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Radiation Backscatter-Based Non-destructive Technology Detects Corrosion under Insulation on Offshore Oil and Gas Platforms

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Typical pipe damage caused by CUI. Photo courtesy of EM&I Stantec.

One of the most common forms of corrosion found in the offshore oil and gas industry is corrosion under insulation (CUI). Many components on offshore platforms, such as piping systems, pressure vessels, tanks, and other equipment, are insulated for personnel protection and/or to keep fluids at appropriate temperatures for process efficiency. When insulated equipment is exposed to the harsh offshore marine environment (salt spray and mist), the ingress of chloride-laden moisture into the insulating material renders the underlying metal substrate vulnerable to accelerated localized corrosion, which often goes undetected.

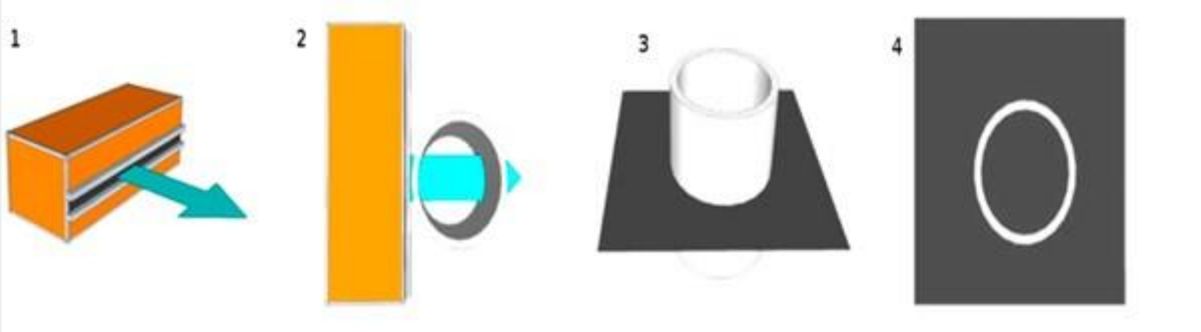
According to Danny Constantinis, CEO of EM&I Group, BCT allows inspection of the internal and external wall surfaces of any size pipe and vessel with multiple layers of various overlay materials, such as protective cladding and insulation or cementitious passive fire protection coatings, with accuracy that is comparable to ultrasonic testing. The single-side tomographic inspection technology is similar to a medical computerized tomography (CT) scan, where narrow beams of radiation are discharged into an object and captured by a detector that sends the data to a computer to generate an image of the inside of the object.

A BCT scanner, hoisted into place with an overhead line, is strapped to a 12-in (305-mm) insulated process gas line. Photo courtesy of EM&I Stantec and Inversa.

Unlike a CT scan, where the object to be imaged is placed inside the scanner and transmitted radiation is measured, a BCT scan creates an image by clamping the scanner onto the exterior of the object to be evaluated and measuring the backscattered (reflected) radiation. The scanner moves a focused beam of gamma radiation across the targeted inspection area, which is about as wide as the scanner and a few centimeters tall. Basically, Constantinis explains, as the beam of radiation passes through the insulation covering the object, the radiation collides with the material's molecules. These collisions throw off tiny photons that bounce back toward a bank of gamma radiation detectors built into the scanner. As the radiation travels further and penetrates the steel, which is denser than the insulation, a greater number of photons are reflected back. The distance of the reflected photons is measured by the scanner, and the resulting measurements are processed by the accompanying computer program, which calculates the density of the materials and constructs a computer-generated, cross-sectional image that depicts the insulation and the outside diameter (OD) and the inside diameter (ID) of the steel wall, and provides a quantitative wall thickness measurement. Any diminishing thickness of the OD or ID surfaces can be identified. This enables any insulated pipe or pressure vessel, regardless of its size, to be inspected for CUI through the insulation material.

The technology has been tested and validated in several field trials since 2010, including a study at ExxonMobil's Goldboro natural gas processing facility in Canada, where the BCT system was evaluated for its ability to identify CUI and internal wall thickness variations of large insulated pipes and vessels, Constantinis says. A separate offshore study was also conducted using coupons to assess the technology's capability to gauge wall thickness.

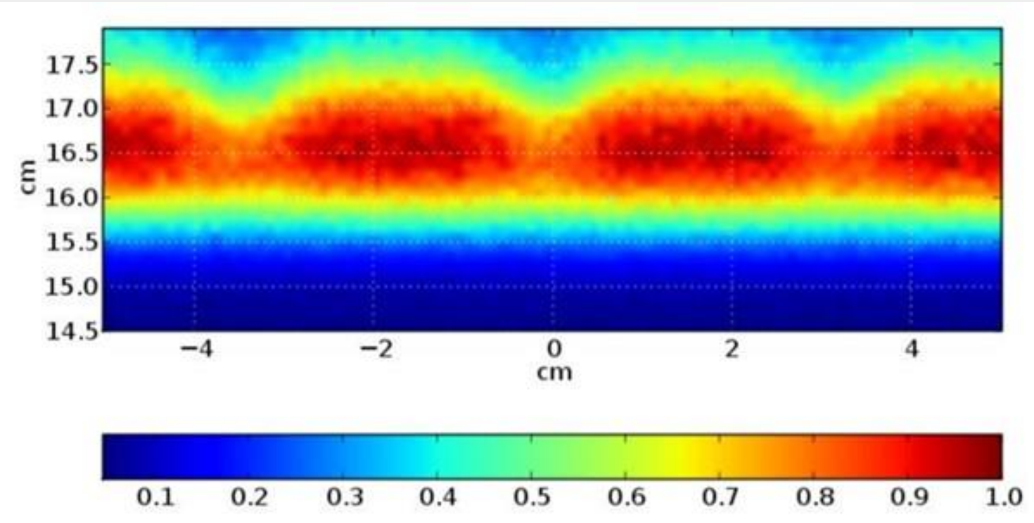
Constantinis notes that it can be challenging to locate CUI on an offshore platform because of the large percentage of components that are insulated—he estimates between 25 and 30% of piping is insulated, and the percentage increases when platforms are located in the northernmost areas of the world where the climates can get very cold. Additionally, it is not always obvious where CUI may be occurring. "In an ideal world, it would be good to be able to have a rapid screening tool to tell us where conditions for CUI might exist," he says, adding that three conditions required for CUI to occur are water ingress and moisture in the insulation material, damage to the coating on the metal surface, and operating temperatures between 60 °C and 90 °C.



The illustration shows steps for creating a BCT scan. 1) The BCT scanner houses the radiation collimator and detector; 2) the scanner is placed adjacent to asset to be inspected; 3) data are collected for a single plane through the asset by measuring backscattered radiation; 4) measurements are numerically processed (reconstructed) by a computer algorithm to create a cross-sectional image of the object's density. Image courtesy of EM&I Stantec.

Although protective cladding over insulation may appear intact, it may leak because of mechanical damage, degradation of joint sealants, and loose or missing inspection port sealing caps, which enable water to enter the insulation. Because migrating water tends to flow to low points in the insulation system, it can be difficult to predict where water will contact the metal surface. Since it is cost prohibitive to remove all insulation material or test under every inch of insulation, Constantinis comments that an evolving strategy in the industry is to use risk-based assessment to help narrow the search for CUI.

First, plant operators determine which insulated systems have a critical need for CUI to be identified, and then they determine which areas of those systems have a high probability that CUI will occur. Factors to determine the probability of CUI include the environment, service conditions, the age and type of coating, operating temperature, and the condition of the insulation. Visual inspections can identify indications that particular areas on piping or vessels may be experiencing CUI, such as missing or damaged cladding, poor seals at cladding seams, deficient overlaps, wet insulation, and rust stains.



This BCT image shows the cross section of an insulated steel wall. Image courtesy of EM&I Stantec.

Once general areas of susceptibility are pinpointed, then the underlying metal surface can be assessed by either removing the insulation or employing nondestructive testing (NDT) without removing the insulation to further identify specific areas where corrosion may be present. A number of NDT techniques are used, including pulsed eddy current, guided wave ultrasonics, and several radiography methods that, when implemented correctly, are able to provide a quantitative wall loss measurement as well as a visual image of the ID and OD surfaces. Because the BCT system is a single-side inspection method, says Constantinis, it fills a technology gap for assessing larger pipes and pressure vessels with a digital, radiation-based inspection technology. Until its development, he adds, effective quantitative measurements using digital radiography were typically limited to small bore piping.

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