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OBJECT:

Totally controlled safety system with zero impact on productivity for a bar Rolling Mill

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INTRODUCTION

Between 2007 and 2009 a major Revamping of Ferriera Valsabbia plant (Brescia, Italy) was performed with the aim of reaching the maximum safety with minimal impact on productivity. A totally integrated state-of-the-art new complete automation system was implemented by AIC together with activities performed on mechanical, hydraulic and totally controlled safety system.
AIC is a global system integrator and supplier of Electrical and Automation systems for the whole Metals industry.
Ferriera Valsabbia is an international point of reference for the reinforcing bars market as well as for electrowelded wire mesh; the company was founded in 1954 and represent one of the most important Italian groups in the metal industry.
Ferriera Valsabbia employs today about 360 workers and employees in Brescia's facilities and it has other production and service sites in Italy, Czech Republic and Slovakia.
The headquarters and the main production site are in Odolo (Brescia, Italy) where the 850.000 t/y good billet capacity plant consists of a complete production line from the scrap yard to final bars bundles, with 2 CCMs, hot billet charging system in the reheating furnace and 21 continuous stands rolling mill for 8÷40 mm rebar. In two slit rolling mode maximum bar diameter is 20 mm.
Figure 1 shows the layout of the described plant.

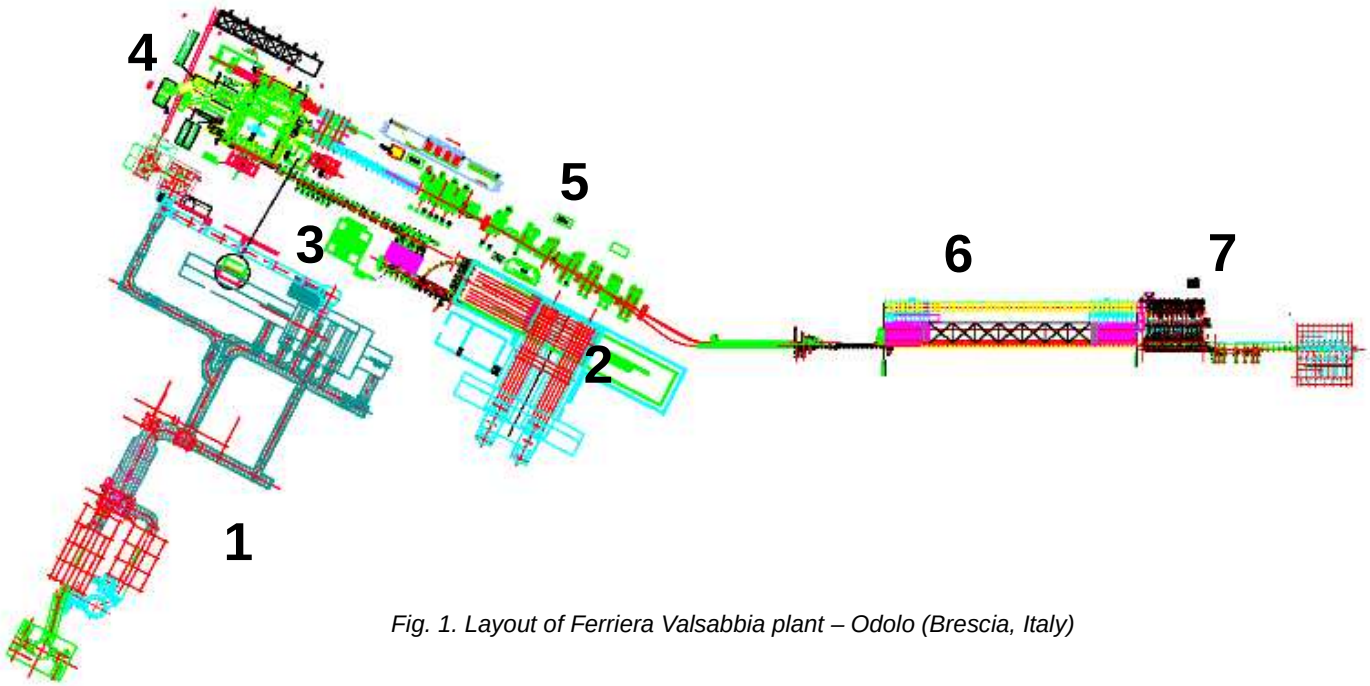

Fig. 1. Layout of Ferriera Valsabbia plant – Odolo (Brescia, Italy)

1- Dedusting plant
2- CCM machines (nr.2)
3- Hot charging
4- Reheating furnace
5- Rolling stands
6- Cooling bed
7- Delivery Area

THE REVAMPING PROJECT

This major revamping project started in 2007 and finished at the beginning of 2009 concerns a new billet hot-charging system, 14 so-called RedRing rolling stands and a new cooling bed equipped with both apron and high-speed delivery equipment (7 of the existing rolling stands were retrofitted). Furthermore the project includes new reheating furnace, lubrication and hydraulic system, operational change parts, all of the shearing equipment for the rolling line and cold-cutting area, machines for counting and bundling steel bars
The electrical and automation scope of supply was the complete turn-key new electric plant, including the supply of:

- Electrical Engineering
- MV switchgears
- MV/LV transformers
- Power distribution system
- About 100 AC&DC Drives suited to command about 500 motors up to 1MW
- 10 automation PLCs with more than 7000 I/O
- innovative safety system based on 3 safety PLCs with more than 1500 I/O, totally integrated in the main automation architecture
- SCADA control system with 2 servers units and 10 client stations
- Upper level interface (MES)
- Main desks
- Local control stations
- Hydraulic control and water treatment
- Dedusting plant management
- CCTV system
- Spare part management

The implemented solution allows Ferriera Valsabbia to increase the productivity together with the improvement of efficacy, efficiency and rolling performances, thanks to a reduction of gas consumption and a better use of mechanical and hydraulic resources.
Meticulous project planning and the flawless interface with customers' production schedule kept mill shutdown time to an absolute minimum. The associated loss in production was more than compensated for in the following months through enhanced mill performances; all the project targets were achieved.

ARCHITECTURE OF THE SAFETY SYSTEM

The innovative safety system was designed starting from the structure of the productive plant: the Ferriera Valsabbia plant was ideally partitioned in 3 macro-areas, each relating to a homogeneous phase of the production line.
The 3 macro areas are in detail:

- Hot charging billet (in reheating furnace)
- Rolling mill
- Cooling bed and Delivery area

The figures 2 and 3 show using different colours the safety areas in the general layout of the plant.

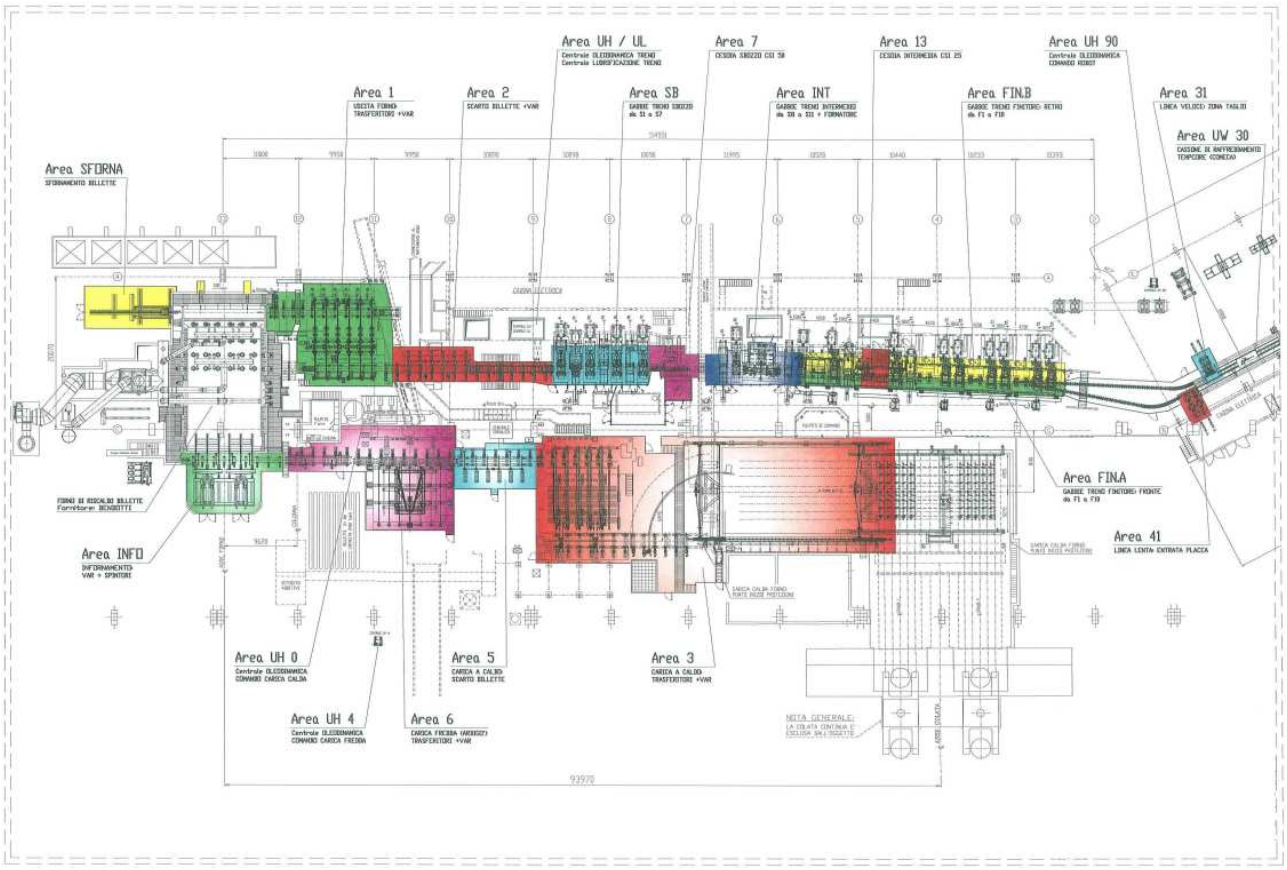

Fig. 2. Safety zones – Hot charging billet (Zones 0, 3,4,5,6) and Rolling Mill (Other zones)

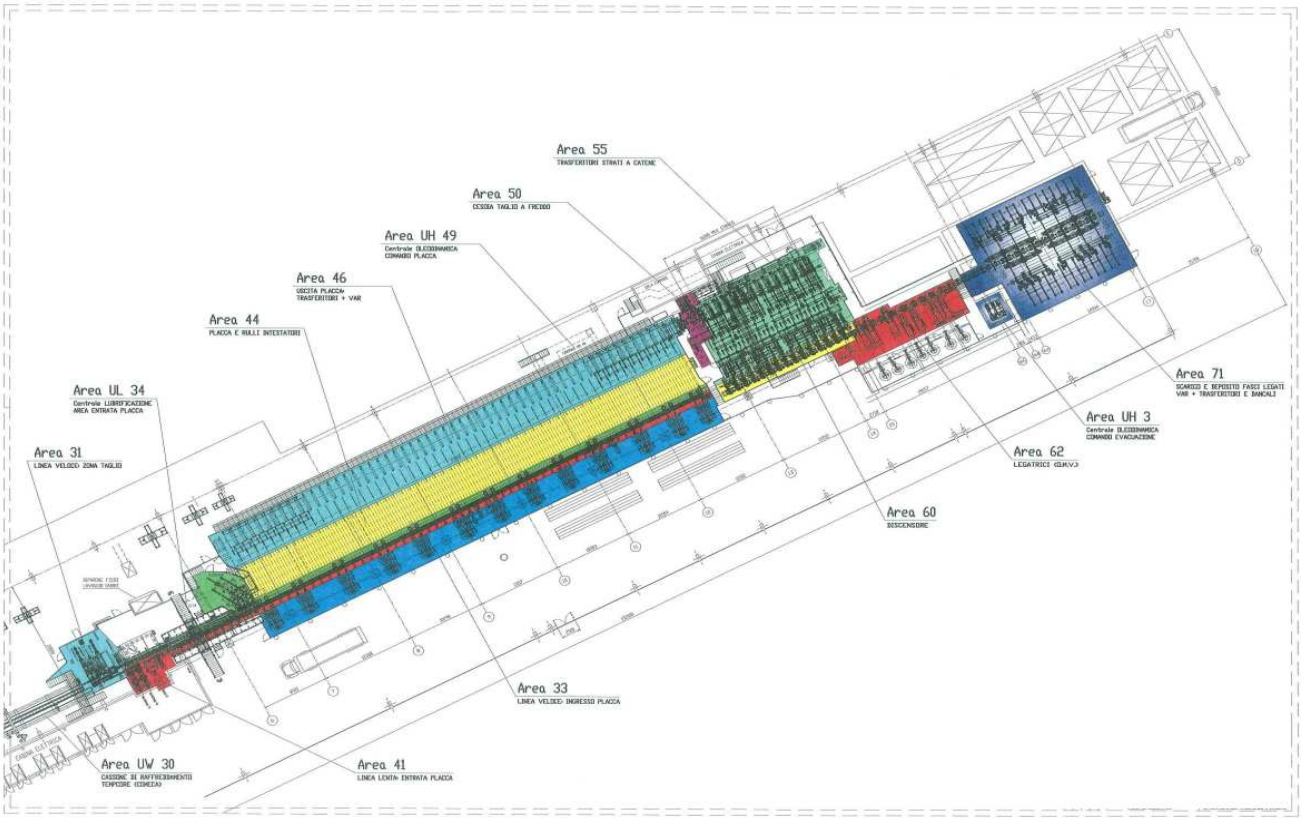

Fig. 3. Safety zones – Cooling bed and Packing&Delivery area

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The safety conditions have been achieved through a great number of proper protections and dedicated devices:

- The 3 main areas are divided in 24 zones, each one controlled with an individual policy.
- 7 additional zones are dedicated to hydraulic units
- The 31 zones are protected by 92 gates installed in order to control the accesses. The different type of gates are controlled through:
    - Electric lock
    - Lock with released key
    - Manhole
    - Limit switches
- Fixed and sliding security shields
- Fixed and removable fences and carters
- Properly designed hydraulic circuits

The base of the safety system design is a safety matrix for each area. The matrix is an intersection of rows and columns and aims to reproduce the cause/effect relationship; the matrix defines how many and which machines/parts must be secured against each single Input signal, both an Emergency command and an access request. Thus the matrix is the logic connection to the operative conditions and the safety system requirements.

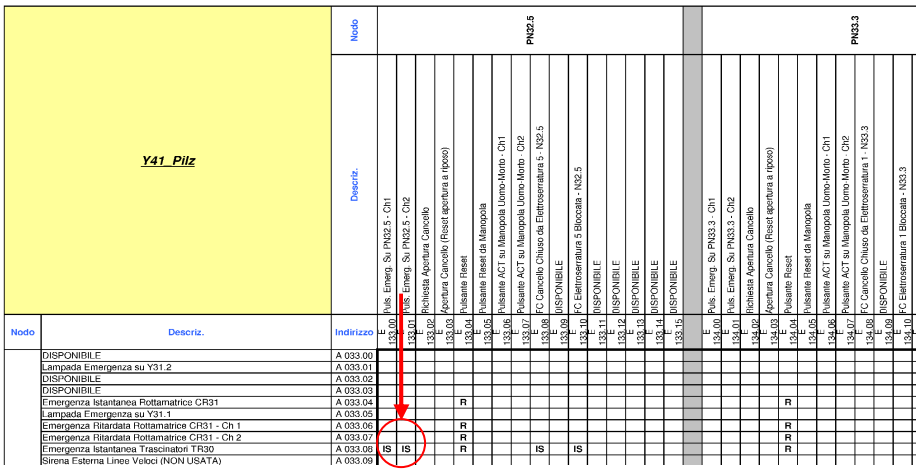

Fig. 4. Safety matrix: relationship between Inputs and Outputs (for example the first emergency pushbutton cause an instantaneous emergency of one of the pinch rolls)

TOTALLY INTEGRATED PLC's SAFETY SYSTEM

The state-of-the-art safety system is based on 3 safety CPUs referring to different macro-areas described ahead.

The figure 5 shows the characteristics of the general automation layout:

- The safety CPUs are interconnected by Safety Bus
- The safety CPUs are in communication to the main automation PLC through Profibus connection
- The safety CPUs are in communication to the SCADA and upper level through Ethernet connection.

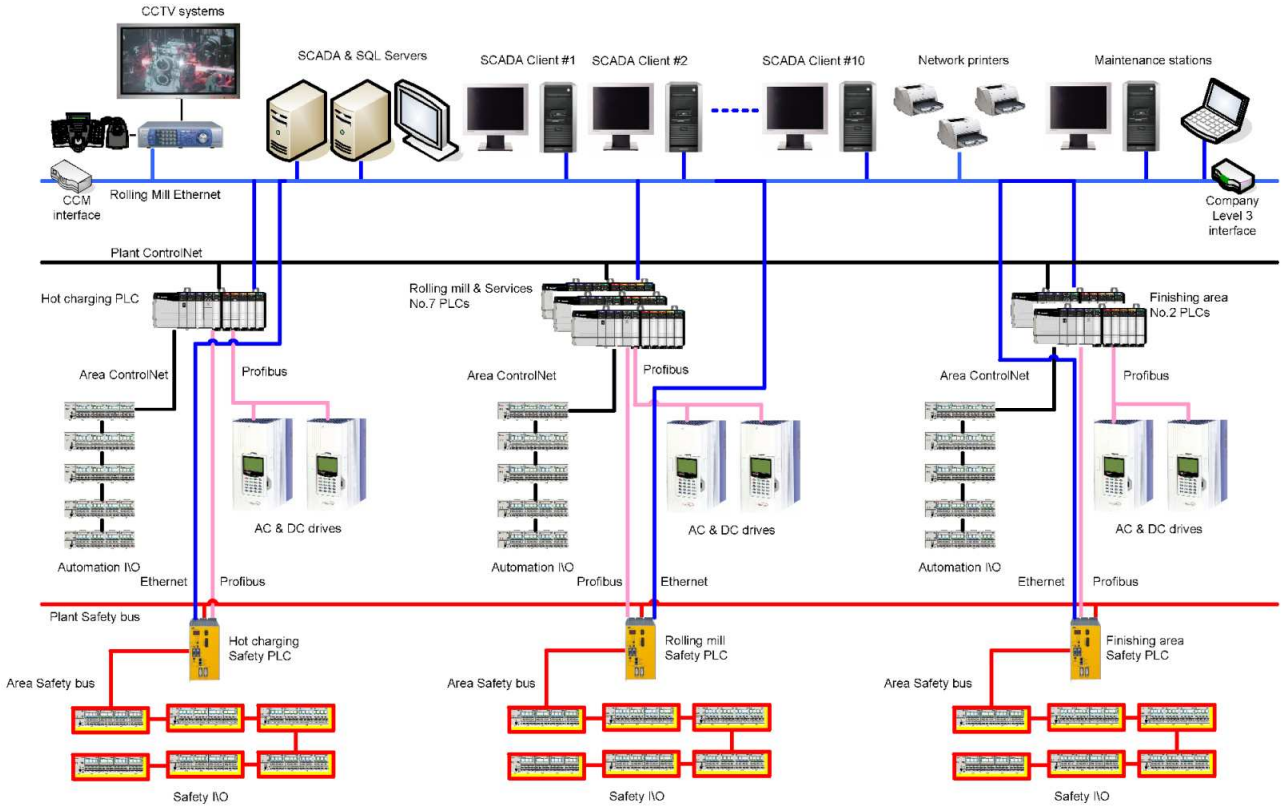

Fig. 5. General automation layout with network communications.

To implement the safety system the engineering team handled 45 remote I/O units with more than 1500 I/O signals from a total of more than 7000 I/O automation signals.

	Safety I/O	Nr.
Hot charging Area	Input	150
	Output	80
	Total	230
Rolling Mill Area	Input	382
	Output	260
	Total	642
Cooling Bed and Delivery Area	Input	403
	Output	256
	Total	659
PLANT	Input	935
	Output	596
	Total	**1531**

The safety system is exclusively based on PLC control logic system and it does not require traditional wired safety hardware/electromechanical modules or cable pulling. It allows safe access to different areas securing AC&DC Drives (with control of motor zero speed), the hydraulic devices and the gates/fences/shields/carters opening.

General switch off of the plant against general emergency conditions as well as interface with fire prevention system are also included.

Such design approach grants several advantages:

- Programmable logic instead of hardware wiring as well as total and easy integration with the main automation plant
- Complete integration of the safety system with automation control
- Safety Bus instead of field wiring
- Application really flexible and expandable
- Realtime diagnostic on SCADA system and upper levels

Programmable logic instead of hardware wiring as well as total and easy integration with the main automation plant

Previous traditional safety systems were based on standard hardware modules that needed to be wired; thus the main problem was the difficult integration with the command system. The integration in the main automation system was frequently well-nigh impossible, except against additional wirings that always complicate the hardware structure.
At the opposite the designed PLC's safety system is totally integrated in the main automation system and can be very easily modified, expanded or reduced both in erection phase and in commissioning or after-starting phase.

Safety Bus instead of field wiring.

In the safety system all data exchanges (input reading as well as output execution) travel through field bus: therefore all safety information pass in only one net cable.
This architecture allows to avoid the cable pulling between switchboards and control desks; the advantages about erection, connections and maintenance are really great:

- Reduction of necessary cables;
- It isn't necessary to look for dedicated routes for additional cables;
- Reduction of cabling and connection mistakes, as well as of risks of interferences or transit troubles;
- The only wiring required is the connection between safety field devices (locks, switches, valves and pressure decay control devices) and the nearest point of I/O collection (local box or desk…)
- Easy trouble shooting during the start-up and very manageable maintenance
- Easy check of state: Figure 6 shows the Safety Bus and CPU's Diagnostics on SCADA screen.

Application really flexible and expandable, also in different times or phases (through local safety or junction boxes, for example)

The safety system based on PLC technology and network distribution is very manageable because of its characteristics of flexibility: it grants the possibility to easily move, modify or integrate each part (such as gate, local box or desk, safety area…); the possible expansion only requires to increase the number of nodes, remote I/O and control devices; furthermore the configuration designed does not require to set limits in order to use the necessary I/O to command the desired new functions.
Updating or adding functions fulfil customer requests (different partitioning of areas, different associations between machines and safety area or device…) will be done exclusively by software programming.
A safety system like this one takes great advantage of modular safety PLCs that are not restricted to the amount of the I/O handled (no limits expansion: it requires only to increase number of CPUs).
The CPU is equipped with safety network interfaces in order to create the necessary communication channel for diagnostics of the safety system between automation and safety. The system supports the major standard fieldbuses and data exchange via Ethernet and Profibus. The possibility of distributing and de-localising safety commands and functions by means of safety BUS networks allows remoting I/O to the single zone to be controlled.
The software architecture for implementing the logic allows splitting of the emergency system into simple macro areas in order to implement a safety system that can reduce plant downtime during the intervention.
The extreme flexibility of the programming system allows a capillary distribution of the emergency functions that allows the safe shutdown of individual machines/devices; the operators of the plant can thus carry out safe maintenance and check activities in isolated areas, without stopping the production line.

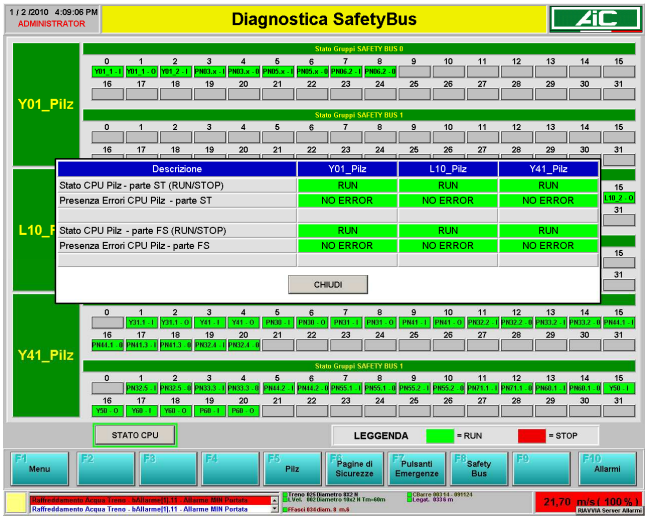

Figure 6: SCADA Screenshot showing CPU's state and related nodes in power and control switchboards

Realtime diagnostic and SCADA system and upper levels.

The implemented safety system is complete of HMI certified platform (Allen Bradley RSView SE) that enables real time control of plant conditions as well as their quick and easy visualization through SCADA screens showing:

- Secured areas
- the present maintenance/various activities
- Operators in dangerous areas
- Emergency request
- Malfunctions or faults of single devices

The SCADA Screenshots allow to continuously monitor the state of the safety protections and the state of the machines controlled too.

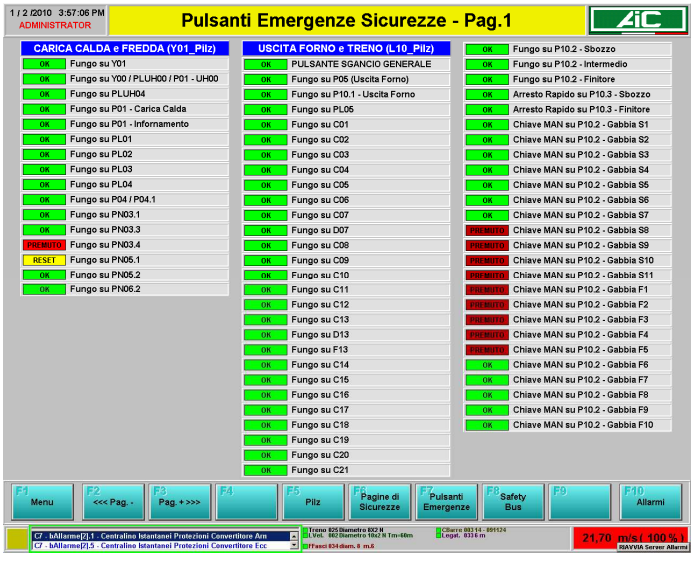

Fig. 7. The state of mushroom emergency pushbuttons:
Pressed – flashing red: the pushbutton keeps the machine in emergency
Reset – flashing yellow: waiting reset command from PLC
Ok – fixed green: pushbutton already reset

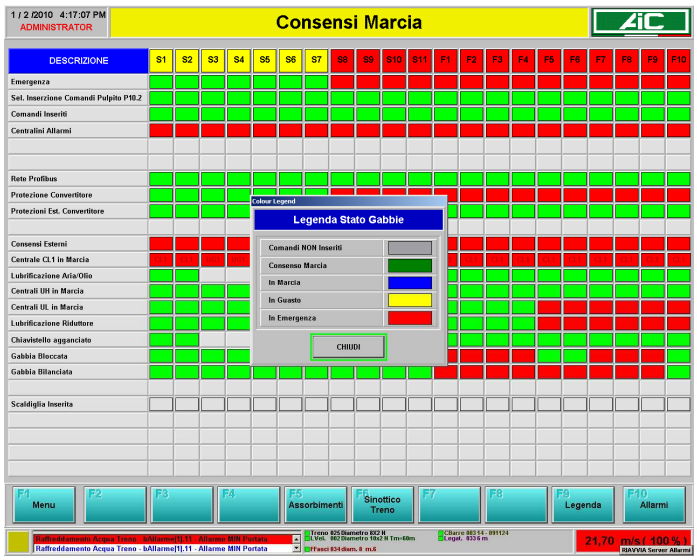

Fig. 8. The necessary permissions to allow running the machines

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SAFETY ACCESS CONTROL

The 92 gates installed to control the 31 zones are commanded through different type of lock:

- Electric lock
- Lock with released key
- Manhole
- Limit switches

To execute maintenance activities the system allows the access to desired areas by dedicated “dead-man” handset pushbutton (inspection modality) using fast plug in socket installed on each local safety box.
For the rolling mill area wireless remote controls with emergency pushbutton were also foreseen in order to manage the stands.

FIRST SYSTEM OF SAFETY ACCESS CONTROL: ELECTRIC LOCK

AIC designed the management and control of different safety devices through the most appropriate state-of-the-art technologies. The most frequent access protection control is the Electric lock, because it allows to shield single machines, single access and more or less extensive areas.
Every electric lock is managed and controlled through the safety system, therefore the admission to different devices for maintenance and inspection operations comply with “safe access” conditions (stopped machines in home position); the operators can also monitor that residual pressures decay before entering the zone.

Fig. 9. Close-up: Safe gate with electric lock controlled by safety dedicated local box.
Behind: fixed (passage protections) and sliding security shields (in front of rolling machines)

Fig. 10. Left: Safety gate with electric lock open; green light over the local box means safety access. Right: gate closed (the machines of this area are running); red light means forbidden access.

Fig. 11. Sliding shields (ahead finishing stands) controlled through electric bolt unlocked from safety control accesses.

When the Operator requires the securing of an area and the consequent opening of related safety gates or security shields, he can inhibit every further moving action; thanks to this feature the system prevents wrong, accidental or unintentional protection re-closing and thus avoids every possible re-start of the machines and the production plant.

The operators of the main control desks can be always updated about the state of accesses and gates and possible presence of workers in isolated areas.
Figure 12 shows one of the SCADA screens designed to check the electric lock and protections state.

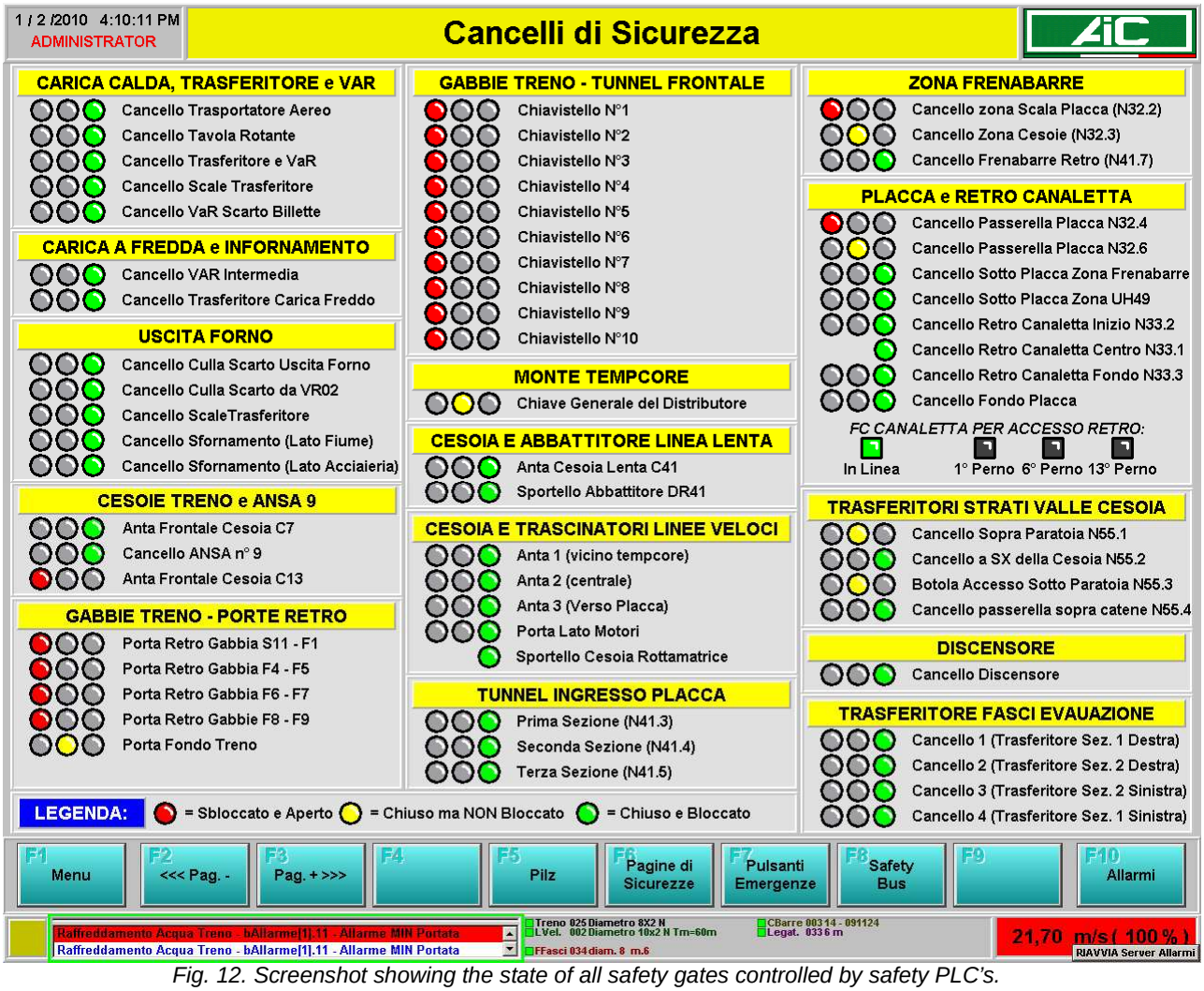

Fig. 12. Screenshot showing the state of all safety gates controlled by safety PLC's.
Red state: gate unblocked and open – Machines in emergency
Yellow state: gate closed but unblocked – Machines in emergency
Green state: gate closed and blocked – Machines running

SECOND SYSTEM OF SAFETY ACCESS CONTROL: LOCK WITH RELEASED KEY

This kind of access protection was chosen from engineering team, in agreement with the technical management of Ferriera Valsabbia, for those gates and fences that need to be periodically removed, for example to allow the transit of forklift trucks or other bulky or lifting machines.
The same solution was similarly considered the most suitable in other situations:

- Near areas needing the transit of hanging wide loads that have to be moved very close to the floor.
- Where local conditions of the plant don't allow to wire the electric locks on the gates (for example against risks of cobble that may cause an expulsion of hot material and burn or damage the cables of the electric devices)
- Protection and securing of extremely dangerous areas: in this case the safe access must be checked by the supervision of one of the technical chiefs and the release of the safe codified keys is subject to the insertion of two or more unlocking keys.

For this access control system opening of the protection devices is allowed only under conditions of absolute safety.

The following figures show a typical installed safety box: the box can handle an emergency in a single macro area. This, together with the traditional mushroom push button, means that other functions such as a ‘gate open’ request and ‘safe area’ lamp, can be implemented; the yellow colour identifies the role played by this device.

Fig. 13. Safety gates and removable fences controlled through released keys

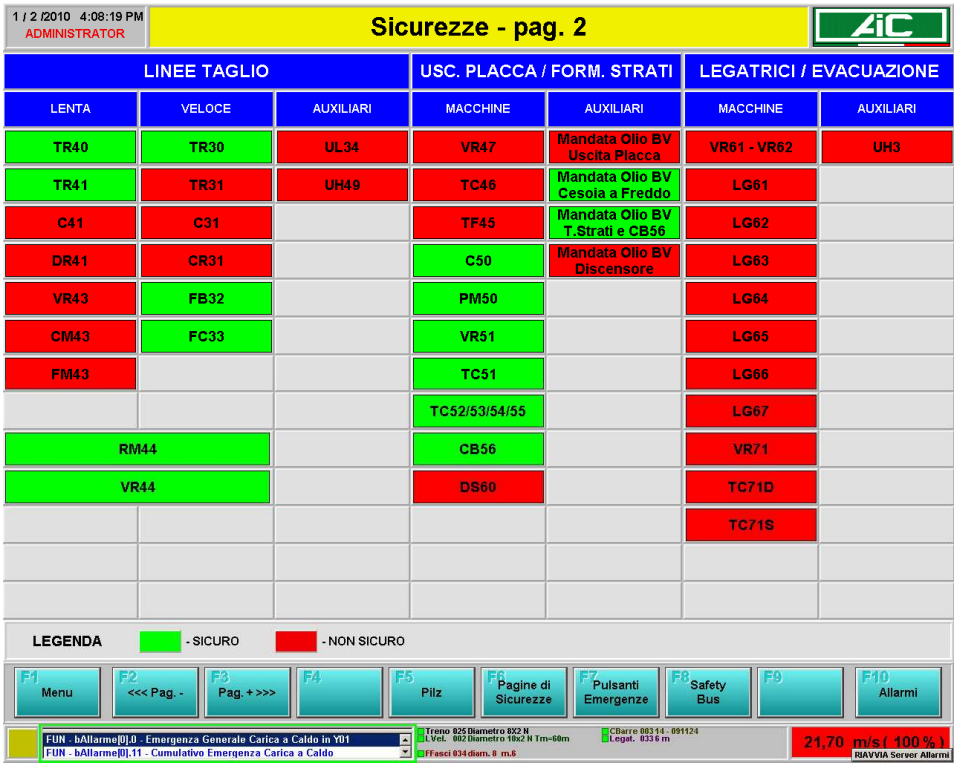

Fig. 14. SCADA Screenshot showing the state of all the machines in the plant.
Green state: machine blocked in emergency from safety PLC (accessible). Red state: unsafe machine, it can start at any time

"MANHOLE" ACCESS CONTROL

The "manhole" access control is a specific kind of safety application that must be used for accesses where the operator can not be seen once he passed the gate.
For this reason both the safety boxes at the entrance of hole and the dedicated SCADA screen on main command desks must indicate the "operator in hole"; the system must thus prevent every kind of machine movement.

Fig. 15. Manhole controlled by safety system.
Red light means running machine (unsafe area) – Green light means hole accessible.
Green flashing light and buzzer means operator in hole.

This particular safety control is designed to enable the operator (who may be accidentally trapped in the hole) to quickly run away, opening the related gates without stopping the production line (particularly dangerous situation).

SAFETY CONTROL PROTECTIONS CONTROLLED THROUGH LIMIT SWITCHES

In order to control carters and simple protections engineers chose dedicated limit switches. The safety system checks that necessary protections mounted on moving or rotating machines (such as shears) are in right position and that no one is trying to approach to potentially dangerous areas.
This kind of control only verifies the state of the protection device (effective condition of “protection closed”) and does not integrate access control or request of access.

Fig. 16. Protection carter controlled through limit switch

Fig. 17. Safety system applied on hydraulic devices and distribution: hydraulic bank, main delivery block valves controlled by local safety box and pressure decay control.

CONCLUSIONS

After only one year of production Ferriera Valsabbia reached the following results:

- one shift maximal productivity: 130 t/h → more than theoretical designed capacity
- yearly average productivity: 100 t/h
- time lost for safety access < 0,5%

The target of the project was achieved within the first year of production and every operator can work safely without loss of rolling efficiency because of the flexibility of the safety system and its integration with high level automation.

ACKNOWLEDGMENTS

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