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Adhesives — Guidelines for the surface preparation of plastics

Adhésifs — Guide pour la préparation de surface des plastiques

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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Introduction

Plastics materials are often bonded to other types of surface, particularly metals. Consequently, reference is made to ISO 4588:1995, *Adhesives — Guidelines for the surface preparation of metals*. Plastics surfaces often require preparation to remove contamination and additionally to improve the wetting characteristics of those possessing a low-energy surface. Preparative techniques such as abrasion improve performance by increasing mechanical interlocking.

Certain adhesives possess the ability to dissolve light oils and some polymeric materials. Consequently, some surfaces may not require preparation prior to bonding. Reference is made to this in table 1. Consult the suppliers involved for specific advice.

Most of the preparative techniques cited here involve some degree of hazard. Users are advised to comply with relevant national health and safety regulations and requirements.

Particular attention is drawn to the general principles of good industrial hygiene and the use of appropriate protective clothing — including goggles and gloves. In the same context, the use of liquid-based, chemically reactive surface preparation techniques is not recommended. Such methods should only be used where there is no practical alternative. Similarly, according to current legislation, proper means should be employed for the disposal of residual solvents, solutions and reactive chemicals.

Adhesives — Guidelines for the surface preparation of plastics

1 Scope

These guidelines describe mechanical, chemical and electrical methods of surface preparation for plastics adherends to be used prior to adhesive bonding.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 472:1988, *Plastics — Vocabulary.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 472 apply. The following definition is of particular relevance.

3.1 plastic (noun): A material which contains as an essential ingredient a high polymer and which at some stage in its processing into finished products can be shaped by flow.

NOTES

1 Elastomeric materials, which are also shaped by flow, are not considered as plastics.

2 In some countries, particularly in the United Kingdom, the official position now is that it is a permitted option to use the term "plastics" as the singular form as well as the plural form.

4 Surface treatments

The surface treatments are grouped as follows:

Cleaning, surface roughening, physical or chemical treatment and the use of primers. Treatments may be combined.

WARNING — The use of some chemicals can be dangerous — refer to their material safety data sheet (MSDS) prior to use.

4.1 Cleaning

To maximize adhesion, it is essential to remove all traces of oil, grease and mould release agents from the surfaces prior to bonding. Additionally, surfaces shall be free of dust and general soil. Surfaces may be cleaned with either a solvent or a detergent solution, depending upon the type of contaminant or the likelihood of surface damage.

Care shall be taken to avoid the stress cracking of certain thermoplastic materials. If in doubt, seek advice from the plastics manufacturer.

The preferred cleaning materials are propan-2-ol (= isopropyl alcohol) and a detergent solution. The more powerful agents such as the ketones and the permitted halogenated solvents may be used on thermoset plastics and, with care, on certain thermoplastics. If in doubt, seek advice from the plastics manufacturer.

Ultrasonic agitation may be used in conjunction with the foregoing materials.

4.2 Surface roughening

The roughening of surfaces by either grit-blasting or abrasion improves performance. The process comprises these steps: abrasion, removal of debris, solvent wiping, drying.

4.3 Physical treatment

Physical techniques bring about chemical changes in the surface but do not require the use of hazardous chemical solutions. They comprise plasma treatment in air at ambient pressure (corona) or at reduced pressure (glow discharge) and flame oxidation. All such processes require specialized equipment.

4.3.1 Plasma — ambient pressure (corona)

The bombardment by electrons and ions of the substrate exposed to the corona formed between the electrodes causes its oxidation and improves its adhesion.

4.3.2 Plasma — reduced pressure (glow discharge)

This is a variation on corona discharge, carried out at a low pressure in the presence of an inert gas or in combination with specific chemically active substances.

4.3.3 Flame treatment

The controlled oxidation of a surface is obtained by means of an oxidizing flame generated by burning methane, propane or butane with approximately 5 % to 10 % excess oxygen. Considerable care is required to generate the correct conditions.

4.3.4 Silanation

This derivative of the surface-roughening technique (4.2) introduces a permanently bound silane coupling group to the plastics surface. This group promotes covalent adhesion with suitable adhesives. It is carried out by blasting with a suitably prepared grit (silane-coated corundum).

4.4 Chemical treatment

Chemical treatments modify the surface to improve wetting and thereby improve adhesion. Well known methods are the use of chromic acid (direct oxidation) or sodium naphthalenide solution (indirect oxidation).

4.5 Primers

Primers usually modify the surface without the use of the aggressive materials required for chemical treatments (see 4.4). Unlike chemical treatments, which normally have several stages, primers are generally applied by either

simply brushing or spraying on to the surface and then allowing it to dry. They are often specific to generic types of adhesive and may induce stress cracking in certain plastics. Consequently, it is important to ensure, by checking, that the surface, primer and adhesive are mutually compatible.

5 List of common plastics

The following lists primary polymer types which may be obtained in both filled and unfilled forms.

Acrylonitrile/butadiene/styrene (ABS) copolymer
Cellulose esters
Epoxy-resin-based plastics and composites
Melamine-based plastics
Phenol-based plastics and composites
Polyacetal
Poly(allyl phthalate)
Polyamide
Poly(butylene terephthalate)
Poly(ethylene terephthalate)
Polycarbonate
Polychlorinated ethers
Polyester thermoplastics
Polyester thermosets
Polyetheretherketone
Polyethylene
Polyimide
Poly(methyl methacrylate)
Poly(phenylene ether)
Poly(phenylene sulfide)
Polypropylene
Polystyrene
Polysulfone
Polytetrafluoroethylene
Polyurethane
Poly(vinyl chloride)
Urea-based plastics

6 Preparative methods

6.1 No treatment

6.2 Cleaning

a) Clean with a fresh solvent or a detergent solution. Depending on the circumstances, use either a bath (liquid or vapour — take due care) or preferably wipe with a clean lint-free cloth or tissue.

b) Ensure surface is dry.

c) Bond immediately — preferably within 1 min.

Additional procedures

Ensure that any solvent selected will not damage the plastic, paying particular attention to the problem of stress cracking. Wherever possible, use propan-2-ol. Otherwise, use a ketone such as butan-2-one (MEK) or 4-methylpentan-2-one (MIBK), or an approved halogenated solvent.

WARNING — Alcohols and ketones are flammable — ketones are particularly hazardous. All are narcotic at high concentrations. Ventilate properly, take account of vapour density and draw fumes away from the operator.

If preparation for cyanoacrylate adhesive is necessary, then only use alcohols or ketones, as halogenated solvents could be slightly acidic, which interferes with, or even prevents, polymerization.

6.3 Surface roughening

a) Clean as in 6.2 a), taking note of the relevant additional procedures relating to the use of solvent.

b) Abrade or grit-blast the dried surface.

Care must be taken when roughening the surface of epoxy and phenolic resin composites as damage to fibres may result. This could have a detrimental effect on adhesively bonded components.

c) Remove coarse debris (vacuum).

d) Proceed as in 6.2 b) and c).

6.4 Physical treatment

For both variants of plasma treatment and for flame oxidation, consult the manufacturers of the specialized equipment required.

6.5 Chemical treatment

6.5.1 Chromic acid

a) Clean as in 6.2 a), taking note of the relevant additional procedures relating to the use of solvent.

b) Immerse the dried item in chromic etch solution (see below) for 15 min at room temperature.

c) Remove the item and rinse thoroughly in cold (20 °C ± 5 °C) distilled or deionised water.

d) Rinse again in warm (55 °C ± 5 °C) distilled or deionised water.

e) Dry in a warm (55 °C ± 5 °C) air stream.

f) Bond immediately — preferably within 1 min.

Chromic etch solution

When preparing this solution, only use vessels made of polyethylene, polypropylene or polytetrafluoroethylene.

	Parts by weight
Potassium dichromate or sodium dichromate	1,0
Concentrated sulfuric acid (ρ 1,84 g/ml)	10,0
Distilled/deionised water	30,0

Preparation

With constant stirring, gradually add the acid with caution to the water, and then add the dichromate. Stir until dissolution is complete.

WARNING — Both acid and dichromate are toxic and corrosive. Follow approved procedures for handling and disposal.

ADD ACID TO WATER — NEVER WATER TO ACID

Because of the acidic nature of this particular treatment, the subsequent polymerization of any cyanoacrylate adhesive used on this surface may be inhibited — check carefully.

6.5.2 Sodium naphthalenide

a) Clean as in 6.2 a) and b), taking note of the relevant additional procedures relating to the use of solvent.

b) Immerse the item in a commercial solution of sodium naphthalenide in accordance with the manufacturer's instructions — usually 5 s to 10 s.

c) Wash and dry, again following the instructions given. Normally this will require rinsing, in sequence, with water (distilled or deionised), acetone and water again prior to drying.

6.5.3 Toluene sulfonic acid

a) Clean as in 6.2 a) and b), taking note of the relevant additional procedures relating to the use of solvent.

b) Immerse the dry item in hot (94 °C ± 5 °C) sulfonic etch solution (see below) for 8 s ± 2 s.

c) Heat (110 °C ± 10 °C) in an oven for 45 s ± 15 s.

d) Wash thoroughly with warm (55 °C ± 5 °C) distilled or deionised water.

e) Dry in a warm (55 °C ± 5 °C) air stream.

f) Bond immediately — preferably within 1 min.

Sulfonic etch solution

When preparing this solution, only use vessels made of polyethylene, polypropylene or polytetrafluoroethylene.

	Parts by weight
Perchloroethylene	96,0
Dioxane	3,7
p-Toluene sulfonic acid	0,3

Preparation

Make a solution of the perchloroethylene and dioxane. Add the acid and stir until dissolution is complete.

WARNING — The mixture is toxic and corrosive. Follow approved procedures for handling and disposal.

Because of the acidic nature of this particular treatment, the subsequent polymerization of any cyanoacrylate adhesive used on this surface may be inhibited — check carefully.

6.5.4 Resorcinol solution

a) Clean as in 6.2 a) and b), taking note of the relevant additional procedures relating to the use of solvent.

b) Immerse the dry item in resorcinol solution (see below) for 8 s ± 2 s.

c) Dry, with good ventilation, for not more than 30 min at room temperature (23 °C ± 2 °C).

d) Bond as soon as the surface is dry (15 min to 30 min after removal from the resorcinol solution).

Resorcinol solution

When preparing this solution, only use vessels made of polyethylene, polypropylene or polytetrafluoroethylene.

	Parts by weight
Ethyl acetate	91,0
Resorcinol	9,0

Preparation

Add the resorcinol to the ethyl acetate and stir until dissolution is complete.

WARNING — The mixture is toxic and corrosive. Follow approved procedures for handling and disposal.

Because of the acidic nature of this particular treatment, the subsequent polymerization of any cyanoacrylate adhesive used on this surface may be inhibited — check carefully.

7 Surface preparation table for common plastics

In table 1, the surface preparation methods applicable to common plastics are indicated by a cross. Physical and chemical surface preparation may be combined with a prior cleaning.

NOTES

1 The information given in table 1 corresponds to the state of the art. Other methods may be used. For other plastics, surface preparation will have to be considered on a case for case basis.

2 Table 1 is not an exhaustive list of plastics, and surface treatment methods for other plastics are available, or may become available.

Table 1 — Surface preparation table for common plastics

Polymer	No treatment	Cleaning	Roughening	Plasma		Flame	Silanation	Chromic acid	Sodium naphthalenide	Toluene sulfonic acid	Resorcinol
				Ambient pressure	Low pressure						
Acrylonitrile/butadiene/styrene (ABS) copolymer	X	X	X					X			
Cellulose esters[1]	X	X	X								
Epoxy-resin-based plastics and composites	X	X	X								
Melamine-based plastics	X	X	X	X	X						
Phenol-based plastics and composites	X	X	X								
Polyacetal	X	X	X	X	X			X		X	
Poly(allyl phthalate)	X	X	X	X	X						
Polyamide[2]	X	X	X	X	X						X
Poly(butylene terephthalate)	X	X	X	X	X	X	X				
Poly(ethylene terephthalate)	X	X	X	X	X	X	X				
Polycarbonate	X	X	X	X	X						
Polychlorinated ethers								X			
Polyester thermoplastics	X	X	X	X	X	X	X				
Polyester thermosets	X	X	X								
Polyetheretherketone				X	X						
Polyethylene				X	X	X	X	X	X		
Polyimide				X	X						
Poly(methyl methacrylate)	X	X	X								
Poly(phenylene ether)	X	X	X	X	X						
Poly(phenylene sulfide)	X	X	X	X	X						
Polypropylene	X			X	X	X	X	X	X		
Polystyrene	X	X	X								
Polysulfone	X	X	X	X	X						
Polytetrafluoroethylene				X	X				X		
Polyurethane	X	X	X	X	X						
Poly(vinyl chloride)	X	X	X								
Urea-based plastics	X	X	X	X	X						

1) If preparing for use with epoxides, heat the plastic parts for 1 h at 93 °C and apply adhesive while the parts are still warm. Ensure that the epoxy adhesive does not cure prematurely because of use at this elevated temperature.

2) Ensure absorbed surface water has been expelled.

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