Reaction to Fire and **Fire Resistance** as it applies to the ETA of an anchor

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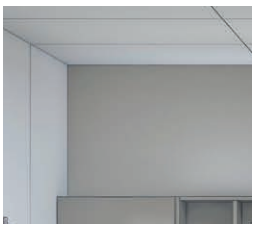
One of the most critical considerations a building designer must review is the flammability of materials and their contribution to fire. The designer must determine how much time the occupants of a building have to escape and not be harmed in the evacuation process. There are two evaluations that are made in European codes that are used in an ETA (European Technical Assessment) and are very similar to Australian requirements, namely **Reaction to Fire** and **Fire Resistance.** Examination of products are completed in specially devised test rooms.

Reaction to Fire

Reaction to Fire is a measure of how a material contributes to the growth of fire. A European classification (**EN 13501-1:2018 - Fire classification of construction products and building elements**) has been established and is described with examples as follows;

Table 1: A description and examples of materials with the Reaction to Fire Classification.

Reaction to Fire (EN 13501-1:2018)			
Classification	**Description**	**Flashover**	**Examples**
A1	Non-combustible material.	Nil	Concrete, steel, glass, natural stone, bricks, some mineral wools (used for fire proof insulation) and ceramics.
A2		Nil	Specified plasterboards, particle boards, cement, and glass wool.
B	Very limited contribution to fire.	Possible	Plasterboard and fire resistant MDF.
C	Limited contribution to fire.	10 Minutes to flashover	Phenolic foam, foil faced and fire resistant MDF.



Classification	Description	Flashover	Examples
D	Medium contribution to fire.	Flashover before 10 minutes	Expanded fire rated foams, materials and wood products without protection, where their reaction depends on their thickness and density.
E	Fuel, causes flashover before 2 minutes.	Flashover before 2 minutes	Low density plywood, laminated timber, fibreboard, or plastic composite insulation systems.
F	Easily flammable.	Immediate	Materials and products not tested and polystyrene.
Note: Flashover is the moment when combustible materials that were not involved in the original fire begin to burn, increasing the temperature in the room and increasing its **speed** of propagation.			

These are sub categorised into 2 groups as follows: **smoke emission** levels and **flaming droplets.** Smoke emission is a measure of the speed and quantity of smoke. Flaming droplets is a measure of the amount of flaming droplets being formed. The standard classifies these into a 's' class and a 'd' class as described below.

Speed of smoke emission		
Class	**Quantity/Speed**	**Description**
s1	Absent or Weak	Little or no smoke
s2	Average intensity	Medium amount of smoke
s3	High Intensity	Substantial smoke

Burning droplets		
Class	**Level**	**Description**
d0	No burning	No droplets
d1	Slow dripping	Non-inflamed droplets
d2	Fast dripping	Inflamed droplets

Note: These sub categories are rarely used for fasteners and metal fixings.

Fire Resistance

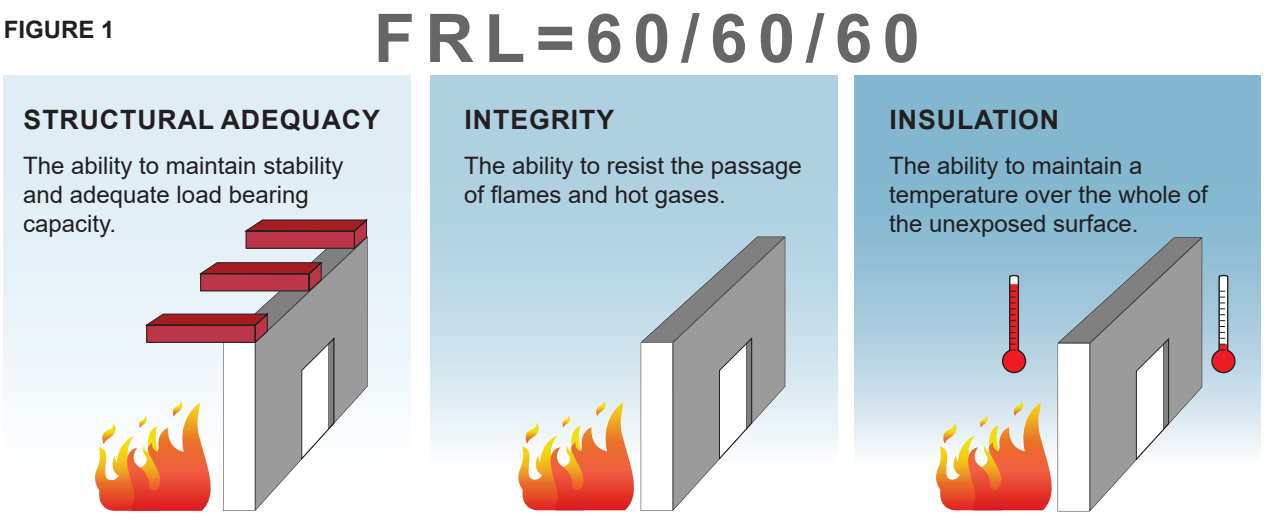
Fire Resistance is a measure of how long a system can protect a load bearing structure such as a beam, column, floor, wall, door or fire barrier. It is a measure of the time (in minutes) the system can resist the effects of fire and maintain **load bearing capacity, integrity** and **insulation** without heat transfer as indicated in figure 1 below. **AS 1530.4** stipulates FRL's (Fire Resistance Levels) for the three categories measured in minutes; **Structural Adequacy, Integrity** and **Insulation** as described in the table below. This system is similar to the European system where they refer to a REI where the same characteristics are expressed namely R = Load Bearing, E = Integrity and I = Thermal Insulation.

(**AS 1530.4** Methods for fire tests on building materials, components and structures Fire-resistance tests for elements of construction)

AS 1530.4 Fire Resistant Levels (measured in minutes)	
Structural Adequacy	**Load bearing capacity without the loss of structural stability**
Integrity	**Integrity without fire (flame and/or smoke) passage**
Insulation	**Insulation without significant heat transfer**

Figure 1 shows a wall with a Fire Resistance rating of 60/60/60 as per AS1530.4. This means the wall can maintain its designed load bearing capacity for 60 minutes, resist the flow of flames or hot gases for 60 minutes and be able to maintain a consistent temperature over the unexposed surface for 60 minutes

FIGURE 1



Fire Rated Anchors with ETA's

Anchor ETA's will often display results of the performance essential characteristics **(Reaction to Fire and Resistance to Fire)**. For example our **XBolt®** concrete screw anchor – **EXHMSR15M, (ETA 19/0621)** has the following essential characteristics published;

Under section 3.2 Safety in case of fire (BWR2), the characteristics of "Reaction to fire" meets the performance for Class A1: Non-combustible material. The characteristics of "Resistance to fire" are detailed in Annex D1 and D2. Annex D1 and D2 summarise the mechanical properties of the fastener for periods of 30, 60, 90 and 120 minutes.

As per the ETA:

- The anchor shall be used in dry internal conditions.
- The anchor may be used for fixings with requirements related to resistance to fire.

Table D1: Characteristic values to fire resistance

Fire resistance duration = 30 minutes		HEC 7.5	HEC 10.5	HEC 12.5	HEC 16.5
Tension loads, steel failure					
$N_{Rk,s,fi,30}$ Characteristic resistance	[kN]	0.23	0.61	1.28	2.90
Pull-out failure					
$N_{Rk,p,fi,30}$ Character. Resistance in concrete C20/25 to C50/60	[kN]	1.50	2.25	3.00	7.50
Concrete cone failure **)					
$N_{Rk,c,fi,30}$ Character. Resistance in concrete C20/25 to C50/60	[kN]	2.06	2.45	3.51	12.35
Shear loads, steel failure without lever arm					
$V_{Rk,s,fi,30}$ Characteristic resistance	[kN]	0.23	0.61	1.28	2.90
Shear loads, steel failure with lever arm					
$M_{Rk,s,fi,60}$ Characteristic bending resistance	[Nm]	0.19	0.66	1.73	5.90

Fire resistance duration = 60 minutes		HEC 7.5	HEC 10.5	HEC 12.5	HEC 16.5
Tension loads, steel failure					
$N_{Rk,s,fi,60}$ Characteristic resistance	[kN]	0.21	0.53	0.96	2.17
Pull-out failure					
$N_{Rk,p,fi,60}$ Character. Resistance in concrete C20/25 to C50/60	[kN]	1.50	2.25	3.00	7.50
Concrete cone failure **)					
$N_{Rk,c,fi,60}$ Character. Resistance in concrete C20/25 to C50/60	[kN]	2.06	2.45	3.51	12.35
Shear loads, steel failure without lever arm					
$V_{Rk,s,fi,60}$ Characteristic resistance	[kN]	0.21	0.53	0.96	2.17
Shear loads, steel failure with lever arm					
$M_{Rk,s,fi,60}$ Characteristic bending resistance	[Nm]	0.17	0.57	1.30	4.42

Fire resistance duration = 90 minutes		HEC 7.5	HEC 10.5	HEC 12.5	HEC 16.5
Tension loads, steel failure					
$N_{Rk,s,fi,90}$ Characteristic resistance	[kN]	0.16	0.41	0.83	1.88
Pull-out failure					
$N_{Rk,p,fi,90}$ Character. Resistance in concrete C20/25 to C50/60	[kN]	1.50	2.25	3.00	7.50
Concrete cone failure **)					
$N_{Rk,c,fi,90}$ Character. Resistance in concrete C20/25 to C50/60	[kN]	2.06	2.45	3.51	12.35
Shear loads steel failure without lever arm					
$V_{Rk,s,fi,90}$ Characteristic resistance	[kN]	0.16	0.41	0.83	1.88
Shear loads, steel failure with lever arm					
$M_{Rk,s,fi,90}$ Characteristic bending resistance	[Nm]	0.13	0.44	1.13	3.83

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Performances
Characteristic values for fire resistance

Annex D1

Fire resistance duration = 120 minutes		HEC 7.5	HEC 10.5	HEC 12.5	HEC 16.5
Tension loads, steel failure					
$N_{Rk,s,\ fi,120}$ Characteristic resistance	[kN]	0.12	0.33	0.64	1.45
Pull-out failure					
$N_{Rk,p,fi,120}$ Character. Resistance in concrete C20/25 to C50/60	[kN]	1.20	1.80	2.40	6.00
Concrete cone failure **)					
$N_{Rk,c,fi,120}$ Character. Resistance in concrete C20/25 to C50/60	[kN]	1.65	1.96	2.81	9.88
Shear loads, steel failure without lever arm					
$V_{Rk,s,fi,120}$ Characteristic resistance	[kN]	0.12	0.33	0.64	1.45
Shear loads, steel failure with lever arm					
$M_{Rk,s,fi,120}$ Characteristic bending resistance	[Nm]	0.10	0.35	0.87	2.95

Fire resistance duration = 60 minutes			HEC 7.5	HEC 10.5	HEC 12.5	HEC 16.5
$S_{cr,N}$	Spacing	[mm]	168	180	208	344
S_{min}	Minimum spacing	[mm]	45	50	60	100
$C_{cr,N}$	Edge distance	[mm]	84	90	104	172
C_{min}	Minimum edge distance (one side fire)	[mm]	84	90	104	172
C_{min}	Minimum edge distance (two sides fire)	[mm]	300	300	300	300
γ_{Msp}	Partial safety factor*)	[-]	1.0	1.0	1.0	1.0

*) In absence of other national regulations

**) As a rule, splitting failure can be neglected when cracked concrete and reinforcement is assumed.

Concrete pry-out failure		HEC 7.5	HEC 10.5	HEC 12.5	HEC 16.5
k factor	[--]	1	1	1	2
According EN 1992-4:2018, these values of k factor and the relevant values of $N_{Rk,c,fi}$ given in the above tables have to be considered in the design.					

Concrete edge failure

The characteristic resistance $v^0_{Rk,c,fi}$ in C20/25 to C50/60 concrete is determined by:
$V^0_{Rk,c,fi} = 0.25 \times V^0_{RK,c}$ (≤ R90) and $V^0_{RK,c,fi} = 0.20 \times V^0_{RK,c}$ (R120)
With $V^0_{RK,c}$ initial value of the characteristic resistance in cracked concrete C20/25 under normal temperature according to EN 1992 - 4:2018.

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Performances
Characteristic values for fire resistance

Annex D2

Designers can look up these tables to determine the load capacities of these fasteners for varying fire resistance durations. **An example of this table being used is for determining the compliance of say a pipe suspension system in a building where fasteners are used to hold overhead pipes and cables. The fasteners can be chosen to at least match the reaction to fire and fire resistance of the system being installed.**