Paper No.
11338

NACE INTERNATIONAL CORROSION 2011 CONFERENCE & EXPO

Stray Current Interference from a Light Rail Traction System

By
Earl L. Kirkpatrick, P.E.
Principal Engineer
ELK Engineering Associates, Inc.
8950 Forum Way
Fort Worth, TX 76140
earlk@elkeng.com

ABSTRACT

Presents an actual case history of stray current interference from a LRT system on a three circuit 69kV pipe-type cable system, the corrective action taken, and its results.

Keywords: LRT, Stray Current Influence, Pipe-type Cable System,

INTRODUCTION

Construction of the Dallas Area Rapid Transit (DART) light rail transit (LRT) starter system, comprising slightly more than twenty miles of dual track right-of-ways (R/W) began in 1993. The rail guideway was constructed in conformance with modern LRT construction practices. The following standards were established for acceptance testing of the various segments of track work:

- 625 Ohm/1000 track feet (304.8 track meter) – concrete tie and ballast track work
- 625 Ohm/1000 track feet (304.8 track meter) – direct fixation track work
- 150 Ohm/1000 track feet (304.8 track meter) – at-grade imbedded track work
- 150 Ohm/1000 track feet (304.8 track meter) – special track work (wood tie and ballast)
- 150 Ohm/1000 track feet (304.8 track meter) – grade crossing track work
- 50 Ohm/1000 track feet (304.8 track meter) – Service and Inspection (S&I) Yard wood tie and ballast

Franchise owner water lines crossing the track R/W were replaced with new, utilizing PVC pipe up through ten inch diameter. Larger diameter water lines were replaced with ductile iron pipe, employing pipe joint continuity bonds, protective coatings, dielectric isolation from

existing lines, and cathodic protection. All of these measures resulted in an LRT system that was a good neighbor, producing essentially no stray current interference problems on the franchise owner utilities.

We documented one utility that was directly affected by initial operation of the LRT system. This was a three circuit pipe-type cable (P-TC) system with a north south orientation just beyond the east fence of the S&I yard.

Pipe–Type Cable Circuits

A local electric power supplier (power company) operates a city wide pipe-type cable underground system in the City of Dallas. The newly constructed DART LRT system crossed these pipe-type cables at several locations throughout the City. Additional test stations were installed at or close to each of these new crossings. Pipe-to-soil potentials and pipeline currents were monitored at each of these locations with train passage. No significant electrical influence was noted at any of these crossings.

However, a different situation was encountered on the three P-TC circuits at the Service and Inspection Yard. Normal train movement within the yard would not cause significant stray current influence on the nearby P-TC system even though the yard trackwork was designed for limited electrical isolation. This is due to slow train speeds and limited accelerations within the yard. The yard lead track was provided with insulating joints (IJ) at the tie-in to the main line to avoid stray current in the yard. The S&I yard was provided with its own separate traction power substation (TPSS) to power train movement within the yard. At the junction of the yard lead track with the mainline a knife switch was provided between the two overhead catenary systems (OCS). Another knife switch was provided across the yard lead IJs. These two knife switches make provision to power trains in the S&I under emergency conditions should the S&I TPSS be taken out of service for maintenance or repair. Short duration stray current under emergency conditions is tolerable, provided that it is not a long term condition.

The 138KV Medill to East Network circuit is comprised of three pipe-type cables installed 2 (60 cm) feet on center backfilled with thermal sand. Average depth of cover ranges from 3 to 7 (0.9 to 2.1 m) feet. The distance between substations is approximately 5,700 feet (1.737 km). Each circuit is constructed of 6-5/8 (16.8 cm) inch O.D. by 0.250 (6.35 mm) inch wall thickness line pipe provided with a typical coal tar and felt outer wrap coating system. Three insulated phase conductor potheads are provided at each end of each circuit. Since the pipe wall is the concentric neutral for that circuit, it must be solidly bonded to the substation grid at each end, while at the same time being electrically separated from the grid for the purposes of cathodic protection (CP). This is accomplished by installing a resistor rectifier at each end of the circuit. A 0.008 ohm stainless steel resistor shunts the pipe wall immediately below the pothead insulators to ground in order to provide a safe, low resistance fault current path to the substation grid. A 1.0 volt 125 ampere rectifier's output is impressed across the shunt resistor to bias the P-TC negative with respect to the substation grid, providing CP to the pipe wall. But, this does leave the circuit effectively grounded to the power system at each end. By actual measurement, coating resistance was 7,741 ohms per square foot (719 ohms per square meter). This low value is the long term result of elevated temperature operation of the P-TC system and makes the pipe more susceptible to stray DC. Three phase conductors are pulled into each pipe. Phase conductors are steel tape armored, paper insulated 1,250 MCM

(635 mm squared) copper. This oil static system is filled with insulating oil maintained at 115PSIG (793 kPa) or greater, generally about 260 PSIG (1,379 kPa).

During the pre-revenue train operational period, the power company contracted for installation of test leads at multiple locations where the new LRT system crossed one of the existing P-TC circuits. A complex test lead installation was constructed on the three Madill to east network circuits where they laid very close to the eastern edge of the S&I yard. Each circuit was provided with two sets of calibrated IR drop test leads, one to the north and one to the south of the nearest edge of the S&I yard. The north and south test leads were provided with different color coding. Each of the circuits had a steel casing underneath an abandoned track approximately 250 feet (76.2 meters) north of the test station. Each casing was provided with a pair of color coded test leads. Finally, each circuit was provided with a reference electrode, also with a color coded test lead placed directly underneath the pipe. Figure 1 provides details of the installation, including a wiring diagram for the junction box which contains a total of 33 test leads.

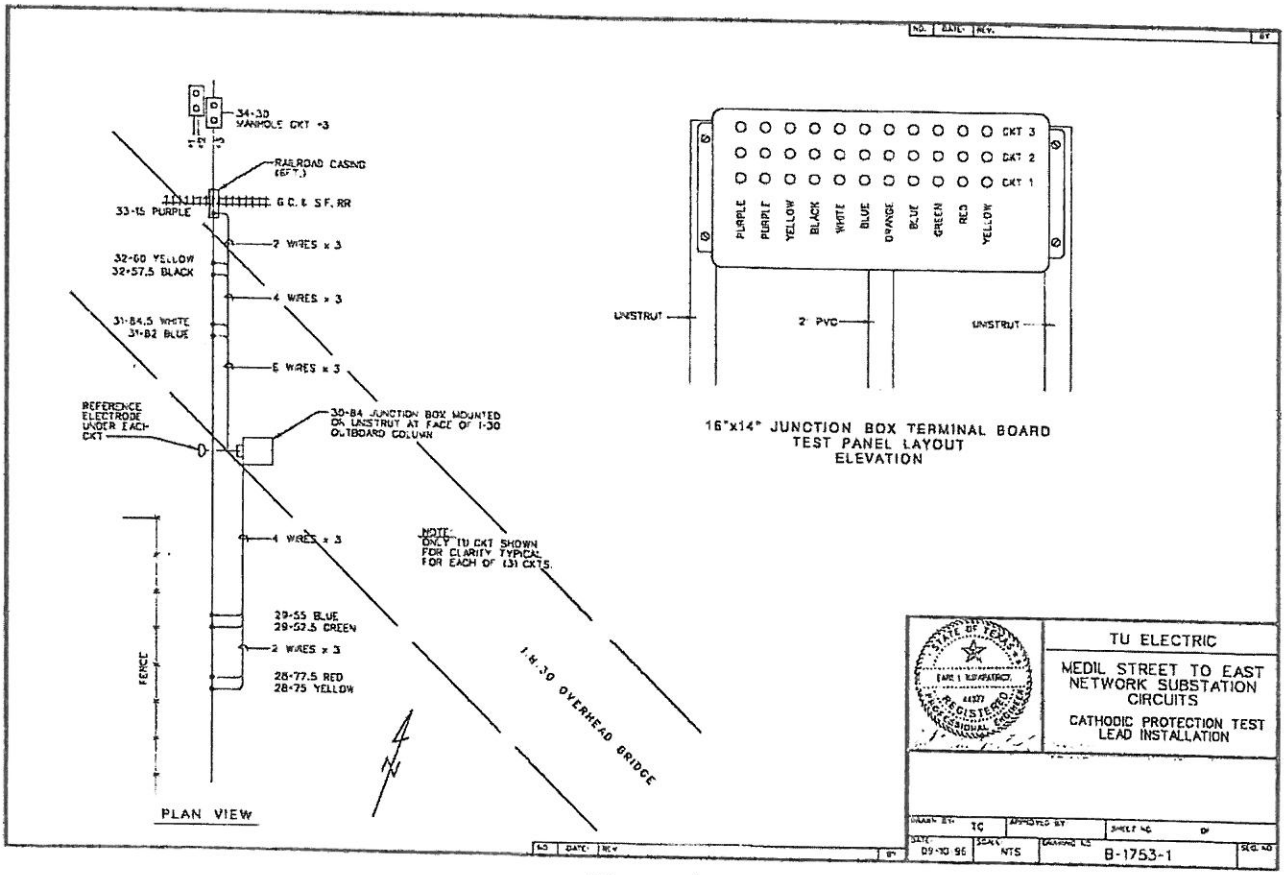

Figure 1

INVESTIGATION

Initial testing of the Medill-East Network test lead installations showed excessive voltage excursions on all three circuits with attendant significant line current excursions on all six IR Drop test leads. Three M.C. Miller model number NR-1 DC strip chart recorders were installed

on Circuit one, which was closest to the S&I, to simultaneously measure pipe-to-soil potential, pipe current flow to the south, and pipe current flow to the north. Figure 2, taken at the start of the 24 hour recording, is a representative sample of the data gathered.

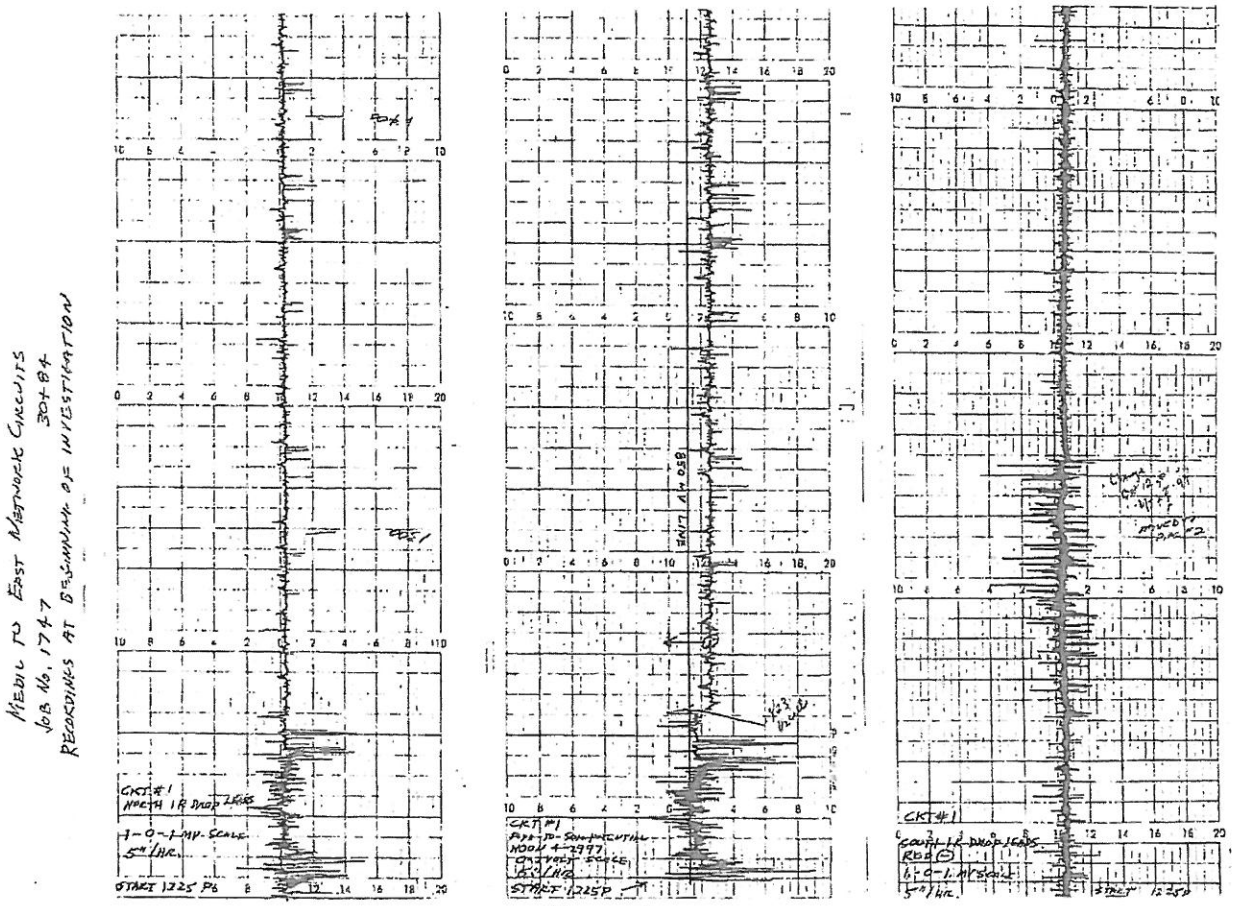

Figure 2

Clearly all three circuits were being influenced by mainline traction currents. This should not have been the case. Joint testing by DART and the consultant for the power company confirmed that the yard lead track IJs were still effective. Further extensive testing by DART staff revealed that an impedance bond across the yard lead IJs had been mis-wired when installed. This was allowing main line rail traction current to enter the S&I yard trackwork. After repairs were made, new recordings were obtained. Figure 3, again taken at the start of the recording period, shows a vastly different picture.

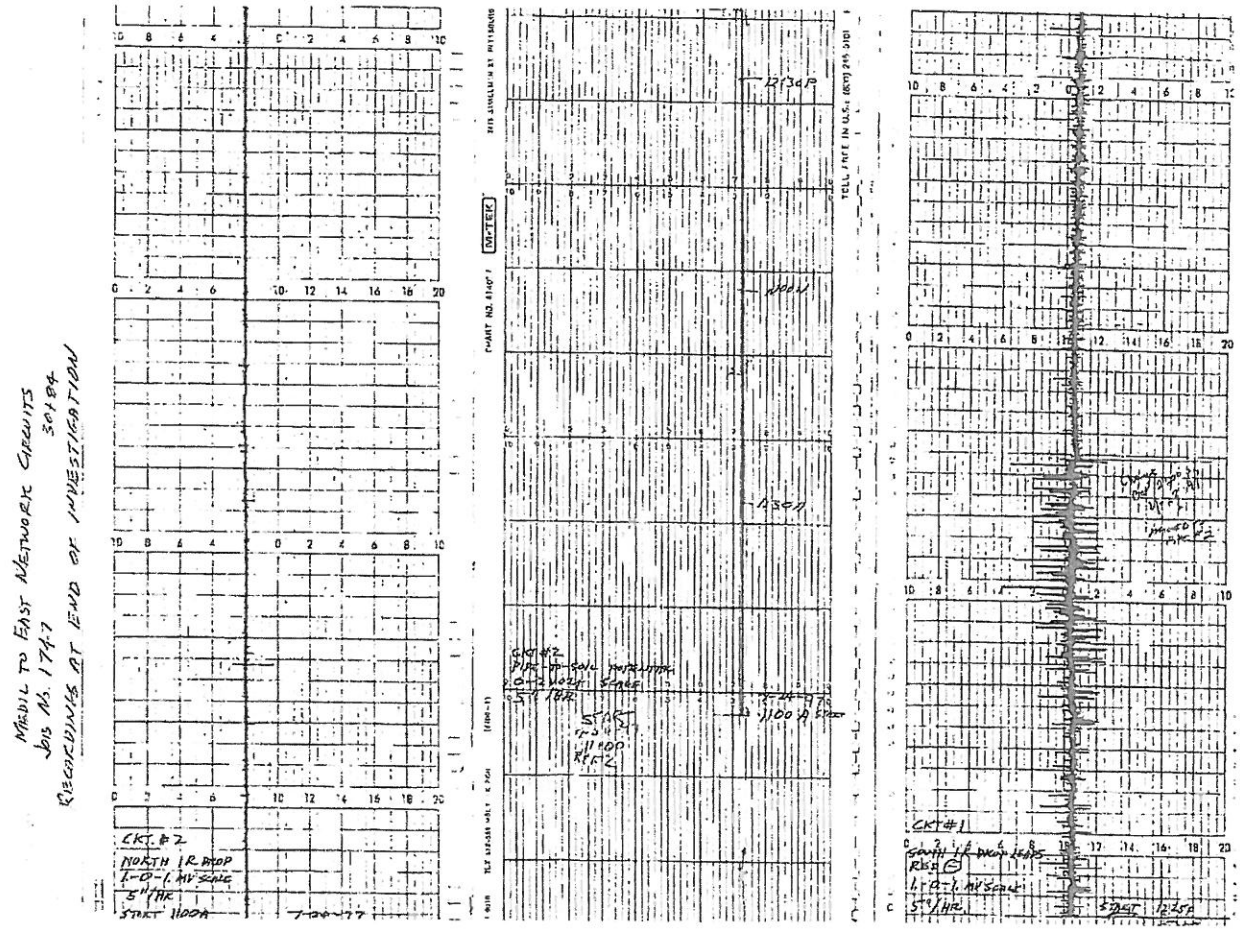

Figure 3

Note that the pipe-to-soil voltage excursions have completely disappeared, leaving a steady trace. Some current excursions were still noted in the two IR drop recordings. This is attributed to traction current pickup and discharge between the two substation grids with the three P-TC circuits providing the connecting pathway. Problem solved. The presence of the noted current flow in the pipe wall is not deleterious to CP on the three circuits.

LESSONS LEARNED

Even with the best specifications in place, there is no substitute for thorough inspection during construction and commissioning of new facilities. This case history highlights the importance of conducting thorough stray current testing on utilities adjacent to LRT guideways.

ACKNOWLEDGEMENT

The author gratefully acknowledges permission to publish granted by Dallas Area Rapid Transit.