Dry Ice Cleaning for the 2nd surface preparation

Dipl.- Ing. (FH) Lars-Eric Etzold

MEYER WERFT GmbH, Papenburg, Germany, lars-eric.etzold@meryerwerft.de

Abstract

At MEYER WERFT in Germany the method Dry Ice cleaning is used since the 90th as alternative 2nd surface preparation method. With this method already 2 million m² have been treated with great success.

The Dry Ice cleaning which is also called as CO_2 blasting is a pore-deep cleaning method. The result after using this advanced technology: a surface without dust and hygroscopic and adhesion-reducing particles. And the surrounding area will not be contaminated during the de-rusting process with dust as from dry blasting and not with water as from high pressure washing.

The Dry Ice cleaning method is a proven alternative where the coating system requires a surface free from salt and other contaminations. And especially in areas where dust and water will great a risk for the surrounding area, like electrical equipment, this method must be taken into consideration.

Dry Ice Cleaning

What is Dry Ice?

The carbon dioxide is won from natural sources and also arises during industrial processes where CO_2 results as waste product, like for example from incineration plants.

From 1 kg liquid CO2 about 450 g Dry Ice and 550 g CO2 gas can be produced. Together with a pressure of 200 bars the 450 g Dry Ice will result in 420 g CO2 pellets, see Fig. 1.

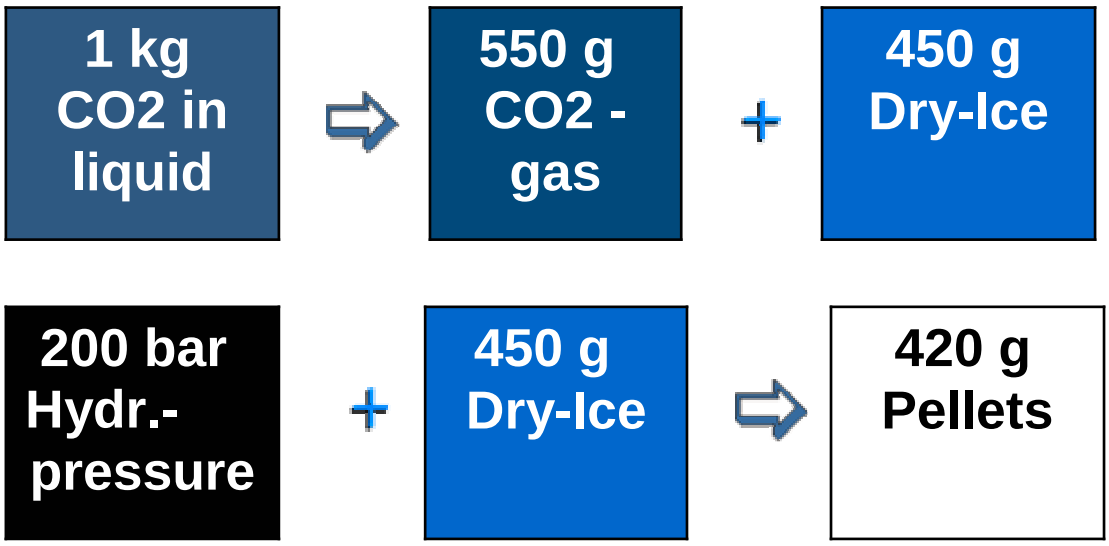

Fig. 1 Principe of Dry Ice production

Please Note: 1 kg of liquid CO2 becomes about 525 Litre of CO2 gas at normal atmospheric conditions. Or with other relation: liquid CO2 in the size of a lump sugar becomes about ½ Litre of gas.

And this volume change from liquid to gas is the first key factor of the Dry Ice cleaning.

How does it work?

The Dry Ice cleaning methods has less abrasive properties, like e.g. grit blasting. On the other site, the blast material, the CO_2, is not remaining in the area as waste, like grit or water. Also the surface is clean and dry directly after the cleaning and the coating work can start.

The mechanism behind it is as follows. The Dry Ice is blasted onto the substrate via an air pressure of 6 to 12 bar. When the Dry Ice pellets hit the surface the following mechanism starts:

The Thermal Effect

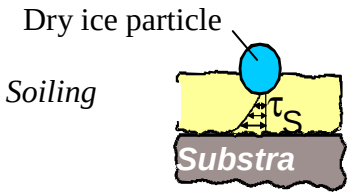

Fig 2: The Thermal effect
Due to the local chilling of the soiling it becomes brittle and looses the adhesion from the base material by the use of tensions caused by different thermal expansion coefficients.

The Sublimation Effect

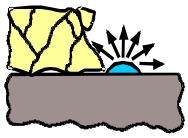

Fig 3: The sublimation Effect
The abrupt volume increase of CO2 due to a phase change from solid to gaseous causes a kind of “explosion”. The volume change from the liquid to the gaseous status is 525 times.

The mechanical Effect

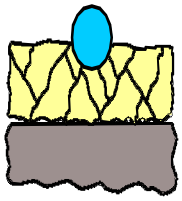

Fig 4: The mechanical Effect
Removal of Soiling due to the impulse transfer with the dry ice hardness of 1,5 to 2,5 Mohs.

Fehler! Es ist nicht möglich, durch die Bearbeitung von Feldfunktionen Objekte zu erstellen.
Fig 5: The temperature influence

The Substrate, within the ship building industry mainly steel, will be cleaned. An abrasive mechanism with removal of intact paint is not practical, since the time for removing the paint takes to long. This process is not economically. But damages paint after welding or fairing

work will be removed. And also dirt likes fumes, salt and others. This deep cleaning results also in a roughness as got in the shop-primer plant.

In case you need to apply a coating scheme, which is tolerant with the used shop-primer and which needs a roughness as origin from the shop-primer plant, than the CO_2 cleaning method can be considered.

The Equipment

The equipment is available form several suppliers. It consists of store boxes for the pellets, which are in liquid state frozen to minus 79°C.

Photo 1 Pellet store box


Photo 2 Dry Ice Cleaning equipment


Photo 3 The pellets


Photo 4 The cleaning nozzle

Where is CO_2 used?

The MEYER WERFT GmbH started in 1995 together with company G. Th. Freese Bremen to use this cleaning method for areas behind insulation, also called cold steel or condensate areas. The MEYER WERFT is a specialist for Cruise Liners and builds these ones in covered building docks.

Photo 5: The MEYER WERFT in 2003

Due to the complex building process with more than 1800 suppliers and the excessive outfitting work the use of blasting and applications halls is not useful. Up to 75 blocks are needed to build one cruise liner. During the day time the outfitting work will be finished and the coating work can be done during the night shift. And this overlapping result in a much shorter building period.

CO2 cleaning has been used first only for areas behind insulation, also called as cold steel area. This is mainly the inner side of the outer shell. The following distribution of surfaces for a cruise liners will show the importance of this not corrosion critical area.

under Water	5,00%
vertical sides and Superstruture	20,00%
cold steel	40,00%
Internal visible	20,00%
Tanks	15,00%

Fig 6: Distribution of surface of a Cruise Liner

Photo 6: The inner side of the outer shell with needles for fixing the insulation

Especially the removal of the fume was more than critical with a wire brush or any other method. The risk for an accident at work is with a wire brush very high. With the Dry Ice cleaning it is very easy.

Photo 7: cleaned needles, no fume any more

But also the dust during the de-rusting process is more than less for the CO2 cleaning.

Photo 8: Dry blasting of under water hull for an Ice breaker coating system

Photo 9: CO2 cleaning in proges

And especially the less dust was at the end the main factor for the MEYER WERFT to use this advanced technology instead of using wire brushing or any kind of abrasive blasting.

The removed dirt falls down from the substrate to the floor. There the residuals can be can be removed by a broom. Afterwards the coating work can start.

How does a CO2 cleaned surface look like?

Photo 10 Before the CO_2 cleaning

Photo 11 after the cleaning, even the burned shop primer has been fully removed

Are there any limitations?

Yes, there are some. First of all CO_2 is a dangerous gas. A small amount of CO_2 in the air can kill you. Therefore MEYER WERFT requests to their applicator to use CO2 warning devices every time. In tanks or closed areas, where the CO2 can cause any danger, the use is forbidden.

And the price?

If we only compare the de-rusting and cleaning of CO_2 with e.g. ST 2 by brush, than of course CO_2 is more expansive. But if we look to the benefit of all parties involved including H&S, than CO_2 becomes much cheaper.

Summery

CO_2 cleaning is nothing brand new. It's an already proven system. But it is still an uncommonly method. But as long as you have de-rusting work together with outfitting work in one hall and in one block the use of dust or water intensive methods will reduce the efficiency of the whole building process itself.

References

Fig 1 to 5 from Linde Gas
Photos 1 to 4 and 9 to 11 from EDL, application team at MEYER WERFT
Heck, Walter, Dry Ice Cleaning for Surface Preparation, Schiffbauforschung – Schriftenreihe für Ingenieurwissenschaften 1 2007, Universität Rostock