UTILITY INFRASTRUCTURE: CORROSION

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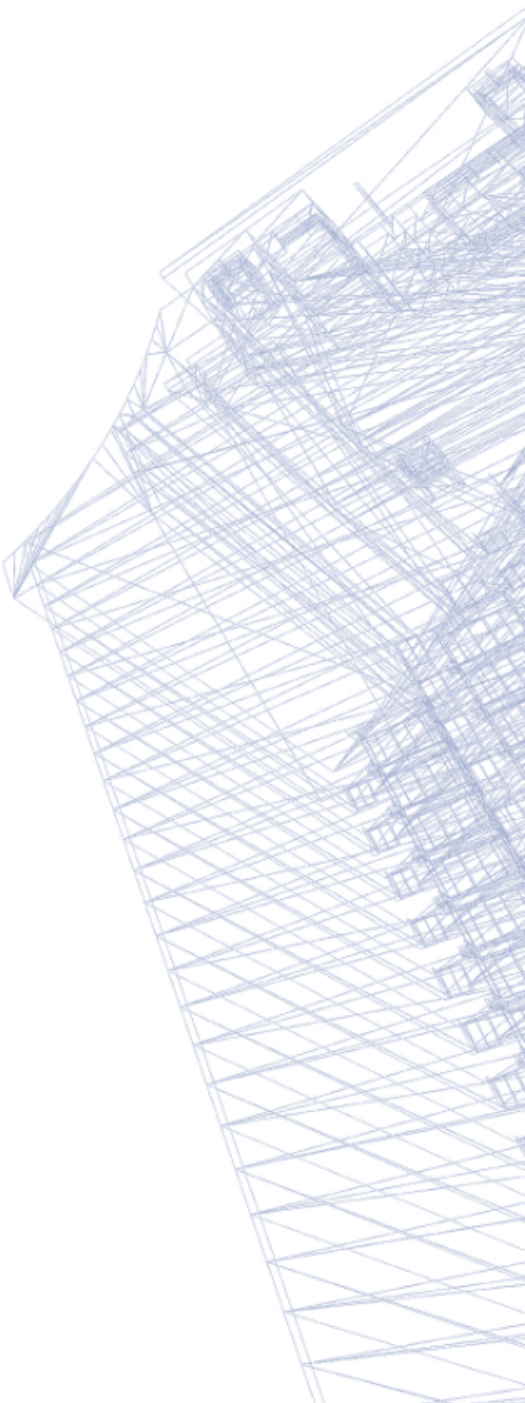
UTILITY INFRASTRUCTURE

- Transmission tower above-ground steel and grillage footings (four-legged and guyed structures).
- Hydro generation infrastructure (e.g. penstocks, gates, powerhouse steel).
- Thermal generation plant infrastructure (e.g. pipe saddles and supports).

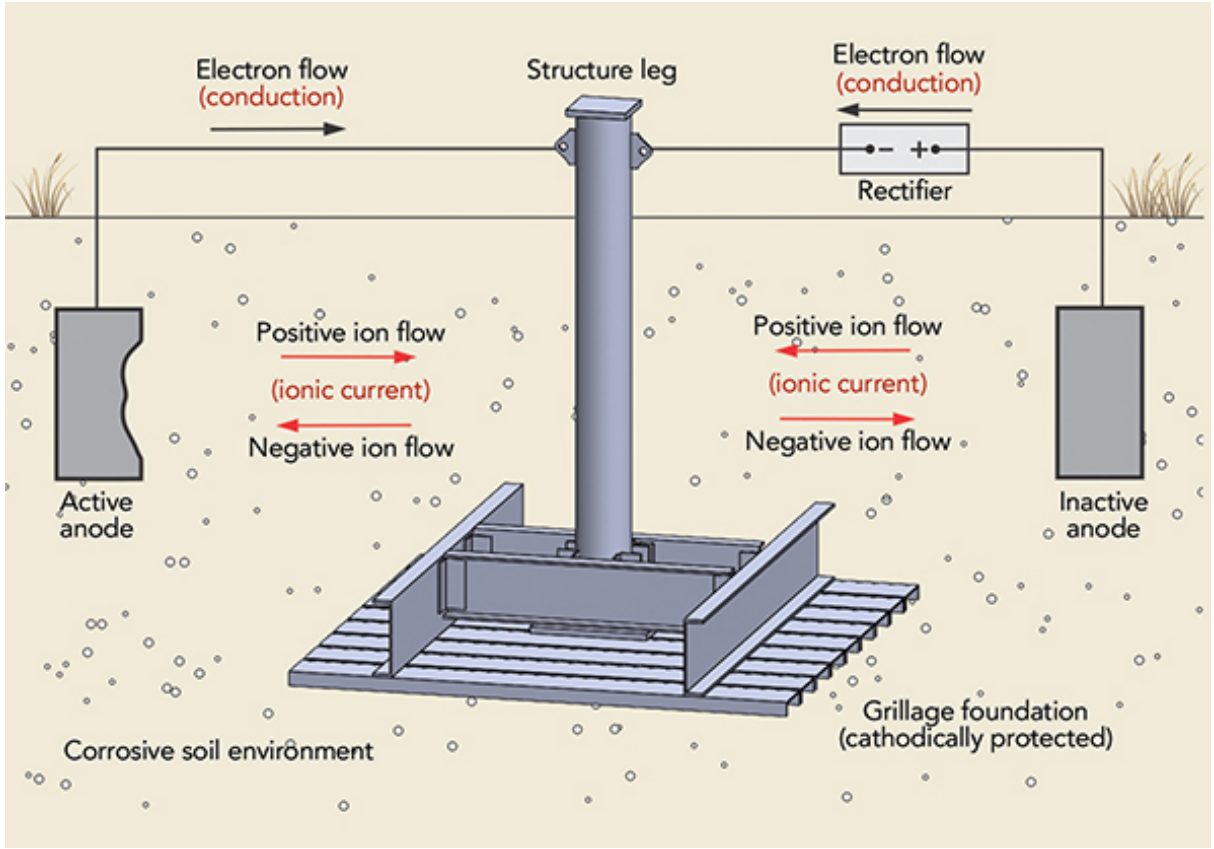
TRANSMISSION STRUCTURES

- Above-ground corrosion of steel lattice structures and steel poles.
- Transmission hardware corrosion (e.g. U-bolts, shackles, ball-eye links, guy anchor attachments, etc.).
- Steel grillage footing and concrete foundation reinforcement corrosion.



ABOVE-GROUND STEEL AND HARDWARE

STRUCTURE TYPES



GRILLAGE FOOTING

The grillage connects to the structure leg with one or more angle members and is attached to a steel platform or bearing surface at the base, which is comprised of channel sections, W-shapes, or angles. (Diagram from T&D World)

GRILLAGE FOOTING: GUYED TOWER

- Many of the tower footings are located in depressions which fill with water contributing to prolonged seasonal wet and dry cycles.

BURIED STEEL CORROSION

- Soil resistivity
- Water (wet/dry cycles)
- Soil pH
- Bedrock type (acid content)
- Road salt, other contaminants in the soil
- Transmission tower insulation (stray current), counterpoise grounding

BURIED STEEL CORROSION CONTD.

- Decaying vegetation
- Bogs, swamps, anaerobic bacteria
- Residual steel stresses at fabrication bends
- Historical galvanizing practices
- Galvanizing thickness
- Construction defects and damage

BOLTED CONNECTIONS

- **Profile loss of nut**

- **Generalized pitting corrosion**

PRIMARY ANGLE MEMBERS

- **Corrosion at mechanical bend**

- **Steel thickness loss at ground line**

SINGLE TOWER LEG: FOUR-LEGGED LATTICE STRUCTURE

- **Pitting corrosion**

- **Loss of steel thickness**

GUYED AND FOUR-LEGGED STRUCTURES

- **Submerged footing – bog, swamp**

- **Single leg – inside**

STEEL GUY-WIRE FAILURE

- **Guy-wire anchor assembly**

- **Guy-wire failure**

STANDARDS

- ASCE/ANSI 10-15 Design of Latticed Steel Transmission Structures
- ASCE Design of Guyed Electrical Transmission Structures
- CSA C22.3 Overhead Systems
- CSA 60826 (Reliability Design)
- Steel standards such as Handbook of Steel Construction CAN/CSA S16-01 Limit States Design of Steel Structures
- G40.20/21 General requirements for rolled or welded structural quality steel/structural quality steel

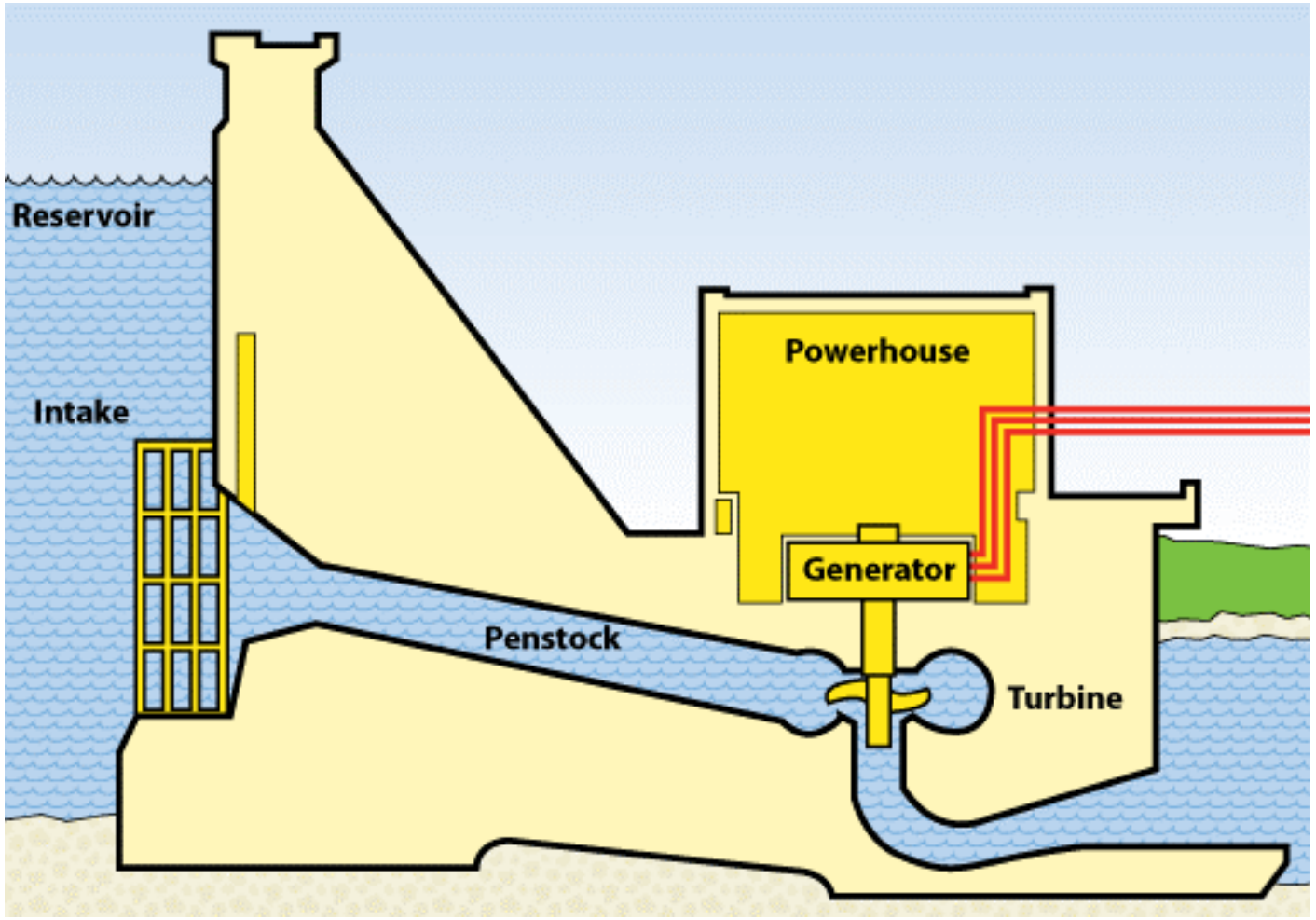
REPAIRS - FOOTINGS

- Repairs typically completed under energized conditions.
- If a failure occurs on a higher voltage transmission line, penalties and fines can be imposed.
- Towers are located in remote sites; difficulty accessing the structures and transporting materials.
- Structure may require temporary supports (costly).

HYDRO GENERATION INFRASTRUCTURE

- Remote dam/powerhouse sites.
- Dam Safety Reviews are required as per Canadian Dam Association Guidelines.
- Steel penstock inspections require rope access and confined space training.
- The penstock must also be dewatered for inspection (internal).

HYDROELECTRIC DAM



U.S. Dept. of Energy

INTERNAL PENSTOCK INSPECTION

- Penstocks are typically constructed using different plate thicknesses along the length.
- The penstock wall thicknesses are measured with a UT gauge.
- Existing plate thicknesses extracted from record drawings are compared to the measured thickness readings to determine percent change.
- Welds and internal coating (if present) are visually inspected.

INTERNAL PENSTOCK INSPECTION CONTD.

- The reduction of steel plate thickness of the penstock walls can be attributed to corrosion, erosion and/or cavitation.
- Leaking at joints or couplings.
- Organic growth.

INTERNAL INSPECTION

(Twitter NFLD. Hydro)

INTERIOR SURFACE (NO COATING)

DATA ANALYSIS

- Average and 97.5% confidence interval thicknesses are calculated.
- The recorded wall thicknesses are used to calculate hoop stresses.
- The stresses are calculated under static loads (maximum static head), water hammer, vacuum pressures (vents).
- Exterior loads for buried penstocks (soil, surcharge loading, seismic).
- Above ground penstock loads include environmental (e.g. snow) and point loads where there is contact with the saddle.

STANDARDS

- ASCE Manual-79 Steel Penstocks
- ASCE Guidelines for Evaluating Aging Penstocks
- AWWA-M11 Steel Water Pipe: A Guide for Design and Installation
- Steel standards such as Handbook of Steel Construction CAN/CSA S16-01 Limit States Design of Steel Structures

REPAIRS - PENSTOCK

- Remote areas, difficult to mobilize and transport material for construction.
- Repair work completed during a shut down/ dewatered conditions.
- Recoating of the interior surface can increase life span.
- Penstock replacement or repairs may be necessary.

STEEL PENSTOCK REPLACEMENT

(AMIBLU.COM)

THERMAL GENERATION INFRASTRUCTURE

- Pipe and pipe supports/saddles.
- Maximum supported length of pipe between saddles/supports to reduce pipe bending stresses.
- Other loading conditions: environmental, thrust, thermal.
- Pipe wall stresses increased at the pipe/saddle contact point.
- Pipe insulation (where cut) may remain wet around the saddle increasing corrosion potential.

PIPE SUPPORTS AND SADDLES

COMMENTS

- Environmentally safe coatings that can be easily applied (especially to anchor rods).
- Change design practices, (e.g. increase galvanization thickness for buried steel, install anodes, thicker steel members).
- Difficult to repair (e.g. energized conditions, waiting for shut downs, access issues, etc.).

Questions?