TECHNICAL REPORT

ISO/TR 10825-2

First edition
2022-10

Gears — Wear and damage to gear teeth —

Part 2: Supplementary information

Engrenages — Usure et défauts des dentures —

Partie 2: Informations supplémentaires

Reference number
ISO/TR 10825-2:2022(E)

© ISO 2022



COPYRIGHT PROTECTED DOCUMENT

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

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

Published in Switzerland

© ISO 2022 – All rights reserved

Contents

Page

Foreword ..... **vi**
Introduction ..... **vii**
1 Scope **1**
2 Normative References **1**
3 Terms and definitions **1**
4 Overview and warnings **1**
4.1 Overview 1
4.2 Warnings 2
5 Tribological damage (non-fatigue) **2**
5.1 General 2
5.2 Polishing 2
5.2.1 General 2
5.2.2 Summary of methods that have been observed to reduce the risk of polishing 3
5.3 Scratches 3
5.4 Abrasive wear 3
5.4.1 General 3
5.4.2 Sources of particles that cause abrasive wear 3
5.4.3 Methods for reducing abrasive wear 4
5.5 Scuffing 5
5.5.1 General 5
5.5.2 Methods for reducing the risk of scuffing 6
5.5.3 Summary of methods that have been observed to reduce the risk of scuffing 7
5.6 Adhesive wear (Adhesion) 8
5.6.1 General 8
5.6.2 Summary of methods that have been observed to reduce the risk of adhesive wear 9
5.7 Fretting corrosion 9
5.7.1 General 9
5.7.2 False brinelling 9
5.7.3 Fretting corrosion 10
5.7.4 Summary of methods that have been observed to reduce the risk of fretting 10
5.8 Interference wear 11
6 Fatigue damage **11**
6.1 Fatigue cracks 11
6.2 Contact fatigue 11
6.2.1 General 11
6.2.2 Micropitting 11
6.2.3 Macropitting 15
6.2.4 Case crushing (subcase fatigue) 19
6.2.5 White layer flaking 20
6.2.6 Tooth flank fracture (TFF) (subsurface initiated bending fatigue) 20
6.2.7 Tooth interior fatigue fracture, TIFF 21
6.3 Bending fatigue 22
6.3.1 Tooth root fatigue fracture 22
6.3.2 Rim web and hub cracks 28
7 Non-fatigue fracture **29**
7.1 General 29
7.1.1 Brittle fracture 29
7.1.2 Summary of methods that have been observed to reduce the risk of brittle fracture 30
7.1.3 Ductile fracture 31

© ISO 2022 – All rights reserved

7.1.4 Mixed mode fracture 31
7.2 Tooth root rupture 31
7.3 Tooth end rupture 31
7.4 Tooth shear fracture 32

8 Plastic Deformation 32
8.1 General 32
8.2 Indentation 32
8.3 Brinelling 32
8.4 Cold flow 32
8.5 Hot flow 33
8.6 Root fillet yielding 33
8.7 Fracture after plastic deformation 33
8.8 Rolling 33
8.9 Tooth hammer 33
8.10 Rippling 33
8.11 Ridging 33
8.12 Burr 33
8.13 Interference deformation 34
8.13.1 Tip to root fillet interference 34
8.13.2 Tip-to-dedendum interference 34
8.13.3 Tight mesh 34

9 Manufacturing problems 34
9.1 Forging cracks 34
9.2 Hardening cracks 34
9.2.1 General 34
9.2.2 Thermal stresses 34
9.2.3 Stress concentration due to heat treatment 35
9.2.4 Quench severity 35
9.2.5 Phase transformation 35
9.2.6 Material defects 35
9.2.7 Heat treating practice 35
9.2.8 Tempering practice 36
9.2.9 Detection of hardening cracks 36
9.2.10 Summary of methods that have been observed to reduce the risk of hardening cracks 36
9.3 Grinding cracks 36
9.3.1 General 36
9.3.2 Summary of methods that have been observed to reduce the risk of grinding cracks 37
9.4 Hydrogen and internal residual stress gear failures 37
9.4.1 General 37
9.4.2 Hydrogen flake term 38
9.4.3 Fish eye 39
9.4.4 Segregation cracks 39
9.4.5 Deferred breakage 40
9.5 Grinding burn (temper due to grinding) 40
9.6 Grinding notch 40
9.7 Scaling 40
9.8 Case/core separation 40
9.8.1 General 40
9.8.2 Summary of methods that have been observed to reduce the risk of case/core separation 41

10 Other surface damage 41
10.1 Corrosion 41
10.1.1 General 41
10.1.2 Summary of methods that have been observed to reduce the risk of corrosion 42

© ISO 2022 – All rights reserved

10.2 Cavitation 42
10.3 Erosion 43
10.4 Electric discharge 43
10.4.1 General 43
10.4.2 Summary of methods that have been observed to reduce the risk of electrical discharge damage 43
10.5 Overheating 44
Bibliography **45**

© ISO 2022 – All rights reserved

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

The main changes are as follows:

— ISO 10825:1995 has now two parts: ISO 10825-1 and ISO/TR 10825-2 that gives additional information on failure modes.

A list of all parts of 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.

© ISO 2022 – All rights reserved

Introduction

This document has been developed to assist readers in identifying possible causes of gear tooth damage and potential ways to avoid future damage. However, it is not intended to give a definitive reason for the damage observed. Some causes that are included are still a topic of research and discussion but are presented with the intent to provide possibilities. Also, in some cases, steps taken to reduce the risk of one type of damage can increase the risk of another type of damage.

This document is intended as a supplement to ISO 10825-1. To facilitate the correlation of the information in the two parts, both documents have the same structure. Some sections in this document are mainly place holders to keep the structures parallel.

© ISO 2022 – All rights reserved

Gears — Wear and damage to gear teeth —

Part 2:
Supplementary information

1 Scope

This document provides information on gear tooth wear and damage. The material contained herein is intended to help the user better understand damage to gear teeth, but the potential reasons for damage and preventive measures discussed are not definitive. Also, for individual cases, other reasons for damage or measures can exist that are not mentioned in this document. At the same time, reasons for damage or measures mentioned in this document are not always of importance. In many cases, damage can be the result of multiple interacting factors. Some causes that are included are still a topic of research and discussion but are presented with the intent to provide possibilities.

The solution to many gear problems involves detailed investigation and analysis by specialists; this document is not intended to replace such expert knowledge.

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 10825-1, *Gears — Wear and damage to gear teeth — Part 1: Nomenclature and characteristics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10825-1 and the following 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 Overview and warnings

4.1 Overview

Gears can be damaged by a wide variety of mechanisms. Damage can range from insignificant damage that can be ignored to damage that makes the gearset unusable. The term “gear failure” is subjective and a source of considerable disagreement. In the case of flank surface damage, there is no single definition of gear failure, since whether a gear is considered to have failed depends on the specific application. When there are only small changes to the surface, such as gear teeth that have a bright, mirrorlike appearance, by observing them, one can think the gears have “run-in” properly. However, another observer can think the gears have failed by polishing wear. There are numerous ways that the tooth surface can change over time. Whether the gears are considered failed or not depends on how much change is tolerable.

© ISO 2022 – All rights reserved