PROPER GROUNDING AND TVSS INSTALLATION REDUCES ELECTRICAL MAINTENANCE BY 65%

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INTRODUCTION

Artificial Lift Systems are under constant attack from storms, load and utility grid switching and internally generated switching. The associated voltage phenomena are cumulative in nature and degrade the integrity of these electric/electrical powered systems. The cost associated with adding equipment which is designed to protect system from this type of damage is far less than the cost encountered when attempting to recover from the damaging effects.

When using Variable Frequency Drives (VFDs) in ESP and Rod Pump applications many benefits can be realized, however an increased level of awareness regarding a properly designed electrical system is needed. Input and output waveforms are distorted by the very nature of VFD technology (fixed speed AC input current / variable speed AC output current). The use of properly selected and coordinated protection, such a secondary surge suppression and chemical grounding, can effectively minimize the negative effects (increased system total cost of ownership, loss of production) of premature equipment failure due to voltage irregularities inherent to the system.

A reliable Surge Protective Device (aka TVSS) installed at critical points in the Artificial Lift distribution system will prevent damage and degradation of electrical equipment from voltage transients and lightning. Lightning protection systems function optimally when ground resistance readings are low. The ideal protection scenario combines overvoltage protection with a grounding system which achieves low levels and improves over time.

American Petroleum Institute Recommended Practices 11S (API RP11S) suggests proper grounding and the installation of primary lightning arrestors and secondary transient voltage surge suppression on all submersible equipped wells. Many oil production companies have adopted API RP11S suggestions as their own best practices; the results of which are a proven reduction of electrical maintenance by some 65%.

The following are proven methods for reducing electrical maintenance:

- Adopting API RP11S as a Corporate Best Practice has proven to decrease electrical maintenance on Electric Submersible Pumps by up to 65%.

- Chemical grounding meets safety codes and allows for all forms of overvoltage protection (primary and secondary surge suppression) to operate more effectively and significantly reduce failures of electrical equipment.

- Secondary surge suppression installed to Switchboards and VFDs feeding pumps of all kinds mitigates harmful transients which are known to deteriorate cable and motor insulation.

- Secondary surge suppression used in conjunction with chemical grounding systems have been proven to operate in an arid/desert environment. The combination of the two products is an effective form of protection against externally (storm related) and internally (normal equipment operation) generated transient energies.

- Installation of secondary surge suppression and chemical grounding systems will extend equipment run time.

DISCUSSION

During 2008 and 2009 testing of Chemical Ground Sytems and TVSS installion was conducted and documented on over fifty (50) ESP sites in two (2) locations.

The first location experienced ten (10) VFD/ESP installations with numerous problems and high costs associated with operation. A Surface Electrical study was conducted and based upon the finding the recommendations included Chemical Ground System and TVSS installation on all ten (10) wells and dummy primary line feeders, where applicable.

The second location had two (2) VFD/ESP installations with low reliability and high costs associated with operation. Chemical Ground System and TVSS were installed.

Grounding Systems

A Grounding System provides a low impedence path to the supply source, so in the event of failure to earth of a live conductor, sufficient currrent flows safely along the predetermined route to enable circuit protective devices to operate. Proper grounding also limits the rise of potential on metalwork accessible to persons or animals to a safe value under normal and abnormal circuit conditions. Figure 1 and Figure 2 represent Grounding Systems.

The recommended values of these grounding requirements are as folows:

- Personnel safety (NEC Emerald Book) 25 ohms or less
- Lightning Protection 10 ohms or less
- Fault protection devices to operate safely 10 ohms or less

Chemical Ground Systems can maintain function for over thirty (30) years with minimal maintenance. The supporting data (see Table 1) was derived over a three (3) year period in a field in Hobbs, NM.

Power Quality

Power Quality is a vital ingredient for electrical and electronic sytems to operate cost effectively. The power Quality Phenomenon can be broken down into six (6) major categories, as shown in Table 2.

Of these power quality anaomolies nearly nine (9) out of ten (10) harmful power lines disturbances can be traced back to transients. Seven (7) out of twelve (12) common causes of electrical failure in three (3) phase motors have reference to transient voltage surges. These surges can be caused by lightning, reclosure coordination, grid switching, short circuits and load switching.

Transients

Eighty percent (80%) of all transient activity is associated with loads on the distribution system (VFDs, motor loads, capacitor banks, soft starters, equipment failure or any load which cycles on and off). The other twenty percent (20%) is generated by external sources (lightning, line slapping and utility switching). In the Permian Basin thunder can be heard an average of fifty to sixty (50-60) days/year.

Lightning is the most powerful and least understood of all surges and is atributed to over (two) $2 Billion annually for equipment maintenance with associated downtime estimated at (twenty-six) $26 Billion annually. Each lightning flash can contain one to twenty-six (1-26) strokes with each stroke lasting on average fifty (50) milliseconds with fifty percent (50%) as one (1) million volts. A lightning stroke can also travel over two (2) miles.

The result is heat generated causing fires, the direct effect of moisture vaporizing. There are also high volume and high current surges along conductors over long distances and high volume and high current surges along the ground over shorter distances. At the end of a power line the lightning surges can double at the crest (see Figure 3) as it returns on the incoming path.

Transients, on the other hand, have less energy but are more repetitive. This cumulatively damages insulation until a path to ground can be attained. The included graphs (see Figure 4, Figure 5 and Figure 6) depict transient activity from a lighning storm, a contactor switching on and a six (6) pulse VFD.

The first graph (see Figure 4) depicts a lightning storm. Figure 4 shows the complete outage and then loads coming back on line. The bottom of the graph shows the lightning activity over the next hour as power is restored.

The second graph (see Figure 5) shows a motor contactor switching on. The transient occurs at the peak of the sinewave.

The final graph (see Figure 6) shows the switching transients associated with a six (6) pulse SCR VFD. There are six (6) distinct pulses (or switches) for each cycle.

The overall effects of transients on electronic and electrical equipment are among the following: premature failures (windings, circuit cards), degredation of equipment insulation, erratic data exchange and overall system degradation.

Field Results

The installations for each of the fields were standardized and all sites will be upgraded as shown in Figure 7 and Figure 8.

The two (2) fields (YTD - as of November 2009) have documented sixty-two (62) electrical related failures out of one hundred forty-three (143) total ESP failures. Of the sixty-two (62) electrical failures only (seven) 7 were deemed to be storm related and at least one of these seven (7) was yet not covered by TVSS protection and chemical grounding. The overall savings have amounted to some 65% in maintenance dollars spent over last year.

CONCLUSION

In conclusion, proper grounding and TVSS can significantly lower overall cost of ownership. It is important to maintain proper grounding for equipment protection, proper overvoltage protection function and most importantly field personnel safety. TVSS installations have a proven track record for over twenty (20) years on ESP systems.

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Table 1
Chemical Ground Systems Data

NHU	Ground rod 1 Before installing CG	Ground rod 2 Before installing C G	Chemical Ground tested 3 years later
19-232	80	90	7.5
24-231	70	100	7
24-321	60	60	7.5
24-411	50	80	9
24-414	30	35	8.5
24-431	40	na	6
24-441	100	90	7.5
28-241	120	60	11
28-243	10	14	3.5
28-331	100	na	9
28-341	100	120	7.5
28-342	30	35	10.5
29-231	50	na	4.5
29-241	100	75	9
29-321	35	25	7.5
30-113	100	na	3
30-211	150	100	5
30-221	200	100	6
30-312	200	500+	5
30-441	200	350	7.5
30-444	250	200	3
32-143	200	80	8.5
32-211	80	200	9
32-232	150	na	7
32-241	200	500+	6.5
32-312	5	30	10
32-343	120	200	12
32-421	100	50	9
33-131	30	na	9
33-141	500+	na	8
33-233	60	50	6
33-311	200	na	8
33-331	75	na	7.5
33-411	60	na	11
33-412	60	na	9
33-421	150	na	4.5
33-431	55	na	4
33-433	30	na	3.5
34-221	100	na	2.5

All readings are in Ohms The tests were made using the three point fall of potential method recommended by the IEEE

Table 2
Summary of IEEE Standard 1159 power quality terms, along with respective duration and cause.

Category	**Types**	**Typical Duration**	**Common Causes**
Transients	Oscillatory, Impulsive	Less than 1 Cycle	Lightning, Switching Loads
Short-duration variations	Sags, Swells, Interruptions	Less than 1 minute	Faults, motor starting, utility protective equipment
Long-duration variations	Undervoltages, Overvoltages, sustained interruptions	More than 1 minute	Poor voltage regulation, incorrect transformer tap setting, overloaded feeder, utility equipment
Voltage Imbalance	N/A	Steady-State	Unbalanced loads, equipment failure
Waveform Distortion	Harmonics, notching, noise	Steady-State	Electronic loads
Voltage Fluctuations	N/A	Steady-State	Arcing loads, loose connections
Power frequency variations	N/A	Steady-State	Poor generator control

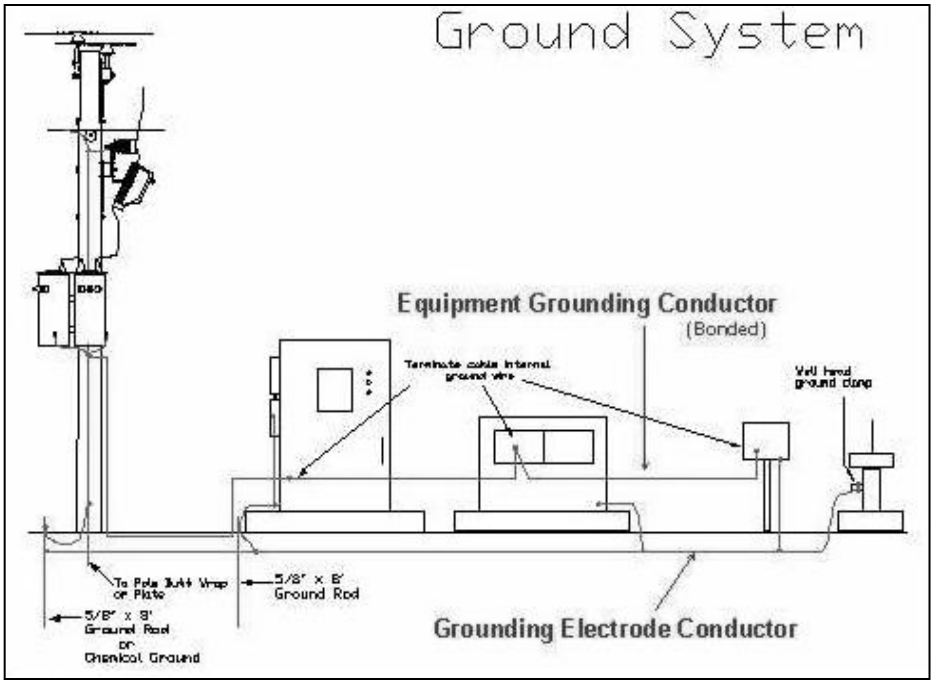

Figure 1 – This is a grounding system for an ESP with a variable frequency drive.

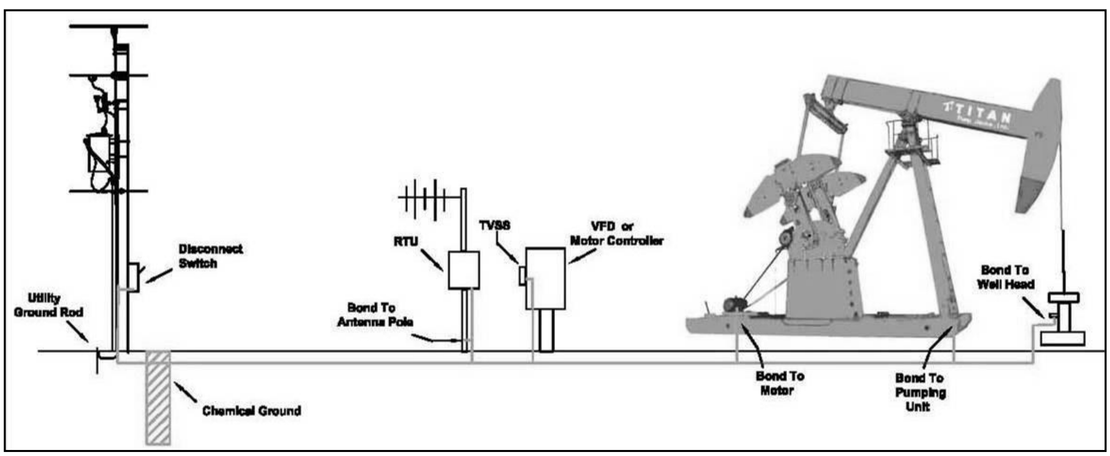

Figure 2 – This is a grounding system for typical pumping unit installation.

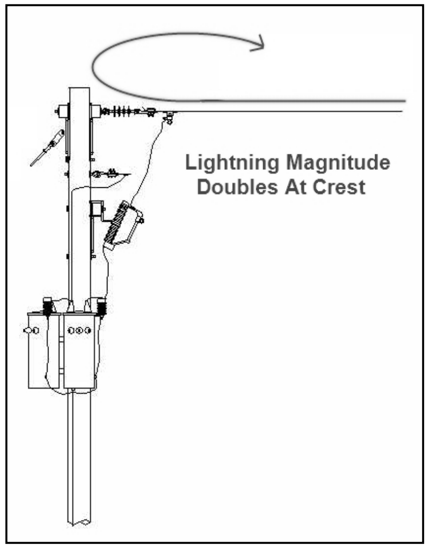

Figure 3 – At the end of a power line the lightning surges can double at the crest as it returns on the incoming path.

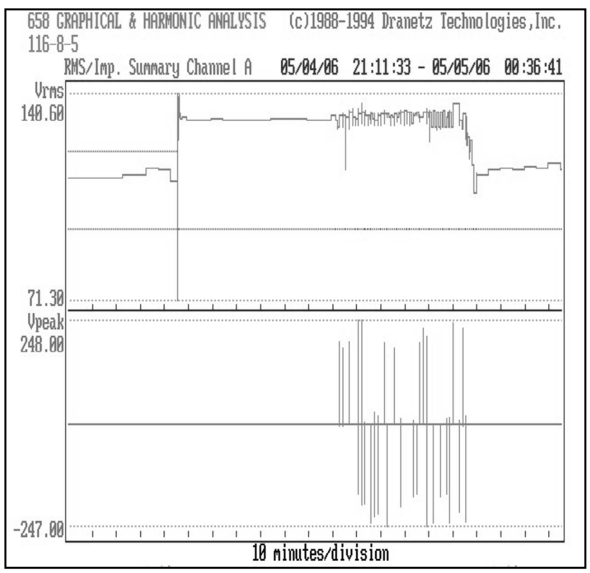

Figure 4 - This graph depicts a lightning storm. It shows the complete outage and then loads coming back on the line. The bottom portion of the graph shows lightning over the next hour as power is restored.

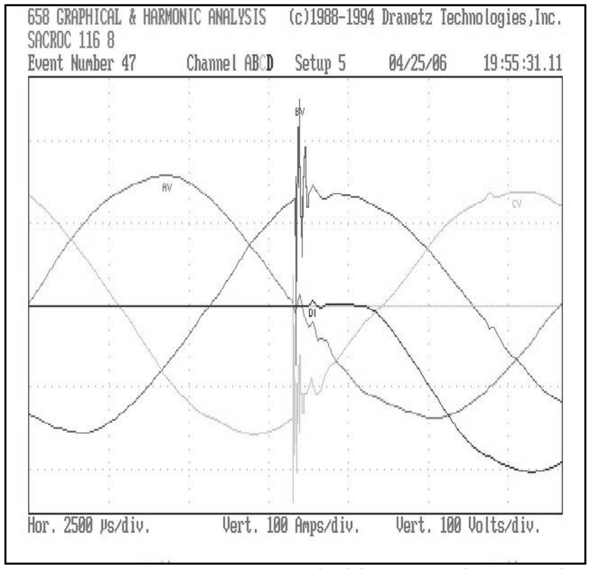

Figure 5 – This graph illustrates a motor contactor switching on. The transient occurs at the peak of the sinewave.

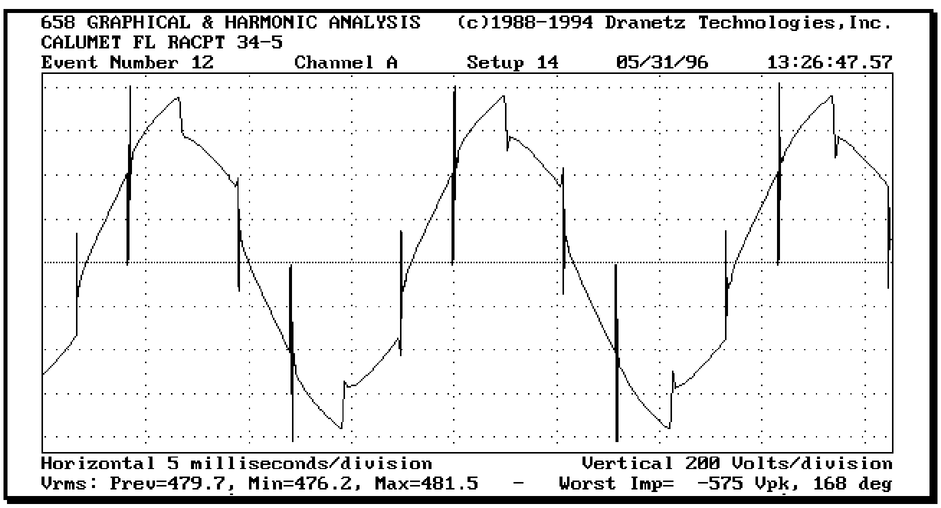

Figure 6 – This graph shows the switching transients associated with a six-pulse SCR VFD. There are six distinct pulses (or switches) for each cycle.

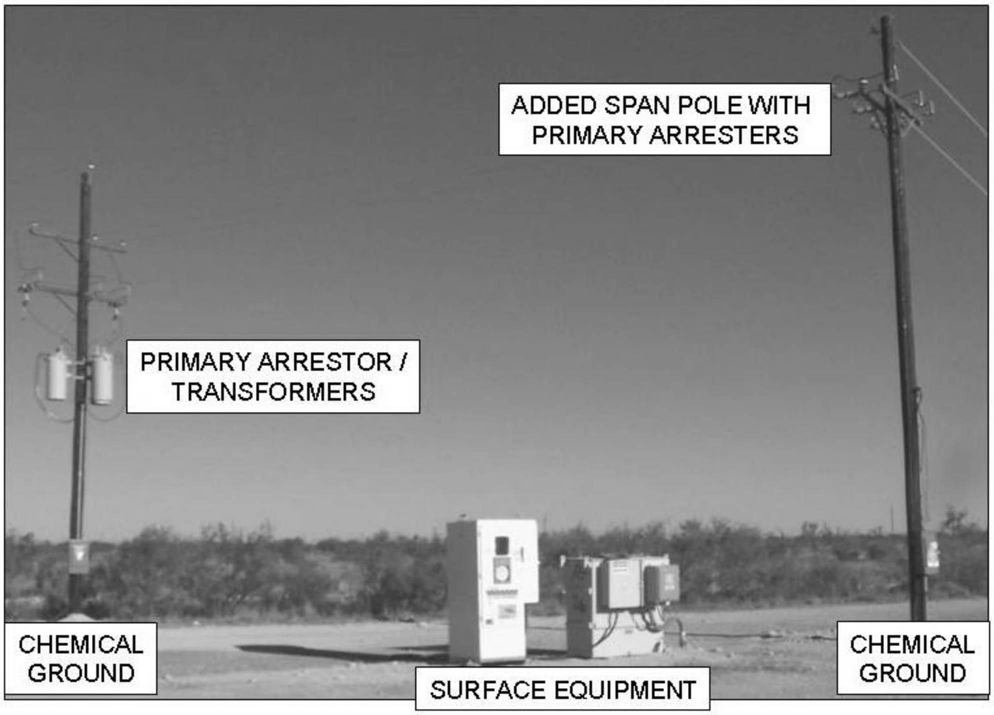

Figure 7 - Installations for each field were standardized and all sites will be upgraded as seen in this photo.

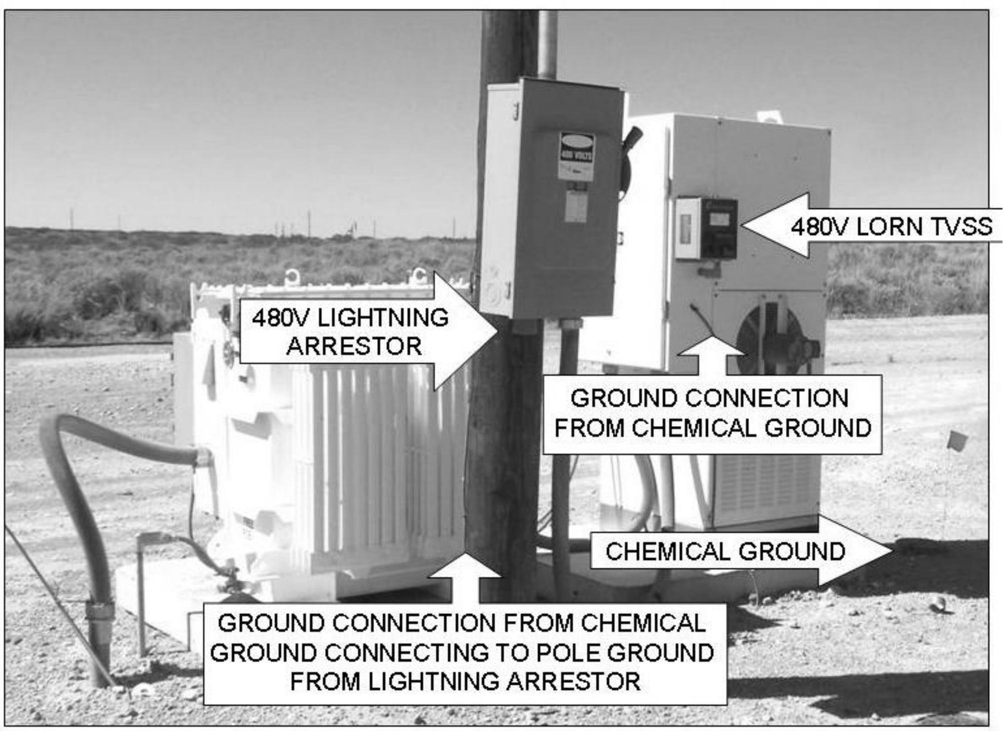

Figure 8 – This photo is an up-close example of equipment placement at a site which has been standardized.