Surge Protection for Modern Process Control and AutomationTechnology

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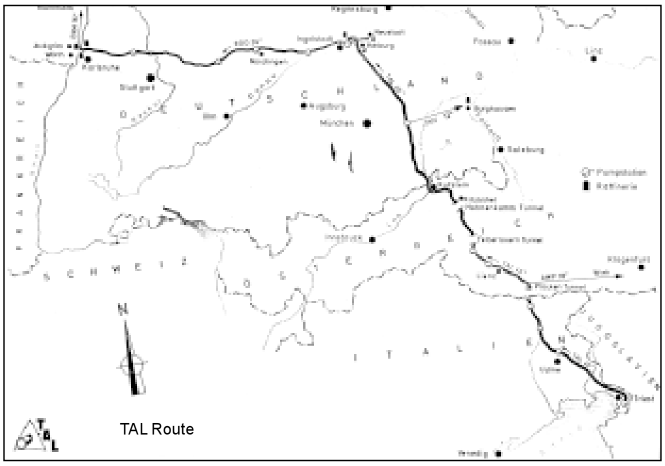

Fig. 1: TAL Route

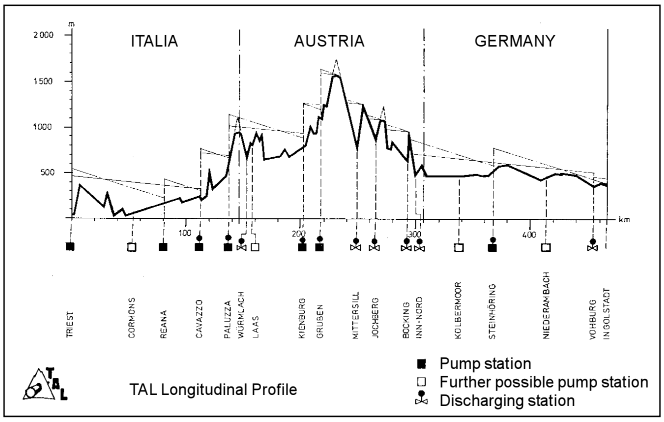

Fig. 2: TAL Longitudinal Profile

1. Introduction

Within the modernizing programme for the measuring and control technology of Europe's most important crude-oil pipeline (TAL), considerable surge protective measures have been taken. The German Transalpine Oil Pipeline PLC (TAL) runs the transport way between Triest, Italia and Ingolstadt/Bavaria in Germany. Not only for the power supply surge protective measures had to be taken but especially for the signals going to the process control equipment like pressure, temperature or liquid level.

2. TAL Modernizing Project

Already since 1967, the German Transalpine Oil Pipeline PLC (TAL) has run Europe's most important crude-oil pipeline between Triest, Italia and Ingolstadt/Bavaria in Germany. 465 km the "Black Gold" must cover to reach the central station in Ingolstadt. From there, another arm of 270 km length must be covered. It ends close to Karlsruhe, Germany (**see Fig. 1**). Regarding the total pipeline route, almost 1,600 m of difference in altitude have to be crossed over the Italian and Austrian Alps (**see Fig. 2**). TAL covers 100% of Bavaria's crude-oil demand, 75% of Austria and 55% of Baden-Württemberg.
As in 1996 the CEL (Central European Line) with its route from Genua over the Alps was closed because of insufficient utilization, environmental problems and high sanitation costs, the importance of the pipeline supplying Germany with crude oil from the Mediterranean increased considerably. Therefore, in 1996, the order for the modernization of the automation and communication technology was placed. Apart from the functional reinstrumentation, also the utilization of modern surge protective measures was significant part of the concept planning and the realization.

3. Surge Effects

Surges occur, among others, by on- and off-switches in power-supply systems. This also includes the connection of transformers as well as the disconnection of a short-circuit by fuse. A further cause are lightning discharges.
In case of direct lightning strikes, an impressed lightning current affects a concerned object directly, e.g. a supervisory console (**see Fig. 3**); a local potential increase is caused which can amount up to 10,000 V. Concretely: A measuring transmitter 0/4...20 mA, installed in a 50 m to 100 m distance, is located in another earth-resting potential than the process control system (**see Fig. 4**) to which the measured value is transmitted. If lightning hits the supervisory console (process control system), this local potential is increased, however, the earth-resting potential of the measuring transmitter is not. Thus, a potential difference comes up between the process control system and an "inducted" potential, the 0/4...20 mA-signal. As the voltage resistance of control-systeminput cards only comes up to min. requirements, it is not sufficient for the interference case "lightning". As a consequence, open spark gaps on the printed wiring board and in the intergrated circuits may occur.

Indirect lightning strikes are lightning strikes hitting the surroundigs of the object concerned. As a consequence, surges are inducted into electrical power supply systems, measuring and control lines and data and communication lines through the electromagnetic field surrounding the lightning discharge. Depending on the distance of the lightning strike and the cable lay-out, inducted voltages of 100...1,000 V may come up.

Circuit surges and inducted surges in installation loops caused by indirect lightning strikes are often the reason for damages in terminals and system parts. Here also insufficient equipment surge resistance is the cause for damages.

Here, modern surge protective devices are employed. In such situations, they establish an equipotential bonding, i.e. the bonding is made under control within the protective device and thus, damages and destructions are prevented.

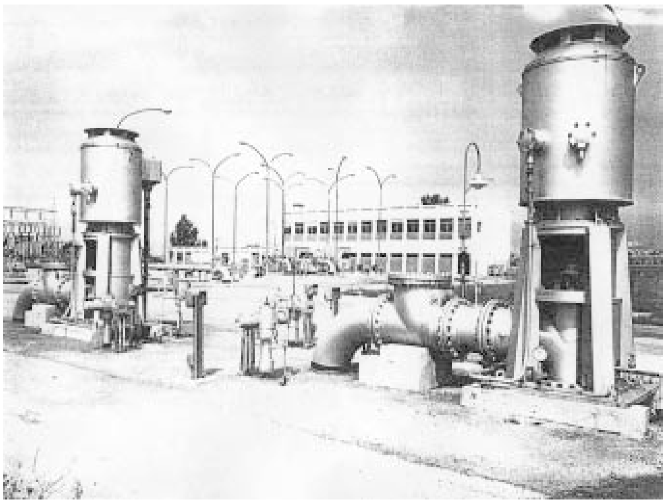

Fig. 3: Pumps with measuring transmitters in the field with an operating building in Ingolstadt

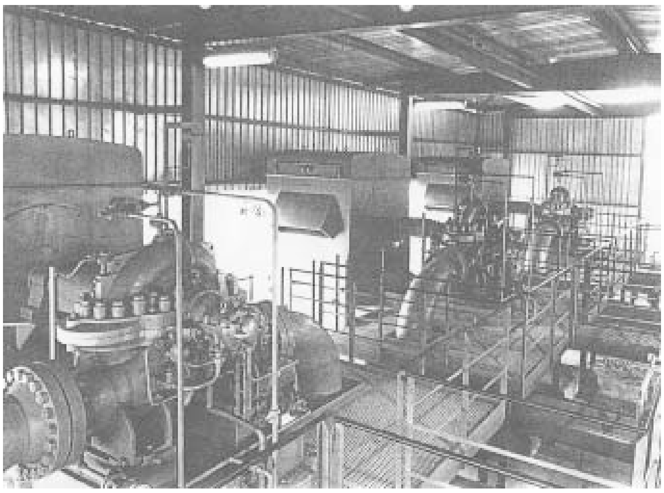

Fig. 4: Pump stations

4. Lightning Protection Zone Concept at TAL

It was kept in consideration that special attention had to be paid on the lightning and surge protection when replacing the "old", tough relais groups by sensitive electronic control systems. Therefore, the Lightning Protection Zone Concept as per IEC 61312-1 was used in the planning status.
The volume to be protected (supervisory console, local measuring point) is divided up into protection zones. Existing metal constructions, e.g. external lightning protection systems, distribution boards or equipment housings are used for forming protection zones. From the field side (Zone 0), zones having a minor hazard potential are following, both regarding electromagnetic interferences and performance-related interferences. Zone 0 is the zone most at risk; here, direct lightning strikes can occur, the electromagnetic field takes its unattenuated effects. At the interfaces of protection zones 0 to 1, all lines coming in from the field side are included into the lightning protection equipotential bonding. This comprises metal conduits as well as power, measuring and control and communication lines. Connections for the lightning protection equipotential bonding have to be made sufficiently surge-proof. Surge arresters to be used at zone interface 0/1 must be able to arrest lightning currents or great parts of them without any damage. These arresters are called lightning-current arresters. At each further zone interface, a local equipotential bonding must be established. If there are operational power-conducting lines at zone interface 1 to 2, so surge arresters must be installed there. The dimensioning of the arresters, such as nominal voltage, discharge capacity or surge protection level comes after the hazard potential existing at the interface.

4.1. Power Supply

During the modernization of the process control system and the automation technology, the existing distributions were used for power supply. Thus, the existing infrastructure was considered and the existing lightning protection was used. Principally, the new control technology was concentrated on. At the entering side, new installed power supply systems were connected with surge arresters on varistor basis Type DEHNguard T. For the 230/400 V side the protective devices DEHNguard T 275 V were used and for the 24 V DC side DEHNguard T 75. The difference between the arresters is the arrester - rated voltage, i. e. the max. nominal voltage up to which the arresters can be used (**see Fig. 5**). In case of a defect, the pluggable protective modules can simply be exchanged.

Fig. 5: Surge Arrester DEHNguard T 275

4.2. Measuring and Control Circuits

For the protection of approximately 18,000 I/O-signals the universal DEHN+SÖHNE surge protective device Blitzductor CT is used and installed in separate lightning protection boards (**see Fig. 6**). Being a two-part construction, different prot e modules can be adapted to the base part which serves as a feed-through terminal. The protective modules can be used as lightning-current arresters, surge arresters and combined arresters. In this connection, the combined arrester comprises the performance of a lightning-current arrester and the one of a surge arrester, i. e. the arrester is able to both arrest lightning currents without any damage and, simultaneously, to offer a sufficiently low surge protective level for the downstream device electronic assembly. In the protective devices, there are integrated sequential protective circuits consisting of expulsion-type arresters, decoupling resistors and suppressor diodes. Only in case of an overload of the protective device, a defined short circuit occurs according to the definition "fail safe". Thus, defect devices can be noted via the measuring circuit malfunction indication made by the automation system.

Fig. 6: Universal Surge Protective Device Blitzductor CT

Having done extensive system tests, interferences, e.g. a defect surge arrester in the tested field, were simulated in order to check the faultless performance of the process control system.
Measurands like temperature, density, pressure or liquid level are transmitted to the supervisory console via measuring transmitter 0/4...20 mA. Because of the huge quantity of signals entering into the supervisory consoles at a central part , it was decided to use surge arresters Type Blitzductor CT Type ME 30 V. A sufficient impulse current capacity is achieved by spreading several signal lines. The reason why the decision was made for a 30V version is that the supply devices used are indeed able to reach voltages up to 28 V in no-load operation. However, for 24 V protective devices, this amount of voltage is too high as permanent voltage.
Upstream of the measuring transmitters, combined arresters Type Blitzductor CT Type BE 30 V have been installed. Should higher loads caused by surges come up at the local measuring points - only few current paths can be used here for spreading impulse currents - a very capacitive device is installed using the combined surge arrester.
For checking slide status, binary contacts are used. These are also connected with the mentioned modules of the Blitzductor CT-range. Signal lines which are not used are earthed via so-called earthing kits. With help of the protective device, also an indirect shield earthing can be made. This is done via an upgradable expulsion type arrester.

5. Measuring and Control Circuits with Protection Type EEx(i)

The application of the intrinsic safety as an effective possibility against explosions is very widespread in the explosion protection technology for measuring and control circuits. In intrinsically safe measuring circuits the saved power is not sufficient to strike explosive atmospheres. No sparks or heatings within the current circuit can cause a strike.
Intrinsically safe measuring circuits in the TAL-Project are protected with Blitzductor CT Type MD/Ex (**see Fig. 7**) which is specially adapted to EEx(i) circuits. The protective device comes up to the high requirements which are demanded in accordance with the Ex-Protection Standards. Thus, the surge arrester is marked "EEx ia IIC T6", i.e. the arrester is an intrinsically safe equipment, Category ia, Explosion Group IIC and Temperature Class T6. As the arrester's inductances and capacities are negligibly small, they need not to be observed regarding the intrinsic safety, according to the Admission Certificate of the Federal Physical and Technical Institute (PTB). Thus, a simple installation into EEx (i)-circuits is possible. The blue housing colour allows an immediate recognition of its application in intrinsically safe measuring circuits.

Bild 7: Surge Arrester for intrinsically safe measuring circuits BLITZDUCTOR CT MD/Ex

6. Equipotential Bonding

Consequent equipotential bonding is important when installing surge arresters. Along the whole pipeline route, intermeshed equipotential bonding is used. So, a low-impedant mesh network is achieved. In order to maintain the the arresters'complete protective effect, short earth connection lines are necessary as well as equipotential bonding conductors between the earth connection of the surge-arresters and the device electronic assembly to be protected.

7. Final Conclusion

Lightning and surge protection are an important part of controlling systems because of decreased interference distances and increased system sensitivity. Especially concerning petrochemical systems, the installation of surge protective devices has to be regarded as State of the Art. Extensive costs for surge protection have been avoided by observing the measures during planning and constructing the systems. Especially through this procedure the owner and user of petrochemical and transport systems has a considerably efficient protection in comparison with installations made as an additional system because of previous damage in the system or in system parts. By taking lightning and surge protection measures, the system availability is increased considerably. The idea of environmental protection is also performed as this is a contribution for the system operation and environmentally critical situations such as leaks are avoided.

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