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RETROFIT INDUCED AC MITIGATION

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ABSTRACT

It was necessary to retrofit induced AC mitigation on a newly installed 30 inch natural gas pipeline due to an inadequate pre-construction study. This paper presents details of the study and of the novel mitigation approach taken.

Keywords: grounding grid, HVAC, induced AC, induced AC mitigation, point ground, transferred potential.

INTRODUCTION

Mitigation of induced AC voltages on pipelines paralleling high voltage alternating current (HVAC) power lines is a serious matter and is not to be taken lightly.[1] A Texas pipeline company proposed to build a 9.8 mile 30" natural gas pipeline to supply fuel gas to a merchant power plant (MPP) under construction. Approximately two miles of the proposed pipeline would parallel a dual 345kV power line circuit supported on galvanized steel lattice work towers. The dual shield wires are bonded to each structure.

The gas pipeline company retained a consulting firm to evaluate AC induction on the proposed parallel pipeline. The "Induction Analysis Study" basically said that AC induction from steady state or fault conditions was a problem. No mitigation grounding scheme was proposed. The recommendations consisted essentially of:

1. Advise the power company of the pipeline activity on their right-of-way (R/W).
2. All personnel should use eleven inch low voltage lineman's rubber gloves protected with lineman's leather gauntlet gloves.
3. Measure the line voltage and ground the pipeline if it exceeds fifteen volts. Or if pipe potential exceeded fifteen volts AC, employ ground mats.
4. Ground pipe up on skids at necessary intervals to reduce the voltage to fifteen volts.
5. Curtail work if an electrical storm is in the area and the supervisor in charge feels it poses an additional hazard.

Based on the assumptions and recommendations contained in the report, the pipeline was constructed in the spring and early summer of 1999 during the worst drought conditions encountered in that part of Texas in the prior twenty years. This was fortunate since the dry soil conditions greatly increased the tolerable steady state step and touch voltages. The pipeline was constructed without the benefit of any form of electrical grounding. We understand that some workers did complain of the discomfort of electrical shock during construction of the pipeline. However, there were no injuries reported. If the pipeline had been construction under wet conditions typical of early spring in Texas, the consequences would have been much more serious.

INVESTIGATION

After the pipeline was constructed and placed into operation, the pipeline operator contacted ELK Engineering Associates, Inc. (ELK) to perform an induced AC mitigation study and make recommendations to control the observed detrimental induced AC effects on the pipeline. After we gathered all necessary field data and contacted the power company for the appropriate electrical parameters, Electro Sciences, Inc. constructed a mathematical model of the R/W and exercised their proprietary AC induction program to predict the peak voltages under maximum line loading conditions. This computer run determined that steady state voltages as high as 160 VAC could be experienced on the pipeline under emergency level load current conditions. Peaks as high as 40 VAC would occur under normal daily load profile conditions.

Computer modeling various mitigation schemes clearly showed that installation of a single zinc ribbon mitigation wire would have provided effective grounding of the pipeline in the very low electrical resistivity (800 ohm/centimeter) soil conditions. However, since the pipeline was already constructed, this was no longer an economically viable alternative. It also was necessary to install supplemental grounding at the meter station serving the MPP. Stray AC flowing in the pipeline was damaging or destroying the remote transmitter units (RTU) for the meter station SCADA system.[2]

MITIGATION DESIGN

Computer modeling showed that installing a low resistance "point ground" at the points of entry and exit on the power line R/W could adequately clamp the induced AC voltages to a tolerable level. The required grounding resistance needed to be less than or equal to 0.167 ohms at each end of the parallel R/W. Even in the very low electrical resistivity soil found on this particular pipeline R/W, a rather long groundrod was indicated. Calculations showed that the minimum acceptable groundrod length would be 200 feet. Local power line construction contractors did not have equipment available to drive coupled groundrods to this depth. Therefore, we chose a novel approach to achieving a long, deep low electrical resistance ground. See Figure Number 1. A conventional water well drilling rig was utilized to drill a nominal four inch diameter hole to a total depth of 210 feet. The groundrod was constructed of 3/4 inch galvanized steel electrical conduit in 10 foot joints. A length of Number 2 AWG stranded copper type HMWPE insulated wire was exothermically welded to the top joint of the groundrod pipe prior to installation. See Figure Number 2. The exothermic welds were coated with an approved pipeline dielectric mastic. The groundrod pipe was made up wrench tight and lowered into the hole through the drill rig's slips. An adapter was rigged between the 3/4 inch groundrod pipe and the rig's wash hose. A slurry of 75/20/5 magnesium anode backfill was mixed as thick as possible and was placed in the hole with the rig pump. In this manner, the backfill was placed from the bottom of the hole and pumped until surface returns were visible. A short, direct connection was made to the pipeline with the Number 2 cable. The cable was provided with a minimum of five feet of cover for physical protection. No cathodic decoupling devices (CDD) were required since the galvanized steel surfaces readily polarize and represent a very minimal current demand on the CP system.

The 75/20/5 backfill is very low in electrical resistance which allows characterizing the ground rod as equivalent to the hole diameter of 3-7/8 inches. Also, the backfill is benign to zinc/iron on the inside of the conduit which does not receive the benefit of cathodic protection (CP). The hygroscopic nature of the backfill is an additional benefit in that it will draw moisture from the surrounding soil and will remain a permanent, moist, low resistance ground. With a minimum separation of 80 feet between the new pipeline and the center line of the existing power line, there was no concern about a direct power arc puncture of the pipeline steel.[3] It was only necessary to design mitigation to assure acceptable step and touch potentials on the R/W under power line fault conditions. The proposed grounding scheme was shown, by computer modeling, to be adequate for fault current mitigation at any one of the towers on the parallel section.

We next turned our attention to the meter station where improved grounding was necessary to limit damage to the RTUs associated with the SCADA system. The meter station, as installed, had a limited bare copper grounding grid that was more than adequate to provide safe grounding for an electrical fault originating in the meter station yard. However, it was not sufficiently low in electrical resistance to mitigate excessive AC flow onto the meter station grid from the induction on the pipeline. In the as found condition, the meter station grid was essentially the only ground on the pipeline. This meter station was located less than 1/2 kilometer (0.3 miles) from the point of separation from the dual 345 kV power line which was one of the major voltage peaks on the pipeline. A 30 volt 30 ampere rectifier powering a deep anode groundbed was installed close to this location. The installed rectifier had plenty of capacity to effectively polarize the proposed expanded bare copper grounding grid installed at the meter station. Even with the increased wire footages and bare copper surface areas, the grid was much smaller than a typical electrical substation. It did represent a major load on the CP system, but was within the rectifier's capacity to protect the pipeline steel. Given the existence of a bare copper grid, it was not considered practical or cost effective to remove the present grid and replace it with one more compatible with CP.[4] Therefore, no CDDs were called for between the pipeline and the grid. The meter station grid was reinforced by installing a #2 AWG stranded bare copper conductor around the meter station perimeter fence. Four separate #2 AWG leads were run from the new perimeter grid conductor back to the original grid. Driven copper groundrods were installed at the corners of the grid. Computer modeling showed that under maximum emergency level load currents the meter station grid would ground even more steady state current than would either point ground.

Where not on the power line R/W, the new 30 inch pipeline parallels an existing 24 inch (Circa 1960s) tape coated pipeline. Due to the state of deterioration of the 24 inch pipeline coating, rectifiers have been installed at 5 mile intervals or less to effectively cathodically protect the line. Consequently, the existing 24 inch pipeline electrically represents a horizontal grounding conductor on the pipeline R/W. A deliberate cross bond was established between the 30 inch and the 24 inch pipeline at three separate locations remote from the power line R/W to further clamp down on transferred potential.[5] The pipeline company's preference was to maintain the CP systems on the two pipelines separate from each other. Therefore, CDDs, in the form of wet polarization cells, were installed in each of these bond paths.

The computer model showed possible induced pipeline voltages for the grounded pipeline slightly above 15 volts at some locations.[6] In addition, we had concerns about future population growth in the immediate area of the pipeline. With population growth, the statistical probability of children playing on the R/W increases. Due to their decreased body weight, children are far more susceptible to electric shock than is the case for healthy adult males.[5] These concerns and considerations led us to recommend dead front construction on all CP facilities and ground mats at all aboveground pipeline appurtenances, including test leads.

The installed induced AC mitigation grounding systems and CP systems have been operating on this pipeline as designed. The net result is an effectively grounded, safe pipeline after it was retrofitted with induced AC mitigation and compatible CP systems. The retrofit system was designed and installed at a reasonable cost.

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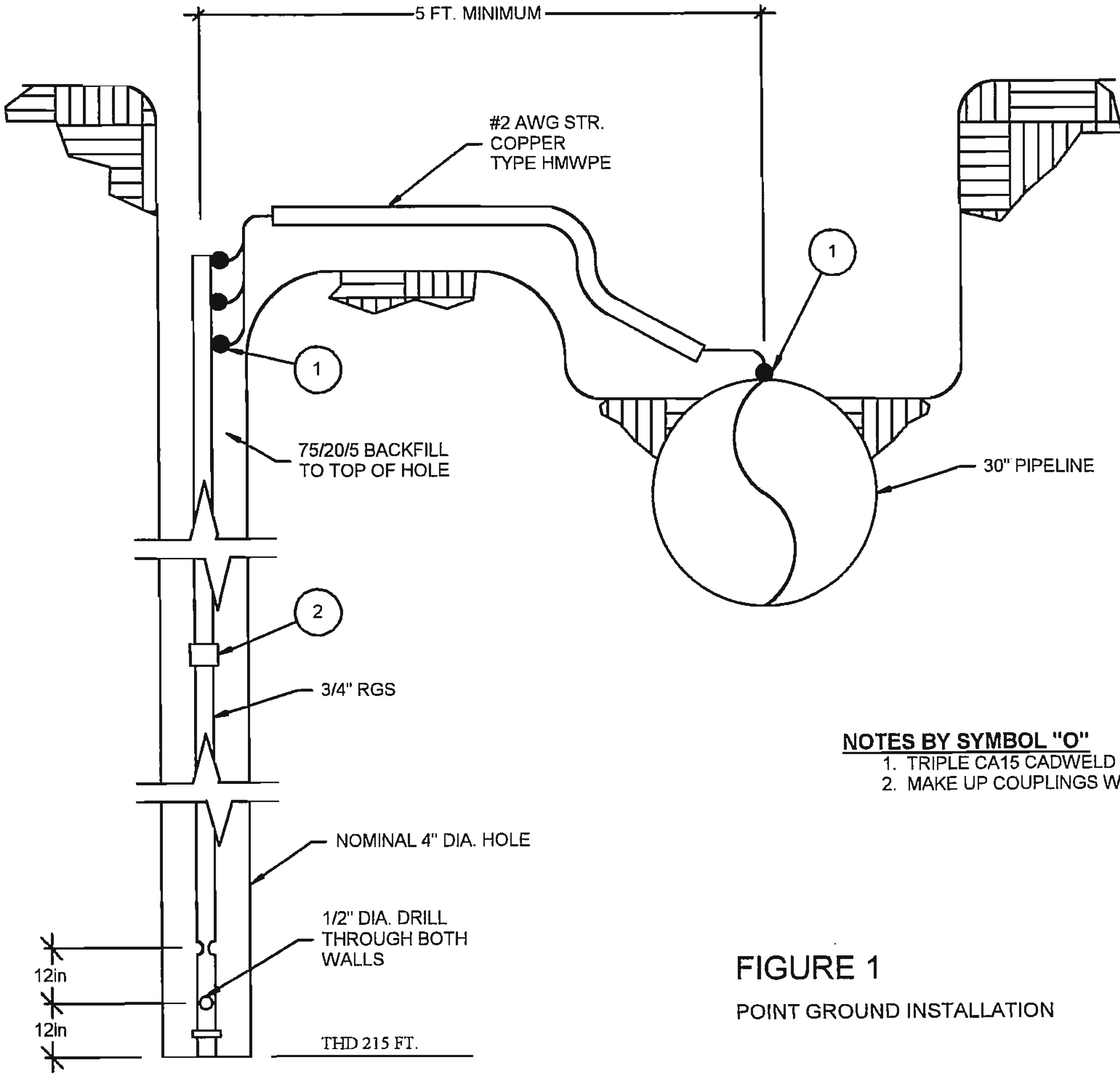

NOTES BY SYMBOL "O"

1. TRIPLE CA15 CADWELD ON SPLIT STRANDS.
2. MAKE UP COUPLINGS WRENCH TIGHT

FIGURE 1

POINT GROUND INSTALLATION

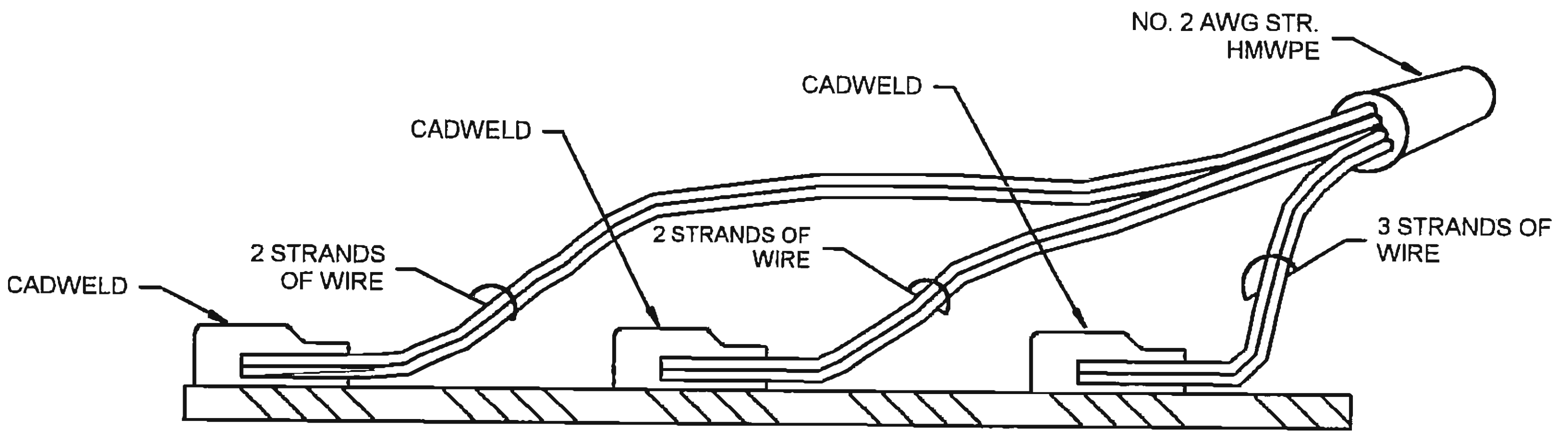

FIGURE 2

MULTIPLE WELD CONNECTION