FIRE RESISTANCE

Kerto®, like wood products generally is classified as a combustible material. The ignition tempera-ture of Kerto, when exposed to a flame, is about 270 °C. Spontaneous ignition does not occur until a temperature of over 400 °C is reached.

In the event of a fire, Kerto performs better than many non-combustible materials. As a result of burning, the surface of Kerto is charred. This protects the product, insulates it and slows down the burning process.

The fire design of a Kerto product is conducted according to EN 1995-1-2 standard and its national annexes.

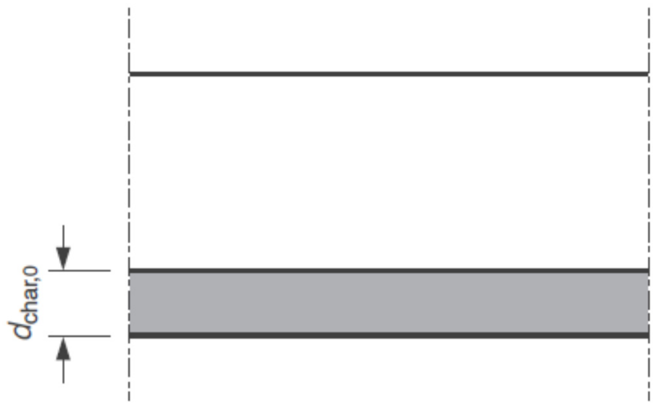


Figure 1: One-dimensional charring of wide cross section when fire exposure is on one side (Source: EN 1995-1-2).

CHARRING DEPTH

The charring depth is the distance between the outer surface of the original member and the position of the char-line and should be calculated using the time of fire exposure and the relevant charring rate.

There are two different types of charring rates depending on whether the product is exposed to fire from single or multiple sides. If the fire exposure is for a single side in panel type structure, for ex-ample slab or wall, the one-dimensional charring depth may be used. For all other structures, generally columns and beams, the notional charring depth should be used.

The design charring depth for one-dimensional charring $d_{char,0}$ should be calculated as follows when the surface is unprotected throughout the time of fire exposure.

$$d_{char,0} = \beta_0 t \qquad (1)$$

where t is the time of fire exposure and β_0 is the one-dimensional design charring rate under standard fire exposure, see Table 1

The notional design charring depth $d_{char,n}$, which includes the effect of corner roundings and fissures should be calculated as follows when the surfaces are unprotected throughout the time of fire expo-sure.

$$d_{char,n} = \beta_n t \qquad (2)$$

where t is the time of fire exposure β_n is the notional design charring rate, the magnitude of which includes the effect or cor-ner roundings and fissures, see Table 1.

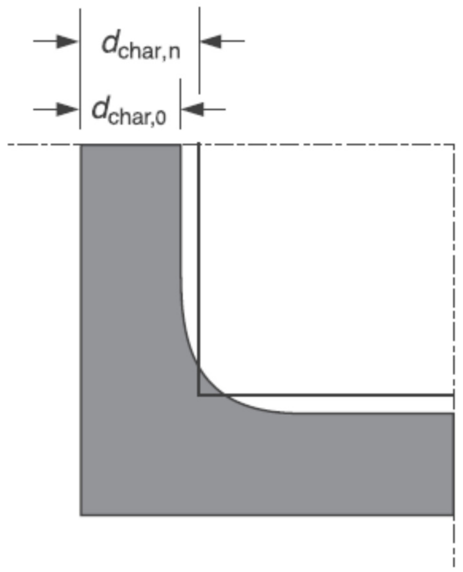


Figure 2: Charring depth $d_{char,0}$ for one-dimensional and notional charring depth $d_{char,n}$. (Source: EN 1995-1-2)

Table 1. The charring rates of Kerto products

	β_0 (mm/min)	β_n (mm/min)
Kerto-S, Kerto-Q	0,65 *	0,70 *
Kerto-T, Kerto-L	0,70 *	0,75 *
Kerto-Kate		
- thickness 15 mm	0,75	
- thickness 18 mm	0,70	

* If the product thickness is less than 20 mm, the charring rate should be increased with a factor $k_h = \sqrt{20mm / h_p}$, where h_p is the product thickness.

Example:

What are the one-dimensional and notional charring depths if the fire exposure time is 15 minutes?

$$d_{char,0} = 0{,}65\,mm / \min \cdot 15 \min = 9{,}8\,mm$$
$$d_{char,n} = 0{,}70\,mm / \min \cdot 15 \min = 10{,}5\,mm$$

NOTE. The fire resistance of the connections has to be notified in design in addition of the fire resistance of the Kerto members.

The charring rates of Kerto products have been tested up to 120 minutes. Research report VTT-S-04746-16.

DESIGN VALUES OF MATERIAL PROPERTIES

For verification of mechanical resistance, the design values of strength and stiffness properties should be determined as follows:

$$f_{d,fi} = k_{\mathrm{mod},fi} \frac{f_{20}}{\Upsilon_{M,fi}} \quad (3)$$

$$S_{d,fi} = k_{\mathrm{mod},fi} \frac{S_{20}}{\Upsilon_{M,fi}} \quad (4)$$

where:

- $f_{d,fi}$ is the design strength in fire
- $S_{d,fi}$ is the design stiffness property (modulus of elasticity $E_{d,fi}$ or shear modulus $G_{d,fi}$) in fire
- f_{20} is the 20 % fractile of a strength property at normal temperature
- S_{20} is the 20 % fractile of a stiffness property (modulus of elasticity or shear modulus) at normal temperature
- $k_{mod,fi}$ is the modification factor for fire
- $\Upsilon_{M,fi}$ is the partial safety factor for timber in fire

The 20 % fractile of a strength or a stiffness property should be calculated as follows.

$$f_{20} = k_{fi} \cdot f_k \quad (5)$$

$$S_{20} = k_{fi} \cdot S_{05} \quad (6)$$

where:

- f_{20} is the 20 % fractile of a strength property at normal temperature
- S_{20} is the 20 % fractile of a stiffness property (modulus of elasticity or shear modulus) at normal temperature
- S_{05} is the 5 % fractile of a stiffness property (modulus of elasticity or shear modulus) at normal temperature
- k_{fi} is 1,1 for Kerto products

NOTE! The modification factor for fire takes into account the reduction in strength and stiffness properties at elevated temperatures. The modification factor for fire replaces the modification factor for normal temperature design given in EN 1995-1-1. Values of $k_{mod,fi}$ fi are given in the relevant clauses of EN 1995-1-2.

NOTE! The Eurocode 5 recommended partial safety factor in fire is $\Upsilon_{M,fi} = 1{,}0$. Information on national choice may be found in the National Annex. In Finland the national choice for partial safety factor in fire $\Upsilon_{M,fi} = 1{,}0$.

SECTION PROPERTIES

The section properties should be determined according to reduced cross-section method as per EN 1995-1-2 standard. Also the reduced properties method according to EN 1995-1-2 may be used.

NOTE! The recommended procedure is the reduced cross-section method. Information on National choice may be found in the National annex. In Finland, the National choice is to use the reduced cross-section method, which is presented below.

The effective cross-section should be calculated by reducing the initial cross-section by the effective charring depth d_{ef} (figure 3).

$$d_{ef} = d_{char,n} + k_0 \cdot d_0 \qquad (7)$$

where:

d_0 is 7 mm

$d_{char,n}$ is the notional design charring depth, see equation 2

k_0 is given in Table 2 and Figure 4.

For unprotected surfaces, k_0 should be determined from Table 2. For protected surfaces with $t_{ch} > 20$ minutes, it should be assumed that t_0 varies linearly from 0 to 1 during the time interval from $t = 0$ to $t = t_{ch}$, see Figure 4 (right). For protected surfaces with $t_{ch} \leq 20$ minutes Table 2 applies.

TABLE 2. Determination of k_0 for unprotected surfaces with time t minutes.

	k_0
$t \leq 20$ minutes	t / 20
$t > 20$ minutes	1,0

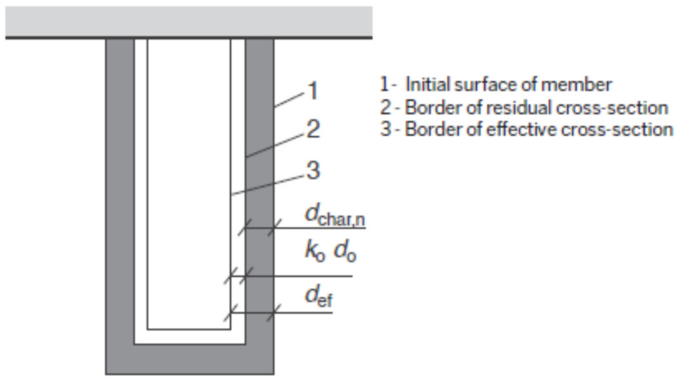


Figure 3. Definition of residual cross-section and effective cross-section (Source: EN 1995-1-2)

NOTE. It is assumed that material close to the char-line in the layer of thickness $k0 \cdot d0$ has zero strength and stiffness, while the strength and stiffness properties of the remaining cross-section are assumed to be unchanged.

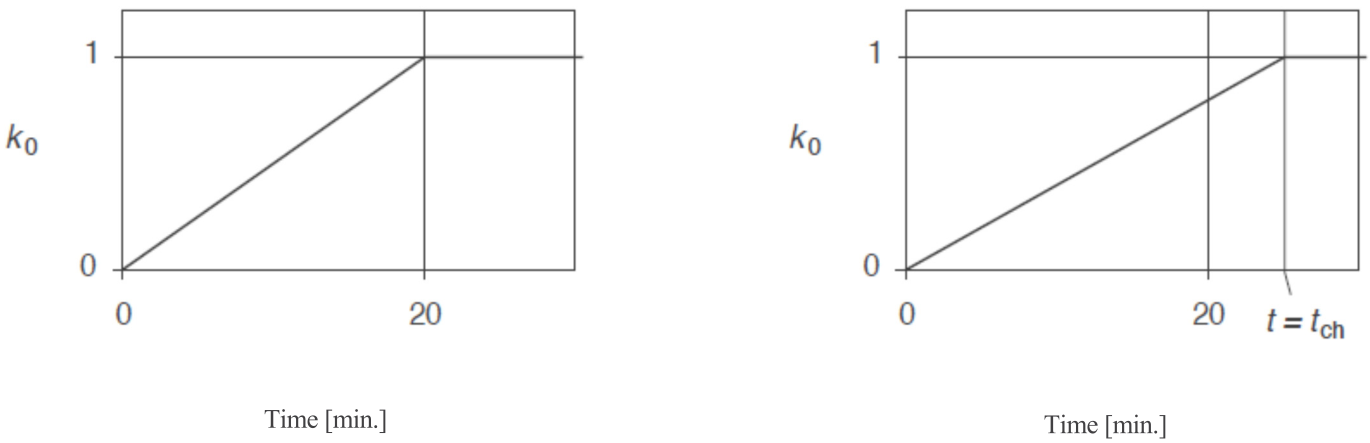


Figure 4. Variation of k_0 (left) for unprotected members and members where $t_{ch} \leq 20$ minutes, (right) for unprotected members where $t_{ch} > 20$ minutes (Source: EN 1995-1-2).

For timber surfaces facing a void cavity in a floor or wall assembly (normally the wide sides of a stud or a joist), the following applies:

- Where the fire protective cladding consists of one or two layers of gypsum plasterboard type A, wood paneling or wood-based panels, at the time of failure t_f of the cladding, k_0 should be taken as 0.3. Thereafter k_0 should be assumed to increase linearly to unity during the following 15 minutes.
- Where the fire protective cladding consists of one or two layers of gypsum plasterboard type F, at the time of start of charring t_{ch}, should be taken as unity. For times $t < t_{ch}$, linear interpolation should be applied, see Figure 4 (right).
- The design strength and stiffness properties of the efficient cross-section should be calculated using $k_{mod,fi} = 1{,}0$.

Example:

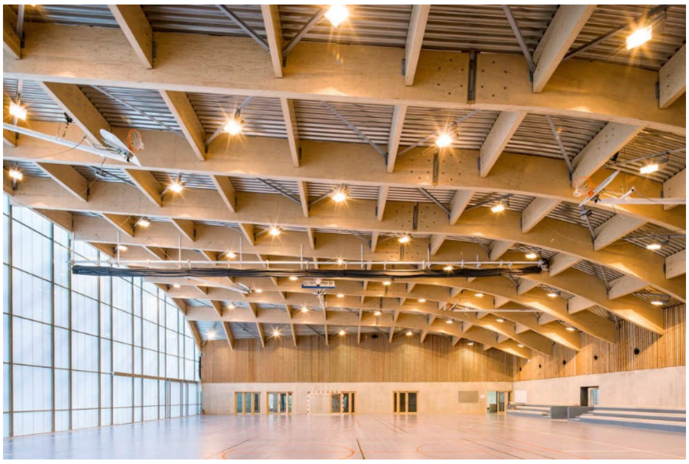
Calculate the effective cross-section and bending strength of an unprotected Kerto-S beam 63 × 300 mm exposed to fire from all sides for 15 min.

$$d_{ef} = d_{char,n} + k_0 \cdot d_0 = 0{,}70\,mm/\min \cdot 15\min + \frac{15\min}{20\min} \cdot 7mm = 15{,}75\,mm$$

Width: 63 mm – 31,5 mm = 31,5 mm

Height: 300 mm – 31,5 mm = 268,5 mm

$$f_{m,d,fi} = k_{\text{mod},fi} \frac{f_{fi} \cdot f_{m,k}}{\Upsilon_{m,fi}} = 1{,}0 \cdot \frac{1{,}1 \cdot 44\,N/mm^2}{1{,}0} = 48{,}4\,N/mm^2$$



REACTION TO FIRE

Kerto members without surface treatment have Euroclass D-s1, d0 with regard to reaction to fire (EN 13501-1). National building regulations define the fire class requirements in different applications.

The fire resistance of Kerto can be improved by impregnating it with fire protection chemicals or by surfacing it with thin, fire-resistant, inorganic laminates. With fire impregnated products it is possible to have the Euroclass B-s1, d0, but the classification depends on the used fire retardant.

Kerto products can be treated with FireResist to improve the product's Euroclass to B-s1, d0 for the structures specified in the classification report. More information is available from country specific web pages.

NOTE. There are also national fire classification systems and separate certificates in every country.

COMBUSTION

The heat combustion of Kerto product is17 MJ/kg.

MetsäWood