Day 1 Review

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AUCSC

Appalachian Underground Corrosion Short Course

Mathematics Reminder!

- Any number times itself is always equal to itself!
  - 1 x 18 = 18
  - 235 x 1 = 235
  - 64 x 1 = 64
  - 73526 x 1 = 73526
  - 53 x1 x 1 x 1 x 1 = 53
  - 1 x 348 x 1 x 1 x 1 = 348

- A number divided by itself is "1"
  - $\frac{5}{5} = 1$
  - $\frac{23}{23} = 1$
  - $\frac{156}{156} = 1$
  - $\frac{7846}{7846} = 1$

UNITS IS EVERYTHING!

- 5280 Feet = 1 Mile
- 1 Dollar = 20 Nickels
- 1 Volt = 1000 millivolts
- 24 Hours = 1 Day

$$\frac{1}{5280} = 0.0001894$$

$$\frac{1\ mile}{5280\ feet} = 1$$

$$\frac{1}{20} = .05$$

$$\frac{1\ dollar}{20\ nickles} = 1$$

$$\frac{1}{1000} = .001$$

$$\frac{1\ Volt}{1000\ Millivolts} = 1$$

How to Convert

- If we have 15,000 feet that we want to convert to miles;
- We must convert the units

$$15000\,mile \text{ x } \frac{1\,mile}{5280\,feet} = \frac{2.84\,\cancel{feet}{-}mile}{\cancel{feet}}$$

$$\text{Answer: } 15000 \text{ feet} = 2.84 \text{ miles}$$

How to Convert

- If we have 8.62 miles that we want to convert to feet;
- We must convert the units

$$8.62\ mile \times \frac{5280\ feet}{1\ mile} = \frac{45{,}513.6\ \cancel{mile}-feet}{\cancel{mile}}$$

Answer: $8.62\ miles = 45{,}513.6\ feet$

How to Convert

- If we have Volts to Millivolts [1 Volt = 1000 mV]
- We must convert the units; .084 Volts to millivolts

$$\frac{1\,Volt}{1000\,millivolts} = 1 \qquad \frac{1000\,millivolts}{1\,Volts} = 1$$

$$.084\,Volts \times \frac{1000\,mV}{1\,Volt} = \frac{840\,\cancel{Volt}\text{–}mV}{Volt}$$

$$\text{Answer: } .084\,Volt = 840\,mV$$

Moving the Decimal Point for conversions

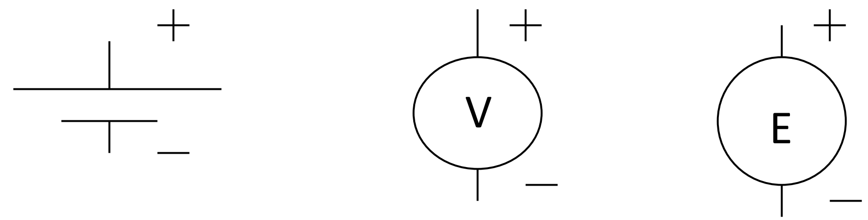
$$\frac{1\ Volt}{1000\ millivolts} = 1$$

Unit #1	=	Unit #2
2.856 mV	=	0.002856 V
0.0056 mV	=	0.0000056 V
435.05 mV	=	0.43505 V
8.37 mV	=	0.00837 V
0.06 mV	=	0.00006 V
84.6 V	=	84600 mV
0.00054 V	=	0.54 mV
0.15 V	=	150 mV
679163.2 V	=	679163200 mV
462 mA	=	0.462 A
5.5 mA	=	0.0055 A
4.9823 A	=	4982.3 mA
0.000005 A	=	0.005 mA

$$\frac{1000\ millivolts}{1\ Volts} = 1$$

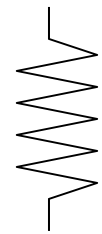
Electricity Symbols

- Voltage source- Electrical Pressure, usually represented by an “E” or “V”



- Current flowing – Flow of Electrons, usually represented by an “I”

- Resistor- Resistance to the flow of electrons, usually represented by an “R”



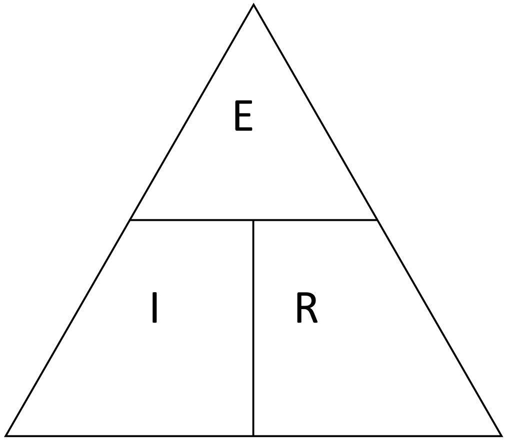
Ohm's Law

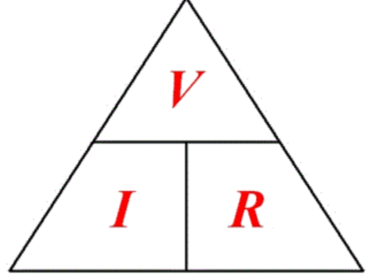
A potential of 1 volt across a resistance of 1 ohm causes 1 amp of current to flow

$E = I * R$

$I = E / R$

$R = E / I$





Volts = 12 V
Resistance = 3.5 Ω
Current = ? A

$$\frac{12\ V}{3.5\ \Omega} = 3.42\ \text{A}$$

Volts = 6 V
Resistance = ? Ω
Current = 1.5 A

$$\frac{6\ V}{1.5\ A} = 4\ \Omega$$

Volts = ? V
Resistance = 5 Ω
Current = .4 A

$$.4\ \text{A} \times 5\ \Omega = 2\ \text{V}$$

Volts = 2 mV
Resistance = .04 Ω
Current = ? A

$$\frac{2\ mV}{.04\ \Omega} = .05\ \text{A}$$

$$\frac{.002\ V}{.04\Omega} = .05\ \text{A}$$

Volts = 2 V
Resistance = ? Ω
Current = 54 mA

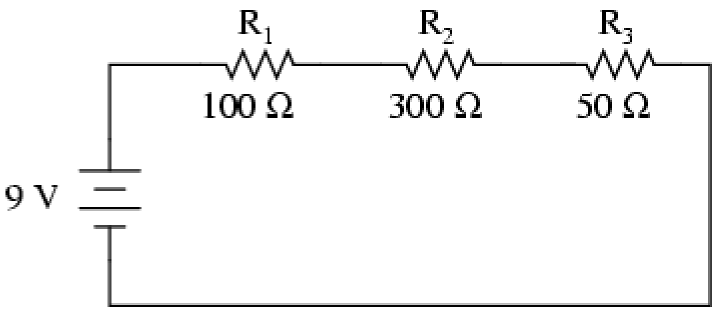
$$\frac{2\ V}{54\ mA} = 37.04\ \Omega$$

$$\frac{2\ V}{.054\ A} = 37.04\ \Omega$$

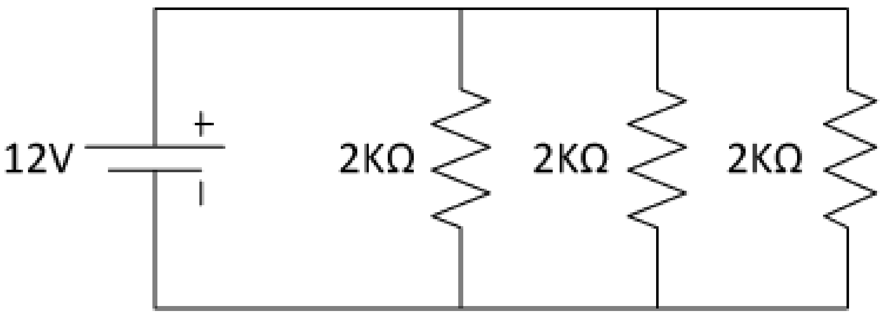
Volts = ? mV
Resistance = 11 Ω
Current = 5 mA

$$11\ \Omega \times 5\ \text{mA} = 55\ \text{mV}$$

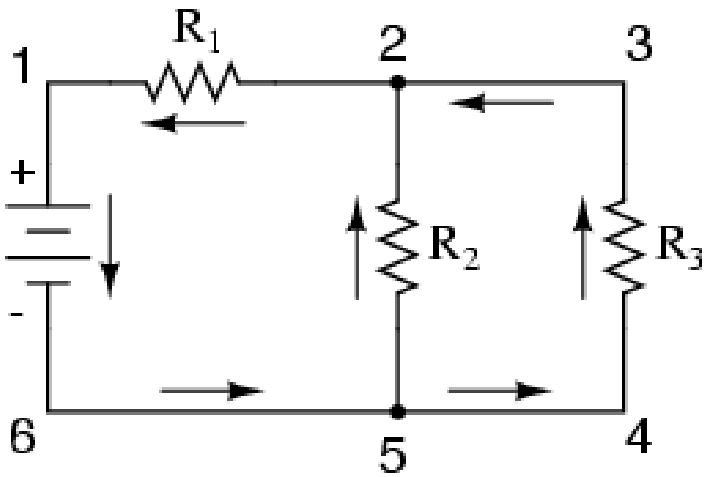
Ohms Law



Series Circuit

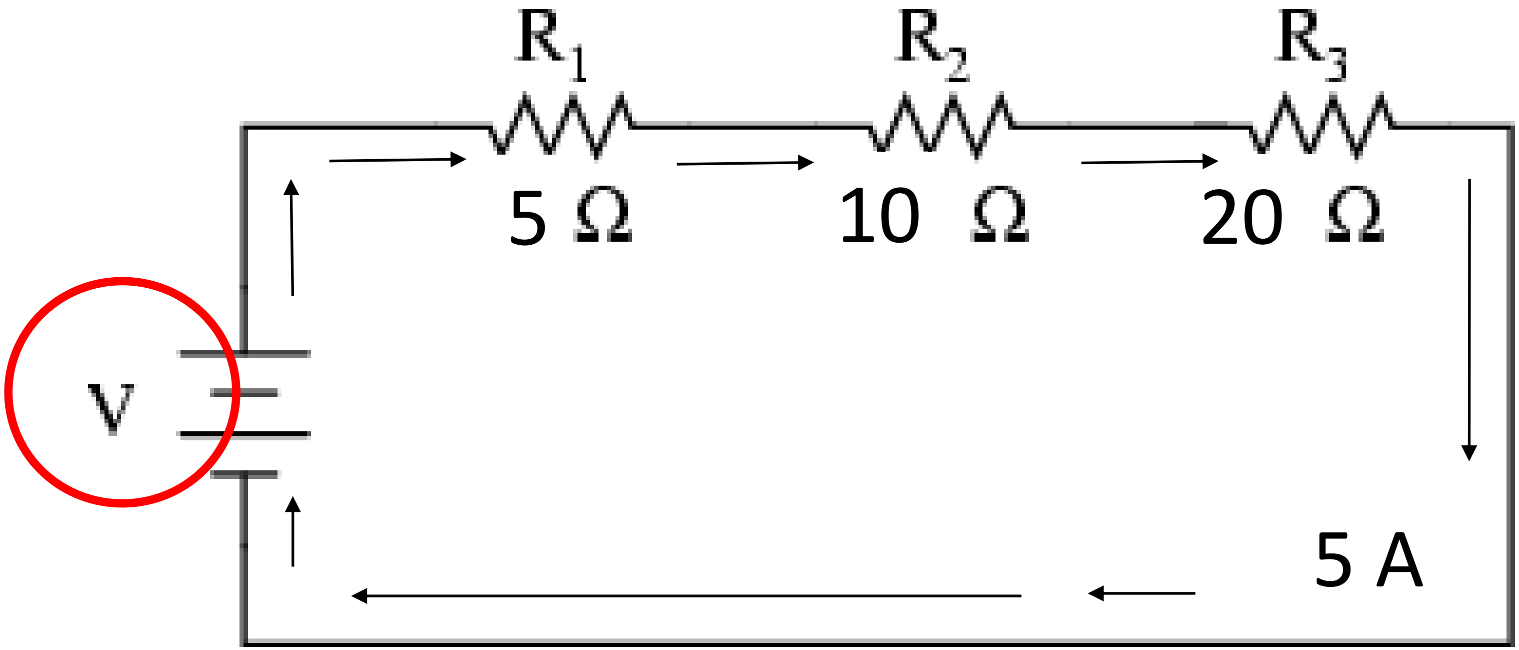


Parallel Circuit

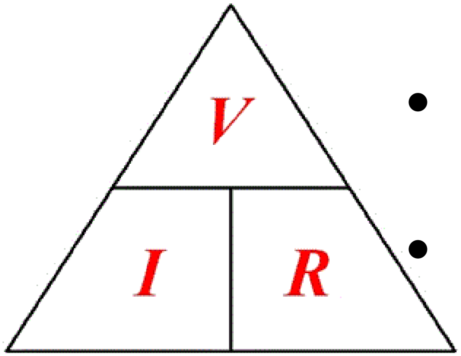


Series-Parallel Circuit

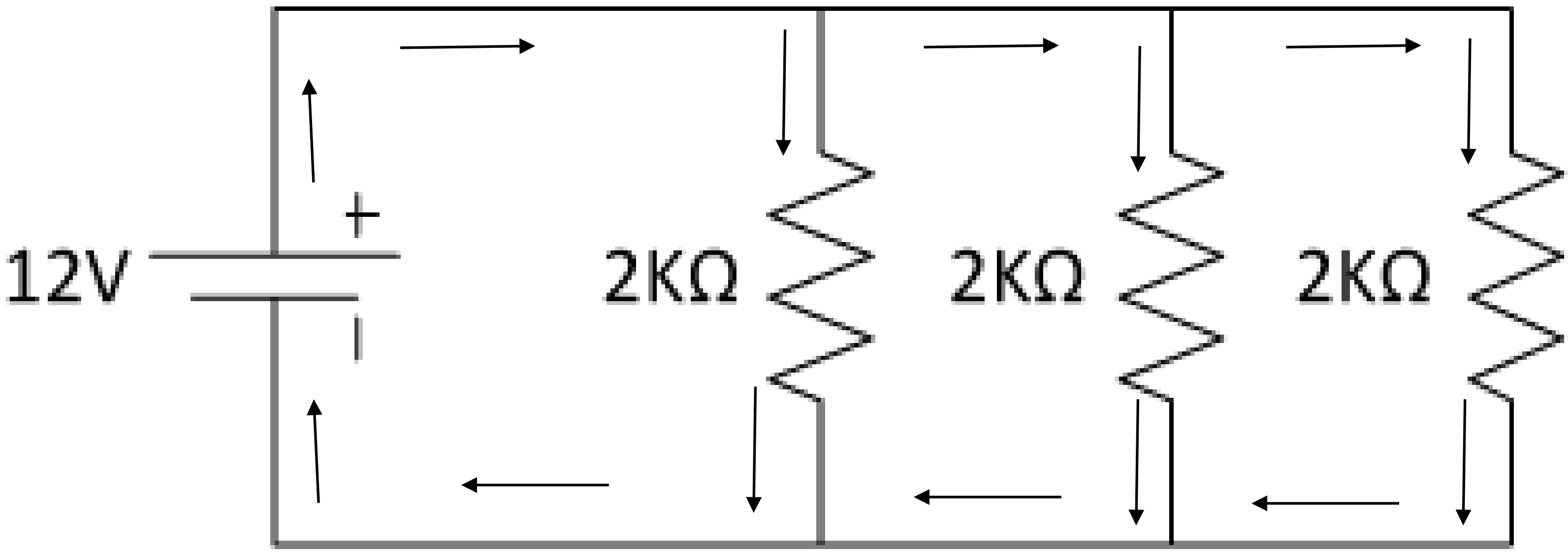
Series Circuit



- Current Total (I_T) = $I_1 = I_2 = I_3$
- Resistance Total (R_T) = $R_1 + R_2 + R_3$
- Voltage Total (V_T)= $V_1 + V_2 + V_3$ *Kirchoff's Law



Parallel Circuit

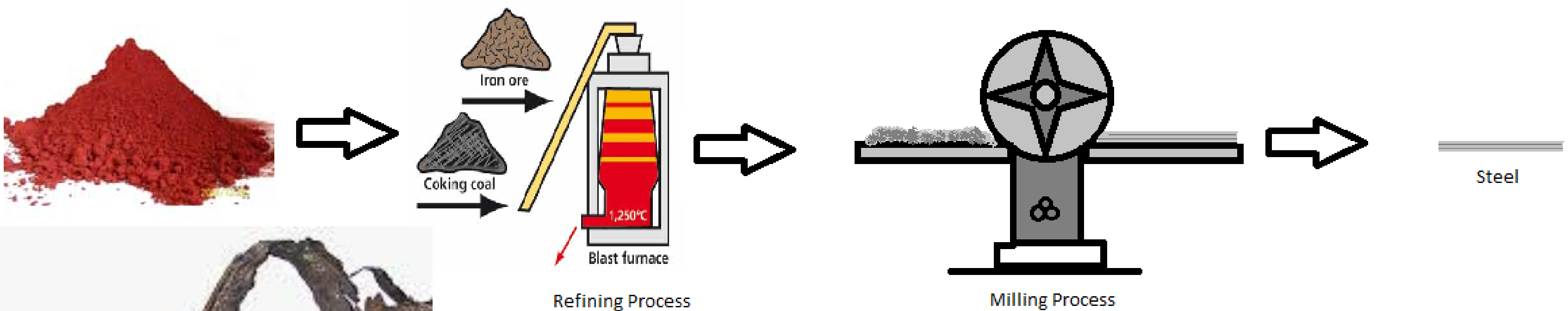


- Current Total (I_T) = $I_1 + I_2 + I_3$ *Kirchoff's Law
- Resistance Total ($\frac{1}{R_T}$) = $\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ **or** $\frac{R_1 \times R_2}{R_1 + R_2}$
- Voltage Total (V_T)= $V_1 = V_2 = V_3$

Pipeline Locating

- An electrical device used to locate underground metallic structures.
- Modes of Operation include:
  - Inductive (indirect)
  - Conductive (direct)
  - Inductive Clamp
  - Passive
- Choosing the Right Tool; ALWAYS FOLLOW MANUFACTURERS' INSTRUCTIONS!
  - Split box
  - Single frequency electronic locator
  - Multi-Frequency electronic locator
  - Valve Box Locator
  - Ferromagnetic Locator
  - Ground Penetrating Radar
- If in Doubt- Don't Mark it out and Hand Dig

What is Corrosion?



THE <u>DETERIORATION</u> OF A MATERIAL, DUE TO A <u>REACTION WITH</u> <u>ITS ENVIRONMENT</u>

Corrosion Cell

Corrosion cannot be present without these **<u>four</u> things**;

1. **ELECTROLYTE**
2. **ANODE**
3. **CATHODE**
4. **METALLIC PATH**

Take one of the four away and corrosion will be mitigated.

Galvanic Series:

Active (More Electro-Negative)

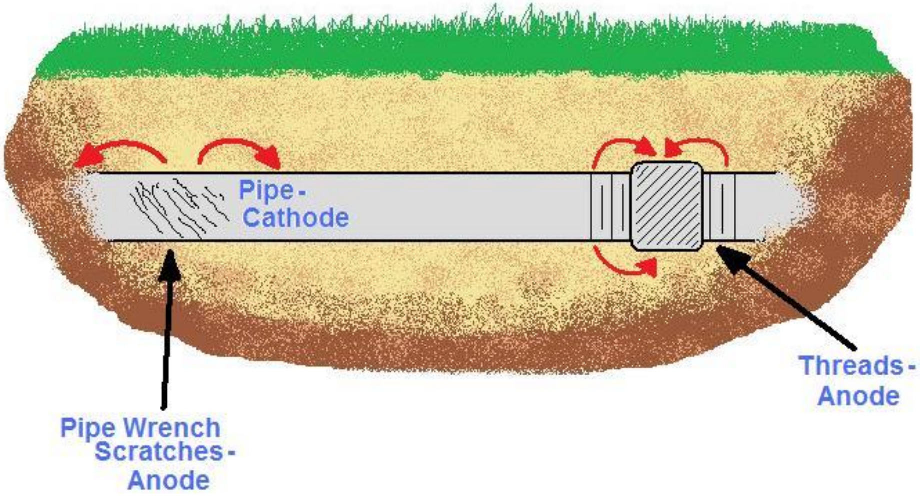
(-)

- High Potential Magnesium (-1.75 v)
- Magnesium Alloy (-1.5 v)
- Zinc (-1.1 v)
- Aluminum Alloys (-1.05 v)
- Clean Carbon Steel (-0.5 to -0.8 v)
- Rusted Carbon Steel (-0.2 to -0.8 v)
- Cast/Ductile Steel (-0.5 v)
- Lead (-0.5 v)
- Steel in Concrete (-0.2 v)
- Copper (-0.2 v)
- High Silicon Iron (-0.2 v)
- Gold (+0.2V)
- Graphite, Carbon (+0.3v)

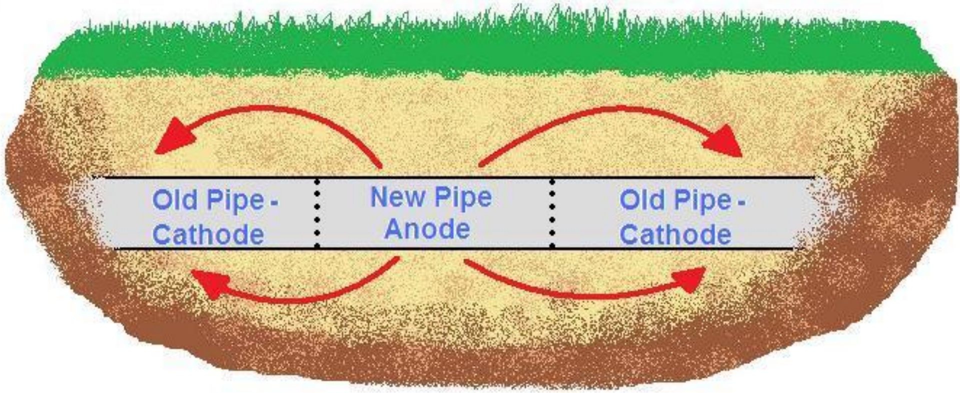
(+)

Noble (More Electro-Positive)

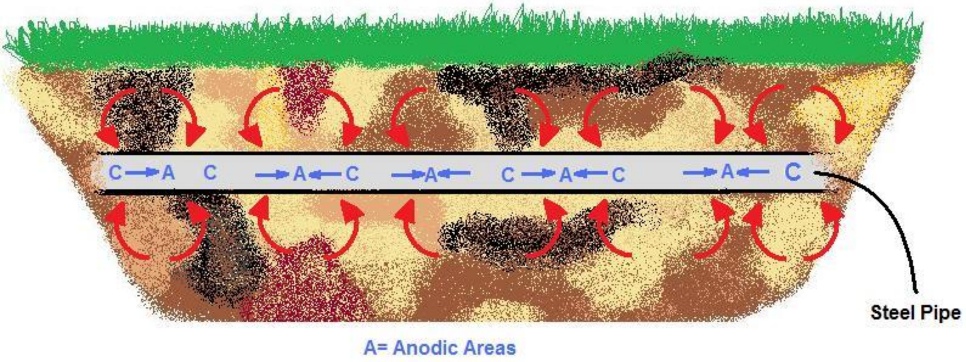
* Potentials with respect to saturated Cu-$CuSO_4$ Electrode



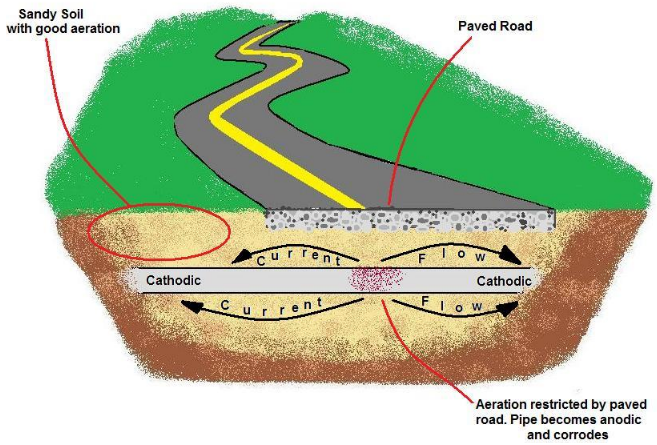
Pipe - Cathode
Threads - Anode
Pipe Wrench Scratches - Anode



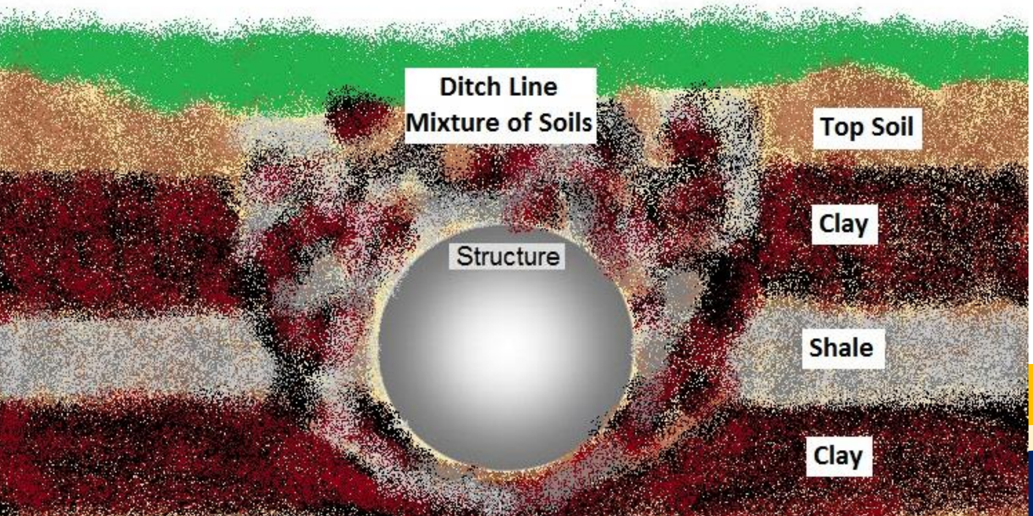
Old Pipe - Cathode
New Pipe Anode
Old Pipe - Cathode



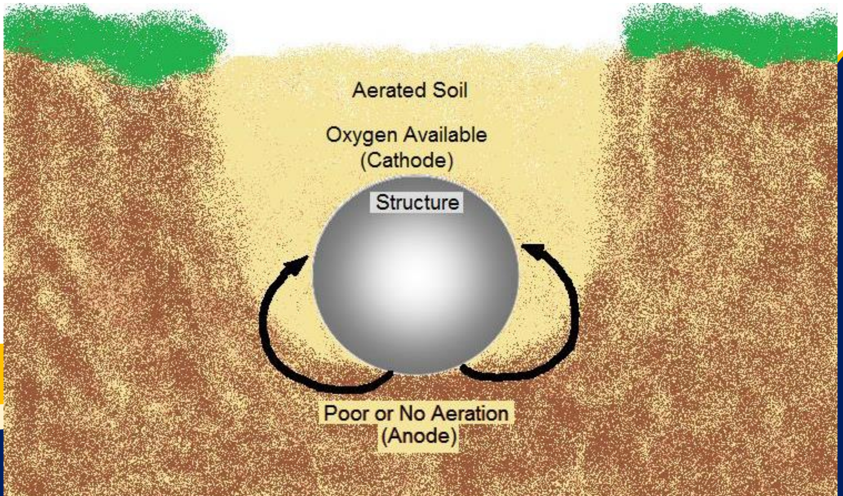
C → A C → A ← C → A ← C → A ← C → A ← C
Steel Pipe
A= Anodic Areas



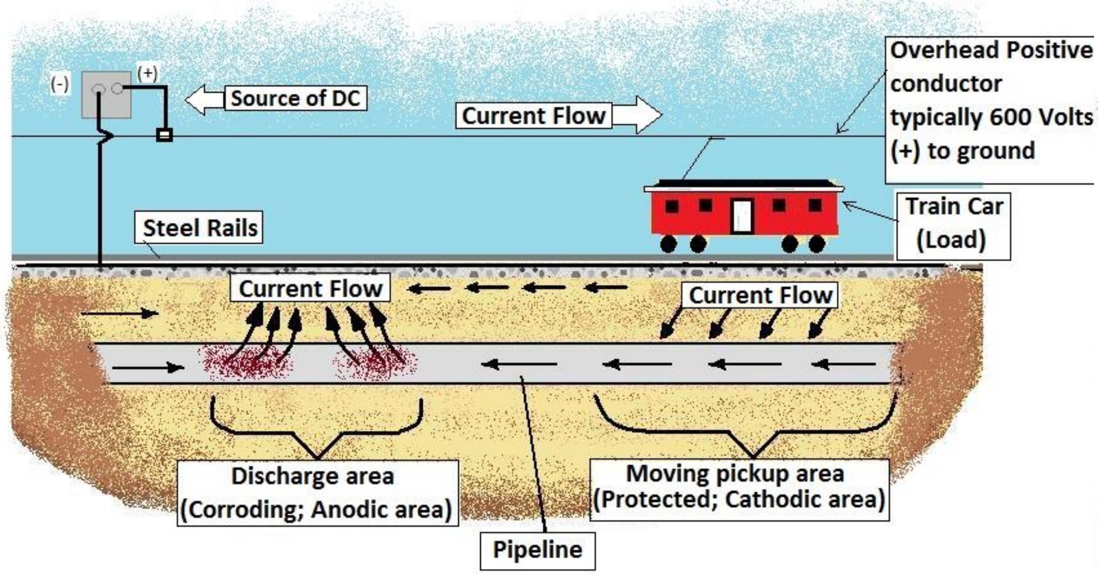
Sandy Soil with good aeration
Paved Road
Current Flow
Cathodic
Cathodic
Current Flow
Aeration restricted by paved road. Pipe becomes anodic and corrodes

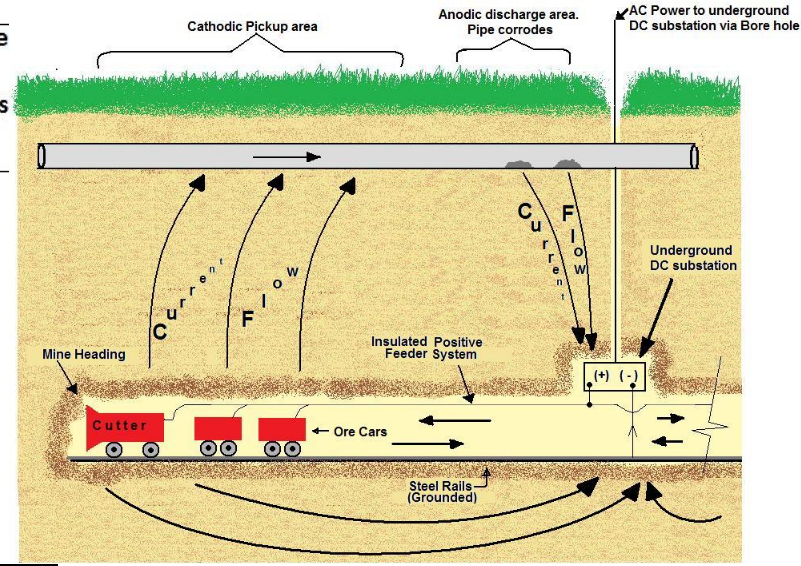


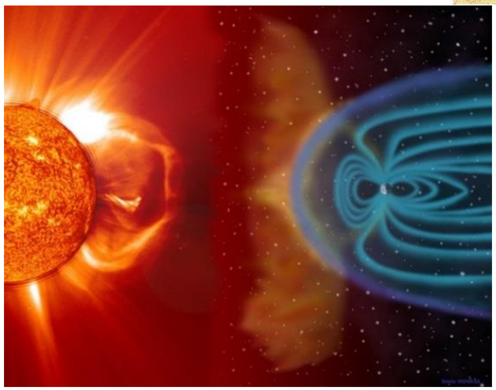
Ditch Line Mixture of Soils
Top Soil
Clay
Structure
Shale
Clay

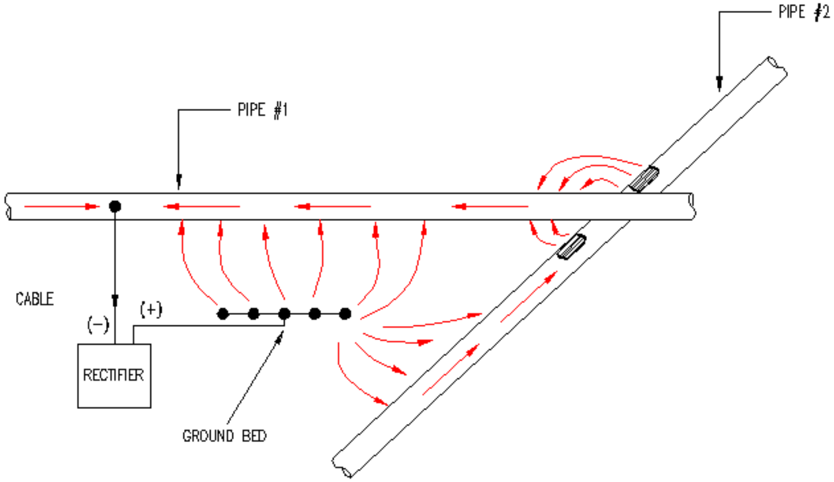


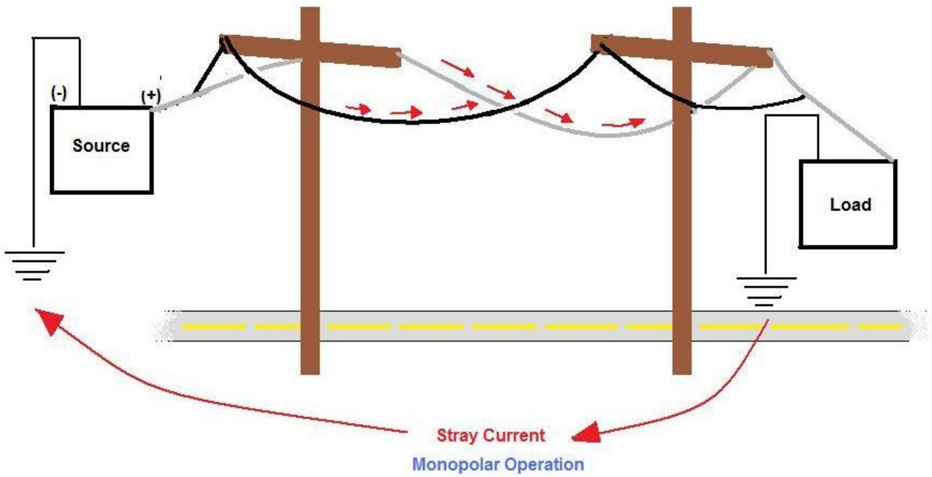
Aerated Soil
Oxygen Available (Cathode)
Structure
Poor or No Aeration (Anode)


(-)
(+)
Source of DC
Current Flow
Overhead Positive conductor typically 600 Volts (+) to ground
Train Car (Load)
Steel Rails
Current Flow
Current Flow
Discharge area (Corroding; Anodic area)
Moving pickup area (Protected; Cathodic area)
Pipeline


Cathodic Pickup area
Anodic discharge area. Pipe corrodes
AC Power to underground DC substation via Bore hole
Current Flow
Current Flow
Underground DC substation
Mine Heading
Insulated Positive Feeder System
(+) (-)
Cutter
Ore Cars
Steel Rails (Grounded)

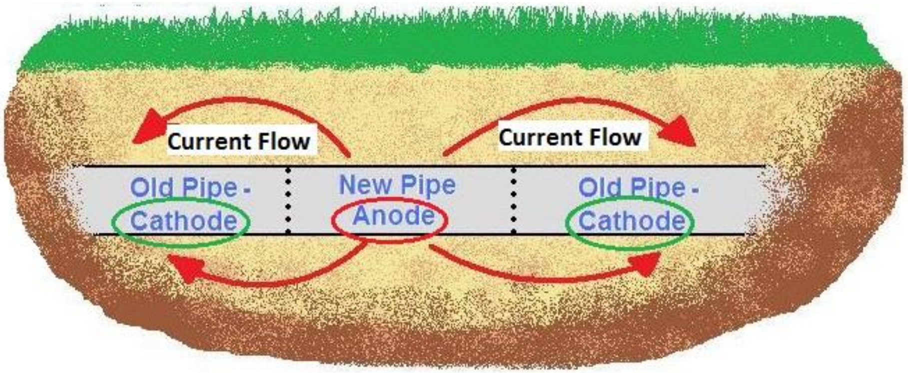


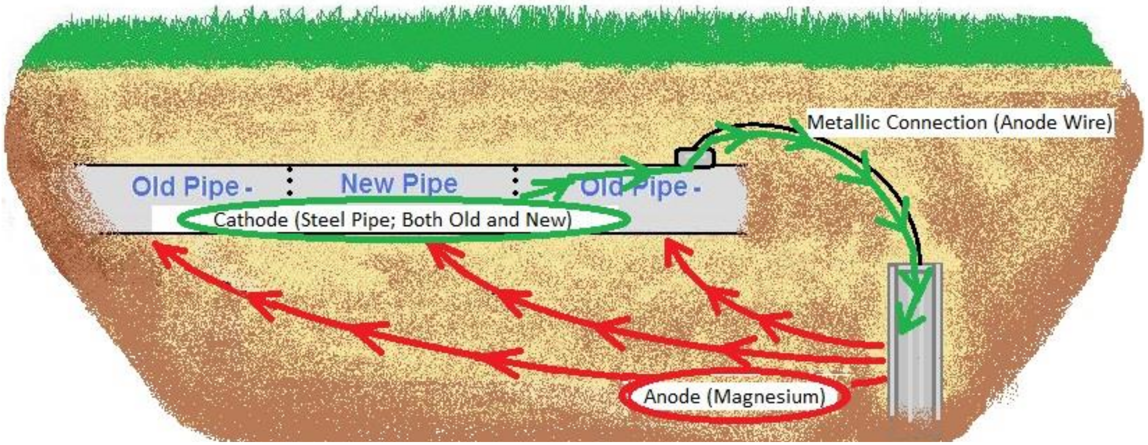

PIPE #2
PIPE #1
CABLE
(-)
(+)
RECTIFIER
GROUND BED


(-)
(+)
Source
Load
Stray Current
Monopolar Operation

Cathodic Protection

Galvanic Anode Cathodic Protection





Advantages:

- Seldom cause stray current interference
- Relatively low installation cost
- Self-Powered
- Low Maintenance

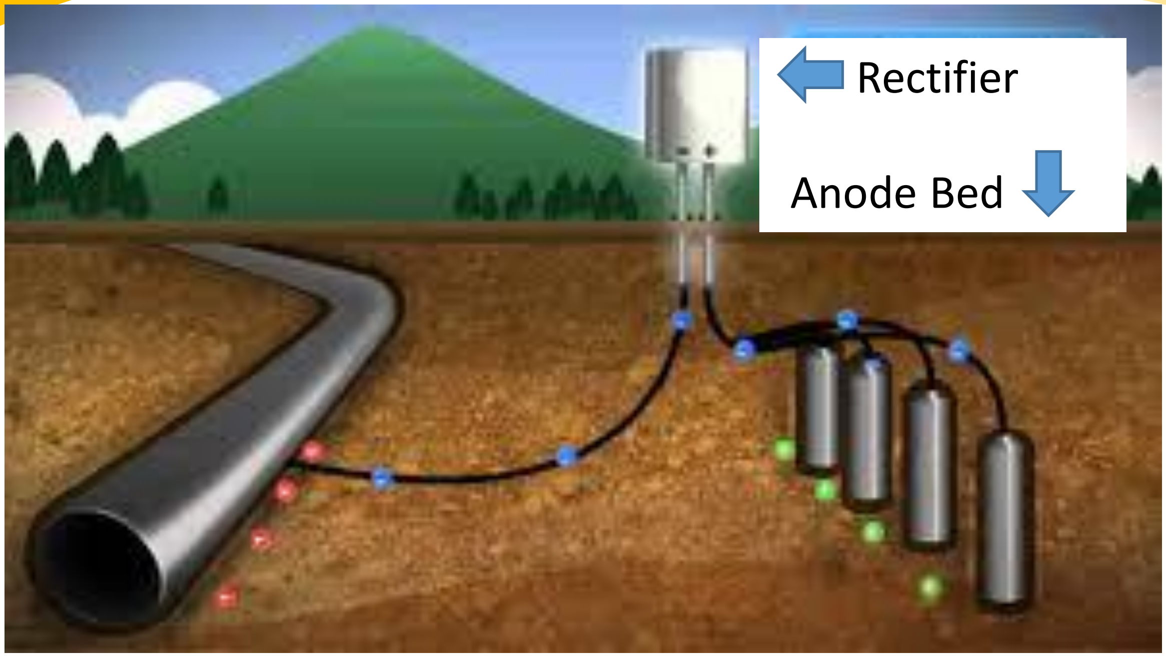
Disadvantages:

- Limited on current output- doesn't work in high-resistivity soils
- Not practical for bare or poorly coated pipelines
- Relatively high consumption rate

Sacrificial Anodes

Zinc, Aluminum, and Magnesium

Impressed Current Cathodic Protection



Advantages

- Capable of protecting large structures
- Capable of protecting structures which require greater magnitudes of current (Higher Driving Voltage)
- May be more economical than sacrificial anode systems
- Lower consumption rates than galvanic anodes
- Better in High Soil Resistivity areas

Disadvantages

- Increased maintenance requirements
- Tendency for higher operating costs
- Possibility of contributing to stray current interference on neighboring structures
- Electric power may be needed

Impressed Current Anodes

- Graphite Anode
- High Silicon Cast Iron
- Mixed Metal Oxide Anode
- Platinum
- Scrap Steel – Abandoned Structures
- Aluminum
- Lead Silver
- Magnetite