Paper No.
PP10

CORCON 2017
17-20 September
Mumbai, India

CASE STUDIES ON PROBLEM FACED IN CP SYSTEM DUE TO GROUNDING INTERCONNECTIONS.

NAVNEET KUMAR SHARMA

GAIL GAS LIMITED,AGRA
navneetsharma@gail.co.in

ABSTRACT

Normally in an electrical circuit, the grounding circuit has an important role for maintaining safety concerns due to unintentional discharge of charge. All the equipment, structures and switchgear are needed to be grounded at regular distances to achieve the safety criteria and enabling functionality of Electrical circuit protection to address the safety concerns in abnormal conditions. However in Cathodic protection the grounding system is used for the conduction of current and help is achieving the corrosion protection criteria by controlling the flow of current in normal case. At most of the installations where CP system is in place will likely to have station grounding system for the Electrical system which must be in complete isolation to maintain intended charge flow.
In practical situation, the perfect isolation between the grounding system of the installation and CP system may not be possible and it may lead to serious issues which might affect the performance of the CP system. This paper includes two case studies which elaborate the effect due to interaction of station grounding system with the positive (Anodic) and negative (Cathodic) circuit of the CP system by using the designed electrical circuit of the CPPSM and modelling of the field circuit to get the better understanding of issues. Although these interactions happen in almost every CP site but their effects are just incremental whereas both of these cases caused serious issues affecting the reliable performance of the CP system and could be addressed by following a systematic approach in getting to the root cause of the problem. The endeavor is to sensitize about such issues and developing an approach to identify such problems during the routine preventive maintenance activities so that performance of the system can be ensured to achieve the desired result.

INTRODUCTION

Although CP protection criteria are achieved through electrochemical process system but in actual CP system is designed to achieve the protection criteria using simple method of DC electrical circuit. The problems which happen in normal electrical circuit may very well happen in the DC circuit designed for achieving the CP protection criteria. However the normal protection system designed to address the circuit issues may get inadequate for the performance of the CP system. This paper mainly highlights two cases which were faced practically in field situations that affected the performance of the CP system due to the interaction of the grounding system and the CP circuit designed for the station. In normal circumstances, these interactions may continue for long durations if systemic approach is not applied to address these issues and to eliminate them. The first case is relating to the shorting of grounding system in the incoming supply to the CPPSM and the next one is due to shorting in the output circuit.

CASE-I: TRIPPING OF CPPSM DUE TO SHORTING IN INPUT CIRCUIT

In one of the CP station in pipeline network, a serious problem was happening in the operation of CPPSM unit. Either the CPPSM unit output MCB having 20 A rating was getting tripped or the main source for the power supply rated for 500 Watt capacity was getting overloaded and getting tripped on high temperature on intermittent basis after starting of the CPPSM unit. Sometimes the CPPSM unit was getting tripped on high output current or else additional current drawn by CPPSM unit was leading to high temperature trip in the TEG system because of shooting of CP current in the range of 15-22 Amps from the normal range of 0.3-0.6 Amps creating output current of almost 15-16 Amps which was not being sustained by the captive power system. There was no particular pattern observed for shooting of such current and would happen all of sudden at any moment and will lead to either tripping of the CPPSM or the tripping of power source. The system was restarted after checking the any possible shorting in the main circuit, but no suspicious component or event was noticed. Further the PSP readings were also shooting to abnormal range of -3.0 to -4.0 Volts all of a sudden because of high impressed current. The situation was really tricky as the problem was intermittent in nature and would happen most of the time when there is no body to observe the sequence of events at the site. The nature of the problem was indicating about some kind of partial short circuiting of the main CP circuit with the grounding system. All the circuit connections at various points were checked even on the main power supply but no conclusive sequence or its effect was evident. All the grounding connections were removed even on the main power supply side, but this only helped in reducing output current in the range on 12-14 Amps but such high current was leading to PSP reaching in the range of -3.5 Volts around and thus it was not possible to keep the system ON for continuous operation. In the meantime, the occurrence of incident got frequent and the system will get to this high CP current (Over protection) alarm state within 15 minutes of starting of the CPPSM. Since there was no prior experience for this kind of problem, discussion were done with other colleagues and on the basis of the same, some idea was drawn to develop a systematic approach for addressing the issue. The Input power supply reading was taken to get the idea of the nature of power supply. After discussion with other persons who had also experienced this kind of problem, it was decided to check the input power supply. The readings at the input supply voltage at the CPPSM were noted as under.
Input power supply (+VE) to ground voltage- 5 Volts
Input Negative supply (-VE) to ground voltage- (-ve) 22 Volts

As soon as these values were checked, it got clear that the power supply was behaving as positive grounded in nature but whether the same can be the cause of this abnormal working of the CPPSM needs to be ascertained. The same readings were also taken at other CP station where the similar set up was there and it was working perfectly normal. The power supply at the other station was found to be working as floating type showing perfect isolation with respect to the ground at both positive and negative ends. This reinforced our belief that the grounded nature of power supply may have happened due to shorting of the positive supply wire with grounding system in the circuit. All the visible physical connections and the cable in the positive supply were checked but no observable contact point was evident. After that all the intermittent grounding points were removed so that the problem could be resolved, but still the problem remained as such. Only effect which was happening was slight reduction in CP current output. Even the grounding connections to all the panels and circuit connections were removed with no avail. This also led us to believe that the problem might be due to some other causes and the following conditions were also identified which had happened just prior to the problem being faced.

- The interference issues with some DC motor kind of circuit which may be situated in the warehouse located almost 100-150 mtrs from the station. Further the discussion with the previous Electrical engineer, the same fact was getting more strong as he pointed out this particular problem was happening after coming of the warehouse. The problem was discussed with the adjoining warehouse. However no DC motor was found to be in use for which can interfere with the CP system of the station. So this angle was not followed much.
- Local interference/interaction with the station grounding system. But how and why. We were totally clueless on this. And therefore no further checking was done except looking at the route points for having some indications.
- Malfunctioning of the CPPSM unit. But this angle was also ruled out once the CPPSM was operated through external 24 V Battery system. The unit was found to be working perfectly alright without any signs observed in this particular problem.
- Some partial shorting in the CP cable system at some point which is not visible.

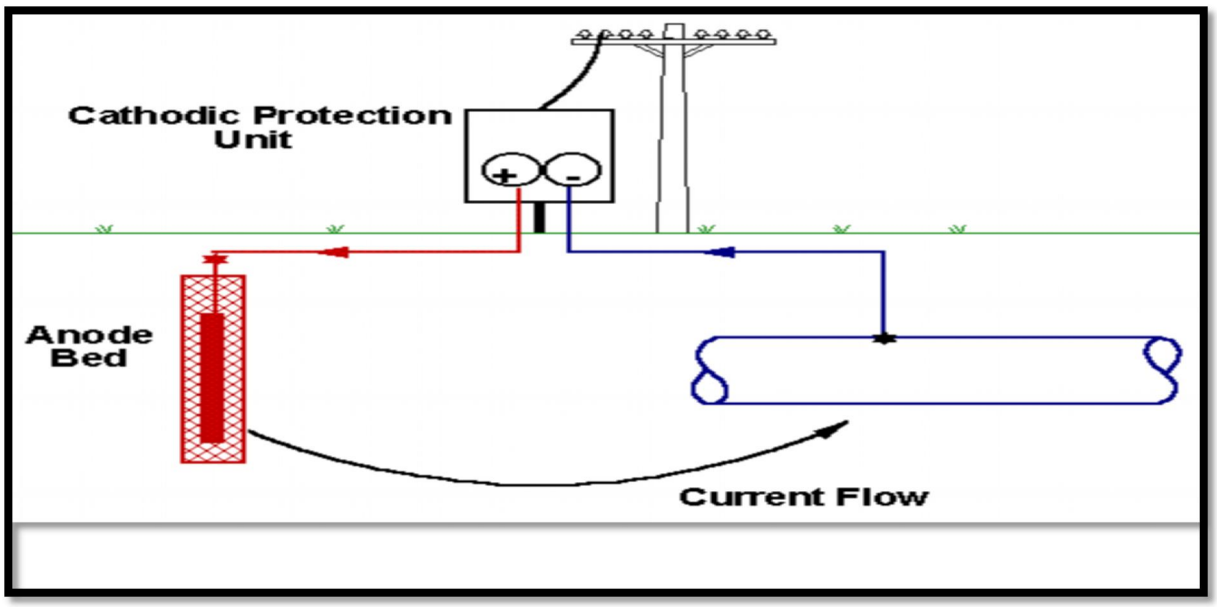

FIGURE 1: WORKING OF ICCP

With the experience gained using the above points, It got clear that the power system itself needs to be changed and we used separate battery system along with the solar panels for making totally separate power supply arrangement for the CPPSM unit to restore the CP system temporarily. The working of the CPPSM unit was observed for 7-8 days and found to be working fine.

Now we got sure that power system itself is creating positive grounded power supply behavior even without any contact with the earthing system physically as all the visible contacts with the system were removed. This was mainly because of solid grounding achieved through the supporting metallic GI structure for the TEG system provided at the site. The support system which was made up of GI frame was giving perfect grounding to the positive side of the TEG system and it was grouted deep in the ground and providing enough grounding system to change the behavior of the power supply.

FIGURE 2: TEG SYSTEM WITH MOUNTING STRUCTURE

Although the problem was resolved by proving the alternate power supply, but other options like providing galvanic isolation between input and output circuit could also be used if the same input power supply was to be used for operating the CPPSM.

Once the problem was resolved by arranging new power supply for the CPPSM system, but now the big question is that how such a high CP current was flowing into the CP circuit. The root cause of this problem was tried to be identified by modelling the station grounding system resistance in parallel with the anode system resistance, still things were not looking to be clear and sure. The thought was invoked persistently to have the exact cause and effect situation in this case. Incidentally while observing the CPPSM drawing provided by the vendor, the things which were happening in this case got slightly clearer. Since the CP circuit is perfectly DC circuit, the relation should be in terms of Voltage and resistance in the circuit. The analysis for this was done using the actual circuit diagram at the CPPSM which can explain the generation of such high CP current and may affect the performance of the CP system. The cause of this problem was not just the power system (TEG) as input power source for the supply but the main factor was mainly the design of the DC power circuit used in the control of CP output voltage which in normal case is designed to control the output voltage which in turn will control the flow of the current based on the feedback of the PSP.

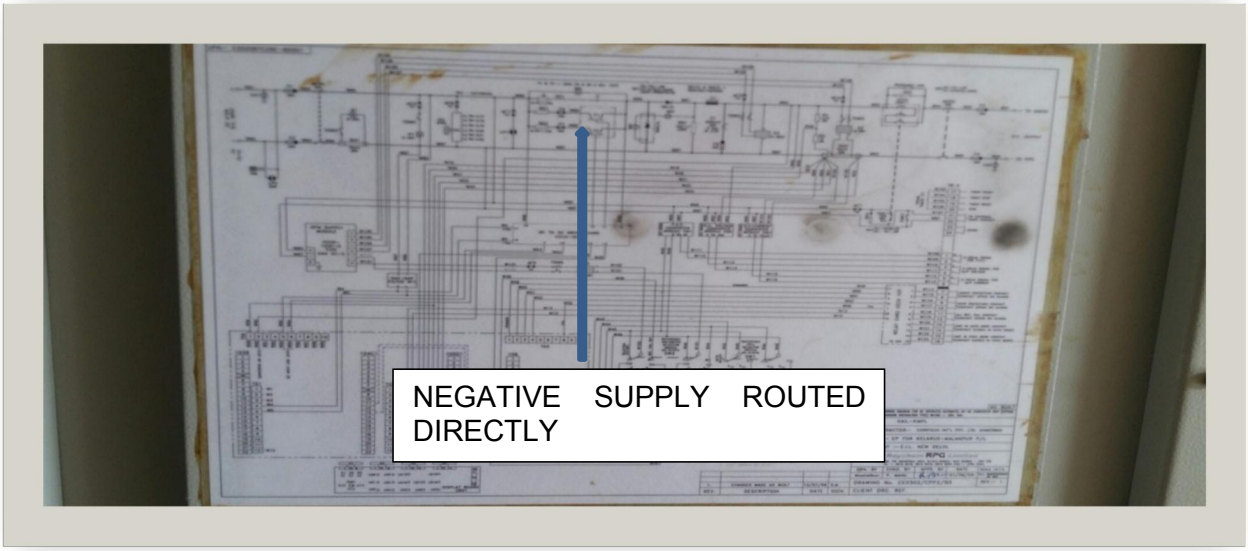

FIG 3: 24 V DC CPPSM CIRCUIT DRAWING

Anode bed resistance- R (Resistance of anode bed system mainly)
In case the Supply is –ve grounded or floating- The anode voltage will be controlled through the bridge rectified circuit which is provided in the positive side of the circuit to achieve the desired output voltage and current to meet the protection criteria. In this case the negative side is directly routed to the output without any circuit component will most likely to have almost zero voltage. However in case of floating supply some minor voltage in output circuit will affect the CP current output marginally without any appreciable effect on the protection of the pipeline system which can easily be offset using the control of the positive circuit voltage with respect to the ground..
Now in case the supply is positive grounded- The positive supply voltage will be controlled by the bridge rectified to achieve the desired positive supply voltage but the negative supply will be passed through as such without any upside/downside. Here we were getting negative supply voltage of -22 Volts with respect to the ground.
So even in no load condition Anode to cathode voltage- 22 volts approximately (0- (-22)).
That's why even in case of no load condition the Anode current/CP current will be= 22/R
The anode circuit resistance is typically in the range of 1 Ohms.

In no load condition the current was in excess of 20 Amps and leading to fault condition not only for the current protection MCB but also to the feeding power supply. This was precisely happening in this case and no physical interaction was occurring in the output circuit with the actual grounding system at the station. Till now we were only concentrating on the physical connection with the grounding system but in actual the nature of power supply because of physical connection at source and which was also not visible and the design of the circuit were creating this problem.

RESULTS FOR CASE 1:

Thus it is evident that the negative supply must be either grounded or floating type for the proper working of the CP system if the CPPSM is not having electrical isolation between input and output side. Otherwise also maximum 1-2 Volts of negative voltage can be allowed with respect to the ground for the working of the system which can easily be offset by voltage control provided in the positive side assuming the driving potential for current injection is good enough to compensate for the no load voltage in the circuit. In case the negative supply voltage is more than that, we must put isolator between the input and output supply voltage. Further such kind of grounding issues in the main power supply may arise and it is important to have some insight into the normal working of the CP circuit which may help in doing the troubleshooting exercise. This problem was quite regular in the CP stations of this pipeline system which could be addressed permanently with these fresh inputs. All the TEG hardware which was showing positive supply grounding was isolated and thereafter the CP system was found to be working perfectly alright. There may also be a situation in which current increment is marginal as in case of floating power supply and unit may supply slightly higher current than what is actually required. This may be more serious when the anode ground bed resistance is quite less. So the best solution can be by provide galvanized isolation between the input and output side.

CASE 2: HIGH CP CURRENT AND UNDERPROTECTION OF P/L DUE TO SHORTING IN OUTPUT CIRCUIT.

This particular case happened in one of the spur line, Initially the CP current feeding in this pipeline was there from only the originating side of the spur line although temporary bonding was made using other CP feeding station at other end. But later on permanent CP connection was provided through 35 Sq mm cable found on the pipeline. Initially the current reading in the TR unit of terminating end of pipeline was from 0.3-0.5 Amps before bonding of this spur line. But as soon as the new connection was provided, the CP current shooted in the range of 5.5-6.0 Amps range which was indicating that the newly connected pipeline was drawing a current of almost 5 Amps. As mentioned one more feeding point was there at the originating side where the spur line was also drawing almost 0.7-0.8 Amps of current. The current was really on higher side with respect to such kind of pipeline system. It was suspected that coating condition was not satisfactory. The following methodology was adopted to address the issue.

- Recently an express highway was constructed near to the pipeline and lot of soil was removed from various fields which resulted in severe coating/pipe damage at some points in the pipeline. So there was apprehension that coating might have been damaged at many locations and which may have increased the current requirement of the CP system. Already we had repaired the coating at 3-4 points without observing any metal loss.
- Initially the CP ON-OFF survey was carried out In-house and which indicated OFF reading in the range on 0.7 from end chainage of 52.7 to Ch 40 approximately. In other pipeline section the CP OFF reading was almost in the safe protection zone of -0.85 to -1.0 Volts. So more emphasis was attributed for this particular pipeline section w.r.t various inspections and checking.
- CPL and DCVG survey. At 3-4 locations, major coating defects were found which were attended after taking UT thickness readings to verify the metal loss due to external corrosion.

However till date no noticeable thickness loss was found. All the coating defects were attended.

- Even after attending the coating defects, the OFF PSP reading was noted up to -0.76 Volts and the current consumption in the pipeline was still in the range of 5.0 Amps.
- Once the Off readings found to inadequate, it was decided to carry out the coating survey using the CAT method to get the points of CP charge leakage.
- After carrying out the CAT survey in the focused pipeline survey, no serious coating defect was noticed in the pipeline section.
- The matter was discussed with other experienced persons and on the basis of guidance taken, it was decided to provide temporary Cathode and anode cables to check the integrity of all cables used in the CP system. The main thought which guided this idea was that lot of construction job had happened in the terminal station, So there may be possibility of some insulation damage in the cables and it may come in contact with other cable or grounding system at the station.
- The existing cathode cable was removed and totally new cable was connected temporarily directly from the TR unit to this pipeline. Then the TR unit was re-started and to our surprise, the total current came down to just 0.7-0.8 Amps and in this particular pipeline the current was only 0.5 Amps.
- It became quite clear that the existing drain point Cathode cable is either accidently came in contact with the grounding electrode or connected underground with the earthing system.
- The shorting was observed between the Cathode junction box and the pipeline using the megger testing of the existing cable.
- Accordingly a new cable was provided from the Cathode junction box and the pipeline.
- After carrying out this rectification job, the ON-OFF survey was again carried out and it was noted that the entire pipeline section was more electro negative than 0.85 Volts OFF PSP criteria which was pointing satisfactory CP performance in the pipeline system.
- Earlier there was understanding that pipeline or CP system should be isolated with grounding system, but this was surprising where no physical connection could be seen but its effect was so serious that it created lot of concerns for almost 6-7 Months. Even in between lot of experts were counseled and the system was also physically checked but the problem could be only found because of elimination of other causes.

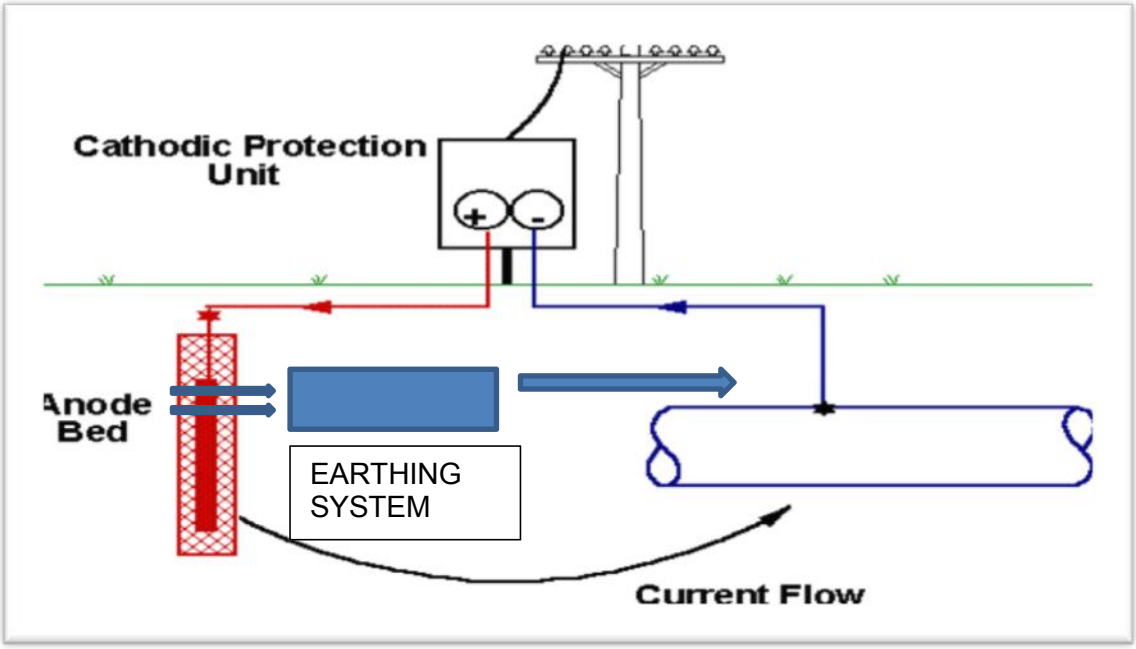

FIGURE 4: CIRCUIT SHOWING SHORTING OF CP DRAIN CABLE WITH STATION GROUNDING SYSTEM

RESULTS FOR CASE 2

All the CP cables and the grounding system are designed for the underground sections. There can be a possibility of partial or direct shorting between them which can create circulating of CP current within the premises of a terminal station/plant. This can increase the current level in the pipeline section but in actual it is not feeding the pipeline section and may lead to inadequate CP protection to the pipeline section. In order to address such situations in a timely manner, the system should have various checks and measures by devising preventive maintenance checklist to point out these subtle changes which may happen during the operations of the CP system. Further there can be a system of current appropriation at various levels in the CP system which can indicate the actual current that is feeding into the pipeline. Apart from these measures the same concept may be extended to develop system for identifying approximate current flow in the pipeline sections to have an indication of unintended current diversion which may happen due to presence of other underground utilities.

CONCLUSION & RECOMMENDATION:

Although some CP current leakage happens in most of the field situations due to lack of coating in underground valves or because of inadequate insulation between support structures and main pipeline, But there may be possibility that direct shorting type of situation may happen either with the pipe directly or through underground cable system provided in the CP system. Any kind of unusual current consumption in the pipeline system needs to be checked properly. Further the input and output supply points may be checked w.r.t ground to have proper isolation and basic terminology used in the Electrical maintenance systems may also be applied for CP circuits as well. Although the CP system is designed keeping in mind the electrochemistry of the protected structure and protecting anode system, But the protection criteria is essentially be achieved through Electrical

circuit and there may be issues which may affect the working of CP system due to bonding/shorting with other Electrical systems/Metallic structures. There must be system to check such issues during the periodic preventive maintenance jobs like Insulation resistance checking, continuity checking etc for ensuring the perfect working of the CP systems.

Moreover such cases must be shared with all concerned as such practical field problems and their solutions may not be available in any literature and thorough analysis and prior experience comes handy in understanding such scenarios. Further we may also employ the methods used in Electrical systems during the maintenance and inspection of the main power circuit using small voltage megger for checking the galvanic isolation of the grounding circuit w.r.t the grounding system. Any direct or indirect interconnection, fully or partially may be detected using these techniques. It is important to appropriate the current consumption to the pipeline or any other interconnection so that we may have better idea about the coating condition and protection level of the pipeline system.

REFERENCES

1. Maintenance of Cathodic protection systems by James B. Bushman P.E.
2. Peabody A.W- Control of pipeline corrosion.
3. Instruction manual for TR unit.