Cunifer® 10 – alloy CuNi 90/10

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Cunifer 10 is a copper-nickel-iron alloy with a small alloy content of manganese. Compared with other copper alloys Cunifer 10 shows excellent resistance to sea and brackish water and combines easy fabrication with good mechanical properties between – 100 and + 300 °C (– 150 to + 570 °F). The minor contents of iron and manganese improve the alloy's mechanical properties and its resistance to corrosion and erosion if the iron content is kept in solution by suitable processing.

Cunifer 10 is characterised by:

- excellent resistance to pitting, stress-corrosion cracking and bio-fouling in marine environments
- excellent resistance to erosion and impingement in moving seawater
- very good workability and weldability

Cunifer 10 surfaces tarnish slightly in air and marine atmospheres but do not corrode.

Designation and standards

Country / National standards	Material designation	Specification							
		Chemical composition	Tube and pipe seamless	Tube and pipe welded	Sheet and plate	Rod and bar	Strip	Wire	Forgings
France									
AFNOR	CuNi10Fe1Mn		A 51-102						
Germany (F.R.)	**W.-Nr. 2.0872** CuNi10Fe1Mn								
DIN		17664	1755 1785 17671 17679	86018	17670 17675	1756 1761 1763 1782 17672	1791 17670	17677	17673
AD-Merkblatt			W 6/2		W 6/2	W 6/2	W 6/2		
United Kingdom									
BS	CN 102		2871	2870 2871	2870 2875	2874	2870		
USA	UNS C70600								
ASTM			B 111 B 395 B 466 B 552	B 467 B 543 B 552	B 122 B 171 B 402	B 122 B 151	B 122		
ASME			SB 111 SB 395 SB 466	SB 467 SB 543	SB 171 SB 402				
MIL-			T-16420 T-15005	T-16420	C-15726	C-15726	C-15726		C-15726
ISO	CuNi10Fe1Mn	R 429							

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Chemical composition (%)

	Ni*	Cu	Fe	C	Mn	Zn	Pb	P	S	others
min	9.0	bal.	1.0		0.5					
max	11.0		1.8	0.05	1.0	0.5	0.01	0.02	0.02	0.3

*Cunifer 10 with limited content (10–11 %) is available on order

Physical properties

Typical physical properties at room temperature (or as indicated).

Density	8.9 g/cm³	0.32 lb/in³	Permeability at 20 °C/68 °F (RT)	usually < 1.05 higher values after annealing between 400–750 °C 750–1380 °F
Melting range	1100–1145 °C	2010–2090 °F		

Temperature T		Specific heat		Thermal conductivity		Electrical resistivity		Modulus of elasticity		Coefficient of thermal expansion between room temperature and T	
°C	°F	J/kg K	Btu / lb °F	W/mK	Btu in / ft² h °F	μΩ cm	Ω circ mil / ft	kN/mm²	10³ ksi	10⁻⁶/K	10⁻⁶ / °F
– 128	– **200**								20.9		7.7
– **100**	– 148					18.8	113	142		14.5	
0	32										
20	**68**	380	0.090	45	312	19.0	114	135	19.6		
93	**200**		0.095		339		121		19.1		9.0
100	212	400		49		21.0		132		16.0	
200	392	420		57		22.0		128		16.5	
204	**400**		0.100		401		132		18.6		9.2
300	572	425		65		23.0		124		17.0	
316	**600**		0.101		457		140		17.8		9.5
400	752	430		71		24.0		117		17.5	
427	**800**		0.104		505		146		16.4		9.8
500	932	460		77		25.0				18.0	
538	**1000**		0.113		554		155				10.1
600	1112	500				27.0				18.5	

Physical properties are affected by the presence of nickel-iron-containing precipitates.

Cunifer® 10 – alloy CuNi 90/10

Mechanical properties

The following mechanical properties are applicable to Cunifer 10 in the specified conditions and forms as well as indicated size ranges. They are based upon a number of different specifications. Material outside these size ranges is subject to special enquiry.

Form	Dimensions (thickness, diameter)		Tensile strength		0.2% Yield strength		Elong. A_5	Hardness	according to
	mm	inches	N/mm²	ksi	N/mm²	ksi	%		
soft									
Flat products (strip, sheet, bar, plate)	0.3 – < 15	0.012 – < 0.6	300	44	100	14.5	30	~ 70 HB	DIN 17670, AD W 6/2
	15 – 60	0.6 – 2 3/8	300	44	120	17.4	30	~ 80 HB	DIN 17675, AD W 6/2
	> 60 – 120	> 2 3/8 – 4 3/4	280	41	100	14.5		~ 70 HB	
	all	all	280	41	–	–	40	≤ 90 HV	BS 2870, 2875
	≤ 127	≤ 5	275	40	105	15	30	10-27 RB	ASTM B 111, 402
		≤ 0.021					20		
		> 0.021 – 3/16	260	38	105	15	25		MIL-C-15726
		> 3/16					30		
Rod, bar	≥ 10 – 100	≥ 3/8 – 4	280	41	100	14.5	30	~ 75 HB	DIN 17672, AD W 6/2
	> 6	> 1/4	280	41	–	–	27		BS 2874
	all	all	260	38	105	15	30		ASTM B 151
Rod	≤ 127	≤ 5	260	38	105	15	30		MIL-C-15726
Tube, pipe	s ≤ 5 75 ø	s ≤ 3/16 3 ø	290	42	90	13	30	~ 70 HB	DIN 17671, AD W 6/2
	2 – 500 ø	3/64 – 20 ø	300-380	44-55	–	–	30	< 100 HV	BS 2871
	≤ 50 ø	≤ 2 ø	275	40	105	15			ASTM B 111, 395, 543
	≤ 114 ø	≤ 4 1/2 ø	260	38	105	15	30		MIL-T-16420
	> 114 ø	> 4 1/2 ø			90	13			
light hardened									
Flat products	15 – 60	0.6 – 2 3/8	320	46	200	29	15	~ 100 HB	DIN 17675, AD W 6/2
	≤ 10	≤ 3/8	310	45	–	–	30	≤ 100 HV	BS 2870
Tube, pipe	≤ 250 ø	≤ 10 ø	310	45	240	35	–	R 30T 45-70	ASTM B 466
	≤ 114 ø	≤ 4 1/2 ø	310	45	240	35	15		ASTM B 111 MIL-T-16420

This table is continued on the next page.

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Form	Dimensions (thickness, diameter)		Tensile strength		0.2% Yield strength		Elong. A_5	Hardness	according to
	mm	inches	N/mm²	ksi	N/mm²	ksi	%		
hard									
Flat products	15 – 60	0.6 – 2 3/8	350	51	250	36	14	~ 110 HB	DIN 17675, AD W 6/2
	≤ 5	≤ 3/16	380	55	205	30	10		MIL-C-15726
Rod, bar	≤ 20 ø	≤ 3/4 ø	350	51	300	44	5	~ 110 HB	DIN 17672
Rod	≤ 10 ø	≤ 3/8 ø	415	60	260	38	10		
	> 10 – 25 ø	> 3/8 – 1 ø	345	50	205	30	15		ASTM B 151 MIL-C-15726
	> 25 – 75 ø	> 1 – 3 ø	275	40	105	15	30		
Bar, plate	5 – ≤ 10 ø	3/16 – ≤ 3/8 ø	380	55	205	30	10		
	> 10 – ≤ 12.5 ø	> 3/8 – 1/2 ø	345	50	195	28	12		ASTM B 151
	> 12.5 – 75 ø	> 1/2 – 3 ø	275	40	115	17	20		MIL-C-15276
	> 75 – 127 ø	> 3 – 5 ø	260	38	105	15	20		
Pipe (cr strip)	≤ 114 ø	≤ 4 1/2 ø	375	54	310	45	–		ASTM B 467
Tube			430	62	–	–	–	≥ 130 HV	BS 2871

Table 4 – Minimum mechanical properties at room temperature.

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Some alloying additions show a marked influence on metal characteristics. Manganese deoxidises and desulphurises the alloy during melting and improves its mechanical properties and workability. Iron (up to 2% in solid solution) improves corrosion resistance and mechanical properties especially in flowing sea water.

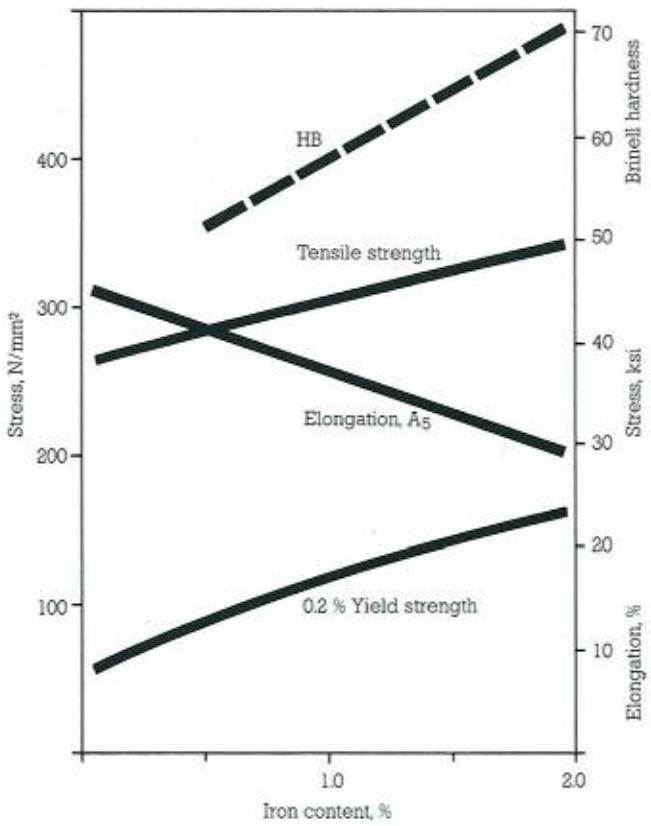

Fig. 1 – Influence of iron content in Cunifer 10 on mechanical properties after recrystallisation.

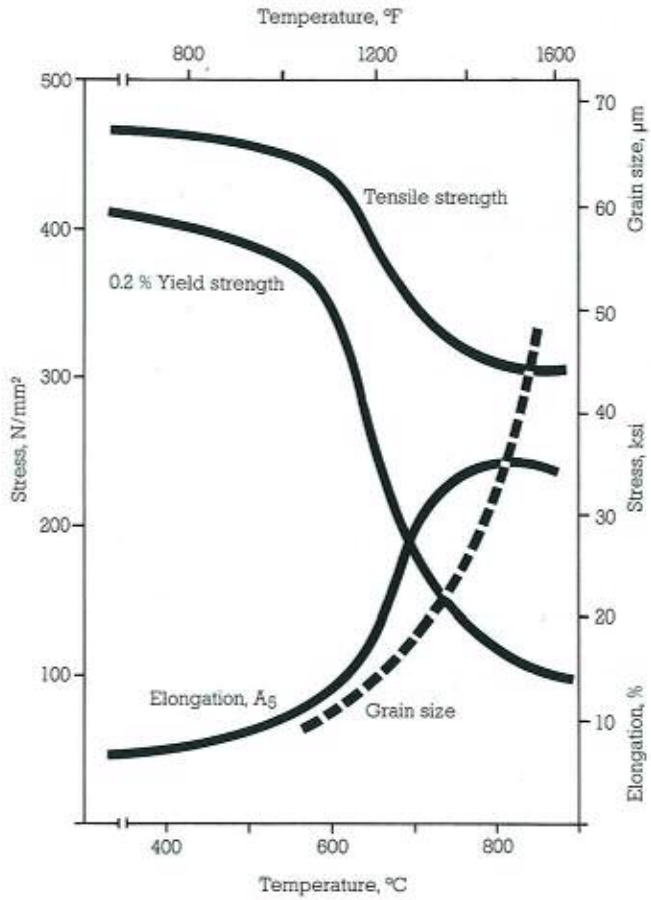

Fig. 2 – Influence of temperature on mechanical properties and grain sizes of 50% cold rolled Cunifer 10, annealing time 5 mins per mm (0.04 in) thickness.

Cunifer® 10 – alloy CuNi 90/10

Temperature		1% Yield strength in soft condition						0.2% Yield strength in condition light hardened		hard	
		Sheet, strip, rod, bar, plate 60–120 mm		Plate 15–60 mm (F 30)		Tube and pipe (F 29)		Sheet and plate (F 32)		Sheet, plate, bar (F 35)	
°C	°F	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi
20/50	68/122	125	18.1	145	21.0	115	16.7	200	29.0	250	36.5
100	212	118	17.1	138	20.0	108	15.7	190	27.6	235	34.1
150	302	114	16.5	133	19.3	105	15.2	185	26.8	225	32.6
200	392	109	15.8	128	18.6	102	14.8	175	25.4	220	31.9
250	482	104	15.1	123	17.8	98	14.2	170	24.7	210	30.5
300	572	99	14.4	118	17.1	93	13.5	165	23.9	205	29.7

Table 5 – Minimum short-time properties of Cunifer 10 products at elevated temperatures according to AD-Merkblatt W 6/2.

Temperature		1% Yield strength in soft condition						0.2% Yield strength in condition light hardened		hard	
		Sheet, strip, rod, bar plate 60–120 mm		Plate 15–60 mm		Tube and pipe		Sheet and plate		Sheet, plate, bar	
°C	°F	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi
20/50	68/122	83	12.0	97	14.1	77	11.2	133	19.3	167	24.2
100	212	79	11.5	92	13.3	72	10.4	127	18.4	157	22.8
150	302	76	11.0	89	12.9	70	10.2	123	17.8	150	21.8
200	392	73	10.6	85	12.3	68	9.9	117	17.0	147	21.3
250	482	69	10.0	82	11.9	65	9.4	83	12.0	83	12.0
300	572	(66) 62	(9.6) 9.0	(74) 62	(10.7) 9.0	62	9.0	(74) 62	(10.7) 9.0	(74) 62	(10.7) 9.0

Table 6 – Maximum allowable stress values of Cunifer 10 at elevated temperatures and times 10^5 hrs according to AD-Merkblatt W 6/2. Values in parentheses match with 10^4.

Temperature		SB-466 Seamless tube and pipe		SB-543/467 Seam-welded tube and pipe		SB 171 Sheet and plate		SB 402 Sheet and plate		SB 111/395 Tube and pipe	
°C	°F	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi
38	100	60	8.7	59	8.5	69	10.0	70	10.1	69	10.0
93	200	57	8.3	56	8.1	66	9.5	66	9.5	66	9.5
149	300	54	7.8	52	7.6	62	9.0	62	9.0	62	9.0
204	400	52	7.6	50	7.2	59	8.5	59	8.5	59	8.5
260	500	50	7.3	43	6.3	55	8.0	55	8.0	55	8.0
316	600	41	6.0	30	4.3	41	6.0	41	6.0	41	6.0

Table 7 – Maximum allowable design-stress values of Cunifer 10 at elevated temperatures according to ASME Section VIII-Division, Tbl. UNF-23.2.

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Metallurgical structure

Copper and nickel have the same crystallograhic structure and there is little difference in their atomic diameters and lattice constants. Copper and nickel are thus mutually soluble in all proportions in the liquid and solid states.

The solubility of iron in Cunifer 10 is temperature dependent. This may lead to Ni-Fe enriched precipitates.

Corrosion resistance

Copper-nickel alloys belong to the group of copper materials with highest corrosion resistance. They are, for example, resistant to dilute, non-oxidising acids, saline solutions, organic acids, hydrofluoric acid, and dry gases such as oxygen, chlorine, hydrogen chloride, sulphur dioxide and carbon dioxide.

Cunifer 10 is resistant to stress-corrosion cracking in sea water and brackish water and also to corrosion fatigue and marine biofouling. Water velocity should be not less than 0.7 m/s (28 in/s) to avoid corrosion due to deposited foreign material. In order to prevent erosion and impingement attack, the maximum velocity should be, for piping

less than	50 mm (2 in) ID, 2.5 m/s (100 in/s);
and for piping	
more than	50 mm (2 in) ID, 3.5 m/s (138 in/s).

Cunifer 10 is resistant to dry NH_3 gas as well as to dry H_2S gas. In damper atmospheres, NH_3 and/or H_2S contents cause corrosive attack. In dilute solutions of NH_4OH in water, Cunifer 10 is resistant to stress-corrosion cracking. The NH_4OH level should not exceed 50 ppm at ambient temperature. Hydrogen sulphide also increases the corrosion rate in aqueous media.

Cunifer 10 is not resistant to oxidising media, i.e. Fe (III)-chloride and hypochlorite solutions.

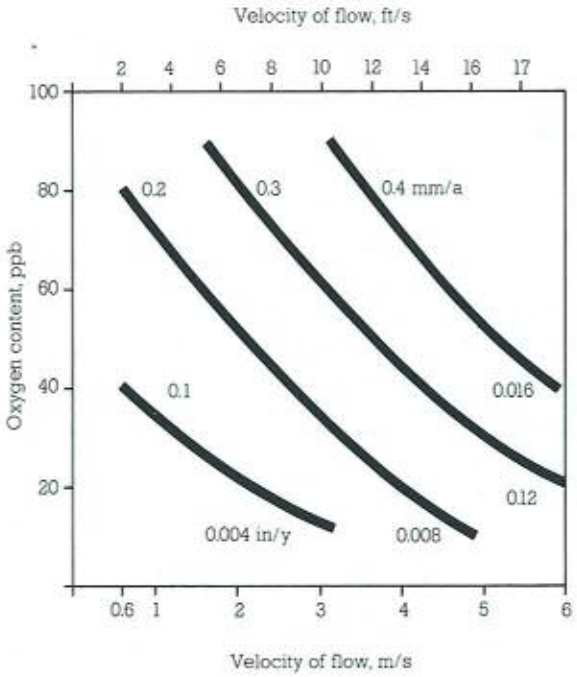

Fig. 3 – Abrasion of Cunifer 10 (mm/a – in/year) in appr. 110 °C (230 °F) seawater, pH ~ 7 dependent on oxygen content and flow velocity.

Applications

Cunifer 10 finds extensive application due to its very good resistance to corrosion in sea and brackish water. It is particularly popular for

- construction elements in the shipbuilding industry
- offshore, sheathing of platform legs and cross-members
- power generation
- seawater desalination units
- heat-exchanger condensers, preheaters and evaporators
- seawater cooling systems and cooling pipes, tank-heating coils
- bilge and ballast systems
- hydraulic lines

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Fabrication and heat treatment

Cunifer 10 is easily hot and cold formed, machined and joined. Cold working is to be preferred.

Heating

It is very important that the workpiece be clean and free from any contaminant before and during heating.

Cunifer 10 may become embrittled if heated in the presence of contaminants such as sulphur, phosphorus, lead and other low-melting-point metals. Sources of contamination include marking and temperature-indicating paints and crayons, lubricating grease and fluids, and fuels. Fuels must be low in sulphur; e.g. natural and liquefied petroleum gases should contain less than 0.1% by mass and town gas 0.25 g/m³ maximum of sulphur. Fuel oils containing no more than 0.5% by mass of sulphur are satisfactory.

The furnace atmosphere should be neutral to slightly reducing and must not fluctuate between oxidising and reducing. Flame impingement on the metal must be avoided. Oxidising atmosphere cause surface scaling.

Hot working

Cunifer 10 may be hot-worked in the range 950 to 800 °C (1750 to 1500 °F). Hot bending is carried out at about 750 °C (1380 °F). Air cooling is satisfactory.

Annealing after hot working is not necessary.

For hot working, material may be charged into the furnace at maximum working temperature.

Cold working

Cold working should be carried out on annealed material.

When cold working is performed, interstage annealing may become necessary if the cold forming rate is higher than about 50%.

Tubes should be bent by means of bending machines. At nominal diameters of 80 mm and less, a tube bend of r = 2d can be obtained. The use of elbows and other fittings is recommended to reduce prefabrication and installation times.

Heat treatment

Recrystallisation annealing is carried out in the temperature range 750 – 800 °C (1380 – 1470 °F), soacking for 3 to 5 minutes per mm (0.04 in) of thickness.

Stress relieving at 250 – 500 °C (480 – 930 °F) is seldom used, because Cunifer 10 is not susceptible to stress cracking either in the soft or in the cold work-hardened condition.

During any heating operation the precautions outlined earlier regarding cleanliness must be observed.

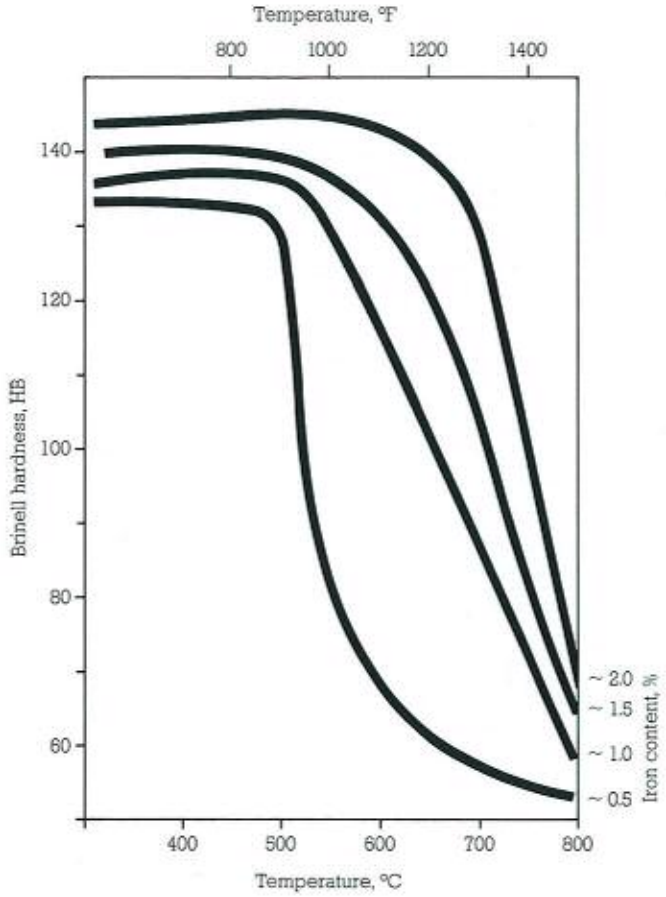

Fig. 4 – Softening effect on 50% cold rolled Cunifer 10 sheets as a function of iron content and temperature.

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Descaling
Oxides of Cunifer 10 and discoloration adjacent to welds, are more adherent than on stainless steels. Grinding with very fine abrasive belts or discs is recommended.

Before pickling in a mixture of 10 – 15% sulphuric acid with 2% sodium nitrate or bichromate, oxides can be broken up by grit-blasting.

After pickling, components must be rinsed in water (if possible 2% ammoniacal water), then dried in (hot) air.

Machining
Due to its high ductility machining of Cunifer 10 in the soft condition is difficult. Long turnings are produced and the surface quality may be poor.

Low cutting speeds, carbide-tipped tools and excellent cooling emulsion or sulphurous drilling oil are recommended.

The usual depth of cut during roughing is 2 – 3 mm (0.08 – 0.12 in) at cutting speeds of approx. 200 m/min (600 ft/min) using tungsten carbides. Finishing is carried out at up to 0.8 mm (0.03 in) depth and speeds up to 350 m/min (1000 ft/min).

Joining
Cunifer 10 can be welded by all conventional processes, including gas tungsten-arc (GTAW/TIG) gas metal-arc (GMAW/MIG) and shielded metal-arc welding (SMAW/MMA).

Prior to welding, material should be in the annealed condition, clean and free from scale, grease, marking paints etc. A zone approximately 25 mm (1 in) wide on each side of the joint should be ground to bright metal.

Low heat input is necessary. Interpass temperature should not exceed 120 °C (250 °F).

Neither pre- nor post-weld heat treatment is required.

The following welding products are recommended:

GTAW/GMAW	Cunifer S 7030	W.-Nr. 2.0837 SG-CuNi 30Fe AWS A 5.7 ER CuNi
SMAW		W.-Nr. 2.0838 EL-CuNi 30Mn AWS A 5.7 E CuNi

For optimum corrosion resistance argon-arc welding (i.e. GTAW) is preferred. In special cases, coated electrodes can be applied.

During the welding of Cunifer 10 with Cunifer 30 (SMAW), thermoelectric effects may result in arc deflection.

Brazing
Brazing (silver-alloy hard soldering) is recommended, for pipes and fittings up to 50 mm (2 in) diameter. It should be carried out only where the parts to be joined are closely mated at their contact surfaces, to assure capillary action. Maximum brazing gap should be 0.2 mm (0.008 in). Only high-silver filler metals are recommended, to minimise selective corrosion risks.

Well proven brazing materials are

L-Ag 60 Cd Ni	DIN 8513 UNS P07501	W.-Nr. 2.5160, AWS A 5.8 BAg-3
L-Ag 55 Sn	DIN 8513 UNS P07563	W.-Nr. 2.5159, AWS A 5.8 BAg-7
together with F-SH 1	flux DIN 8511	

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Availability

Cunifer 10 is available in the following standard mill product forms.

Sheet and plate

(for cut-to-length availability, refer to strip)

Conditions:
hot or cold rolled (hr, cr),
as rolled or annealed,
pickled or ground

Thickness mm			Width* mm	Length* mm
2.0	< 4.0	cr	2500	6100
≥ 4.0	< 10.0	cr	2500	6200
≥ 4.0	< 10.0	hr	2500	6200
≥ 10.0	< 50.0	hr	2500	6200**
inches			**inches**	**inches**
0.08	< 0.16	cr	100	240
≥ 0.16	< 3/8	cr	100	245
≥ 0.16	< 0.40	hr	100	245
≥ 0.40	< 2	hr	100	245**

*other sizes subject to special enquiry
**depending on piece weight (max 2500 kg)

Disc and ring

Conditions:
hot rolled or forged,
as formed or annealed
pickled

Product	Weight kg	Thickness mm	O D* mm	I D mm
Disc	≤ 2000	4 – 30	≤ 2500	–
Ring	≤ 2000	4 – 30	≤ 2500	on request
	lb	**inches**	**inches**	**inches**
Disc	≤ 4400	0.16 – 1 1/4	≤ 100	–
Ring	≤ 4400	0.16 – 1 1/4	≤ 100	on request

*other sizes subject to special enquiry

Rod and bar

Conditions:
forged, rolled, drawn,
as formed or annealed,
pickled, machined, peeled or ground

Product		forged* mm	rolled* mm	drawn* mm
round	d	25 – 220	8 – 75	10 – 75
square	a	25 – 200	7 – 200	12 – 40
flat a x b		40 – 80 x 200 – 600	5 – 50 x 120 – 1000	10 – 20 x 30 – 80
hexagonal	s	25 – 80	15 – 40	12 – 60
		inches	**inches**	**inches**
round	d	1 – 9	0.32 – 3	0.04 – 3
square	a	1 – 8	0.28 – 8	1/2 – 1 5/8
flat a x b		1 5/8 – 3 1/8 x 8 – 24	0.20 – 2 x 5 – 40	0.40 – 0.80 x 1 1/4 – 3 1/8
hexagonal	s	1 – 3 1/8	0.60 – 1 5/8	1/2 – 2 3/8

*other sizes subject to special enquiry

Forgings

Shapes other than discs, rings, rod and bar are subject to special enquiry.

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Strip*

Conditions:
annealed and pickled or
bright annealed**

Thickness mm		Width mm	Coil I D mm			
0.10	≤ 0.25	4–300	300	400		
> 0.25	≤ 0.60	5–100	300	400		
		> 100–635		400	500	600
> 0.60	≤ 1.00	8–100	300	400		
		> 100–635		400	500	600
> 1.00	≤ 1.60	15–100	300	400		
		> 100–635		400	500	600
> 1.60	≤ 2.00	25– 50		400		
		> 50–635		400	500	600
> 2.00	≤ 2.50	25–300		400	500	600
		> 300–635				600
> 2.50	– 3.0	100–635				600

inches		inches	inches			
0.004	≤ 0.010	0.16–12	12	16		
> 0.010	≤ 0.024	0.20– 4	12	16		
		> 4 –25		16	20	24
> 0.024	≤ 0.040	0.32– 4	12	16		
		> 4 –25		16	20	24
> 0.040	≤ 0.063	0.60– 4	12	16		
		> 4 –25		16	20	24
> 0.063	≤ 0.080	1 – 2		16		
		> 2 –25		16	20	24
> 0.080	≤ 0.10	1 –12		16	20	24
		> 12 –25				24
> 0.10	– 0.12	4 –25				24

*cut-to-length available in lengths from 500 to 3000 mm (20 to 120 in)
**maximum thickness 3.0 mm (⅛ in)

Wire

Conditions:
bright drawn, bright annealed

Dimensions:
0.1 – 12 mm (0.004 – ½ in) diameter
in coils, pail-packs, or on spools and spiders.

Rods 3.0–12.7 mm up to 4 m in length (⅛–½ in up to 13 ft).

Welding filler metals

Suitable welding rods, wire, wire electrodes and electrode core wire are available in standard sizes.

Seamless tube and pipe

Conditions:
cold finished,
annealed or temper annealed,
cold drawn (hard)

Outside diameter	10– 419	mm	0.40– 16½ in.
Wall thickness	1– 15	mm	0.04– 0.60 in.
Length max	26	m*	85 ft*

*depending on tube size

Seam-welded pipe (from sheet and plate)

Conditions:
as seam-welded or annealed

Outside diameter	368–1620	mm	14½–63¾ in.
Wall thickness	3– 20	mm	0.12– 0.80 in.
Length max	17.5	m*	57 ft*

*depending on tube size

Condenser tube

Conditions:
cold finished,
annealed or temper annealed

Outside diameter	10– 50	mm	0.40– 2 in.
Wall thickness	1– 5	mm	0.04– 0.20 in.
Length max	26	m*	85 ft*

*depending on tube size

U-bent tube (hairpins) can be supplied with various bend radii.

Fittings and flanges

Butt welding and brazing type are available to match the size range of the tube and pipe programme.

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