Rectifier Monitoring

Fundamentals Course

Period 7

Instructor: Josh Brewer

JUSTICE NEWS

Department of Justice

Office of Public Affairs

FOR IMMEDIATE RELEASE

Wednesday, January 7, 2015

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 test 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 insure that the pipeline is adequately protected from corrosion. PHMSA is the primary agency responsible for regulating and enforcing the PSA.

Objective of Presentation

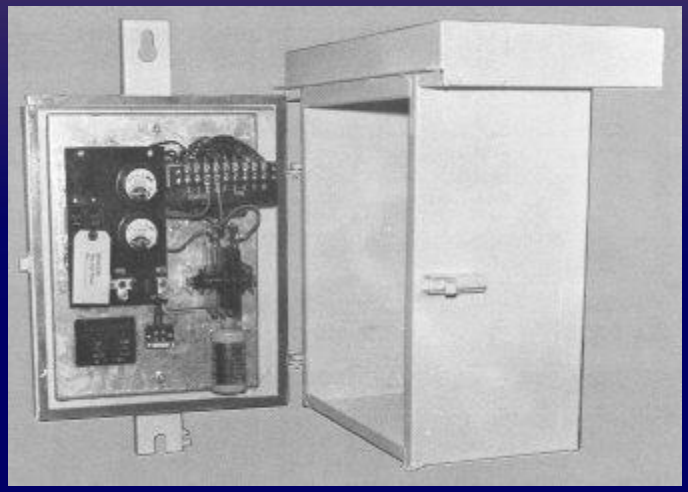
- Familiarize everyone with components of Rectifiers
- Understand workings of components
- Understand the Why, What, How, and When of Rectifier Monitoring

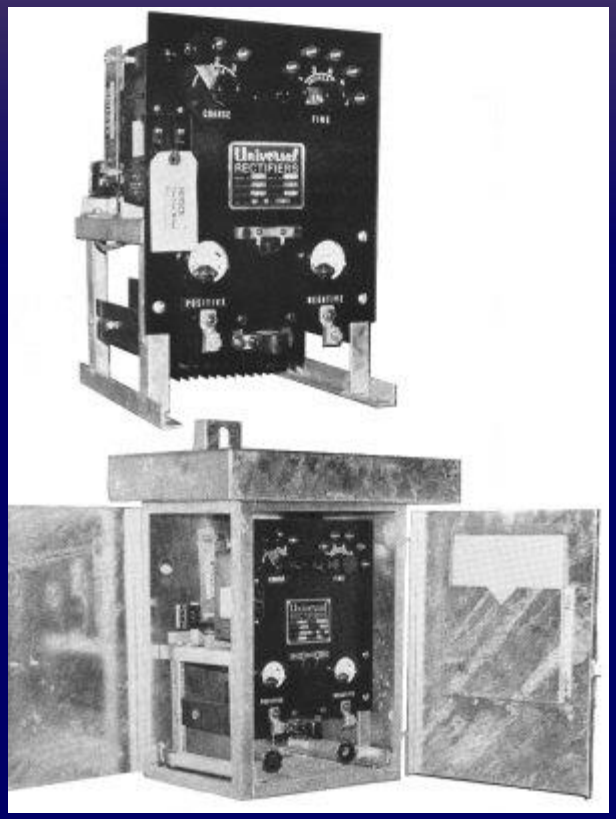
What is a Rectifier ?

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

- DC current then flows to groundbed - then to structure needing cathodic protection

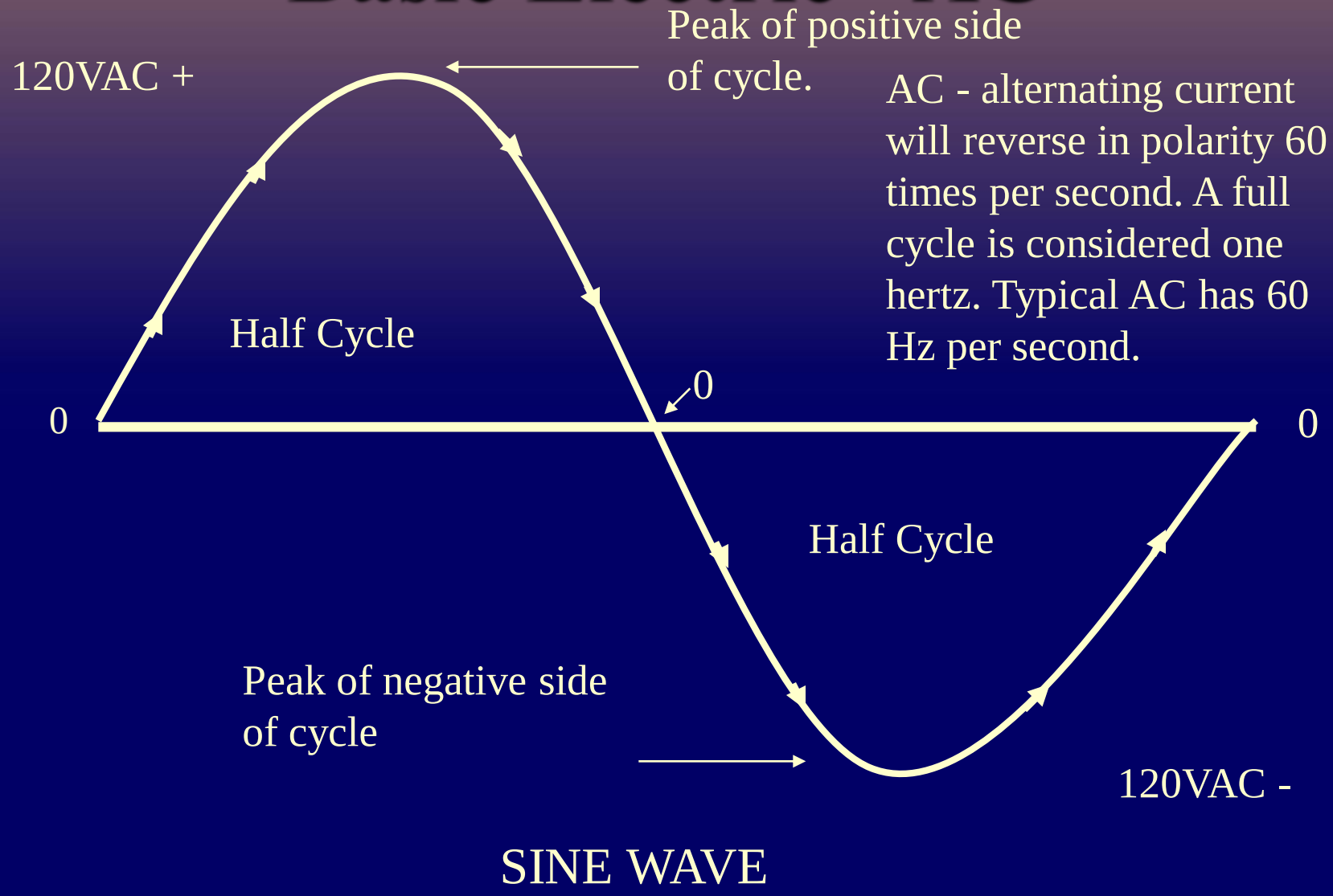
Samples of Rectifiers





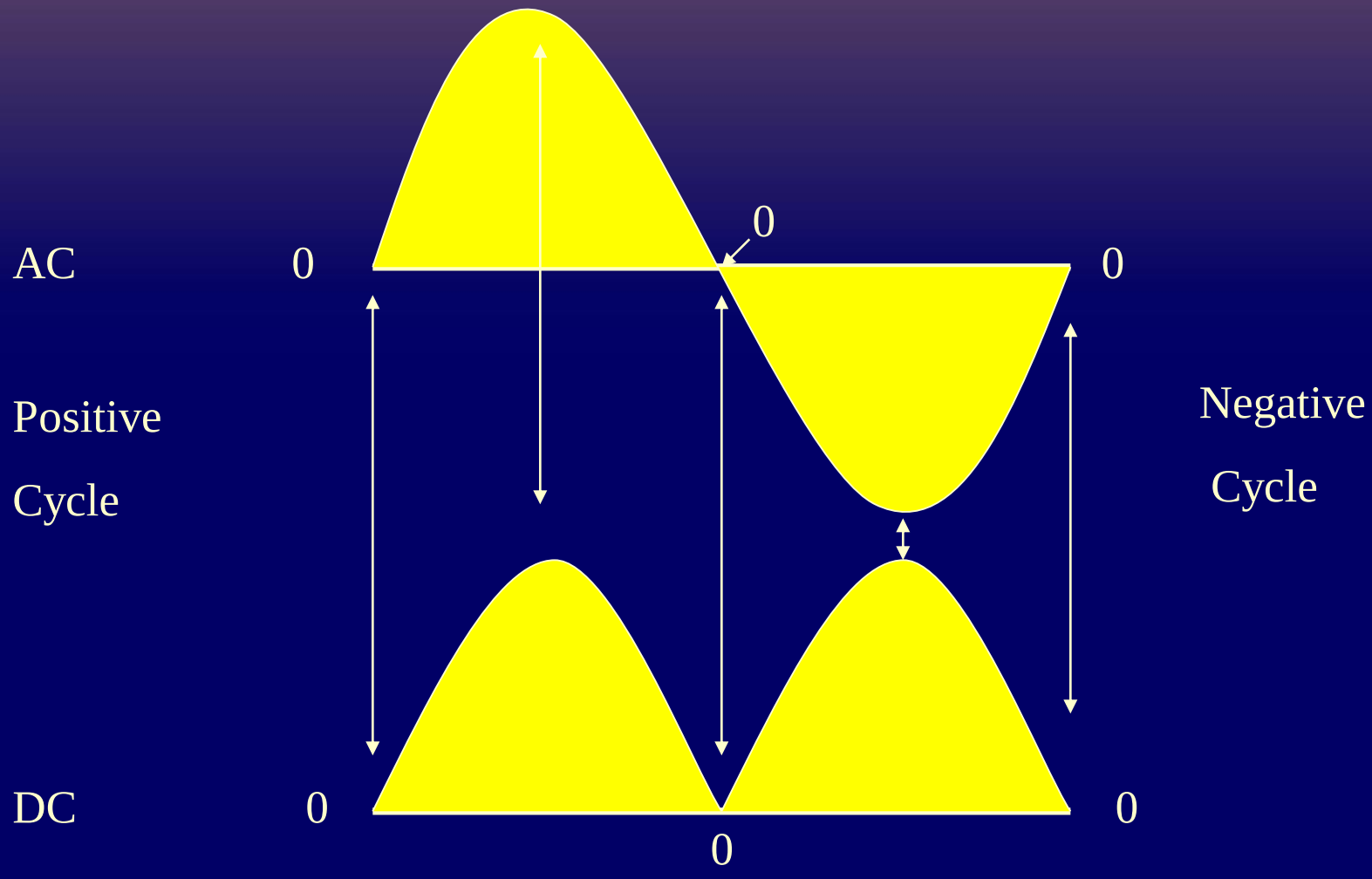
Samples of Rectifiers

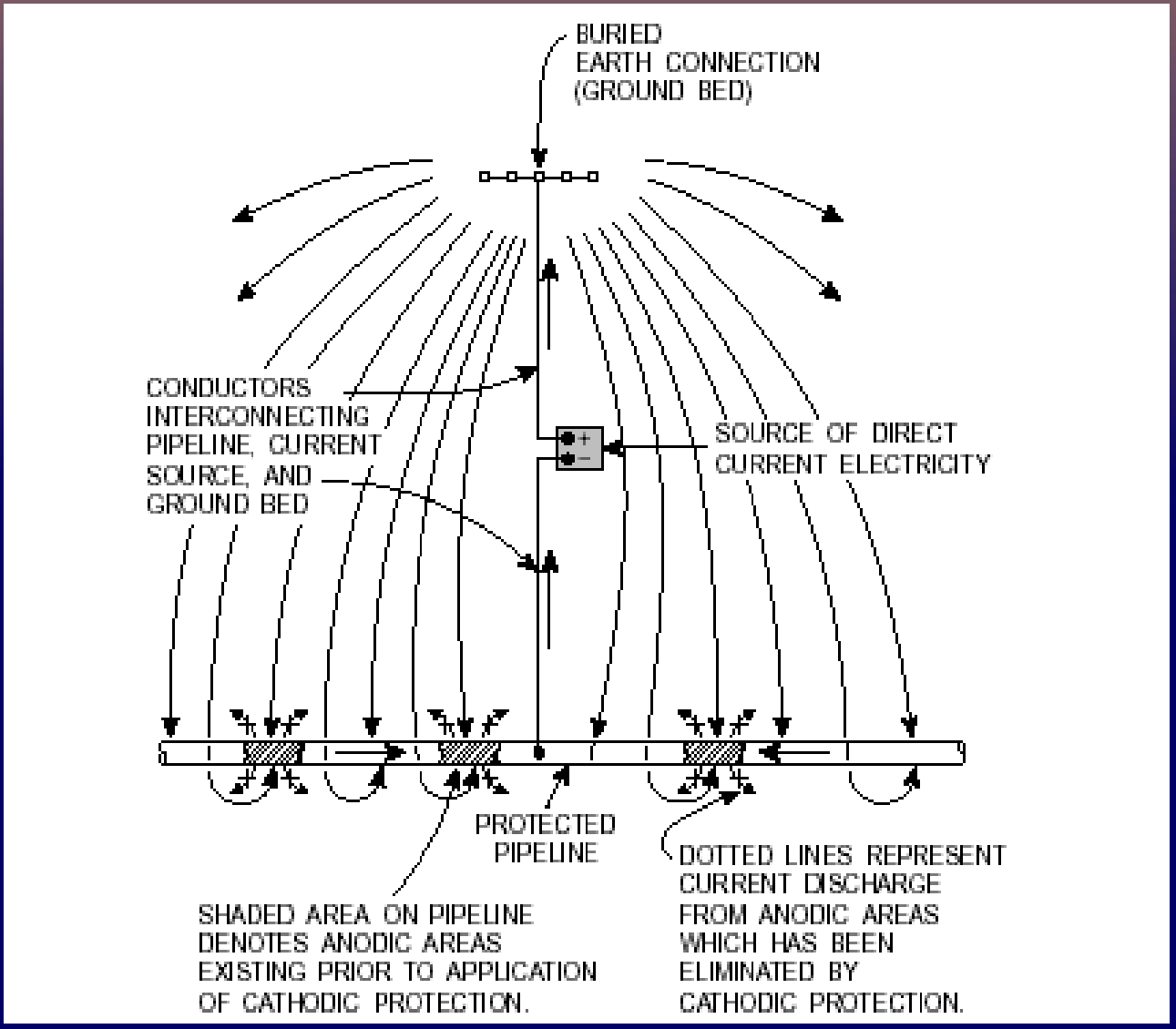
Basic Electric - AC



SINE WAVE

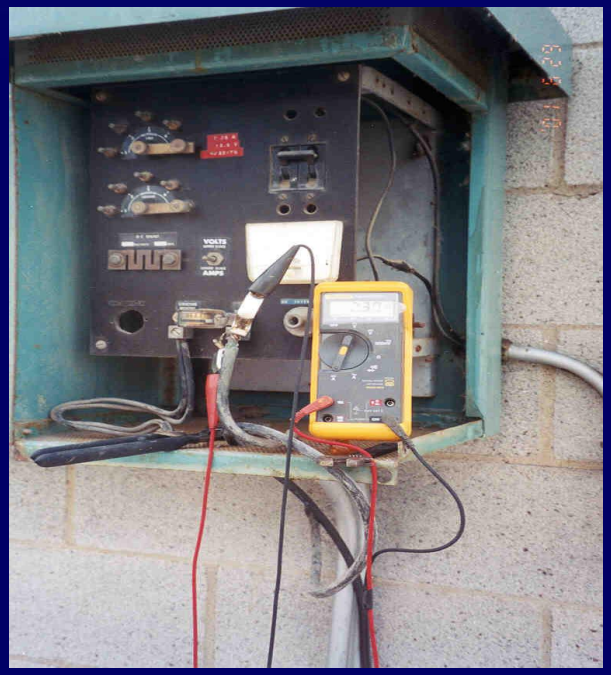
Basic Electric - Rectifying AC

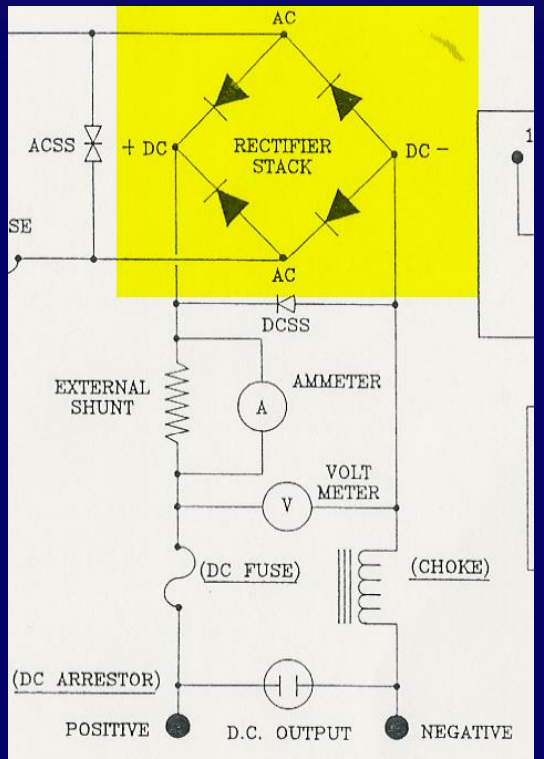



BURIED
EARTH CONNECTION
(GROUND BED)
CONDUCTORS
INTERCONNECTING
PIPELINE, CURRENT
SOURCE, AND
GROUND BED
SOURCE OF DIRECT
CURRENT ELECTRICITY
PROTECTED
PIPELINE
SHADED AREA ON PIPELINE
DENOTES ANODIC AREAS
EXISTING PRIOR TO APPLICATION
OF CATHODIC PROTECTION.
DOTTED LINES REPRESENT
CURRENT DISCHARGE
FROM ANODIC AREAS
WHICH HAS BEEN
ELIMINATED BY
CATHODIC PROTECTION.

Header Cables

- Negative cable connected to the structure
- Positive cable hooked to the groundbed

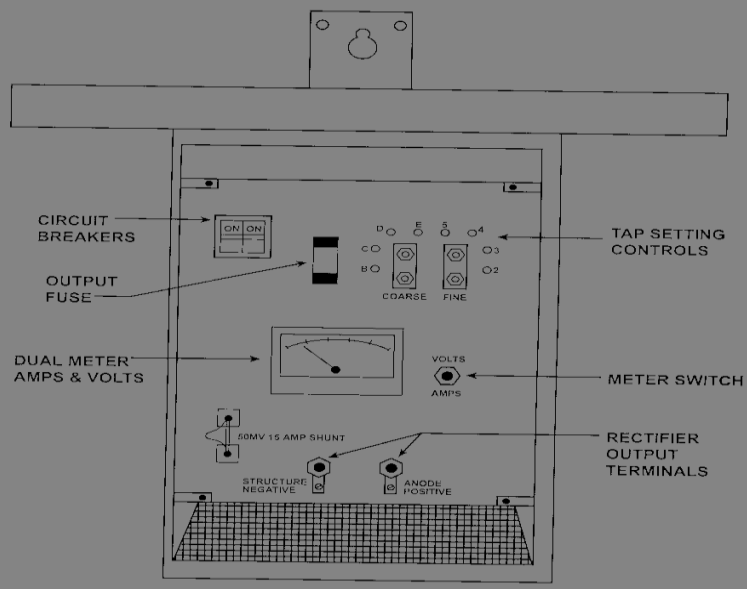




Basic Components of a Rectifier

- Circuit Breaker
- Transformer
- Rectifying Elements
- Accessory Equipment

Standard Rectifier Unit



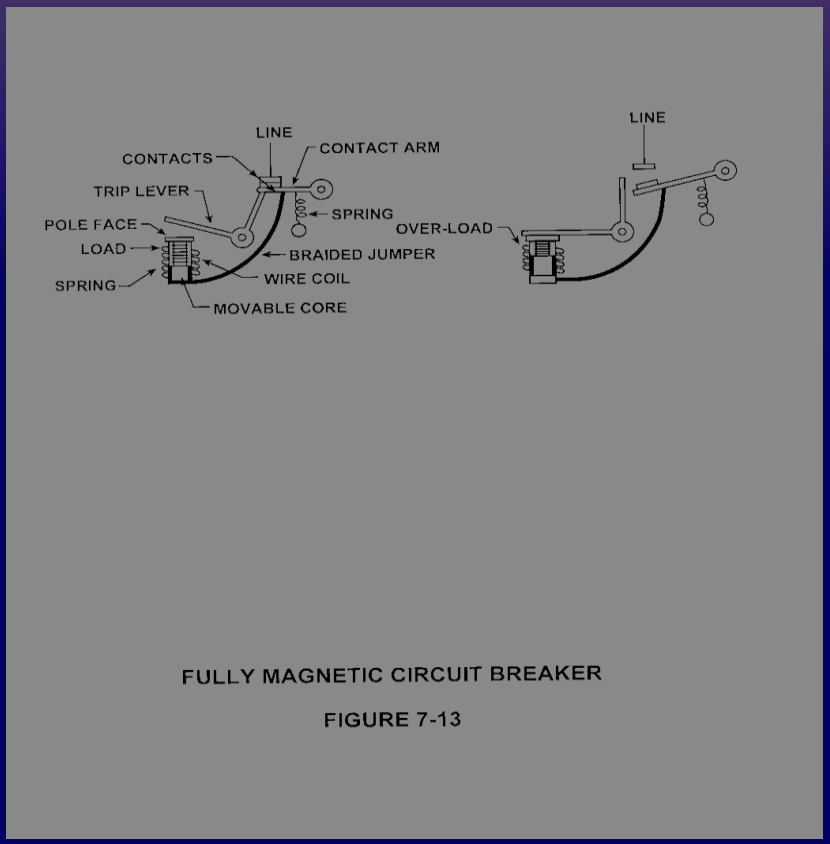
TYPICAL AIR COOLED RECTIFIER

FIGURE 7-17

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

Circuit Breaker

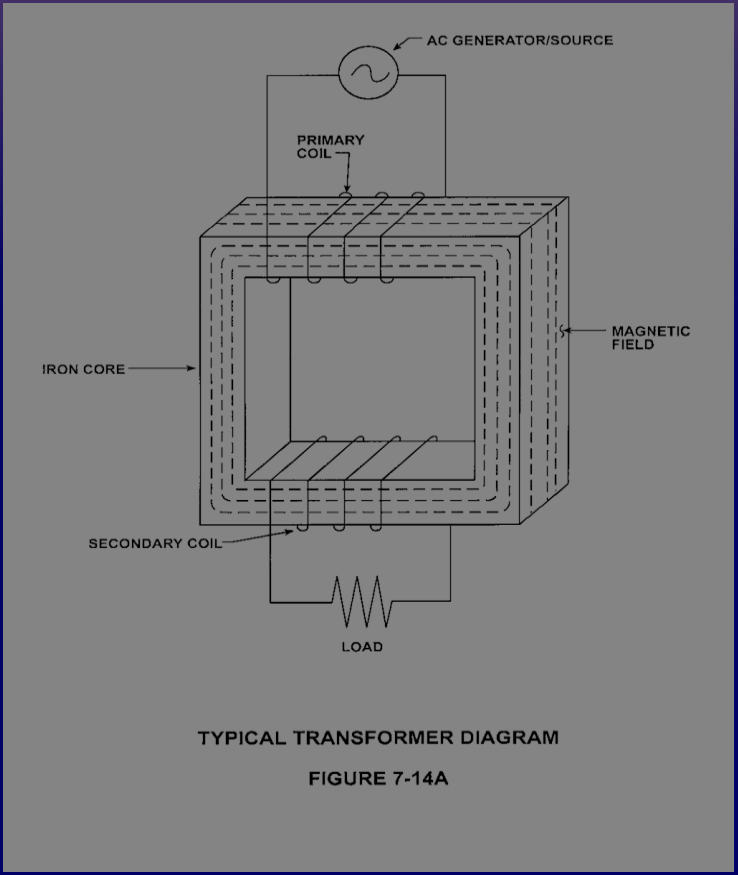
- **Primary Function**
  - provide overload protection for the circuit in which it's installed
  - serves as an on-off switch for the rectifier



FULLY MAGNETIC CIRCUIT BREAKER

FIGURE 7-13

Standard Transformer



TYPICAL TRANSFORMER DIAGRAM

FIGURE 7-14A

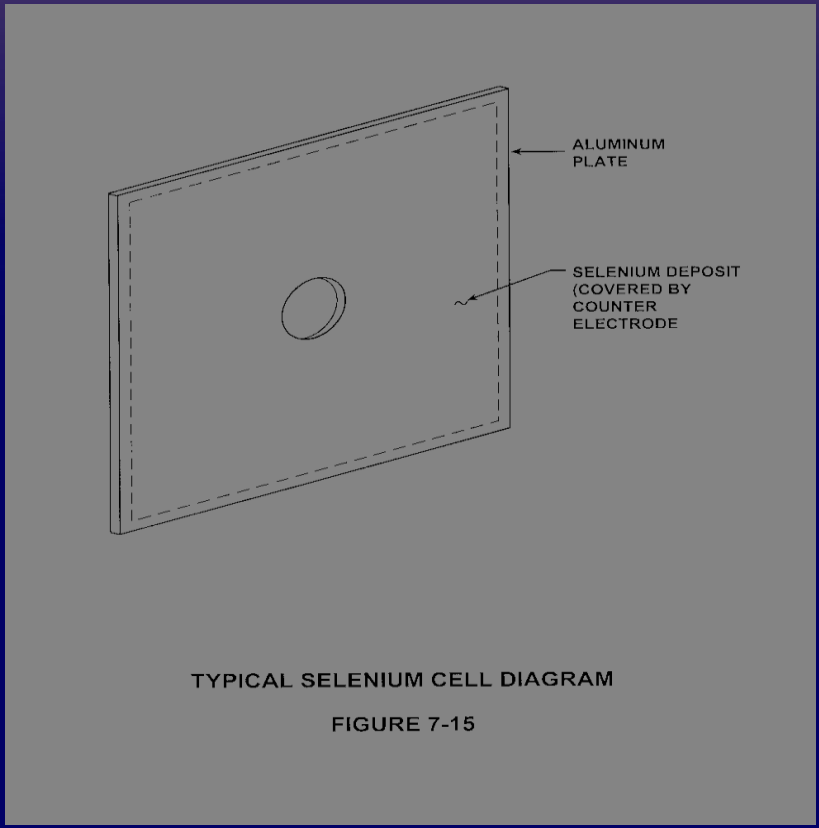
- **Primary Function**
  - used to “step up” or “step down” voltage
  - isolate voltage from source

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

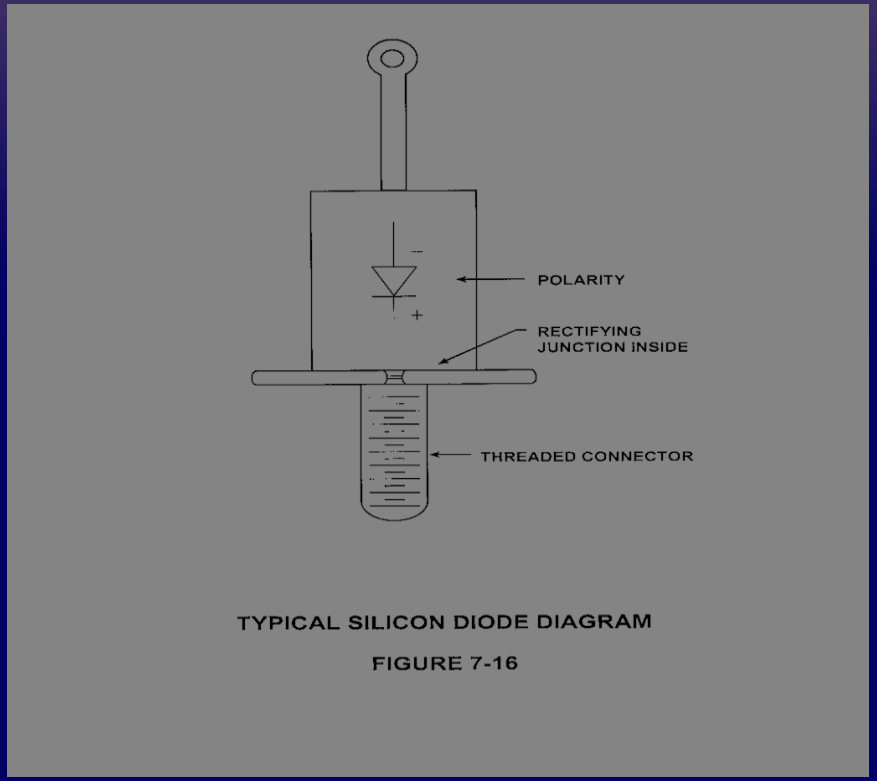


TYPICAL SELENIUM CELL DIAGRAM

FIGURE 7-15

Silicon Diode

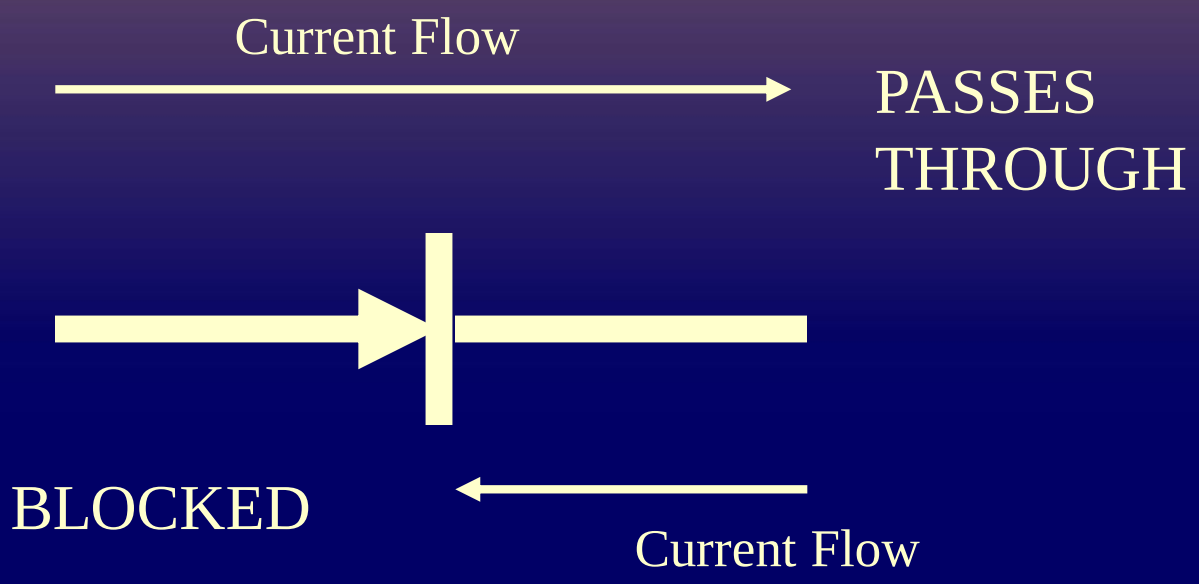
- **Primary Function**
  - permits current to flow in only one direction
  - provides high current and voltage outputs



TYPICAL SILICON DIODE DIAGRAM

FIGURE 7-16

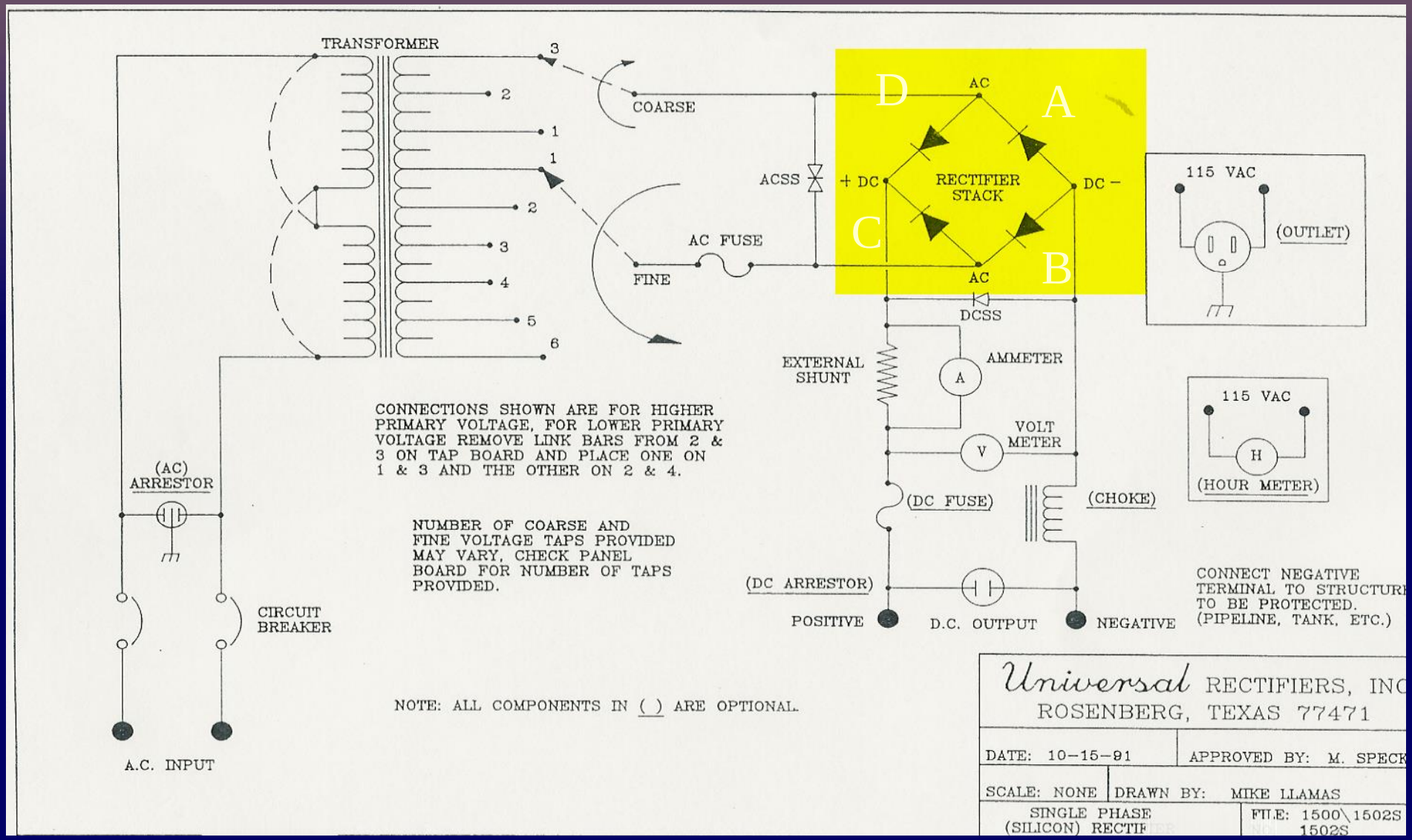
Basic Electric - Diodes

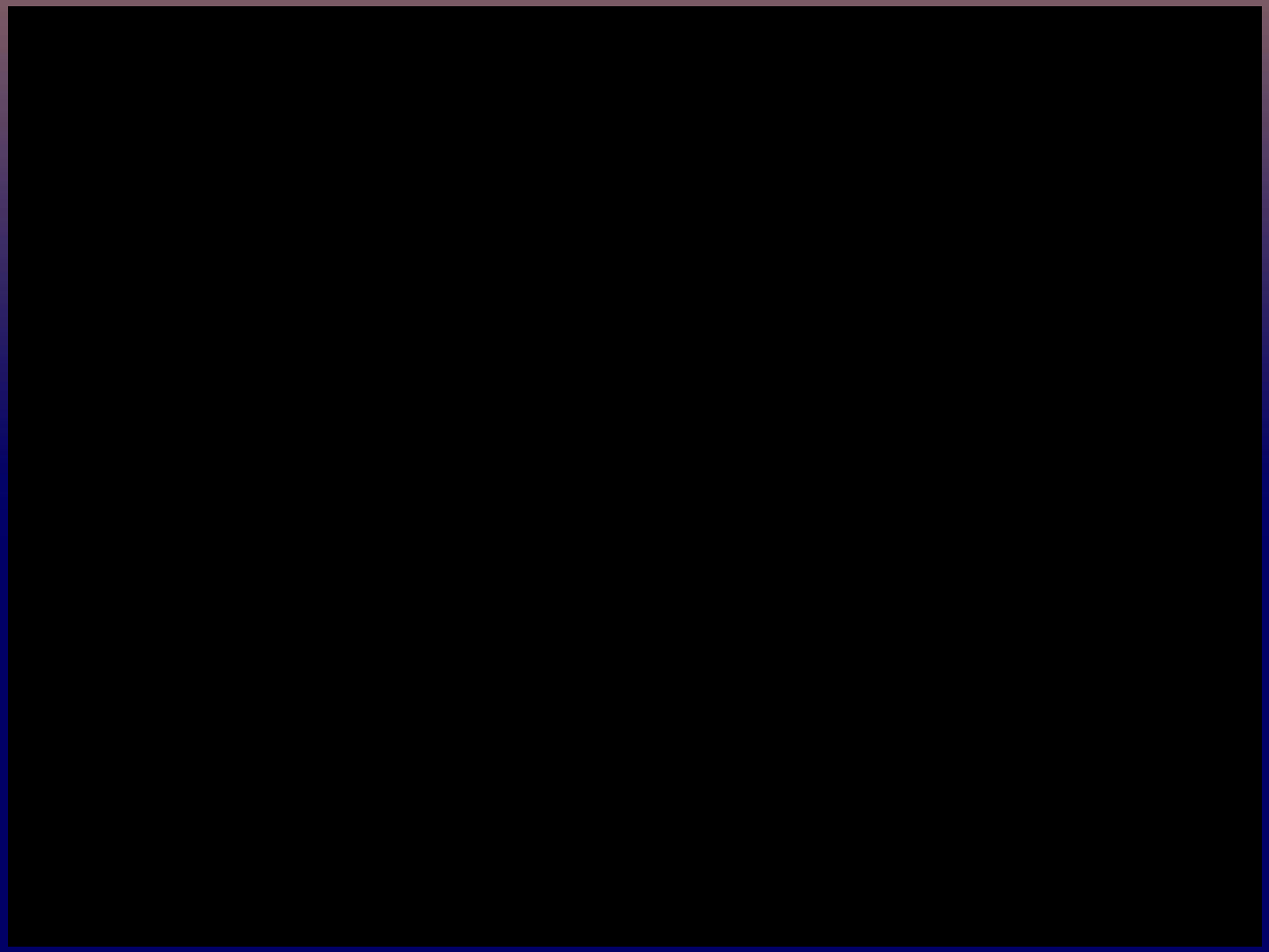


Current Flows one direction.

Used in rectified systems to change AC to DC with a Rectified diode.

Basic Electric - Rectified diode bridge





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

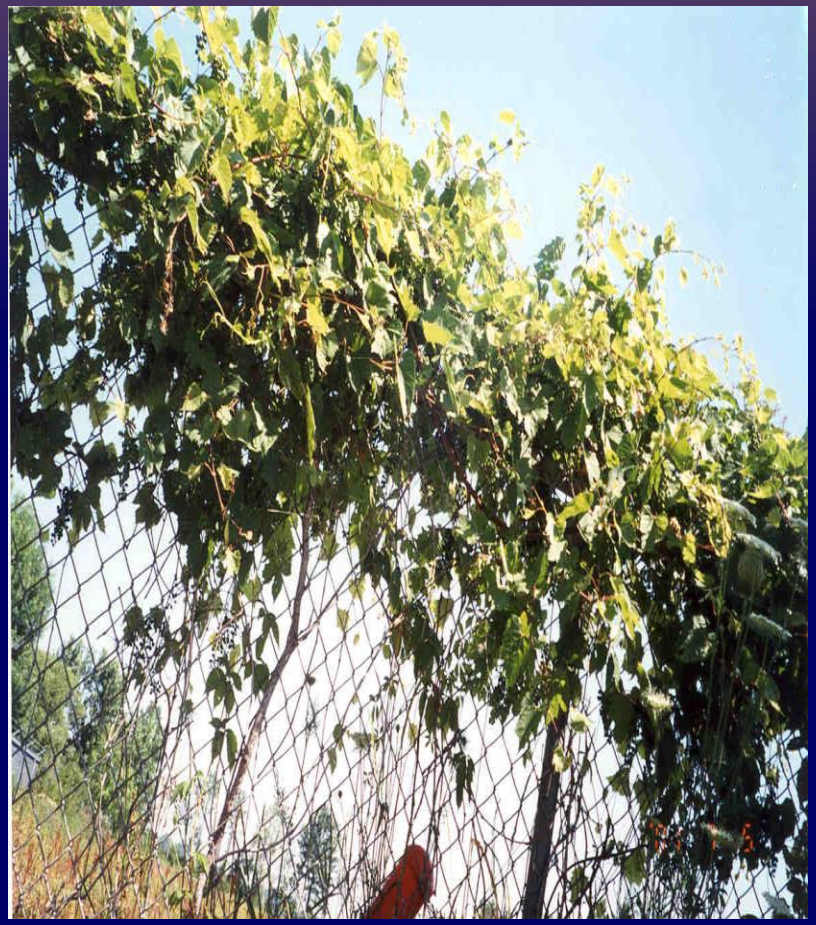
- **Rectifiers inspected 6(six) times per year not to exceed 2.5 months between inspections**
- **Inspection Includes**
  - **General Condition of rectifier**
  - **Recording rectifier DC volts and amps output**

- **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



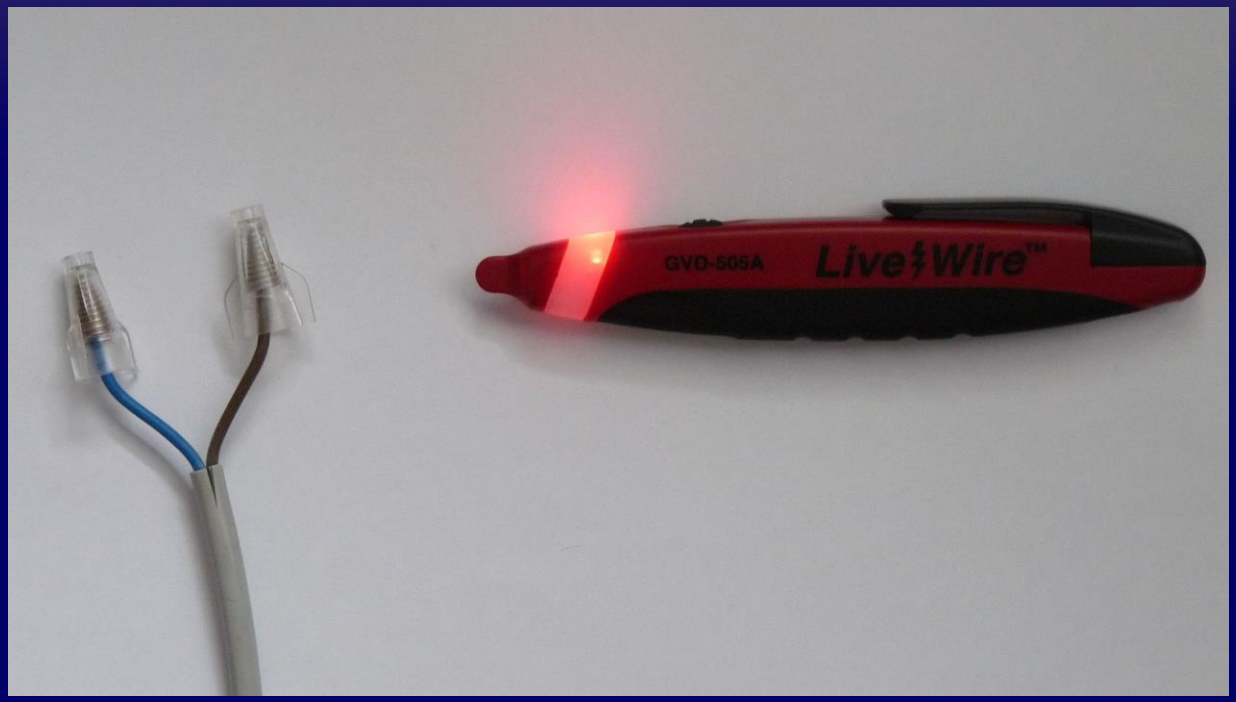
- **Will detect any outside interference problems**
- **Ensure entire area surrounding rectifier is maintained**

Rectifier Inspection Safety Precautions

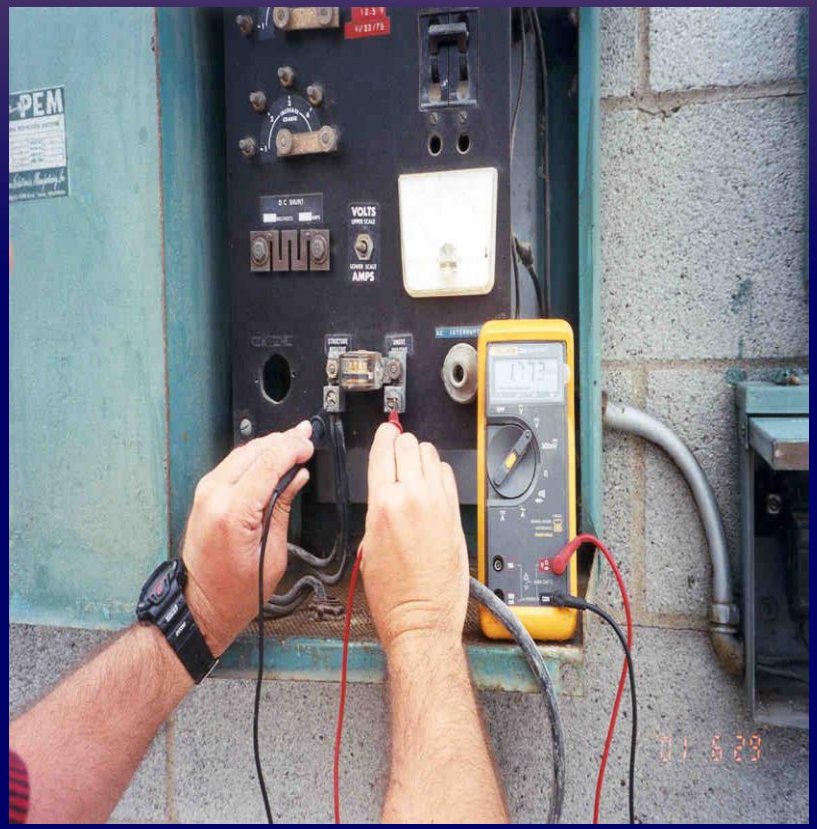
- **Look for presence of insects, rodents or other hazards around rectifier**
- **Check for electrical shorts by brushing rectifier unit with back of your hand**

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

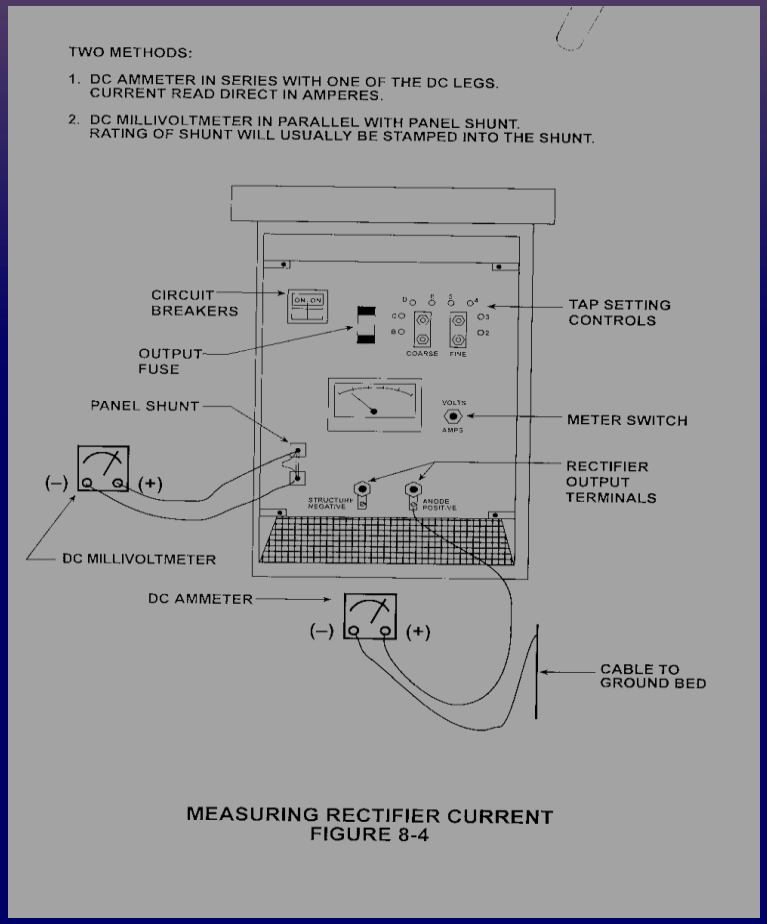
Required Electrical Inspections

- **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**

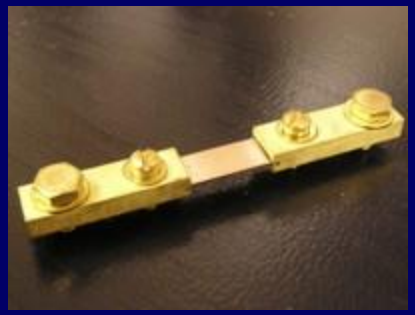
Required Electrical Inspections



MEASURING RECTIFIER CURRENT
FIGURE 8-4

- **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



Features:

Circuit Board – Makrolon® polycarbonate is one of the world's toughest plastics.

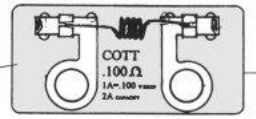
Current Strips and Potential Posts – Nickel plated brass.

Resistance Wire – Manganin (ASTM B267, CI.VI)

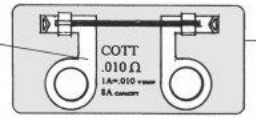
Standard ¼" holes on 1" centers fits all FINK® brand cathodic protection test stations.

Quality Assurance – All **COTTShunts**® are 100% tested and calibrated to within ± 1% of advertised resistance value.

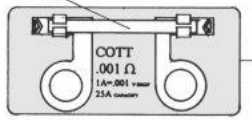
Color coded for easy value recognition:



Red
.1 ohm
2 amp capacity



Yellow
.01 ohm
8 amp capacity



Orange
.001 ohm
25 amp capacity

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 4.2 Shunt Types and Values

	Shunt Rating		Shunt Value	Shunt Factor
	Amps	MV	Ohms	A/mV
Holloway Type				
RS	5	50	.01	.1
SS	25	25	.001	1
SO	50	50	.001	1
SW or CP	1	50	.05	.02
SW or CP	2	50	.025	.04
SW or CP	3	50	.017	.06
SW or CP	4	50	.0125	.08
SW or CP	5	50	.01	.1
SW or CP	10	50	.005	.2
SW	15	50	.0033	.3
SW	20	50	.0025	.4
SW	25	50	.002	.5
SW	30	50	.0017	.6
SW	50	50	.001	1
SW	60	50	.0008	1.2
SW	75	50	.0067	1.5
SW	100	50	.0005	2
J.B. Type				
Agra-Mesa	5	50	.01	.1
Cott or MCM				
Red (MCM)	.1	100	.1	.01
Red (Cott)	.5	50	.1	.01
Yellow	5	50	.01	.1
Orange	25	25	.001	1

OHM'S Law

- **Mathematically it can be stated three ways:**

(1) I = E/R

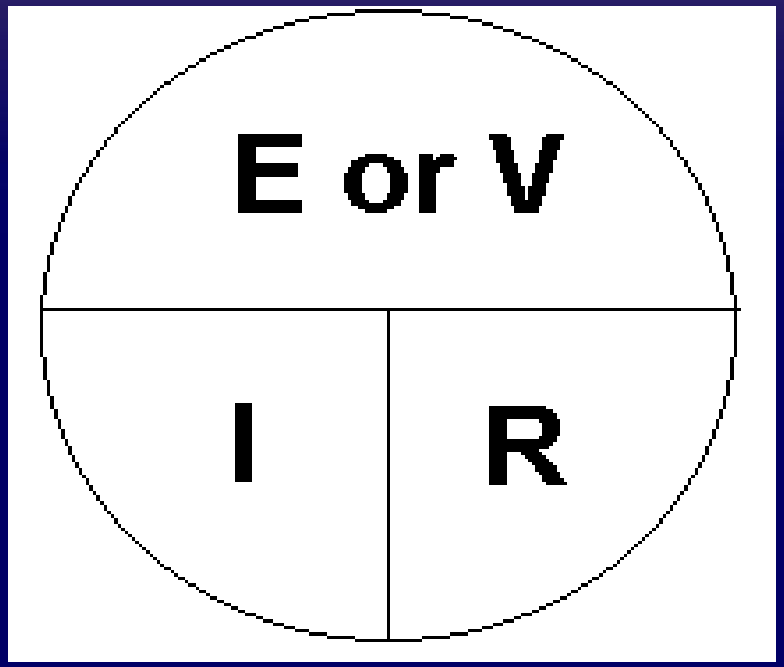
(2) R = E/I

(3) E = I x 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:

	I	V	R
1.	2	10 V	5 ohms
2.	3A	6	2 ohms
3.	100 mA (.1 A)	10 mV	0.1 ohms
4.	1200 mA	12V	10 ohms

Shunts

Calculation

50 mV - 50 A

Determine Amps/mV

$$1\ mV = \frac{50}{50}\ A = \frac{1}{}\ A / mV$$

Shunt Resistance

$$R = \frac{E}{I} = \frac{0.050}{50}\ V = 0.001\ \Omega$$

If Measure - 50 mV

$$I = \frac{V}{R} = \frac{50}{0.001}\ mV = \frac{50{,}000}{\Omega}\ mV = 50\ A$$

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 1

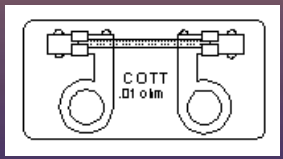
SF 1 X 4.2 mV = 4.2 A

50A / 25mV shunt = SF of 0.5

SF 0.5 X 4.2 mV = 2.1 A

Shunts

Calculation



V / R = I

Measurement (V) / R (0.1Ω, 0.01Ω, or 0.001Ω) = I (A)

Measurement of 32.1 mV = .0321 V / 0.1Ω = .321 A

Measurement of 32.1 mV = .0321 V / 0.01Ω = 3.21 A

Measurement of 32.1 mV = .0321 V / 0.001Ω = 32.1 A

Basic Electrical Efficiency Rating Calculation

$$\frac{\text{DC Watts (Output)}}{\text{AC Watts (Input)}} = \text{(answer)} \bullet 100 = \text{Eff. Rating \%}$$

For example,

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

$$\frac{I \bullet E = P \text{ (watts) DC Output}}{I \bullet E = P \text{ (watts) AC Input}}$$

$$\frac{10\text{amps} \bullet 20\ \text{Volts} = 200\ \text{Watts}}{20\text{amps} \bullet 30\text{Volts} = 600\ \text{Watts}} = .33 \bullet 100 = 33\%$$

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!

Contact Information
Josh Brewer
josh.brewer@isfieldservices.com
989-388-3051