Duplex stainless steels, austenitic stainless steels, and nickel-based alloys used in the oil and gas industry are resistant to atmospheric corrosion in most industrial environments. However, corrosion may result from surface damage that often occurs during storage and transportation. A thorough visual inspection should therefore be performed prior to the pipe entering service. Where the damage has resulted from contact with a noncorrosion-resistant steel, foreign material embedded in the surface may form rust. Embedded rust may act as an initiation site for further corrosion or create a stress riser where stress corrosion cracking could initiate, resulting in a catastrophic failure. This article explains the difference between embedded rust and superficial rust, a technique for remediation, and postremediation inspection of pipe for oil and gas production.

During storage and transportation of pipe, it is likely to come in contact with foreign materials containing iron or iron oxide (meaning, rust). This can range from iron oxide in the air settling on the pipe to damage from chains, racks, or forklifts during material movement. This will result in the appearance that the corrosion-resistant alloy pipe has corroded, when in fact it is the rusting of the foreign material. If this rust hasn’t disturbed the original pipe surface, it is considered to be superficial and not detrimental to the product. Superficial rust is not bonded to the surface of the pipe and the passivation layer providing corrosion resistance to the base metal still exists. However, if the foreign material has become embedded in the surface, it can be detrimental and should therefore be removed. Examples of superficial and embedded rust have been provided in Figure 1.
Visual testing is the most efficient nondestructive testing (NDT) method for identifying embedded rust. Where embedded rust is associated with a pit or gouge, it is easily recognized through visual inspection. One hundred percent visual testing should be performed in accordance with established company procedures by Level II personnel or Level I personnel under the direct supervision of Level II personnel who are qualified in accordance with SNT-TC-1A (ASNT 2016). The inspectors will require proper training and the visual acuity to differentiate between superficial and embedded rust. API product specifications typically specify the lighting level to be a minimum of 500 lux (50 foot-candles) at the inspection surface.

Embedded rust imperfections may be removed by grinding. The ground area should be blended to avoid sharp edges or contours. An example of an acceptable blended area is shown in Figure 2. A #36 grit or finer grinding wheel is recommended to reduce the risk of excessive material removal and to obtain an acceptable surface roughness. Abrasives containing iron or iron oxide should not be used, as they will form superficial rust. The operator must use caution to prevent excessive removal of material and heat buildup. The alloy should remain cool to the touch during grinding operations. After grinding, a commercially available copper sulfate spray solution can be applied to determine whether all of the embedded material has been removed. If any free iron is still present, copper will plate out and become visually apparent within 30 seconds to a minute. If copper plates out, additional grinding should be performed and copper sulfate solution reapplied until all contamination has been removed. Once completed, the area should be wiped with a cloth to remove excess copper sulfate solution.

Where defects have been removed by grinding, the remaining wall thickness of the pipe needs to be measured to verify it meets the requirements of API 5CRA or other applicable specification. API 5CRA requires the wall thickness be within 87.5% of the specified wall thickness for hot-finished products, or 90% for other products (API 2010; API 2018). This inspection should be performed by qualified personnel using a calibrated UT thickness device, following written company procedures. Localized areas are
typically tested with a handheld device, while large areas may be inspected by automated equipment, as determined by company procedures. The ultrasound velocity of the UT device needs to be verified. To do this, the typical process is to use a calibrated round tip × flat tip outside micrometer and measure the wall thickness of the test material. Then, calibrate the velocity of the handheld UT gauge to the known thickness of the test material. Ensure the proper amount of coupling gel and scan the entire remediated surface to ensure that the wall thickness is greater than the specification limits. Document the thinnest wall reading measured on the inspection report. The mechanical remediation can be followed by grit blast to ensure thorough removal of contamination and uniform surface finish (Figure 3). As always, Level I or II technicians should consult with their Level III personnel and company procedures for inspection and documentation requirements.

In summary, superficial surface contamination may be of no concern when using corrosion resistant alloys; however, the material needs to be properly inspected to confirm the contamination is not embedded. If embedded contamination is present, a proper remediation and reinspection needs to be performed. Embedded contamination in the form of rust may become an initiation site for corrosion, as well as a stress riser, leading to a catastrophic failure by stress corrosion cracking.

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Figure 3. Uniform surface of pipe visible after grit blasting.