EFFECTIVE SEALANTS FOR EXISTING STORAGES FROM FLOOR TO ROOF

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ABSTRACT

Complete sealing has to take into account the main elements of existing storages, e.g. concrete floors, connections to vertical walls, vertical walls with cracks and/or joints, connections to flat or angular roof and roofs with or without insulation. Apart from general requirements an external sealing material has to meet the following specifications: gastight sealing with crack bridging properties, elastic filling of joints and cracks, heat reflection, long lasting UV-resistance and, for metal surfaces, protection against corrosion.

An internal sealing material has to comply with similar requirements plus smoothing of surfaces, formation of abrasion resistant layers, compatibility with foodstuffs, and stability to fumigants. Systems of sealants have been developed which effectively meet these requirements.

As external sealants (walls and roofs) - acrylic resin dispersion as primer - if necessary with rust preventing agents - with subsequent white heat reflecting acrylic coating (eg Wastolan-B white).

As internal sealants - floor - flexible polymer concrete; joins in floor and walls - Acrylic mortar with cement (e.g. Barument); walls - bituminous primer (e.g. Eubit-Plast) plus polychloroprene coating (e.g. Wastolan-A).

These systems (excepting Barument) have proven their effectiveness on grain storages for 4 years in internal application and 2 years in external application in Western Australia. They have also proved successful in the farm silo sealing programme in Western Australia.

1. THE PURPOSE OF SEALANTS AND COATINGS

There are three reasons why sealants and coatings are applied:

a) because of beauty and to make buildings look nicer,

b) to protect buildings against attacks from light, atmosphere, water, chemicals and mechanical treatment by use,

c) to avoid escaping gases and liquids out of storage or to protect materials which are stored in sealed rooms.

In our case the most interest is given to point c) but also point b) is rather important. Of course it is nice to have materials which give satisfaction in these matters and which have a good appearance as well, but beauty is not treated here.

2. BUILD-UP OF SEALANTS AND COATINGS

Three components of sealant are important: the base, the primer and of course the sealant itself.

Mostly the base is not mentioned when sealing is discussed. However the success of the substrate is very important to a sealing system. A coating never can be better than the base to which it must adhere. Defects found in the substrate include porosity, roughness, excessive smoothness, dustiness, coverage with old paints or dirt of all sorts and dampness.

The primer has various tasks. In many cases it only has to overcome defective substrates. A sealant can often be used without a primer when the base is in good condition. However this is rare. Generally, the primer has to bind dust, close pores, increase cohesion in the base and absorb all kinds of dirt. In some cases the primer must be a true adhesive when the coating itself does not stick well to the base. Because of all these reasons the primer has to meet some special specifications. In particular, it must penetrate and it must adhere both to the base and the top sealant coat. Furthermore, a top coat must never be harder than a lower layer. So the primer should not be softer than the sealant. This requirement is sometimes difficult to meet as the harder a primer is the less adhesive it is. A primer mostly has no sealing function itself, but it only prepares the substrate for the sealant.

The top coat or sealant has quite a different task to the primer. As its name implies, it coats or seals. That means it must possess all the properties needed to meet the requirements described in Section 1. To fulfil this there must be a satisfactory method to apply the sealant. In particular, bubble-holes, cracks or gaps in coating must be avoided. Furthermore it is necessary to ensure the thickness of the layer is at least as much as it is wanted all over the treated surface. A little instrument was developed which can measure thickness of wet films between 25 microns and 2 mm in small steps. The instrument is called a 'comb' (Fig. 1).

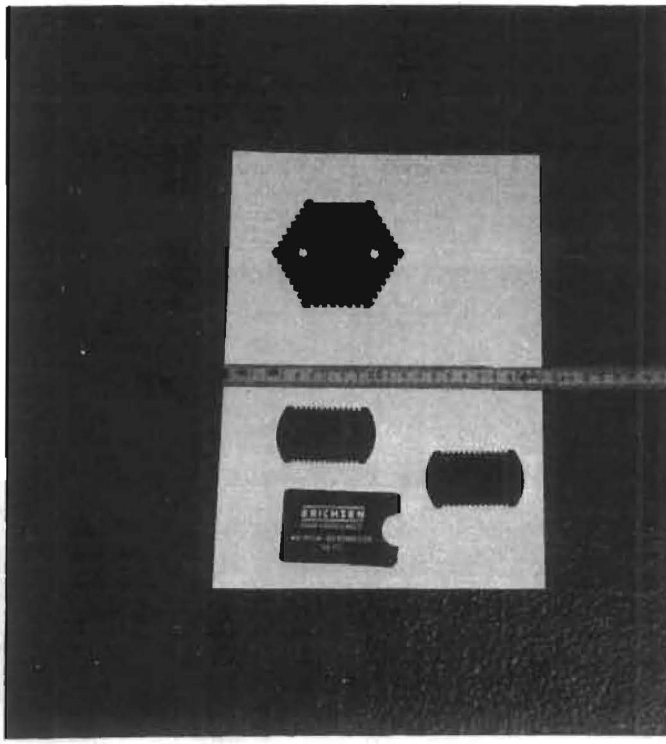

Fig. 1 Some 'combs' for measuring the thickness of wet layers.

The wet layer must usually be much thicker than the dry layer. If solvent or something else evaporates, there is a volume contraction and the layer thickness decreases. So the solids content by volume must be known when the material is applied so that allowance can be made for solvent loss when the expected dry film thickness is calculated.

If the material contracts during drying, there is a danger that cracking may occur. This danger differs from one product to the other and the producer must specify the upper limit for wet layer thickness that can be applied in one operation. Mostly two coats of material are necessary to reach the required dry layer thickness. If two coats are used it is more likely that the coverage will be uniform and gastight, as it is very improbable that two defective spots coincide. However, today more and more products are applied in one operation to save money. This needs operators who are very skilled in their jobs.

3. METHODS OF APPLICATION

There are three different kinds of application technique:

a) Manual, i.e. brushing, rolling or trowel application.
b) By sprayers either air-entrained or by airless spraying.
c) Bridging over cracks, joints and connections using a 'fleece' for reinforcement.

Fig. 2 A fleece being applied to a construction join precoated with Wastolan. The Wastolan penetrates the fleece giving a reinforced cornice over the join.

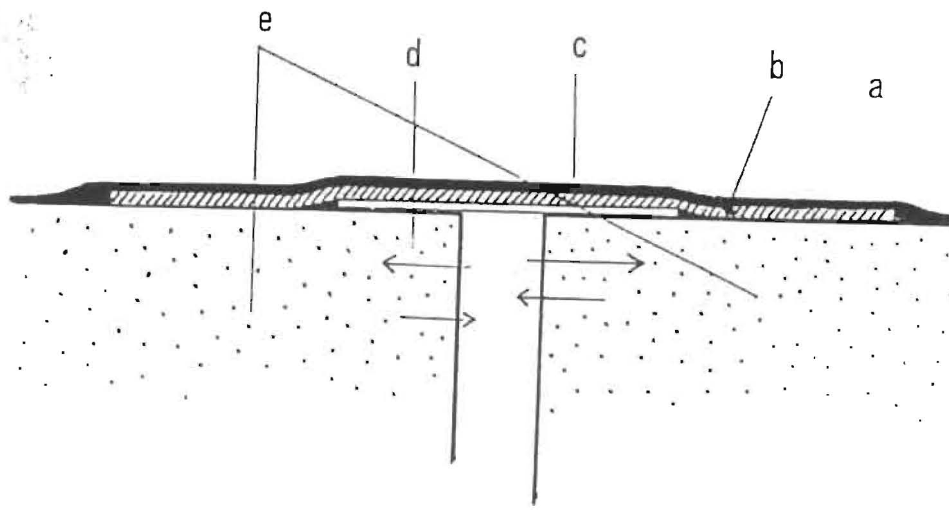

Fig. 3 A sealing of a joint a = sealant, b = penetrated fleece, c = loose foil, d = movement of the joint, e = concrete. The loose foil gives a much wider stretch area for the sealing.

Application of coating's by roller or brush are well known techniques. However, there is a great difference between the two methods. If a material is brushed on, it is really rubbed into all unevenesses of the treated surface (eg. holes, cracks, pores). The material gets a very good grip on the surface. Furthermore, residual dust and loose stuff are rubbed into the sealant material. On the other hand, if a roller is used for application, the material is only laid on the surface and it must adhere by its own power. The minimum requirement for this is good penetration of the substrate. This is dependant on the viscosity of the coating. In most cases, the roller technique needs a special primer for optimal adhesion. Trowel application can give good results, because the material is pressed into all unevennesses of the substrate. However, the traces of the trowel very often are obvious and the thickness of the layer can vary considerably.

Spraying techniques require specialised equipment. With simple air-assisted spraying, air is pumped at 4-6 bar into the material to be applied, forcing it out of a gun as a fine spray. This kind of spraying is sometimes called the 'low pressure technique'. With airless spraying, a much higher pressure is required at the gun (eg. 300 bar). The material is released from the spraying nozzle at high speed.

Fig. 4 Wastolan Red is sprayed with air in the low pressure method to penetrate a fleece for tightening a pit.

Both spraying methods are very economical. Large areas can be coated in a short time with very little manpower. However, a compressor must be available which not only gives enough pressure but also enough air volume. Furthermore, the airless method can be used only if the material is absolutely free of foreign bodies. If there are lumps in the liquid which plug the nozzle the spraying angle is altered and the thickness of the applied layer becomes very uneven. Thus liquid materials to be sprayed must be manufactured under very clean conditions.

The spraying techniques have other advantages over manual application. The material is sprayed into all unevenesses of the surface, particularly if the high pressure method is used. All dust and loose stuff on the surface is blown off. The airless method does not produce air pockets and foam in the applied layer because the drops are very small and meet the surface at a very high speed. If bubbles and holes do appear, they always result from pores in the substrate (Fig. 5).

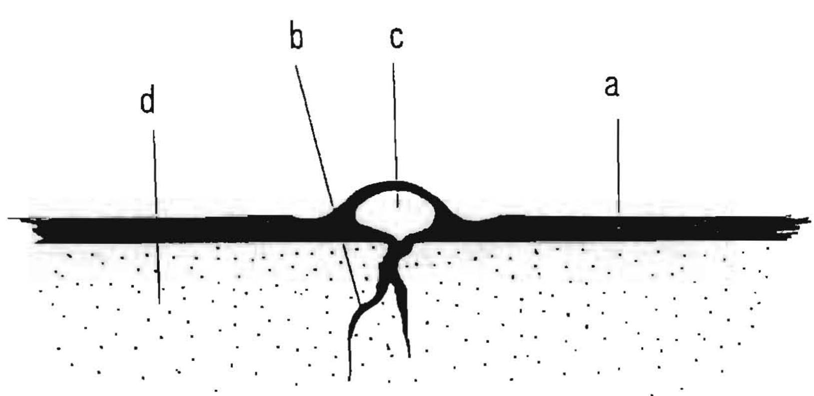

Fig. 5 A bubble develops in the sealant where it penetrates into a pore and removes the air, a = sealant, b = pore, c = bubble, d = concrete.

Using fleece as a membrane reinforcement is a special technique. It can only be applied manually, (Fig. 3) but is always necessary when the building to be sealed has special critical points, such as joints, connections or cracks that must be bridged over. The sealing material itself is normally not able to withstand the movement in these regions. There is a rule for bridging over joints or cracks: if a slit is to be bridged by an elastic or plastic material, the thickness of the layer must be at least three times the width of the slit (Fig. 6).

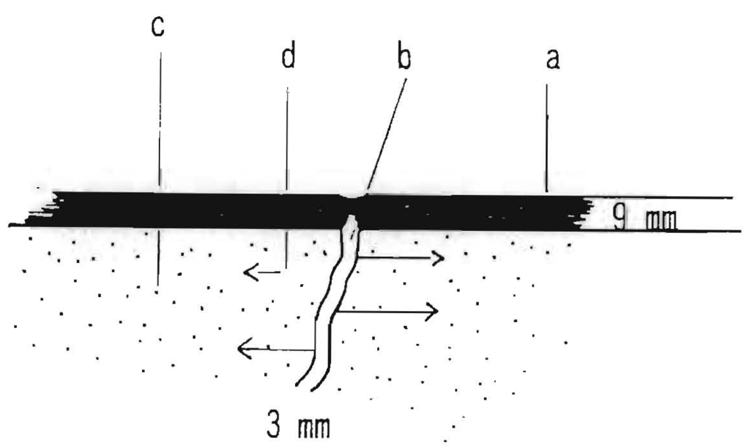

Fig. 6 A crack has formed suddenly and elongates the sealant. On the bottom it is streched from zero and begins to tear. a = sealant, b = crack, c = concrete, d = movement. The sealant thickness should be more than 3 x the crack width to ensure that the seal does not fail.

Fleeces for reinforcing membranes must have special characteristics: they must be elastic and as isotropic as possible, because they must withstand movement and stretch in all directions. The liquid sealing material must totally penetrate the fleece and it must be completely free of tension. The latter feature allows the fleece to be laid on all bends, hollows etc. without loosening as long as the sealant has not yet hardened.

When applying a fleece, the surface is first coated with material. Then the fleece is rolled into the wet sealant starting from one end to the other of the fleece, so that folds and turns are avoided. The roller enables the liquid to penetrate the fleece without tension. After the fleece has been penetrated totally, a new layer of sealant is applied by roller or spray.

If the surface to be treated is in poor condition, the fleece must be taken over the entire area. This gives much more stability in the sealant and is always advisable where a sealant has to withstand pressure. Furthermore use of a fleece guarantees a certain thickness of the sealant as the layer cannot be made thinner than the penetrated fleece itself.

When a large crack is to be sealed, it is useful to put a loose cover over it before applying the fleece and sealant (Fig. 6). This spreads the tension resulting from movement of the crack over a larger area of sealant, reducing the posibility of failure.

4. THE WASTOLAN SYSTEM

Some general aspects

In water-based media, insoluble binders can only be emulsified or dispersed. This means that a polymer forms very small drops in water that are prevented from agglomerating by giving them a charge or a protective coat. But as small as the drops may be, the whole mixture always remains a two phase system. The drop size of polymer dispersions normally is between 0.1 and 1.0 micron.

The following figures (Figs. 7, 8 and 9) show the setting mechanism of dispersions of various types:

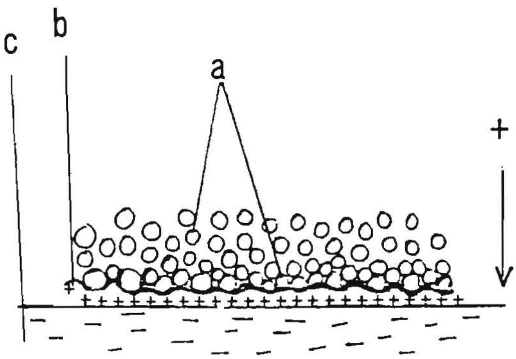

Fig. 7 Mechanism of setting in a cationic emulsion. The cationic emulsifier adheres to the anionic base. a = cationic drops of the emulsion, b = the first cationic film, c = concrete.

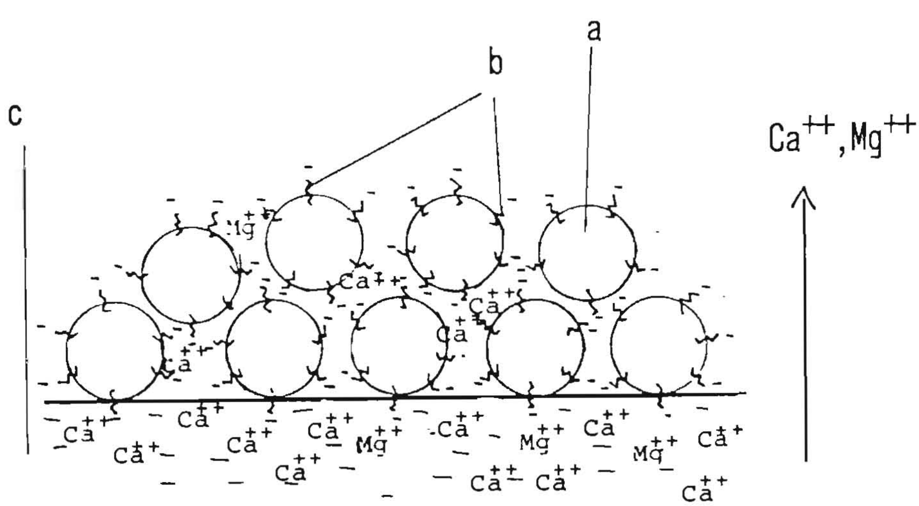

Fig. 8 Mechanism of setting in an anionic emulsion. Ca^{++} and Mg^{++} ions are dissolved out of the base and form an insoluble compound with the emulsifier. a = anionic drops of the emulsion, b = anionic emulsifier, c = concrete.

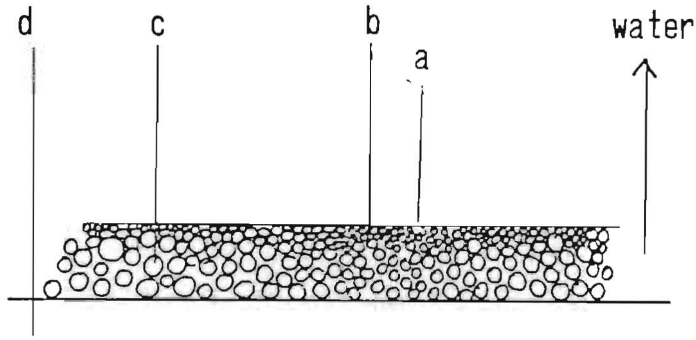

Fig. 9 Mechanism of setting in nonionic emulsion. Water evaporates and forms a skin after the protective layers around the drops have evaporated. a = skin, b = drops with dried protective layer, c = original nonionic drops of the emulsion, d = concrete.

Cationic emulsions normally adhere by exchanging their charge with the substrate which carries anionic charges. Anionic emulsions must react with the substrate. This can only happen if metal ions are set free that react with the emulsifier-soap to give water-insoluble compounds. both types form films and sealants which are highly resistant to water swelling because the emulsifiers are destroyed. Nonionic emulsions, which are stabilised by a protective nonionic coat around the polymer drops, are very stable indeed but they only dry and do not react to give a sealant. So the emulsifier stays unchanged in the sealant and can be reactivated if water treats it. Only very few emulsifiers of this type can be used without any risk, but nonionic emulsifiers are often preferred because they give more stability in manufacture and application of the sealant.

Wastolan Primers

In contrast to dissolved (single phase) primers, emulsified primers have difficulty in penetrating into the pores of the substrate. The surface forms a sort of sieve and the droplets of the emulsion are left on the surface, while the water is sucked into the substrate (Fig. 10). Therefore, an emulsion primer must contain emough water so that it does not stick to the brush or roller while being applied. If it dries too fast it does not have time to agglomerate to form a film.

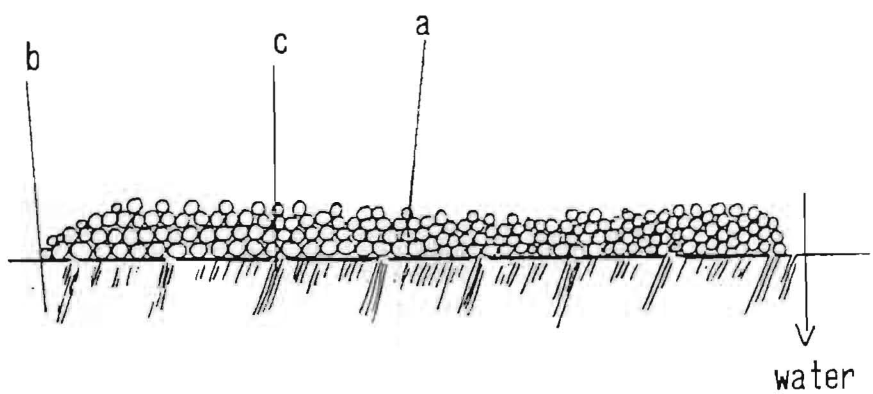

Fig. 10 Sieve-effect of concrete. The water is sucked out of an applied emulsion and the dispersed phase stays on top. a = emulsion drops, b = concrete, c = water sucked into the concrete.

Because of being left on the surface, an emulsion primer is well suited to seal pores and holes. This is especially important for a material used as a sealant. Of course the primer has to ensure good adhesion of the top coat as well. For these reasons, Wastolan Primer is made from very special materials: bitumen/neoprene/acrylic resin. Wastolan Primer shows the following properties: good pore sealing, very good adhesion, extremely gastight, good strength for carrying the top sealant and very tacky. It can be applied very easily by all methods described in Section 3, although best by brushing or spraying. The colour of the primer is black only because of the bitumen content. This black primer is rather thixotropic, so the consumption is about 0.5 kg/m^2, but depending on the roughness of the substrate.

The surface to be treated has to be very clean and solid enough to carry the whole sealant. If the surface is too weak the total sealant may loosen (Fig. 11). Technical data on Wastolan Primer is given in Table 1.

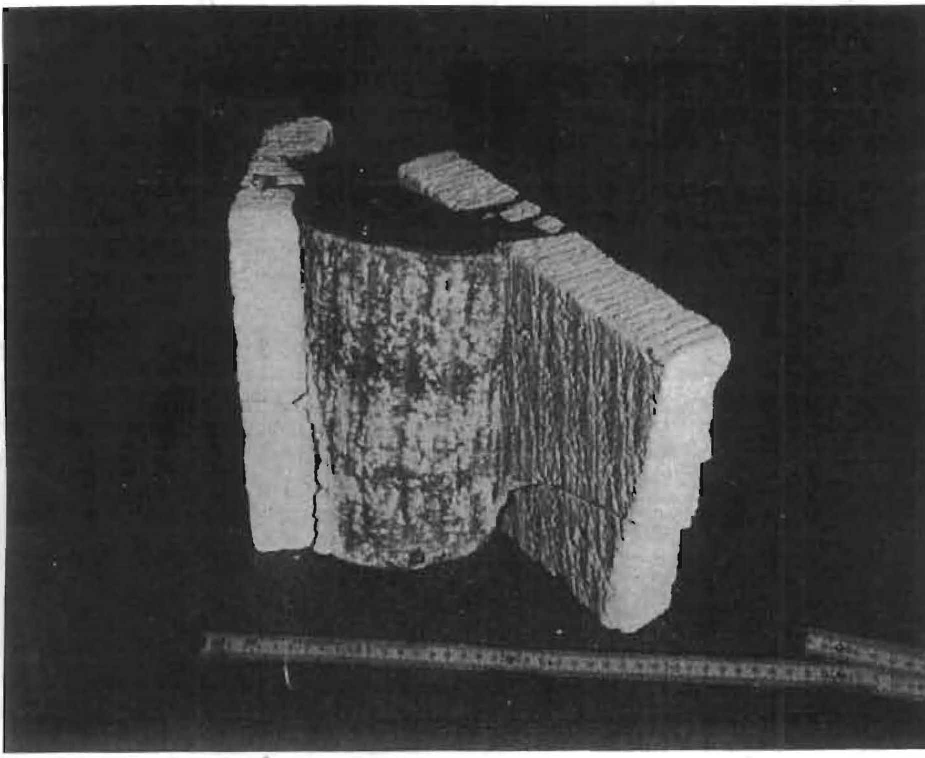

Fig. 11 The Wastolan sealant was removed from a weak surface. The loosened concrete still adheres well to the Wastolan.

Table 1. Technical data for Wastolan Primer.

Density:	1000 kg/m^3
Solids content by weigh:	60 %
Solids content by volume:	60 %
Charge of the emulsion:	anionic
Characteristic of dried material:	
Resistance to heat (DIN 52123)	100°C
Resistance to cold (DIN 52123)	-10°C
Waterproofness, 2.5 mm:	2 bar
Elongation at break depending on thickness:	300 - 400 %

There is also another primer available for Wastolan. It is also an emulsion but containing acrylic resin and being free from bitumen and pigments it dries rather colourless, is much harder than the other primer and is not thixotropic. It is thus an adhesive primer only without sealing properties itself (see Table 2).

Table 2. Technical data for the acrylic-based primer for Wastolan.

Density:	1000 kg/m^2
Solids content by weight:	38 %
Solids content by volume:	38 %
Charge of the emulsion	anionic
Cleaning agent, wet:	water
Cleaning agent, dry:	butyldiglycolacetate
Consumption:	200 - 300 g/m^2
Drying:	1 - 3 hours dependent on weather conditions

Wastolan Top Sealant

This material is based on an emulsion of acrylic resin. It is solvent-free and filled with china clay mineral powder and pigments. The acrylic resin forms a highly elastic sealant film which is able to bridge over cracks. The sealant has a very good resistance to UV-light and keeps its white colour for many years. Of course it may happen that dirt and dust darkens the surface, but this is not unusual.

Wastolan can be used to seal all kinds of buildings against water, humidity or escape of gases through porous walls. It is particularly suited for sealing grain storages for controlled atmospheres and fumigation.

Wastolan can also be used in sealing of pits (Fig. 12). The technique differs quite a lot from that used for sealing walls. Here a big sheet of fleece is put on the bottom of the pit in the soil as evenly as possible. Then the fleece is impregnated with the Wastolan material (thinned a little with water) to give a very strong, elastic membrane. After the impregnation, a second coating is usually applied to guarantee full sealing and give a smooth surface. The whole application can only be done by spray. Air-assisted spraying is most suitable.

Fig. 12 A pit sealed with Wastolan. It is supposed to be impervious to sewage to avoid seepage and pollution of the soil.

For sealing of pits and all other kinds of sealing there is also a second type of Wastolan based on polychloroprene rubber (Neoprene).

Wastolan is available in different colours: red, green, grey and white. Of course the white one reflects light best, so it should always be used where maximum reflection of light is required, especially if heating by the sun is to be avoided. The white colour is favoured in sealing of grain silos to avoid this heating.

Wastolan layers are very tough and elastic after full drying. But at critical points a fleece should be laid in to increase the strength of bridging over all sorts of slits. It also is able to bridge over cracks in *"Statu nascendi"*. In this situation a crack may appear very suddenly. Only if it is very tough and elastic can the sealant still bridge over the crack and only if it is thick enough (Fig. 6).

Technical data for Wastolan sealants are given in Table 3.

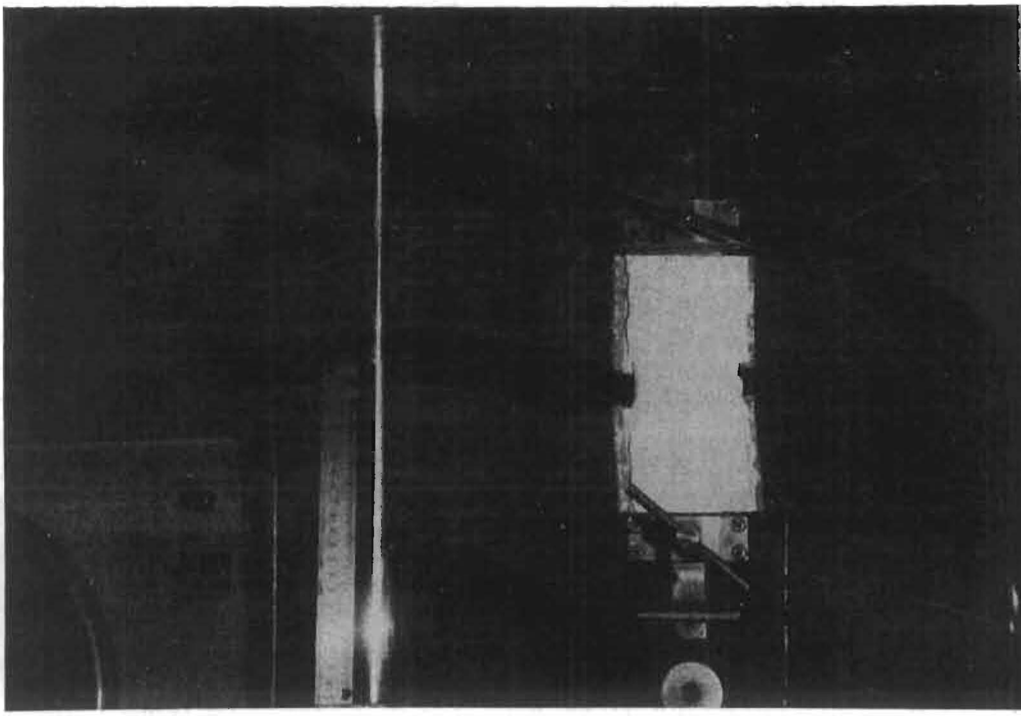

Fig. 13 Wastolan reinforced with fleece under tension. The crack has been opened from 0 to 40 mm without failure of the sealant. The sealant has lost adhesion to the substrate from 20 - 40 mm from the slit.

Table 3 Technical data for Wastolan sealants.

	Wastolan White acrylic resin	Wastolan polychloroprene
Number of components:	1	2 (100 : 30)
Potlife:	-	2 hours, 20°C
Density:	1300 kg/m^3	1250 kg/m^3
by weight: (DIN 53219)	70 %	
Solids content by volume:	60 %	50 %
pH-value:	8 - 9	10
Charge of the emulsion:	nonionic	anionic
Temperature of film-forming:	5°C	4°C
Resistance to heat (DIN 52123)	+ 130°C passed	+ 130°C passed
Resistance to cold (DIN 52123)	- 15°C passed	- 35°C passed
Elongation at break (DIN 53571) (without fleece, 1.5 mm thick film)	250 %	650 %
Maximum thickness of layer applied in one operation	1.5 kg/M^2 1150 µm wet 700 µm dry	1.0 kg/m^2 800 µm wet 400 µm dry
Conditions for airless spraying (without fleece)	5 bar, nozzle width 0.79 mm 1:45, initial pressure	5 bar, nozzle width 1.09 mm 1:60, initial pressure
Spraying with air compressor for 6 bar (1200 L air/min)	5 - 6 bar, nozzle width 1.02 mm	5 - 6 bar, nozzle width 1.02 mm
Resistance to UV-light	very good, no change of colour	good but change of colour
H_2O-vapor permeability	3.2 g/m^2 . d 1.5 mm film	appr. 0.4 g/m^2 . d 2.5 mm film
Cleaning agents		
Wet emulsion:	water	soft water
dry polymer:	butyldiglycolacetate, ethylglycolacetate	aromatic oils

Wastolan Fleeces

The main features of fleeces were described above (Section 3). It must be emphasized that the fleeces have to be totally isotropic and very elastic or otherwise they do not give the necessary elastic quality to the Wastolan to resist all forces caused by movement of the building in all directions. Furthermore the fleece must be very soft so that it fits in all unevenesses of the surface. The normal weight of the fleece is approximately 150 g/m^2 and it is available in rolls of 300 m length and 420 cm width.

Barument

Barument is a mortar made with acrylic resin despersion instead of water. The mortar is made by mixing 1 part by volume of cement and 2 parts by volume of dry sand. 1 part by volume of Barument emulsion is added and the ingredients are mixed until a pasty mortar is formed. Then water is added very carefully in small amounts. The viscosity of the mortar is very sensitive to the quantity of water added (Fig. 15) There is less danger of cracking the less water is added. The mortar gets stiff rather fast and dries quickly. A certain volume concentration is unavoidable. Though rather highly viscous, the mortar flows into all holes, joints and cracks. Before it is applied into cavities these must be treated with a primer (1 part by volume of Barument dispersion with 2 parts by volume of water). The adhesion is so good that under strain the material cracks in itself rather than loosen from concrete. After drying the mortar produces a very elastic (Fig. 14) and hydrophobic material.

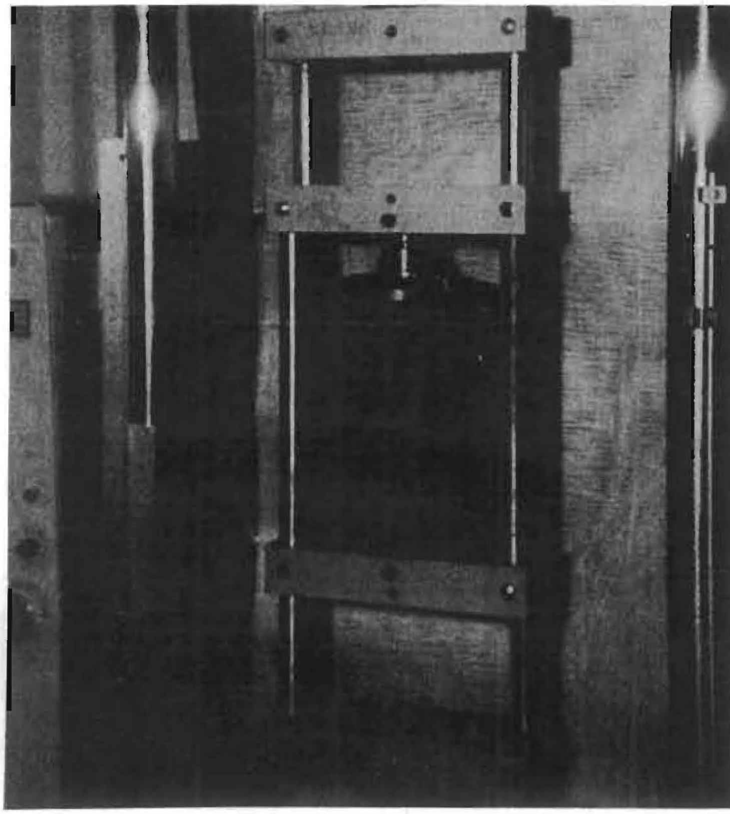

Fig. 14 A sample (4 x 4 x 16 cm) of Barument is tested under DIN 1164. It is obvious how much it can be bent without breaking.

Being an acrylic resin dispersion Barument is compatible with the Wastolan System. It is highly elastic, has good adhesion and is a very good sealant. Technical data for Barument is given in Table 4.

Table 4 Technical data for Barument.

Density:		appr. 1.04 kg/m^3
Charge:		nonionic
pH-value:		7.5 - 9.0
Solid content	by weight by volume	56 m% 54 %
Viscosity:		200 - 350 mPa's
Temperature of film-footing		0^oC
Colour of film:		transparant, colourless
Density of dry mortar, 28 days old:		1900 - 2000 kg/m^3
for the following test 10 % water is added to the mortar		
	bending strength	after 7 days: 1.8 N/mm^2 after 28 days: 6.9 N/mm^2
	crushing strength	after 7 days: 3.6 N/mm^2 after 28 days: 13.0 N/mm^2

Samples were so elastic that the values are difficult to measure.

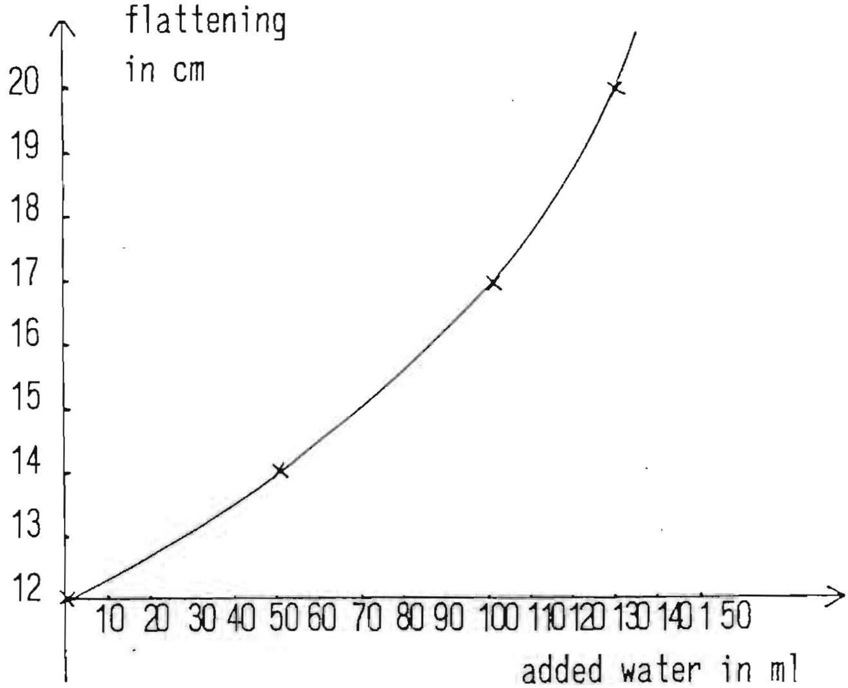

Fig. 15 Barument Mortar becomes the lower viscous the more water is added. The consistency is measured by a compression test (DIN 1060).

5. REQUIREMENTS AND TEST METHODS OF SEALANTS FOR GRAIN STORAGE

There are three different aspects of testing and proving sealant materials:

a) Conditions and features of application and storage
b) The physical properties relating to sealing and resistance against all sorts of influences and ageing.
c) The requirements that the sealants be safe for use in contact with foodstuffs.

For the first two items there are many national standard methods (eg. ASTM, AS, DIN, FTM, BS).

The test methods used here are mostly based on DIN standards because Wastolan is a German development. However, both types of Wastolan were tested by CBH in Australia on the basis of Australian Standards (AS). The standards used by many other nations are similar.

It is much more difficult to set proper standards for the use of polymers in sealing materials which have contact with foods. Of course there are several nations which have strict regulations and laws in this regard, but they often differ a lot and are more or less severe. In addition, copies of the regulations are difficult to obtain. Here only German requirements can be cited. These were published by the "Kunststoff-Kommission des Bundesgesundheitsamtes" (Plastics Committee of the German Federal Health Office). Polychloroprene and acrylic resins may be readily used if they are fully cured. Wastolan, moreover, does not contain any agents which are contrary to these German rules. So no influence is to be expected on the grain by the sealant Wastolan.