EAD **180002-00-0706**

www.eota.eu

September 2017

European Assessment Document for

# Opening and perimeter barriers for flood protection of a building or other structure

This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

# Contents

# 1 SCOPE OF THE EAD

## 1.1 Description of the construction product

This EAD covers kits, which are either opening or perimeter barriers for flood protection of a building or other structure to the maximum water depth, hereinafter referred to as “opening or perimeter barriers”.

Opening and perimeter barriers are kits consisting of a collection of elements. Individual kits are to be arranged from elements specified according to the application.

The kit shall, at minimum, consist of barrier elements, water tightness elements, mounting elements to allow the barriers to be anchored and connected to the works.

Perimeter barriers shall include jointing elements to allow multiple individual barriers to be connected together to form a longer barrier of the required length and shape. Opening barriers may also include such elements.

Examples of such elements are listed below:

- for barrier elements:
    - panel;
    - planks;
    - membrane;
    - glazing;
    - door;
- for water tightness elements:
    - foam gaskets;
    - inflatable rubber seals;
    - sealants;
    - liners and liner tape;
- for mounting elements:
    - frame;
    - receiver;
    - wall closure;
    - ground anchors;
    - floor closure.
- for jointing elements:
    - barrier joint connection;
    - angled connection;
    - clamp;
    - bolts.

Diagrams illustrating examples of how the above listed example elements may be arranged are shown below in figures 1.1.1 and 1.1.2, these diagrams are non-exhaustive in nature and are shown to illustrate possible arrangement types only.

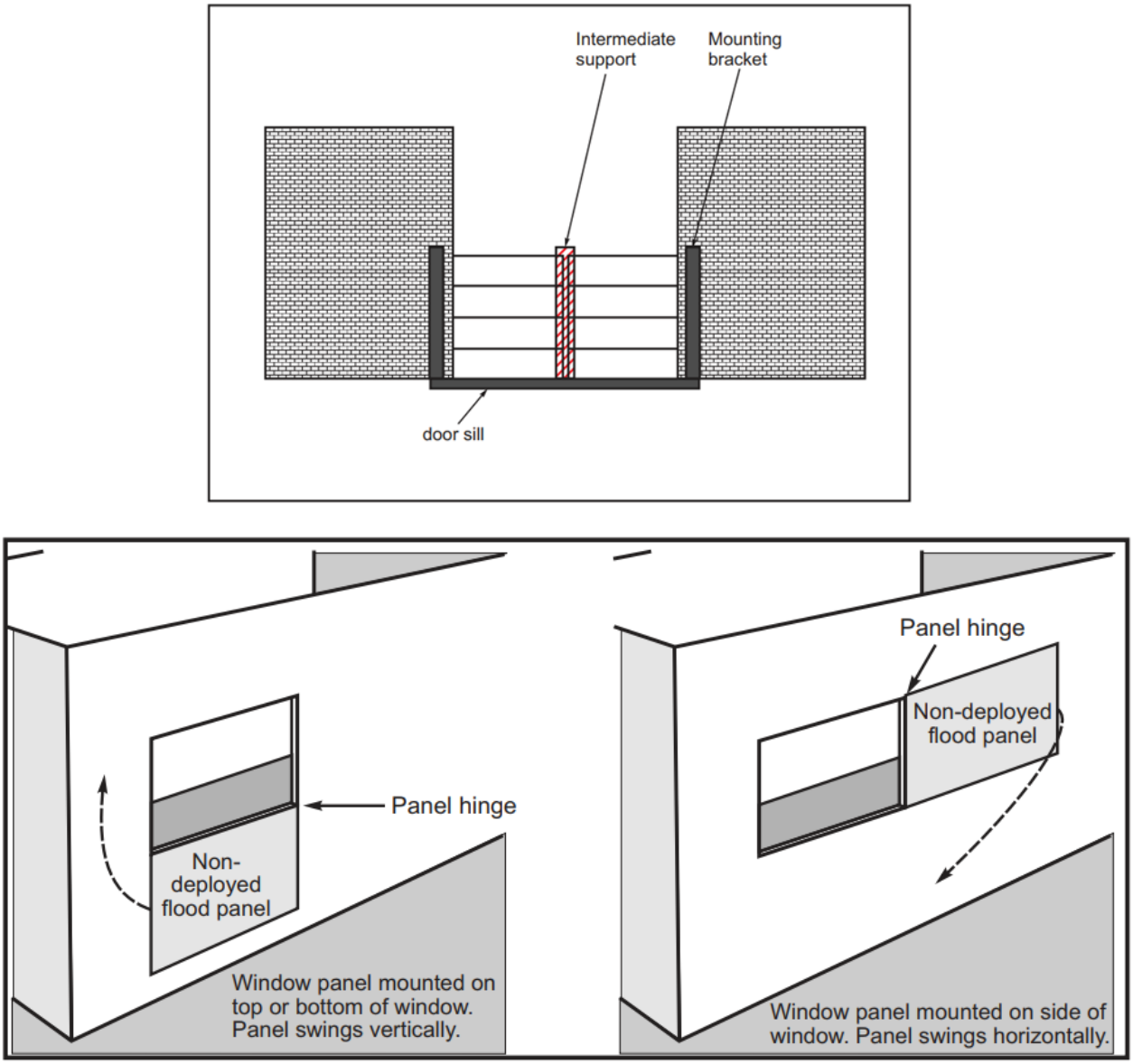


**Figure 1.1.1: Examples of opening type barriers**

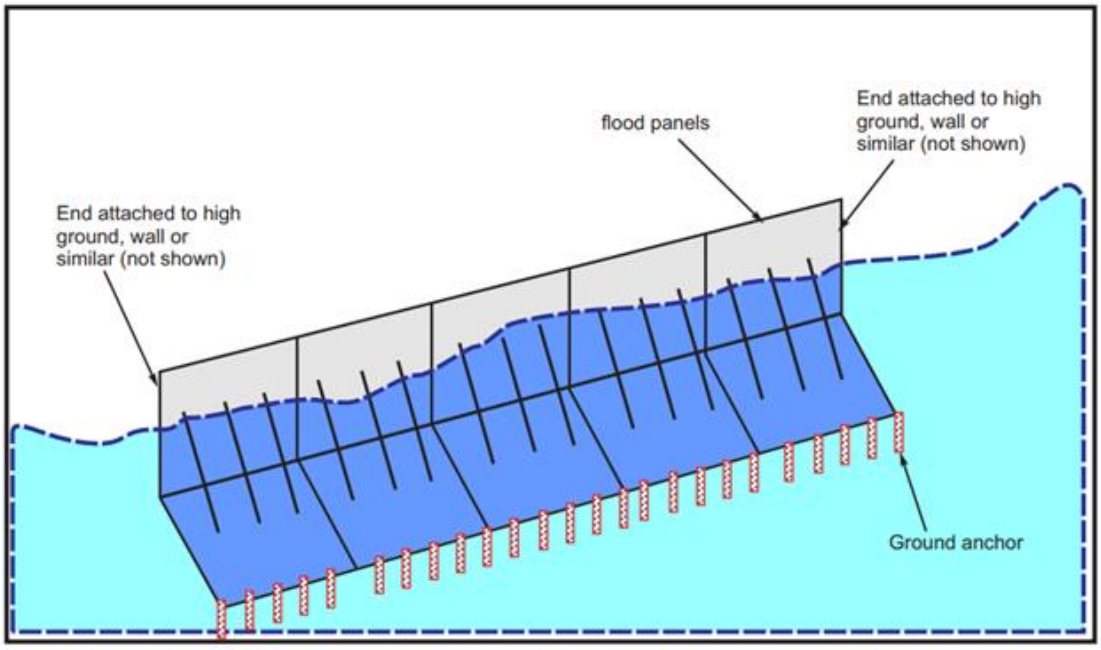


**Figure 1.1.2: Example of perimeter type barriers**

These opening or perimeter barriers are not covered by a harmonised European standard (hEN).

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

## 1.2 Information on the intended use(s) of the construction product

### 1.2.1 Intended use(s)

The opening or perimeter barriers are intended to provide a defence against the ingress of flood water into a building or other structure to be protected. The flood types covered by this EAD are those caused by bodies of waters overflowing their normal boundaries, water accumulation or the result of storm water runoff flood exposure anywhere but excluding coastal flooding.

### 1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the opening or perimeter barriers for the intended use of 20 years when installed in the works. These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[1].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

## 1.3 Specific terms used in this EAD

### 1.3.1 Barrier/panel

Component of an opening barrier, which provides partial or complete coverage of an exterior or interior opening with the principle function of preventing flood waters from entering into a building or other structure.

### 1.3.2 Building aperture

Any opening in the building or other structure where water can flow through.

Example: Doorways, windows, air bricks or vent bricks, portals, garage entrance or loading dock entrance etc.

### 1.3.3 Deflection

Distance an opening or perimeter barriers barrier moves from its original location.

### 1.3.4 Deployment time

Amount of time required for setting up and/or operating an opening or perimeter barrier.

### 1.3.5 Dry-side

Side of the water basin protected by the opening or perimeter barrier.

### 1.3.6 Enclosure

Large pool or other basin for the testing of opening or perimeter barrier, including both a dry protected area behind the product and a wet area.

### 1.3.7 Leakage rate

Rate at which water moves past or through an opening or perimeter barrier from the wet-side to the dry-side of the barrier.

### 1.3.8 Opening barrier

Any product capable of preventing flood water from passing through a building aperture.

---

1 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

### 1.3.9 Overtopping

Action of water flowing over the top of a perimeter flood barrier.

### 1.3.10 Perimeter

Area surrounding or along a building or other structure.

### 1.3.11 Perimeter barrier

Product intended to protect an area surrounding or along a building or other structure from flood water.

### 1.3.12 Protected opening

Total length of the building aperture width (measured from barrier seal-to-seal) plus two times the maximum water depth or, in the case of door sets, windows, industrial, commercial and garage doors and gates and shutters the length of flooded outline (i.e., maximum two times the distance between the uprights plus two times the height, if completely flooded).

### 1.3.13 Seal (barrier seal)

Part on a barrier where the product meets the ground or wall of the basin to prevent water from moving from the wet-side of the basin to the dry-side, a seal can also be made between different components or sections of the opening or perimeter barrier.

### 1.3.14 Tensile set

The extension remaining after a specimen has been elongated and then allowed to retract in the specified manner, expressed as a percentage of the original length.

### 1.3.15 Wet-side

Side of the water basin containing the flood water.

# 2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

All undated references to standards or to EADs in this EAD are to be understood as references to the dated versions listed in chapter 4.

## 2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of opening or perimeter barriers is assessed in relation to the essential characteristics.

**Table 2.1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics**

| No | Essential characteristic | Assessment method | Type of expression of product performance |
|---|---|---|---|
| **Basic Works Requirement 4: Safety and accessibility in use** | | | |
| 1 | Operational reliability | 2.2.1 | Level |
| 2 | Performance testing of opening barriers for quasi-static flood conditions | 2.2.2 | Level, description |
| 3 | Performance testing of opening and perimeter barriers for dynamic flood conditions | 2.2.3 | Level, description |
| **Aspects of durability** | | | |
| Durability of operational reliability | | | |
| 4 | Non-metallic materials ultraviolet light and water test | 2.2.4 | Level, description |
| 5 | Tear and puncture resistance (Perimeter type barriers) | 2.2.5 | Level, description |

## 2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

Testing will be limited only to the essential characteristics which the manufacturer intends to declare. If for any components covered by harmonised standards or European Technical Assessments the manufacturer of the component has included the performance regarding the relevant characteristic in the Declaration of Performance, retesting of that component for issuing the ETA under the current EAD is not required.

### 2.2.1 Operational reliability

*Purpose of the assessment*

Opening or perimeter barriers containing components with moving parts (e.g., assemblies with hinges) shall have the operational reliability of the component through its operational range assessed.

*Assessment method*

One specimen of each moving part of the opening or perimeter barriers shall be cycled through its operational range (i.e., one full cycle shall be from the opening or perimeter barriers fully closed position to its fully open and back to its fully closed position, or through the opening or perimeter barriers full range of travel and back, etc.) a minimum of 500 times or until it displays a failure, whichever occurs first.

*Expression of results*

The ETA shall state the number of times the opening or perimeter barrier cycled through its operational range

### 2.2.2 Performance testing of opening barriers for quasi-static flood conditions

*General*

Where opening barriers are intended to be used in dynamic flood conditions and testing according to 2.2.3 has been conducted, testing to this clause can be considered as unnecessary.

*Purpose of the assessment*

The maximum leakage rate of opening barrier kits for use in for quasi-static flood conditions shall be determined. The test method is intended for evaluating the leakage rate of opening or perimeter barriers intended for the protection of building apertures.

*Assessment method*

Performance testing shall be conducted according to the method detailed in Annex A which has been designed to simulate quasi-static flood conditions, (i.e., slow rising and receding floodwaters with minimal wave exposure and blunt debris impact). All tests shall be conducted, in the stated sequence, using the same test specimen.

When multiple pre-installation options exist for the opening barrier, the option giving rise to the highest leakage conditions shall be tested according to this EAD. If no option can be determined to offer the highest leakage conditions, then the performance test series shall be conducted on all the foreseen barrier pre-installation options.

Where a flood protection opening or perimeter barrier is available in different sizes, the test result may also be applied to the smaller size opening or perimeter barriers on condition that the opening or perimeter barriers are identical in structure and design other than the total width and depth being smaller than those of the opening or perimeter barriers tested. The maximum water depths shall be measured from the floor in the enclosure to the surface of the water adjacent to the face of the barrier.

The leakage rate, being the volume of water in litres per hour per linear meter (l/h/m) of protected opening, where the protected opening is the length of the opening width (measured from barrier seal-to-seal) plus two times the maximum water depth, shall be determined after each test cycle.

*Expression of results*

The ETA shall state the level of the following:

The highest rate of leakage determined at any time during any of the test cycles. The leakage rate shall be expressed as the volume of water in litres per hour per linear meter (l/h/m) of protected opening, where the protected opening is considered to be the length of the opening width (measured from barrier seal-to-seal) plus two times the maximum designated water depth.

The maximum permanent deflection of the barrier determined at any time during any of the test cycles. The description shall include the location, description and size (in mm) of any deflections or deformations in any component of the assembly. The deflection of the barrier may be expressed in either metres, centimetres or millimetres as appropriate.

The ETA shall describe the following information:

The maximum designated water depth in m.

The deployment instructions used and the time required to deploy the barrier according to those instructions.

### 2.2.3 Performance testing of opening and perimeter barriers for dynamic flood conditions

*General*

Testing according to 2.2.2 shall be considered as unnecessary if testing according to this clause is performed.

*Purpose of the assessment*

The maximum leakage rate of opening barrier and perimeter barrier for use in for dynamic flood conditions shall be determined.

*Assessment method*

Performance testing shall be conducted according to the method detailed in Annex B which has been designed to simulate dynamic flood conditions. All tests shall be conducted, in the stated sequence, using the same test specimen.

For flood protection opening barriers including flood protection door sets, windows, industrial, commercial and garage doors and gates and shutters, the B.5.6 debris impact test method shall be replaced by the A.5.4 dynamic impact load at the weakest point of the opening or perimeter barriers method as detailed in Table B.5.1.1.

When multiple pre-installation options exist for the opening barrier, the option giving rise to the highest leakage conditions shall be tested according to this EAD. If no option can be determined to offer the highest leakage conditions, then the performance test series shall be conducted on all indicated barrier pre-installation options.

Where a flood protection opening or perimeter barriers is available in different sizes, the test result may also be applied to the smaller size opening or perimeter barriers on condition that the opening or perimeter barriers are identical in structure and design other than the width and/or depth being smaller than those of

the opening or perimeter barriers tested. The maximum water depths shall be measured from the floor in the enclosure to the surface of the water adjacent to the face of the barrier.

The leakage rate, being the volume of water in litres per hour per linear meter (l/h/m) and where the opening or perimeter barriers length is measured along the centre point of the barrier seal to the ground, shall be determined after each test cycle.

*Expression of results*

The ETA shall state the level of the following:

The highest rate of leakage determined at any time during any of the test cycles. The leakage rate shall be expressed as the volume of water in litres per hour per linear meter (l/h/m) of barrier length where the barrier length is measured along the centre point of the barrier seal to the ground.

The maximum permanent deflection of the barrier determined at any time during any of the test cycles. The description shall include the location, description and size (in mm) of any deflections or deformations in any component of the assembly. The deflection of the barrier may be expressed in either metres, centimetres or millimetres as appropriate.

The ETA shall describe the following information:

The maximum designated water depth in m.

The deployment instructions used and the time required to deploy the barrier according to those instructions.

### 2.2.4 Non-metallic materials ultraviolet light and water test

*Purpose of the assessment*

The UV resistance of any non-metallic materials shall be assessed to determine the degradation due to environmental outside conditions, e.g., sunlight.

*Assessment method*

One test specimen of each non-metallic materials shall be exposed to ultraviolet light and water for ($720^{+0,1}_{-0}$) h in accordance with Table 3, Method A Cycle 1, of EN ISO 4892-2 with the following adaptations:

- irradiance at 340 nm shall be in the range of 0,33 to 53 W/(m$^2$ × nm);
- the air temperature within the apparatus during operations shall be in the range of (35 to 45) ºC and the relative humidity shall be in the range of 25 % to 60 %;
- during each operating cycle, the specimen(s) shall be exposed to light and water spray for 18 min and to light only for 102 min.

The specimen shall be visually inspected and assessed.

*Expression of results*

The ETA shall describe any cracking or crazing and state the number and lengths of any cracks in centimetres (cm) and the area covered by any crazing in square centimetres (cm$^2$).

### 2.2.5 Tear and puncture resistance (perimeter type barriers)

*Purpose of the assessment*

The resistance to impact from potentially damaging objects of perimeter barriers incorporating barrier membranes and any other non-metallic construction materials that may come into contact with debris shall be determined.

*Assessment method*

Testing shall be conducted on a specimen of the opening or perimeter barriers comprising an impermeable portion of the barrier in accordance with EN 12730, Method A with the following exceptions:

- the applied weight shall be $(16 \pm {}^{0,1}_{0})$ kg;
- the specimen material shall be secured to each side of the test fixture using C-clamps or a similar device;
- the downward movement of the ball shall not be limited other than by the resistance of the material being tested.

The specimen shall be visually inspected and assessed.

*Expression of results*

The ETA shall describe the nature of any damage (e.g., tear, puncture) and state the length and width of the damage stated in centimetres (cm).

# 3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

## 3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is: Commission Decision 2003/655/EC.

The system is: 2+.

## 3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

For kits: The manufacturer (regarding the components he buys from the market with DoP) shall take into account the Declaration of Performance issued by the manufacturer of that component. No retesting is necessary.

**Table 3.2.1 Control plan for the manufacturer; cornerstones**

| No | Subject/type of control | Test or control method | Criteria, if any | Minimum number of samples | Minimum frequency of control |
|---|---|---|---|---|---|
| **Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]** | | | | | |
| 1 | Control of incoming materials and components.<br>Inspection of delivery documentation<br>Compliance with specified characteristics of the material or component with reference to relevant specifications and declarations of performance including EN or ISO standards | Review of documents (especially, where relevant the declaration of performance) thickness measurement, visual inspection for damage to components | Compliance with the specification for material or components<br>Maintenance of a consistent level of the properties of the components (e.g., Inspection document “type 3.1” in accordance with EN 10204) | As defined in control plan | Every delivery |
| 2 | Main dimensions | Verification of dimensions per manufacturers technical file | As defined in control plan | As defined in control plan | As defined in control plan |
| 3 | Complete and correct assembly and marking | Visual inspection and operation of each opening or perimeter barrier | As defined in control plan | As defined in control plan | As defined in control plan |
| 4 | Combination of the kit components | Checking of the components, end control | Compliance of the combinations of the kit components with the intended use | 1 | Each kit once per year |

## 3.3 Tasks of the notified body under AVCP system 2+

The cornerstones of the actions to be undertaken by the notified body of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.3.1.

**Table 3.3.1 Control plan for the notified body; cornerstones**

| No | Subject/type of control | Test or control method | Criteria, if any | Minimum number of samples | Minimum frequency of control |
|---|---|---|---|---|---|
| **Initial inspection of the manufacturing plant and of factory production control** | | | | | |
| 1 | Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the opening or perimeter barriers. | Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer | As defined in control plan | As defined in control plan | When starting the production or opening of a new production line |
| Continuous surveillance, assessment and evaluation of factory production control | | | | | |
| 2 | The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan. | Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.2.1 | As defined in control plan | As defined in control plan | 1 / year |

# 4 REFERENCE DOCUMENTS

| | |
|---|---|
| EN ISO 4892-2:2013/A1:2021 | Plastics – Methods of exposure to laboratory light sources |
| EN 10204:2004 | Metallic products - Types of inspection documents |
| EN 12730:2015 | Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Determination of resistance to static loading |

# ANNEX A: Opening or perimeter barriers - Determination of the hydrostatic leakage rate for quasi-static flood conditions

## A.1 Principle of the test

This test method simulates quasi-static flood conditions, i.e., slow rising and receding floodwater, with minimal wave exposure, with or without blunt debris impact and specifies a test method to determine the hydrostatic leakage rate of opening or perimeter barriers.

During testing there is a risk of the test specimen deflecting and collapsing due to water pressure. Persons shall not access the test enclosure during testing. Testing shall be terminated immediately if there is any risk regarding the safety of persons.

## A.2 Test apparatus

The test enclosure shall permit retaining water for at least ($22 \pm {}^{0,1}_{0}$) h at designated water depth. The tests are carried out with fresh clean water. The length of the enclosure shall accommodate all the requirements for each part of the test.

The test apparatus shall comprise:

- Equipment to measure deformation shall have a tolerance of ± 5 % of the measured value.
- Equipment to measure static water levels shall have a tolerance of ± 5 % of the measured value.
- Equipment to measure leakage rate over time shall have a tolerance of ± 5 % of the measured value.
- An impact object comprising a piece of saw-cut log with a diameter of (300 ± 15) mm and a nominal density of (500 ± 25) kg/m³. One end of the log shall have a straight perpendicular cut and the other shall be cut at an angle of 15 degrees off-centre with no round edges. The straight cut end of the log shall be attached to a steel block so that the total mass of object is (50 ± 1) kg. A similar impact object may be substituted as long as the trajectory of impact and impact energy criteria are met.

  NOTE Given that the impact is designed to replicate debris in the flood (i.e., a wooden fencepost or a tree), any similar impact object shall have mass, be hard and sharp and therefore likely present a threat to the integrity of the product, regardless of its design or materials.

- Recipient, e.g., a drip tray and collection tank, to collect water that moves past or through a flood barrier from the wet-side to the dry-side of the barrier. The recipient permits measuring the amount of leaked water according to the prescribed schedule.

## A.3 Test specimen

The test specimen shall be stored at the test conditions, permitting in-situ applied sealants, if any, to cure.

## A.4 Test conditions

The test shall be performed indoors at (20 ± 10) °C.

## A.5 Test procedure

### A.5.1 Test Sequence

The test shall be performed in accordance with the sequence specified in Table A.5.1.1.

**Table A.5.1.1 – Test sequence**

| Sequence of the test | Parts of the test | Clause in EAD | Condition | Duration |
|---|---|---|---|---|
| 1 | Deployment | A.5.2 | In accordance with documented instructions where provided | Deployment time shall be registered |
| 2 | Filling of the enclosure | - | Fill rate shall allow the designated water depth of the barrier to be reached in a time up to 3 h | - |
| 3 | Hydrostatic load | A.5.3 | Head: maximum water depth ± 5 mm | $(22 \pm_{0}^{0,1})$ h |
| 4 | Draining of the enclosure | - | Drain rate shall allow the maximum water depth of the barrier to be reached in a time up to 1 h | - |
| 5 | Disassemble and redeploy | A.5.2 | In accordance with documented instructions where provided | Disassembly and redeployment time shall be registered |
| 6 | Dynamic impact load at the weakest point of the opening or perimeter barriers | A.5.4 | - | Not applicable |
| 7 | Filling of the enclosure | - | Fill rate shall allow the maximum water depth of the barrier to be reached in a time up to 3 h | - |
| 8 | Post-hydrostatic load | A.5.5 | Head: maximum water depth ± 5 mm | 1 h |
| 9 | Draining of the enclosure | - | Drain rate shall allow the maximum water depth of the barrier to be reached in a time up to 1 h | - |
| 10 | Disassemble and redeploy | A.5.2 | In accordance with documented instructions where provided | Disassembly and redeployment time shall be registered |
| 11 | Dynamic impact load at the connection to the test rig | A.5.6 | - | Not applicable |
| 12 | Filling of the enclosure | - | Fill rate shall allow the maximum water depth of the barrier to be reached in a time up to 3 h | - |
| 13 | Post-hydrostatic load | A.5.7 | Head: maximum water depth ± 5 mm | 1 h |

### A.5.2 Deployment, disassembly and redeployment

The test specimen shall be installed/deployed/assembled, disassembled and redeployed in the test rig in accordance with the documented instructions and used in accordance with the use instructions (where provided).

For opening or perimeter barriers where multiple installation options exist then only where it is possible to determine that one specific installation option offers a 'worst case scenario' shall be used for testing, evaluations may be limited to the option giving rise to the highest leakage conditions.

For opening or perimeter barriers which are retractable, "disassemble and redeploy" shall be understood to mean that the opening or perimeter barriers is brought into a position where it does not limit or prevent ingress of flood water and consequently redeployed.

For opening or perimeter barriers which are not retractable, it is not necessary to remove from the rig and refit any components which are not intended to be removeable after initial installation, but all components intended to be removable by the manufacturer, shall be completely removed and fitted again.

Where any sealants are used, then these shall be applied.

### A.5.3 Hydrostatic load

Photographs of the test specimen before and after the test shall be taken.

Once the opening or perimeter barriers has been deployed, the wet side of the enclosure shall be filled until the opening or perimeter barriers lowest part is reached.

Thereafter, the enclosure shall be filled to the maximum water depth at a rate of the maximum water depth ≤ 3 h. Once the maximum water depth has been reached, the water level shall be maintained for 22 h. Measure the leakage rate over 15 min intervals until the leakage rate has either stopped or stabilized. If neither has occurred then the leakage rate shall be measured of the following increments, at a minimum:

- 15 min;
- 30 min;
- 45 min;
- 1 h;
- 22 h.

After 22 h, the water shall be drained until below the opening or perimeter barriers lowest part and any permanent deflection shall be measured and recorded.

### A.5.4 Dynamic impact load at the weakest point of the opening or perimeter barriers

Photographs of the test specimen before and after the test shall be taken.

An opening barrier shall be capable of withstanding two impacts of 600 J each from the impact object.

Water shall be drained completely from the wet-side of the test apparatus before conducting the test.

The first impact location shall be the predetermined weak point of the opening or perimeter barriers, i.e., the horizontal centre point of the opening or perimeter barriers at four fifths (4/5) × height of the test specimen.

The second location shall be as close to the barrier perimeter as possible, at the same height as the first impact. This location is intended to evaluate the connection to the supporting structure.

Additional impact locations on the barrier or frame may be included (e.g., hinges, plastic parts, etc.) if deemed to represent a weaker test point and therefore representing a higher likelihood of failure than the two previously tested locations.

The impact to the barrier shall be such that the leading edge of the impacting object hits the predetermined location on the barrier. Figure A.5.4.1 specifies the layout for this test.

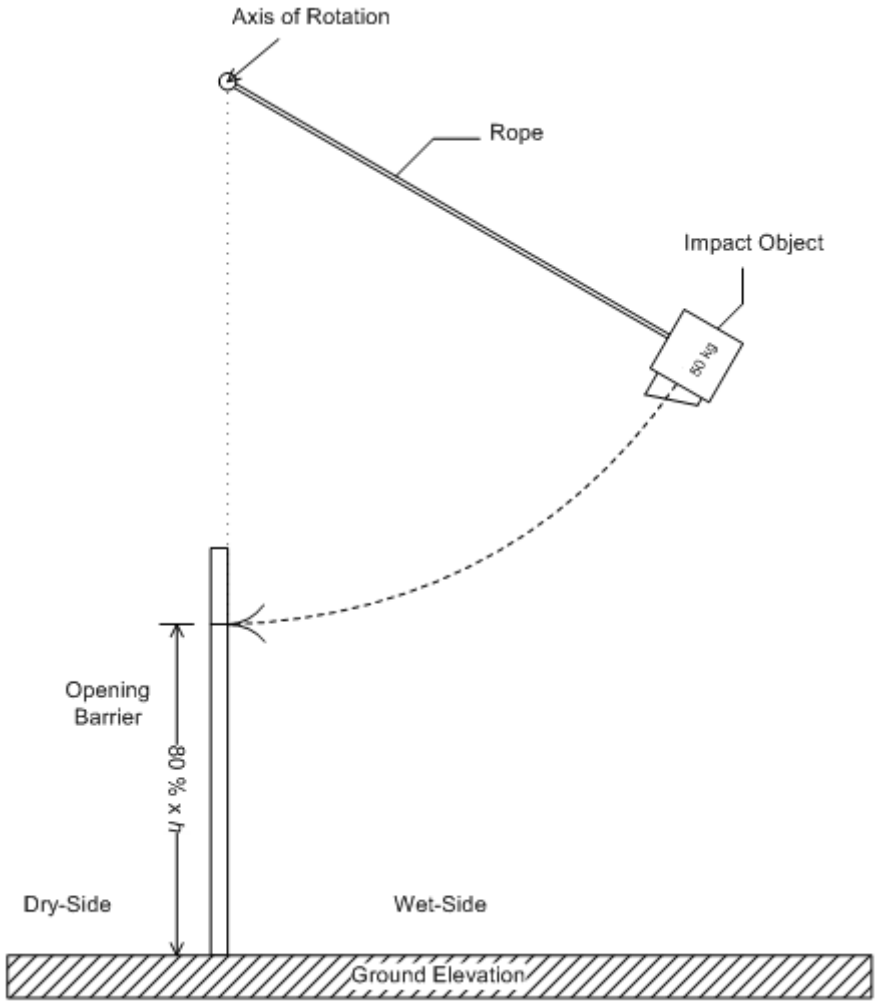


**Figure A.5.4.1 Test Layout: Dynamic Impact**

Impact the opening or perimeter barrier by lifting the impact object to a height above the point of impact. Then drop the object so that it accelerates under gravitational acceleration, through a circular trajectory, and impacts the barrier in the horizontal position. The impact force *F*, calculated as potential energy, is determined by the length of trajectory and weight of the impacting object:

$$F = mgH \qquad \text{(A.5.4.1)}$$

where

- m is the mass of the impacting object;
- g is gravitational acceleration; and
- H is the height between the centre of the impacting object and the centre of the predetermined impact location.

Note: The impact energy is 600 J.

Measure the permanent deflection and/or deformations after each impact and assess any permanent dents at the point of impact which would impair the functionality of the barrier.

### A.5.5 Post-hydrostatic load

The hydrostatic load test shall be repeated, but once the maximum water depth has been reached, the water level shall be maintained for 1 h.

### A.5.6 Dynamic impact load at the opening or perimeter barriers connection to the test rig

Photographs of the test specimen before and after the test shall be taken.

The dynamic impact load test shall be repeated, but the impact location shall be the predetermined weak point of the barrier near the opening or perimeter barriers connection to the test rig at the same height as the previous impact load test.

### A.5.7 Post-hydrostatic load

The hydrostatic load test shall be repeated, but once the maximum water depth has been reached, the water level shall be maintained for 1h.

Photographs of the test specimen after the test shall be taken.

# ANNEX B: Opening or perimeter barriers - Determination of the hydrodynamic leakage rate for dynamic flood conditions.

## B.1 Principle of the test

This test method simulates dynamic flood conditions, i.e., slow rising and receding floodwater, with static water, wave exposure and dynamic lateral water currents, and blunt debris impact and is designed to represent more demanding scenarios than those detailed in Annex A.

During testing there is a risk of the test specimen deflecting and collapsing due to water pressure. Persons shall not access the test enclosure during testing. Testing shall be terminated immediately if there is any risk regarding the safety of persons.

## B.2 Test apparatus

The test enclosure shall permit retaining water for at least $(22 \pm_{0}^{0,1})$ h at the designated water depth. The tests are carried out with fresh clean water. The length of the enclosure shall accommodate all the requirements for each part of the test.

The test apparatus shall comprise:

- Equipment to generate random waves of height from 50 mm to 300 mm and mean wave period of 2 s perpendicular to the face of the opening or perimeter barriers.
- Equipment to generate currents of 2 m/s parallel to the face of the opening or perimeter barriers.
- Equipment to measure deformation, which shall have a tolerance of ± 5 % of the measured value.
- Equipment to measure static water levels, which shall have a tolerance of ± 5 % of the measured value
- Equipment to measure current velocities, which shall have a tolerance of ± 5 % of the measured value.
- Equipment to measure leakage rate over a time period to a tolerance of ± 5 % of the maximum allowable leakage rate.
- Recipient, e.g., a drip tray and collection tank, to collect water that moves past or through a flood barrier from the wet-side to the dry-side of the barrier. The recipient permits measuring the amount of leaked water according to the prescribed schedule.

## B.3 Test specimen

The test specimen shall be stored at the test conditions, permitting in-situ applied sealants, if any, to cure.

## B.4 Test conditions

The test shall be performed indoors at (20 ± 10) °C.

## B.5 Test procedure

### B.5.1 Test Sequence

The test shall be performed in accordance with the sequence specified in Table B.5.1.1.

**Table B.5.1.2 – Test sequence**

| Sequence of the test | Parts of the test | Clause in EAD | Condition | Duration |
|---|---|---|---|---|
| 1 | Deployment | B.5.2 | In accordance with documented instructions where provided | Deployment time shall be registered |
| 2 | Filling of the enclosure | - | Nominal maximum fill rate 200 mm/h, higher fill rates may be used | - |
| 3 | Hydrostatic load | B.5.3 | Head: 1/3 × maximum water depth ± 15 mm | $22 \pm_{0}^{0,1}$ h |
| | | | Nominal maximum fill rate 200 mm/h, higher fill rates may be used | - |
| | | | Head: 2/3 × maximum water depth ± 15 mm | $22 \pm_{0}^{0,1}$ h |
| | | | Nominal maximum fill rate 200 mm/h, higher fill rates may be used | - |
| | | | Head: maximum water depth ± 15 mm | $22 \pm_{0}^{0,1}$ h |
| 4 | Draining of the enclosure to 2/3 × maximum water depth | - | Nominal maximum drain rate 200 mm/h, higher drain rates may be used | - |
| 5 | Wave induced hydrodynamic load | B.5.4 | Head: 2/3 × maximum water depth ± 15 mm, low waves between 50 and 75 mm | $7 \pm_{0}^{0,1}$ h |
| | | | Head: 2/3 × maximum water depth ± 15 mm, medium waves between 150 and 200 mm<br>Overtopping of the barrier may be expected during medium and high waves<br>Leakage measurements are only taken during low wave conditions | $3 \times 10 \pm_{0}^{0,1}$ min |
| | | | Head: 2/3 × maximum water depth ± 15 mm, high waves between 250 and 300 mm<br>Overtopping of the barrier may be expected during medium and high waves<br>Leakage measurements are only taken during low wave conditions | $10 \pm_{0}^{0,1}$ min |
| | | | Maximum fill rate to 4/5 maximum water depth 200 mm/h, higher fill rates may be used | - |
| | | | Head: 4/5 × maximum water depth ± 15 mm, low waves between 50 and 75 mm | $7 \pm_{0}^{0,1}$ h[1] |

| Sequence of the test | Parts of the test | Clause in EAD | Condition | Duration |
|---|---|---|---|---|
| | | | Head: 4/5 × maximum water depth± 15 mm, medium waves between 150 and 200 mm<br>Overtopping of the barrier may be expected during medium and high waves.<br>Leakage measurements are only taken during low wave conditions | $3 \times 10 \pm {}^{0,1}_{0}$ min |
| | | | Head: 4/5 × maximum water depth ± 15 mm, high waves between 250 and 300 mm<br>Overtopping of the barrier may be expected during medium and high waves.<br>Leakage measurements are only taken during low wave conditions | $10 \pm {}^{0,1}_{0}$ min |
| 6 | Overtopping[3] | B.5.5 | ≥ 25 mm | $1 \pm {}^{0,1}_{0}$ h |
| 7 | Draining of the enclosure to 2/3 × maximum designated water depth[4] | - | Nominal maximum drain rate 200 mm/h, higher drain rates may be used r | - |
| 8 | Debris impact[4] | B.5.6 | Head: 2/3 × maximum water depth ± 15 mm<br>Log of 300 mm and 280 kg at 2,0 m/s | Not applicable |
| | | | Head: 2/3 × maximum water depth ± 15 mm<br>Log of 450 mm and 360 kg at 2,0 m/s | |
| 9 | Current | B.5.7 | Head: 2/3 × maximum water depth ± 15 mm, lateral current with a velocity of 2,0 m/s | $1 \pm {}^{0,1}_{0}$ h |
| 10 | Filling of the enclosure | - | Nominal maximum fill rate 200 mm/h, higher fill rates may be used | - |
| 11 | Post-hydrostatic load | B.5.8 | Head: maximum water depth ± 15 mm | $1 \pm {}^{0,1}_{0}$ h to $22 \pm {}^{0,1}_{0}$ h [2] |

[1] For a water depth of four fifths (4/5) × maximum water depth with low waves, if no negative effects are observed during the first hour of testing (i.e., increased leakage rates or deflection measurements), the test duration may be reduced to 1 h.
[2] If negative effects (i.e., increased leakage rates or deflection measurements) are observed during the first hour of the test, then the test shall be conducted for maximum 22 h.
[3] Overtopping is not applicable/possible for flood protection door sets, windows, industrial, commercial and garage doors and gates and shutters.
[4] For flood protection opening barrier including flood protection door sets, windows, industrial, commercial and garage doors and gates and shutters, the stated debris impact test method shall be replaced by A.5.4. In this case, the enclosure shall be completely drained at the stated rate above and the test conducted. Following this the enclosure shall be re-filled to 2/3 × maximum water depth at the rate stated above and the remaining parts of the test program sequence conducted as normal. This deviation shall be clearly stated in the resulting ETA.

### B.5.2 Deployment

The test specimen shall be installed/deployed/assembled, disassembled and redeployed in the test rig in accordance with the documented instructions and used in accordance with the use instructions (where provided).

If different installation options are available, the option giving rise to the highest leakage conditions shall be evaluated.

For in-situ applied sealants, the instructions of the applicant shall be closely observed.

### B.5.3 Hydrostatic load

Photographs of the test specimen before and after the test shall be taken.

Once the opening or perimeter barriers has been deployed, the wet side of the enclosure shall be filled until the opening of perimeter barriers lowest part is reached. During filling, the leakage rate and the maximum deflection at least at three locations shall be measured.

The enclosure shall be filled at maximum 200 mm/h to one-third of the maximum water depth ± 15 mm. Measure the total leakage over a period of 22 h and register the result. Maintain the depth of water to within ± 10 mm for the duration of this part of the test. The leakage rate and the maximum deflection (at least at three locations, up to six if the design merits additional measurements) shall be registered after 15 min, 30 min 45 min, 1 h and during the last 2 h of the test, i.e., the last 2 h of the 22-h period after filling.

Thereafter, the enclosure shall be filled at maximum 200 mm/h to two-thirds of the maximum water depth ± 15 mm. Measure the total leakage over a period of minimum 22 h and register the result. Maintain the depth of water to within ± 10 mm for the duration of the test. The leakage rate and the maximum deflection (at least at three locations, up to six if the design merits additional measurements) shall be registered after 15 min, 30 min 45 min, 1 h and during the last 2 h of the test, i.e., the last 2 h of the 22-h period after filling.

Thereafter, the enclosure shall be filled at maximum 200 mm/h to the maximum water depth ± 15 mm. Once the maximum water depth has been reached, the water level shall be maintained to within ± 10 mm for minimum 22 h. The leakage rate and the maximum deflection (at least at three locations, up to six if the design merits additional measurements) shall be registered after 15 min, 30 min 45 min, 1 h and during the last 2 h of the test, i.e., the last 2 h of the 22-h period after filling.

Measure the opening or perimeter barriers deflection from the horizontal and vertical centre of each wall.

### B.5.4 Wave induced hydrodynamic load

Photographs of the test specimen before and after the test shall be taken.

Six tests shall be performed, consisting of three different size wave heights (low, medium and high) at the following still water depths: 2/3 × the maximum water depth ± 15 mm and 4/5 × the water depth ± 15 mm.

Impact the barrier with waves normally incident to the face of the opening or perimeter barriers, as specified in Table B.5.4.1. At the end of each test condition, allow the waves to dissipate before starting the next test.

**Table B.5.4.1 – Wave spectra**

| Wave description | Wave height in mm (measured from trough to crest) | Mean wave period in s | Test duration |
|---|---|---|---|
| Low waves [1] | 50 to 75 | 2 | 7 h [2] |
| Medium waves | 150 to 200 | | 3 × 10 min<br><br>NOTE The separation into three 10 m periods is designed to ensure that the wave height does not enter a feedback loop where previous waves build upon new ones leading to a wave height that exceeds the required height. |
| High waves | 250 to 300 | | 10 min |

[1] Measure the leakage rate for the duration of each low wave test every 15 min.

[2] For a water depth of four fifths (4/5) × maximum water depth, if no negative effects are observed during the first hour of testing (i.e., increased leakage rates and deflection measurements), the test duration may be reduced to 1 h.

Measure the opening or perimeter barriers deflection at the completion of each test from the horizontal and vertical centre of each wall (three locations). Additional locations (up to 6 total) shall be required if deemed appropriate for the composition of the opening or perimeter barriers (see Figure B.5.6.1, with the centres of the three barrier faces being those shown).

The leakage rate shall be measured and recorded during the low wave condition tests, leakage rate measurement is not applicable during medium and high wave conditions due to the potential for water overtopping of the barrier.

### B.5.5 Overtopping

Photographs of the test specimen before and after the test shall be taken.

Fill the wet-side of the enclosure at a maximum 200 mm/h until the water level equals 100 % of structure height plus 25 mm. Maintain the water level for 1 h.

At the completion of the test for perimeter barriers measure the opening or perimeter barriers deflection from the horizontal and vertical centre of each wall (three locations). Additional locations (up to 6 total) shall be required if deemed appropriate for the composition of the opening or perimeter barriers (see Figure B.5.6.1, with the centres of the three barrier faces being those shown). For opening barriers, measure the opening or perimeter barriers deflection from the horizontal and vertical centre of the barrier (at least 1 location).

This clause is not applicable for flood protection door sets, windows, industrial, commercial and garage doors and gates and shutters.

### B.5.6 Debris impact test

Photographs of the test specimen before and after the test shall be taken.

Drain the wet-side of the enclosure at a maximum 200 mm/h until the water level equals 2/3 × maximum water depth ± 15 mm.

A series of two tests shall be conducted, one test with each of the two different size logs specified below:

- 300 mm in diameter, nominal 3 m in length to achieve a test weight of 280 ± 14 kg;
- 450 mm in diameter, nominal 3 m in length to achieve a test weight of 360 ± 18 kg.

The logs shall be of suitable density pine or similar wood per the length, diameter, weight specification and conditioned by submerging in water for at least one week and not more than two weeks prior to testing.

The cut edges of the logs shall be perpendicular saw-cut with no round edges.

Each floating log shall be pulled into the centre of the opening or perimeter barriers with a velocity of 2,0 m/s at a trajectory angle of approximately 70 degrees, see Figure B.5.6.1.

The pulling action shall be ceased immediately before the log impacts the opening or perimeter barriers.

Measure the leakage rate during each test at intervals no greater than 15 min.

At the completion of each test, measure the opening or perimeter barriers deflection from the horizontal and vertical centre of each wall (three locations). Additional locations (up to 6 total) shall be required if deemed appropriate for the opening or perimeter barriers.

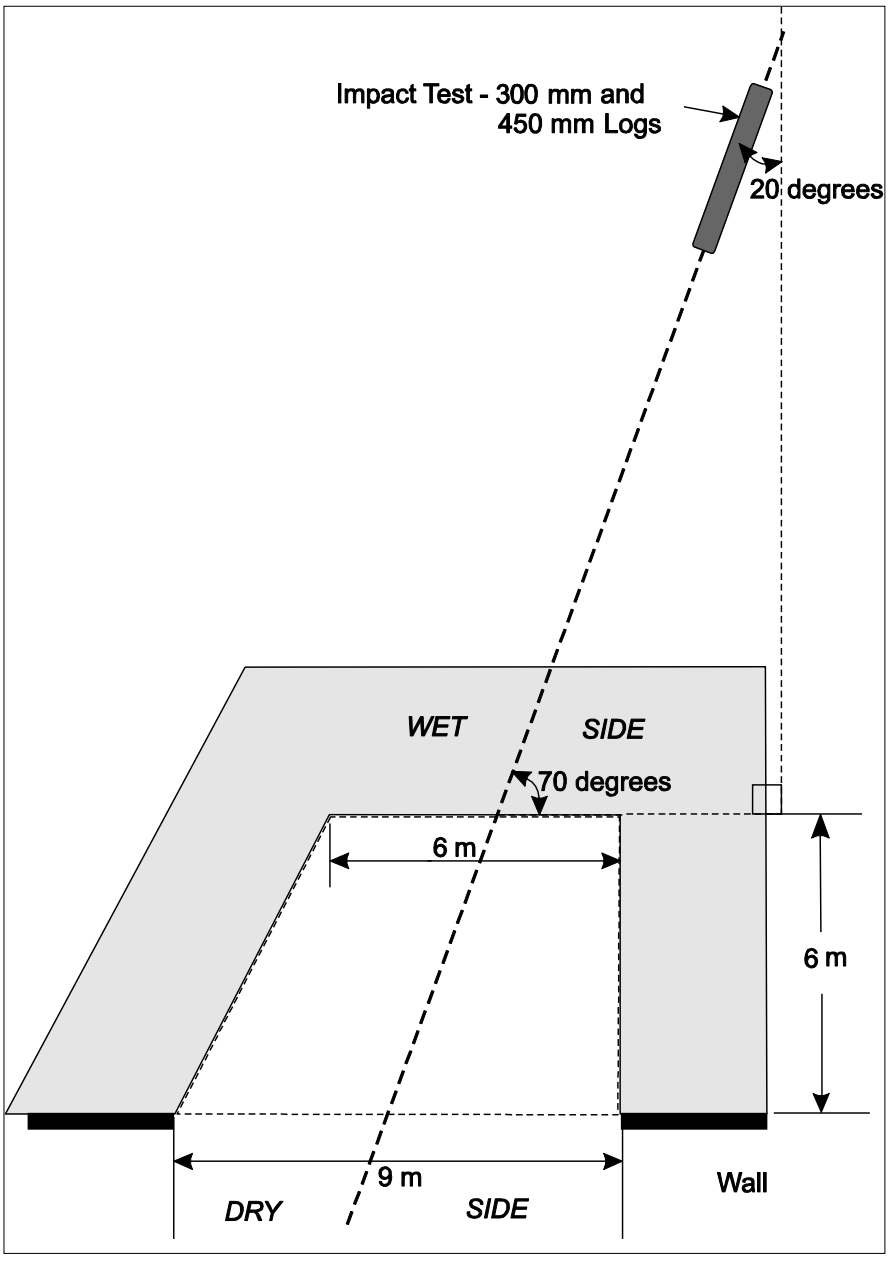


**Figure B.5.6.1 - Test Layout: Dynamic Impact Test**

For flood protection opening barrier including flood protection door sets, windows, industrial, commercial and garage doors and gates and shutters, the stated debris impact test method shall be replaced by A.5.4. In this case, the enclosure shall be completely drained at the stated rate above and the A.5.4 test conducted. Following this the enclosure shall be re-filled to 2/3 × maximum water depth at the rate stated above and the remaining parts of the test program sequence conducted as normal. This deviation shall be clearly stated in the resulting test report.

### B.5.7 Current test

Photographs of the test specimen before and after the test shall be taken.

Testing shall be conducted at a water height of two thirds (2/3) × maximum water depth ± 15 mm.

A minimum channel width of 150 mm should be created for the water flow.

Current shall be applied parallel to the face of the opening or perimeter barriers. The water velocity shall be increased to 2,0 m/s and then maintained steady for 1 h.

The water velocity shall be measured at approximately 50 % of the water depth, approximately 150 mm from the front face of the barrier, and the horizontal midpoint of the section of opening or perimeter barriers exposed to the current or half the distance from the opening or perimeter barriers to the wall, whichever is less.

Measure the leakage rate for the duration of the test at intervals no greater than 15 min.

At the completion of the test, measure the opening or perimeter barriers deflection from the horizontal and vertical centre of each wall (at least three locations).

### B.5.8 Hydrostatic load test

Photographs of the test specimen before and after the test shall be taken.

Fill the wet-side of the enclosure at a maximum 200 mm/h until the water level equals 1 × maximum water depth ± 15 mm. Measure the total leakage over a period of minimum 1 h and register the result. Maintain the depth of water to within ± 15 mm for the duration of this part of the test.

If negative effects (i.e., increased leakage rates or deflection measurements) are observed during the first hour of the test, then the test shall be conducted for maximum 22 h.