

Making our world more productive



# CRYOCLEAN<sup>®</sup> dry ice blasting.

The coolest cleaning  
method you will ever use.



From now on, you can do without cleaning agent residues.

Read on to learn why dry ice blasting is an attractive alternative to conventional cleaning processes.



During numerous natural, as well as industrial and other production processes, residues and other unwanted substances become attached to substructures, machine parts or storage tanks. Think for instance of oils, fats, waxes, resins, soot, inks, rubber, dyes, bitumen, paint, glue, moss, dirt etc. The contamination of surfaces, equipment, machines, tools or pieces of work has undesirable consequences:

- Substandard quality (necessitating either rejection or refinishing)
- Longer production cycles
- Safety risks
- Reduced efficiency of subsequent surface treatments
- Unattractive appearance

Then there are, of course, many intentionally applied coatings that have to be removed for a variety of reasons.

However, apart from the often difficult task of cleaning itself, most conventional cleaning processes cause additional problems:

- Wear as a result of using abrasive cleaning agents
- Costs for disposal and processing of used cleaning agents (sand, glass beads, water etc.)
- Downtimes and/or costly cool-down and warm-up times because equipment has to be dismantled to remove contaminated parts for cleaning

Dry ice blasting with Linde Gas technology removes various kinds of contamination quite effortlessly, while being environmentally friendly. Unlike cleaning techniques that use substances such as sand or glass beads as blast-cleaning agents, it doesn't leave behind residues. Therefore, it is an attractive alternative to conventional cleaning processes. It lets you clean right at the production site, reduces downtimes, is gentle on substrates and doesn't require the disposal of cleaning agent residues.



# A valuable product with unique abilities. Carbon dioxide (CO<sub>2</sub>).

## CO<sub>2</sub> is important for life

Life on earth would not be possible without carbon dioxide (CO<sub>2</sub>). It is continuously released and absorbed by different processes in the continuous atmospheric cycle, such as photosynthesis, fermentation and rotting, which keep the greenhouse effect at a constant level.

The increased amount of carbon dioxide due to the combustion of fossil fuels disrupts the atmospheric cycle. This is the reason why many people associate carbon dioxide with global warming and consider it negative overlooking its general importance. Carbon dioxide is extracted from by-products of combustion or chemical processes. This carbon dioxide would be released directly into the atmosphere if Linde did not capture it and upgrade it to a valuable product.

We might say that we borrow carbon dioxide and then use it for something good, replacing environmentally hazardous substances, before it is released to the atmosphere. Carbon dioxide produced as a by-product of different fermentation processes is a part of the natural atmospheric cycle and does not change the greenhouse effect level. Carbon dioxide is also found in natural deposits. This carbon dioxide is normally recovered in conjunction with mineral water.

## CO<sub>2</sub> and the environment

In many Linde applications, carbon dioxide replaces substances which have a negative impact on the environment. For example, it replaces halons in fire extinguishers and freons (CFCs) in the production of polystyrene and polyurethane foams. These substances destroy the ozone layer in the stratosphere and are forbidden to use. Carbon dioxide is the best alternative agent as it is both quick and effective. Carbon dioxide is used in swimming pools to neutralise the water instead of hydrochloric acid.

The risk of dangerous chlorine gas being formed is reduced, the safety of swimmers is increased and the working environment of the employees is improved. In dry-ice cleaning processes, carbon dioxide works without any further cleaning solvents, which are often harmful or contaminate the surface to be cleaned. Automobile air conditioning systems which use CO<sub>2</sub> as refrigerant instead of HFCs are not only environmentally friendly but also more economical (lower petrol consumption) than systems using fluorinated greenhouse gases. Replacing diesel-driven chilling units in foodstuffs transport with carbon dioxide units reduces the impact on the environment. In industrial production, carbon dioxide is recovered from waste products of the production of ethylene oxide, alcohols and fertilisers. It is captured, cleaned and compressed in several stages and then condensed. Liquid carbon dioxide is stored and distributed in tanks under pressure at low temperature. Smaller quantities of liquid carbon dioxide are stored in gas cylinders. Carbon dioxide can also be supplied as dry ice. Dry ice is produced from liquid carbon dioxide, which is expanded to form carbon dioxide snow and then compressed to ice. Dry ice is supplied as pellets or blocks in insulated containers.



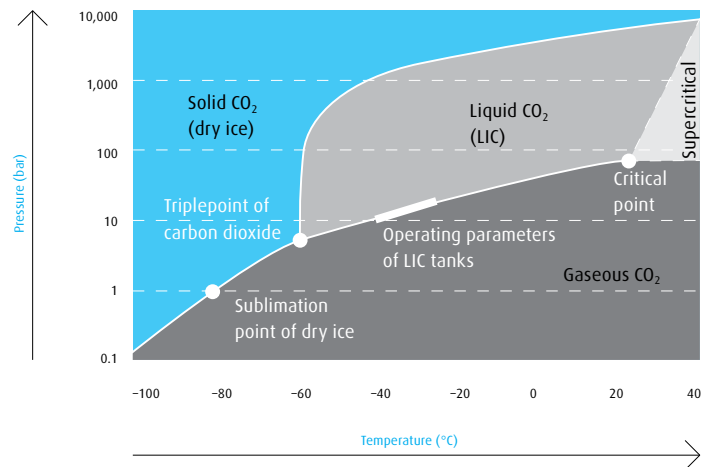
## The versatile gas

Carbon dioxide has properties which can be used safely in many different ways without any impact on the atmospheric cycle. It is therefore not surprising that carbon dioxide is used in products and processes we meet every day:

- In carbonated drinks: improving their lifetime and adding the fresh and tangy taste
- In the catering and food industries: versatile cooling and freezing agent for everyday use
- Cleaning of drinking water: making it less corrosive
- In greenhouses: increasing growth rates of vegetables
- Water treatment: neutralizing of waste water before it is released into the environment
- Carbon dioxide as ICEBITZZZ® dry ice pellets: a highly efficient and flexible chilling agent, requiring no additional energy is required for keeping goods cool and fresh
- In metal working: as a shielding gas for welding of steel and in laser cutting processes
- In industrial processes: for a great variety of cooling purposes

# From dry ice to gas in no time flat. The special properties of CO<sub>2</sub>.

CO<sub>2</sub> state diagram



Dry ice is the solid form of carbon dioxide, or CO<sub>2</sub> for short. Liquid CO<sub>2</sub> is stored either in cylinders at ambient temperature under about 60 bar pressure or in vacuum-insulated tanks at about -20 °C under 20 bar pressure. When liquid CO<sub>2</sub> expands, finely powdered snow is formed. Dry ice closely resembles normal water ice, but has very different properties.

- Dry ice contains no water
- Its temperature remains constant at -78 °C
- When energy is applied (e.g. heat or energy released by impact), dry ice is directly converted into its gaseous state without liquefying first. This eliminates the necessity of special disposal measures, thus saving you money
- Carbon dioxide is considered non-toxic
- It is also non-flammable
- Carbon dioxide behaves as an inert substance. This means that there is usually no chemical reaction with other products
- There is no liquid phase of CO<sub>2</sub> below the triple point (5,18 bar). As a consequence the cleaning process is supplied with solid and gaseous carbon dioxide only



Cleaning a coffee production plant.

## It's a dirty job but now someone's going to love it. Cleaning with dry ice has many advantages.

### Faster, and therefore cheaper

Machines no longer need to be disassembled for cleaning, as in-line cleaning is often possible. This cuts downtime to a minimum.

### Eco-friendly

Dry ice can be an excellent replacement for corrosive and aggressive solvents – though without the harmful emissions. As this cleaning process doesn't use water, waste water treatment measures are not required. Sticky, elastic dirt is removed quickly and easily without leaving remnants of any blast-cleaning agent, thus eliminating additional cleanup and removal costs. Industrial carbon dioxide originates from natural sources or is a purified by-product from chemical reactions such as ammonia synthesis. Therefore it has no influence on the CO<sub>2</sub> balance.

### Non-abrasive

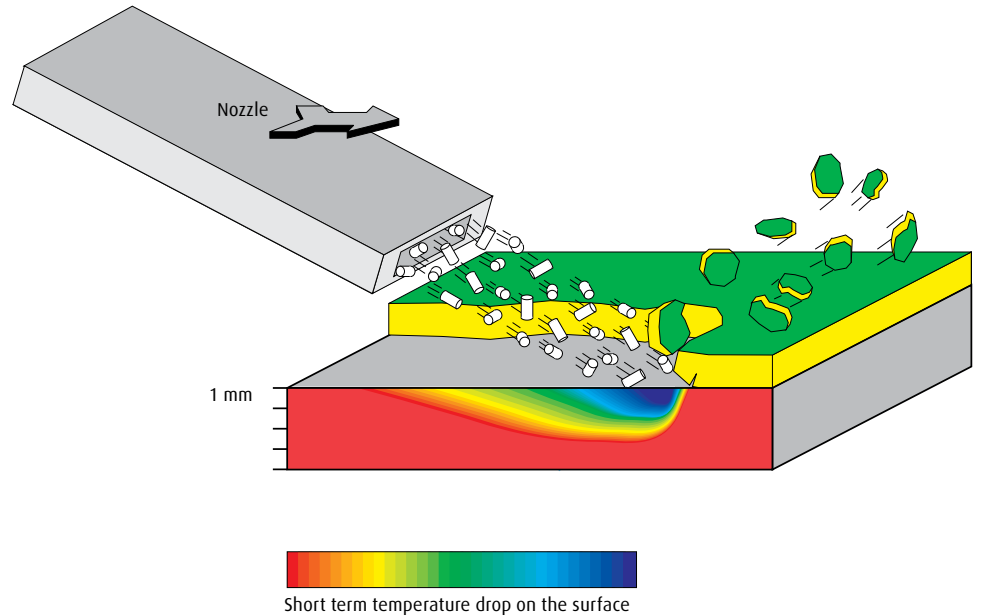
Dry ice pellets are no harder than plaster and change into gas the moment they hit the surface. Contrary to conventional blasting media, the soft dry ice doesn't cause wear to the substrate. In dry ice cleaning, the blasting pressure can be adjusted between 2 and 16 bar, thus adapting the aggressiveness of the process to the individual demand of the particular cleaning job.

### Dry

Dry ice blasting is a dry method of cleaning. Because the cleaning agent evaporates, there is no mixing with the removed contaminant. No water is released during the process. This eliminates a lot of problems when cleaning processing units for water-sensitive products.



# A convincing combination of amazing effects. How dry ice blasting works.



Blast cleaning with pellets of dry ice is based on a combination of four effects:

#### 1. Embrittlement

Organic materials harden and embrittle under cooling. This reduces their elasticity and adhesiveness, making removal easier.

#### 2. Thermoshock

Because of the sudden local cooling, differences in the rate of shrinkage create intense thermal tensions in the boundary area and loosen the compound between the contamination layer and the substrate.

#### 3. Impact

Upon impact – generated by the speed and mass of the dry ice pellets – kinetic energy is transformed into an intensive cleaning force.

#### 4. Spontaneous sublimation

The transfer of heat from the very cold pellets to the relatively warm surface to be cleaned causes the solidphase carbon dioxide to sublime almost instantly to the gas phase. This process is accompanied by a volume increase with a factor of approximately 500; this virtual microexplosion of carbon dioxide blasts away the contamination, which has already been loosened, carrying it along on the flow of compressed air.

The result achieved with dry ice blasting depends on:

- The blasting pressure
- The nozzle (available in a wide range of shapes)
- The properties of the contaminant to be removed
- The material, temperature and surface roughness of the substrate

The interrelation between the above factors determines the success.



The many advantages of the blasting units CRYOMAX® and CRYOMINI® include easy handling, high efficiency and low maintenance.

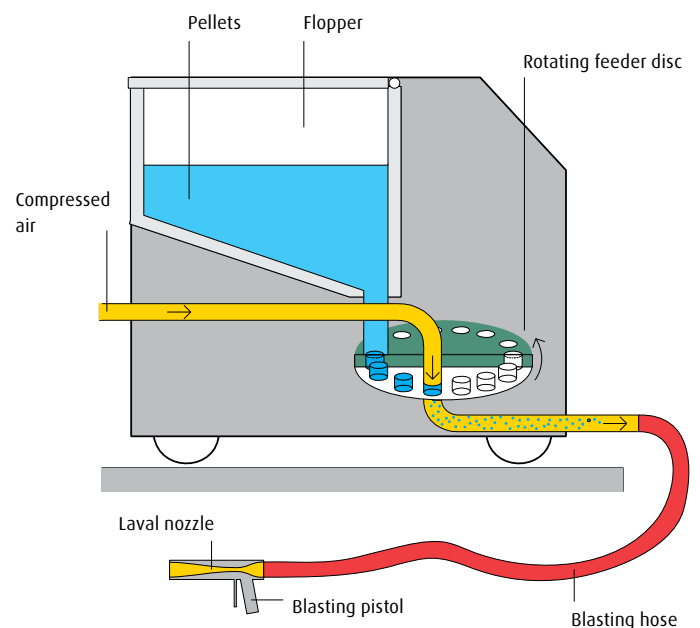
## Reliable, efficient, outstanding – a look at our hardware. CRYOMAX® , CRYOMINI® and others.

### 1-hose blasting systems

By means of a (rotary) air lock, rice-grain-sized pellets are fed from the machine's hopper into a stream of compressed air, carried towards the pistol and finally accelerated in a laval-type blasting nozzle to almost sonic speed. The pellets then blast against the surface being cleaned.

Many well-known enterprises use the easy-to-operate CRYOMAX® and CRYOMINI® systems. Former Hoek Loos, the Dutch subsidiary of Linde, has been developing and building these blasting machines for over 15 years.

Linde Gas has been exporting the CRYOMINI® and CRYOMAX® to scores of countries all over the world for a number of years. Our references include many leading companies.



CRYOMAX® and CRYOMINI®: Pressure-blasting unit (1-hose system).



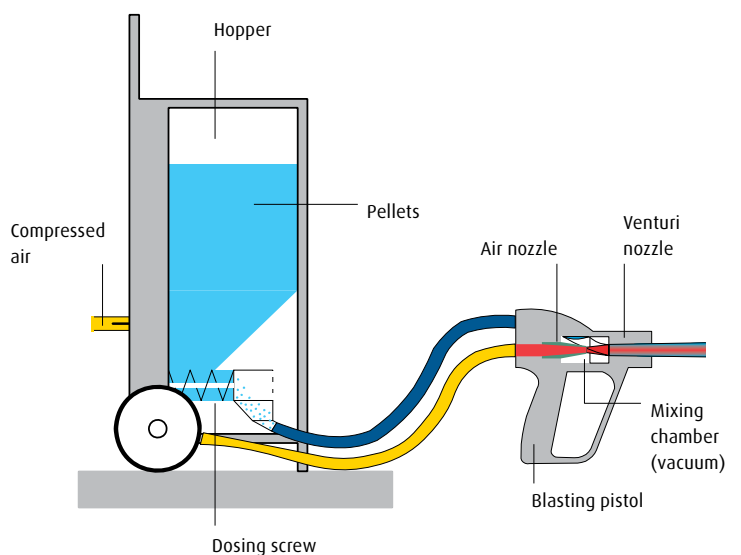
Graffiti removal with LT-280.

## 2-hose blasting systems

An alternative, slightly simpler design uses the suction principle to achieve the same result: The stream of compressed air produces a partial vacuum in the blasting gun. Dry ice pellets are fed from the unit's hopper into the sucked-in air by means of a simple dosing screw. These pellets are entrained by the air stream in the blasting hose and supplied to the Venturi blasting nozzle, where they are accelerated rapidly towards the cleaning target.

Some useful technical features are available for the CryoGen 2-hose units, for instance a built-in grinder for a soft cleaning effect on sensitive surfaces and a scraper device which can be fed with bigger chunks of dry ice (e.g. finger-sized nuggets).

Every cleaning job has its own requirements. The best solution can be selected for every application from among several different models of 1- or 2-hose blasting units. The small and mobile blasting machines can be connected and disconnected in almost no time at all, which is why they are an attractive alternative to conventional cleaning methods. If you want to use the dry ice blast-cleaning technique only from time to time, we can recommend experienced blast-cleaning service companies ready to serve you. Linde has highly reliable partners for professional industrial cleaning jobs in nearly every location. The number of professional blast-cleaning establishments using CRYOCLEAN® technology by Linde continues to increase day by day. A result of the efficiency and reliability of these machines.



LT-100: Suction principle (2-hose system).



Dry ice cleaning in action.



CRYOCLEAN® CryoAdd in action.

## The most powerful dry ice cleaning procedure. CRYOCLEAN® CryoAdd using abrasive cleaning media.

Conventional dry ice blasting is a very effective way of cleaning a great variety of surfaces. Since it is non-abrasive, this method may, however, encounter certain limits. For cases of heavy-duty cleaning where particular challenges have to be met, specially designed blasting nozzles are available – they can mix dry ice pellets and additional blasting media, accelerating this mixture with compressed air. Linde recommends adding CryoAdd to standard CO<sub>2</sub>-blasting in these cases, for CryoAdd provides maximum cleaning power while still being gentle to the underlying surfaces.

### Outstanding advantages with CryoAdd

- Strong: adding CryoAdd reinforces the power of dry ice cleaning wherever this is needed
- Effective: even oxides on metal surfaces like steel or aluminum can be easily removed
- Hassle-free: CryoAdd reduces the effort during subsequent cleaning-up
- Safe: different additives are available – ranging from maximum cleaning power to even food-grade cleaning jobs

# Slightly different method, great results: dry ice blasting without pre-produced pellets. The CRYOCLEAN® snow system works with liquid CO<sub>2</sub>.

For some automated cleaning applications, a new, modified dry ice blasting system is available. The dry ice particles are produced directly on demand from a liquid CO<sub>2</sub> supply. Though less aggressive than the common dry ice pellet blasting process, the system is quite advantageous for many applications as it doesn't need any pellet handling and requires only low-grade maintenance.

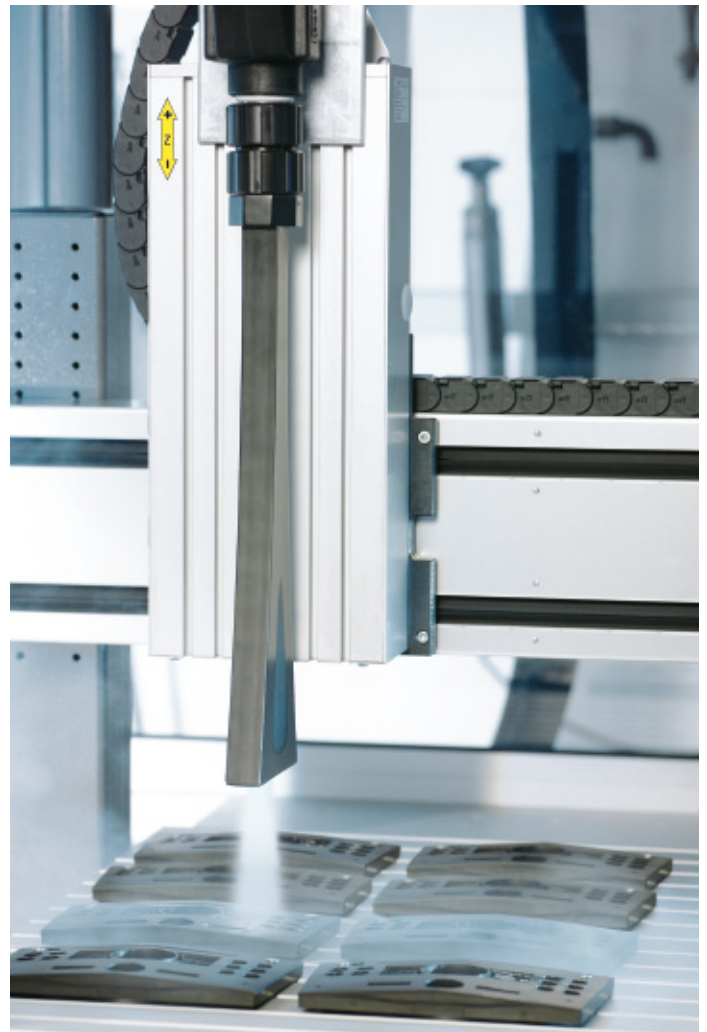
This special working principle has obvious advantages:

- Logjams in blasting units due to clogged pellets can no longer happen.
- No personnel are required for refilling pellets or for other handling activities.
- Purchasing, storage of pellets and manual handling are not required.
- As it is easily possible to store liquid CO<sub>2</sub> (LIC) on a long-term basis, cleaning power is immediately ready on demand, even for highly erratic cleaning tasks.

These benefits make the CRYOCLEAN® snow system a perfect solution for automation, where the cleaning process takes place in fixed locations such as:

- Special cleaning cabins
- Conveyor belts
- Process stations (e.g. coating or welding)

However, the required power of the cleaning process should be in medium range and the layer thickness should not exceed 1 mm. Our specialists are available to adapt the CRYOCLEAN® snow system to your requirements.



# The formula for the ideal cleaning agent. Production of dry ice pellets.



## Pelletizer

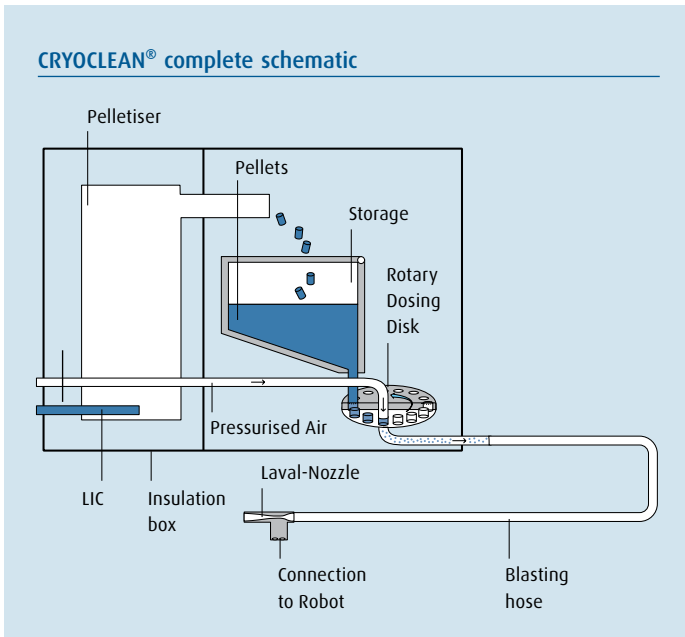
Dry ice pellets consist of pure carbon dioxide (CO<sub>2</sub>) in the solid state. They are produced in a so-called pelletizer in our ICEBITZZZ® factories. Dry ice pellets (-78 °C) have approximately the same hardness as plaster.

## Pellets

For use as a cleaning agent, cryogenic carbon dioxide snow is compacted into dry ice pellets by pressing it through special dies. The bulk density of the pellets is about 1000 kg/m<sup>3</sup>. They have a characteristic ricegrain shape (approximately 5 to 10 mm long and 3 mm wide).

## ICEBITZZZ®

Because Linde Gas has its own production facilities in several dozen worldwide locations, we are able to supply dry ice according to the demand. Deliveries are made in insulated cryocontainers with capacities between 200 and 400 kg. The cryocontainers keep the dry ice usable for at least 5 to 7 days from the production date. Dry ice can also be produced on site when higher demand arises.



CRYOCLEAN® complete schematic.

# Automated dry ice blasting. CRYOCLEAN® complete.

## The Challenge

At conventional blasting with dry ice pellets there are repeating operations such as handling the boxes of pellets and refilling of the blasting unit. In cases that call for continuous automated operation, this is hardly practical, since a reliable operation cannot be kept up.

## The Solution

CRYOCLEAN® complete is Linde's offer for automated on-site production of pellets for dry ice blasting on demand. This solution is especially designed for cleaning rotary or flat surfaces.

## Convincing arguments using CRYOCLEAN® complete

- Automated cleaning procedure
- Safe and reliable process without manpower
- Gentle and efficient surface treatment
- Quick start-up procedure
- Integrated interface to customer's process
- Level controlled CO<sub>2</sub> pellet storage
- Environmentally friendly cleaning without any VOC
- No blasting agent residues



Cleaning polyurethane molds.



Removing resinated oil for renovation purposes.

## Maximum effect with minimum downtime. Dry ice blasting: before and after cleaning.

In recent years, Linde Gas has achieved excellent results in various branches of industry. Particularly in situations where conventional cleaning methods have detrimental side effects, CRYOCLEAN® dry ice blasting methods can be the answer. The total absence of blast medium residues, the non-abrasive nature of the pellets and the intensive cleaning action have proved their value in industrial applications time and again.

The following applications are but a small selection of the numerous present day uses. The successful application of dry ice blasting depends largely on your work process and your product (or that of your client) and the type of contamination that has to be removed. To establish the efficacy of dry ice blasting in your situation, Linde Gas can offer testing in its own Test and Demonstration Centres or at your site. Traversing systems are available for work of a repetitive nature, such as the cleaning of rollers and/or moulds. It is also possible to use robots for cleaning moulds. Linde Gas has the right partners to arrange this.

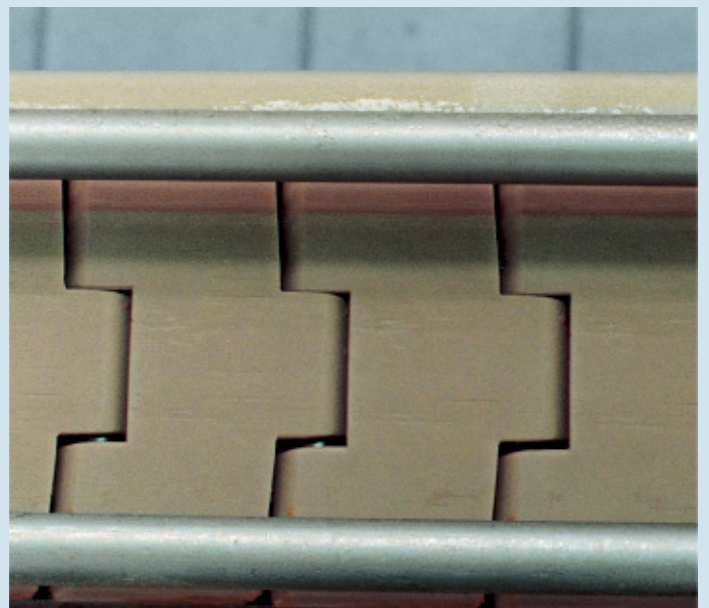
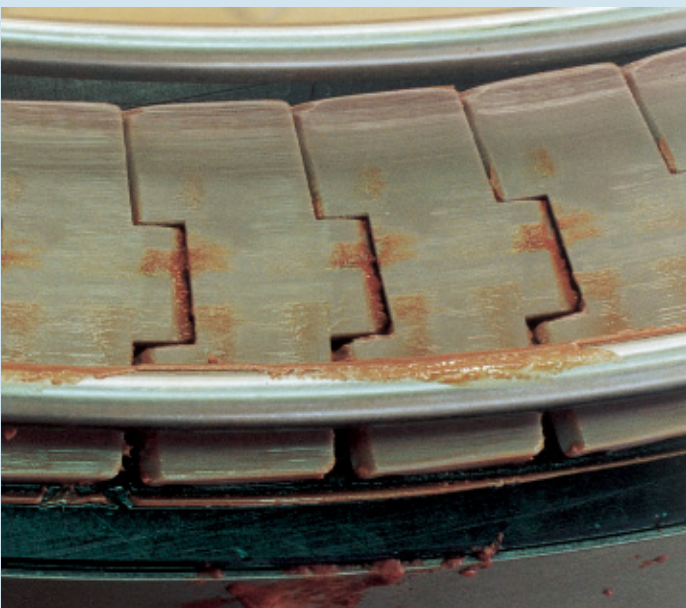




Cleaning the Spanish coast after the "Prestige" disaster.



Before and after cleaning: streetcar platforms.



Before and after cleaning: conveyor belts.

# Tried and tested: dry ice blasting works in most professional cleaning areas.

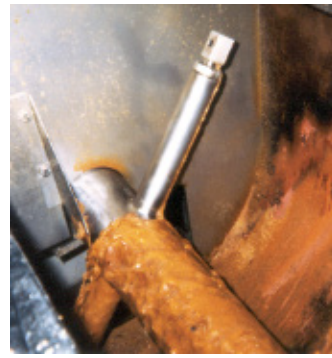
Device or location	Type of contamination
<b>Printing and allied trades</b>	
offset printing presses, conveyor belts	printing inks, oil, grease
photocopier manufacture/parts	dyes, toners
toner extruder screws	hardened toner
crown-cork production machine parts/printing devices	printing inks, oil, grease
die plates, punching tools	product residues
finishing (and labelling) machines	remnants of glue, ink, stickers etc.
paper mills, filter screens	cellulose fibres
<b>Food industry</b>	
bread and pastry machines	(preliminary) product residues, fat, arabic gum
chocolate industry	caramel, (preliminary) product residues, fat, arabic gum
fat-processing industry	product residues (fat, additives)
ovens and conveyor belts	cooking residues, grease, arabic gum
deep cleaning in industrial kitchens (e.g. cooker hoods)	fat and oil remnants etc.
packaging (and labelling) machines	remnants of glue, ink, stickers etc.
machinery and halls	remnants of fats, cocoa, arabic gum etc.
fish and cheese processing (machinery, tiled walls)	product leftovers, deposits of protein material
<b>Metal-working industry/Foundries</b>	
core boxes	release agent, sand residues
casting moulds/dies	release agent
rolling mill rollers	deposits of any kind
welding robots	welding vapour deposits, spatter
site decontamination	dust, smoke, deposits of any kind
steel machine parts	rust film
<b>Rubber/Plastic/Foam industry</b>	
presses and moulds, e.g. in the automotive industry	fat, oil, dirt, product residues on peripheral parts
polyurethane moulds (examples: dashboards, PU foaming, seats, back shelves)	releasing agent residues
manufacture of packaging materials	glue, product residues
production of plastics (tunnel driers etc.)	vapour deposits
vulcanisation moulds, automobile tire moulds	releasing agents, chemical evaporation
conveyor belts	rubber dust
splitter rollers, production	plastic foils, various types of remnants



Matrixes and moulds.



Works of art.



Cleaning a caramel mixer.



Intensive cleaning in canteen kitchens.

### Device or location

#### Cleaning services

restoration of cars and other old machinery  
 railway platforms, shopping malls, escalators, walls, decorative paving  
 public spaces and gardens  
 parquet floor  
 hardwood  
 boats (yachts)  
 building facades  
 acrylate billboards, trucks  
 aluminum window/door frames  
 offshore accessory equipment, bridges and lock towers  
 public buildings, showrooms, production halls and equipment  
 building decontamination

#### Industrial cleaning

turbine blades  
 accessory equipment (e.g. stop valves and piping)  
 flues and ventilation ducts  
 high-voltage installations  
 conveyor belts  
 labelling machines  
 road construction machinery, storage tanks, transport equipment (trucks),  
 filling stations  
 paint manufacture and processing, paint mixers, spraying cabins  
 storage tanks and production halls  
 welding robots  
 switchboxes  
 PVD machines  
 asbestos removal  
 steel machine parts  
 heat exchangers  
 electric power plants/generators

### Type of contamination

paint, glue, oil, fat, wax, resin, dirt etc.  
 chewing gum, grease, dirt, paint  
 weeds, green moss  
 varnishes and waxes, contaminated with dirt or hazardous substances  
 smoke residues of fire hazards, paint or coatings  
 antifouling  
 paint, dirt, moss  
 stickers, glue remnants and lettering  
 anti-graffiti coatings  
 rust, oil, grease, paint  
 smoke residues of fire hazards  
 PCB-contaminated expansion joints

combustion deposits, grease, dirt, anti-corrosion coatings  
 various types of deposits  
 dust, fat  
 dirt, dust, moss  
 various production residues  
 remnants of glue, ink etc.  
 fat, oil, bitumen, product residues  
 dry paint remnants, overspray  
 paint, resin respectively preliminary products, chemical substances  
 of any kind etc.  
 welding vapour deposits, spatter  
 dust  
 vapour deposits  
 (sprayed) asbestos  
 rust film  
 various types of deposits  
 dirt, attrition



# What to keep in mind when dry ice blasting. Dangers and precautions.

## Ventilation

Gaseous carbon dioxide can displace the ambient air; always ensure that there is adequate ventilation in order to prevent the build-up of a dangerous concentration of carbon dioxide.

## TLV (threshold limit value)

The TLV is the concentration to which operation staff may be exposed during eight hours a day without any harm to their health. The limit for carbon dioxide is 5000 ppm, which is set to 0.5 Vol % or 9 g/m<sup>3</sup>. Compared to ambient conditions this is approximately three times of the natural concentration.

## Gas detection (CO<sub>2</sub>)

Carbon dioxide is 50 % heavier than air. It can accumulate in confined spaces or sub-level areas such as cellars and working pits. In such circumstances use suitable gas detection equipment and ensure adequate ventilation. Linde Gas will be glad to advise you on this.

## Explosive atmospheres

Unfortunately, dry ice and liquid CO<sub>2</sub> are prone to electrostatic charging. Even grounding all blasting equipment is no adequate precaution against electrical discharge. For cleaning jobs in those areas, the explosion-risk area has to be suspended, e.g. by proper ventilation accompanied by diligent control measurements.



When dry ice blasting (e.g. when renovating an old half-timbered house, as shown here), always wear protective clothing.



In some cases, gas masks are highly recommended – e.g. when cleaning heat exchangers and wherever harmful materials are blasted loose.

### Gloves

In case of skin contact, the cold ( $-78\text{ }^{\circ}\text{C}$ ), solid-phase carbon dioxide can give rise to cold burn; always use gloves when handling dry ice.

### Ear protection

Dry ice blasting generates noise (from 70 up to more than 110 dBA), depending on the nozzle and the blasting pressure used; always use suitable ear protection.

### Protective clothing

Released contaminants or even  $\text{CO}_2$  pellets may reflect to your body with high impact. Always wear protective clothing while dry ice blasting, together with a face shield or safety goggles.

### Harmful material

The material blasted loose (the contaminant) is often harmful. Protect yourself and your surroundings from it by using a blasting cubicle, a gas mask and proper ventilation. Finest contaminant particles may affect your lungs.

You can profit from our international contacts for dry ice blasting. Linde's services and subsidiaries can be found worldwide.



For many of its customers, from industrial companies to privately run enterprises, Linde has become much more than just a supplier of gases. With our in-depth knowledge and decades of experience, we are able to provide a wide range of services in all fields related to the use of gases. And with our worldwide network of international contacts, we can help you, our customers, to find just the kind of professional support you need.

Please note: Dry ice is available in many countries throughout the world, including the USA, most European as well as many South American and Asian countries. Where no pellets are available, liquid CO<sub>2</sub> or dry ice in other supply forms may be found.

Just ask your local Linde partner for further information.

# Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages, and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation, and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.

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