EUROPA-FACHBUCHREIHE
für metalltechnische Berufe

Dr. Eckhard Ignatowitz, Christina Murphy, Falko Wieneke, Heinz Bernhardt

TECHNISCHES ENGLISCH
zur
FACHKUNDE METALL

3. Auflage

VERLAG EUROPA-LEHRMITTEL · Nourney, Vollmer GmbH & Co. KG
Düsselberger Straße 23 · 42781 Haan-Gruiten

Europa-Nr.: 12357

Autoren:

Heinz Bernhardt		OStR a. D.	Waldbronn
Dr. Eckhard Ignatowitz	Dr.-Ing., Dipl.-Ing.	StR. a. D.	Waldbronn
Christina Murphy	Dipl.-Berufspäd. (Univ.)	StD in	Wolfratshausen
Falko Wieneke	Dipl.-Ing.	StD	Essen

Leitung des Arbeitskreises und Lektorat:

Dr. Eckhard Ignatowitz

Bilder und Bildentwürfe:

Ein Teil der Bilder stammen aus dem Buch Fachkunde Metall oder sind auf der Basis dieser Bilder erstellt. Weitere Bilder wurden von Unternehmen zur Verfügung gestellt, entstammen dem Bilderarchiv des Verlags oder wurden von den Autoren entworfen.

Die Autoren danken den Autoren der Fachkunde Metall, den Unternehmen sowie dem Verlag Europa-Lehrmittel für die Bereitstellung der Bilder.

Bildbearbeitung:

Zeichenbüro des Verlags Europa-Lehrmittel, Ostfildern

3. Auflage 2023

Druck 5 4 3 2 1

Alle Drucke derselben Auflage sind parallel einsetzbar, da sie bis auf die Korrektur von Druckfehlern identisch sind.

ISBN 978-3-7585-1359-6

Satz: Satz+Layout Werkstatt Kluth GmbH, 50374 Erftstadt
Umschlag: Grafische Produktionen Jürgen Neumann, 97222 Rimpar
Umschlagfotos: Sauter Feinmechanik GmbH, 72555 Metzingen, © md3d und © somartin – Fotolia.com
Druck: Plump Druck & Medien GmbH, 53619 Rheinbreitbach

Vorwort

Das Buch **TECHNISCHES ENGLISCH zur FACHKUNDE METALL** dient zum systematischen Erlernen des technischen Englisch für die metalltechnischen Berufe.

Es erfüllt damit die Forderung der Rahmenlehrpläne zur Erlangung der sprachlichen Kompetenz in technischem Englisch im Berufsfeld der metalltechnischen Berufe: Werkzeug- und Industriemechaniker, Feinwerk-, Fertigungs- und Zerspanungsmechaniker sowie der entsprechenden Meister und Techniker des Berufsfeldes.

Zur sprachlichen Vereinfachung sind die Berufe genannt. Sie gelten für weibliche und männliche Auszubildende.

Auch für Schüler technischer Gymnasien, für Praktikanten und Studierende der Fachrichtung Maschinenbau sowie für Praktiker in der metallverarbeitenden Industrie und im Metallhandwerk ist es geeignet.

Voraussetzung des Lernens und Arbeitens mit dem Buch **TECHNISCHES ENGLISCH zur FACHKUNDE METALL** sind Grundkenntnisse des Englischen, die einem mittlerem Schulabschluss (Sekundarstufe 1) entsprechen und im Europäischen Fremdsprachen-Referenzrahmen in A2/B1 eingeordnet werden können.

Das Buch basiert auf den Inhalten wesentlicher Kapitel der FACHKUNDE METALL.

Es besteht aus drei Elementen:
- Technische Fachinhalte. Sie präsentieren das wesentliche technische Wissen einer Lerneinheit in Englisch.
- Berufsspezifische Situationen aus dem Alltag der Berufsbildung im Berufsfeld Metall.
- Basiswissen zur Grammatik des Englischen anhand von Beispielen aus dem Berufsfeld Metall.

Das Buch kann begleitend zum Unterricht mit der FACHKUNDE METALL oder anderen Lehrwerken des Berufsbereichs eingesetzt werden. Zu empfehlen ist z. B. nach der Einführung der Fachinhalte im deutschen Fachkundeunterricht der Einsatz des Buches **TECHNISCHES ENGLISCH zur FACHKUNDE METALL** zur Vertiefung und Festigung der Fachinhalte in englischer Sprache.

Die Lerneinheiten im Buch **TECHNISCHES ENGLISCH zur FACHKUNDE METALL** werden in derselben Reihenfolge wie im Buch FACHKUNDE METALL dargeboten.

Es handelt sich beim Buch TECHNISCHES ENGLISCH zur FACHKUNDE METALL jedoch nicht um eine Übersetzung der entsprechenden Kapitel und Inhalte aus dem Buch FACHKUNDE METALL.

Im Buch **TECHNISCHES ENGLISCH zur FACHKUNDE METALL** ist der Inhalt der jeweiligen Kapitel in Englisch in einem Konzentrat zusammengefasst. Darin werden die Fachausdrücke des Sachgebiets, wichtige Redewendungen und die erforderlichen englischen Sachwörter eingeführt und vertieft.

Durch die berufsspezifischen Situationen erlangt der Auszubildende Sprech-, Schreib- und Handlungskompetenz im beruflichen Alltag. Die Grammatik-Einheit frischen seine sprachlichen Fähigkeiten im Berufsbereich auf.

Das Buch **TECHNISCHES ENGLISCH zur FACHKUNDE METALL** ist in Lerneinheiten gegliedert, die einem technischen Sachgebiet entsprechen. Die im Text der Lerneinheit neu verwendeten englischen Fachausdrücke werden am rechten Rand der Seite in einem Kurzwörterbuch (Words) mit deutscher Übersetzung genannt. Dadurch ist ein zügiges Erarbeiten des Textes und der Inhalte ohne Umblättern oder zeitraubendes Suchen in einem Wörterbuch oder einem Übersetzungsprogramm des Internets möglich. Der/die Lernende kann sich voll auf das Verstehen des Textes konzentrieren.

Jede Lerneinheit des Buches enthält vielfältige Übungen (Exercises) mit unterschiedlichem Schwierigkeitsgrad zu den technischen Inhalten der Lerneinheit. Mit ihrer Hilfe kann die Englischkompetenz zum Sachthema vertieft und/oder geprüft werden. Die Aufgabentypen decken auch Teilkompetenzen (Comprehension, Writing, Mediation) ab, die zur Vorbereitung der KMK-Zertifikatsprüfung Englisch dienen können.

Am Ende des Buches befindet sich ein **Dictionary Englisch – Deutsch** sowie ein **Wörterbuch Deutsch – Englisch** mit sämtlichen im Buch verwendeten Fachwörtern. Dies ermöglicht auch die Bearbeitung fremder Texte zu den im Buch behandelten Sachgebieten.

Die Englischschreibung entspricht dem **britischen Englisch**.

In der vorliegenden 3. Auflage wurden wesentliche Ergänzungen aufgenommen

- die berufsspezifischen Situationen
- das Basiswissen der englischen Grammatik.

Die Autoren und der Verlag sind allen Nutzern des Buches für kritisch-konstruktive Hinweise und Verbesserungsvorschläge dankbar. Bitte senden Sie Ihre Hinweise per E-Mail an: Lektorat@europa-lehrmittel.de.

Frühjahr 2023 Die Autoren, der Verlag

Table of Contents

Inhaltsverzeichnis

A new colleague from England in vocational training . . 6
Ein neuer Kollege aus England in der Berufsausbildung
Simple sentences 7
Einfache Aussagesätze
Direct questions 7
Direkte Fragesätze
Simple Present and Present Progressive 7
Präsens und Verlaufsform
Simple Past and Past Progressive 7
Vergangenheit und Verlaufsform

1 Measuring technique 8
Prüftechnik
1.1 Physical quantities and units 8
Physikalische Größen und Einheiten
1.2 Fundamentals of measuring technique 10
Grundlagen der Messtechnik
1.3 Length Measuring Instruments 12
Längenmessgeräte
1.4 Digital calliper 14
Messschieber
1.5 Micrometer (screw gauge) 15
Bügelmessschraube
1.6 Surface testing 16
Oberflächenprüfung
1.7 Fits 18
Passungen
1.8 Fit Systems 19
Passungssysteme

2 Quality management 20
Qualitätsmanagement
2.1 Basics of quality management 20
Grundlagen des Qualitätsmanagements
2.2 Quality tools 21
Qualitätswerkzeuge
2.3 Normal distribution 22
Normalverteilung
2.4 Statistical characteristics of data quantities . . . 23
Statistische Kennwerte von Datenmengen
2.5 Machine capability 24
Maschinenfähigkeit
2.6 Process capability 25
Prozessfähigkeit
2.7 Statistical process control with quality control chart 26
Statistische Prozessregelung mit Qualitätsregelkarten

3 Production engineering 28
Fertigungstechnik
3.1 Safety at work 28
Grundlagen des Qualitätsmanagements
3.2 Prevention of accidents 29
Vermeidung von Unfällen
3.3 Overview of manufacturing processes 30
Überblick der Herstellungsverfahren
3.4 Casting 31
Gießen
3.5 Reforming 32
Umformen
Hand tools for the vocational training 34
Handwerkzeuge für die Berufsausbildung
Regular and irregular verbs 35
Regelmäßige und unregelmäßige Verben
Important Irregular Verbs 35
Wichtige unregelmäßige Verben
3.6 Basics of metal-cutting manufacturing 36
Grundlagen der spanenden Fertigung
3.7 Filing and sawing by hand 37
Feilen und Handsägen
How to use an assembly instruction 38
Wie man eine Montageanleitung benutzt
Imperative sentences 39
Aufforderungssätze
Relative clauses 39
Relativsätze
Active and passive clauses 39
Aktivsätze und Passivsätze
3.8 Cutting materials 40
Schneidestoffe
3.9 Cooling lubricants for cutting 41
Kühlschmierstoffe zum Spanen
3.10 Drilling 42
Bohren
How to translate an operating instruction 44
Wie man eine Betriebsanleitung übersetzt
Hinweise zum Übersetzen 45
Internet-Wörterbücher 45
3.11 Tapping 46
Senken
3.12 Countersinking (counterboring) 46
Gewindebohren
3.13 Turning 47
Drehen
How to correct a machine fault of a lathe 50
Wie man einen Maschinenfehler bei einer Drehmaschine behebt
The most important prepositions of place 51
Die wichtigsten Präpositionen zur Ortsbeschreibung
The most important prepositions of time 51
Die wichtigsten Präpositionen zur Zeitbeschreibung
3.14 Milling 52
Fräsen
3.15 Grinding 54
Schleifen
3.16 Overview of joining technologies 55
Überblick der Verbindungstechniken
3.17 Welding 56
Schweißen
3.18 Assembly technique 58
Montagetechnik

4 Material engineering 60
Werkstofftechnik
4.1 Overview of materials 60
Überblick der Werkstoffe
4.2 Important properties of materials 62
Wichtige Werkstoffeigenschaften

4.3 Designation system for steels 64
Bezeichnungssystem für Stähle
4.4 Steel groups and their applications 66
Stahlgruppen und ihre Anwendungen
4.5 Semi-finished steel products 68
Stahl-Halbzeuge
4.6 Cast iron materials 69
Gusseisen-Werkstoffe
How to order material by the internet 70
Wie man Werkstoffe im Internet bestellt
Plurals of substantives 71
Mehrzahl von Hauptwörtern
Comparisons 71
Steigerungen
Conditional Sentences 71
Bedingungssätze
4.7 Light metals 72
Leichtmetalle
4.8 Heavy metals 74
Schwermetalle
4.9 Sintered materials 75
Sinterwerkstoffe
4.10 Heat treatment of steels 76
Wärmebehandlung der Stähle
4.11 Corrosion and corrosion protection 78
Korrosion und Korrosionsschutz
4.12 Plastics 80
Kunststoffe
How to place an order by a telephone call 82
Wie man ein Telefonat zur Materialbestellung führt
Common phrases on telephone calls 83
Häufig benutzte Redewendungen in Telefonaten

5 Mechanical engineering 84
Maschinentechnik
5.1 Classification of machines 84
Einteilung der Maschinen
5.2 Functional units of machines 86
Funktionseinheiten der Maschine
5.3 Screw connections 88
Schraubenverbindungen
5.4 Shaft-hub connections 90
Welle-Nabe-Verbindungen
5.5 Friction and lubricants 92
Reibung und Schmierstoffe
5.6 Bearings 94
Lager
5.7 Seals 96
Dichtungen
5.8 Shafts, axles, couplings 98
Wellen, Achsen, Kupplungen
5.9 Gear boxes 100
Getriebe
5.10 Maintenance 102
Instandhaltung
How to carry out the lubrication service of a pillar drill 104
Wie man den Schmierdienst einer Säulenbohrmaschine ausführt
Important Auxiliaries 105
Wichtige Hilfsverben
Simple Past and Present Perfect 105
Vergangenheit und vollendete Gegenwart

6 Electrical engineering 106
Elektrotechnik
6.1 Electrotechnical basics 106
Elektrotechnische Grundlagen
6.2 Types of current and electric networks 108
Stromarten und elektrische Leitungsnetze
6.3 Electric work and electric power 109
Elektrische Arbeit und elektrische Leistung
6.4 Faults in electrical systems 110
Fehler an elektrischen Anlagen
6.5 Protection measures 111
Schutzmaßnahmen
6.6 Electric motors 112
Elektrische Motoren
How to handle electricity in the shop floor 114
Wie man mit der Elektrizität im Fertigungsbetrieb umgeht
Reported speech 115
Indirekte Rede
The sequence of times in indirect speech 115
Indirekte Fragesätze

7 Technical communication 116
Technische Kommunikation
7.1 Technical drawings 116
Technische Zeichnungen
7.2 Presentation of technical relationships 118
Darstellung technischer Zusammenhänge
How to apply for a job in an English company 120
Wie man sich für einen Job in einer englischen Firma bewirbt
Übersicht der gebräuchlichsten Zeitformen am Beispiel des Verbs *to draw* 121

Appendix 122
Anhang
English numerals 122
Englische Zahlwörter
Fractional numbers 123
Bruchzahlen
Muliples 123
Vervielfältigungszahlen
Time information 123
Uhrzeit – Angaben
Mathematical operators 123
Mathematische Operatoren

Dictionary English – German 124
Wörterbuch Englisch – Deutsch
Dictionary German – English 141
Wörterbuch Deutsch – Englisch

Danksagung sowie Firmen- und Bildquellenverzeichnis 157

A new colleague from England in vocational training

Max is an apprentice at the company FINE METALS near Munich. This morning in the training workshop, the instructor introduces a new colleague from England to Max.

"Hello Max, this is John Mulligan from Manchester. He will join you during the vocational training."

"Hello John, welcome in Germany. I have been an apprentice in this company for two months."

"Nice to see you, Max. Can you tell me something about the training?"

"Of course John. Please ask if you can't understand it."

Max shows John the training area. There are workbenches with bench vices and the tools for the skilled manual work: files, chisels, hammers, screwdrivers, twist drills etc.

On the first day of the training, they learn how to file a small piece of a flat bar. They practise to file flat areas and perpendicular side faces on the workpiece.

The instructor shows them how to measure the length, width and thickness of the workpiece with a calliper.

The flatness of the surfaces is checked with a straight edge.
The right angle of the side faces is measured with an engineer's square.

The next day they practise drilling bores into the workpiece. The bores have different diameters and definite distances from the edges.

They learn to read measures out of an engineering drawing.

They mark lines with a scriber on the workpiece and set centre punches.

The instructor shows them how to determine the right rotational speed of the drilling machine and the suitable type of drill.

After leaving the training section in the afternoon, Max shows John the manufacturing shop floors of the company.

For the weekend Max invites John to go on a trip to a German Biergarten. "There you can enjoy German brass music, eat Brezels and drink beer." You can meet many friendly young people there.

Words	
colleague	Kollege
vocational training	Berufsausbildung
apprentice	Auszubildender
company	Firma
training workshop	Ausbildungswerkstatt
instructor	Ausbilder
to introduce	einführen, vorstellen
to join	anschließen
training area	Ausbildungsbereich
workbench	Werkbank
bench vice	Schraubstock
skilled manual work	handwerkliche Arbeit
file, to file	Feile, feilen
chisel	Meißel
screwdriver	Schraubendreher
twist drill	Spiralbohrer
flat bar	Flachstahl
to practise	üben
flat area	ebene Fläche
perpendicular	rechtwinklig
side face	Seitenfläche
workpiece	Werkstück
to measure	messen
length	Länge
width	Breite
thickness	Dicke
calliper	Messschieber
flatness	Ebenheit
surface	Oberfläche
to check	prüfen
straight edge	Haarlineal
right angle	rechter Winkel
engineer's square	Haarwinkel
to drill	bohren
bore	Bohrloch
diameter	Durchmesser
definite	genau, festgelegt
distance	Abstand
edge	Kante
to read measure	ein Maß ablesen
engineering drawing	technische Zeichnung
to mark a line	Anreißlinien zeichnen
scriber	Anreißnadel
centre punch	Körnerpunkt
to determine	bestimmen
rotation speed	Drehzahl
drilling machine	Bohrmaschine
suitable	geeignet
type of drill	Bohrertyp
to leave	verlassen
manufacturing shop floor	Fertigungshalle
to invite	einladen
to enjoy	genießen
brass music	Blasmusik
beer	Bier
to meet	treffen

How to form sentences, questions, Present and Past Tense

(Wie man Aussagesätze, Fragesätze sowie die Zeiten Gegenwart und Vergangenheit bildet)

Simple sentences (einfache Aussagesätze)

The instructor introduces a new colleague.
Max is an apprentice in a company.
Max shows John the training area.
John and Max learn how to file a flat bar.
The length of a workpiece is measured by a calliper.
You can enjoy brass music in a Biergarten.

Direct questions with question words (direkte Fragesätze)

Max has been an apprentice for two months.	What is an apprentice? How long has he been an apprentice?
The instructor is an important person.	What is the job of an instructor? Why is the instructor an important person?
John came from England yesterday.	Where did John come from? When did John come from England?
John and Max learn by working with the instructor.	How do they learn? With whom do they learn?

Simple Present and Present Progressive
(Einfaches Präsens und Präsens, Verlaufsform)

The instructor introduces a new colleague from England.
Max often stays longer in the training workshop.
John sometimes thinks of his hometown Manchester.
Every day, John and Max work together in the shop.

John is drilling bores now.
At the moment all colleagues are working.
Look! The instructor is coming.

Simple Past and Past Progressive
(Einfaches Präteritum und Präteritum, Verlaufsform)

Last year John worked in a workshop in Manchester.
The instructor started as an apprentice in the company.
Yesterday Max came into the workshop and started to work.

The instructor was standing beside him, when John was drilling.
While Max was drilling, John was reading the instructions.

Regeln und Erklärungen

Einfache **Aussagesätze** werden im Englischen in der Reihenfolge S V O gebildet.

S Substantiv (Hauptwort)
V Verb (Satzaussage)
O Objekt (Satzglied, das vom Verb gefordert wird)

Fragesätze werden mit Fragewörtern gebildet:

Who	(Frage nach dem Subjekt)	= Wer
What	(Frage nach Subjekt/Objekt)	= Was
Whose	(Frage nach dem Objekt)	= Wessen
Whom	(Frage nach dem Objekt)	= Wem
Where	(Frage nach dem Ort)	= Wo
When	(Frage nach der Zeit)	= Wann
How	(Frage nach dem Umstand)	= Wie
Why	(Frage nach dem Grund)	= Warum
Which	(Frage nach Subjekt/Objekt)	= Welcher

Bei Vollverben wird die Frage mit „to do“ gebildet.

Präsens (Gegenwart), einfache Form:
beschreibt die Gegenwart.
Schlüsselwörter zum Gebrauch des einfachen Präsens sind: always, usually, often, every day, sometimes etc.

Präsens, Verlaufsform:
beschreibt einen Vorgang, der gerade im Augenblick geschieht.
Schlüsselwörter: now, at the moment, just, while

Präteritum (Vergangenheit), einfache Form:
beschreibt eine einmalige, beendete Handlung.
Schlüsselwörter: yesterday, five minutes ago

Präteritum, Verlaufsform:
Drückt aus, dass eine Handlung zu einer bestimmten, vergangenen Zeit gerade vor sich ging.

Exercises

1. Übersetzen Sie unter Beachtung der Reihenfolge S V O im Satz.
   a) Der Ausbilder zeigt John einen Bohrer.
   b) Mit dem Haarlineal misst man die Ebenheit von Werkstücken.
   c) John feilt ein Werkstück und bohrt Löcher.
   d) Man trifft freundliche Leute im Biergarten.

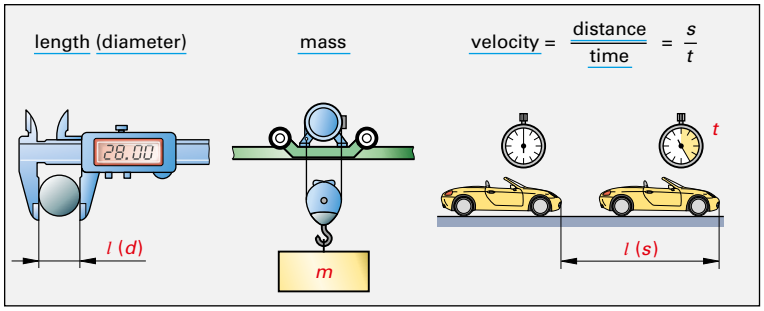
2. Bilden Sie die Fragesätze in Englisch.
   a) In welchem Land produziert die Firma von Max?
   b) Wer ist der Chef von Max und John?
   c) Wann kommt Max jeden Tag in die Werkstatt?
   d) Mit welchem Werkzeug wird die Ebenheit von Werkstückoberflächen geprüft?

3. Form the suitable tenses in the following sentences by using the Simple Present and Past Progressive.
   a) Max (to wash) _____ his hands after work.
   b) Look! John (to drill) _____ bores into the flat bar.
   c) The instructor (to sit) _____ in his room now and (to examine) _____ the workpieces.
   d) Please be quiet, John, I (to write down) _____ the measured value of the diameter.

1 Measuring technique

1.1 Physical quantities and units

The properties, states and processes of an object, which can be measured, are called physical quantities **(figure).**



Base quantities

The base quantities are described in accordance to DIN 1304 by a defined symbol (quantity symbol), for example *l* for length, *s* for distance, *m* for mass, *t* for time, *I* for electric current, *T* for temperature and so on.

The value of a physical quantity is written in abbreviated form by a letter. It is the product of a numerical value and a unit.

Example:

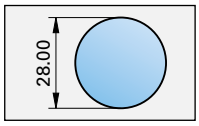
A workpiece has a diameter *d* of 28.00 mm **(figure):** ⇒ ***d* = 28.00 mm**

The expression consists of:

d physical quantity (*d* stands for diameter)

28.00 numerical value

mm unit for length (mm stands for millimeter)



Units

Every physical quantity has a certain unit. The International System of Units SI is based on seven basic quantities **(table).** These basic quantities cannot be transferred into another quantity.

They form the basis for other derived quantities.

Table: Base quantities and base units in accordance to SI

Base quantity	Quantity symbol	Base unit	
		Name	Symbol
Length	*l*, *d*, *s*	metre	m
Mass	*m*	kilogram	kg
Time	*t*	second	s
Electric current	*I*	Ampere	A
Temperature	*T*	Kelvin	K
Amount of substance	*n*	mole	mol
Luminous intensity	I_v	Candela	cd

Words	
measuring technique	Messtechnik
physical quantity(-ies)	physikalische Größe(n)
unit	Einheit
property (-ies)	Eigenschaft(en)
state	Zustand
process	Vorgang
length	Länge
diameter	Durchmesser
mass	Masse
velocity	Geschwindigkeit
time	Zeit
distance	Weg, Strecke
base quantity	Basiseinheit
to describe	bezeichnen
in accordance	gemäß
defined	festgelegt
electric current	Elektrischer Strom
value	Wert
abbreviated form	Kurzform
letter	Buchstabe
to equal	gleichen
product	Produkt
numerical value	Zahlenwert
example	Beispiel
workpiece	Werkstück
expression	Ausdruck
System of Units SI	SI-Einheitensystem
to base on	basieren auf
table	Tabelle
to transfer	umrechnen
derived quantity	abgeleitete Größe
quantity symbol	Formelzeichen
amount of substance	Stoffmenge
luminous intensity	Lichtstärke
second	Sekunde
speed	Geschwindigkeit
to define	definieren, festlegen
to answer	beantworten
following	folgende
questions	Fragen

Exercises

1. Working with words. Which words from the text are described here?
   a) Every material has certain _____ for example it can be very hard.
   b) In order to find out the correct diameter of a workpiece, you need to _____ it with an instrument.
   c) The speed of a car is also called _____.
2. Define physical quantities in German by using the information from the text above.
3. Answer the following questions in English.
   a) Which two elements does a physical quantity have? Find an example to explain it.
   b) Which 7 base quantities does the International System of Units IS define?
   c) What is the difference between base quantities and derived quantities?

Prefixes

It is easier to use decimal multiples or factors in front of units to avoid very high or low values **(table).**

Example: The length of a shaft is 0.030 m.

The prefix milli (m) is added: $l = 30.00$ mm

Table: Prefixes for decimal multiples and factors of units

Prefix		Meaning	Factor
M	mega	millionfold	10^6 = 1 000 000
k	kilo	thousandfold	10^3 = 1 000
h	hecto	hundredfold	10^2 = 100
da	deca	tenfold	10^1 = 10
d	deci	tenth	10^{-1} = 0.1
c	centi	hundredth	10^{-2} = 0.01
m	milli	thousandth	10^{-3} = 0.001
µ	micro	millionth	10^{-6} = 0.000 001

Derived quantities and units

Derived quantities are needed to describe physical properties of materials or processes in machines and production. The derived units are determined by a formula and consist of two or more base units **(table).**

Table: Examples for derived quantities and units

Derived quantity	Derived unit	Unit symbol	Relationship (formula)	Definition of the derived unit
Volumen V	Cubic meter	m^3	$V = l \cdot b \cdot h$ $[V] = 1\ m \cdot 1\ m \cdot 1\ m = 1\ m^3$	One cubic metre
Force F	Newton	N	$F = m \cdot a$ $[F] = 1\ N = 1\ \frac{kg \cdot m}{s^2}$	One kilogram times metre **per (over)** square second
Work W	Joule	J	$W = F \cdot s$ $[W] = 1\ N \cdot m$	One Newton times one metre

Example: The volume is calculated by the formula $V = l \cdot b \cdot h$

The volume equals the length times the width, times the height (e.g. $V = 2\ m \cdot 3\ m \cdot 4\ m = 24\ m^3$)

The unit of the volume V results from inserting the base units into the formula:

$[V] = [l] \cdot [b] \cdot [h] = m \cdot m \cdot m = m^3$ (cubic metre)

Imperial Units

Imperial units (Non SI-Units) are used in Great Britain and in the USA. This is a traditional measuring system, in which short distance units are based on standardised dimensions of the human body, e.g. one inch represents the width of a thumb. The foot (= 12 inches) is the length of a human foot. These countries have also different units for weight, mass and temperature.

The imperial units can be converted into the SI-Units.

Example:

1 inch (*in*/")	= 25.4 mm	1 pound (*pd*)	= 453.6 g
1 foot (*ft*)	= 0.3048 m	1 barrel (*bl*)	= 158.8 dm³
1 mile (*mi*)	= 1.609 km	1° Fahrenheit (*F*)	= –17.77 °C

Words

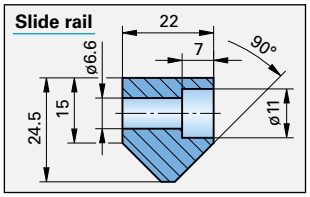
prefix	Vorsatz
decimal multiples	dezimale Vielfache
in front of	vor
to avoid	vermeiden
high	groß, hoch
low	niedrig
millionfold	Millionenfaches
tenth	Zehntel
shaft	Welle
to add	hinzufügen
to need	benötigen
process	Prozess
to determine	bestimmen
formula	Formel
to consist of	bestehen aus
relationship	Beziehung
times	multipliziert mit (mal)
per (over)	dividiert durch
force	Kraft
square second	Quadrat Sekunde
times	mal
work	Arbeit
to calculate	berechnen
equals	entspricht, ist gleich
width	Breite
height	Höhe
to result	(sich) ergeben
to insert	einsetzen
imperial unit	britisch-amerikanische Maßeinheit
bar	Stange
Great Britain	Großbritannien
standardised dimension	festgelegtes Maß
human body	menschlicher Körper
e.g. (for example)	z.B. (zum Beispiel)
thumb	Daumen
foot	Fuß
weight	Gewicht
to convert	umrechnen
tension	Spannung
pressure	Druck
rod	Stab
density	Dichte
turning tool	Drehmeißel
feed velocity	Vorschub-geschwindigkeit

Exercises

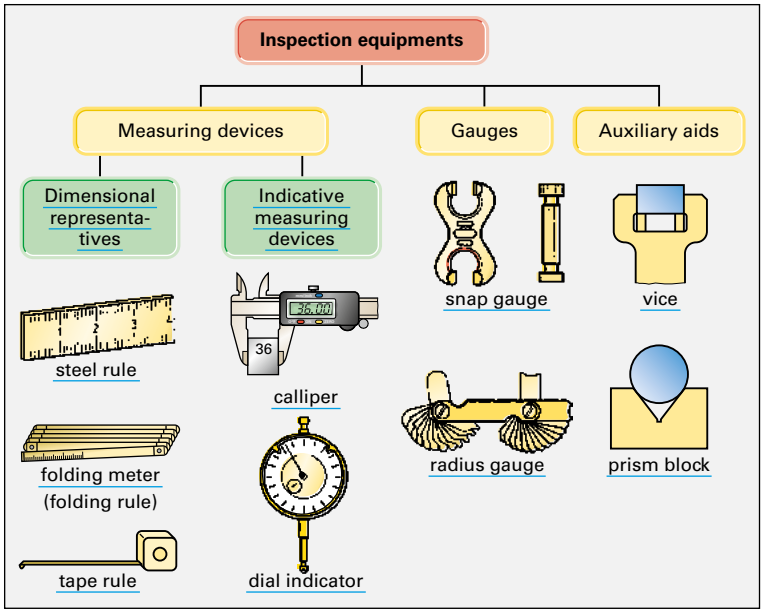
1. Write down the formula and explain the correct derived units. (Use your **Metal Trades Handbook**)
   a) pressure p b) velocity v c) density ϱ
   d) tension σ e) electrical work W f) frequency f
2. Convert the measurements from imperial units into metric units. (Use your **Handbook**)
   a) 120 miles in km b) 3,300 ft in metres c) $1^1/_2$ pints in litres
   d) 4.5 ounces in kilogram e) $^1/_8$ inch in mm f) 22.5 pounds in kg
3. Calculate the physical quantities by using SI-Units.
   a) A compact disc (CD) has a diameter of 120 mm. Calculate the area in mm².
   b) The volume of a steel rod is 0,500 dm³ and has a density of 7.85 kg/dm³. Calculate the mass in kg.
   c) A turning tool moves 9.3 cm in a time of 3 seconds. Calculate the feed velocity in mm/s.

1.2 Fundamentals of measuring technique

If components are produced in a workshop, e. g. a slide rail **(figure)**, the dimensions of the workpiece must be given precisely. Important dimensions of the slide rail are the length of 22 mm, the height of 24.5 mm, the angle of 90° and the internal diameters of 6.6 mm and 11 mm.



In order to measure these features, different inspection aids are needed **(figure)**. They can be divided into three main categories: measuring devices, gauges and auxiliary aids.



With some measuring devices you compare a certain dimension, such as the height of 24.5 mm with a scale of a measuring device. These instruments are called dimensional representations, e. g. steel rules or folding meter.

If you read the dimension from a scale of the measuring device you use an indicative measuring device, such as a calliper, a protractor, or a micrometer.

With gauges you can test e. g. the diameter of a ∅ 6.6 mm hole (bore) with a plug limit gauge, or you can check the radius of R9 by a radius gauge.

Words	
fundamentals	Grundlagen
measuring technique	Messtechnik
component	Bauteil
workshop	Werkstatt
slide rail	Führungsschiene
precise	präzise, genau
important	wichtig
angle	Winkel
internal diameter	Innendurchmesser
feature	Größe
different	unterschiedlich
inspection aid	Messmittel
to divide	unterscheiden
category (-ies)	Bereich, Kategorie
measuring device	Messgerät
gauge	Lehre
auxiliary aid	Hilfsmittel
dimensional repre-sentative	Maßverkörperung
indicative measuring devices	anzeigende Messgeräte
steel rule	Stahlmaßstab
folding meter (folding rule)	Gliedermaßstab
tape rule	Bandmaßstab
calliper	Messschieber
dial indicator	Messuhr
snap gauge	Rachenlehre
radius gauge	Radienlehre
vice	Schraubstock
prism block	Prisma, V-Block
to compare	vergleichen
scale	Skala
protractor	Universalwinkelmesser
micrometer	Bügelmessschraube
to test	prüfen
hole (bore)	Loch/Bohrung
plug limit gauge	Grenzlehrdorn
groove	Nut
result	Ergebnis

Exercises

1. Translate the following inspection aids and name the main group of these devices.
   a) plug limit gauge b) prism block c) folding rule
   d) micrometer e) snap gauge f) calliper
2. Name the correct inspection aid to find out these measurements.
   a) the diameter of a shaft of 22 mm b) the length of a rail of 1.80 m c) the angle of 120°
   d) the hole of ∅ 20 mm e) the depth of 10 mm of a groove f) the radius R5
3. Answer the questions in English.
   a) What are dimensional representatives?
   b) Which result do you get when you use a gauge? Give an example.
   c) Which result do you get when you use an indicative measuring device? Give an example.
   d) When do you need an auxiliary help? Give an example.

Measuring errors

The indicated values of a measuring instrument are afflicted with different measuring errors. The errors can be caused by:

– Deviation of the standard temperature of 20 °C

Operator variations:

– thin workpieces could be deformed by a high measuring force
– parallax error is due to the incorrect eye position when reading the scale

Measuring errors can be divided into two categories:

Systematic errors: They are caused by constant variations, such as the temperature in the workshop, the measuring force or an inaccurate scale or wear of the measuring instrument. Systematic errors can be avoided by eliminating the cause of the error, such as a proper calibration of the measuring instrument.

Random errors are caused by unknown variations, such as an unintended change in temperature or measuring force or parallax error. They can be reduced by repeating the measurement for a few times and using a calculated mean value.

Measuring capability

If you need to measure a workpiece, it is difficult to know which measuring instrument should be used. The correct choice of measuring device saves time, money and can provide you with an accurate result.

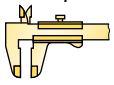
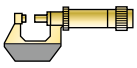
The choice of a suitable measuring instrument for a certain measuring task depends on the required accuracy and the dimension of the workpiece.

By using your Metal Trade Handbook **(extract in the table)** you can find out the uncertainty and the range of the instrument.

Example:

The uncertainty of mechanical measuring instruments is one scale interval. Digital measuring instruments have an uncertainty of three numerical intervals.

Table: Range of measuring and uncertainty of measuring instruments

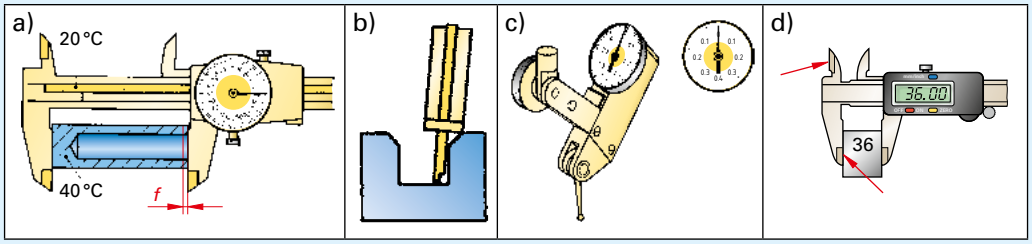
Measuring instrument	Measuring range	Measuring uncertainty
Calliper  Scale interval 0.05 mm	0…150 mm	$U \geq 50$ µm = 0.05 mm
Micrometer  Scale interval 0.01 mm	50…75 mm	$U = 10$ µm = 0.01 mm

Words

measuring error	Messfehler
indicated value	angezeigter Wert
to be afflicted with	mit etwas behaftet sein
deviation	Abweichung
operator variation	Ableserabweichung
thin	dünn
to be deformed	verformt sein
measuring force	Messkraft
parallax error	Parallaxefehler
to be due to	bedingt werden durch
reading	Ablesung
systematic error	systematischer Messfehler
to be caused by	verursacht werden von
inaccurate	ungenau
wear	Abnutzung/Verschleiß
to avoid	vermeiden
to eliminate	beseitigen
calibration	Kalibrierung, Einstellung
random error	zufälliger Messfehler
unknown	unbekannt
unintended	unbeabsichtigt
repeating	wiederholen
mean value	Mittelwert
measuring capability	Messfähigkeit
choice	Auswahl
measuring device	Messgerät
to save	sparen
to provide	liefern
accurate result	genaues Ergebnis
the choice	die Auswahl
suitable	geeignet
measuring task	Messaufgabe
uncertainty	Unsicherheit
required	gefordert
range	Messbereich
scale interval	Skalenteilungswert
numerical interval	Ziffernschrittwert
to match	zuordnen
common	üblich

Exercises

1. Match the pictures a) – d) to the type of measuring error (1) – (4). Specify if it is a systematic or a random error.



Type of measuring error: (1) parallax error (2) wear of measuring surfaces
(3) bad positioning of device (4) too high temperature

2. Make a list of six common measuring devices (e.g. steel rule, vernier calliper, gauge block, dial gauge protractor, etc) and find out their type of inspection aid/range/accuracy.
(Use a webpage of a company for measuring devices e.g. www.mitutoyo.com; www.mahr.de; www.hoffmann.de).

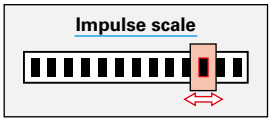
Measuring device	Type of inspection aid	Measuring range	Accuracy
steel rule	dimensional representative	150 – 1000 mm	0.5/1 mm
…	…	…	…

1.3 Length Measuring Instruments

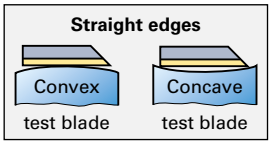
For measuring the length of a workpiece, there is a variety of test instruments with different degrees of accuracy. You can measure the length with a rule or a tape rule and check the size with a gauge or a gauge block.

Rules (figure) represent the length measurement by the distance of little lines on a scale. There are different types of rules available: flexible steel rules, tape rules or folding meters.

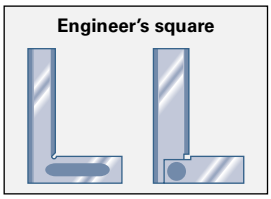
Scales (figure) for the position measurement systems are made of glass or steel and are operated by the photoelectronic scanning principle. When parallel light passes through a scale, light and dark surfaces are projected at a certain distance and signals are generated.



Straight edges (figure) are used to check the straightness and flatness. They have lapped test blades with a high flatness. These accurate test blades enable the naked eye to realize different tiny light gaps. The light gap between the test blade and the workpiece could be as small as 2 µm.



Engineer's squares (figure) are form gauges and represent mostly an angle of 90°. They are used to check the perpendicularity and flatness of surfaces. Besides, cylindrical or flat surfaces can be adjusted.



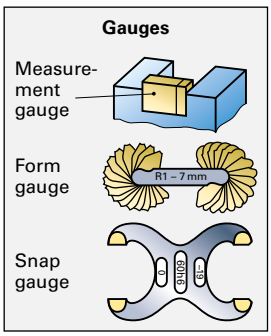
The measuring tubes can have dimensions up to 100 × 70 mm with a class of accuracy of 00. The limit of perpendicularity deviation is only 3 µm.

Gauges represent certain dimensions or geometric forms **(figure)**.

Measurement gauges come in sets, e. g. gauge blocks or test pins.

Form gauges can check angles, radii and threads using the light gap method.

Plug gauges and **snap gauges** represent the admissible maximum and minimum limit dimension. Some gauges represent also the form, e. g. to test the cylindrical form of a bore as well as the dimension of the hole.

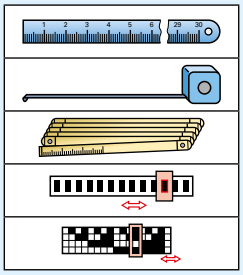


Words	
degree of accuracy	Genauigkeitsgrad
rule	Lineal
tape rule	Maßband
size	Größe
gauge	Lehre
gauge block	Endmaß
to represent	darstellen
distance	Entfernung
folding meter	Meterstab
scale	Maßstab
position measurement system	Wegmesssystem
to operate	bedienen, arbeiten
scanning principle	Abtast-Prinzip
impulse scale	Impulsmaßstab
light	hell
dark	dunkel
surface	Fläche/Feld
to project	projizieren
to generate	erzeugen
straight edge	Haarlineal
straightness	Geradheit
flatness	Ebenheit
lapped	geläppt
test blade	Messfläche
naked eye	mit bloßem Auge
tiny	winzig
light gap	Lichtspalt
engineer's square	Haarwinkel
perpendicularity	Rechtwinkligkeit
to adjust	einstellen
measuring tube	Messschenkel
class of accuracy	Genauigkeitsklasse
test pin	Prüfstift
thread	Gewinde
plug gauge	Lehrdorn
snap gauge	Rachenlehre
admissible	zulässig
absolute scale	Absolutmaßstab
to mention	nennen

Exercises

1. Match the correct expression of the following measuring devices to the pictures at the right.
   a) absolute scale b) flexible steel rule c) tape rule
   d) folding rule e) impulse scale

	1
	2
	3
	4
	5



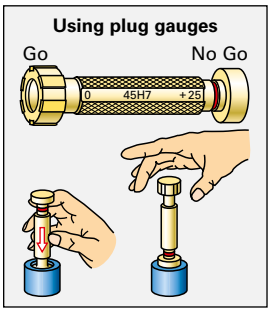
2. Answer the following questions in English.
   a) What is the difference between measuring instruments and gauges?
   b) Why do straight edges and engineer's squares have lapped test blades?
   c) What can you check with straight edges?
   d) What is the light gap method?
   e) Mention 3 different types of gauges and choose a certain measurement of a workpiece which can be checked by them.

Working with plug gauges, snap gauges and gauge blocks

The specified limits of bores of toleranced workpieces can be checked by plug gauges. Snap gauges or ring gauges are used to test the specified limits of shafts.

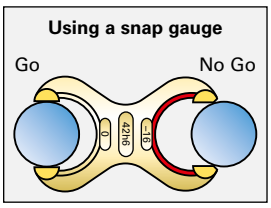
Plug gauges (figure)
When using a cylindrical plug gauge, the diameter of one side, the Go should enter while the No Go should fail to enter the hole. As a result, it is stated to be within the specified limits.

Cylindrical plug gauges are made from alloyed steel or tungsten carbide. They are ground and lapped. They can be produced to any size up to 250 mm diameter.

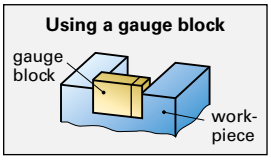


The Go side should slide into the bore by its own weight. A minimal insertion of the No Go gauge may be tolerated at the entry fit. The Go side is longer and often has carbide inserts to reduce the wear of the surface. The No Go side is shorter, marked with a red ring and shows the maximum limit size.

Snap gauges (figure)
The Go side represents the maximum limit size. It must slide over the measured surface by its own weight. The No Go member is smaller and should fail to slide over the surface. It has slightly angled measuring surfaces, which are red and show the minimum limit size.



Gauge blocks
Gauge blocks are the most important and precise dimensional representations. They are usually made in sets of rectangular, square or angular steel blocks or ceramic blocks **(figure)**. Each block has two opposite faces lapped flat and parallel to a definite size within an extremely tight tolerance. In order to assemble a gauge block stack of a certain size, you first write down the correct combination of gauge blocks for these dimensions. Tip: start with the smallest available gauge block.



Example: Assemble a gauge block stack for the dimension: 57.005 mm.

Careful: There is no gauge block of 0.005 mm. It would break!

Gauge block combination	
1. Gauge block	1.005 mm
2. Gauge block	6.000 mm
3. Gauge block	50.000 mm
Total dimension	57.005 mm

Words	
plug gauge	Grenzlehrdorn
snap gauge	Grenzrachenlehre
gauge block	Endmaß
specified limit	Grenzmaße
ring gauge	Lehrring
shaft	Welle
diameter	Durchmesser
Go side	Gutseite
to enter	eindringen
No Go side	Ausschussseite
to fail	scheitern
result	Ergebnis
to state	feststellen
alloyed steel	legierter Stahl
tungsten carbide	Wolframkarbid, Hartmetall
to grind, ground	schleifen, geschliffen
to lap	läppen
to slide	gleiten
own weight	Eigengewicht
minimal insertion	Anschnäbelung
to tolerate	tolerieren
entry fit	Ansatz-Passung
carbide insert	Hartmetalleinsatz
wear	Abnutzung, Verschleiß
surface	Oberfläche
to designate	beschriften
maximum limit size	Höchst-Grenzmaß
slightly angled	leicht angeschrägt
rectangular	viereckig
square	quadratisch
angular	winkelig
opposite	gegenüberliegend
definite size	bestimmte Größe
tight	eng
to assemble	zusammenstellen
gauge block stack	Endmaßstapel
available	verfügbar
to tick	ankreuzen
mating	passend
to create	herstellen

Exercises

1. Find the correct answer of the questions and tick it in the table below ✓

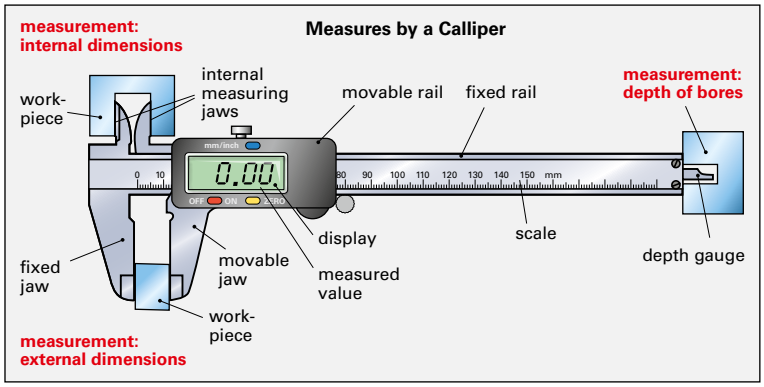
a) A tolerance is a …	clearance between a shaft/mating bore	measurement error	variation in manufacturing
b) Which of the following statement of plug gauges is true (only 1)?	The Go side is smaller than the No Go side of the plug gauge.	Only slight pressure is needed to slide the Go member into the bore.	The No Go member is designated with the minimum limit size.
c) Which of the following statement of snap gauges is true (only 1)?	The Go member should fail to slide into the bore.	The Go member is marked in red.	The Go member doesn't represent the minimum limit size.

2. Create a stack of gauge blocks and write down the combination of blocks.
   a) 42.123 mm b) 74.357 mm c) 81.685 mm

1.4 Digital calliper

The digital calliper, shortly called calliper, is the most common precision measuring instrument for length dimensions used in mechanical engineering.

It consists of a fixed and a movable rail **(figure).** The measuring unit with a display and the operating buttons are located on the movable rail.



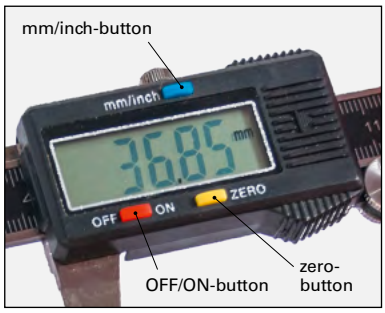
The calliper can be used to measure external and internal dimensions of parts as well as the depth of bores or grooves.

The accuracy of a calliper is between 0.05 mm to 0.10 mm.

The measured value display shows 0.01 mm. The last digit is to be rounded.

The measuring unit has several buttons **(figure):**

- The OFF/ON-button for starting and finishing the measurement.
- The mm/inch-button to choose the reading.
- The zero-button for setting the zero-point in any position.



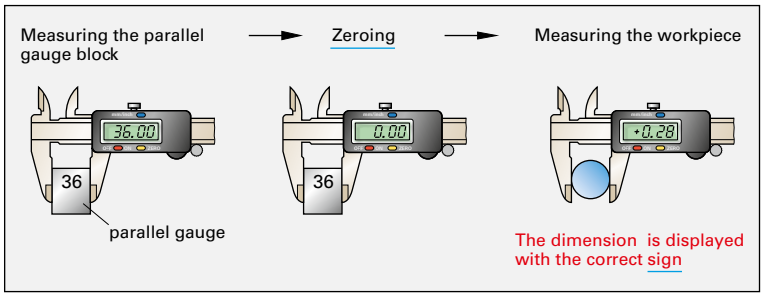
With the digital calliper you can run the following applications:

- **Accurate measurement of dimensions**

External and internal dimensions as well as bore depths can be measured with the various measuring devices on the calliper.

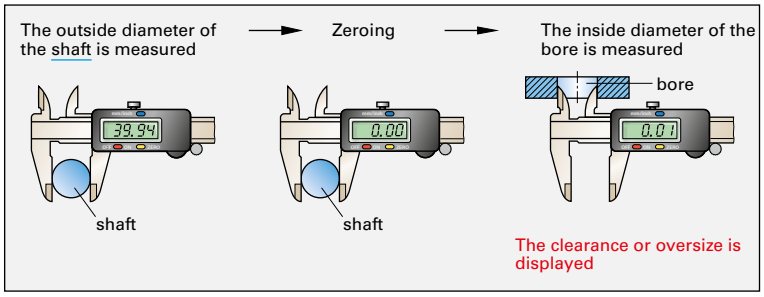
- **Measurement of deviating dimensions**

The deviation of a workpiece from the nominal dimension is determined by comparison with a parallel gauge block.



- **Measuring of fits**

The clearance or oversize is directly displayed by a comparison measurement.

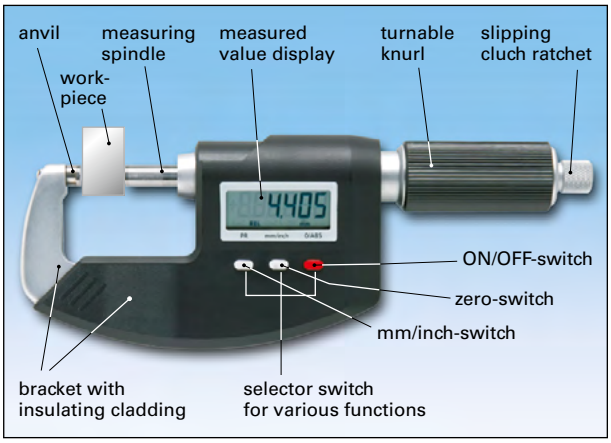


Words	
digital calliper	digitaler Messschieber
to slide	gleiten
short	kurz
most common	gebräuchlichste(r)
precision measuring instrument	Präzisions-Mess-instrument
length dimension	Längenmaß
mechanical engineering	Maschinenbau
to consist	bestehend aus
fix	feststehend
movable	beweglich
rail	Schiene
depth gauge	Tiefenmaß
measuring unit	Messeinheit
display	Anzeige
operating button	Bedienknopf
external dimension	Außenmaß
internal dimension	Innenmaß
depth	Tiefe
bore	Bohrung
groove	Nut
accuracy	Genauigkeit
digit	Ziffer
to round	runden
button	Knopf, Schalter
measurement	Messung
to choose	auswählen
reading	Ablesen, Ablesewert
zero-button	Nullstellung-Schalter
to set	setzen, feststellen
to run	ausführen
application	Anwendung
measuring device	Messvorrichtung
deviating dimension	abweichendes Maß
nominal dimension	Nennmaß
comparison	Vergleich
parallel gauge block	Parallel-Endmaß
zeroing	Auf-Null-stellen
sign	Vorzeichen
fit	Passung
clearance	Spiel
oversize	Übermaß
shaft	Welle

Exercises

1. Translate the third paragraph of the text of page 14 into German.
2. Some of the following statements are wrong. Find these statements and correct them.
   a) The digital calliper is the least used measuring device in the workshop.
   b) A calliper can measure diameters of bores and shafts, the width and thickness of a part.
   c) With a digital calliper, measurements of 0.03 inch and 0.05 mm are possible.
   d) A digital calliper can be used to measure dimensional deviations with direct display.
3. Name the measure value from page 14, figure 2, rounded to one decimal place.

1.5 Micrometer (screw gauge)



The digital micrometer is a precision measuring device for workpiece dimensions. It is used when the measuring accuracy of the calliper is not sufficient.

Micrometers have a measuring accuracy of 0.01 mm.

The displayed value has three digits after the decimal point **(figure).** It is given rounded to two digits.

The micrometer consists of a bow-shaped frame with insulating cladding for touching. The measuring range is indicated on the bracket, e. g. 0 to 25 mm.

The measurement is made between an anvil and the movable measuring spindle. It is approached with a turnable knurl and applied to the workpiece with slight force using the slip clutch ratchet.

The measured value is shown on a display.

The high measuring accuracy can be achieved only under controlled measuring conditions:

– The test surfaces of the workpiece must be clean and burr-free.
– During the measuring process, the measuring spindle must be applied to the workpiece with the ratchet until it slips through.
– The spindle must be at right angle to the measured surfaces.

Digital micrometers have selector switches that are used to make measurements similar to those made with callipers. See page 14.

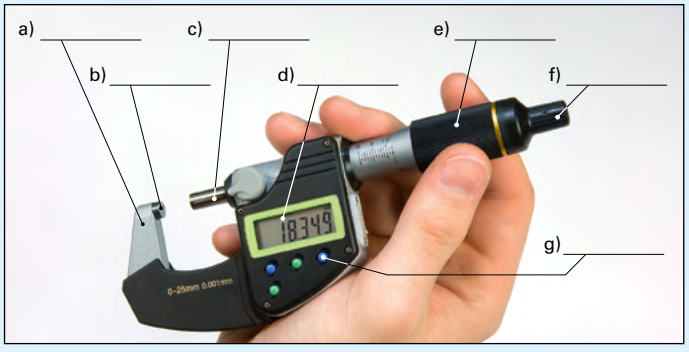
– Measurements of dimensions and with zero setting.
– Measurement of fit dimensions with direct display.

Micrometers are sensitive instruments. They must be handled and stored with care. This will maintain their precision.

The accuracy must be checked regularly with parallel gauge blocks. The dimensional reference temperature of 20 °C must be observed.

Exercises

1. Label the parts in the figure of the micrometer.

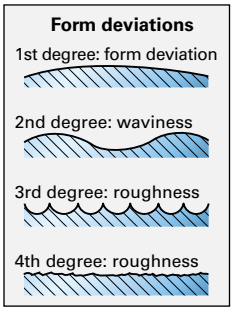


Words	
micrometer/screw gauge	Bügelmessschraube
device	Gerät
sufficient	ausreichend
to give	angeben, nennen
bow-shaped frame	bügelartiger Rahmen
insulation cladding	isolierende Verkleidung
touching	Anfassen
measuring range	Messspanne
bracket	Bügel
anvil	Amboss
measuring spindle	Messspindel
to approach	heranführen
turnable knurl	Drehrändel
to apply	anlegen
slight	leicht
slip clutch ratchet	Rutschkupplungs-Rätsche
to achieve	erreichen
burr-free	gratfrei
to slip through	durchdrehen
right angle	rechtwinkelig
selector switch	Wahlschalter
zero setting	Nullstellen
sensitive	empfindlich
to store	aufbewahren
to maintain	erhalten
parallel gauge block	Parallel-Endmaß
dimensional reference temperature	Maßbezugs-temperatur
to label	benennen

1.6 Surface testing

In industrial manufacturing the machined surface has a major influence on the quality and performance of the end product.

The surface texture of a workpiece is the deviation of a surface from its ideal shape e. g. perfect flat, cylindrical or spherical form. The measure of the surface texture indicates the form, the waviness and the roughness **(figure).**



The **form deviation** (1st degree of deviation describes the straightness or roundness of the part. Deviations from the required form can result from clamping marks or wear in the guides of the machine tool.

Waviness (2nd degree deviation) usually relates to the characteristics of an individual machine or to external environmental factors. It may result from the machine itself, e. g. its vibrations.

The **roughness** (3rd/4th degree deviation), e. g. grooves or bumps result from the production process. It is influenced by the geometry or the material structure of the cutting tool and the feed or the depth of the tool.

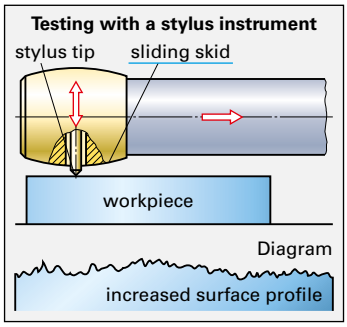
The irregularities of a surface can be checked by different measuring instruments. The output of these devices are certain profiles. The base of a roughness (R) and waviness (W) profile is the primary (P) profile.

Types of surface testing

Surface roughness comparators are used for touch and sight comparison. In order to get an accurate measuring result you need to use the same material of the test specimen and workpiece and the correct manufacturing technology, e. g. turning, milling, grinding etc.

You need to scrape the comparator specimen with your fingernail or use a small copper coin. Then you can compare the surface of the workpiece with the comparator specimen. If you compare it visually, you need an optimum light source angle or use a magnifying glass.

Stylus instruments are surface roughness testers, which record the peaks and valleys by a diamond stylus **(figure).** The stylus is drawn at a constant speed across the workpiece. The amount to which the stylus is raised or lowered is printed in a diagram. It shows the increased surface profile.



Words	
machined surface	bearbeitete Oberfläche
major	bedeutend
influence	Einfluss
performance	Leistung
texture	Struktur
deviation	Abweichung
shape	Form
spherical	kugelförmig
to indicate	kennzeichnen
waviness	Welligkeit
roughness	Rauheit
degree	Grad
clamping mark	Einspannkratzer
wear	Abnutzung
guide	Führung
to relate to	zusammenhängen
characteristic	Kennzeichen
environmental	umgebungsbedingt
groove	Rille
bump	Erhebung
feed	Vorschub
depth	Tiefe (hier: Zustellung)
irregularity	Unregelmäßigkeit
output	Ausgabe
roughness comparator	Oberflächenvergleichsmuster
touch sight comparison	Tast-/Sichtvergleich
turning	Drehen
milling	Fräsen
grinding	Schleifen
to scrape	kratzen
fingernail	Fingernagel
copper coin	Kupfermünze
light source angle	Lichteinfallwinkel
magnifying glass	Lupe
stylus instrument	Tastschnittgerät
to record	aufzeichnen
peak	Spitze
valley	Tal
stylus	Tastnadel
to be drawn	gezogen werden
to raise	anheben
to lower	senken
sliding skid	Gleitkufe

Exercises

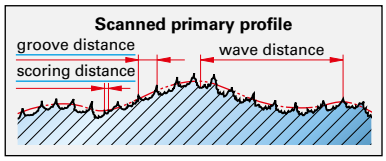
1. Complete the missing information about form deviations in the table.

Degrees of form deviation	Examples	Possible cause
1st degree: form deviation	...	...
...	waves	...
3rd degree: roughness	...	...
...	...	Sequence of chip formation surface deformation during fabrication

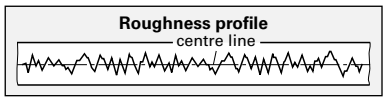
2. Answer the questions in English.
   a) Which surface testing instrument is very quick and easy to use? Why?
   b) Explain why you can compare the surface roughness visually and by touching.
   c) Describe how a stylus instrument works.

Surface texture parameters

The scanned primary profile **(figure)** shows the total heights of a surface.



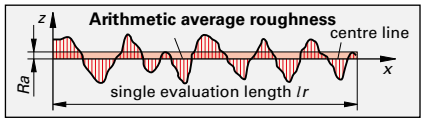
Filtering the primary profile (P-profile) leads to the roughness profile (R-profile) and the waviness profile (W-profile).



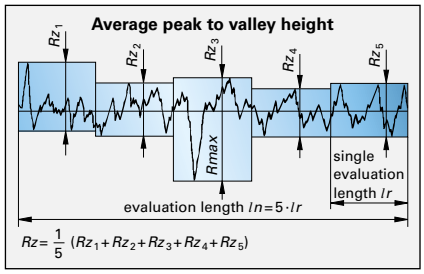
The R-profile **(figure)** shows the peaks, the valleys around a centre line.

The surface texture parameters are mostly calculated by the R-profile. There are several surface parameters:
Rz is widely used in Europe, ***Ra*** is the most specified U.S. parameter. Another parameter is ***Rmax*** (maximum peak to valley height).

Ra (arithmetic average roughness) considers all peaks and valleys of the roughness profile **(figure)**. One deep scratch in material is neutralised and has no significant influence on the final result.



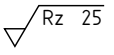
Rz (average peak to valley height) considers only the five highest peaks and the five deepest valleys **(figure)**. Extremes have a much greater influence on the final result. The complete evaluation length is divided into 5 cut-offs. In each cut-off the highest distance between peak and valley is a value (R_{z1}–R_{z5}).



Rmax (maximum peak to valley height) is the maximum height of the five values in the sampling length.

The surface parameters are shown in technical drawings by symbols **(table)**. To achieve a very high surface texture you need to choose the correct type of manufacturing. In your *Metal Trades Handbook* are tables to choose the correct manufacturing technology.

Table: Surface finish symbols

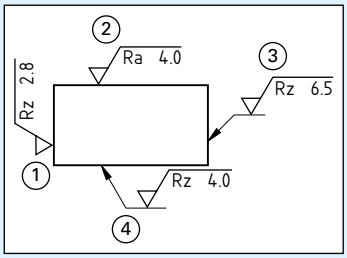
Symbol	Meaning
	All manufacturing processes are allowed
	Material removal not allowed or surface remains in delivered condition
	Material removal specified, e. g. turning, milling
	Material removal machining R_z = 25 µm

Achievable *Rz*-values:
Grinding: *Rz* = 1.6–4 µm
Milling: *Rz* = 10–63 µm
Drilling: *Rz* = 40–160 µm

Words	
surface texture parameter	Oberflächenkenngröße
to scan	abtasten
primary profile	Primärprofil
total height	Gesamthöhe
groove distance	Rillenabstand
wave distance	Wellenabstand
scoring distance	Riefenabstand
roughness profile	Rauheitsprofil
waviness profile	Welligkeitsprofil
peak	Spitze
valley	Tal
centre line	Mittellinie
specified	vorgeschriebene
arithmetic average roughness *Ra*	Mittelrauwert R_a
to consider	berücksichtigen
scratch	Kratzer
to neutralise	ausgleichen
significant	bedeutend
final result	Endergebnis
average peak to valley height *Rz*	Mittlere Rautiefe R_z
extreme	Grenzwert
evaluation length	Messstrecke
cut-off	Einzelmessstrecke
maximum peak to valley height *Rmax*	Maximale Rautiefe R_{max}
technical drawing	technische Zeichnung
to achieve	erreichen
to choose	wählen
type of manufacturing	Fertigungsverfahren
grinding	Schleifen
milling	Fräsen
drilling	Bohren
material removal	Materialabtrag
to allow	erlauben
to remain	verbleiben
delivered	angeliefert
reliable	zuverlässig

Exercises

1. Answer the questions in English.
   a) Which surface texture parameters are often used in USA and which in Germany?
   b) Explain the difference between the surface parameter *Rmax* and *Rz*.
   c) Why is the surface texture parameter *Rmax* not a very reliable value?
   d) Explain the surface texture parameter *Ra*.
2. Name the type of surface parameters and its value of the positions (1) to (4) shown in the right figure.
3. Copy a roughness profile from a book and draw in the three parameters: *Rmax*, Rz_1–z_5 and *Ra*.



1.7 Fits

A fit is the dimensional relationship of two mating construction components. The components have the same nominal size at the fitting location. They differ in the quantity and range of the tolerance.

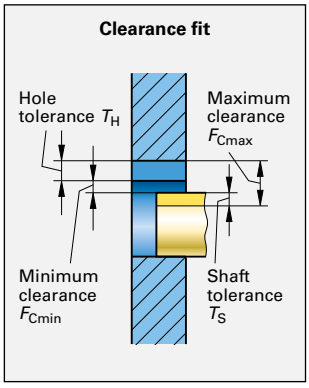
There are three different kinds of fits, depending on the dimensional difference between the matching components. The choice of the different fit is determined either by the use or by the production of the parts.

Clearance fit (figure)

Clearance fit always enables some space between the hole and shaft. The lower limit size of the hole is greater or at least equal to the upper limit size of the shaft.

The maximum clearance (F_{Cmax}) equals the hole maximum dimension (G_{UH}) minus the shaft minimum dimension (G_{IS}).

$\Rightarrow F_{Cmax} = G_{UH} - G_{IS}$



The minimum clearance (F_{Cmin}) is calculated by the hole minimum dimension (G_{IH}) minus the shaft maximum dimension (G_{US}).

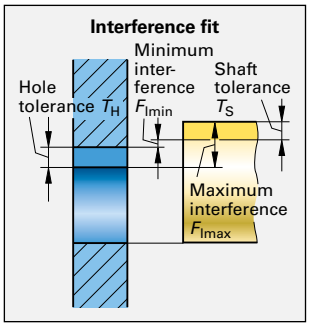
$\Rightarrow F_{Cmin} = G_{IH} - G_{US}$

Interference fit (figure)

It is a type of fit which always has some excess material between the hole and shaft. The upper limit size of the hole is smaller or at least equal to the lower limit size of the shaft.

The maximum interference (F_{Imax}) is calculated by the hole minimum dimension (G_{IH}) minus the shaft maximum dimension (G_{US}).

$\Rightarrow F_{Imax} = G_{IH} - G_{US}$

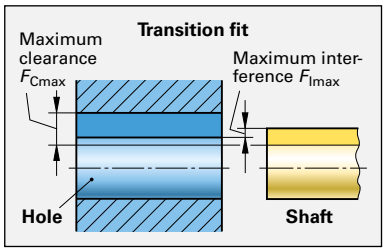


The minimum clearance (F_{Cmin}) equals the hole maximum dimension (G_{UH}) minus the shaft minimum dimension (G_{IS}).

$\Rightarrow F_{Imin} = G_{UH} - G_{IS}$

Transition fit (figure)

It is a fit where both types of fit may occur. The tolerance zones of the hole and shaft partly or completely interfere. There can be a clearance fit or an interference fit.



Words	
fit	Passung
dimensional relationship	Größenbeziehung
mating	passend
construction component	Bauteil
nominal size	Nenngröße
to differ	sich unterscheiden
range	Spannweite
tolerance	Toleranz
to depend on	abhängig sein von
difference	Unterschied
matching	zusammengehörend
choice	(Aus-)wahl
to determine	bestimmen
use	Einsatz
production	Herstellbarkeit
clearance fit	Spielpassung
to enable	ermöglichen
space	Spiel/Raum
hole	Bohrung
shaft	Welle
lower limit size	Mindestmaß
at least	mindestens
upper limit size	Höchstmaß
hole max. dimension	Höchstmaß Bohrung
shaft max. dimension	Höchstmaß Welle
hole minimum dimension	Mindestmaß Bohrung
shaft minimum dimension	Mindestmaß Welle
interference fit	Übermaßpassung
excess	Überschuss
transition fit	Übergangspassung
to occur	vorkommen
to interfere	überlagern
criteria	Kriterium
to select	auswählen
expression	Begriff
abbreviation	Abkürzung

Exercises

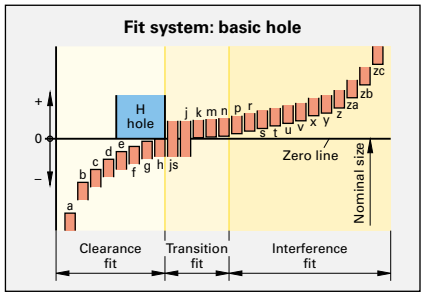
1. Answer the following questions in English.
   a) What is a fit?
   b) Which two criterias are given to select the type of fit?
   c) What are the dimensions of the hole and shaft, when a clearance fit is given?
   d) Which three types of fits are possible? Explain!
2. Find the correct expressions and match them to the abbreviation.
   a) F_{Imin}/F_{Imax}
   b) G_{IH}/G_{UH}
   c) T_H/T_S
   d) G_{IS}/G_{US}
   e) F_{Cmin}/F_{Cmax}

1.8 Fit Systems

Fit systems are needed to limit the amount of tolerances of two mating parts. In a fit system one of the parts is produced with a basic tolerance and the other part has the tolerance according to the specific fit system.

Fit system: Basic hole system

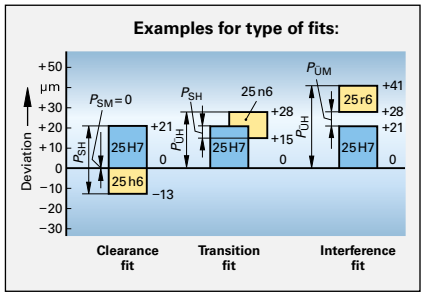
When the basic hole system is used, the diameter of the hole is produced with the fundamental deviation H **(figure)**. The basic hole system is attached to different basic sizes of the shaft, e.g. d, e or k, m. The basic hole system is widely used in mechanical engineering and in the automotive industry.



Range for type of fits

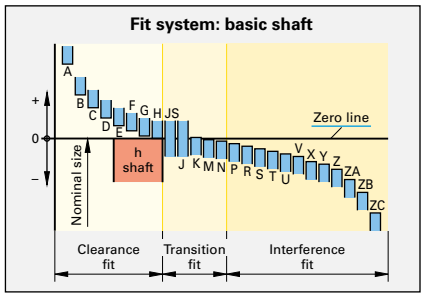
There are three general type of fits according to the different basic sizes of the shaft **(figure beside)**.

Clearance fits: H/a…h
Transition fits: H/j…n or p
Interference fits: H/n or p…z



Fit system: Basic shaft system

When the basic shaft system is applied, all shaft dimensions have the fundamental deviation h **(figure),** e.g. clearance fit: h/A…H
The basic shaft system is used for shafts that are produced in standard sizes; the mating hole must be calculated.



Words	
fit system	Passungssystem
to limit	begrenzen
mating	passend
basic tolerance	Grundtoleranz
diameter	Durchmesser
basic hole system	Einheitsbohrung
fundamental deviation	Grundabmaß
to attach	zuordnen
basic size	Grundabmaß
widely	weitgehend
mechanical engineering	Maschinenbau
automotive industry	Automobilindustrie
according	entsprechend
range for type of fits	Bereiche der Passungsarten
basic shaft system	Einheitswelle
to apply	anwenden
zero line	Nulllinie
standard size	Normgröße
to create	erzeugen
nominal size	Nennmaß
letters	Buchstaben
to determine	bestimmen
required	erforderlich

Range for the type of fits

The different type of fits are achieved by different fundamental deviations of the hole.

Clearance fits: h/A…H Transition fits: h/J…N or P Interference fits: h/N or P…Z

Example of the calculation of a fit:

Which important values need to be calculated to create a fit of 8.2 H7/d9?
*Use the tables of a **Metal Trades Handbook** to look up the different limits of the shaft and hole.*

8.2 H7/d9 ⇒ clearance fit Nominal size N = 8.2 mm

Hole limits: maximum dimension (G_{UH}) = 8.215mm; minimum dimension (G_{IH}) = 8.200 mm
Shaft limits: maximum dimension (G_{US}) = 8.160 mm; minimum dimension (G_{IS}) = 8.124 mm
Clearance limits: Maximum clearance (F_{Cmax}) = $G_{UH} - G_{IS}$ = 8.215 mm – 8.124 mm = 0.091 mm
Minimum clearance (F_{Cmin}) = $G_{IH} - G_{US}$ = 8.200 mm – 8.160 mm = 0.040 mm

Exercises

1. Answer the questions in German.
   a) Which difference do the basic hole system and the basic shaft system have?
   b) Where is the basic hole system used?
   c) Which letters are used in the basic hole system for interference fits?
2. Determine the type of fit of the following fits:
   a) 8H9/d9 b) 24H7/s6 c) 9K7/h6 d) 153 H11/c11
3. a) Read the required values for the fit of Nr. 2 a) to d) from a **Metal Trades Handbook**.
   b) Calculate the maximum and minimum clearance or interference, by using your **Metal Trade Handbook**.

2 Quality management

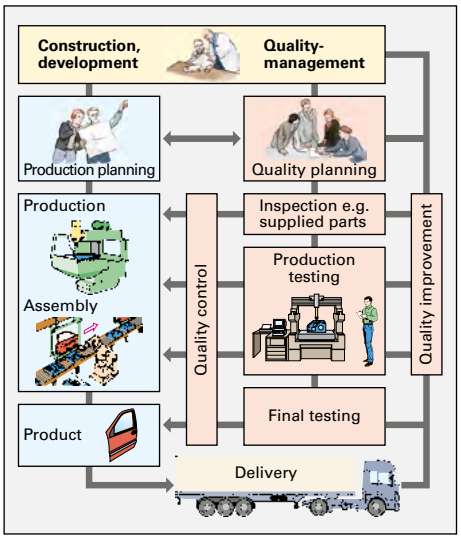
2.1 Basics of quality management

If a company wants to be successful on the market, the product quality must match the satisfaction of the customer. Customer's requirements are e. g. an appealing design, performance, functionality, reliability, maintainability and a good customer service.

Therefore, many companies have become certified and implemented a quality management system according to ISO 9000 standards.

Operating areas of quality management

Modern quality management encompasses all activities in a company, e.g. quality planning, quality control, quality assurance and quality improvement **(figure).**



It is carried out successfully if all employees follow the guidelines of the ISO standards. In this way the quality of work processes can be controlled. Errors can be detected as early as possible so that production costs can be decreased.

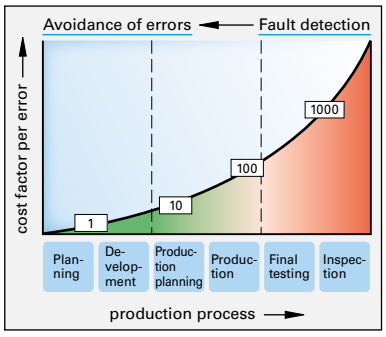
Quality characteristics and errors

There are two different categories of quality characteristics:

- **Quantitative (variable) characteristics**
  can be measured or counted, e.g. the length of a workpiece or the diameter of a shaft.
- **Qualitative (attributive) characteristics**
  describe a quality, e.g. the quality of the painting of a vehicle.

Errors are present when one or more quality requirements are not fulfilled, e.g. a dimension is not correct or there is a malfunction in production.

The 1-10-100 rule **(figure)** states that when a product moves through a production sequence, the cost of correcting an error multiplies by 10 from stage to stage.



Words

quality management	Qualitätsmanagement
successful	erfolgreich
to match	erfüllen
satisfaction	Zufriedenheit
customer	Kunde
requirement	Anforderung
appealing	ansprechend
performance	Leistungsfähigkeit
reliability	Zuverlässigkeit
maintainability	Instandhaltungs-fähigkeit
customer service	Kundendienst
to certify	zertifizieren
to implement	umsetzen
operating area	Arbeitsbereich
to encompass	umfassen
quality assurance	Qualitätssicherung
quality improvement	Qualitätsverbesserung
to carry out	durchführen
employee	Arbeitnehmer
guideline	Richtlinie
error	Fehler
to detect	erkennen
to decrease	vermindern
quality characteristics	Qualitätsmerkmale
quantitative	mengenmäßig
present	vorhanden
to fulfill	erfüllen
malfunction	Störung
to state	aussagen
sequence	Abfolge
to correct	korrigieren
to multiply by	multiplizieren mit
stage	Phase
avoidance of error	Fehlervermeidung
fault detection	Fehlerentdeckung

Exercises

1. Working with words. Which words from the text are described here?
   a) If the product looks really good, the design is very _____.
   b) If the device runs without a problem for a long time, it is very _____.
   c) If the product can be used in many different ways, the _____ is very high.
2. Translate the definition of quantitative and qualitative characteristics, in German.
3. Answer the following questions in English.
   a) Which 3 quality characteristics (= requirement of the customer) should your next smart phone have?
   b) Which system supports the quality process in companies?
   c) What does the 1-10-100 rule describe?
   d) Which different stages appear in a product circle?