INTERNATIONAL STANDARD

**ISO 10825-1**

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# Gears — Wear and damage to gear teeth —

## Part 1: Nomenclature and characteristics

*Engrenages — Usure et défauts des dentures —*
*Partie 1: Nomenclature et caractéristiques*



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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.



This document was prepared by Technical Committee ISO/TC 60, *Gears*, Subcommittee SC 1, *Nomenclature and wormgearing*.



This first edition of ISO 10825-1, together with ISO/TR 10825-2, cancels and replaces ISO 10825:1995, which has been technically revised.



The main changes are as follows:

— the document has been split into two parts: ISO 10825-1 and ISO/TR 10825-2 that gives additional information on failure modes;

— some additional modes of failures are described;

— most figures have been replaced and are in colour.

A list of all parts in the ISO 10825 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# Introduction

This document provides a common language to describe gear wear and failure and serves as guidelines to uniformity and consistency in the use of that language. It describes the appearance of gear tooth failure modes. It is intended to improve communication between equipment users and gear manufacturers for failure and wear analysis. Since there can be many different causes for each type of gear tooth wear or failure, it is not possible in this document to identify a single cause for each type of wear or failure, nor to prescribe remedies.

# Gears — Wear and damage to gear teeth —

# Part 1: Nomenclature and characteristics

**IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.**

## 1 Scope

This document provides nomenclature for general modes of gear tooth wear and failure. It classifies, identifies, and describes the most common types of failure and provides information that, in many cases, enables the user to identify failure modes and evaluate the degree or change from original condition.

This document is based on experience with steel gears; however, many of the failure modes discussed apply to gears made from other materials. Not all failure modes that can occur on other types of gears, such as plastic, bronze, or powder metal gears, are included.

The solution to many gear problems requires detailed investigation and analysis by specialists and is beyond the scope of this document.



This document specifies only the terminology intended to help with the identification and reporting of the appearance and conditions of gears after a period of operation. Neither causes nor preventive measures for any condition described are discussed.



In this document, gear refers to both gear wheels and pinions, unless the gear is specifically identified.



This document does not define “gear failure”.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1122-1, *Vocabulary of gear terms — Part 1: Definitions related to geometry*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1122-1 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

## 4 Classes and modes of failure

This document does not define gear failure. One observer's "failure" is another observer's "run-in". There is no single definition of gear failure, since whether or not a gear has failed depends on the specific application.

NOTE The term "gear failure" is subjective and a source of considerable disagreement. For example, a person observing gear teeth that have a bright, mirrorlike appearance can think that the gears have "run-in" properly. However, another observer can think that the gears have failed by polishing wear. Whether the gears are considered failed or not depends on how much change from original condition is tolerable.

Changes made to reduce the risk of one failure mode can sometimes worsen or create other failure modes or have other unintended consequences. Therefore, it is imperative that any remedy be evaluated prior to implementation and thoroughly tested and evaluated after implementation. See ISO/TR 10825-2[1)] for additional discussion on the potential causes of the different failure modes and some suggestions to minimize the risk of them occurring.

Table 1 groups the common modes of gear failure into six general classes. For each class, the preferred terminology is listed, and older or other commonly used names are listed as non-preferred. Additional terms which can help to clarify the general mode are listed in Table 2.

**Table 1 — Nomenclature of gear failure modes**

| General mode | Non-preferred terminology | Sub-clause |
|---|---|---|
| **Tribological damage (non-fatigue)** | | |
| Polishing (unintentional) | Burnishing | 5.2 |
| Scratches | | 5.3 |
| Abrasive wear | Cutting, Scoring[a] | 5.4 |
| Scuffing | Scoring[a], Welding, Microwelding, Galling, Seizing | 5.5 |
| Adhesive wear | Normal, Running-in wear, Tearing, Plucking, Microwelding | 5.6 |
| Fretting corrosion | | 5.7 |
| Interference wear | | 5.8 |
| **Fatigue damage** | | |
| Micropitting | Frosting, Gray staining, Peeling | 6.2.2 |
| Macropitting | Contact fatigue, Destructive, Arrowhead | 6.2.3 |
| Case crushing (subcase fatigue) | Internal rupture | 6.2.4 |
| White layer flaking | | 6.2.5 |
| Tooth flank fracture (TFF) | | 6.2.6 |
| Tooth interior fatigue fracture (TIFF) | | 6.2.7 |
| Tooth root fatigue fracture | | 6.3.1 |
| Rim, web, and hub cracks | | 6.3.2 |
| **Non-fatigue fracture** | | |
| Tooth root rupture | Fast fracture | 7.2 |
| Tooth end rupture | | 7.3 |
| Tooth shear fracture | | 7.4 |
| **Plastic deformation** | | |
| Indentation | Bruising, Peening | 8.2 |
| Brinelling | Denting | 8.3 |

[a] The use of the term "scoring" is strongly discouraged because it can be applied to different types of wear. While it is often considered as a form of adhesive wear, it is sometimes used for abrasive wear.

1) Under preparation. Stage at the time of publication: ISO/DTR 10825-2:2022.

**Table 1** *(continued)*

| General mode | Non-preferred terminology | Sub-clause |
|---|---|---|
| Cold flow | | 8.4 |
| Hot flow | | 8.5 |
| Root fillet yielding | | 8.6 |
| Fracture after plastic deformation | | 8.7 |
| Rolling | | 8.8 |
| Tooth hammer | | 8.9 |
| Rippling | Fish scaling, Scalloping | 8.10 |
| Ridging | | 8.11 |
| Burr | | 8.12 |
| Interference deformation | | 8.13 |
| **Manufacturing issues** | | |
| Forging cracks | | 9.1 |
| Hardening cracks | Quenching cracks | 9.2 |
| Grinding cracks | | 9.3 |
| Hydrogen and internal residual stress | | 9.4 |
| Grinding burn (temper due to grinding) | | 9.5 |
| Grinding notch (not a failure mode) | | 9.6 |
| Scaling | | 9.7 |
| Case/core separation | | 9.8 |
| **Other surface damage** | | |
| Corrosion | | 10.1 |
| Cavitation | | 10.2 |
| Erosion | | 10.3 |
| Electrical discharge | Arcing | 10.4 |
| Overheating | | 10.5 |

[a] The use of the term “scoring“ is strongly discouraged because it can be applied to different types of wear. While it is often considered as a form of adhesive wear, it is sometimes used for abrasive wear.



**Table 2 — Additional terms**

| Additional terms | Mentioned in subclause on: | Subclause |
|---|---|---|
| Point-surface-origin | Macropitting | 6.2.3 |
| Spall, Spalling | Macropitting | 6.2.3 |
| Root fillet cracks | Tooth root fatigue fracture | 6.3.1 |
| Non-fatigue overload | Tooth root rupture | 7.2 |
| False brinelling | Fretting corrosion | 5.7 |
| Gross plastic deformation | Fracture after plastic deformation | 7.1, 8.7 |
| Subsurface-initiated bending fatigue | Tooth flank fracture | 6.2.6 |

# 5 Tribological damages (non-fatigue)

## 5.1 General information on wear

Wear describes changes to a gear tooth flank surface involving the removal of material without any evidence of fatigue cracks. It can be accompanied by some displacement of material. See ISO 1122-1 for definition of flank.

Wear includes polishing, scratches, and abrasive wear. It can be categorized as mild, moderate or severe.

Figures 1 and 2 show moderate and severe wear. They are not intended to indicate the mode of wear.

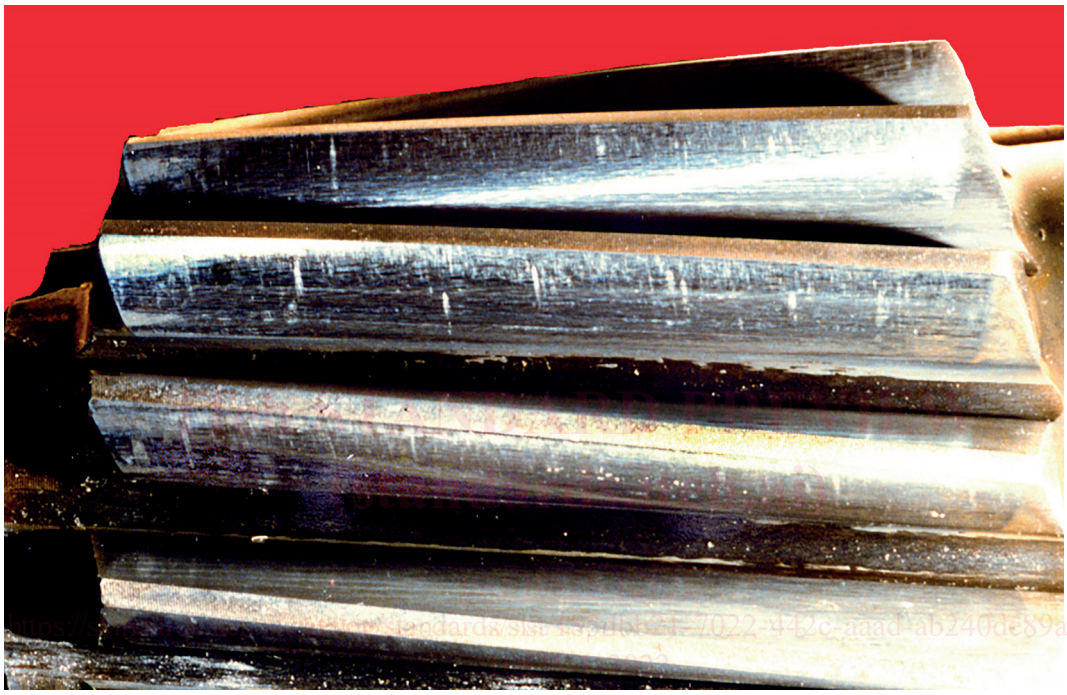


**Figure 1 — Moderate wear**

**Figure 2 — Severe wear**



## 5.2 Polishing wear

### 5.2.1 General

Polishing wear is a very slow wearing-in process in which the irregularities of the contacting surfaces are gradually worn until mirror-like, smooth surfaces develop. The gear tooth flank can be smooth or wavy with local bumps. Under sufficient magnification, the surface appears to be covered by fine scratches that are oriented in the direction of sliding.

NOTE Intentional polishing can occur during the manufacturing process or during running-in.

### 5.2.2 Mild polishing wear

Polishing wear is classified as mild if it is confined to the peaks of the surface asperities. Mild polishing wear typically occurs during running-in and ceases before the original machining marks are removed from the tooth surface.

### 5.2.3 Moderate polishing wear

Polishing wear is classified as moderate if remnants of the original machining marks are visible on the tooth surface.

### 5.2.4 Severe polishing wear

Severe polishing wear removes all of the original machining marks from the active flank of the tooth. The polished surface can be wavy and there can be wear steps at the ends of the active face and in the dedendum. See Figures 3 and 4.

**Figure 3 — Severe polishing on both flanks**

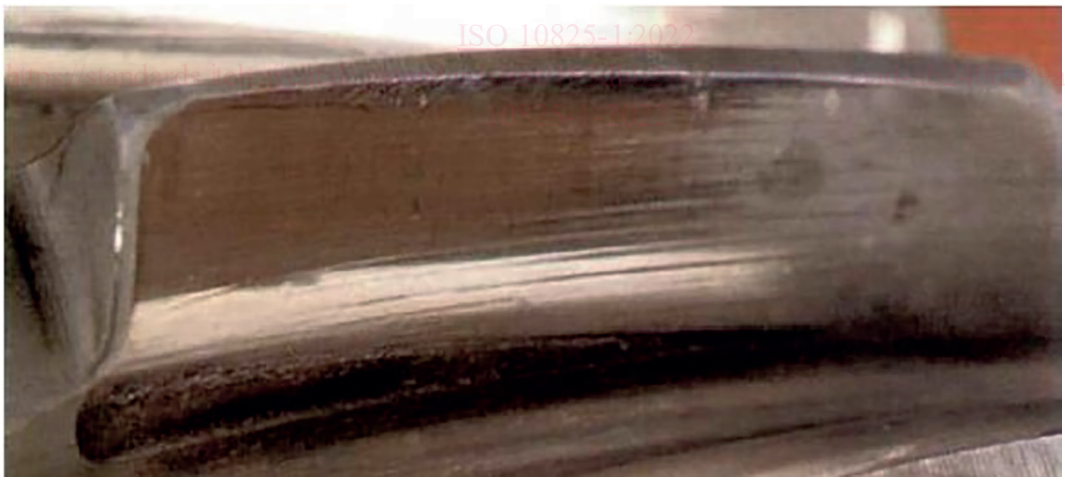


**Figure 4 — Severe polishing on a misaligned gear**

## 5.3 Scratches

Scratches are narrow and shallow grooves or furrows in the surface. They are usually oriented in the sliding direction. This is a specific type of abrasive wear. See Figure 5.

Scratches can also occur during the manufacturing or assembly process; and such scratches can be in any direction.

**Figure 5 — Scratches in sliding direction**



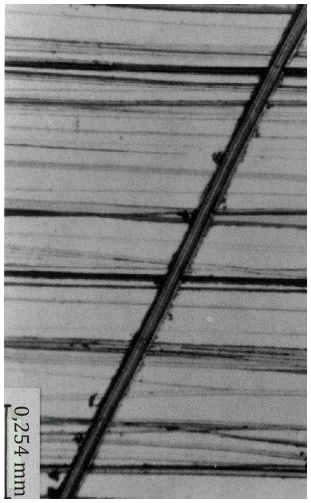
## 5.4 Abrasive wear

### 5.4.1 General



Abrasive wear, also known as abrasion, is the removal or displacement of material due to the presence of hard particles (for example, metallic debris, scale, rust, sand, or abrasive powder, suspended in the lubricant or embedded in the flanks of the mating teeth).

Abrasive wear causes scratches or gouges on the tooth surface that are oriented in the direction of sliding. Under magnification, the scratches appear as parallel furrows that are smooth and clean. See Figure 6.




NOTE The diagonal line is a scratch, an abrasive wear furrow cut by a hard particle showing smooth, clean appearance. The horizontal lines are the original grind marks.

**Figure 6 — A scratch due to abrasive wear, scanning electron microscope (SEM) image**

Abrasive wear due to loose contaminants is called three-body abrasion. The three bodies are the two gear elements and the loose contaminant. Three-body abrasive wear appears as small, usually square, randomly distributed areas that are scuffed or scored. See Figures 7 and 8. Two-body abrasive wear occurs when embedded particles or asperities on one gear tooth abrade the opposing tooth surface, leaving long scratches that often form a repeating pattern.

Based on the severity, abrasive wear can be categorized as mild, moderate, or severe.

**Figure 7 — Three body abrasive wear**

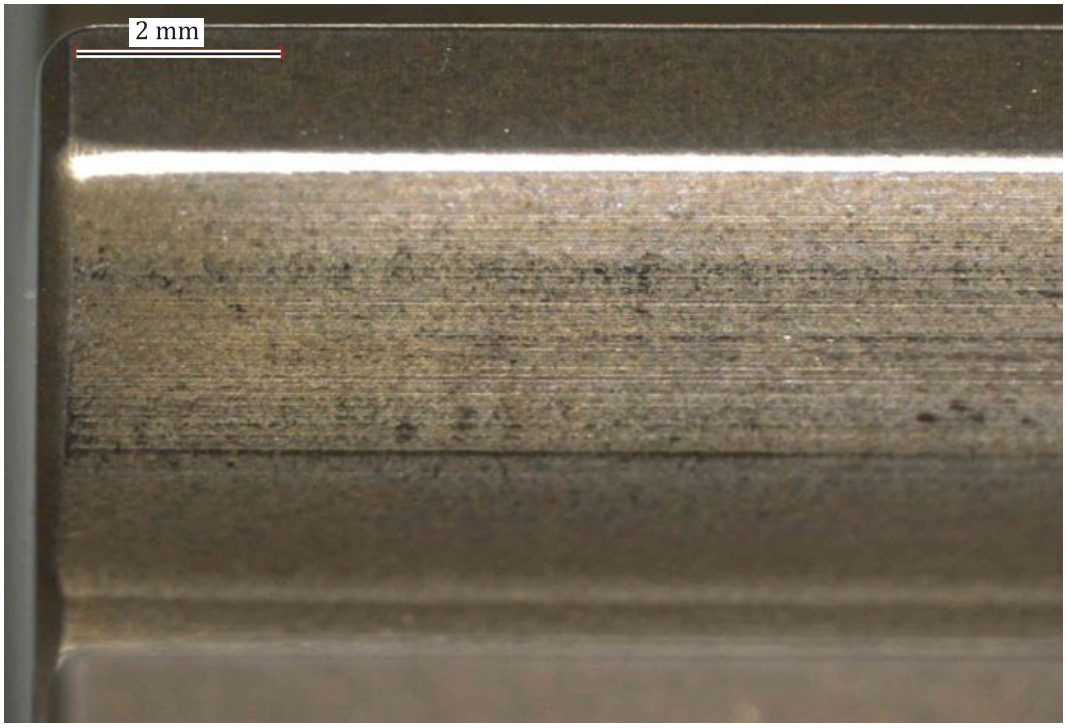



**Figure 8 — Three body abrasive wear**



### 5.4.2 Mild abrasive wear

Abrasive wear is classified as mild if it consists of fine scratches that are not so numerous or deep enough to remove significant amounts of material from the tooth flank surface and some machining marks are visible on the tooth surface. See Figure 9.



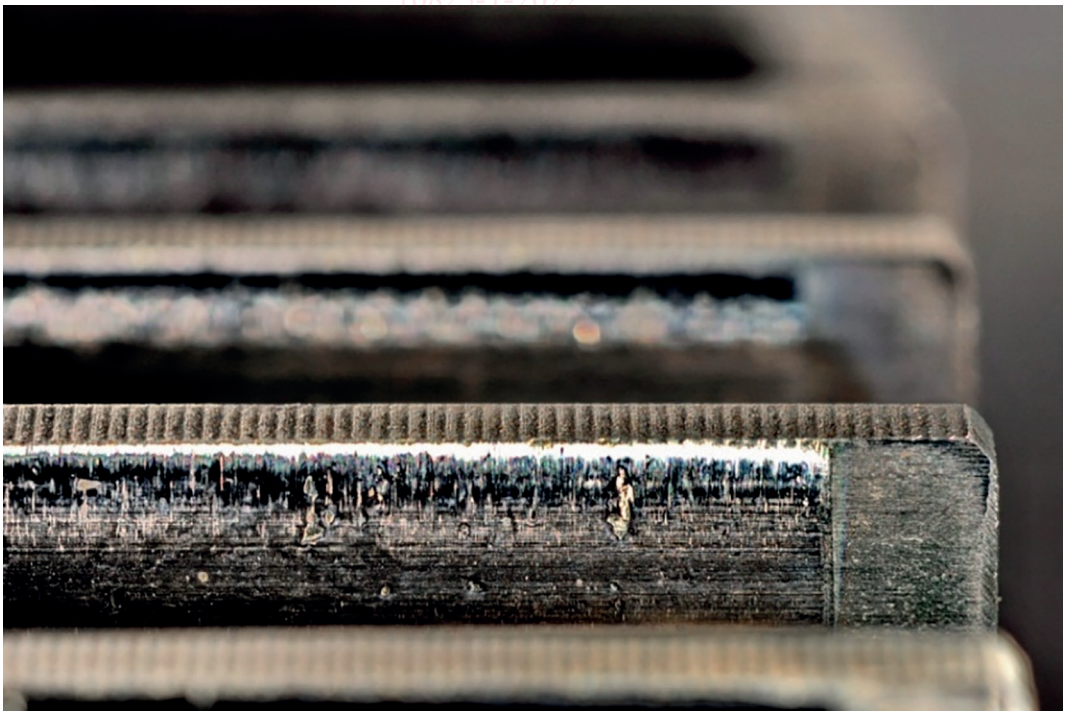


**Figure 9 — Mild abrasive wear near the tip of a ground gear**