General information

Designation

High Strength Carbon Fiber/Epoxy Composite, 0/90° Biaxial lamina.

Material was produced from woven fabric prepreg, fiber volume fraction nominally 0.48 - 0.58. Autoclave cure at 120-180°C, 6-7 bar.

Tradenames

Cycom; Fiberdux; Scotchply

Typical uses

Lightweight structural members in aerospace, automotive components, sporting goods, springs, pressure vessels.

Composition overview

Compositional summary

Epoxy + Carbon fiber reinforcement

Material family	Plastic (thermoset)			
Base material	EP (Epoxy resin)			
% filler (by weight)	60	-	65	%
Filler/reinforcement	Carbon			
Filler/reinforcement form	Woven fabric, Biaxial lay-up			
Polymer code	EP-CF60			

Composition detail (polymers and natural materials)

Polymer	35	-	40	%
Carbon (fiber)	60	-	65	%

Price

Price	* 1,17e3	-	1,3e3	CZK/kg
Price per unit volume	* 1,8e6	-	2,09e6	CZK/m^3

Physical properties

Density	1,54e3	-	1,61e3	kg/m^3

Mechanical properties

Young's modulus	62,7	-	68,7	GPa
Specific stiffness	39,6	-	43,8	MN.m/kg
Yield strength (elastic limit)	627	-	910	MPa
Tensile strength	627	-	910	MPa
Specific strength	398	-	579	kN.m/kg
Elongation	0,98	-	1,41	% strain
Compressive modulus	57,2	-	63,4	GPa
Compressive strength	655	-	937	MPa
Flexural modulus	63	-	69	GPa
Flexural strength (modulus of rupture)	627	-	910	MPa

Shear modulus	3,5			GPa
Bulk modulus	* 7,86	-	10,2	GPa
Poisson's ratio	0,058			
Shape factor	8			
Hardness - Vickers	* 10,8	-	21,5	HV
Hardness - Rockwell M	* 80	-	110	
Hardness - Rockwell R	* 117	-	129	
Elastic stored energy (springs)	3,08e3	-	6,14e3	kJ/m^3
Fatigue strength at 10^7 cycles	* 345	-	592	MPa

Impact & fracture properties

Fracture toughness	* 37,9	-	50,3	MPa.m^0.5
Toughness (G)	22,2	-	38	kJ/m^2
Impact strength, notched 23 °C	* 109	-	137	kJ/m^2

Thermal properties

Glass temperature	100	-	180	°C
Heat deflection temperature 0.45MPa	* 279	-	337	°C
Heat deflection temperature 1.8MPa	* 250	-	305	°C
Maximum service temperature	* 140	-	220	°C
Minimum service temperature	* -123	-	-73	°C
Thermal conductivity	* 1,08	-	2,2	W/m.°C
Specific heat capacity	* 949	-	1,09e3	J/kg.°C
Thermal expansion coefficient	* 5,51	-	29,3	µstrain/°C
Thermal shock resistance	* 390	-	2,1e3	°C
Thermal distortion resistance	* 0,0511	-	0,288	MW/m

Electrical properties

Electrical resistivity	* 1,71e5	-	5,64e5	µohm.cm
Electrical conductivity	3,06e-4	-	0,00101	%IACS
Galvanic potential	0,14	-	0,22	V

Magnetic properties

Magnetic type	Non-magnetic			

Optical, aesthetic and acoustic properties

Transparency	Opaque			
Acoustic velocity	6,29e3	-	6,62e3	m/s
Mechanical loss coefficient (tan delta)	* 0,0014	-	0,0033	

Critical materials risk

Contains >5wt% critical elements?	No			

Absorption & permeability

Water absorption @ 24 hrs	* 0,0416	-	0,063	%

Durability

Water (fresh)	Excellent
Water (salt)	Excellent
Weak acids	Acceptable
Strong acids	Unacceptable
Weak alkalis	Limited use
Strong alkalis	Excellent
Organic solvents	Limited use
Oxidation at 500C	Unacceptable
UV radiation (sunlight)	Good
Flammability	Slow-burning

Primary production energy, CO2 and water

Embodied energy, primary production	* 616	-	679	MJ/kg
CO2 footprint, primary production	* 42,8	-	47,2	kg/kg
Water usage	* 1,25e3	-	1,38e3	l/kg

Processing energy, CO2 footprint & water

Autoclave molding energy	* 20,9	-	23	MJ/kg
Autoclave molding CO2	* 1,67	-	1,84	kg/kg
Autoclave molding water	* 13,6	-	20,4	l/kg
Compression molding energy	* 3,33	-	3,68	MJ/kg
Compression molding CO2	* 0,266	-	0,294	kg/kg
Compression molding water	* 6,31	-	9,46	l/kg
Matched die (preform) molding energy	* 9,62	-	10,6	MJ/kg
Matched die (preform) molding CO2	* 0,77	-	0,849	kg/kg
Matched die (preform) molding water	* 8,93	-	13,4	l/kg

Recycling and end of life

Recycle	✗			
Recycle fraction in current supply	0,1			%
Downcycle	✓			
Combust for energy recovery	✓			
Heat of combustion (net)	* 31,2	-	32,8	MJ/kg
Combustion CO2	* 3,11	-	3,27	kg/kg
Landfill	✓			
Biodegrade	✗			

Links

ProcessUniverse
Producers
Reference
Shape

General information

Designation

6061, wrought

Condition	T6 (Solution heat-treated and artificially aged)
UNS number	A96061
EN name	EN AW-6061 (EN AW-Al Mg1SiCu)
EN number	3.3211

Typical uses

Transportation equipment, heavy duty structures, marine uses, pipe, furniture, bridges, rail, towers, pylons.

Composition overview

Compositional summary

Al96-99 / Mg0.8-1.2 / Si0.4-0.8 / Cu0.15-0.4 / Cr0.04-0.35 (impurities: Fe<0.7, Zn<0.25, Mn<0.15, Ti<0.15, Other<0.15)

Material family	Metal (non-ferrous)
Base material	Al (Aluminum)

Composition detail (metals, ceramics and glasses)

Al (aluminum)	* 95,8	-	98,6	%
Cr (chromium)	0,04	-	0,35	%
Cu (copper)	0,15	-	0,4	%
Fe (iron)	0	-	0,7	%
Mg (magnesium)	0,8	-	1,2	%
Mn (manganese)	0	-	0,15	%
Si (silicon)	0,4	-	0,8	%
Ti (titanium)	0	-	0,15	%
Zn (zinc)	0	-	0,25	%
Other	0	-	0,15	%

Price

Price	* 49,2	-	57,1	CZK/kg
Price per unit volume	* 1,32e5	-	1,56e5	CZK/m^3

Physical properties

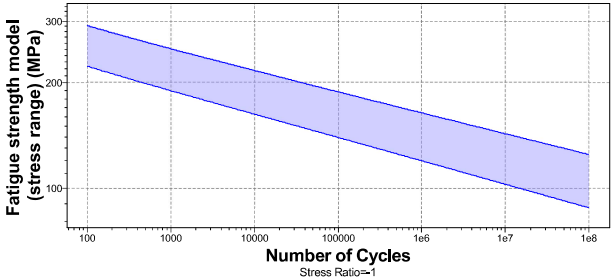
Density	2,69e3	-	2,73e3	kg/m^3

Mechanical properties

Young's modulus	66,6	-	70	GPa
Specific stiffness	24,5	-	25,8	MN.m/kg
Yield strength (elastic limit)	240	-	280	MPa
Tensile strength	290	-	338	MPa
Specific strength	88,4	-	103	kN.m/kg
Elongation	10	-	14,4	% strain

Compressive modulus	67,9	-	71,3	GPa
Compressive strength	* 240	-	280	MPa
Flexural modulus	* 66,6	-	70	GPa
Flexural strength (modulus of rupture)	* 240	-	280	MPa
Shear modulus	25,6	-	26,9	GPa
Shear strength	186	-	217	MPa
Bulk modulus	* 66,6	-	70	GPa
Poisson's ratio	0,325	-	0,335	
Shape factor	24,8			
Hardness - Vickers	100	-	107	HV
Hardness - Brinell	90	-	100	HB
Elastic stored energy (springs)	423	-	572	kJ/m^3
Fatigue strength at 10^7 cycles	* 112	-	131	MPa
Fatigue strength model (stress range)	* 103	-	143	MPa

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



Impact & fracture properties

Fracture toughness	* 30	-	36	MPa.m^0,5
Toughness (G)	13,3	-	18,9	kJ/m^2

Thermal properties

Melting point	580	-	650	°C
Maximum service temperature	130	-	150	°C
Minimum service temperature	-273			°C
Thermal conductivity	152	-	169	W/m.°C
Specific heat capacity	878	-	914	J/kg.°C
Thermal expansion coefficient	22,7	-	23,9	µstrain/°C
Thermal shock resistance	150	-	177	°C
Thermal distortion resistance	* 6,5	-	7,3	MW/m

Latent heat of fusion	384	-	393	kJ/kg

Electrical properties

Electrical resistivity	3,9	-	4,1	µohm.cm
Electrical conductivity	42,1	-	44,2	%IACS
Galvanic potential	* -0,79	-	-0,71	V

Magnetic properties

Magnetic type	Non-magnetic

Optical, aesthetic and acoustic properties

Transparency	Opaque			
Acoustic velocity	4,95e3	-	5,08e3	m/s
Mechanical loss coefficient (tan delta)	* 1e-4	-	0,002	

Critical materials risk

Contains >5wt% critical elements?	Yes
Notes	Al (aluminum) added to the 2018 US critical minerals list

Processing properties

Metal casting	Unsuitable	
Metal cold forming	Excellent	
Metal hot forming	Excellent	
Metal press forming	Acceptable	
Metal deep drawing	Acceptable	
Machining speed	85,3	m/min
Weldability	Good	
Notes	Preheating is not required, post weld heat treatment is required	

Durability

Water (fresh)	Excellent
Water (salt)	Acceptable
Weak acids	Excellent
Strong acids	Excellent
Weak alkalis	Acceptable
Strong alkalis	Unacceptable
Organic solvents	Excellent
Oxidation at 500C	Unacceptable
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Limited use
Notes	Aluminum alloys perform poorly when self-mated but can be processed without galling when mated with steels.
Flammability	Non-flammable

Corrosion resistance of metals

Stress corrosion cracking	Not susceptible

Notes	Rated in chloride; Other susceptible environments: Halide, water

Primary production energy, CO2 and water

Embodied energy, primary production	* 190	-	210	MJ/kg
CO2 footprint, primary production	* 12,6	-	13,9	kg/kg
Water usage	* 1,13e3	-	1,25e3	l/kg

Processing energy, CO2 footprint & water

Roll forming, forging energy	* 6,03	-	6,67	MJ/kg
Roll forming, forging CO2	* 0,452	-	0,5	kg/kg
Roll forming, forging water	* 4,13	-	6,2	l/kg
Extrusion, foil rolling energy	* 11,8	-	13	MJ/kg
Extrusion, foil rolling CO2	* 0,884	-	0,977	kg/kg
Extrusion, foil rolling water	* 6,59	-	9,88	l/kg
Wire drawing energy	* 43,4	-	48	MJ/kg
Wire drawing CO2	* 3,25	-	3,6	kg/kg
Wire drawing water	* 16,4	-	24,5	l/kg
Metal powder forming energy	* 22,2	-	24,6	MJ/kg
Metal powder forming CO2	* 1,78	-	1,96	kg/kg
Metal powder forming water	* 24,2	-	36,3	l/kg
Vaporization energy	* 1,55e4	-	1,71e4	MJ/kg
Vaporization CO2	* 1,16e3	-	1,28e3	kg/kg
Vaporization water	* 6,46e3	-	9,69e3	l/kg
Coarse machining energy (per unit wt removed)	* 1,34	-	1,48	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0,1	-	0,111	kg/kg
Fine machining energy (per unit wt removed)	* 9,1	-	10,1	MJ/kg
Fine machining CO2 (per unit wt removed)	* 0,682	-	0,754	kg/kg
Grinding energy (per unit wt removed)	* 17,7	-	19,6	MJ/kg
Grinding CO2 (per unit wt removed)	* 1,33	-	1,47	kg/kg
Non-conventional machining energy (per unit wt removed)	* 155	-	171	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	* 11,6	-	12,8	kg/kg

Recycling and end of life

Recycle	✓			
Embodied energy, recycling	* 32,4	-	35,8	MJ/kg
CO2 footprint, recycling	* 2,54	-	2,81	kg/kg
Recycle fraction in current supply	40,5	-	44,7	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			

Notes

Other notes

Immediate strength extrusion alloy. Prices of Aluminum alloys fluctuate greatly and are dependent on batch size, unit size, forming methods, etc.

Standards with similar compositions

• Australia:
6061 to AS 1734, 6061 to AS 1865, 6061 to AS 1866, 6061 to AS 1867, 6061 to AS 2848.1, 6061A to AS 2848.1
• Canada:
0.6061 to CSA HA.4, 0.6061 to CSA HA.5, 0.6061 to CSA HA.6, 0.6061 to CSA HA.7, 0.6061 to CSA HA.7.1, 0.6061 to CSA HA.8
• Europe:
EN AW-6061 to CEN EN 573-3
• France:
6061 to NF A50-411, 6061 to NF A50-451
• Germany:
3.3211/AlMgSi1Cu to DIN 1725-1
• International:
AlMg1SiCu to ISO 209-1
• Japan:
6061 to JIS H4120, A6061FD to JIS H4140, A6061FH to JIS H4140, A6061P to JIS H4000, A6061S to JIS H4100, A6061TB to JIS H4180, A6061TD to JIS H4080, A6061TE to JIS H4080
• Russia:
1330 to GOST 4784, AD33 to GOST 4784
• UK:
6061 to BS 1471, 6061 to BS 1473, 6061 to BS 1474, 6061 to BS 1475
• USA:
6061, 6061 to AMS 4025, 6061 to AMS 4026, 6061 to AMS 4027, 6061 to AMS 4043, 6061 to AMS 4053, 6061 to AMS 4115, 6061 to AMS 4116, 6061 to AMS 4117, 6061 to ASTM B209M, 6061 to ASTM B210M, 6061 to ASTM B211M, 6061 to ASTM B221M, 6061 to ASTM B234, 6061 to ASTM B241M, 6061 to ASTM B247M, 6061 to ASTM B308/B308M, 6061 to ASTM B313/B313M, 6061 to ASTM B316/B316M, 6061 to ASTM B345/B345M, 6061 to ASTM B404/B404M, 6061 to ASTM B429, 6061 to ASTM B483/B483M, 6061 to ASTM B547/B547M, 6061 to ASTM B632/B632M, 6061 to MIL F-17132, 6061 to MIL P-25995B, 6061 to QQ A-225/8, 6061 to QQ A-250/11, 6061A, 6062, UNS A96061
• Venezuela:
6061 to COPANT 862
• Yugoslavia:
3.5456.00/AlMg1SiCu to JUS C.C2.100
• Tradenames:
ALCOA 6061 COLD FINISHED BAR, ALUMINUM C58, ANTICORODAL-082, BAW 6061, KAISER ALUMINUM 6061

Links

ProcessUniverse

Producers

Reference

Shape

General information

Designation

7020, wrought

Condition	T6 (Solution heat-treated and artificially aged)
UNS number	A97020
EN name	EN AW-7020 (EN AW-Al Zn4,5Mg1)
EN number	3.4335

Typical uses

Transportable bridging, weapons industry, armour plating, Engineering-Corps equipment.

Composition overview

Compositional summary

Al91-95 / Zn4-5 / Mg1-1.4 / Mn0.05-0.5 / Cr0.1-0.35 / Zr0.08-0.2 (impurities: Fe<0.4, Si<0.35, Cu<0.2, Ti<0.05, Other<0.15)

Material family	Metal (non-ferrous)
Base material	Al (Aluminum)

Composition detail (metals, ceramics and glasses)

Al (aluminum)	* 91,4	-	94,8	%
Cr (chromium)	0,1	-	0,35	%
Cu (copper)	0	-	0,2	%
Fe (iron)	0	-	0,4	%
Mg (magnesium)	1	-	1,4	%
Mn (manganese)	0,05	-	0,5	%
Si (silicon)	0	-	0,35	%
Ti (titanium)	0	-	0,05	%
Zn (zinc)	4	-	5	%
Zr (zirconium)	0,08	-	0,2	%
Other	0	-	0,15	%

Price

Price	* 96,3	-	113	CZK/kg
Price per unit volume	* 2,66e5	-	3,19e5	CZK/m^3

Physical properties

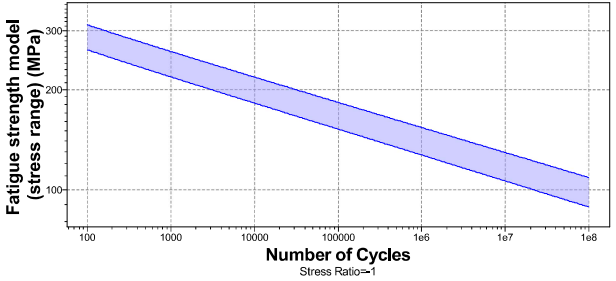
Density	2,75e3	-	2,81e3	kg/m^3

Mechanical properties

Young's modulus	70	-	74	GPa
Specific stiffness	25,1	-	26,7	MN.m/kg
Yield strength (elastic limit)	318	-	352	MPa
Tensile strength	361	-	399	MPa
Specific strength	114	-	127	kN.m/kg

Elongation	11,1	-	12,9	% strain
Compressive strength	* 318	-	352	MPa
Flexural modulus	* 70	-	74	GPa
Flexural strength (modulus of rupture)	318	-	352	MPa
Shear modulus	25	-	27	GPa
Bulk modulus	65	-	72	GPa
Poisson's ratio	0,325	-	0,335	
Shape factor	21			
Hardness - Vickers	119	-	131	HV
Elastic stored energy (springs)	702	-	862	kJ/m^3
Fatigue strength at 10^7 cycles	* 116	-	118	MPa
Fatigue strength model (stress range)	* 106	-	129	MPa

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



Impact & fracture properties

Fracture toughness	* 33	-	35	MPa.m^0.5
Toughness (G)	15,1	-	17,1	kJ/m^2

Thermal properties

Melting point	605	-	645	°C
Maximum service temperature	80	-	100	°C
Minimum service temperature	-273			°C
Thermal conductivity	137	-	143	W/m.°C
Specific heat capacity	875	-	911	J/kg.°C
Thermal expansion coefficient	22,7	-	23,9	µstrain/°C
Thermal shock resistance	187	-	212	°C
Thermal distortion resistance	* 5,81	-	6,21	MW/m
Latent heat of fusion	384	-	393	kJ/kg

Electrical properties

Electrical resistivity		4,8	-	5	µohm.cm
Electrical conductivity		34,5	-	35,9	%IACS
Galvanic potential	*	-0,78	-	-0,7	V

Magnetic properties

Magnetic type	Non-magnetic

Optical, aesthetic and acoustic properties

Transparency		Opaque			
Acoustic velocity		5,01e3	-	5,17e3	m/s
Mechanical loss coefficient (tan delta)	*	1e-4	-	0,002	

Critical materials risk

Contains >5wt% critical elements?	Yes
Notes	Al (aluminum) added to the 2018 US critical minerals list

Processing properties

Metal casting	Unsuitable	
Metal cold forming	Limited use	
Metal hot forming	Limited use	
Metal press forming	Acceptable	
Metal deep drawing	Limited use	
Machining speed	116	m/min
Weldability	Poor	
Notes	Preheating is not required, post weld heat treatment is required	

Durability

Water (fresh)	Excellent
Water (salt)	Acceptable
Weak acids	Excellent
Strong acids	Excellent
Weak alkalis	Acceptable
Strong alkalis	Unacceptable
Organic solvents	Excellent
Oxidation at 500C	Unacceptable
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Limited use
Notes	Aluminum alloys perform poorly when self-mated but can be processed without galling when mated with steels.
Flammability	Non-flammable

Corrosion resistance of metals

Stress corrosion cracking	Susceptible
Notes	Rated in chloride; Other susceptible environments: Halide, water

Primary production energy, CO2 and water

Embodied energy, primary production	*	187	-	206	MJ/kg
CO2 footprint, primary production	*	12,4	-	13,7	kg/kg
Water usage	*	1,1e3	-	1,21e3	l/kg

Processing energy, CO2 footprint & water

Roll forming, forging energy	*	7,91	-	8,74	MJ/kg
Roll forming, forging CO2	*	0,593	-	0,655	kg/kg
Roll forming, forging water	*	4,93	-	7,4	l/kg
Extrusion, foil rolling energy	*	15,5	-	17,2	MJ/kg
Extrusion, foil rolling CO2	*	1,16	-	1,29	kg/kg
Extrusion, foil rolling water	*	8,19	-	12,3	l/kg
Wire drawing energy	*	57,5	-	63,5	MJ/kg
Wire drawing CO2	*	4,31	-	4,76	kg/kg
Wire drawing water	*	21,7	-	32,5	l/kg
Metal powder forming energy	*	22,5	-	24,9	MJ/kg
Metal powder forming CO2	*	1,8	-	1,99	kg/kg
Metal powder forming water	*	24,6	-	36,9	l/kg
Vaporization energy	*	1,55e4	-	1,71e4	MJ/kg
Vaporization CO2	*	1,16e3	-	1,28e3	kg/kg
Vaporization water	*	6,46e3	-	9,69e3	l/kg
Coarse machining energy (per unit wt removed)	*	1,62	-	1,79	MJ/kg
Coarse machining CO2 (per unit wt removed)	*	0,121	-	0,134	kg/kg
Fine machining energy (per unit wt removed)	*	11,9	-	13,2	MJ/kg
Fine machining CO2 (per unit wt removed)	*	0,893	-	0,987	kg/kg
Grinding energy (per unit wt removed)	*	23,3	-	25,8	MJ/kg
Grinding CO2 (per unit wt removed)	*	1,75	-	1,93	kg/kg
Non-conventional machining energy (per unit wt removed)	*	155	-	171	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	*	11,6	-	12,8	kg/kg

Recycling and end of life

Recycle	✓				
Embodied energy, recycling	*	31,9	-	35,3	MJ/kg
CO2 footprint, recycling	*	2,51	-	2,77	kg/kg
Recycle fraction in current supply		40,5	-	44,7	%
Downcycle	✓				
Combust for energy recovery	✗				
Landfill	✓				
Biodegrade	✗				

Notes

Other notes

Prices of Aluminum alloys fluctuate greatly and are dependent on batch size, unit size, forming methods, etc.

Keywords

UNIDAL, Alusuisse-Lonza Group (SWITZERLAND); UNIDUR-100, Aluminium Walzwerke Singen GmbH (GERMANY);

Standards with similar compositions

• Australia:
7005 to AS 2848.1
• Austria:
AlZn4.5Mg1 to ONORM M3430
• Denmark:
7005 to DS 3012
• Europe:
EN AW-7005 to CEN EN 573-3, EN AW-7020 to CEN EN 573-3
• France:
7020 to NF A50-411, 7020 to NF A50-451, 7020 to NF A50-501
• Germany:
3.4335/AlZn4.5Mg1 to DIN 1725-1
• Hungary:
AlZn5Mg1 to MSZ 3714/1
• International:
AlZn4.5Mg1 to ISO 209-1, AlZn4.5Mg1.5Mn to ISO 209-1
• Norway:
17410 to NS 17410
• Russia:
1911 to GOST 4784
• USA:
7005, 7005 to ASTM B221M, 7020, UNS A97005, UNS A97020
• Tradenames:
ALUMINUM X7005, UNIDUR-100

Links

ProcessUniverse
Producers
Reference
Shape

General information

Designation

Ti-6Al-4V

Condition	Aged

Typical uses

Gas turbines, aircraft, de-icing and air conditioning ducting, condenser tubes, surgical implants, ultrasonic devices, lacing wire, welding wire, cryogenic vessels and components.

Composition overview

Compositional summary

Ti88-91 / Al5.5-6.8 / V3.5-4.5 (impurities: Fe<0.4, O<0.2, C<0.1, N<0.05, H<0.012, Other<0.4)

Material family	Metal (non-ferrous)
Base material	Ti (Titanium)

Composition detail (metals, ceramics and glasses)

Al (aluminum)	5,5	-	6,75	%
C (carbon)	0	-	0,1	%
Fe (iron)	0	-	0,4	%
H (hydrogen)	0	-	0,0125	%
N (nitrogen)	0	-	0,05	%
O (oxygen)	0	-	0,2	%
Ti (titanium)	* 88	-	91	%
V (vanadium)	3,5	-	4,5	%
Other	0	-	0,4	%

Price

Price	* 441	-	527	CZK/kg
Price per unit volume	* 1,95e6	-	2,33e6	CZK/m^3

Physical properties

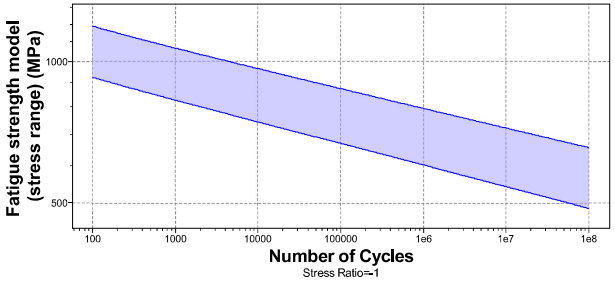
Density	4,42e3	-	4,43e3	kg/m^3

Mechanical properties

Young's modulus	111	-	119	GPa
Specific stiffness	25,1	-	26,9	MN.m/kg
Yield strength (elastic limit)	1,02e3	-	1,08e3	MPa
Tensile strength	1,1e3	-	1,27e3	MPa
Specific strength	231	-	244	kN.m/kg
Elongation	8	-	13	% strain
Compressive strength	* 1,1e3	-	1,15e3	MPa
Flexural modulus	* 111	-	119	GPa
Flexural strength (modulus of rupture)	1,02e3	-	1,1e3	MPa
Shear modulus	40	-	45	GPa

Bulk modulus	123	-	153	GPa
Poisson's ratio	0,35	-	0,37	
Shape factor	11			
Hardness - Vickers	380	-	420	HV
Hardness - Brinell	361	-	400	HB
Elastic stored energy (springs)	4,49e3	-	5,12e3	kJ/m^3
Fatigue strength at 10^7 cycles	* 613	-	638	MPa
Fatigue strength model (stress range)	* 542	-	722	MPa

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



Impact & fracture properties

Fracture toughness	82	-	100	MPa.m^0.5
Toughness (G)	58,9	-	86,4	kJ/m^2

Thermal properties

Melting point	1,61e3	-	1,66e3	°C
Maximum service temperature	350	-	420	°C
Minimum service temperature	-273			°C
Thermal conductivity	7,1	-	7,3	W/m.°C
Specific heat capacity	560	-	570	J/kg.°C
Thermal expansion coefficient	8,7	-	9,1	µstrain/°C
Thermal shock resistance	976	-	1,08e3	°C
Thermal distortion resistance	* 0,788	-	0,831	MW/m
Latent heat of fusion	360	-	370	kJ/kg

Electrical properties

Electrical resistivity	168	-	170	µohm.cm
Electrical conductivity	1,01	-	1,03	%IACS
Galvanic potential	* -0,12	-	-0,04	V

Magnetic properties

Magnetic type	Non-magnetic			

Optical, aesthetic and acoustic properties

Transparency	Opaque			
Acoustic velocity	5,01e3	-	5,19e3	m/s
Mechanical loss coefficient (tan delta)	0,001	-	0,005	

Critical materials risk

Contains >5wt% critical elements?	Yes			
Notes	Al (aluminum) and Ti (titanium) added to the 2018 US critical minerals list			

Processing properties

Metal casting	Excellent			
Metal cold forming	Limited use			
Metal hot forming	Acceptable			
Metal press forming	Acceptable			
Metal deep drawing	Limited use			
Machining speed	11,9			m/min
Weldability	Good			
Notes	Preheating and post weld heat treatments are not required			

Durability

Water (fresh)	Excellent
Water (salt)	Excellent
Weak acids	Excellent
Strong acids	Acceptable
Weak alkalis	Excellent
Strong alkalis	Acceptable
Organic solvents	Excellent
Oxidation at 500C	Excellent
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Limited use
Notes	
High tendency to gall can be overcome by anodizing.	
Flammability	Non-flammable

Corrosion resistance of metals

Stress corrosion cracking	Susceptible
Notes	Rated in chloride; Other susceptible environments: Halide, organic liquids, dinitrogen tetroxide

Primary production energy, CO2 and water

Embodied energy, primary production	* 655	-	722	MJ/kg
CO2 footprint, primary production	* 38,4	-	42,3	kg/kg
Water usage	* 187	-	207	l/kg

Processing energy, CO2 footprint & water

Casting energy	* 12,8	-	14,2	MJ/kg
Casting CO2	* 0,963	-	1,06	kg/kg
Casting water	* 24,3	-	36,5	l/kg
Roll forming, forging energy	* 16,4	-	18,1	MJ/kg
Roll forming, forging CO2	* 1,23	-	1,36	kg/kg
Roll forming, forging water	* 8,55	-	12,8	l/kg
Extrusion, foil rolling energy	* 32,5	-	35,9	MJ/kg
Extrusion, foil rolling CO2	* 2,44	-	2,69	kg/kg
Extrusion, foil rolling water	* 15,4	-	23,2	l/kg
Wire drawing energy	* 121	-	134	MJ/kg
Wire drawing CO2	* 9,08	-	10	kg/kg
Wire drawing water	* 45,6	-	68,4	l/kg
Metal powder forming energy	* 45,6	-	50,7	MJ/kg
Metal powder forming CO2	* 3,65	-	4,05	kg/kg
Metal powder forming water	* 49,9	-	74,8	l/kg
Vaporization energy	* 1,46e4	-	1,61e4	MJ/kg
Vaporization CO2	* 1,09e3	-	1,21e3	kg/kg
Vaporization water	* 6,07e3	-	9,11e3	l/kg
Coarse machining energy (per unit wt removed)	* 2,89	-	3,19	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0,217	-	0,24	kg/kg
Fine machining energy (per unit wt removed)	* 24,6	-	27,2	MJ/kg
Fine machining CO2 (per unit wt removed)	* 1,85	-	2,04	kg/kg
Grinding energy (per unit wt removed)	* 48,8	-	53,9	MJ/kg
Grinding CO2 (per unit wt removed)	* 3,66	-	4,04	kg/kg
Non-conventional machining energy (per unit wt removed)	* 146	-	161	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	* 10,9	-	12,1	kg/kg

Recycling and end of life

Recycle	✓			
Embodied energy, recycling	* 82,8	-	91,5	MJ/kg
CO2 footprint, recycling	* 6,5	-	7,18	kg/kg
Recycle fraction in current supply	21,8	-	24,1	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			

Notes

Other notes

Most widely used of all titanium alloys. Bars and forgings may be heat treated to a range of strength levels and is used in highly stressed structures. Weldable alloy.
Brinell Hardness, 3000kg load, 10mm ball

Standards with similar compositions

• Australia:
Ti-6Al-4V to AS 2320/3
• Europe:
AECMA prEN2530, AECMA prEN2531, AECMA prEN3310, AECMA prEN3311, AECMA prEN3312, AECMA prEN3313, AECMA prEN3314, AECMA prEN3315, AECMA prEN3353, AECMA prEN3354, AECMA prEN3355, AECMA prEN3456, AECMA prEN3457, AECMA prEN3458, AECMA prEN3464, AECMA prEN3467, Ti-P63 to AECMA prEN2517, Ti-P63 to AECMA prEN2530
• France:
T-A6V to AIR 9184
• Germany:
3.7165 to DIN 17851, TiAl6V4 to DIN 17851
• International:
Ti 6-Al 4-V to ISO 5832-3
• Japan:
TAB 6400 to JIS H4657, TAB 6400E to JIS H4657, TAF 6400 to JIS H4657, YTAB 640 to JIS Z3331, YTAB 640E to JIS Z3331, YTAW 640 to JIS Z3331, YTAW 640E to JIS Z3331
• UK:
BS 3531 to BS 3531 P2
• USA:
6Al-4V to AMS 4905A, 6Al-4V to AMS 4906, AB-1 to MIL T-81556A, AB-2 to MIL T-81556A, C(6Al-4V) to MIL T-9046H, Class 2 to MIL DTL-46077F, Class 3 to MIL DTL-46077F, D(6Al-4VELI) to MIL T-9046H, ERTi-5 to AWS A5.16, F-23 to ASTM B381, F-5 to ASTM B381, Grade 23 to ASTM B265, Grade 23 to ASTM B338, Grade 23 to ASTM B348, Grade 23 to ASTM B861, Grade 23 to ASTM B862, Grade 23 to ASTM B863, Grade 29 to ASTM B862, Grade 29 to ASTM B863, Grade 5 to ASTM B265, Grade 5 to ASTM B338, Grade 5 to ASTM B348, Grade 5 to ASTM B861, Grade 5 to ASTM B862, Grade 5 to ASTM B863, H(6Al-4V-SPL) to MIL T-9046H, Ti 23 to ASTM F467M, Ti 23 to ASTM F468M, Ti 5 to ASTM F467M, Ti 5 to ASTM F468M, Ti-6Al-4V ELI to ASTM F136, UNS R56400, UNS R56404, UNS R56407
• Tradenames:
ATI 64-MIL, ERGITAN 7165 TV, REPUBLIC RS-120A, RMI 6AL-4V, RMI 6AL-4V ELI, TI-6AL-4V, TI-6AL-4V (STA), TI-6AL-4V ELI, UT A6 V

Links

ProcessUniverse

Producers

Reference

Shape

General information

Designation

Ti-3Al-2.5V (Grade 9)

UNS number	R56320

Tradenames

Ti-3A1-2.5V ALLOY, Haynes (USA); Ti-3Al-2.5V, Sandvik (Sweden);

Typical uses

Tubing in aircraft and engine hydraulic systems, pipes and vessels, foil for honey-comb applications, sporting equipment - golf club shafts, tennis racquets, bicycle frames, etc.

Composition overview

Compositional summary

Ti93-96 / Al2.5-3.5 / V2-3 (impurities: Fe<0.25, C<0.08, N<0.02)

Material family	Metal (non-ferrous)
Base material	Ti (Titanium)

Composition detail (metals, ceramics and glasses)

Al (aluminum)	2,5	-	3,5	%
C (carbon)	0	-	0,08	%
Fe (iron)	0	-	0,25	%
N (nitrogen)	0	-	0,02	%
Ti (titanium)	* 93,2	-	95,5	%
V (vanadium)	2	-	3	%

Price

Price	* 447	-	523	CZK/kg
Price per unit volume	* 2e6	-	2,35e6	CZK/m^3

Physical properties

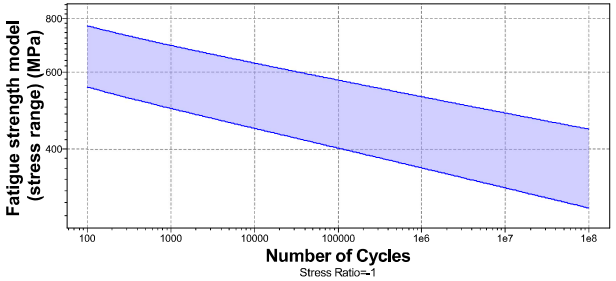
Density	4,47e3	-	4,49e3	kg/m^3

Mechanical properties

Young's modulus	91	-	95	GPa
Specific stiffness	20,3	-	21,2	MN.m/kg
Yield strength (elastic limit)	483	-	620	MPa
Tensile strength	621	-	750	MPa
Specific strength	108	-	138	kN.m/kg
Elongation	15	-	20	% strain
Compressive strength	* 580	-	744	MPa
Flexural modulus	* 91	-	95	GPa
Flexural strength (modulus of rupture)	531	-	682	MPa
Shear modulus	33	-	36	GPa
Bulk modulus	101	-	122	GPa

Poisson's ratio	0,35	-	0,37	
Shape factor	17			
Hardness - Vickers	* 103	-	113	HV
Hardness - Brinell	* 92	-	100	HB
Elastic stored energy (springs)	1,27e3	-	2,04e3	kJ/m^3
Fatigue strength at 10^7 cycles	* 363	-	432	MPa
Fatigue strength model (stress range)	* 325	-	483	MPa

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



Impact & fracture properties

Fracture toughness	* 70	-	75	MPa.m^0.5
Toughness (G)	52,6	-	60,6	kJ/m^2

Thermal properties

Melting point	* 1,62e3	-	1,63e3	°C
Maximum service temperature	327	-	402	°C
Minimum service temperature	-273			°C
Thermal conductivity	7,5	-	7,7	W/m.°C
Specific heat capacity	* 535	-	545	J/kg.°C
Thermal expansion coefficient	7,9	-	8,1	µstrain/°C
Thermal shock resistance	648	-	835	°C
Thermal distortion resistance	* 0,933	-	0,967	MW/m
Latent heat of fusion	360	-	370	kJ/kg

Electrical properties

Electrical resistivity	120	-	126	µohm.cm
Electrical conductivity	1,37	-	1,44	%IACS
Galvanic potential	* -0,09	-	-0,01	V

Magnetic properties

Magnetic type	Non-magnetic			

Optical, aesthetic and acoustic properties

Transparency	Opaque			
Acoustic velocity	4,51e3	-	4,61e3	m/s
Mechanical loss coefficient (tan delta)	* 0,001	-	0,002	

Critical materials risk

Contains >5wt% critical elements?	Yes
Notes	Al (aluminum) and Ti (titanium) added to the 2018 US critical minerals list

Processing properties

Metal casting	Limited use	
Metal cold forming	Limited use	
Metal hot forming	Acceptable	
Metal press forming	Acceptable	
Metal deep drawing	Limited use	
Machining speed	14,6	m/min
Weldability	Excellent	
Notes	Preheating and post weld heat treatments are not required	

Durability

Water (fresh)	Excellent
Water (salt)	Excellent
Weak acids	Excellent
Strong acids	Acceptable
Weak alkalis	Excellent
Strong alkalis	Acceptable
Organic solvents	Excellent
Oxidation at 500C	Acceptable
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Limited use
Notes	
High tendency to gall can be overcome by anodizing.	
Flammability	Non-flammable

Corrosion resistance of metals

Stress corrosion cracking	Susceptible
Notes	Rated in chloride; Other susceptible environments: Halide, organic liquids, dinitrogen tetroxide

Primary production energy, CO2 and water

Embodied energy, primary production	* 622	-	686	MJ/kg
CO2 footprint, primary production	* 36	-	39,7	kg/kg
Water usage	* 148	-	164	l/kg

Processing energy, CO2 footprint & water

Casting energy	* 12,6	-	13,9	MJ/kg
Casting CO2	* 0,941	-	1,04	kg/kg
Casting water	* 23,8	-	35,6	l/kg
Roll forming, forging energy	* 9,57	-	10,6	MJ/kg
Roll forming, forging CO2	* 0,718	-	0,793	kg/kg
Roll forming, forging water	* 5,64	-	8,46	l/kg
Extrusion, foil rolling energy	* 18,9	-	20,8	MJ/kg
Extrusion, foil rolling CO2	* 1,41	-	1,56	kg/kg
Extrusion, foil rolling water	* 9,61	-	14,4	l/kg
Wire drawing energy	* 69,9	-	77,3	MJ/kg
Wire drawing CO2	* 5,25	-	5,8	kg/kg
Wire drawing water	* 26,4	-	39,5	l/kg
Metal powder forming energy	* 44,5	-	49,3	MJ/kg
Metal powder forming CO2	* 3,56	-	3,94	kg/kg
Metal powder forming water	* 48,6	-	72,9	l/kg
Vaporization energy	* 1,46e4	-	1,61e4	MJ/kg
Vaporization CO2	* 1,09e3	-	1,21e3	kg/kg
Vaporization water	* 6,07e3	-	9,11e3	l/kg
Coarse machining energy (per unit wt removed)	* 1,87	-	2,06	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0,14	-	0,155	kg/kg
Fine machining energy (per unit wt removed)	* 14,4	-	15,9	MJ/kg
Fine machining CO2 (per unit wt removed)	* 1,08	-	1,19	kg/kg
Grinding energy (per unit wt removed)	* 28,3	-	31,3	MJ/kg
Grinding CO2 (per unit wt removed)	* 2,13	-	2,35	kg/kg
Non-conventional machining energy (per unit wt removed)	* 146	-	161	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	* 10,9	-	12,1	kg/kg

Recycling and end of life

Recycle	✓			
Embodied energy, recycling	* 79,6	-	88	MJ/kg
CO2 footprint, recycling	* 6,25	-	6,91	kg/kg
Recycle fraction in current supply	21,8	-	24,1	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			

Notes

Other notes

Half 6-4 offers 20 to 50% higher strength than C.P. grades, but is more formable than Ti-6Al-4V.

Keywords

TI-3AL-2.5V, Damascus Bishop Tube Co. (USA); OMC 3A1-2.5V, Manufacturer unknown (); ALLVAC 3-2.5, Teledyne Allvac, Vasco Mktg. (USA); TI-3AL-2.5V, Wah Chang (USA);

Standards with similar compositions

• Germany:
3.7195 to DIN 17851, TiAl3V2.5 to DIN 17851
• Japan:
TAB 3250 to JIS H4657, TAT 3250CF to JIS H4637, TAT 3250CL to JIS H4637, TAT 3250F to JIS H4637, TAT 3250L to JIS H4637, TAT 3250W to JIS H4637, TAT 3250WCF to JIS H4637, TAT 3250WCL to JIS H4637, TAT 3250WF to JIS H4637, TAT 3250WL to JIS H4637, YTAB 325 to JIS Z3331, YTAW 325 to JIS Z3331
• USA:
3Al-2.5V to AMS 4943D, ERTi-9 to AWS A5.16, ERTI-9ELI to AWS A5.16, F-28 to ASTM B381, F-9 to ASTM B381, Grade 28 to ASTM B338, Grade 28 to ASTM B348, Grade 28 to ASTM B861, Grade 28 to ASTM B862, Grade 28 to ASTM B863, Grade 9 to ASTM B265, Grade 9 to ASTM B337, Grade 9 to ASTM B338, Grade 9 to ASTM B348, Grade 9 to ASTM B862, Grade 9 to ASTM B863, UNS R56320, UNS R56321, UNS R56323
• Tradenames:
RMI 3AL-2.5V, TI 3-2.5, TI-3AL-2.5V, TITANIUM 3 AL-2.5 V, UTA3V

Links

ProcessUniverse
Producers
Reference
Shape

General information

Designation

ASTM AZ61A, wrought

UNS number	M11610, M11611
US name	ASTM AZ61A, MIL AZ61A, SAE AZ61A, AWS ER AZ61A, AWS R AZ61A
EN name	~EN-MA21140, ~EN-MAMgAl6Zn1, ~EN-MB21140, ~EN-MBMgAl6Zn1
EN number	~3.5612
ISO name	~MgAl6Zn1,
JIS (Japanese) name	~MB2, ~MS2, ~MT2

Typical uses

Aerospace and defense applications.

Composition overview

Compositional summary

Mg91-94 / Al5.8-7.2 / Zn0.4-1.5 / Mn0.15-0.5 (impurities: Si<0.1, Cu<0.05, Fe<0.005, Ni<0.005, Other<0.3)

Material family	Metal (non-ferrous)
Base material	Mg (Magnesium)

Composition detail (metals, ceramics and glasses)

Al (aluminum)	5,8	-	7,2	%
Cu (copper)	0	-	0,05	%
Fe (iron)	0	-	0,005	%
Mg (magnesium)	90,6	-	93,6	%
Mn (manganese)	0,15	-	0,5	%
Ni (nickel)	0	-	0,005	%
Si (silicon)	0	-	0,1	%
Zn (zinc)	0,4	-	1,5	%
Other	0	-	0,3	%

Price

Price	* 62,2	-	63,6	CZK/kg
Price per unit volume	* 1,12e5	-	1,15e5	CZK/m^3

Physical properties

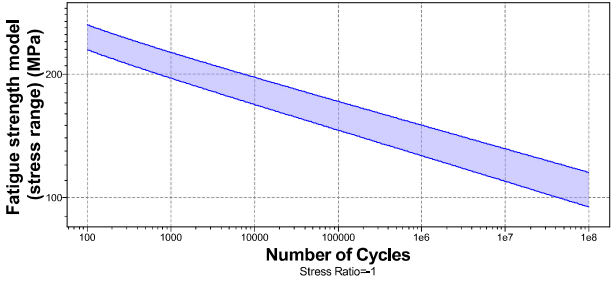
Density	1,8e3	-	1,81e3	kg/m^3

Mechanical properties

Young's modulus	44	-	46	GPa
Specific stiffness	24,4	-	25,5	MN.m/kg
Yield strength (elastic limit)	165	-	220	MPa
Tensile strength	285	-	305	MPa
Specific strength	91,4	-	122	kN.m/kg

Elongation	8	-	16	% strain
Compressive strength	* 110	-	150	MPa
Flexural modulus	* 44	-	46	GPa
Flexural strength (modulus of rupture)	170	-	180	MPa
Shear modulus	16	-	18	GPa
Bulk modulus	36	-	41	GPa
Poisson's ratio	0,3	-	0,31	
Shape factor	23			
Hardness - Vickers	55	-	70	HV
Elastic stored energy (springs)	308	-	529	kJ/m^3
Fatigue strength at 10^7 cycles	* 115	-	125	MPa
Fatigue strength model (stress range)	* 109	-	131	MPa

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



Impact & fracture properties

Fracture toughness	* 16	-	18	MPa.m^0.5
Toughness (G)	5,7	-	7,19	kJ/m^2

Thermal properties

Melting point	* 450	-	620	°C
Maximum service temperature	* 190	-	210	°C
Minimum service temperature	-273			°C
Thermal conductivity	77	-	79	W/m.°C
Specific heat capacity	1e3	-	1,01e3	J/kg.°C
Thermal expansion coefficient	27,3	-	27,5	µstrain/°C
Thermal shock resistance	134	-	179	°C
Thermal distortion resistance	* 2,81	-	2,88	MW/m
Latent heat of fusion	358	-	367	kJ/kg

Electrical properties

Electrical resistivity		14,1	-	14,5	µohm.cm
Electrical conductivity		11,9	-	12,2	%IACS
Galvanic potential	*	-1,59	-	-1,51	V

Magnetic properties

Magnetic type		Non-magnetic			

Optical, aesthetic and acoustic properties

Transparency		Opaque			
Acoustic velocity		4,94e3	-	5,05e3	m/s
Mechanical loss coefficient (tan delta)	*	0,003	-	0,008	

Critical materials risk

Contains >5wt% critical elements?	Yes
Notes	Al (aluminum) added to the 2018 US critical minerals list

Processing properties

Metal casting	Unsuitable	
Metal cold forming	Limited use	
Metal hot forming	Excellent	
Metal press forming	Acceptable	
Metal deep drawing	Limited use	
Machining speed	283	m/min
Weldability	Excellent	
Notes	Preheating may be required, post weld heat treatment is required	

Durability

Water (fresh)	Excellent
Water (salt)	Acceptable
Weak acids	Limited use
Strong acids	Unacceptable
Weak alkalis	Excellent
Strong alkalis	Acceptable
Organic solvents	Excellent
Oxidation at 500C	Unacceptable
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Acceptable
Notes	
Can be machined without lubricant due to galling resistance when mated with steel.	
Flammability	Non-flammable

Corrosion resistance of metals

Stress corrosion cracking	Slightly susceptible
Notes	Rated in chloride; Other susceptible environments: Potassium dichromate

Primary production energy, CO2 and water

Embodied energy, primary production	*	298	-	329	MJ/kg
CO2 footprint, primary production	*	41,5	-	45,8	kg/kg
Water usage	*	937	-	1,04e3	l/kg

Processing energy, CO2 footprint & water

Roll forming, forging energy	*	4,79	-	5,3	MJ/kg
Roll forming, forging CO2	*	0,359	-	0,397	kg/kg
Roll forming, forging water	*	3,6	-	5,4	l/kg
Extrusion, foil rolling energy	*	9,3	-	10,3	MJ/kg
Extrusion, foil rolling CO2	*	0,697	-	0,771	kg/kg
Extrusion, foil rolling water	*	5,53	-	8,29	l/kg
Wire drawing energy	*	34,1	-	37,7	MJ/kg
Wire drawing CO2	*	2,56	-	2,83	kg/kg
Wire drawing water	*	12,9	-	19,3	l/kg
Metal powder forming energy	*	20,7	-	22,9	MJ/kg
Metal powder forming CO2	*	1,66	-	1,83	kg/kg
Metal powder forming water	*	22,6	-	33,9	l/kg
Vaporization energy	*	1,45e4	-	1,6e4	MJ/kg
Vaporization CO2	*	1,08e3	-	1,2e3	kg/kg
Vaporization water	*	6,03e3	-	9,04e3	l/kg
Coarse machining energy (per unit wt removed)	*	1,15	-	1,27	MJ/kg
Coarse machining CO2 (per unit wt removed)	*	0,0863	-	0,0954	kg/kg
Fine machining energy (per unit wt removed)	*	7,24	-	8	MJ/kg
Fine machining CO2 (per unit wt removed)	*	0,543	-	0,6	kg/kg
Grinding energy (per unit wt removed)	*	14	-	15,5	MJ/kg
Grinding CO2 (per unit wt removed)	*	1,05	-	1,16	kg/kg
Non-conventional machining energy (per unit wt removed)	*	145	-	160	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	*	10,8	-	12	kg/kg

Recycling and end of life

Recycle	✓				
Embodied energy, recycling	*	45,5	-	50,3	MJ/kg
CO2 footprint, recycling	*	3,57	-	3,95	kg/kg
Recycle fraction in current supply		36,8	-	40,7	%
Downcycle	✓				
Combust for energy recovery	✗				
Landfill	✓				
Biodegrade	✗				

Notes

Standards with similar compositions

• France:
G-A6Z1 to NF A65-717
• Germany:
3.5612 to DIN 1729/1, MgAl6Zn to DIN 1729/1
• International:
Mg-Al6Zn1Mn to ISO 3116
• Japan:
MB2 to JIS H4203, MS2 to JIS H4204, MT2 to JIS H4202
• UK:
2L 503 to BS 2L 503, MAG-E-121 to BS 3373, MAG-F-121 to BS 3372
• USA:
AZ61A to ASTM B107/B107M, AZ61A to ASTM B275, AZ61A to ASTM B91, AZ61A to MIL R-6944B, AZ61A to SAE J466, ER AZ61A to AWS A5.19, R AZ61A to AWS A5.19, UNS M11610, UNS M11611
• Tradenames:
A.M. 57 S, AZM, DOMAL AZ61X, ELECTRON A,Z,M, ELECTRON Z-1-B, ELEKTRON A6, ELEKTRON AZ61, ELEKTRON AZM, MELMAG AZ61 BATTERY PLATE, REVERE J-1, WHITELIGHT AZ61A

Links

ProcessUniverse
Producers
Reference
Shape

General information

Designation

AISI 440C, wrought

Condition	Tempered at 316°C
UNS number	S44004
US name	~ASTM
EN name	X105CrMo17
EN number	1.4125

Typical uses

Processing of potentially corrosive liquids e.g. chemicals/oil/beverages/sewage, structural uses in corrosive environments, e.g. nuclear plants, ships, offshore oil installations, underwater cables and pipes

Composition overview

Compositional summary

Fe78-83 / Cr16-18 / C0.95-1.2 (impurities: Mn<1, Si<1, Mo<0.75, P<0.04, S<0.03)

Material family	Metal (ferrous)
Base material	Fe (Iron)

Composition detail (metals, ceramics and glasses)

C (carbon)	0,95	-	1,2	%
Cr (chromium)	16	-	18	%
Fe (iron)	* 78	-	83	%
Mn (manganese)	0	-	1	%
Mo (molybdenum)	0	-	0,75	%
P (phosphorus)	0	-	0,04	%
S (sulfur)	0	-	0,03	%
Si (silicon)	0	-	1	%

Price

Price	* 25	-	26,4	CZK/kg
Price per unit volume	* 1,93e5	-	2,08e5	CZK/m^3

Physical properties

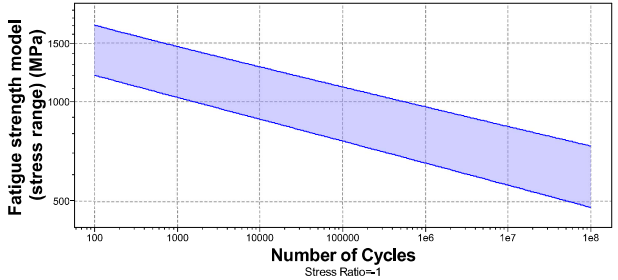
Density	7,7e3	-	7,9e3	kg/m^3

Mechanical properties

Young's modulus	190	-	210	GPa
Specific stiffness	24,3	-	27	MN.m/kg
Yield strength (elastic limit)	1,71e3	-	2,09e3	MPa
Tensile strength	1,77e3	-	2,17e3	MPa
Specific strength	219	-	268	kN.m/kg
Elongation	* 1	-	2	% strain
Compressive strength	* 1,71e3	-	2,09e3	MPa

Flexural modulus	* 190	-	210	GPa
Flexural strength (modulus of rupture)	1,71e3	-	2,09e3	MPa
Shear modulus	73	-	83	GPa
Bulk modulus	140	-	163	GPa
Poisson's ratio	0,275	-	0,285	
Shape factor	12			
Hardness - Vickers	590	-	690	HV
Hardness - Rockwell B	* 100	-	119	HRB
Hardness - Rockwell C	53	-	60	HRC
Hardness - Brinell	550	-	610	HB
Elastic stored energy (springs)	7,35e3	-	1,09e4	kJ/m^3
Fatigue strength at 10^7 cycles	* 638	-	737	MPa
Fatigue strength model (stress range)	* 559	-	842	MPa

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



Impact & fracture properties

Fracture toughness	* 12	-	28	MPa.m^0.5
Toughness (G)	0,818	-	3,46	kJ/m^2

Thermal properties

Melting point	1,37e3	-	1,48e3	°C
Maximum service temperature	* 256	-	306	°C
Minimum service temperature	-73	-	-43	°C
Thermal conductivity	23	-	27	W/m.°C
Specific heat capacity	450	-	500	J/kg.°C
Thermal expansion coefficient	9	-	11	µstrain/°C
Thermal shock resistance	822	-	1,1e3	°C
Thermal distortion resistance	* 2,21	-	2,84	MW/m
Latent heat of fusion	* 260	-	285	kJ/kg

Electrical properties

Electrical resistivity	55	-	65	µohm.cm
Electrical conductivity	2,65	-	3,13	%IACS
Galvanic potential	* -0,19	-	-0,11	V

Magnetic properties

Magnetic type	Magnetic

Optical, aesthetic and acoustic properties

Transparency	Opaque			
Acoustic velocity	4,93e3	-	5,19e3	m/s
Mechanical loss coefficient (tan delta)	* 1,9e-4	-	2,5e-4	

Critical materials risk

Contains >5wt% critical elements?	Yes

Processing properties

Metal casting	Unsuitable
Metal cold forming	Unsuitable
Metal hot forming	Acceptable
Metal press forming	Limited use
Metal deep drawing	Unsuitable
Machining speed	6,71 m/min
Weldability	Poor
Notes	Preheating and post weld heat treatments are required
Weldability - MIG	Not recommended
Weldability - plasma	Not recommended
Weldability - SAW	Not recommended
Weldability - TIG	Not recommended
Brazeability	Good
Carbon equivalency	4,15 - 5,12

Durability

Water (fresh)	Excellent
Water (salt)	Excellent
Weak acids	Excellent
Strong acids	Acceptable
Weak alkalis	Excellent
Strong alkalis	Limited use
Organic solvents	Excellent
Oxidation at 500C	Excellent
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Excellent
Notes	Tempering at a low temperature increases hardness and therefore galling resistance.
Flammability	Non-flammable

Corrosion resistance of metals

Pitting resistance equivalent number (PREN)	16	-	20,5	
Pitting and crevice corrosion resistance	Low (<20)			
Stress corrosion cracking	Susceptible			
Notes	Rated in chloride; Other susceptible environments: Hydrogen sulfide			
Intergranular (weld line) corrosion resistance	Restricted			
Inorganic acids	Restricted			
Organic acids	Restricted			
Alkalis	Restricted			
Humidity / water	Good			
Sea water	Restricted			
Sour oil and gas	Restricted			

Primary production energy, CO2 and water

Embodied energy, primary production	* 66,7	-	73,6	MJ/kg
CO2 footprint, primary production	* 5,12	-	5,64	kg/kg
Water usage	* 115	-	127	l/kg

Processing energy, CO2 footprint & water

Roll forming, forging energy	* 15,6	-	17,3	MJ/kg
Roll forming, forging CO2	* 1,17	-	1,3	kg/kg
Roll forming, forging water	* 8,23	-	12,4	l/kg
Extrusion, foil rolling energy	* 31	-	34,2	MJ/kg
Extrusion, foil rolling CO2	* 2,32	-	2,57	kg/kg
Extrusion, foil rolling water	* 14,8	-	22,2	l/kg
Wire drawing energy	* 115	-	128	MJ/kg
Wire drawing CO2	* 8,66	-	9,57	kg/kg
Wire drawing water	* 43,5	-	65,2	l/kg
Metal powder forming energy	* 36,4	-	40,3	MJ/kg
Metal powder forming CO2	* 2,91	-	3,23	kg/kg
Metal powder forming water	* 39,7	-	59,6	l/kg
Vaporization energy	* 1,09e4	-	1,2e4	MJ/kg
Vaporization CO2	* 815	-	900	kg/kg
Vaporization water	* 4,53e3	-	6,79e3	l/kg
Coarse machining energy (per unit wt removed)	* 2,78	-	3,07	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0,208	-	0,23	kg/kg
Fine machining energy (per unit wt removed)	* 23,5	-	26	MJ/kg
Fine machining CO2 (per unit wt removed)	* 1,76	-	1,95	kg/kg
Grinding energy (per unit wt removed)	* 46,5	-	51,4	MJ/kg
Grinding CO2 (per unit wt removed)	* 3,49	-	3,86	kg/kg
Non-conventional machining energy (per unit wt removed)	* 109	-	120	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	* 8,15	-	9	kg/kg

Recycling and end of life

Recycle	✓				
Embodied energy, recycling	*	14,6	-	16,1	MJ/kg
CO2 footprint, recycling	*	1,14	-	1,27	kg/kg
Recycle fraction in current supply		35,5	-	39,3	%
Downcycle	✓				
Combust for energy recovery	✗				
Landfill	✓				
Biodegrade	✗				

Notes

Keywords

SLATER TYPE 440-C, Slater Steels (USA);

Standards with similar compositions

• Canada:
440C to CSA G110.3
• China:
11Cr17 to GB 1220, 11Cr17 to GB 4226, 11Cr17 to GB/T 4356
• France:
Z100CD17 to AFNOR NF A35-575
• India:
105Cr18Mo50 to IS 6529, 105Cr18Mo50 to IS 6911, X108Cr17Mo to IS 1570/5, X108Cr17Mo to IS 6603
• Italy:
X102CrMo17KU to UNI 2955/3
• Japan:
SUS440C to JIS G4303, SUS440C to JIS G4308, SUS440C to JIS G4309
• Mexico:
440C to NMX-B-83
• South Korea:
STS 440C to KS D 3706, STS440C to KS D 3702
• USA:
440C to ASTM A473, 440C to FED QQ-S-763F, 440C to MIL-B-913, 440C to MIL-S-862B, 440C to SAE J467, S44004 to ASTM A276, S44004 to ASTM A314-97, S44004 to ASTM A493-95, S44004 to ASTM A580/A580M-98, S44004 to ASTM A959, UNS S44004
• Tradenames:
AL TECH STAINLESS TYPE 440C, ALLEGHENY LUDLUM 440C, CMXC, EASTERN N-7, LESCALLOY 440C VAC-ARC, RNO 100, SLATER TYPE 440-C, SOLEIL D9, SS CUT C, STERLING STAINLESS BHHX, UNILOY 440 C, UNILOY 440 F

Links

ProcessUniverse
Producers
Reference
Shape

General information

Designation

AISI 4130

Condition	Normalized
UNS number	G41300, ~H41300, ~K13047
US name	AMS 6345, AMS 6346, AMS 6348, AMS 6350, AMS 6356, AMS S 6758, AMS 6370, AMS 6371
EN name	30CrMo4
EN number	1.7216, 1.7220, 1.7221, 1.7226, 1.7230

Typical uses

General construction, general mechanical engineering, automotive, pressure vessels, pipework

Composition overview

Compositional summary

Fe97-98 / Cr0.8-1.1 / Mn0.4-0.6 / C0.28-0.33 / Si0.15-0.35 / Mo0.15-0.25 (impurities: S<0.04, P<0.035)

Material family	Metal (ferrous)
Base material	Fe (Iron)

Composition detail (metals, ceramics and glasses)

C (carbon)		0,28	-	0,33	%
Cr (chromium)		0,8	-	1,1	%
Fe (iron)	*	97,3	-	98,2	%
Mn (manganese)		0,4	-	0,6	%
Mo (molybdenum)		0,15	-	0,25	%
P (phosphorus)		0	-	0,035	%
S (sulfur)		0	-	0,04	%
Si (silicon)		0,15	-	0,35	%

Price

Price	*	17,9	-	18,6	CZK/kg
Price per unit volume	*	1,4e5	-	1,46e5	CZK/m^3

Physical properties

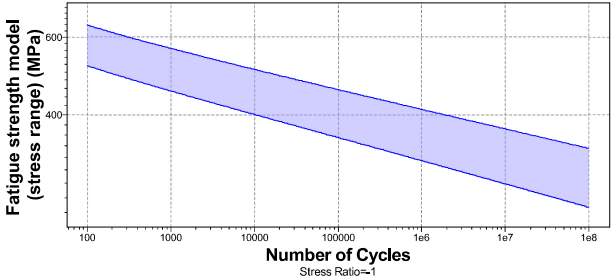
Density		7,79e3	-	7,87e3	kg/m^3

Mechanical properties

Young's modulus		200	-	210	GPa
Specific stiffness		25,5	-	26,9	MN.m/kg
Yield strength (elastic limit)		483	-	534	MPa
Tensile strength		621	-	686	MPa
Specific strength		61,6	-	68,2	kN.m/kg
Elongation		5	-	18	% strain
Compressive strength	*	483	-	534	MPa

Flexural modulus	*	200	-	210	GPa
Flexural strength (modulus of rupture)		483	-	534	MPa
Shear modulus		76	-	79,9	GPa
Bulk modulus		185	-	195	GPa
Poisson's ratio		0,32	-	0,333	
Shape factor		46			
Hardness - Vickers		183	-	223	HV
Elastic stored energy (springs)		569	-	695	kJ/m^3
Fatigue strength at 10^7 cycles	*	299	-	347	MPa
Fatigue strength model (stress range)	*	279	-	372	MPa

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



Impact & fracture properties

Fracture toughness	*	72	-	114	MPa.m^0.5
Toughness (G)		26,4	-	60,7	kJ/m^2

Thermal properties

Melting point		1,46e3	-	1,51e3	°C
Maximum service temperature		445	-	496	°C
Minimum service temperature	*	-73	-	-48	°C
Thermal conductivity		41,5	-	45	W/m.°C
Specific heat capacity		461	-	480	J/kg.°C
Thermal expansion coefficient		12,4	-	13,1	µstrain/°C
Thermal shock resistance		183	-	207	°C
Thermal distortion resistance	*	3,24	-	3,55	MW/m
Latent heat of fusion	*	265	-	280	kJ/kg

Electrical properties

Electrical resistivity		20	-	25	µohm.cm

Electrical conductivity	6,9	-	8,62	%IACS
Galvanic potential	* -0,5	-	-0,42	V

Magnetic properties

Magnetic type	Magnetic			

Optical, aesthetic and acoustic properties

Transparency	Opaque			
Acoustic velocity	5,05e3	-	5,18e3	m/s
Mechanical loss coefficient (tan delta)	* 7e-4	-	8,7e-4	

Critical materials risk

Contains >5wt% critical elements?	No			

Processing properties

Metal casting	Unsuitable			
Metal cold forming	Excellent			
Metal hot forming	Excellent			
Metal press forming	Excellent			
Metal deep drawing	Limited use			
Machining speed	24,4			m/min
Weldability	Good			
Notes	Preheating and post weld heat treatments are required			
Carbon equivalency	0,537	-	0,7	

Durability

Water (fresh)	Acceptable			
Water (salt)	Limited use			
Weak acids	Limited use			
Strong acids	Unacceptable			
Weak alkalis	Acceptable			
Strong alkalis	Limited use			
Organic solvents	Excellent			
Oxidation at 500C	Acceptable			
UV radiation (sunlight)	Excellent			
Galling resistance (adhesive wear)	Acceptable			
Flammability	Non-flammable			

Corrosion resistance of metals

Stress corrosion cracking	Slightly susceptible			
Notes	Rated in chloride; May be susceptible in halide, ammonia, nitrogen, acidic, caustic, carbonate environments			

Primary production energy, CO2 and water

Embodied energy, primary production	30,8	-	33,9	MJ/kg
Sources				

19,4 MJ/kg (Dhingra, Overly, Davis, 1999); 23 MJ/kg (Norgate, Jahanshahi, Rankin, 2007); 27,9 MJ/kg (Ecoinvent v2.2); 29,2 MJ/kg (Hammond and Jones, 2008); 32,8 MJ/kg (Hammond and Jones, 2008); 34,7 MJ/kg (Hammond and Jones, 2008); 35,4 MJ/kg (Hammond and Jones, 2008); 37,2 MJ/kg (Sullivan and Gaines, 2010); 38 MJ/kg (Hammond and Jones, 2008); 45,4 MJ/kg (Hammond and Jones, 2008)

CO2 footprint, primary production	2,26	-	2,49	kg/kg
Sources	0,396 kg/kg (Voet, van der and Oers, van, 2003); 1,75 kg/kg (Ecoinvent v2.2); 1,81 kg/kg (Voet, van der and Oers, van, 2003); 2,23 kg/kg (Voet, van der and Oers, van, 2003); 2,3 kg/kg (Norgate, Jahanshahi, Rankin, 2007); 2,74 kg/kg (Hammond and Jones, 2008); 2,77 kg/kg (Hammond and Jones, 2008); 2,87 kg/kg (Hammond and Jones, 2008); 2,89 kg/kg (Hammond and Jones, 2008); 3,03 kg/kg (Hammond and Jones, 2008); 3,27 kg/kg (Hammond and Jones, 2008)			
Water usage	* 47,9	-	53	l/kg

Processing energy, CO2 footprint & water

Casting energy	* 10,8	-	12	MJ/kg
Casting CO2	* 0,813	-	0,899	kg/kg
Casting water	* 20,5	-	30,8	l/kg
Roll forming, forging energy	* 4,39	-	4,86	MJ/kg
Roll forming, forging CO2	* 0,329	-	0,364	kg/kg
Roll forming, forging water	* 3,43	-	5,14	l/kg
Extrusion, foil rolling energy	* 8,5	-	9,4	MJ/kg
Extrusion, foil rolling CO2	* 0,638	-	0,705	kg/kg
Extrusion, foil rolling water	* 5,18	-	7,78	l/kg
Wire drawing energy	* 31,1	-	34,4	MJ/kg
Wire drawing CO2	* 2,33	-	2,58	kg/kg
Wire drawing water	* 11,7	-	17,6	l/kg
Metal powder forming energy	* 37,8	-	42	MJ/kg
Metal powder forming CO2	* 3,02	-	3,36	kg/kg
Metal powder forming water	* 41,3	-	62	l/kg
Vaporization energy	* 1,09e4	-	1,2e4	MJ/kg
Vaporization CO2	* 815	-	901	kg/kg
Vaporization water	* 4,53e3	-	6,8e3	l/kg
Coarse machining energy (per unit wt removed)	* 1,09	-	1,21	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0,0818	-	0,0905	kg/kg
Fine machining energy (per unit wt removed)	* 6,64	-	7,34	MJ/kg
Fine machining CO2 (per unit wt removed)	* 0,498	-	0,55	kg/kg
Grinding energy (per unit wt removed)	* 12,8	-	14,1	MJ/kg
Grinding CO2 (per unit wt removed)	* 0,96	-	1,06	kg/kg
Non-conventional machining energy (per unit wt removed)	* 109	-	120	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	* 8,15	-	9,01	kg/kg

Recycling and end of life

Recycle	✓			
Embodied energy, recycling	* 8,1	-	8,96	MJ/kg
CO2 footprint, recycling	* 0,636	-	0,703	kg/kg
Recycle fraction in current supply	39,9	-	44	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			

Biodegrade	✖

Notes

Warning

Some rare heat treatments of certain alloys may produce values for mechanical properties outside the given ranges, e.g. AISI 9255, tempered at 205C

Keywords

BSC-SR-95, British Steel plc (UK); TKS 34CRMO4, ThyssenKrupp Stahl AG (GERMANY); TKS 25CRMO4, ThyssenKrupp Stahl AG (GERMANY); A-1251, AFORA (Aceros Afora S.A.) (SPAIN); A-1250, AFORA (Aceros Afora S.A.) (SPAIN);

Standards with similar compositions

• Argentina:
IRAM 4130 to IAS
• Australia:
4130 to AS 1444, 4130H to AS 1444
• Czech Republic:
15131 to CSN 415131
• India:
30Cr4Mo2 to IS 1570/4, IS 963 to IS 963
• Italy:
30CrMo4 to UNI 6403, 30CrMo4 to UNI 7845, 30CrMo4 to UNI 7874
• Japan:
SCM 1 to JIS G4105, STH 21 to JIS G3429, STKS1 to JIS G3441, STKS3 to JIS G3441
• Mexico:
4130 to NMX-B-203-SCFI, 4130 to NMX-B-300, 4130H to NMX-B-268, 4130H to NMX-B-300
• Pan America:
4130 to COPANT 334, 4130 to COPANT 514
• Poland:
30HM to PN-H-84030/04, 30HMA to PN-H-84030/04
• Romania:
25MoCr11 to STAS, 33MoCr11q to STAS 9382/4
• UK:
30CrMo4 to BS EN 10297-1
• USA:
4130, 4130 to ASTM A29/A29M, 4130 to ASTM A331-95, 4130 to ASTM A513, 4130 to ASTM A519, 4130 to ASTM A829/A829M, 4130 to ASTM A866, 4130 to DoD-F-24669/1, 4130 to SAE J404, 4130H to ASTM A331-95, 4130H to SAE J1975, G41300 to ASTM A1031, G41300 to ASTM A506, G41300 to ASTM A507, G41300 to MIL-S-46059, Grade 11 to ASTM A646-95, Grade 3 to ASTM A983/A983M, Grade E Class 55 to ASTM A372/A372M, Grade E Class 65 to ASTM A372/A372M, Grade E Class 70 to ASTM A372/A372M, MIL-T-6736 to MIL-T-6736B, UNS G41300, UNS H41300, UNS K13047, UNS K13147
• Tradenames:
AIRCO 4130, HARDWEAR 500F, KROPP 23, RQ AR-321, RQ AR-340, RQ AR-360, RQ AR-400, RQAR 300/311, VERTOMAR CM30, VL-30

Links

ProcessUniverse
Producers
Reference
Shape

General information

Designation

AISI 1020

Condition	Normalized
UNS number	G10200
US name	ASTM MT1020, ASTM M1020, ASTM 1020, ASME G10200, ASME G10170, ASME 1017, ~SAE 040 X, Y, Z, ~SAE 035S, ~SAE 035C, ~SAE 035B, ~SAE 035A, ~SAE 035 X, Y, Z, ~ASTM A836, ~ASTM 1018 Class A, ~ASME G10210, ~ASME G10180, ~ASME 1021
EN name	S240GP, ~P355NB, ~P310NB, ~HS15
EN number	~1.0021
ISO name	~E235 Quality A, ~CE20E4, ~CC21A
GB (Chinese) name	~ML20AI,
JIS (Japanese) name	SWRM 20, SWRCH20A, SG 255, ~SWRCH18A, ~STKM12C, ~STKM12B, ~STKM12A, ~SPHT 2

Typical uses

Forgings, machined parts, shafts, car wheel hubs, general haulage gear

Composition overview

Compositional summary

Fe99.1-99.5 / Mn0.3-0.6 / C0.17-0.23 (impurities: S<0.05, P<0.04)

Material family	Metal (ferrous)
Base material	Fe (Iron)

Composition detail (metals, ceramics and glasses)

C (carbon)	0,17	-	0,23	%
Fe (iron)	* 99,1	-	99,5	%
Mn (manganese)	0,3	-	0,6	%
P (phosphorus)	0	-	0,04	%
S (sulfur)	0	-	0,05	%

Price

Price	* 16,6	-	17,3	CZK/kg
Price per unit volume	* 1,3e5	-	1,36e5	CZK/m^3

Physical properties

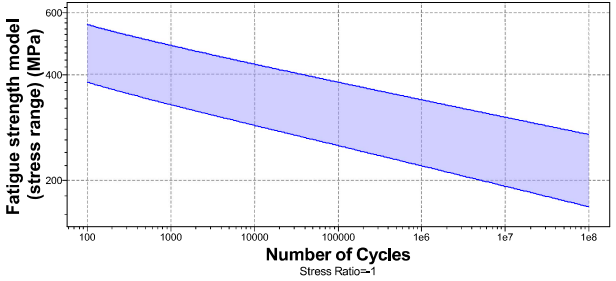
Density	7,8e3	-	7,9e3	kg/m^3

Mechanical properties

Young's modulus	205	-	215	GPa
Specific stiffness	26,1	-	27,4	MN.m/kg
Yield strength (elastic limit)	310	-	350	MPa

Tensile strength	395	-	490	MPa
Specific strength	39,5	-	44,6	kN.m/kg
Elongation	28	-	43	% strain
Compressive strength	* 310	-	350	MPa
Flexural modulus	* 205	-	215	GPa
Flexural strength (modulus of rupture)	310	-	350	MPa
Shear modulus	79	-	84	GPa
Bulk modulus	158	-	175	GPa
Poisson's ratio	0,285	-	0,295	
Shape factor	59			
Hardness - Vickers	125	-	150	HV
Elastic stored energy (springs)	229	-	291	kJ/m^3
Fatigue strength at 10^7 cycles	* 223	-	260	MPa
Fatigue strength model (stress range)	* 192	-	302	MPa

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



Impact & fracture properties

Fracture toughness	* 43	-	63	MPa.m^0,5
Toughness (G)	9,08	-	18,3	kJ/m^2

Thermal properties

Melting point	1,48e3	-	1,52e3	°C
Maximum service temperature	* 340	-	356	°C
Minimum service temperature	* -68	-	-38	°C
Thermal conductivity	50	-	54	W/m.°C
Specific heat capacity	465	-	505	J/kg.°C
Thermal expansion coefficient	11,5	-	12,5	µstrain/°C
Thermal shock resistance	121	-	141	°C
Thermal distortion resistance	* 4,1	-	4,58	MW/m

Latent heat of fusion	* 270	-	275	kJ/kg

Electrical properties

Electrical resistivity	16	-	18	µohm.cm
Electrical conductivity	9,58	-	10,8	%IACS
Galvanic potential	* -0,51	-	-0,43	V

Magnetic properties

Magnetic type	Magnetic

Optical, aesthetic and acoustic properties

Transparency	Opaque			
Acoustic velocity	5,11e3	-	5,24e3	m/s
Mechanical loss coefficient (tan delta)	* 0,00101	-	0,00121	

Critical materials risk

Contains >5wt% critical elements?	No

Processing properties

Metal casting	Unsuitable			
Metal cold forming	Acceptable			
Metal hot forming	Excellent			
Metal press forming	Excellent			
Metal deep drawing	Acceptable			
Machining speed	39,6			m/min
Weldability	Good			
Notes	Preheating and post weld heat treatments are required			
Carbon equivalency	0,22	-	0,33	

Durability

Water (fresh)	Acceptable
Water (salt)	Limited use
Weak acids	Limited use
Strong acids	Unacceptable
Weak alkalis	Acceptable
Strong alkalis	Limited use
Organic solvents	Excellent
Oxidation at 500C	Acceptable
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Acceptable
Notes	
Aluminum bronze is the most suitable mating material to minimize galling.	
Flammability	Non-flammable

Corrosion resistance of metals

Stress corrosion cracking	Not susceptible
Notes	

	Rated in chloride; Other susceptible environments: Nitrate, hydroxide, carbonate, ammonia

Primary production energy, CO2 and water

Embodied energy, primary production	30,8	-	33,9	MJ/kg
Sources	19,4 MJ/kg (Dhingra, Overly, Davis, 1999); 23 MJ/kg (Norgate, Jahanshahi, Rankin, 2007); 27,9 MJ/kg (Ecoinvent v2.2); 29,2 MJ/kg (Hammond and Jones, 2008); 32,8 MJ/kg (Hammond and Jones, 2008); 34,7 MJ/kg (Hammond and Jones, 2008); 35,4 MJ/kg (Hammond and Jones, 2008); 37,2 MJ/kg (Sullivan and Gaines, 2010); 38 MJ/kg (Hammond and Jones, 2008); 45,4 MJ/kg (Hammond and Jones, 2008)			
CO2 footprint, primary production	2,26	-	2,49	kg/kg
Sources	0,396 kg/kg (Voet, van der and Oers, van, 2003); 1,75 kg/kg (Ecoinvent v2.2); 1,81 kg/kg (Voet, van der and Oers, van, 2003); 2,23 kg/kg (Voet, van der and Oers, van, 2003); 2,3 kg/kg (Norgate, Jahanshahi, Rankin, 2007); 2,74 kg/kg (Hammond and Jones, 2008); 2,77 kg/kg (Hammond and Jones, 2008); 2,87 kg/kg (Hammond and Jones, 2008); 2,89 kg/kg (Hammond and Jones, 2008); 3,03 kg/kg (Hammond and Jones, 2008); 3,27 kg/kg (Hammond and Jones, 2008)			
Water usage	* 43,1	-	47,7	l/kg

Processing energy, CO2 footprint & water

Casting energy	* 11	-	12,2	MJ/kg
Casting CO2	* 0,826	-	0,913	kg/kg
Casting water	* 20,9	-	31,3	l/kg
Roll forming, forging energy	* 2,94	-	3,25	MJ/kg
Roll forming, forging CO2	* 0,221	-	0,244	kg/kg
Roll forming, forging water	* 2,81	-	4,21	l/kg
Extrusion, foil rolling energy	* 5,6	-	6,19	MJ/kg
Extrusion, foil rolling CO2	* 0,42	-	0,464	kg/kg
Extrusion, foil rolling water	* 3,95	-	5,92	l/kg
Wire drawing energy	* 20,2	-	22,3	MJ/kg
Wire drawing CO2	* 1,52	-	1,68	kg/kg
Wire drawing water	* 7,62	-	11,4	l/kg
Metal powder forming energy	* 38,9	-	42,8	MJ/kg
Metal powder forming CO2	* 3,11	-	3,43	kg/kg
Metal powder forming water	* 42,4	-	63,5	l/kg
Vaporization energy	* 1,09e4	-	1,2e4	MJ/kg
Vaporization CO2	* 815	-	901	kg/kg
Vaporization water	* 4,53e3	-	6,8e3	l/kg
Coarse machining energy (per unit wt removed)	* 0,874	-	0,966	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0,0655	-	0,0724	kg/kg
Fine machining energy (per unit wt removed)	* 4,46	-	4,93	MJ/kg
Fine machining CO2 (per unit wt removed)	* 0,335	-	0,37	kg/kg
Grinding energy (per unit wt removed)	* 8,45	-	9,34	MJ/kg
Grinding CO2 (per unit wt removed)	* 0,634	-	0,7	kg/kg
Non-conventional machining energy (per unit wt removed)	* 109	-	120	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	* 8,15	-	9,01	kg/kg

Recycling and end of life

Recycle	✓			
Embodied energy, recycling	* 8,1	-	8,96	MJ/kg

CO2 footprint, recycling	* 0,636	-	0,703	kg/kg
Recycle fraction in current supply	39,9	-	44	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			

Notes

Keywords

CS1020, Steelmark-Eagle & Globe (AUSTRALIA); LASALLE 1018, LaSalle Steel Co. (USA);

Standards with similar compositions

• Australia:
S1020 to AS 1442, S1020 to AS 1443, S1020 to AS 1446
• Austria:
C22SP to ONORM M3167
• China:
CRB650 to GB 13788, ML20AI to GB/T 6478, Q235 to GB/T 3524
• Hungary:
B38X to MSZ 500
• India:
17C5 to IS 8053, ERW-3 to IS 3074, Grade 8 to IS 7887, Grade 8 to IS 8952
• International:
CC21A to ISO 4954
• Italy:
C21 to UNI 6922, CB20FF to UNI 7356
• Japan:
SWRCH20A to JIS G3507, SWRM 20 to JIS G3505
• Mexico:
1020 to NMX-B-301, MT1020 to NMX-B-201, MT1020 to NMX-B-203-SCFI
• Pan America:
1020 to COPANT 330, 1020 to COPANT 331, 1020 to COPANT 333
• South Korea:
SWRCH20A to KS D 3592, SWRM 20 to KS D 3554
• Spain:
18KA-DF to UNE 36032, 20KA-DF to UNE 36032, F.7516 to UNE 36032, F.7517 to UNE 36032
• UK:
040A20 to BS 970/1
• USA:
1020, 1020 to ASTM A29/A29M, 1020 to ASTM A512-96, 1020 to ASTM A513, 1020 to ASTM A519, 1020 to ASTM A568/A568M, 1020 to DoD-F-24669/1, 1020 to FED QQ-S-635B, 1020 to FED QQ-S-698, 1020 to FED QQ-W-461H, 1020 to MIL-S-7952A, 1020 to MIL-T-3520, 1020 to SAE J403, 1023, 1023 to ASTM A513, 1023 to ASTM A568/A568M, 1023 to SAE J403, 5032 to AMS 5032E, C2 to MIL-S-16788A, CS1020 to MIL-S-11310E, G10200 to ASTM A510/A510M, G10200 to ASTM A576-90b, G10200 to ASTM A830/A830M, G10200 to MIL-S-46059, Grade A to ASTM A595, Grade B to ASTM A730, M1020, M1020 to ASTM A29/A29M, M1020 to ASTM A575-96, M1020 to SAE J403, MT1020 to ASTM A512-96, MT1020 to ASTM A513, MT1020 to ASTM A519, MT1020 to ASTM A787, UNS G10200, UNS G10200 to UNS, UNS G10230, UNS K01900, UNS K02000, UNS K02004, UNS K11900
• Tradenames:
ASCOMETAL XC18, B-W STANDARDIZED, CS1020, MARREL M5, POMPEY FFC 2, TOLEDO 15, UNION MC QUAID-EHN, V2

Links

ProcessUniverse	
Producers	
Reference	
Shape	

Description

Image



Caption

1. Bamboo green woods © PublicDomainPictures at Pixabay [Public domain] 2. Bamboo hut © Suc at Pixabay [Public domain] 3. Lamp made of bamboo © at Pixabay [Public domain]

The material

Bamboo is nature's gift to the construction industry. Think of it: a hollow tube, exceptionally strong and light, growing so fast that it can be harvested after a year, and - given a little longer - reaching a diameter of 0.3 meters and a height of 15 meters. This and its hard surface and ease of working makes it the most versatile of materials. Bamboo is used for building and scaffolding, for roofs and flooring, for pipes, buckets, baskets, walking sticks, fishing poles, window blinds, mats, arrows and furniture. Tonkin bamboo is strong and flexible (fishing poles); Tali bamboo is used for structural applications (houses or furniture); Eeta bamboo is the fastest growing and is used as a source of cellulose for the production of cellulose or Rayon.

Composition (summary)

Cellulose/Hemicellulose/Lignin/12% H2O

General properties

Density	602	-	797	kg/m^3
Price	* 29,8	-	44,5	CZK/kg

Mechanical properties

Young's modulus	15,1	-	19,9	GPa
Yield strength (elastic limit)	* 35,8	-	44,1	MPa
Tensile strength	160	-	319	MPa
Elongation	* 2,3	-	2,8	% strain
Hardness - Vickers	* 3,49	-	4,3	HV
Fatigue strength at 10^7 cycles	29,3	-	39,4	MPa
Fracture toughness	* 5,69	-	7,01	MPa.m^0.5

Thermal properties

Maximum service temperature	118	-	142	°C
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0,148	-	0,195	W/m.°C

Specific heat capacity	1,67e3	-	1,7e3	J/kg.°C
Thermal expansion coefficient	2,59	-	4,11	µstrain/°C

Electrical properties

Electrical conductor or insulator?	Poor insulator

Optical properties

Transparency	Opaque

Eco properties

Embodied energy, primary production	32,5	-	35,9	MJ/kg
CO2 footprint, primary production	1	-	1,11	kg/kg
Recycle	✖			

Supporting information

Typical uses

Building & construction, scaffolding, furniture, pulp & paper making, ropes, reinforcement for concrete, frames for early aircraft, pipes, baskets, walking sticks, fishing poles, window blinds, mats, arrows and furniture.

Links

ProcessUniverse

Values marked * are estimates.
No warranty is given for the accuracy of this data