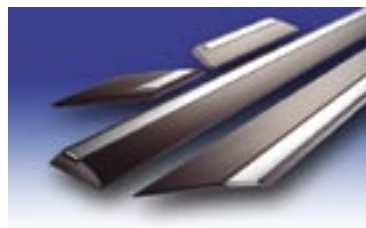


# AIRMOULD®

PLASTICS TECHNOLOGY

INJECTION MOLDING TECHNOLOGY

Airmould®





# Airmould® – A Process to Increase Efficiency

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Airmould® is the patented gas-assisted injection molding process developed by Battenfeld. Besides the Airmould® process, which involves internal gas pressure, Battenfeld also offers Airmould Contour®, a process based on external gas pressure. Both processes are explained in detail below.

In addition to equipment and machine components for the implementation of both processes, Battenfeld offers its customers special counseling to assist with selecting and optimizing the process to suit each application. Our customers will be assured of extensive support in solving problems and in efficient manufacturing of plastic parts.

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- 2 Injection molding with Airmould Contour® external gas pressure
- 3 The Airmould® modular system
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# Gas Injection Processes

## Gas-assisted injection molding with Airmould®

There is a choice of two processes:

1. Airmould® with internal gas pressure: gas is injected into the melt.

2. Airmould Contour® with external gas pressure: gas is injected between the melt and the cavity wall.

Both Airmould® and Airmould Contour® serve to improve the quality of molded parts:

- Better surface quality: shrinkage effects such as sink marks are eliminated.
- Better dimensional stability: less internal stresses and virtually no deformation in molded parts.

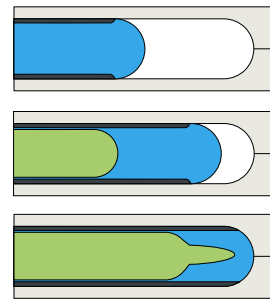
Depending on the molded part, Airmould® offers the additional advantage of:

- Reduced part weight, and consequently a reduction in material consumption.

Moreover, it is possible to reduce cycle times, clamping forces and shot volumes, depending on part geometries or on the gas injection process chosen. Finishing steps are also reduced.

## 1. Airmould® with internal gas pressure

First, a specified quantity of melt is injected into the cavity, then the inert gas nitrogen is injected into the melt. Through the injection of gas the cavity is



- Gas (Nitrogen)
- Plastic
- Mold
- Solidified layer

completely filled. The gas pressure counteracts shrinkage of the plastic material and assumes the function of holding pressure. Gas is injected either through the machine nozzle or through Airmould® injection modules which are mounted in the runner or in the mold.

Following complete filling of the cavity, gas holding pressure is maintained until the molding has sufficiently cooled and reached dimensional stability. An even gas pressure across the whole gas channel counteracts volume contraction. Gas pressure is reduced before the mold is opened, thus releasing nitrogen into the atmosphere.

This process yields molded parts free of sink marks and with low internal stresses. Airmould® is suitable for most applications which involve internal gas pressure.

## Processes with internal gas pressure

Besides the process described above – partly filling the cavity with plastic material and then completing the filling by gas injection – there are several other process variants using gas injection technology. These consist of special mold technology and/or equipment and control system variants in injection molding machines. Which internal gas pressure process is most advantageous for any given product depends on the part's geometry, the material used and the product requirements.

With the Airmould® process and the Airmould® modular system it is basically possible to implement all of the following process variants:

- Short shot process: partial filling of the cavity with melt, then completion of the filling with gas.
- Full shot process: complete filling of the cavity with melt, then gas injection to counteract shrinkage.

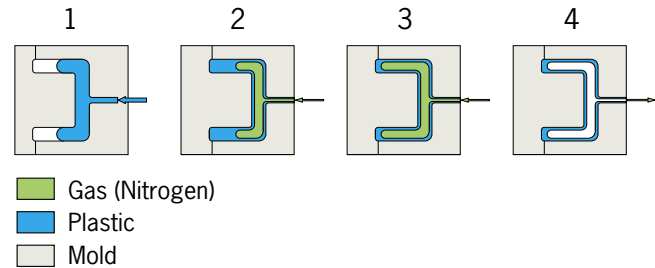
- Overflow process: complete filling of the main cavity with the melt, then melt displacement into an overflow channel by gas injection.
- Back-to-screw process: complete filling with melt, then melt displacement into the barrel by gas injection.
- Core-back process: complete filling of the cavity while its volume is reduced by inserted cores, then gas injection with simultaneous withdrawal of the cores.
- Multifoam process: combination of multi-component injection molding with Airmould®.

The choice of gas-assisted process depends on part geometry, plastic material and product requirements.

Airmould®, a process developed by Battenfeld, is protected by numerous national and international patents.

Whether or not the purchase of additional licenses must be checked depends on the molded part, the individual process and the country involved.

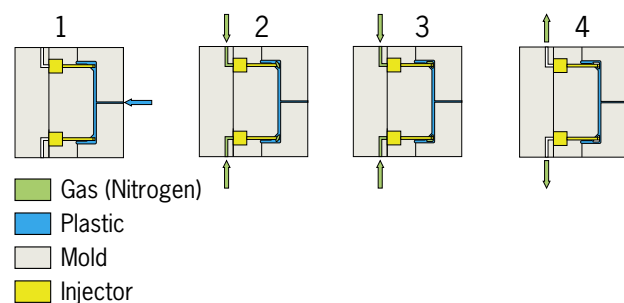
## The short shot process



The short shot process is also known as the standard internal gas pressure process. The cavity is first filled with a specific quantity of the melt (1), subsequently gas is injected (2), which displaces the melt and completes the filling of the cavity.

The gas pressure is maintained as holding pressure throughout the cooling phase (3), then reduced prior to mold opening (4). If the gas is injected through the Airmould® machine nozzle, the feed channel can be sealed.

## The full shot process

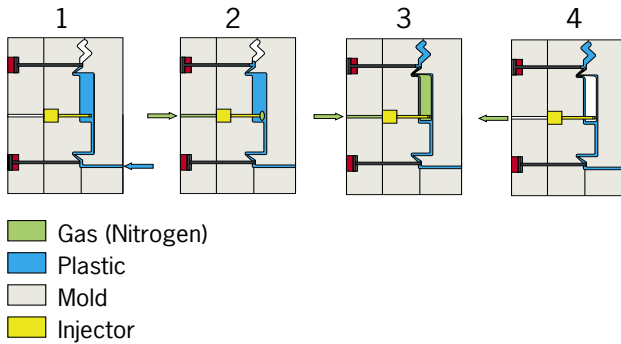


First, the cavity is completely filled with melt (1). Then nitrogen is injected to provide the holding pressure (2), and thus immediately counteracts shrinkage (3). This leads to the

formation of gas channels. Gas injection is effected through injection modules in the cavity. Gas pressure is reduced prior to mold opening. (4).

# Gas Injection Processes

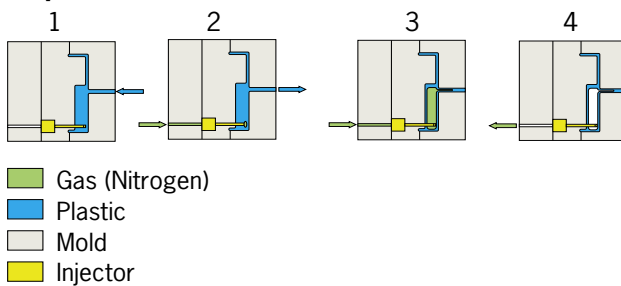
## The overflow process



First, the cavity is completely filled with melt (1). If necessary, holding pressure is generated in the melt. Then nitrogen is injected (2) with melt displacement from the cavity into the overflow.

Gas pressure is maintained as holding pressure throughout the cooling phase (3), thus counteracting shrinkage. Prior to mold opening, gas pressure is reduced (4).

## The back-to-screw process



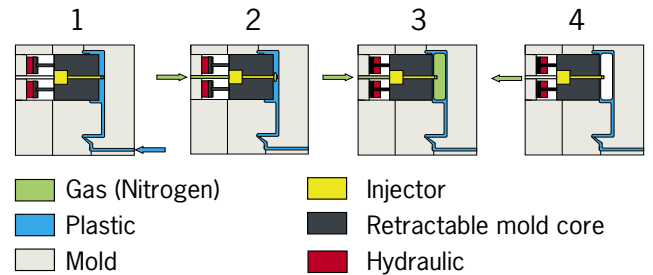
First, the cavity is completely filled with melt (1). If necessary, holding pressure is generated in the melt. Then nitrogen is injected into the gas channel at the end of the flow distance through an injection module (2).

The gas displaces the melt back to the barrel. Next, the machine nozzle is closed. Gas pressure is maintained throughout the cooling phase (3) to compensate for shrinkage, then reduced prior to mold opening (4).

## The core-back process

First, the melt is injected into the cavity whose volume has been reduced by the insertion of cores (1). Then nitrogen is injected through injection modules in the cavity (2), and the cores are simultaneously withdrawn. Gas pressure is maintained through-

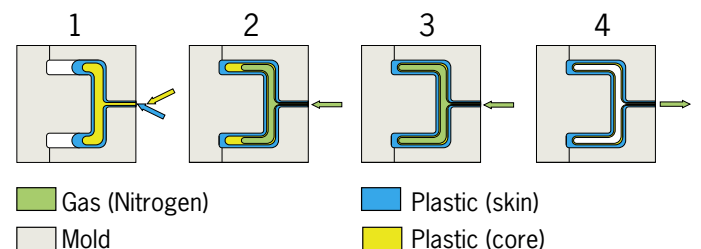
out the cooling phase (3) to compensate for shrinkage. The pressure is then reduced prior to opening the mold (4).



## The Multifoam process

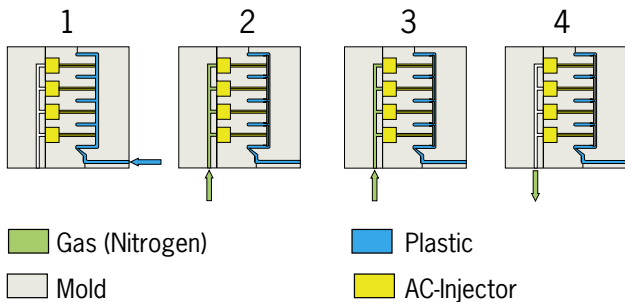
Following injection of a specified quantity of skin material the core material is injected. However, the quantity of core material, used is not sufficient to fill the mold (1). Filling is then completed by the injection of nitrogen (2). The gas pressure is maintained as holding pressure through-

out the cooling phase (3), then reduced prior to mold opening (4). If the gas is injected through the Airmould® machine nozzle, it is possible to seal the feed channel with skin material.



## 2. Air mould Contour® with external gas pressure

Air mould Contour® is the logical companion to Air mould®, opening up new fields of application for gas-assisted injection molding. In conventional injection molding processes, there is a risk of sink marks opposite



ribs in molded parts if the holding pressure is insufficient. Contrary to Air mould®, the nitrogen is not injected into the interior of the melt in the Air mould Contour® process, but rather between the melt and the cavity wall.

The individual steps are as follows: first, the cavity is completely filled with melt (1). Then nitrogen is injected between the melt and the cavity wall through injection modules specially designed for Air mould Contour® (2).

The gas pressure acts as a holding pressure cushion, packing the cooling plastic material against the cavity wall on the opposite side. Throughout the cooling phase (3), the nitrogen applies holding pressure to a selected area and thus prevents the formation of sink marks on the visible surface of the molded part op-

posite ribbed sections. Gas pressure is released prior to mold opening (4).

Air mould Contour® brings substantial benefits to processors and their customers: the application of gas pressure to selected areas prevents sink marks and deformation of the parts. Thanks to these advantages, this process is suitable for part geometries which would present problems in conventional compact injection molding or would be difficult to realize with the Air mould® internal gas pressure process. Quite often it is not desirable to have hollow sections, which is inevitable with Air mould®. Therefore the Air mould Contour® process is recommended mainly for thin-walled, ribbed parts and especially for amorphous plastic materials. Another advantage is that it is usually not necessary to adjust the part design to the process. Retrofitting existing molds for Air mould Contour® is also often possible.

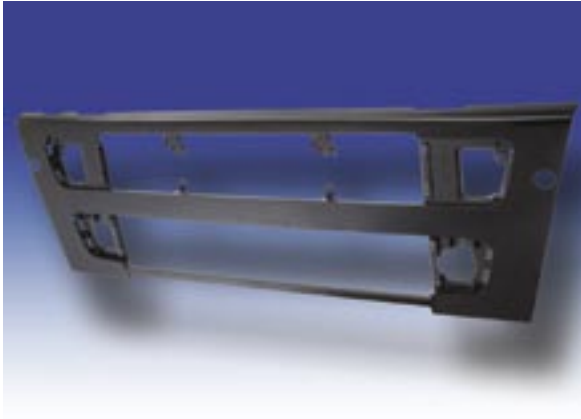


The Air mould® and Air mould Contour® processes developed by Battenfeld can be recommended for the following reasons:

- Battenfeld can look back on almost 60 years of injection molding machine engineering experience.
- Battenfeld has gathered experience and expertise in gas injection technology for more than 20 years.
- Battenfeld is the market leader in combining Air mould® technology with other special processes, such as in-mold decoration, multi-component technology and overmolding.
- Battenfeld holds numerous patents in connection with Air mould® and Air mould Contour®.

# Airmould® Product Examples

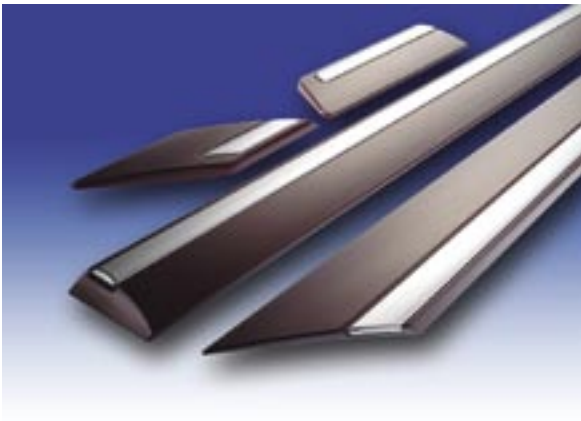
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*Truck front end*



*Steering wheel for pedal car*



*Exterior body trim*



*Lawn mower handle*



*Interior grab handle*



*Key element*



*Seat adjustment lever for garden chair*



*Gearshift lever for pedal car*

# The Airmould® Modular System

## 3. The Airmould® modular system

Airmould® is a modular system, readily adaptable to a great variety of part geometries, machine sizes and various fields of application. The Airmould® modular system is suitable for both the Airmould® and Airmould Contour® processes. All components are compatible with each other.

The Airmould® system consists of four basic components:

- Nitrogen generators.
- Compressor units.
- Gas pressure regulators.
- Gas injection modules.

An inert gas which does not react with the plastic material is used for all gas-assisted processes.

Airmould® and Airmould Contour® operate with nitrogen, an inert gas which makes up about 78% of the atmosphere. The following options are available for nitrogen supply:

- **Nitrogen bottles:** nitrogen bottles or bottle batteries are the form of gas supply recommended for low gas consumption.
- **Liquid nitrogen:** liquid nitrogen tanks are recommended in case of extremely high nitrogen consumption.
- **Nitrogen generation from the atmosphere:** on processors site, by air fractionation with Airmould® nitrogen generators.

## 3.1 SE series nitrogen generators

Airmould® SE nitrogen generators store nitrogen filtered from the surrounding atmosphere through a multi-membrane system. Airmould® nitrogen generators are mobile units which can be placed either next to or at some distance from the injection molding machine and the pressure generator. The standard performance of SE nitrogen generators ranges from 130 to 500 liters/min. Sizes outside this range can be custom-built upon request.





SE series nitrogen generators

The nitrogen generators can be retrofitted to existing pressure generators. They have been optimized for connection to DE pressure generators.

The advantages of Air-mould® nitrogen generators:

- High-performance, low-cost units.
- Small footprint.
- Clear, simple design.
- Easy access to all parts.
- Easy maintenance.
- High reliability.
- The unit is equipped with a chill dryer to reduce residual moisture.
- Nitrogen generation from environmental air (SE series).
- Large nitrogen storage accumulators.

### 3.2 DE series pressure generators

The pressure generators are mobile units which can be placed either next to or at some distance from injection molding machines. They are connected to injection molding machines with high-pressure gas hoses and tubes with screw joints. In the pressure generator the nitrogen is compressed to an operating pressure of 300 bar. Battenfeld offers the DE pressure generators in several different sizes. The standard performance range is from 130 to 500 liters/min. other sizes can be custom-built upon request.

The advantages of Air-mould® pressure generators:

- High-performance, low-cost units.
- Small footprint.
- One pressure generator is capable of supplying gas simultaneously to several injection molding machines.
- Large storage accumulators for pressurized gas.



DE series pressure generator

# The Airmould® Modular System

## Overview of nitrogen generators and pressure generators

Type	Delivery quantity <sup>1</sup>		Power supply	Max. operating pressure	Accumulator	Weight	Dimensions (W x L x H)
	NL/min	Nm <sup>3</sup> /h					
SE 22	130	7,8	7,5	8,0	1 x 90	664	1650 x 950 x 2012
SE 23	250	15	11,0	8,0	1 x 90	690	1650 x 950 x 2012
SE 24	500	30	22,0	8,0	1 x 90	863	1650 x 950 x 2012

Type	Delivery quantity		Power supply	Min. intake pressure	Max. operating pressure	Accumulator	Weight	Dimensions (W x L x H)
	NL/min	Nm <sup>3</sup> /h						
DE 22	130	7,8	4,0	5,5	330	1 x 50	480	1360 x 820 x 1930
DE 23	250	15,0	5,5	5,5	330	1 x 50	490	1360 x 820 x 1930
DE 24	500	30,0	7,5	5,5	330	2 x 50	570	1360 x 820 x 1930

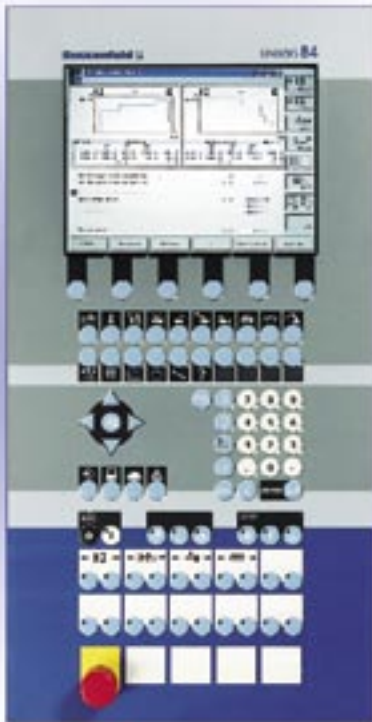


<sup>1</sup> with max. 2% residual oxygen

Values listed are based on an ambient temperature of 20 °C.

### 3.3 Gas pressure control

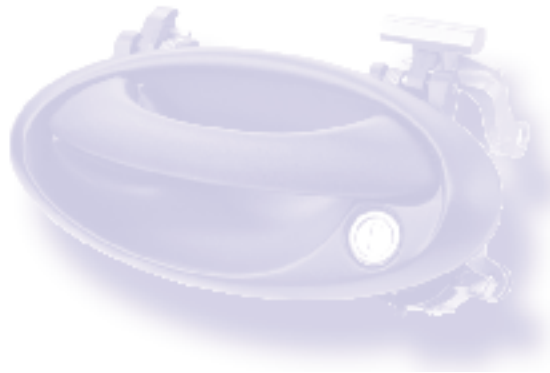
The gas pressure control consists of an electrical control system combined with one or more pressure control modules or Monomodules. The electrical control system is constructed as either a fixed or a mobile unit.



### Stationary control unit

The stationary control unit consists of the electrical control unit which is integrated in the UNILOG B4 machine control system combined with one or more pressure control modules or Monomodules.

It is capable of controlling up to four pressure control modules and one retraction control module to operate retractable injection modules. The pressure control modules are linked to the injection molding machine by a simple plug-in connection or by tubing.



# The Airmould® Modular System

## Mobile control unit

The mobile control unit is connected to the control system of the injection molding machine via a standardized Battenfeld Airmould® interface. The mobile control unit can be used in combination with Battenfeld injection molding machines as well as machines of other brands.



Airmould® interface

Operational safety is ensured through signal exchange via the Airmould® interface.

The mobile control unit is equipped, for example, with the following programs:

- Pressure monitoring.
- Impulse program (for automatic blowing to clean the injection modules).
- Activating of retractable injection modules.
- Addressing of core pull functions (directional valves).

The exchange of signals is checked by diagnostics. This is a safety feature to ensure faultless operation with Airmould® and Airmould Contour®.

Various Airmould® control components can be connected via the Airmould® machine interface, dependent on the layout of the mold.

- If gas is injected only at a single point through an Airmould® machine nozzle or an injection module in the mold, a single Mono-module with a manual programming unit is connected directly to the injection molding machine via the Airmould® interface.

- If two injection modules in the mold must be addressed, two Mono-modules with manual

programming units can be connected directly to the injection molding machine via a duplex cable and the Airmould® interface.

- If more than two injection modules in the mold must be activated, or if core pull functions or movable injection modules must be operated, a mobile UNILOG B4 AC control system is used.



Mobile UNILOG B4 AC control unit

## The advantages of the mobile control unit UNILog B4 AC with touch-screen control:

Standard version:

- Large, high-resolution VGA color screen.
- Simple operation by touch-screen control.
- User-friendly input menu navigation.
- Pressure profile input with set value curve with up to nine freely programmable positions.
- All time parameters with an accuracy of 1/100 s.
- Simultaneous graphic display of up to four actual value pressure profiles for up to four pressure control modules.
- Connection facility for up to four pressure control modules or up to four Monomodules.
- Compatible with all Airmould® components, such as pressure control modules, Monomodules and retraction control module.
- Control system identical with the Battenfeld machine control system UNILog B4.
- Storage of more than 100 data sets.
- External data storage on floppy disk.
- Common data storage of data from the injection molding machine control system UNILog B4 with Airmould® control system data possible on one floppy disk.
- Standard display in German/English.
- Display of all types of characters possible.
- Program to address cores (directional valves): standard software, optional hardware.
- Program to address retractable injection units.
- Diagnostics (monitoring of signal exchange).
- Manual operation functions (checking of blowing function, movements of injection modules and cores).

## Gas pressure control

### Gas pressure control module

The gas pressure is regulated via at least one pressure control module (blue housing) or one Monomodule (yellow housing). These modules are small, compact units which can be installed close to the position of gas injection on the

The special design of the pressure control modules ensures extremely precise pressure control and monitoring for small as well as for large gas volumes. The pressure control modules are equipped with entry and exit filters.



Pressure control module with (right), or without (left) high-speed pressure discharge valve

machine or on the mold. Thus, nitrogen consumption is minimized, while precise pressure regulation is ensured. The modules are connected with short, small-volume, high-pressure gas hoses and electric cables. The gas pressure is regulated via high-precision valves.

# The Airmould® Modular System

## Monomodule

In many applications gas injection is required only at a single point. The Monomodule has been developed for these applications (yellow housing).

It offers a choice of two operation modes:

- Mode 1: Pressure control module function, in connection with a fixed machine control system or the mobile control cabinet UNILOG B4 AC.
- Mode 2: Independent Monomodule function. In this case neither a fixed control system nor a mobile control cabinet is required. The Monomodule is programmed via the manual programming unit.

The operating mode is selected via the manual programming unit. The Monomodule is connected directly to the injection molding machine via the Airmould® interface.

With the help of a duplex cable, up to two Monomodules can be connected directly to the Airmould® interface of an injection molding machine.

The Monomodules are compatible with Battenfeld machines as well as with injection molding machines of other brands.



Left: Mono-module with manual programming unit, right: Mono-module with high-speed pressure exhaust valve

## High-speed pressure exhaust valves

When processing specific materials, such as plastics with filler content, reinforced plastics, plastics compounds, plastics with special additives (for example flame retardants), or in the case of high melt temperatures, volatile gaseous substances may be released with pressure discharge, taking on either liquid or solid form. High-speed pressure exhaust valves are recommended to reduce the formation of deposits. In these modules gas pressure is also controlled by high-

precision control valves, however pressure exhaust takes place directly into the surrounding atmosphere through a separate valve equipped with a silencer, instead of via the regulator valves. This minimizes any possible deposition and leads to a quick pressure discharge. In the case of large gas volumes high-speed pressure exhaust valves also reduce cycle times.

### Facts in favor of Airmould® pressure control and control modules:

- All Airmould® components are compact and modular.
- Possibility to extend the system at a later date.
- Flexibility of modules and control systems, which are compatible with Battenfeld machines as well as with injection molding machines of other brands.
- The pressure regulation system for gas injection has been developed by Battenfeld.
- Pressure regulation by high-precision valves ensures reproducible parts with high quality standards through reliable manufacturing with the Airmould® process.
- Airmould® pressure regulator modules and Monomodules are small, compact appliances installed close to the gas injection position, thus minimizing gas consumption and ensuring quick response.
- Only electric power and nitrogen supplies are required, without the need for compressed air or hydraulics.
- Simple, user-friendly parameter setting and process monitoring.
- Reduced deposits and faster pressure discharge through high-speed pressure exhaust valves.

### 3.4 Gas injection

Gas is injected either together with plastic material through an Airmould® machine nozzle at the same position, or separately from plastic injection via Airmould® injection modules.

#### Airmould® nozzles

Airmould® nozzles are designed for injecting nitrogen through the machine nozzle. Thus, nitrogen is transported into the interior of the plastic material. The Airmould® nozzles prevent the nitrogen from entering the barrel during gas injection.

Two types of Airmould® nozzle are available:

- The open Airmould® nozzle.
- The Airmould® shut-off nozzle.

The open Airmould® nozzle is used if the melt does not require a shut-off nozzle. It is also recommended for simple retrofitting to existing injection molding machines. Its outstanding advantage is its compact size. If the material processed requires a shut-off nozzle, the Airmould® nozzle head is connected to a needle or a cross-bolt shut-off nozzle.



Open Airmould® nozzle

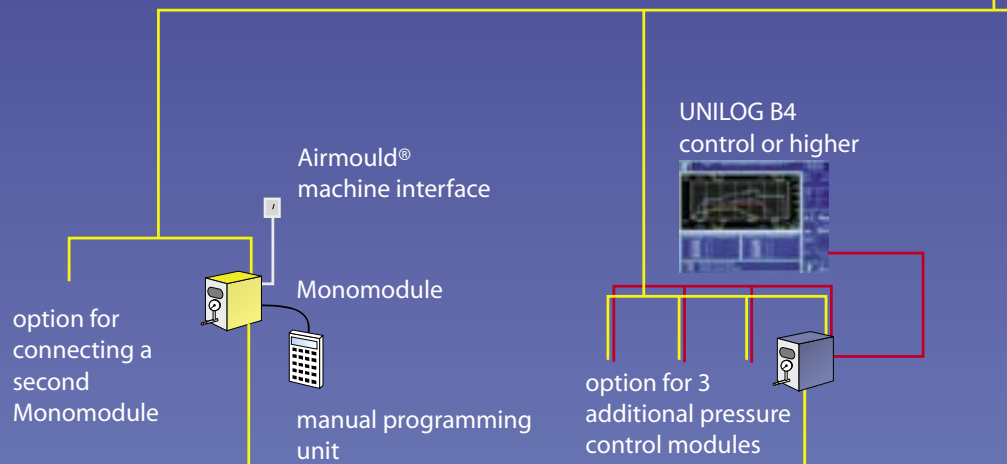
# The Airmould® Modular System – Overview and Configuration Options

DE pressure generators and SE nitrogen generators

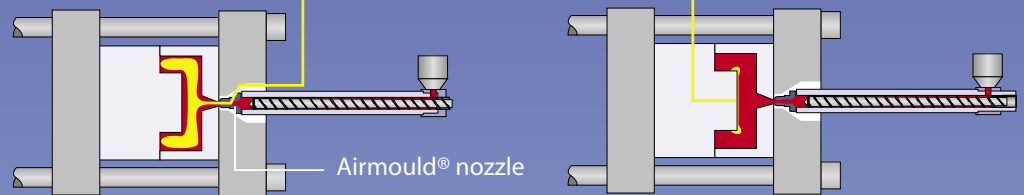
DE22/SE22  
130 l/min nitrogen



pressure control

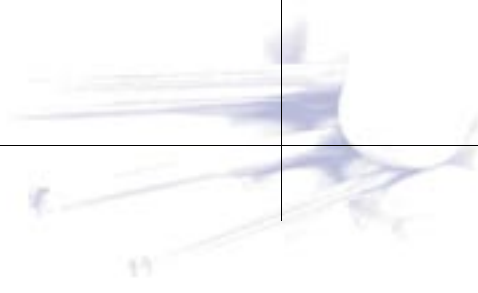


gas injection



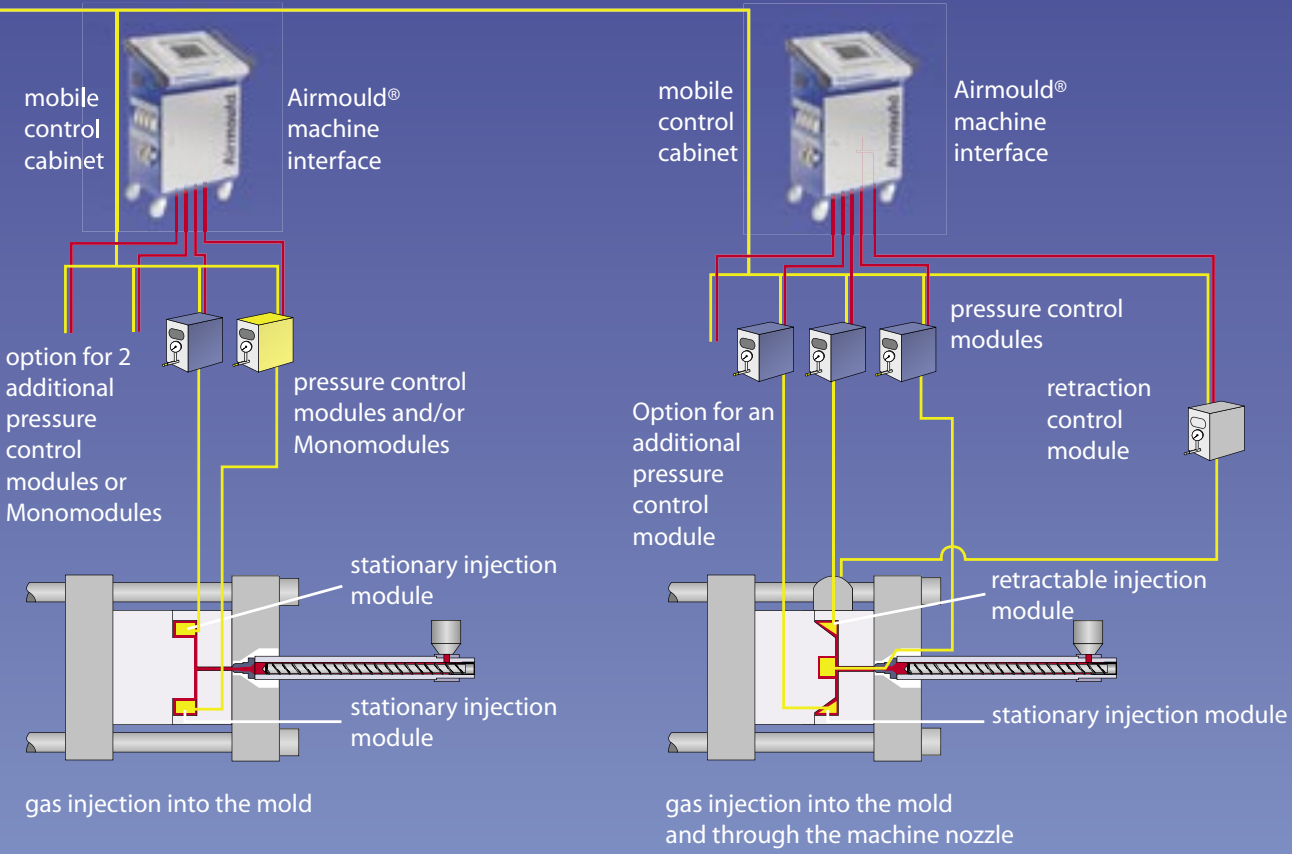
gas injection through the machine nozzle

gas injection into the mold



DE23/SE23  
250 l/min nitrogen

DE24/SE24  
500 l/min nitrogen



# The Airmould® Modular System

## Gas injection modules

Two types of gas injection modules are available:

- Stationary injection modules.
- Retractable injection modules.

### Stationary injection modules

Stationary injection modules are integrated into the mold. These modules can be used if the module is oriented in the direction of demolding.

Battenfeld has developed a range of injection modules with external diameters of 3, 5 and 8 mm in different standard lengths for Airmould®, which offer the following advantages:

- Lateral gas injection\*.
- Small dimensions.
- Compact, slim construction.
- Depth of penetration can be adjusted via means of adapters.
- Cleaning without dismantling possible while the mold is open.
- Low maintenance.
- Compatible with all Battenfeld injection components.

\* axial gas injection available on request



Stationary injection modules of different sizes

### Retractable injection modules

If the orientation of modules is not identical with the direction of demolding, the modules must be retracted prior to mold opening. For this purpose, the modules are equipped with nitrogen-driven cylinders. Retractable injection units require a retraction control module, capable of controlling up to 4 x 2 retractable injection modules, with electronic end position monitoring.

The retractable control module is constructed with the same dimensions as the pressure control module. It is linked to the fixed or mobile control unit by simple plug-in connection. The cylinders operate with nitrogen from the pressure generator. Operation and programming take place via the control system.



### 4. Airmould® services

Battenfeld offers the following services for Airmould® and Airmould Contour®:

- Technical support from planning to production.
- Adaptation of part design to the process.
- Counseling and selection of injection molding machine, Airmould® equipment, mold adaptations, automation equipment.
- Optimization of molded parts.
- Production tests in one of Battenfeld's technical labs.
- Process technology training at Battenfeld or on customers site.
- Continued technical support following equipment delivery.



We have taken great care to collect the data and technical information contained in this brochure. However, this does not exclude the possibility of technical inaccuracies or typographical errors having been overlooked. We reserve the right to make improvements or changes to this publication and to the products at any time.

**THE POWER to SUCCEED**

**Battenfeld**   
Injection Molding Technology  
SMS group

Battenfeld GmbH  
Scherl 10 · 58540 Meinerzhagen · Germany  
Tel. +49 2354 72-0 · Fax +49 2354 72-528  
welcome@bmf.battenfeld.com

Battenfeld Kunststoffmaschinen Ges. m. b. H.  
Wiener Neustädter Straße 81 · 2542 Kottlingbrunn · Austria  
Tel. +43 2252 404-0 · Fax +43 2252 404-7002  
welcome@bku.battenfeld.com

[www.battenfeld.com](http://www.battenfeld.com)