Advanced Materials

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# APPLICATION AND BONDING METHODS

The Technical Guide for Adhesives

**This brochure is an abstract of "The Complete Technical Guide for Adhesives".**

Get the Complete Guide

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# 4.0 APPLICATION AND BONDING METHODS

The method for applying an adhesive can range from simple hand mixing and manual application to fully automated application lines.

Selecting an appropriate application method is key to the success of adhesive bonding. The selection process includes factors such as adhesive type, part geometry, production volume, portability, quality requirements and economics.

This guide aims to provide guidance and key information for engineers to identify suitable application methods according to their specific requirements. At Huntsman Advanced Materials, our application laboratory provides support to our customers for many of the common equipment types and application methods.

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# SELECTING AN APPROPRIATE APPLICATION METHOD

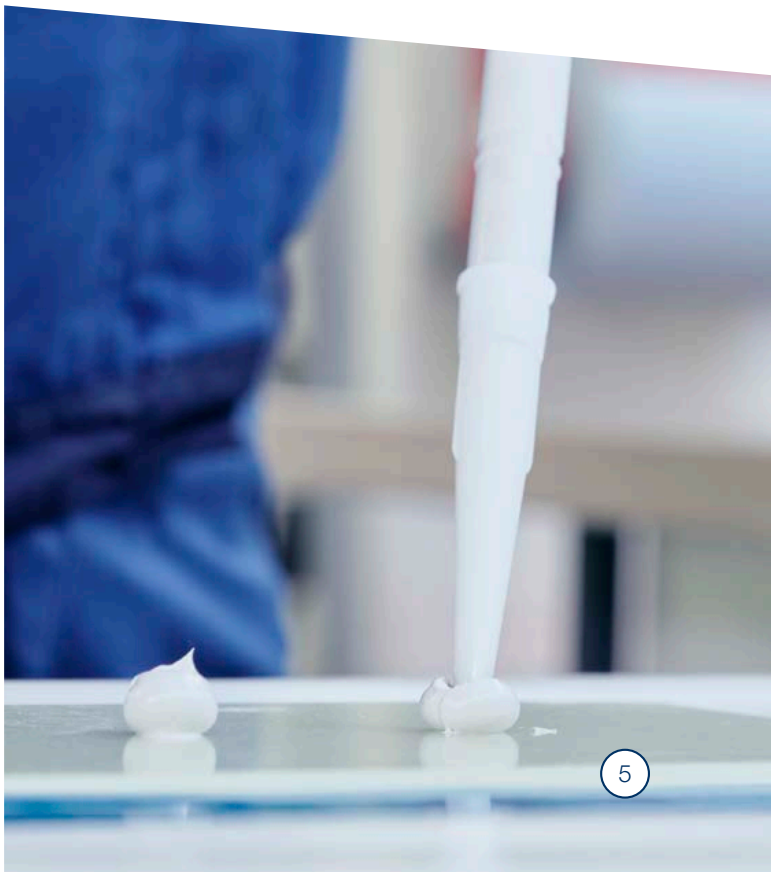
There are two main application techniques for applying reactive adhesives: bead / dot application and slot or roller coating.

The application technique is usually selected according to the size and shape of the bonded areas and the part geometry.

## Criteria to consider when selecting an adhesive application method include the following:

- **Adhesive type**
- **Part size to be bonded**
- **Time needed to apply the adhesive**
- **Cycle time: number of parts to be bonded per hour / day**
- **Outdoor / indoor application**
- **Viscosity of the adhesive to be applied**
- **Investment level**

| | BEAD/DOT APPLICATION | SLOT/ROLLER COATING |
|---|---|---|
| Targeted application | ✔ | ✘ |
| Large surface application | ✘ | ✔ |
| Complex part geometry | ✔ | ✘ |
| Manual application | ✔ | ✘ |
| Robotic application | ✔ | ✘ |
| Continuous line application | ✔ | ✔ |
| Control of bond line thickness | ✘ | ✔ |
| Visible bond lines / deformation | ✘ | ✔ |
| Fast-cure adhesives | ✔ | ✘ |
| Use of gap-filling adhesive for uneven parts | ✔ | ✘ |



4.1 BASIC APPLICATION METHODS

# BEADS & DOTS FOR TARGETED APPLICATIONS

Beads and dots of adhesive are applied as single or multiple rows, either manually from a cartridge or from automated dispensing equipment. It is a very versatile method as it can be used for many types of adhesive from low viscosity products to highly viscous or thixotropic pastes.

This method is suitable for application of adhesives to targeted areas of parts and for three-dimensional forms. Robotic application may be combined with automated mixing / dispensing equipment to achieve consistent application even on complex forms.

For most applications, the adhesive can be dispensed directly from a disposable static mixer, meaning that there is no equipment cleaning between applications and only the disposable mixer must be changed. This application method allows fast-cure adhesives to be used.

Clamping pressure is normally applied to the bonded parts when they are brought together in order to spread the adhesive over the bonded area. However, this can lead to inhomogeneity in the bond line, or to air entrapment. If the bonded substrates are thin or flexible, this can cause an uneven surface or 'witness lines', visible on the exterior of the bonded parts.

## How to achieve a good beads and dots application

Watch the video

### ADVANTAGES

- **Targeted application on complex forms possible**
- **Very little waste**
- **Simple and quick cleaning of application equipment**
- **No need for solvent flushing**
- **Equipment can be very mobile**
- **Suited to robotic application**

### DISADVANTAGES

- **Precise control of adhesive thickness difficult**
- **Bead application pattern may be visible through thin substrates**
- **Relies on even pressure to spread the adhesive**
- **Slow application method for large, flat surfaces**

4.1 BASIC APPLICATION METHODS

# ROLLER COATING FOR LARGE SURFACES

Usually associated with low to medium viscosity products, a film of adhesive is applied to a substrate using either a slot applicator or a roller coater. Small manual roller coaters are available, but the method often employs automated lines with an integrated coater.

This kind of applicator may also be linked to automated mixing-dispensing equipment. The installation is generally stationary (not portable) and must be flushed and cleaned regularly with solvents - e.g. at the end of a shift.

Only adhesives with relatively long working times (slow-cure) are normally suited to this kind of equipment. Very even adhesive application, with accurate control of bond line thickness can be achieved on flat substrates. This makes it especially suited for bonding large, flat panels.

### ADVANTAGES

- **Accurate control of adhesive thickness**
- **Fast application on large, flat surfaces**
- **Even bond line**

### DISADVANTAGES

- **Suitable for long open-time adhesive systems only**
- **Cleaning equipment is essential - in most cases solvent flushing / cleaning is required**
- **Equipment often not mobile**

# SELECTING AN APPROPRIATE METERING PUMP

Metering mixing equipment enables two-component adhesives to be dispensed directly from bulk packs (pails, drums or tanks).

Metering pumps have several technical characteristics which make them more or less suited to certain product types.

## Factors to consider when selecting metering pump type include the following:

- **Output rate**
- **Pumping consistency / accuracy**
- **Flexibility to modify component mix ratios**
- **Adhesive viscosity / rheology**
- **Suitability for use with abrasive or lightweight fillers in the adhesive components**
- **Cost and pump maintenance**

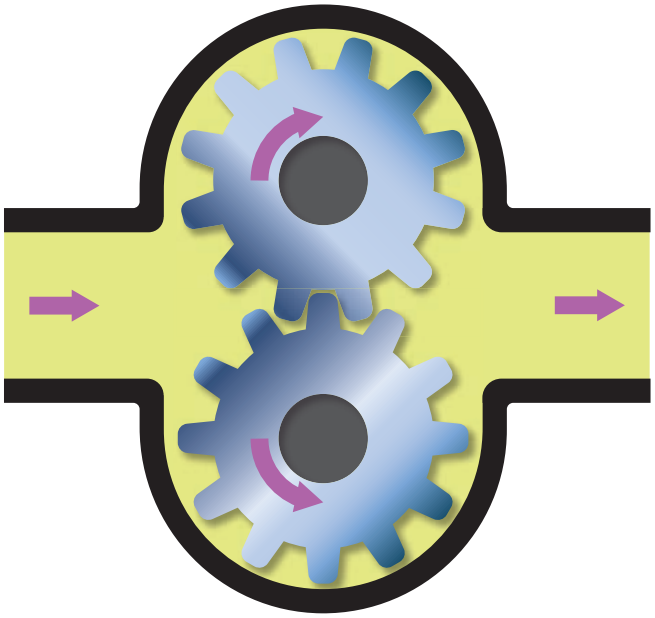
| | PISTON PUMP | GEAR PUMP | SCREW PUMP | PROGRESSIVE CAVITY PUMP |
|---|---|---|---|---|
| Constant output (no pulsing) | ✗ | ✓ | ✓ | ✓ |
| Variable component mix ratio | ✗ | ✓ | ✓ | ✓ |
| Low-medium viscosity fluids | ✓ | ✓ | ✓ | ✓ |
| High viscosity / thixotropic fluids | ✓ | ✗ | ✓ | ✓ |
| Very high viscosity fluids | ✗ | ✗ | ✗ | ✓ |
| Fluids with abrasive fillers | ✓ | ✗ | ✗ | ✓ |
| Fluids with hollow fillers | ✗ | ✗ | ✓ | ✓ |
| Cost | ●○○ | ●○○ | ●●○ | ●●● |
| Variability of output rate | ●●● | ●○○ | ●●○ | ●●○ |
| Pumping pressure | ●●● | ●●● | ●●● | ●●○ |
| Pump maintenance | ●●○ | ●○○ | ●○○ | ●●● |

## The equipment has two main functions:

- Separate pumping of each adhesive component using special metered pumps.
  These accurately control the volume of each component to ensure the correct mixing ratio.

- Mixing of the two adhesive components as they are dispensed from the equipment.

# GEAR PUMPS



There are four main types of metering pumps used for metering-mixing of adhesives. All work on the principle of dispensing a calculated volume of material per stroke or revolution.

**A gear pump operates using two driven, intermeshed gears inside a closed chamber which displace a fixed volume as they turn. Product is drawn into the revolving gears at the inlet and forced out as the gears intermesh at the outlet.**

This type of pump works with low to medium viscosity materials and offers constant output, coupled with accurate volume control. The speed of each pump is variable, meaning that mix ratio can be easily adjusted. Since the pumps rely on closely intermeshing gears, they are not suited to products containing abrasive fillers, which can wear the gear parts. Gear pumps may damage lightweight fillers (hollow microspheres) causing a change in material density.

The relatively high shear rates generated by gear pumps may alter the rheological behaviour of some thixotropic adhesives (overshear) leading to sag or slumping.

## ADVANTAGES

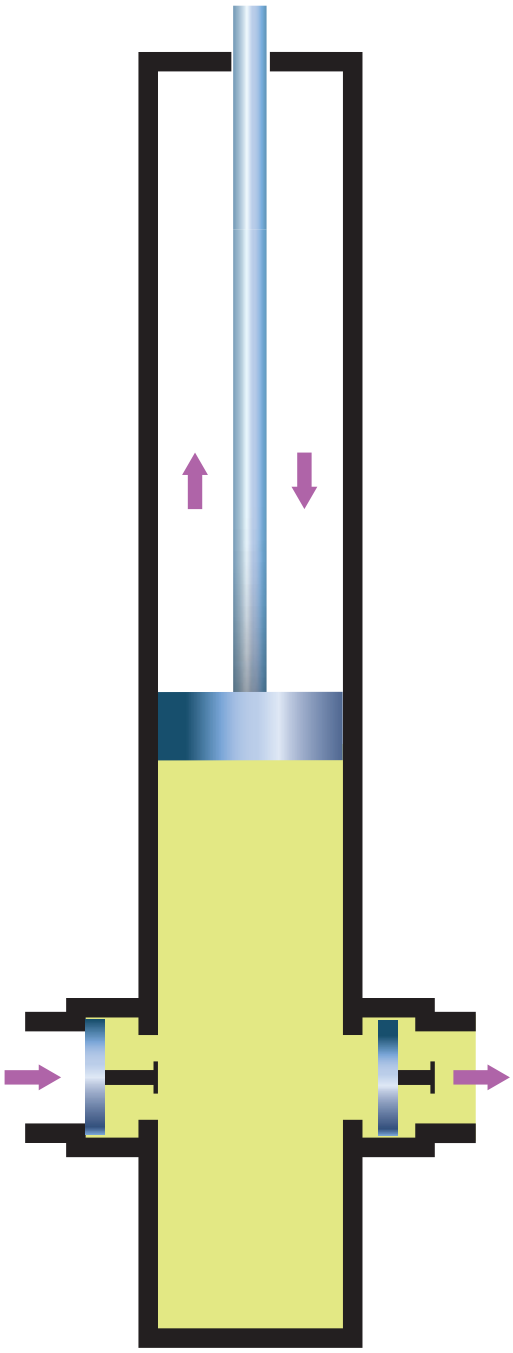
- **Constant output with no pulsing**
- **Extremely accurate output**
- **Can develop high pressure**
- **Simple to modify output with electric stepping motors, chain or gear drives**
- **Easy to change mix ratio**

## DISADVANTAGES

- **Cannot operate with abrasive filler systems or hollow fillers (crushing)**
- **Limited output for each pump size**
- **Due to the close tolerances of the component parts of the pump they need to be kept clean**
- **Can only be used on low to medium viscosity products**
- **Can overshear product due to pumping action**

4.2 METER MIX MACHINES

# PISTON PUMPS



**This type of pump works on a reciprocating piston system: one stroke of a piston fills a volumetric chamber, whilst the opposite stroke discharges.**

Piston pumps generally provide accurate volume control and can be used with a wide range of material viscosities, but output is not constant due to the reciprocal nature of the pump. Some equipment uses a set of two pistons working in opposite cycles to increase consistency of the output.

Overall flow rate can be controlled, but the volume ratio of one component to another may be fixed by the piston (cylinder) bore. This means that changing adhesive mix ratio may require installation of alternative pistons/cylinders.

High pressures can be generated during the filling and discharge cycle, especially with highly viscous or thixotropic materials. This can cause breakage of hollow microspheres and lead to a gradual heating of the equipment (and adhesive) over the period of application, causing a change in reactivity. Compressible materials are particularly prone to heating with this type of pump. Piston pumps are relatively inexpensive compared to other pump types.

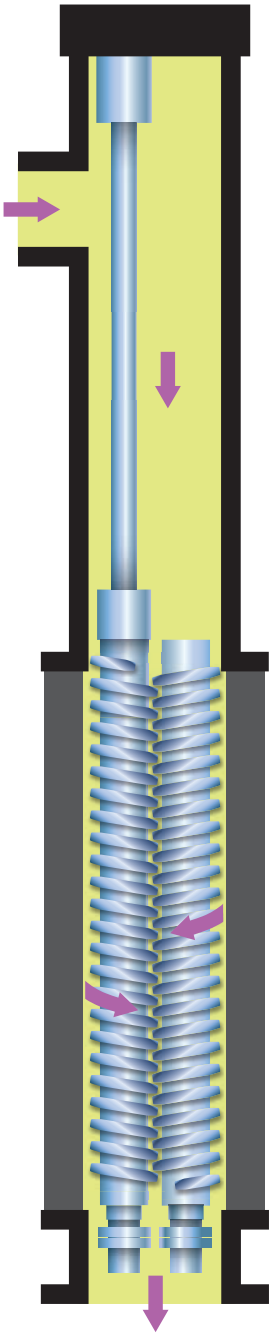
## ADVANTAGES

- **Very reliable**
- **Very accurate**
- **Relatively inexpensive**
- **Handles virtually all adhesive systems, low to high viscosity's as well as thixotropic materials**
- **Variable output and variable ratio**
- **Simple and well-developed technology**

## DISADVANTAGES

- **Difficult to obtain constant output**
- **Some hollow fillers like mineral spheres can be crushed, then leading to product density change**

# SCREW PUMPS



**Screw pumps work using one or more rotating Archimedes' screws (spindles). Pumps for viscous materials such as adhesives typically use two or three meshing spindles, turning in opposite directions within a closed chamber. The continued rotation of the screws produces a volume displacement, transferring product from inlet to outlet.**

Screw pumps have similar characteristics to gear pumps, but generate lower pressures/ less abrasion, meaning that they are more suitable for use with lightweight fillers (hollow microspheres).

Screw pumps are suitable for use with medium to high viscosity products. However, these pumps are generally more expensive than gear pumps.

## ADVANTAGES

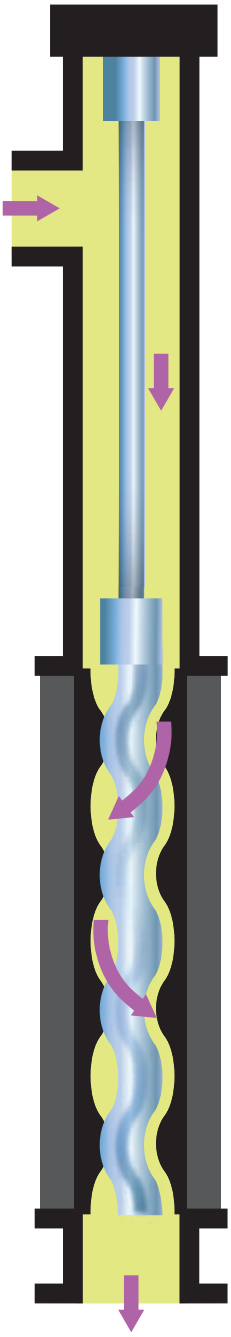
- **Constant output with no pulsing**
- **Extremely accurate output**
- **Can develop high pressures**
- **Simple to change output with electric stepping motors, chain or gear drives**
- **Easy to change the mix ratio**
- **Gentle on product - can operate with low pressure**

## DISADVANTAGES

- **Struggles to achieve high output with high viscosity products**
- **Cannot operate with abrasive filler systems.**
- **Due to the close tolerances of the component parts of the pump, they need to be kept clean**
- **Can overshear product due to pumping action**

4.2 METER MIX MACHINES

# PROGRESSIVE CAVITY PUMPS



**Progressive cavity pumps appear somewhat similar to screw pumps, but work by a different principle. A rigid helicoidal rotor forms cavities within a specially shaped elastomeric stator. As the rotor turns within the stator, the cavities move from the inlet to the outlet, transferring material. In this respect, the principle is similar to a peristaltic pump.**

The output is constant and is modified by altering the rotor speed. Progressive cavity pumps can be used for extremely high viscosity fluids, or difficult to pump fluids, e.g. with very high filler levels.

Progressive cavity pumps apply low levels of shear to the pumped material, making them suitable for lightweight fillers (hollow microspheres). The shape of the cavities also makes them suitable for pumping fluids with large filler particles.

Some slippage can occur with cavity pumps, meaning that material passes through gaps between the rotor and stator. This worsens as parts wear and can lead to inaccurate pumping rates. The elastomeric stator therefore requires regular changing to ensure pumping accuracy.

## ADVANTAGES

- **Good for very high viscosities and other difficult media**
- **Can handle air entrained, multiple phase and abrasive fluids**
- **Precise dosing**
- **Suited to high and low viscosity applications**
- **Allows continuous, gentle and low-pulsation flow**
- **Very accurate as a metering pump**

## DISADVANTAGES

- **These pumps fail if run dry**
- **Do not produce high flow rates**
- **Volumetric efficiency affected if viscous fluid doesn't enter pumps quickly enough**
- **Can only pump a limited distance**
- **Slippage rates can be high if parts are worn**

# SELECTING AN APPROPRIATE MIXER TYPE

| | STATIC MIXER | DYNAMIC MIXER |
|---|---|---|
| Perfect mix from start of application needed | ✗ | ✓ |
| High viscosity resin mixing with low viscosity hardener | ✗ | ✓ |
| Mixing ARALDITE® adhesive core range | ✓ | ✓ |
| Low investment | ✓ | ✗ |
| Dispensing from cartridges | ✓ | ✗ |

## Factors to consider when selecting a mixer type include the following:

- Viscosity / rheologial behavior of the adhesive
- Application type (manual cartridge or dispensing machine)
- Output rate
- Pumping pressure
- Portability
- Cleaning

4.3 MIXER TYPES

# STATIC MIXERS FOR LIGHT WEIGHT AND SIMPLICITY

Two-component reactive adhesives require the components to be thoroughly mixed in order to achieve their full final properties.

Cartridges and dispensing machines are therefore usually equipped with a mixer.

**A static mixer is composed of a series of spiral or square elements aligned in a tube.**

As the two adhesive components are pumped together past each element, they are separated, creating layers. The number of layers doubles as it passes each element, meaning that 20 elements in series creates more than 1 million layers. This process effectively creates a homogenous mix of the two components.

Static mixers are generally disposable, meaning that they are lightweight, maintenance free and require no cleaning between applications. They are available in a range of sizes and can be mounted on either manual cartridges or on automated dispensing machines. Static mixers work well with low-to-medium viscosity products but may not achieve a sufficiently homogenous mix if i) the viscosity of the different adhesive components is very different, or ii) the viscosity is very high or the components are strongly thixotropic.

Static mixers tend to create a back pressure as the flow of material is constricted through them. This can lead to very high pumping pressures or low output rates, particularly if the viscosity of the adhesive is high.

### ADVANTAGES

- **Suitable for cartridges and meter-mix equipment**
- **Very simple, reliable operation**
- **No cleaning required**
- **Inexpensive**

### DISADVANTAGES

- **Low output with high-viscosity products**
- **Can create high back-pressure on metering pumps**
- **May not mix all product types**

4.3 MIXER TYPES

# DYNAMIC MIXERS FOR HARD-TO-MIX PRODUCTS

**A dynamic mixer is generally composed of a shaped (often spiral) rotor which is turned inside a tube or chamber mounted on a mixing head.**

The two adhesive components are pumped through holes at the inlet and become mixed as the rotor turns. The rotor must be independently driven (e.g. electrically or pneumatically), meaning that it is not suited to manual cartridge application and that the mixing head is heavier and less portable than a static mixer.

Dynamic mixers can overcome some of the limitations of static mixers, as they will effectively mix components of very different viscosities or materials with very high viscosity.

Dynamic mixers normally require a cleaning operation between applications, such as solvent flushing or disassembly and cleaning. Dynamic mixers create low back-pressure so can be used with lower pressure pumps or to achieve high output rates.

Some automated dispensing machines use a combination of dynamic and static mixer to optimize mix quality versus the size of the mixing head.


### ADVANTAGES

- **Can mix high-viscosity or highly thixotropic products**
- **Create low back pressure for metering machines**

### DISADVANTAGES

- **Only suitable for meter-mix equipment**
- **Increased size of mixer makes them les portable**
- **Cleaning / flushing necessary between applications**
- **Higher cost than static mixers**

4.4 CHEMICAL COMPATIBILITY

# CONSIDER THE CHEMICAL TYPE

| MACHINE PARTS | EPOXY RESIN | EPOXY HARDENER | MMA/ ACRYLATE ADHESIVES |
|---|---|---|---|
| **ELASTOMERIC MACHINE SEALS (O-ring seals, seals for follower plates…)** | | | |
| EPDM (ethylene propylene diene monomer rubber) | ✔ | ✔ | ✔ |
| FKM (fluorocarbon elastomer) | O-ring seals only | | |
| **METAL MACHINE PARTS (pipes, connectors, pumps…)** | | | |
| Stainless steel grades AISI 304 / ISO 1.4301 | ✔ | ✔ | ✔ |
| Stainless steel grades AISI 316 / ISO 1.4401 | ✔ | ✔ | ✔ |
| Aluminium (all grades) | ✔ | ✖ | ✔ |
| Steel (all grades) | ✔ | ✖ | ✖ |

When choosing dispensing equipment, it is important to consider the chemical compatibility of the adhesive with the different parts of the machine.

- For manual cartridges, chemical compatibility of the adhesive components and the cartridge materials is checked by the adhesive manufacturer.
- For automated dispensing machines, it is important to consider the chemical compatibility of the adhesive with metal parts and the elastomeric machine seals. Failure to do so can result in degradation of the dispensing machine or modification of the adhesive's properties.

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At Huntsman Advanced Materials, we make things possible. Serving many of the world's leading businesses across virtually every industry, we enable greater innovation, performance and sustainability to address global engineering challenges and contribute towards a better quality of life.

Our capabilities in high-performance adhesives and composites, delivered by more than 1600 associates, support over 2000 global customers with innovative, tailor-made solutions and more than 1500 pioneering epoxy, acrylic, phenolic and polyurethane-based polymer products.

## We operate synthesis, formulating and production facilities around the world


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