The expensive solution is more economical

Electrical equipment for a paint mixing plant for a car manufacturer

by Thorsten Arnhold and Thomas Riecke

Figure 1: Paint conditioning station in the paint mixing plant during commissioning without the presence of an explosive atmosphere

Based on the example of a paint mixing plant installed abroad for a large car manufacturer it will be shown how, particularly during the planning of an industrial plant for hazardous areas, it is worthwhile not just considering the simple procurement costs, but in the early concept stage also considering other costs such as transport, installation, commissioning, operation, maintenance and the like, up to and including withdrawal from service and dismantling. The case described relates to a paint mixing plant that was planned, installed and placed in operation for an end customer in South Africa by Eisenmann, a company based in southern Germany and a world-wide leader in providing paint equipment to the car industry. The solution for the electrical installation and the process automation in potentially explosive atmospheres was drawn up at the start of the planning process in close collaboration with R. STAHL.

Layout of the mixing plant

The part of the plant described is a sub-system of a paint mixing plant for a car manufacturer; here the various paints for the actual painting process are prepared and pre-conditioned. The plant comprises 42 individual stations, of which 39 are used for the supply of paint and two stations contain the solvent necessary for cleaning the plant prior to changing the colour (Figure 1). A further station is used for collecting the soiled solvent after flushing. Explosion protection is necessary in the entire plant due to the presence of the solvent. Even with the water-soluble paints commonly used today it is not possible to completely avoid the use of inflammable substances for cleaning and conditioning purposes.

Each of the stations has a tank with 1,000 kg of liquid. A control system per station processes the parameters for the liquid in the tank as well as the higher level process signals.

The stirring system for the station is used for the preparation of the paint after storage and before the painting process. The agitator is operated by a motor controlled using a frequency converter. As a result it is possible to vary the agitator speed as a function of the process.

During the design of the overall plant and the individual stations, the following requirements from the end customer, among other requirements, had to be taken into account:

- The plant should be operated with as few staff as possible.
- Information as comprehensive as possible on the ongoing process is to be displayed to the personnel.
- The plant should be well suited to subsequent expansion, e.g. due to an additional colour.
- All exterior parts of the plant must be highly resistant to solvents, as soiling of the exterior is certainly possible even though paints and solvent are handled in a closed process.

Control system for the paint mixing stations

As described above, each paint mixing station has a dedicated control system. The individual control systems are linked over a subnetwork to an S7 programmable logic controller (PLC) responsible for the entire plant. The latter is in turn connected to the superior management level via an Ethernet interface.

A central element of the station control system is the explosion protected operater interface type ET 306 data display terminals manufactured by R. STAHL (Figure 2). The control panels are connected to the PLC using an ethernet star structure. The connection to the discrete I/O level is made using Remote I/O systems and an intrinsically safe Profibus line. Both the operating commands and the signals for the process states are handled at this I/O level.

Operation is either via the pushbuttons and switches integrated into the control panel or using the keypad on the data operator interface.

Figure 2: Explosion protected control panel with operator interface ET 306 and discrete controls and indicators

The control systems are standardised making it possible to significantly reduce the programming effort required.

The following process parameters and messages are displayed to the plant operator on the data operator interface:

- paint colour
- level in the tank
- liquid pressure before and after the filter
- temperature of the liquid
- the complete process scheme
- various alarm signals, e.g., about pumps running dry or overfilling.

The entire paint mixing plant is explosion protected. The interior of the tanks and the other parts of the plant are classified as Zone 0. As a result the sensors and solenoid valves fitted must be apparatus of category 1. The rest of the plant is classified as Zone 1 in the case of solvent-based paints and as Zone 2 in the case of water-soluble paints, but to keep things simple products in equipment category 3 were used in both cases. Along with the control panel, this equipment includes the agitator (the frequency converter is not installed in the hazardous area), connectors, and sensors. The two plugs and sockets of type 8175 manufactured by R. STAHL and fitted to the control panel, as can be seen in Figure 3, are used for the electrical connection of the motor and for the connection of the thermistor motor protection. The entire paint mixing station is connected to the electrical line using the explosion protected connector as can be seen on the right edge of the picture. ➔

Figure 3: View of the paint mixing plant

The remaining area around the stations is classified as Zone 2. For this reason ECOLUX 6600 light fittings for equipment category 3 manufactured by R. STAHL were installed.

It was not just the electrical equipment that had to be of explosion protected design, all non-electrical parts of the plant had to comply with the requirements of the European ATEX directive 94/9/EC for mechanical equipment.

Optimal solution for the end user

In the past this type of plant was equipped with conventional control consoles. As a consequence, the plant was controlled exclusively using pushbuttons, selector switches, and potentiometers.

In a further development stage, small digital displays for the indication of process parameters were added.

At the start of the concept phase, this conventional solution was preferred due to the lower procurement costs compared to that of a modern solution.

After more detailed consideration, however, it was found that the high cost for the installation, calibration, and commissioning, as would be incurred in the case of a solution with simple digital displays, would considerably exceed the difference in the procurement prices.

The conventional solutions are based on direct point-to-point wiring between the individual mixing stations. As a result it is only possible to run the parts of the plant after installation at the end customer. Experience would suggest that just the calibration of the digital displays would have meant more than three man-weeks on site in South Africa.

In the case of the modern solution with the largely autonomously operating control panels with an operator interface, it was possible to significantly reduce the costs for installation and commissioning. The filling stations were fully prepared, including the adjustment of the parameters and the calibration of the measuring devices in Germany on completion of the assembly of the parts of the plant. It was possible to significantly reduce the necessary effort by standardising the devices. On completion of this work the parts of the plant were transported to the end customer. On site the parts of the plant were plugged together in a relatively straight forward way (quasi ›plug and play‹!) and the entire plant commissioned. If other significant cost savings due to lower material costs for the installation material and due to lower logistics costs are taken into account, the savings in total costs up to the completion of the turn-key plant was approx. 25 %!

If the technical advantages of the modern solution are also taken into account along with the reduced probability of errors, it is clear that the effort for all the activities from planning to completion of the plant certainly paid off. Due to the close co-operation between the manufacturer of the plant and the supplier of the key sub-systems with the explosion protected electrical equipment during the entire planning and implementation phase, it was possible to supply the end customer with the best technical solution at a low price.