EIGHT FORMS OF CORROSION

(1) Uniform attack (general corrosion);

(2) Galvanic corrosion;

(3) Crevice corrosion;

(4) Pitting;

(5) Intergranular attack ("IGA");

(6) Selective leaching;

(7) Erosion corrosion;

(8) Stress corrosion cracking ("SCC")

1. UNIFORM ATTACK

Most common form of corrosion.

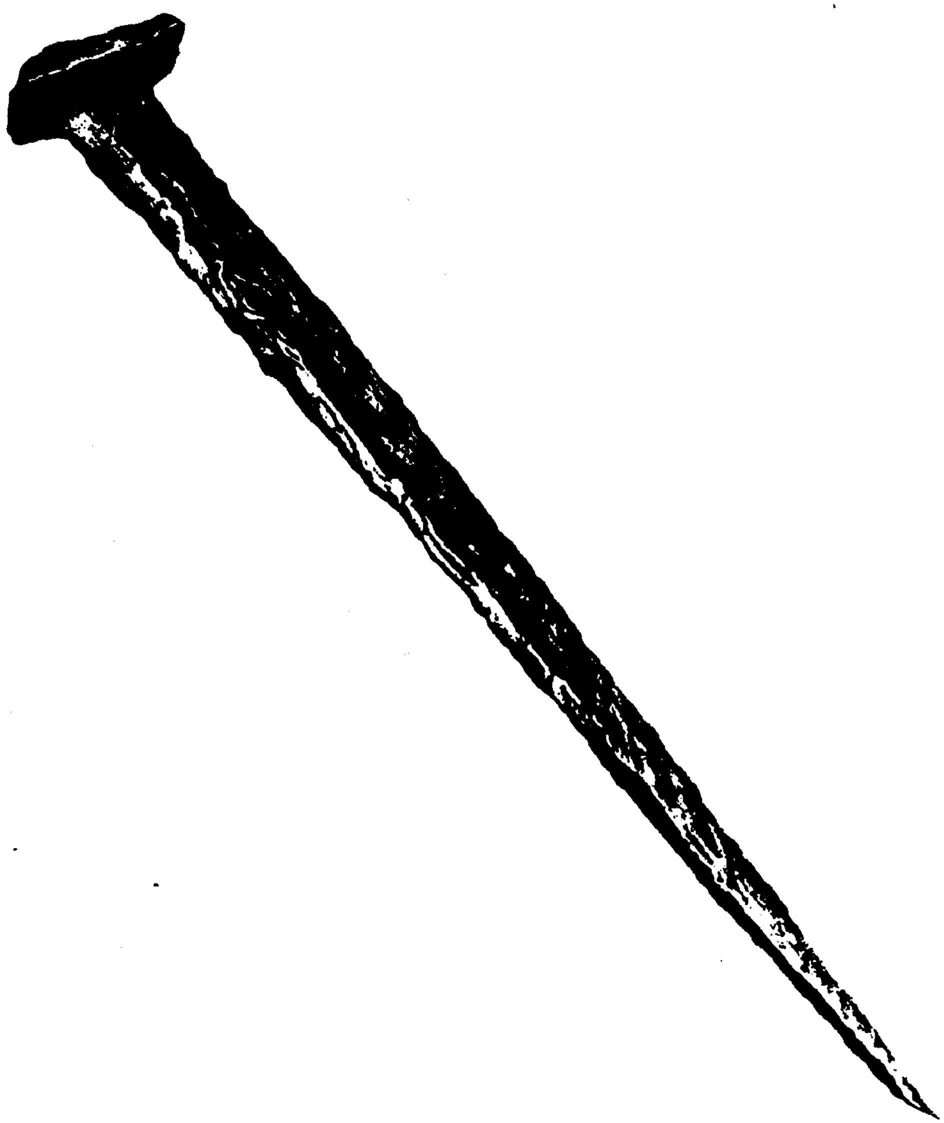
Chemical reaction (or electrochemical reaction) occurs over entire exposed surface (or large areas) more or less uniformly.

Metal thins............ fails.

Not usually serious....... predictable from simple tests (e.g., coupon or specimen immersion) .... can be designed "around" by specifying an adequate CORROSION ALLOWANCE for the expected lifetime of the component.

Uniform attack minimized by:

- **specifying proper materials;**
- **correctly applying coating;**
- **using corrosion inhibition;**
- **protecting cathodically.**



1800-year-old Roman nail shows how iron and steel can withstand burial underground.

N.B. Environment is crucial!

ATMOSPHERIC CORROSION

Usually "uniform".

Dry, damp or wet conditions have profound effect on corrosion.

Dry atmospheres:

- at ambient temperatures, most metals corrode very slowly;
- atmospheric oxygen promotes a protective oxide film... such films are defect-free (sort of!), non-porous (more or less!) and self-healing;
- "passivity" of metals like SS, Ti, Cr depends on protective oxide films (but such passivity extends to other environments, e.g., aqueous).

EXAMPLE

Ag & Cu tarnish in dry air with traces of H_2S (undesirable - aesthetically, technically - affects electrical contacts, etc.).

The S^{2-} incorporation in the normally-protective oxides creates lattice defects which destroy protective nature of films.. → tarnishing.

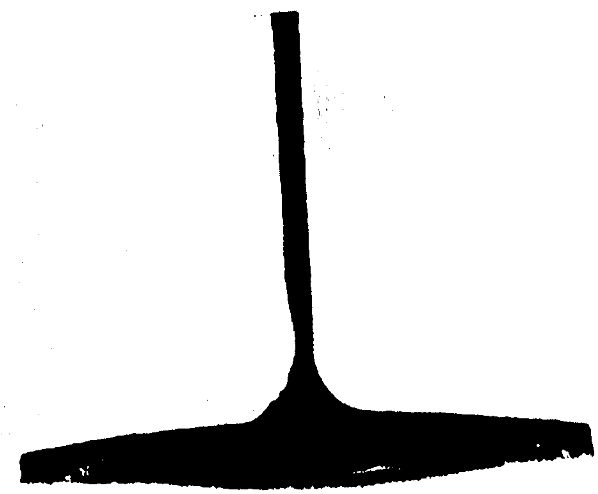
Moisture not required for tarnishing, it can actually retard tarnishing of Cu in presence of traces of H_2S.

Damp atmospheres:

- corrosion increases with moisture content;
- at critical moisture level (~70%RH), invisible, thin film of moisture forms on (metal) surface, provides "electrolyte" for current (critical RH depends on surface condition: cleanliness, presence of oxide or scale, presence of salts or other contaminants that may be hygroscopic).

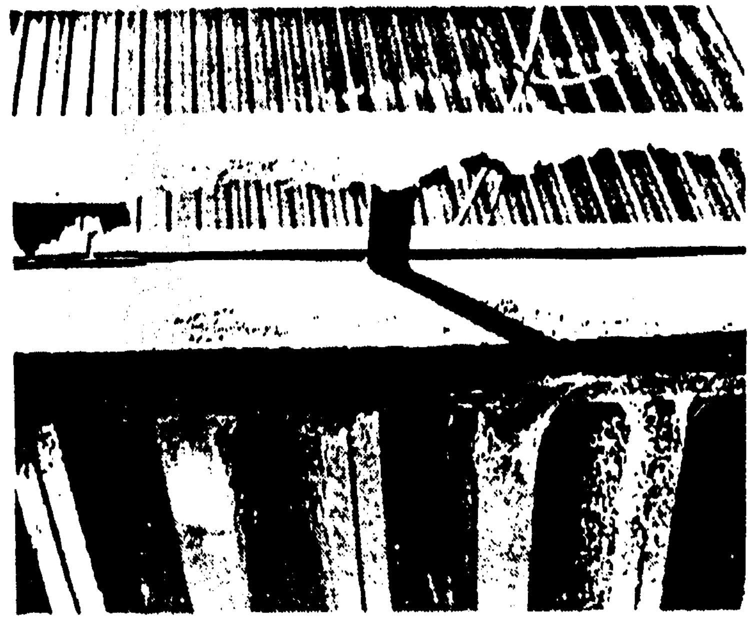
Wet atmospheres:

- promote puddles, pockets, visible water layers (from dew, sea spray, rain, etc.);
- crevices, condensation traps, etc., create water pools, and lead to "wet atmospheric corrosion" even when rest of surface dry;
- soluble corrosion products increase wet corrosion (dissolved ions increase conductivity, sustain higher electrical currents);
- insoluble corrosion products may retain moisture during alternate wet and dry conditions, lead to continuous wet corrosion.



Corroded weathering steel I-beam. Note how corrosion has thinned the bottom of the vertical web where corrosion products have fallen and formed a moist corrosive deposit.

Corroded steel formwork on the ceiling of a parking garage. The seams in this corrugated structure act as condensation traps and lead to wet atmospheric corrosion. Courtesy of R.H. Heidersbach, California Polytechnic State University



Corroded weathering steel gutter. Courtesy of R.H. Heidersbach, California Polytechnic State University

Rusting of iron and steel, formation of patina on copper, examples of damp → wet corrosion.

Corroded regions of a painted highway bridge.

Corroded weathering steel highway bridge girder.

ATMOSPHERIC CONTAMINANTS

- **Wet atmospheric corrosion is often governed by level of contaminants. e.g., marine salts vary drastically with distance from the sea:**
  steel at 25 m from the sea will corrode 12x faster than same steel 250 m away.

- **Industrial atmospheres more corrosive than rural, mainly because of sulfur compounds produced by burning fuels.**
  SO_2 selectively adsorbs on metals - under humid conditions metal oxide corrosion products catalyze oxidation to SO_3:

$$SO_2 + 1/2\ O_2 \xrightarrow{cat} SO_3$$

$$H_2O + SO_3 \longrightarrow H_2SO_4$$

- **Small additions (~ 0.2%) of Cu, Ni or Cr increase resistance of steel to sulfur pollution by enhancing formation of tighter, more protective rust film.**

NOTE: longevity of ancient Fe probably due to SO_2 - free environments rather than high degree of corrosion resistance.