For many decades, electromagnetic flowmeters (EMFs) have been the first choice for recording the volume flow of electrically conductive liquids. This is true for many industries such as chemical, pharmaceutical, water/wastewater and the food industry.

The basis of the EMF measuring principle is Faraday’s Law of Induction. This requires that the inner wall of the measuring tube is electrically isolated. That is why with most EMFs the measuring tubes are lined, e.g. with PTFE, PFA or PP or entirely made of ceramic.

**EMF grounding**

Like all electrical equipment, EMFs must be grounded in accordance with safety regulations e.g. protective grounding or potential equalisation. Firstly, EMF grounding ensures protection against contact and prevents electric shock. Hence in the event of an error there is no hazardous voltage to the conductive parts of the device.

Secondly, grounding provides a fixed reference potential to the EMF signal voltage. This EMF signal voltage is typically about a millivolt or less. The converter can only process such small signals without interference and with maximum resolution provided there is not a great difference between the potential (the voltage) of the medium and the reference potential of the signal processing in the converter. There are several methods to ensure this. In addition to the three classical methods of grounding, there is the method of virtual reference, which is done without separate grounding of the medium.

**Three classical grounding methods**

**Grounding in pipelines which are electrically conductive**

This is the simplest case for grounding: In pipelines which are electrically conductive on the inside (e.g. blank steel or stainless steel), the liquid in the pipe has the same potential as the grounded pipe. The signal voltage on the electrodes thus has a fixed reference potential.

**Grounding in electrically non-conducting pipelines**

For ceramic, plastic or concrete pipelines and for lines isolated on the inside, the product is brought to known fixed potential using additional measures. Usually, metal grounding rings (grounding discs) are used. The ring is in conductive contact with the product and usually jointly grounded with the sensor. When assembling the pipeline and the EMF flanges, two additional gaskets are usually necessary. Groundings rings and gaskets must not disturb the flow profile at the measuring point. Careful selection and assembly of grounding rings and gaskets will prevent leaks. This method is technically reliable and has been proven for many decades.

Disadvantages include higher costs when special materials are needed for aggressive media or in case of large pipe sizes. In addition, when there are electrical potential differences, stray currents will occur between the product and the earth via the grounding rings and the grounding cable. The grounding rings can be destroyed as a result of electrochemical reactions with the product.

**Grounding with grounding electrodes**

The grounding electrode is situated at the invert of the pipe and in direct contact with the housing which is connected to functional earth (FE) of the EMF sensor. Often the cost of this additional grounding electrode is less compared to grounding rings. In the event of electrical potential differences in the plant, these grounding electrodes can be destroyed by electrolytic action, resulting in leakage or destruction of the whole EMF. Abrasive solids in horizontal pipelines can also quickly destroy these grounding electrodes. In some cases, deposits on the grounding electrode can prevent the proper function of the product grounding, thus also inhibiting correct measuring results. In the case of large EMFs with grounding electrodes, significant deviations also occur when – as is often the case – the EMF was calibrated in an electrically conductive pipeline and then used in an isolated pipeline.

**The alternative to classical grounding: virtual reference**

In certain applications, the conventional grounding methods of EMFs pose problems: for example, in lines with cathodic corrosion protection or in galvanisation plants, voltage is also present between the electrodes and the earth. When using aggressive media in the application, the grounding rings for conventional grounding must usually be manufactured from expensive special material, which amounts to extremely high costs.
costs when dealing with large pipe sizes. The solution to this problem is called "virtual reference" or "virtual grounding". With the virtual reference, the EMF sensor can be installed in any type of pipeline without grounding rings or electrodes. The converter's input amplifier records the potentials of the measuring electrodes and a patented method is used to create a voltage which corresponds to the potential of the ungrounded liquid. This voltage is used as the reference potential for signal processing. Thus there are no interfering potential differences between the reference potential and the voltage on the measurement electrodes.

Diagram of virtual reference:
This method has several advantages: For one thing, no additional means of grounding that come in contact with the product are necessary. The elimination of grounding rings and the simpler installation of the EMFs results in lower costs. This advantage should not be underestimated, as faulty grounding is the most common cause of error when commissioning an EMF. There is no risk of electrolytic destruction when there are potential differences in the system, such as when using grounding electrodes. No stray currents flow over the product or grounding lines. Ungrounded use is also possible where voltage and current are applied to the pipeline, such as with electrolytic and galvanic treatment. The virtual reference is basically possible from a diameter (nominal width) of DN10 (9.5 mm) and from a conductivity of ≥ 200 μS/cm.

Virtual reference in practice
The German-based measuring instrument manufacturer Krohne patented this method for the virtual referencing of EMFs back in 1998 and is the only manufacturer permitted to use the method in their flowmeters. The following example illustrates an application in which virtually grounded EMFs are proven in practice.

The technology company Andritz, based in Austria, uses Krohne EMFs with virtual grounding. They use Optiflux 4300 in sizes of DN10 to 300 mm to 300 mm. The instruments are used in acid treatment processes, such as with stainless steel pickling. Here, the flow of mixed acids, consisting of hydrofluoric acid, nitric acid and water, is measured. In the process at 90°C and a pressure of 3 bars, the acid flows at a speed of approx. 1.5 m/s.

It has been said that without this virtual reference electrode, grounding rings would have to be used. As these rings must be made of different materials for different media, it would be easy to confuse them during installation. Hence, there will most likely be problems as the chemical resistance is uncertain. At the same time, these grounding rings can be very expensive – so not using them results in a significant reduction of cost.

Switching from a built-in reference electrode to a virtual electrode can be justified due to the easy technical feasibility. If the conditions mentioned regarding the diameter and conductivity of the product are fulfilled, the EMFs can be installed in all systems in which classical grounding is a challenge.

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