Gesellschaft für Tribologie e.V.

Wear parts

Position paper of the Gesellschaft für Tribologie e.V.

'Wear' and 'wear parts' in contextual relation with 'obsolescence'

Tribology in Germany

Wear Parts

Position paper of the Gesellschaft für Tribologie e.V.

'Wear' and 'wear parts' in contextual relation with 'obsolescence'

Initiators:

Dr. Mathias Woydt
MATRILUB, Berlin

Rolf Luther
FUCHS Schmierstoffe GmbH, Mannheim

Under the participation of:

Member of committees of the Gesellschaft für Tribologie e.V.

Imprint

Publisher and distribution:
Gesellschaft für Tribologie e.V.
Adolf-Fischer-Str. 34, D-52428 Jülich, Germany
E-Mail: tribologie@gft-ev.de – Internet: www.gft-ev.de

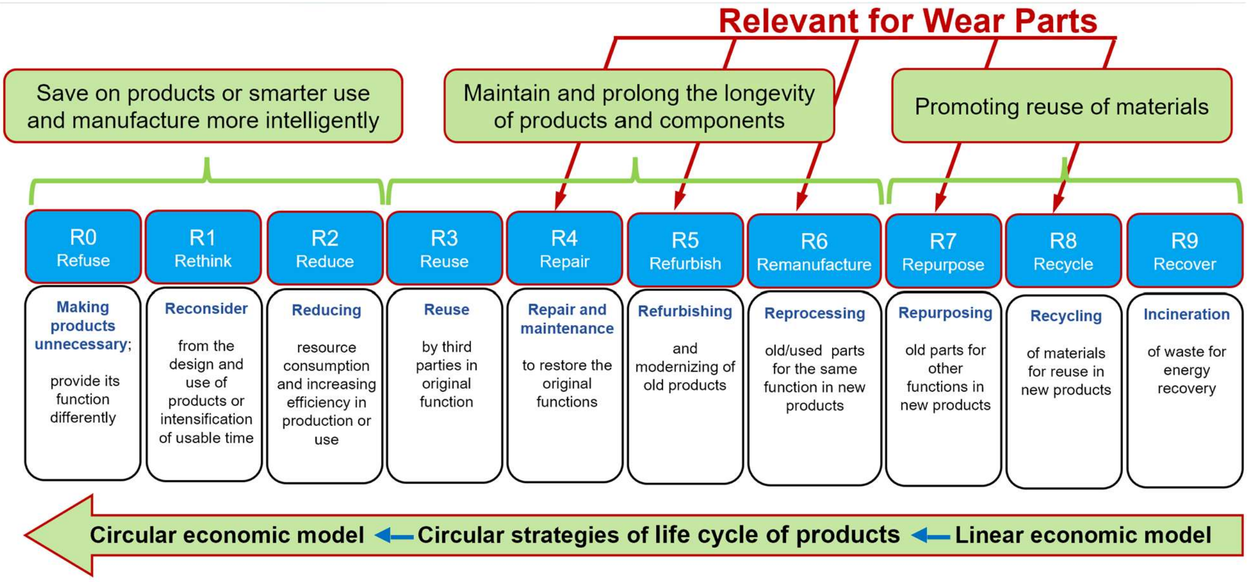
Design and typesetting:
pulcinello
Marcus Depenbusch
E-Mail: info@pulcinello.de – www.pulcinello.de

English Translation:
Schmitt Language Solutions
Helmut Schmitt
Valentinstraße 19, D-76189 Karlsruhe, Germany
Phone: +49 1703810154
E-Mail: info@schmitt-language-solutions.de

1) Introduction

The terms “wear” and “wear part” insinuate a direct contextual relation. Following, an in-depth terminological examination shall demonstrate that a “wear part” cannot imperatively be associated with mechanical wear.

Improving product longevity offers a strategy for achieving the goals of the 2015 Paris Agreement on Climate Change. Material efficiency translates into resource conservation and contributes significantly to energy efficiency. Consequently, the reduction of material waste is paramount for achieving the objectives of the Paris Agreement. This includes the extension of service life, avoiding planned obsolescence, and, generally, the manufacture of more sustainable products. Technological considerations not only encompass recycling and circular economy, but also repair (R4), reuse (R3), remanufacture (R6), refurbishment (R5), etc. The concept of durability/service life[1] represented in the following figure features longevity, repairability and ease of maintenance of the product [1, 2].



As part of the European Green Deal, the European Commission introduced a new “right to repair” (EC/2024/1799) in the framework of an Action Plan for the circular economy. The term “wear part” appears more frequently in the context with the Ecodesign Directive (e.g. EU/2024/1781). This term must be distinguished unambiguously from the term “wear ”. While “wear” is clearly defined within the framework of tribology and lubrication technology, the term “wear part” must be redefined and delimited in order to avoid possible misuse.

[1] The 9R Framework; source: own representation based on Potting et al. (2017), p. 5, [1].

The objectives of the EU Taxonomy - Regulation EU/2020/852 provide a number of attributes for wear protection as follows:

Objectives	**Attributes and contributions of tribology**
(1) An economic activity makes a significant contribution to the transition to a circular economy, including ***waste prevention***, reuse and recycling, if:	Wear protection = technical longevity and service life extensions reduce the amount of waste produced
a) It uses ***the natural resources***, including bio-based and other raw materials of sustainable origin ***more efficiently*** in production, e.g. through	Bio-lubricants and lubricants from biogenic resources; bio-plastics
i. ***reduction in the use of primary raw materials*** or an increase in the use of by-products and secondary raw materials; or	Wear protection = material efficiency and resource conservation.
ii. ***resource and energy efficiency measures;***	Energy efficiency due to friction reduction and resource efficiency through wear protection lead to CO_2 reduction.
b) It improves the ***durability***, repairability, upgradability or reusability of products, in particular in design and manufacturing activities;	Longevity through wear protection reduces waste volumes and resource consumption
e) Prolongs the use period of products, also through reuse, ***design for longevity***, refunctioning, disassembly, remanufacturing, modernization and ***repair***, and sharing of products;	Low-wear tribological systems and their remanufacturing conserve resources with the embedded CO_2-footprint.
k) ***Avoids or reduces waste.***	Longevity, repairability and refurbishment reduce waste volumes

In EU/2020/852, the "**inefficiency in the use of materials**", including the lack of wear protection and repairability, is classified as an economic activity significantly impairing environmental objectives (Art. 17(1) d) i)). Wear protection and increased longevity are core strategies for the prevention of waste and reduction of embedded CO_2-footprint

In such a context, terms like ***service life***, ***durability and life span*** are essential to identify the capability of a part or a product to function as required under defined conditions of use, maintenance and repair until a limit state is attained. Under consideration of customer or market requirements and the technical complexity of the product, this "service life" is determined in advance.

Direct reuse, comprehensive refurbishment, and remanufacturing are among the **value retention processes** additionally extending the potential useful life of a product beyond the traditionally expected life span.

The G7 Toyama Framework on Material Cycles focuses on **Value Retention Processes** (VRP) and is fine-tuned with the current objectives of resource efficiency and resource productivity within circular economy and waste prevention [3]. At their core, value retention processes preserve both material value and product functionality. Repair is considered one of the value retention processes.

The United Nations International Resource Panel defines “value retention processes” as follows [1]:

> **“Value retention processes** are activities, typically production-related activities, promoting the completion and/or potential extension of the useful product life beyond its traditionally expected use period. Such processes include direct reuse, repair, extensive refurbishment and remanufacturing.”

The concepts for **retention of value** or **functionality** are in line with the United Nations Sustainable Development Goal #12 safeguarding sustainable consumption and production patterns.

Following, a compilation of sources for various definitions of “wear” and “wear part” (and equivalent terms) which shall illustrate the wide range of different perceptions among stakeholders.

Uniform terminology for the terms “wear” and “wear part” will promote mutual footing and understanding between scientists, industry, regulating authorities and public mandatory to define the scope of legislation.

2) Wear

Globally, various standardized definitions of the term “wear” exist, all of which are essentially similar. Additionally, DIN50320 depicts special cases not readily apparent from the main set of definitions. GfT Worksheet No. 7 corresponds with DIN50320-1979. Even if the public perception of the term “wear” may vary, the following selection offers, from a technical standpoint, both strong convergence and large consensus:

i. TGL[2] 0-50320, April 1963

Wear from a technical viewpoint is perceived as undesirable, mechanically caused separation of small particles from the surface of commodities in day-to-day use.

Note:

“Mechanical” - In contrast, corrosion is caused by chemical or electrochemical effects. Friction oxidation and the transition of metals on contacting surfaces constitute processes of alternating chemical and physical reactions on the mating surfaces. When numerous objects are subject to simultaneous stress caused by wear, corrosion and other effects, it is generally referred to as wear-out (see chapter 4).

ii. DIN[3] 50320-1979

Wear is the progressive material loss from a surface of a solid body caused by mechanical causes, such as contact and relative motion of a solid, liquid or gaseous mating body.

Notes: Technical standards, quality regulations and delivery conditions

a) The stress on the surface of a solid body through contact and relative movement of a solid, liquid or gaseous mating body is referred to as tribological stress.
b) Wear manifests in the occurrence of small particles (wear particles) as well as in the deformation of material and shape of the tribologically stressed subsurface area.

[2] TGL stands for “Technical Standards, Quality Regulations, and Delivery Conditions“ of the former German Democratic Republic (GDR). Office for Standardization, Metrology and Quality Control, Berlin – GDR.

[3] Deutsches Institut für Normung e.V. (German Institute for Standardization), 10787 Berlin; Germany

c) Wear is usually considered undesirable, i.e. depreciating the value. In particular cases, such as running-in processes, wear can be favorable for technological reasons. In relation to the manufactured workpiece, machining as a value-creating technological process is not considered wear, although tribological processes such as wear occur on the mating surface between workpiece and tool.

iii. **ASTM[4] G40-22a**
Wear — Alteration of a solid surface by progressive loss or progressive displacement of material due to relative motion between that surface and a contacting substance or substances.

iv. **ASTM D4175-23a**
Wear — Damage to a solid surface, generally involving progressive loss of material due to relative motion between that surface and a contacting substance or surface.

v. **NLGI[5] Grease Glossary**
Wear — Damage that involves the cumulative and gradual removal of material from surfaces.

vi. **Prof. Dr. Gerd Fleischer [4], Otto-von-Guericke University of Magdeburg**
"Wear is a permanent alteration in shape, size or material of the material areas forming the surface of solids due to friction".

vii. **Prof. Dr. Erik Kuhn [5], Hamburg University of Applied Sciences (HAW Hamburg)**
“Wear is a generation of irreversibility occurring as a result of frictional energy and comprises all elements of a tribological system.”

Based on the financial term “depreciation”, the German language also uses the technically connotated term “wear-out” (German: Abnutzung) in lieu of "wear" (German: Verschleiß). Common practice uses the term “wear” in ‘dual’ fashion both for the wear process and the result as in “worn”.

3) Wear part

Currently, no binding definitions exist for the term “wear part”[6]. Nonetheless, various terms circulate that are used and perceived similarly. Particularly, the term “spare part” is used with alike connotation. Worksheet No. 7 of the Society for Tribology reveals the following definitions under entry #116:

“Part stressed by wear. Predominantly used for parts subject to wear stress".

Every equipment, machine or system is composed of individual components or assemblies (hereinafter referred to as “part”). Each part may fail or become obsolete for various reasons, making continued operation impossible. Ideally, every worn, defective or obsolete part is replaceable. Subsequently, every part is potentially also a **spare part** or ultimately a “replaceable part”. As a result, any kind of functional subsystem loss leads to a loss of usability of the entire product. Conversely, this means that all subsystems causing foreseeable functional loss, regardless of the mechanism causing it, must be replaceable.

[4] ASTM= American Society for Testing and Materials, West Conshohocken, PA 19428, USA.
[5] NLGI= National Lubricating Grease Institute, Liberty, MO 64068, USA.
[6] A sub-committee of the DIN Environmental Protection Helpdesk (EPH) deals with issues of wear parts (KU-AK7, “Resource conservation and environmentally compatible product and process design, section II ”Wear parts").

Function-maintaining spare parts needing to be replaced on a regular basis are frequently summarized as **wear parts**, regardless of their failure mechanism. However, they are not faulty or defective. Instead, they are parts to be replaced as scheduled prior to the end of the product's useful life, if the product was used as intended. Such parts are hence considered consumables.

Consequently, a **wear part** is a replaceable part (or assembly) that may be substituted by a spare part which is either identical in function or covering its function. That is applicable for maintaining or restoring the function and value of a consumed product or part (preventive maintenance) at risk of failure or defective.

Wear mechanisms causing loss of function only tread one wear path. Such wear-out failures are described in EN 45552:2020 as failures caused by cumulative degradation due to stress during normal use. Fatigue, material embrittlement, corrosion, degradation, oxidation, diffusion, exposure to environmental/weather impact, etc. are other potential mechanisms leading to failure (defects, part degeneration) or to the depletion of the intended function [6].

In terms of tribological functionality, also the lubricant[7] constitutes a potential wear part. In machine and system manufacturing, wear parts include spare parts intended to be replacing as precautionary measure to maintain functionality (preventive maintenance), e.g.:

- legally prescribed replacement intervals,
- elements to be replaced periodically for safety reasons (e.g. suspension cables, chains, bearings),
- parts composed of ageing or degrading materials (e.g. hydraulic hoses).

Filters, oils, greases and seals primarily serve to retain value, although they do not actually wear. DIN 24420-1 mentions “wear” only in relation to spare parts. The irreversible, wear-induced loss of material on surfaces requires concepts for predictive and preventive maintenance.

When elaborating on maintaining functionality, a spare part often offers improvement of machine or system as a retro-fit, by modernization or tuning instead of replacing the original part 1 by 1. Instead, a more sophisticated or, after many years of operation, more advanced state-of-the-art technology is incorporated. Due to their ease of replacement, lubricants are particularly well-suited for retro-fitting intended to enhance energy efficiency by friction reduction. Obsolescence caused by outdated technology can be thus avoided.

[7] The main purposes of lubricants are to reduce friction, minimize wear, and protect against adhesive failure (scuffing). Therefore, all aspects of resource and energy efficiency apply equally to lubricants. A lubricant is also a valuable source of information for observing the temporal changes over time on the wear parts it lubricates.

Primary body and counter body (interacting surfaces) form a tribological system by means of an interfacial media and constitute a material partner. Although a lubricant is accessible to mathematical simulation and represents a design element in the sense of a tribological system. Therefore, many do not regard it as a “part”, but rather as an “operation material”, as it is not permanently installed in a fixed location and usually circulates (does not apply for greases). Some argue, that according to the definition of wear in DIN50320 or GfT Worksheet No. 7 a lubricant cannot “wear”. Yet, it disintegrates primarily through oxidation and degradation of functional additives. Physical and/or oxidative evaporation also results in a “progressive loss of material” during operation which is easier replenished by top-ups compared to a fixed and installed wear part.

Lubricants ensure wear protection and protection against adhesive failure (scuffing, seizure) through functional additives forming tribo-films, which in turn wear or wear out and can only be replenished from the lubricant in the tribo-contacts. At some point, additives for replenishing are no longer available resulting in a functional loss. Ultimately, the lubricant is consumed and thus “worn out” and seen as “wear part”.

Prof. Dr. E. Kuhn defines rheological wear or lubricant wear of fluids as follows: “Irreversible structural changes occurring in stressed areas of a structurally viscous lubricant as a result of tribological stress” [5].

A multitude of definitions are available for the term **spare part:**

i. **DIN 24420-1**
   Spare parts are "parts (e.g. also called individual parts), groups (e.g. also called assemblies and part groups) or complete products intended to replace damaged, worn or lacking parts, groups or products."

ii. **VDI 2892 (2019):**
   "**Spare parts** serve to maintain the function and retain the value of machines and systems in use. Provision of tailored spare parts is an essential influencing parameter for the availability and thus the economic efficiency of such machines and systems."

iii. **Directive 2011/65/EU, article 3 (27)**
   Spare Part — Spare part means a separate part of an EEE that can replace a part of an EEE. The EEE cannot function as intended without that part of the EEE. The functionality of EEE is restored or is upgraded when the part is replaced by a spare part.
   Note: EEE means electrical and electronic equipment.

iv. **Automotive Parts Remanufacturers Association (APRA)**[8]
   Spare Parts — Replaceable component, sub-assembly and assembly identical to and interchangeable with the item it is intended to replace.
   Note: Often called spare or service part (in the US).

v. **Basics of maintenance according to DIN 31051-2019**
   A **spare part** constitutes a part, component, device, subsystem, functional unit, operating equipment or system, which can be described and considered as intended to replace a corresponding object in order to maintain the originally required function of the object.
   Note: According to DIN 31051, a lubricant (operating equipment) can be described and considered as a spare part. Lubricants are integral elements of maintenance plans and intended for replacement as such.

4) Wear reserve and wear-out

Within the context of "wear", DIN 31051-2019 introduces another term: **wear reserve** (section 3.3.4, ibid) describes the reserve of possible functions implemented under specified conditions. Once the wear reserve has been depleted, the machine loses the capability to provide guaranteed or specific performance properties and must be repaired in order to restore the predefined nominal condition.

Wear-out[9] (connotated as "Abnutzung") is defined in DIN 31051-2019 (section 3.3.1) as follows:

> "Degradation of the wear reserve caused by chemical and/or physical processes".
> Note 1: Such processes are caused by different stresses, e.g. by friction, corrosion, fatigue, ageing, cavitation, fracture, etc.
> Note 2: Wear-out is unavoidable.

TGL 0-50320, April 1963, describes **wear-out** as follows:

---

8 Remanufacturing Terminology - Remanufacturing Term Guideline, 06.03.2012, Automotive Parts Remanufacturers Association, APRA Europe AISBL, Brussels

9 The *International Research Group on Wear of Engineering Materials* of the OECD (OECD-IRG) pointed out in 1969 [7] that a possible distinction in German between wear (Verschleiß) and wear-out (Abnutzung) = wear + corrosion (i.e. combined solicitations/stresses) does not exist in English. Wear (connotated as Abnutzung) should be referred to in English as wear-out" or "wear-out part". The authors of this paper opt to use "wear-out", since it makes a clear distinction to the colloquially used terms "wear and tear". "Wear-out part" part distinctly describes the result from wear rather than the not so relevant process as in "wearing part".

> “The term ‘wear-out’ should be used as a generic term for mechanical impact (wear), chemical or electrochemical impact (corrosion) as well as for thermal and other impacts” (see 2.i.).

“Depreciation for wear-out of fixed assets” is firmly anchored in business management and tax law. Wear-out parts and wear parts are eventually synonymous variants.

5) Obsolescence

In an industrial environment, obsolescence (from the Latin obsolescere = to wear out) is perceived as a product no longer having up-to-date performance or also as the concept of finite durability of technical parts in the shift of technical progress and market demand.

According to DIN 13306-2018 “Maintenance - terms of maintenance”, obsolescence (section 4.19) is defined as the “incapacity of an object to be repaired because of the market coming short of providing the required resources under acceptable technological and economic conditions”.

Obsolescence overlays the efforts of the United Nations with Goal #12 of striving for sustainable consumption and production patterns. The concept of durability features longevity, repairability and ease of maintenance of a product. In relation to resource consumption and future CO_2-reduction, attributes such as “lifespan/durability/life cycle” are initially out of focus.

“Zero wear” or “no wear” can be considered hostile towards technological progress. On the occasion of a wear conference in 1938 (!) held by the Society of German Engineers (VDI), the following was postulated [8]:

> "Wear research should never be aimed at maintaining operational facilities beyond their technical or economic viability. Only a short-sighted person will therefore equate this goal with the discovery of a non-wearing material …”.

Prior to an evaluation, a clear distinction must be made between wear[10] and obsolescence[11]. An obsolete commodity must be replaced regardless of the cause for its obsolescence, whereas replacing a commodity which is simply worn but still up-to-date causes senseless consumption of resources - all provided that spare parts are available and repairability is provided. Consequently, sustainable wear protection or maintenance should go beyond the life span of obsolete commodities, but also requires updating the overall system in order to prevent obsolescence. This is, for example, applicable for software updates. As a matter of fact, political measures enhancing product life cycles are key strategies for implementing the vision of a circular economy because extended life cycles can eventually save resources and ultimately reduce CO_2.

In individual cases, this goal must be examined for an equilibrium between the CO_2-footprint for a new production and a more energy-efficient use phase. Therefore, the decision on “old or new” largely depends on the duration of the period under consideration.

Furthermore, technological obsolescence arises from the functional properties of existing products inferior to those of newer models, such as compliance with legal requirements or CO_2-emissions during the use phase (Scope 3, category 11).

In 2016, the German Federal Environment Agency (abbreviated in German: UBA) published a study elaborating on this topic. For the first time, this study investigated in detail consumer

[10] Technical or physical wear, material obsolescence: Material obsolescence is caused by the inadequate performance of materials and components, but also by extensive or intensive use.

[11] Functional obsolescence, moral wear: causes of functional obsolescence are the rapidly shifting technical and functional requirements for a product or the obsolescence due to technical progress.

behavior, replacement habits and the causes of defects in electrical and electronic appliances of the four product categories: large household appliances, small household appliances, information and communication technology and consumer electronics. The findings served to develop strategies against obsolescence [9]. The study also demonstrated that there is a multitude of reasons for the replacement of electrical and electronic appliances. Quote: "Material, functional, psychological and economic manifestations of obsolescence are all interconnected hence creating a highly complex pattern. Even the causes of material obsolescence are generally very diverse and therefore do not allow defining a sharp focus."

Analysis shows a trend that the initial use period of most examined product groups has decreased. In the field of consumer electronics and information technology, but also for large household appliances, technological leaps and the impulse to own a new appliance often triggers a new purchase. However, the study was unable to prove that manufacturers intentionally manufacture products with built-in defects leading to short lifespans or the so-called planned obsolescence. Rather, manufacturers calculate a certain product lifespan directed to target groups, areas of use and product cycles.

A clear definition of "planned obsolescence" and the objectives thereof are subjects of a highly controversial debate. In recent years, the debate on obsolescence, particularly the discussion on material and functional obsolescence, has become livelier.

Quote from the aforementioned study of UBA: "In view of the technological further developments and innovations ... *service life requirements* and *standardization* shape the higher-level remedies against obsolescence. In addition, extensive measures are required to implement innovative manufacturer service concepts, the definition of minimum software requirements, better consumer information, more mandatory manufacturers information and improved repairability."

6) Definition of 'wear part'

As part of an intensive consensus finding process[12], GfT suggests to condense the following definition by limitation to tribological stresses:

> "A wear part is a replaceable part, subassembly or assembly identical to and interchangeable with the object it is intended to replace, all with the purpose of restoring the loss of function caused by wear mechanisms impairing either product or part."

7) Appendix

Since an object no longer functional is widely considered as "worn", the term 'wear part', terminologically restricted to tribological aspects in chapter 6, is commonly used in a much broader sense. A seal, for example, usually fails due to shrinkage, swelling, post-crosslinking, etc., but not due to "wear". Nevertheless, a seal showing leakage is generally considered worn. Such examples are the reason why elaborating an exact technical definition still remains the matter of expert discussions within the GfT.

Expanding the term "wear part" beyond immediate tribology can lead to the following wording:

[12] This accompanying text including footnotes also reveals controversial views on the integration of lubricants as "wear part".

“A **wear-out part** is a replaceable part, component, device, subsystem, functional unit, operating medium or system identical to and interchangeable with the object it is intended to replace, for the purpose of restoring the value or function of a faulty or defective product or a part consumed as intended.”

Note: In addition to wear, also corrosion, degradation, oxidation, diffusion, fatigue, etc. can be subsumed as failure mechanisms (defects) or reasons for a reduction in functionality or value.

8) Bibliography

[1] J. Potting, M. Hekkert, E. Worrell and A. Hanemaaije, Circular economy: Measuring innovation in the product chain, English translation of the report ‘Circulaire economie: Innovatie meten in de keten’, PBL Netherlands Environmental Assessment Agency, The Hague, 2017, PBL publication number: 2544

[2] N. Nasr, J. Russell, S. Bringezu, S. Hellweg, B. Hilton, C. Kreiss and N. von Gries, Re-defining Value – The Manufacturing Revolution. Remanufacturing, Refurbishment, Repair and Direct Reuse in the Circular Economy. A Report of the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya, 2018

[3] J. D. Russell and N. Z. Nasr, Value-retained vs. impacts avoided: the differentiated contributions of remanufacturing, refurbishment, repair, and reuse within a circular economy, Journal of Remanufacturing (2023) 13:25–51, https://doi.org/10.1007/s13243-022-00119-4

[4] G. Fleischer, H. Gröger and H. Thum, Verschleiß und Zuverlässigkeit (Wear and reliability). VEB Verlag Technik, Berlin, Germany, 1980.

[5] E. Kuhn, Zur Tribologie der Schmierfette (On the tribology of lubricating greases). Renningen, p. 9f, second edition, 2014, expert Verlag, 71272 Renningen, Germany, ISBN 978-3-8385-5182-1

[6] H. Czichos, Cyber-physische Systeme und Industrie 4.0 (Cyber-physical systems and Industry 4.0), in: Technologie, Springer Vieweg, Cham, 2023, https://doi.org/10.1007/978-3-031-44243-8_5

[7] Glossary of terms and definitions in the field of friction, wear and lubrication, OECD working group on Wear of Engineering Materials (OECD-IRG), Paris, 1969; page 64 und item 486.

[8] E. Siebel and M. Würges, Verschleißforschung (Wear Research), lectures at the VDI wear conference "Reibung und Verschleiß" (friction and wear), 28.-29. October 1938, Stuttgart, VDI-Verlag GmbH, Berlin NW7, pp. 1-3

[9] S. Prakash, G. Dehoust, M. Gsell, T. Schleicher, R. Stamminger, Influence of the service life of products in terms of their environmental impact: Establishing an information base and developing strategies against "obsolescence", TEXTE 09/2020, Ressortforschungsplan of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, ISSN 1862-4804,