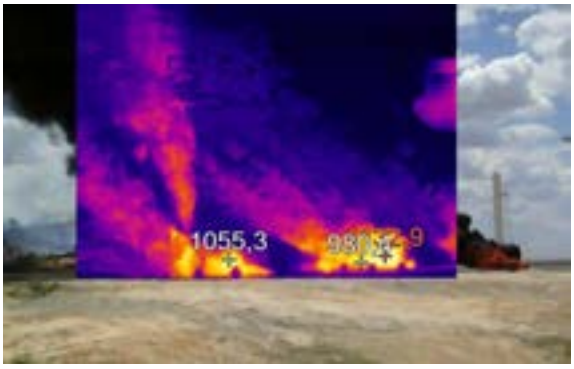

PHOTO Nº 17 TER.IS2
23/05/2019 13:55:34

Max Temp.	1132,9°C
A Fuel Tank Temp.	980,4°C
B Fuel Tank Temp.	1055,3°C

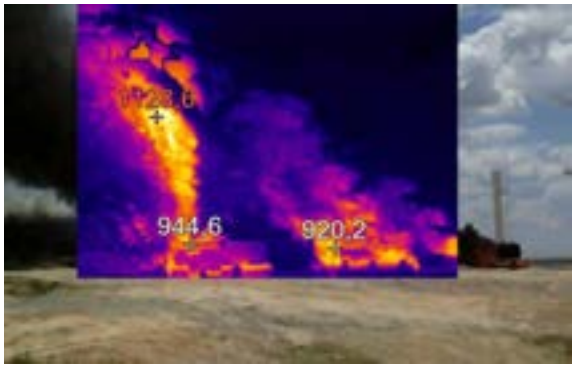

PHOTO Nº 18 TER
23/05/2019 13:56:59.

Max Temp.	1128,6°C
A Fuel Tank Temp.	920,2°C
B Fuel Tank Temp.	944,6°C

PHOTO Nº 19
23/05/2019 13:57:51

PHOTO Nº 20
23/05/2019 13:58:33

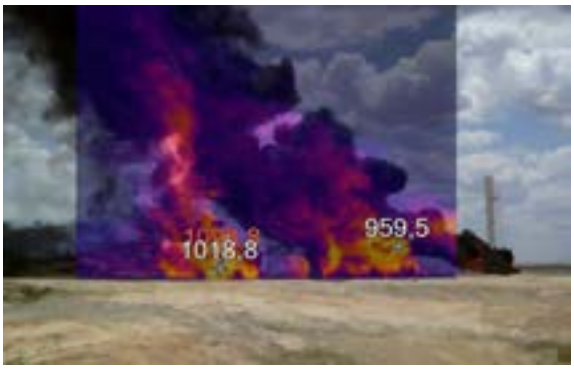

PHOTO Nº 19 MIXED
23/05/2019 13:57:51

PHOTO Nº 20 MIXED
23/05/2019 13:58:33

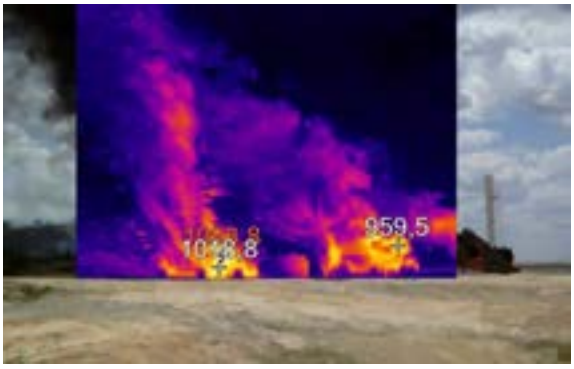

PHOTO Nº 19 TER
23/05/2019 13:57:51

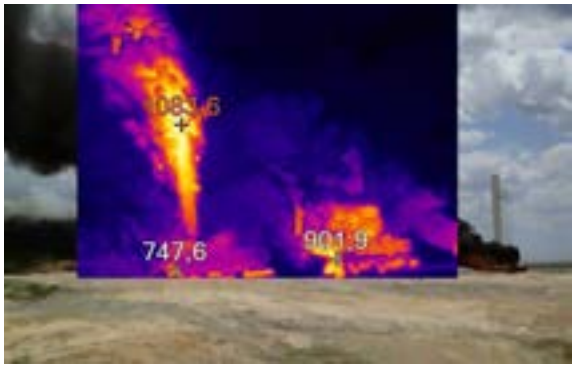

PHOTO Nº 20 TER
23/05/2019 13:58:33

Max Temp.	1093,8°C
A Fuel Tank Temp.	959,5°C
B Fuel Tank Temp.	1018,8°C

Max Temp.	1083,6°C
A Fuel Tank Temp.	901,9°C
B Fuel Tank Temp.	747,6°C

PHOTO Nº 21
23/05/2019 13:59:47

PHOTO Nº 22
23/05/2019 14:00:40

PHOTO Nº 21 MIXED
23/05/2019 13:59:47

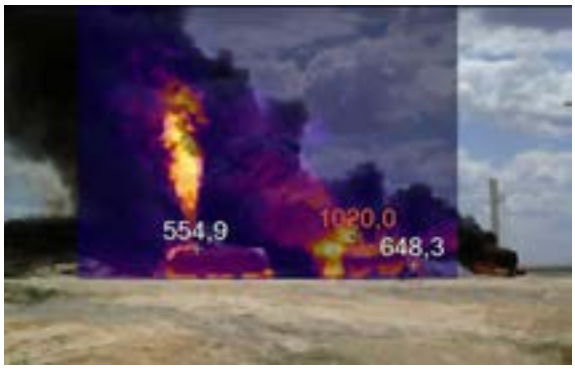

PHOTO Nº 22 MIXED
23/05/2019 14:00:40

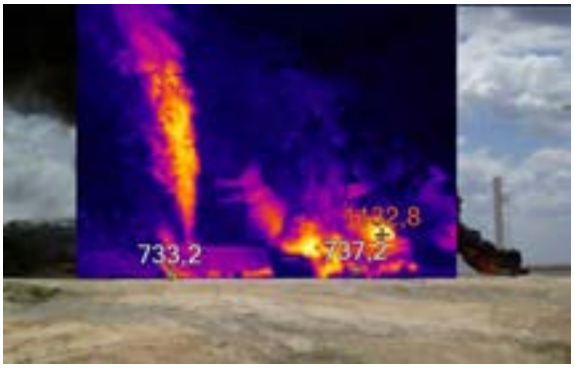

PHOTO Nº 21 TER
23/05/2019 13:59:47

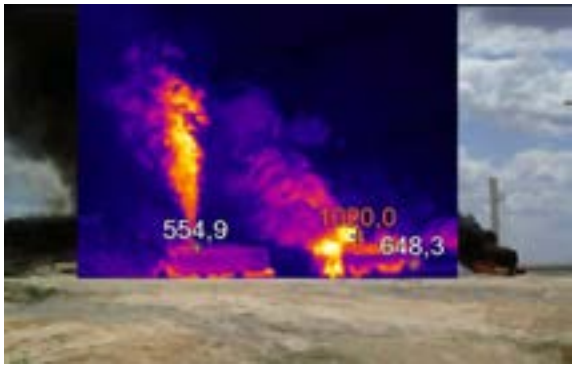

PHOTO Nº 22 TER
23/05/2019 14:00:40

Max Temp.	1132,8°C
A Fuel Tank Temp.	737,2°C
B Fuel Tank Temp.	733,2°C

Max Temp.	1020,0°C
A Fuel Tank Temp.	648,3°C
B Fuel Tank Temp.	554,9°C

PHOTO Nº 23
23/05/2019 14:01:12

PHOTO Nº 24
23/05/2019 14:02:15

PHOTO Nº 23 MIXED
23/05/2019 14:01:12

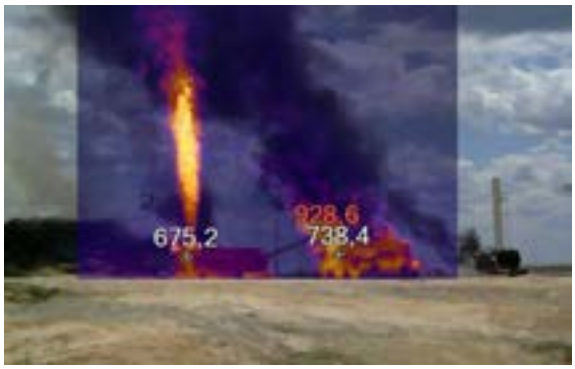

PHOTO Nº 24 MIXED
23/05/2019 14:02:15

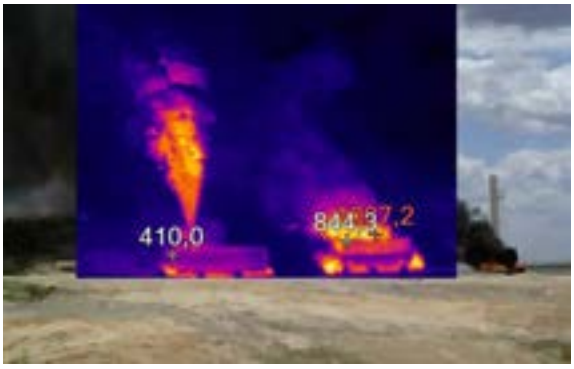

PHOTO Nº 23 TER
23/05/2019 14:01:12

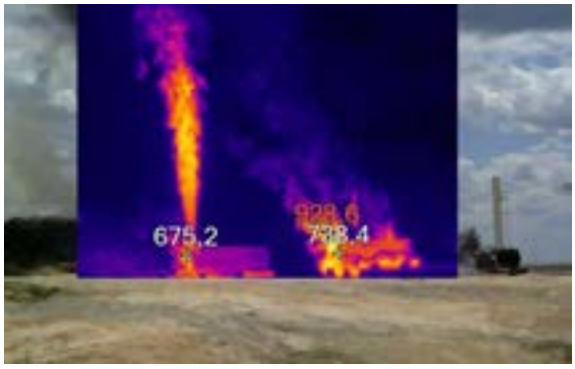

PHOTO Nº 24 TER
23/05/2019 14:02:15

Max Temp.	1087,2°C
A Fuel Tank Temp.	844,3°C
B Fuel Tank Temp.	410,0°C

Max Temp.	928,6°C
A Fuel Tank Temp.	738,4°C
B Fuel Tank Temp.	675,2°C

PHOTO Nº 25
23/05/2019 14:03:19

PHOTO Nº 26
23/05/2019 14:04:22

PHOTO Nº 25 MIXED
23/05/2019 14:03:19

PHOTO Nº 26 MIXED
23/05/2019 14:04:22

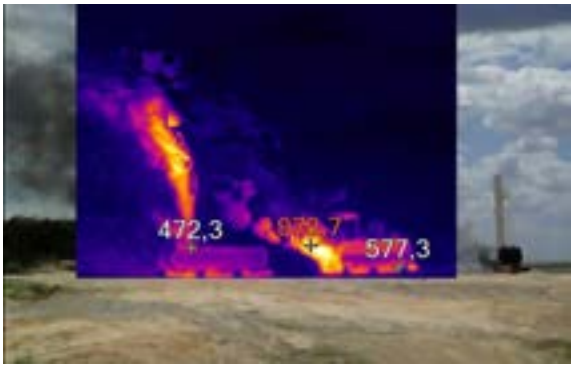

PHOTO Nº 25 TER
23/05/2019 14:03:19

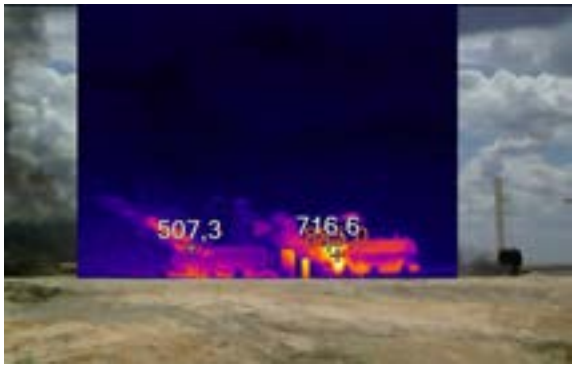

PHOTO Nº 26 TER
23/05/2019 14:04:22

Max Temp.	973,7°C
A Fuel Tank Temp.	577,3°C
B Fuel Tank Temp.	472,3°C

Max Temp.	885,0°C
A Fuel Tank Temp.	716,6°C
B Fuel Tank Temp.	507,3°C

PHOTO Nº 27
23/05/2019 14:05:04

PHOTO Nº 28
23/05/2019 14:06:49

PHOTO Nº 27 MIXED
23/05/2019 14:05:04

PHOTO Nº 28 MIXED
23/05/2019 14:06:49

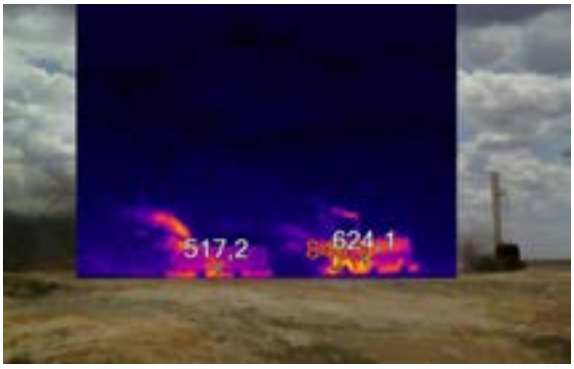

PHOTO Nº 27 TER
23/05/2019 14:05:04

Max Temp.	840,7°C
A Fuel Tank Temp.	624,1°C
B Fuel Tank Temp.	517,2°C

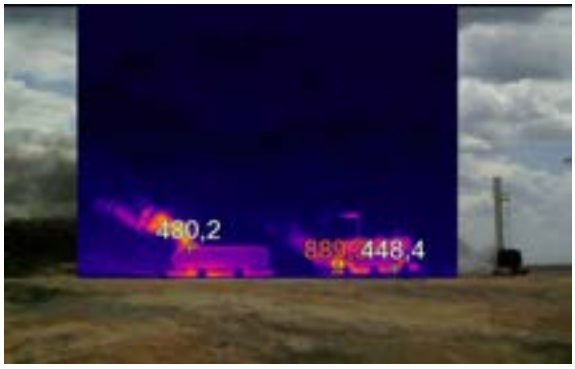

PHOTO Nº 28 TER
23/05/2019 14:06:49

Max Temp.	889,3°C
A Fuel Tank Temp.	448,4°C
B Fuel Tank Temp.	480,2°C

PHOTO Nº 29
23/05/2019 14:07:00

PHOTO Nº 30
23/05/2019 14:08:35

PHOTO Nº 29 MIXED
23/05/2019 14:07:00

PHOTO Nº 30 MIXED
23/05/2019 14:08:35

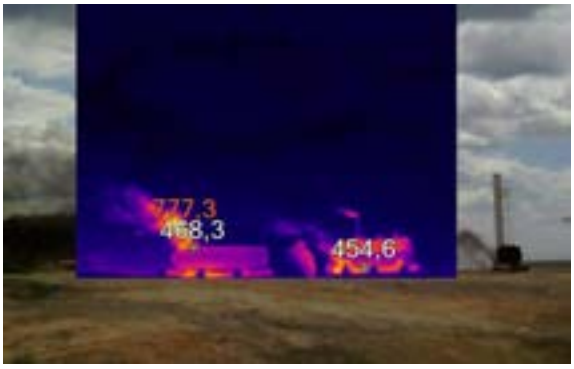

PHOTO Nº 29 TER
23/05/2019 14:07:00

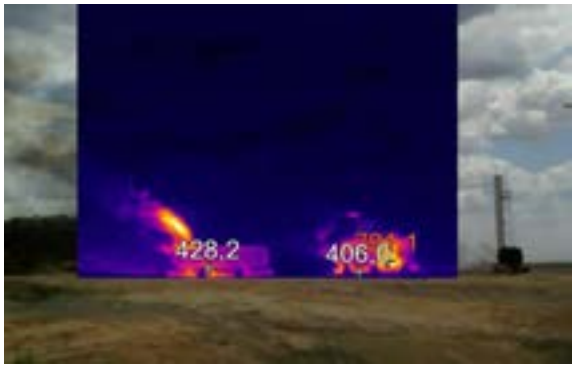

PHOTO Nº 30 TER
23/05/2019 14:08:35

Max Temp.	777,3°C
A Fuel Tank Temp.	454,6°C
B Fuel Tank Temp.	468,3°C

Max Temp.	791,1°C
A Fuel Tank Temp.	406,0°C
B Fuel Tank Temp.	428,2°C

PHOTO Nº 31
23/05/2019 14:09:17

PHOTO Nº 32
23/05/2019 14:10:10

PHOTO Nº 31 MIXED
23/05/2019 14:09:17

PHOTO Nº 32 MIXED
23/05/2019 14:10:10

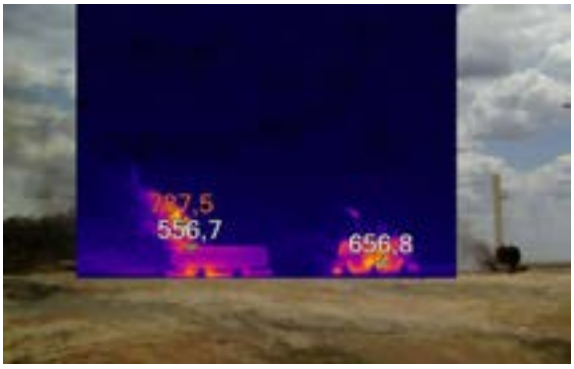

PHOTO Nº 31 TER
23/05/2019 14:09:17

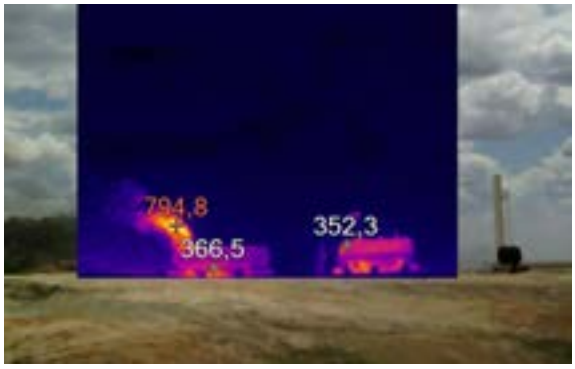

PHOTO Nº 32 TER
23/05/2019 14:10:10

Max Temp.	787,5°C
A Fuel Tank Temp.	656,8°C
B Fuel Tank Temp.	556,7°C

Max Temp.	794,8°C
A Fuel Tank Temp.	352,3°C
B Fuel Tank Temp.	366,5°C

PHOTO Nº 33
23/05/2019 14:11:14

PHOTO Nº 34
23/05/2019 14:12:38

PHOTO Nº 33 MIXED
23/05/2019 14:11:14

PHOTO Nº 34 MIXED
23/05/2019 14:12:38

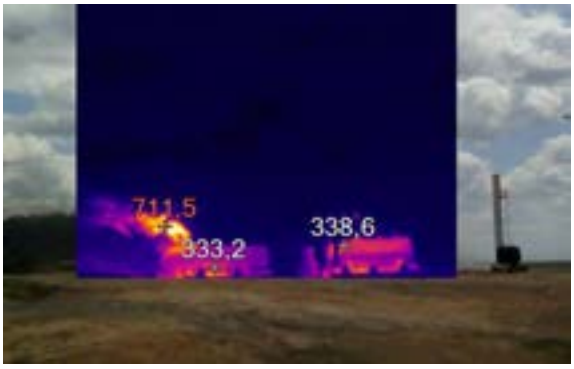

PHOTO Nº 33 TER
23/05/2019 14:11:14

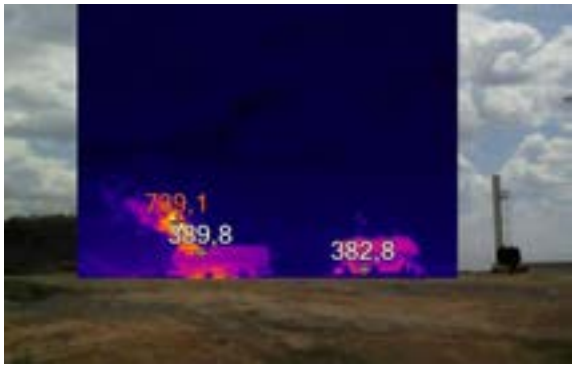

PHOTO Nº 34 TER
23/05/2019 14:12:38

Max Temp.	711,5°C
A Fuel Tank Temp.	338,6°C
B Fuel Tank Temp.	333,2°C

Max Temp.	797,4°C
A Fuel Tank Temp.	382,8°C
B Fuel Tank Temp.	389,8°C

PHOTO Nº 35
23/05/2019 14:13:00

PHOTO Nº 36
23/05/2019 14:14:45

PHOTO Nº 35 MIXED
23/05/2019 14:13:00

PHOTO Nº 36 MIXED
23/05/2019 14:14:45

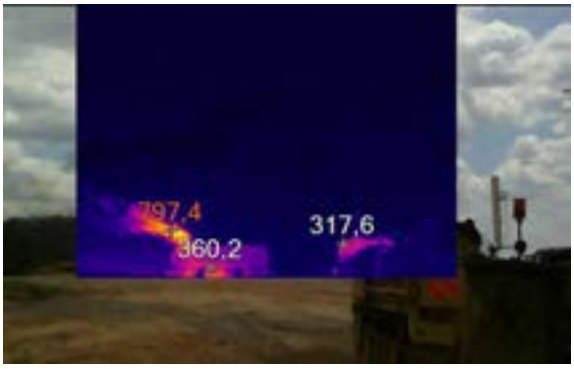

PHOTO Nº 35 TER
23/05/2019 14:13:00

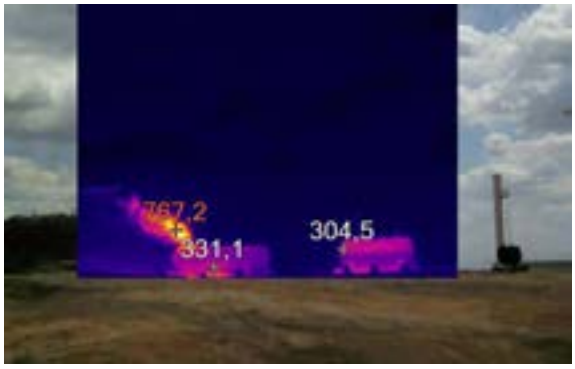

PHOTO Nº 36 TER
23/05/2019 14:14:45

Max Temp.	797,4°C
A Fuel Tank Temp.	317,6°C
B Fuel Tank Temp.	360,2°C

Max Temp.	767,2°C
A Fuel Tank Temp.	304,5°C
B Fuel Tank Temp.	331,1°C

PHOTO Nº 37
23/05/2019 14:15:27

PHOTO Nº 38
23/05/2019 14:16:10

PHOTO Nº 37 MIXED
23/05/2019 14:15:27

PHOTO Nº 38 MIXED
23/05/2019 14:16:10

PHOTO Nº 37 TER
23/05/2019 14:15:27

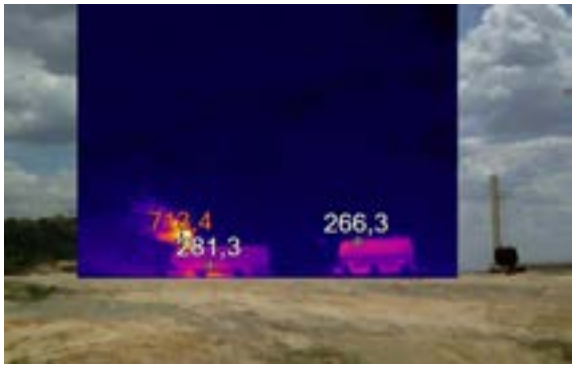

PHOTO Nº 38 TER
23/05/2019 14:16:10

Max Temp.	699,0°C
A Fuel Tank Temp.	265,5°C
B Fuel Tank Temp.	307,7°C

Max Temp.	713,4°C
A Fuel Tank Temp.	266,3°C
B Fuel Tank Temp.	281,3°C

PHOTO Nº 39
23/05/2019 14:17:02

PHOTO Nº 40
23/05/2019 14:18:16

PHOTO Nº 39 MIXED
23/05/2019 14:17:02

PHOTO Nº 40 MIXED
23/05/2019 14:18:16

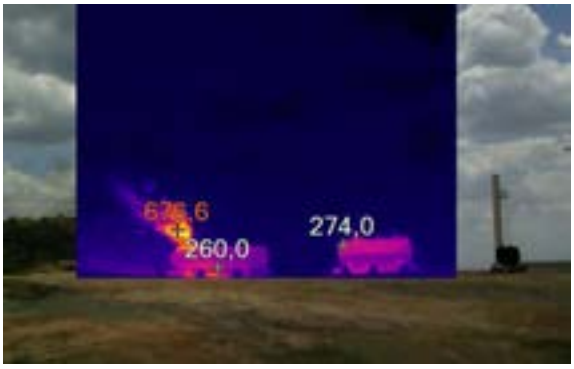

PHOTO Nº 39 TER
23/05/2019 14:17:02

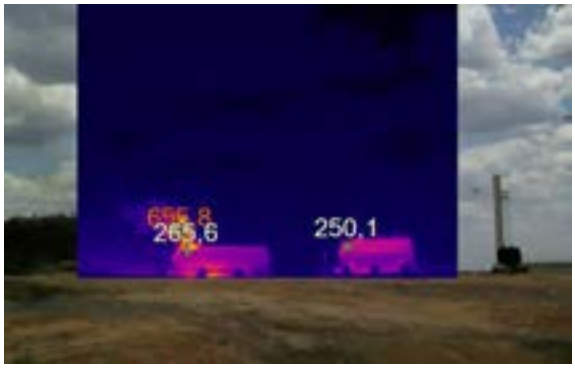

PHOTO Nº 40 TER
23/05/2019 14:18:16

Max Temp.	676,6°C
A Fuel Tank Temp.	274,0°C
B Fuel Tank Temp.	260,0°C

Max Temp.	655,8°C
A Fuel Tank Temp.	250,1°C
B Fuel Tank Temp.	265,6°C

PHOTO Nº 41
23/05/2019 14:19:19

PHOTO Nº 42
23/05/2019 14:20:23

PHOTO Nº 41 MIXED
23/05/2019 14:19:19

PHOTO Nº 42 MIXED
23/05/2019 14:20:23

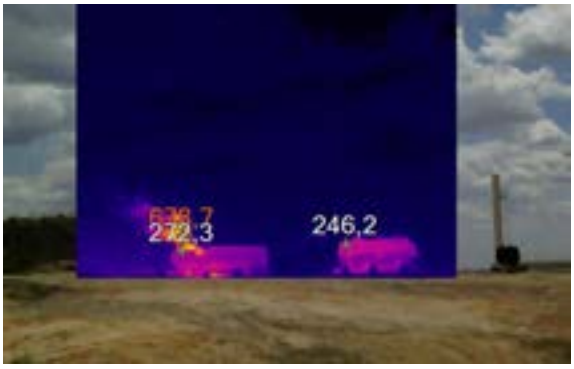

PHOTO Nº 41 TER
23/05/2019 14:19:19

Max Temp.	678,7°C
A Fuel Tank Temp.	246,2°C
B Fuel Tank Temp.	272,3°C

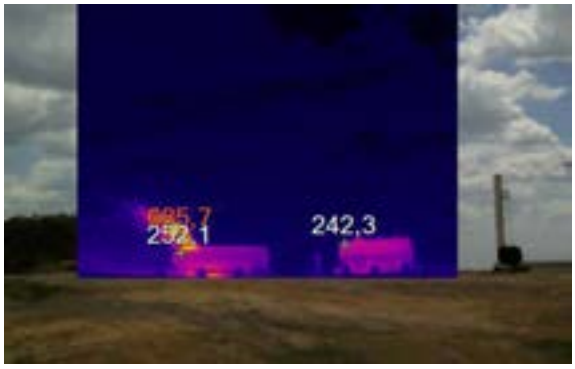

PHOTO Nº 42 TER
23/05/2019 14:20:2

Max Temp.	685,7°C
A Fuel Tank Temp.	242,3°C
B Fuel Tank Temp.	252,1°C

PHOTO Nº 43
23/05/2019 14:21:26

PHOTO Nº 44
23/05/2019 14:22:39

PHOTO Nº 43 MIXED
23/05/2019 14:21:26

PHOTO Nº 44 MIXED
23/05/2019 14:22:39

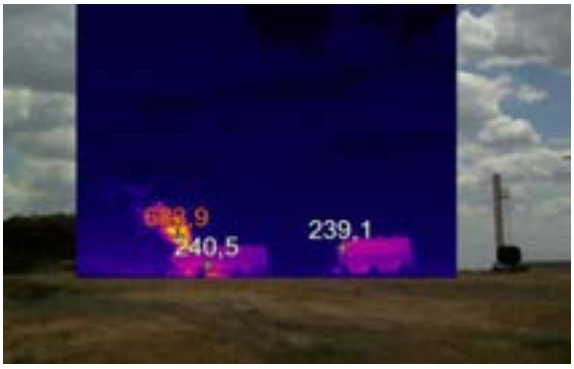

PHOTO Nº 43 TER
23/05/2019 14:21:26

PHOTO Nº 44 TER
23/05/2019 14:22:39

Max Temp.	683,9°C
A Fuel Tank Temp.	239,1°C
B Fuel Tank Temp.	240,5°C

Max Temp.	668,1°C
A Fuel Tank Temp.	297,9°C
B Fuel Tank Temp.	257,4°C

PHOTO Nº 45
23/05/2019 14:23:42

PHOTO Nº 46
23/05/2019 14:24:46

PHOTO Nº 45 MIXED
23/05/2019 14:23:42

PHOTO Nº 46 MIXED
23/05/2019 14:24:46

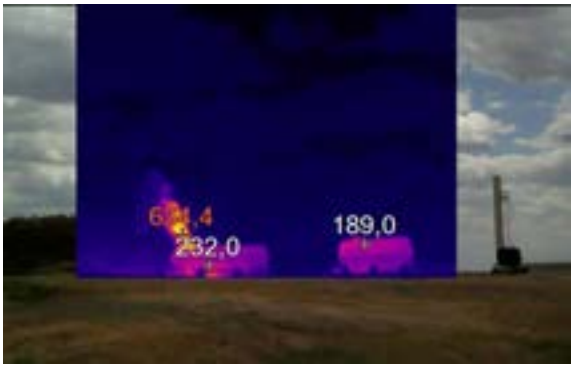

PHOTO Nº 45 TER
23/05/2019 14:23:42

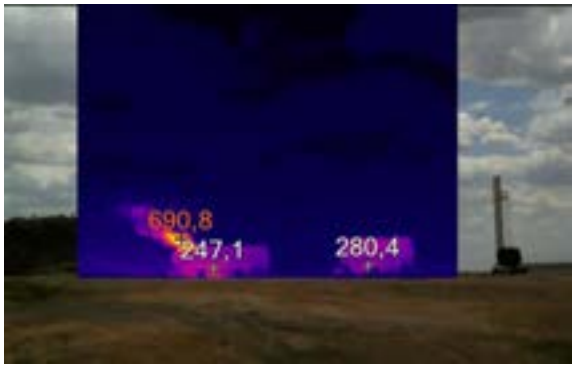

PHOTO Nº 46 TER
23/05/2019 14:24:463

Max Temp.	634,4°C
A Fuel Tank Temp.	189,0°C
B Fuel Tank Temp.	232,0°C

Max Temp.	690,8°C
A Fuel Tank Temp.	280,4°C
B Fuel Tank Temp.	247,1°C

PHOTO Nº 47
23/05/2019 14:25:39

PHOTO Nº 48
23/05/2019 14:26:21

PHOTO Nº 47 MIXED
23/05/2019 14:25:39

PHOTO Nº 48 MIXED
23/05/2019 14:26:21

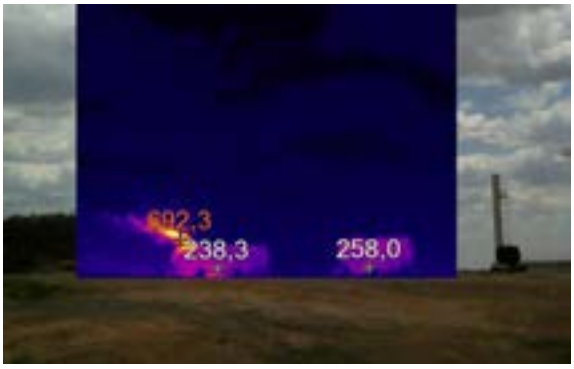

PHOTO Nº 47 TER
23/05/2019 14:25:39

PHOTO Nº 48 TER
23/05/2019 14:26:21

Max Temp.	692,3°C
A Fuel Tank Temp.	258,0°C
B Fuel Tank Temp.	238,3°C

Max Temp.	712,8°C
A Fuel Tank Temp.	248,7°C
B Fuel Tank Temp.	252,3°C

PHOTO Nº 49
23/05/2019 14:27:34

PHOTO Nº 50
23/05/2019 14:28:48

PHOTO Nº 49 MIXED
23/05/2019 14:27:34

PHOTO Nº 50 MIXED
23/05/2019 14:28:48

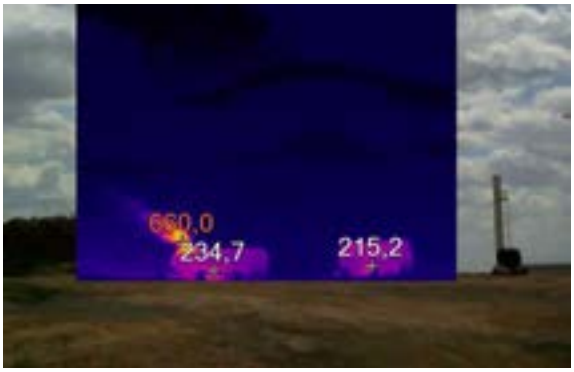

PHOTO Nº 49 TER
23/05/2019 14:27:34

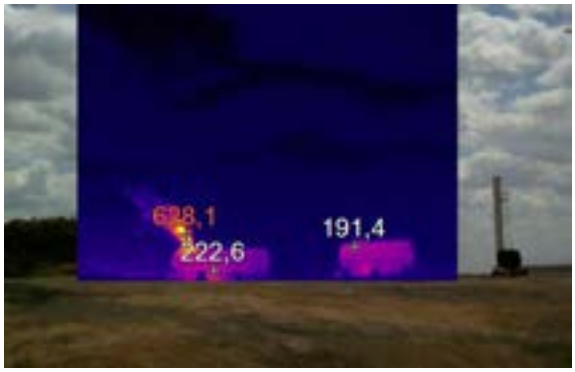

PHOTO Nº 50 TER
23/05/2019 14:28:48

Max Temp.	660,0°C
A Fuel Tank Temp.	215,2°C
B Fuel Tank Temp.	234,7°C

Max Temp.	628,1°C
A Fuel Tank Temp.	191,4°C
B Fuel Tank Temp.	222,6°C

PHOTO Nº 51
23/05/2019 14:29:30

PHOTO Nº 52
23/05/2019 14:30:23

PHOTO Nº 51 MIXED
23/05/2019 14:29:30

PHOTO Nº 52 MIXED
23/05/2019 14:30:23

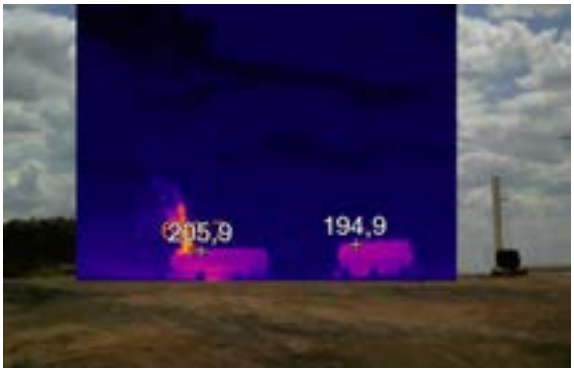

PHOTO Nº 51 TER
23/05/2019 14:29:30

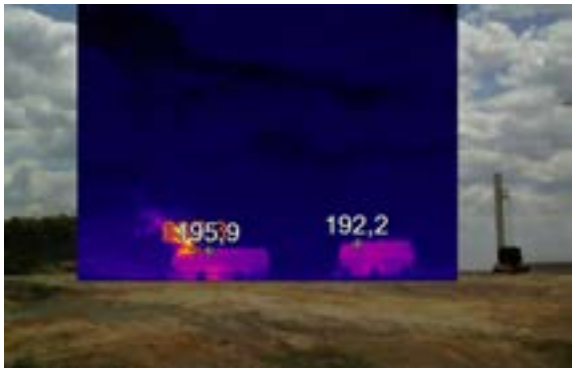

PHOTO Nº 52 TER
23/05/2019 14:30:23

Max Temp.	610,7°C
A Fuel Tank Temp.	194,9°C
B Fuel Tank Temp.	205,9°C

Max Temp.	637,3°C
A Fuel Tank Temp.	192,2°C
B Fuel Tank Temp.	195,9°C

PHOTO Nº 53
23/05/2019 14:31:26

PHOTO Nº 54
23/05/2019 14:32:40

PHOTO Nº 53 MIXED
23/05/2019 14:31:26

PHOTO Nº 54 MIXED
23/05/2019 14:32:40

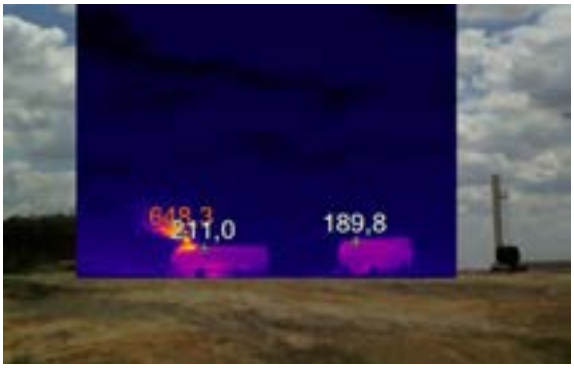

PHOTO Nº 53 TER
23/05/2019 14:31:26

PHOTO Nº 54 TER
23/05/2019 14:32:40

Max Temp.	648,3°C
A Fuel Tank Temp.	189,8°C
B Fuel Tank Temp.	211,0°C

Max Temp.	654,0°C
A Fuel Tank Temp.	191,0°C
B Fuel Tank Temp.	209,4°C

PHOTO Nº 55
23/05/2019 14:33:01

PHOTO Nº 56
23/05/2019 14:34:04

PHOTO Nº 55 MIXED
23/05/2019 14:33:01

PHOTO Nº 56 MIXED
23/05/2019 14:34:04

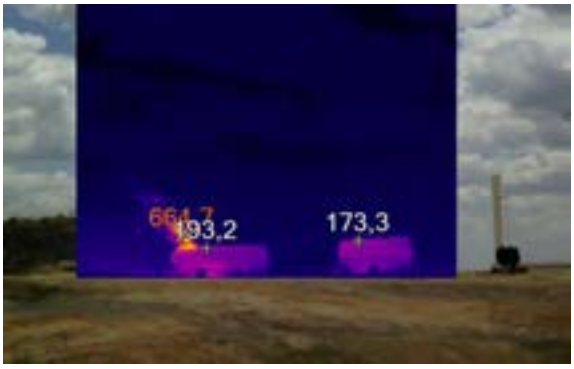

PHOTO Nº 55 TER.IS2
23/05/2019 14:33:01

Max Temp.	664,7°C
A Fuel Tank Temp.	173,3°C
B Fuel Tank Temp.	193,2°C

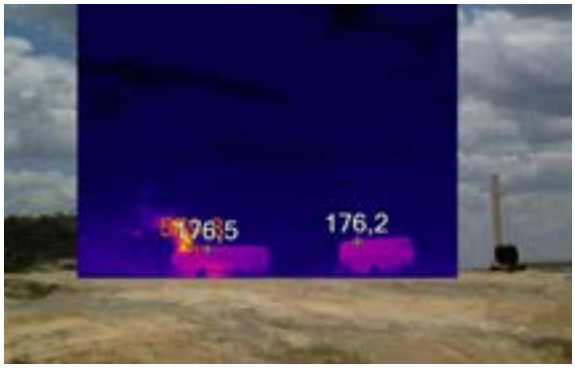

PHOTO Nº 56 TER
23/05/2019 14:34:04

Max Temp.	579,8°C
A Fuel Tank Temp.	176,2°C
B Fuel Tank Temp.	176,5°C

PHOTO Nº 57
23/05/2019 14:35:29

PHOTO Nº 58
23/05/2019 14:36:21

PHOTO Nº 57 MIXED
23/05/2019 14:35:29

PHOTO Nº 58 MIXED
23/05/2019 14:36:21

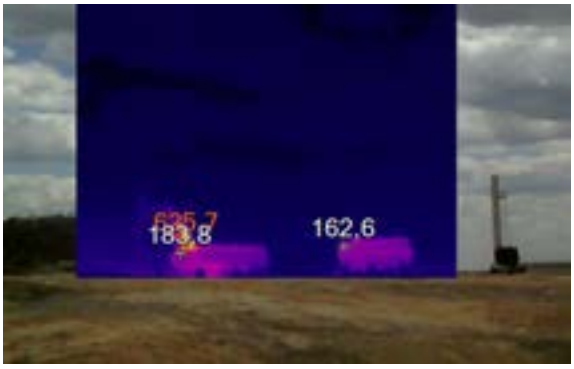

PHOTO Nº 57 TER
23/05/2019 14:35:29

PHOTO Nº 58 TER
23/05/2019 14:36:21

Max Temp.	625,7°C
A Fuel Tank Temp.	162,6 ºC
B Fuel Tank Temp.	183,8°C

Max Temp.	577,9°C
A Fuel Tank Temp.	157,0°C
B Fuel Tank Temp.	169,2°C

PHOTO Nº 59
23/05/2019 14:37:35

PHOTO Nº 60
23/05/2019 14:38:28

PHOTO Nº 59 MIXED
23/05/2019 14:37:35

PHOTO Nº 60 MIXED
23/05/2019 14:38:28

PHOTO Nº 59 TER
23/05/2019 14:37:35

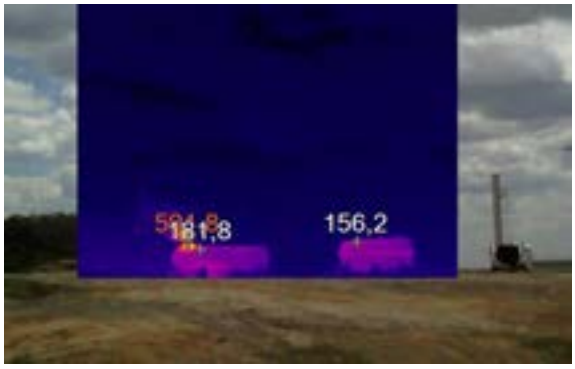

PHOTO Nº 60 TER
23/05/2019 14:38:28

Max Temp.	639,1°C
A Fuel Tank Temp.	148,8ºC
B Fuel Tank Temp.	150,1°C

Max Temp.	591,8°C
A Fuel Tank Temp.	156,2°C
B Fuel Tank Temp.	181,8°C

PHOTO Nº 61
23/05/2019 14:39:00

PHOTO Nº 62
23/05/2019 14:40:31

PHOTO Nº 61 MIXED
23/05/2019 14:39:00

PHOTO Nº 62 MIXED
23/05/2019 14:40:31

PHOTO Nº 61 TER
23/05/2019 14:39:00

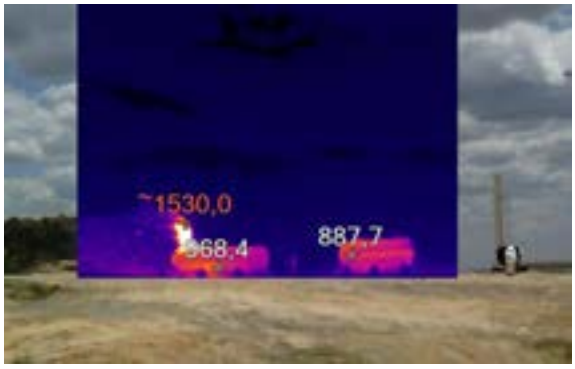

PHOTO Nº 62 TER
23/05/2019 14:40:31

Max Temp.	589,7°C
A Fuel Tank Temp.	156,8°C
B Fuel Tank Temp.	310,1°C

Max Temp.	~1530,0°C
A Fuel Tank Temp.	887,7°C
B Fuel Tank Temp.	968,4°C

PHOTO Nº 63
23/05/2019 14:41:06

PHOTO Nº 64
23/05/2019 14:42:10

PHOTO Nº 63 MIXED
23/05/2019 14:41:06

PHOTO Nº 64 MIXED
23/05/2019 14:42:10

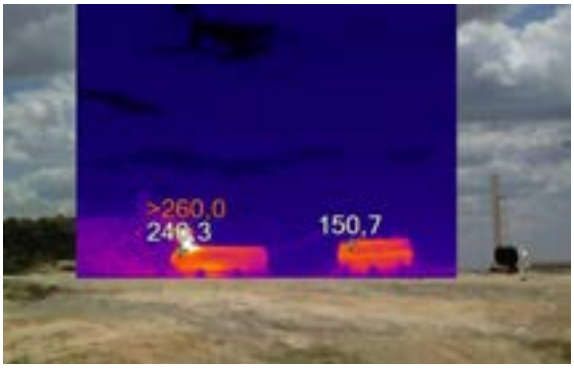

PHOTO Nº 63 TER
23/05/2019 14:41:06

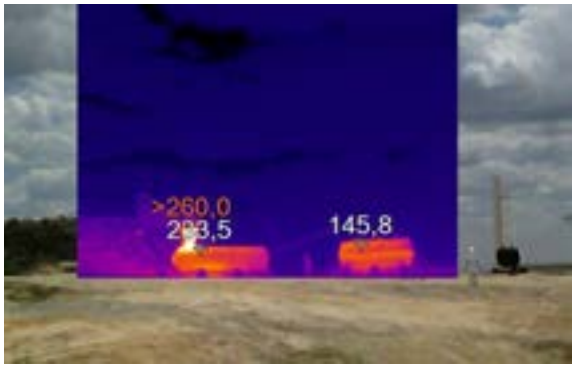

PHOTO Nº 64 TER
23/05/2019 14:42:10

Max Temp.	>260,0°C
A Fuel Tank Temp.	150,7°C
B Fuel Tank Temp.	240,3°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	145,8°C
B Fuel Tank Temp.	233,5°C

PHOTO Nº 65
23/05/2019 14:43:02

PHOTO Nº 66
23/05/2019 14:44:06

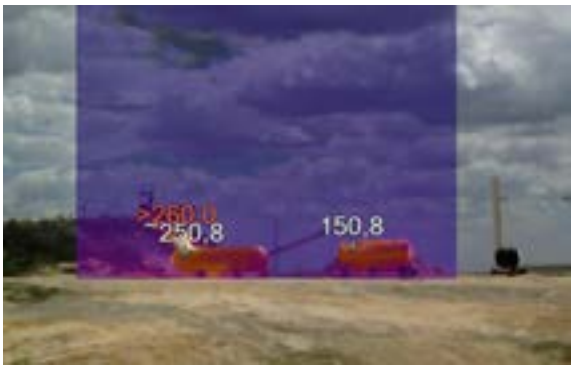

PHOTO Nº 65 MIXED
23/05/2019 14:43:02

PHOTO Nº 66 MIXED
23/05/2019 14:44:06

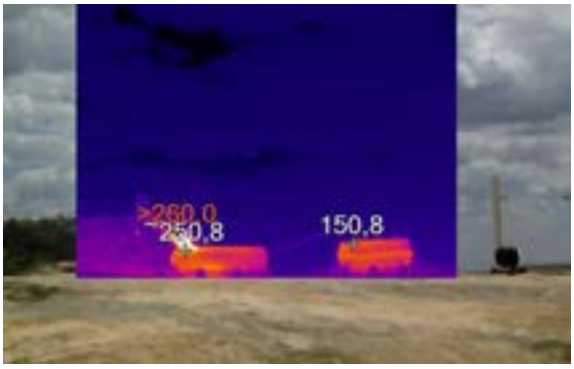

PHOTO Nº 65 TER
23/05/2019 14:43:02

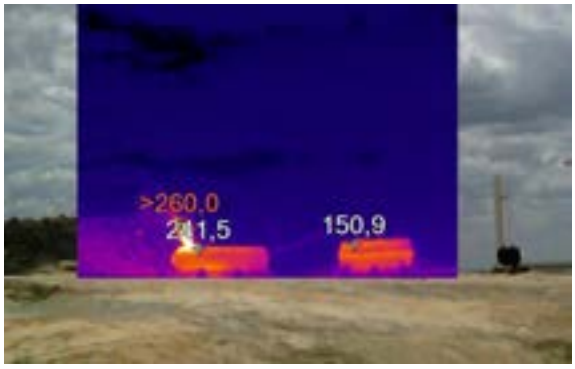

PHOTO Nº 66 TER
23/05/2019 14:44:06

Max Temp.	>260,0°C
A Fuel Tank Temp.	150,8°C
B Fuel Tank Temp.	~250,8°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	150,9°C
B Fuel Tank Temp.	241,5°C

PHOTO Nº 67
23/05/2019 14:45:09

PHOTO Nº 68
23/05/2019 14:46:02

PHOTO Nº 67 MIXED
23/05/2019 14:45:09

PHOTO Nº 68 MIXED
23/05/2019 14:46:02

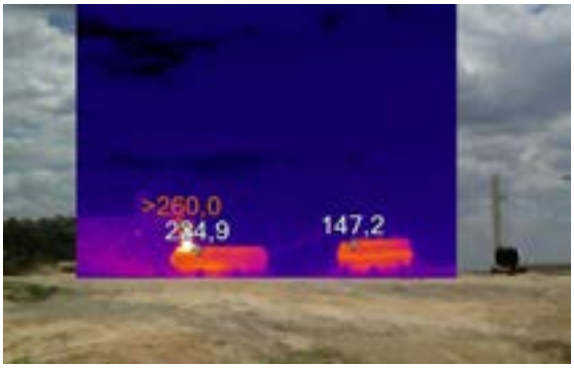

PHOTO Nº 67 TER
23/05/2019 14:45:09

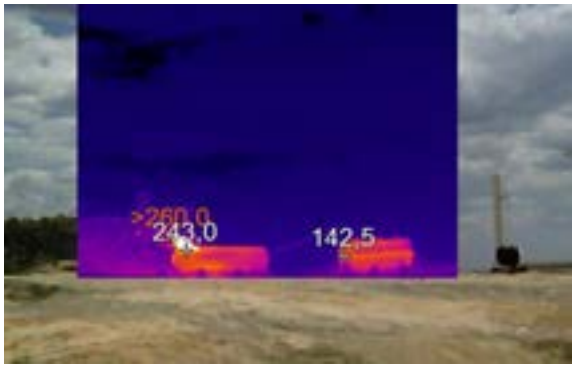

PHOTO Nº 68 TER
23/05/2019 14:46:02

Max Temp.	>260,0°C
A Fuel Tank Temp.	147,2°C
B Fuel Tank Temp.	224,9°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	142,5°C
B Fuel Tank Temp.	243,0°C

PHOTO Nº 69
23/05/2019 14:47:06

PHOTO Nº 70
23/05/2019 14:48:09

PHOTO Nº 69 MIXED
23/05/2019 14:47:06

PHOTO Nº 70 MIXED
23/05/2019 14:48:09

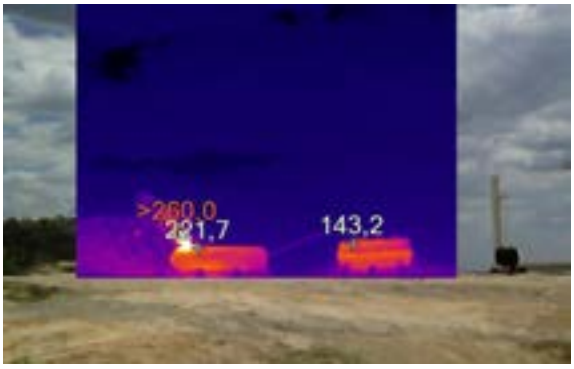

PHOTO Nº 69 TER
23/05/2019 14:47:06

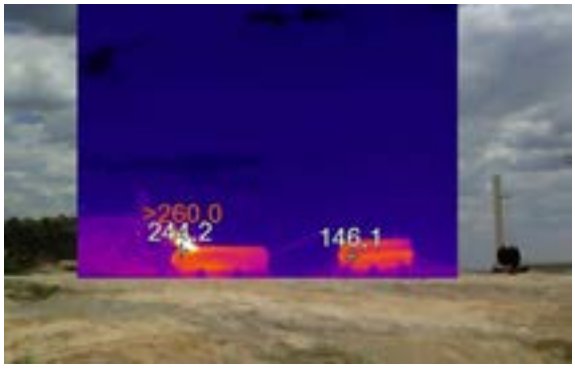

PHOTO Nº 70 TER
23/05/2019 14:48:09

Max Temp.	>260,0°C
A Fuel Tank Temp.	143,2°C
B Fuel Tank Temp.	221,7°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	146,1°C
B Fuel Tank Temp.	244,2°C

PHOTO Nº 71
23/05/2019 14:49:02

PHOTO Nº 72
23/05/2019 14:50:05

PHOTO Nº 71 MIXED
23/05/2019 14:49:02

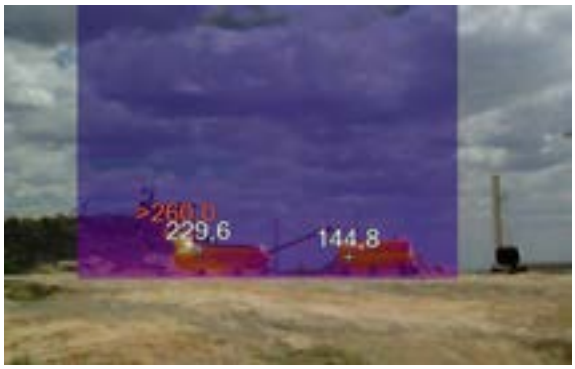

PHOTO Nº 72 MIXED
23/05/2019 14:50:05

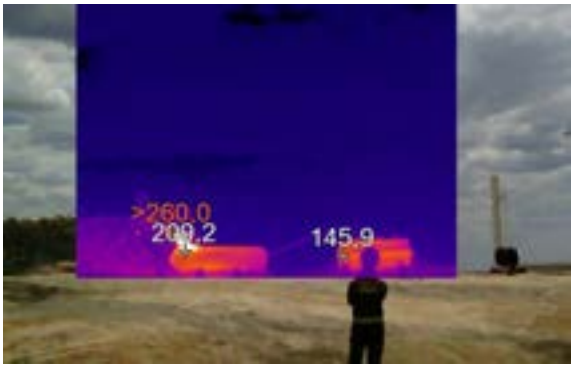

PHOTO Nº 71 TER
23/05/2019 14:49:02

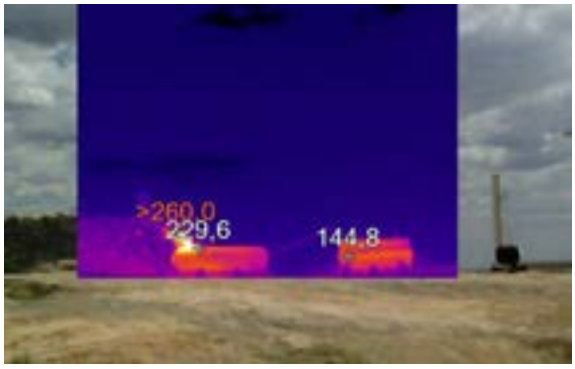

PHOTO Nº 72 TER
23/05/2019 14:50:05

Max Temp.	>260,0°C
A Fuel Tank Temp.	145,9°C
B Fuel Tank Temp.	209,2°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	144,8°C
B Fuel Tank Temp.	229,6°C

PHOTO Nº 73
23/05/2019 14:51:08

PHOTO Nº 74
23/05/2019 14:52:01

PHOTO Nº 73 MIXED
23/05/2019 14:51:08

PHOTO Nº 74 MIXED
23/05/2019 14:52:01

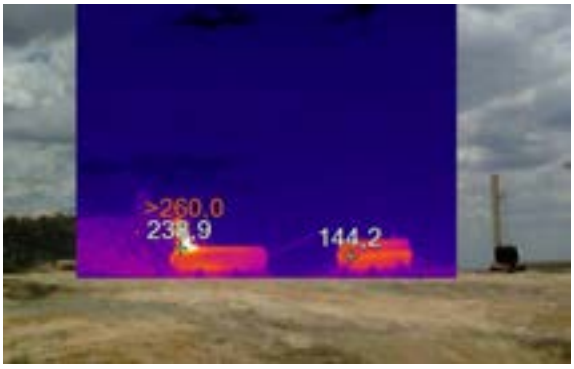

PHOTO Nº 73 TER
23/05/2019 14:51:08

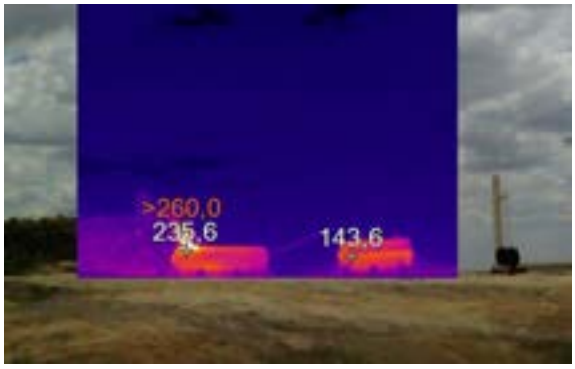

PHOTO Nº 74 TER
23/05/2019 14:52:01

Max Temp.	>260,0°C
A Fuel Tank Temp.	144,2°C
B Fuel Tank Temp.	238,9°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	143,6°C
B Fuel Tank Temp.	235,6°C

PHOTO Nº 75
23/05/2019 14:53:04

PHOTO Nº 76
23/05/2019 14:54:08

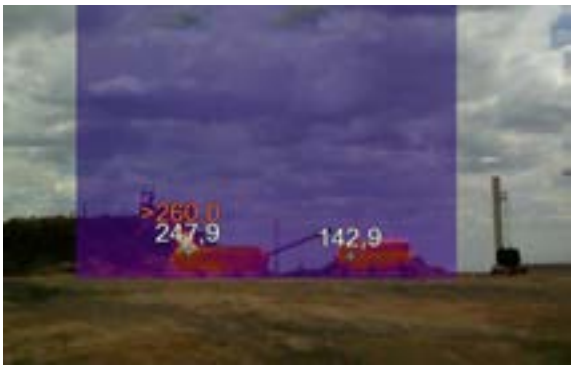

PHOTO Nº 75 MIXED
23/05/2019 14:53:04

PHOTO Nº 76 MIXED
23/05/2019 14:54:08

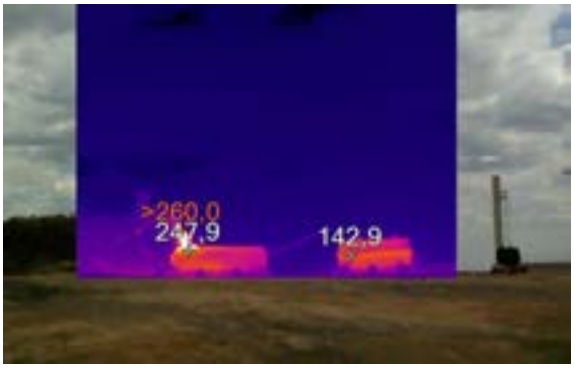

PHOTO Nº 75 TER
23/05/2019 14:53:04

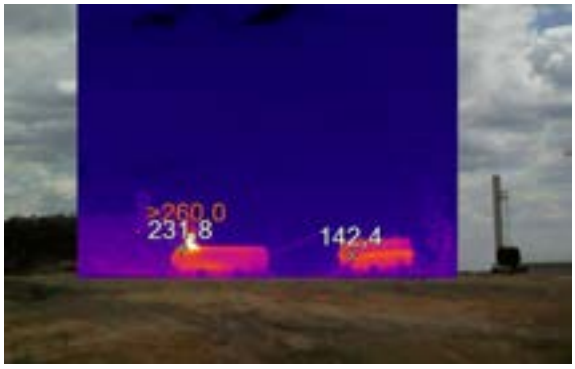

PHOTO Nº 76 TER
23/05/2019 14:54:08

Max Temp.	>260,0°C
A Fuel Tank Temp.	142,9°C
B Fuel Tank Temp.	247,9°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	142,4°C
B Fuel Tank Temp.	231,8°C

PHOTO Nº 77
23/05/2019 14:55:01

PHOTO Nº 78
23/05/2019 14:56:05

PHOTO Nº 77 MIXED
23/05/2019 14:55:01

PHOTO Nº 78 MIXED
23/05/2019 14:56:05

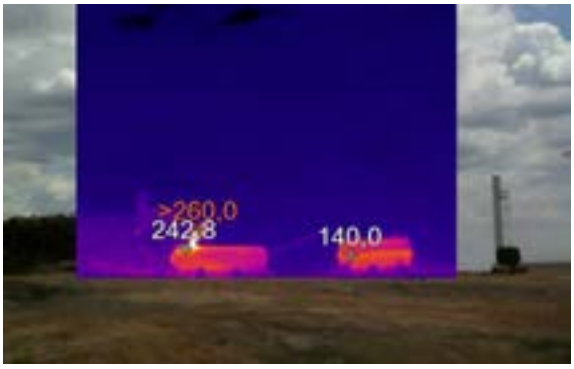

PHOTO Nº 77 TER
23/05/2019 14:55:01

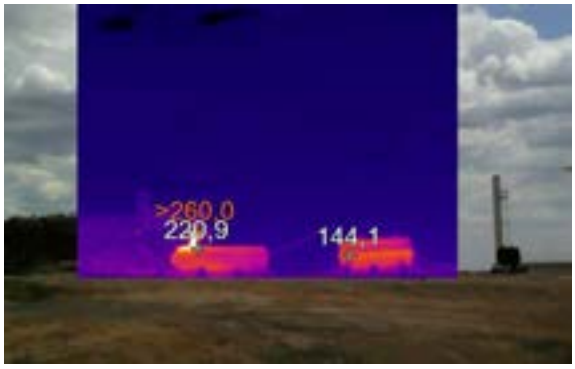

PHOTO Nº 78 TER
23/05/2019 14:56:05

Max Temp.	>260,0°C
A Fuel Tank Temp.	140,0°C
B Fuel Tank Temp.	242,8°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	144,1°C
B Fuel Tank Temp.	220,9°C

PHOTO Nº 79
23/05/2019 14:57:08

PHOTO Nº 80
23/05/2019 14:58:22

PHOTO Nº 79 MIXED
23/05/2019 14:57:08

PHOTO Nº 80 MIXED
23/05/2019 14:58:22

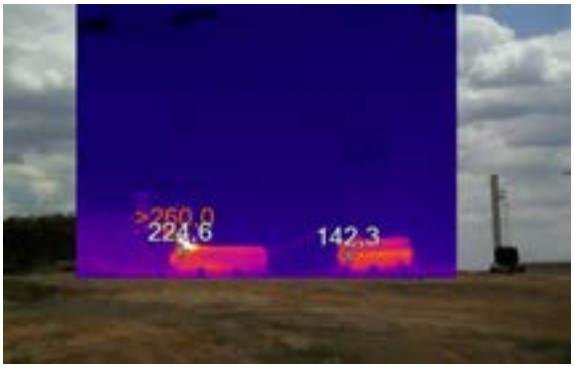

PHOTO Nº 79 TER
23/05/2019 14:57:08

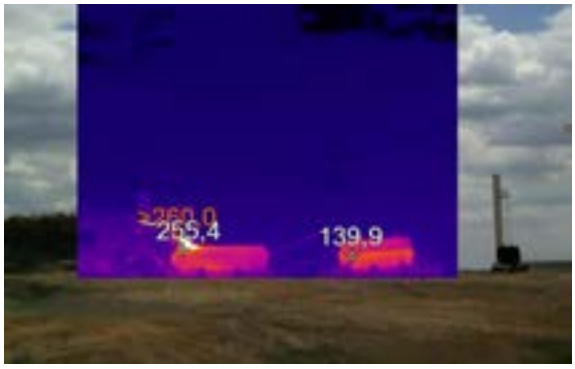

PHOTO Nº 80 TER
23/05/2019 14:58:22

Max Temp.	>260,0°C
A Fuel Tank Temp.	142,3°C
B Fuel Tank Temp.	224,6°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	139,9°C
B Fuel Tank Temp.	~255,4°C

PHOTO Nº 81
23/05/2019 14:59:04

PHOTO Nº 82
23/05/2019 15:00:08

PHOTO Nº 81 MIXED
23/05/2019 14:59:04

PHOTO Nº 82 MIXED
23/05/2019 15:00:08

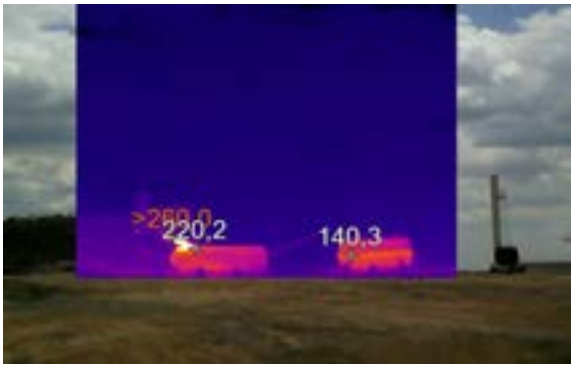

PHOTO Nº 81 TER
23/05/2019 14:59:04

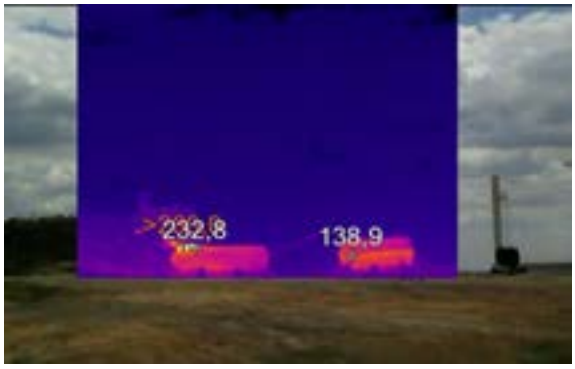

PHOTO Nº 82 TER
23/05/2019 14:59:04

Max Temp.	>260,0°C
A Fuel Tank Temp.	140,3°C
B Fuel Tank Temp.	220,2°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	138,9°C
B Fuel Tank Temp.	232,8°C

PHOTO Nº 83
23/05/2019 15:01:02

PHOTO Nº 84
23/05/2019 15:02:05

PHOTO Nº 83 MIXED
23/05/2019 15:01:02

PHOTO Nº 84 MIXED
23/05/2019 15:02:05

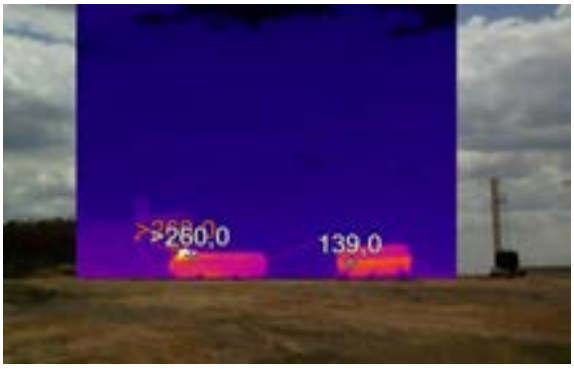

PHOTO Nº 83 TER
23/05/2019 15:01:02

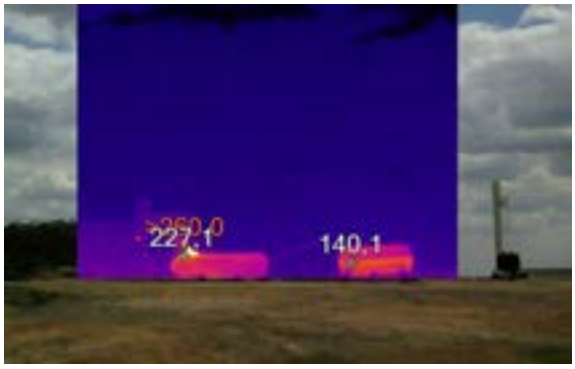

PHOTO Nº 84 TER
23/05/2019 15:02:05

Max Temp.	>260,0°C
A Fuel Tank Temp.	139,0°C
B Fuel Tank Temp.	>260,0°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	140,1°C
B Fuel Tank Temp.	227,1°C

PHOTO Nº 85
23/05/2019 15:03:09

PHOTO Nº 86
23/05/2019 15:04:02

PHOTO Nº 85 MIXED
23/05/2019 15:03:09

PHOTO Nº 86 MIXED
23/05/2019 15:04:02

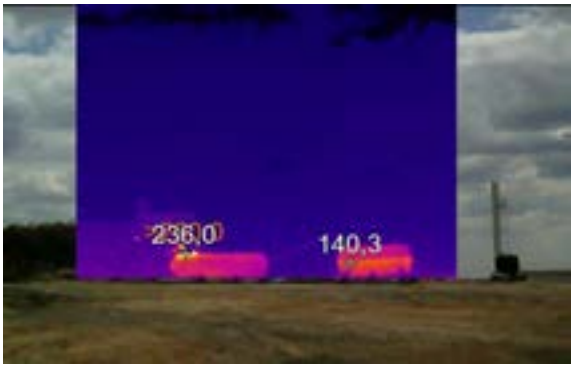

PHOTO Nº 85 TER
23/05/2019 15:03:09

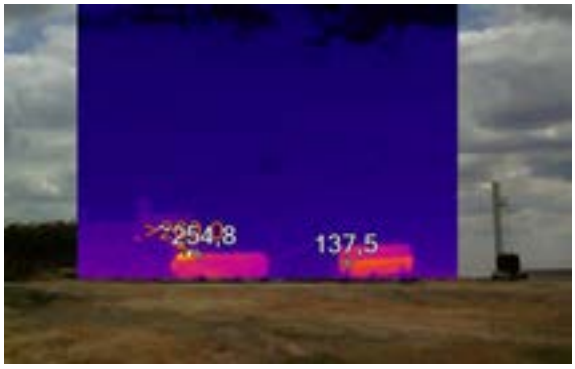

PHOTO Nº 86 TER
23/05/2019 15:04:02

Max Temp.	>260,0°C
A Fuel Tank Temp.	140,3°C
B Fuel Tank Temp.	236,0°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	137,5°C
B Fuel Tank Temp.	~254,8°C

PHOTO Nº 87
23/05/2019 15:05:06

PHOTO Nº 88
23/05/2019 15:06:17

PHOTO Nº 87 MIXED
23/05/2019 15:05:06

PHOTO Nº 88 MIXED
23/05/2019 15:06:17

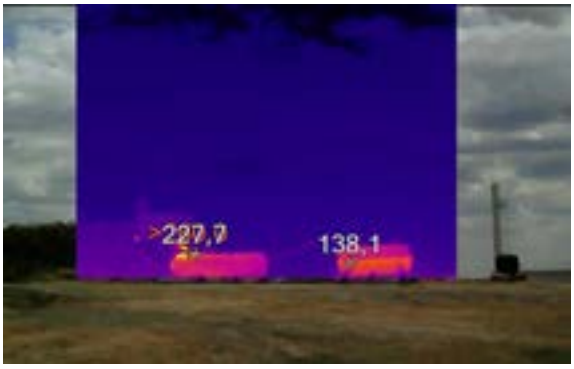

PHOTO Nº 87 TER
23/05/2019 15:05:06

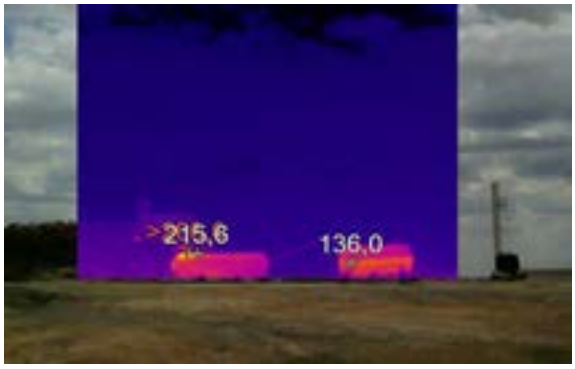

PHOTO Nº 88 TER
23/05/2019 15:06:17

Max Temp.	>260,0°C
A Fuel Tank Temp.	138,1°C
B Fuel Tank Temp.	227,7°C

Max Temp.	>260,0°C
A Fuel Tank Temp.	136,0°C
B Fuel Tank Temp.	215,6°C

PHOTO Nº 89
23/05/2019 15:07:27

PHOTO Nº 90
23/05/2019 15:08:38

PHOTO Nº 89 MIXED
23/05/2019 15:07:27

PHOTO Nº 90 MIXED
23/05/2019 15:08:38

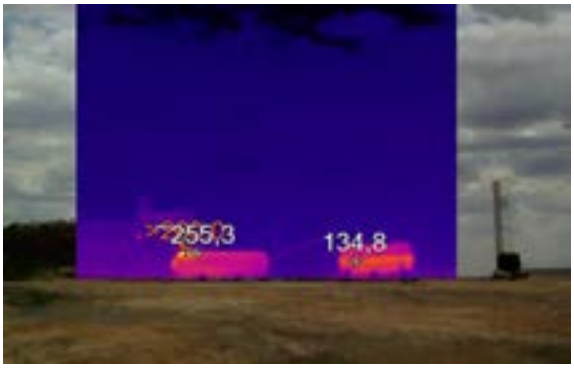

PHOTO Nº 89 TER
23/05/2019 15:07:27

Max Temp.	>260,0°C
A Fuel Tank Temp.	134,8°C
B Fuel Tank Temp.	~255,3°C

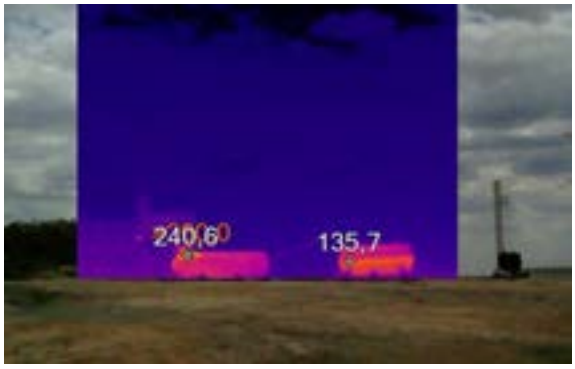

PHOTO Nº 90 TER
23/05/2019 15:08:38

Max Temp.	>260,0°C
A Fuel Tank Temp.	135,7°C
B Fuel Tank Temp.	240,6°C

Test

Conclusions
Tank A / Tank B / Tank C

Fuel Tank A

10,000 litres/5,000 litres DIESEL-TK3D MESH

1. TK3D Safety Alloys fully demonstrated that there was no explosion known as B.L.E.V.E (Boiling Liquid Expanding Vapour Explosion) during the 90 minutes test period applying the technology.
2. The TK3D Safety Alloy in MESH format eradicated the full risk of explosions due to its "Anti-B.L.E.V.E" technology in non pressurized fuel tanks with liquid fuels .
3. There were no after test structural damage in any part of the fuel tank structure.
4. There was no partial or total fuel tank metallurgical smelting.
5. There were no other types of explosions either on a secondary or lower level at any time during the test.
6. The temperatures of the fuel fire tray and fuel tank test surpassed 1050ºC.
7. The thermal radiation/flames only managed to damage externally the tank visually.
8. The TK3D Safety Alloy Mesh format after opening the fuel tank were slightly tarnished on the top non liquid fuel contact area due to the extreme internal fuel tank thermal radiation(+1050ºC) but still fully operational. The mid-section and inferior direct contact liquid fuel areas fuel were INTACT and in PERFECT operating condition.
9. The TK3D fuel tank after a technical revision could be returned to operation.

10. The fuel tank valves could be easily repaired, changed and re-activated.

11. The duration of the test was 90 minutes from the test ignition to the end with the total consumption of the 900 liters of fuel in the fuel tray fires.

12. The fire fuel tray extinguished itself autonomously without any external or third party assistance.

13. The TK3D Safety Alloy technology for eradicating explosions is unique in the world for non presurized fuel tanks. No other simliar or same anti-explosion technology exists.

Fuel Tank B

10,000 litres/5,000 litres LPG PROPANE-TK3D MESH

1. TK3D Safety Alloys fully demonstrated that there was no explosion known as B.L.E.V.E (Boiling Liquid Expanding Vapour Explosion) using the technology.
2. The TK3D Safety Alloy in MESH format eradicated the risk of explosions due to its "Anti-B.L.E.V.E" technology in pressurized fuel tanks as this test with conducted with PROPANE GAS.
3. There were no after test structural damage in any part of the fuel tank structure.
4. There was no partial or total fuel tank metallurgical smelting.
5. There were no explosions either on a secondary or lower level.
6. The test temperatures of the fuel fire tray and tank surpassed 1100ºC
7. The peak test temperatures peaked at 1500ºC-1800ºC during the test.
8. The thermal radiation/flames only managed to damage the tank visually.
9. The TK3D Alloy Mesh after opening the tanks were INTACT and in PERFECT operating condition.
10. The TK3D LPG gas tank after a technical revision could be returned operational.
11. The fuel tanks valves could be easily repaired, changed and activated.

12. There was extreme thermal radiation accumulation from tank "A" and "C" fuel fire trays due to the lateral wind increasing the thermal radiation load at temperatures above 1500ºC - 1800ºC and also due to the PSV remaining open during all of the test.

13. The duration of the test was 90 minutes from the ignition to the total fuel fire tray consumption of 1,100 liters.

14. The existing flames of the valve section were extinguished autonomously without any need external or third party assistance.

15. The TK3D Safety Alloy technology for eradicating explosions is unique in the world for pressurized fuel tanks. No other simliar or same anti-explosion technology exists.

Fuel Tank C

1,000 litres/500 litres LPG PROPANE-TK3D SPHERES

1. TK3D Safety Alloy demonstrated that there was no explosion known as B.L.E.V.E (Boiling Liquid Expanding Vapour Explosion) using the technology.
2. The TK3D Safety Alloys in SPHERES/BALLS format eradicated the risk of explosion due to its an "Anti-B.L.E.V.E" technology.
3. There were no after test structural damage in any part of the fuel tank structure.
4. There was no partial or total fuel tank metallurgical smelting.
5. There were no explosions either on a secondary or lower level.
6. The fuel tank and fuel fire tray test temperatures surpassed 1000ºC.
7. The thermal radiation/flames only managed to damage the tank visually.
8. The TK3D Safety Alloy in SPHERE/BALLS format after opening the tanks were in INTACT and in PERFECT operating condition.
9. The fuel tank after a technical revision would be operational.
10. The fuel tank valves could be easily repaired, changed and re-activated.
11. The duration of the test was 90 minutes from the start and up to a total of 150 liters of fuel was consumed from the "Fuel Fire Trays".

12. A small valve fire from the fuel tank through its lower discharge valve continued burning in a minor way for 3 three hours without any risk of an explosion and was extinguished with minimal external assistance. This small valve fire would of auto-extinguished itself once the fuel tank LPG Propane had been consumed through this same or through top valves.

13. The TK3D Safety Alloys technology for erradicating explosions is unique in the world. No other simliar or same anti-explosion technology exists or is on record.

Lateral Thermal Radiation Accumulation Test Conclusions

14 Fuel drums protected by TK3D.
7 Fuel drums protected by TK3D mesh and 25 liters of gasoline.
Fuel drums protected by TK3D spheres with 10 liters of gasonline.

1. It was demonstrated that was no type of B.L.E.V.E (Boiling Liquid Expanding Vapour Explosion) explosion in the 14 fuel drums.
2. The TK3D Alloy format in both Mesh and Spheres erradicated the risk of an explosion as it is an "ANTI-B.L.E.V.E" technology.
3. There were no explosions either in a secondary or menor category.
4. The temperatures of the test reached higher than 1,100ºC.
5. The TK3D Alloys in both Mesh and Spheres after opening the tank were in intact.
6. Consumption during the entire test in the fuel drums with 25 liters of gasoline was 13 liters. Therefore, there was a surplus of 12 liters per barrel.
7. Consumption during the entire test in the fuel drums with 10 liters of gasoline was 100%.
8. The duration of the test was 90 minutes from the start up until the total consumption of the 10 liters in the fire trays.
9. The flames were extinguished in an automonous form and without any assistance from third party´s.
10. The TK3D Safety Alloys are unique in the world at erradicating explosions.


TKSD ANTI-EXPLOSION
PETROL TANKS

BUREAU
VERITAS

ATTESTATION

The undersigned, representing Bureau Veritas Marine Division Madrid, Spain, declares hereby, having witnessed the tests described hereunder and carried out during the 22nd and 23rd of May 2019, in San Antonio de la Parrilla, Cuenca-Spain; confirming the results of a product identified in the market as TK3D® developed and patented by *TechnoKontrol*®, as an Anti-Explosion/Anti-B.L.E.V.E product acting statically on the thermodynamic principle of heat absorption and distribution along an ultralight metallic mesh fabricated with a film of 0.78 mm thick composed by an alloy of different metals claimed by the inventor as proprietary information.

The different tests carried out on the 22nd and 23rd of May, 2019, the setup of the test rig, the equipment, materials, fire-fighting support and suitability of the area to run the tests were previously approved by the local Authority Having Jurisdiction (AHJ) on the location of the test and the methods were previously agreed between *TechnoKontrol*® and Bureau Veritas.

Test conditions were duly identified and confirmed by Bureau Veritas Representatives on site. All equipment, materials and consumables were inspected as per the list submitted by *TechnoKontrol*® representatives on site, and found to be in line with the requirements from the Authority Having Jurisdiction, being suitable and in good conditions for the specific purpose.

All equipment and/or materials including consumables and PPE were duly identified and labeled and were found to the satisfaction of Bureau Veritas Representatives.

The testing methods were established and agreed in advanced based on *TechnoKontrol*® specifications and Bureau Veritas recommendations when deemed necessary reducing to a minimum the level of uncertainty of the test within practical limits and were found to be safe for the people and the environment and in compliance with the Bureau Veritas Guideline NI 525 *Risk Based Qualification of New Technology Methodological Guidelines*, and complementary guidelines issued by the Bureau Veritas *Offshore Division* in Paris, France, meeting the requirements in the NFPA Standards as applicable.

All technical documentation has been reviewed making emphasis on the type of pressure vessels used, in terms of design, manufacturing and conditions to which the pressure vessels were exposed, including the type of fluid, evaluating the behavior of the dual phase liquid vapor in the reservoirs when exposed to high pressure and temperatures.

ATTESTATION

The witnessing of the tests and their results were carried out bearing in mind the criterion and requirements found in the following NFPA Standards:

- NFPA 69
- NFPA 68
- NFPA 77
- NFPA 30
- Other standards of reference as applicable to the tests.

OBJECTIVE and SCOPE OF THE TEST

The capabilities of the product were evaluated using some criterion found in the mentioned standards among other documents and research carried out by Bureau Veritas Offshore in Paris, France as deemed necessary to analyze the methodology used by *TechnoKontrol® engineering* in developing this product.

The evaluation was prescriptive to the protection against excess heat input from the outside of the vessel which may result in a significant change in temperature and/or pressure within the tank or pressure vessel; excluding variants related to the process of fluids in the system, where the loss of control may lead to undesirable upsets and chain reactions within the system and that may affect the integrity of the tank or vessel. Therefore, the vessel having no inflow or outflow and excluding the deeds concerning gases' critical points.

Neither this attestation nor the acceptance of the product address the correlation between the use of the product and the pressure relieving rates of the protection devices in future applications.

The objective of the test was to simulate in the most realistic way possible, the degree of protection of the TK3D in preventing the explosion of an enclosed flammable and the consequences of what is classified as B.L.E.V.E. (Boiling Liquid Expanding Vapor Explosion).

TYPE AND SEQUENCE OF TESTS

Different tests were carried out in San Lorenzo de La Parrilla-Cuenca, including small scale and large scale tests (Please refer to supplementary document with details on sequence of events and photos).

ATTESTATION

Small Scale Test

On May 22nd, 2019 twelve fuel drums with a capacity of 50 liters each, were partially filled with different quantities of 95 octane gasoline applying a punctual heat source as follows:

a. One test using a high temperature flame in the order of 3.000 Celsius degrees such as an Oxy-Fuel Cutting Torch applied on the upper half of the tank or saturated vapor zone.

b. One test using a high temperature heat source in the order of 20.000 C degrees using an electric arc welding machine, and one test with a TIG welding machine.

c. Transfer of fuel from a jerry can to one of the said drums while the transfer is engulfed in flames simulating a fire produced during a fuel transferring process.

d. A cut on the top of one of the drums opening a triangle on the top of the drum of about 150 mm by 100 mm in its base using a hand grinding/cutting tool turning at 3,000 RPM furnished with a cutting disc of a material developing enough heat to ignite the fuel by friction.

Note:
In cases a); b) & c) the holes made by overheating the metal were plugged back using the same welding method. The test proved that no explosion developed in the drums after being exposed to a high temperature concentration creating active points capable to initiate a detonation.

All tests showed good results as predicted by *TechnoKontrol*® and none of the drums exploded.

Large Scale Tests

On May 23rd, 2019, several tests were carried out in the field close to San Lorenzo de La Parrilla being the area duly selected and agreed with Bureau Veritas Representatives and after obtaining the authorization of the AHJ and in the presence of the local Fire Department.

1. The first test consisted on a roofless tank of about two meters in diameter and one meter height filled up with gasoline to about 200 mm in depth and was set on fire.

- A round *safety cage* made out of a steel frame holding a packed *TechnoKontrol*® TK3D mesh was inserted inside the roofless tank by using a portable crane.
- After the introduction of the cage, the fire was extinguished.

The invention proved the capability of putting out the flames as soon as the cage was immersed in the tank.

2. The second test consisted of setting fire on tray filled up with gasoline engulfing a 69 liters capacity LPG cylindrical tank, the same type used today in automobiles, containing LPG Propane with *TechnoKontrol*® TK3D inside.
   - The pressure relief valve open after a few seconds and some plastic hose and fittings melted but no detonation took place.
   - After visual confirmation that the tank was depressurized, a fireman cut a rectangular opening on the wall of the tank using an engine driven circular metal cutting machine.
   - When the opening was about to be completed, it was observed that propane vapors were still coming out from the inside of the tank and the vapors getting ignited; nevertheless, the flame was too weak and was put out without any risk or special concerns.

3. The third and last test consisted on placing three tanks aligned one to another matching their longitudinal axis simulating a road trailer transport.

Preliminary Considerations

Bearing in mind the fact that it is not possible to forecast how much time a vessel may take when exposed to a fire before undergoing a detonation and B.L.E.V.E, and estimating the induction time from registered historic records from accidents where some vessels exploded within a few minutes of fire engulfment or from missile hits from other tanks in the vicinity, while others did not explode until after several hours later, and having no way to estimate more precisely what that period of time may be for the test in Cuenca; the induction time was estimated and agreed on being in the order of 7 to 20 minutes average in case of a detonation occur.

Preparation of the Test Rig

The large scale test was set-up using three reservoirs with the following characteristics:

1. One pressurized vessel of 1000 liters maximum capacity filled up to 50% of its volume with LPG (Propane).
2. One atmospheric tank of 10,000 liters capacity filled up to 50% with Diesel Oil suitably vented to the atmosphere through venting means and flame arrester supplied by the manufacturer.
3. One pressurized vessel of 10.000 liters maximum capacity filled up to 50% of its volume with LPG (Propane).

The test was also planned to concurrently represent a catastrophic accident akin to ground transportation of LPG by truck which may also apply to a terrorist attack; thence placing the three tanks “in line” simulating a truck tractor head unit.

Therefore, in addition to the pool fires set in the trays, several 50 liter drums closed and half-filled with gasoline were placed inside trays containing gasoline were placed nearby the tanks adding heat simulating the truck tires in flames.

The product TK3D was already introduced inside the three tanks mentioned here above in quantity and distribution conforming to the instructions and specifications of *TechnoKontrol*® occupying a volume in the order of 1% of the total volume of each tank, condition previously verified by Bureau Veritas during small scale tests carried out in 2017 at *TechnoKontrol*® Headquarters in Madrid.

Each fuel tank was set inside its own individual “Fuel Fire Tray” made out of steel, containing a blend of 95-octane Gasoline and Diesel oil blend of 80/20 respectively and the quantity pre-estimated for a duration of about one hour depending on the wind, and burning in delusion mode and after all parties (AHJ, Fire Department, *TechnoKontrol*® and Bureau Veritas representatives concurring and accepting the potential risks associated with such a test.

Bureau Veritas agreed on preparing the site in such a way that a reasonable distance was left between the Bureau Veritas Representatives and the test rig, enough to see the sequence of the event while being protected by suitable means at a distance of about 300 meters and being duly protected to avoid personal injuries.

Bureau Veritas Representatives witnessed the event from the said observation point arranged with walls made out of cubic sand bags of about 1m3 capacity filled out with sand and small rocks and the wall having a height of about 2.5 to 3 meters, capable to absorb any potential wave shock in case of detonation in addition to a metallic container providing protection against flying objects in case being dispersed in the air due to the rupture of an LPG vessel.

The heat sources were distributed providing the maximum thermal radiation possible and embracing each tank from underneath impinging directly on them in the form of delusion flames capable of reaching temperatures in the order of 1100 C degrees (see photos for details).

Tanks' Characteristics

Bureau Veritas verified that all tanks were new, made out of carbon steel design and fabricated following international recognized standards and supplied by a recognized manufacturer.

Bureau Veritas Offshore Division reviewed the specifications of each tank to make sure that in case the invention not performing as expected, at least one of the LPG tanks will explode, considering the maximum operational pressure and maximum bursting pressure at the temperatures predicted for the test; based on the Low Heating Value of the blend, its mass, and estimated duration of the heat released from the Fire Trays.

All of the above, having been already evaluated in reference to the LPG thermodynamic processes and fluid mechanics as expressed in the complementary report.

Whereas,

- The Diesel Oil tank was vented to the atmosphere and supplied with a flame arrestor.
- The LPG pressure vessels were furnished with Pressure Safety Valves of the self-closing/spring loaded type and pop-lifting action having a discharge flow capacity of 173 m3 /minute.
- The 10.000 liter capacity pressure vessel was furnished with two PSVs and the 1.000 liter capacity tank was furnished with only one PSV.
- No information was found on the Maximum Allowable Temperature of the PSVs.
- The PSVs were set at 20 barg and installed fin compliance with the requirements in the ASME Code Section VIII Division 1, and the API standard 520 sections 1 & 2.

- Bureau Veritas confirmed that the PSVs were designed and manufactured in compliance with recognized standards. *TechnoKontrol*® representatives also confirmed that these PSVs were part of the scope of supply of the tank manufacturer.
- Both LPG pressure vessels were furnished with pressure gauges and vents.
- The 1.000 liter capacity pressure vessel was furnished with a drain.

Additional Drums simulating Truck Tires adding heat to the system

No detonation took place on this drums, only a slight deformation was observed due to the fact that both, the filling cap and vent cap were closed. Bearing in mind that the maximum pressure that can be held by a top closed drum of this kind is in the order of 7 barg before bursting when cold, it can be concluded that the pressure inside was way below that pressure when considering the temperature to which these tanks were exposed for more than one hour. No leaks were found on any of them so no depressurization took place either.

CONCLUSIONS

The undersigned Bureau Veritas Representatives declare hereby that:

1. Based on the results of the tests, the invention proved with an acceptable level of confidence that is fit for purpose in marine applications and that can be extensive to industrial stationary and mobile applications other than maritime activities.

2. In accordance with the Bureau Veritas Rule NR 445 Part A Chapter 1 Section 1 article [2.3] the selected equivalent alternative standards such as the NFPA Standards, The ASME Code and API Standards; are appropriate for the certification of this invention as a Anti Explosion/Anti B.L.E.V.E technology for being the same standards used in the offshore industry for certifying process equipment handling hydrocarbon fluids and are considered by Marine Classification Societies as the primary source of reference for standardizing the Offshore Oil & Gas Industry.

3. Based on the aforesaid, Bureau Veritas Representatives confirm hereby that:

    - The capabilities of the TK3D have passed the test to be accepted as an Anti-Explosion/Anti-B.L.E.V.E as claimed by *TechnoKontrol®.*

ATTESTATION

- The results of the tests proof that the TK3d acts as a static and self-sustained heat exchange system within the enclosed fluid re-condensing the evaporated gas within the enclosure, extending the cooling effect of the evaporation and limiting the LPG vapor discharge through the PSV without raising the pressure inside the tank beyond the maximum rated mass flow of the PSV.
- The TK3D proved being suitable for protecting the tanks from the hazards eradicating detonations found in a variant of B.L.E.V.E case histories.

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