Paper No.
CAP22

Conventional AC Mitigation with Zinc versus Engineered AC Mitigation system – Case Study

Ted Huck

MATCOR Inc, 101 Liberty Lane Chalfont, USA
thuck@matcor.com

ABSTRACT

High Voltage AC Transmission lines can adversely influence pipelines that are collocated along the same right of way by high Induced AC voltage and current, that can cause corrosion and safety issues of the steel pipelines. The conventional method used for the mitigation of the AC voltage is to install zinc ribbon anode and connecting it to pipeline through a decoupler.

Zinc when used for AC Mitigation on pipelines may have some concerns related to passivation and consumption. This paper will discuss the benefits of engineered AC Mitigation system, a packaged grounding system that combines the best of copper grounding with low resistance, corrosion-inhibiting backfill over conventional grounding using Zinc Ribbon. Engineered AC mitigation system provided superior performance over conventional grounding system that used Zinc. We shall discuss a case study where Zinc, Bare Copper and Engineered AC Mitigation system were installed and connected to a pipeline through decoupler to the pipeline under the severe influence of AC interference.

Use of the Engineered AC Mitigation system can greatly increase the performance of the grounding system when an equal length is used versus a bare copper ground cable or a zinc ribbon anode.

Keywords: Alternating Current, AC Mitigation, AC Interference, Zinc Ribbon, Mitigation Wire,

INTRODUCTION

When pipelines are collocated with overhead high voltage AC power transmission lines (herein referred to as HVAC lines) the pipeline is subject to both inductive and conductive couplings. Inductive couplings are the result of the buried pipeline(s) being affected by electromagnetic fields generated by the HVAC. Conductive couplings occur when an HVAC tower fault causes a rapid discharge of fault current into the soil around the tower footing.

During such faults, current being discharged to ground can be transferred to the pipeline. It is important to recognize that inductive couplings occur as the result of current flowing through the HVAC and as such occur normally. The magnitude and effect of inductive coupling is proportional to the current flowing through the HVAC. Unlike inductive couplings that occur as a result of normal HVAC operation, conductive couplings are transient occurring only during fault conditions that are by definition rare and unpredictable.

Excessive AC voltage, whether the result of inductive or conductive couplings, can be sufficient in magnitude to endanger personnel and/or compromise the pipeline's integrity. Mitigation technologies are available to reduce the risk to personnel and pipelines. One of the most common mitigation measures is to install a gradient control wire parallel to the pipeline and connected to the pipeline at regular intervals by a DC decoupler.

The gradient control wire acts as a drain to ground for AC induced currents and as a shield for conductive fault current. As AC current is drained to ground, the resultant AC voltage levels diminish quickly. Common gradient control wire materials include zinc ribbon and bare copper cable. This paper provides results of comparative performance testing of three AC mitigation gradient control materials – zinc ribbon, bare copper cable, and an engineered copper grounding system incorporating an enhanced backfill with an internal copper conductor.

EXPERIMENTAL PROCEDURE

This paper details the results of a series of side by side performance tests conducted on a pipeline in New York State, USA. The pipeline details are as follows:

- Pipeline installed in 1991
- 12-inch diameter high pressure transmission pipeline
- Extruded polyethylene mainline coating
- A functioning galvanic cathodic protection system was installed and maintained since the pipeline was built.
- Up to 80 volts of induced AC voltage measured in the winter peak load conditions
- In 2002, the pipeline had a documented leak believed to be due to AC corrosion
- 2,500 ft (762 m) of bare #2/0 AWG copper grounding cable was installed and connected through a solid state decoupler in 2003 in selected areas subsequent to the 2002 leak.
- In 2012, the HVAC transmission system was upgraded for a higher current capacity to meet growing AC power demand resulting in additional AC Interference load necessitating.

In looking at different options for AC Mitigation, the pipeline company agreed to perform testing of various gradient control wire options.

PHASE ONE – Testing of bare copper against two different sizes of Engineered AC Mitigation cable.

The test configuration is shown on Figure 1 in this paper. The test was to compare the performance of the existing #2/0 bare copper grounding cable with two types of the engineered AC Mitigation cable. The engineered AC Mitigation cable is manufactured system that consists of a copper cable packed in a continuous flexible cloth tube filled with conductive carbon backfill employing copper corrosion inhibitors. The final manufactured diameter of the engineered AC Mitigation is approximately 1.5-inches (38 mm) for both versions of the engineered AC Mitigation tested.

Two sizes of engineered AC Mitigation were used in the test: one with an AWG #1/0 bare copper cable and one with AWG # 2 bare copper cable. Both sizes have the same electrode to ground resistance and are manufactured the same with identical fabric and backfills. The two sizes were both tested in 1,250 ft. lengths.

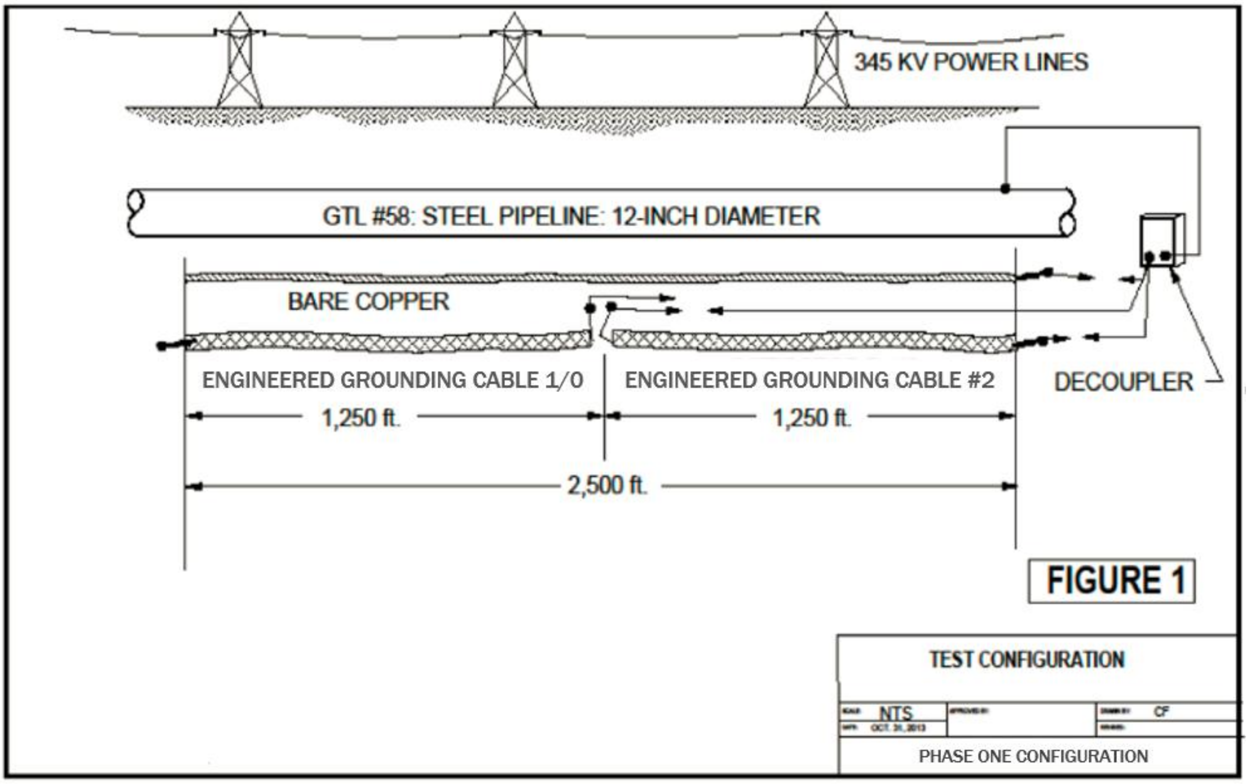


Figure 1: Phase One Configuration

The two lengths of engineered AC Mitigation were placed parallel to the existing bare copper grounding cable and to the overhead power line. The engineered AC Mitigation segment A (AWG #1/0) and engineered AC Mitigation Segment B (AWG #2) were placed in-line to create a 2,500 ft. (762 m) long total length.

Engineered AC Mitigation A & B were installed so that the effect of each individually, or together, could be measured. All other components such as the galvanic cathodic protection system and existing bare copper grounding were not changed and remained operating.

PHASE TWO – Testing of Engineered AC Mitigation cable against bare copper and against zinc ribbon.

As a follow up to the Phase One testing, a second phase of testing was conducted to compare the performance of the engineered AC Mitigation cable with the performance of a similar segment of zinc ribbon. As part of this second phase, bare copper cable was also installed to continue to validate that results of the Phase One testing.

The test site arrangement for the Phase II test is shown on Figure 2 and consisted of three sets of zinc ribbon anode, bare copper cable and the Mitigator (AWG #2 only). Each section had 333 ft. (101.5 m) of each grounding material. Tests were conducted with just Segment 1 connected, then with Segments 1 & 2 connected and finally with segments 1, 2 & 3 connected together.

Measurements were made at three locations along the pipeline. The tests were conducted in a different location along the same pipeline as in phase one.

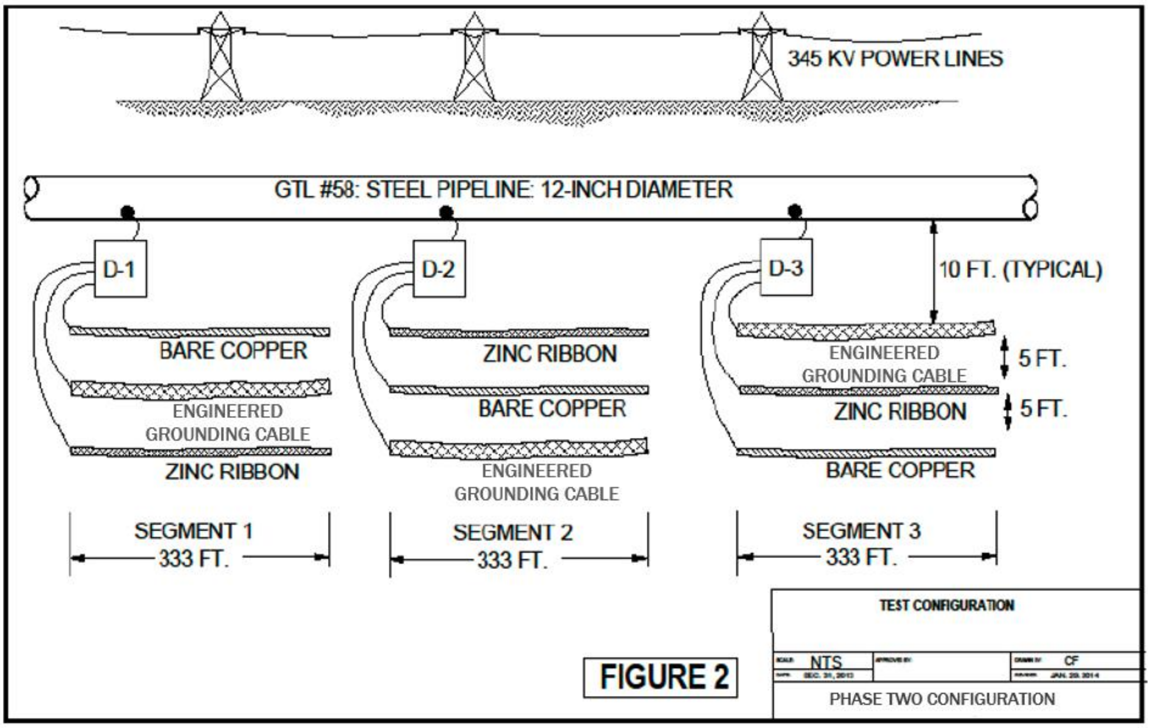


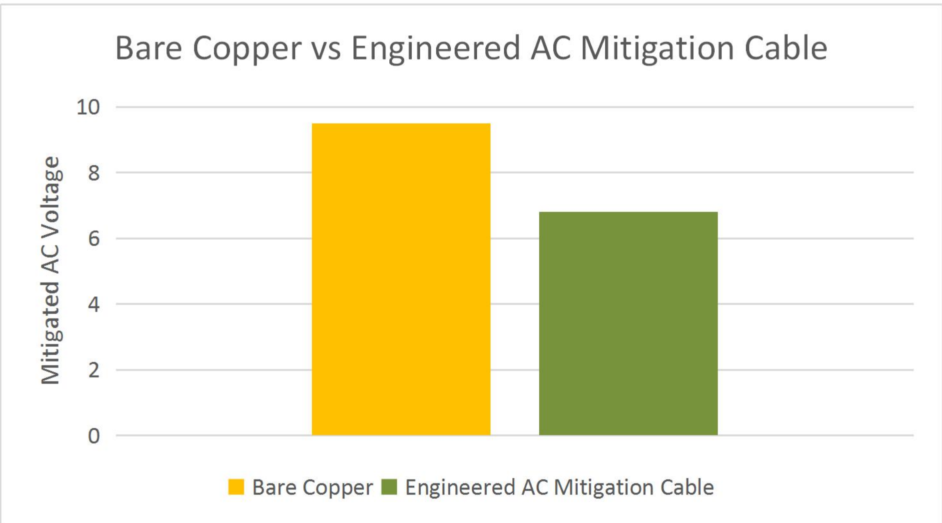
Figure 2: Phase Two Configuration

SUMMARY OF RESULTS

The following is a summary of the measured test results:

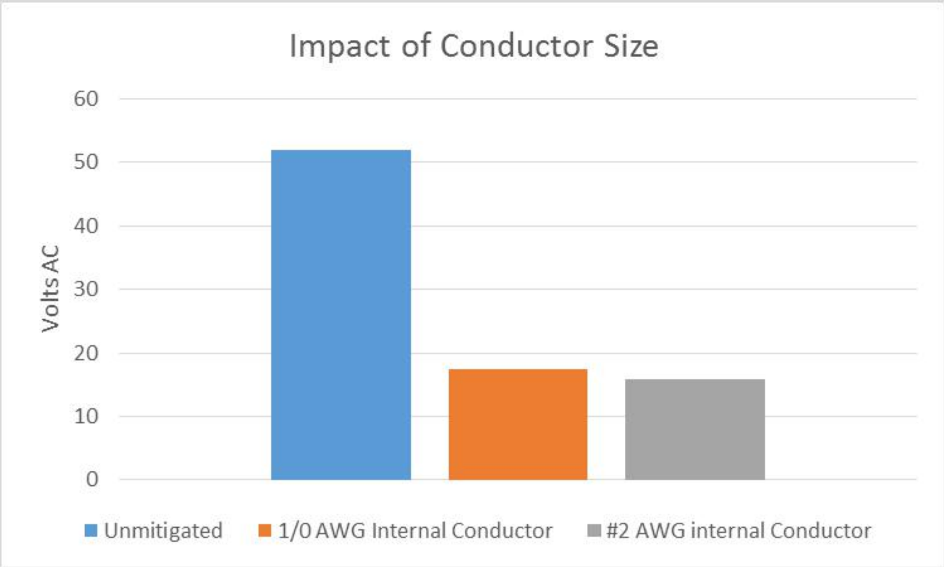
PHASE ONE

Multiple readings were taken using a calibrated voltage meter and Table 1 shows that the average mitigated value of 9.5 V_{AC} for the 2500 ft (762 m) of bare copper versus 6.8 V_{AC} for 2500 ft (762 m) of Engineered Mitigation Cable



Graph 1: Bare Copper vs Engineered AC Mitigation Cable

Additionally, data was collected on the performance of the two 1,250 ft (381 m) segments with different sizes of internal conductor cable.



Graph 2: Impact of Conductor Size

PHASE TWO

The phase two data is summarized below:

Volts AC - Mitigated				
	TS #1	TS #2	TS #3	Average
Single Segment (333 ft)				
Bare Copper	21.0	22.8	22.6	22.1
Zinc Ribbon	16.4	16.9	19.8	17.7
Engineered AC Mitigation Cable	12.0	15.5	14.7	14.1
Two Segments (666 ft)				
Bare Copper	18.0	18.6	27.8	21.5
Zinc Ribbon	13.9	14.3	27.1	18.5
Engineered AC Mitigation Cable	10.6	9.3	26.2	15.4
Three Segments (999 ft)				
Bare Copper	16.2	16.9	16.8	16.6
Zinc Ribbon	12.4	9.0	14.3	11.9
Engineered AC Mitigation Cable	9.0	8.1	8.6	8.6

Table 1: Summary of Phase Two Test Data

CONCLUSIONS

The data provided during these field tests offer several clear conclusions:

Phase One:

1. The Engineered AC Mitigation Cable outperformed the bare copper conductor reducing the AC voltage by 28% with a comparable length of gradient control wire.

2. There was only a modest difference between using the AWG 1/0 and the AWG #2 internal conductor – surprisingly the smaller internal conductor outperformed the larger internal conductor. Further study is warranted on this point.

Phase Two:

1. The Engineered AC Mitigation cable continued to show a significant reduction in induced AC current over the bare copper cable. The average improvement was 39% in lowering the induced AC voltage on the pipeline.

2. The Engineered AC Mitigation cable showed an average of 22% improvement in lowering the induced AC voltage on the pipeline over the bare zinc ribbon.

ACKNOWLEDGMENTS

These tests were conducted by National Grid with the assistance and support of MATCOR Inc.

ADDITIONAL REFERENCES

For additional information on AC Interference and Mitigation the following references are recommended:

NACE SP0177-2014, Standard practice for mitigation of alternating current and lightening effects on metallic structures and corrosion control systems, NACE International

CAN/CSA-C22.3 NO. 6-M9 - Principles and practices of electrical coordination between pipelines and electric supply lines, Canadian Standards Association

BS EN15820, 2013, Evaluation of AC Corrosion Likelihood of Buried Pipelines Applicable to Cathodically Protected Pipelines, British Standards Institute

GUMMOW, Robert A., “A/C Interference Guideline Final Report”, June 2014, Canadian Energy Pipeline Association