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# Monitoring and Maintenance of MGL CP system

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## ABSTRACT:

Mahanagar Gas Limited is a city gas distribution company based out in the city of Mumbai and around. MGL currently has around 400 kms of Steel gas pipelines for transportation of natural gas. The diameters of these pipelines are ranging from 2" to 18" and all coated with 3 layer poly ethylene coating (3LPE) .we are installing permanent Cathodic protection system for all commissioned pipelines and temporary Cathodic protection system having design life of 10 years for pipeline un-commissioned.

This paper shall basically outline the CP system in MGL along with various practices being followed in MGL to ascertain the effectiveness of CP. MGL has installed Various CP assets like CP stations, diode stations, external ER probes, corrosion coupons to ascertain the CP effectiveness. This paper shall outline the detailed monitoring procedure along with monitoring frequency of all the assets. MGL is also carrying out health adequacy surveys like DCVG,CIPL etc. over the steel pipeline network. Few case studies arising out of these monitoring results shall be presented in this paper.

(1)Casing-carrier short at Taloja railway crossing .The detailed procedure of monitoring and rectification shall be presented.
(2) Case study on CP under protection at Andheri which was resolved using a Flange isolation kit.

## INTRODUCTION -

M/s Mahanagar Gas Limited is one of India's leading Natural Gas Distribution Company established in 1995. MGL is catering to the requirement of CNG and PNG from 4 city gas stations located in and around Mumbai area. The area of operation of MGL is in Mumbai and adjoining areas like Thane, Mira-Bhayender, Navi mumbai, Taloja, Panvel, Kalyan, Dombivali, Ambernath, Badlapur, Bhivandi.

## STEEL NETWORK OF MGL-

- MGL has around 400 kms of carbon steel pipeline of API 5L Grade B with minimum wall thickness of 6.4 mm used for carrying natural gas in MGL network. The diameters of this pipeline vary as per requirements from 2'',3'' ,4", 6", 8", 12", to18".

- The lines are factory coated with 3 layer Polyethylene coating, the components of which are as below:
  - First layer - Epoxy
  - Second layer -Adhesive
  - Third layer - Polyethylene.

- Entire network has been sectionalized mechanically by installation of Sectionalizing Valves at approximately every 3 kms & electrically by Insulating Joints (IJs) at every sectionalizing valve location. IJs are also installed wherever the medium is changing
- The Pipelines are transporting gas at 16 bar with average flow of 100000 m3/hr and at average temperature of 24 deg C.
- These lines are feeding to
  - CNG Stations- 203 nos.
  - District Regulating Stations- 54 nos.
  - Metering & Regulating Stations – 147 nos. (for Industrial &Commercial Customers)

## CATHODIC PROTECTION IN MGL-

MGL employs two schemes of protection – Temporary Cathodic Protection (TCP) and Permanent Cathodic Protection (PCP)

MGL installs a Temporary Cathodic protection system in coordination with the pipeline laying work. We design the TCP system for a life of 10 years. We install Test stations at every 500 metres. TCP is provided by the installation of galvanic anodes – Magnesium anodes of 2.1Kgs. The following are the steps in installation of TCP:

1. Soil resistivity is carried out for the pipeline section for which TCP is to be provided. This soil resistivity is done for depths of 1,3 and 5 mtrs. The same is done using Wenner's 4 pin method. Resistivity of the soil is calculated using the following formula

   $$\rho = 2 \times \pi \times a \times R$$

   where ρ – Soil resistivity
   a – electrode spacing in metres
   R – measured resistance in ohms
2. The following table is taken as a thumb rule for TCP design

**Table 1:**

| Resistivity (ohm-cm) | Soil Classification | |
|---|---|---|
| | Resistivity | Corrosiveness |
| 1 – 1000 | Very low | Very corrosive |
| 1000-5000 | Low | Corrosive |
| 5000-25000 | High | Mildly corrosive |
| 25000-100000 | Very high | Relatively corrosive |
| 100000-Above | Extremely high | Progressively less corrosive |

3. The current requirement of the pipeline is calculated on the basis of factors like pipeline surface area.
4. Number of anodes is then calculated based on anode weight and anode current output.
5. Once TCP is installed, we monitor the PSP, anode current, anode potential on quarterly basis
6. MGL also has PE-Steel nallah crossings on the network which is protected by TCP for entire life. healthiness of this anodes is monitored on quarterly basis same are replaced if found consumed

TCP is converted to PCP after 3 years or once the pipeline is commissioned. The following procedure is adopted for PCP installation:

**PEREMENENT CATHODIC PROTECTION:**

- Once the pipeline becomes continious the section is converted from TCP to PCP
- The following formulae shall be used for the design of cathodic protection system

**Sa : π x D x L**

**Sa** = Surface Area of Pipeline, m2
**D**-Diameter of pipeline
**L**-length of pipeline

**Current Demand, I = Sa x Cd/1000**

**Cd** = Current density mA/m2

**Protective Current required, I = Sa x Cd x safety factor**

- MMO anodes with carbonious back fill is used for vertical type of anodebeds and High-Si-Cr anodes are used for horizantal type of anode beds.
- Number of anodes is then calculated based on anode weight and anode current output.
- PCP system is designed for 30 years.

**Figure 1: Mixed Metal Oxide (MMO)**

**Figure 2: High- Si - Cr anodes**

**TRANSFORMER RECTIFIER UNITS:**

- MGL has installed 40 TR units
- All this TRU panels are of rating 50 V/50 A. connected to 230v AC supply, considering the power failure issue outside the Mumbai region we have also provided additional battery back –up which will give power back up for 72 Hours.
- All This panels are operating on Auto mode only, in the event of failure of this mode there is also a provision for manual mode.
- All this TRUs are isolated from each other electrically with the help of Insulation joints installed at every sectionalizing valve.
- Physical monitoring of these panels is done on quarterly basis.
- Parameters like DC output voltage, DC output current, mode of operation, and reference selector etc. are recorded during monitoring.

**Remote Monitoring**

- GSM Based Remote Monitoring Units (RMU) have been installed at all transformer rectifier (TR) unit & Diode station (DS) locations.
- Data is being received on regular basis on CP server located at control room as well as on two designated mobile numbers as a SMS.
- Recently MGL has also integrated this RMU to SCADA system for live monitoring of CP system
- Alarms of abnormal readings of the unit are being received which include-
    a. Under protection – If PSP value goes below -850 mV
    b. Overprotection – If PSP valve goes above -1.5 V
    c. Reference Fail - If PSP value goes below -300 mV
    d. Door Open – If somebody opens the panel door
    e. Power Fail – If Power Supply fails

## 2.1 CP MONITORING:

PSP survey is done at every test station on the network, on a quarterly basis. The PSP is maintained such that it is the range of -0.85 V DC to -1.2V DC. The same is checked during every visit.

The CP assets installed in MGL steel pipeline network are as below: These are monitored as per the scheduled frequency mentioned below.

**Table 2:**

| CP ASSET | FREQUENCY | QUANTITY |
|---|---|---|
| Transformer rectifier units | Quarterly | 39 nos. |
| Diode stations | Quarterly | 15 nos. |
| Test Stations | Quarterly | 1200 nos. |
| Cased crossings | Quarterly | 41 nos. |
| Electrical resistance probes and corrosion coupons | Quarterly | 60 ER probes and 69 corrosion coupons |
| Interference survey | Yearly | - |
| CIPL survey | Once in 5 years | 400 kms |
| Soil Resistivity | Once in 10 years | |
| Interference free reading | Yearly | All CP assets |
| Aesthetic improvement | Once in 3 years | All CP assets |
| DCVG survey | Based on CIPL survey | - |

**Insulating Joints (IJs) –**

- Insulating Joints are provided on MGL pipelines whenever change of medium (Soil to air / water or vice versa) occurs.
- Also insulating joints acts as electrical isolation of pipeline limiting the CP current only up-to the protected zone.

**PE STEEL Nallah Crossings –**

- There are 300 locations on MGL's Polyethylene pipeline network, where Polyethylene pipeline has been connected to Steel pipeline through a transition fitting in order to cross the Nallah.
- All this small sections are protected with the help of TCP.
- Considering the anode consumption and difficulty in getting permission for anode replacement 4 number of Mg anodes are installed at each locations at the time of pipeline laying phase only to provide CP current to the underground steel pipeline.
- The transition fittings are coated with cold applied Denso tapes to avoid corrosion.

**ER Probes & Corrosion coupons-**

- As coupons are removed on opportunistic basis MGL is also installation external ER probes and corrosion coupons
- At least One ER probe and one CC is installed in each sections of the TRU.
- All the ER probes are of type FL 20
- Active and native coupons have been installed close to the pipeline.
- Instant off reading is also taken for active coupon to monitored de polarization of coupon.

**CP Adequacy Surveys**

MGL carries out following surveys on the steel network:

- Closed Interval Potential Logging (CIPL) survey – Once in every 5 years
- Direct Current Voltage Gradient (DCVG) survey-
    1. Once in every 5 years (carried out only at those locations where CIPL gives abnormal readings)
    2. Before commissioning of new steel pipeline.
- Soil Resistivity survey-
    1. Once in every 10 years
    2. Before designing CP system for new pipeline section
- Current Requirement Survey – Before Commissioning of new CP station

In MGL, the following table is taken as a reference for the rectification of defects, depending on the defect severity

**Table 3:**

| Sr. no | Defect Severity (in % IR) | Classification | Conclusion |
|---|---|---|---|
| 1 | 0 to 15% | Small defects | Such coating defects can usually be left un-repaired provided the pipeline Cathodic protection is good and there are not too many coating defects in close proximity |
| 2 | 15% to 35% | Medium defects | These coating defects may need repair usually within normal maintenance activities |
| 3 | 35 % to 70% | Medium Large defects | These coating defects need to be excavated for inspection and repair in order to fix what could be considered a significant coating fault |
| 4 | 70 % - 100% | Large / important defects | These coating defects should be excavated early for inspection & repair |

## AC / DC interference Mitigation

### Overhead HT line Crossings-

- MGL steel pipeline is in close proximity of 33 KV and above HT line crossings at 50 different locations (mostly in outside Mumbai area).
- At these locations HT lines are either crossing or running parallel to the steel pipeline:

    1. Wherever pipeline is coming directly below the power line or in close proximity, concrete protection along with Neoprene sheets is provided over the Steel pipeline. The concrete slab is 100 mm thick & is placed over the sand padding & width is 500 mm on either side of the pipeline centre. This avoids the direct strike in case of break & fall of conductors wherever the AC line is parallel to our pipeline.
    2. At crossing locations also, MGL follows the same procedure as above. Neoprene sheet is extended 1 m on either side of crossing location.
    3. As a general practice a minimum distance of 15 m is maintained from the tower footing for pipeline laying. Wherever this is not possible, concrete slabs of 100 mm thickness are placed between the tower footing & the pipeline as barrier protection.
- Also DC Decoupling devices – kirk cells and Solid state polarization panels are installed at all crossing locations with Zinc grounding anodes to ground the induced AC potential in the pipeline.

### Diode Stations-

- Where ever pipeline is crossing railway traction to mitigate the DC interference & to return the induced DC current from the pipeline to Railway Tracks, MGL has installed diode stations at crossing locations.
- As diode is unidirectional it gives DC current back to the tracks
- All this diode stations are rated for 100 A continuous DC current.
- The Pipe to Soil potential reading on the pipeline shoots up in the vicinity of Railway Crossing as soon as the train passes.

This leads to momentary “Overprotection” of the steel pipeline. The effect of DC traction can profoundly be established when Diode stations are remotely monitored during night time 2AM to 4:30 AM in the absence of local trains.

## OTHER ACTIVITIES IN MGL:

We carry out the following maintenance activities as & when required:

1. Calibration of TR/ DS – This is done annually. Faulty panel meters and components are replaced as per the reports.
2. TLP maintenance works of TLP straightening, TLP cable cut rectification, TLP door replacement, TLP shifting etc.
3. Patrolling of CP assets on daily basis: Patrolmen who patrol the steel pipeline have also been given the responsibility of carrying out a visual check of CP assets every day. Since Mumbai is a highly congested city, CP assets are prone to third party damage.
4. Whenever we receive any communication of coating damage, the rectification of the same is done using cold wrap. Thickness testing and peel test are also done during this.
5. ALL the CP assets are plotted on GIS.
6. KOH solution is replaced on quarterly basis.
7. History of minor maintenance is maintained in SAP.

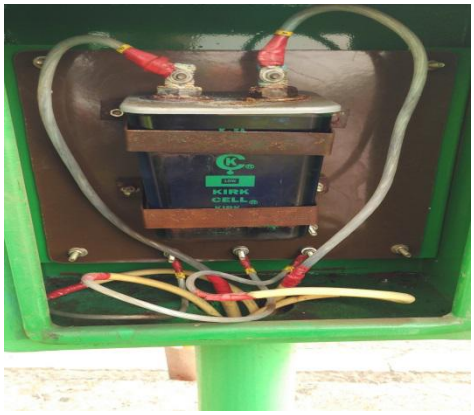

**Figure 3:KOH solution solidification Due to AC interference**

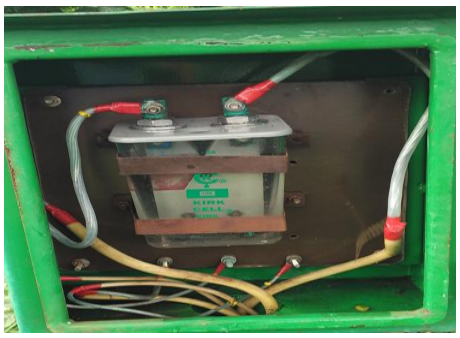

**Figure 4:After KOH solution replacement**

**CHALLENGES:**

- Mumbai is a highly populated & congested city with large number of utilities sharing the same right of way due to space constraint.
- Third party damages of CP assets during road construction, widening works or damage due to vehicular movement.
- Most of the parts where steel line has been laid in & around Mumbai are areas with heavy traffic throughout the year leading to major obstacle in carrying out any major maintenance surveys on steel pipeline.
- Continuous infrastructural improvements are going on in the city like construction of metro, mono rails etc. This leads to damage of coating / CP assets sometimes. .
- Obtaining excavation permission from Municipal corporation for the repairs
- Interference due to foreign pipelines, AC transmission systems and DC traction

## Case study on Casing carrier shorting.

**Location –Taloja Railway Crossing**
**Length-144 m 12'' Diameter**
**Coating type: 3 Layer Polyethylene coating**

- Railway guidelines mandate a minimum top cover of 2.5m to be ensured for pipelines crossing railway tracks. Casing installation was also a mandate of the railways guideline.
- Top cover of 4.5 m was maintained while crossing of railway track.
- Casing of 24'' was inserted initially
- Carrier of 12'' with insulating spacers mounted on it was inserted through this 24 '' casing
- Zn ribbon anodes were also installed 4 o'clock to 8 o' clock position at a distance of 1 m on carrier
- Casing and carrier were sealed at both end points to avoid water ingress.
- TLPs were installed at both ends to monitor the casing and carrier PSP
- Reading recorded after complete installation indicated that the same potential was developing on casing and carrier after connecting the anode.
- On off survey was done to check the shortage of casing and carrier. Same potential was developed on casing and carrier during on and off.

**Table 4:**

| INITIAL READING | On (PSP) | Off (PSP) |
|---|---|---|
| Pipe | -2.02 | -0.84 |
| Casing | -2.08 | -0.84 |

- This leads to the conclusion that casing and carrier were electrically shorted
- Air flushing was carried out at 5 bar pressure to flush out any water that must have accumulated during the time of installation
- Potential at carrier improved after flushing.

**Table 5:**

| AFTER FLUSHING | PSP When anode Disconnected | PSP When anode connected |
|---|---|---|
| Pipe | -0.896 | -1.013 |
| Casing | -0.771 | -0.865 |

- This leads to the conclusion that casing and carrier are metallically isolated but voltage is getting induced on casing.
- To avoid current drainage of TRU, installation of Insulating joints at both ends have been proposed so that in future if there is any electrical / metallic short between casing and carrier, the same can be protected as an isolated section through TCP / PCP

**Figure 5:**Spacers and Zn ribbon anodes on carrier.

## CASE STUDY ON IJ FAILURE AT INTEL CARPORT ANDHERI:

**Pipeline section – Kamani VC to Leela VC**
**TR Unit location – Intel Carport**
**Pipeline Length – 4 kM**
**Pipeline Diameters – 3'' & 12"**

- Low psp issue was observed in section from Kamani to Leela VC due to coating damages on a pipeline section
- Repair of the coating was difficult because of line was in newly constructed CC road, so it was decided to install a new TRU at Intel Carport CNG
- During commissioning of TRU it was observed that PSP at drain point needed to be maintained at -1.7v instead of -1.2v in order to reach the psp at extreme end to -0.85
- Further investigation was done found that same PSP was developing on both side of IJ Tlp at Intel carport CNG
- This concludes that because of ij failure current requirement of the section was high.

**Table 6:**

| Before installation of IJ Kit | | |
|---|---|---|
| | Before | After |
| TR Output Voltage(v) | 6 | 3.2 |
| TR Output Current(A) | 3.9 | 1.9 |

- Flange isolation kit was installed across the IJ and found psp is within desired range.

**Table 7:**

| After installation of IJ Kit | | |
|---|---|---|
| | Before | After |
| PSP at Drain Point | 1.8 | 1.520 |
| PSP at Extreme End | 0.82 | 0.880 |

**REFERENCES:**


1. NACE SP0169-2014
2. OISD 188
3. MGL Corrosion Control Philosophy
4. COP - Steel Gas Pipeline CP Monitoring