Transporting fuels, chemicals and oil products in a pipeline can be a dangerous undertaking. Having the pipelines monitored for both safety and environmental reasons is therefore a priority for the oil industry, not to mention the economic impact of an accident. With thousands of miles of pipelines that need to be monitored, even a very small leak can cause millions of dollars in damages.

There are several types of systems used to monitor pipelines. One proven Leak Detection Systems (LDS) uses software based on a compensated volume-balanced method that continually monitors the difference in flowrates between measurement devices. Siemens offers such an LDS that features ultrasonic clamp-on flowmeters, using WideBeam technology to achieve the performance required by the industry.

Benefits of ultrasonic clamp-on flowmeter technology
The ultrasonic clamp-on flowmeter that Siemens uses for its pipeline monitoring system is unique in that it is sensitive to liquid flow and velocity. The principle design of ultrasonic clamp-on flowmeters is that sound moves at a faster velocity when travelling in the direction of flow and slower when travelling against the flow. The fluid flow velocity can be computed by measuring the independent travel times of the sound as it is transmitted in each direction (upstream and downstream). The Siemens ultrasonic clamp-on flowmeters are extremely sensitive to very low velocities and can even measure at zero flow. This allows the system to detect extremely small leaks and the opening and closing of valves along the pipeline.
The leak detection system explained

The Siemens LDS uses a method of averaging data over time in order to identify the normal operations of the pipeline versus an actual pipeline leak. The ‘brain’ of the Siemens leak detection system is the Master Station, which is basically a computer. It receives data from the flowmeters, known as site stations, and identifies the pipeline that exists between two site stations as the pipeline segment. The Master Station collects flowrate, temperature, liquid density, liquid viscosity, and other important diagnostic information. It then compiles all of this information and observes the pipeline segments, displaying the results on a monitor for the operator to view and evaluate.

The Master Station uses a patented thermal model that computes and corrects for liquid expansion due to pipeline temperature or pressure changes. By combining temperature measurement with known liquid relationships, the leak detection software is able to normalise the liquid’s sonic velocity for temperature using the liquid variable. This method allows the site stations to provide data that precisely identifies the liquid and how it is flowing through any part of the pipeline.

When the Siemens LDS averages data over time, the software sequentially polls each site station on the pipeline for data once a minute. The site station samples flow data five times per second and averages it over the one minute polling interval. Therefore, the data sent to the leak detection software every minute is pre-averaged for the entire preceding minute. The averaged 1 minute data acquired by the software is placed into four separate, continuously rolling integrators; 1 minute, 5 minutes, 15 minutes, and 60 minutes. As new information is gathered, it is placed into each of the rolling averages and the oldest data is archived. This routine allows the four integration periods to be continually updated and averaged independently for their own time periods. Each of the four rolling averages are separated and compared to the same rolling average periods of an adjoining site station located either upstream or downstream along the same pipeline.

Volume balance between site stations is not limited to a single instantaneous flow measurement from each site station, but rather four rolling averages over four periods between each site station. This process allows separate and independent leak thresholds to be set for each rolling average. The longer the averaging period, the lower the threshold can be set.

Minimising alarms

The Siemens LDS does not require continuous operator attention, because the thresholds are set and alerts the operator when attention is needed. Once a minute, the leak detection system will monitor all of the pipeline segments for volume input/output imbalance. If any of its extremely sensitive leak alarm thresholds are exceeded, which can be set as low as 1% in most cases, an alarm goes off. By establishing different threshold settings at different time intervals, the system allows normal operations like pump starts and line packing to take place, without triggering false alarms. Volume imbalance of any pipeline segment exceeding preset alarm thresholds of any of the four integration periods; 1, 5, 15, or 60 minutes, activates an alarm and calls for operator attention. User-friendly graphic screens then quickly show which pipeline segment triggered the alarm. Operators can instantly view any of 30 graphic and numeric data screens merely by touching a ‘hot key’. These help confirm the leak condition and its extent.

The LDS does not preempt the operating staff’s responsibility to confirm a leak, but it can be used for automatic pipeline shutdown if desired. Although the LDS does not require continuous operator monitoring, the ability to sense very small leaks, down to a few tenths of a percent, can be achieved by utilising ‘visual trending’, where an operator
can visually see small imbalances that may not be great enough to exceed alarm threshold settings.

**Leak location capabilities**
Leak location for the Siemens LDS is accomplished by sensing the amount of time that a low pressure wave (caused by a leak) takes to travel from its source to each of the segment’s site stations. The site stations can sense the low pressure wave’s arrival by its effect on the density of the fluid, which is being measured several times each second. If the leak is in the centre of the segment, then the pressure wave will arrive at each of the segment’s site stations at the same time.

The most important feature of leak location is being able to come as close to the location of the leak as possible. The speed at which the low pressure wave (known as the pressure transient) travels through the pipeline is determined by the speed of sound for the product being transported. In order to be accurate, it is critical to account for the different liquids within the monitored pipeline segment. Should half the pipeline contain diesel fuel while the other half contains gasoline, and if the different travel times caused by the different liquids are not taken into account, then this will cause a considerable error in the calculations. This is the problem that many pressure-based systems face when determining transient time arrival. However, the Siemens LDS system knows the precise locations of each interface within a pipeline segment and can use this information to compensate for the differences in the pressure transient speeds. This offers a more accurate leak location capability, which is not influenced by the types of liquid in the pipeline.

**Clamp-on LDS advantages**
A software-based LDS depends on data from existing third-party turbine or PD flowmeters, and pressure and temperature instruments. These instruments are not specified to provide the extraordinarily high accuracy and calibration stability needed for an effective leak detection system. As a consequence, system performance cannot be assured by the software system supplier and no single party can be held responsible for the performance of the software-based system.

Siemens LDS, on the other hand, offers a complete turnkey solution to assure the specified leak detection accuracy. Siemens takes responsibility for the complete system. This includes the hardware, software, system installation, startup, optimisation and maintenance. In addition, the ultrasonic clamp-on meters have a number of useful diagnostic variables, such as flowrate, signal strength, aeration levels, sonic velocity and other parameters that can be utilised by the Siemens leak detection software.

Another important advantage to consider is that ultrasonic clamp-on flowmeters offer data regardless of the flowrate. Ultrasonic clamp-on flowmeters, unlike most mechanical meters, have a live zero, meaning that they can detect flow very close to zero. Most mechanical meters will simply stop working under low flow conditions, leaving leak detection simply non-functional at these times. It would require the pipeline to restart before a possible leak would be detected. These restrictions put software systems using mechanical meters at a disadvantage regarding their leak detection capability.

**Conclusion**
There are many factors to consider when purchasing a leak detection system, and every company has unique requirements and operating conditions that need to be taken into account when evaluating leak detection systems. However, what is clear is that the industry is up against an increasing number of rules and regulations that relate to the transportation of liquids through pipelines. In addition, environmental and economic considerations that aim to better control the situation in the event of a leak need to be taken into account.

The Siemens LDS offers a complete solution, including everything from the ultrasonic clamp-on flowmeters mounted directly onto the pipeline up to the software that monitors the pipeline through collection of various types of data. This complete system lives up to many of the requirements that pipeline companies have while ultimately satisfying one major goal: providing a reliable and properly optimised system that minimises the number of false alarms. In the event of an actual leak, the operator will be immediately notified when and where the event has occurred, minimising loss of liquid.

When the initial cost of a leak detection system is compared to the overall functionality and performance, including operating costs, precision and security, the Siemens leak detection system, presented here, may prove itself as an investment well worth making.