Cathodic Protection Problem for a Gas Pipeline near a Compressor Station

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A 56-in (1.4-m) diameter gas pipeline was monitored with a magnetic flux leakage pig. Fortunately, significant local corrosion close to a compressor station was diagnosed before the gas pipeline experienced a failure. The nominal pipeline wall thickness was ~30 mm, but it had been reduced to ~4 mm at the local corrosion site. A field study showed that cathodic protection (CP) potentials in the corroded area did not satisfy established criteria for protection because of concentration cells and CP interference. After replacing the gas pipeline with a new coated one, effective CP potentials were achieved by adding local CP.

A 56-in (1.4-m) diameter buried gas pipeline that passes close to a gas compressor station had been connected to a pig launcher and receiver located in the compressor station. The pipeline was electrically isolated from the pipelines within the compressor station; therefore, this pipeline and the compressor station are cathodically protected by two separate cathodic protection (CP) systems. Recent inspection by a magnetic flux leakage (MFL) pig showed that the thickness of the pipeline in front of the compressor station was locally reduced at several points—from ~30 to 4 mm. Because this represented a very dangerous condition, the decision was quickly made to replace the corroded portion of the pipeline.

The geographical location of the buried pipeline has very low annual rainfall, thus it was expected that the soil around it contained very little moisture. After excavation, however, a rocky layer that is impervious to water was found under the pipeline, and trapped rainwater had created a muddy environment. The soil resistivity was measured by the Wenner method to determine the value at the depth of the buried pipeline. According to Table 1, there was a great difference between the resistivity of the soil located a distance away from the compressor station, which was in the approximate range from 5,000 to 6,000 Ω-cm, and the soil in the corroded location, which was 47.1 Ω-cm. There was no significant difference between the type of soil in the different areas, indicating that the difference in soil resistivity was mainly related to soil moisture content. Soil strata outside of the corroded area did not include a rocky layer that could collect rainwater.

Figure 1 shows severe local corrosion in areas of the removed pipeline segment. CP potential survey data for the pipeline in locations away from the compressor station were available because remote test points were located away from the compressor station, typically at 1-km intervals; however, there was no information about CP potentials close to the compressor station. Potentials at available test points were ~–0.860 to –0.920 V vs. a copper/

copper sulfate ($Cu/CuSO_4$) reference electrode (CSE).

The localized corrosion of the 56-in adjacent pipeline is attributed to interference from the CP system for the pipelines within the gas compressor station or problems achieving sufficient CP current distribution to the corroded portion of the pipeline. After replacing the corroded pipe segment with coated pipe, a distributed flexible cable anode (AnodeFlex†) was installed parallel and closely coupled to the replacement pipeline segment, as shown in Figure 2(a).

For CP monitoring of the pipeline adjacent to the compressor station, three new test points were added as part of the pipeline repair: Test Points 1, 2, and 3 in Figure 2(b). Because of the urgent need for pipeline replacement, a detailed investigation of the root cause of corrosion was not conducted; however, this was planned as part of the next steps.

Field Tests

After completion of pipeline repairs, free potential of the gas pipeline was measured vs. a CSE. As shown in Table 2, the free corrosion potentials at Test Points 1, 2, and 3 were more positive than the remote free corrosion potential at Test Point 3.

During the second step of the CP testing, the original rectifier for the pipeline was turned on (output of 3.86 A, 13.75 V). After 24 h, CP "on" potentials at Test Points 1, 2, 3, and remote from the repair were measured. Table 2 shows that, again, CP potential at points 1, 2, and 3 were more positive than the remote CP potential from Test Point 3.

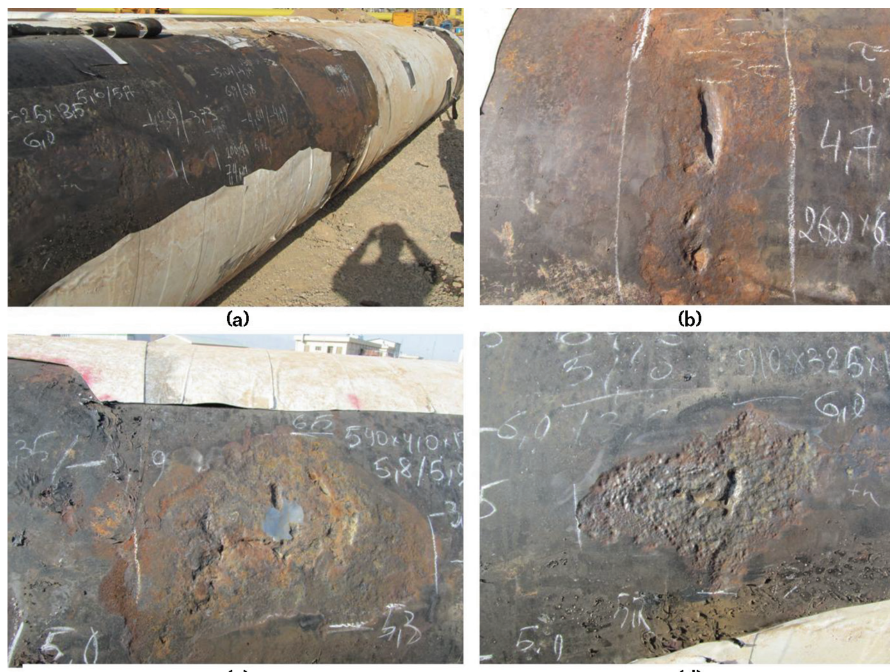
During the third step of CP testing, both the original pipeline rectifier and the new flexible cable anode rectifier (output of 2.95 A, 6.76 V) were turned on. Table 2 indicates the CP "on" potentials in this step show substantial improvement.

In some gas compressor stations, steel-reinforced concrete foundations (RCFs) and grounding systems experience interference from CP for buried gas pipelines.[1-2]

†Trade name.

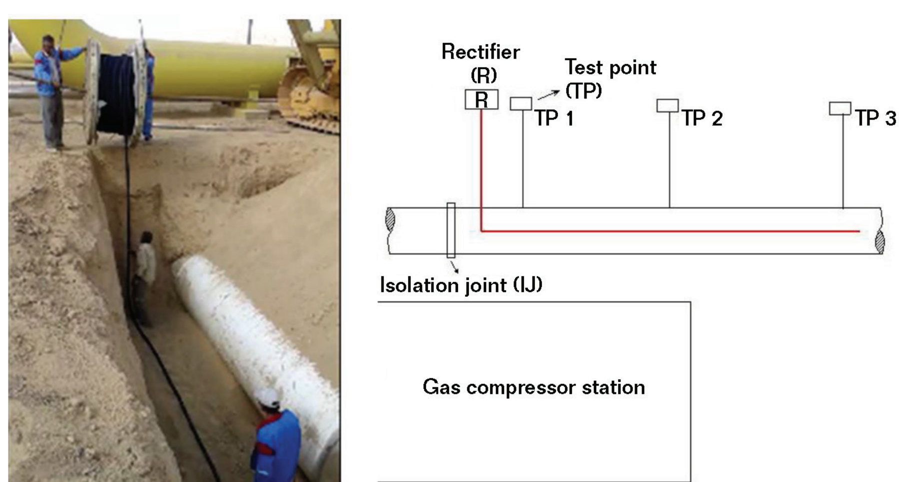
TABLE 1. SOIL RESISTIVITY IN THE CORRODED AND REMOTE LOCATIONS

Location	Soil resistivity (Ω·cm)
At corroded location (Location 1)	47.1
Remote from the compressor station (Location 2)	5,150
Remote from the compressor station (Location 3)	5,762
Remote from the compressor station (Location 4)	6,390



(a) (b) (c) (d)

FIGURE 1 (a-d) After removing the coating from the corroded segment of the gas pipeline, local corrosion can be seen.



(a) (b)

FIGURE 2 (a) and (b) Local CP repairs use flexible cable anode close to the replacement segment.

TABLE 2. SUMMARY OF PIPELINE POTENTIALS AT TEST POINTS[(A)] DURING THE THREE PHASES OF CP TESTING

Potential Conditions	Test Point 1	Test Point 2	Test Point 3	Remote from Test Point 3
Free corrosion potential	–0.27	–0.27	–0.27	–0.44
Original pipeline rectifier "on"	–0.27	–0.30	–0.36	–0.91
Original and flexible cable anode rectifiers "on"	–1.40	–0.85	–0.80	–0.92

[(A)] vs. CSE.

Electrical interconnections of RCFs and grounding systems to buried gas pipelines located in compressor stations may be required for safety considerations. These interconnections substantially increase CP current requirements, which can create CP interference with isolated, adjacent gas pipelines. For this reason, the effects of the gas compressor station's CP on the adjacent 56-in diameter pipeline were investigated. The output of the rectifier in the compressor station was 11.3 A, 18.0 V. The effect of this rectifier on the adjacent pipeline potentials was investigated by turning the compressor station rectifier on and off. The potential shifts were on the order of 100 mV and not considered large enough to account for the severe corrosion that had been found.

Discussion

When a pipeline traverses areas with widely differing soil resistivity, long-line corrosion cells can be established with anodic behavior in the areas with lower soil resistivity. Current densities required for achieving the CP criterion (–0.85 V vs. CSE) will be drastically different.[3-5] Therefore, a single CP system may not be effective for CP of a gas pipeline that is located in soil with very different resistivities. If one groundbed (or CP system) is used, then the rectifier output that is sufficient to protect the portions of the pipeline in higher resistivity soils may be inadequate for portions of the pipeline located in soil with low resistivity. Adjustments to rectifier output are unlikely to achieve the necessary protective current distribution. For this reason, CP potentials indicated that the corroded portion of the adjacent 56-in diameter pipeline was underprotected, and increasing the output of the rectifier would have little effect on this critical area.

For this situation, the most effective approach is to divide the pipeline into several isolated segments according to soil resistivity, and protect each segment with a dedicated CP system. If the gas pipeline is already in operation and installation of isolation joints is impractical, then pipeline segments located in low-resistivity soils can be cathodically protected with closely coupled anodes such as parallel linear anodes.

Conclusions

Local variations in soil resistivity can affect the CP potentials of a pipeline and sometimes cause local underprotection. Therefore, the type of soil layers located around and under the pipeline must be considered in CP design. Segmenting a pipeline that traverses soils with differing conditions offers the option of providing effective corrosion control with separate CP systems.

Acknowledgment

The assistance of Tavakoli, Najafi, and Gogerdchiyan is greatly acknowledged.

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