ULTRA FOG®

FIRE EXTINGUISHING SYSTEM

High pressure water mist sprinkler system for fighting fires

Enhancing Tunnel Safety:
The Efficacy of Water Mist Fire Suppression systems through full-scale Fire Tests

TUNNEL FIRE TESTS:

- Purpose of the test session.
- Testing facility in San Pedro de Anes.
- Fire scenarios (200MW Class A and 60MW Class B).
- Test procedures.
- Performance criteria and test results.
- Conclusions.

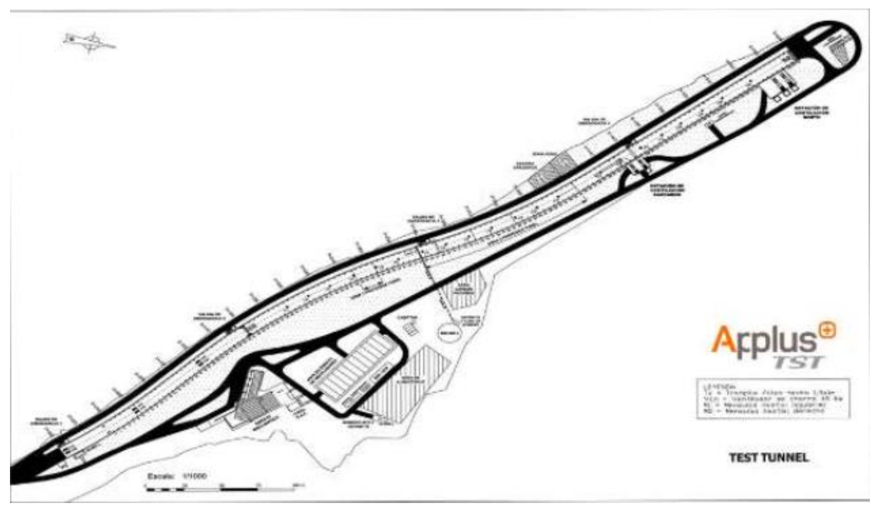
Purpose of the testing session.

- In April and May 2024, Ultrafog planned a full scale fire test session in San Pedro de Anes, Spain, in Applus TST facilities , to determine the effectiveness of the Ultrafog watermist system against a CLASS A fire (wood pallets fire) and CLASS B fires (diesel fuel pool fire) in the environment of a road tunnel, following the SOLIT2 guidelines.

- During this session, we focused on big fire sizes, simulating a fire from a truck or a tanker. In order to determine the performance, several data were recorded and analyzed. Test report is not yet ready, but we received first set of data.

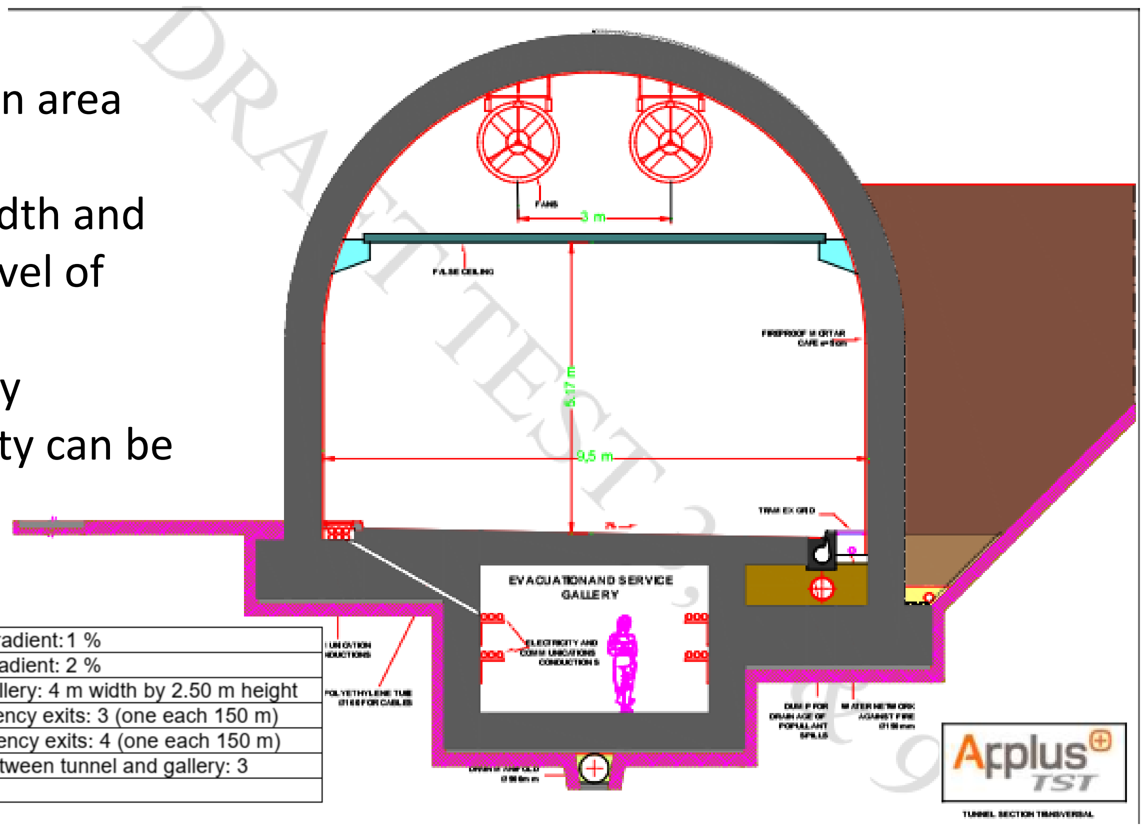
Testing facility in San Pedro de Anes

The best way to verify the real performance of a watermist system is to carry out tests in a tunnel inside of which would be possible to develop a full scale scenario. Applus+TST facilities are the optimal option because of the availibility of a tunnel, built in concrete, with the equivalent dimensions of a two lane road tunnel, designed for tests with controlled ventilation and data acquisition system.



Testing facility in San Pedro de Anes

The tunnel is built in a open area (false tunnel) with internal dimension of 9,5 meter width and 5,2 meters height at the level of the insulated false ceiling. Ventilation can be remotely controlled and wind velocity can be recorded during the tests.



Length: 600 m	Longitudinal gradient: 1 %
Width: 9.50 m	Transversal gradient: 2 %
Height: 8.12 m	Emergency gallery: 4 m width by 2.50 m height
Height (with false ceiling): 5.17 m	Tunnel emergency exits: 3 (one each 150 m)
Cross-section: 66 m^2	Gallery emergency exits: 4 (one each 150 m)
Cross-section (with false ceiling):48 m2	Connection between tunnel and gallery: 3
Width of the concrete walls: 0.60 m	

Fire scenarios:

- The idea behind the configuration of the fuel loads is to simulate a big size vehicle with a corresponding HRR (Heat Realease Ratio) of 200MW+ for Class A fire and 60MW for Class B fire.

- Class A fire consisted of an array of stacks of wood pallets positioned on a platform located inside the tunnel (370 meters from the South entrance, 230 meters from the North one), 1,5 meters from the side of the tunnel, as indicated in Solit2 guideline.

- A fire target (a stack of pallets) was placed 5 meters away from the fire load, in downstream direction.

- The HRR figures are based on experimental data from large scale testing in fire test laboratories. The total number of pallets used for a 200MW+ scenario was 544.

Fire scenarios:

- Class B fire consisted of 8 pools with a total surface of 32 square meters, filled with diesel fuel and positioned on the floor at the same position of a class A fire load (located inside the tunnel 370 mtr from South entrance, 230 mtr from the North one).

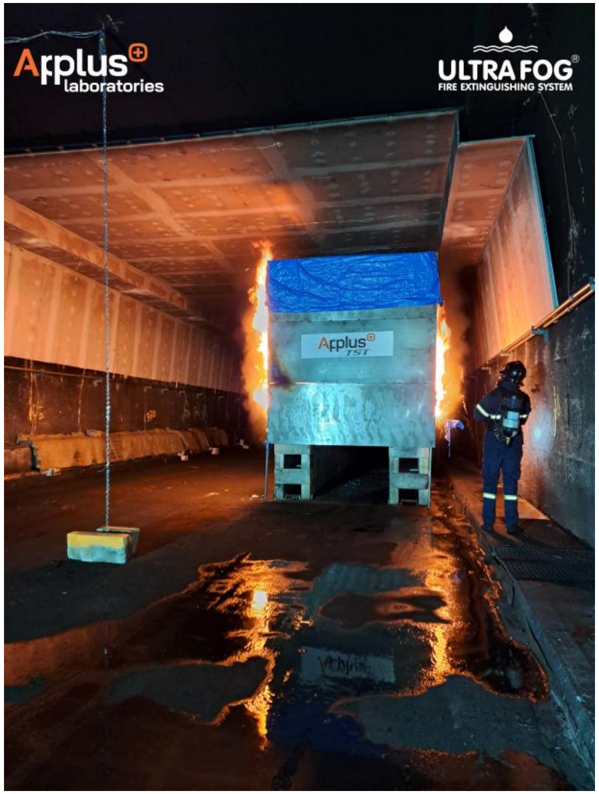
- This presentation will focus on the 200MW Class A fire tests, for which we received from Laboratory a full set of data, while waiting for the final report.

System configuration:

- Ultrafog nozzles, with a K factor of 4.2, were installed on both sides of the tunnel following the same configuration used for our previous 100MW test done in 2020.
- All nozzles had an inclination angle of 40°.
- 20 nozzles each side were installed, with a spacing of 4 meters, covering a total lenght of 80 meters.
- Our target was to get good results mantaining the same configuration used for the previous 100MW tests. For the 200MW tests only working pressure changed to 65 bar.

Test procedure:

- Let's start with some action!



Test procedure:

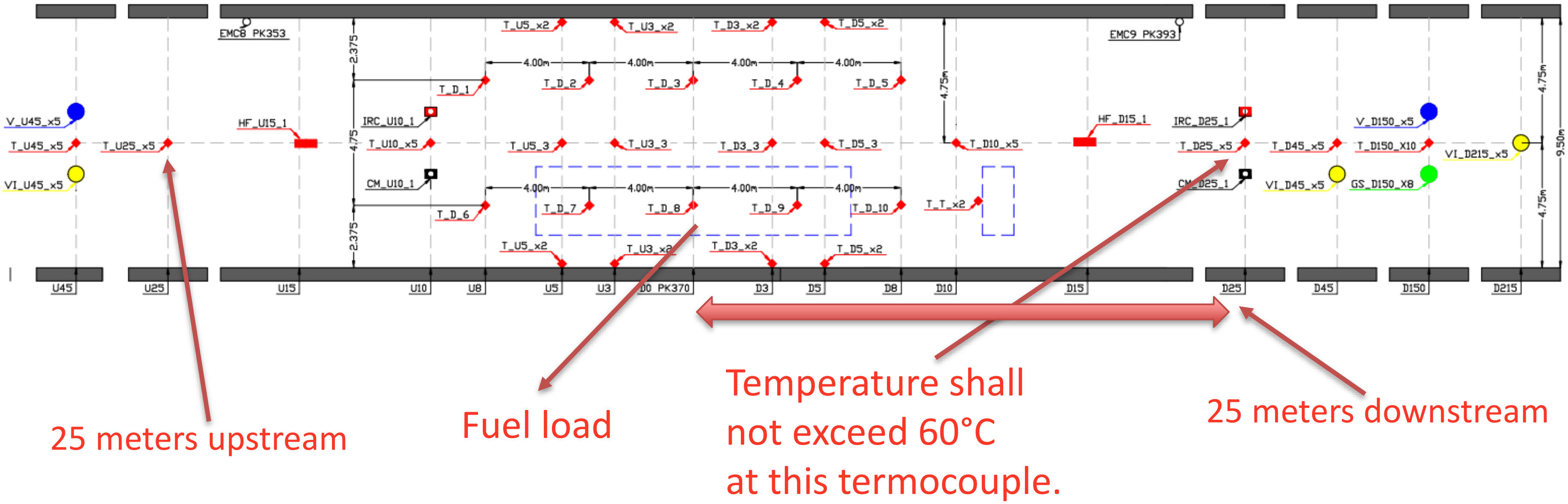
- In accordance with the Solit2 guideline, fire was initiated using 2 rectangular trays with gasoline, inserted into the first pallets at the side of the fire load. At the start signal, both trays were ignited simultaneosly.
- The detection of the fire was defined as the time necessary for at least one of the thermocouples installed around the fuel load was exceeding the temperature of 60°C.
- The watermist system was activated 2 minutes after the detection of fire.

Test procedure:

- The duration of the test was set at 30 minutes after the activation of the watermist system. Tests ended after these 30 minutes, when the fire brigade took control of the fire for total extinguishment.

Performance data and test results:

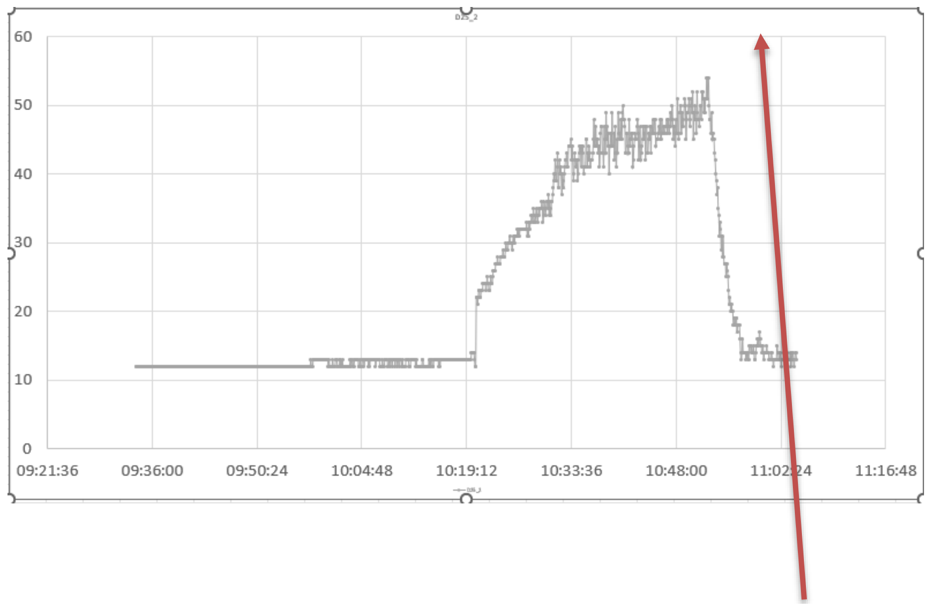
- First performance criteria relates to tunnel temperature at 1.8mtr height, **25 meters downstream** of the fire load, that shall not exceed 60°C for a duration of 10 minutes, no later than 120 seconds after activation of the watermist system.



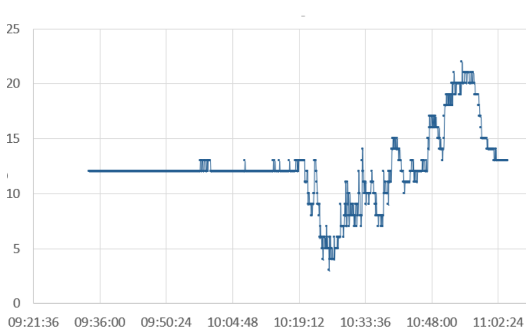
Performance data and test results:

- TEST RESULTS FOR **200 MW** SCENARIO:

Temperature at 1.8mtr height, 25 meters **downstream** of the fire load, peaked at 55°C and never reached the limit of 60°C.

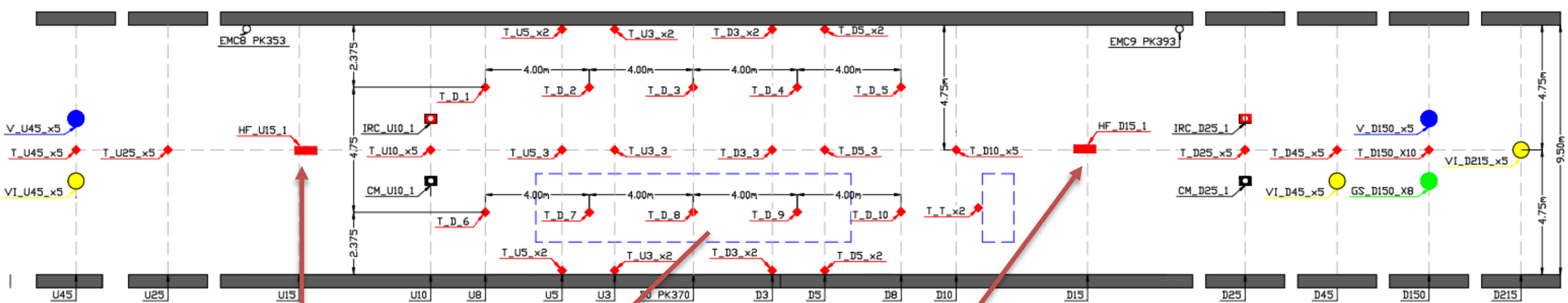


Upstream temperature (U25) at the same height was equivalent to ambient temperature (Max 21°C).



Performance data and test results:

- Another factor to be evaluated is the radiant heat flux at 25 meters downstream, at 1.5mtr height, that shall not exceed 5.0kW/m2 for a duration of 10 minutes, no later than 120 seconds after the activation of the watermist system.



15 meters upstream

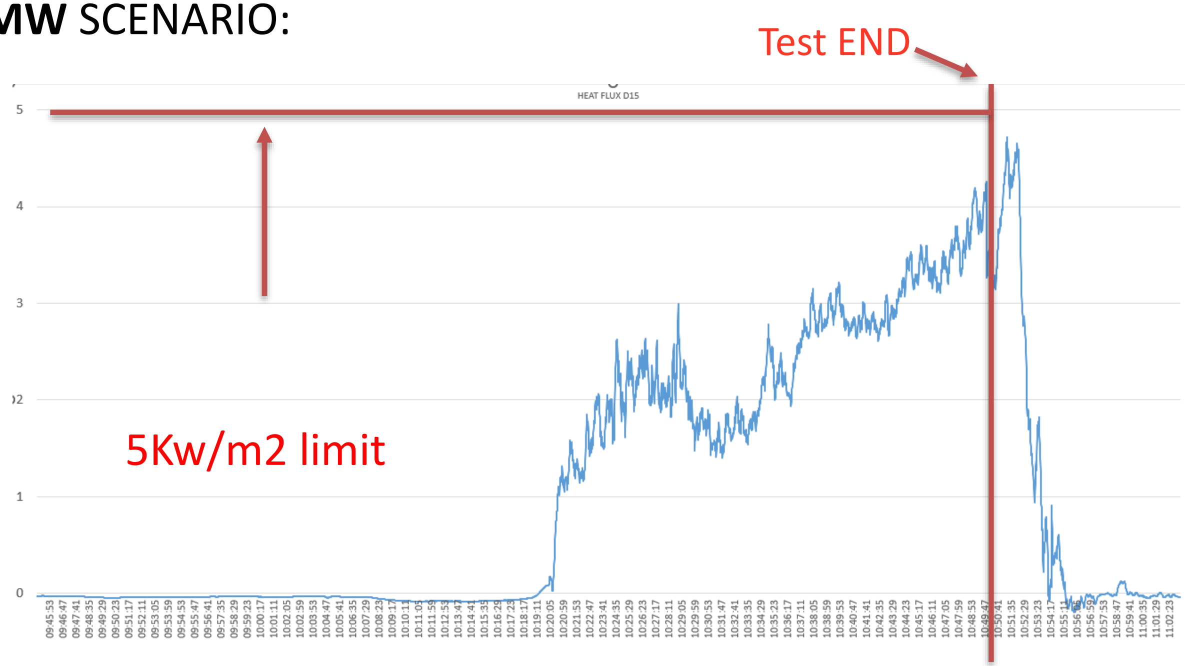
Fuel load

Heat flux shall not exceed 5kW/m2 at this sensor.

15 meters downstream

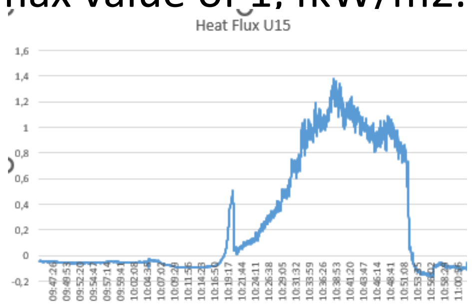
Performance data and test results:

- TEST RESULTS FOR **200 MW** SCENARIO:



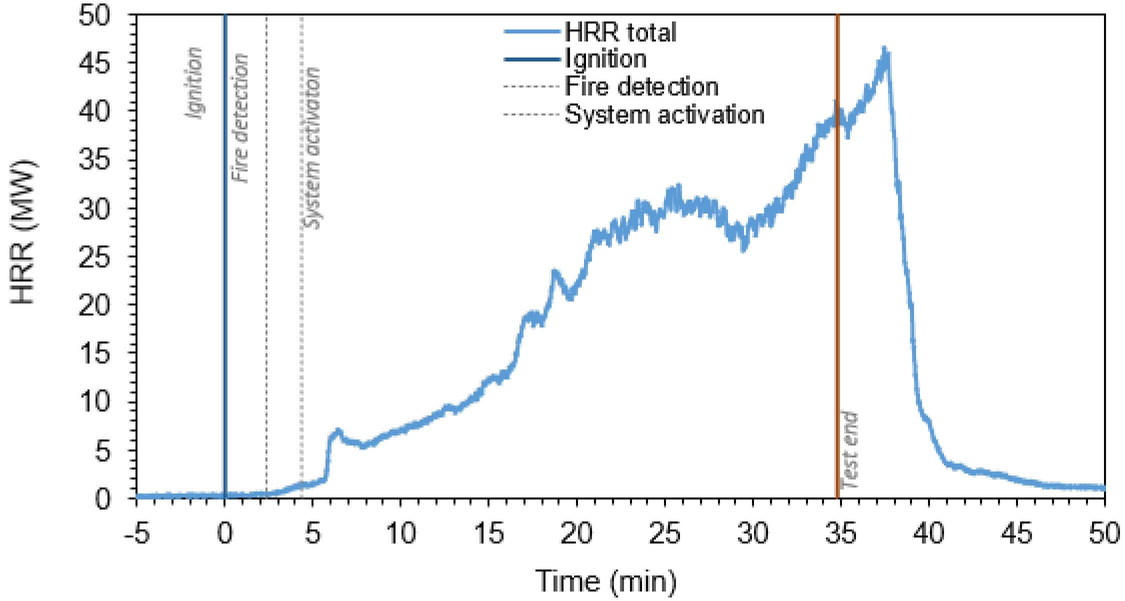
Radiant heat flux at 25 meters downstream, at 1.8mtr height, did not exceed 5.0kW/m2 during the duration of the test.

The same measurement at 25 meters upstream had a max value of 1,4kW/m2.



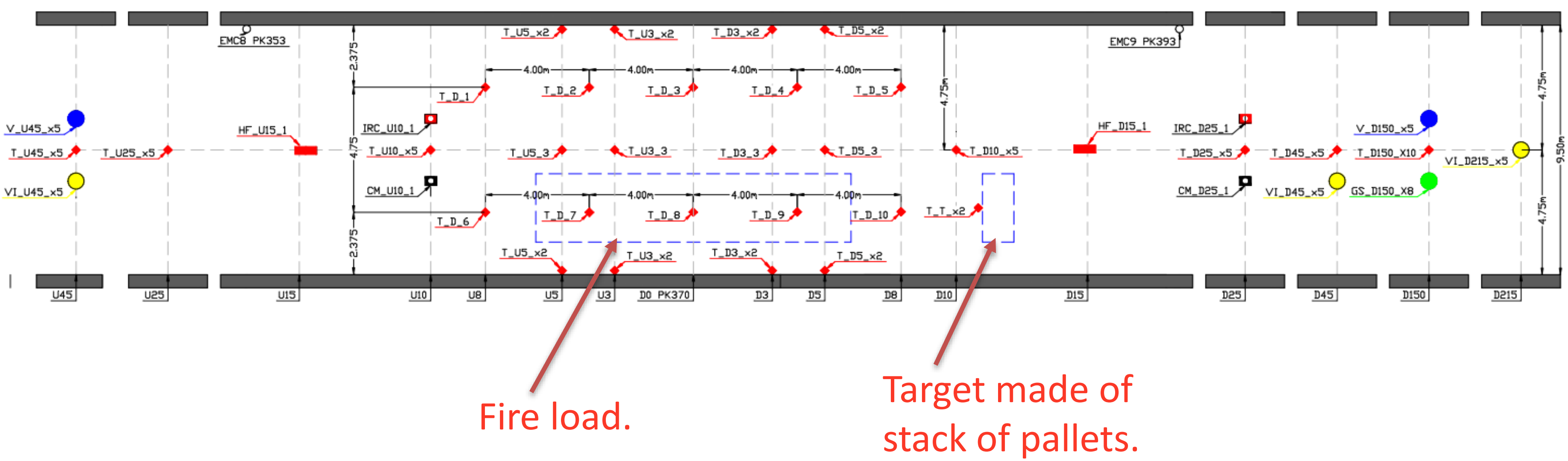
Performance data and test results:

- HRR (Heat release ratio) is reduced by WMS. In comparison to free burn of the fire load , the WMS is lowering significantly the HRR.
  The 200MW fire load was reduced to a peak of 40MW (20% of nominal fire load)



Performance data and test results:

- In accordance to Solit 2, a target of pallets shall be positioned 5 meters away from the fire load. This target shall not ignite to prove that the system is blocking the fire spreading between vehicles in case of fire inside a tunnel.

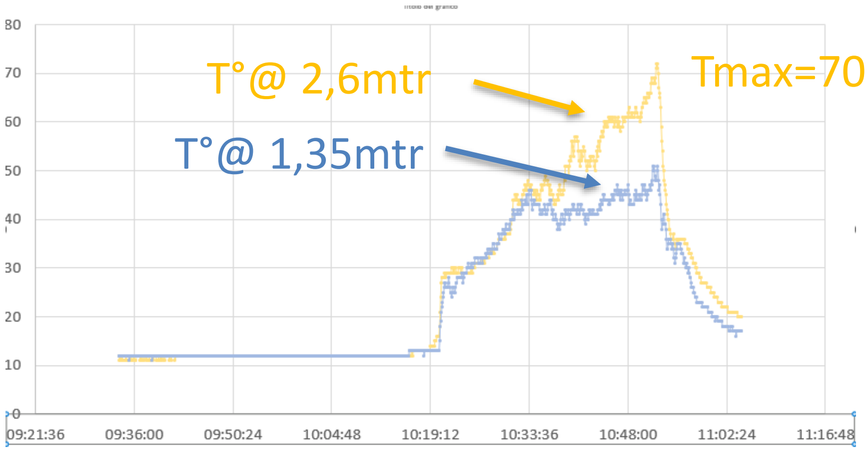


Performance data and test results:

- TEST RESULTS FOR THE **200 MW** SCENARIO:

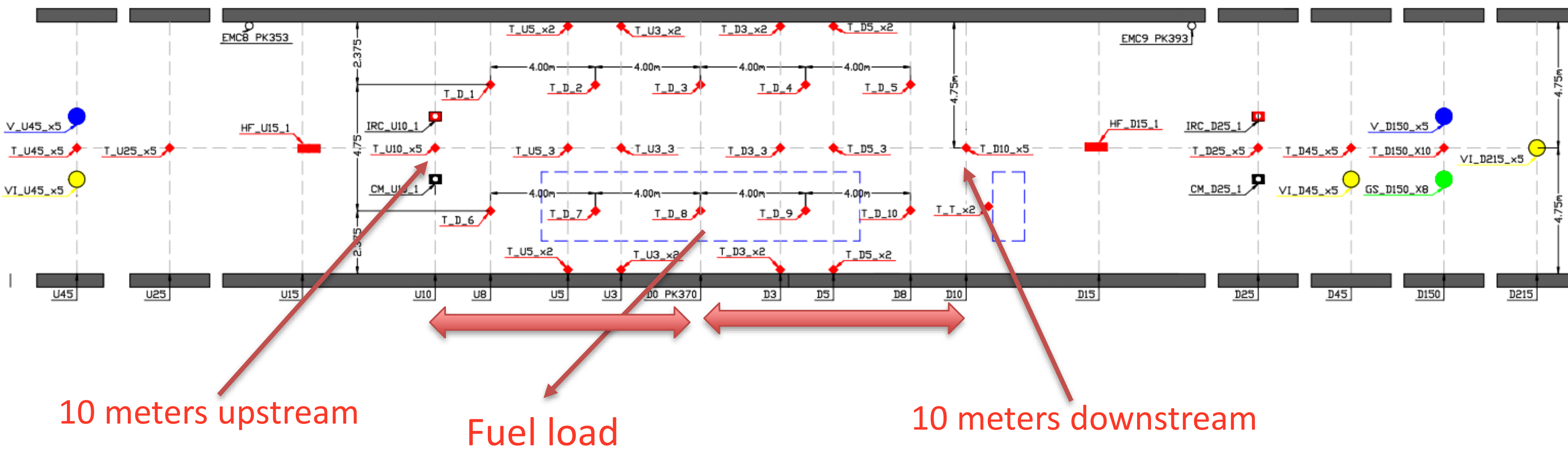
The target was not burning during the test. Visual inspection confirmed the low temperature reading.

Target after the test.



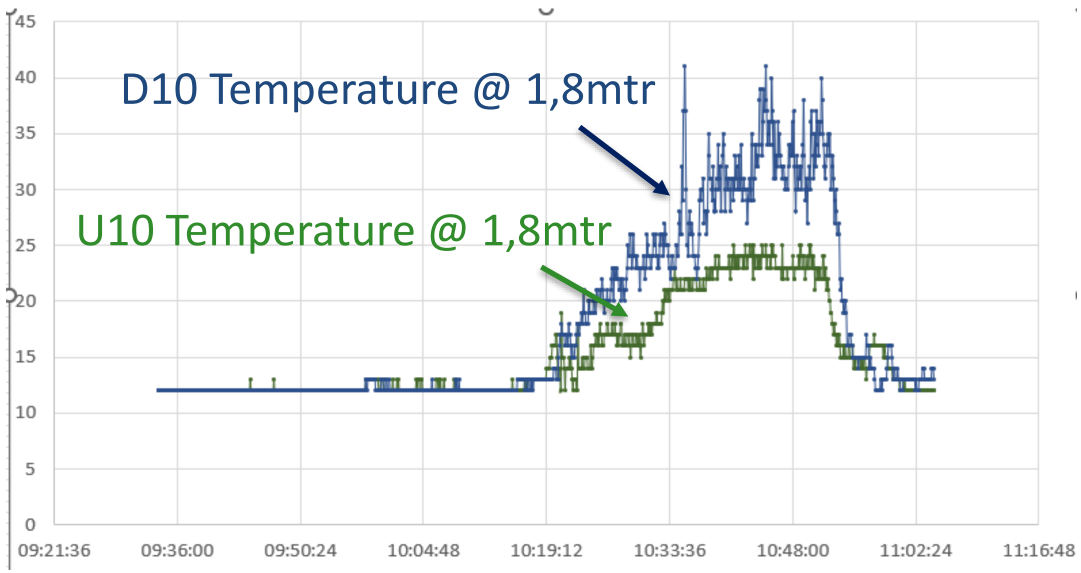
Performance data and test results:

- It is quite impressive how low the temperatures around the fire load are mantained during the fire test.
  We can check the thermocouples at the D10 (Downstream 10 @ 1.8 meters height) and the U10 (Upstream 10 @ 1.8 meters height) , 10 meters away from the center of the fire load.



Performance data and test results:

- The environment temperatures around the fire load were significantly lowered by WMS. You can see that only 10 meters away from a massive 200MW fire load, at 1.8 meters height, the temperature was always compatible with life and fire brigade operation.



Performance data and test results:

- The working pressure of the system was set @65bar and all the data shown in this presentation are taken from tests done at this pressure.

- We decided to investigate how the increased pressure could affect the system performance.
- This situation could happen when the tunnel has an inclination generating a significant height difference between the entrance and the exit of the tunnel. Based on experience from previous projects, where the pump unit was located on the top position, we found a significant increase of pressure at the nozzles installed at the other end of the tunnel.

- How could the system react if we significantly increase the pressure? All equipment used for high pressure watermist system is rated for higher pressure values compared to the working pressure (65bar). But what could be the behaviour of the system from a performance point view?

Performance data and test results:

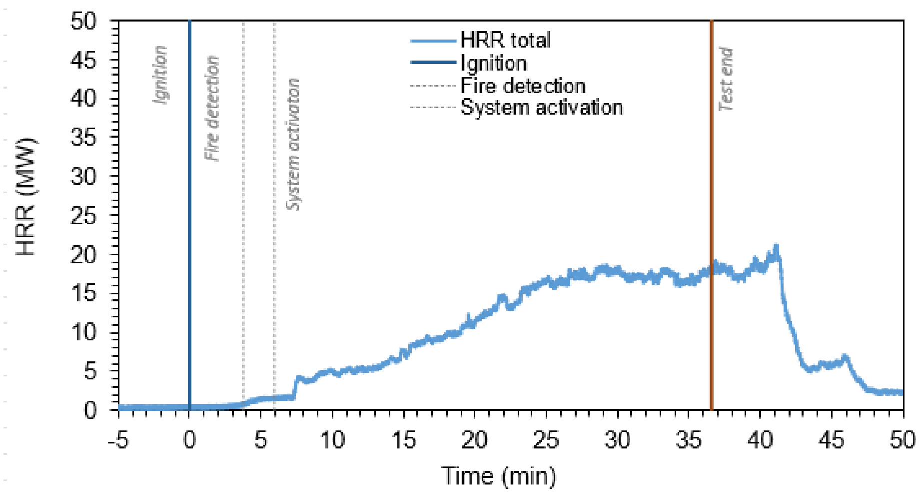
- Same 200MW Class A scenario was tested alst at a higher working pressure, increasing the value to 100bar.
  The results were really good, getting better performance than the ones achieved at the lower pressure of 65bar. The status of the fire load at the end of the test can be seen in the pictures below and confirmed by HRR graphs.

Fire load after test @100bar

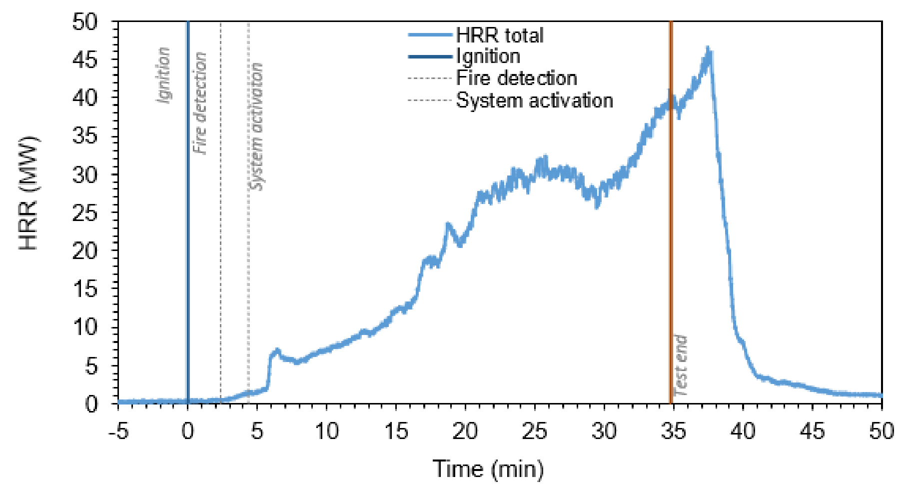
Fire load after test @65bar

Performance data and test results:

- HRR Comparison: the system was able to better control the fire and HRR peaked at 20MW, representing 1/10 of the potential HRR.



HRR @100bar



HRR @65bar

Conclusions:

- The outcome of the test session gave us some important data about the effectiveness of the watermist system used in a full scale fire test in tunnels:
- • The combination of lowering temperatures, controlling the fumes, reducing the heat flux radiation, keeping the visibility to good levels, will make the tunnel ambient compatible with tenability criteria to allow a safe escape of the people from the tunnel and a safe, quick and effective intervention of the fire brigades.
- • The watermist system was able to reach the shown data with less than 1350 liters/minute for the whole 80 meters protected area. This means that the need of big infrastructures to store large amounts of water normally necessary for traditional water deluge systems are not needed.
- • All tests were performed with pure water, without any other additive or foam, making the system configuration easier (no foam proportioner or additive injector are required) and the after discharge activities reduced to nearly zero.

Conclusions:

- The test with increased pressure showed interesting results and better performance using higher pressure. This will give us more flexibility on the working pressure when we have specific projects with tunnels having important inclination that can generate a pressure increase at the bottom of the line. Having the increased pressure tested and validated will also give us confidence about system effectiveness when making the system design with a potential higher pressures due to the tunnel shape.

- All tests were performed in Applus TST, where we were allowed to invite authorities, consultants and professionals from various countries and let them witness the live action during tests. Thus providing an opportunity to spread the knowledge about watermist application in tunnel and increase the trust in this tecnology with a firsthand experiential partecipation.

Thank You!