LEAK DETECTION IN PIPELINES – TWO EXAMPLES

LENNART JÖNSSON

Senior Lecturer, Department of Water Resources Engineering, University of Lund,
P.O.Box 118, S-221 00 Lund, Sweden
(Tel: +46-46-2228101, Fax: +46-46-2224435, e-mail: Lennart.Jonsson@tvrl.lth.se)

Hydraulic transients in pressurized pipelines arise due to rapid flow changes and are characterized by pressure waves propagating back and forth through the pipeline. The characteristics of the transients are affected by different properties of the pipeline and a measurement and a careful analysis of a transient make it possible to derive some information about the pipeline, i.e. a hydraulic transient might be considered as a kind of a "probe". This paper will discuss the possibility of detecting a leak in a single pipeline by means of analyzing the transient. The basic idea is that a transient will partly be reflected at the leak and a determination of the reflection time and knowledge of the wave propagation speed will provide the basis for locating the leak. However, with a complete rupture of the pipeline the pressure oscillation time period can be used for the same purpose. Two different cases will be described, the first case referring to an experimental, 135 m long pipeline set-up with a simulated leak and one real field case referring to a long (several km) pipeline located on the bottom of a strait and delivering drinking water to an island. A very significant leak occurred on this important pipeline. In both cases the effect of the leak is evident on the measured hydraulic transient and comparison between the estimated and real locations of the leaks could be performed. Some computational simulations of transients in the leak cases for the experimental set-up were also done in order to show that the effect of a leak could, at least qualitatively, be obtained with a straightforward computational description of the leak.

The experimental set-up consisted of a 135 m long galvanized steel pipeline, basically made up of an upstream part, 34.9 m long, a 90 ^{0} bend, a flowmeter and a downstream part, 98.35 m long. The upstream part was attached to a large main acting as a reservoir. The downstream end discharged to the atmosphere via a ball valve, which could be closed very rapidly thus generating a strong, positive pressure front. A simulated leakage point – a T-junction, a shut-off valve and a flowmeter – was located at a distance of 42.85 m from the ball valve. A number of transient measurements were performed for leakage rates Q_{leak}/Q_{pipe} in the range 5 – 17% with Q_{pipe} of the order of 1 l/s. The leak location was estimated with a relative, absolute error of 2 % based on the wave reflection from the leak point and experimental data on the wave velocity.

The second example concerns a real, field situation with two 5 km long water supply PEH pipelines on the bottom of a strait from the mainland to an island. One of the pipelines was damaged, most probably due to anchor operations from a boat. The unfavourable circumstances, water depths up to 45 m and strong currents, made the work very difficult for investigations by a diver, who finally found a complete cut-off of the pipeline. As this was an interesting field case for analyzing a transient in terms of a very large leak, subsequent measurements of transients were performed on the pipeline in its original, damaged condition. The leak location was estimated based on the pressure oscillation period $T = \frac{4 \cdot L}{a}$ and a theoretical value of the wave velocity a. As the pipeline

was about 25 years old, the modulus of elasticity E_{PEH} was determined in a deformation test on a sample from a small piece of the pipeline. The transient analysis showed, that the leak should be located at 3,870 m from the shore as compared to about 4,000 m (depth about 45 m) according to the in-situ inspection. A further transient measurement on the pipeline, now shortened 500 m for repairing purposes, assessed the length to be 3,330 m as compared to the real length about 3,500 m. Thus, a fairly good estimation of the leak location could thus have been done initially, which would have facilitated the difficult diving operation to a significant extent. The transient method will be used in the future, if further accidents happen on this pipeline.