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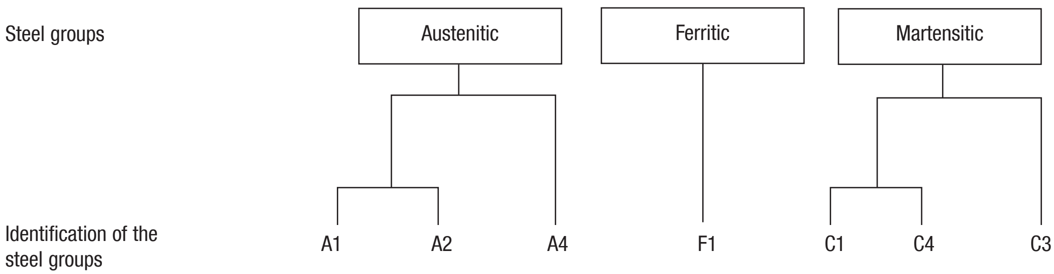
OVERVIEW TABLE FOR ISO STEEL GROUP DESIGNATION FOR FASTENERS MADE OF CORROSION- AND ACID-RESISTANT STEELS

Excerpt from ISO 3506



CHEMICAL COMPOSITION

Materials group	Steel group	Chemical composition in %							
		C	Si	Mn	P	S	Cr	Mo	Ni
Austenitic	A 1	0,12	1,0	2,0	0,20	0,15 to 0,35	17,0 to 19,0	0,6	8,0 to 10,0
	A 2	0,08	1,0	2,0	0,05	0,03	17,0 to 20,0		8,0 to 13,0
	A 4	0,08	1,0	2,0	0,05	0,03	16,0 to 18,5	2,0 to 3,0	10,0 to 14,0
Martensitic	C 1	0,09 to 0,15	1,0	1,0	0,05	0,03	11,5 to 14,0		1,0
	C 3	0,17 to 0,25	1,0	1,0	0,04	0,03	16,0 to 18,0		1,5 to 2,5
	C 4	0,08 to 0,15	1,0	1,5	0,06	0,15 to 0,35	12,0 to 14,0	0,6	1,0
Ferritic	F 1	0,12	1,0	1,0	0,04	0,03	15,5 to 18,0		0,5

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OVERVIEW TABLE OF SIMILAR CORROSION- AND ACID-RESISTANT STEELS DESIGNATIONS AND PROPERTIES

Austenitic			
Material no. DIN	Steel group DIN	AISI standard	Distinguishing characteristics Properties
1.4310 – 1.4305 1.4570	A 1	301 302 303 303 Cu	partially corrosion resistant, partially acid resistant
1.4301 1.4303 1.4306 1.4541 1.4550 1.4567	A 2	304 305 (L) 304 L 321 347 304 Cu	increased corrosion resistance, increased acid resistance
1.4401 1.4404 1.4529 1.4435 1.4436 1.4571 1.4578	A 4	316 316 L alloy 926 316 L / 316 LM 316 (316 Ti) 316 Cu	highly corrosion resistant, highly acid resistant, increased resistance to non-oxidizing acids

Ferritic			
1.4016	F 1	430	resistant to corrosion due to water, steam, weak acids and bases as well as strongly oxidized acids

Martensitic			
1.4006 1.4021 1.4034	C 1	410 420 –	resistant to corrosion due to water and steam
1.4057	C 3	431	resistant to corrosion due to water, ambient air, weak acids and bases

Chlorine, bromine and iodine significantly degrade corrosion resistance (pitting)

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OVERVIEW TABLE – SPECIAL MATERIALS

17-4 PH (ARMCO)

Material group	Material no. DIN	Chemical composition in %						
		C	Mn	Si	Cr	Ni	Nb	Cu
Martensitic hardening possible	1.4542 (AISI 630)	0,06	1,0	1,0	15,0–17,0	3,5–5,0	0,15–0,40	2,5–4,0

Properties:
- partially corrosion resistant
- partially acid resistant

MONEL 400

Nickel-copper alloy

Material no. DIN	Chemical composition in %							
	Ni 1)	Cu	Fe	Mn	C	Si	S	Al
2.4360	63–70	Remainder	2,5	2,0	0,16	0,5	0,02	0,5

1) with cobalt content

Properties:
- very good general corrosion resistance to all forms of water
- partially resistant to sea water
- insensitive to stress corrosion cracking

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OVERVIEW TABLE – ALUMINIUM ALLOYS

Designation EN 485 / 754	Designation DIN	AA-No. Standard	Properties
EN AW-1050 A	Al99,5	1050 A	• good corrosion resistance • good electrical conductivity
EN AW-5251	AlMg2	5251	• higher strength than Al99,5 • good corrosion resistance
EN AW-5052	AlMg2,5	5052	• medium strength • good corrosion resistance, also to sea water
EN AW-5754	AlMg3	5754	
EN AW-5154 A	AlMg3,5	5154 A	• the same as AlMg3 except with higher strength
EN AW-5019	AlMg5	5019 A / 5056	• high strength • good corrosion resistance, also to sea water • when exposed to adverse conditions tendency for intercrystalline and stress corrosion cracking

EN AW-2024	AlCu4Mg1	2024	• very high strength for highly stressed components • moderate corrosion resistance
EN AW-7075	AlZnMg5,5Cu	7075	• very high strength • moderate corrosion resistance

EN AW-6262	AlMg1SiPb	6262	• high strength • good corrosion resistance

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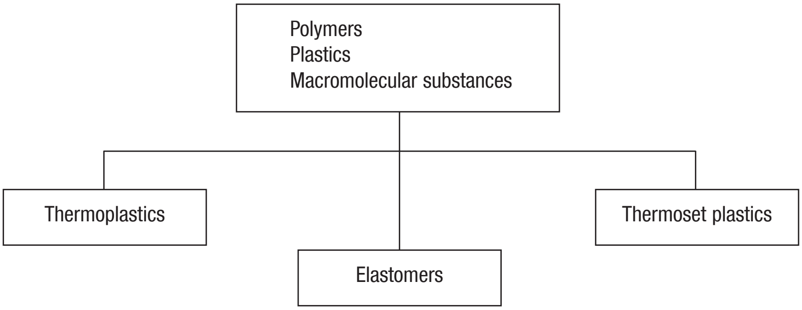
OVERVIEW TABLE – POLYMER MATERIALS
THERMOPLASTICS, THERMOSET PLASTICS AND ELASTOMERS



THERMOPLASTICS

Letter symbol	Polymer materials	Common trade names
ABS	Acrylonitrile butadiene styrene	Cycolac® Lustran® Novodur® Terluran®
PA 6	Polyamide	Ultramid® B Grilon® Nylon® Durethan® B
PA 66		Zytel® Ultramid® A Maranyl® A
PA 11		Rilsan®
PA B3K		Ultramid® B
PC	Polycarbonate	Lexan® Makrolon® Orgalan®
PE	Polyethylene	Alcathene® (EVA) Ertalene® Hostalen® Lupolen® Moplen® Vestolen®

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OVERVIEW TABLE – POLYMER

THERMOPLASTICS

Letter symbol	Polymer materials	Common trade names
PMMA	Polymethylmethacrylate (acrylic glass)	Diakon® Oroglas® Plexiglas®
POM	Polyacetal	Delrin® Hostaform® C Vitraform®
PP	Polypropylene	Hostalen® PP Ertalene® PP Lacqtere® P Moplen® Novolene® Propathene® Vestolen® P
PPO	Polyphenylenoxide	Tetraphenyl® Lyranyl® Noryl®
PSU	Polysulfone	Udel® Bakelite® BP Mindel®
PES	Polyethersulfone	Ultrason® S + E Vitrex PES®
PTFE	Polytetrafluorethylene	Algoflon® Fluon® Hostaflon® Teflon® Tetraflon®
PUR	Polyurethane	Desmopan® (BAYER) Elastollan® (BASF) Adiprene® Vulkollan®
PVC	Polyvinylchloride	Hostalit® Trosiplast® Vestolit® Vinnol® Vinoflex® Welvic® Supradur®

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OVERVIEW TABLE – POLYMER MATERIALS

THERMOSET PLASTICS

Letter symbol	Polymer materials	Common trade names
PF	Phenol formaldehyde resin	Bakelit® Gedetite® Resinol® Troliton®
EP	Epoxy resin	Araldit® (CIBA) Epikote® (SHELL) Epoxin® (BASF) Grilonit® (EMS) Hostapox® (HOECHST)

ELASTOMERE

Letter symbol	Polymer materials	Common trade names
CR	Polychloroprene	Neopren®
EPDM	Ethylen propylenes	Buna ap® Dutral Ter® Epcar®

LETTER SYMBOLS FOR REINFORCED PLASTICS

CFRP Carbon fiber reinforced plastic
GFRP Glass fiber reinforced plastic
SFRP Synthetic fiber reinforced plastic
MFRP Metallic fiber reinforced plastic

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OVERVIEW TABLE – SURFACE PROTECTION

GALVANIC PROCESSES

Process	Description
Cadmium plating passivation	Offers better protection in an ocean climate than zinc plating. Prohibited in many countries because it is detrimental to the environment.
Zinc plating plus chromate conversion coating (passivation)	Zinc plating and blue chromate conversion coating. (Cr3) compliant to RoHS
Zinc plating and chromate conversion coating (DISP) (passivation)	Zinc plated and thick-film passivated, corrosion protection similar to yellow. (Cr3)
Nickel plating	For decorative interior applications.
Chrome plating	As supplement after nickel plating. Increases corrosion resistance, decorative effect.
Zinc plating	Improves solderability (soft solders), corrosion protection for interior applications.
Anodizing	For aluminum. Decorative, possible in almost every color. Good corrosion protection for outdoor applications.

OTHER PROCESSES

Process	Description
Hot-dip galvanizing	Immersion in a hot zinc bath at approx. 450 °C. Excellent corrosion protection. Minimum layer thickness approx. 40 µm.
Phosphating	In a spraying or immersion process, a phosphate is transferred to a workpiece using a aqueous manganese- or zinc-phosphate solution. Only light corrosion protection. Good primer surface for paints and oils, etc.
Dacrotized Durocoat	Dacromet/Durocoat is an inorganic coating made of chrome-passivated laminar zinc. The sintering of the layer takes place in a tunnel kiln. Excellent corrosion protection. Especially well suited for fasteners.
Varnish and paint	Base coat and top coat applied by brush, spraying or immersion. One or multiple layers. Good corrosion protection for indoor and outdoor applications.

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NON-BINDING SELECTION TABLE
CONTACT CORROSION WITH FASTENERS

In the case of contact between two different metals in an electrically conducting liquid (e.g. 5% liquid sodium-chloride solution). The less noble metal or its surface protection serves as a sacrificial anode and is consumed in preference to the more noble metal.

Material		Workpiece				
		Stainless Steel	Copper	Bare steel	Galvanized steel	Aluminium-alloys
Fasteners	Zinc-plated Monel	1	1	1	1	1
	Stainless steel	neutral	1	1	1	1
	Copper, brass	2/3	neutral	1	1	1
	Bare steel	3	3	neutral	1	2
	Galvanized steel	3	3	2	neutral	2
	Aluminum alloys	3	4	3	2	neutral

1 Corrosion of fasteners is **not** accelerated by the workpiece. (good)

2 Corrosion of fasteners can be accelerated by the workpiece. (moderate)

3 Corrosion of fasteners can be **significantly** accelerated by the workpiece. (poor)

4 This combination is not recommended. (very poor)

Recommendation to prevent contact corrosion:

• Use metal pairs with small (neutral) or no potential difference (1).

• Create designs that reduce corrosion: water must be able to run off, humidity must be able to be removed by ventilation.

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OVERVIEW TABLE – SI UNITS

MECHANICAL

Quantity	SI units and other legally allowed units: Name	Symbol	Relationship	Old designations
Mass	**kilogram** gram metric ton (tonne)	**kg** g t	Basic unit 1 g = 10^{-3} kg 1 t = 10^{3} kg	
Density	**kilogram/ meter^{3}**	**kg/m^{3}**		
Force	**newton**	**N**	1 N = 1 kg·m/s^{2}	1 dyn = 10^{-5} N 1 kp = 9,80665 N 1 kgf = 1 kg = 9,80665 N
Torque	**newton-meter**	**N·m**		1 kp·m = 9,80665 N·m
Mechanical stress	**newton/meter^{2}**	**N/m^{2}**		1 kp/m^{2} = 9,80665 N/m^{2}
Pressure	**pascal** bar millimeter of mercury column	**Pa** bar mm Hg	1 Pa = 1 N/m^{2} 1 bar = 10^{5} Pa 1 mm Hg = 1,33322·10^{2} Pa	1 atm = 1,01325·10^{5} Pa 1 at = 0,980665·10^{5} Pa 1 torr = 1,33320·10^{2} Pa 1 barye = 0,1 Pa 1 pz (pièze) = 10^{3} Pa 1 mm WC = 9,80665 Pa
Dynamic viscosity	**pascal-second**	**Pa·s**	1 Pa·s = N·s/m^{2}	1 P (poise) = 10^{-1} Pa·s
Kinematic viscosity	**meter^{2}/second**	**m^{2}/s**		1 St (stokes) = 10^{-4} m^{2}/s

MULTIPLES OF UNITS

Factor	Symbol	Designation
0,000’001 (10^{-6})	μ	micro
0,001 (10^{-3})	m	milli
0,01 (10^{-2})	c	centi
0,1 (10^{-1})	d	deci
1 (10^{0})	-	-
10 (10^{1})	da	deca
100 (10^{2})	h	hekto
1’000 (10^{3})	k	kilo
1’000’000 (10^{6})	M	mega

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OVERVIEW TABLE OFHARDNESS FOR UNALLOYED AND ALLOYED STEELS

Tensile strength 2) N/mm²	Vickers hardness (F ≥98 n)	Brinell hardness 1)	Rockwell hardness $\left(0{,}102 \cdot \frac{F}{D^2} = 30 \frac{N}{mm^2}\right)$		
			HRB	HRC	HRA
255	80	76,0			
270	85	80,7	41,0		
285	90	85,5	48,0		
305	95	90,2	52,0		
320	100	95,0	56,2		
335	105	99,8			
350	110	105	62,3		
370	115	109			
385	120	114	66,7		
400	125	119			
415	130	124	71,2		
430	135	128			
450	140	133	75,0		
465	145	138			
480	150	143	78,7		
495	155	147			
510	160	152	81,7		
530	165	156			
545	170	162	85,0		
560	175	166			
575	180	171	87,1		
595	185	176			
610	190	181	89,5		
625	195	185			
640	200	190	91,5		
660	205	195	92,5		
675	210	199	93,5		
690	215	204	94,0		
705	220	209	95,0		
720	225	214	96,0		
740	230	219	96,7		
755	235	223			
770	240	228	98,1	20,3	60,7
785	245	233		21,3	61,2
800	250	238	99,5	22,2	61,6
820	255	242		23,1	62,0
835	260	247	(101)	24,0	62,4
850	265	252		24,8	62,7
865	270	257	(102)	25,6	63,1
880	275	261		26,4	63,5
900	280	268	(104)	27,1	63,8
915	285	271		27,8	64,2
930	290	276	(105)	28,5	64,5
950	295	280		29,2	64,8
965	300	285		29,8	65,2
995	310	295		31,0	65,8
1030	320	304		32,2	66,4
1060	330	314		33,3	67,0
1095	340	323		34,3	67,6
1125	350	333		35,5	68,1
1155	360	342		36,6	68,7
1190	370	352		37,7	69,2
1220	380	361		38,8	69,8
1255	390	371		39,8	70,3
1290	400	380		40,8	70,8
1320	410	390		41,8	71,4
1350	420	399		42,7	71,8
1385	430	409		43,6	72,3
1420	440	418		44,5	72,8
1455	450	428		45,3	73,3
1485	460	437		46,1	73,6
1520	470	447		46,9	74,1
1555	480	(456)		47,7	74,5
1595	490	(466)		48,4	74,9
1630	500	(475)		49,1	75,3
1665	510	(485)		49,8	75,7
1700	520	(494)		50,5	76,1
1740	530	(504)		51,1	76,4
1775	540	(513)		51,7	76,7
1810	550	(523)		52,3	77,0
1845	560	(532)		53,0	77,4
1880	570	(542)		53,6	77,8
1920	580	(551)		54,1	78,0
1955	590	(561)		54,7	78,4
1995	600	(570)		55,2	78,6
2030	610	(580)		55,7	78,9
2070	620	(589)		56,3	79,2
2105	630	(599)		56,8	79,5
2145	640	(608)		57,3	79,8
2180	650	(618)		57,8	80,0
	660			58,3	80,3
	670			58,8	80,6
	680			59,2	80,8
	690			59,7	81,1
	700			60,1	81,3
					81,181,3
	720			61,0	81,8
	740			61,8	82,2
	760			62,5	82,6
	780			63,3	83,0
	800			64,0	83,4
	820			64,7	83,8
	840			65,3	84,1
	860			65,9	84,4
	880			66,4	84,7
	900			67,0	85,0
	920			67,5	85,3
	940			68,0	85,6

The numbers in parentheses are hardness values that lie outside the defined region of the standard hardness test procedures, however they are frequently used as approximate values. Furthermore, the Brinell hardness values in parentheses are valid only if they are measured with a tungsten carbide ball.

1) Calculated from: HB = 0.95 · HV

2) The tensile strength values listed in the table are to be considered only as approximate values. For the exact determination of tensile strength values, a tensile test is mandatory.

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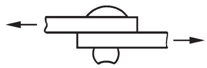
DEFINITION OF TERMS
MECHANCAL

Shear force at break:

- single shear



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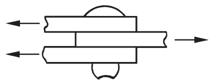
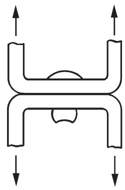
- double shear
  (note the special notes on the standard specification sheets)



Tensile strength at break:



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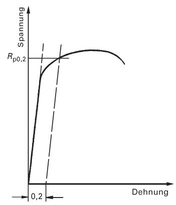
MECHANICAL STRESS

Offset yield point $R_{p0,2}$

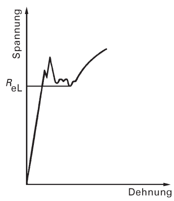
The offset yield point of the material reached in a tensile test describes the permanent transition from the elastic to the plastic state at 0.2% remaining deformation.



N/mm²

Lower yield strength R_{eL}

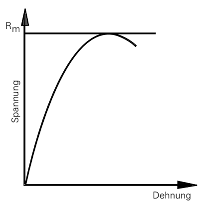
The lower yield strength of the material reached in the tensile test describes the permanent transition from the elastic to the plastic state.



N/mm²

Tensile stress R_m

The highest tensile stress in the tensile test that leads to breakage.



N/mm²

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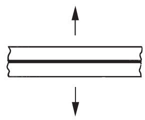
DEFINITION OF TERMS

ADHESIVE TECHNOLOGY

Tensile strength ISO 6922

The tensile strength σ_B is the ratio of the highest force Fmax. and the adhesion surface A.

$$\sigma_B = \frac{F_{max.}}{A}$$



N/mm²

Tensile shear strength ISO 4587

The tensile shear strength τ_B is the ratio of the highest force Fmax. and the adhesion surface A.

$$\tau_B = \frac{F_{max.}}{A}$$

N/mm²

T-peel strength DIN EN ISO 11339

Crack peel resistance
Crack peel resistance p_A is the ratio of the crack force F_A and the sample width b.

$$p_A = \frac{F_A}{b}$$

N/mm

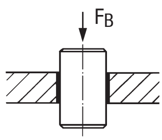
Peel resistance
Peel resistance p_s is the ratio of the mean separating force $\bar{F}$, which is determined from the peeling curve, and the sample width b.

$$p_s = \frac{\bar{F}}{b}$$

Compressive shear strength DIN 10123

The compressive shear bond strength τ_D is the ratio of the axial force to break F_B and the shearing surface A in a rotationally symmetric joining gap.

$$\tau_D = \frac{F_B}{A}$$



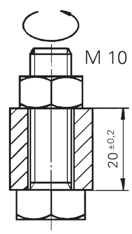
N/mm²

Breakaway torque DIN EN ISO 10964

The breakaway torque M_{LB} is the torque measured at the first relative movement between a nut and a bolt.

Prevailing torque DIN EN ISO 10964

The prevailing torque M_{LW} is the measured torque after a bolt has broken loose.



Nm

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TERMS FROM ADHESIVE TECHNOLOGY

Adhesion
The effect of the forces of attraction on the boundary surface between the adhesive and the bonded component.

Activators
Materials that accelerate or initiate the complete hardening of reactive adhesives.

Active materials
Materials that act as a catalyst during the hardening of anaerobic adhesives, e.g. non-ferrous metals, some steels and some aluminum alloys.

Application
Distribution of an adhesive on the adhesive surfaces. The application can be made on one adhesive surface (one-sided application) or on both adhesive surfaces (double-sided application).

Curing conditions
Parameters that significantly influence the curing of reactive adhesives such as temperature, humidity, etc.

Curing
Process whereby a fluid adhesive changes into a solid material. In the process, the adhesive solidifies both on the parts being bonded (adhesion) and also within itself (cohesion).

Curing time
Time between when two pieces to be bonded are brought together and complete curing of the adhesive.

Compressive strength
Basic types of loadings.

Compression/shear strength
Basic types of loadings.

One-part adhesive
Adhesives that, in their commercial form, contain all the components necessary for adhesion are designated one-part adhesives.

Degreasing
Removal of grease and oil layers from the surfaces of the parts to be bonded by means of cleaning agents / solvents.

Strength
Adhesive strength.

Place
Holding the components to be bonded steady in the desired position with or without pressure during the curing process.

Bonding
a) Joining of solid components.
b) Process of bringing together components to be joined with a adhesive.

Bonded parts
Solid components to be bonded to each other or that are already bonded to each other.

Bonding process
Process of joining components (which are already applied with adhesive) whereby an adhesive layer develops from the adhesive film(s).

Basic types of loadings
Forces that have an effect on the adhesive bond and lead to mechanical loading. A distinction is made between: tensile loads, tensile shear loads, peeling loads and compressive loads.
In practice, several types of loads frequently appear at the same time.

Closed waiting time
Period of time from joining the workpieces until the curing conditions have been reached.

Activator / accelerator
Material that causes an adhesive to cure due to a chemical reaction.

Fixture time
An adhesive bond is considered fixed when a force of 0.1 N per mm^2 of adhesive surface must be applied as a shearing load (basic types of loadings) in order to separate the bond. Times indicated after the term Fixture time refer to the time which must pass after the bonding process until the adhesive joint is bonded.

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TERMS FROM ADHESIVE TECHNOLOGY

Catalyst
Material whose presence initiates or accelerates a chemical reaction without itself being chemically altered.

Adhesive strength
The force that must be applied to an adhesive layer to separate a bond when subject to stress, pressure, peeling or stress loads (basic types of loadings).

Adhesive surface
The surface of a bonded component to which the adhesive is applied.

Adhesive layer
Cured or not yet cured adhesive between the parts to be bonded.

Adhesive
Non-metallic material that bonds components through adhesion and cohesion.

Cohesion
The forces that dominate between the molecules of a body and hold the particles together.

Shelf life
Time between the manufacture of an adhesive and the time when it is still usable if certain storage conditions (temperature, humidity, etc.) are maintained.

Solvent
Organic liquid that dissolves the basic materials and soluble adhesive components without any chemical change.

Multicomponent adhesive
In multicomponent adhesives, those components capable of reacting are kept separate from each other and must be mixed together before application in order to allow curing of the adhesive. After the components are mixed, the adhesive is usable only for a certain period of time (pot life). In a new generation of two-component adhesives, both components (adhesive and activator) are not mixed but rather simply applied separately to the surfaces to be bonded. When the components are brought together, (minimal) mixing of the components takes place and brings about the polymerization of the adhesive

Passive material
Materials that do not support the curing process of anaerobic adhesives, e.g. stainless steel, various aluminum alloys, rare earth metals, and non-metallic substances.

Reaction adhesive
Adhesives whose curing is based on a chemical reaction. The reaction causes the creation of larger molecules, cross-linked plastics with greater strength. A distinction is made between one-part adhesives and multicomponent adhesives.

Peeling forces
Basic types of loadings.

Shear forces
Basic types of loadings.

Pot life
Time during which an adhesive, following the mixing of all its components, is still usable for an application. After the pot life has been exceeded, no sufficient cross-linking of the surfaces to be bonded with the adhesive is possible.

Viscosity
Stiffness of fluids or paste-like materials due to their internal friction.
low viscosity = thin, easily flowing
high viscosity = thick, poor flowing

Tensile strength
Basic types of loadings.

Tensile shear strength
Basic types of loading.