



# Compendium of practice for Commercial Dishwashing

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Section 03

**Commercial dishwashers**



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## 1. Basic aspects

Today, a dishwasher is a standard appliance in the most private households for cleaning dishes, glasses, kitchen utensils, etc. While in the private context, the focus is on reducing what is regarded as a tedious chore, in the commercial section, the use of commercial dishwashers is essential, not least to satisfy hygiene regulations. Commercial dishwashers are found in practically every catering business and every professional kitchen.

Unlike household dishwashers, commercial dishwashers clean the wash item in very short cycles. In commercial dishwashers with a tank-dishwashing system, the washing principle is based on a tank filled with continuously regenerating detergent solution that is used to clean the wash item. In fresh-water dishwashers, or water-change machines, the entire detergent solution is replaced with fresh water per washing stage. The technical features of commercial dishwashers are based primarily on a high hourly output. They are adapted to the demands of commercial washing and allow efficient operation at favourable operating costs.

## 2. Process of commercial dish washing

The process of commercial dish washing is divided into the following four individual stages: Pre-cleaning, cleaning, rinsing and drying.

### Pre-cleaning

To prevent more soiled material from entering the dishwasher, the used, soiled dish is pre-cleaned. This can be performed manually using a water spray or mechanically in a pre-cleaning zone of a corresponding appliance.



## **Cleaning**

In the cleaning process, a detergent solution comprising water and detergent is applied to the soiled wash item using pump units. This loosens the food residues.

## **Rinsing**

Detergent solution residues and loosened soil particles are rinsed off with the rinse aid during a separate rinse process. The addition of rinse aids also supports the wash item drying by reducing the surface tension of the water.

## **Drying**

In tank dishwashers, drying is usually performed outside the machine by means of the heat retained in the wash item during the cleaning process. The drying can be accelerated in the machine using various drying appliances.

In water-change machines, the drying sequence takes place predominantly in the machine.

## **3. Influence on the cleaning result**

In commercial dish washing, as with any other cleaning process, the following fundamental factors are responsible for a clean result:

- Mechanics
- Temperature
- Contact time
- Process chemicals
- Water



According to the Sinner's circle, the first four factors represent the aforementioned loop (Sinner's circle). The fifth factor (water) is the substrate used to transfer both energy in the form of heat and to discharge the dissolved soil particles. The factors are in direct relation to each other. Changing one factor requires the adjustment of one or more other factors to achieve the same cleaning result. However, this is only possible to a limited extent.

### 3.1. Mechanics

Variable pressure, which has been developed especially for the wash item in question, as well as a continuous circulation rate in the spray systems guarantees instant treatment of the wash item with detergent solution, which loosens soil and contamination.

### 3.2. Temperature

The necessary temperatures are reached using heating units. This helps to remove soil and contamination, and also guarantees hygienic results (see *Compendium of practice for Commercial Dishwashing Section 11 "Hygiene"*).

### 3.3. Contact time

The contact time is the action time during which the detergent solution wets the wash item at the present and achieved washing temperature. Therefore, sufficient contact time is a prerequisite for the complete removal of soil and contamination from the wash item (see *Compendium of practice for Commercial Dishwashing Section 11 "Hygiene"*).

### 3.4. Process chemicals

Suitable process chemicals (detergent and rinse aid) must be dosed for the corresponding requirements (see *Compendium of practice for Commercial Dishwashing Section 06 "Process chemicals"*).

### 3.5. Water

The dishwasher cannot perform the cleaning without water. The water quality is subject to special requirements (see *Compendium of practice for Commercial Dishwashing 05 "Water quality"*).

## 4. Types of commercial dishwashers

Commercial dishwashers (commercial dishwashing machines) can be differentiated into the following types, depending on the items to be washed:

- Glass washing machine
- Dishwashers
- Dishwashers for kitchenware / containers.

Further distinction is made according to the operation:

- Programmable machines (front-loading machines, rack pass-through dishwashers)
- Dishwashers with a transport system (flight-type and rack conveyor dishwashers)
- Water-change machines (fresh water dishwasher)

The selection should be made with the assistance of experts (see *Compendium of practice for Commercial Dishwashing Section 02 "Planning and organisation of dishwashing systems"*).

### 4.1. Programmable machines

The machine types are explained in detail below.

#### 4.1.1. Tank machines

In tank machines, the rack is loaded and unloaded into the machine either manually via the front door, or in rack pass-through dishwashers via a table feed.

For these machine types, the pre-cleaning is performed manually outside the machine. The different programme stages such as detergent circulation and rinse aid are performed consecutively. However, there is no spatial separation in one zone (tank). The wash item normally dries once the rack has been removed from the machine.



#### **4.1.2. Water-change machines (fresh water dishwasher)**

Water-change machines are commercial dishwashers with fresh water for each cleaning and rinsing cycle. In water-change machines, the upper and lower basket are generally fixed on pull-outs, similar to household dishwashers. In principle, two baskets / trays are always washed simultaneously.

The different programme steps such as detergent recirculation and rinse aid are performed consecutively. However, there is no physical separation in different zones.

These appliances are used predominantly in small commercial operations, particularly if the loads contain variable wash items.

### **4.2. Dishwashers with a transport system**

Hereby the wash item passes automatically into the next zone in which the individual operations are performed. A distinction is made between two machine constructions:

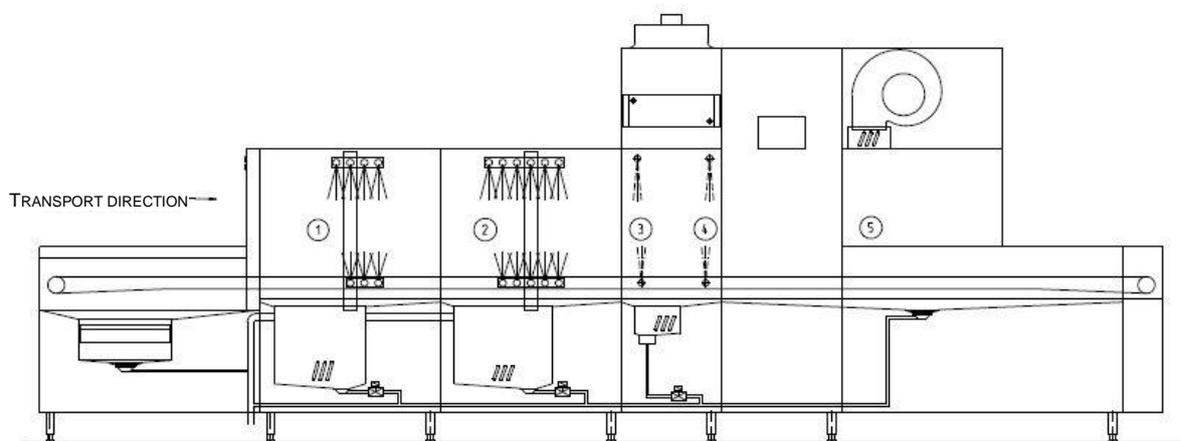
#### **4.2.1. Rack conveyor dishwasher**

The racks loaded with wash items are automatically transported through the machine.

#### 4.2.2. Flight-type dishwasher

The wash item is placed directly in a continuous belt and is automatically transported through the dishwasher.

The following diagram illustrates the individual functions of a conveyor dishwasher.



① Pre-cleaning: Pre-cleaning can be performed manually upstream of the machine or within the machine using fresh water pre-cleaning and / or pump pre-cleaning.

Irrespective of this, large soiled material (e.g. napkins, bones) must be removed before the wash item is loaded into the dishwasher.

Fresh water pre-cleaning: Zone in which food residue is cleared from the wash item directly using fresh water.

Pre-cleaning pumps: Circulation tank in multi-tank dishwashers in which food residue is cleared from the wash item using detergent solution. No detergent is added directly to this zone.

② Detergent recirculation zone: The actual cleaning of the wash item is performed here. Detergent is added directly to this zone. Several consecutive tanks can be arranged to increase performance.

③ Rinse aid pump: An additional rinse aid pump, which is operated with the rinse aid solution collected from the fresh-water rinse, can be used to improve the rinsing impairment.

④ Fresh water rinse: Here, the wash item is sprayed with hot fresh water mixed with rinse aid.

⑤ Drying zone: The wash item is dried using air from a fan.



## 5. Supply of water, energy and process chemicals

The supply of

- water
- energy and
- process chemicals

is essential for the operation of a commercial dishwasher.

### 5.1. Water

The water transfers the mechanical and thermal energy to the wash item surface.

The process chemicals are dissolved in water. The water quality is decisive for a good washing result.

The water requirements are described in more detail in the *Compendium of practice for Commercial Dishwashing 05 "Water quality"*.

### 5.2. Energy

The energy is required to operate the circulation pumps and to heat the water, among other things.

Further explanations on the topic of "energy" are provided in the *Compendium of practice for Commercial Dishwashing Section 02 "Planning and organisation of dishwashing systems"*.

### 5.3. Process chemicals

The detergent dissolves the soiling to generate a clean washing result. The purpose of the rinse aid is to reduce the surface tension of the water, ensuring optimal wetting and drying of the wash item.

For further information on process chemicals, see *Compendium of practice for Commercial Dishwashing Section 06 "Process chemicals"*.



## 6. Hygiene requirements

The DIN standards DIN 10510 to DIN 10512, DIN 10522, as well as DIN SPEC 10534, describe the requirements for the functions and operation of commercial dishwashers, as well as testing and assessment methods for the washing result.

Washing systems, whose design deviates from DIN, should be proven capable of achieving the requirements for hygienic washing results in all aspect, even under practical conditions, as described in the DIN standards.

The dishwasher operator must ensure that operating staff are trained and proficient in operating the dishwasher. Hygiene rules of the staff must be observed as a part of this (see *Compendium of practice for Commercial Dishwashing Section 11 "Hygiene"*).

## 7. Operation

The operator is responsible for the correct operation of the dishwasher in accordance with the manufacturer's specifications. The regulations that arise from the standards and legislations that are relevant for the operation (including operating manuals and instructions) should be observed.

## 8. Maintenance

Regular maintenance of all components of the washing system should be performed by authorised expert staff of the manufacturer. On the one hand, maintenance preserves the operational and functional reliability, as well as the value of the system. The conclusion of maintenance contracts for dishwashers is advisable.



## 9. Material compatibility

Based on technical enhancements, a variety of materials is used in commercial dishwashers, for example, in the form of high-quality plastic.

The properties of the individual materials specified in the sections below should be interpreted as “guide values”, which should be confirmed in practice under the normal operating conditions in thousands of commercial dishwashers. However, certain conditions can occur under individual circumstances, which necessitate a special choice of material. Particularly with modified cleaning methods (such as spraying concentrated alkalis or acids, using new chemicals or higher process temperatures), the stability of the materials used must be tested.

### 9.1. Metallic materials

#### 9.1.1. Stainless steel

Steels that are alloyed with 12 % or more chrome that may also contain nickel, molybdenum and other metals are referred to as stainless steel. Depending on the level of the individual constituents, the degree of corrosion-resistance can be influenced. This can also lead to the alteration of further properties, e.g., the hardenability or the magnetisability.

Stainless steels are distinguished by alloy constituents and the percentages of these. Chrome-nickel steel with the abbreviation X5CrNi18-10, material no. 1.4301 is used predominantly for dishwashers. The considerably stronger corrosion resistance, compared with other steels, is based predominantly on the presence of the “passive layer”. This is composed largely of chromium oxides and can regenerate itself in the event of localised damage. This is contingent upon the presence of oxygen and sufficient action time.

For example, the passive layer can be destroyed by:

- Accumulation of certain metal particles (e.g. iron, copper, etc.)
- Hydrochloric acid (e.g. in cement residue remover)



- High chloride contamination (table salt / food residue)
- Mechanical impact in combination with one of the aforementioned points on the surface

Every stainless steel can become corroded under unfavourable conditions.

### **Extraneous rust**

Extraneous rust is caused by iron particles that adhere to the steel surface. The source of these particles can vary. Water supply pipes, steel wool scourers that were used to pre-clean the wash item or paper clips, staples, drilling chips, screws, etc., to name just a few. As all these parts are brought in from the outside, they are referred to as extraneous rust. If the rust spots and source of these are not remedied immediately, this can lead to considerable corrosion damage as a result of rusting through.

### **Pitting**

Pitting is the result of excessive chloride load. Pitting is a rust-coloured stain, at the centre of which is a small crater. If this and the cause of the pitting is not remedied, a pit can appear relatively quickly.

High chloride loads are caused by irregularities in the demineralisation system, which leads to the ingress of regeneration salt in the softened water. Contributing factors can also be food residues with high table salt contents, inflowing water with a high chloride content, as well as improper dosing of chlorine-based bleaching agents (disinfection components). To prevent pitting, the chloride load in fresh water should not exceed 50 mg/l.

### **Stains**

Occasionally light to heavy discolouration of the stainless steel occurs, caused by constituents of the drinking water or the food. Brown / black discolourations in the transition from the fresh water rinse to the detergent zone can be caused by exces-



sive copper content in the fresh water rinse (e.g. from copper pipes, which were corroded by aggressive water). These discolourations do not represent corrosion. They can occur both inside the machine and on the stainless steel wash item. The majority of tarnish can be remedied with a suitable descaling solution (free of hydrochloric acid), especially immediately after the tarnish appears.

Full surface, brown or black-brown spots, which appear mostly on the base of the scullery and / or the tank occur when a powdered caustic-alkali detergent is dosed into a low-flow area of a tank and settles on the tank base. This impairment can also occur if the powdered, caustic-alkali detergent is dosed by hand or using a dosing device long before the dishwasher is started. Although this action does not destroy the tank base, please ensure that no undissolved powdered detergent can settle over the long term. Should “deposition” occur nevertheless, the tank bases should be thoroughly cleaned. To avoid this, it is advisable to scatter the detergent (either automatically or manually) generously on the surface of the water or in a high-flow area and to start the dishwasher without delay.

Stainless steel can discolour (darken) around the liquid detergent dosing area. These are merely an optical impairment. It is caused by oxidation of the chrome content in the stainless steel. The discolouration is very difficult to remove; however, is merely an optical impairment. Extensive machining of the stainless steel at the areas concerned, however, can produce undesirable material changes and should therefore be avoided.

For further information, see *Compendium of practice for Commercial Dishwashing Section 01 “Definitions”, Section 08 “Metal wash items” and Section 05 “Water quality”*.



### ***Stainless steel baking trays and profiles***

<b>Material no.</b>	<b>1.4016</b>
Short name:	X6Cr17
Application:	Partly for sub-assemblies
Properties:	Magnetisable. Resistant to detergent and rinse aid solution. Resistance at weld seams is critical, therefore, these must be treated carefully.

<b>Material no.</b>	<b>1.4104</b>
Short name:	X14CrMoS17
Application:	As 1.4016, but for chipping production
Properties:	As 1.4016, but not suitable for welding

<b>Material no.</b>	<b>1.4301</b>
Short name:	X5CrNi18-10
Application:	Main construction material for dishwashers, stainless steel dishes are also manufactured preferably from this material.
Properties:	Not magnetisable. When used properly, the material is resistant to all chemical influences occurring in the dishwasher.



<b>Material no.</b>	<b>1.4305</b>
Short name:	X8CrNiS18-9
Application:	As 1.4301, but only suitable for machining precision parts
Properties:	As 1.4301, but not suitable for welding

<b>Material no.</b>	<b>1.4571</b>
Short name:	X6CrNiMoTi17-12-2
Application:	Used for parts exposed to high thermal and chemical loads, e.g., vapour pipes, heating register and similar components exposed to high loads.
Properties:	Not magnetisable. Due to its alloy, the material has greater chemical resistance and has greater resistance to pitting. Otherwise, it is comparable with 1.4301.

### ***Stainless steel casting***

<b>Material no.</b>	<b>1.4308</b>
Short name:	GX5CrNi19-10
Application:	Cast parts, pump housing, etc.
Properties:	Comparable with 1.4301



<b>Material no.</b>	<b>1.4312</b>
Short name:	GX10CrNi18-8
Application:	As 1.4308, but for cast parts with greater resistance
Properties:	As 1.4301

### ***Spring steels***

<b>Material no.</b>	<b>1.4310</b>
Short name:	X10CrNi18-8

<b>Material no.</b>	<b>1.4401</b>
Short name:	X5CrNiMo17-12-2

<b>Material no.</b>	<b>1.4568</b>
Short name:	X7CrNiAl17-7

### ***High-resistance stainless steel alloys***

<b>Material no.</b>	<b>1.4876 (Incoloy alloy 800)</b>
Short name:	X10NiCrAlTi32-20
Application:	Pipes for electric radiators
Properties:	High chemical-thermal resistance, even to pitting and stress crack corrosion



<b>Material no.</b>	<b>2.4858 (Incoloy alloy 825)</b>
Short name:	NiCr21Mo
Application:	As 1.4876, but for even greater stresses
Properties:	Even more resistant than 1.4876

### 9.1.2. Copper and copper alloys

Copper and all copper alloys are not resistant to acids. Acidic rinse aid solutions dissolve copper.

#### ***Copper***

Application:	Copper is used for fresh water supply pipes and heat exchanger pipes. To guarantee universal application, copper and copper alloys must not be used for pipes in the rinse aid area.
Properties:	Resistant to drinking water, provided no excessive iron content is present and no mixed system is used. It has limited resistance to: <ul style="list-style-type: none"><li>• Acidic water (pH &lt; 7) and acidic rinse aid solution</li><li>• Demineralised water (through osmosis or ion exchange)</li></ul> Copper dissolved in rinse aid solution can cause tough discolourations in the dishwasher and on the wash item.



### ***Copper-nickel alloys***

<b>Material no.</b>	<b>e.g. 2.0872</b>
Short name:	CuNi10Fe
Application:	For pipes, particularly heat exchanger
Properties:	Like copper, but with greater resistance

### ***Copper-tin alloys (bronze or gunmetal)***

Short name:	e.g. Rg5 or Rg10
Application:	For cast parts, mounts, fittings, nozzles, bearings and similar parts.
Properties:	More resistant than copper, greater rigidity and a good sliding material.

### ***Copper-zinc alloy (brass)***

Application:	Use as cast and profile material for fittings and simple construction elements, etc.
Properties:	Resistant to fresh water, not resistant to alkaline cleaners.

### **9.1.3. Aluminium alloys**

Application:	For heat exchanger blades
Properties:	Not resistant to acids and alkalis



## 9.2. Coatings

### 9.2.1. Zinc coating (galvanising)

Application:	For water pipes and fittings outside the scullery
Properties:	Good corrosion protection against drinking water, but not for 0 °dH and desalinated water

### 9.2.2. Polyamide coating (Rilsan®, Ultralan® etc.)

Application:	Coating on wire dish racks
Properties:	Good resistance in aqueous solutions, but is sensitive to surface damage caused by cutting, impact or breakage Note: The coating is designed to: <ul style="list-style-type: none"><li>• protect the non-resistant base material,</li><li>• prevent metal abrasion on the wash items</li></ul>

## 9.3. Plastics

### 9.3.1. Thermosetting plastics (glass-fibre reinforced polyester)

Application:	Pump impellers, pump housing, protective covers and similar parts
Properties:	Resistant to alkaline and acidic solutions, depending on the temperature and processing



### 9.3.2. Thermoplastics

#### ***Polyethene (low-pressure polyethene with low to moderate molecular weight)***

(brand names Hostalen®, Lupolen®P and several others)

Short name:	LDPE
Application:	Hoses and parts with low mechanical and thermal strain
Properties:	Good resistance to all substances in the dishwasher. Low thermal resistance, soft surface, non-coloured, food-safe

#### ***Polyethene, with high molecular weight***

Short name:	HDPE
Application:	Sliding bearing and guides
Properties:	Good sliding properties, wear resistance and high chemical resistance, typical technical plastic

#### ***Polypropylene***

(Hostalen®PP, Novolen®, Vestolen®P)

Short name:	PP
Application:	In stable detergent solution; the most frequently used plastic in commercial dishwashers
Properties:	Resistant to alkaline and acidic solutions, suitable for thermoforming and pressure-resistant. Smooth and hydrophobic (water-repellent) surface



### ***Polyoxymethylene***

(e.g. Hostaform®, Ultraform®)

Short name:	POM
Application:	Typical technical plastic for higher-stress parts
Properties:	Not resistant to acids and acidic solutions with pH < 5. Where descalers are used, exercise caution and observe the instructions of the supplier. Otherwise, similar properties as PP. Improper use of descalers, e.g., excessive action times or spraying the inside of the machine and leaving it to react over extended periods, and the associated drying lead to damage. Provided descaler is used correctly, parts made of POM are not damaged

### ***Polyvinyl chloride***

Short name:	PVC
Application:	Hoses, insulation of electrical lines
Properties:	Resistant to drinking water, alkaline and acidic solutions, sensitive to UV in uncoloured state, not very thermally stable, prone to harden

### ***Polytetrafluorethylene (Teflon®)***

Short name:	PTFE
Application:	Seals, sliding material
Properties:	Very high chemical and thermal resistance



#### 9.4. Permanently elastic materials (elastomers)

Application:

Elastomers are used for seals and hoses. The suitable material is selected according to the respective mechanical, chemical and thermal stress.

The following material groups are available:

- Silicon
- Perbunan®
- Viton®
- Neoprene®
- EPDM and others

Properties:

Permanently elastic. Depending on the respective formula, resistance to acids and alkalis is possible.

### 9.5. Table: Materials that are resistant or non-resistant to commercial dishwashers

Material no.	Short name	Notes for use	Properties
1.4016	X6Cr17	for sub-assemblies	magnetisable; resistant to detergent and rinse aid solution
1.4104	X14CrMoS17	as material 1.4016, but predominantly for machining steel	as material 1.4016, but not suitable for welding
1.4301	X5CrNi18-10	Main construction material for commercial dishwashers; also for dosing device housings	not magnetisable; when used as intended, resistant to all stresses occurring in the dishwasher, with the exception of excess chlorine
1.4305	X8CrNiS18-9	as material 1.4301, but not suitable for machining precision parts	as material 1.4301, but not suitable for welding
1.4571	X6CrNiMoTi17-12-2	for parts with high-temperature exposure such as electric radiators, vapor radiators, standpipes	non-magnetisable; properties as 1.4301, but thanks to the alloys, increased resistance to pitting and corrosion at high temperature
1.4308	GX5CrNi19-10	Cast parts, pump housing, etc.	as material 1.4301
1.4312	GX10CrNi18-8	Cast parts, pump housing, etc.	as material 1.4301
1.4310	X10CrNi18-8	for spring elements such as pressure springs, tension springs	resume their original shape after discharge, if the yield strength is not exceeded
1.4401	X5CrNiMo17-12-2	as material 1.4310	as material 1.4310
1.4568	X7CrNiAl17-7	as material 1.4310	as material 1.4310
1.4876	X10NiCrAlTi32-20	Pipes for electric radiators	in the critical range between 80 and 100 °C of an aqueous solution resistant to pitting and stress cracks; high Ni proportion, which is also stabilised with Cr and Ti
2.4858	NiCr21Mo	Pipes for electric radiators	in the critical range between 80 and 100 °C of an aqueous solution resistant to pitting and stress cracks; high Ni proportions, which are also stabilised with Cr and Mo; Mo can also be partially replaced with Ti
Copper	---	for fresh water supply pipes and heat exchangers	resistant to drinking water, provided no excessive iron content is present and no mixed system is used
2.0872	CuNi10Fe	for pipes, particularly in heat exchangers	like copper but with greater resistance
Copper-tin alloy (bronze or gunmetal)	Rg 5 and Rg10	Cast parts, fittings, nozzles, bearings	more resistant than copper; greater mechanical strength; good sliding material

Material no.	Short name	Notes for use	Properties
<b>Copper-zinc alloy (Brass)</b>	---	Cast and profile material, simple construction elements and nozzles, door guides, pipes	resistant to fresh water
<b>Aluminium alloys</b>	---	Blades for heat exchangers	not resistant to acids and alkalis
<b>Zinc coating</b>	---	for water pipes and fittings outside the scullery	good corrosion protection against drinking water, but not for 0 °dH and desalinated water
<b>Polyamide coating e.g. Rilsan®</b>	---	Coating on wire dish racks	Good resistance in aqueous solutions, but sensitive to surface damage
<b>Polyester-Glass-fibre reinforced (Thermosetting plastic)</b>	---	Pump impellers, pump housing, protective covers	resistant to alkaline and acidic solutions, depending on the temperature
<b>Polyethene LDPE (e.g. Hostalen®, Lupolen®P)</b>	---	in supply hoses for dosing devices for commercial dishwashers	Good resistance to alkaline and acidic solutions; low thermal resistance; soft surface; food-safe, as they contain no additives if they're not coloured
<b>Polyethene HDPE with high molecular weight</b>	---	Sliding bearing and guides	good sliding properties, wear resistance and high chemical resistance, typical technical plastic
<b>Polypropylene PP (e.g. Hostalen®PP, Novolen®, Vestolen®P)</b>	---	most frequently used plastic in commercial dishwashers; is used for dishwashing systems, nozzles, covers, sieves, fully plastic racks, conveyor belts	exceptionally resistant to alkaline and acidic solutions; thermally stable and pressure-resistant
<b>Polyoxymethylene POM (e.g. Hostaform®, Ultraform®)</b>	---	used for high-strain parts that must be accurately dimensioned, e.g., gears in transport apparatus, chain links, pulleys, guides, scanning elements	typical technical material, similar properties to PP; not resistant to acids
<b>Polyvinyl chloride</b>	PVC	Hoses, insulation of electrical lines	resistant to drinking water, alkaline and acidic solutions; prone to harden
<b>Polytetrafluorethylene (Teflon®)</b>	PTFE	Seals, sliding material	very high chemical and thermal resistance
<b>Elastomers, e.g. Perbunan®, Viton®, silicon, Neoprene®, EPDM</b>	---	Valves, seals, membranes, hoses, bellows, etc.	permanently elastic; depending on the respective formula, resistance to acids and alkalis is possible



This compendium of practice, which has been drawn up by experts, should remind the reader that commercial machine washing cannot be successfully conducted on a superficial level or without the corresponding input of all persons involved in the cleaning process.

Only the understanding of technical processes, the resulting interrelations and the cooperation of all participants, particularly the dishwasher operator and staff, as well as having regular maintenance of the dishwasher, the dosing equipment and the water treatment system by the manufacturer, can produce the cleaning results expected by the user.

Consistent cooperation between the dishwasher, detergent and dosing equipment manufacturers, as well as the manufacturers of wash items, guarantees constant and optimal adaptation to practical requirements for the benefit of customers and the environment.