

3.5 Fire Resistance

3.5.1 Rationale

Simulates exposure of [RESS] to fire from the outside of the vehicle due to e.g. a fuel spill from a vehicle (either the vehicle itself or a nearby vehicle). This situation should leave the driver and passengers with enough time to evacuate and no explosion should occur in a later stage.

3.5.2 Requirement

The test is required for [RESS] to be placed at a level less than 1.5 m above ground. The test is carried out on one item.

3.5.2.1 Conditions – vehicle based test

3.5.2.1.1. SOC

The [RESS] shall be at any state of charge, which allows the normal operation of the power train as recommended by the manufacturer.

3.5.2.1.2. The RESS shall be conditioned of period of not less than 8 h at a temperature of 20 ± 5 °C.

3.5.2.1.3. The RESS shall be installed in a testing fixture simulating actual mounting conditions as far as possible; no combustible material should be used for this except the material that is part of the RESS. The method whereby the RESS is fixed in the fixture shall correspond to the relevant specifications for its installation. In the case of [RESS] designed for a specific vehicle use, vehicle parts which affect the course of the fire in any way shall be taken into consideration.

3.5.2.1.4. The flame to which the RESS is exposed shall be obtained by burning commercial fuel for positive-ignition engines (hereafter called "fuel") in a pan. The quantity of fuel poured into the pan shall be sufficient to permit the flame, under free-burning conditions, to burn for the whole test procedure, i.e. at least 15 litres/m². The fuel temperature should be $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$.

Water should be poured at the bottom of the pan to ensure a flat bottom of the pan. The water temperature should be $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The pan dimensions shall be chosen so as to ensure that the sides of the RESS are exposed to the flame. The pan shall therefore exceed the horizontal projection of the RESS by at least 20 cm, but not more than 50 cm. The sidewalls of the pan shall not project more than 8 cm above the level of the fuel at the start of the test.

In cases when the RESS is distributed over the vehicle it is possible to run the test on each subpart of the RESS.

If it is not possible to arrange with a $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ of the fuel and the water then the test needs to be conducted with a 1 minute pre-heating period.

3.5.2.1.5. The pan filled with fuel shall be placed under the RESS in such a way that the distance between the level of the fuel in the pan and the RESS bottom

corresponds to the design height of the RESS above the road surface at the unladen mass. Either the pan, or the testing fixture, or both, shall be freely movable.

3.5.2.1.6. During phase C of the test, the pan shall be covered by a screen placed 3 cm +/- 1 cm above the fuel level. The screen shall be made of a refractory material, as prescribed in [Annex 2]. There shall be no gap between the bricks and they shall be supported over the fuel pan in such a manner that the holes in the bricks are not obstructed. The length and width of the frame shall be 2 cm to 4 cm smaller than the interior dimensions of the pan so that a gap of 1 cm to 2 cm exists between the frame and the wall of the pan to allow ventilation. Before the test the screen shall be heated to 308 K +/- 5 K (35 degrees C +/- 5 degrees C). The firebricks may be wetted in order to guarantee the repeatable test conditions.

3.5.2.1.7. -If the tests are carried out in the open air, sufficient wind protection shall be provided and the wind velocity at pan level shall not exceed 2.5 km/h.

3.5.2.1.8. The test shall comprise of three phases B-D. If it is not possible to arrange with a $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ of the fuel and the water then the test shall comprise of four phases.

3.5.2.1.8.1. Phase A: Pre-heating to ensure stable fuel temperature (Figure 1)

This phase is required if it is not possible to arrange with a $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ of the fuel and the water. The fuel in the pan shall be ignited at a distance of at least 3 m from the RESS and mock-up being tested. After 60 seconds pre-heating, the pan shall be placed under the RESS and mock-up. If the size of the pan is too large to be moved without risking liquid spills etc. then the RESS and test rig can be moved instead of the pan.

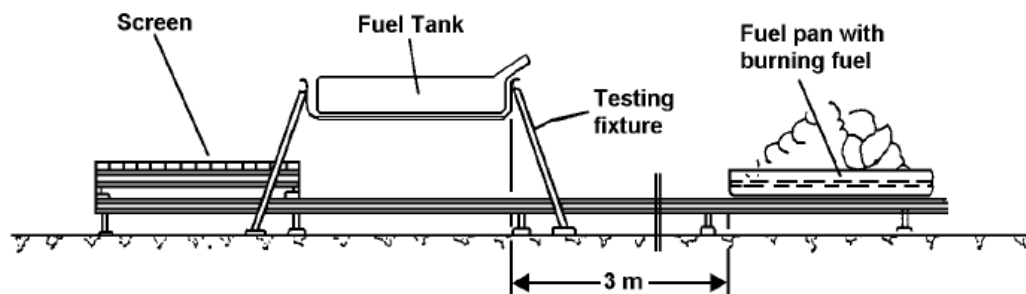


Figure 1

3.5.2.1.8.2. Phase B: Direct exposure to flame (Figure 2)

For 70 seconds the RESS and mock-up shall be exposed to the flame from the freely burning fuel.

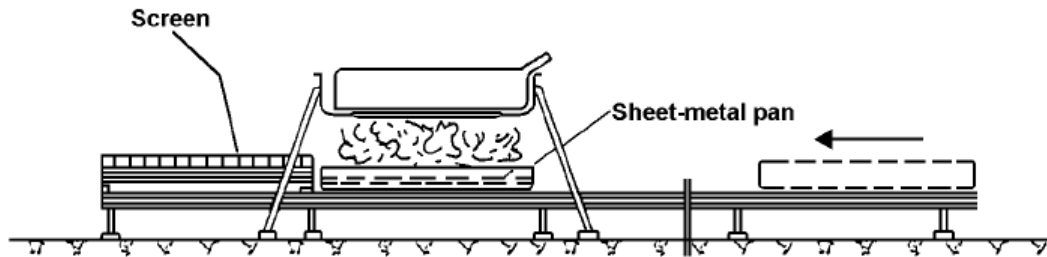


Figure 2

3.5.2.1.8.3. Phase C: Indirect exposure to flame (Figure 3)

As soon as phase B has been completed, the screen shall be placed between the burning pan and the RESS and mock-up. The RESS shall be exposed to this reduced flame for a further 60 seconds.

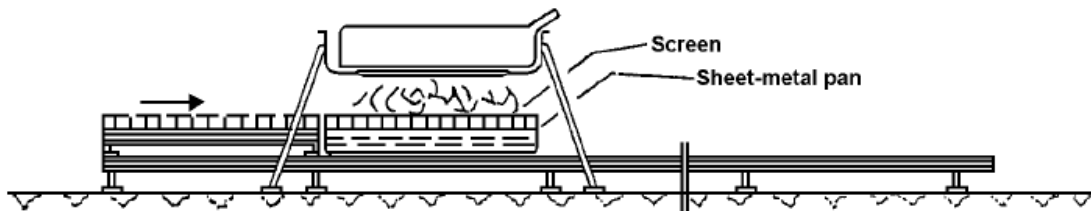


Figure 3

3.5.2.1.8.4. Phase D: End of test (Figure 4)

The burning pan covered with the screen shall be moved at least 3 m away from the RESS. No extinguishing of the RESS shall be done. The RESS shall be monitored for 24 h after the removal of the pan. At the manufacturer's discretion, temperature measurements might be installed in the RESS and then phase D can be stopped as soon as a stable decrease of the RESS temperature is observed.

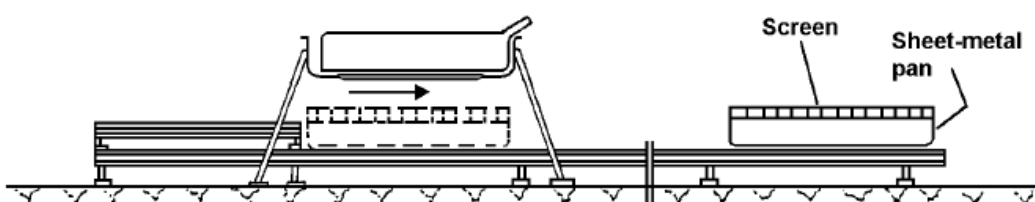


Figure 4

3.5.2.2 Conditions - component based test

A complete RESS is to be tested for this condition. However, if conducting this test on a RESS is deemed inappropriate due to size or weight; this test may be conducted utilizing subsystem(s) including respective battery module(s), provided that all portions of the battery module(s) of the RESS are evaluated. If tests are performed on subsystem basis, evidence shall be provided that the results are representative for RESS.

3.5.2.2.1. SOC

The [RESS] shall be at any state of charge, which allows the normal operation of the power train as recommended by the manufacturer.

3.5.2.2.2. The RESS shall be conditioned of period of not less than 6 h at a temperature of 20 ± 5 °C.

3.5.2.2.3. The RESS or module should be placed on a grating table positioned above the pan. The grating table shall be constructed by steel rods, diameter 6-10 mm, with 4-6 cm in between. If needed the steel rods could be supported by flat steel parts.

3.5.2.2.4. The flame to which the RESS is exposed shall be obtained by burning commercial fuel for positive-ignition engines (hereafter called "fuel") in a pan. The quantity of fuel poured into the pan shall be sufficient to permit the flame, under free-burning conditions, to burn for the whole test procedure, i.e. at least 15 litres/m². The fuel temperature should be $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$.

Water should be poured at the bottom of the pan to ensure a flat bottom of the pan. The water temperature should be $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The pan dimensions shall be chosen so as to ensure that the sides of the RESS or module are exposed to the flame. The pan shall therefore exceed the horizontal projection of the RESS or module by at least 20 cm, but not more than 50 cm but for small RESS or module the minimum pan size shall be 50x50 cm. The sidewalls of the pan shall not project more than 8 cm above the level of the fuel at the start of the test.

If it is not possible to arrange with a $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ of the fuel and the water then the test needs to be conducted with a 1 minute pre-heating period.

3.5.2.2.5. The pan filled with fuel shall be placed under the RESS or module in such a way that the distance between the level of the fuel in the pan and the RESS bottom is 50 cm. Either the pan, or the testing fixture, or both, shall be freely movable.

3.5.2.2.6. During phase C of the test, the pan shall be covered by a screen placed 3 cm +/- 1 cm above the fuel level. The screen shall be made of a refractory material, as prescribed in [Annex 2]. There shall be no gap between the bricks and they shall be supported over the fuel pan in such a manner that the holes in the bricks are not obstructed. The length and width of the frame shall be 2 cm to 4 cm smaller than the interior dimensions of the pan so that a gap of 1 cm to 2 cm exists between the frame and the wall of the pan to allow ventilation. Before the test the screen shall be heated to 308 K +/- 5 K (35 degrees C +/- 5 degrees C). The firebricks may be wetted in order to guarantee the repeatable test conditions.

3.5.2.2.7. If the tests are carried out in the open air, sufficient wind protection shall be provided and the wind velocity at pan level shall not exceed 2.5 km/h.

3.5.2.2.8. The test shall comprise of three phases. If it is not possible to arrange with a $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ of the fuel and the water then the test shall comprise of four phases.

3.5.2.2.8.1. Phase A: Pre-heating to ensure stable fuel temperature (Figure 5)

This phase is required if it is not possible to arrange with a $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ of the fuel and the water. The fuel in the pan shall be ignited at a distance of at least 3 m from the

RESS or module being tested. After 60 seconds pre-heating, the pan shall be placed under the RESS or module. If the size of the pan is too large to be moved without risking liquid spills etc. then the RESS and test rig can be moved instead of the pan.

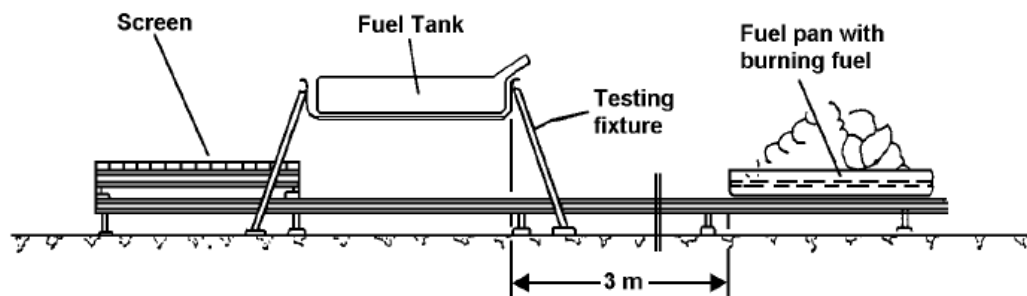


Figure 5

3.5.2.2.8.2. Phase B: Direct exposure to flame (Figure 6)

For 70 seconds the RESS or module shall be exposed to the flame from the freely burning fuel.

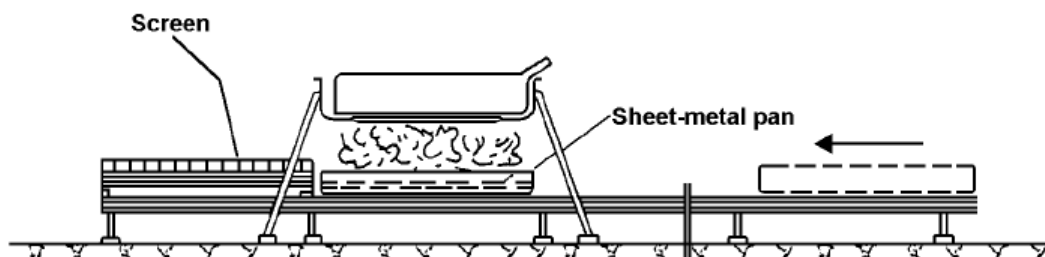


Figure 6

3.5.2.2.8.3. Phase C: Indirect exposure to flame (Figure 7)

As soon as phase B has been completed, the screen shall be placed between the burning pan and the RESS and mock-up. The RESS shall be exposed to this reduced flame for a further 60 seconds.

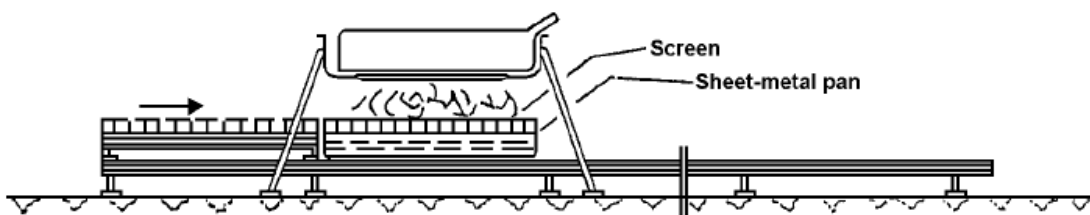


Figure 7

3.5.2.2.8.4. Phase D: End of test (Figure 8)

The burning pan covered with the screen shall be moved at least 3 m away from the RESS or module. No extinguishing of the RESS or module shall be done. The RESS or module shall be monitored for 24 h after the removal of the pan. At the manufacturers discretion temperature measurements might be installed in the RESS or module and then phase D can be stopped as soon as a stable decrease of the RESS or module temperature is observed.

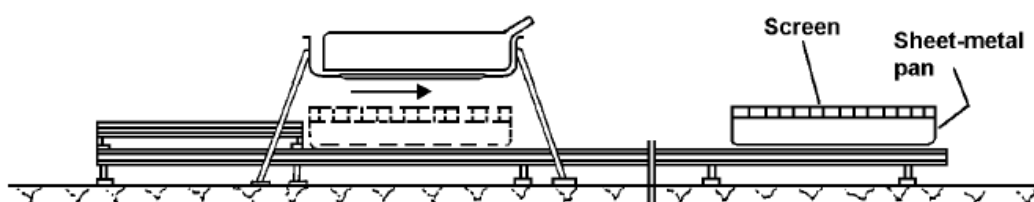


Figure 8

3.5.2.3 Acceptance criteria

During Phase A to D of the test, the RESS shall exhibit no evidence of explosion or rupture. Explosion is determined as no flying parts larger than 5 cm in size or sudden large increase of flames.

No dangerous voltages shall be available on the chassis or RESS.

3.5.3 Verification

The explosion and rupture criterion is verified by visual inspection.

Voltage levels towards ground shall be continuously measured during phase A to D