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The authors would like to thank the discussers for the meaningful contribution. The experimental data presented by the discussers demonstrate that rigid orifice-like leaks with various shapes of the opening can induce similar reflections under a transient event. The authors agree that the theoretical orifice equation [Eq. (12) in the original paper] is applicable to the rigid shaped leaks as reported by the discussers. However, the discharge coefficients can vary for orifices with different shapes. For any specific orifice, the relationship between the head loss and the flow under transient events is complex, but the steady-state orifice equation can be used as a good first approximation of the characteristics (Washio et al. 1996).

The discussion of the orifice equation in the original paper was in the section 'challenges in field applications'. Leaks in real pipeline systems can be much more complex than the leaks as simulated by rigid orifices in the laboratory. Leaks in field pipelines can be induced by longitudinal or circumferential cracks rather than a small hole on the pipe wall. The opening of a real leak can vary within a transient event due to the circumferential and longitudinal expansion of the pipe wall, rather than maintaining a constant shape. As a result, the authors believe that dealing with the complexities of leaks in the field can be a challenge as identified in the original paper.

Published literature has reported that the theoretical orifice equation [Eq. (12) in the original paper under discussion] is unable to accurately describe the behavior of some real leaks even under the steady state. The theoretical orifice equation is written as $Q = cH^{\alpha}$, where Q and H are the discharge through and the head across a leak, c is the leakage coefficient and α is the leakage exponent. Greyvenstein and Van Zyl (2007) reported that in the field the leakage exponent was often considerably higher than the theoretical value of 0.5, as used for rigid orifice shapes. Experimental results for leaks with various shapes and different pipe materials were presented in their paper. An example is that a corrosion cluster in steel pipes can have a leakage exponent up to 1.90 – 2.30.

The leakage coefficient and exponent have no effects on the determination of the leak location using the proposed three-resonant-responses-based technique. Eq. (10) in the original paper describes the relationship between the location of a leak and the relative sizes of the first three resonant peaks, and this equation is independent from any other properties of the leak. To accurately locate a leak is considered to be more important than the accurate estimation of its size. As a result, despite the challenges imposed by the complexities of leaks in the field, the proposed new technique is useful and can contribute to leak detection in water transmission pipelines.

References

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