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STUDY ON TROUBLE SHOOTING IN ICCP PROTECTED UNDERGROUND PIPELINE FOR LOW INSTANT OFF PSP VALUES.

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ABSTRACT

Successfully designed, installed and commissioned ICCP systems should demonstrate, a polarized PSP of -850 mV or more negative as measured w.r.t. saturated Copper/Copper Sulphate (CSE) Reference Electrode. Alternatively, A minimum of 100 mV of cathodic polarization. Either the formation or the decay of polarization must be measured to satisfy this criterion as per NACE RP-0169.

This paper is a case study related to identifying the probable causes of low instant OFF PSP values of pipeline. During ON-OFF PSP monitoring, it was observed that the instant OFF PSP values at many locations were less electronegative than protection criteria of -850 mV with respect to copper/copper Sulphate reference electrode. Pipeline was not getting adequate CP protection of -850 mV or more negative, but it was ensured that the P/L was protected by 100 mV cathodic polarization shift criterion.

Various efforts were made to identify the exact cause of low instant OFF PSP such as CAT survey, DCVG, checking of anode bed, data logging, faults in cables across IJ, checking of IJ with RFIT etc. After carrying out numerous surveys one of the probable causes was identified as shorting of IJ at one of the ends of pipeline. This paper describes the challenges faced in identifying causes of low instant OFF PSP values and various actions taken to rectify the same.

INTRODUCTION

6 Inch Dia, 24 KM length P/L spreads from Dispatch Terminal at location A to another Dispatch Terminal at location B. This P/L is ICCP protected having TR Units at Location A and Location B. During routine ON-OFF PSP monitoring, it was observed that the value of OFF PSP of 6 inch Dia, 24 Km pipeline was less electronegative than -850mV w.r.t. copper/copper Sulphate reference electrode across the majority length of pipeline towards Dispatch terminal A. The CP system of the pipeline was investigated to identify the problem in following manner:

- Existing Cathodic Protection System in Dispatch terminals was inspected and detailed testing carried out for checking the effectiveness of respective CP-TR Units and found working normal.
- All incoming & outgoing cables coming from both sides of IJ (un-protected & protected) in test station at Dispatch terminal A were checked and were found healthy.
- Healthiness of existing Anode bed at Dispatch Terminal A was checked and additional 02 Nos. anodes were also installed at Dispatch Terminal A for getting less resistance of complete anode bed.
- Healthiness of cathodic header cable checked and found joint on the cable. Hence, the same cable was encapsulated & insulated/isolated from the system and new cathodic cable of appropriate size was brazed on pipeline inside Dispatch Terminal A.
- Data logger was installed at Dispatch Terminal A & pipe to soil potential and AC voltages were logged for 24 hours and found no abnormality.
- Healthiness of surge diverter across IJ at Dispatch Terminal A was checked and found healthy.
- Natural PSP were measured at test stations after switching off TRU at both ends of pipeline (i.e. depolarizing the entire pipeline for 24 hrs.) and observed that pipeline falls under “protected” zone as per 100 mV potential shift criterion, although most of spans of the pipeline did not meet the primary criterion of -850mV.
- CAT (Current Attenuation Test) was carried out on entire length of pipeline to identify grounding locations on pipeline if existed any. In CAT survey, any sizable grounding location along the pipeline route was not found.
- CAT survey was also performed to the point just after IJ (unprotected side) to check if the same current is passing through IJ to further ascertain the healthiness of IJ. Current drainage was found on above ground pipe also; although, the reading was not steady. However, it was noted that current at IJ point was 2.17 A against feeding current of 3.0 A at CJB which was returning from aboveground pipeline to underground pipeline across the Isolation Joint.
- Healthiness of Insulating Joint (IJ) was checked by swing test i.e. switching ON & OFF TRUs and no major swing was observed. Then, in second step, the IJ was tested using RFIT tester and found that IJ is partially conducting.

After conducting all relevant surveys, it was almost ascertained that the existing IJ itself was not completely providing electrical isolation between unprotected and protected sides of the pipeline.

EXPERIMENTAL PROCEDURE

Different tests and surveys conducted were as follows:-

TR Units at both the locations were thoroughly inspected and checked for healthiness. For carrying out ON-OFF PSP survey both TR units were kept in manual mode and current interrupters were installed at both TR units. The readings of both TR units as recorded were as follows:-

Table 1: Output Parameters of TR units

Sl. No.	TR Unit Location Description	DC O/P Voltage	DC O/P Current	Mode of operation
1	Dispatch Terminal A	1.9V	1.2A	AVCC
2	Dispatch Terminal B	3.5V	0.9A	AVCC

Lists of Equipment and Tools used:-

1) Digital Multimeter
2) Digital Clamp meter suitable for AC and DC current measurements.
3) Portable reference (Copper / Copper Sulphate) Electrodes.
4) Hand tools

TR units were thoroughly checked. Digital meters were installed at TR units (Inbuilt) for indication of output voltage and output current. Reading's displayed by these meters were crossed checked using readings measured by digital hand held meters.

Observations and Findings:-

TR unit at Dispatch Terminal B was set for ON/OFF and TR unit at Dispatch Terminal A was kept OFF to observe the changes in PSP values at terminal A. Readings at each reference cell inside Terminal A by interrupting TR unit at terminal B were as follows:-

Table 2: ON/OFF readings at Reference cells inside Dispatch Terminal A after interrupting TR unit at Dispatch Terminal B.

Terminal B TR Unit in ON-OFF condition and Terminal A TR Unit in OFF condition			
Ref Cell No.	**ON Potential (V)**	**OFF Potential (V)**	**ON-OFF Difference**
Ref Cell 1	-0.884	-0.817	67mV
Ref Cell 2	-0.897	-0.811	86mV
Ref Cell 3	-0.792	-0.748	44mV

Similarly, readings of all the reference cells at Dispatch Terminal A were taken by interrupting TR units of both Dispatch Terminal A and Dispatch Terminal B. Observed readings were as follows:-

Table 3: ON/OFF readings at Reference cells inside Terminal A after interrupting both TR units at Terminal A & B.

Both TR Units in ON-OFF condition			
Ref Cell No.	**ON Potential (V)**	**OFF Potential (V)**	**ON-OFF Difference**
Ref Cell 1	-1.436	-0.810	626mV
Ref Cell 2	-1.427	-0.816	611mV
Ref Cell 3	-1.331	-0.787	544mV

Since observed OFF potentials were not as per required criteria, it was decided to increase TR output at Dispatch Terminal A to bring OFF potentials as per required criteria. After increasing TR units Output, ON-OFF potentials were monitored at different TLPs at different crossings (Rail, Road, HT etc.) by interrupting both TR units. Readings observed were as follows:-

Table 4: (ON-OFF PSP Values)

Sl.No.	TLP No.	Chainage (KM)	Crossing	ON PSP (Volts)	OFF PSP (Volts)	Other readings	
						Type of reading	Value (Volts)
1	3	0.260	Rail	-2.102	-0.805	Casing	-0.459
2	5	0.385	Rail	-2.210	-0.800	Casing	-0.424
3	7	1.300	Road	-2.009	-0.840	Casing	-0.406
4	21	11.520	HT	-1.712	-0.820	AC	1.02
5	22	11.590	Rail	-1.463	-0.811	Casing	-0.493
6	23	12.035	Rail	-1.452	-0.842	Casing	-0.495
7	24	12.400	HT	-1.392	-0.825	AC	0.921
8	25	12.890	SV	-1.587	-0.850	AC	0.712
9	28	14.610	Road	-1.678	-0.832	Casing	-0.551

From above observed readings it was suspected to be grounding of Pipeline at some locations along the length of pipeline. Therefore it was intended to carry out current attenuation survey (CAT) for identification of pipeline grounding locations. It was also observed that PSP readings were varying with time. So we intended to carry out data logging as well.

DATA LOGGING

Data logger was installed inside Dispatch Terminal A at chainage 0.010KM in CJB. Intended parameters like AC Voltages, DC Voltages, and PSP values were recorded using data logger. Data logger was set for 24 hrs with logging interval of 1 second. From recorded data following were the testing details.

Table 5: Data Logged Details

Details of Data logging	Recorded parameters
Max. AC voltage as per data logger	0.19 Volts
Min. AC voltage as per data logger	0.04 Volts
Max. DC voltage as per data logger	-1.375 Volts
Min. DC voltage as per data logger	-1.332 Volts
Average PSP recorded	-1.36 Volts

From recorded data it was observed that there were no significant variations in pipe to soil potentials with time. As such, effect of telluric interference on pipeline was ruled out.

CURRENT ATTENUATION SURVEY (CAT)

Based on observations of ON-OFF PSP monitoring. CAT survey was carried out to identify the current draining locations

List of equipments used:-
1) Transmitter
2) Receiver
3) A-frame
4) Digital Multimeter
5) Connecting cables, ground stakes, hammer, battery, measuring Tape etc.

Experimental Procedure

Instrument: PCM-TX Rediodetection
Current feed from Transmitter: 3.0 Ampere (Amp)
Current measured by Receiver as per below:-

1) Between IJ to CJB (Approx. 12 meters from IJ):
   U/G Start Point (A): 1.91 Amps, 3 Meters away from above (A+3): 2.17 Amp
2) Between CJB to Main Discharge Valve (MOV-Approx. 70 Meters from IJ):
   10 Meter away from Start Point (A+10): 1.20 Amp, 15 Meter away from Start Point (A+15): 1.36 Amp, Meter away from Start Point (A+20): 1.25 Amp, 3 Meter before MOV: 0.863 Amps
3) Between Main Discharge Valve (MOV) to Mainline (In side Terminal premise):
   5 Meter after MOV: 0.423 Amps, 1st Railway Crossing start: 0.361 Amp, 1st Rly Crossing end: 0.388 Amp, 2nd Railway Crossing start: 0.364 Amp, 2nd Railway Crossing end: 0.361 Amp, 15Mtr from 2nd Railway Crossing end: 0.354 Amp, 30Mtr from 2nd Railway Crossing end: 0.360 Amp, 45Mtr from 2nd Railway Crossing end: 0.363 Amp, Road crossing start: 0.349 Amp, Road crossing end: 0.345 Amp

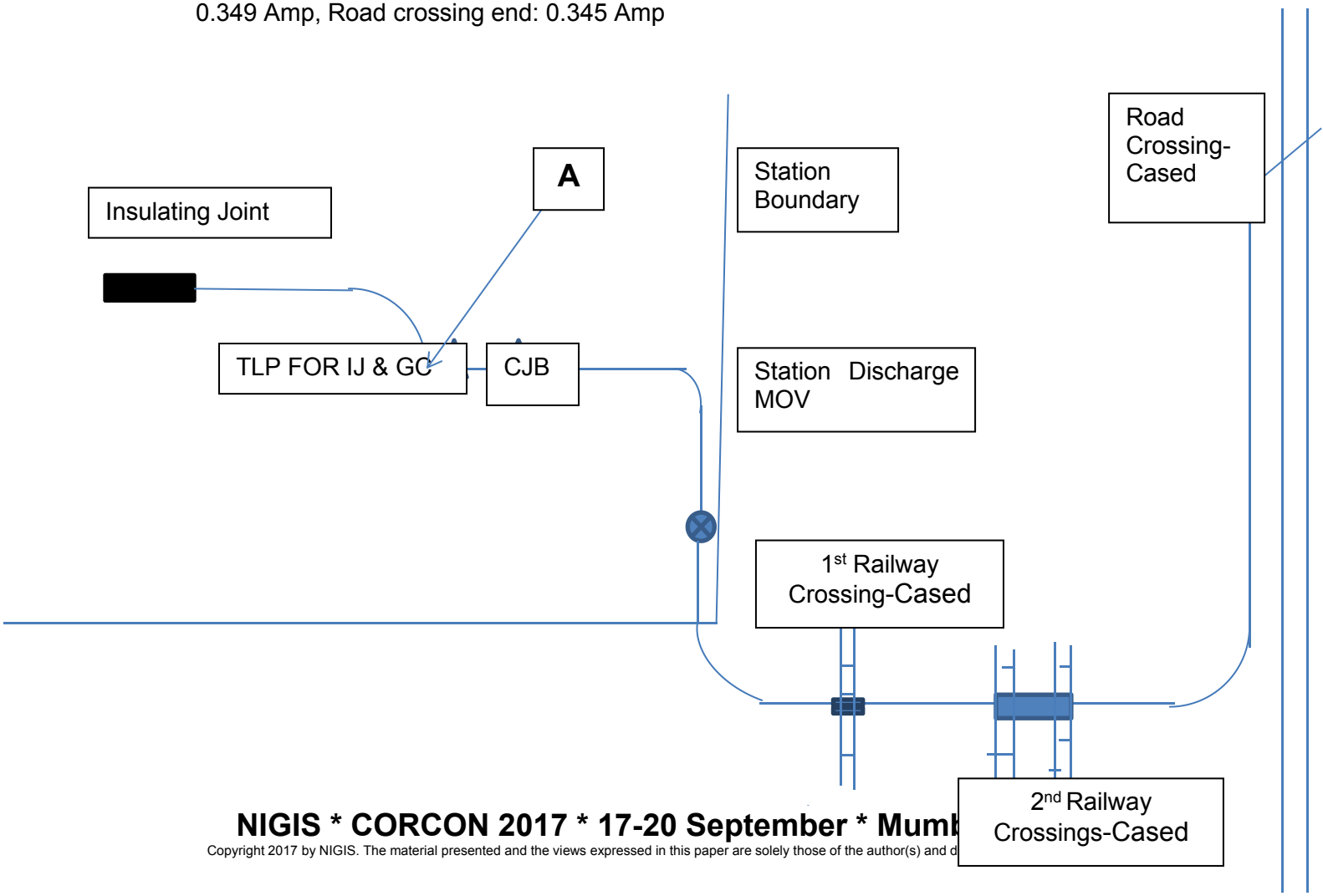

Figure 1: Sketch of pipeline for which CAT survey carried out

Observations and findings

After conducting CAT survey it was observed that overall current loss in coating inside and near IJ in Dispatch Terminal A was much higher as compared to other spans of pipeline. Therefore it was suspected that grounding of pipeline is inside the terminal itself. After all the findings it was suspected for possibility of grounding through above ground pipeline across insulation joint. It was suspected that current was grounded through earthing system at above ground piping. For further investigation it was decided to carry out IJ checking.

TEST PROCEDURE FOR IJ CHECKING

We have checked integrity of IJ by two methods namely potential swing test and IJ test by using radio frequency insulation tester

Swing Test

For carrying out swing test both the TR units at Dispatch Terminal A and B were interrupted simultaneously in the cycle of 4:1 Sec. ON-OFF PSP was monitored and recorded on both sides of IJ at Dispatch Terminal A (i.e. PSP on protected and unprotected side of IJ).
Following readings were recorded across IJ at Dispatch Terminal A.

Table 6: Swing Test Parameters

Set PSP in TR Unit at Terminal A	ON PSP (Protected side)	OFF PSP (Protected side)	ON PSP (Un-Protected Side)	OFF PSP (Un-Protected Side)
-1.3 V	-1.307V	-0.596V	-0.560V	-0.507V
-1.5 V	-1.508V	-0.595V	-0.573V	-0.508V
-2.0V	-2.052V	-0.599V	-0.614V	-0.508V
-2.5 V	-2.508V	-0.608V	-0.650V	-0.513V
-3.0V	-3.041V	-0.620V	-0.693V	-0.520V
-5.0V	-5.032V	-0.635V	-0.850V	-0.530V

From above readings it was observed that PSP on unprotected side was also increasing negatively whenever we increased PSP from TR unit at Dispatch Terminal A. From potential swing test it was observed that PSP on unprotected side is marginally moving towards negative side. Ideally, ON-OFF PSP values should remain same on unprotected side or sometimes OFF potentials shall be more negative than OFF potentials. (Ref: Clause 6.58 from NACE level 2 manual).

RFIT Checking

To further ascertain leakage of IJ at Dispatch Terminal A, we conducted testing of IJ with RF-IT (Radio frequency insulation tester).

At Dispatch Terminal B IJ was found ok with RF-IT however IJ at Dispatch Terminal A was found partially conducting. Ref photographs of both IJs with RF-IT

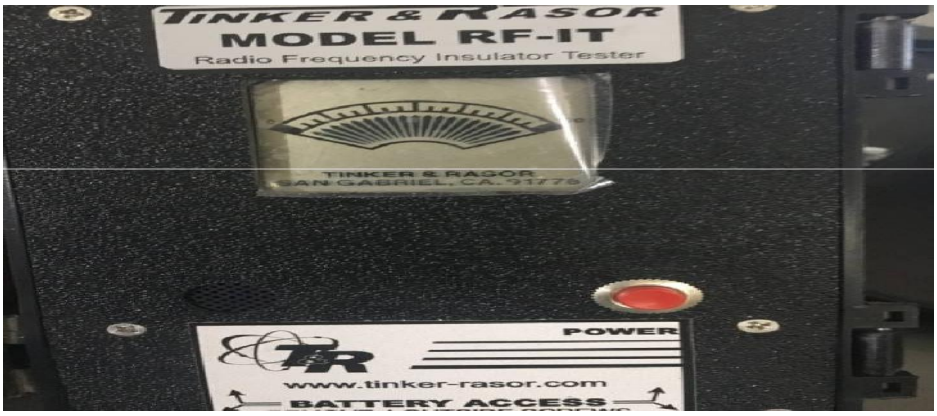

Figure 2: RF-IT shows IJ at Dispatch terminal B was Isolated and Healthy

Figure 3: RF-IT shows IJ at Dispatch terminal A was partially short and conducting.

From above all surveys and tests conducted, it was certain that pipeline was not getting adequate Cathodic Protection of -850mV or more electronegative pipe to soil potential. Therefore it was decided to check that if pipeline was protected by 100mV polarization shift criteria. (Ref – NACE RP 0169-2013)

DEPOLARIZATION TEST

To ascertain that pipeline is protected by 100mV polarization shift criteria, entire pipeline was depolarized for 24hrs and PSP values were recorded at all TLPs to get natural potential of pipeline (Decay of polarization). These values were compared with ON-OFF PSP values in following Table:-

Table 7: Monitoring of natural PSP

TLP No.	ON PSP (Volts)	OFF PSP (Volts)	Natural PSP (Volts)	Polarization Shift (Volts)
1	-1.395	-0.650	-0.520	-0.130
2	-1.400	-0.677	-0.520	-0.157
3	-1.420	-0.651	-0.520	-0.131
4	-1.424	-0.665	-0.520	-0.145
5	-1.420	-0.671	-0.460	-0.211
6	-1.419	-0.683	-0.472	-0.211
7	-1.410	-0.690	-0.493	-0.197

TLP No.	ON PSP (Volts)	OFF PSP (Volts)	Natural PSP (Volts)	Polarization Shift (Volts)
8	-1.404	-0.700	-0.531	-0.169
9	-1.373	-0.652	-0.519	-0.133
10	-1.376	-0.652	-0.519	-0.133
11	-1.359	-0.660	-0.515	-0.145
12	-1.317	-0.668	-0.510	-0.158
13	-1.281	-0.677	-0.517	-0.160
14	-1.332	-0.689	-0.515	-0.174
15	-1.310	-0.698	-0.520	-0.178
16	-1.334	-0.718	-0.525	-0.193
17	-1.331	-0.756	-0.517	-0.239
18	-1.321	-0.735	-0.513	-0.222
19	-1.462	-0.712	-0.509	-0.203
20	-1.349	-0.740	-0.470	-0.270
21	-1.332	-0.845	-0.482	-0.363
22	-1.244	-0.807	-0.503	-0.304
23	-1.205	-0.770	-0.494	-0.276
24	-1.204	-0.770	-0.510	-0.260
25	-1.312	-0.813	-0.501	-0.312
26	-1.324	-0.861	-0.493	-0.368
27	-1.421	-0.898	-0.488	-0.410
28	-1.401	-0.924	-0.476	-0.448
29	-1.350	-0.954	-0.425	-0.529
30	-1.410	-0.975	-0.387	-0.588
31	-1.421	-0.915	-0.600	-0.315
32	-1.443	-0.926	-0.525	-0.401
33	-1.446	-0.937	-0.494	-0.443
34	-1.392	-0.950	-0.480	-0.470
35	-1.372	-0.971	-0.477	-0.494
36	-1.352	-0.957	-0.470	-0.487
37	-1.971	-0.941	-0.420	-0.521

From above recorded readings, it was established that pipeline was protected by 100mV polarization shift criteria.

CONCLUSIONS

After conducting all relevant surveys, it was almost ascertained that the existing IJ itself was not completely providing electrical isolation between unprotected and protected side of the pipeline at Dispatch Terminal A.

Further, there were TWO probable solutions for resolution of identified problem of IJ:

REPLACEMENT OF COMPLETE IJ: Possibility for installing new Insulating Joint of same specifications was explored. For executing this exercise, there were lots of challenges like taking complete shutdown of Dispatch Terminal A, Venting huge amount of product from identified section(s) of pipeline, lining up of new contract for executing mechanical jobs i.e. cutting of old IJ, welding of new IJ and various testing thereafter etc.

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INSTALLATION OF FLANGE INSULATION GASKETS: The possibility for installing the insulating gaskets in flanges was explored. Total 05 Nos. flanges were identified in which insulating gaskets were to be installed. All insulating gaskets were to be protected against surges by installing Surge Diverters

Replacement of IJ was not feasible without shut down of Dispatch Terminal A and evacuation of product from Pipeline Section from Dispatch Terminal to Battery Limit Valve. Therefore it was decided to install insulation gaskets at identified flanges. All the existing gaskets in identified flanges were replaced with insulation gaskets. This exercise was successful and provided the required electrical isolation of CP system. Immediately after this exercise the ON-OFF PSP was observed inside Dispatch Terminal A. Instant OFF PSP was more electronegative than 1000 mV (with respect to a saturated Copper/Copper Sulphate Reference Electrode). But isolation provided by these insulation gaskets lasted only for one day. After checking of these insulation gaskets it was found that there were shorting at many nut bolts of installed insulation gaskets. Therefore it is now decided to replace the IJ itself with new healthy IJ. This process is under progress.

REFERENCES

1. NACE RP-0169-2013:- Control of External Corrosion on Underground or Submerged Metallic Piping Systems

2. CP-2 Cathodic Protection Technician Course Manual.

3. A.W.Peabody : Control of Pipeline Corrosion.