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European Standards for Adhesives Explained

As an American company, **Custom Building Products** is familiar with the ANSI standards that govern the performance of tile and stone adhesives. However as we move into the international arena we are becoming exposed more often to the European standards (EN) as well as the even newer ISO version. We are lucky that most regions are still happy to work with all three however, it is important to understand how the EN and ISO standards are structured as many of our competitors do not always have performance data tested to ANSI. I also think it is an advantage for us to be technically fluent in both the US and European standards because many of our competitors in the field are not. So I thought it prudent this month to set out the basic structure of how the EN and ISO standards work. They are both structured in the same way but differ slightly in that the EN standards are European norms (hence EN) where as the ISO standards (International Standards Organization) are an attempt to unify the major international standards (European, British and American). This attempt at unification has been driven by the Europeans and has not yet been internationally accepted. As most of our European competitors still use predominantly the EN standards I will specifically refer to these knowing that the ISO standard (though different in some detail) is structured in the same manner. For your reference before I start the relevant standards are EN-12004: 2007 and ISO 13007 (approved in 2005).

Like the ANSI standards (the world's first tile and stone installation material standards) the EN standard is designed to cover adhesives used to install tile and stone.

Types of Adhesives

Adhesives are broken into 3 basic types, defined as follows:

Type C – cementitious adhesives – defined as mixtures of hydraulic binders, aggregates and organic additives, mixed with water or a liquid admix just prior to use.
Type D – dispersion adhesives – a pre-mixed blend of organic binder(s) in the form of an aqueous polymer dispersion, organic additives and mineral fillers.
Type R – reaction resin adhesives – mixtures of synthetic resins, mineral fillers and organic additives. The adhesive cures by chemical reaction.

Each of these three types of adhesives C, D and R are further classified by different optional characteristics as follows:

1. Normal Adhesive
2. Improved Adhesive (meets requirements for "additional characteristics" see table 1,2,3 below)

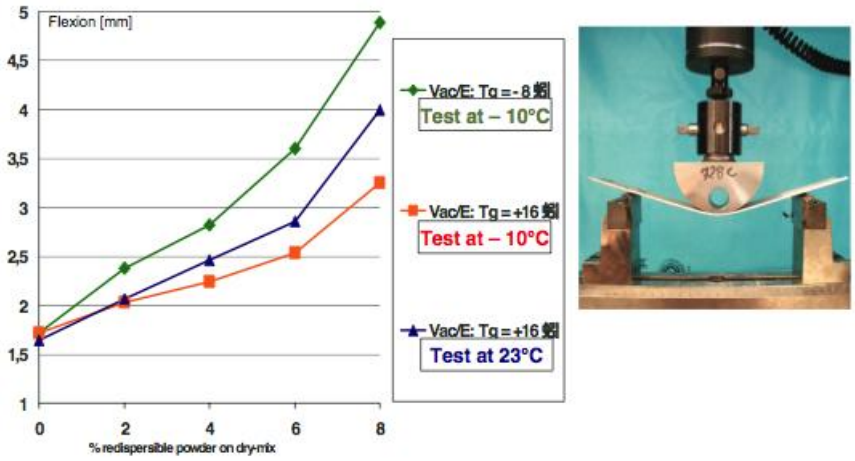
F. Fast setting adhesive

T. Adhesive with reduced slip

E. Adhesive with extended open time. This applies to cementitious and improved dispersion adhesives only.

There are two other classifications for what many in the industry refer to as flexible adhesives. The EN standard defines this characteristic (I think correctly) as transverse deformation and is for cementitious adhesives only. Testing is carried out using a three point bending test as per EN 12002. The illustration below shows the device in action.

Fig. 3: Deformation ability [mm] of a cement based ceramic tile adhesive according to EN 12002 depending on the polymer dosage (% redispersible powder based on Vac/E = vinyl acetate/ethylene), the glass transition temperature (Tg) of the polymer and the testing temperatures (+23°C and – 10°C)



The deformability of a cementitious adhesive is classified as follows:

S1. An adhesive that has deformability of > 2.5 mm & < 5 mm

S2. An adhesive that has deformability of > 5 mm

I feel this is a very good test and nicely "defines" what we normally mean by flexibility in cement adhesives. It is something that ANSI hopefully picks up on because at present there is no ANSI test or standard for this characteristic. However when you think of the deflection codes for substrates (L/720 for stone) and the lack of ability for ceramic tile and natural stone to "bend or flex" you have to wonder if the S2 category is really required in the real world.

Adhesives under the EN system use these categories for adhesive identification. Therefore, an adhesive for example that is categorized with the code C2F S1 is improved fast setting cement adhesive with deformability of > 2.5 mm & < 5 mm.

Table 5 — Examples of classification and designation

SYMBOL		DESCRIPTION
TYPE	CLASS	
C	1	Normal setting cementitious adhesive
C	1 E	Normal setting cementitious adhesive with extended open time
C	1 F	Fast setting cementitious adhesive
C	1 F T	Fast setting cementitious adhesive with reduced slip
C	2	Improved cementitious adhesive
C	2 E	Improved cementitious adhesive with extended open time
C	2 F	Improved fast setting cementitious adhesive
C	2 S1	Improved deformable cementitious adhesive
C	2 S2	Improved highly deformable cementitious adhesive
C	2 F T	Improved fast setting cementitious adhesive with reduced slip
C	2 F TS1	Improved deformable fast setting cementitious adhesive with reduced slip
D	1	Normal dispersion adhesive
D	1E	Normal dispersion adhesive with extended open time
D	1 T	Normal dispersion adhesive with reduced slip
D	2	Improved dispersion adhesive
D	2 T	Improved dispersion adhesive with reduced slip
D	2 T E	Improved dispersion adhesive with reduced slip and extended open time
R	1	Normal reaction resin adhesive
R	1 T	Normal reaction resin adhesive with reduced slip
R	2	Improved reaction resin adhesive
R	2 T	Improved reaction resin adhesive with reduced slip

Adhesive Tests

The EN standard has a raft of tests and standards for adhesive performance characteristics and many of these are similar to what is tested under ANSI, and amongst these are:

Open Time EN 1324, Wetting capacity EN 1347,Transverse Deformation EN 12002 (this is to determine if an adhesive fits in the S1 or S2 category), Chemical Resistance EN 12808-1 (this is applied to Type R adhesives only), Slip EN 1308 (measures slippage of tile under its own weight when vertically mounted on a surface applied with adhesive).

The EN standard also tests to see how some extreme conditions affect the adhesive hence testing such as freeze/thaw, exposure to water and high temperature are included in the standard.

But perhaps the most important test is the one used to determine adhesive bond strength. For cementitious adhesives, Type C, EN 1348 is used and tests bond strength by measuring the tensile force required to break the adhesive's bond. (Note for the other two types of adhesive, D and R a shear test is used, EN 1324 for type D and EN 12003 for type R).

The test is called the pull test. This is perhaps the biggest difference between the EN standards and ANSI where bond strength is measured by testing shear.

Table 1 — Requirements for cementitious adhesives (C)

FUNDAMENTAL CHARACTERISTICS			
1 a	**NORMAL SETTING ADHESIVES**		
Characteristic		**Requirement**	**Test Method**
Initial tensile adhesion strength		≥ 0,5 N/mm^2	8.2 of EN 1348:2007
Tensile adhesion strength after water immersion		≥ 0,5 N/mm^2	8.3 of EN 1348:2007
Tensile adhesion strength after heat ageing		≥ 0,5 N/mm^2	8.4 of EN 1348:2007
Tensile adhesion strength after freeze-thaw cycles		≥ 0,5 N/mm^2	8.5 of EN 1348:2007
Open time: tensile adhesion strength		≥ 0,5 N/mm^2 after not less than 20 min	EN 1346
1 b	**FAST SETTING ADHESIVES**		
Characteristic		**Requirement**	**Test Method**
Early tensile adhesion strength		≥ 0,5 N/mm^2 after not more than 6 h	8.2 of EN 1348:2007
Open time: tensile adhesion strength		≥ 0,5 N/mm^2 after not less than 10 min	EN 1346
All other requirements as in Table 1a			EN 1348
OPTIONAL CHARACTERISTICS			
1 c	**SPECIAL CHARACTERISTICS**		
Characteristic		**Requirement**	**Test Method**
Slip		≤ 0,5 mm	EN 1308
Extended open time: tensile adhesion strength		≥ 0,5 N/mm^2 after not less than 30 min	EN 1346
Deformable adhesive: transverse deformation		≥ 2,5 mm and < 5 mm	EN 12002
Highly deformable adhesive: transverse deformation:		≥ 5 mm	EN 12002
1 d	**ADDITIONAL CHARACTERISTICS**		
Characteristic		**Requirement**	**Test Method**
High initial tensile adhesion strength		≥ 1 N/mm^2	8.2 of EN 1348:2007
High tensile adhesion strength after water immersion		≥ 1 N/mm^2	8.3 of EN 1348:2007
High tensile adhesion strength after heat ageing		≥ 1 N/mm^2	8.4 of EN 1348:2007
High tensile adhesion strength after freeze-thaw cycles		≥ 1 N/mm^2	8.5 of EN 1348:2007

Table 2 — Requirements for Dispersion Adhesives (D)

2 a	**FUNDAMENTAL CHARACTERISTICS**	
Characteristic	**Requirement**	**Test Method**
Initial shear adhesion strength	≥ 1 N/mm^2	7.2 of EN 1324:2007
Shear adhesion strength after heat ageing	≥ 1 N/mm^2	7.4 of EN 1324:2007
Open time: tensile adhesion strength	≥ 0,5 N/mm^2 after not less than 20 min	EN 1346
OPTIONAL CHARACTERISTICS		
2 b	**SPECIAL CHARACTERISTICS**	
Characteristic	**Requirement**	**Test Method**
Slip	≤ 0,5 mm	EN 1308
Extended open time: tensile adhesion strength	≥ 0,5 N/mm^2 after not less than 30 min	EN 1346
2 c	**ADDITIONAL CHARACTERISTICS**	
Characteristic	**Requirement**	**Test Method**
Adhesion strength after water immersion	≥ 0,5 N/mm^2	7.3 of EN 1324:2007
Adhesion at elevated temperature	≥ 1 N/mm^2	7.5 of EN 1324:2007

Table 3 — Requirements for reaction resin adhesives (R)

3 a	FUNDAMENTAL CHARACTERISTICS	
Characteristic	**Requirement**	**Test Method**
Initial shear adhesion strength	≥ 2 N/mm^2	7.3 of EN 12003:1997
Shear adhesion strength after water immersion	≥ 2 N/mm^2	7.4 of EN 12003:1997
Open time: tensile adhesion strength	≥ 0,5 N/mm^2 after not less than 20 min	EN 1346
OPTIONAL CHARACTERISTICS		
3 b	**SPECIAL CHARACTERISTICS**	
Characteristic	**Requirement**	**Test Method**
Slip	≤ 0,5 mm	EN 1308
3 c	**ADDITIONAL CHARACTERISTICS**	
Characteristic	**Requirement**	**Test Method**
Shear adhesion strength after thermal shock	≥ 2 N/mm^2	7.5 of EN 12003:1997

Comparing EN and ANSI

For many of the test results the two standards can be compared. Then in some instances there are tests and standards in one system that the other simply does not have, such as the EN test for deformation. However we all know the test most people want is the one testing an adhesives' bond strength. It is this one very important area where not only do the two systems differ philosophically but also you cannot necessarily compare results and draw conclusions.

A typical conclusion made by many in the industry is that a higher tensile pull out test result will mean a correspondingly higher shear bond number and visa versa. This is unfortunately not necessarily true as there is no correlation between the two types of tests.

To give you an example I will compare a well-known premium adhesive from Mapei with one from **CUSTOM**. Mapei Kerabond mixed with Isolastic (called Keralastic in some markets) has a published tensile (28 d sc) result of 2.4 N/mm^2 and CUSTOM MegaFlex, 1.92 N/mm^2 (**Global Tile** distribute MegaLite, Custom's Light weight equivalent of MegaFlex). However the shear bond result (both results are 28 d to vitreous tile) for the Mapei system is 358 psi whereas MegaFlex is 680 psi. A 25% higher tensile result for the Mapei system is in stark contrast to the 90% higher shear bond result for MegaFlex. If we take a closer look at some tensile and shear bond numbers you can also see that the tensile numbers are nowhere near as discriminatory as the shear bond results.

The tensile results (28d sc **in black** and shear bond 28 d on vitreous tile **in red**) for 4 Custom thin-sets are as follows (tensile units = N/mm^2 and shear bond = psi):

Versa-Bond = 1.73/290 Flex-Bond = 1.93/375 Prolite = 1.35/450 Mega-Flex = 1.92/680

The range in shear bond results shows a 135% increase from the low result to the high whereas the same range for tensile is only 43%. The shear bond numbers discriminate quite clearly between the lower performance product, Versa-bond and the premium Mega-Flex. In contrast the tensile results shuffle the pack indicating ProLite as having the lowest performance and then little difference between the other three.

When it comes to selecting adhesives on the basis of bond strength I feel that shear bonds better discriminate between different levels of performance.

It is my personal opinion that the best way to gauge adhesive bond strength is to measure shear, as this is the most consistent and **"real"** force on a tile/adhesive system. However it doesn't really matter whether you are a supporter of the EN tensile philosophy or the ANSI shear bond, the bottom line is that there is no correlation between the two. A higher tensile result does not necessarily mean a higher shear bond and the same in reverse.

In summary it is important for CUSTOM to be fluent in the EN (ISO) standards so we can better service our clients. In many areas of adhesive testing the two systems' (EN and ANSI) results can be used to make product comparisons. However in the most important area of gauging adhesive bond strength the two systems are simply not compatible. The debate over whether the EN tensile or ANSI shear bond is the best test to measure bond strength will no doubt go on for some time to come.

However I will make my preference very clear – it is shear bond all the way.

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