General information

Designation

Iron-base-superalloy, Cr-Ni alloy, A-286, solution treated & aged

Condition	Solution treated & aged
UNS number	S66286
US name	AMS 5528, AMS 5726, AMS 5731, AMS 5732, AMS 5734, AMS 5737, AMS 5804, AMS 5805, ASTM A453 660
EN name	BS HR 650, 286S31
EN number	1.4944, 1.4943
JIS (Japanese) name	JIS G4311 SUH660

Tradenames

Aeroval; Altemp; Armco; Inco; Incoloy; Jessop; Jessop-Saville; Krupp; Lescalloy; Nickelvac; Pyromet; Udimar; Witten

Typical uses

Aerospace, turbine parts, petrochemical processing equipment, heat treating equipment, motor and transformer core laminations, toroids, magnetic shields, electrical relays, communications equipment

Included in Materials Data for Simulation	✓
Materials Data for Simulation name	Alloy steel, iron-base-superalloy, A-286

Composition overview

Compositional summary

Fe49-60 / Ni24-27 / Cr14-16 / Ti1.9-2.4 / Mo1-1.5 / V0.1-0.5 / B0.001-0.01 (impurities: Mn<2, Si<1, Al<0.35, C<0.08, P<0.04, S<0.03)

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

Composition detail (metals, ceramics and glasses)

Al (aluminum)		0	-	0,35	%
B (boron)		0,001	-	0,01	%
C (carbon)		0	-	0,08	%
Cr (chromium)		13,5	-	16	%
Fe (iron)	*	49,1	-	59,5	%
Mn (manganese)		0	-	2	%
Mo (molybdenum)		1	-	1,5	%
Ni (nickel)		24	-	27	%
P (phosphorus)		0	-	0,04	%
S (sulfur)		0	-	0,03	%
Si (silicon)		0	-	1	%
Ti (titanium)		1,9	-	2,35	%
V (vanadium)		0,1	-	0,5	%

Price

Price	*	6,49	-	10,2	USD/kg
Price per unit volume	*	5,13e4	-	8,14e4	USD/m^3

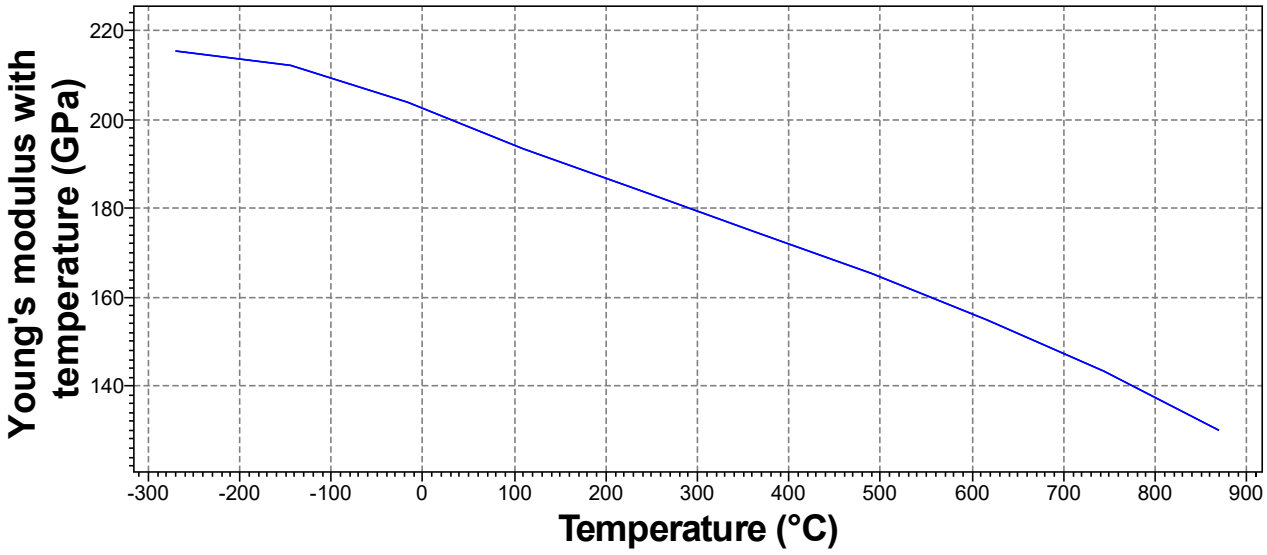
Physical properties

Density	7,9e3	-	7,98e3	kg/m^3

Mechanical properties

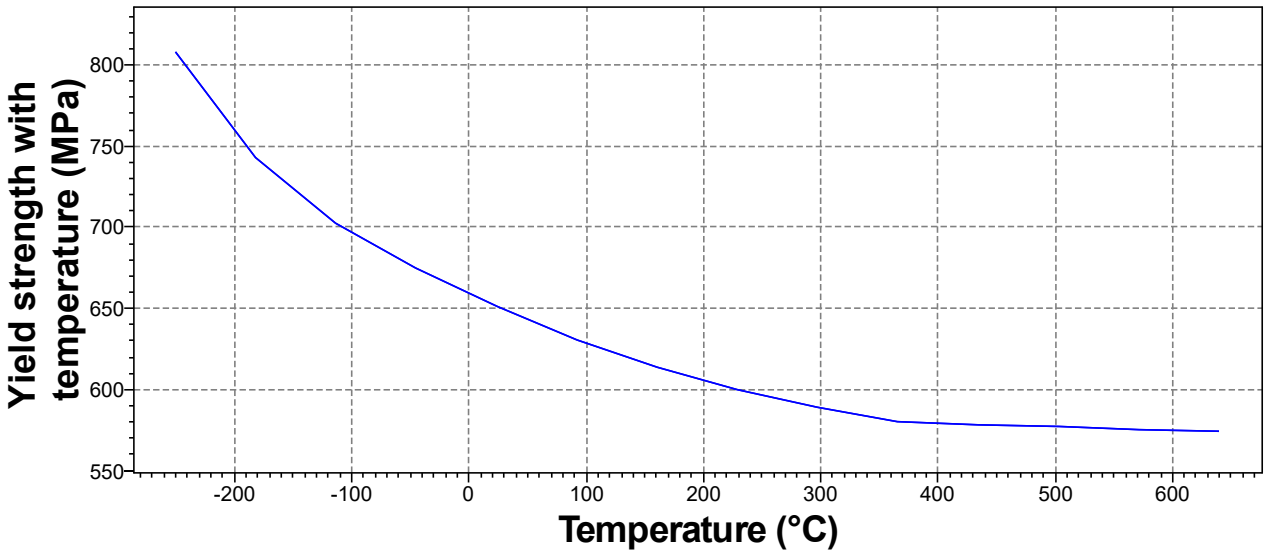
Young's modulus	201	-	211	GPa
Young's modulus with temperature	201	-	201	GPa

Parameters: Temperature = 23°C



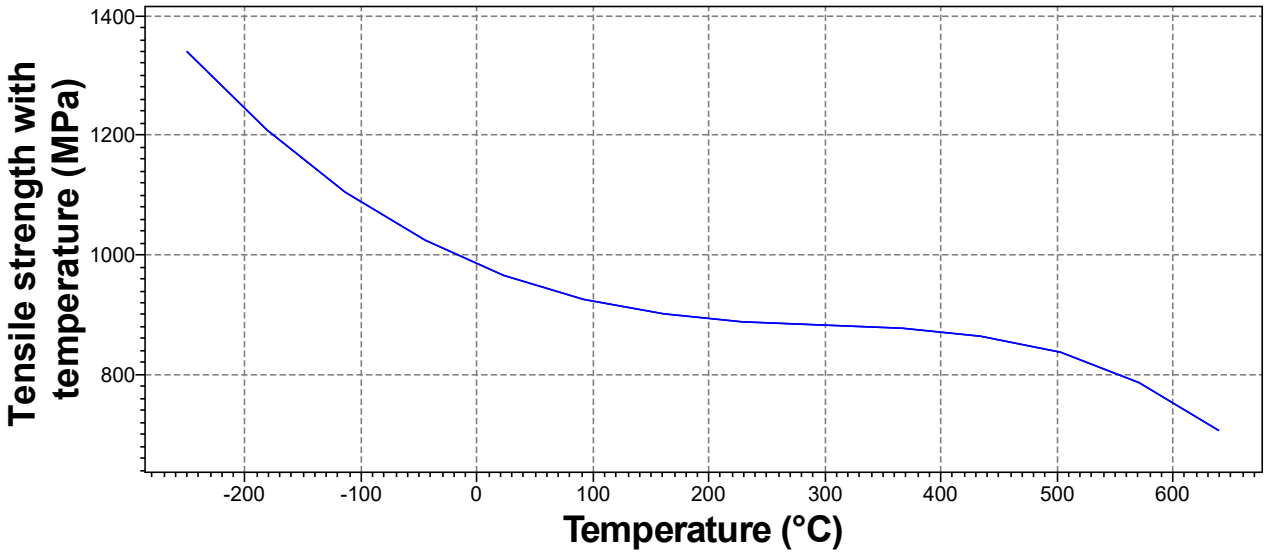
Specific stiffness	25,3	-	26,6	MN.m/kg
Yield strength (elastic limit)	590	-	793	MPa
Yield strength with temperature	651	-	651	MPa

Parameters: Temperature = 23°C



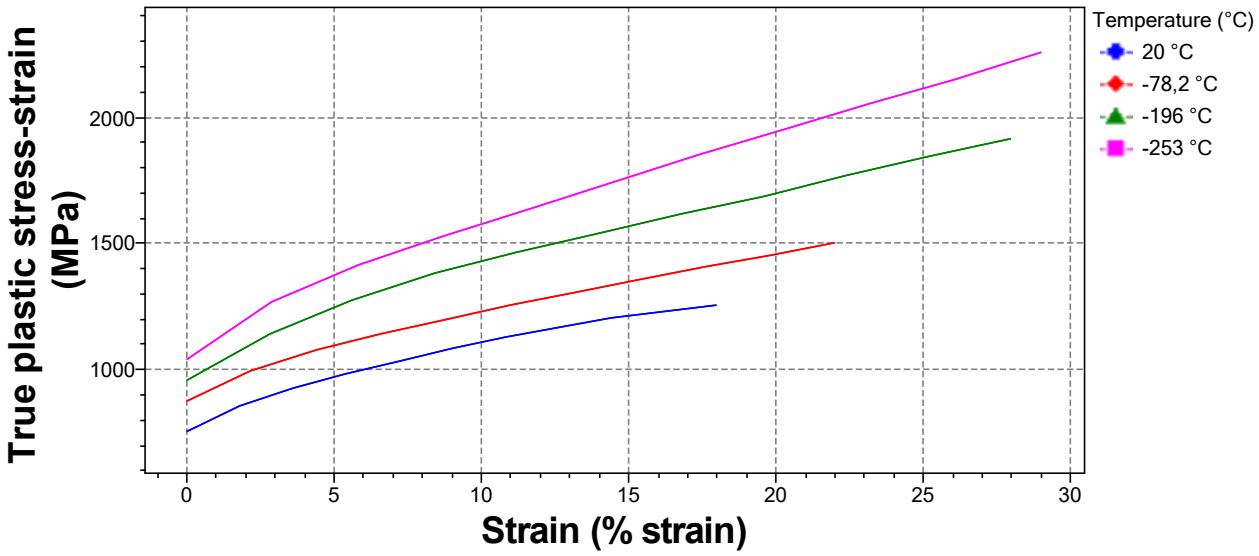
Tensile strength	900	-	1,1e3	MPa
Tensile strength with temperature	965	-	965	MPa

Parameters: Temperature = 23°C



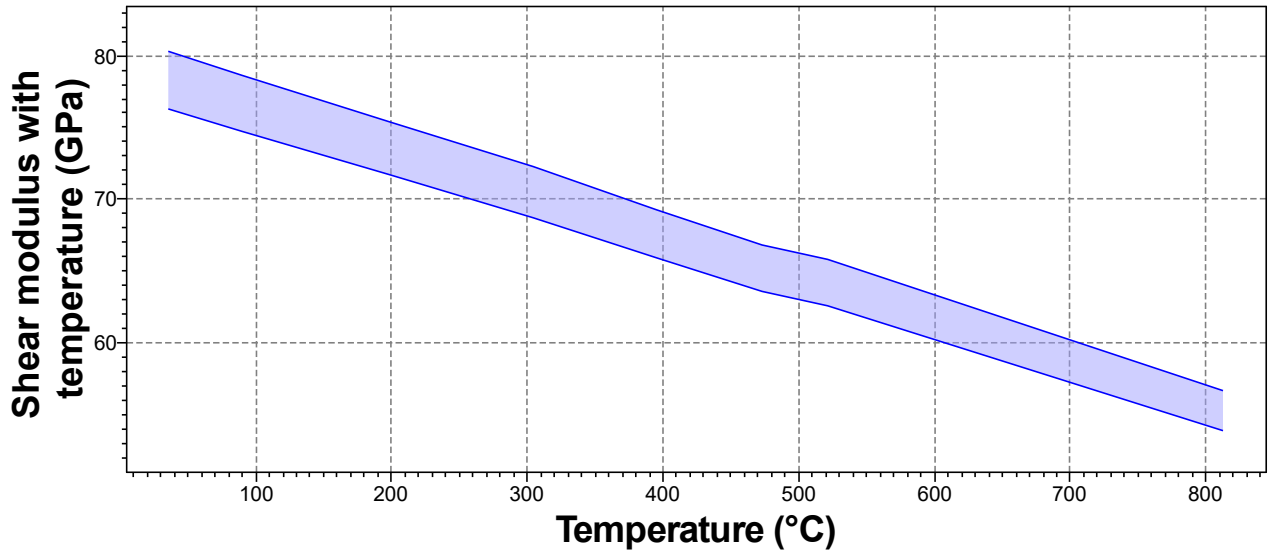
Specific strength	74,3	-	99,8	kN.m/kg
Elongation	15	-	24	% strain
Tangent modulus	3,25e3			MPa
True plastic stress-strain	Out Of Range			MPa

Parameters: Strain = 0% strain, Temperature = 23°C



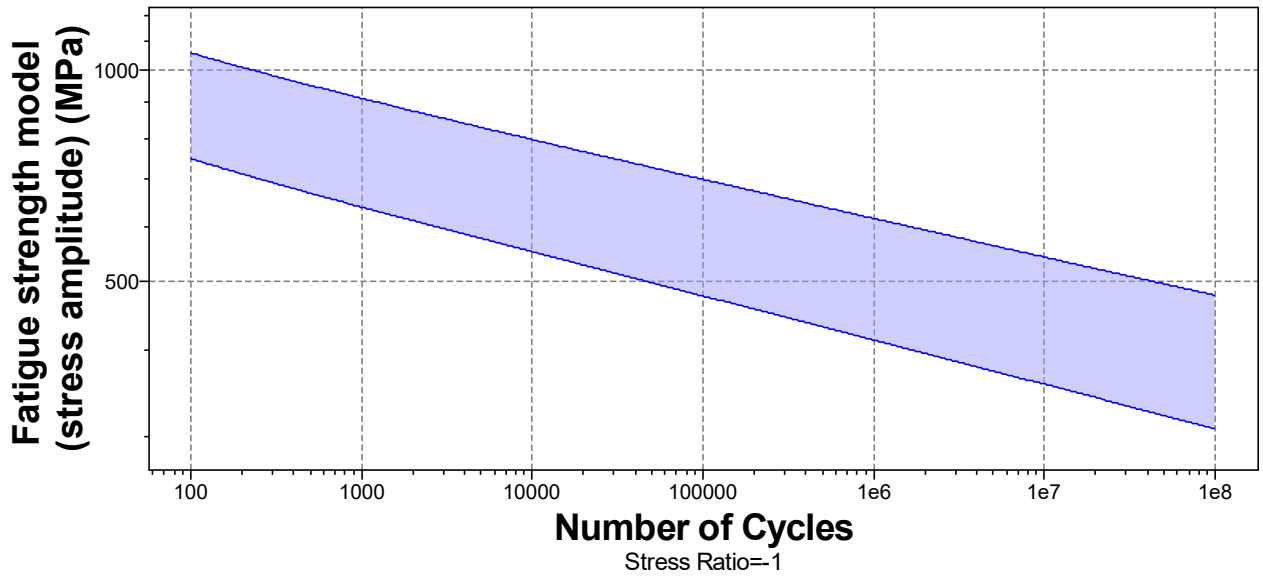
Compressive strength	* 590	-	793	MPa
Flexural modulus	* 201	-	211	GPa
Flexural strength (modulus of rupture)	* 590	-	793	MPa
Shear modulus	77	-	80,9	GPa
Shear modulus with temperature	Out Of Range			GPa

Parameters: Temperature = 23°C



Bulk modulus		176	-	185	GPa
Poisson's ratio		0,31	-	0,323	
Shape factor		36			
Hardness - Vickers	*	287	-	330	HV
Hardness - Rockwell C		32	-	35	HRC
Elastic stored energy (springs)		860	-	1,5e3	kJ/m^3
Fatigue strength at 10^7 cycles	*	407	-	475	MPa
Fatigue strength model (stress amplitude)	*	357	-	542	MPa

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



Impact & fracture properties

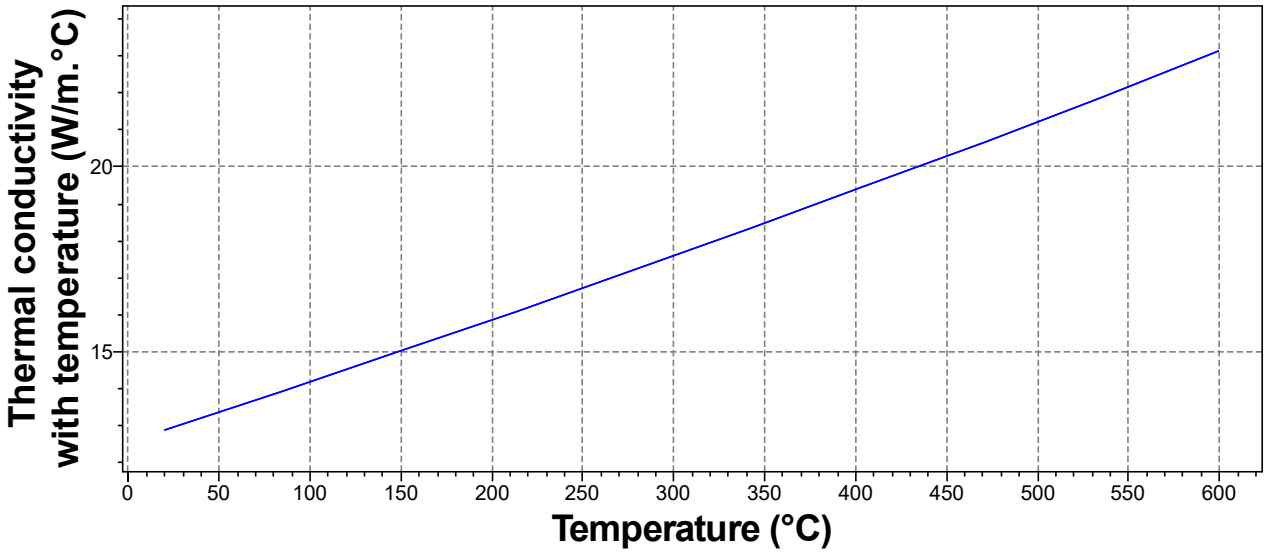
Fracture toughness	180	-	199	MPa.m^0.5
Toughness (G)	157	-	192	kJ/m^2

Thermal properties

Melting point	1,37e3	-	1,4e3	°C

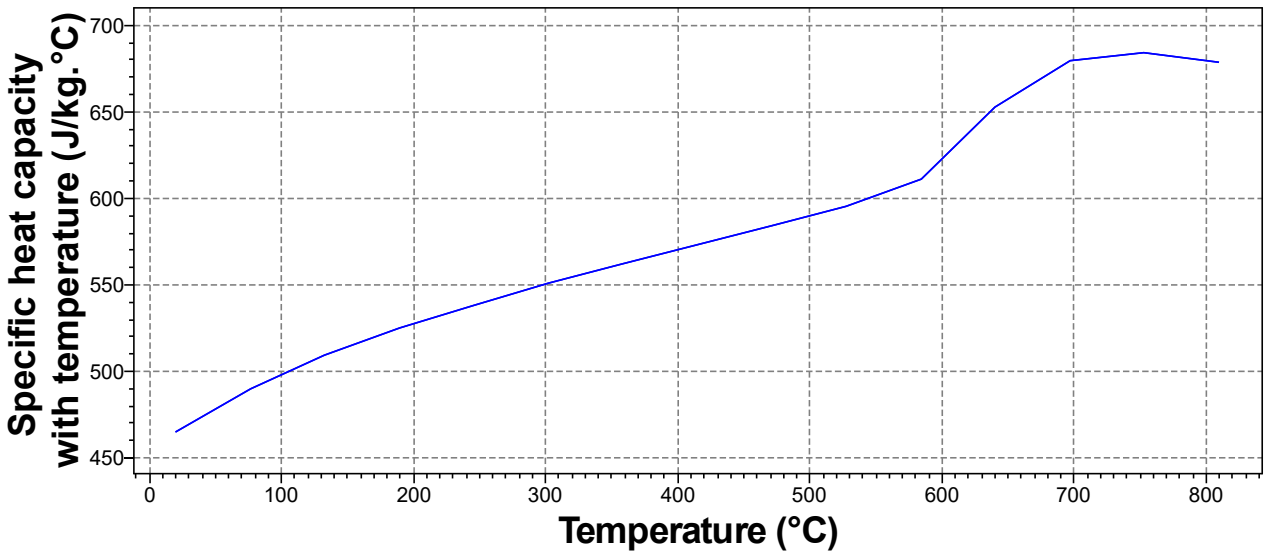
Maximum service temperature	632	-	705	°C
Minimum service temperature	* -73	-	-53	°C
Thermal conductivity	12,5	-	13,5	W/m.°C
Thermal conductivity with temperature	12,9	-	12,9	W/m.°C

Parameters: Temperature = 23°C



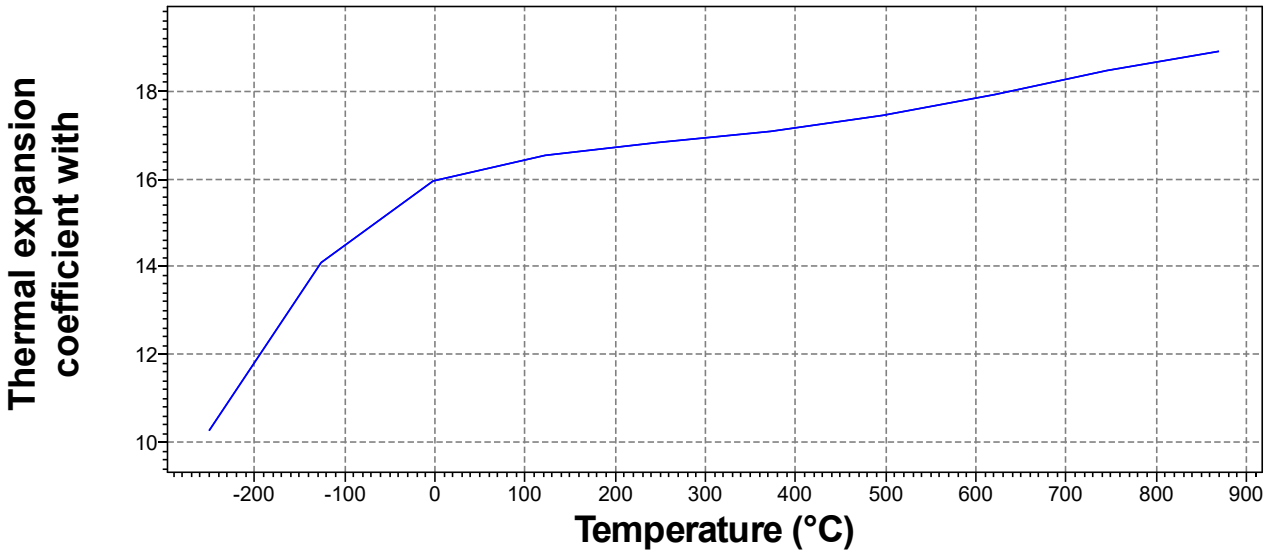
Specific heat capacity	452	-	470	J/kg.°C
Specific heat capacity with temperature	466	-	466	J/kg.°C

Parameters: Temperature = 23°C



Thermal expansion coefficient	16,6	-	17,4	µstrain/°C
Thermal expansion coefficient with temperature	16,1	-	16,1	µstrain/°C

Parameters: Temperature = 23°C

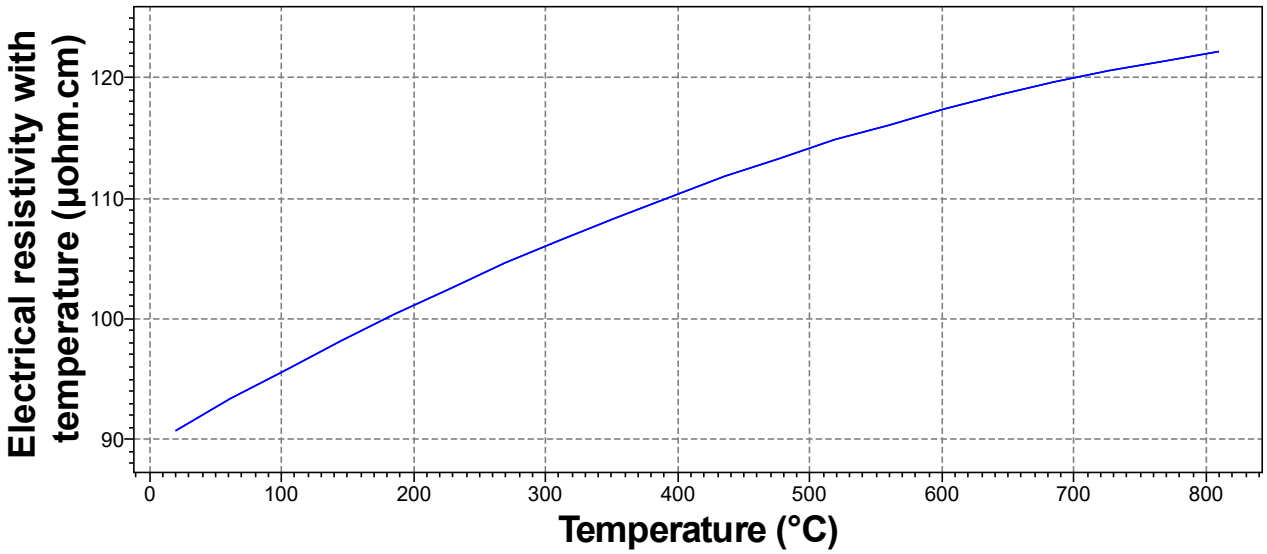


Reference temp	20			°C
Thermal shock resistance	168	-	227	°C
Thermal distortion resistance	* 0,731	-	0,803	MW/m
Latent heat of fusion	* 222	-	310	kJ/kg

Electrical properties

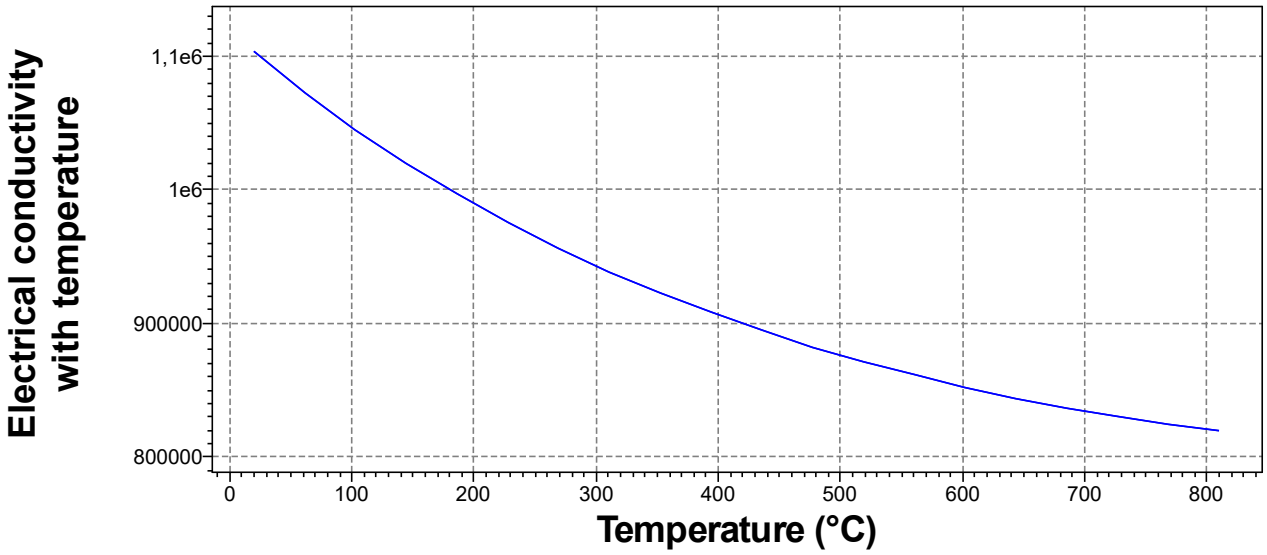
Electrical resistivity	91	-	93	µohm.cm
Electrical resistivity with temperature	90,9			µohm.cm

Parameters: Temperature = 23°C



Electrical conductivity	1,85	-	1,89	%IACS
Electrical conductivity with temperature	1,1e6			Siemens/m

Parameters: Temperature = 23°C



Galvanic potential	*	-0,16	-	-0,08	V

Magnetic properties

Magnetic type		Non-magnetic			

Optical, aesthetic and acoustic properties

Transparency		Opaque			
Acoustic velocity		5,03e3	-	5,16e3	m/s
Mechanical loss coefficient (tan delta)	*	2e-4	-	5e-4	

Restricted substances risk indicators

SIN List indicator (0-1, 1 = high risk)		0			

Critical materials risk

Contains >5wt% critical elements?		Yes			

Processing properties

Metal casting		Limited use			
Metal cold forming		Excellent			
Metal hot forming		Excellent			
Metal press forming		Acceptable			
Metal deep drawing		Limited use			
Machining speed		7,92			m/min
Weldability		Poor			
Notes		Preheating and post weld heat treatments may be required			
Carbon equivalency		1,16	-	1,66	

Durability

Water (fresh)		Excellent			
Water (salt)		Excellent			
Weak acids		Excellent			
Strong acids		Acceptable			
Weak alkalis		Excellent			

Strong alkalis	Excellent
Organic solvents	Excellent
Oxidation at 500C	Excellent
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Limited use
Notes	Bronze or zinc alloy dies should be used to minimize galling.
Flammability	Non-flammable

Corrosion resistance of metals

Pitting resistance equivalent number (PREN)	16,8	-	21	
Pitting and crevice corrosion resistance	Low (<20)			
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 (virgin grade)	* 122	-	135	MJ/kg
Sources	Estimated from sources including ecoinvent v3.9.1; Fthenakis, Wang, Kim, 2009; Norgate, Jahanshahi, Rankin, 2007; Sullivan and Gaines, 2010; Nickel Institute, 2003; Dhingra, Overly, Davis, 1999; Hammond and Jones, 2008			
Embodied energy, primary production (typical grade)	* 68,2	-	80,8	MJ/kg
CO2 footprint, primary production (virgin grade)	* 9,25	-	10,2	kg/kg
Sources	Estimated from sources including ecoinvent v3.9.1; Voet, van der and Oers, van, 2003; Norgate, Jahanshahi, Rankin, 2007; Nickel Institute, 2003; Hammond and Jones, 2008			
CO2 footprint, primary production (typical grade)	* 5,2	-	6,07	kg/kg
Water usage	* 160	-	177	l/kg

Processing energy, CO2 footprint & water

Casting energy	* 10,4	-	11,5	MJ/kg
Casting CO2	* 0,781	-	0,861	kg/kg
Casting water	* 19,8	-	29,8	l/kg
Roll forming, forging energy	* 5,75	-	6,34	MJ/kg
Roll forming, forging CO2	* 0,431	-	0,475	kg/kg
Roll forming, forging water	* 3,98	-	5,97	l/kg
Extrusion, foil rolling energy	* 11,2	-	12,4	MJ/kg
Extrusion, foil rolling CO2	* 0,842	-	0,928	kg/kg
Extrusion, foil rolling water	* 6,28	-	9,42	l/kg
Wire drawing energy	* 41,3	-	45,5	MJ/kg
Wire drawing CO2	* 3,1	-	3,41	kg/kg
Wire drawing water	* 15,3	-	23	l/kg
Metal powder forming energy	* 35,1	-	38,6	MJ/kg
Metal powder forming CO2	* 2,63	-	2,9	kg/kg
Metal powder forming water	* 39,7	-	57,2	l/kg
Vaporization energy	* 1,05e4	-	1,16e4	MJ/kg
Vaporization CO2	* 788	-	869	kg/kg
Vaporization water	* 4,55e3	-	6,56e3	l/kg
Coarse machining energy (per unit wt removed)	* 1,3	-	1,43	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0,0974	-	0,107	kg/kg
Fine machining energy (per unit wt removed)	* 8,68	-	9,57	MJ/kg

Fine machining CO2 (per unit wt removed)	* 0,651	-	0,718	kg/kg
Grinding energy (per unit wt removed)	* 16,9	-	18,6	MJ/kg
Grinding CO2 (per unit wt removed)	* 1,27	-	1,4	kg/kg
Non-conventional machining energy (per unit wt removed)	* 105	-	116	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	* 7,88	-	8,69	kg/kg

Recycling and end of life

Recycle	✓			
Embodied energy, recycling	* 23,4	-	25,3	MJ/kg
CO2 footprint, recycling	* 1,84	-	1,99	kg/kg
Recycle fraction in current supply	49,4	-	54,6	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			

Notes

Warning

All nickel compounds should be regarded as toxic. Some can cause cancer and/or fetal abnormalities.

Other notes

The best known Ni/Fe Alloy is "INVAR", which has a thermal expansion coefficient that is close to zero at room temperature.

Keywords

0Cr15Ni25Ti2MoAlVB; 1.4943; 1.4944; 286S31; 286S31 to BS 1506; 660 Class D to ASTM A453/A453M; 660 to ASTM A453/A453M; 660 to ASTM A638/A638M-00; A286 Superalloy; Aeroval AN5; ALLEGHENY A-286; ALTEMP A-286; AMANOX 3980; Armco A-286; ATI A286; BOHLER T200; BS HR 650; CRONIFER 1525 TI - ALLOY 286; Dominial Hwf; Electralloy A286; Emvac 286; Grade 660 to ASTM A638 to ASME SA638/SA638M; Grade 660A to ASTM A453; Grade 660B to ASTM A453; Grade 660C to ASTM A453; Grade 660D to ASTM A453; HR-51; HR-650; Inco A-286; INCOLOY ALLOY A-286; Jessop-Saville G 68; JIS G4311 SUH660; Krupp WI 1.4943; Krupp WI 1.4944; Lescalloy A-286; LSS A286; M17B; M17BM; MB17B; MB17BM; NAS 660; Nickelvac A286; PYROMET A-286; PYROMET ALLOY A-286; SAE AMS 5525; SAE AMS 5528; SAE AMS 5726; SAE AMS 5731; SAE AMS 5732; SAE AMS 5734; SAE AMS 5737; SAE AMS 5804; SAE AMS 5805; SAE AMS 5853; SAE AMS 5858; SAE AMS 5895; SAE AMS 7235; SS 2570-04; STH 660-WSA to KS D 3697; STR 660; SUH 660; SUS660-WSA; SUS660-WSB; Udimet A-286; UNS S66286; Witten Da 1525 Lva; Witten S 1525 Lva; X 5 NiCrTiMoV 26 15; X4NiCrTiMoV26-15; X5NiCrTiMoVB25-15-2; X6NiCrTi26-15; X6NiCrTiMoV26-15; X6NiCrTiMoVB25-15-2; Z6NCTDV25.15

Standards with similar compositions

- South Korea:
STH 660-WSA to KS D 3697
- USA:
660 Class D to ASTM A453/A453M, 660 to ASTM A453/A453M

Links

MMPDS equivalent alloys
MMPDS similar alloys
ProcessUniverse
Producers
Reference
Shape