Copper Corrosion Control

Prepared by the Palo Alto Regional Water Quality Control Plant

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Regional Water Quality Control Plant

1. Introduction to the RWQCP
2. Copper and water quality
3. Causes of pipe corrosion
4. Your installation methods can reduce that corrosion!

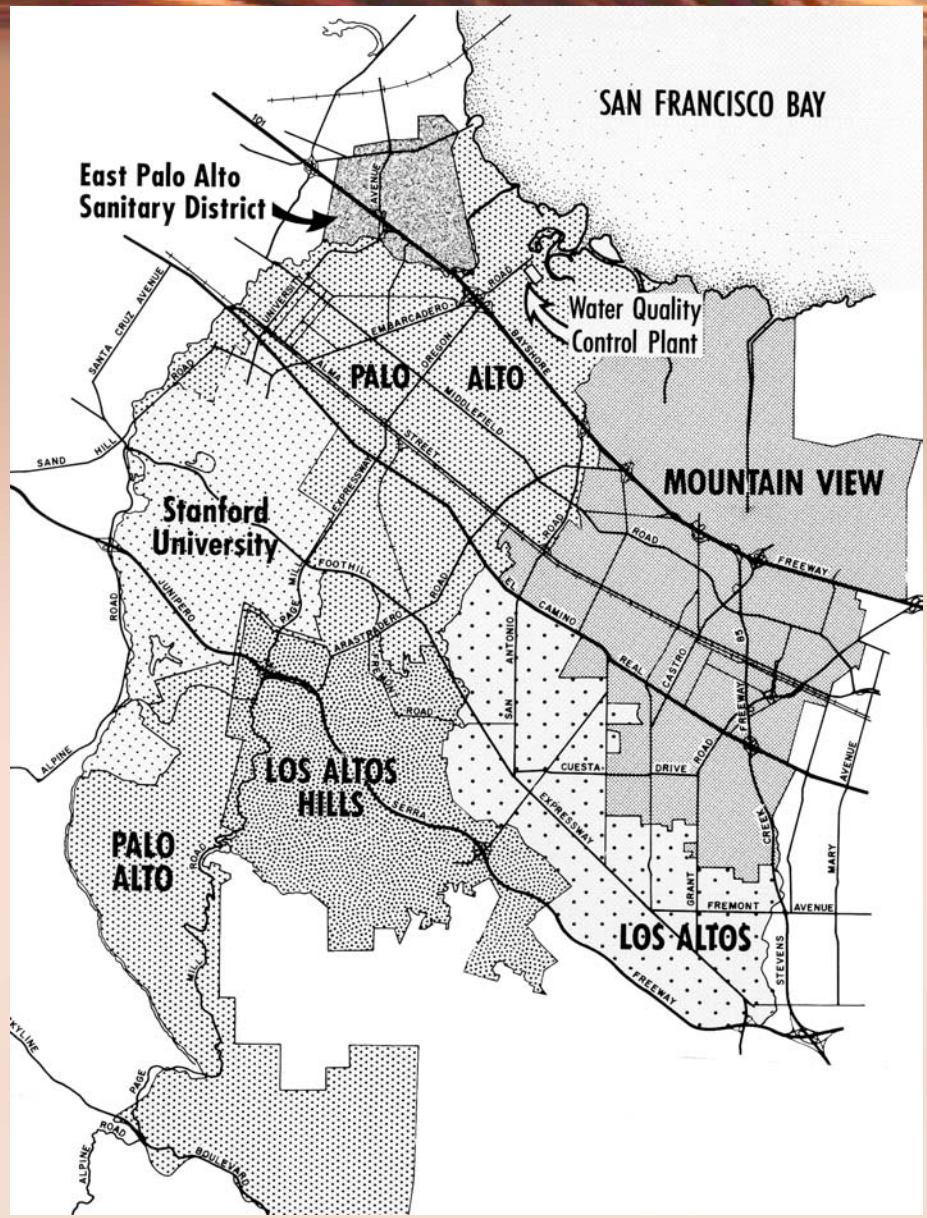
Palo Alto RWQCP

- Treats wastewater (sewage) for 5 cities
- Operates 24 hrs/day
- Cleans 26 million gallons of water a day

Regional Water Quality Control Plant

Palo Alto RWQCP Service Area

Mountain View, Los Altos, Los Altos Hills, Palo Alto, East Palo Alto Sanitary District, Stanford University

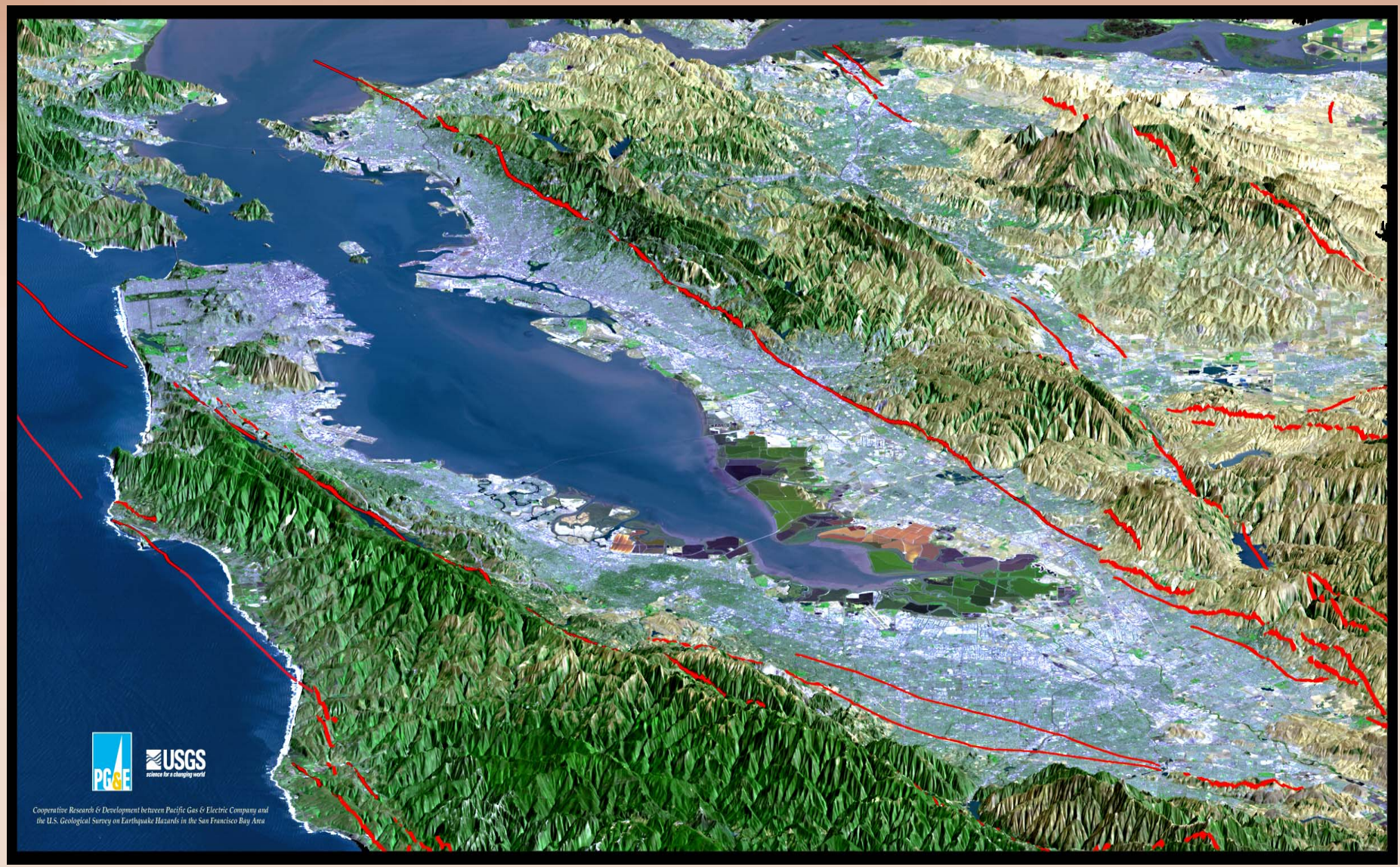


Regional Water Quality Control Plant

39 wastewater treatment plants discharge into San Francisco Bay…

…and treat 620,000,000 gallons of wastewater every day from homes, industry and businesses

San Francisco Bay



Copper Affects Bay Ecosystem

- Toxic to plankton (base of food chain)
- Accumulates in clams
  - affects reproduction & growth
- Other Bay species sensitive to copper
  - Upsets natural balance of species

We Need Your Help

- Wastewater plants are designed to remove certain pollutants…
  - Examples: human wastes, food waste, biodegradable soaps
- …but not to remove other pollutants
  - Examples: metals (such as **copper**, mercury, nickel, silver), pesticides, motor oil

Regulatory Conditions

- The RWQCP has discharge permit
  - limits Cu in Plant effluent to Bay
    - 12 μg/L
  - requires source control programs
    - industrial pretreatment
    - pollution prevention
- RWQCP limits industrial discharges
  - as low as 0.25 mg/L

Copper Sources to South Bay

- Stormwater
  - 3,760 kg/year
- Treated Wastewater
  - 1,100 kg/year
  - from three POTWs (Palo Alto, Sunnyvale and San Jose)

Stormwater Sources

- Vehicle brake pads
- Copper roofs and gutters
- Auto repair shops

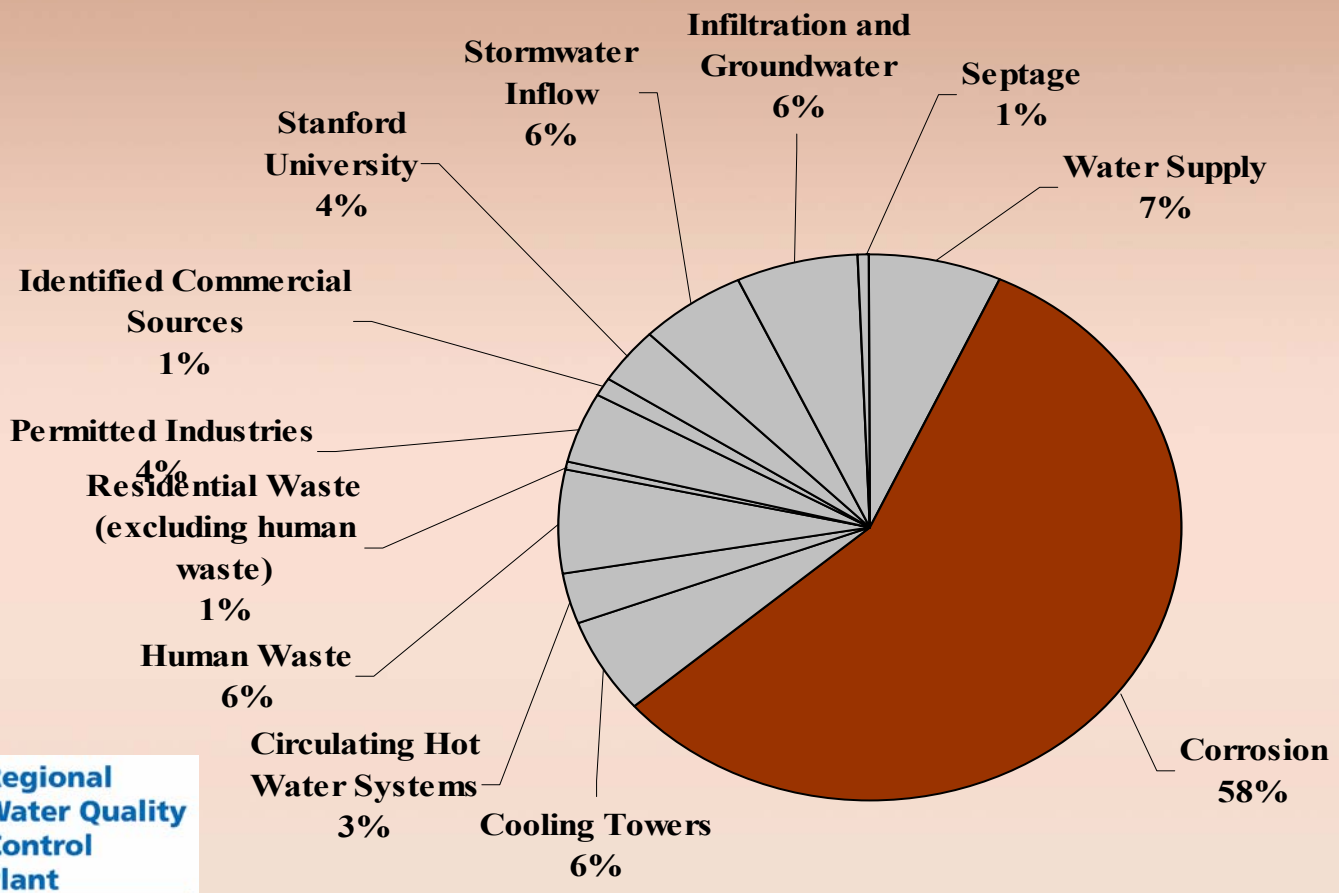
Controlling Stormwater Sources

- Vehicle brake pads
  - National collaboration with manufacturers
- Copper roofs and gutters
  - Palo Alto drafted ordinance to prohibit new architectural copper
- Auto repair shops
  - Annual inspections
  - Recognition and incentives for compliance

Wastewater Sources

- Metal finishers &PCB manufacturers
- Cu-based root control products
- Auto repair shops
- Cooling towers
- Recirculating hot water systems
- Pipe corrosion

Cu Sources to RWQCP



Regional Water Quality Control Plant

Fate of Copper at RWQCP

- 90% of copper removed from the water
  - Ends up in the sludge
  - Sludge is incinerated, creating ash
  - Excess copper in sludge causes ash disposal problems
- 10% remains in water
  - exits to Lower South SF Bay

Controlling Wastewater Sources

- Metal finishers &PCB manufacturers
  - Aggressive discharge limits and ordinance requirements
  - Semi-annual inspections and appropriate enforcement actions
- Cu-based root control products
  - In 1995, spearheaded ban in SF Bay Area

Controlling Wastewater Sources

- Auto repair shops
  - Annual inspections
  - Recognition and incentives for compliance
  - Permit and monitor discharge

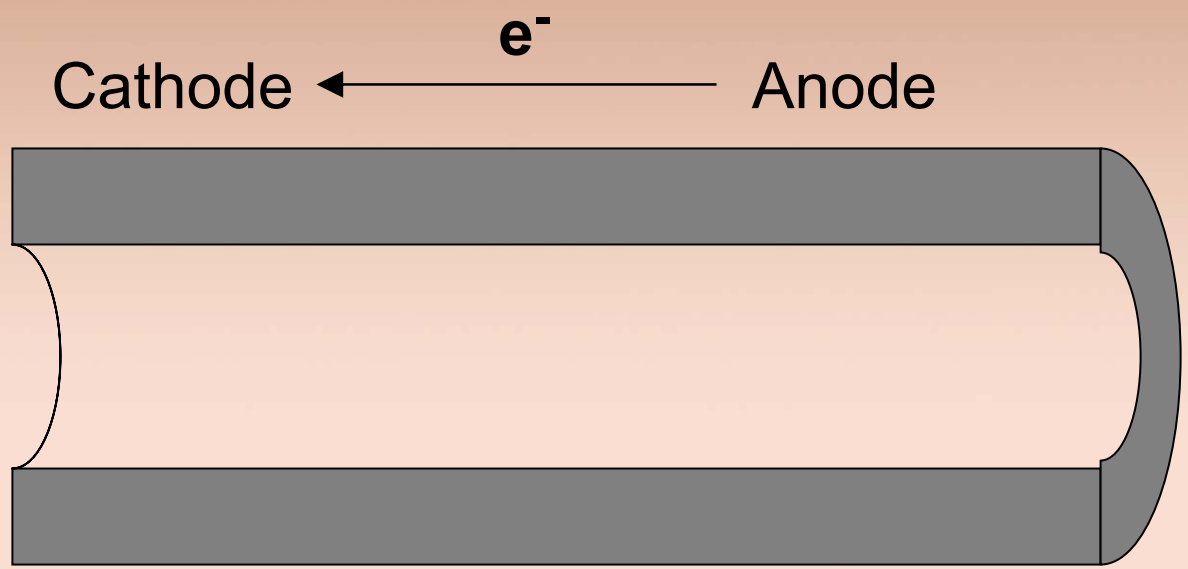
Controlling Wastewater Sources

- Cooling towers
  - Review new projects
  - Prohibiting copper additives
  - Testing of cooling system cleaning solutions prior to discharge
- Corrosion in copper plumbing
  - Here we are!

Permit Requirements

- Permit Order Number 00-109
  - Palo Alto's RWCQP shall educate plumbers and designers to reduce corrosion of copper pipes via design and installation practices

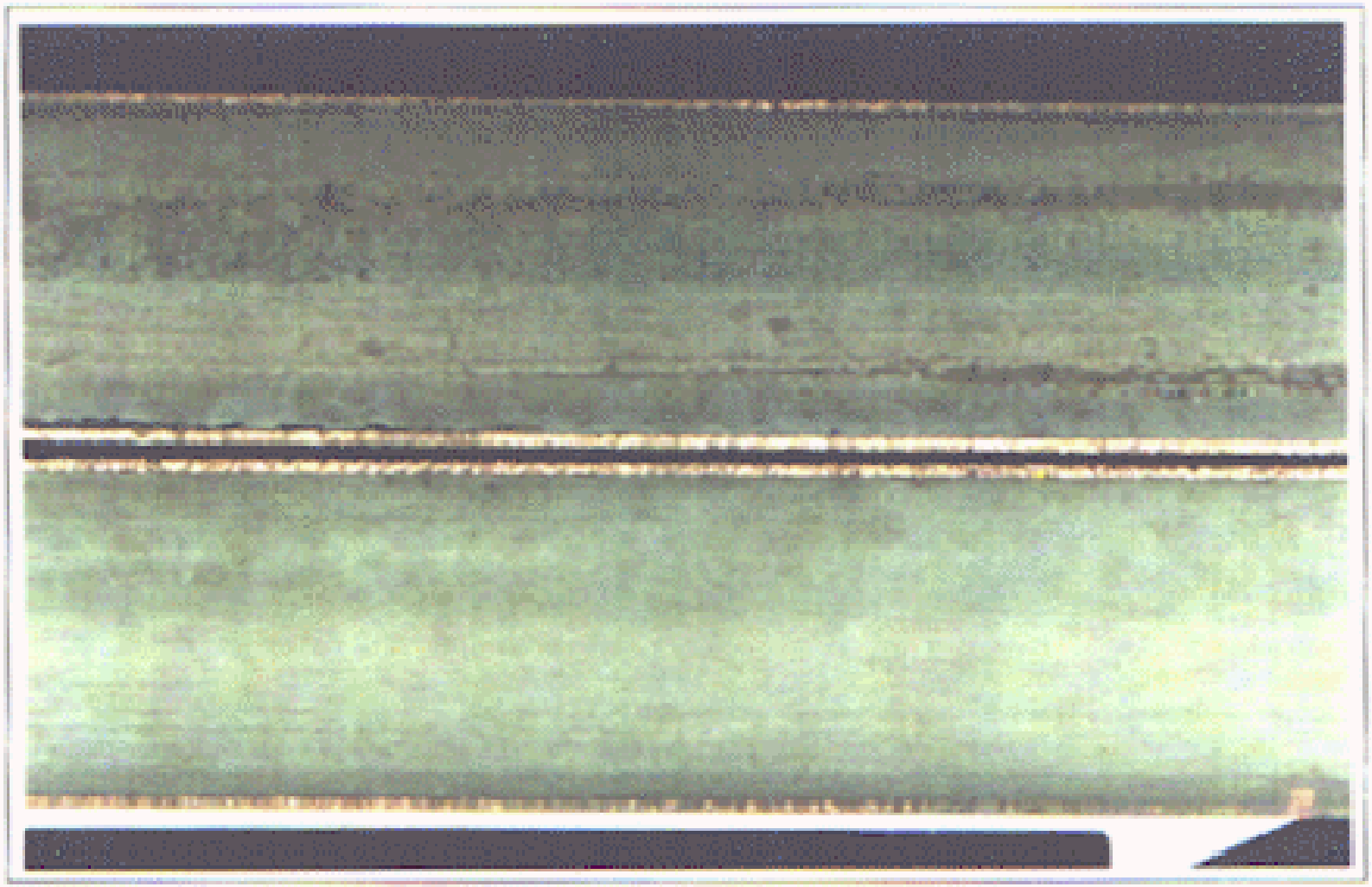
How Corrosion Occurs



$2H^+ + 2e^- = H_2$

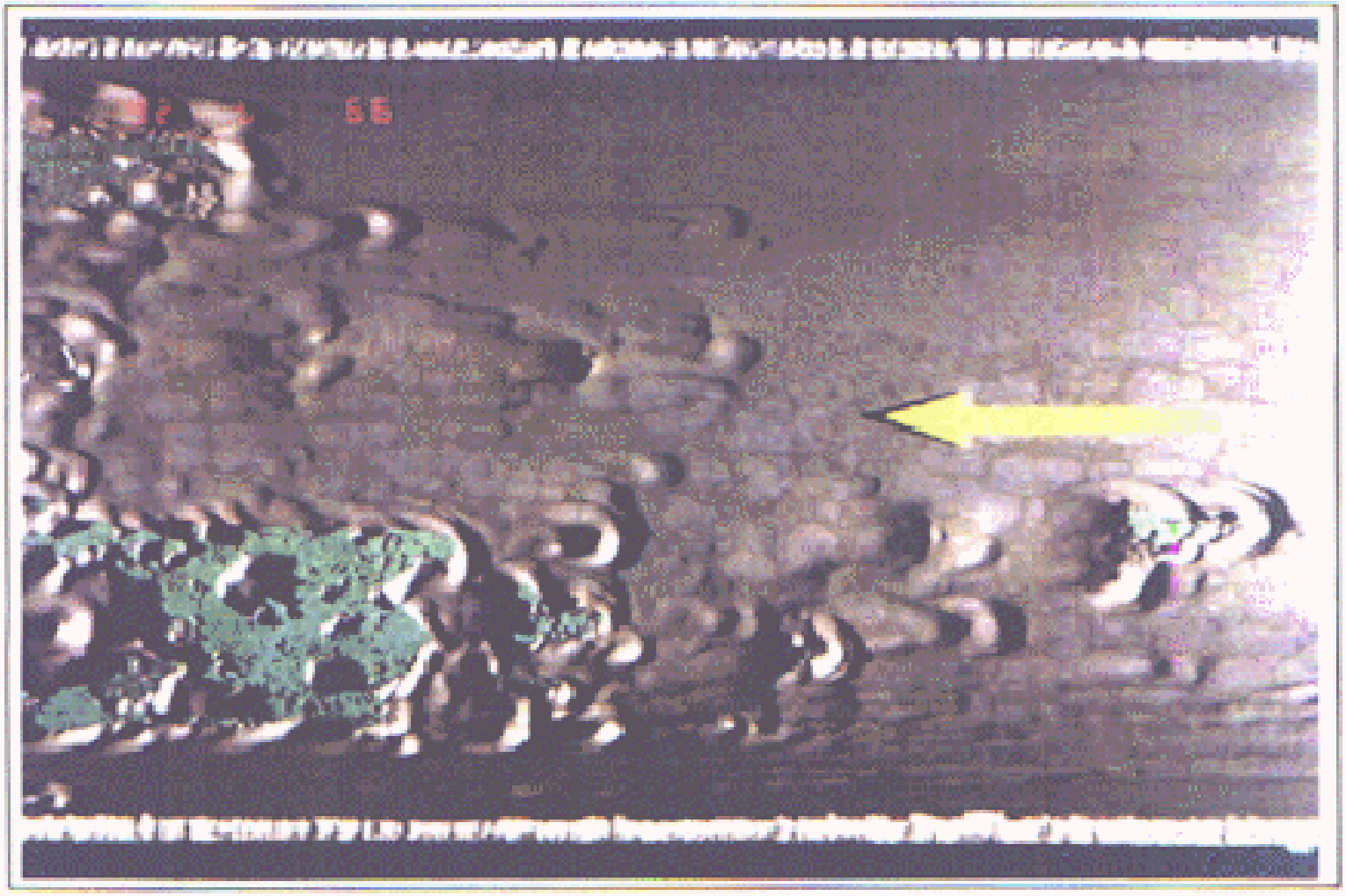
$Cu^0 - 2e^- = Cu^{++} + 2e^-$

Uniform Corrosion (Protective)



Source: R. Lewis <http://www.wssc.dst.md.us>

Physical Erosion



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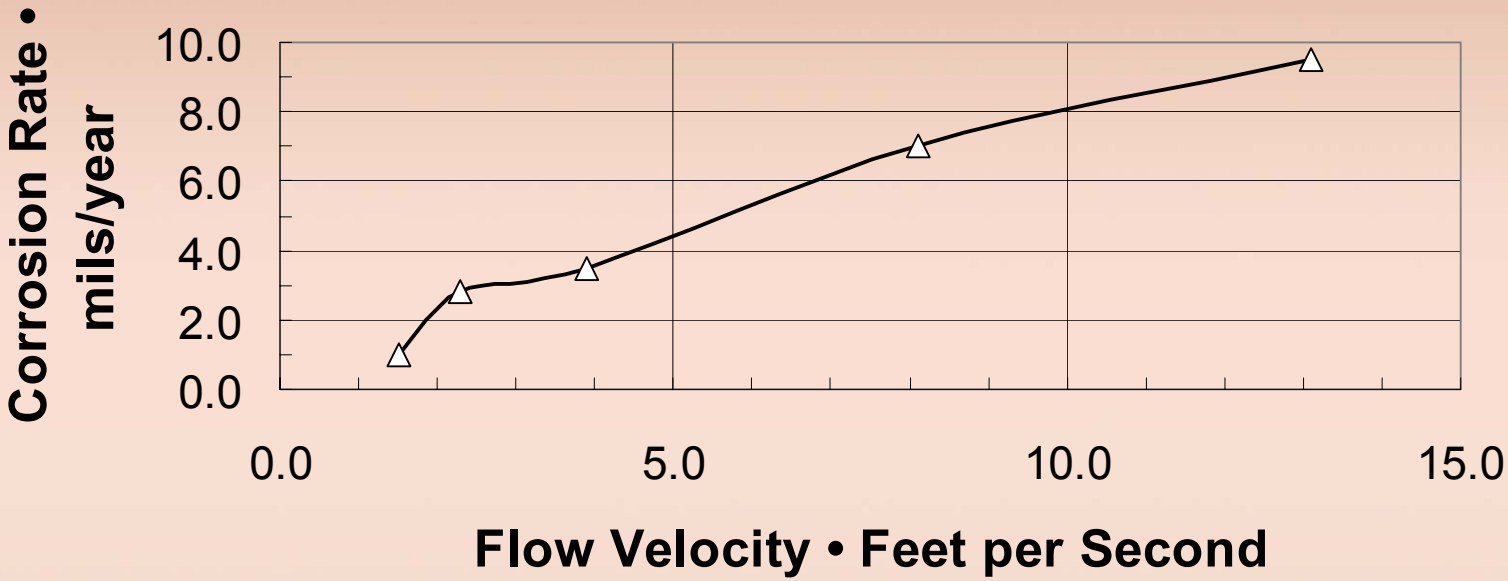
Physical Factors

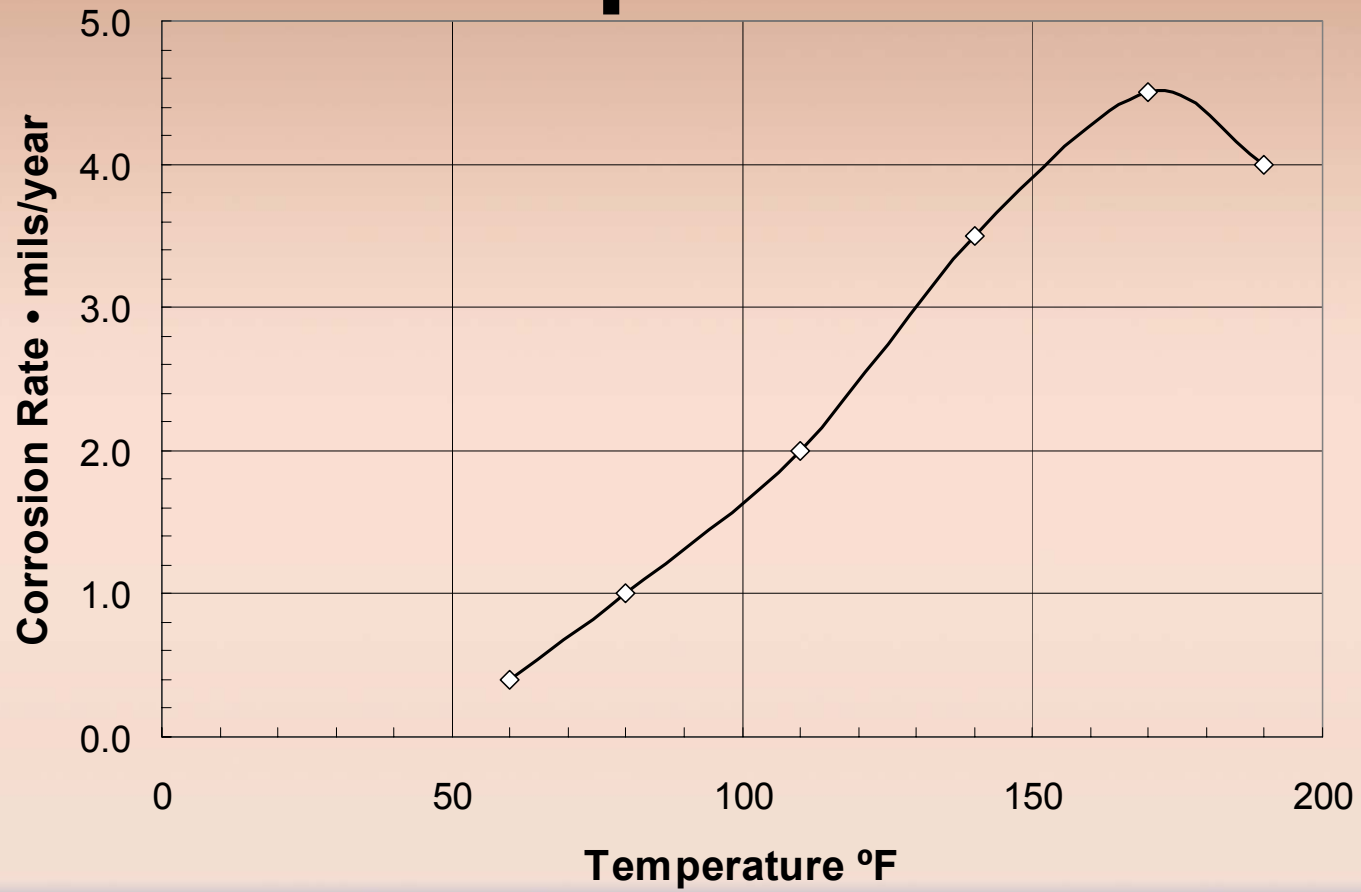
Faster Corrosion

- High Velocity
- Zero Velocity (Stagnant)
- High Turbulence
- High Temperature
- Repeated Wet / Dry Cycles

Corrosion Rate vs. Velocity



Corrosion Rate vs. Temperature



Chemical Factors

Faster Corrosion:

- pH < 5
- Low Carbonate Alkalinity
- High Oxygen or Chlorine
- High Total Dissolved Solids (TDS)
- High Chloride or Sulfide

Corrosion Controls: Important At Every Step

- Manufacturing & Shipment
- Piping System Design
- Installation
- Operation

Corrosion Control: Design

- Size & Orientation
- Fittings & Supports
- Materials Compatibility
- Maintainability
- Stray Currents

Size & Orientation

Keep Velocity Low

- Cold: < 8 ft/sec
- Hot: < 4-5 ft/sec

Avoid Stagnant Sections

Minimize Direction & Size Changes

Fittings & Supports

- Use Compatible Materials
  - Specify Copper or Brass Straps
  - Specify Insulating Unions
- Avoid Induced Stresses
  - Provide Enough Support
  - Allow Thermal Expansion

Stray Electrical Currents

- “AC” Typically Not A Problem
- More “DC” Devices Being Used Today
  - Hair Dryers
  - Computers
  - Battery Chargers
- Currents Affect Outside Of Pipe More

BMP: Use Grounding Rods

Corrosion Control: Manufacturing

Careful Storage and Handling

http://www.nationalcopper.com

Corrosion Control: Installation

Cutting of Tube

- Be careful not to deform tubing
- Measure accurately to avoid strains that affect service life

Source: CDA <http://tubebookcopper.org>

Skilled Reaming

- Removes small burrs and rough edges created from cutting
- Protects water quality and the Bay
  - Eliminating rough edges reduces sites of local turbulence and increased velocity which would have led to corrosion

Source: CDA <http://tubebookcopper.org>

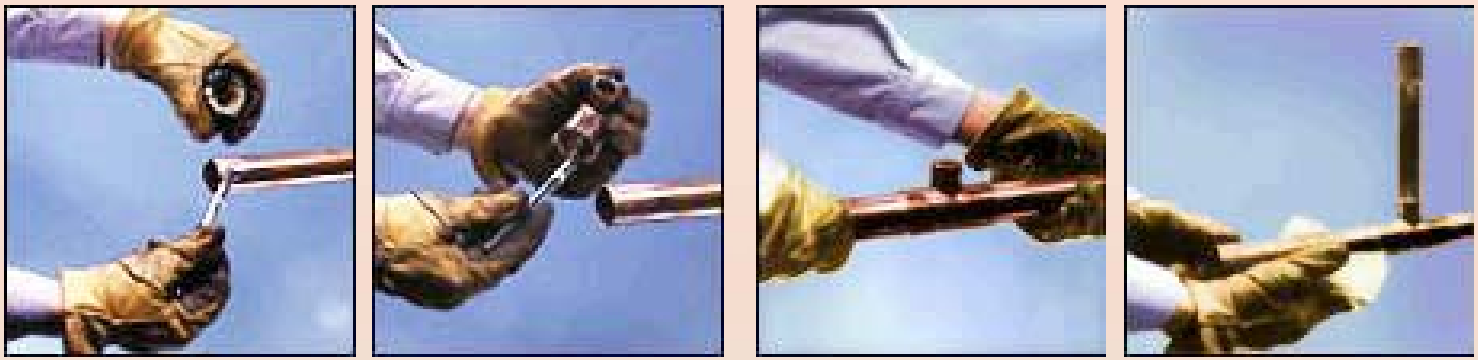
Skilled Cleaning

- Remove all oxides, debris, and surface soil from the pipe

Source: CDA <http://tubebookcopper.org>

Skilled Fluxing

- Excess flux residue can cause corrosion
  - Avoid excess flux
  - Wipe off excess flux from exterior



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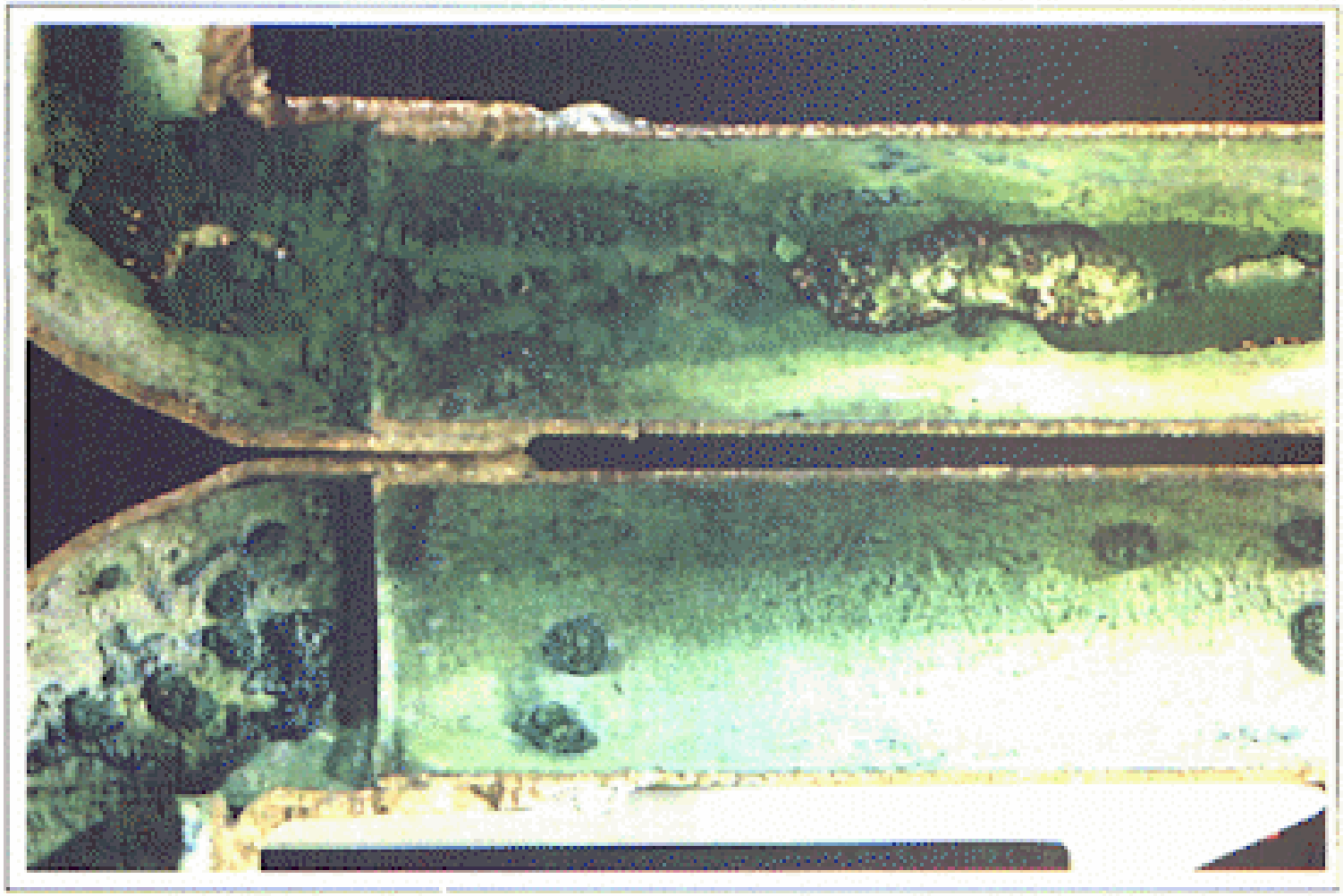
Excess Flux in Cold H2O Pipe



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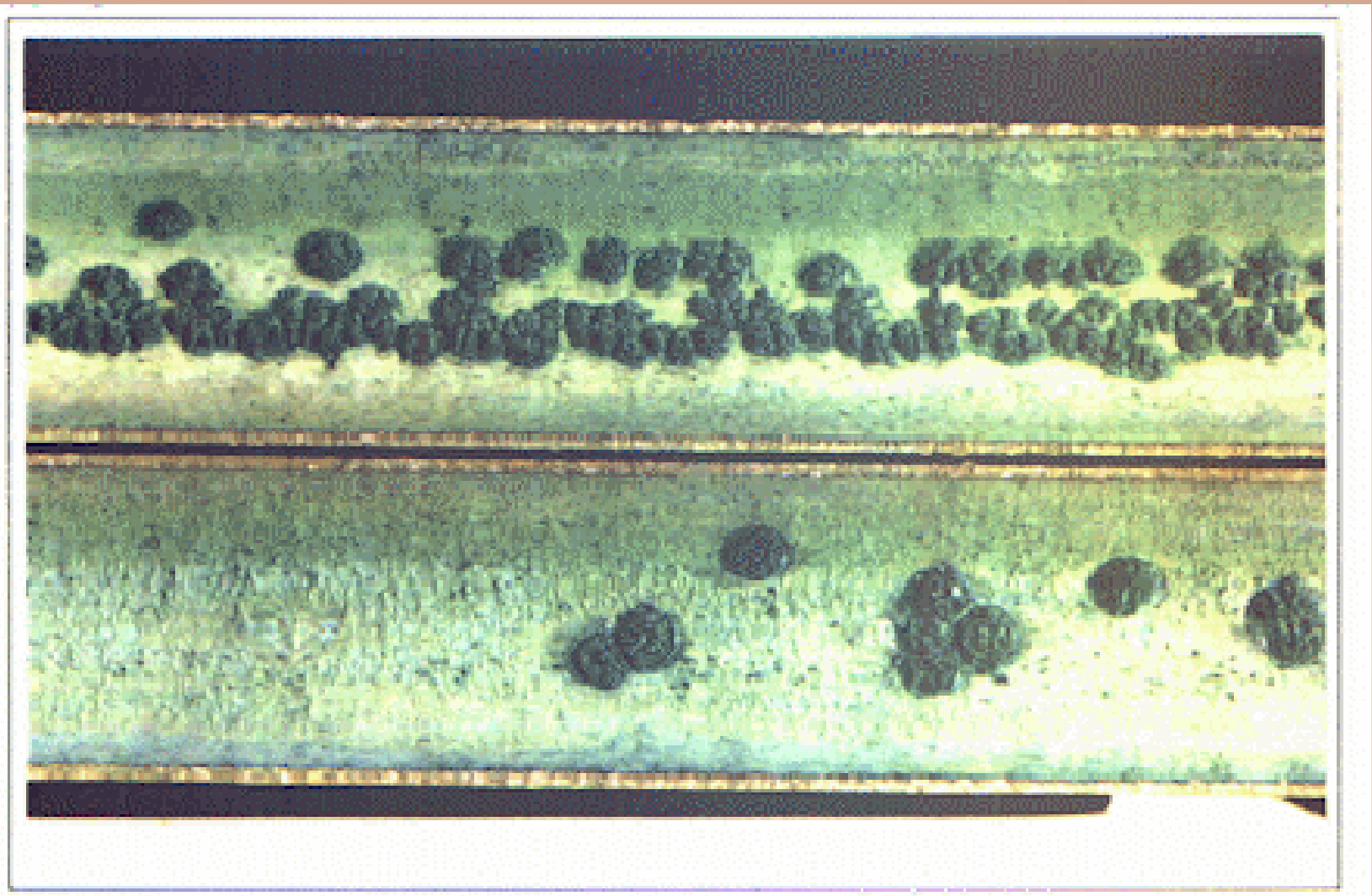
Downstream Corrosion



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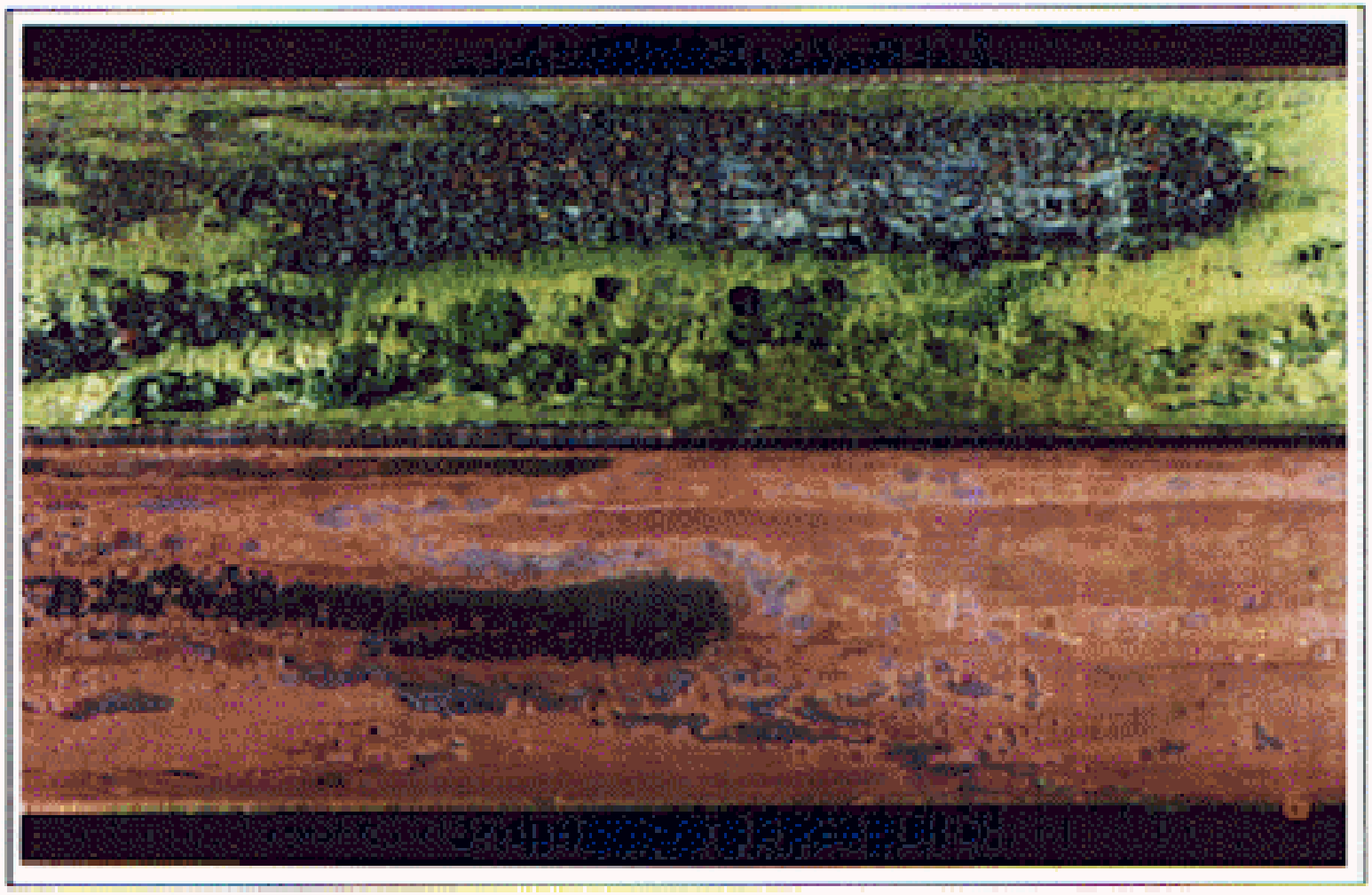
Pitting Under Flux



http://www.wssc.dst.md.us/

Health Hazards of Flux

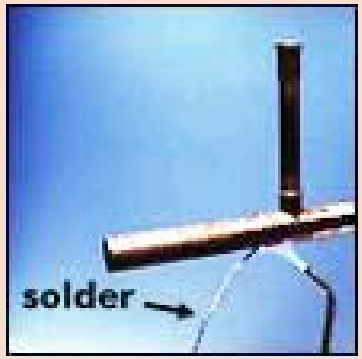
- Contains glycol ethers or zinc chloride
  - Material or fumes may cause skin, eye, and respiratory irritation or burns
  - Chronic exposure affects liver, kidneys, and lungs
  - Both enter body via inhalation or ingestion
  - Glycol ethers also absorb through skin

Precautions

- Obtain and read MSDS
- Minimize use of the material
- Use gloves and eye protection
- Avoid inhalation or ingestion of fumes and material
- Wash contaminated clothing before reuse

Skilled Soldering & Cleanup

- Cool naturally
- Clean off excess flux
- Flush immediately to remove excess flux and debris



Corrosion Control: Operations

- Flow & Temperature Management
- Line Flushing
- Corrosion Inhibitors
- Disinfectants (Chlorination)
- Corrosion Monitoring

Flow & Temp. Management

- Keep Flow Rates Within Design Limits
- Flush Stagnant Lines Monthly
  - Frequent flushing should help eliminate slugs of copper and keep effluent concentration below the industrial discharge limits
- Set Temperatures < 120° F

Corrosion Inhibitors

- Adjust pH to 6.5 - 7.5
- Add Orthophosphate to 1 - 3 mg/l
  - Specify zinc-free
- Decrease TDS (Decrease Conductivity)

Conclusions

- Copper can negatively impact San Francisco Bay
- Pipe corrosion is a significant source of this problem
- Proper design, installation, and maintenance can significantly reduce corrosion
- Plumbers should be aware of health hazards of flux and use appropriate precautions

More Information

- http://tubebook.copper.org
- http://www.sweets.com
- http://www.nace.org
- http://www.awwa.org
- http://www.wssc.dst.md.us

Acknowledgements

References

- 1996 edition of “Guidelines for Plumbers”
- “Corrosion Prevention and Control in Water Treatment and Supply Systems
  - By Singley, et al., Noyes Publications, 1985
- Richard Lewis (Consultant to MSSC)

Reviewers

- Robert Ryder (Kennedy/Jenks)
- Copper Development Association

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