FOR IMMEDIATE RELEASE

**Pipeline Corrosion Monitor Pleads Guilty to Pipeline Safety Violations and False Statements**

Randy Jones, 44, a former corrosion coordinator for Shell Pipeline Company L.P. (Shell), pleaded guilty in Milwaukee today to failing to conduct bi-monthly voltage readings and an annual survey of a pipeline used to transport jet fuel in violation of the Pipeline Safety Act (PSA) and making a false statement to the Pipeline and Hazardous Material Safety Administration (PHMSA).

Jones, a resident of Louisiana, pleaded guilty to knowingly failing to conduct required safety tests between January and December 2011 and submitting false data to PHMSA. The violations were in connection with a pipeline owned by Shell that delivered commercial aviation jet fuel to General Mitchell International Airport in Milwaukee, Wisconsin. In January 2012 a hole was discovered in the pipeline at Mitchell Airport after jet fuel began showing up in soil surrounding the airport and in nearby Wilson Creek. Fuel eventually reached and melted asphalt on airport property. Shell reported that approximately 9,000 gallons of jet fuel was released. The response and cleanup cost for the spill was approximately $19.3 million.

Jones was employed by Shell from 1992 through 2012. From 2010 until 2012, Jones was employed as a corrosion coordinator and was responsible for Shell pipelines servicing Mitchell and Chicago O’Hare airports. Jones failed to conduct the required testing for 2011 and when advised of an audit by PHMSA scheduled for December 2011, he submitted false data indicating the required test had been conducted.

Consistent with requirements of the PSA, which establishes standards for the safe operation of the hazardous materials in pipelines, buried or submerged metal pipelines must be protected to prevent corrosion. This involves the use of a device called a rectifier which applies a negative current to soil near the pipeline to keep corrosion away from the pipe. The operator of the pipeline is required to conduct bi-monthly readings of the voltage generated from a rectifier and conduct an annual survey of the pipeline to ensure that the pipeline is adequately protected from corrosion. PHMSA is the primary agency responsible for regulating and enforcing the PSA.
Objective of Presentation

- Familiarize everyone with components of Rectifiers
- Understand workings of components
- Understand the Why, What, How, and When of Rectifier Monitoring
What is a Rectifier?

- Rectifier converts or **rectifies** alternating current (AC) to direct current (DC).

- DC current then flows to groundbed - then to structure needing cathodic protection.
Samples of Rectifiers
Samples of Rectifiers
Basic Electric - AC

Peak of positive side of cycle.

AC - alternating current will reverse in polarity 60 times per second. A full cycle is considered one hertz. Typical AC has 60 Hz per second.

120VAC +

Half Cycle

Peak of negative side of cycle

SINE WAVE

120VAC -
Basic Electric - Rectifying AC

AC
Positive Cycle
DC
0

0

0

0

Negative Cycle
Header Cables

- Negative cable connected to the structure
- Positive cable hooked to the groundbed
Basic Components of a Rectifier

- Circuit Breaker
- Transformer
- Rectifying Elements
- Accessory Equipment
Standard Rectifier Unit

- Standard Rectifier
- Circuit Breaker
- Output Fuse
- Tap Setting Controls
- Dual Meter - Amps and Volts
- Meter Switch
- Rectifier Output Terminals

TYPICAL AIR COOLED RECTIFIER

FIGURE 7-17
Circuit Breaker

- **Primary Function**
  - provide overload protection for the circuit in which it’s installed
  - serves as an on-off switch for the rectifier
Standard Transformer

- **Primary Function**
  - used to “step up” or “step down” voltage
  - isolate voltage from source
Rectifying Elements

- Allow current to flow in only ONE direction
- Two Types of Rectifying Elements
  - Selenium Cell
  - Silicon Diode
Selenium Cell

- Primary Function
  - barrier layer on selenium side of plate prevents current from passing from the selenium side to the aluminum side
Silicon Diode

- Primary Function
  - permits current to flow in only one direction
  - provides high current and voltage outputs
Current Flows one direction.

Used in rectified systems to change AC to DC with a Rectified diode.
Basic Electric - Rectified diode bridge

CONNECTIONS SHOWN ARE FOR HIGHER PRIMARY VOLTAGE, FOR LOWER PRIMARY VOLTAGE REMOVE LINK BARS FROM 2 & 3 ON TAP BOARD AND PLACE ONE ON 1 & 3 AND THE OTHER ON 2 & 4.

NUMBER OF COARSE AND FINE VOLTAGE TAPS PROVIDED MAY VARY, CHECK PANEL BOARD FOR NUMBER OF TAPS PROVIDED.

NOTE: ALL COMPONENTS IN () ARE OPTIONAL.
Basic Electric
Checking the Diode Module

- Place your meter on the diode checker
- Disconnect the structure or ground bed cable
- Remove the tabs on the course and fine
- Do the four part test
Basic Electric Diode Module Check
Four Part Test

- Test across the course and the structure terminal
- Test across the fine and the ground bed terminal
- Test across the course and the ground bed terminal
- Test across the fine and the structure terminal
- Reverse all polarities on lead for each test
Accessory Equipment

- Amp/Volt meters
- Lightning Arresters
- Filters
- Shunts
Accessory Equipment

- Amp and Volt meters
  - installed to measure and monitor amp and voltage output of rectifier

- Lightning Arrestors
  - installed on AC input and DC output circuits of rectifier
  - prevent damage to rectifier unit during lightning surges
Accessory Equipment

- **Efficiency Filters**
  - improve the efficiency of the rectifier
  - eliminate electronic noise/interference on electronic circuits
  - can also provide lightning protection to the DC side of circuit

- **Shunts**
  - provide a way of measuring the output current of the rectifier
Impressed Current Groundbed

- Cast Iron
- Platinum
- Graphite
- Mixed Metal Oxide
- Coke Breeze
Groundbed Design

- Leave it to the experienced Corrosion Control Engineer

- Things to consider
  - Right-of-way
  - Soil resistivity
  - Pipe diameter
  - Pipe wall thickness
  - Coating condition and type
  - Proximity to other structures
Review

- What is a rectifier?
- Can you name the major components of a rectifier?
- What are their functions?
Rectifier Monitoring

Department of Transportation
Inspection Requirements
Monitor and Evaluate
New and Existing Rectifiers
Per CFR-49 Part 192

- Rectifiers inspected 6(six) times per year not to exceed 2.5 months between inspections
- Inspection Includes
  - General Condition of rectifier
  - Recording rectifier DC volts and amps output

  - Additional Information
    - readings taken from either rectifier meters OR handheld digital meters
    - record all data and changes made
Rectifier Required Inspections

- Importance of Inspections
  - To ensure rectifier unit and ground bed are in good condition
Required Inspections

- Will detect any outside interference problems
- Ensure entire area surrounding rectifier is maintained
Rectifier Inspection
Safety Precautions

- Look for presence of insects, rodents or other hazards around rectifier
- Check for electrical shorts by brushing rectifier unit with back of your hand
Rectifier Inspection
Safety Precautions

no contact voltage detector
Required Electrical Inspections

- DC voltage output readings
- reading DC volts meter on rectifier unit
  - To ensure meter accuracy
- multimeter is connected in parallel to rectifier output terminals
Required Electrical Inspections

- DC voltage output readings
  - reading DC volts meter on rectifier unit
  - To ensure meter accuracy
  - multimeter is connected in parallel to rectifier output terminals
Required Electrical Inspections

- DC Amperage Output reading obtained by
  - Reading DC amps meter on rectifier unit
  - With mtr. On DC amps setting - connect in series to rectifier output terminals
    - ensure rectifier is turned off then on
Required Electrical Inspections

- DC amperage output reading also can be obtained by
  - connecting multimeter in parallel with panel shunt
  - obtain reading and perform calculations
Various types of shunts
Basic Electric - Shunt

- Shunts are resistors; therefore is considered a load.

- Measure voltage across shunt with meter connected in parallel.

- Shunts are used mainly for measuring current flow in a circuit.
  - Rectifiers
  - Bonds
<table>
<thead>
<tr>
<th>Shunt Types and Values</th>
<th>Shunt Rating</th>
<th>Shunt Value</th>
<th>Shunt Factor</th>
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<td></td>
<td>Amps</td>
<td>MV</td>
<td>Ohms</td>
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<tr>
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<td>50</td>
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**OHM’S Law**

- Mathematically it can be stated three ways:
  
  (1) \( I = \frac{E}{R} \)
  
  (2) \( R = \frac{E}{I} \)
  
  (3) \( E = I \times R \) or \( E = IR \)

  
  - \( I \) = Current in Amperes
  - \( E \) = Voltage in volts
  - \( R \) = Resistance in Ohms
Volt

The volt is the basic unit of electrical pressure which forces an electrical current (electrons) to flow through an electrical circuit.

1000 mV = 1 V

1 mV = 0.001 V

SYMBOL is either V or E

50 mV = 0.05 V

250 mV = 0.250 V

850 mV = 0.85 V

2.5 V = 2,500 mV

10.0 V = 10,000 mV

3.67 V = 3,670 mV
## OHM’S Law

### Sample Calculations:

<p>| | | | |</p>
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<thead>
<tr>
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<tbody>
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<td><strong>I</strong></td>
<td><strong>V</strong></td>
<td><strong>R</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2</td>
<td>10 V</td>
<td>5 ohms</td>
</tr>
<tr>
<td>2.</td>
<td>3A</td>
<td>6</td>
<td>2 ohms</td>
</tr>
<tr>
<td>3.</td>
<td>100 mA (.1 A)</td>
<td>10 mV</td>
<td>0.1 ohms</td>
</tr>
<tr>
<td>4.</td>
<td>1200 mA</td>
<td>12V</td>
<td>10 ohms</td>
</tr>
</tbody>
</table>
Shunts Calculation

50 mV - 50 A

Determine Amps/mV

\[ 1 \text{ mV} = \frac{50}{50} \text{ A} = \frac{1}{\text{mV}} \]

Shunt Resistance

\[ R = \frac{E}{I} = \frac{0.050}{50} \text{ V} = 0.001 \text{ } \Omega \]

If Measure - 50 mV

\[ I = \frac{V}{R} = \frac{50}{0.001} \text{ mV} = \frac{50,000}{\text{mV}} \text{ mV} = \frac{50}{\text{A}} \]

Additional samples provided at the end of the chapter.
Shunts Calculation

Determine Shunt Factor (SF)

SF X Measurement (mV) = Amps

50A / 50mV shunt = SF of \( \frac{1}{1} \)

\[
\text{SF } 1 \times 4.2 \text{ mV} = 4.2 \text{ A}
\]

50A / 25mV shunt = SF of \( \frac{1}{2} \)

\[
\text{SF } 0.5 \times 4.2 \text{ mV} = 2.1 \text{ A}
\]
Shunts
Calculation

\[ V / R = I \]

Measurement \( (V) / R \) \((0.1\Omega, 0.01\Omega, \text{or} 0.001\Omega) = I \) \( (A) \)

Measurement of 32.1 mV = \[ .0321 \text{ V} \div 0.1\Omega = .321 \text{ A} \]

Measurement of 32.1 mV = \[ .0321 \text{ V} \div 0.01\Omega = 3.21 \text{ A} \]

Measurement of 32.1 mV = \[ .0321 \text{ V} \div 0.001\Omega = 32.1 \text{ A} \]
Basic Electrical Efficiency Rating Calculation

\[
\frac{\text{DC Watts (Output)}}{\text{AC Watts (Input)}} = \text{ (answer)} \cdot 100 = \text{Eff. Rating %}
\]

For example,

Measurement of AC current and AC voltage on the inlet of the transformer.

\[10 \text{amps} \cdot 20 \text{ Volts} = 200 \text{ Watts}\]
\[20 \text{amps} \cdot 30 \text{Volts} = 600 \text{ Watts}\]

\[\frac{100}{300} = .33 \cdot 100 = 33\%\]
Review: Rectifier Inspections

- Observe all safety precautions while performing rectifier inspections!
- Check physical condition of rectifier unit and area surrounding rectifier
- Obtain DC voltage reading and record
- Obtain DC amps reading by either method illustrated
- Record accurate readings on appropriate forms
Additional Information - Annual Inspections

- Clean and tighten all connections
- Clean all screens, vents
- Check all meters for accuracy
- Replace damaged wires

- Check all protective devices - fuses, lightning arresters
- Inspect all components for damage
- Clean rectifier unit of dirt, insects,
Questions?

Thanks!

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