EAD **090074-00-0504**

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European Assessment Document for

Glass-ceramic panels for external cladding

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) No 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

The EAD covers glass-ceramic panels for external cladding (in the following referred to as “glass-ceramic panels”) made of a glass-ceramic known as “LAS”, because they are made of lithium aluminosilicate (Li_2O–Al_2O_3–SiO_2). It is manufactured in thin self-supporting sheets obtained through a controlled crystallization process and treated subsequently with thermal annealing and ceramization cycles. The resulting panels have an opalescent appearance similar to that of natural stones such as alabaster and onyx, to which different levels of sanding or polishing can be applied afterwards in order to obtain different kinds of colours. The different types of surface treatment are not covered by this EAD.

The product is not fully covered by the following harmonised technical specification: EN 1748-2-2[1], since the percentage of its constituents is different from that given in EN 1748-2-1, referred to in EN 1748-2-2. In particular, in the product covered by this EAD, aluminium oxide, Al_2O_3, is in the range 8%-27% and lithium oxide, Li_2O, is in the range 0%-12%. For this reason, some of the assessment methods have been updated or articulated differently to take into account the specificity of the product and the intended use. In particular, with respect to EN 1748-2-2:

- resistance to fire is not covered by this EAD, due to the difference in the intended use,
- external fire performance is not covered by this EAD, due to the different intended use as glass-ceramic panels of this EAD are used for external claddings only,
- explosion resistance and burglar resistance have been detailed in order to better specify the expression of results,
- resistance against sudden temperature changes and temperature differentials has been specified through a test method, instead of using the generally accepted value given in EN 1748-2-1,
- resistance against wind, snow, permanent load and/or imposed loads of the glass unit has been specified through a test method, instead of using the generally accepted value given in EN 1748-2-1,
- direct airborne sound reduction and thermal properties have been detailed addressing assessment methods,
- total solar energy transmittance and UV-transmittance have been added.

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, i.e., with regard to the intended end use conditions, 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 as long as the details of the assessment methods as laid down in this EAD are respected.

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

1.2.1 Intended use(s)

The glass-ceramic panels are used for external cladding of buildings and are intended to be used on new constructions as well as on existing buildings.

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 glass-ceramic panels for the intended use of 25 years

[1] All undated references to standards in this EAD are to be understood as references to the dated versions listed in chapter 4.

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[2].

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 Glass ceramics

Type of glass consisting of a crystalline and a residual glass phase. The glass is obtained by normal glass manufacturing methods, e.g., casting, floating, drawing, rolling and is subsequently subjected to a heat treatment, made of thermal annealing and ceramization cycles, which transforms, in a controlled manner, part of the glass into a fine grained crystalline phase. The glass ceramics has properties which deviate from those of the glass from which it was transformed.

2 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.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of the glass-ceramic panels 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 2: Safety in case of fire			
1	Reaction to fire	EN 1748-2-2, clause 4.2.2.2	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Bullet resistance: shatter properties and resistance to attack	EN 1748-2-2, clause 4.2.2.4	Class
3	Explosion resistance: shatter properties and resistance to impact	2.2.1	Class
4	Burglar resistance: shatter properties and resistance to attack	2.2.2	Class
5	Pendulum body impact resistance: shatter properties (safe breakability) and resistance to impact	EN 1748-2-2, clause 4.2.2.7	Class
6	Mechanical resistance: resistance against sudden temperature changes and temperature differentials	2.2.3	Level
7	Mechanical resistance: resistance against wind, snow, permanent and imposed load and/or imposed loads of the glass-ceramic unit	2.2.4	Level
Basic Works Requirement 5: Protection against noise			
8	Direct airborne sound reduction	2.2.5	Level
Basic Works Requirement 6: Energy economy and heat retention			
9	Thermal properties	2.2.6	Level
10	Radiation properties: light transmittance and reflectance	EN 1748-2-2, clause 4.2.2.12	Level
11	Solar energy characteristics: solar direct transmittance and solar direct reflectance	EN 1748-2-2, clause 4.2.2.13	Level
12	Solar energy characteristics: total solar energy transmittance	2.2.7	Level
13	Solar energy characteristics: UV-transmittance	2.2.8	Level

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.

A summary of the minimum number of specimens for each test foreseen in the EAD is presented in Annex A.

2.2.1 Explosion resistance: shatter properties and resistance to impact

Purpose of the assessment

The purpose of this assessment is to determine the resistance of the glass-ceramic panels against explosives with respect to human safety.

Assessment method

The explosion resistance shall be determined and classified in accordance with EN 13541 on three specimens for each attack face and each class according to Table 1 of EN 13541 for which testing is envisaged.

Expression of results

The category of resistance against explosive blast shall be given in the ETA. The specific suffix “NS” (no splintering, meaning that no fragmentation occurred of the last pane rear face of the specimen) or “S” (splintering, meaning that the last pane rear face of the specimen is fragmented, broken or splinters are detached from the specimen), as also specified by note of clause 8 of EN 13541, shall be stated in parentheses after the category, like in the examples below.

EXAMPLES: EN 13541-ER4 (S); EN 13541-ER1 (NS)

2.2.2 Burglar resistance: shatter properties and resistance to attack

Purpose of the assessment

The purpose of this assessment is to determine the resistance of the glass-ceramic panel against actions of forced or manual attack, by means of a hard body and an axe.

Assessment method

The burglar resistance shall be determined and classified in accordance with EN 356 on three specimens for each category, as specified in Manufacturers Product Installation Instructions (MPII).

Expression of results

The category of resistance against burglar attack shall be given in the ETA, like in the examples below.

EXAMPLES: EN 356-P1A by means of a hard body; EN 356-P6B by means of an axe.

2.2.3 Mechanical resistance: resistance against sudden temperature changes and temperature differentials

Purpose of the assessment

The purpose of this assessment is to determine the mechanical resistance of the glass-ceramic panels against sudden temperature changes and temperature differentials by water quenching.

Assessment method

The resistance against sudden temperature changes and temperature differentials shall be determined in accordance with EN 820-3. Type A bar-shape test pieces shall be used. A strength test in accordance with EN 60672-2 shall be employed to check whether weakening has occurred after the thermal shock test.

Expression of results

The critical quenching temperature interval where the mean flexural strength is reduced by 30% compared to the unshocked strength, shall be given in the ETA, expressed in °C.

2.2.4 Mechanical resistance: resistance against wind, snow, permanent and imposed load and/or imposed loads of the glass-ceramic unit

Purpose of the assessment

The purpose of this assessment is to determine the mechanical resistance of the glass-ceramic panels against wind, snow, permanent and imposed load and/or imposed loads of the glass-ceramic unit.

Assessment method

The resistance against wind, snow, permanent and imposed load and/or imposed loads of the glass-ceramic panels shall be conducted on ten specimens in accordance with Annex B, performing a coaxial double ring test in order to develop a equibiaxial stress state in the core of the specimen, avoiding preferential directions of fracture.

Expression of results

The breaking load F [N] and the equibiaxial strength σ_f [MPa], expressed by their mean value ($\bar{x}$), standard deviation (s) and percent coefficient of variation (% C.V.), shall be determined and shall be given in the ETA.

2.2.5 Direct airborne sound reduction

Purpose of the assessment

The purpose of this assessment is to determine the airborne sound reduction of the glass-ceramic panel.

Assessment method

The sound reduction indexes shall be determined in accordance with EN ISO 10140-1 Annex D and EN ISO 10140-2.

Expression of results

The sound reduction indexes shall be given in the ETA, in accordance with EN ISO 10140-1, EN ISO 10140-2 and EN ISO 717-1. The two spectrum adaptation terms shall be stated in parentheses after the single number quantity separated by a semicolon, like in the example below.

EXAMPLE: $R_w(C;C_{tr})=41(0;-5)$ dB

2.2.6 Thermal properties

Purpose of the assessment

The purpose of this assessment is to determine the thermal properties of the glass-ceramic panels.

Assessment method

The thermal transmittance value (U-value) shall be determined on panels without any treatment (sanding or polishing) by calculation in accordance with EN 673, with the value of emissivity in accordance with EN 12898 and the nominal thickness of the glass-ceramic panels.

Expression of results

The thermal transmittance value (U-value) shall be given in the ETA.

2.2.7 Solar energy characteristics: total solar energy transmittance

Purpose of the assessment

The purpose of this assessment is to determine the total solar energy transmittance of the glass-ceramic panels.

Assessment method

The total solar energy transmittance shall be determined in accordance with EN 410, clause 5.4.

Expression of results

The total solar energy transmittance, *g,* shall be given in the ETA.

2.2.8 Solar energy characteristics: UV-transmittance

Purpose of the assessment

The purpose of this assessment is to determine the UV-transmittance of the glass-ceramic panels.

Assessment method

The UV-transmittance shall be determined in accordance with EN 410, clause 5.5.

Expression of results

The UV-transmittance, τ_{UV}, shall be given in the ETA.

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 2000/245/EC** amended by **2001/596/EC**.

The systems are:

- **1**: for use in a glazed assembly intended specifically for use as anti-bullet or anti-explosion glazing.
- **3**: for uses liable to present “safety-in-use” risks and subject to such regulations, for uses relating to energy conservation and/or noise reduction.
- **4**: for uses other than those specified above.

3.2 Tasks of the manufacturer

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

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum No. 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	*Incoming materials:* Raw material	Checking of supplier certificates or supplier tests	Conformity with the order	According to Control plan / as agreed with supplier	Standard operating procedure/ According to audit plan/supplier
2	*Incoming materials:* Bought-in cullet	Visual check	Conformity with the order	According to Control plan / as agreed with supplier	Each delivery
3	*Incoming materials:* Raw material transport (check for contamination of vehicle)	Visual check	Conformity with the order	According to Control plan / as agreed with supplier	Each delivery
4	*Product control: Glass-ceramic* - Chemical composition	Chemical analysis	According to Control Plan	According to Control plan	Once per week
5	*Product control: Glass-ceramic* - Light transmittance	Spectrophotometer	According to Control Plan	According to Control plan	Once per week
6	*Product control: Glass-ceramic* - Solar energy transmittance	EN 410, Clause 5.4	Claimed performance value	According to Control plan	Once per week
7	*Product control: Glass-ceramic Panels* - Thickness	Measurement (calliper micrometre type) / EN 1748-2-1, Clause 6.2	EN 1748-2-1, Clause 6.2.1 and Table 3	According to Control plan	Once per day
8	*Product control: Glass-ceramic Panels* – Plate dimensions	Measurement / EN 1748-2-1, Clause 6.3	EN 1748-2-1, Clause 6.3 and Table 4	According to Control plan	Once per day
9	*Product control: Glass-ceramic Panels* - Optical quality	Measurement / EN 1748-2-1, Clause 7.1.1	EN 1748-2-1, Clause 7.1.1 and Table 5	According to Control plan	Once per day
10	*Product control: Glass-ceramic Panels* - Visual quality	Measurement/visual test / EN 1748-2-1, Clause 7.1.2	EN 1748-2-1, Clause 7.1.2 and Table 5	According to Control plan	One stock size per day

3.3 Tasks of the notified body

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

The tasks of the Notified Body foreseen in Table 3.3.1 are to be undertaken by the Notified Body only if the conditions foreseen in the applicable AVCP decision for System 1 are satisfied. These tasks are limited to the cases where the glazed assembly is intended specifically for use as anti-bullet or anti-explosion glazing.

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 *(for system 1 only)*					
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 glass-ceramic panels.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	According to Control plan	According to Control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control *(for system 1 only)*					
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	According to Control plan	According to Control plan	Twice a year for new production facilities, reduced to once a year[3]

[3] The frequency of production surveillance shall be twice per year for new production facilities or for facilities that to not already have a factory production control system in accordance with this document. When assessment of FPC fails to identify major non-conformances, the outcome fulfils the requirements during four successive assessments, the frequency can be reduced to once a year.

4 REFERENCE DOCUMENTS

EN 356:1999	Glass in building – Security glazing – Testing and classification of resistance against manual attack
EN 410:2011	Glass in building – Determination of luminous and solar characteristics of glazing
EN 673:2024	Glass in building - Determination of Thermal Transmittance (U Value) - Calculation method
EN 820-3:2004	Advanced technical ceramics - Methods of testing monolithic ceramics - Thermomechanical properties - Part 3: Determination of resistance to thermal shock by water quenching
EN 1063:1999	Glass in building – Security glazing – Testing and classification of resistance against bullet attack
EN 1748-2-1:2004	Glass in building – Special basic products – Glass ceramics - Part 2-1: Definitions and general physical and mechanical properties
EN 1748-2-2:2004	Glass in building – Special basic products – Glass ceramics - Part 2-2: Evaluation of conformity / Product standard
EN 12898:2019	Glass in building - Determination of the emissivity
EN 13541:2012	Glass in building - Security glazing - Testing and classification of resistance against explosion pressure
EN 60672-2:2000	Ceramic and glass insulating materials - Part 2: Methods of test
EN ISO 717-1:2000	Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation
EN ISO 10140-1:2021	Acoustics - Laboratory measurement of sound insulation of building elements - Part 1: Application rules for specific products
EN ISO 10140-2:2021	Acoustics - Laboratory measurement of sound insulation of building elements - Part 2: Measurement of airborne sound insulation

ANNEX A: SUMMARY OF TESTS

BWR	ESSENTIAL CHARACTERISTIC	TEST TYPE (clauses)	MINIMUM NUMBER OF SPECIMENS
BWR 4	Bullet resistance: shatter properties and resistance to attack	EN 1748-2-2, clause 4.2.2.4	3 for each category
	Explosion resistance: shatter properties and resistance to impact	2.2.1	3 for each chosen class
	Burglar resistance: shatter properties and resistance to attack	2.2.2	3 for each category
	Pendulum body impact resistance: shatter properties (safe breakability) and resistance to impact	EN 1748-2-2, clause 4.2.2.7	4
	Mechanical resistance: resistance against sudden temperature changes and temperature differentials	2.2.3	5 traveller specimens + 5 specimens for each temperature steps
	Mechanical resistance: resistance against wind, snow, permanent and imposed load and/or imposed loads of the glass-ceramic unit	2.2.4	10
BWR 5	Direct airborne sound reduction	2.2.5	1
BWR 6	Thermal properties	2.2.6	1
	Radiation properties: light transmittance and reflectance	EN 1748-2-2, clause 4.2.2.12	1
	Solar energy characteristics: solar direct transmittance and solar direct reflectance	EN 1748-2-2, clause 4.2.2.13	1
	Solar energy characteristics: total solar energy transmittance	2.2.7	1
	Solar energy characteristics: UV-transmittance	2.2.8	1

ANNEX B: MECHANICAL RESISTANCE: RESISTANCE AGAINST WIND, SNOW, PERMANENT AND IMPOSED LOAD AND/OR IMPOSED LOADS OF THE GLASS-CERAMIC UNIT

B.1 Purpose of the test

The purpose of this assessment is to determine the mechanical resistance against wind, snow, permanent and imposed load and/or imposed loads of the glass-ceramic unit. The test shall be conducted by determining the equibiaxial strength of the glass-ceramic panels at ambient temperature, by using a concentric ring configuration under monotonic uniaxial loading, in order to develop a stress state in the core of the specimen, avoiding preferential directions of fracture. This method provides information on the strength and deformation of the glass-ceramic panels under tensile stresses, where the sizes of the load and support rings depend on the dimensions and the properties of the specimen to be tested. The strength refers to the maximum strength obtained under a monotonic application of loads, applied at a constant rate with no reversals from the starting point till the final fracture.

B.2 Test specimens

The test shall be performed on ten circular specimens, with relative dimensions chosen to ensure behaviour reasonably described by simple plate theory, such the test specimen thickness h is:

$$\frac{D_s}{10} \geq \mathrm{h} \geq \sqrt{2\,\sigma_f\,D_s^2/3E} \qquad \text{(B.2.1)}$$

where: D_S is the support ring diameter in mm, σ_f is the expected equibiaxial fracture strength in MPa, and E is the modulus of elasticity in MPa. The test specimen and the support diameters shall be such that the difference in diameters is:

$$2 \leq \frac{\mathrm{D}-\mathrm{Ds}}{h} \leq 12, \qquad \text{(B.2.2)}$$

where D is the test specimen diameter in mm and D_S is the support ring diameter in mm.
The test specimen shall be flat to 0.1 mm in 25 mm.

B.3 Test setup

The test setup shall consist in:

- A testing device, as schematically represented in Figure B.3.1, capable of obtaining a constant monotonic loading through load cells that shall be accurate within 1 % at any load. Surfaces of the support platen shall be flat and parallel to 0.05 mm. The face of the load rod in contact with the support platen shall be flat to 0.025 mm. The two loading rods shall be parallel to 0.05 mm per 25 mm length and concentric to 0.25 mm when installed in the test apparatus. The base of the load and support fixture shall be made of steel. The tip radius, r, of the cross sections of the load and support rings shall be $h/2 \leq r \leq 3h/2$.
  Parallelism and flatness of faces as well as concentricity of the load and support rings shall be respected. The ratio between the load ring diameter and the support ring shall be between 0.2 and 0.5. The rings shall be sized to the thickness, diameter, strength, and elastic modulus of the glass-ceramic specimens. Care must be taken to avoid introducing any unintended stresses during the setup process. In order to minimize the effects of friction at the load ring interface in the point of contact, a sheet of carbon foil or Teflon tape may be placed between the compressive surface of the test specimen and the load-ring, to avoid crack initiation and fracture other than the actual equibiaxial strength, considering the brittle nature of glass-ceramic materials and the sensitivity to misalignment, especially if the test specimen is not perfectly flat. Multiple strips of tape shall not be used in order to avoid any non-uniform loading.
  The load ring and support ring shall be aligned concentrically to 0.5 % of the support ring diameter. The specimen shall be concentric with the load and support rings to 2% of the support ring diameter.
- Measuring devices, such as micrometres, for measuring linear dimensions, accurate to at least one half the smallest unit to which the individual dimension is required to be measured. For measuring the thickness, a micrometre with resolution better than or equal 0.002 mm shall be used.

- A recording device for digital data acquisition, able to record and to obtain a graphic of applied load versus time, accurate to within ± 1 % of the selected range for the testing system, with a minimum data acquisition rate of 10 Hz with a rate of 50 Hz preferred.

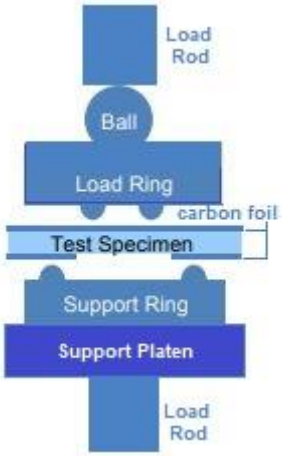

Figure B.3.1: Schematic example of coaxial double ring configuration for resistance against wind, snow, permanent and imposed load and/or imposed loads of the glass-ceramic unit

B.4 Test procedure

The load and support ring diameters, test specimen lengths and thickness shall be measured and recorded with extreme caution to prevent damages to the test specimen. The average of the multiple measurements shall be used in the processing of test results (see clause B.5).

The specimens shall be exposed at ambient conditions temperature to incremental loads applied to the centre of the specimen at a constant rate until it reaches failure. Test modes and rates can have distinct influences on fracture behaviour. Test modes may involve load or displacement control. The rates of testing shall be sufficiently rapid to nominally obtain the maximum equibiaxial strength at fracture of the material in the test environment considered.

If displacement control mode is used, the displacement rate shall be related to the maximum stress state in the concentric ring test specimen as follows:

$$\dot{\delta} \cong \left(\frac{D_s^2}{6Eh}\right)\dot{\sigma} \tag{B.4.1}$$

where: $\dot{\delta}$ is the displacement rate of the actuator or crosshead in mm/s and $\dot{\sigma}$ the maximum value of the nominal recommended stress rate occurring within the test specimen in MPa/s. The other variables are as defined for equation (B.2.1). Stress rates >30-35 MPa/s shall be used.

For test systems employing closed loop controllers, a load rate shall be directly applied to the test specimen and shall be calculated as follows:

$$\dot{F} = \left(\frac{2}{3}\pi h^2 \left[(1-\nu)\frac{D_s^2 - D_L^2}{2\,D^2} + (1+\nu)\ln\frac{D_s}{D_L}\right]^{-1}\right)\dot{\sigma} \tag{B.4.2}$$

where $\dot{F}$ is the required load rate in N/s, D is the test specimen diameter in mm, D_s is the support ring diameter in mm, D_L is the load ring diameter in mm (see Figure B.4.3 for the legend of all diameters), and ν is the Poisson's ratio. The other variables are as defined for equations (B.2.1) or (B.4.1). Alternatively, stress or load rates shall be selected such to minimize environmental effect by producing fracture in 10 to 15 s, i.e., $t_f = \sigma_f/\dot{\sigma}$, with t_f time to fracture in s.

A cellophane tape shall be applied to the compressive surface of the test specimen, in order to retain any fracture fragments, using a wide tape enough to cover the test specimen face, taking care not to damage it. The test specimen shall be aligned in such a way that the two load rings are concentric and parallel to the test specimen faces, inspecting load rings in order to clean or remove any nicks in the load and support rings.
The test mode and test rate shall be set on the test machine; at first, a small pre-load like 10% of the failure load shall be applied, going to zero and then applying the constant rate, recording data with the acquisition systems till failure.
Any test specimen fragments shall be collected and put into a non-metallic container.
For a properly conducted equibiaxial test, fracture shall typically occur on the tensile surface within the diameter of the load-ring. Some fractures may also initiate from the region between the load ring and the support load ring. Frequent fracture at or near the load ring/test specimen interface implies excessive contact or friction stresses, or fixture/test specimen misalignment. The location of the specimen fracture shall be determined with a fractographic examination (see Figure B.4.1), in particular for evidence of edge-related fractures or repeated fractures near the load ring (edge fracture indicates an invalid test to be repeated, see Figure B.4.2).

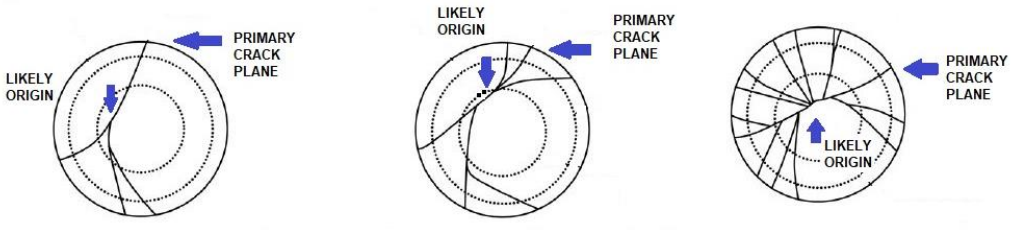

Figure B.4.1: Schematic example of admissible failure fractures

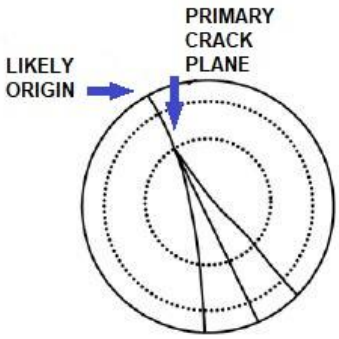

Figure B.4.2: Schematic example of edge initiated failure (invalid test)

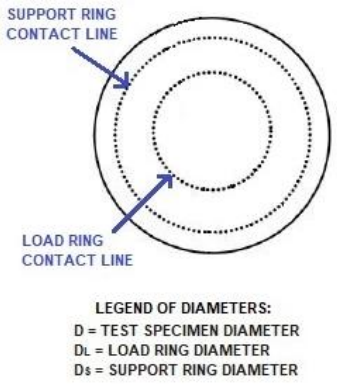

Figure B.4.3: Legend of diameters

B.5 Processing of test results

The breaking load (F) at which the failure occur shall be recorded and expressed in N.
The equibiaxial strength σ_f shall be calculated, expressed in MPa, according to the following equation:

$$\sigma_f = \frac{3F}{2\,\pi\,h^2}\left[(1-\nu)\frac{D_s^2 - D_L^2}{2\,D^2} + (1+\nu)\ln\frac{D_s}{D_L}\right] \qquad \text{(B.5.1)}$$

where F is the breaking load in N and the other symbols are defined before above.

For each test series the mean value, the standard deviation and the percent coefficient of variation shall be determined for each measured value as follows, where x_i is the valid measured value and n is the number of valid tests:

Mean value: $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ (B.5.2)

Standard deviation (s) = $\sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}}$ (B.5.3)

Percent coefficient of variation (% C.V.) = $\frac{100\ (s)}{\bar{x}}$ (B.5.4)