CORPO NAZIONALE DEI VIGILI DEL FUOCO
Istituto Superiore Antincendi
Dipartimento dei Vigili del Fuoco, del Soccorso Pubblico e della Difesa Civile

INVESTIGATING THE CAUSES OF FIRE
2ND INTERNATIONAL WORKSHOP

TUESDAY, MAY 7, 2013

Causes and dynamics of the multiple explosion occurred in the tank park of a plant that processed raw pomace oil to get edible olive oil

Loris MUNARO - Luca MARMO
Norberto PICCININI - Paola RUSSO – Gennaro RUSSO

The facts

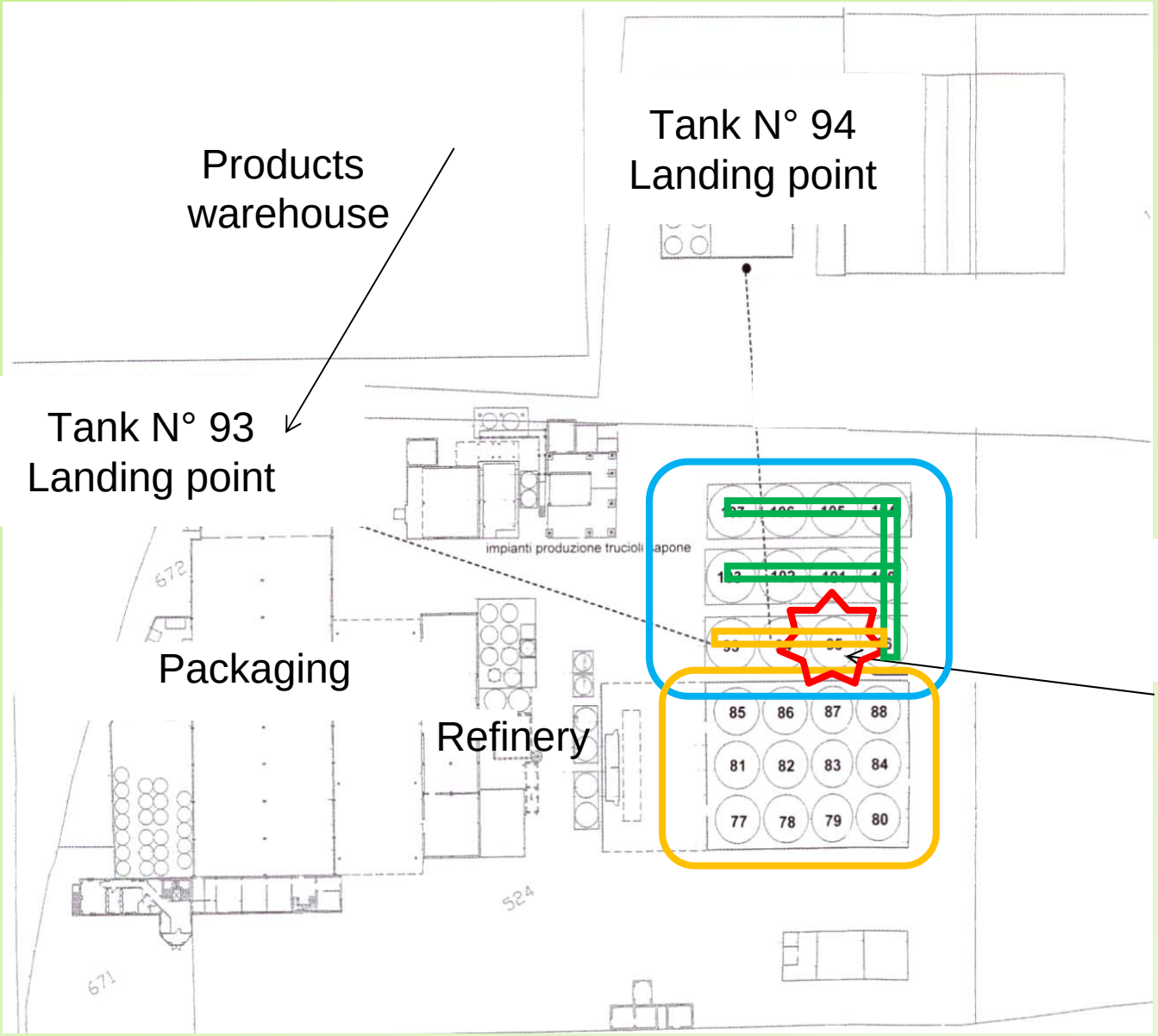
- Causes and dynamics of the multiple explosion occurred in the tank park of a plant that processed raw pomace oil to get edible olive oil.

- Methods of investigation adopted on-site and during the trial.

- The facility produced edible olive oil by refining raw oil of different quality (raw pomace and lamp oil, capacity ≈ 350 tons/day).

- The explosion occurred occurred when 5 workers were realizing footbridges on the roof of the reservoirs for their inspection.

The facts


Products warehouse
Tank N° 94 Landing point
Tank N° 93 Landing point
Packaging
Refinery
impianti produzione trucioli sapone
672
524
671
85 86 87 88
81 82 83 84
77 78 79 80

The facts

•On Nov. 25, 2006 five workers of a subcontractor firm were realizing a structure of footbridges on the roof of the tanks N° 93 to 107.

•Works started 4 days before, at the moment of the accident the footbridges were already installed on tanks from n° 100 to 107.

•At 12.56 tank n° 95 exploded.

•At that time four out of five workers were on the tank roof.

•The tank n°95 rose up of about 10 m and then fell down almost in the same position.

•A wide pool fire spread in the tank park.


12:55:52 11.25.2006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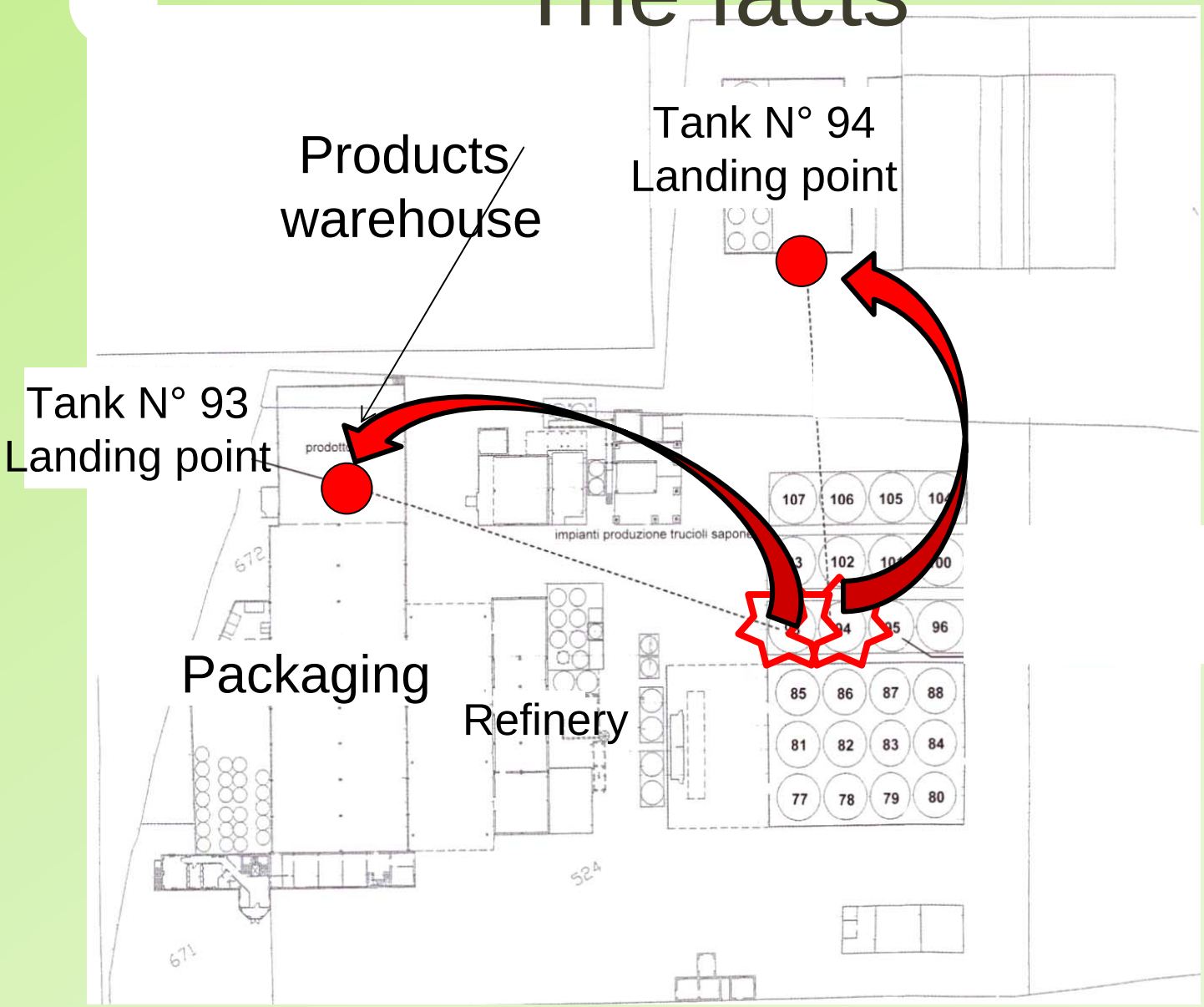
The facts


Products warehouse
Tank N° 94 Landing point
Tank N° 93 Landing point
Packaging
Refinery
107
106
105
102
96
85
86
87
88
81
82
83
84
77
78
79
80
672
524
671

The facts

The facts

The reservoirs content poured into the tank park, the pool fire further spread, also involving the indoor tank park causing the collapse of the tanks 77 to 88.

70 firemen, with 20 fire fighter trucks (including a special unit for aeroplane crash fire extinguishing) were used.
The fire was estinguished at 11.00 PM.

Preliminary investigations

Indoor tank park

Outdoor tank park

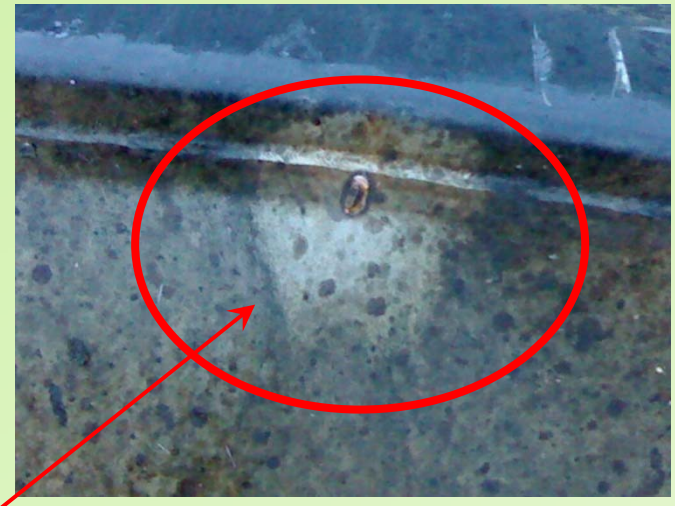
Preliminary investigations

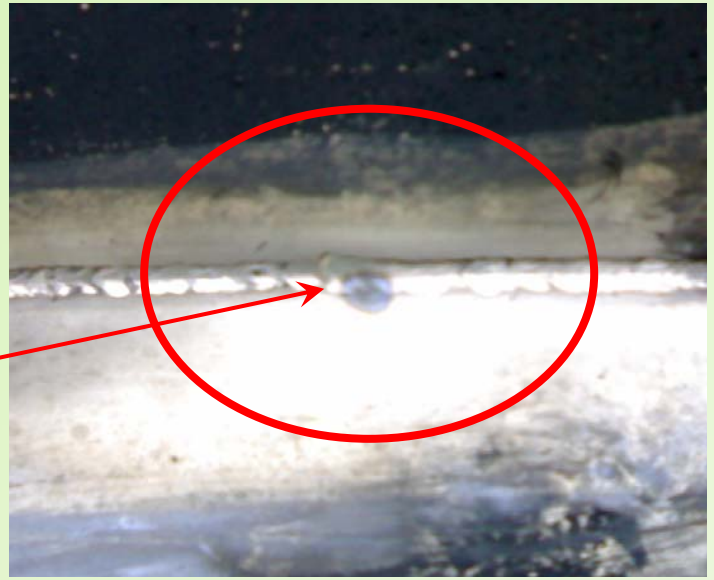
- State of the site
- Witnesses
- Conditions of tank # 93 and 94
- Conditions of tank # 95 (recovery by VVF – SAF)
- Tanks content
- Movies from security cameras
- Database generated by the tank park control system (inventories each 10 min.)
- Oil samples collected from the site and from subcontractors
- Docs about incoming and outcoming goods

Preliminary investigations

Tank # 94

Preliminary investigations





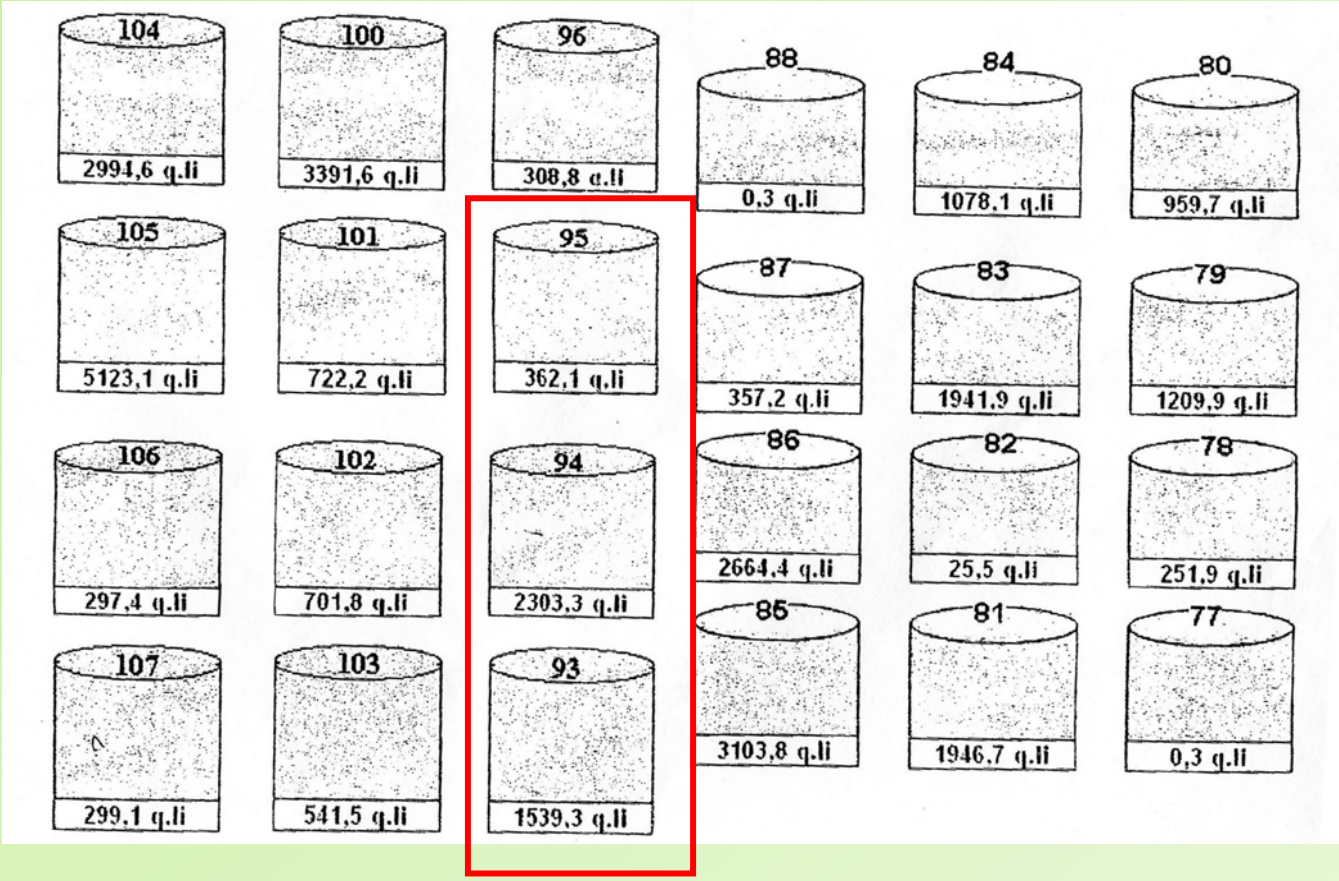
Tank # 95: Weld bead on top of the tank (outside).

Overheating (at least 750 °C) fingerprint inside the tank.

One worker found still holding the clamp of the welding machine

Preliminary invesigations

Oil content (figure from control system)



Oil quality: N° 93, 94, 95, 86 and 103: raw pomace oil, tanks N°96, 100, 87, 89: refined oil, tanks N°101-102 and 104-107: lamp oil

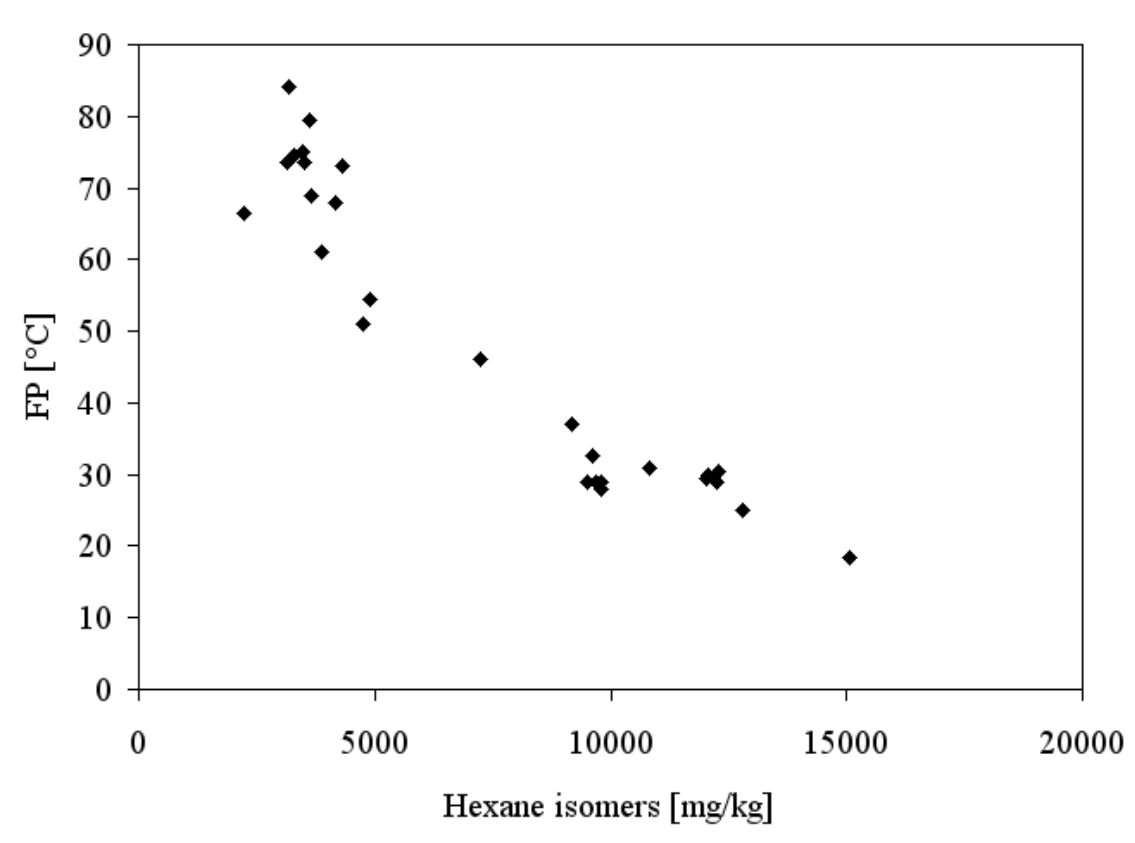
Preliminary invesigations

More than 100 samples from varoius sources except tanks (internal lab, subcontractors, ecc.)
Flash point (ISO 3679: 2004), residual hexane (UNI EN ISO 9832, GC-MS).
The lowest FP was 18,5 °C. More than 20% of the samples had FP⩽60 °C)

Good correlation between FP and hexane isomers content.

FP of oil contained in tank 95 was 29 °C

Average ambient temperature ≈ 10 ° C



Thesis after preliminary invesigations

Workers started to weld a bracket to the top of tank # 95.

Deflagration of the tank content.

Rupture of the welding at the bottom of the tank,

Tank # 95 rises almost ten meters,

A flash fire occurred, almost simultaneously the oil contained in the tank poured into the tank park provoking a pool fire.

One hour later a deflagration inside tank # 94 occurred. The tank flew 60 meters away.

Shortly after, a deflagration inside tank # 93 occurred. The tank flew 80 meters away.

Thesis by the defense, phase 1

Tank N° 95 contained raw pomace oil with FP much higher than 29° C (76? >>> 110 ° C??).

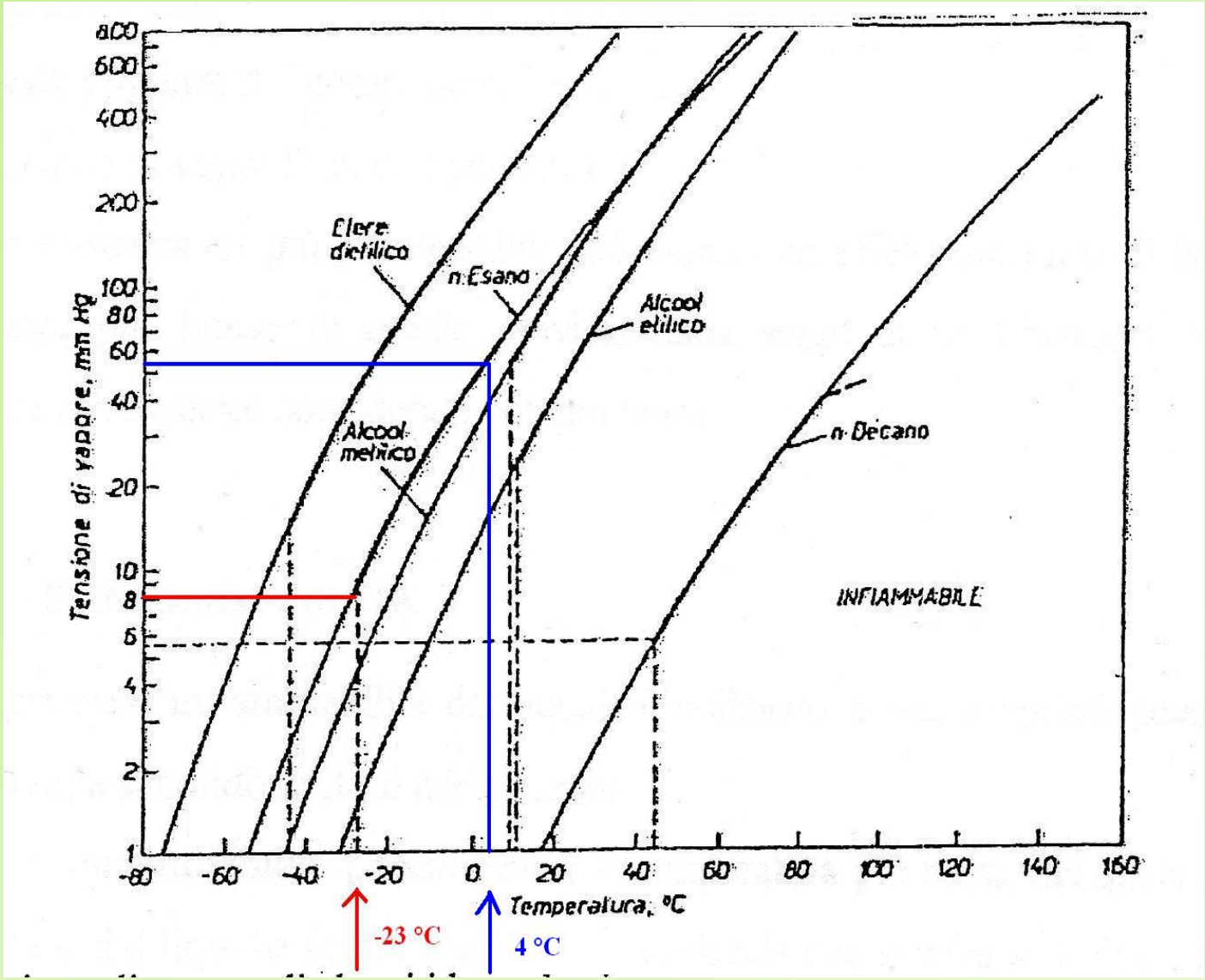
The samples collected and analyzed were not representative of the actual tanks content.

A fire or explosion in the headspace of a tank can occur only if the entire liquid inventory temperature rises above the FP and if the flammable concentration in the headspace lies between LEL and UEL.

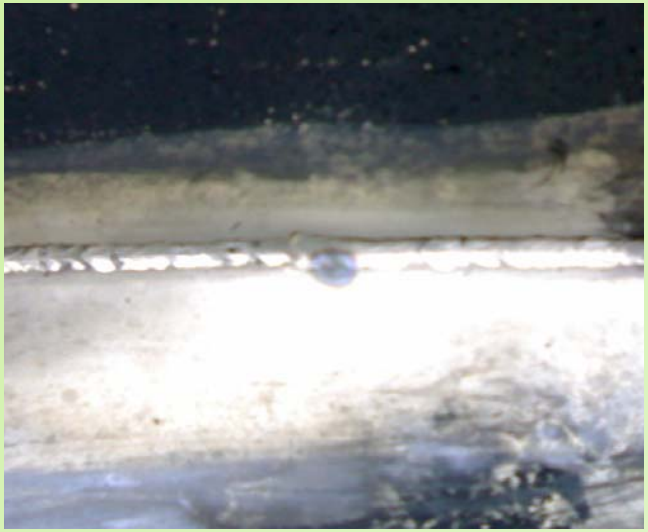
Hexane flammability limits are such that liquid hexane is flammable if its temperature ranges between -23 and 4 ° C

The overheating fingerprint found on the roof of tank N° 95 do not indicate an effective ignition source.

Thesis by the defense, phase 1



Thesis by the defense, phase 1



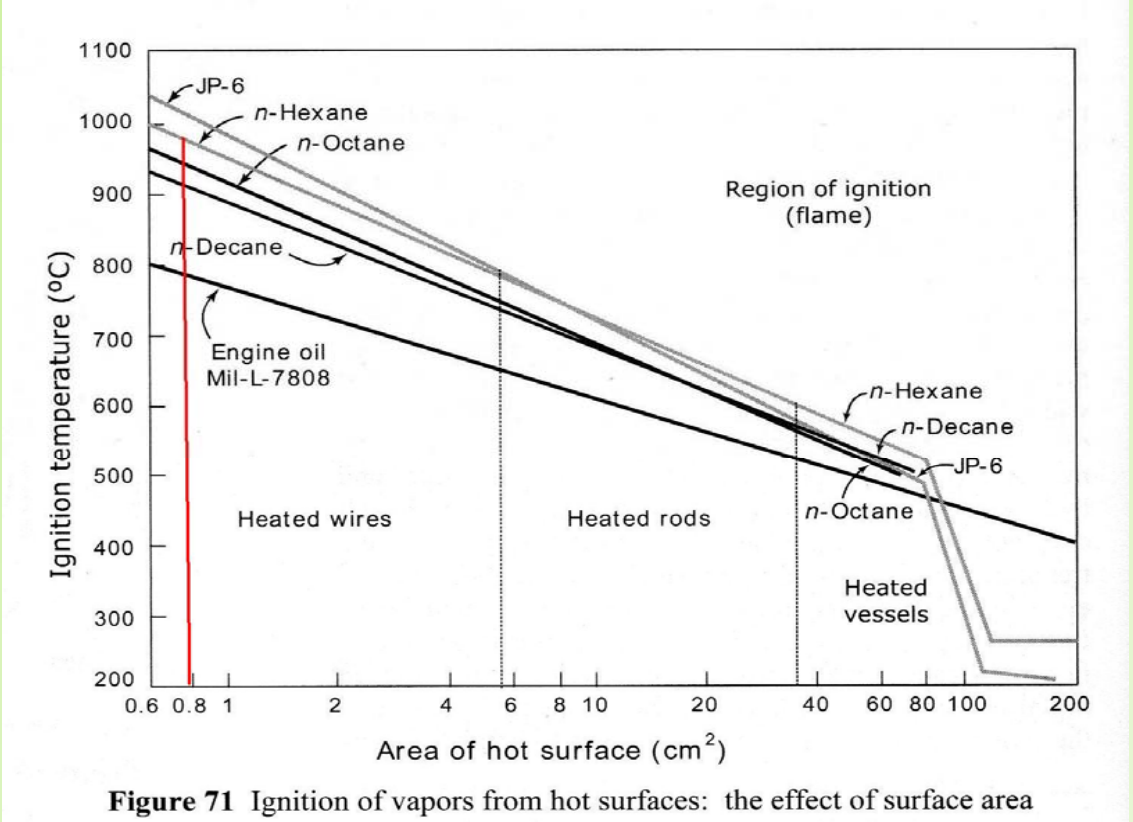


Figure 71 Ignition of vapors from hot surfaces: the effect of surface area

J.M. Kuchta, R.J. Cato, Technical Report AFAPL-TR-67-126 (1968)

Thesis by the defense, phase 1

No explosion occurred in tank N° 95

Thesis by the defense, phase 1

Tank # 94:

Explosion inside: Roof clearly deformed, Manhole opened

Thesis by the defense, phase 1

Tank # 95

No deformation of the tank roof

Thesis by the defense, phase 1

Tank N° 93

Roof clearly deformed

Thesis by the defense, phase 1

Tank # 95

No deformation of the tank roof

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The fishing rod theory


C1
12:54:16
11.25.2006
11,5m
14m


C1
12:58:34
11.25.2006
11,5m
14m


C1
12:58:34
11.25.2006
11,5m
14m


C1
12:58:34
11.25.2006
11.5m
14m


C1
12:58:34
11.25.2006
11,5m
14m


C1
12:58:34
11.25.2006
11,5m
14m


C1
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11.25.2006
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C1
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C1
12:58:34
11.25.2006
11.5m
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C1
12:58:34
11.25.2006
115m
14


C1
12:58:34
11.25.2006
11.5m
14m


C1
12:58:34
11.25.2006
11.5m
14m


C1
12:58:34
11.25.2006


C1
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C1
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11.25.2006


C1
12:58:35
11.25.2006


C1
12:58:35
11.25.2006

Thesis by the defense, phase 1

No explosion occurred in tank # 95

“before the tank lifts no welding activity is visible;
one can see the four chains to which is attached the catwalk
when the tank tilts no blaze or smoke is visible above, where the tank is opened;
the first blaze is at the bottom;
the crane operator at ground level can not see neither the hook nor what the work mates they are doing and, without radio communications, the operation is blind”

Thesis by the defense, phase 1

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Thesis by the defense, phase 1

No explosion occurred in tank # 95

“By the vision of the movie it is clear as the arm of the crane first operates a traction (the rope is moving ever closer to the arm), then suddenly the rope is loosened.
Notice even the curls (frame 12) due to the sudden loosening when the tank is uprooted from the base and rises to one side.
The oil spills through the gash, the tear causes sparks which ignite the oil on the ground

Thesis by the defense, phase 1

Genesis of the fire and explosion

1.The walkways are partly assembled at ground, connecting three pieces (≈10 m).

2. Once assembled, the walkway must be lifted above the tanks: it is bound using four chains which are connected to the crane hook.

3. Once the bridge is placed on the tanks it should be manually released from the crane

.

4. As there is no coordination between the workers and the crane operator, (radio were lacking), the walkway is tensioned by the crane before its release, as evident from the movie.

Thesis by the defense, phase 1

Genesis of the fire and explosion

“

5. The traction tensioned the tank which is joined to the walkway asymmetrically. Then the tank lifts to one side.

6.The bottom welding bead is thin (max 3 mm)

7. The traction operated by the crane broke the bottom welding bead.
Steel plates fracture is considered, in the literature (Tutorials by the Fire Brigade; Affens WA, EA Lange: Ignition of flammable gases in crude oil tankers as a result of metal fracture. Naval Engineers Journal, February 1979 p .76), an ignition cause of combustible substances such as the oil which spilled after the fracture
After ignition of the spill (see the frame next to the one where the tank is tilted, there was a blaze that affected the entire free surface of olive-pomace resulting in massive ignition of the content”