COMBEX

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Fires and explosions in the fuel tanks

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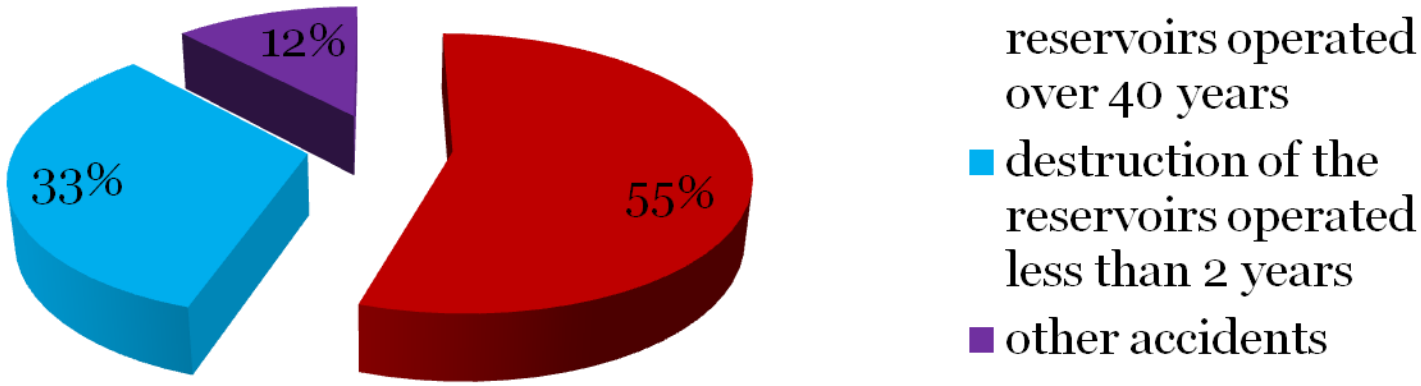
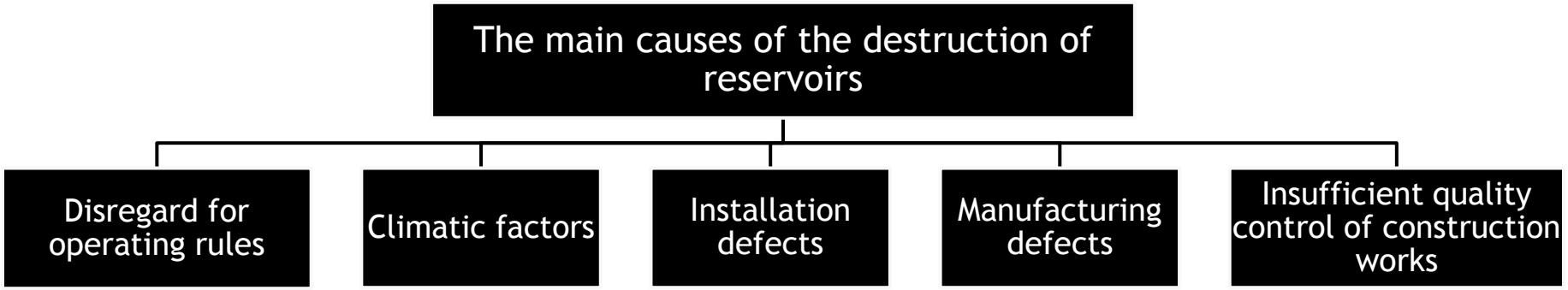
Russian reservoir park

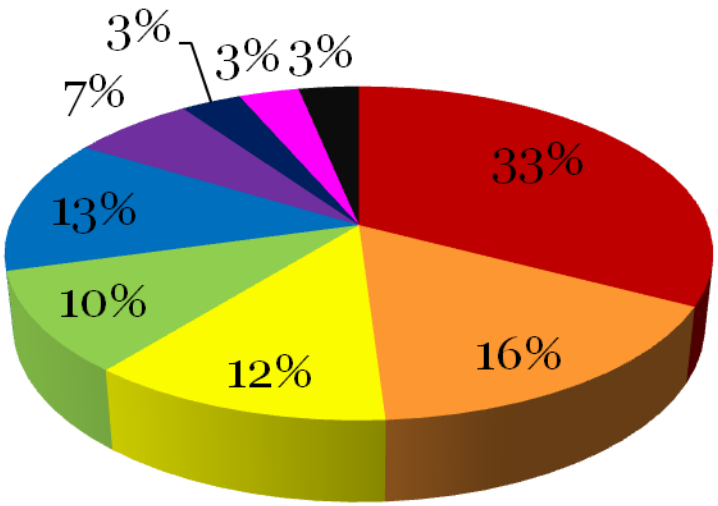
- reservoir park includes over 20000 large reservoirs with total capacity about 22.5 million m^3
- reservoir maximum capacity is 100000 m^3

Destruction of the reservoirs depending on service life



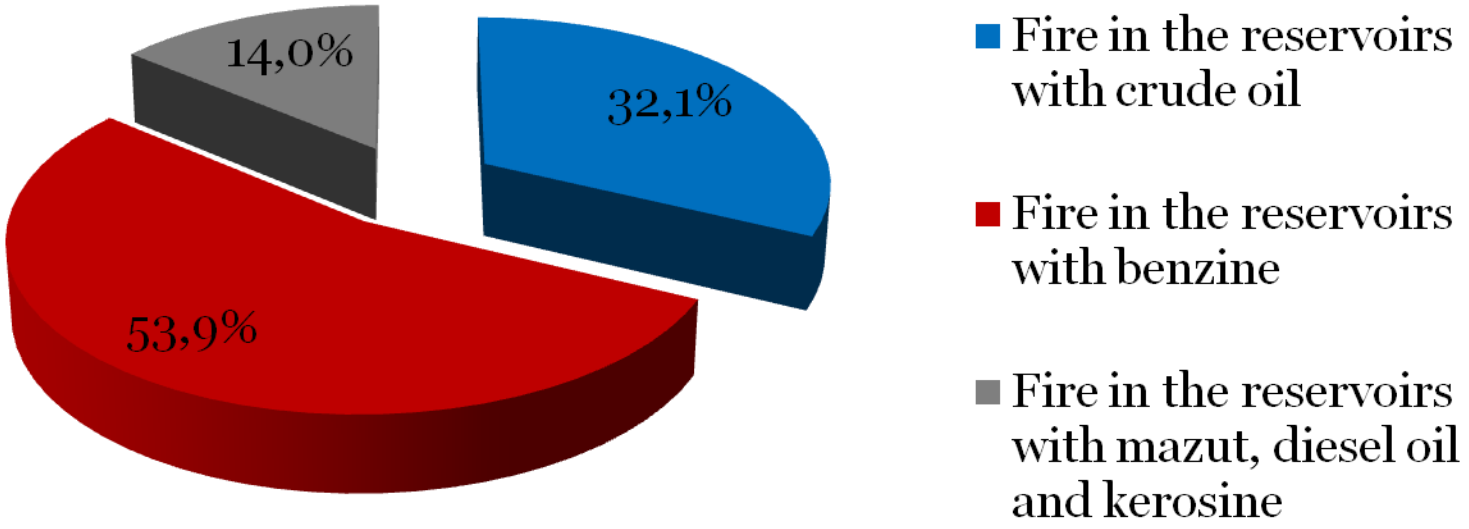


Explosion and fire ignition sources

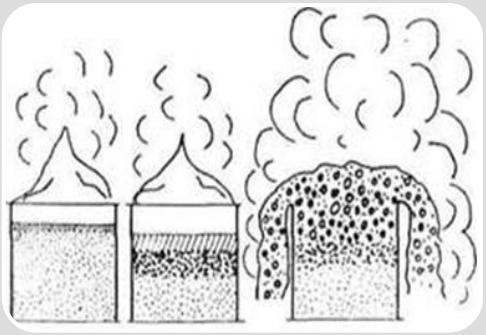


- Works with fire
- Mechanical sparkles
- Fire tecnological system
- Lightning stroke
- Electrical sparkles
- External source of fire
- Discharge of static electricity
- Careless of fire usage
- Reason isn't detected

Fire in the land storage tanks

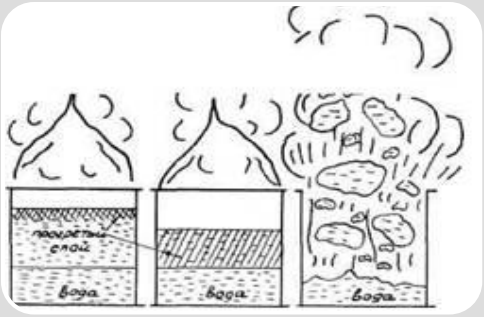


BLOWOUT



Boiling

• take place if moisture content in the petroleum product is over 0,3%



Release

•take place if homothermal layer reaches bottom water

Approximate time of the potential blowout

$$T = \frac{H - h}{W + i + V}$$

- T – time from the beginning of the fire to the potential moment of the release's assault, h
- H – initial altitude of the flammable liquid layer in the reservoir, m
- h – altitude of the bottom water layer, m
- W – peripheral heating speed of the flammable liquid, m/h
- i - peripheral burn out speed of the flammable liquid, m/h
- V - peripheral speed of the level's decreasing due to pumpdown, m/h

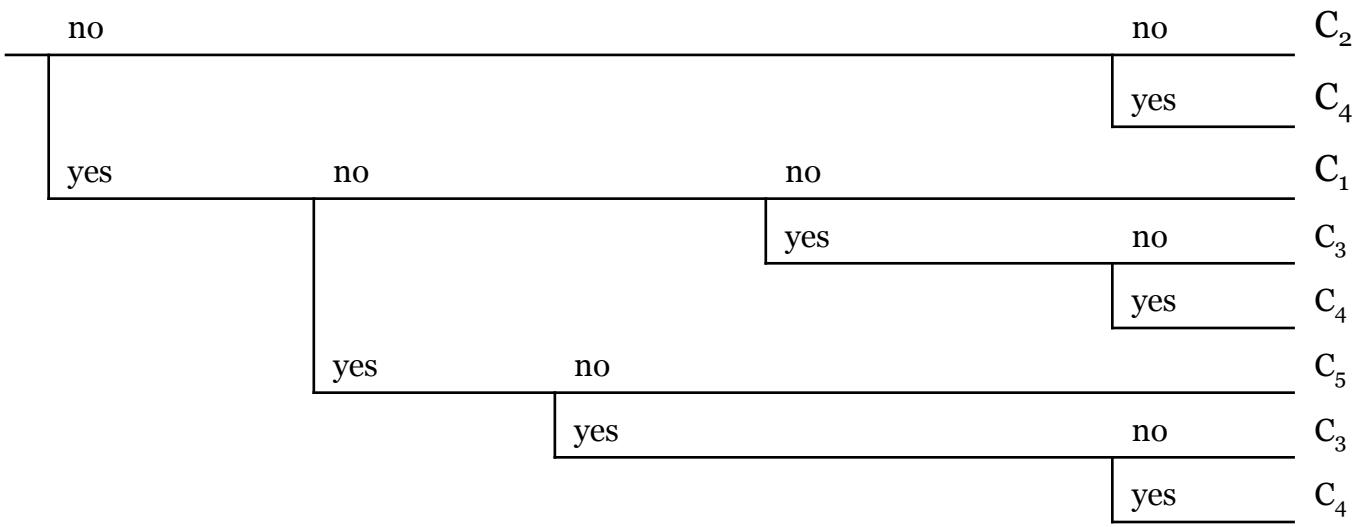
Types of the accidents

Symbol	Type of the accident
C_1	Fire in the reservoir
C_2	Fire in the breathing valve
C_3	Fire in the object's adjacent territory
C_4	Fire in the nearby buildings and constructions
C_5	Fire in the diking

«Event tree» for fire in the breathing valve

Taking measures for fire-fighting operations insufficient; Explosions of the fire-air mixture inside of the reservoir	Construction of the reservoir didn't withstand the thermal load; reservoir was destroyed	Diking didn't withstand hydrodynamic wave of the blow out	Insufficient measures for reservoir cooling; warming up of the petroleum product to the bottom layer of water; boiling and release of the petroleum product	Further accident escalation

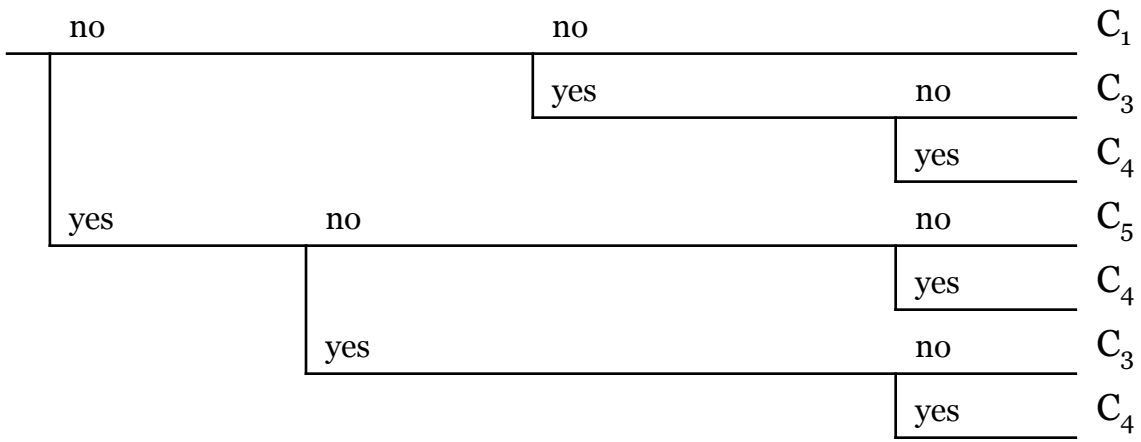
Fire in the breathing valve



«Event tree» for explosion of the fuel-air mixture inside of the reservoir

Construction of the reservoir didn't withstand the load; reservoir was destroyed	Diking didn't withstand hydrodynamic wave of the blow out	Insufficient measures for reservoir cooling; warming up of the petroleum product to the bottom layer of water; boiling and release of the petroleum product	Further accident escalation

Explosion of the fuel-air mixture inside of the reservoir

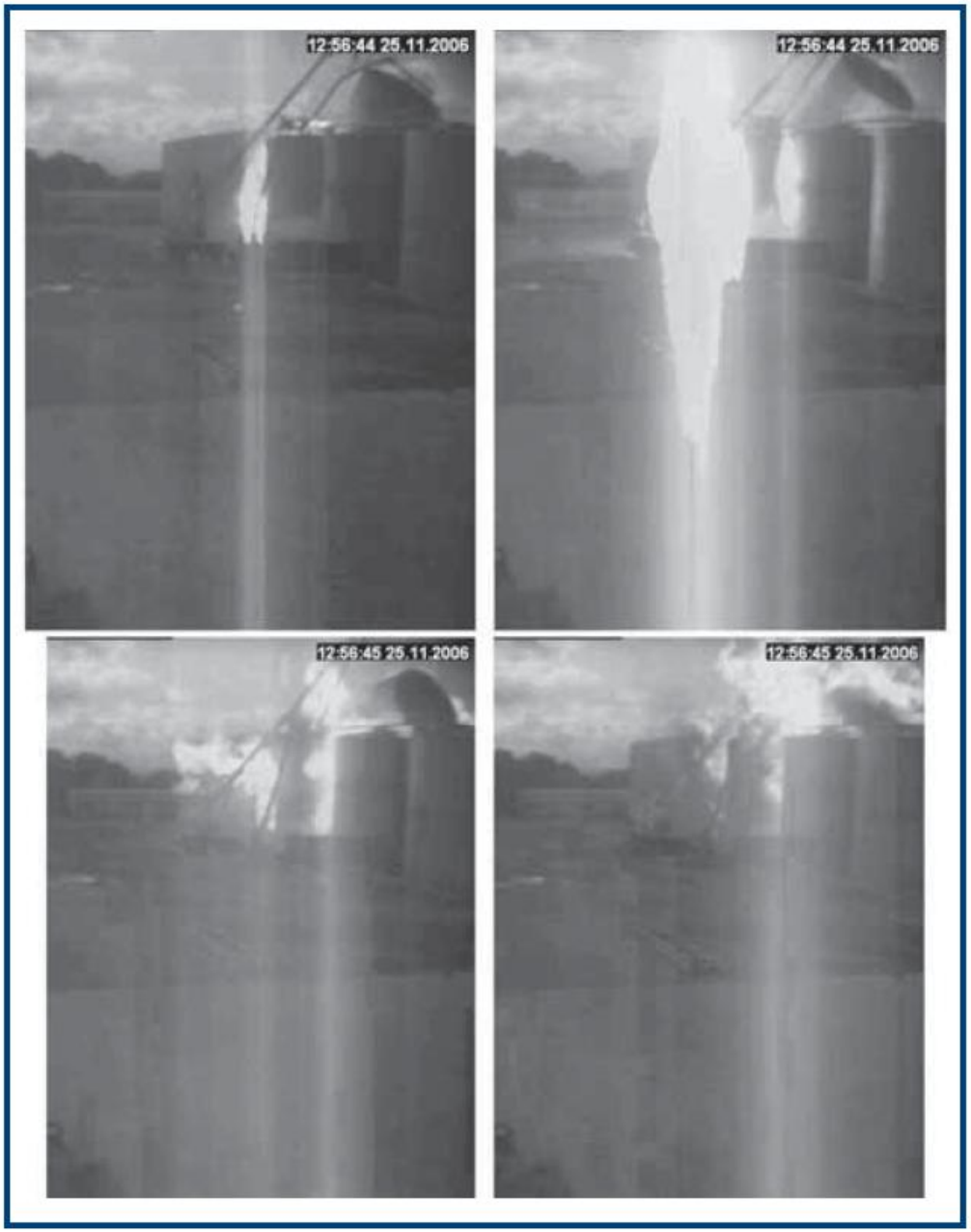


Types of the explosions

- Lid's blowing up followed by burning
- Destruction corner weld joint and reservoir's flight
- Complete collapse of the reservoir
- Explosion of the empty reservoir

Lid’s blowing up

- The most frequently explosion of the reservoir leads to lid’s blowing up followed by burning of the entire surface of flammable liquid



Destruction of the corner weld joint and reservoir's flight

Abstract Book. 8-th International Symposium on Hazards,
Prevention and Mitigation of Industrial Explosions.
Multiple tank explosion of pomace oil reservoirs.
L.Marmo, N.Piccinini, G.Russo, P.Russo, L.Munaro
September, 2010. Yokohama, Japan

This part of report presents the analysis of the causes and lessons learned from the August 22nd 2009 accident occurred on production and control station "KONDA" near Yugra, Khanty-Mansiysky region, Russia/

- **As a result** of explosion four firefighters were killed and four firefighters were injured
- **As a result** of a fire three tanks were completely destroyed and three tanks were partially damaged. There were damage also the equipment of two tanks.

Reservoir park «KONDA»

General information about reservoir park

№	The name of parameter	Quantity
1	The total area of reservoir park, m^2	89600
2	Quantity of reservoir	8
3	The reservoir square surface, m^2	1632
4	The reservoir square of the diking, m^2	6642
5	The reservoir height, m	12,8

All tanks are equipped with:

1. installation of automatic foam fire-fighting systems
2. stationary (nonautomatic) settings underlauer fire extinguishing
3. stationary (nonautomatic) systems of cooling of the surface of the walls of the tanks in the form of rings of irrigation

1. automatic fire alarm systems
2. gas equalization system (except the tank №4) with defined on it fire arresters
3. respiratory valves, installed on them fire arresters
4. lightning protection

The work condition of a reservoir park (16.00 msk)

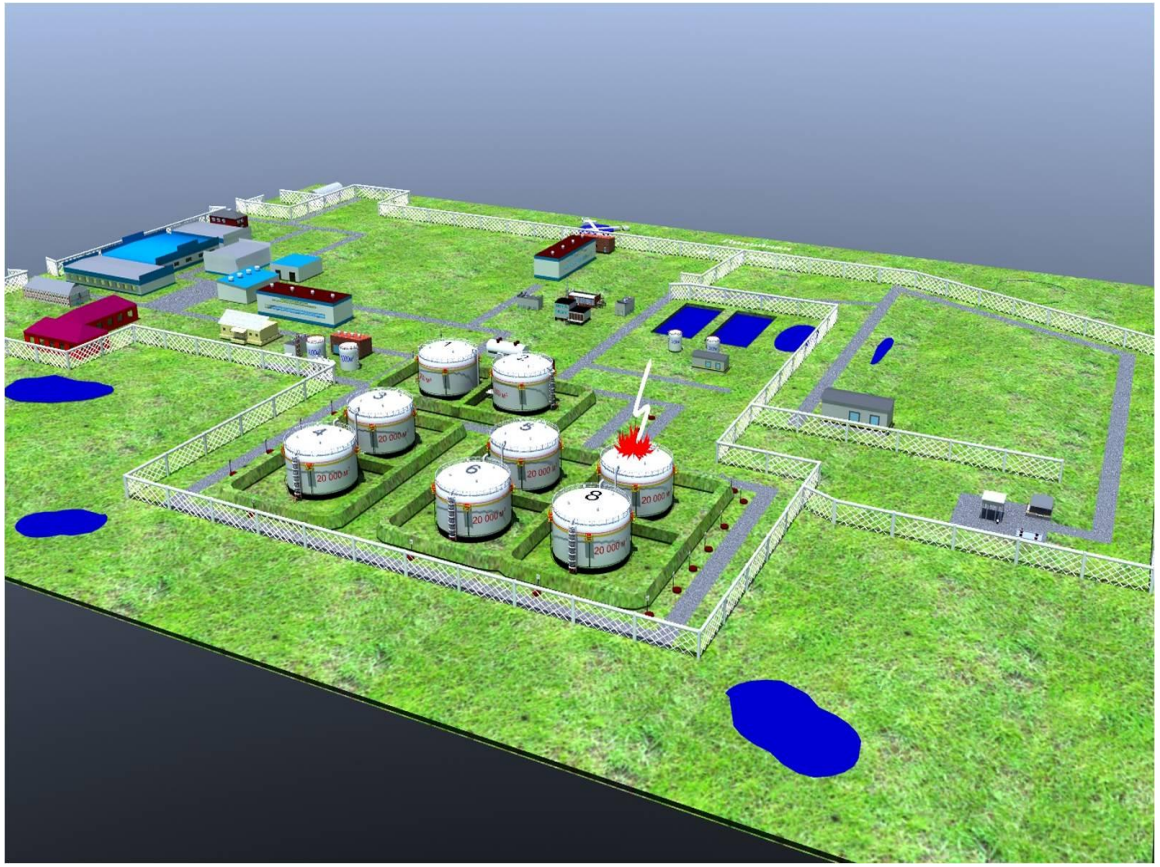
The reservoir number	Oil level, mm	Dimension, m^3	Density, kg/m^3	Mass, t	The reservoir free volume
1	4838,0	7897,4	860,5	6795,7	11605,4
2	2771,0	4520,2	848,0	3833,2	13208,8
3	0,0	0,0	0,0	0,0	17909,3
4	8564,0	13984,8	856,0	11971,0	5469,5
5	8506,0	13900,9	856,7	11908,9	3755,1
6	0,0	0,0	0,0	0,0	17909,3
7	3517,0	5740,1	849,9	4878,5	13692,3
8	4185,0	6838,9	849,8	5811,7	12627,2

Weather condition

Time (Moscow time)	Temperature, °C	Wind direction, speed, m/s	Air pressure, Mb
16.00	+20,4 C	north, 2-6	1004,9
19.00	+17,2	the calm	1005,1
22.00	+17,2	north-west, 3-6	1004,1

On 22th of August in 2009 at 17.06

- during thunderstorm the lightning resulted in explosion in tank №7
- Valves № 1, 2 at the tank №7 were closed automatically



17:10

- Sound and light alarm system of the tank №7 and foam system were activated. Tank of crude oil was burning by free flame all over the whole area

17.24

- The valves of irrigation system of tanks №5, 8 were opened

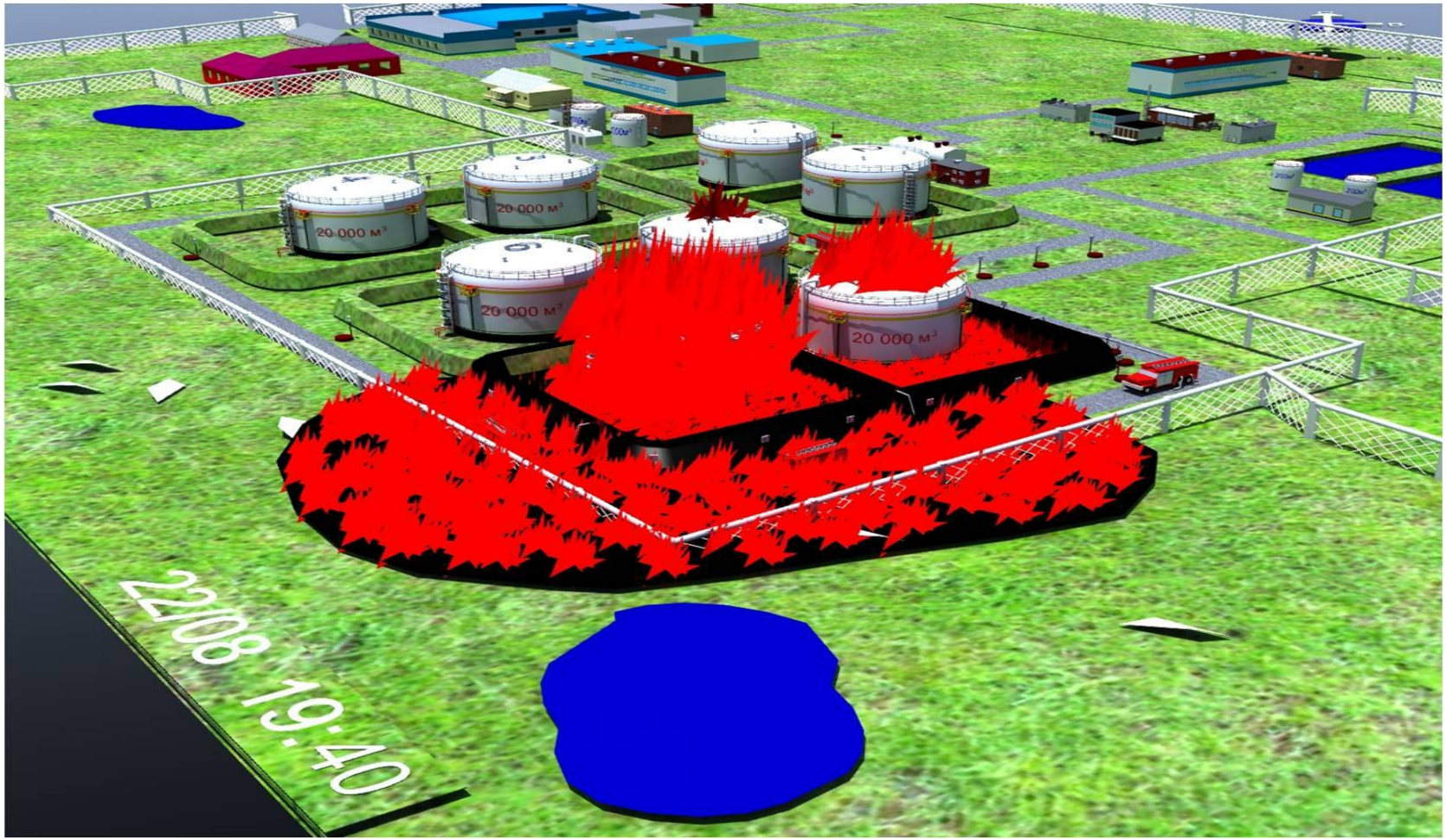
17.34

- Fire alarm of the tank №8 is activated

17.35

- The explosion in tank №8 occurred, as a result the tank was fully destroyed. The metal parts of the tank scattered on the Park territory and outside it at a distance up to 300 meters

The situation on 22.08 time 19.40



02.25

- Tanks №5, 7 are burning, oil spills in the diking of tanks № 6,7,8. In tank №4 fire was not observed

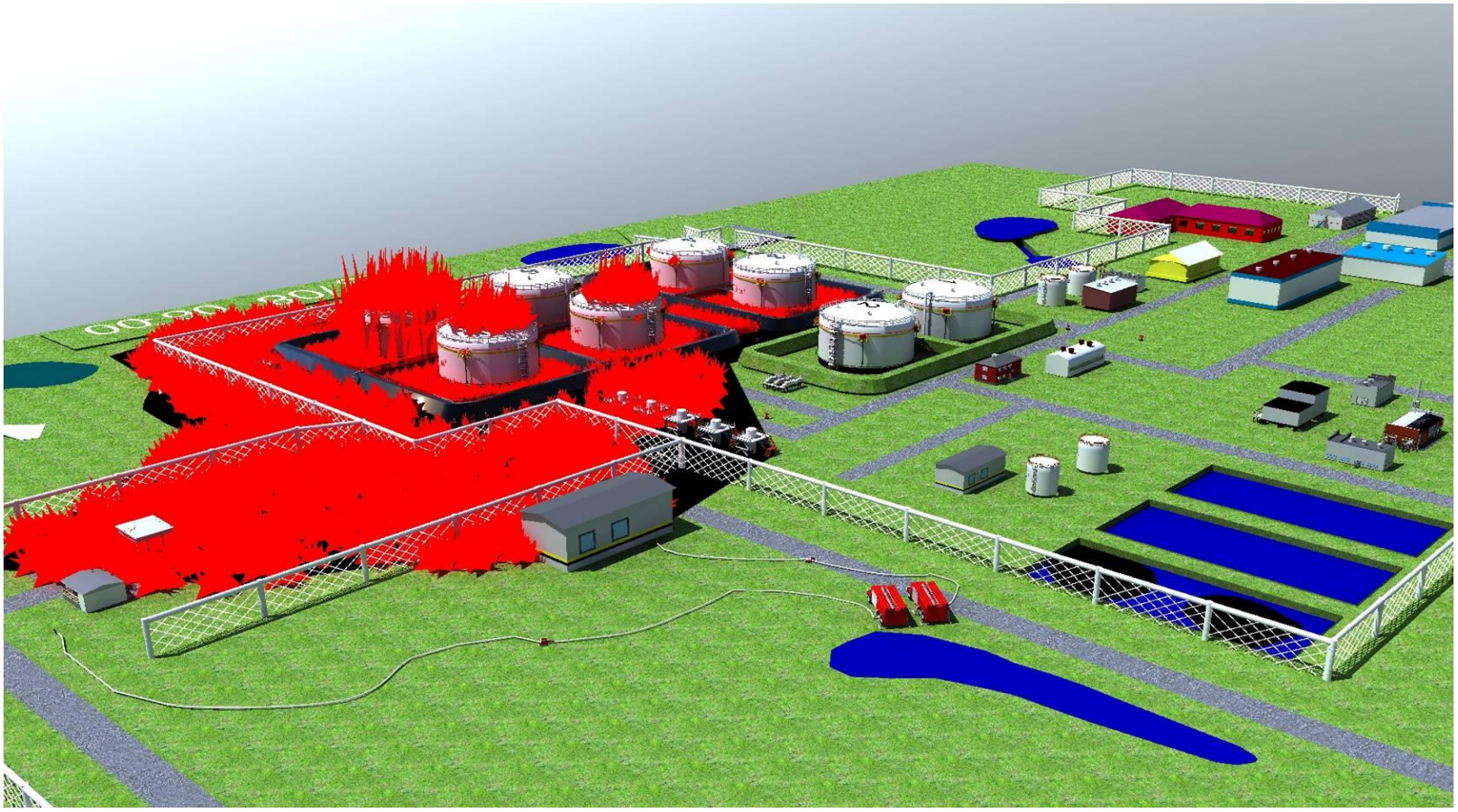
About 04.00

- blowout from the tank №5 occurred (Rys. 6, 7). It resulted in fire spreading on the tank №4






The situation on 23.08 time 06.00



- Three foam attack using sublayer method of extinguishing fires in the tank №4 were organized in the period of time from 20.00 on 23rd August, 2009 to 04.00 on 24th August, 2009. This made it possible to practically stop the burning and to prevent an explosion in the tank №4.

On 24th of August at 5.54	• the fire in reservoir park "KONDA" was contained
12.10	• The fire is completely liquidated

THE ACCIDENT

- As a result of a fire the tanks № 5,7,8 were completely destroyed. Tanks 3, 4, 6 were partially damaged. There is damage to the equipment of tanks № 1, 2

THE ACCIDENT CAUSES

The cause of the fire in the tank №7 was a direct hit on the roof of the tank of lightning. During the first hit lightning protection system protected the object. But it caused a high level of electric field intensity over the territory of the object and the metal elements of all structures, including tanks. Re-lightning discharge was directed in the tank and resulted in the explosion of gas-air mixture in the tank. This led to the partial destruction of the roof and the ignition of vapors of oil. The roof was dropped from the tank

The conclusions concerning the cause of tank №8 explosion are as follows:

- contact open-fire in the tank №8 through the respiratory valve and gas equalizing system has not happened, because they are equipped with fire arresters;

- the destruction of flame arrestors gas equalizing system occurred as a result of explosion of the tank №8, the destruction of the flame arrester mechanical, because inside gas equalizing system of tank farm were no traces of burning;

- the explosion of the tank №8 occurred on 30th minute of combustion, when the temperature of the wall was 357^{0}C, and the temperature of the total gas space of the tank - 52^{0}C. This allows to make a conclusion on the creation of conditions for self-ignition of vapors in the wall region;

- on 29th minute there occurred decompression of the tank №8 by reason of the loss of strength and stability of the tank wall, as evidenced calculations of the strength;

Other conclusions :

- Ignition of the tank №5 occurred from entering the burning oil from the tank №8. The fire at the tank №4 arose from the heat of the impact of burning spilled oil with its blowout from the tank №5.

Organizational causes of the accident have not been identified.

At the station all the requirements of safety were performed.

The peculiarity of this accident in the fact that the investigation has not identified the perpetrators defaulter of the accident at the station of "KONDA".

Conclusions

- Commonly reservoir explosion, which is full leads to the lid's blowing up (seldom to the separation)
- The most drastic consequences occur due to explosion of the partially filled reservoirs. Reservoir devastation leads to the increasing of the consequences extent
- Modeling of the explosive processes by fire, experiments and theoretical researches could contribute forecasting of the potential consequences of the reservoir explosions
- At the burning of the oil and/or petroleum product reservoir park it is rational to prevent formation of the fuel-air mixture inside inflammability limits by inert gas pumping (for example azote) into reservoir