

In case of inert gases, the oxygen concentration can be measured. Then for calculating oxygen concentration from agent concentration and vice versa, the measured start concentration of oxygen shall be taken into account, using Formula (C.6):

$$C_E = 100 \left(1 - \frac{C_O}{C_{\text{start}}} \right) \quad (\text{C.6})$$

where

C_E is the extinguishant concentration, as a volume fraction in percent;

C_O is the oxygen concentration measured in the test enclosure, as a volume fraction in percent;

C_{start} is the oxygen concentration measured in the test enclosure at the start of the test, as a volume fraction in percent.

The extinguishing concentration for each fire test is then calculated from the highest mass of agent that has been used in the three positive fire tests. For the calculation, the formula verified (and if necessary modified) on basis of the cold discharge test shall be used.

That means for evaluation of the fire test data in case of using the modified formula that the room temperature and atmospheric pressure at beginning of each fire test have to be chosen, the general correction factor is room specific and stays the same.

C.5 Nozzle distribution verification tests

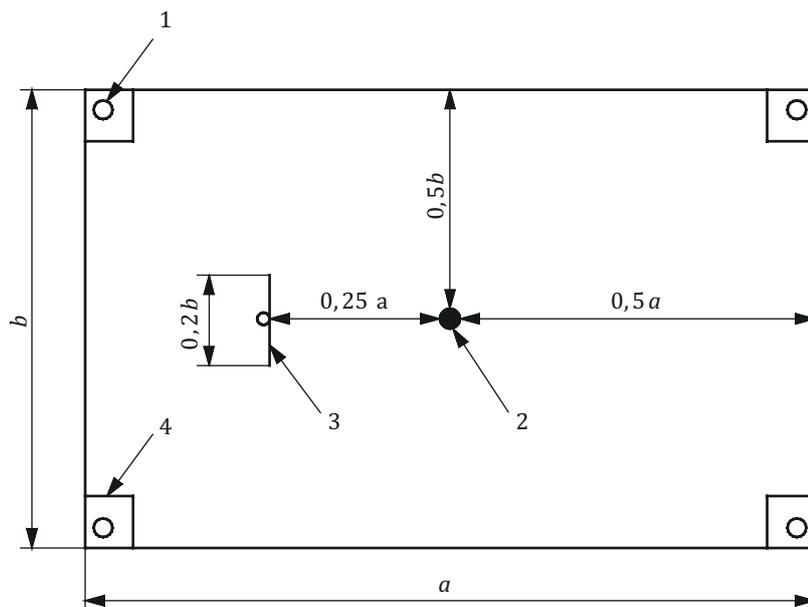
C.5.1 Nozzle minimum height/maximum area coverage test

C.5.1.1 Test facility

C.5.1.1.1 Construction

The test enclosure shall meet the following requirements.

- a) The area, $a \times b$ (see [Figures C.1](#) and [C.2](#)), and height, H , of the enclosure shall correspond respectively to the maximum nozzle area coverage and minimum nozzle height as specified in the extinguishing system unit manufacturer's installation instructions.
- b) A means of pressure relief shall be provided to limit the pressure change with a cold discharge to ± 300 Pa.
- c) Closable openings shall be provided directly above the test cans to allow for ventilation prior to system actuation.
- d) One baffle shall be installed between the floor and ceiling with the height of the enclosure. It shall be installed halfway between the nozzle location and one wall of the enclosure. The baffle shall be perpendicular to the long walls of the enclosure and 20 % of the length of the short wall of the enclosure (see [Figure C.1](#) for 360° nozzle and [Figure C.2](#) for 180° nozzle).

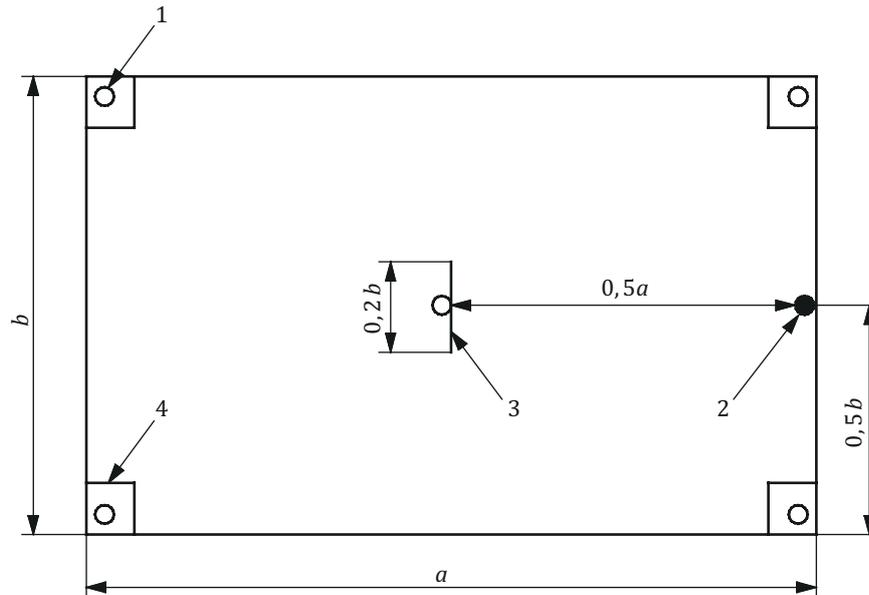


Key

- 1 test cans
- 2 nozzle
- 3 baffle
- 4 vents

NOTE $a \times b$ = maximum nozzle area coverage for a single nozzle.

Figure C.1 — Example configuration for nozzle minimum height/maximum area coverage test for 360° nozzle

**Key**

- 1 test cans
- 2 nozzle
- 3 baffle
- 4 vents

NOTE $a \times b$ = maximum nozzle area coverage for a single nozzle.

Figure C.2 — Example configuration for nozzle minimum height/maximum area coverage test for 180° nozzle

C.5.1.1.2 Instrumentation

Sampling and storage of data from the sensors described below shall occur at a rate of at least 10 Hz.

NOTE The single data points to determine agent mass and atmospheric pressure are not required to be sampled and stored at a rate of at least 10 Hz.

C.5.1.1.2.1 Oxygen concentration sensors

The oxygen concentration shall be measured and recorded using a calibrated oxygen analyzer having an accuracy of 0,1 vol % oxygen or better. The sensing equipment shall continuously monitor and record the oxygen level within the enclosure throughout the duration of the test. The accuracy of the measuring devices shall not be influenced by any of the fire products.

At least three sensors shall be located within the enclosure (see [Figures C.3](#) and [C.4](#)). All sensors shall be located horizontally 850 mm to 1 250 mm from the centre of the enclosure and at least three sensors at the following heights: 0,1 H, 0,5 H and 0,9 H (H = height of the enclosure).

C.5.1.1.2.2 Nozzle pressure sensor

During system discharge, the nozzle pressure shall be measured and recorded by a pressure transducer attached to the pipe at a distance no greater than 1 m from the nozzle.

C.5.1.1.2.3 Enclosure temperature sensors

The temperature within the enclosure shall be measured and recorded (See [Figures C.3](#) and [C.4](#)). At least one sensor shall be located horizontally 850 mm to 1 250 mm from the centre of the enclosure and at the following height: 0,5 H (H = height of the enclosure).

The temperature in the test enclosure shall be $20\text{ °C} \pm 5\text{ °C}$ at the beginning of each test.

C.5.1.1.2.4 Nozzle temperature sensor

During system discharge of liquefied extinguishants, the liquid jet temperature just outside the nozzle shall be measured and recorded.

C.5.1.1.2.5 Agent concentration sensors

For the cold discharge tests with liquefied extinguishants, the agent concentration shall be measured and recorded by a calibrated extinguishant analyzer appropriate for the extinguishant in use having an accuracy of 0,2 vol % or better.

For the cold discharge tests with non-liquefied extinguishants, the agent concentration or alternatively the oxygen concentration shall be measured and recorded. For measurement of agent concentration, the requirements specified for liquefied extinguishants apply. For measurement of oxygen concentration, the requirements according to [C.5.1.1.2.1](#) apply.

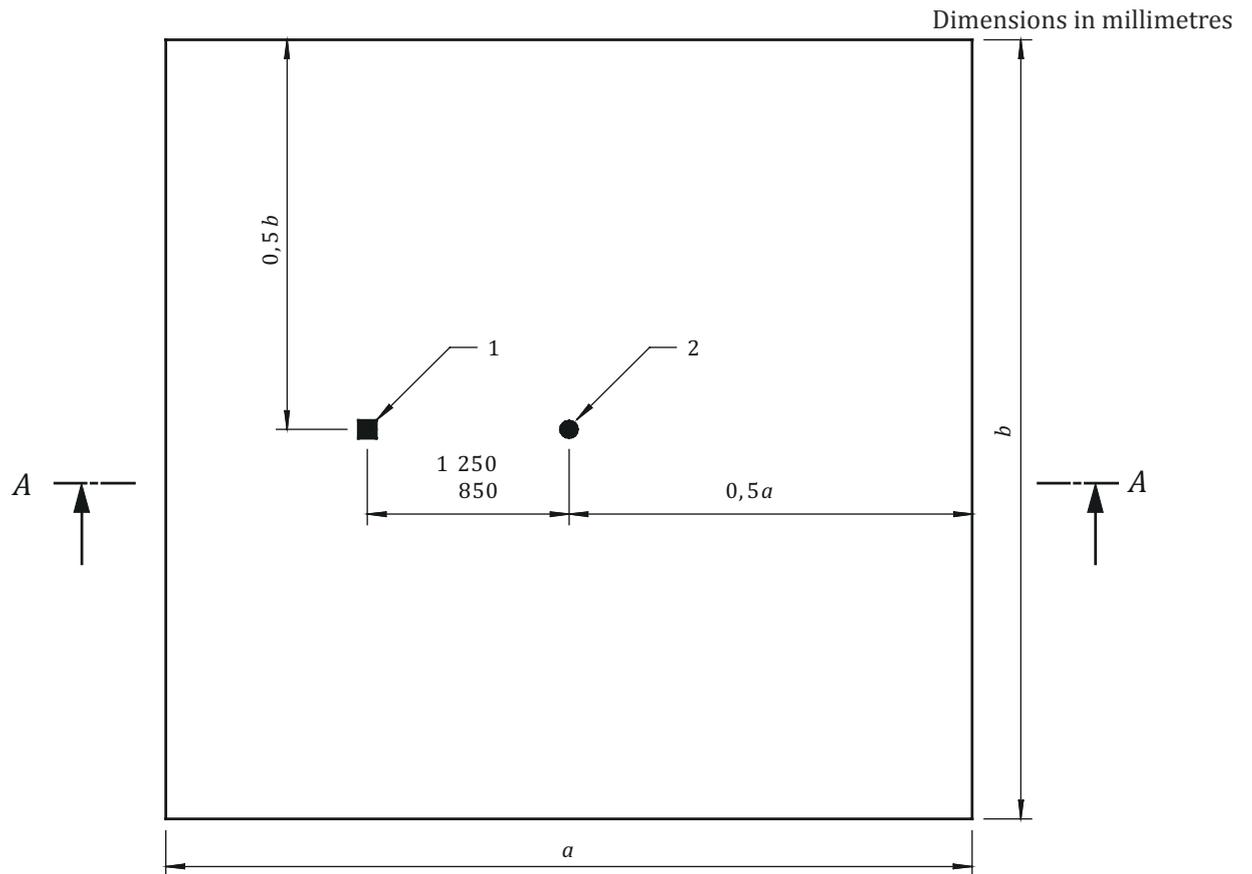
The sensors for measurement of agent concentration or oxygen concentration shall be located as specified in [C.5.1.1.2.1](#). The sensing equipment shall continuously monitor and record the concentration within the enclosure at least until the concentration stabilizes.

C.5.1.1.2.6 Agent mass

The mass of agent discharged shall be determined by calculation from the measured mass of the agent container before and after filling the container and before and after the discharge. The mass shall be measured and recorded using a calibrated weighing device capable of measuring the mass to one decimal place (0,1 kg) or better.

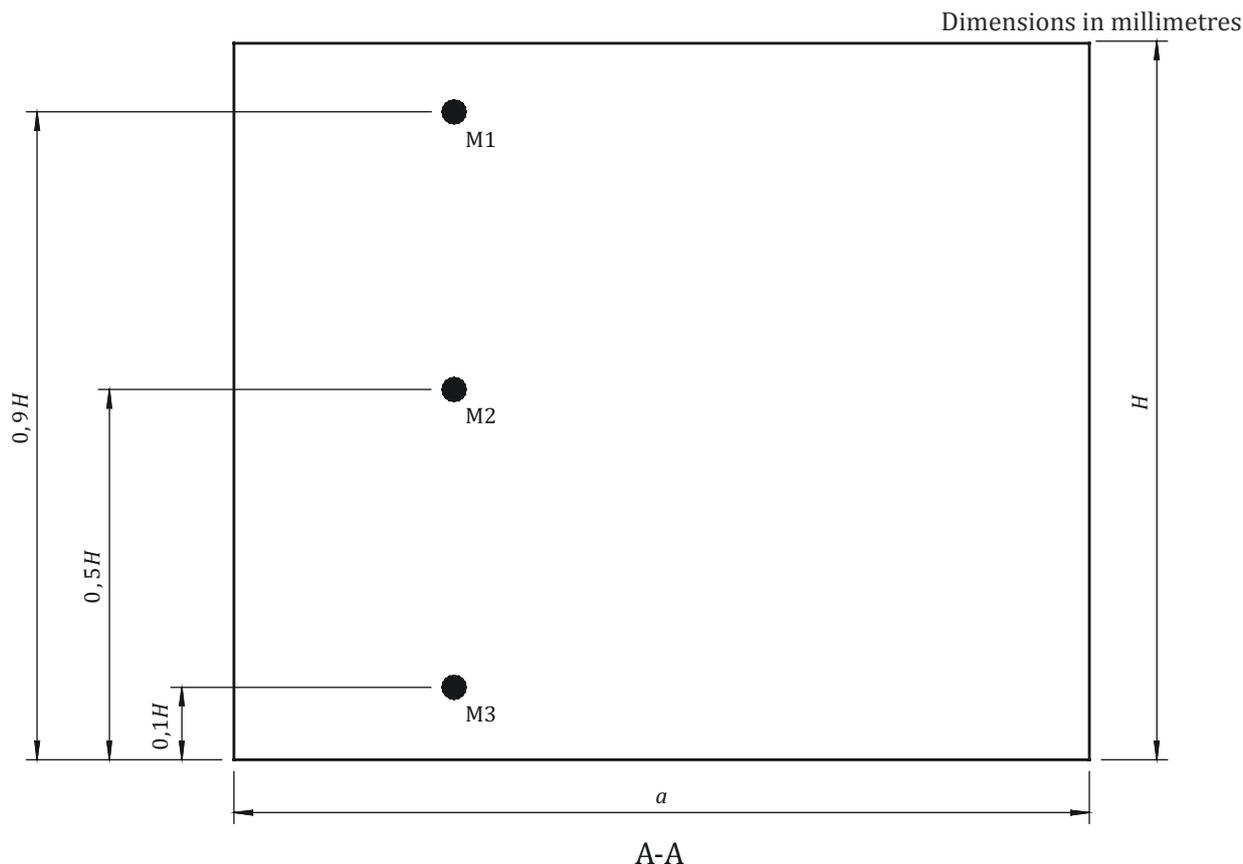
C.5.1.1.2.7 Atmospheric pressure

The atmospheric pressure shall be determined before each test. The atmospheric pressure shall be measured and recorded using a calibrated device having an accuracy of 100 Pascal or better.

**Key**

- 1 measuring point
- 2 nozzle

Figure C.3 — Plan view instrumentation placement for nozzle minimum height/maximum area coverage test



NOTE The measuring points at heights $0,9 H$, $0,5 H$ and $0,1 H$ (M1 to M3), are permitted to be at different horizontal distances from the centre of the enclosure provided each are within a horizontal distance of 850 mm to 1 250 mm from the centre of the enclosure.

Figure C.4 — Side view instrumentation placement for nozzle minimum height/maximum area coverage test

C.5.1.2 Fuel specification

C.5.1.2.1 Test cans

The test cans shall be cylindrical $80 \text{ mm} \pm 5 \text{ mm}$ in diameter and at least 100 mm high, made of mild or stainless steel with a thickness of 5 mm to 6 mm.

C.5.1.2.2 Heptane specification

The heptane used shall have the following characteristics:

- a) distillation
 - 1) initial boiling point: $90 \text{ }^\circ\text{C}$ minimum;
 - 2) dry point: 100°C maximum;
- b) density (at $15,6 \text{ }^\circ\text{C}$): $700 \pm 50 \text{ kg/m}^3$.

C.5.1.2.3 Fuel-test can configuration

The test cans may contain either heptane or heptane on water. If they contain heptane and water, the heptane shall be at least 50 mm deep. The level of heptane in the cans shall be at least 50 mm below the top of the can.

A thermocouple is permitted to be located 30 mm above the centre of each fire test can as additional information.

C.5.1.2.4 Test can placement

A test can shall be placed in each corner of the enclosure within 50 mm of the corners of the enclosure wall. In addition, one or two test cans, depending on enclosure height, shall be placed directly behind the baffle (see [Figures C.1](#) and [C.2](#)). The top of the test cans shall be positioned within 300 mm of the top or bottom of the enclosure, or both top and bottom, if the enclosure height is able to accommodate such placement.

C.5.1.3 Test procedure

C.5.1.3.1 Pretesting

The composition of the extinguishing agent used shall be verified by certificate of conformance or by test.

C.5.1.3.2 Operation

The heptane-filled test cans shall be ignited and allowed to burn for at least 30 s with the closable openings in the open position.

After at least 30 s all openings shall be closed and the extinguishing system shall be manually actuated. At the time of actuation of the system, the oxygen concentration within the enclosure shall be no less than 20,4 vol %. During the test, the oxygen concentration shall not change more than 1,5 vol % due to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the measured oxygen concentration in this test (averaged over the three sensors).

NOTE End of discharge is the point when discharge has effectively ceased. For superpressurized liquefied extinguishants, it is the instant when the discharge is predominantly gaseous. For non-superpressurized liquefied extinguishants and non-liquefied extinguishants where a cut-off mechanism is used to stop discharge, it is the instant when the pressure at the nozzle reduces to zero.

C.5.1.3.3 Recording of data

After the required pre-burn period, record the following data for each test.

- a) The effective discharge time: i.e. for liquefied extinguishants the time of the pre-liquid gas phase plus the time of the two-phase flow; for non-liquefied extinguishants, the time from opening the container valve(s) to cutting off the discharge; the discharge time for liquefied extinguishants shall be determined by nozzle pressure, nozzle temperature or combination of both.
- b) The time from the end of agent discharge required to achieve extinguishment, in seconds; this time shall be determined by visual observation or other suitable means.
- c) The total mass of extinguishant discharged into the test enclosure.

C.5.1.4 Determination of distribution performance of the nozzle

All test cans shall be extinguished within 30 s of the end of agent discharge.

As an alternative to the use of the test cans, the concentration of the extinguishing agent (or for non-liquefied gases, the oxygen concentration) is permitted to be measured at the locations specified

for the steel test cans. The concentration shall be measured at each location and shall be at least the extinguishing concentration, to be reached 30 s after end of discharge time at latest.

C.5.1.5 Reporting of test results

In addition to the data specified in [C.5.1.3.3](#), documentation of performance in [C.5.1.4](#), and the information in [C.2.2](#), at least the following shall be reported for each series of tests.

- a) Description of the test enclosure, preferably in the form of a schematic, including the following:
 - 1) baffle width, location, and orientation;
 - 2) location of nozzle(s) within the test enclosure;
 - 3) test can locations within the test enclosure.
- b) Description of fuel specifications, including the following:
 - 1) test can material and dimensions;
 - 2) heptane characteristics by certificate of conformance or by test;
 - 3) heptane depth and level below the top of the can.
- c) Description of test method including details for operation including the following:
 - 1) pre-burn duration;
 - 2) oxygen concentration at system discharge.

C.5.2 Nozzle maximum height test

C.5.2.1 Test facility

C.5.2.1.1 Construction

The test enclosure shall meet the following requirements.

- a) The test enclosure shall have a minimum volume of 100 m³. The floor dimensions shall be at least 4 m wide by 4 m long. The test enclosure shall have the maximum ceiling height as specified in the extinguishing system unit manufacturer's installation instructions.
- b) A means of pressure relief shall be provided to limit the pressure change with a cold discharge to ± 300 Pa.
- c) Closable openings shall be provided directly next to or above the test cans to allow for ventilation prior to system actuation.
- d) One baffle shall be installed between the floor and ceiling with the height of the enclosure. It shall be installed halfway between the nozzle location and one wall of the enclosure. The baffle shall be perpendicular to the long walls of the enclosure and 20 % of the length of the short wall of the enclosure (see [Figure C.1](#) for 360° nozzle and [Figure C.2](#) for 180° nozzle).

C.5.2.1.2 Instrumentation

Instrumentation of the enclosure is as described in [C.5.1.1.2](#).

C.5.2.2 Fuel specification

Test fire can construction, configuration, placement and fuel specifications shall be as given in [C.5.1.2](#).

C.5.2.3 Test procedure

C.5.2.3.1 Pretesting

The composition of the extinguishing agent used shall be verified by certificate of conformance or by test.

C.5.2.3.2 Operation

The heptane shall be ignited and allowed to burn for at least 30 s with the closeable openings in the open position.

After at least 30 s all openings shall be closed and the extinguishing system shall be manually actuated. At the time of actuation of the system, the oxygen concentration within the enclosure shall be no less than 20,4 vol %. During the test, the oxygen concentration shall not change more than 1,5 vol % due to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the oxygen concentration measured in this fire test (averaged values).

C.5.2.3.3 Recording of data

Data shall be recorded as specified in [C.5.1.3.3](#).

C.5.2.4 Determination of distribution performance of the nozzle

Using the extinguishing concentration for heptane, determined in accordance with [C.6.2](#), all test cans shall be extinguished within 30 s of the end of agent discharge.

As an alternative to the use of the heptane steel cans, the concentration of the extinguishing agent (or for non-liquefied gases, the oxygen concentration) can be measured at the locations specified for the steel test cans. The concentration shall be measured at each location and shall be at least the extinguishing concentration, to be reached no longer than 30 s after end of discharge time.

C.5.2.5 Reporting of test results

In addition to the data specified in [C.5.2.3.3](#), documentation of performance in [C.5.2.4](#), and the information in [C.2.2](#), at least the following shall be reported for each series of tests.

- a) Description of the test enclosure, preferably in the form of a schematic, including the following:
 - 1) baffle width, location, and orientation;
 - 2) location of nozzle(s) within the test enclosure;
 - 3) test can locations within the test enclosure.
- b) Description of fuel specifications, including the following:
 - 1) test can material and dimensions;
 - 2) heptane characteristics by certificate of conformance or by test;
 - 3) heptane depth and level below the top of the can.
- c) Description of test method including details for operation including the following:
 - 1) pre-burn duration;
 - 2) oxygen concentration at system discharge.

C.6 Extinguishing concentration tests

C.6.1 Wood crib test

C.6.1.1 Test facility

C.6.1.1.1 Construction

The test enclosure shall meet the following requirements.

- a) The test enclosure shall have a minimum volume of 100 m³. The height shall be at least 3,5 m. The floor dimensions shall be at least 4 m wide by 4 m long.
- b) A means of pressure relief shall be provided to limit the pressure change with a cold discharge to ± 300 Pa.

C.6.1.1.2 Instrumentation

Sampling and storage of data from the sensors described below shall occur at a rate of at least 10 Hz.

NOTE The single data points to determine agent mass and atmospheric pressure are not required to be sampled and stored at a rate of at least 10 Hz.

C.6.1.1.2.1 Oxygen concentration sensors

The oxygen concentration shall be measured and recorded using a calibrated oxygen analyser having an accuracy of 0,1 vol. % oxygen or better. The sensing equipment shall continuously monitor and record the oxygen level within the enclosure throughout the duration of the test. The accuracy of the measuring devices shall not be influenced by any of the fire products.

At least three sensors shall be located within the enclosure (see [Figures C.5](#) and [C.6](#)). One sensor shall be located horizontally 600 mm to 1 000 mm away from the test object at the equivalent height of the top of the test object. The other sensors shall be located horizontally 600 mm to 1 000 mm away from the test object and at least two sensors at the following heights: 0,1 H and 0,9 H (H = height of the enclosure).

C.6.1.1.2.2 Nozzle pressure sensor

During system discharge, the nozzle pressure shall be measured and recorded by a pressure transducer attached to the pipe at a distance no greater than 1 m from the nozzle.

C.6.1.1.2.3 Enclosure temperature sensors

The temperature within the enclosure shall be measured and recorded (see [Figures C.5](#) and [C.6](#)). One sensor shall be located centrally 100 mm above the test object. One sensor shall be located horizontally 600 mm to 1 000 mm from the test object and at the equivalent height of the top of the test object. At least one sensor shall be located horizontally 600 mm to 1 000 mm from the test object and at the following height: 0,9 H (H = height of the enclosure).

The temperature in the test enclosure shall be 20 °C \pm 5 °C at the beginning of each test.

C.6.1.1.2.4 Nozzle temperature sensor

During system discharge of liquefied extinguishants, the liquid jet temperature just outside the nozzle shall be measured and recorded.