2C/1F ENAMELLING PROCESS – A PROWING DEMAND

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2C/1F Enamelling Process - a Prowing Demand

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I. Introduction

The purpose of this paper is to establish a review of various 2 C/1F systems, which all contribute to an environmentally favourable application system along with energy savings, increased production, capacity and efficiency.

In the industrialized countries there is an increasing demand for enamel application systems that will reduce on going environmental issues. Addressing these concerns will help to bring pollution under control and possibly, to be brought in the future to a standstill. To realize the goal of halting pollution, more and more the principle of “the one who pollutes should pay” will apply. Organizations will be forced to take more stringent, compliant measures.

The driving forces not only concentrate on the environment, but also on the surface quality, economic use of enamel and automatic application flexibility, along with the use of low carbon steel with 0,03 – 0,08% C instead of the more expensive decarburised steel quality with 0,003 – 0,008% C.

A positive contribution to the environment and cost saving can be achieved by:

a. The known process of pre-treatment of the sheet steel by degreasing and rinsing rather than the acid pickling and the nickel treatment
b. Increased enamel material transfer efficiency by utilizing spraying systems with high material transfer efficiency

c. introduction of low fluorine and fluorine free enamels
d. The re-use of recovered enamel as much as possible
e. Spray booths concept designed as closed systems. The air is cleaned from overspray material and carried back into the working environment by passing through a dry filter
f. The re-use of water by using a waste water cleaning and water recycling system.

II. Review of the 2 C/1F enamelling systems

The following 2 C/1F systems are in use today:
comparison between the 3 processes:

A) 2 C/1 F – Powder / Powder
B) 2 C/1 F – Wet / Powder
C) 2 C/1 F - Wet / Wet

In principle, these three systems are based on so-called liberty ground coat enamel combinations and therefore suitable on sheet steel, which is just degreased and not acid pickled.

The application technology is based on the following systems:

a. Powder-Powder

The powder ground coat and the powder cover coat enamel are applied on top of each other by electrostatic powder application. No drying is needed. The coating is then fired simultaneously. This process was introduced in the USA for one side application and in Spain in 1979 at the company Fagor

b. Wet-Powder

The thin ground coat is applied in the wet system by means of electrostatic or robot spraying and then completely dried. After a very short drying process with infra-red drier the powder cover coat enamel is applied by electrostatic application and then fired.

After the introduction and installation of the first 2C/1F wet/dry system in France in 1987, it still took some time before this process was introduced in other countries. During the following years various manufactures started to use this method for their product enamelling. In 1991 Electrolux Sweden and a second company in France moved to the 2c/1f-wet/dry system.

In Italy the firm, Gasfire switched in 1992 form dry/dry to wet/dry (for ranges) and the firm, Indesit (for ranges) started to implement wet/dry in 1992 as well.

Due to the very positive results in Sweden, the Electrolux, the firms Voss in Denmark (for ranges) and Soreman in France (for ranges) both started in 1993 with the wet/dry system.

In 1996 the Italian cooker producers Smalteria, Technogas and Whirlpool also made the move towards the wet/dry system.

Three companies were added to the list in 1997: Gunkol-Teba in Izmir (Turkey), VZUG in Switzerland and Moravia in the Czech Republic.

In 1998 the fourth Electrolux plant followed in Norway.

For 1999 there are two companies on the list: Elekthermax in Hungary and Grepa in Norway.

c. Wet-Wet

The thin wet ground coat is applied by means of electrostatic application or dipping (also possibly by electrophoresis).

As no drying is required after this process, the cover coat is applied wet by electrostatic means. After complete drying the enamel layers are fired together.

Some examples of companies where we installed the 2C/1F in wet/wet:
in Argentina at Orbis Mertig, in Poland at Fagor Mastercook and Whirlpool (PL)

III. The steel quality and the steel pre-treatment

- Although frequently low carbon steel is also used in the application of the powder-powder system a decarburized steel quality is recommended, in particular when the steel is coated on two sides.
- Until now for the wet-powder system (de-greased) decarburized steel was used. Recently acceptable results (one side application) have been reported in using normal steel quality.
- With the 2 C/1 F wet-wet application system good results have been obtained on low carbon steel.

Generally speaking, we can say that the requirements of the customer in relation to the surface aspect might contribute to the choice of the steel quality.

As far as the pre-treatment of the steel is concerned the following points should be taken into consideration.

- The sheet steel should be well de-greased to prevent undesired gas reactions during the firing cycle
- The acid pickling of the steel is not necessary, because in the three mentioned 2 C/1F systems a liberty ground coat enamel combination is applied.
- Pickling should therefore be only used when corrosion remains on the steel surface.

IV. The various enamel combinations for the 2C/1F system

A. <u>The ground coat</u>

The purposes are:
- to achieve a good enamel adherence by using sheet steel, which is only de-greased
- to get a faster out gassing from the ground coat before the cover coat is closed
- to avoid black spots where we recommend to use a lower softening temperature and higher surface tension

B. <u>The coating thickness of the ground coat enamel</u>

In principle the ground coat layer has to be thin but thick enough to allow various repair and firing cycles.
- A thicker ground coat layer means more gas bubbles, which can pose the problem of so-called pinholes in the cover coat enamel.
- A thick powder ground coat enamel may lead to more heavy gas reactions due to organic mill additions to the powder enamel.

A wet ground coat requires:
Slip parameters for wet ground are:

- milling fineness: 2-5 / 16.900 mesh
- specific weight: 1,45 – 1,60 g/ccm
- thickness: 40-80 microns

For the 2C/1F process a very thin layer on all surface areas is always required. To assure a thin ground thickness (depends on the frit suppliers who have different requirements between 40 – 80 microns) a fully automatically applied coating is needed. The application system for both ground at wet/powder and wet/wet is the same.

C. The cover coat enamels

It is recommended to choose a cover coat enamel which remains “open” on the surface during the firing cycle and fuses at a later time.

In this way, bubbles, which have possibly already risen from the ground coat, can escape. In practice, this means using cover coat enamels with a higher softening temperature.

Slip parameters for wet cover coat are:
- milling fineness: 0,5 – 1,5 /3.600 mesh
- specific weight: 1,70 – 1,72 g/ccm
- thickness: 120 - 140 microns

V. Firing conditions for 2 C/1F 1 fire system

Generally speaking there are no special firing conditions needed compared to 1C/1F or 2C/2F. Except for powder where the air curtains may have to be adjusted.

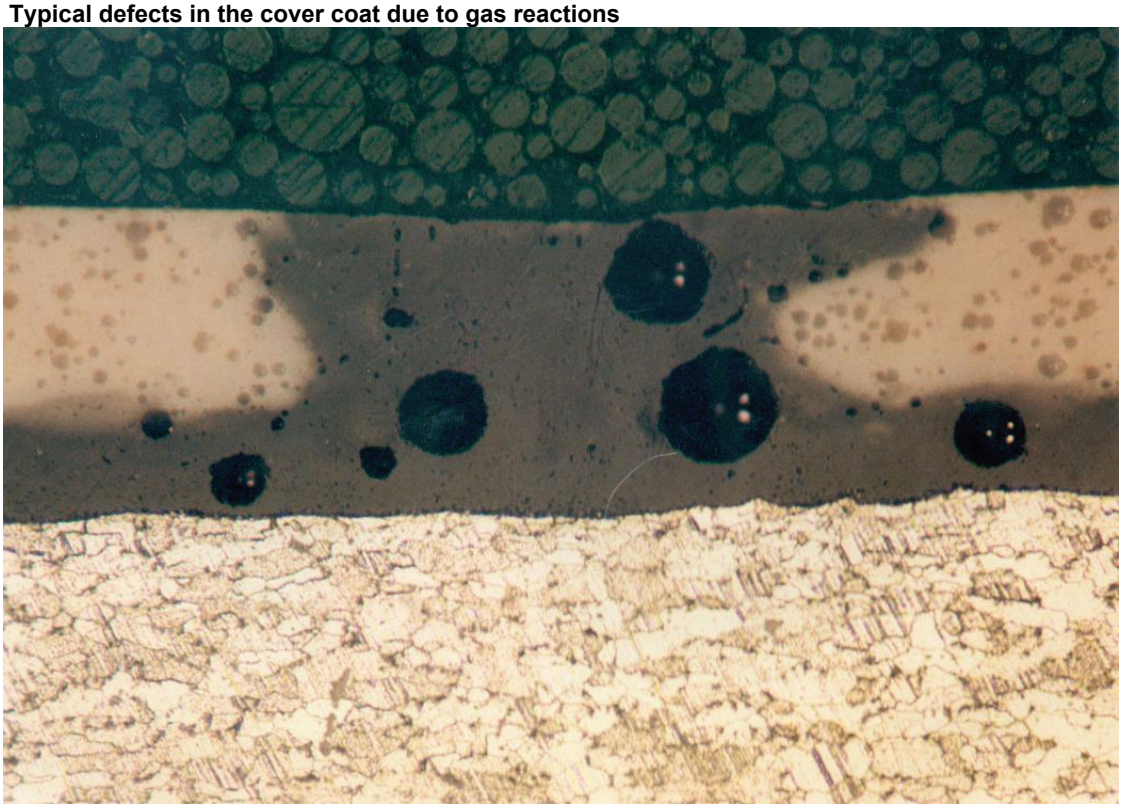
VI. Gas reactions and enamel faults

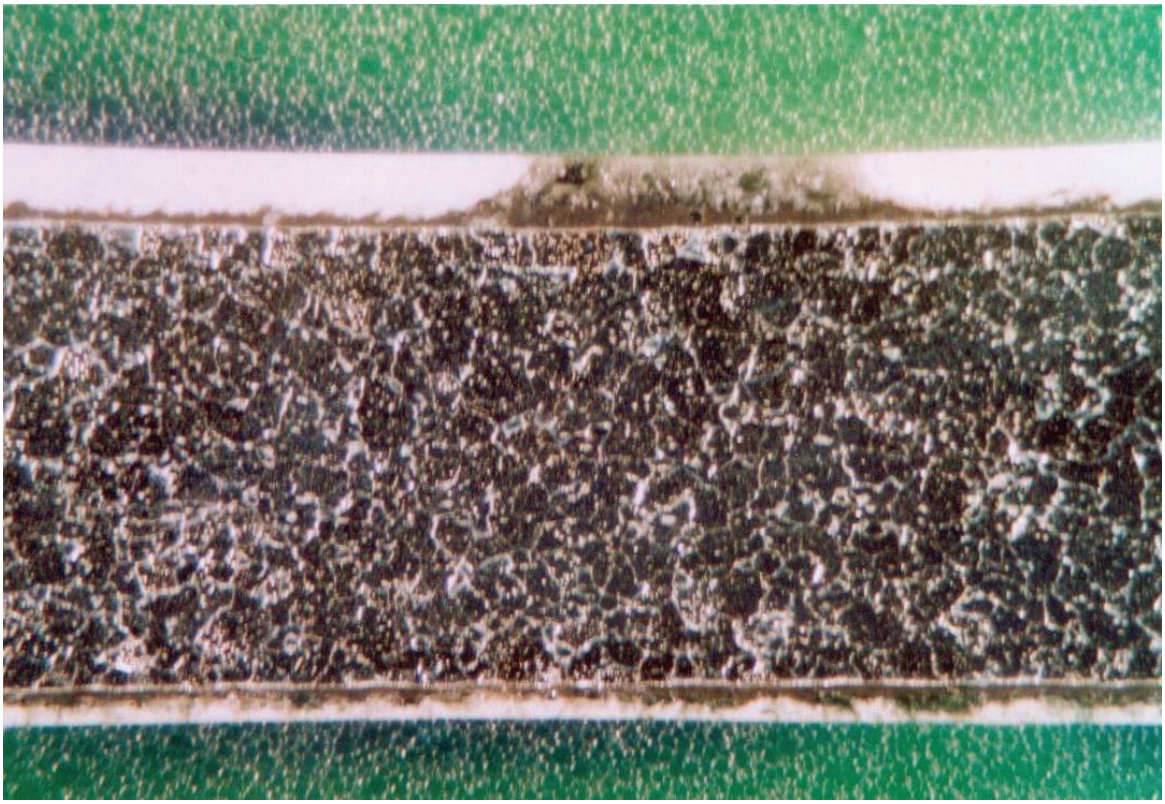
The most frequent faults happening during the firing of ground and cover coat are:
black spots and pinholes which have various origins.

Pinholes rise up through the cover coat according the viscosity degree of enamel.

Black spots which are visible in the cover coat result most of the time from gas bubbles deep in the ground coat. The ground coat enters into the bubbles and rises to the cover coat surface.

Typical defects in the cover coat due to gas reactions





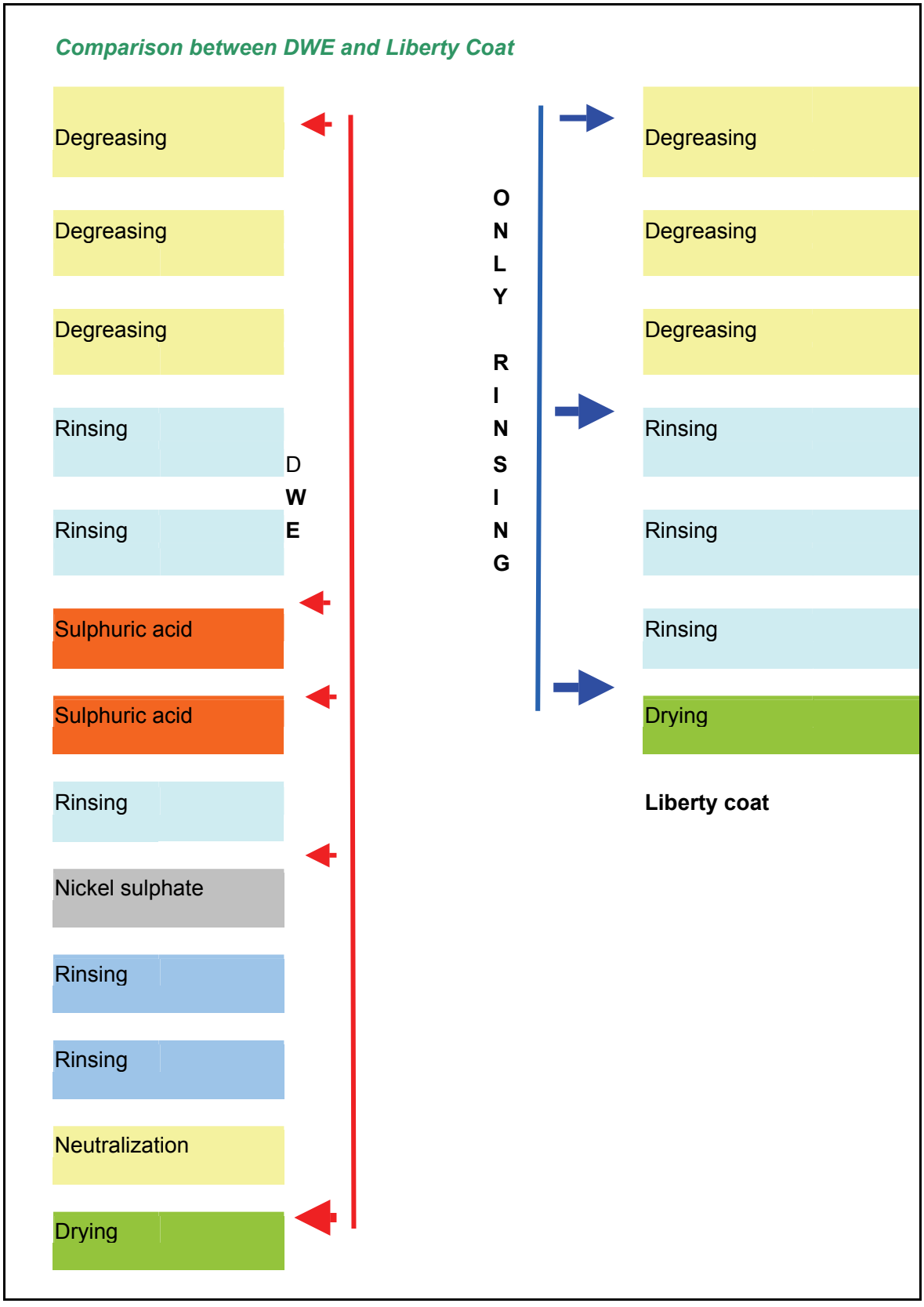
Ground + Cover Coat

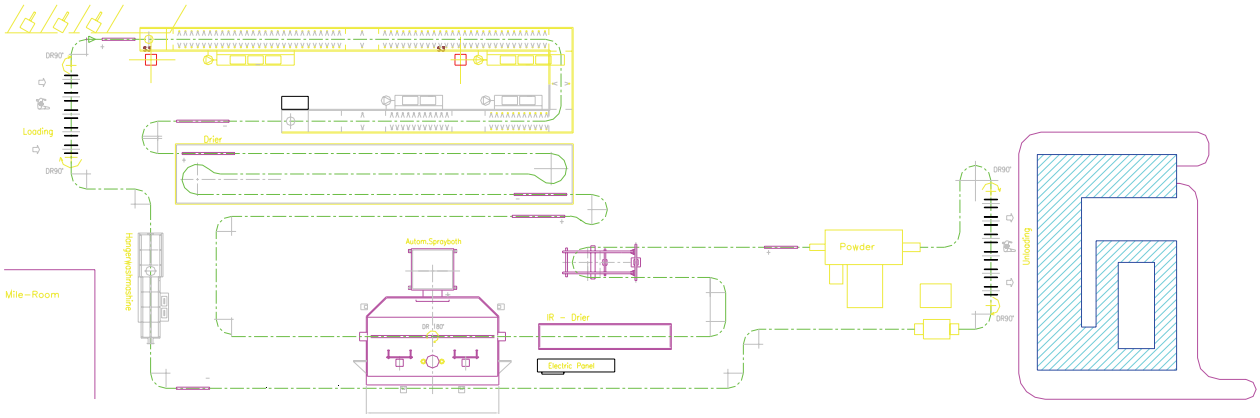
VII Advantages and disadvantages of the various 2C/1F process

POWDER / POWDER		WET / POWDER		WET /WET	
					
Large production of flat parts clean system high degree of automation No milling No drying Possible smooth surface	Difficult with complex part design Limited choice of colours Air conditioning Constant recycling of big quantity of powder High abrasion of spraying nozzles High investment costs	Large production of flat parts clean system high degree of automation coating thickness up to 80 microns	Limited choice of colours Air conditioning Constant recycling of big quantity of powder High abrasion of spraying nozzles High investment costs	All colours possible Except with cadmium Quick colour changes Saving of energy for drying only once No air conditioning needed Lower investment costs	Waste water recycling Less material efficiency Reworks 5-10% higher than P/P or W/P

VIII The 2 C/1F system compared to the direct-on white enamelling System

A major advantage of the 2 C/1F system is the possibility of replacing the direct-on white enamelling.





The direct-on enamelling was introduced in the early sixties and presented extraordinary advantages to the traditional 2 C/2F enamelling system.

The advantages, of course, were that titanium enamel could be applied directly on decarburized steel with a thin nickel layer, just one enamel layer and one firing.

A disadvantaged of the very complicated steel pre-treatment (intensive acid pickling and the nickel treatment) were less important than the big advantages like energy saving, enamel savings and the increase in the production capacity.

However, today the expenses for cleaning the waste water are a burden on the budget (pre-treatment baths). It can therefore be said that the trend is to invest into the 2 C/1F application system instead of the direct-on white enamelling.

This choice also seems to be justified from a technical point of view, certainly with regard to the results obtained today.

Finally, it can be said that when applying a 2 C/1F system the steel pre-treatment can be integrated into the enamel application process, leading to less handling of the item to be enamelled. The complicated charging and discharging of the pre-treatment installation is therefore something belonging to the past.

In new installations, passivation can be eliminated as the parts go to the pre-treatment, through the drier and directly to the various application systems.

IX. Equipment

There is no doubt that the application of enamel on steel in 2C/1F wet/powder or wet/wet has an excellent cost performance ratio. Economics calculation gave that for 50% good results, it was possible to reduce the costs of 25% depending on the conditions of production.

It is nevertheless the prime necessity of the enameller to keep and control strictly the production parameters such as steel quality, pre-treatment, choice of enamel and the choice of the whole plant equipment.

The efficiency of the application process also depends on adequate:

- **pre-treatment systems** by dipping or spraying keeping in one's mind the ecological aspect of the production

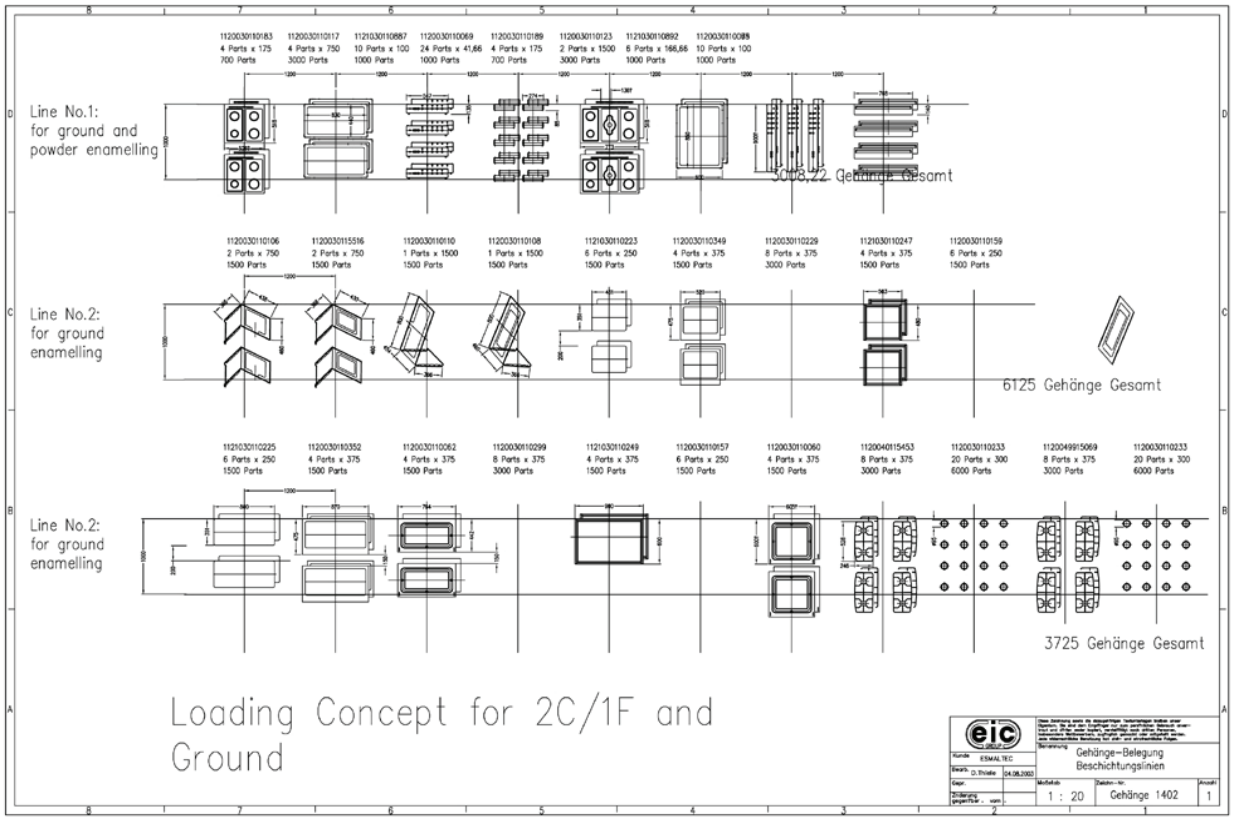
- **spray booths with low pressure spraying systems** allowing a very high efficiency of the over-spray recovery inside the spray booth area

Wet application

Powder application

- **Dry filter technique** collecting the finest enamel particles. A very ecological filtration allowing to resend the filtered air into the enamelling shop

- **Hanger systems**. A customer specific hanging system creates the highest efficiency of application. Designed with components for single and back to back double hanging concepts, the hangers are flexible for positioning and for hanging parts of different sizes



- dryer and furnace

Dryer

Furnace

X. Conclusion

Improved quality at reduced running costs with less material waste, reliable equipment, latest technology, fully automatic production, low cost maintenance allowing investment savings, are the major factors in choosing and installing the new technology. This is the result of practical experience and customer related research.

Source documents:

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