Pitting Corrosion on Elevator Gearbox Output Shafts

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Chloride-Initiated Cavities and Stress Concentration

Technical Note

During ultrasonic testing of output shafts from elevator gearboxes, small cavities are frequently detected on the free zones of the shaft between the reducer housing and the cable sheave. These cavities do not correspond to residual weld metal or to manufacturing defects (forging or machining marks). They are pitting corrosion, a localized form of attack whose initiation is associated with the presence of chloride ions (Cl^-).

Output shafts are normally manufactured from carbon steel (e.g. C45 / AISI 1045) or alloy steel (e.g. 42CrMo4 / SCM440), quenched and tempered. They are not stainless steel. Although 42CrMo4 offers better general corrosion resistance than plain carbon steel due to its chromium and molybdenum content, neither grade forms a stable passive film. Both remain susceptible to localized attack when exposed to moisture and chloride ions.



Figure 1 – Localized surface cavities on the free zone of an output shaft, adjacent to the cable sheave shoulder.

The cavities are small, irregular and appear shallow. This is not a classic example of deep pitting with undercutting; the attack is limited in depth. The location and localized nature are nevertheless consistent with corrosion influenced by moisture and contaminants (including chloride ions) in the machine-room environment.

1. Nature of Pitting Corrosion

Pitting corrosion is a localized and autocatalytic form of corrosion. It initiates at a point on the surface where the protective film (oxide or passive layer) is locally ruptured. The rupture may be caused by chloride ions, sulfide inclusions, differential aeration, condensed moisture or other contaminants.

Once the cavity has formed, dissolution proceeds preferentially in depth. The interior of the pit becomes anodic relative to the adjacent surface, which remains cathodic. Inside the pit, acidic

conditions develop through hydrolysis of metal ions and further chloride concentration occurs, accelerating the attack. This autocatalytic process explains why pits can be deep even when surface material loss appears limited. In many cases the cavity exhibits undercutting: the surface opening is narrower than the cavity beneath.

This form of corrosion is classic in stainless steels and other passivating alloys, but it also occurs in carbon and alloy steels under conditions of moisture and aggressive agents. On the free zones of output shafts the necessary conditions are present: ambient humidity in the machine room, condensation, possible splashes of degraded lubricant and dust.

2. Role of Chloride Ions

Chloride ions (Cl^-) are particularly aggressive. They adsorb locally on the surface, rupture the protective film and initiate metal dissolution at that point. Once the cavity has formed, the environment inside acidifies and attracts further Cl^-, rendering the process self-sustaining. The surrounding surface may remain practically intact, which makes visual detection less obvious unless the surface is examined carefully.

On carbon or alloy steel shafts the mechanism is analogous: the presence of moisture plus residual Cl^- strongly favors the formation of localized cavities.

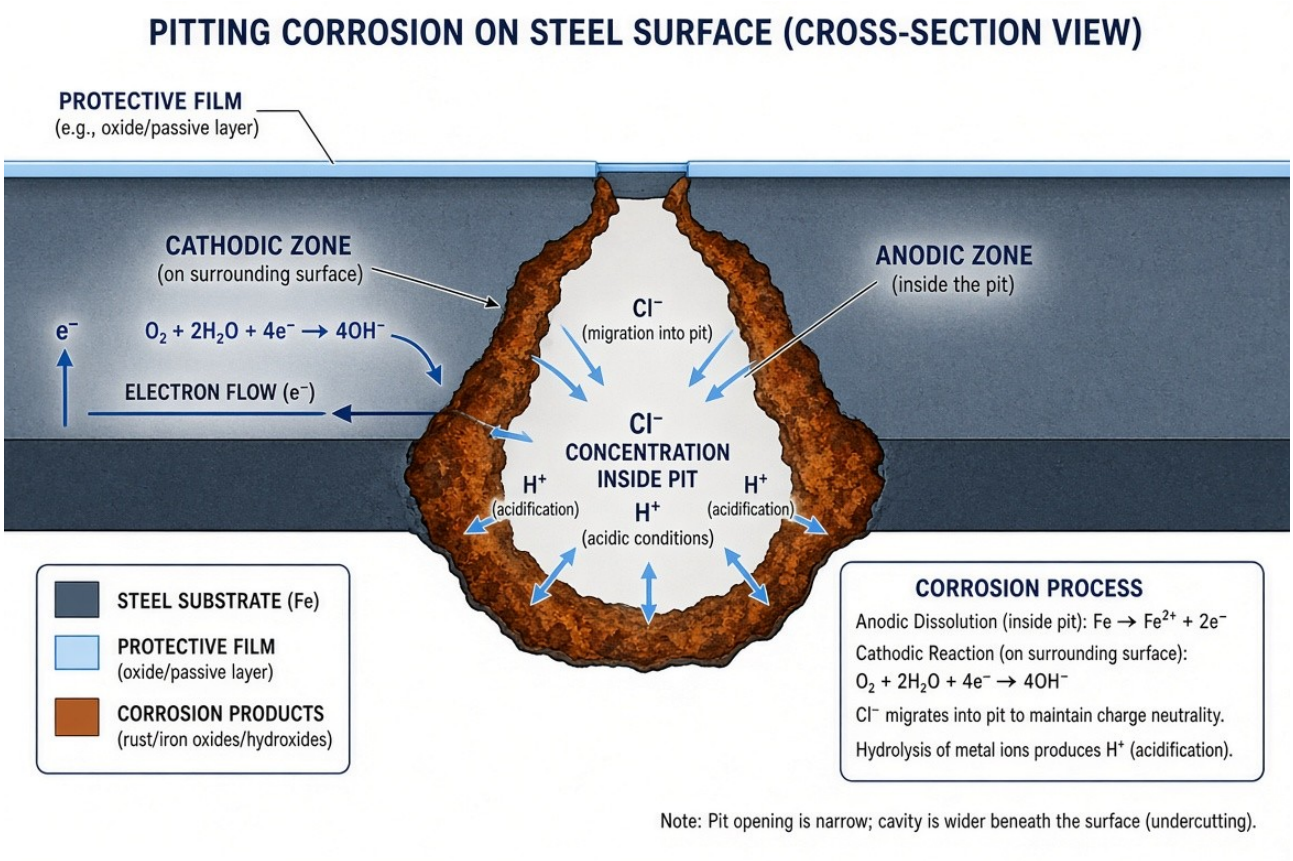


Figure 2 – Schematic of pitting corrosion mechanism.

Chloride ions (Cl^-) concentrate inside the cavity, promoting acidification (H^+) and metal dissolution in the anodic zone. The surrounding surface remains cathodic. The undercutting morphology is characteristic of the autocatalytic process.

3. Origin of Chloride Ions

The chloride ions do not originate from the grease sometimes applied to the free zones. Common industrial greases (lithium or complex-soap based) do not contain chlorides in their formulation; many include corrosion inhibitors instead.

The usual sources are the machine-room environment:

- condensation and ambient humidity,
- atmospheric contamination (dust and residual salinity, particularly near coastal or industrial areas),
- residues from cleaning or degraded lubricants that retain water.

Application of grease can aggravate the situation if performed on a wet or contaminated surface, because it traps moisture underneath and creates conditions favorable to localized corrosion. The practice of applying grease to free zones is typically a protective measure, not the origin of the problem.

The Cl^- ions themselves are not generated by reaction of chlorine with the steel. They are already present in the atmosphere as chloride salts (mainly NaCl from marine aerosols, dust and residual pollution). When moisture or condensation forms on the shaft surface, these salts dissolve and dissociate:

$NaCl \rightarrow Na^+ + Cl^-$

It is the pre-existing chloride ion, dissolved in the water film, that attacks the protective layer and initiates the pit.

4. Stress Concentration and Fatigue Risk

Each pit functions as a notch. Under the cyclic torsion and bending loads to which the output shaft is subjected, the stress concentration factor (K_t) raises local stresses significantly above the nominal value. The cavity thus becomes the preferred site for initiation of fatigue microcracks.

Over time these microcracks can propagate. In ultrasonic testing the pits may generate indications or hinder detection of real cracks. Documentation of depth, density and location relative to high-stress zones is therefore relevant to integrity assessment.

5. Implications for UT Inspection

- Differentiate pits from other types of discontinuity (forging defects, machining marks, residual weld metal).
- Record depth and density, especially in higher-stress zones.
- Treat their presence as a fatigue-life reduction factor.
- Check the protective condition of the free zones and the ventilation and humidity conditions of the machine room.

The vertical-transportation literature confirms that pitting corrosion is a real problem on steel components exposed to moisture (wire ropes, structural parts and, as observed in the field, also output shafts). Standards EN 81-20 and EN 81-50 do not establish specific criteria for this type of discontinuity nor require ultrasonic testing of these shafts; evaluation remains at the inspector’s discretion, based on good NDT practice, the manufacturer’s manual and fatigue-risk assessment.

6. Protection of Free Zones

Several practical measures can reduce the risk of pitting on the free zones of output shafts:

- **Grease application** — Common industrial greases (lithium or complex-soap based) do not contain chlorides and often include corrosion inhibitors. When applied to a clean and dry surface they form a barrier against moisture. If applied on a wet or contaminated surface they can trap humidity and aggravate the problem.
- **Painting** — A continuous protective coating is an effective barrier provided the surface is properly cleaned and dry before application. Synthetic paints (alkyd, epoxy or polyurethane systems, with or without a corrosion-inhibiting primer) offer better adhesion, humidity resistance and durability. Cellulose (nitrocellulose) paints dry quickly but have lower resistance to moisture and are less suitable for long-term protection in environments subject to condensation. Painting is particularly suitable for zones that are not frequently disassembled.
- **Corrosion-inhibiting oils or compounds** — Thin-film corrosion inhibitors (e.g. oil-based or wax-based temporary protectives) can be applied directly to the shaft. These products leave a residual film that displaces moisture and inhibits electrochemical attack. They are useful in situations where painting is impractical.
- **Environmental control** — Improving ventilation and reducing humidity and condensation in the machine room remains the most effective long-term measure, as it limits the availability of the water film necessary for chloride ions to become active.

No single measure is universal. The choice depends on access, frequency of disassembly and the condition of the machine room.