

**NACE**

**Corpus Christi Section**

**Lunch & Learn**

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**Fundamentals of Internal Corrosion**

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# Corrosion Principles

- **Corrosion Circuit**

- Anode
- Cathode
- Metallic Path
- Electrolyte

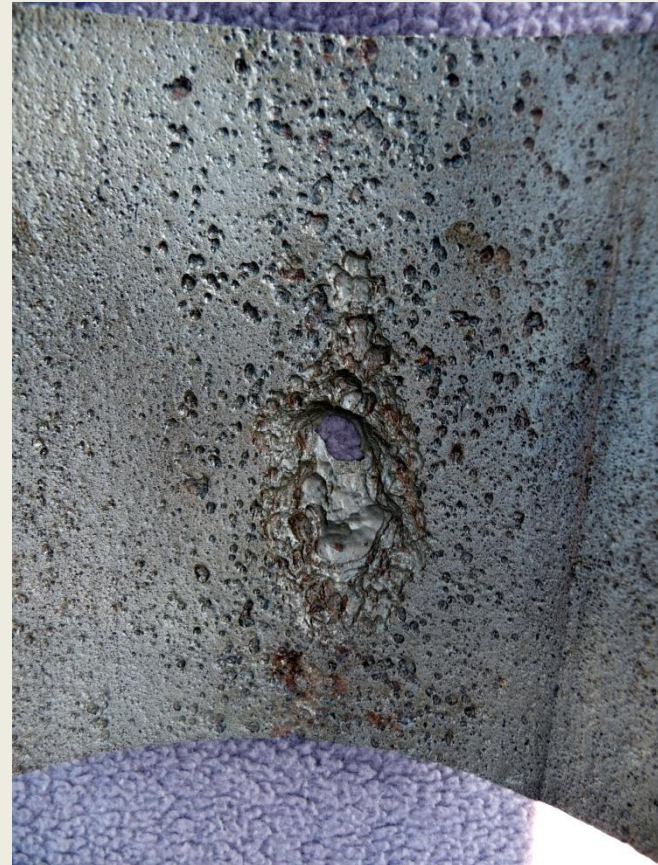
# Corrosion Circuit

- Eliminate one part of the circuit and corrosion stops.
- **Anode** - More anodic (CP), CRA's
- **Cathode** - Coating , inhibitor film, CRA's
- **Metallic Path** - Use non-metallics
- **Electrolyte** - Get rid of water, use inhibitors & coatings

# Acid Gasses

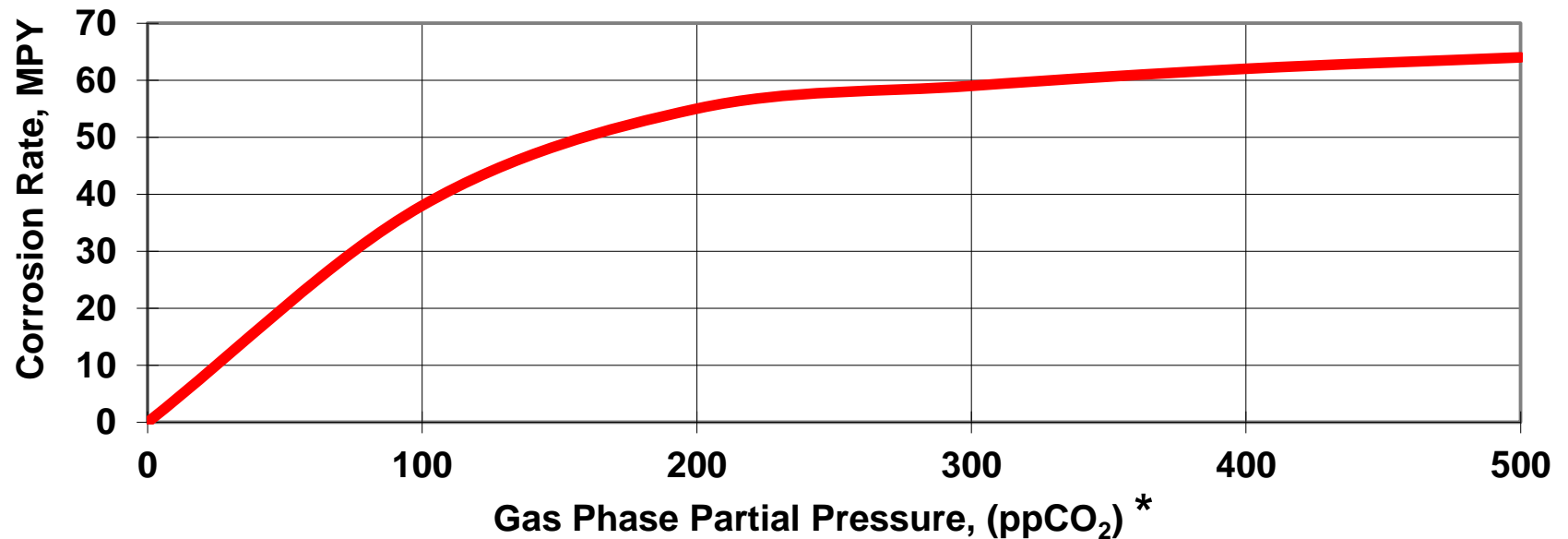
## Carbon Dioxide ( $\text{CO}_2$ )

- $\text{CO}_2$  forms a weak acid that attacks metal
- Often takes the form of “Mesa” pitting type attack



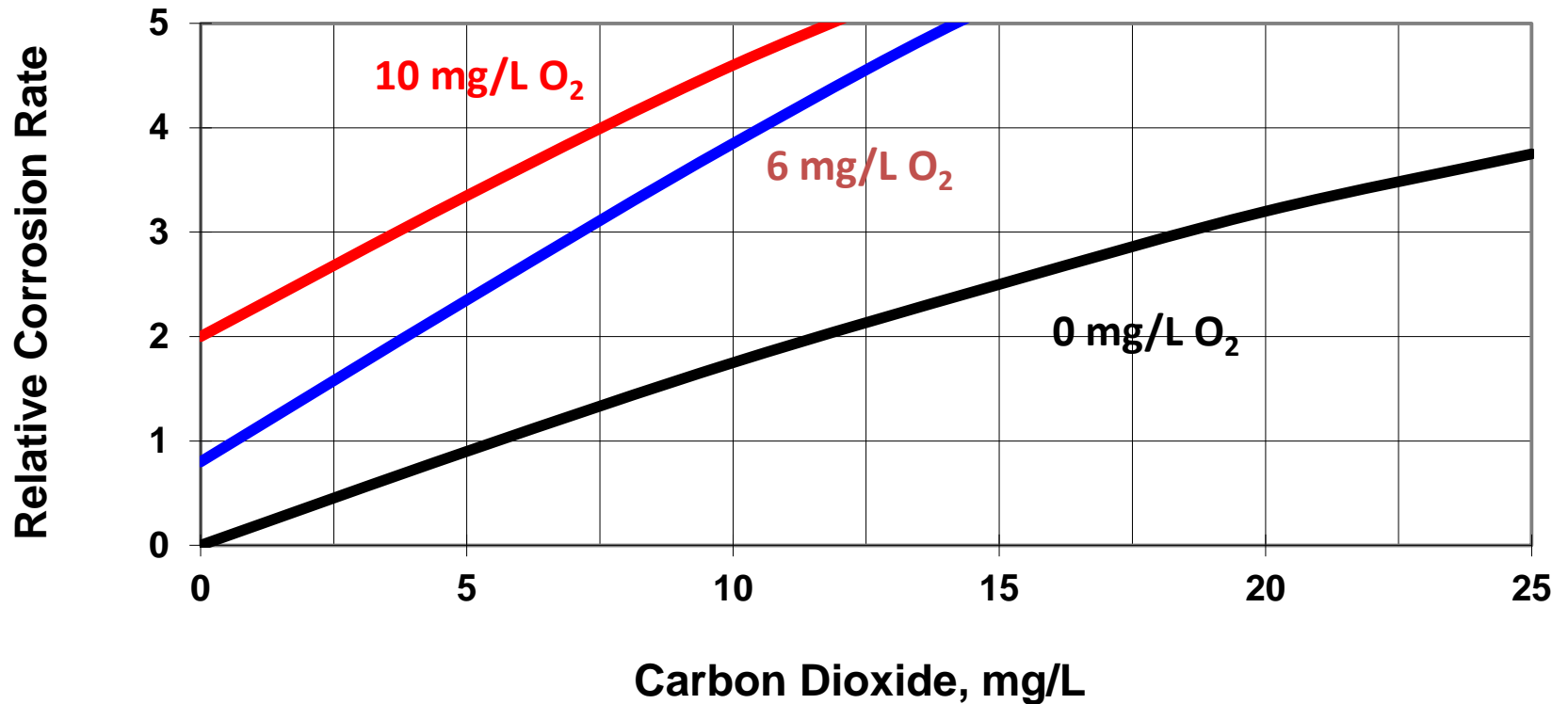
# Carbon Dioxide Corrosion

(Water Containing Low Dissolved Solids)



\*  $ppCO_2 = ((\text{System } CO_2 \text{ Volume } \%) \times (\text{System Pressure} + \text{Atmospheric Pressure}))/100$

## Corrosion Rates vs. Carbon Dioxide & Oxygen (Surface Water)



Estimation:  $\text{ppm O}_2 = 10 - 0.555 (X^\circ\text{F} - 30^\circ\text{F})$ , where  $X^\circ\text{F}$  is the water temperature

# Acid Gasses

## Hydrogen Sulfide ( $H_2S$ )

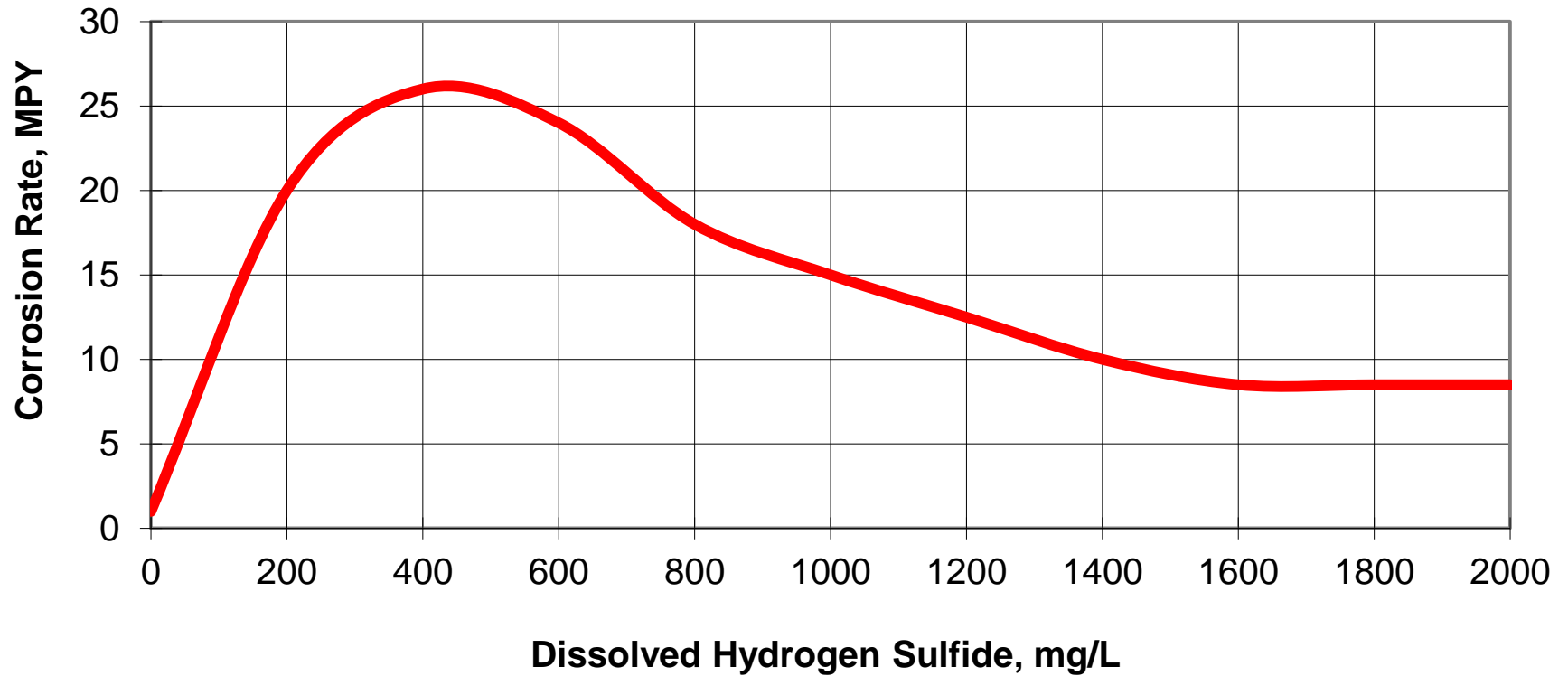
Has characteristic “rotten egg” smell

- ⦿ Creates a black deposit  $FeS$
- ⦿ Usually a shallow dish-type attack, but may have pitting
- ⦿  $H_2S$  forms a weak acid that attacks metal
- ⦿ Usually has etching in the bottom of the pits

Courtesy- Corrosion of Oil and Gas Well Equipment, API cc 1958

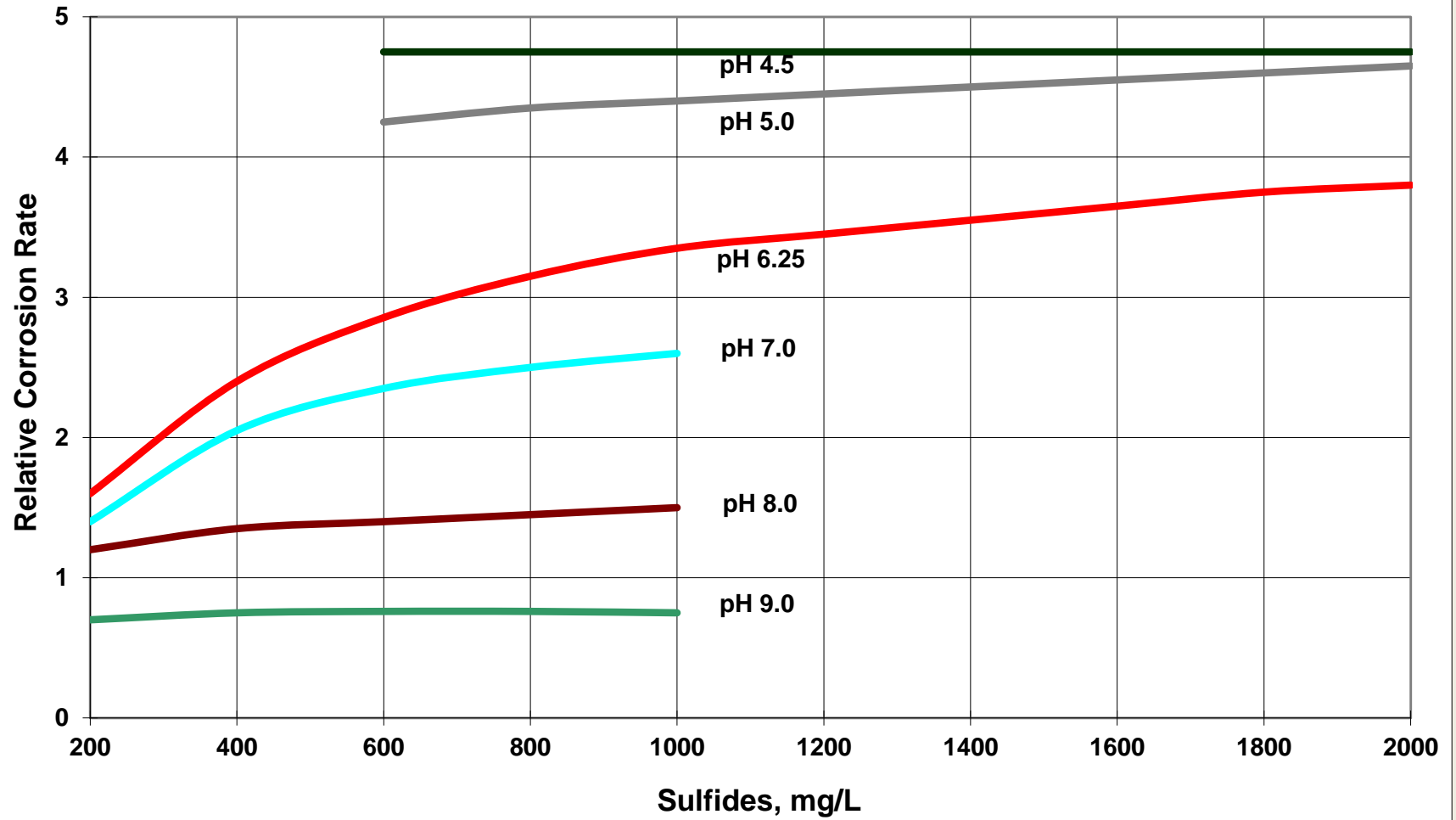


# Hydrogen Sulfide Corrosion (Water Containing Low Dissolved Solids)





# Hydrogen Sulfide Corrosion With Respect to pH



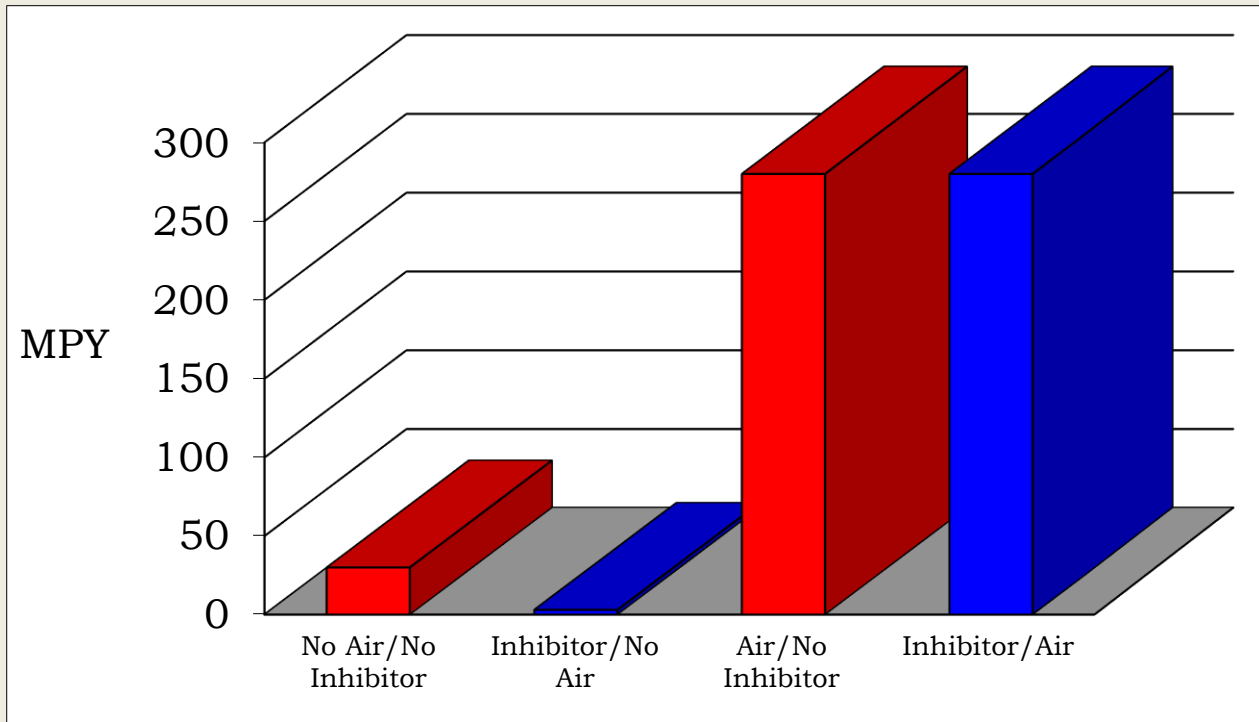
# Acid Gasses

## Oxygen ( $O_2$ )

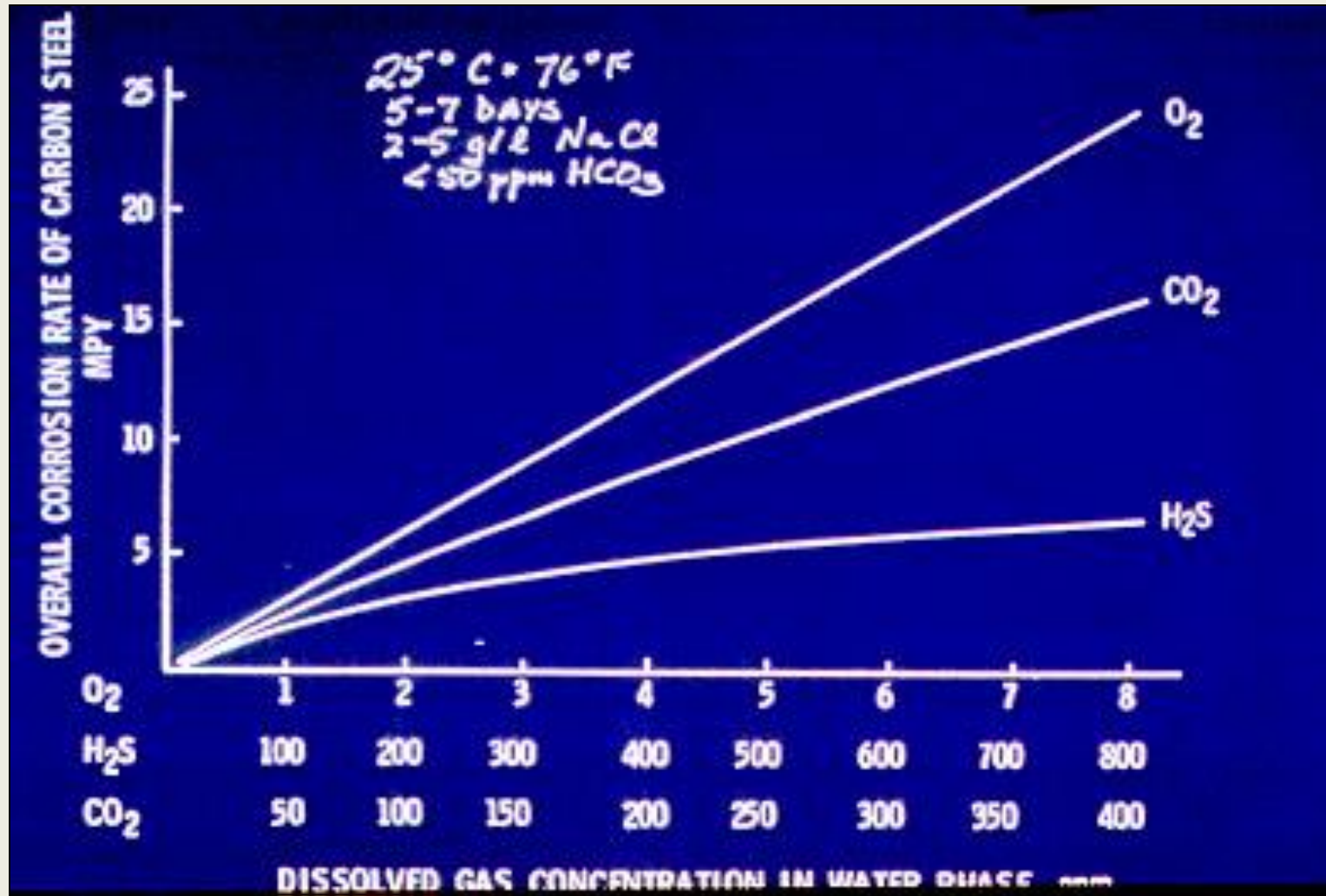
- Strong depolarizer
- Forms deep pits
- Usually found in surface equipment where air has entry point
- Can greatly accelerate other corrosive agents



# Effect of O<sub>2</sub> on Sour Corrosion With and Without Inhibitor



# Acid Gas Corrosion Rates



# Acid Gas “Worry Levels”

Sweet

Any amount of CO<sub>2</sub> with  
5 ppm or less H<sub>2</sub>S

Sour

Any amount of CO<sub>2</sub> with  
10 ppm or more H<sub>2</sub>S

Oxygen Assisted

Any amount of CO<sub>2</sub>  
and/or H<sub>2</sub>S with 10 -20  
ppb or more O<sub>2</sub>

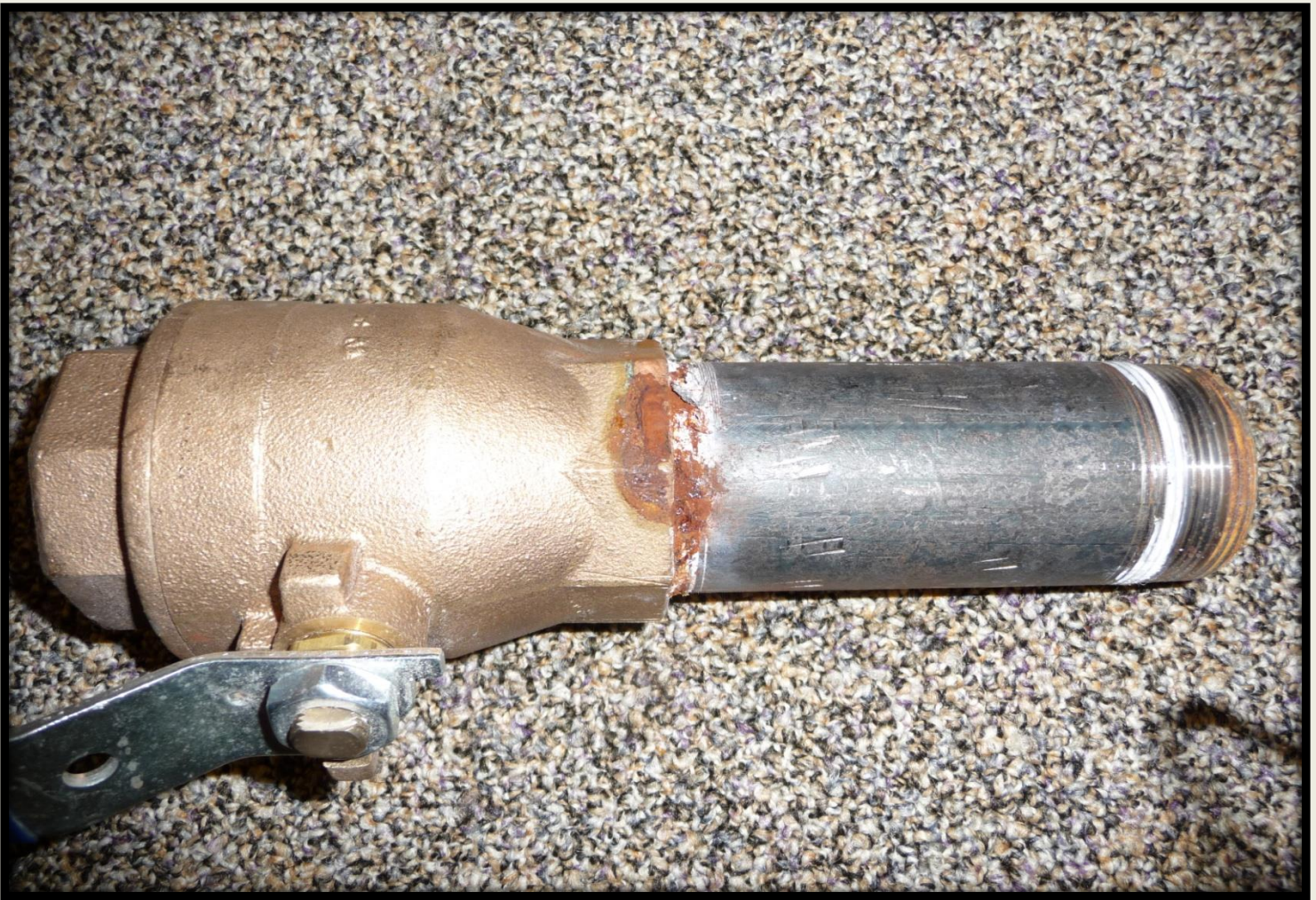
\* Levels relative to measurements made on fresh samples.

# Reality

## Uphill and Downhill Multiphase Flow: Inclination Effects on Flow Regime



# Galvanic Corrosion Brass and Steel



# Corrosion Coupons

- ADVANTAGES

- Easy to Use
- **Allows Examination**
- If located properly, very representative of system
- Inexpensive

- DISADVANTAGES

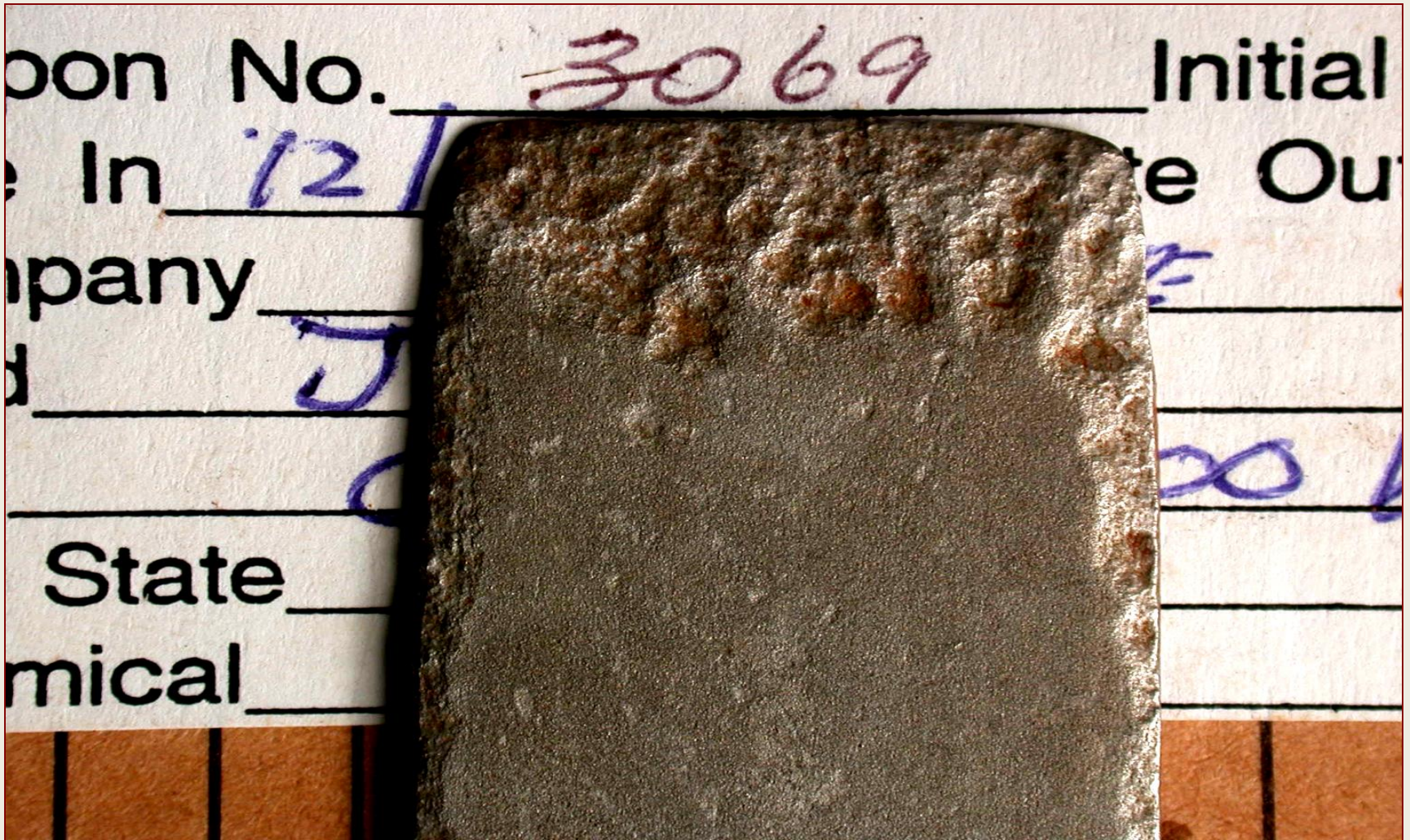
- Long time needed to collect data
- Time consuming
- If not located properly **NOT** representative of system



# Rod Coupons



# Corrosion Coupon 2



# Bacteria Monitoring

- **Planktonic**
  - Serial Dilution
  - Rapid Check
- **Sessile**
  - Serial Dilution
  - “Robbins Device”
  - Screen
  - Swabs

# Serial Dilution Vials



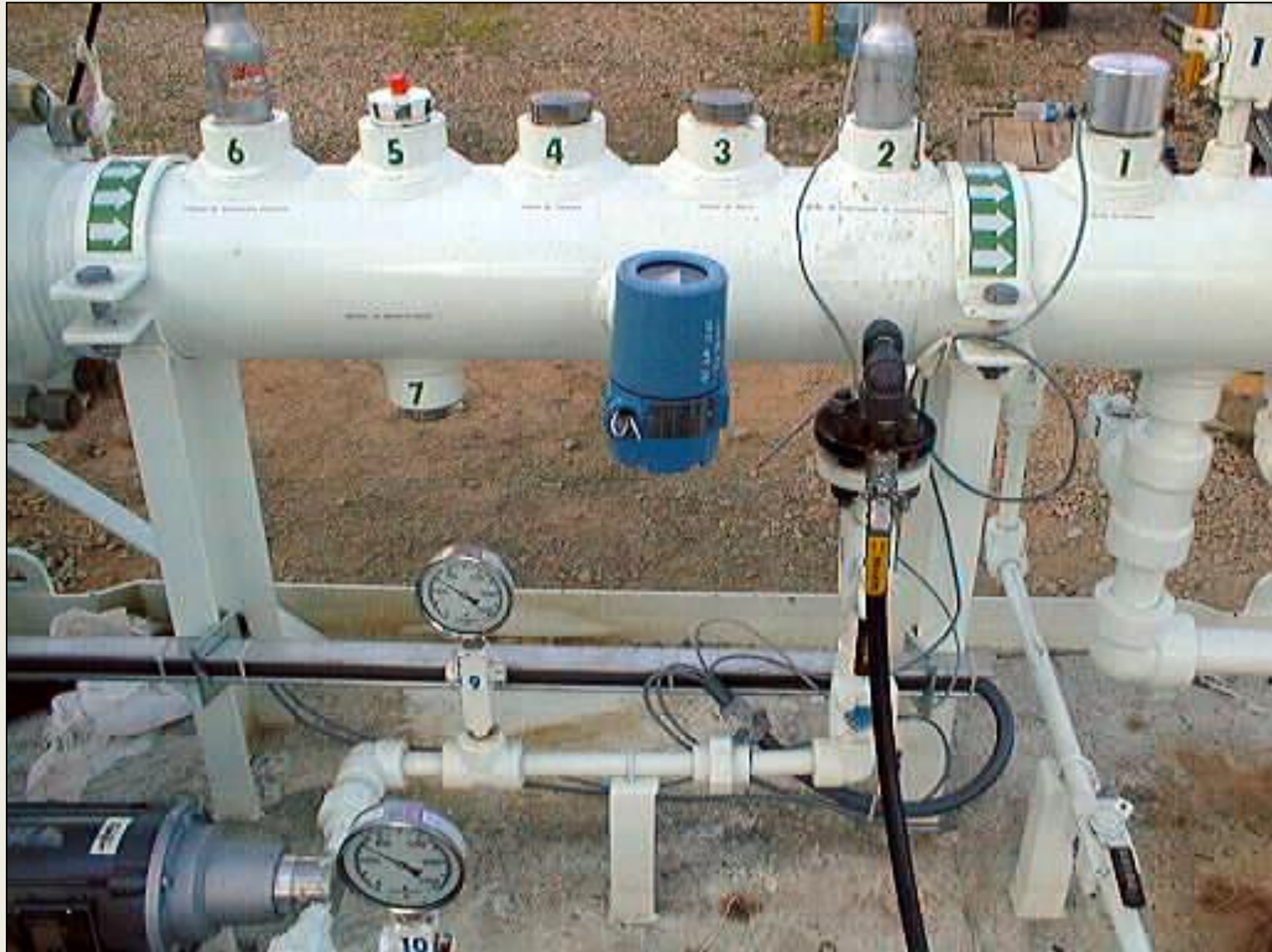
# Electrical Resistance Probes



# Linear Polarization Resistance Probes



# Pipeline Monitor



# Remember

- RUST
- NEVER
- RESTS



# References

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  - Byars, Harry, NACE International, 2<sup>nd</sup> Edition
- Microbiologically Influenced Corrosion Handbook
  - Susan Watkins Borenstein, Woodhead Publishing
- Applied Water Technology C. Patton, Campbell Petroleum Series, Norman OK
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  - E.W. McAllister, Gulf Publishing Co., Houston TX