

Non-invasive clamp-on ultrasonic flow measurement of crude oil

Non-invasive, ultrasonic flow measurement is only an outsider measuring technique in the technical sense: clamp-on ultrasonic transducers are simply mounted on the outside of the pipe so they always measure from the safe side. There is no need for any pipe work when setting up a measuring point which means there is no interruption to production or supply. The non-invasive technology on the discharging pier in Wilhelmshaven has proven successful.

“At least one fifth of the crude oil imported into Germany is measured by our FLUXUS flowmeters”, reports Ingrid Panicke, FLEXIM’s marketing manager who looks after the oil and gas industry sector. Anyone who believes that the flow measurement of almost 20 million tons of crude oil per year would require a huge number of instruments is sadly mistaken: “a total of four measuring systems are enough for 20% of the crude oil supply entering Germany”, she explains: “They measure the crude oil which is handled by the docked tankers at the discharging pier of Nord-West Oelleitung GmbH in Wilhelmshaven.”

Securely Transporting Crude Oil

Nord-West Oelleitung GmbH (NWO), founded in 1956, set out to build and operate the first long-range crude oil pipeline in Europe, which would serve the refineries in the Ems and Rhine-Ruhr regions in Germany, a goal it had already achieved by 1958. Its tanker discharging pier and oil tank farm facilities located at Jade Bay, Wilhelmshaven have been part of NWO’s permanent operations ever since, as has the long-distance pipeline stretching from its North Sea tank farm in Wilhelmshaven all



Clamp-on ultrasonic transducers are simply mounted on the outside of the pipeline during ongoing operation.

the way to Wesseling, near Cologne. In addition, NWO took over the operations of a second long-range pipeline between Wilhelmshaven and Hamburg, as well as the operations of a range of subterranean cavern facilities that are connected to NWO. Crude oil from the docked tankers at the discharging pier is pumped ashore via transfer-pipelines that connect the tanker pier jetties with the tank farm. Following the handling and storage of crude oil, NWO’s core business as a service provider can then begin: this is to transport and deliver crude oil through long-range pipelines to and from a network of oil refineries and connected caverns.

Wilhelmshaven has the only deep water harbour in Germany and NWO acts as an important hub in the handling, storing and transporting of crude oil in Germany, making the city home to one of the most important petroleum ports in the country. There are comparable European facilities in Trieste, Rotterdam and Marseilles. Since the start of operations, more than one billion tons of crude oil have flowed from approx. 18,000 tankers to the discharging pier of Germany’s most significant port for incoming crude oil. In 2014, the turnover rate was 18.6 million tons, accounting for almost 21% of the total 89.6 million tons imported to Germany.

Following the Oil’s Route

Crude oil that arrives at NWO by tanker begins its journey through NWO’s facilities at the tanker pier. This can be reached by tankers from the sea and via a 670 m access bridge from the shore. The tanker pier itself is 1207 m long and is close to the shipping channel, so that the tankers can moor at it easily and unload their cargo. For the transfer of crude oil there are extremely efficient state-of-the-art delivery platforms on it called jetties. These have proven to possess a high standard of environmental safety and guarantee short periods of mooring for the tankers while NWO operates day and night, seven days a week.

Altogether there are three jetties with a total transfer capacity



FLUXUS F709 measuring transmitter for installation in the 19” switching cabinet

(turnover rate) of 40,000 cubic metres per hour. This capacity is divided between two jetties which can be used to transfer 12,000 m³/h of crude oil and one large jetty, which can deliver the crude oil at a rate of 16,000 m³/h. The tankers pump the oil ashore using the ship’s on-board pumps via the jetties with their marine loading arms and into NWO’s storage tanks, meaning that the actual rate of delivery depends on the capacity of the respective tanker’s pumps.

As a rule, the bigger a tanker is, the higher the capacity of its pumps, meaning that the average unloading time of around 24 hours is hardly ever exceeded, even in the case of large tankers.

Safety and Efficiency

For safety reasons, a fixed flow rate per pipeline should not be exceeded and, for this reason, the unloading process must be monitored using flowmeters. In addition to that, by measuring the turnover rate, the ship’s on-board pumps can be controlled so that the equipment and process run as efficiently as possible. Last but not least, flow measurements allow for an initial recording of pumped crude oil quantities. The fiscally relevant quantity is



Measuring point on jetty 1 (above the framework set up for installation)

measured by level measurements in the tanks.

Until now, dynamic pressure probes and turbines have been used for flow measurement. They are installed on land as opposed to on the discharging pier itself. These wetted measuring devices have their known weaknesses: they are subjected to mechanical wear and tear and only have a small turndown ratio which means they only measure accurately in a restricted working range. For any maintenance and repair work, the pipeline has to be opened up so operation is made temporarily unavailable. As part of a modernisation of the plant's systems, the responsible engineers were looking specifically for a better alternative.

Non-invasive Flow Measurement with Clamp-on Ultrasonic Technology

Once again, non-invasive flow measurement with FLUXUS proves to be the ideal solution. Since clamp-on ultrasonic transducers are simply mounted on the outside of the pipe, they are not subjected to any wear and tear by the medium flowing inside. Equipment can be installed without opening the pipeline and during ongoing operation. The acoustic measurement method is inertia-free and has an extraordinary dynamic range resulting in high accuracy from the lowest to the highest flow velocities. This means start-up

and shut-down processes can also be accurately recorded.

After one of FLEXIM's sales engineers demonstrated the suitability of FLEXIM's clamp-on ultrasonic technology for this measurement task using his portable FLUXUS F608 flowmeter, NWO's process engineers decided to fit one of the three jetties with FLUXUS in the first instance. A particular difficulty of the measurement is that the tanker pumps often also convey air which significantly dampens the ultrasonic signals as bubbles in the crude oil flow. This challenge was overcome by using ultrasonic transducers that work with Lamb waves. In order to ensure maximum reliability, the measurement was carried out on two channels. Finally, to achieve the highest possible accuracy, even the density and viscosity values of pumped crude oil that are stored in the process control system were to be calculated for flow measurement. For this reason, the FLUXUS F709 was used as a measuring transmitter. Density and viscosity can be fed in as a current signal via its freely configurable inputs. The measuring transmitter was placed in the control room of the jetty that is secured by a permanent, slight overpressure.

Non-invasive flow measurement with FLUXUS also proved convincing in the long-term test. That's why the other two jetties were also similarly retrofitted. Both crude oil and refinery residue products are handled on one of the two jetties. These residue products are heated when they arrive and then pumped ashore via a heated, insulated pipeline to the tanks on land. Given the fact that the medium is highly viscous, non-invasive acoustic measurement from outside really plays out its strengths. The clamp-on transducers were integrated into the insulation.

All measurements were field calibrated in comparison to tank level measurements. With the help of accurate and dynamic flow measurements, an additional security system is to be implemented for rapid detection of possible leakages.

Ingrid Panicke is certainly not the type of person who is satisfied with 20%: "Of course, crude oils and crude oil products pass measuring points that are fitted with our flowmeters many times in the downstream processes of refining and transport. However, our FLUXUS clamp-on ultrasonic systems are also particularly suitable for non-invasive measurement on large transport pipelines. In short, the remaining 80% appeals to us very much so."



On the heated pipeline for refinery residue products, the ultrasonic transducers are integrated into the insulation.



Non-invasive flow measurement by means of ultrasound is obviously an acoustic method.

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