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Impact of fire protection on a truck fender (RISE, Norway)

Test report – Norwegian Defense Research Establishment

Impact of passive fire protection on a truck fender

Large scale ad-hoc fire test

Authors:
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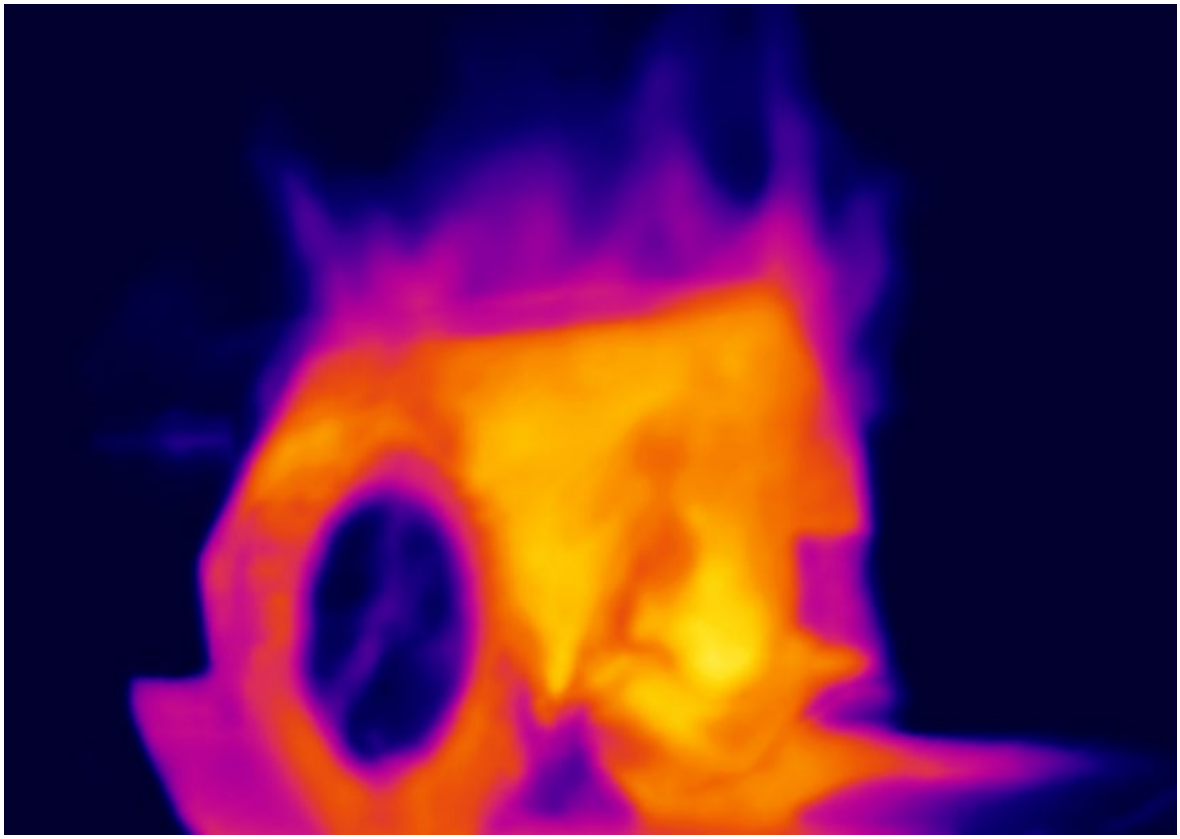

RISE Fire Research
RISE report F19 20405

Impact of passive fire protection on a truck fender

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1	2019-06-06

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TEST OBJECT
Truck fender with and without passive fire protection.

TEST PROGRAMME	TEST LOCATION	DATE OF TESTS
Large scale ad-hoc fire test	RISE Fire Research	2019-02-07

SUMMARY:
Two large scale fire tests were performed on truck chassis with a steel tank filled with water mounted on top. In both tests the heat source was three burning tires. The truck fenders, between the heat source and the tank, were tested both with and without passive fire protection (PFP) in separate tests.

Test 1 - Without PFP-insulation:
The average water temperature in the tank increased with 26 K.
Total energy absorbed by the water was calculated to approximately 193 MJ.

Test 2 - With PFP-insulation:
The average water temperature in the tank increased with 32 K.
The energy absorbed by the water was calculated to approximately 238 MJ.

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1	2019-06-06	First version.

Contents

Appendices

1 Introduction

1.1 Summary

On request from the Norwegian Defense Research Establishment, two large-scale fire tests have been conducted to examine the effect of passive fire protection (PFP), clad on truck fenders, on heat transfer from burning truck tires to a water tank.

The test setup comprised a tank filled with water (approximately 1770 litres) mounted on top of a truck chassis and the truck fenders mounted between the truck's three tires and the tank, which also served as fuel. Temperature measurements were conducted in the water inside the tank and on the unexposed surface of the fender. In addition, the ambient temperature over and underneath the fender was measured.

Test results, together with calculated absorbed energy, are given in Table 1-1.

Table 1-1 Test results from test 1 and test 2.

Test ID	Date of testing	Test scenario	Max avg. water temperature rise	Calculated energy absorbed by the water in the tank from T_{start} to T_{max}*
1	07.03.2019	Without PFP	26 K	193 MJ
2	07.03.2019	With PFP	32 K	238 MJ

* See section 5 for more information on the calculation of energy absorbed.

1.2 Objective

The main objective of the tests was to compare the amount of energy transferred from the heat source to the water in the tank when testing with and without PFP-cladding on the fender.

1.3 Remarks

The water tank was not insulated, which most probably lead to some heat loss during the test. However, the two tests scenarios were conducted under similar conditions and the temperature loss is considered to be neglectable when the test results between the two scenarios are for comparable purposes.

2 Method description

2.1 RISE Fire Research's fire test hall

The tests were conducted inside RISE Fire Research's large fire test hall in Trondheim, Norway. The main dimensions of the hall are approximately 17 m × 34.5 m ~ 600 m² (12 500 m³). The test hall is equipped with a ventilation system where air is supplied through ducts in the floor and extracted at ceiling level by large ventilation fans. The tests were performed with the ventilation system running on two fans and test hall doors open. A schematic sketch of the test hall is presented in Figure 2-1. The hall is also equipped with an adjustable ceiling, which can be positioned at any height. In the tests the ceiling was positioned at 10 meters.

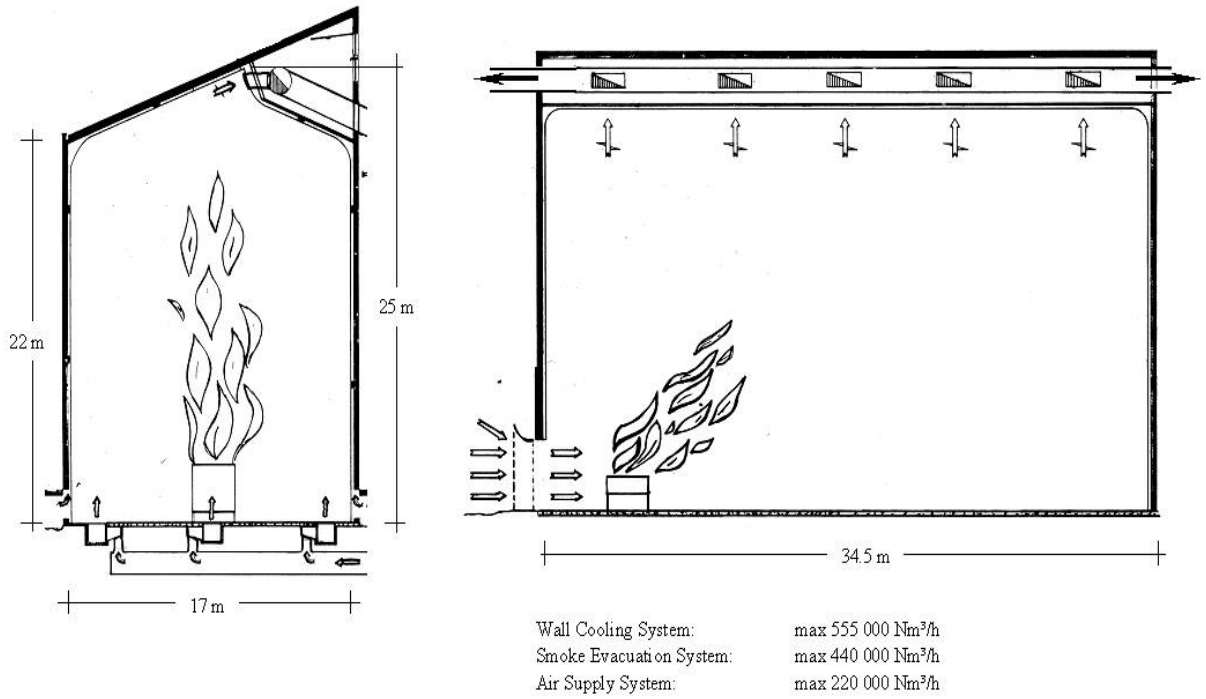

Figure 2-1 Sketch of the test hall.

3 Test setup

A steel tank, with dimensions as stated in Figure 3-1, was mounted on top of a truck chassis. The tank was filled with water and a fender was installed above the truck's three tires. The fender acted as a shield between the heat source (three tires) and the tank. The tests were performed both with and without PFP-cladding on the fender.

A propane burner was positioned under the double tires and burned for a two-minute ignition period before being removed from the tires. The duration of the tests was approximately 1 hour and 15 minutes.

Photo 3-1 *Front view of the test setup before testing. Double tires to the right and the single tyre to the left. Photo is from test 1.*

Photo 3-2 *Side view of the test setup before testing. Photo is from test 1.*

Photo 3-3 *A propane burner used to ignite the tires was placed underneath the double tires. Photo is from test 1.*

3.1 Tank

The tank was constructed in 3 mm thick steel sheets and consisted of a horizontal and a sloped part, see Figure 3-1. Four hollow stiffeners were placed inside the tank which allowed water to move freely inside the whole tank. The internal tank volume was approximately 1770 liters.

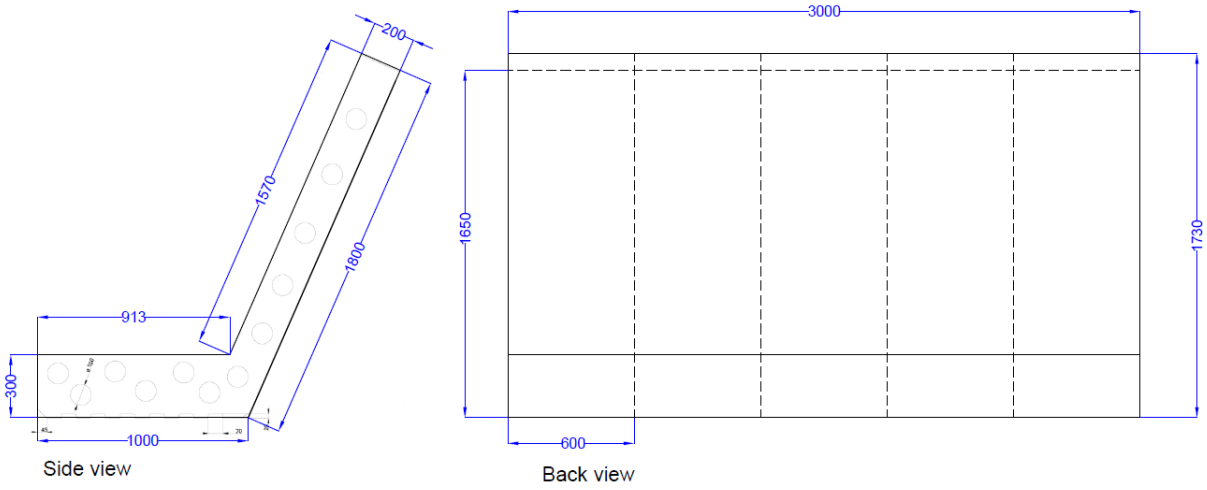

Figure 3-1 Drawing of tank.

3.2 Fender

The fenders were made of 2 mm stainless steel with the dimensions 670 mm × 2750 mm × 675 mm (W × L × H) and was mounted to the truck chassis with the help of a curved steel rod at each end and held in place with U-bolts (Photo 3-4). The fender was installed with a 15 cm gap over the tires, and a 5 cm gap to the tank.

In the PFP scenario, the fender had a 10 mm thick PFP rubber insulation mat attached to the underside of the fender (Photo 3-5).

Photo 3-4 *One of the steel rods holding the fender at the end. Photo is from test 1.*

Photo 3-5 *Exposed side of the fender with PFP. Notice that two fenders are shown in the photo.*

3.3 Tires

The dimension of the single tyre were 385 mm wide, 250 mm high from the rim to the wearing course, and the diameter of the rim 22.5 inches (385/65R22.5).

The double tires were located next to the single tyre and are two tires on the same shaft (see Photo 3-3). The double tires were 315 mm wide, 220 mm high from the rim to the wearing course and the diameter of the rim 22.5 inches (315/70R22.5).

3.4 Propane Burner

The propane burner was connected to a 200 L bottle of propane. The propane burner (NBL 1392) consisted of 19 nozzles with a diameter of 30 mm, distributed on three manifolds (see Photo 3-6). The total amount of propane consumed in each test was approximately 300 g.

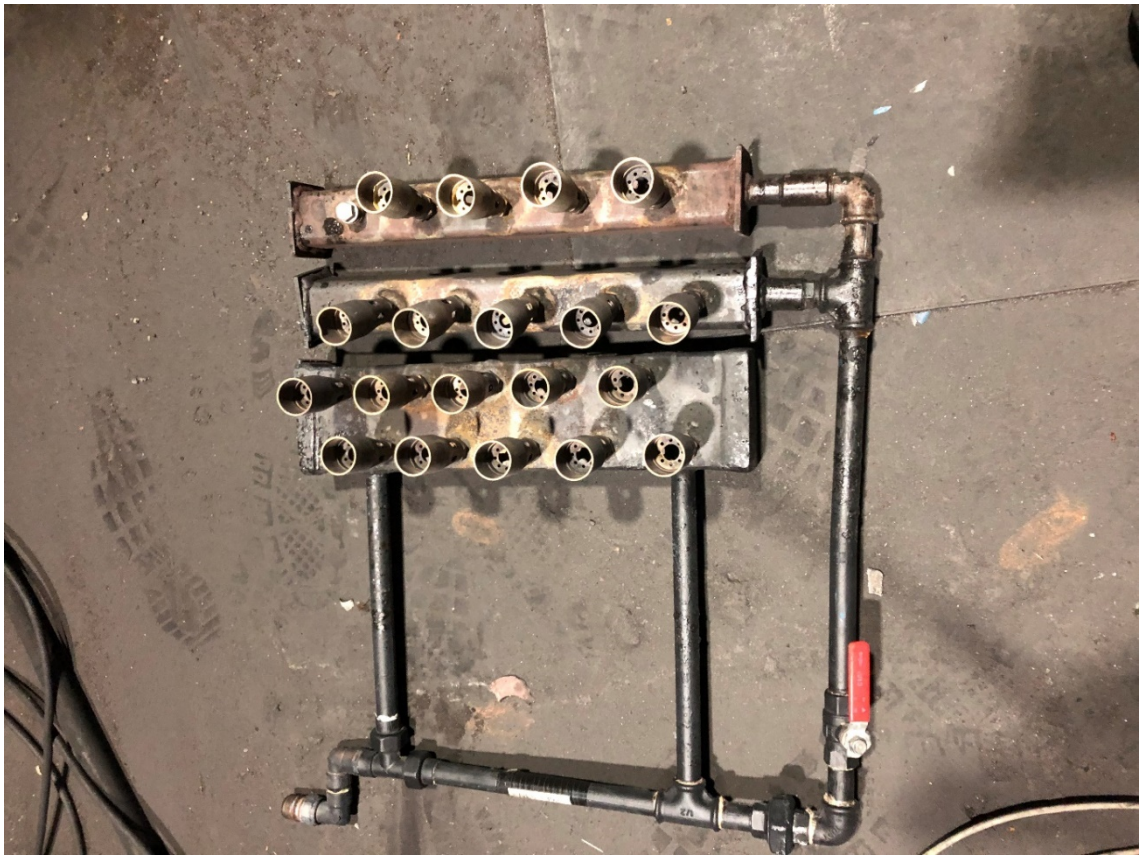

Photo 3-6 *The propane burner (NBL 1392) used in the tests.*

3.5 Instrumentation

Sheathed 1.5 mm type K (alumel/chromel alloy) thermocouples were used in the tests.

Ten thermocouples were mounted inside the tank to monitor the water temperature. There were six thermocouples in the sloped part of the tank; three near the top, one in the center and two near the bottom. Four thermocouples were installed in the horizontal part of the tank; one in the center near the slope and three thermocouples at the edge. See Figure 3-2 and Figure 3-3. The thermocouples were installed with a cone plug inside the tank and positioned at mid-depth for each position (see Figure 3-3). Table 3-1 shows the number and corresponding position (tag name) of the thermocouples.

There were five thermocouples mounted to the unexposed face of the fender to measure the surface temperatures; one thermocouple at each end, one over each tyre and one thermocouple in center (see Figure 3-4).

Two thermocouples measured the ambient temperature 20 cm over and underneath the fender, respectively (see Figure 3-4). The thermocouples were located at the center of the depth of the fender.

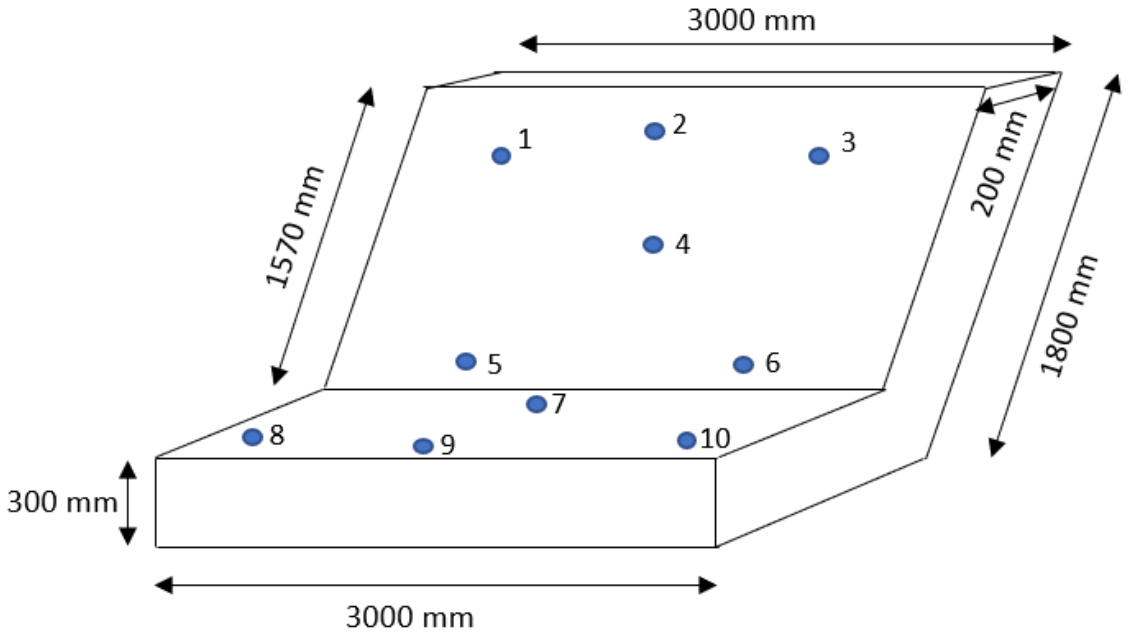

Figure 3-2 *Drawing with the approximate position for each thermocouple installed in the tank. Drawing not in scale.*

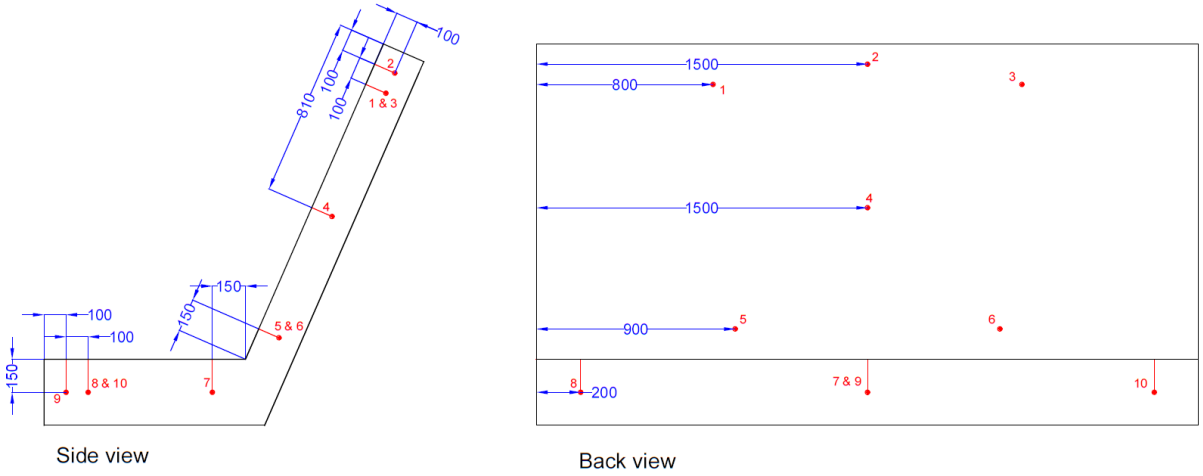

Figure 3-3 *Illustration with the approximate position of each thermocouple installed in the tank.*

Table 3-1 *Position of thermocouples in the water tank.*

Number	Instrument position
1	Slope left top
2	Slope center top
3	Slope right top
4	Slope center
5	Slope left bottom
6	Slope right bottom
7	Bottom center towards slope
8	Bottom left corner
9	Bottom center edge
10	Bottom right corner

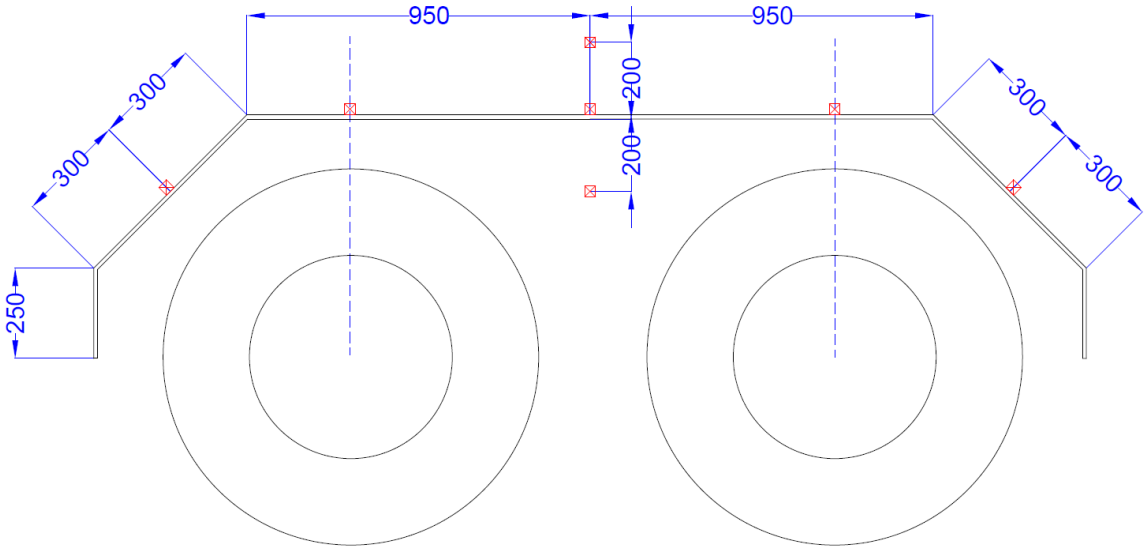

Figure 3-4 *Sketch of the positions of the thermocouples on the unexposed side of the fender and the ambient thermocouples over and underneath the fender.*

4 Photos and observations

4.1 Test 1 - Without PFP

The test was performed with a fender without PFP-cladding.

Photo 4-1 *Photos 4 minutes after ignition. IR photo to the right.*

Photo 4-2 *Photos 22 minutes after ignition. IR photo to the right.*

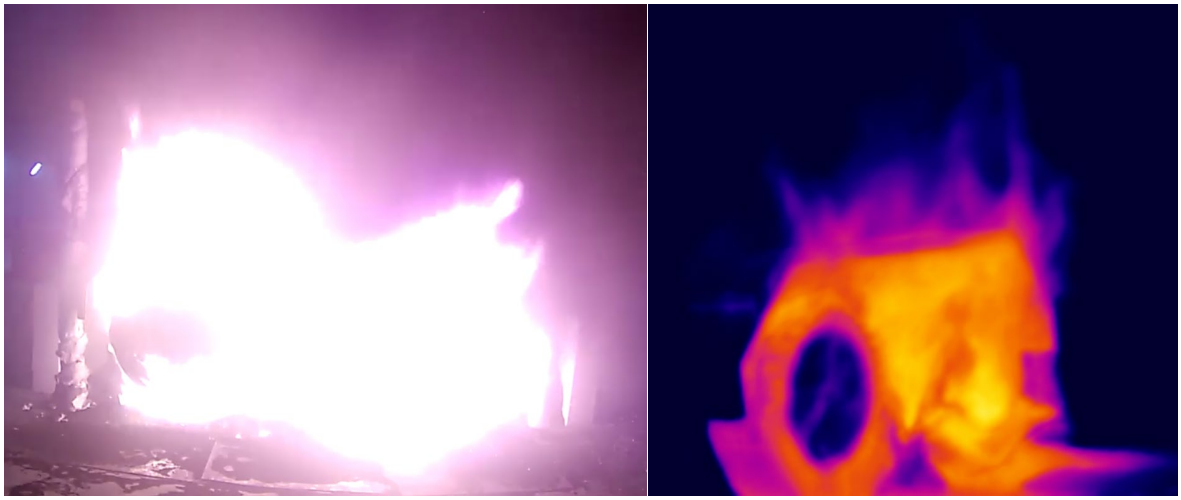

Photo 4-3 *Photos 37 minutes after ignition. IR photo to the right.*

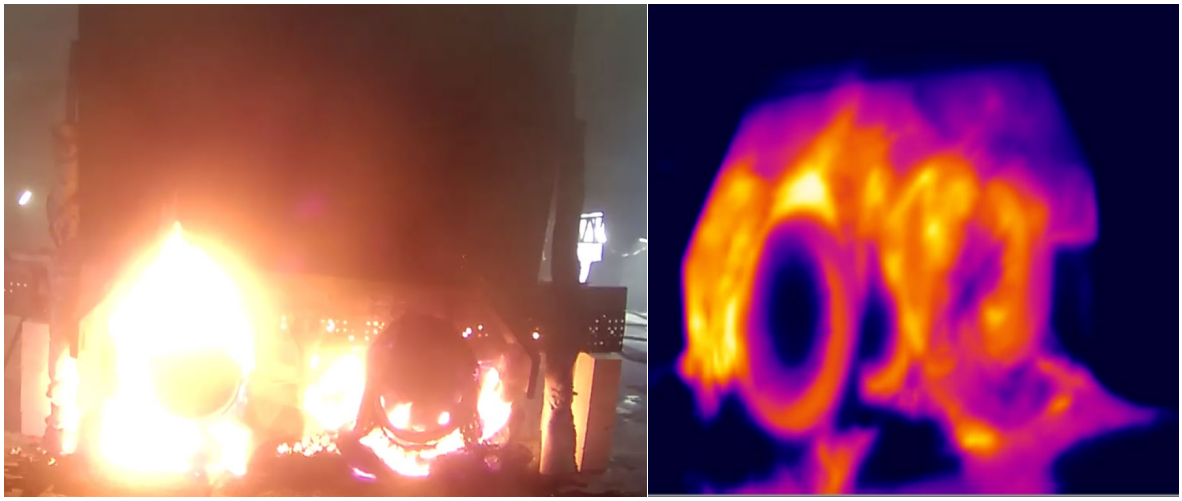

Photo 4-4 *Photos 60 minutes after ignition. IR photo to the right.*

Photo 4-5 Front view of the test setup after test 1.

Table 4-1 Observations made during test 1.

Time [hh:mm]	Observation
00:00	Propane burner is ignited.
00:02	Propane burner is removed.
00:16	The double tires have ignited on the top. The flames progress downwards. Half the single tyre is burning. Flames between the fender and the tank.
00:22	The double tires are engulfed in flames.
00:37	The single tyre is engulfed in flames.
01:02	The double tires have almost burned out. The upper part of the single tyre is still burning.
01:15	The test is terminated. Small remaining flames are extinguished manually with water.

4.2 Test 2 – With PFP

The test was performed with a fender with PFP-cladding.

Photo 4-6 *Photos 4 minutes after ignition. IR photo to the right.*

Photo 4-7 *Photos 20 minutes after ignition. IR photo to the right.*

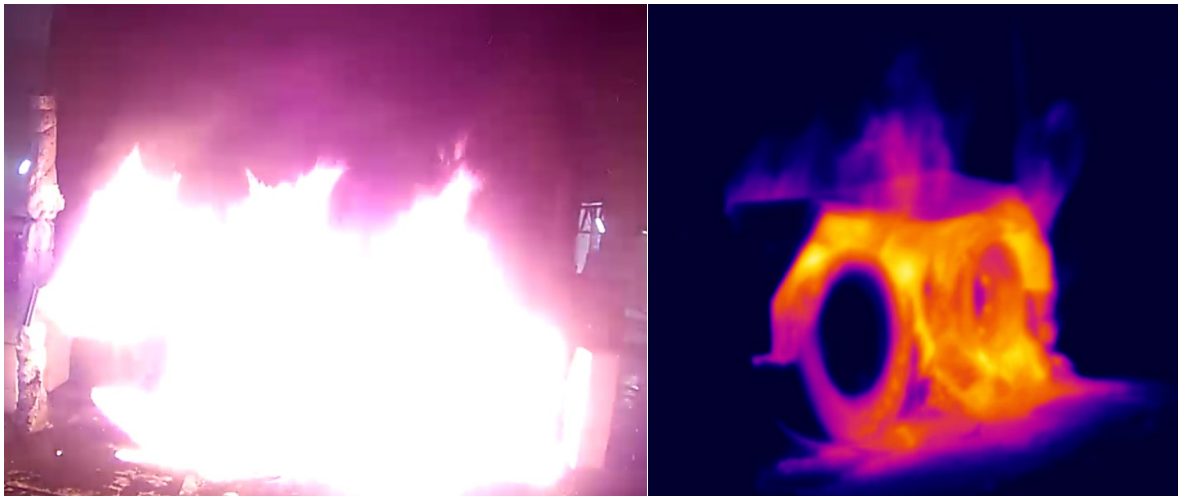

Photo 4-8 *Photos 40 minutes after ignition. IR photo to the right.*

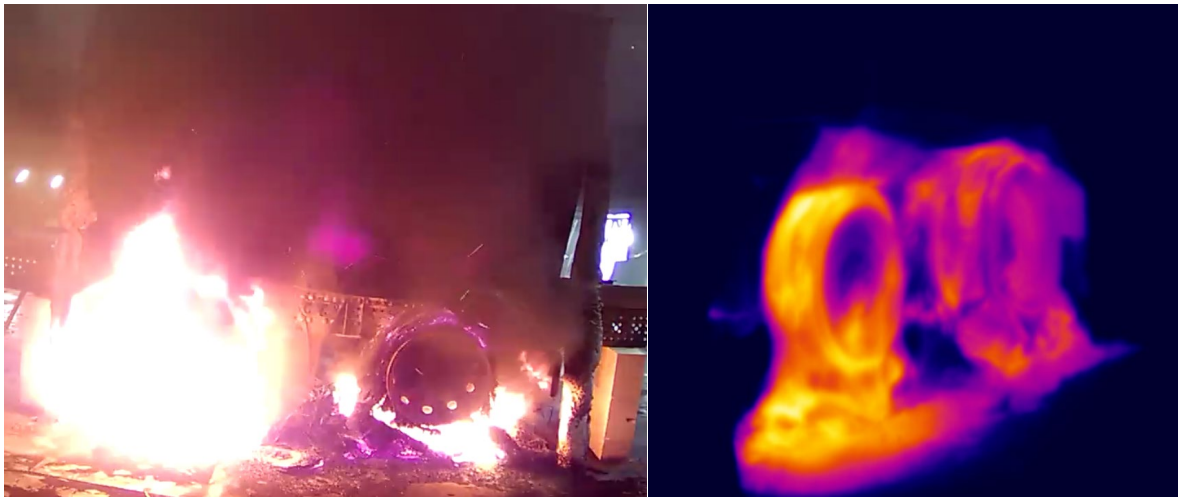

Photo 4-9 *Photos 1 hour and 3 minutes after ignition. IR photo to the right.*

Photo 4-10 Front view of the test setup after test 2.

Table 4-2 Observations made during test 2.

Time [hh:mm]	Observation
00:00	Propane burner is ignited.
00:02	Propane burner is removed.
00:06	The single tyre is burning on the side closest to the double tires and on the top. Flames between the fender and the tank.
00:20	The double tires are engulfed in flames. Half the single tyre is burning.
00:28	The single tyre rotates 90° counterclockwise.
00:40	The single tyre is engulfed in flames.
00:50	The double tires are almost burned out. The single tyre is still burning
01:03	Single tyre is close to be burned out
01:15	Test is terminated. Small remaining flames are extinguished manually with water.

5 Results and calculations

The main results and calculations of absorbed energy for the two tests are presented in Table 5-1.

Table 5-1 Test results and calculated energy absorbed by the water in the tank.

Test ID	Test scenario	Room temp. at test start	Water temp. start T_{start}	Max water temp. T_{max} and approx. time of occurrence*	Max water temp. rise $T_{max\ rise}$	Approx. energy absorbed by the water between T_{start} and T_{max}**
1	Without PFP	10 °C	5 °C	31 °C 67 min	26 K	193 MJ
2	With PFP	5 °C	3 °C	35 °C 60 min	32 K	238 MJ

* The time for the water to reach its maximum temperature have been set to the time of which the maximum temperature minus 0.5 °C was reached. The water temperature refers to the measured average temperature of the water in the tank.

** The energy absorbed by the water in the tank is only calculated using the start temperature of the water and the maximum water temperature. The energy absorbed after the maximum temperature in the water has not been part of the calculations. The calculations have been done assuming an adiabatic process between the heat source, the tank and the water.

5.1 Calculations

From equation (1) [1] the energy absorbed by the water during the test can be estimated.

$$Q = c_v m \Delta T \quad (1)$$

where

Q energy [kJ]
c_v specific heat capacity (isochoric) [kJ/kgK] = 4.2 kJ/kgK
m mass [kg] = 1770 kg
ΔT temperature difference, $T_{max} - T_{start}$ [K]

The calculations are based on a specific heat capacity (water) of 4.2 kJ/kgK.

[1] Johannessen, Jarle: Tekniske tabeller, J.W. Cappelens Forlag A/S, 2002

A Graphical presentation of measured temperatures

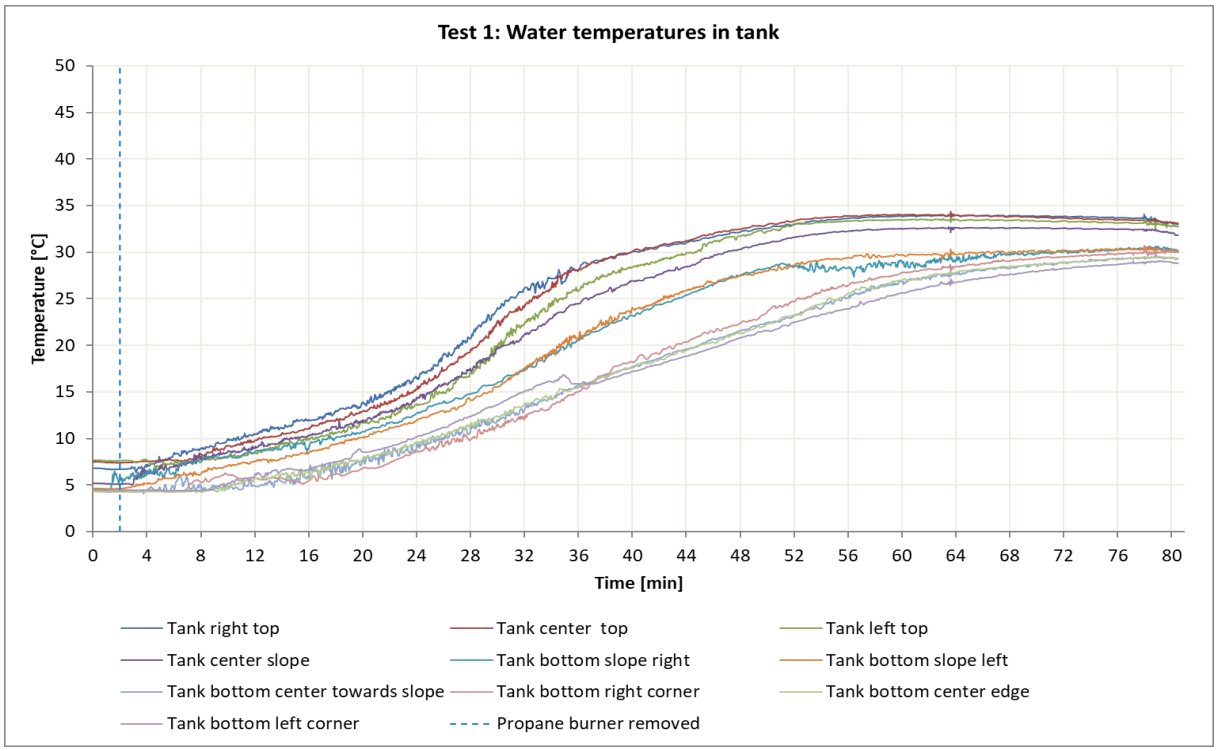

Figure A-1 *Test 1: Water temperatures in tank.*

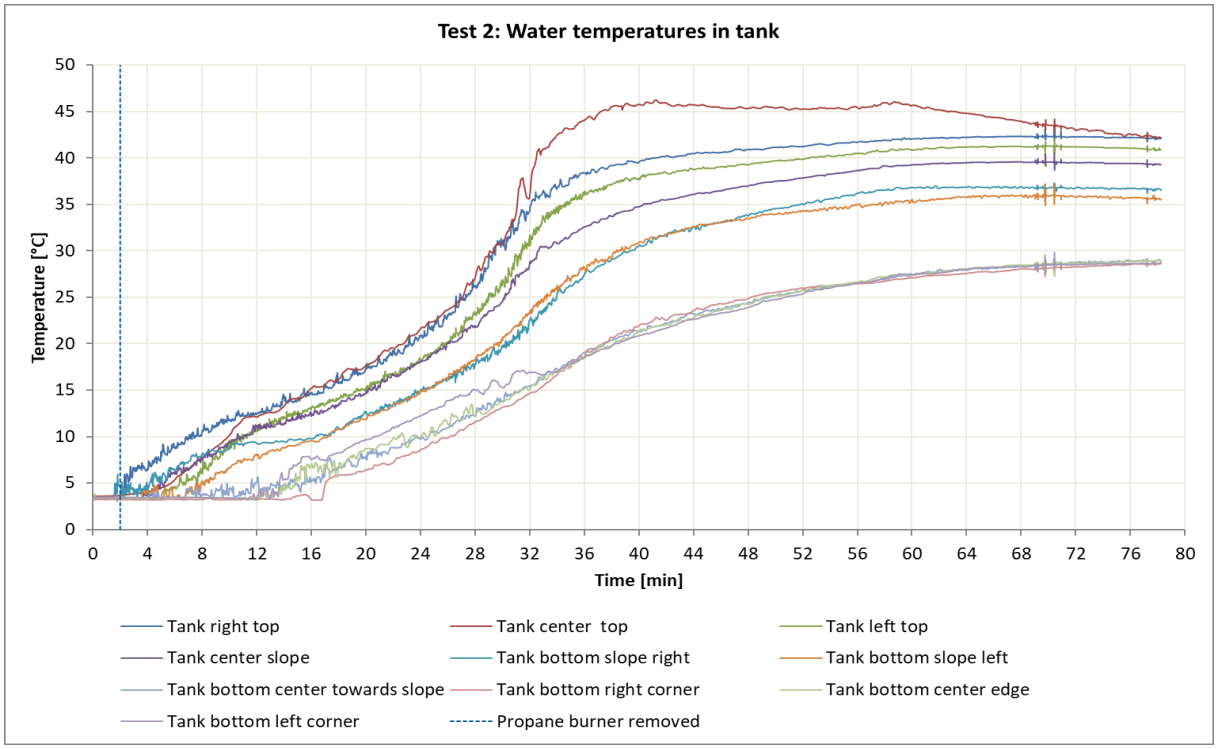

Figure A-2 *Test 2: Water temperatures in tank.*

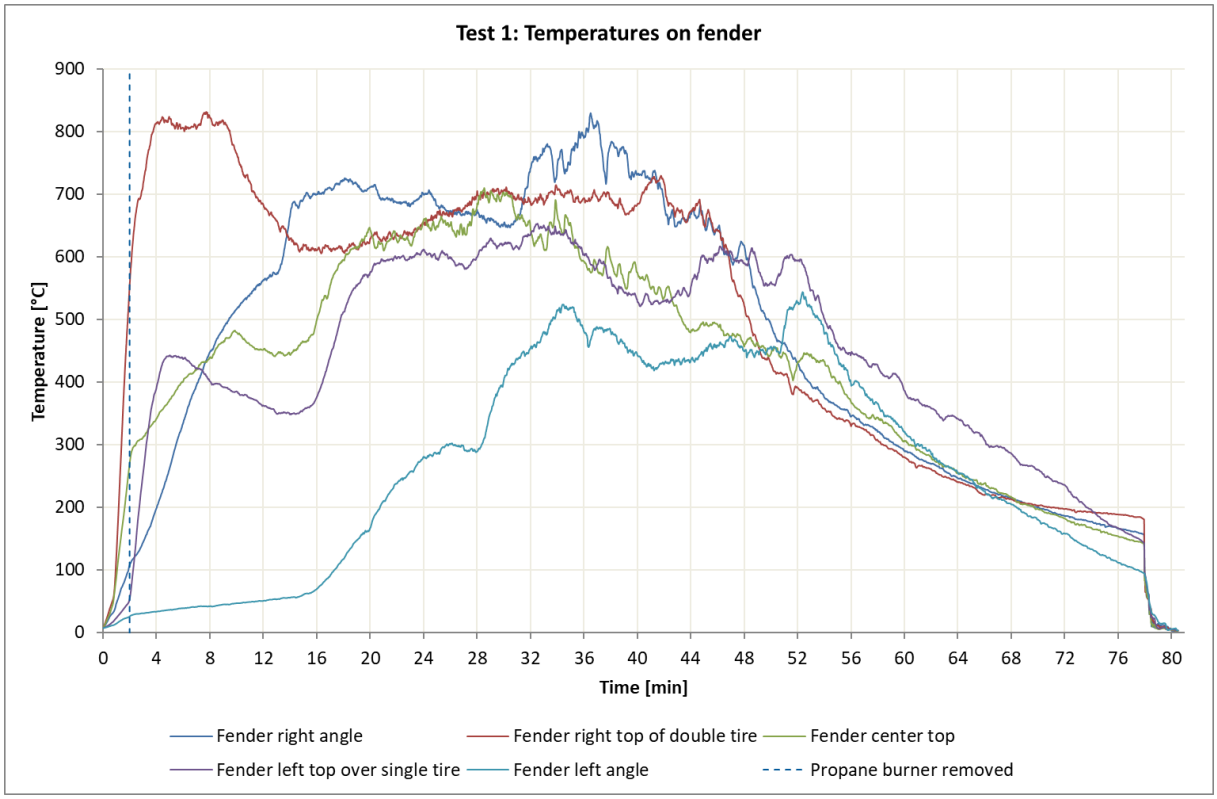

Figure A-3 *Test 1: Temperature on top of the fender.*

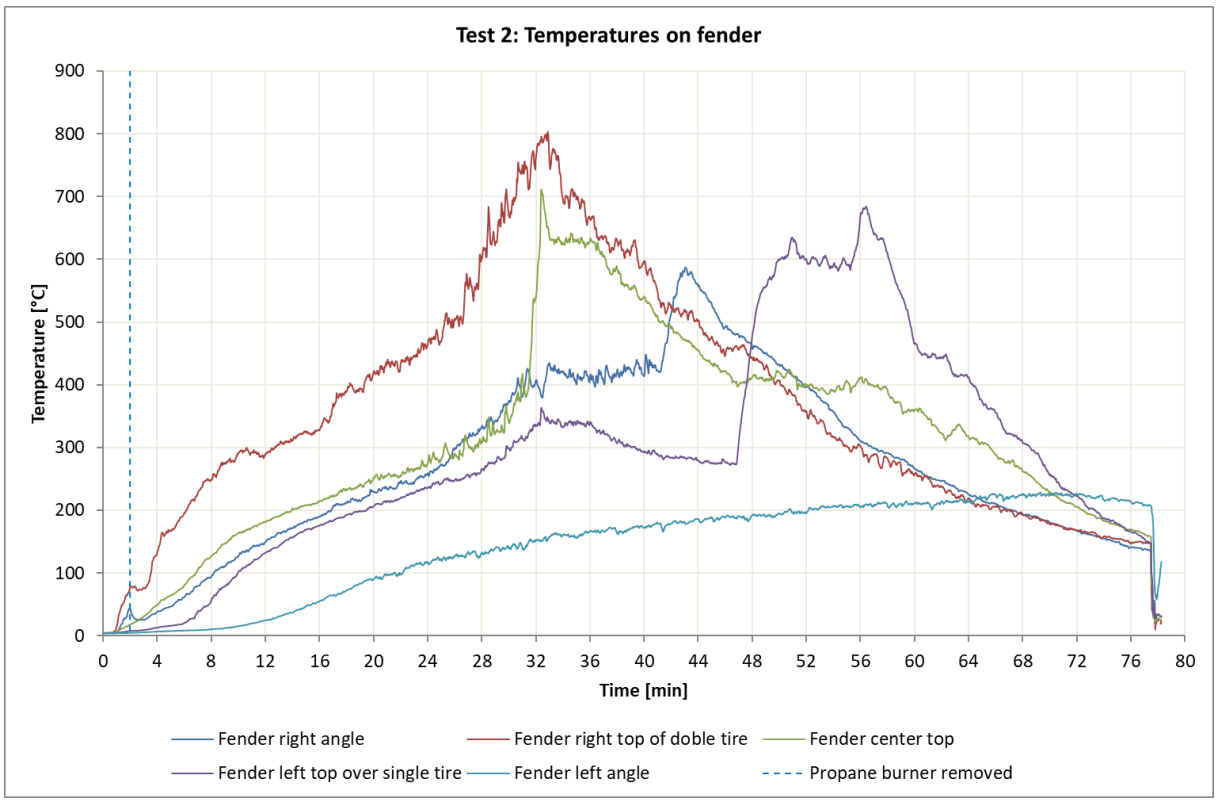

Figure A-4 *Test 2: Temperature on top of the fender*

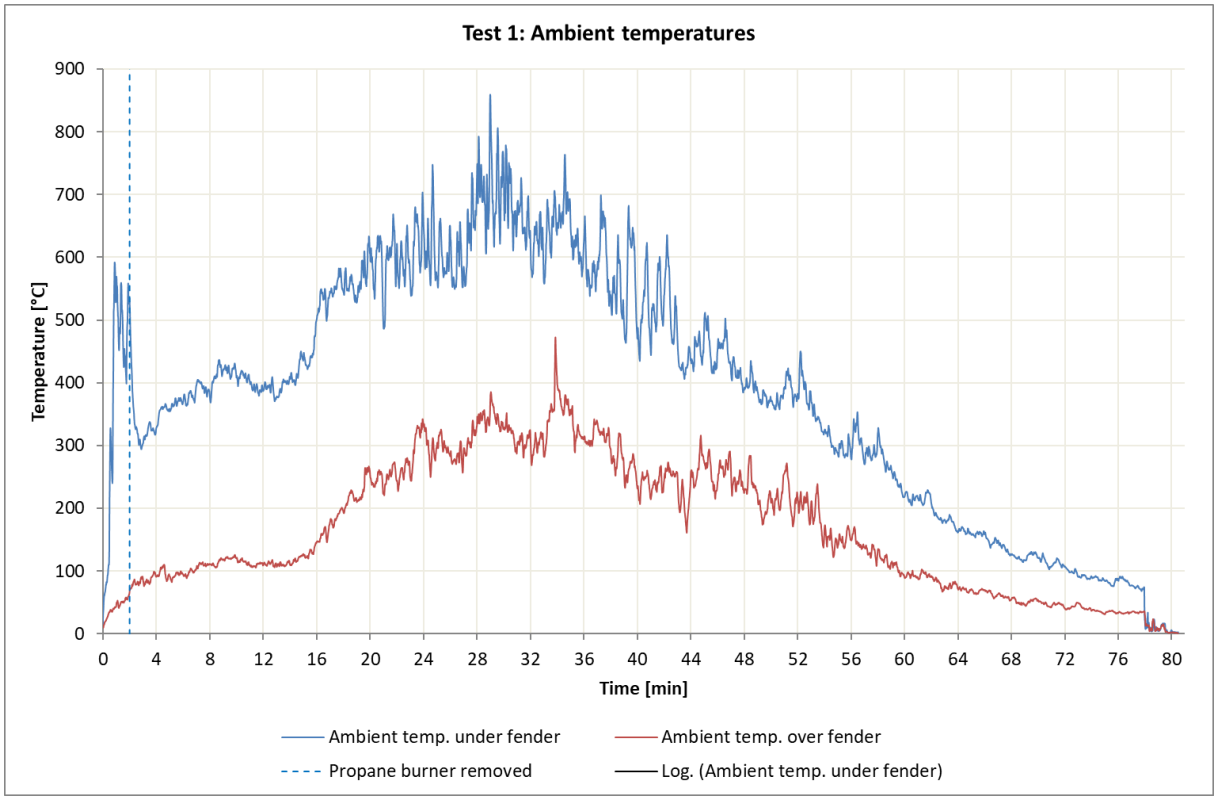

Figure A-5 *Test 1: Ambient temperature at the fender.*

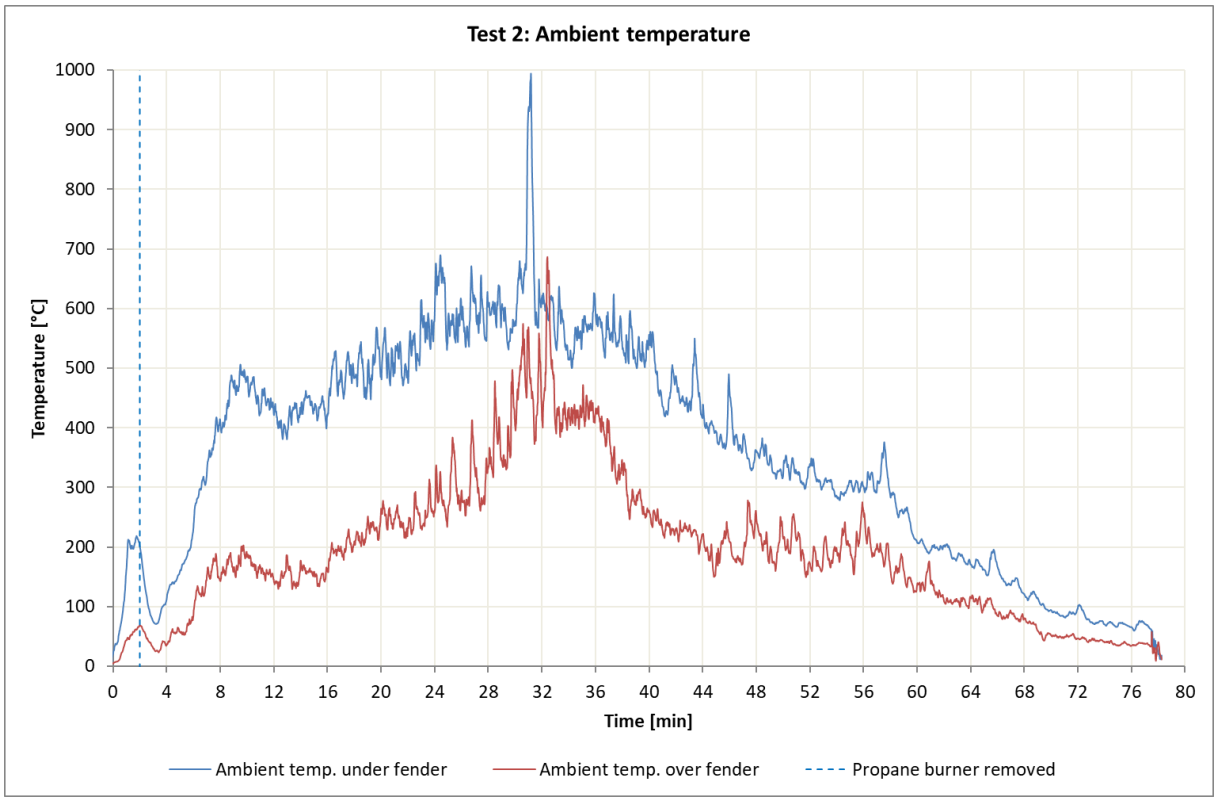

Figure A-6 *Test 2: Ambient temperature at the fender.*

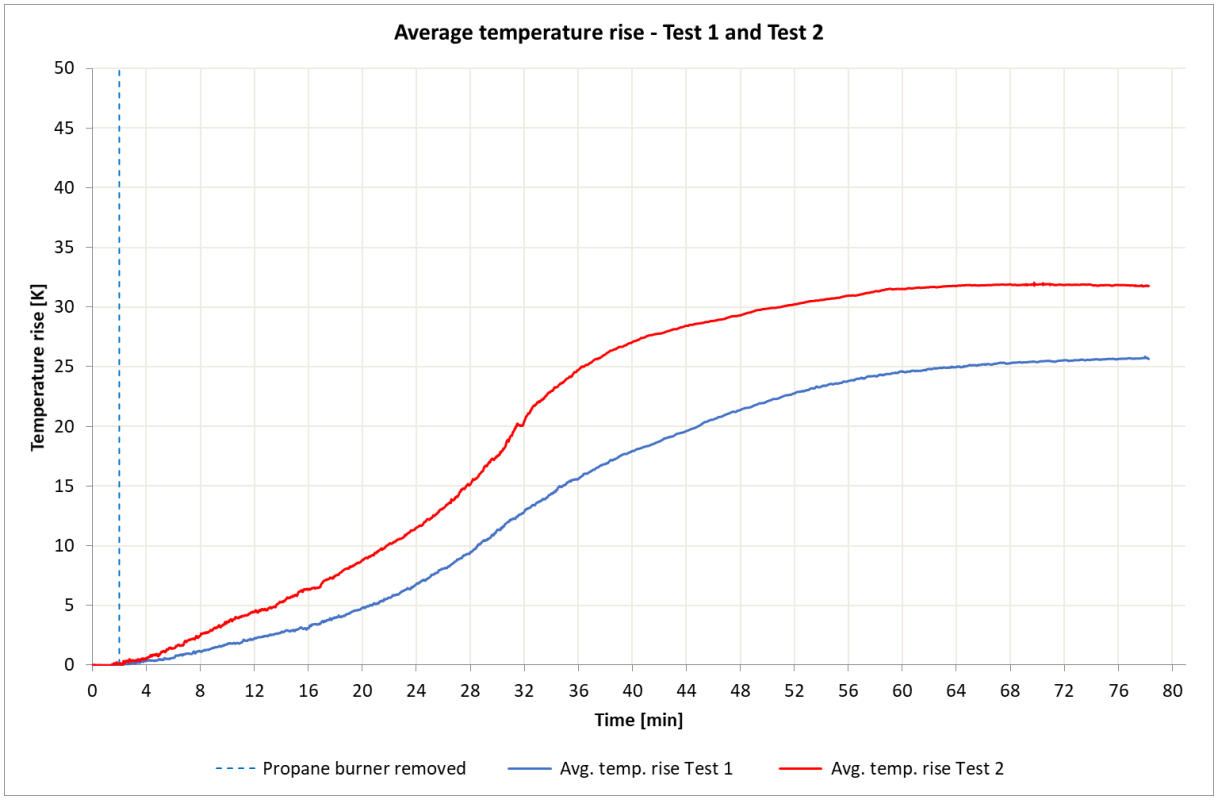

Figure A-7 *Average water temperature rise for test 1 and test 2.*

RISE Fire Research AS

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