Karlovac tests technical data.

Overview of data from tests.

Forest fire started at 08.20
Forest fire attach started at 10.15
Start temp is + 500C
End temp is 20C
Time needed = 5.06
CF7 is 1%
Total water needed is 728 liter
Flow rate water is 130 liter per minute

Car fire water
800 liter used
Time needed 4.16
No CF7
Flow rate water is 130 liter per minute

Car fire CF7
280 liter water including CF7 used
Time needed 2.15 + 30 seconds round 2 bumper restart
CF7 = 2%
Flow rate water is 130 liter per minute

Electric car fire
Electric car start fire is 10:18
Battery is between 15 and 20%
Car on side, battery punctured by forklift
CF7 = 6%
Water used is 1980 liters including CF7
Start temp is (indicational due to limitations of reader) 1500 to 2000C
End temp after attack is 20C
Total time needed is= round 1 = 5.31 and round 2 = 0.30
Total time needed = 6.01 minutes.
Water pressure/flow is 360 L per minute
Car remained small puffs of smoke but no restart.

Plastic in container (replacement of MSW tests)
Total time needed round 1 = 1.30 round 2 = 0.13 seconds
Total time needed is 1.43
Water flow is 130 l per minute
Total water required is 1.75 x 130 = 227.5 liters of water including CF7
CF7 = 2%

Car tires with seawater (around 12 units stacked in pairs)
Added diesel and benzine for starter.
CF7 = 2%
Total time needed is 3.11
Be aware… only 1 liter CF7 used due to calculation failure in volume CF7 tank.
Last seconds was pure seawater
Total indicated seawater used was 400 liter

Original volume seawater tank is 500 liter IBC
Flow rate water is 130 liter per minute

Scrap metal
Mix of car tires on rim (around 8 units) + several car doors and car booths with added diesel and benzine
CF7 is 2%
Total time needed is 2.14
Additional time needed after 3 hours due to restart is 0.30
Flow rate water is 130 liter per minute

Solar panels
Added load of benzine to start fire fully.
Total time needed = 1.27
CF7 is 2%
Flow rate water is 130 liter per minute

Tests to be executed (in order of importance) (CF7):

1. Forest fire
2. Fire stop (part of forest fire)
3. Wood fire
4. Car tyres
5. Car fire
6. Solar panel
7. Furniture/house fire
8. Frying pan
9. Seawater tests
10. MSW fire
11. Scrap metal fire
12. Railway fire
13. Oil fire flash over (oil refinery model)

The following tests are investigations and intended to obtain knowledge on ability/capability of CF7 and/or Foam:

1. Oil fire
2. A1 jet fuel
3. Electric car fire
4. Battery fire (optional)

Explanation per tests.

1. Forest fire (combined with 2 and 3)
Goal:
To show how CF7 reacts on larger wood fires combined with vegetation on the ground.
To demonstrate the efficiency of CF7 on forest fires and to show the reduction of required water/time and show continues cooling of area by CF7.
To show the ability to create a fire stop.

How.
Container has sand as base for materials (option 1) (best option as heat from container transfers underneath to fire stop as happens in real life)
Whole setting is on bare floor (option 2).

Part (1/2) of container/area has several/larger stack of pallets to simulate dense forest.
Other half of container/area (part 2/2) has dry material such as hay
Before starting, part 2 is sprayed with CF7 to prevent flash over and create fire stop.
Part 1 is doused in fuel and set on fire and left to burn for longer period of time.
Part 2/2 could be additionally doused with spray of cf7 to continue cooling…. But should not be needed.
After part ½ is full on fire and really hot… controlled attack with water and CF7 at X% ratio.
Short bursts to control water flow.

<u>Observation.</u>
How long does the fire stop hold?
If the fire stop is breached, how quick does it spread.
If additional CF7 is sprayed on fire stop… does it hold longer? How much longer? Able to completely prevent or stop?
After tests on part 2/2 (fire stop)…. Continuation of attack on part 1/2 (stack of pallets) with water and CF7. How much water +CF7 is needed to stop fire.
Initial temperature measuring on both part 1 and part 2 of tests area to obtain and show actual temp.
During tests continues reading of temp to show how CF7 cools

<u>Required materials.</u>
1 flat container unit as used by fire brigade to transport cars (optional)
Large stack of pallets (around 6 or 8, more is better)
Several larger tree trunks (optional)
Wood residue if available
Several hay bales (3?) to create floor for fire stop
Fuel to start fire
Manual spray unit (Martijn) to spray fire stop.
Fire truck + hoses.
Mixing unit belonging to fire truck to add CF7
Amount of CF7 in jerrycan
Heat camera.

<u>4. Car Tires.</u>
<u>Goal.</u>
Show the ability of CF7 to extinguish a car tire fire.
Show the ability of CF7 to continue cooling after deployment and water has evaporated due to extreme heat.
Show the ability to penetrate the car tire heap and cool the internal fire as well as the eternal visible fire.

<u>How.</u>
Pile of 10 car tires, stacked up to create covered internal area of extreme heat.
If possible, with added shredded car tires to simulate fire in shredded material.
Prolonged fire to create extra heat/intensity.

<u>Observations.</u>
Is CF7 able to extinguish a car tire fire.
(optional) is CF7 able to extinguish shredded car tire material.
How much CF7 is needed to extinguish the fire
Does CF7 continue to cool a situation after it has been deployed.
How much CF7 is needed to extinguish a car tire fire of this size
How much time is needed to extinguish a car tire fire.

Required materials.
10 car tires (with and without rim)
$1M^3$ Shredded car tires (if available)
CF7
1 fire truck with hose.
1 mixing unit.
Thermal camera.

5. Car Fire.
Goal.
To show the efficiency of CF7 on extinguishing a car fire, compared to regular water deployment.
To show that using CF7 reduces the amount of water needed and to reduce the amount of time needed to extinguish a car fire, compared to regular water deployment.

How.
2 identical (in size/volume/shape) cars.
Both cars have an engine and both cars have a full interieur.
Both cars are doused with equal amounts of fuel on identical parts of the car, being the interior and the engine.
Both cars are set ablaze on the same time and left to burn/develop the fire the same time for several minutes to create a full blaze.
Car nr 1 (only water) is handled the normal way (e.g. continues dousing).
Car nr 2 (water +CF7) is handled in CF7 model (e.g. short bursts on strategic areas)

Observations.
How much water is needed to extinguish car nr 1 (regular deployment, only water)
How much water + CF7 I needed to extinguish car nr 2
What is the amount of CF7 used on car nr 2
What is the time needed to extinguish car nr 1.
What is the time needed to extinguish car nr 2.
Does the alternative attack model for CF7 work better or not.
What is the temperature of car nr 1 after fire is extinguished.
What is the temperature of car nr 2 after the fire is extinguished.

Required materials.
2 identical cars is size/volume, including engine and interieur.
CF7
1 fire truck with double hose (1 for only water and 1 for water +CF7)
Or… 2 identical fire trucks.
1 mixing unit.
Thermal camera.

6. Solar panels.
Goal.
To observe and check the ability of CF7 to extinguish a solar panel fire and to see if and how quick CF7 is compared to regular water as main agent.
To check if CF7 is able to cool the solar panels and prevent expansion of fire to other panels.
To check if CF7 is able to perform when doused under a solar panel between roof and panel form the side.

How.
2 sets of 4 panels.
Set 1 is used for only water, set 2 for water +CF7
Panels are placed on the solid floor, simulating a roof with about 10 to 15 cm space between floor and panels.
Panels are placed tight against each other, similar to as on a roof.
Both sets are set ablaze via small wood fire that is added to the sets after placing them.
Wood fire simulated fire from roof that progresses into the solar panels.
If not wood, small cup with flammable liquid can be used as heat and fire source.
Set nr 1 is only treated with water in regular deployment.
Set nr 2 is doused with water + CF7
Attack continues till set is without fire…. Could be that water set (set nr 1) requires more time to stop fire.
CF7 is deployed in shots and not continues.

Observations.
How much water is needed for set nr 1 (only water)
How much water is needed for set nr 2 (water +CF7)
What is the needed time for set nr 1 and set nr 2 to extinguish the fire and the source of the fire (wood or flammable liquid).
Does CF7 function when deployed underneath the solar panels.
Does CF7 cool the panels and prevent flash over to other panels in the set.
Does CF7 maintain the cooling capability after deployment and if so, for how long?

Required materials.
2 sets of 4 solar panels
Sufficient stones to mimic 10 to 15 centimetre hight distance between panels and roof
Flat stone surface to mimic roof
Fire source (wood or flammable liquid in cup)
CF7
1 fire truck with hose.
1 mixing unit.
Thermal camera.

7. Furniture/House fire.
Goal.
To observe and establish the efficiency of CF7 when deployed at a house fire with burning furniture.
To obtain data on required volume of water needed on regular deployment (e.g. just water) versus deployment of CF7.
To obtain data on required time needed to extinguish a house/furniture fire.
To obtain knowledge and proof of the cooling effect of CF7 after deployment.

How.
Container (20ft or 40ft) with open doors and a roof (sea container model) is packed with household furniture, including a couch, a table, chairs and a closet with clothing inside. Old tv is optional.
Container is set ablaze and left to burn for several minutes to built internal heat within the container, mimicking a fire in a living room.
Test nr 1 is done with only water.
After test nr 1 is done, container is cleared and left to cool.
Day 2 is used for test nr 2, water +CF7
Container is constructed again, similar to setting and conent as for thest nr 2 and set ablaze for several minutes.

Container is attacked with water and CF7, using the short blast method till fire is under control.

Observations.
What is the temperature development in the container after several minutes before deployment of water and water +CF7.
What is the water volume needed for the only water container and what is the water + CF7 volume needed for the container with water + CF7.
What is the time needed for container nr 1 and what is the time needed for container nr 2.
What is the residual heat in the container after tests nr 1 (only water) in the container and what is the residual heat left in the container after water + CF7.
Does the container after test nr 2 continue to cool down or not and if so, or what time and to what temperature without adding new water+CF7.

Required materials.
1 container (20 ro 40ft) with opening doors and roof (sea container model).
2 sets of identical household furniture including a couch, a table, chairs, a closet and optional a tv.
CF7
1 fire truck with hose.
1 mixing unit.
Thermal camera.

8. Frying pan.
Goal.
To observe the difference between a regular fire pan doused with a basic fire extinguisher and a frying pan doused with CF7 from a spray can of 200ml.
To observe the cooling abilities of CF7 (200ml spray can) during and after deployment.
To observe if the 200ml spray can with CF7 is enough to battle a regular frying pan fire.

How.
Basic regular frying pan is filled with 100% water free cooking oil (needs to be water free due to risk of explosions when on fire and attacked!!). oil quantity is about 1 to 2 cm on surface of bottom of the pan.
Pan is heated with flame torch, both on the outside and on the oil itself to obtain the effect of an overheating frying pan.
When pan is fully ablaze, it is left to burn for 1 minute.
Burning pan is handled with regular fire extinguisher till fully solved.
This is repeated with the CF200 spray can for comparison.

Observations.
What is the time needed to extinguish the pan with the regular fire extinguisher and what is the time needed to extinguish the pan with the CF200 spray can.
What is the temperature of the pan when fire is extinguished with the regular fire extinguisher and what is the temperature of the pan after being sprayed with the CF200 spray can (both oil temp + temp of pan)
Is the CF200 spray can enough to extinguish the burning frying pan.

Required materials.
1 or 2 basic frying pans.
Set of stones to mimic a stove
Max 2 liters of pure cooking oil (no added water or vegetable oil)
Torch to heat pan and oil
1 regular fire extinguisher

1 spray can of CF200 (200ml)
Thermal camera

9. Seawater tests (combined test of furniture and frying pan).

Goal.

To proof that CF7 can be deployed using seawater instead of fresh water when fighting a household fire (simulating a boat interieur) and can be deployed using seawater when fighting an engine fire (simulated by the burning frying pan.
To proof that CF7 maintains its capabilities when deployed with seawater.

How.

Seawater is brought to the Karlovac area (1000 liters) in an IBC unit.
The IBC unit is connected to a separate water pump as the seawater could damage the fire truck and contaminate the water tanks inside and damage the pumps in the truck.
Sea container with furniture is constructed (similar to furniture/household tests) and frying pan (frying pan test) is added to the container.
Frying pan is set ablaze first, causing the other materials in the container to ignite.
Frying pan simulates the engine on fire whilst the furniture simulates the gally/interieur of the boat.
Fire is attacked with seawater + CF7 to extinguish the fire.
Settings of tests is identical to furniture/household and frying pan tests but now combined into 1 container.

Observations.

Does CF7 work when mixed with seawater.
Is it just as efficient compared to fresh water.
What is the volume of water + CF7 needed to extinguish the fire
What is the time needed to extinguish the fire.
What is the temperature of the fire before attack.
What is the temperature of the fire after the attack with seawater + CF7.
Does the CF7 continue to cool the area after deployment

Required materials.

1 basic frying pans.
Set of stones to mimic a stove
Max 1 liters of pure cooking oil (no added water or vegetable oil)
1 container (20 ro 40ft) with opening doors and roof (sea container model).
1 set of household furniture including a couch, a table, chairs, a closet and optional a tv.
CF7
1 IBC filled with sea water
1 external pump with hose.
1 mixing unit.
Thermal camera.

10. MSW fire.

Goal.

To proof the effects of CF7 on MSW fires and to proof the continued cooling effect of the CF7 on the waste and the container mimicking a landfill situation.
To proof the reduced time needed for attacking a MSW fire when using CF7 compared to only using regular water as extinguishing agent.
To proof the reduced volume of water needed for attacking a MSW fire when using CF7 compared to only using regular water as extinguishing agent.

To proof temperature reduction of the MSW fire when using CF7 compared to only using regular water as extinguishing agent (during and after)
To proof the cooling capacity of CF7 when penetrating the burning waste to deeper layers.

How.
2 identical waste containers are filled with 2 M^3 of regular MSW each. Each container has additional 1M3 of pure plastic waste added. Each container has 1 car battery added (partially loaded), each container has 2 car tires added and has 10 to 20 litres of old engine oil added.
Each container is doused with 10 litres of benzine as an accelerant.
Containers are set ablaze on exactly the same time and left to burn for several minutes to create maximum heat built-up in each container.
2 identical fire truck, both with identical pressure, identical hoses and identical spray gun are deployed.
Both trucks are instructed to deploy timed bursts of water/water +CF7 onto the burning container.
Bursts must be times and identical in volume to enable comparison.
This is continued till the CF7 container is extinguished.
If the water container is not extinguished, the water container receives additional water/time/bursts.
Additional time/bursts/volume is measured for comparison.
Both containers are monitored for temperature during initial blaze (before deployment), during deployment and after deployment to observe temperature development during deployment of water/water+CF7.

Observations.
What is the temperature of each container before deployment.
What is the temperature of each container during deployment.
What is the temperature of each container after deployment.
What is the required water volume for each container
What is the required time needed to extinguish the fire for each container.
Is CF7 able to penetrate the deeper areas of the container/fire and cool these areas as well
What is the overall efficiency of CF7 compared to regular water for MSW fires

Required materials.
2 basic waste containers
4M^3 of MSW
2M^2 of plastic waste.
2 car batteries
4 car tires
20 litres of old engine oil
20 litres of benzine
2 identical fire trucks with identical hoses and identical spray guns
1 mixing unit for CF7
CF7
Thermal camera

11. Scrap-metal fire:
Goal:
demonstrate that CF7 has a (long-term) cooling effect on metal fires.
That CF 7 can achieve depth penetration

How:
Large pile of 3M^3 scrap metal.
In the middle of the scrap heap is a pile of car tires.

Tires completely covered with scrap should not be visible.

<u>Observation:</u>
Long-lasting cooling effect on scrap.
Ability to penetrate deep into the fire.
Evidence of long-lasting cooling effect of CF7.
Prevents re-ignition.

<u>Material:</u>
$3M^3$ scrap metal
5 to 10 car tires,
CF7.
1 fire truck with hose.
1 mixing unit.

<u>12. Railway fire:</u>
<u>Goal:</u>
Can CF7 prevent roadside fires from starting due to braking trains?
Endurance test: 2 days.

<u>How:</u>
Long strip of hay and straw (dry), 30 cm wide, 5 meters long, and 10 centimeters high.
Impregnate with CF7.
Apply a gas torch to straw several times a day for two days, at 1-hour intervals, and impregnate twice a day.

<u>Observations:</u>
Can CF7 prevent long-term roadside fires?
How much CF7 is needed to prevent them?

<u>Required materials:</u>
Two bales of hay,
1 liter of fuel,
CF7,
A spray unit (Martijn)
Thermal camera

<u>13. Oil Fire and Oil fire Flash over (combined test 4 and 5 using CF7 and new Foam)</u>
<u>Goal:</u>
To show CF7 and the foam can extinguish oil fires .
To show CF 7 continuing cooling effect after the fire.
To show that by deploying CF 7 on the none burning oil, CF7 is able to cool drum and prevent flashover.
To investigate the effects of the new foam on oil fires.
To investigate if the foam also has cooling capabilities.
General investigation on the foam to see how it reacts on oil fires.

<u>How:</u>
two empty oil drums with open top, position against each other.
Each drum contains 5 litters of oil (maybe more)
Drum nr 1 is set on fire and remains burning continuously.

At pre determined temperature, heat of drum nr 1 will create critical temp in drum nr 2 with the risk of flash over due to heat transfer.
When drum 2 becomes explosive (self-igniting), begin cooling drum 2 with CF7.
Drum 1 continues to burn.
Drum 2 is cooled regularly (permanently).
After prolonged cooling and no flashover, begin extinguishing drum 1 with CF7 or foam.
Monitor the temperature in drums 1 and 2, both the drum and the liquid, throughout the test.
After initial extinguishing, monitor drum 1, monitor the temperature and, if necessary, add CF7 (provide cooling capacity).
Repeat with foam.

Observation:
cooling capacity of CF7 on non-burning oil drum (preventing flashover).
Capacity to extinguish a severe oil fire with CF7 and with foam.
Capacity/capability to cool both drums after deployment of CF7/Foam without adding additional CF7/foam after extinguishing (does the colling continue or do we need to add more CF7/Foam.

Required Materials:
- 2 open oil drums.
10 to 15 liters of oil (diesel fuel is also permitted).
1 fire truck with hose.
1 mixing unit. 20 liters of CF7. Foam.
Thermal imaging camera.

The following tests are investigations and intended to obtain knowledge on ability/capability of CF7 and/or Foam:

1. A1 Jet fuel.
Goal:
Initial test to investigate the effectiveness of CF7 and foam in extinguishing jet fuel.

How:
Test nr 6.1 Large tub of jet fuel set on fire. Douse with CF7 and again (new test) with Foam.

Test nr 6.2 A sand-demarcated area on which jet fuel is spread (possibly with obstacles).
Area is set on fire to create a crash situation with jet fuel spilling onto surface area.
Area is doused with CF7 and repeated with Foam.

Observation:
What is the temperature of the burning jet fuel?
Is CF7 capable of extinguishing the fire, and is the foam capable of extinguishing it?
What percentage of CF7 is needed?
What percentage of foam is needed?
What is the duration of the extinguishing process?
How much water is used to obtain full shut down of fire.

Required materials:
20 liters of jet fuel,
2 m^3 of sand,
CF7, and foam.
1 fire truck with hose.
1 mixing unit.

Thermal imaging camera.

2. Electric car fire.

Goal.

To observe the effects of CF7 on a battery powered vehicle and to observe if CF7 is able to cool the car and the battery, reducing the damage to the interieur/risk to potential people in the car and protecting the people inside from the extreme heat of the burning battery.
To observe if CF7 contributes to reducing the time needed to extinguish/resolve a battery power vehicle fire.
To observe if CF7 contributes to reducing the water volume needed to extinguish/resolve a battery power vehicle fire.
Please note… we do NOT expect CF7 to extinguish the battery itself but only to reduce the heat/temperature of the battery fire and to create time for extraction of people from a battery powered car that is on fire.

How.

Battery powered car is set on fire similar to initial regular car fire tests with the difference that the fuel is only applied to the battery compartment and NOT on the interior or engine bay!
Car is left to burn to create thermal runaway of the battery in the car… e.g. the fire is concentrated on the battery part of the car and not on the interieur.
Fire is started directly underneath the car on the battery itself to simulate a thermal runaway from the battery.
When battery has gone thermal, attack starts, focussing on the battery unit and focussing on containing the fire and prevention of fire entering/expanding into drivers compartment to enable extraction of people in the car.
Battery is continuously doused with pure CF7 or CF7+water to perform extreme cooling.
Interieur is doused with water+cf7, similar to regular car fire model/test.

Observations.

Is CF7 able to cool the battery itself down to reduce the thermal runaway.
Is CF7 able to protect the interieur of the car (e.g. the people) for enough time to enable extraction of people from the car.
What are the general effects of CF7 on a battery powered vehicle.

Required materials.

1 electric vehicle with partially charged battery
1 open source of fire to start thermal runaway of battery
CF7
1 fire truck
1 mixing unit
1 thermal camera

3. Battery fire

Goal.

To observe the potential of CF7 as an extreme cooling agent on smaller batteries (e.g. phone and power banks) during a thermal runaway.
Is CF7 able to reduce the thermal runaway of the battery and/or to stabilize the battery during a thermal runaway.
Please note, we do NOT expect the thermal runaway to be extinguished or prevented, only to investigate if CF7 is able to extend the time between initial overheating and actual thermal runaway.

How.

Phone battery is overheated using external heat source.
When battery is reaching thermal runaway status, battery is placed in metal od glass tank filled with 100% CF7 and a sand layer at the bottom to prevent damages to the bottom due to extreme heat from thermal runaway.
Battery s completely submerged for longer period of time and taken out on fixed interval moments to see the if the thermal reaction will restart. This is continued till battery is no longer thermal.

Observations.

What is the cooling effect of CF7 on a battery or power bank that is heading towards thermal runaway and on a phone/battery/power bank that has reached thermal runaway.
Can we reduce the time of a thermal runaway of a phone/battery/power bank.
Can we stop/prevent a thermal runaway if the battery/phone/power bank is placed/submerged in 100% CF7.

Required materials.

Several old mobile phones with lithium-ion batteries
Old power bank (lithium-ion)
1 old steel or glass tank
CF7 to fill the old tank
Set of grippers to move a battery/power bank/phone whilst reaching thermal status
Full protective an breathing gear for 1 fire fighter
1 external heat source to cause thermal status of battery
Thermal camera