

HO CHI MIN CITY - APRIL 18,2017 / HANOI - APRIL 20,2017



OFFICINE MECCANICHE

# AUXILIARY EQUIPMENTS FOR E.A.F. AND LADLE METALLURGY

*AUTOMATIC INERT GAS COUPLING  
(I.G.C) SYSTEMS FOR LADLE METALLURGY*

*MELT SHOP PROCESS, SLAG DOOR  
ISSUES AND A SOLUTION FOR ENERGY  
AND YIELD OPTIMIZATION IN THE  
ELECTRIC ARC FURNACE*

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# SHORT COMPANY'S PROFILE

## PROJECTS, ENGINEERING AND MACHINERY CONSTRUCTION:

the headquarters of C.M.P. Officine Meccaniche S.r.l., located on a site of approx 15.000 m<sup>2</sup>, is close to the border with Austria and Slovenia, some 140 Km form Venice in the extreme North-East of Italy



## 1975/2017 MORE THAN 40 YEARS EXPERTISE:

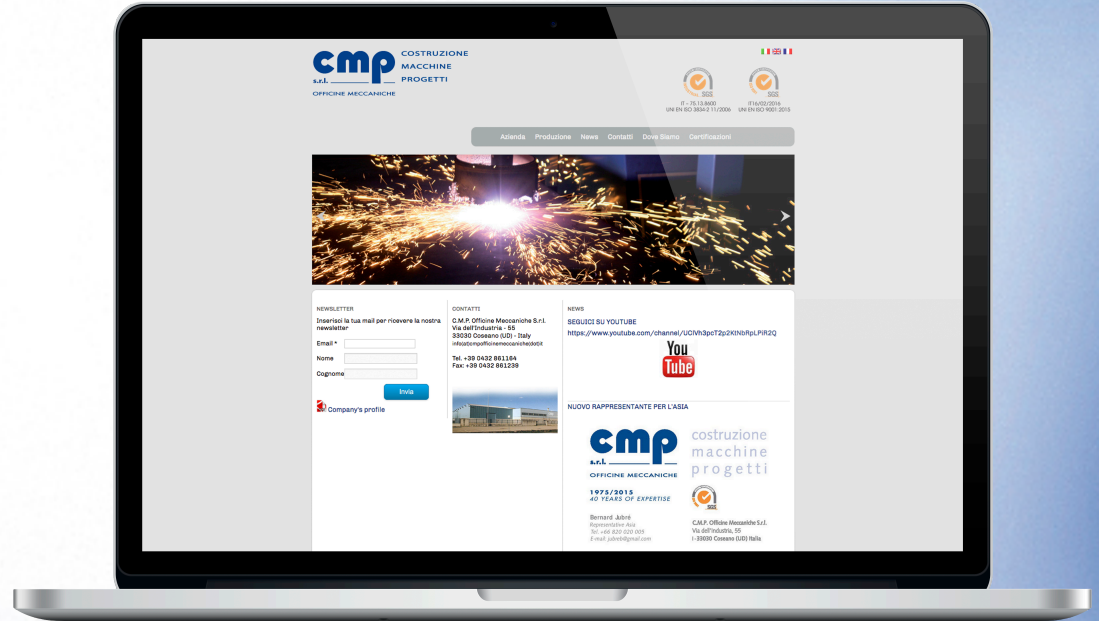
C.M.P. Officine Meccaniche S.r.l. has been operating on the Italian and international market since 1975, offering top quality and consolidated experience in the production of equipment and plants for steel industry, metalworking sector and mechanical engineering in general.



# SHORT COMPANY'S PROFILE

## PRODUCTS AND SERVICES:

the offering includes a broad range of technologically advanced a reliable products and services concerning specific machines and plants for steel industry



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# SHORT COMPANY'S PROFILE

**C.M.P. Officine Meccaniche S.r.l**  
has been certified according to the  
UNI EN ISO 9001: 2015 certificate n° IT16 / 0216  
was issued by SGS for the following activities:  
**“Design and manufacture of machines  
and equipment for the steel and  
mechanical industry”**

**C.M.P. Officine Meccaniche S.r.l**  
has been certified according to the  
UNI EN ISO 3834-2: 11/2006  
The certificate No. 13 / 090P\_IND was issued by  
SGS for the following activities:  
**“Industrial Machines”**

## CERTIFICATIONS:



IT – 75.13.8600  
UNI EN ISO 3834-2 11/2006



IT16/02/2016  
UNI EN ISO 9001:2015

**C.M.P. Officine Meccaniche S.r.l**  
has been certified according to  
EN ISO 1090-1: 2009 + A1: 2011.  
The certificate No. 1381-CPR-396  
was issued by SGS for the following activities:  
**“Compliance of the factory production  
control system for structural steel”**

# AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEMS FOR LADLE METALLURGY

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## WHY AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEMS?

Ladle metallurgy is practiced in nearly every steel plant in the world, and the majority of plants utilize bottom stirring plugs. This stirring plugs require a gas line connection to the ladle. This connection can be made manually or automatically by a different mechanism.

If this connection is made automatically, stirring can be performed in locations that may otherwise not be possible.



# BENEFITS OF AUTOMATIC INERT GAS COUPLING (I.G.C) SYSTEMS

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## Metallurgical benefits:

- Gas stirring during tapping achieves rapid homogenization and can save minutes at subsequent processing locations since a representative sample and temperature/oxygen activity measurement can be taken immediately.
- Slag/metal mixing with synthetic slags is promoted during and after tapping which ensures early slag fluxing and enhances slag/metal reactions which can also save considerable treatment time.
- Post treatment stirring can be carried out at any location to promote inclusion floatation and/or prevent temperature stratification, introducing a new degree of operational flexibility.
- The coupler can be used in conjunction with any process which requires porous plug stirring, e.g. chemical heating station, tank degassing, ladle furnace etc.

# **BENEFITS OF AUTOMATIC INERT GAS COUPLING (I.G.C) SYSTEMS**

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## **Improving porous plugs availability in overall plant operations:**

- Gas stirring during tapping prevents freezing over or skulling of the stir plug.
- Use of the coupler on the ladle preheat stand not only allows the plug operation to be checked (flow, back pressure etc.), but it also allows maintaining a small gas flow throughout preheating to prevent melting slag glaze from covering the plug.

## **Reduction of specific manpower:**

- An automatic coupling system eliminates placing an operator in close proximity to the ladle. Without any operator directly involved in the stirring phase, these couplings could have eliminated a number of accidents that resulted in burns due to ladle eruption

## **SUMMARIZING OF BENEFITS OF AUTOMATIC INERT GAS COUPLING (I.G.C) SYSTEMS**

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Overall, the development of the automatic coupler has brought a new level of flexibility and reliability to the operations of porous plug users. The following summarize the benefits of automatic coupling:

- **simple operation;**
- **easy installations onto existing ladle cars,**
- **supports stands, etc;**
- **only minor ladle modifications are required;**
- **easy integrations into existing gas supply systems;**
- **minimal maintenance required;**
- **metallurgical benefits, i.e. Homogenization during tapping, promotion of synthetic slag reactions, inclusion floatation, prevention of temperature stratification, reductions in secondary treatment**
- **times, improved porous plugs availability;**
- **reduction of specific manpower: no operators directly involved;**



## DIFFERENT SOLUTIONS FOR AUTOMATIC INERT GAS COUPLING (I.G.C) SYSTEMS

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- In a typical steel works situation gas coupling is required at multiple locations. It can be installed to connect the porous plug on the ladle transfer car during tapping other than utilized at the ladle furnace or ladle treatment stations.
- During the engineering phase every position where the ladle may be placed must be checked for interferences. This study is imperative to ensure the system will function and not be damaged. This includes ladle cars, stands, repair locations (both vertical and horizontal), turrets etc.
- Once the engineering has been performed, the most appropriate coupling device(s) can be proposed for each and every location.

# DIFFERENT SOLUTIONS FOR AUTOMATIC INERT GAS COUPLING (I.G.C) SYSTEMS

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To accomplish this, the various options available for automatic gas couplings to supply gas to a ladle supplied by **C.M.P. Officine Meccaniche S.r.l.**, are:

## **VERTICAL AUTOMATIC INERT GAS COUPLING SYSTEM:**

The coupling procedure is performed when the ladle is lowered into the set-down location.

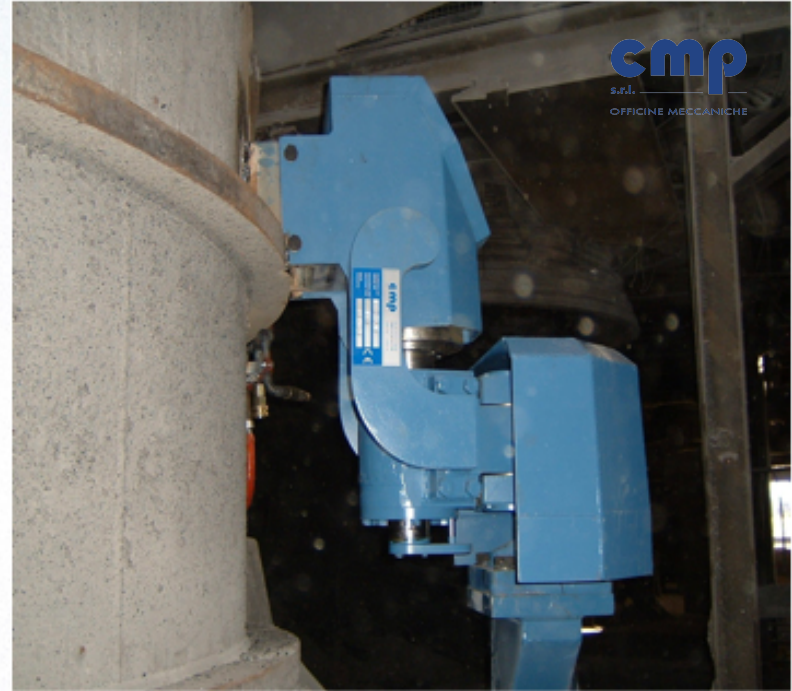
## **HORIZONTAL AUTOMATIC INERT GAS COUPLING SYSTEM**

The coupling procedure is performed horizontally by means of the fixed portion of the connection placed on the set-down location.

For both vertical and horizontal coupling systems, to ensure successful coupling, the ladle must be guided into position with a reasonable level of accuracy by a set of ladle guides located on the support stand

## VERTICAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

This gas coupling can be used to provide an automatic connection for inert gas supply between a mobile ladle and a ladle set-down location; this includes:

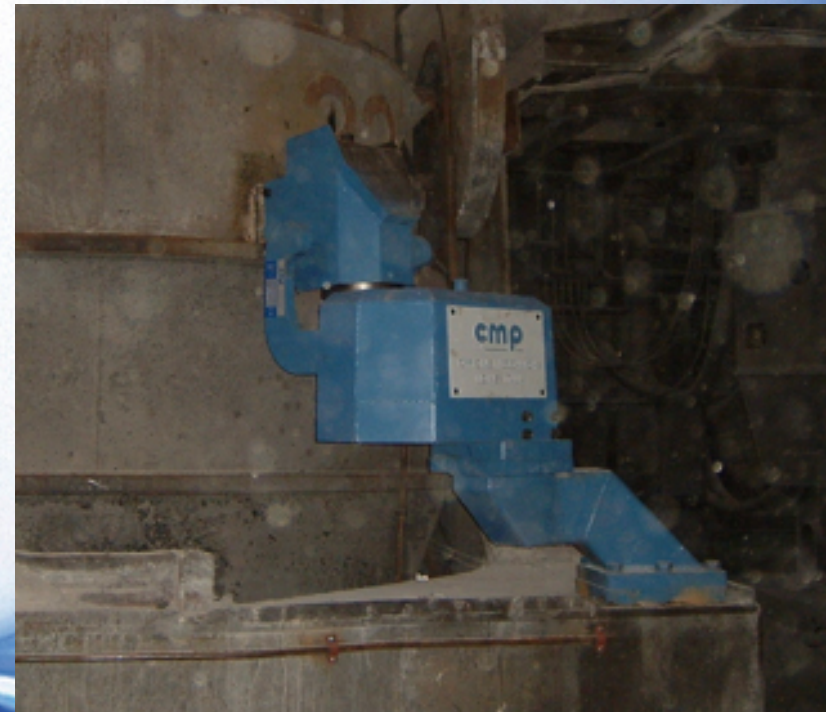


- ladle cars; ladle furnace; ladle stands; VOD/VD; ladle turret; repair locations special application, tailor made for any customer needs
- **The coupling procedure is performed when the ladle is lowered into the set-down location.**
- The coupling can simultaneously supply one, two or three porous plugs, with inert gas.
- **HT Vertical I.G.C.:** the high temperature solution enables the application in VD and VOD plants.

# CONFIGURATION OF VERTICAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

The **Vertical I.G.C. system** consists of:

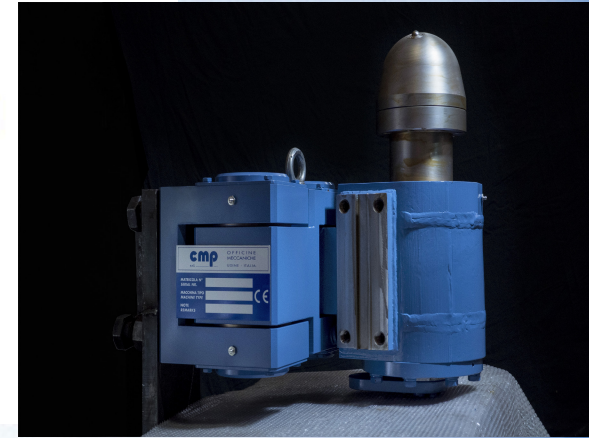
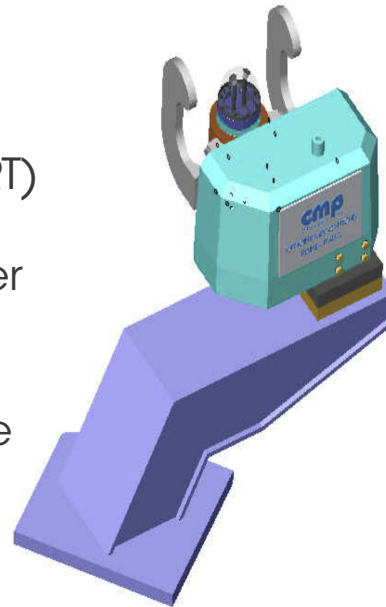
- a **FEMALE COUPLER PART (UPPER PART)** mounted on the ladle;
- an articulated **MALE COUPLER PART (LOWER PART)** mounted on the ladle set-down location;
- The female coupler part on the ladle is connected with the porous plugs using rigid piping.
- The male coupler part is connected to the inert gas supply lines using flexible hoses to compensate for ladle placement and connecting inaccuracies.
- A back-up system is provided.



# MORE IN DETAIL OF CONFIGURATION OF VERTICAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

## MALE COUPLER PART (LOWER PART)

- the MALE COUPLER PART (LOWER PART) will be screwed-up on a supporting structure, welded on the ladle transfer car or other ladle set-down location;
- The male connector part shifts on the vertical axe and its pressure on the female connector part is accomplished by means of a spring;
- The horizontal shifting allows a perfect connection during the ladle down-grading;
- The male connector part is complete of heat resistant, slag, steel spills and bumps protections.



# MORE IN DETAIL OF CONFIGURATION OF VERTICAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

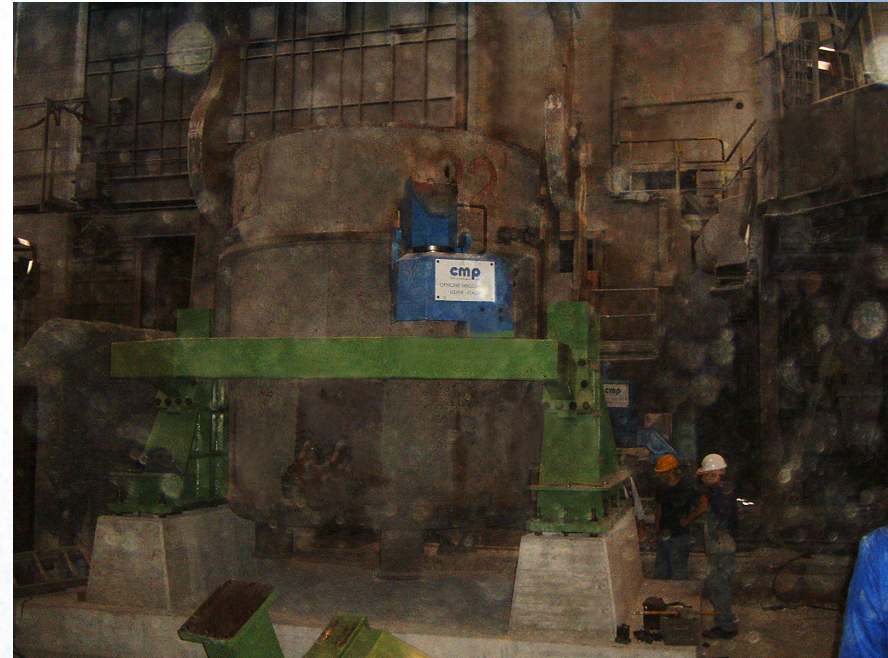
## FEMALE COUPLER PART (UPPER PART)

- the **FEMALE COUPLER PART (UPPER PART)** will be applied to the ladle by means of a support welded to the shell of ladle as well.
- The gas seal between the male coupler part and the female coupler part will be carried out by o-rings.
- Insulating material will be inserted between the support and the female connector in order to protect the seals on the female coupler part.



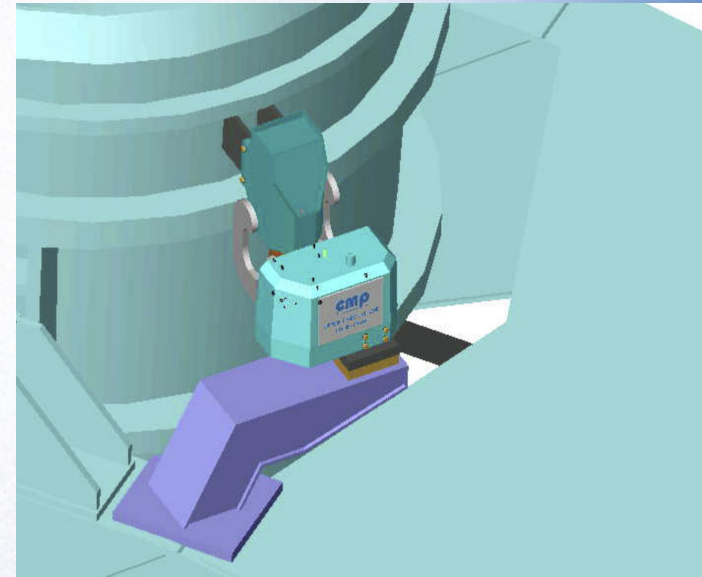
# CONNECTION OF VERTICAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

- During the ladle down-grading on the ladle set-down location, the connection between the MALE COUPLER (LOWER PART) and the FEMALE COUPLER (UPPER PART) part will be accomplished on the vertical axe, with the female coupler's pressure absorbed by a spring assembled on the male coupler part, and on the two orthogonal axes in the horizontal plane of the male coupler part.



## CONNECTION OF VERTICAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

- Vertical inaccuracies while making connection are compensated using a helical spring and the horizontal inaccuracies are taken up by an articulated arm and springs;
- The male coupler part shifts on the vertical axe and its pressure on the female coupler part is accomplished by means of a spring;
- The horizontal shifting allows a perfect connection during the ladle down-grading;
- The gas seal between the male coupler part and the female coupler part it is carried out by an O-ring (wear part). The O-ring replacement is easy and is done without loss of time, normally at the maintenance of the ladle, at the end of a ladle "campaign"





# VERTICAL AUTOMATIC I.G.C MALE/FEMALE PART CONNECTION

## TECHNICAL DATA FOR AUTOMATIC VERTICAL INERT GAS COUPLING (I.G.C.) SYSTEM

- ambient conditions: extremely dusty air
- ambient temperature: max 250°C - HT 600°C
- inert gas: argon or nitrogen
- nominal working pressure: max 24 bar
- working pressure of inert gas: max 30 bar
- number of supply points: max 3
- max vertical movement:  $\pm 30$
- horizontal movement:  $\pm 40$  in both axes
- The inert gas supply is **separately** and remotely controlled via shut-off valve(s).
- The coupling parts, the bolted connections and the hose and pipe connections need to be protected as effectively as possible against slag and steel spills.



## **HORIZONTAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM**

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This automatic coupling unit enables the argon supply to be horizontally connected to the stir plug piping on the ladle automatically.

The coupler connects between a fixed point on ladle set-down location and a mobile ladle; it includes:

- ladle cars; ladle furnace; ladle stands; ladle turret; repair locations
- special application, tailor made for any customer needs
- **The coupling procedure is performed horizontally by means of the fixed portion of the connection placed on the ladle set-down location.**
- The coupling can simultaneously supply one or two separately-controlled porous plugs, with inert gas.

# CONFIGURATION OF HORIZONTAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

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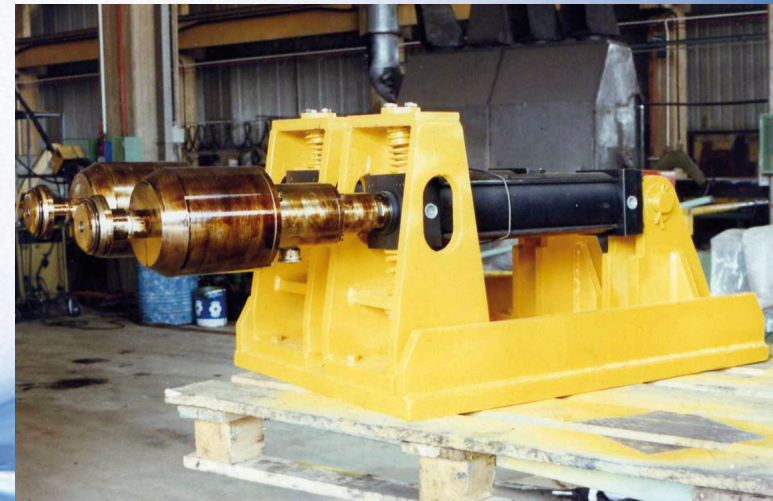
The Horizontal I.G.C. system consists of:

- a **FUNNEL SHAPED RECEIVER (MOBILE PART)** mounted on the ladle;
- **one or two** (depending on the numbers of porous plugs.) **HIGH PRESSURE CYLINDER COUPLER (FIXED PART)** mounted on the fixed part of the ladle set-down location;
- Fixed and flexible pipe work then connects the receiver to the porous plugs located in the bottom of the ladle.
- The male connector part of the coupling is connected to the inert gas supply lines using fixed and flexible hoses.
- A back-up system is provided.

# MORE IN DETAIL OF CONFIGURATION OF HORIZONTAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

## HIGH PRESSURE CYLINDER COUPLER (FIXED PART)

- the **HIGH PRESSURE CYLINDER COUPLER (FIXED PART)** is attached to the fixed structure of a ladle set-down location. This part is mainly made of one or two high pressure cylinders, depending on the numbers of porous plugs.
- The whole assembly is covered and protected by a heavy box with a refractory outer coating. When not in use, the actuated part of the coupler is completely withdrawn and protected inside the box.
- Attached to the piston rod of the cylinder there is an hardened steel end piece which has a drilled hole in its end. This hole is connected by a side tapping to the main stirring argon supply, via fixed and flexible pipe work. The actuation (extension) of the cylinder is accomplished using gas that is tapped off the same argon pipe work the supplies the stir plug.
- The male connector part is complete of heat resistant, slag, steel spills and bumps protections.



## **FUNNEL SHAPED RECEIVER (MOBILE PART)**

the **FUNNEL SHAPED RECEIVER (MOBILE PART)** made from hardened steel. Each ladle will be equipped with an identical receiving funnel and piping system.

The center of the receiver is bored and an O-ring seal is set into a recess round the bored hole.

Insulating material will be inserted between the support and the funnel shaped receiver

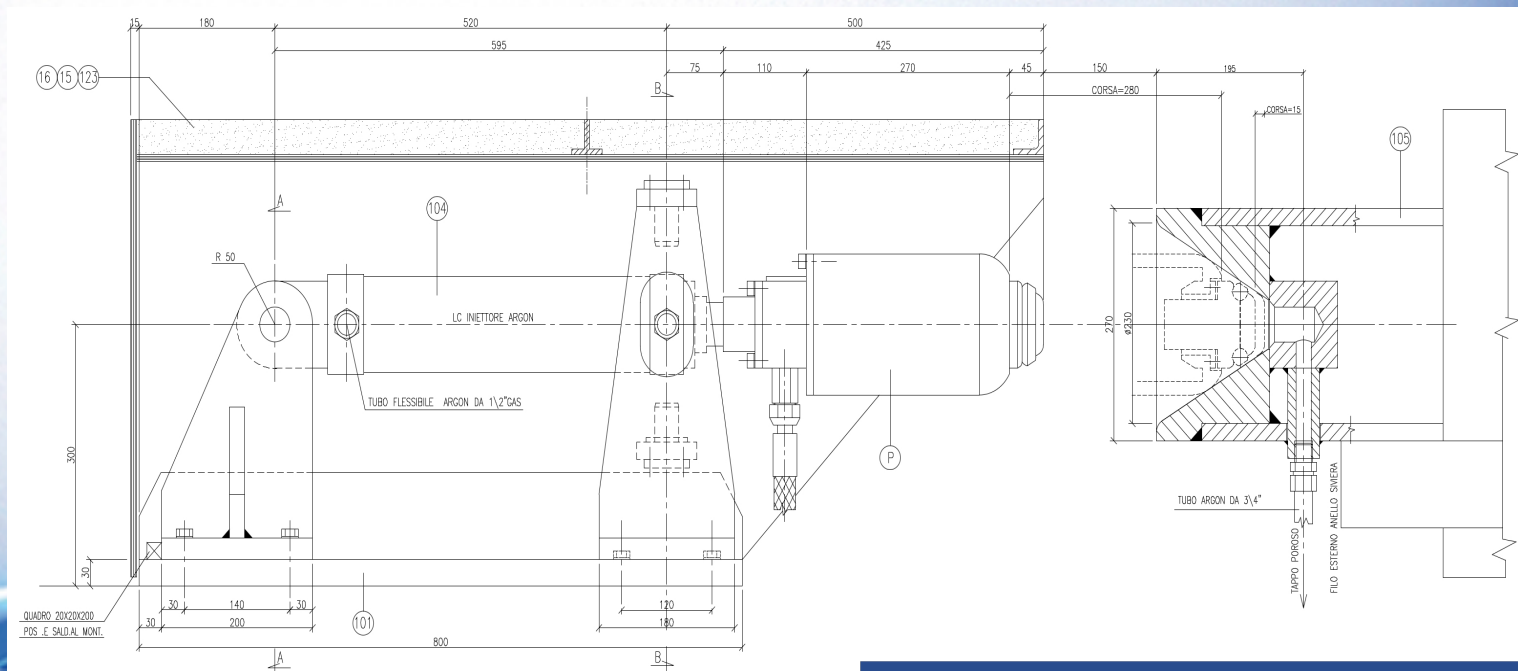
Fixed and flexible pipe work then connects the receiver to the porous plugs located in the bottom of the ladle.



# CONNECTION OF HORIZONTAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

When the ladle has been placed on the car or turret or other ladle stand, the operator presses a push bottom to open a valve in the argon supply line.

The argon flows first into the full bore side of the cylinder, pushing the piston rod out until the end of the piston rod locates in the funnel bolted to the ladle side wall, making a connection.



# CONNECTION OF HORIZONTAL AUTOMATIC INERT GAS COUPLING (I.G.C.) SYSTEM

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Vertical/horizontal inaccuracies while making connection are compensated using a helical springs;

The gas seal between the male connector part and the female connector part it is carried out by an O-ring (wear part).

The O-ring replacement is easy and is done without loss of time

# HORIZONTAL AUTOMATIC I.G.C MALE/FEMALE PART CONNECTION

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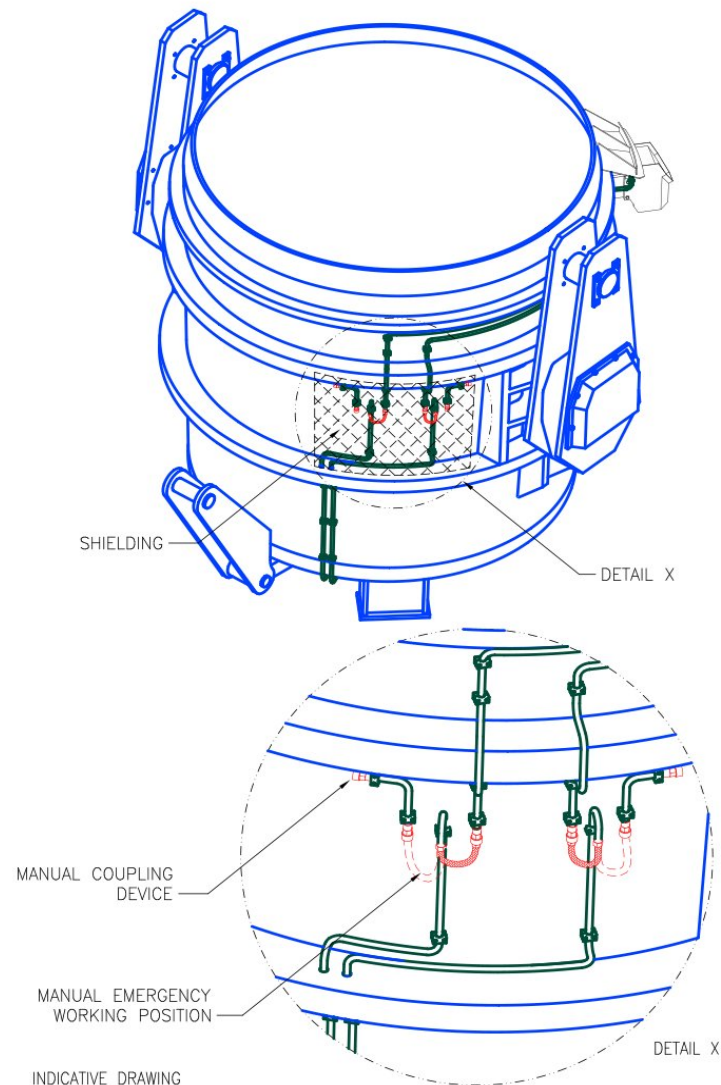
## TECHNICAL DATA FOR AUTOMATIC HORIZONTAL INERT GAS COUPLING (I.G.C.) SYSTEM

- ambient conditions: extremely dusty air
- ambient temperature: max 250C°
- inert gas: argon or nitrogen
- nominal working pressure: max 25 bar
- working pressure of inert gas: max 30 bar
- number of supply points: max 2
- vertical movement:  $\pm 25$  mm
- horizontal movement: 500 nearly
- The inert gas supply is separately and remotely controlled via shut-off valve(s).
- The coupling parts, the bolted connections and the hose and pipe connections need to be protected as effectively as possible against slag and steel spills.



## MANUAL BACK-UP FOR AUTOMATIC INERT GAS COUPLING SYSTEMS

Inert gas from automatic I.G.C. systems to the ladle porous plugs is conducted by a pipe plant on ladle body. The plant is designed to allow operators to bypass the automatic coupling operations and to set on a manual connection of the inert gas feeding, in case of need. This change of use is made by a flexible hose connection. Manual device are complete of slag protections. With reference of the following indicative drawing, there are indicated the positions of the hoses to set on the automatic or manual connection, for a 2-ways I.G.C. system.



## CONCLUSIONS

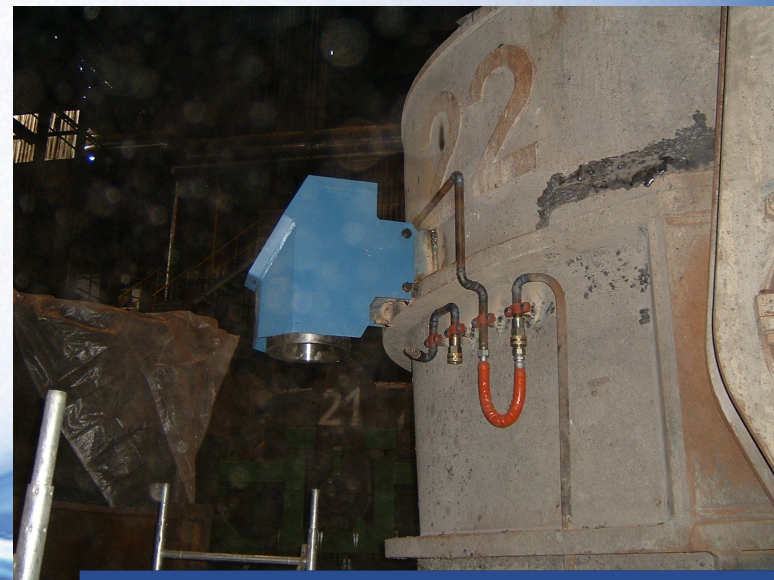
Automatic gas coupling provide a safe, reliable method to connect gas line to the ladle.

Benefits of coupling systems implementation include:

- Improvement of product quality;
- Reduction in treatment times;
- Reduction of costs;
- Increase in the overall reliability of the steel making process;
- Safety to avoid accidents caused by ladle eruptions.

**All these combined define the success of the process technology employed. With the automatic gas coupling, the manual connection is only required as an emergency back up system.**

**C.M.P. Officine Meccaniche S.r.l. has been supplying inert gas coupling systems for ladle metallurgy since 1996. More than 300 ladles have been equipped.**



# MELT SHOP PROCESS, SLAG DOOR ISSUES AND A SOLUTION FOR ENERGY AND YIELD OPTIMIZATION IN THE ELECTRIC ARC FURNACE

## WHY FOCUSING ON SLAG DOOR ISSUES?

E.A.F. tap-to-tap time, energy saving, real time scheduling of operations, life of the slag door refractory layer bricks improving and workforce safety are probably important parts of the success key points of an effective melt shop process. Every melt shop technician and all the people involved in the steel making process well know the issues that the E.A.F. slag process needs to be fulfilled to achieve an economically and metallurgical successful process.



# MELT SHOP PROCESS, SLAG DOOR ISSUES AND A SOLUTION FOR ENERGY AND YIELD OPTIMIZATION IN THE ELECTRIC ARC FURNACE

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## **SLAG DOOR AS TRADITIONAL COLD SPOT**

The cold temperature normally experienced in the slag door area causes the not melted scrap presence in this zone for an important part of the process time. The E.A.F. slag door acts as an open window, that often cannot be closed completely before the scrap present on the inner sill will have finished to melt. By this open window represented by the door, a huge amount of cold air enters the E.A.F. furnace and heavily lowers the furnace efficiency;

## **SLAG DOOR AS A WELL KNOWN TUNNEL TRAP SCRAP**

The cold scrap presence in the inner sill and inside the slag door tunnel is prolonging the phase-on time to get the completed melted bath and the right metallurgical temperature. This extra time represents a dramatic increasing of the economic costs that cuts an important part of the final economic profit.

# MELT SHOP PROCESS, SLAG DOOR ISSUES AND A SOLUTION FOR ENERGY AND YIELD OPTIMIZATION IN THE ELECTRIC ARC FURNACE

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## SLAG DOOR, TEMPERATURE TAKING AND SAMPLING ISSUES

In the E.A.F. steel making process, the slag door geometry level from the bath is changing by the instant between two taping times. This is due to the natural flow of the slag from the steel bath, during the refining phase. In this way, the operators that conduct the melting process must have serious problems to understand which is the right tilting angle, to avoid to pour steel in the slag bucket. In this scenario, the manual temperature and sampling operation becomes more critical, because the furnace position and the slag door level are changing.

## SLAG DOOR AND BASIC DE SLAGGING

Slag is a by-product and accumulates on the top of molten steel in the furnace. De-slagging is the physical separation of slag and steel. De-slagging is a critical process because it impacts:

- End product quality
- Overall production costs

# MELT SHOP PROCESS, SLAG DOOR ISSUES AND A SOLUTION FOR ENERGY AND YIELD OPTIMIZATION IN THE ELECTRIC ARC FURNACE

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## **SLAG DOOR AND REFRACTORY LAYER BRICK AS MAINTENANCE:**

Due to the fact that the traditional managing operations lead to an unknown slag door level, as the productions and the number of taps is progressing, the slag door refractory layer bricks needs to be repaired by dolomite additions very often. This operation is conducted by a manned fork lift or worse hand made or by handwork. This time has to be subtracted to the phase-on time, so this is time lost and increasing the costs of the production.

## **SLAG DOOR AND SAFETY**

The E.A.F. slag door represents the easiest outlet for every exothermic reaction effect that happens inside the E.A.F. furnace. If the injected carbon powder or other reagent joint material experiences a sudden flash-over, the burning flames will be propagating outside the furnace by the slag door clearance. Often, this accident resulted in dead or seriously injured operators.

# A SOLUTION FOR ENERGY AND YIELD OPTIMIZATION IN THE ELECTRIC ARC FURNACE: E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT

To handle the above slag door issues and achieve energy and yield optimization in the Electric Arc Furnace **C.M.P. Officine Meccaniche S.r.l.** offers an

**E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT OPTIONALLY EQUIPPED WITH TEMPERATURE/OXYGEN TAKING EQUIPMENT**



# E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT

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## IS INTENDED TO:

- CLEAR NON-MELTED SCRAP AND EXCESS SLAG DEPOSITS FROM THE EAF SLAG TUNNEL;
- PUSH THE SCRAP TOWARDS THE CENTER OF THE FURNACE THROUGH THE TUNNEL OF THE SLAG DOOR;
- AVOID SCRAP INTRUSION IN THE SLAG TUNNEL DURING BUCKET CHARGING;
- TEMPERATURE OR SAMPLE BEING TAKEN BY AN AUTOMATIC SAMPLING AND MEASURING LANCE MANIPULATOR ;
- ALLOWS CONSTANT AND AUTOMATIC DE-SLAGGING PROCESS WITH BETTER METALLURGICAL CONTROL OF THE STEEL BATH.



# E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT

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## BENEFITS OF E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT:

- **POWERED-ON REDUCTION:** the furnace can remain powered-on as the work of the pushing ram does not interfere with them with plain decrease of tap-to-tap time;
- average saving time of 2 minutes every 50 minutes tap-to-tap time:
  - 45" SAVING, due to waste time during cleaning slag door at the tapping end
  - 45" SAVING, due to waste time during melting phase to clean the slag door scrap pieces
  - 30" SAVING, due to increase oxygen consumption +3 Nm<sup>3</sup>/ ton

**This saved time represent an indispensable advantage to be implemented in every modern melt shop.**

# E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT

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## BENEFITS OF E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT:

- **COSTANT CLEANING OF SLAG DOOR TUNNEL:**  
constant removal of slag surpuls and other possible obstructions from slag door tunnel thanks to the constant availability of the machine use, and consequent reduction of losses of steel during refining step and overall reduction of tap to tap time;
- **COSTANT AND AUTOMATIC DE-SLAGGING PROCESS:**  
by the control of the slag level, the operator knows more precisely the right parameters (tilting angle, time for each melt shop process step) to easily conduct a metallurgically and scheduling reproducible melting process.

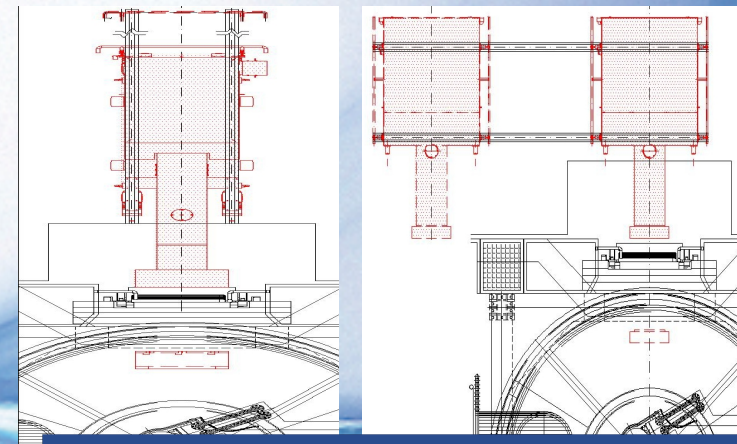
# E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT

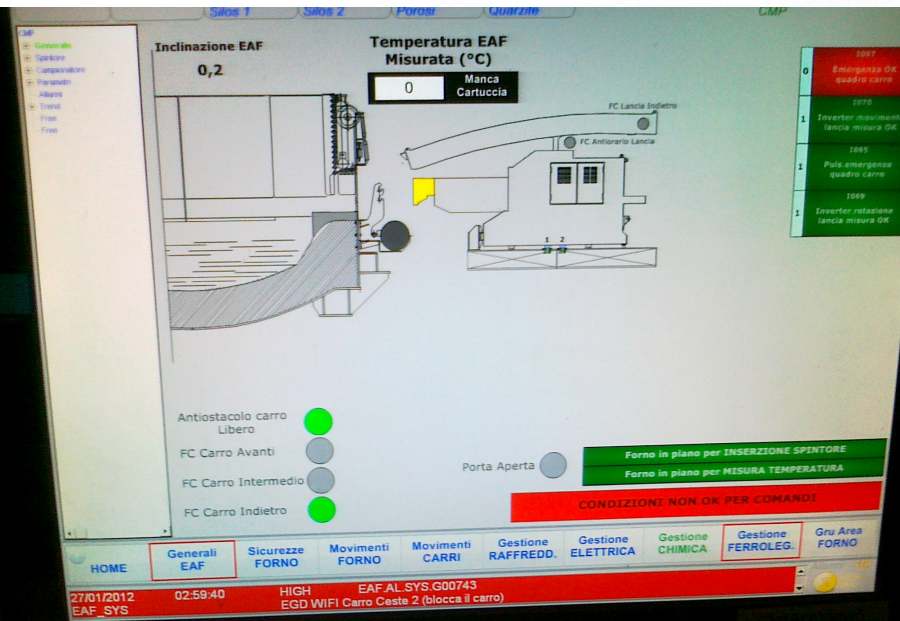
## BENEFITS OF E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT:

- **SAFE AND RELIABLE TEMPERATURE AND SAMPLING BEING TAKEN WITH AN AUTOMATIC MANIPULATOR:** every temperature, sampling and oxygen activity measurement can be more realistic and reliable.
  - No cold scrap will shield molten steel from taking probe thanks to the ram cleaning job;
  - The position of each sampling will not change by the time as the level of the slag is the same too.
- **USE AND MANAGEMENT OF A SINGLE MACHINE:** remote operation from furnace control room in a safe position; no manual intervention in front of E.A.F. slag door area with reduction of specific manpower;

## E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT

can be installed facing the slag door or sideways the slag door, depending on the space availability

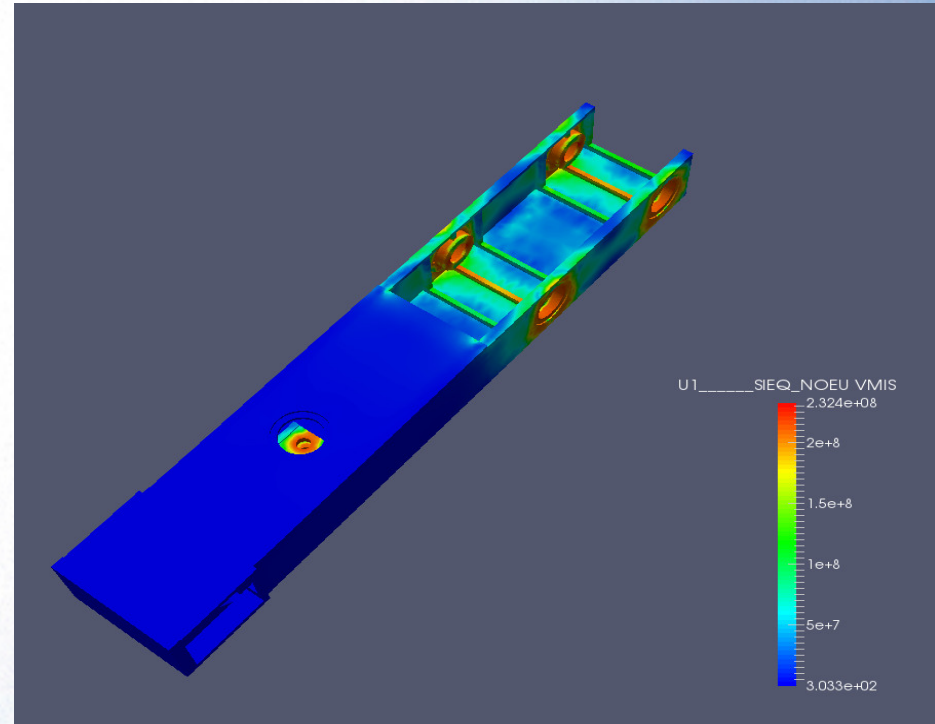






# E.A.F. SCRAP PUSHER AND SLAG DOOR CLEANING ROBOT

The engineering design of the E.A.F. Scrap pusher and slag door cleaning robot has been improving by the years and by feedbacks from our worldwide clients. The product has been constantly tested by the field and by complex numerical simulations of the physical reality. The action of the pushing arm is explicitly designed for reaching the sill cleaned from the scrap and the slag level control, in the safest and most durable way.



## CONCLUSIONS

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E.A.F. Scrap Pusher and slag door cleaning robot a safe, reliable method to improve energy and yield optimization in the electric arc furnace.

Benefits of E.A.F. Scrap Pusher and slag door cleaning robot implementation include:

- Improvement of product quality;
- Reduction in treatment times;
- Reduction of costs;
- Increase in the overall reliability and quality of the steel making process;
- Safety to avoid accidents caused by furnace reactions.

**All these combined define the success of the process technology employed. With E.A.F. Scrap Pusher and slag door cleaning robot the manual intervention in the slag door area during tap-to-tap time is no longer required.**

**C.M.P. Officine Meccaniche S.r.l. has been supplying E.A.F. Scap Pusher and slag door cleaning robot since 1996.**



**Auth:**

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**OFFICINE MECCANICHE**

**Thak you very  
much for your  
kind attention**