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INSIGHT

How Sensitive is a Bubble Test — Really?

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Factors Influencing Sensitivity of Bubble Testing

The basic principle of the bubble test consists of creating a pressure differential across a leak and observing bubbles formed in a liquid medium located on the low pressure side of the leak or pressure boundary. The sensitivity of the bubble test technique can be influenced by factors such as:

- pressure differential acting across the leak;
- viscosity of pressurizing tracer gas;
- test liquid used for bubble formation;
- contamination such as paint, dirt and oil on inside or outside surfaces of object being tested;
- ambient weather conditions (such as rain, temperature, humidity or wind);
- lighting in test area;
- test equipment; and
- test personnel technique and attitude.

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Properties Affecting Leak Detector Solution Performance

- *Surface tension* affects the speed and size of bubble formation. Lower surface tension solutions form many small bubbles and the reforming of new bubbles. Higher surface tension solutions slowly form very large bubbles that are slower to break, but usually do not reform new bubbles.
- Good *wetting action* and a large *contact angle* are the result of lower surface tension. Poor wetting action and a small contact angle are the result of higher surface tension.
- *Viscosity* affects the size of bubble growth. Lower viscosity solutions produce smaller bubbles. Higher viscosity solutions produce larger bubbles.
- *Evaporation rate* controls the amount of test area that may be covered with leak detector solution before the final inspection. It is desirable therefore to limit the evaporation rate to be able to cover a larger test area. Evaporation rate is also temperature dependent with an increase in temperature causing an increase in evaporation rate and vice versa.

Techniques for Attaining Required Bubble Test Sensitivities

As long as the pressure differential can be maintained, the bubble test technique can be used. However, the sensitivity of a leak testing procedure must be adequate to permit detection of all leaks of a certain size and larger so that all detected leaks can be repaired. The hole or crack that constitutes the physical leak is usually characterized for size of leak by the amount of gas passing through it as leakage. The sensitivity of a bubble test can be increased by:

- increasing the time allowed for bubble formation and observation;
- improving conditions for observing bubble emission and
- increasing the amount of gas passing through the leak.

Improving Bubble Test Sensitivity by Better Observational Capabilities

The actual sensitivity of a specific leak test procedure can be improved by an increase in observational ability. An increase in observational ability could be attained by the following means.

- Position test surfaces optimally for visual inspection.
- Improve lighting to highlight bubble emission clearly and use clean translucent immersion liquids.
- Increase time for bubble formation and observation by test operators.
- Eliminate false bubble indications (caused by boiling, entrained air or contamination of inspection liquids, for example).
- Decrease surface tension of the detection liquid that causes more and smaller bubbles to appear.
- Reduce pressure above the inspection liquid, which makes the individual bubbles larger.

- Select test site and time to provide optimum ambient conditions, such as temperature, wind and lighting conditions.
- Use leak detector solutions that are fluorescent and colored for increased contrast with different test surfaces.

Factors affecting operator comfort and ability to see bubble indications must also be considered. Tests might be postponed until proper test conditions can be attained.

Each of these aids to sensitivity enables the test operator to detect the bubble emissions from smaller leaks or to separate the indications for closely adjacent leaks more readily and so improve leak detection reliability.

Increasing Bubble Test Sensitivity by Raising Tracer Gas Flow Rate

Increase in sensitivity resulting from improvements in leak test procedures are typically attained by raising the rate of flow of tracer gas through the existing leaks. The increased amount of gas flow through the leak passageway may be attained by a change in the properties of the gas (lower gas viscosity). Alternatively, the quantity of gas passing through the leak could be increased by applying a higher pressure differential across the leak. This higher differential pressure could be achieved by a higher level of internal gas pressurization of the vessel or component under test, by heating the gas within a sealed component to increase its pressure or by reduction of the pressure acting through the test liquid on the low pressure side of the pressure boundary. These techniques increase the sensitivity of the test procedure to which the components are subjected. They may also result in more easily observed bubble indications that improve the reliability and speed of bubble testing.

Sensitivities Attainable with Liquid Film Bubble Testing

The actual sensitivity attained in bubble testing depends on the control and selection of leak test conditions that influence factors affecting sensitivity. Sensitivity also depends on the selection of the test technique. The liquid application technique (solution film technique), in which a thin film of liquid is applied and bubbles form in air (like soap bubbles floating on water), is typically used only for leak detection and location. A leak is a physical hole; the gas passing through it is leakage. Service requirements or specifications for testing may require that any detectable leakage be taken as cause for rejection or for repair of leaks.

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In this case, it is not necessary to measure actual leakage rates to determine the disposition of the test items. The sensitivity of the liquid application technique of bubble testing is adequate for locating leaks with leakage rates in excess of 10^{-5} Pa·m^3·s^{-1} (10^{-4} std cm^3·s^{-1}). The solution film procedure is widely used on large pressurized systems that cannot be immersed in detection liquid. The technique is ideal for quick detection of large to moderate size leaks (10^{-2} to 10^{-4} Pa·m^3·s^{-1} or 10^{-1} to 10^{-3} std cm^3·s^{-1}) at very low costs (Fig. 1).

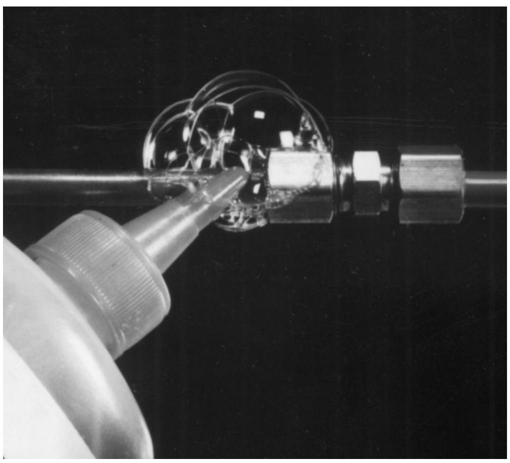

Figure 1. Liquid film bubble testing.

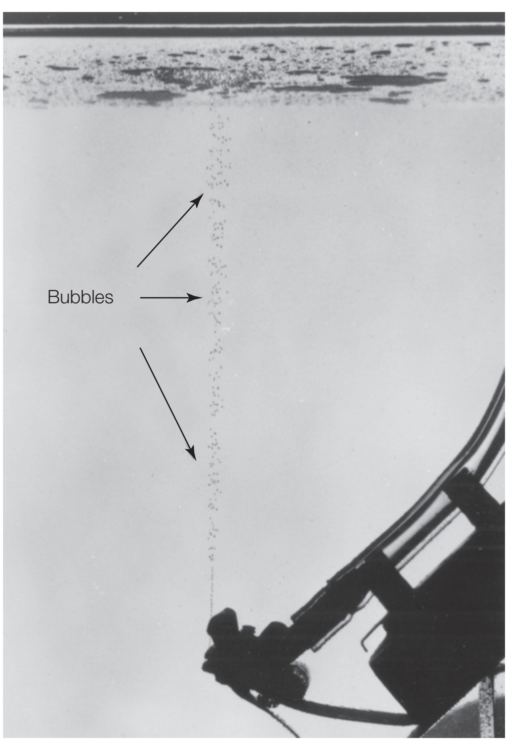

Figure 2. Immersion bubble testing.

Sensitivities Attainable with Immersion Bubble Testing

In bubble testing by the immersion technique, test sensitivity depends on operating conditions and selection of both the tracer gas and the test liquids (Fig. 2). Other factors can also change the test sensitivity actually attained. With certain combinations of tracer gases and detection liquids, sensitivities of 10^{-8} Pa·m^3·s^{-1} (10^{-7} std cm^3·s^{-1}) have been attained with calibrated leaks operating under laboratory conditions. Under excellent industrial immersion bubble testing conditions, maximum sensitivity of bubble testing is in the range of 10^{-5} to 10^{-6} Pa·m^3·s^{-1} (10^{-4} to 10^{-5} std cm^3·s^{-1}).

Operator Training and Motivation to Maintain Bubble Test Sensitivity

The sensitivity of bubble testing is hard to define because it also depends on the observation and alertness of the leak test operator. Practically, under excellent industrial test conditions, there is no question that leakage of 10^{-6} Pa·m^3·s^{-1} (10^{-5} std cm^3·s^{-1}) can be observed by the immersion bubble testing procedure. However, it is a different matter when operators do not know that a leak exists and have to examine a long weld seam for a possible bubble. Conceivably, they might not wait long enough for the bubbles to form or they might fail to look carefully after sufficient time at every portion of every area where a potential leak might exist. Thus, optimum bubble observation conditions and continuing training and motivation of bubble test operators to achieve and maintain their best observational capabilities are essential if the reliability and sensitivity of bubble testing are to be ensured.

Effects of Test Pressures on Bubble Formation

Because a minimum pressure is required to form a bubble in a liquid, bubble testing sensitivity depends on the pressure differential acting across a leak. Bubble testing sensitivity increases with an increase of pressure across a leak. Sometimes, it is possible for the operator to estimate that a certain rate of leakage is observed because a bubble of a particular volume is being observed. However, this type of leakage rate estimation can be inaccurate on very small leaks because of the finite solubility of the tracer gas in the bubble test liquid. It is theoretically possible for a small leak to exist where the tracer gas from a capillary leak dissolves in the test liquid so fast that no leakage bubble indication is visible. Special techniques that serve to increase the pressure differential across leaks can be used to increase bubble testing sensitivity.

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