Pocket guide on dispensing technique

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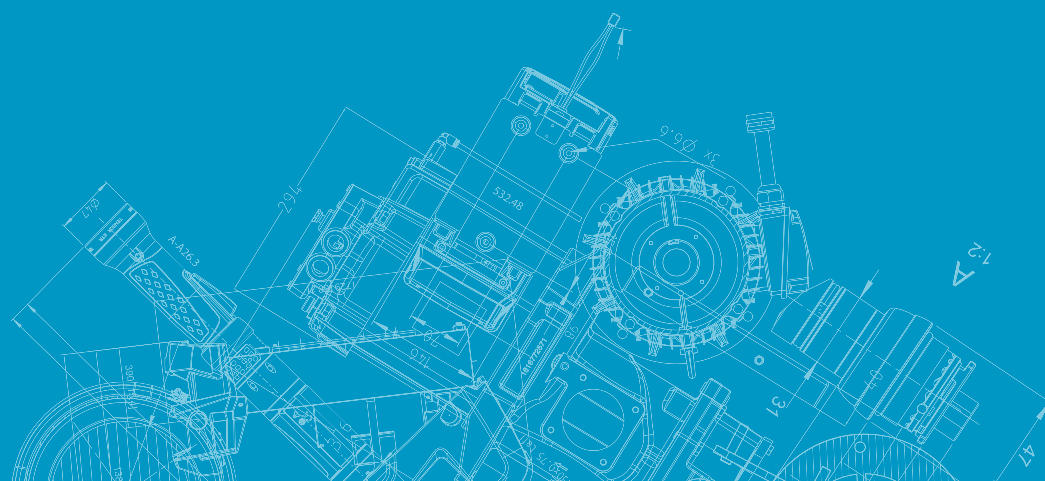


1. Introduction

The Atlas Copco pocket guide is a basic learning tool designed to help the reader gain an overall knowledge of bonding processes. Having laid the foundations with our first pocket guide, Adhesive Bonding, in our second guide, Dispensing Technique, we address dispensing of adhesives and sealants. This is our core business and comprises a major block of information in the knowledge build-up process.

Adhesives increasingly used for assembly

Many companies in different industries are turning to adhesive bonding processes and technologies for their assembly operations. With the SCA product line, Atlas Copco offers high-quality dispensing systems.

Dispensing techniques for supplying and metering the adhesives include manual applicators, automated application units with robots, and special systems. These techniques are available for almost any kind of adhesive material from low to high viscosity. The dispensing technique is selected according to the assembly process and the adhesive material specified.

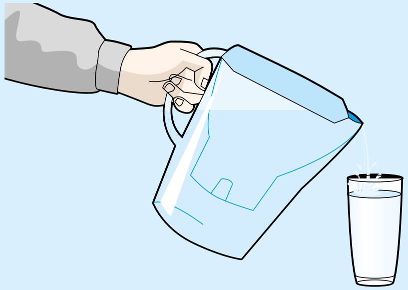
The Atlas Copco pocket guide on dispensing technique explains and compares the different techniques and discusses their areas of application.

2. Dispensing technique

2.1 Terminology and definitions

Dispenser

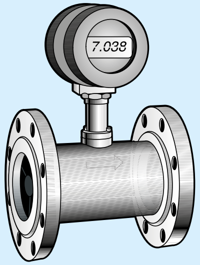
The word dispense comes from the old French word “dispenser” meaning “give out”. To dispense is to give or deal out something, especially in a specific portion or amount.



Controller

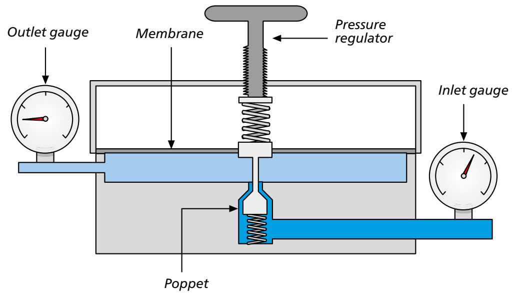
A device which monitors and physically alters the operating conditions of a given dynamical system. Historically a controller employs mechanical, hydraulic, pneumatic or electronic techniques, often in combination. In the last couple of years microprocessors and computers took over. Typical applications of controllers are to maintain settings for temperature, pressure, flow or speed.

A common example is a flow meter, which needs a controller to control the flow. This can be adjusted dynamically to different parameters to maintain the desired flow.



Regulator

A subsystem or independent device that determines and maintains the operating parameters of a system, usually within certain prescribed or preset limits. A common example is the pressure regulator, which enables a system to maintain constantly the pressure to which it is adjusted.



Simple adjustable pressure regulator.

Purging

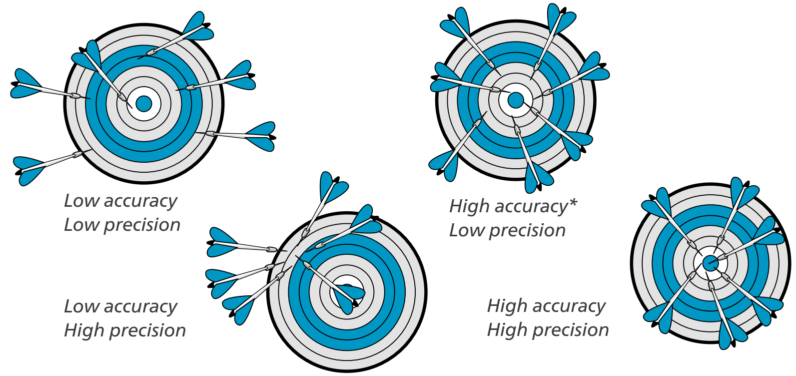
To clear off, or eliminate, unwanted physical matter from an unclear container or space, i.e., to purge the air from a water pipe or to purge the air from within a dispensing system. A good example is purging to eliminate air bubbles, which may enter the dispensing system while changing material containers. Removing air from the dispensing system is very important to ensure quality in dispensing applications. To purge a two-component system also helps to avoide premature curing.

Meter

A device that measures and records the quantity, degree, or rate of something that is used. An example is the meter in a taxi that measures the distance traveled or the amount of time spent traveling and shows the fare to be paid. A dispensing meter in combination with a controller may measure and control the volume, flow and pressure used in applying adhesive material.

Accuracy vs. precision

When talking about the capability of dispensing technique to enhance process quality, the terms accuracy and precision are often used. Although many people think they are the same, this is actually not the case. Accuracy is how close a measured value is to the actual intended value. Precision is how close the measured values are to each other.



** this scenario is only possible depending on the target limits!!*

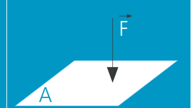
Pressure

Pressure is the amount of force applied perpendicular to the surface of an object per unit area. Various units can be used, but the International System of Units (SI) has the following standard:

Pressure

$P = \frac{F}{A}$

P = pressure
F = normal force in [N] Newton
A = area of the surface in contact in square meters m^2



Pressure
Common symbols: *p, P*
SI Unit: Pascal (Pa)
In SI base units: 1 N/m^2 or 1 $kg/(m \cdot s^2)$
Derivations from other quantities: $p = F / A$

Viscosity

Viscosity is the resistance of a substance to flow. It is related to the concept of shear force and can be understood as the effect of different layers of the fluid exerting shearing force on each other, or on other surfaces, as they move against each other. From an adhesive bonding perspective, viscosity is important due to its influence on the quality of an application bead.

$\mu = v \cdot \rho$
μ = dynamic viscosity
v = kinematic viscosity
ρ = density

1 Pas = 1 Ns/m² = 1 kg/ms
1 mPas = 0.001 Ns/m²
1 mPas = 0.01 Poise (P)
1 Poise = 0.1 Pas

Viscosity range	
[mPas]	**Fluid classification**
10 – 100	*Thin/liquid*
100 – 1 000	*Medium viscosity*
1 000 – 3 000	*Medium viscosity*
3 000 – 15 000	*High viscosity*
>15 000	*High viscosity to pasty*

Domestic examples

Viscosity	
[mPas]	**Material**
1	*Water*
2	*Milk*
100	*Olive oil*
1 000	*Yoghurt*
3 000	*Gear oil*
10 000	*Jam*
10 000	*Honey*
30 000	*Ketchup*
70 000	*Mustard*
140 000	*Toothpaste*
200 000	*Mayonnaise*

Adhesive & sealant example

Viscosity	
[mPas]	**Material**
1-10	*Activator*
1-10	*Isopropanol*
1-100	*Polyol*
1-150	*Isocyanate*
10 000 – 35 000	*PVC*
30 000 – 60 000	*Watery acrylate*
35 000 – 100 000	*Epoxy*
35 000 – 100 000	*Hot epoxy*
80 000 – 200 000	*Butyl*
50 000 – 200 000	*Rubber*

All examples measured under 25°C with Brooksfield method.

A measuring cup can be used to measure volumes of liquids. This cup measures volume in units of cups, fluid ounces and milliliters.

Volume

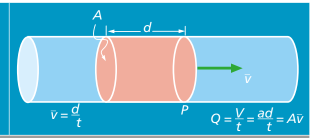
Volume is the amount of three-dimensional space enclosed by a certain boundary; for example, the space that a substance (solid, liquid, gas) or shape occupies or contains. It is possible to calculate volume using different formulae, depending on the shape of an object or room.

Volume of V =		
Cube	a^3	a = length of any side or edge
Cylinder	$\pi r^2 h$	r = radius of circular face, h = height
Prism	$B \cdot h$	B = areas of the base, h = height
Rectangular prism	$l \cdot w \cdot h$	l = length, w = width, h = height

Volume flow

In physics and engineering, particularly in the area of fluid dynamics and hydrometry, the volumetric flow rate is the volume of fluid which passes per unit time. It is represented by the symbol Q. The SI unit is m³/s (cubic meters per second).

Flow
$Q = v \cdot a$
v = flow velocity of the substance elements
A = cross-sectional vector area/surface



Volume flow rate
Common symbols: *V, Q*
SI unit: m^3/s

Density

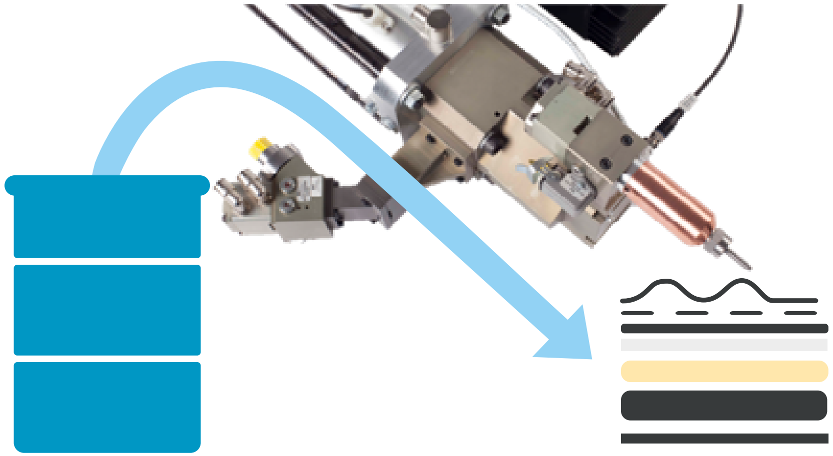
The density or volumetric mass density of a substance is its mass per unit volume. This varies with temperature and pressure. The variation is typically small for solids and liquids but much greater for gases. Increasing the pressure on an object decreases its volume and thus its density.

Density		**Density**
$\rho = \frac{m}{V}$	ρ = density m = mass V = volume	Common symbols: ρ, D SI Unit: kg/m³

A. Vegetable oil, B. Water, C. Corn syrup

2.2 What is dispensing technique?

Dispensing technique is a complex and highly relevant part of the adhesive bonding process where fluid is dispensed in an accurate and controlled manner. When we talk about dispensing technique, we are referring to the application of the adequate amount of liquid adhesives or sealants onto a specific substrate – at the right time, in the right place and in the most efficient bead shape and size.



2.3 Where is it applicable?

Nowadays accurate and precise dispensing techniques are becoming increasingly important in a wide range of industries. They are used for dispensing food products, biomedical products, encapsulants in the semi-conductor industries, and adhesives and sealants in the automotive, general manufacturing and other industries. The dispensing techniques and their areas of use vary according to the needs of these industries and their processes.

2.4 When and why is dispensing technique important?

Dispensing technique plays a major role when a pre-specified volume of adhesive material or sealant has to be applied on a certain substrate. It is important for a variety of reasons, such as to achieve higher bonding quality, lower cycle times, improved accuracy and lower material consumption. The main purpose is to try to minimize the risk of product failures and injuries to the end-user. Another purpose is to save the customers time and money.

Why dispensing technique?	Reasons for using dispensing technique		
	Structural and elastic bonding	Sealing	Insulating
Risks that can possibly be avoided by using dispensing technique.	Damage of safety critical parts or final product, which may lead to life-threatening risks for end-user.	Damage of parts or final product due to any kind of leakage in parts or final product.	Damage of parts or final product due to unintentional subjection to heat, sound or electricity.
Examples	Injured end-user through accident due to insufficient structural/ elastic bonding in safety critical parts.	Car breakdown due to engine oil leakage. Humidity issues inside the car due to water leakage through car windshield.	Overheating of nearby car engine parts. Noise peaks inside the car. Corrosion of crucial metallic parts.

2.5 Why can dispensing technique be challenging?

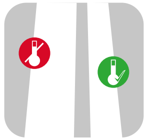
Nearly every process requires a different dispensing technique; it is true to say that there is no system that offers the required dispensing characteristics in an all-in-one solution.

Since it is not a theoretically well-established science, challenges may occur when dispensing. This is due to the rheological complexity of fluids and adhesives, which can be difficult to study and describe in order to fully understand the behaviors of the materials to be dispensed. Insights into the characteristics of materials when static and their characteristics during dispensing are often only acquired through experiments based on trial and error.

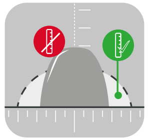
2.5.1 Common challenges

Detection of air bubbles
Avoid corrosion in sealing applications

Volume control
Ensure that structural bonding withstands loads and stresses



Temperature management
Avoid summer and winter material batches



Bead shape
Avoid unnecessary rework and scrapping

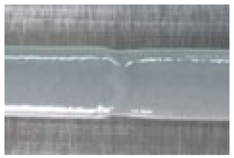
Bead position
Avoid rework and ensure process quality

2.5.2 Air bubble detection

One of the biggest challenges is to detect air in the system or air bubbles in the material application. This can cause serious quality problems in the long-term as it is usually not visible to the eye.

This problems can be classified in four classes:

Class 1	Class 2	Class 3	Class 4
a. Connected bead b. Surface completely covered c. Error hardly recognizable	a. Connected bead b. Surface completely covered c. Error relatively easy to recognize	a. Weakly connected bead b. Surface no longer completely covered c. Error easy to recognize	a. Completely unconnected bead b. Great loss of surface coverage c. Error obviously recognizable




There are different types of equipment and methods available to detect air in the system.

2.5.3 Process challenges

A dispensing system is usually a sub-process of a complete production process. Therefore the industry and the customer are exposed to process challenges in addition to the usual dispensing ones. Here we take a closer look at the challenges which may occur before or after the dispensing process.

Pre-process challenges

- **Correct material choice**
  To achieve the ideal dispensing process for the application, the correct choice of adhesive material is crucial.
- **Correct substrate surface treatment**
  The surface treatment must match the material adhesion requirements, otherwise this may negatively impact the quality of the application.
- **Precise substrate positioning**
  The wrong placing of the substrate may influence the bead positioning.

Post-process challenges

- **Correct curing time**
  The curing time of the adhesive material may be adapted according to the overall process, thus avoiding waiting time for curing.
- **Handling of substrate**
  The substrate should be handled carefully after the adhesive material has been dispensed onto it to allow for curing time.

2.6 Key benefits of dispensing technique

Quality

- **Higher accuracy and precision**
  With optimized dispensing, exact application of the adhesive or sealant can be achieved, which enhances overall quality.
- **Higher process repeatability and reliability**
  The efficient process control provided by a dispensing system contributes to higher repeatability and reliability of the overall process.
- **Reduced defects**
  With efficient process control the required bead size and shape may be reached more easily, avoiding adhesion and cohesion failures.

Productivity

- **Reduced cycle times**
  The efficient process control offered by a dispensing system enables shorter cycle times. The reduction may happen at different levels depending on the degree of automation.
- **Minimized rework**
  In certain cases improved application quality can minimize rework.
- **Lower material consumption and waste**
  As a result of higher accuracy material waste can be reduced and costs are therefore minimized.

2.7 Standards

DIN 2304 – Adhesive bonding technology – Quality requirements for adhesive bonding processes

Consisting of three parts, this standard regulates the general adhesive bonding processes regardless of the industry.

The standard series specifies the requirements for quality-oriented design of bonded joints along the process chain of bonding, from development to production and maintenance.

The DIN 2304 consists of the following three core concepts:

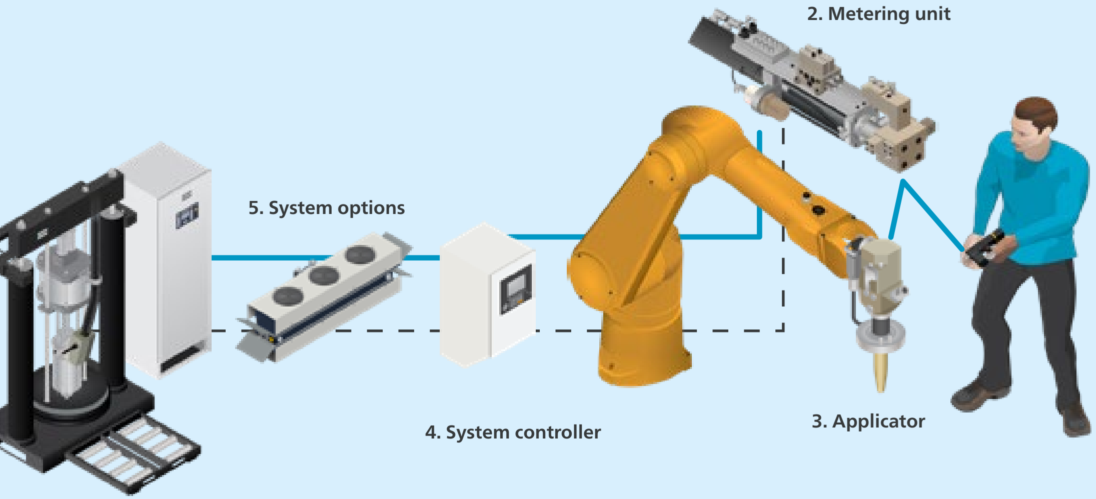
1. Classification of bonded joints in accordance with safety requirements
2. Appointment of supervisors in charge of adhesive bonding work
3. Verification: Actual load < load limit of bonded joint

In addition to the DIN 2304, there is another standard reagarding adhesive bonding, the DIN 6701 which regulates the use of adhesive bonding in the manufacturing of rail vehicles and parts of rail vehicles. This is a comprehensive set of regulations for quality assurance in adhesive bonding technology that will make its use safer and more reliable in the rail vehicle sector.

The classification of the adhesive bond is given by the responsible engineer with regard to the potential impact of its failure in the following safety classes:

Safety classes	Definition of safety requirements
S1	**High safety requirements** The failure of the adhesive bond can lead, directly or indirectly, to: - inevitable risk of personal injury or loss of life - loss of functionality, which is very likely to lead to inevitable risk of personal injury or loss of life
S2	**Medium safety requirements** The failure of the adhesive bond can lead to: - possible risk of personal injury or loss of life - loss of functionality, which is likely to lead to personal injury or major environmental damage - loss of functionality, which is very likely to lead to inevitable risk of financial losses
S3	**Low safety requirements** The failure of the adhesive bond can lead to: - loss of functionality, which is unlikely to lead to personal injury or major environmental damage - loss of functionality, which is primarily linked to degradation of comfort or performance - loss of functionality, which is very likely to lead to inevitable risk of high financial losses
S4	**No safety requirements** The failure of the adhesive bond can lead to: - loss of functionality, which is unlikely under foreseeable conditions to lead to personal injury or major environmental damage - loss of functionality, which is exclusively linked to degradation of comfort or performance - loss of functionality, which does not lead to inevitable risk of high financial losses

3. The dispensing system



Possible dispensing system configuration, using Atlas Copco products.

Five main subsystems

A fully equipped dispensing system may consist of five main subsystems as shown above. These should be flexible enough to accommodate materials of different viscosity ranges while being easily serviceable to minimize downtime.

The entire dispensing system or one of its subsystems can be heated (or not), depending on the dispensed material, its viscosity and on the environmental conditions at the system’s location.

The configuration of the dispensing system will vary depending on performance, safety and quality requirements. The investment will vary accordingly.

3.1 Subsystem components

1. Material supply	*Material containers*	*Displacement pumps*	*Material hoses*	*Control cabinets*
2. Metering unit	*Pressure regulator*	*Gear meter*	*Flow meter*	*Piston meter*
3. Applicator	*Applicators*	*Nozzles*		
4. System controller	*Visualization*	*User interface (HMI)*		
5. System options	*Visual inspection*	*Temperature management*	*Manipulator*	*Tool change station*

3.2 Functional overview of subsystems

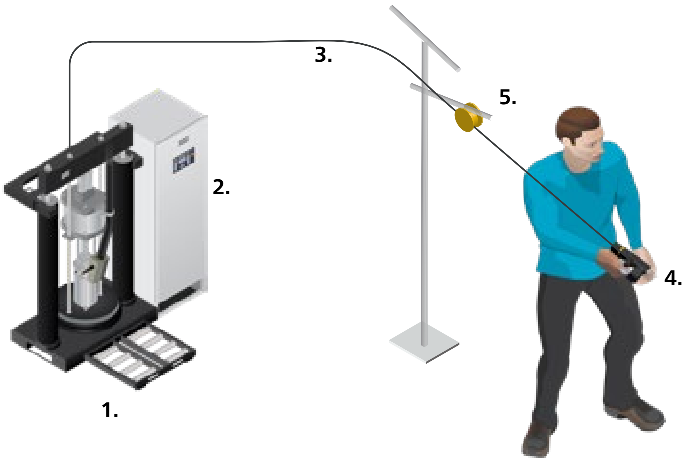
1. Material supply	Conveys the material to be dispensed from the material container throughout the whole system.
2. Metering unit	Meters the exact amount of material dispensed according to the controller pre-settings.
3. Applicator	Achieves the required functional bead shape in the most efficient way according to the needs of the application.
4. System controller	Communicates with all the subsystems to maintain control of the installed parameters and achieves the ideal application of the material in the right bead shape, quality and time.
5. System options	These enhance the system's capabilities in terms of quality, ergonomics and productivity.

3.3 Examples of dispensing system configurations

Depending on the needs of the application and customer a simpler solution may be chosen. This could be a manual station with a lower investment but complete enough to meet the specified needs. Below is a manual station configuration used in several industries.

Manual station

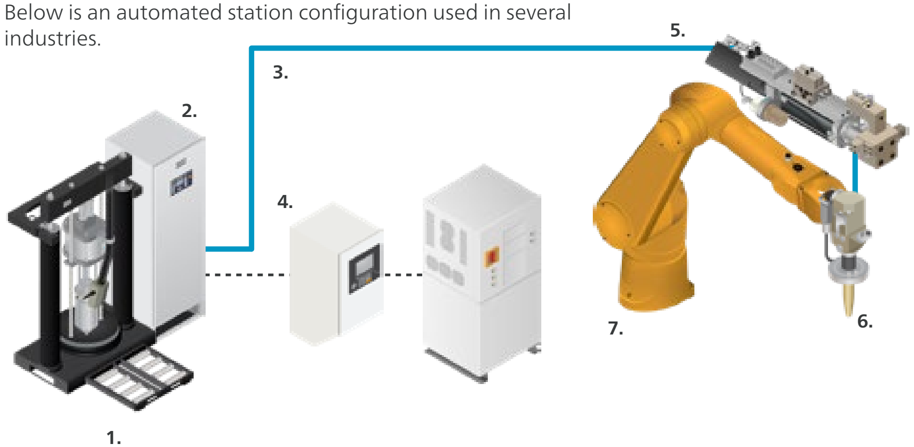
1 Pump / material supply
2 Pump control cabinet
3 Hoses
4 Handheld applicator
5 Balancer (optional)



Possible configuration of a manual solution using Atlas Copco products.

If the customer places high demands on quality and productivity an automated solution may be the best choice. Automated dispensing systems tend to require a higher initial investment but, at the same time, they offer a lower total cost of ownership.

Below is an automated station configuration used in several industries.



Possible configuration of an automated solution using Atlas Copco products.

Automated station

1 Pump / material supply
2 Pump control cabinet
3 Hoses
4 System controller
5 Meter
6 Applicator
7 Robot incl. controller

When comparing an automated dispensing system with a manual solution, there are a number of advantages and disadvantages to take into account. Below is a simple comparison showing the pros and cons of these two solutions:

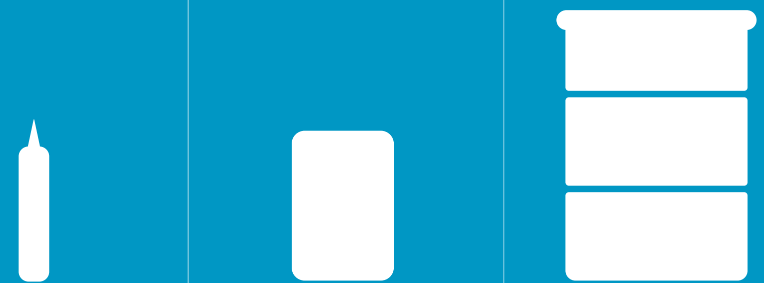
Manual dispensing system	Automated dispensing system
+ lower initial investment	+ shorter cycle times
+ higher flexibility regarding guidance of application	+ higher application quality (accuracy)
+ possible to adapt to an automated solution	+ higher process reliability and repeatability
– Operator dependency: • lower process repeatability and quality control • exposure to ergonomic issues	+ higher availability (equipment)
– longer cycle times	+ lower labor costs
	+ not operator dependent
	– higher initial investment
	– longer on-site commissioning
	lower total cost of ownership

4. Material supply subsystem

In a dispensing system the first main subsystem is the material supply. In this system adhesive or sealing material will be conveyed under pressure by a displacement pump from a material container to the meter or straight to the applicator.

This subsystem consists of material containers (i.e., barrels, cartridges, cans, etc.), displacement pumps, material hoses and material supply control cabinets. The configuration varies according to the application volume and the degree of automation of the dispensing system.

4.1 Typical material containers



Cartridge	Metal can	Barrel
310 ml – 1 l	5 l	20 – 1 000 l
Mostly used in manual stations and for material testing	Mostly used in manual stations and for material testing	Mostly used in automated stations, but also found in manual stations depending on application and production volume
Recommended for low volume application or low production volume, due to higher costs	Recommended for low volume application or low production volume, due to higher costs	Recommended for high volume application and high production volume

4.2 Material supply units

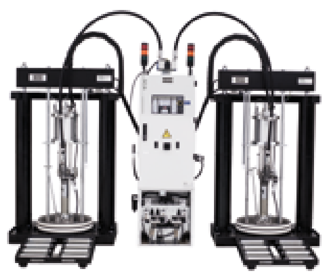
The material supply unit is the material conveyor in the material supply subsystem. These units vary according to application type and size.

Compact material supply

Heated and unheated, cartridge

Heated and unheated, barrel

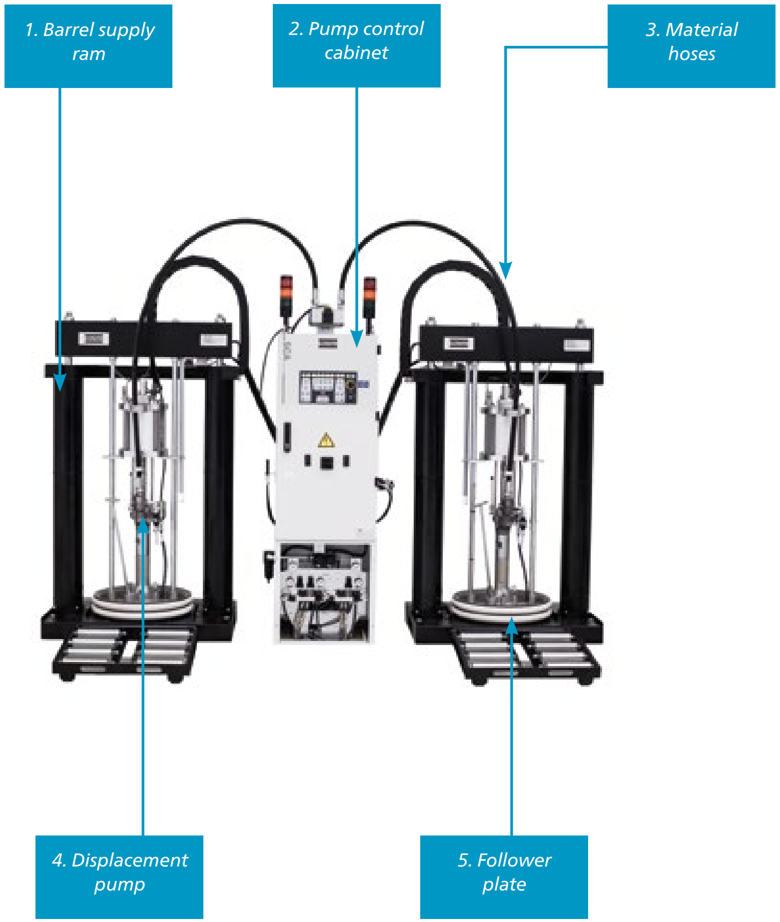
Barrel material supply unit

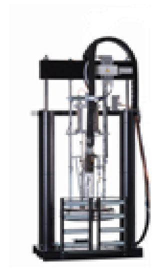


Heated and unheated, double

Heated and unheated, single

4.3 Typical fully equipped material supply subsystem





1. Barrel supply ram
Structure in which material supply components are assembled. This also assists in introducing the follower plate and the displacement pump to the barrel
- The rams can be either pneumatically or hydraulically driven
- Different sizes according to barrel sizes

2. Pump control cabinet
Controller, required for operation of the pumps and changing barrels
Typical functions are:
- Stroke monitoring
- Pump off when the barrel is empty
- Automatic mode for changing to the second barrel when the first barrel is empty

3. Material hoses
Key component of material supply unit where high pressure is created to convey material
- Available in different sizes, lengths, designs and material, depending on technical requirements
- Ballooning effect* is a common challenge which has to be considered when choosing a hose

4. Displacement pump
Key component of material supply unit where high pressure is created to convey material from the barrel to the dispensing system
- Different sizes for different material consumption needs

5. Follower plate
Main function is to seal the barrel and follow the material inside the barrel
- There are standard diameters for different barrel sizes: 20 L, 50 L, 200 L, 1 000 L
- Optimized follower plates are designed to reduce material remaining inside the barrel, allowing:
  - Cost savings
  - Elimination of material waste
  - Reduced disposal costs
  - Less environmental impact

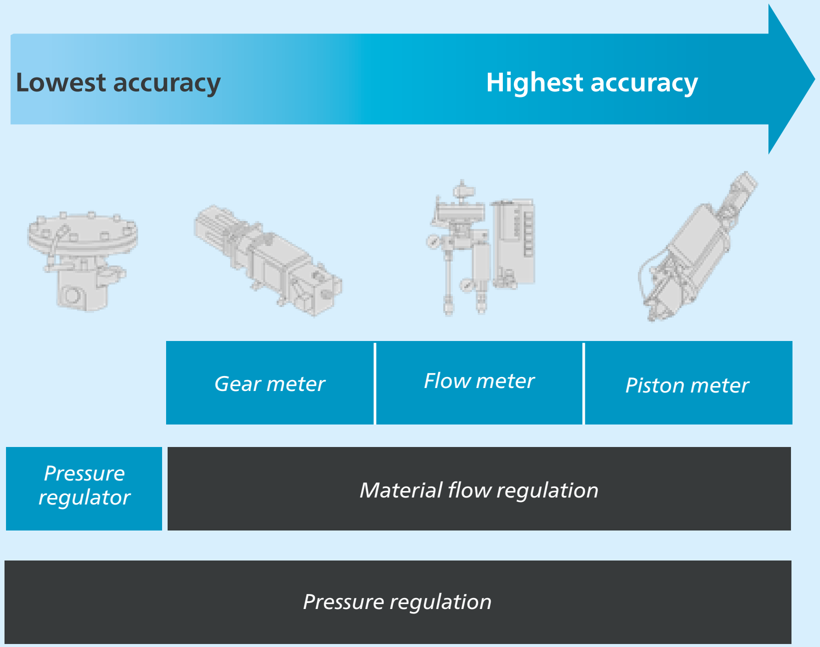
* Ballooning refers to expansion of the material hose due to high material pressure, which could lead to quality issues during material application. A known issue is that when ballooning occurs, the system gives a higher initial application volume than has been pre-set.

5. Metering subsystems

Over the years, many metering systems have been developed for dispensing low and high viscosity material to meet the different customer needs. These systems have specific advantages and limitations which characterize their designs. Some offer flexibility and speed over precision and accuracy while others offer micro-precision and accuracy at the expense of speed and flexibility.

Due to its higher repeatability and accuracy, the piston meter is one of the most common used metering systems, at least in the automotive industry.

Looking at the industry in general, there are many types of metering systems in use. Atlas Copco classifies them according to their accuracy and methods of regulation related to their different operating principles.



5.1 Pressure regulator

Pressure regulators are the simplest way of metering and dispensing material. Using pressure from the pump system they maintain the pre-set pressure and thus offer a continuous flow of material throughout the application.

This type of meter is mainly used for simple, continuous applications. The selection of such a metering system is based on material viscosity and required meter filling pressure. Regulators of this type offer pressure accuracy across the entire range from 25 to 300 bar, thanks to the linear flow characteristics for high and low flow levels.

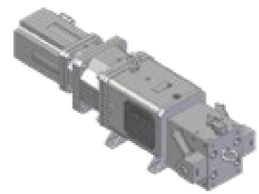
Manual systems

Here the pressure regulator is located between the material supply system and the applicator. This smooths out the effect of pressure peaks from the displacement pump and results in a consistent application pattern.

Automated systems

The pressure regulator is usually located between the material supply system and the next level of metering. This allows a consistent filling pressure to be maintained and reduces stress on the sealings of the metering device.

5.2 Gear meter



Gear meters are the next level of metering after pressure regulators. They also offer a continuous flow throughout the application of the material by maintaining either the pressure or the flow at a constant preset level.

Gear meters employ rotating gears which transport the dispensing material at the desired pressure or flow rate. They are particularly suitable for continuous dispensing of either high or very low viscosity materials without abrasive properties or vulnerability to shearing.

Gear meters are commonly used for continuous metering of PU, silicones or butyl. They are usually found in processes where the accuracy of an electric tandem meter is not required.

Micro gear ring meters

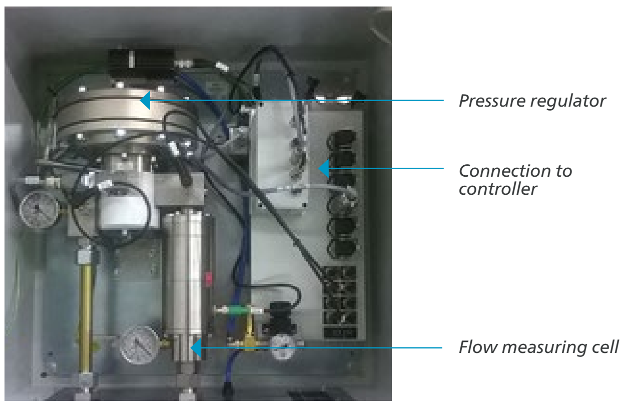
For metering very low viscosity materials, such as activator and primer fluids, micro gear ring meters are available which enable highly accurate dispensing of low volumes. This kind of meter is electrically driven.

5.3 Flow meter

In general flow meters are instruments for measuring, monitoring or recording the flow rate, pressure, or discharge of liquids or gases. Functioning together with a controller and pressure regulator, the flow meter represents the next level of metering.

Flow meters are an excellent choice for continuous metering of low viscosity, single component materials such as PVC in sealing applications. They provide accurate metering by constantly regulating the volume flow, independent of viscosity or temperature effects. This type of meter must be controlled by a dispensing system controller to ensure its functionality.

The illustration below shows a flow meter in an automated system.



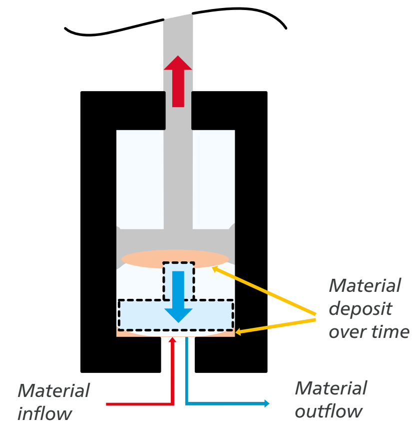
5.4 Piston meter

Piston meters are the most accurate way of metering and dispensing the material and achieving the desired application characteristics. They have a fixed volume material chamber which is emptied by a piston, thus providing defined volumetric dispensing. The application volume is defined depending on the working principle of the piston meter.

They are available in different materials and heating variants to cover a wide range of applications. The various working principles, variations and types of piston meters can be described as follows:

LIFO

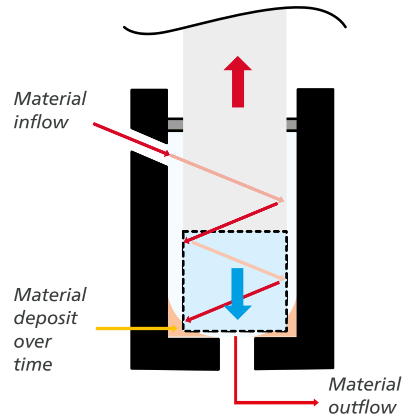
Last-in, First-out
Available in all meters



Used when large material volumes are dispensed and the meter is fully emptied in the process.

FIFO

First-in, First-out
Available only in electric meters



Commonly used for materials with a short pot time and when only a fraction of the total meter volume is dispensed at a time.

Piston meter variations

Piston meters vary according to the requirements of the overall production process and the final application. Below are the most common variations:

Single-component (1C)

Single-component materials such as silicone sealants, UV curable acrylates, urethanes and epoxies, are primarily chosen for their ease of use, but the curing process is long unless energy is used.

Tandem

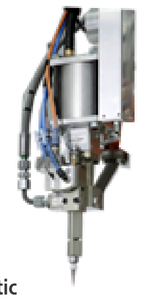
In some applications, it is necessary to process large quantities of sealing and insulating material with high precision. In order to avoid cycle interruption during filling, tandem units are used. The tandem metering unit consists of two single metering units. An Intelligent swap logic ensures that material is applied in a constant flow.

Two-components (2C)

Typically selected for their fast-curing characteristics, two-component materials require meter, mix and dispense machines. Atlas Copco provides fully automated dispensing machines that are integrated with production lines or robots.

Types of piston meters and their differences

The piston or displacer can be driven pneumatically, hydraulically or electrically, enabling dispensing regardless of material viscosity. The pros and cons of these three types are shown below:



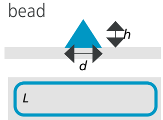
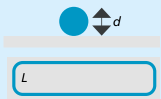
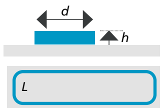
Pneumatic		Hydraulic		Electric	
+	Reliable under different conditions	+	High pressures (up to 400 bar)	+	Accurate
+	Lower initial costs	+	Fast filling time	+	Reliable
–	Lower pressures	+	Lower initial costs	+	Simple installation
–	Lower accuracy	–	Hydraulic oil	+	Cleaner and quieter environment
–	Size and weight	–	Higher installation costs	+	High pressures (up to 300 bar)
–	Higher running costs	–	Higher maintenance costs	+	Lower running costs
				–	Initial investment

The volumes of Atlas Copco standard meters are 10, 20, 30, 60, 80, 160, 400, 700, and 2 100 cm^3. In the following it will be shown how to choose the shot meter volume size according to the customer's application, taking a glazing application* and two others as examples.

**A glazing application is the application of adhesive material, usually polyurethane, for bonding, sealing and insulating windscreens in different types of vehicles.*

How do I choose the right piston meter?

In the case of an glazing application for car windscreens, we usually talk about a triangular shaped application. For powertrain we speak about round bead application and for seam sealing we talk about flatstream application. Typical examples of these applications and their measurements are shown below:

Typical applications	Bead profile	Typical measures	Volume formula	Real bead volume	Piston meter recommendation
Glazing	Triangular shaped bead 	h = 12 mm d = 8 mm L = 5 200 mm	$V=(h \cdot d)/2 \cdot L$	$V=(12 \cdot 8)/2 \cdot$ 5 200=2 496 000 mm³ =249.6 cm³	400 cm³
Liquid Gasket	Round bead 	D=3 mm L=2 000 mm	$V= \pi \cdot (D/2)^2 \cdot L$	V=p.(3 mm/2)². 2 000 mm=141 400 mm³ =14.14 cm³	20 cm³
Seam sealing	Flatstream bead 	h=2.5 mm d=18 mm L=12 000 mm	$V=h \cdot d \cdot L$	$V=2.5 \cdot 18 \cdot 12\,000=$ 540 000 mm³ =540 cm³	80/160 cm³ tandem piston meter

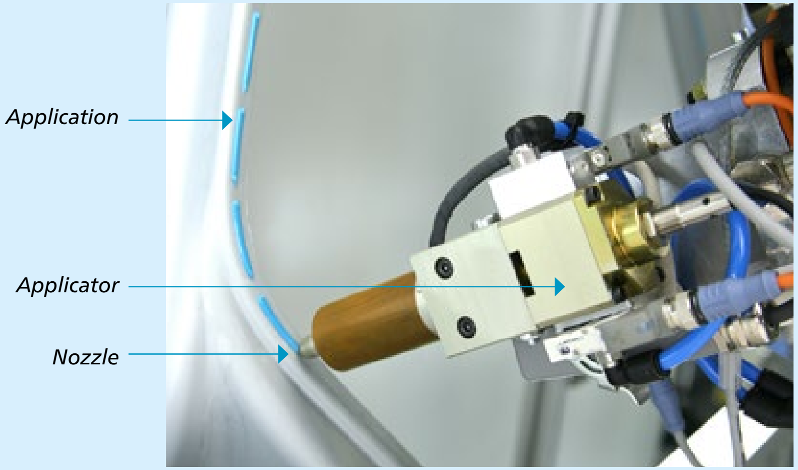
** L Equals the whole bead length*

Due to safety factors we consider using piston meters only up to 80-90% of their possible meter volume, which we call effective volume. Therefore a 400 cm³ piston meter would be the ideal choice in the glazing case. For the powertrain a 20 cm³ would be enough, and in the case of seam sealing the industry tends to use a continuous application technology due to the much higher material volume used. The most common choice in this case are the 80 cm³ and 160 cm³ tandem piston meters as they are still compact and not too big and heavy for the robots used.

The volume size of the meter may also be bigger if lower cycle times are required or if it is necessary to apply twice within a one meter filling cycle. Here the weight of bigger metering units must be taken into consideration since robots that are able to support these heavy meters may be more expensive (as in the seam sealing application). Also, if the meter is too heavy to mount on the robot, long hoses may be required, which may have a negative impact on accuracy.

6. Application subsystem

The application subsystem defines the results that can be expected from the entire dispensing system. Depending on the needs of the customer, it comprises a suitable applicator with a specific nozzle, which defines the application pattern. The applicator chosen may be handheld or automated. The nozzle is selected according to the pattern required in the production process.



6.1 Applicators

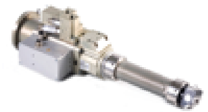
Handheld applicators

Bonder X

These are used in manual dispensing systems and are controlled by an operator pressing the trigger.

The industry offers a wide range of handheld applicators for many different applications depending on the needs of the customer. The main benefits are high accessibility and flexibility in the dispensing process. If required they can be heated and even used for two-component applications. A possible disadvantage is the operator dependency which may lead to lower accuracy and precision than an automated solution.

Automated applicators

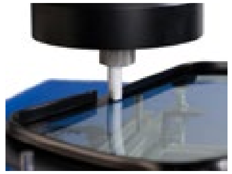


Used in automated dispensing systems, applicators of this type are controlled by the dispensing system controller which maintains the preset parameters for the application pattern.

There is a wide range of applicators available for use in automated processes; they are optimized for different flows and applications. What they normally have in common is a robust design for highest reliability and productivity.

6.2 Nozzles and their applications

Application processes

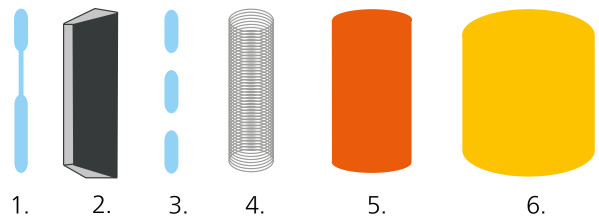


Material extrusion (low energetic)
- *Material is pressed out of a nozzle positioned close to the component*
- *Low energy*

Material streaming (high energetic)
- *Material is applied to the component from a distance using high pressure*
- *High energy*

Most common applications

Low energetic	High energetic
Round bead application	Stitch bead application
Shaped bead application	Swirl application
Stitch bead application	Flat stream application
	Airless application

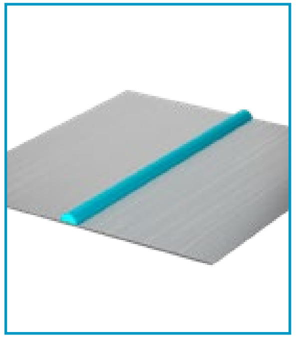


Application technologies
1. Round bead application
2. Shaped bead application
3. Stitch bead application
4. Swirl application
5. Flat stream application
6. Airless application

Round bead application

Nozzle

Application pattern



■ **Properties**
- Bead diameter can be influenced
- Pressure speed regulated

■ **Application**
- Housing / car body sealing
- Structural and constructive adhesive bonding

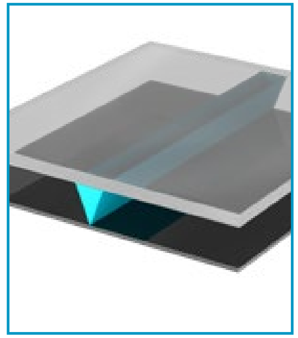
■ **Adhesives**
- 1C and 2C adhesives

■ **Processing**
- Bead diameter 1 mm - 8 mm
- Cold / hot (up to 160°C)
- Usual robot speed range (automated): 200 - 500 mm/s

Shaped bead application

Nozzle

Application pattern



■ **Properties**
- Defined bead geometry

■ **Application**
- Screen glazing

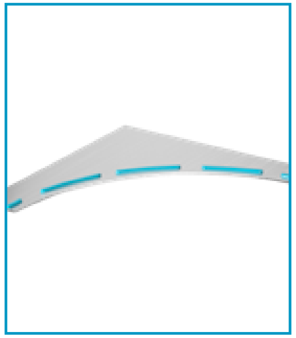
■ **Adhesives**
- PU (Polyurethane)

■ **Processing**
- Bead thickness: up to 2 mm
- Bead width: up to 200 mm, depending on application
- Usual robot speed range (automated): 300 mm/s

Stitch bead application

Nozzle

Application pattern



- **Properties**
- Consistent distances between beads (Can be influenced via controller)
- Jet stream application

- **Application**
- Structural & constructive adhesive bonding, usually used between welding spots
- Stiffness bonding

- **Adhesives**
- 1C and 2C adhesives
- EP - Epoxy adhesives

- **Processing**
- Bead diameter: 0.2 mm - 6 mm
- Temperature max. 60°C
- Usual robot speed range (automated): 200-500 mm/s

Swirl application: electric or air*

Nozzle

Application pattern

- **Properties**
- Consistent application of material
- Very good material distribution and fast adjusting
- Only limited layer thickness

- **Application**
- Hem flange
- Strength bonding for complex outlines

- **Adhesives**
- 1C Epoxy
- PVC

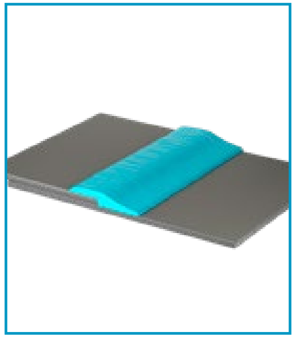
- **Processing**
- Application width: as requested
- Layer thickness 3 mm
- Usual robot speed range (automated): 200-600 mm/s

** The main difference between both swirl applications is that the material is swirled either electrically or with air. The electrically swirled application is usually chosen according to the material used, as the bead could get broken when it comes into contact with a "cold" airstream.*

Flat stream application

Nozzle

Application pattern



Properties
- Variable bead width, can be changed during application
- Suitable for large quantities of material

Application
- Seam sealing
- Application of anti-flutter material (SAM)
- Under Body Protection (UBS)

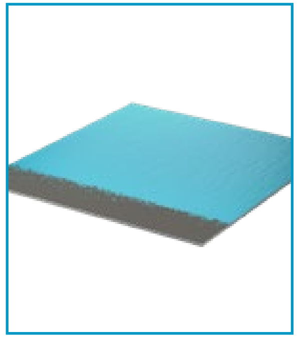
Adhesives
- PVC
- Rubber based materials
- Water-based acrylates

Processing
- Bead thickness: up to 2 mm
- Bead width: up to 200 mm, depending on application
- Usual robot speed range (automated): 300-600 mm/s

Airless application

Nozzle

Application pattern



Properties
- Application distance relatively high
- Wide coverage possible
- Uniform distribution even with thinner thickness
- Pressure regulated

Application
- Under Body Protection (UBS)
- Corrosion Protection

Adhesives
- PVC

Processing
- Layer thickness: up to 0.4 mm (UBS)
- Bead width 350 mm
- Usual robot speed range (automated): 300-600 mm/s

6.3 1C vs. 2C applications

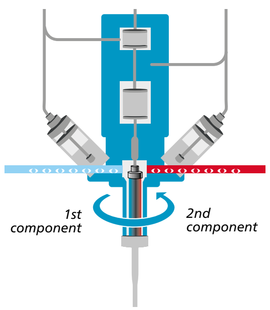
Static mixers

One-component applications

When we talk about dispensing a material without any specification, we usually mean a one-component application, often called a “1C” application. This is usually cured by air, heat or humidity. A one-component application is used when the material curing time matches the rate of productivity.

Two-component applications

For high productivity processes a two-component application, referred to as a “2C” application, is often required. A second component is mixed with the main component to achieve a faster curing time, and the end-product is thus bonded by the end of its production. The mixture of the two components usually occurs statically or dynamically. This kind of application can still be influenced by temperature variations.



Dynamic mixer

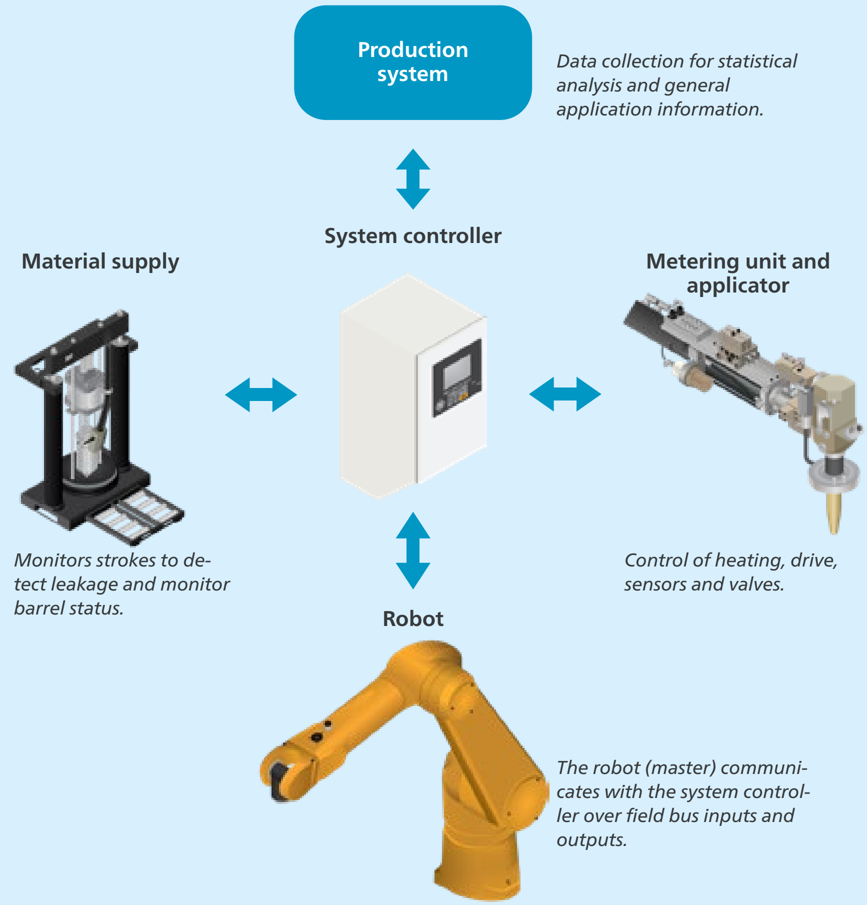
6.3.1 Static and dynamic mixers

To achieve the ideal mixing ratio in a “2C” application the material can be mixed by a static or a dynamic mixer, depending on the accuracy and precision required. If the viscosities of the components in a 2C material are low or very different, static mixing may not be optimal. By using 2C dynamic mixing technology the desired 2C properties are ensured. To achieve the desired result, elements and parameters must be chosen according to material and application.

Dynamic mixer

7. Dispensing system controller

The system controller is the brain of the overall dispensing system. The core is the software, which enables enhanced productivity with high quality. The central task of a dispensing system controller is to communicate with the main subsystems and with the overall production system as follows:



System controllers are mostly used in automated solutions, but are also seen in manual systems depending on the customer's process requirements. The industry usually offers controllers with a range of different features, functions and benefits.

Below is a list of a few of their possible functions along with their main benefits which help in achieving the best value for the customers:

Function	Benefit
Pressure/flow monitoring and regulation	Enables an array of different applications with different volumes using the same dispensing technique
Viscosity monitoring and regulation	Better system repeatability since ideal viscosity for a chosen application can be maintained while dispensing
In-system air bubble detection	Less rework due to bead interruptions caused by air bubbles. Automated purging sequence keeps process interruptions at a minimum.
System temperature management	Avoid premature curing in system and minimize waste
Recording of application statistics	Traceability of any previous application are used for determining service cycles
Programming of different dispensing programs depending on application	Quick access and flexible usage of dispensing system
Programming of parameter tables within dispensing programs	Enhanced application quality through precise application segment monitoring
Applied volume monitoring and deviation warning	Application quality assurance
Visualizing of system In and Out signals	Easy and early system error detection
In-time error and service warnings	Minimized production stops
Central system communication	Quick central system status overview
Hose ballooning effect compensation	Enhanced accuracy and precision of application

8. Dispensing system options

Dispensing system options are additions to the system that enhance quality by helping to overcome common bonding and process challenges. They are controlled by the system controller which communicates with the other subsystems and ensures all parameters are correctly maintained as programmed.

8.1 Visual inspection systems

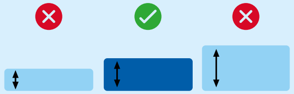
Monitoring of safety critical applications

The use of adhesive bonding is currently increasing in various industries, often in safety critical applications. Bonded joints can be classified as safety critical if failure of the bonding would pose a danger to the endconsumer of a specific product.

A visual inspection system can be used to monitor safety critical applications and meet the strictest quality standards without loss of productivity.

A typical visual system ensures that…

the bead width

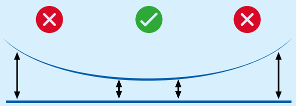


has the right geometry and width

the bead continuity

is continously applied

the bead position

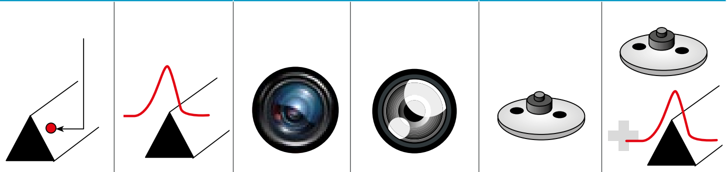


is in the right position

Sensors or cameras used

The type of visual system chosen varies according to the quality check required, which usually relates to the safety classification of the application. Depending on the requirements, the visual inspection system can make the quality checks with either sensors or cameras.

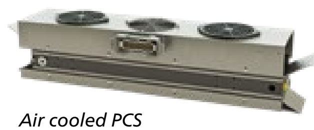
The different possibilities are shown below:



		Sensors		Camera		360° camera	
Type	In-process / inline	√	√	√	–	–	√
	Post-process / offline	–	–	√	√	–	–
Features	Sensor	Point	Profile	–	–	–	Profile
	Light	Laser	Laser	Pulsing LEDs	Pulsing LEDs	Pulsing LEDs	Pulsing LEDs
	No. of cameras	–	–	1	n	3	3
	Picture color	–	–	B/W	Color	B/W	B/W
	Camera reso-lution	–	–	Low	Low	High	High
	Easy start-up	★★★	★★★	★★	★★	★	★
	Ambient light resistance	★★★	★★★	★	★★	★★	★★★
	Easy reteach	★★	★★	★	★	★	★
Check capabilities	Width	–	√	√	√	√	√
	Continuity	√	√	–	–	√	√
	Position	–	–	√	√	√	√
	Height	√	–	–	–	–	√
Investment		$	$$	$$	$$$	$$$	$$$$

8.2 Temperature management

Temperature management may occur throughout the whole dispensing system by heating or not heating the system with the controller according to the material application requirements. However, to maintain a consistent temperature throughout the system, an option such as the Peltier Conditioning System may be used.



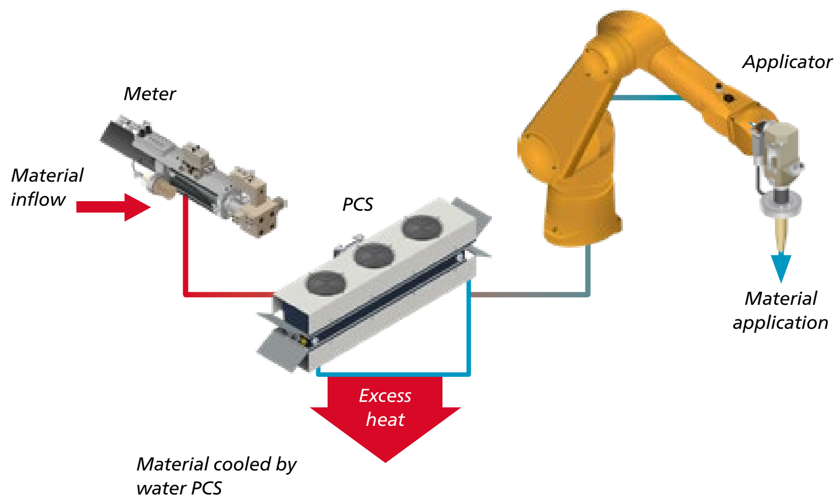
Air cooled PCS

8.2.1 Peltier Conditioning System (PCS)

Varying external temperatures may negatively influence the dispensing process. Some adhesive, sealing and dampening materials have to be dispensed at a constant temperature. A PCS ensures a consistent temperature throughout the dispensing system – one of the factors which guarantee ideal bead shape and application quality.

Reliable material application all year round

To ensure consistent material properties and reliable applications all year round, electric temperature regulation with a PCS can be integrated into the dispensing system. The PCS can be chosen according to customer needs, based on different expected temperature extremes and material flow rates as it cools and heats the material. The PCS is available as an air or water conditioning system.



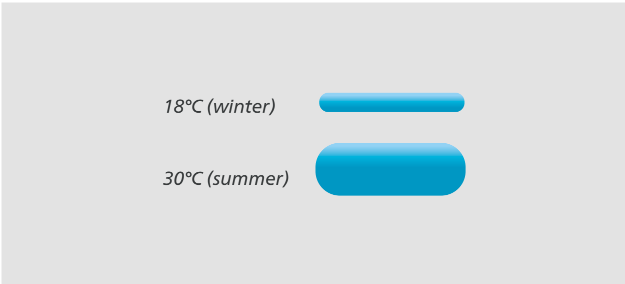
Benefits of the PCS

Resistance against ambient temperature
Due to temperature fluctuations and the problems arising in dispensing, many customers employ seasonally different materials or install water cooling systems.

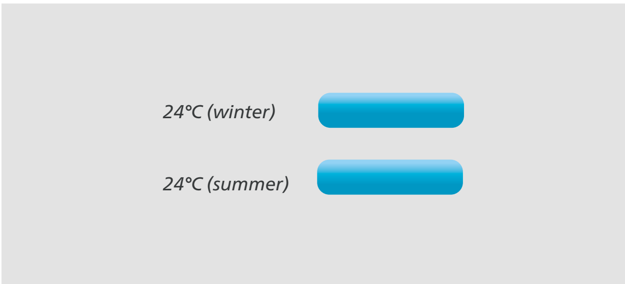
Peltier Conditioning Systems are used to directly cool or heat the material to application temperature thus protecting the dispensing process from the effects of the ambient temperature. This ensures the same application quality all year round without adjusting parameters or using different materials.

Influence of the material temperature on the flat stream application process.

Without Peltier Conditioning System



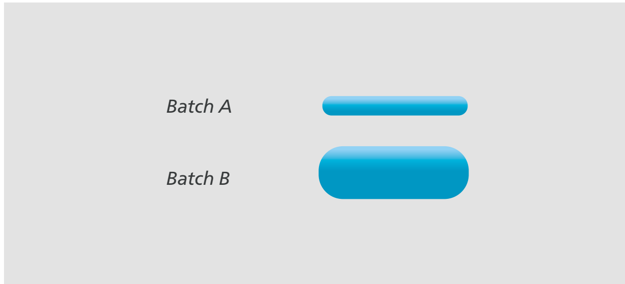
With Peltier Conditioning System



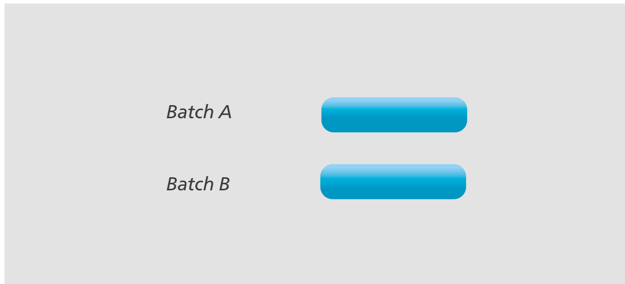
Active viscosity control Aside from the effect of the material temperature, the viscosity may also vary from batch to batch. The system controller offers the option to use PCS to detect viscosity variations and compensate them through a change in temperature.

Flat stream application with and without active viscosity control.

Without PCS



With PCS



8.3 Manipulators

Manipulators, or torque arms, are system options developed to enhance the quality of manually dispensed applications. The operator is guided by a manual applicator mounted on the torque arm. This can increase productivity and reduces muscular stress for the operator of the manual system.

Integrated balancer

Manipulator arms are normally delivered with an integrated balancer to compensate for the weight of the applicator. Additionally, due to its 3-axes movement, it allows the operator to move his arm effortlessly around the workstation.

Other pocket guides in this series

Adhesive bonding

There are a number of joining methods used in the industry nowadays. Adhesive bonding is one of them and it is still perceived by some as less effective than tightening or riveting. But, in fact, bonding is one of the most efficient and productive joining technologies. Thanks to the high demand for products that combine an increasing number of materials, as well as being lighter and cheaper to manufacture, adhesive bonding has become a major joining method.

The Atlas Copco pocket guide on adhesive bonding gives comprehensive information about adhesive bonding and compares different joining methods.

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Benefit from our process and application experience

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We can offer a customized solution to match your needs

Do you want to learn more about our joining technologies and how we can help to boost quality and productivity in your production?

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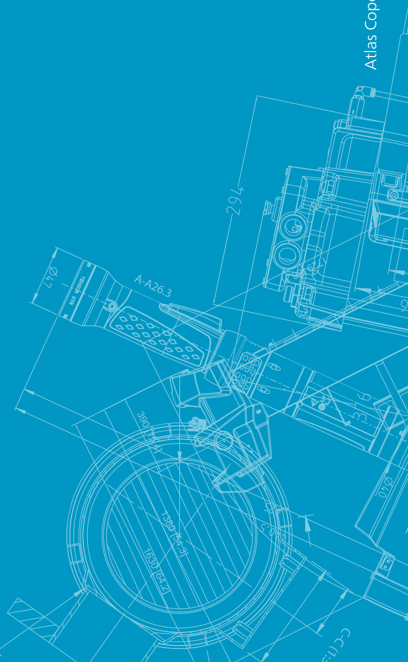

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