

# NUCLEAR POWER TUBING

Precision metal tubes engineered for safety-critical nuclear power applications.

Our high-quality tubes are engineered to the tightest tolerances for extreme heat, pressure and corrosion resistance – to improve nuclear power plant performance. Key advantages include:

- Improved performance, reduced maintenance and cost efficiency
- NADCAP Heat Treatment, NDT and Welding
- RCC-M Accreditations based on ASME III requirements
- Short lead times for qualification and production

## TUBING EXCELLENCE

With more than 75 years expertise in supplying high performance tubes, Fine Tubes works with US-based partner Superior Tube, to support customers worldwide to help them solve their technical challenges. We manufacture quality assured tubes in a wide range of stainless steel, nickel, titanium and zirconium alloys for critical nuclear, thermal and solar power applications.

## TUBING INNOVATIONS

Fine Tubes and Superior Tube benefit from a world-class reputation for innovative and high quality tubing solutions geared towards the power industry. Here are a few examples:



**1940**

Superior Tube supplies tubing for the Manhattan Project, where mankind first learned to control the energy of the atom.



**1970**

Fine Tubes develops 20-25Nb nuclear fuel cladding and supplies for the UK's first generation of Advanced Gas Reactors.



**1954**

Superior Tube manufactures zirconium reactor tubes for the first nuclear powered submarine, the USS Nautilus.



**2000**

The Tennessee Valley Authority's Watts Bar nuclear reactor facility uses Zirconium Zr4 tubing from Superior Tube.



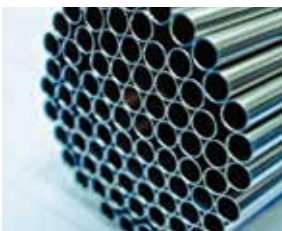
**1957**

Superior Tube supplies cladding to Shippingport Atomic Power Station, the first plant to produce electricity for a civilian population.



**2008**

Fine Tubes supplies CERN with cooling tubes for the Large Hadron Collider experiment.



**1960**

Superior Tube produces fuel cladding for Argonne National Laboratory's Experimental Breeder Reactor-II.



**2012**

Fine Tubes manufactures high performance tubing for the Gemasolar thermosolar plant in Spain.

## TUBING SOLUTIONS

### NUCLEAR POWER

Our involvement with the nuclear industry goes back to as early as the 1930s. Since then, Fine Tubes and Superior Tube have been developing and supplying high quality tubing solutions for in-core reactor components where tubing is critical to the safe operation of nuclear reactors having to withstand extreme temperatures, pressures and radiation.

From developing tubing solutions to be used as fuel cans for the U.K's AGR programme, we have continued to evolve our product range in support of PWR, PHWR, LWR, BWR and FBR reactor technologies.

Superior Tube and Fine Tubes have worked closely with the world's prominent nuclear reactor suppliers to develop tubular solutions for both new builds and maintenance projects globally, including the United Kingdom, United States, Canada, France, India and China.

#### NUCLEAR APPLICATIONS

- Primary and field instrumentation
- Control Rods/RCCA's
- Fuel cans
- Cladding tubes
- Flux thimble guide tubes
- Grid sleeves
- Seamless nickel coils for flux detectors
- Other fuel assembly components

We have a proven background of working with global customers in the renewable energy sector including thermal and solar power. Our team are dedicated to supporting customers in these industries and contributing towards decarbonization of the planet.

### THERMAL POWER

Fine Tubes and Superior Tube supply hollow conductors or cooling tubes for water cooled or helium/hydrogen cooled turbine generators used in 660 MW or above supercritical thermal power plants as well as 1000 MW or above ultra-supercritical coal-fired power plants.

As leading tube manufacturers we also have the capability to supply seamless or welded & redrawn tubes for low pressure and high pressure heaters manufactured in our fully automated multi mill.

#### THERMAL APPLICATIONS

- Control and instrumentation
- Steam turbine generators
- Super heaters
- Condensers

### SOLAR POWER

Superior Tube and Fine Tubes manufacture tubing solutions for use in CSP (Concentrated Solar Power) technology in solar tower or solar thermal power plants.

Our expertise in processing exotic alloys for high performance tubing satisfied the need of mission critical heat exchangers at the heart of the solar process of Gemasolar, the award winning commercial solar power plant near Seville in Spain. We have developed and produced the corrosion resistant heating exchanger tubes for the steam generators as well as the high performance tubing that make up the receiver of the Gemasolar central tower containing molten salt.

#### SOLAR APPLICATIONS

- Control and instrumentation
- Heat collectors
- Heat exchangers
- Super heaters
- Condensers

## HIGH PRECISION TUBES FOR CRITICAL NUCLEAR APPLICATIONS

### ALLOYS

Fine Tubes and Superior Tube produce a wide range of custom-sized tubing in an ever expanding range of alloys – available in three different forms, i.e. seamless, or welded & redrawn (Weldrawn®) finish.

SEAMLESS, WELDED & REDRAWN				
STAINLESS STEEL				
303Se	304/304L	316/316L	316LVM	321
347	Duplex S31803	Superduplex S32750	Superduplex S32760	

NICKEL & NICKEL ALLOYS				
200	201	211	Monel® 400	600
625	690	718	800	825

SEAMLESS ONLY		
TITANIUM	ZIRCONIUM	
Ti CP (Grade2)	Zircaloy-2	Zircaloy-4
Other Titanium and Zirconium alloys are available on request.		

We also manufacture tubing in many other grades. Please contact us for more details.

### SUPPLIED FORMS

Straight Lengths: Maximum 14m (46ft)

Coils: Up to 46m (150 ft) long

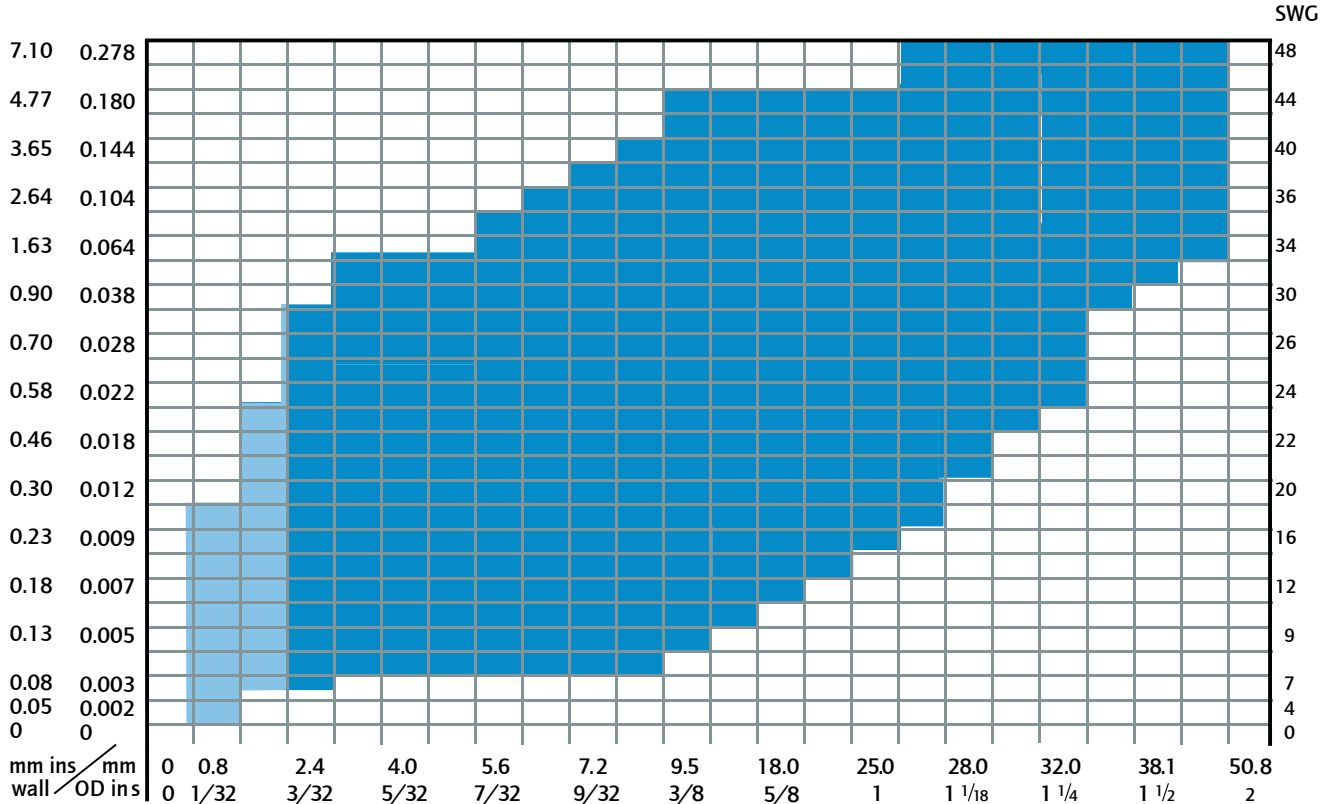
Forms: Straight or U-bent

Surface Finish: ID 0.4 micron Ra (157 micro inch Ra) (as drawn)  
ID 0.1 micron Ra (39 micro inch Ra) (electro-polished)

The exceptional performance of our high performance tubing is a reflection of our years of experience with specialty alloys and our state-of-the-art manufacturing processes. Each manufacturing run is custom-designed, precision fabricated and finished to exacting specifications.

# HIGH PRECISION TUBES FOR CRITICAL NUCLEAR APPLICATIONS

## SIZE RANGE



Our tubing sizes typical for Nuclear power applications range from 2.4mm (0.095") to 45mm (1.77") OD in seamless, welded & redrawn. Other sizes are available on request, starting from 0.15mm (0.006") OD.

TUBING QUALITY		
RCC-M	NADCAP Heat Treatment	NADCAP NDT
NADCAP Welding	ASME NQA-1	10CFR50-Appendix B
ISO 9001 / AS EN 9100 by BSI	ISO 14001	ASME QSC NCA3800 (2011)

Tubing supply is based upon the technical requirements of ASME III.

## PRODUCTION FACILITIES

- Pilger mills
- Multi-roll rolling mills
- Draw benches
- Tube welding mills - In-line weld mills
- Controlled atmosphere heat treatment
- Bright annealing/hydrogen furnace
- Vacuum annealing
- Pickling & passivation plant
- NDT ultrasonic & eddy current testing
- Hydrostatic testing
- Radiographic examination
- Electropolishing capabilities
- Full chemical and physical laboratory analysis

# SUPERCritical TUBING

## GRADE CHART



ALLOY GROUP	ALLOY UNS No.	WNR	Chemical Analysis %											Density		Temper		Tensile Rm (min)		Yield Rp 0.2% (min)		Elong. % min	Hardness HV	Properties	
			C	Mn	Ni	Cr	Fe	Mo	Ti	Nb	N	Other	g/cm³	lb/in³	ksi	MPa	ksi	MPa	ksi	MPa					
STAINLESS STEEL	303 Se S30323	1.4305	.15 max	2.0 max	8.0-11.0	17.0-19.0	1								Se 0.15-0.40 Si1 max	7.93	0.286	ANN	100	670	30-207	670	45	255	Non-magnetic austenitic stainless steel. Not hardenable by heat treatment. Free-machining characteristics with good mechanical and corrosion-resistant properties.
	304 S30400	1.4301	0.08 max	2.0 max	8.0-10.5	18.0-20.0	bal									7.93	0.286	ANN	76	517	31	207	40	200 max	High strength, excellent corrosion resistance and minimized carbon content.
	304L S30403	1.4306	0.035 max	2.0 max	8.0-11.0	18.0-20.0	bal									7.93	0.286	ANN	70	485	25	170	35	200 max	Lower carbon of 304 with good weldability.
	316 S31600	1.4401	0.08 max	2.0 max	10.0-14.0	16.0-18.0	bal	2.0-3.0								7.93	0.286	ANN	75	515	30	205	35	200	Better corrosion resistant properties than 304, with higher resistance to pitting and crevice corrosion in chloride environments.
	316L S31603	1.4404 1.4435	0.035 max	2.0 max	10.0-13.0	16.0-18.0	bal	2.0-2.5 2.5-3								7.93	0.286	ANN	70	485	25	170	35	200 max	Standard AOD melt austenitic stainless steel grade. 316L with minimum molybdenum content of 2.5%.
	316LN S31653	1.4429	0.030 max	2.0 max	10.0-14.0	16.0-18.0	bal	2.0-3.0	0.10-0.16	Si 0.75 max						7.93	0.286	ANN	75	515	30	205	40	200 max	Because of its low magnetic permeability, 316LN has been used in concrete rebar applications in close proximity to sensitive electronic devices.
	316NVM S31673	1.4441	0.030 max	2.0 max	11.0-14.0	17.0-19.0	bal	2.0-3.0								7.93	0.286	ANN	70	485	25	170	35	200 max	Vacuum remelt or ESR to achieve highest microcleanliness levels and structural homogeneity.
	321 S32100	1.4541	0.080 max	2.0 max	9.0-12.0	17.0-19.0	bal					10XC -1.000			Ti 5XC -0.600	7.93	0.286	ANN	75	515	30	205	35	200 max	Titanium stabilised grade with good weldability, improved resistance to weld decay attack & better mechanical properties at elevated temperatures.
	347 S34700	1.4546	0.080 max	2.0 max	9.0-12.0	17.0-19.0	bal					10XC -1.000				7.93	0.286	ANN	75	515	30	205	35	200 max	As for 321 but uses niobium as stabilising element.
	Duplex S31803	1.4462	0.030 max	2.0 max	4.5-6.5	21.0-23.0	bal	2.5-3.5	0.08-0.20							7.8	0.281	ANN	90	620	65	450	25	290 max	High mechanical strength & good resistance to localised cracking & chloride stress corrosion.
Super Duplex S32750	1.441	0.030 max	1.2 max	6.0-8.0	24.0-26.0	bal	3.0-5.0	0.24-0.32						Cu 0.5 max	7.79	0.28	ANN	116	800	80	550	15	310 max	Superduplex alloy combining excellent strength with good corrosion resistance in high chloride and seawater environments.	
Super Duplex S32760	1.4501	0.020 max	1.0 max	6.0-8.0	24-26	bal	3.0-4.0	24-32	Cu 0.50 W 0.50						7.70	0.278	ANN	109	750	73.5	507	35	310 max	Superduplex alloy combining excellent strength with good corrosion resistance in high chloride and seawater environments.	
Ti	CP Grade 2 R50400	3.7035	0.08 max			0.30 max					bal			0.03 max	4.51	0.163	ANN	50	345	40-65	275-450	20		Very high strength to weight ratio combined with excellent seawater corrosion resistance.	
ZIRCONIUM	Zircaloy-2 R60802		0.005 max		0.1 max									Zr+Hf 99.2	6.50		ANN	55	379	30	207	16	150	Zirconium nuclear grade alloy (weight %) 1.2-1.7 Sn, 0.07-0.2 Fe, 0.05-0.15 Cr, 0.03-0.08 Ni. Low absorption of thermal neutrons. Main use is for cladding of fuel rods in nuclear reactors. Zr2 = BWR, CANDU.	
	Zircaloy-4 R60804		0.05 Max											Zr+Hf 97.5 Hf 4.5	6.56		ANN	60	415	35	240	14	150	Zirconium nuclear grade alloy (weight %) 1.2-1.7 Sn, 0.18-0.24 Fe, 0.07-0.13 Cr. Low absorption of thermal neutrons. Main use is for cladding of fuel rods in nuclear reactors. Zr4 = BWR, PWR, CANDU.	

ALLOY GROUP	ALLOY UNS No.	WNR	Chemical Analysis %													Density		Temper	Tensile Rm (min)		Yield Rp 0.2% (min)		Elong. % min	Hardness HV	Properties
			C	Mn	Ni	Cr	Fe	Mo	Ti	Nb	Al	Other	g/cm <sup>3</sup>	lb/in <sup>3</sup>	ksi	MPa	ksi		MPa						
NICKEL ALLOYS	Alloy 59 N06059	2.4605	0.010 max	0.5 max	bal	22.0- 24.0	1.5 max	15.0- 16.5					0.10- 0.40	Co 0.3 max	8.60	0.311	ANN	100	690	45	310	45	270 max	Excellent in sour service environments. Highly resistant to chloride, sea waters and acids.	
	Alloy 75 N06075	2.4951	0.08- 0.15 max	1.0 max	bal	18.0- 21.0	5.0 max		0.20- 0.60					Cu 0.5 max	8.37	0.303	ANN	100- 120	690-830	46	300	30	230 max	High temperature oxidation resistance.	
	Alloy 200 N02200	2.4065	0.15 max	0.4 max	99.0 min	0.4 max								Cu 0.25 max	8.9	0.321	ANN	75	515	15	105	33	150 max	Commercially pure nickel. Good corrosion resistance.	
	Alloy 263 N07263		0.04- 0.08 max	0.6 max	bal	19.0- 21.0	0.7 max	5.6- 6.1	1.9-2.4					Co 19.0- 21.0 N 0.30-0.6	8.36	0.302	HT	140	970	90	620	39	250 min	High creep strength with good weldability.	
	Alloy 276 N10276	2.4819	0.02 max	1.0 max	bal	14.5- 16.5	4.0- 7.0	15.0- 17.0						W 3.0-4.5	8.9	0.321	ANN	100	690	41	283	40	210 max	Excellent sour service corrosion resistance.	
	Alloy 400 N04400	2.4360	0.30 max	2.0 max	63.0- 70.0	2.5 max								Cu bal	8.83	0.319	ANN	70	480	28	195	35	180 max	General purpose Ni alloy with a good combination of strength, ductility & corrosion resistance.	
	Alloy 600 N06600	2.4816	0.15 max	1.0 max	72.0 min	14.0- 17.0	6.0- 10.0							Cu 0.50 max	8.42	0.304	ANN	80	550	35	240	30	200 max	Very good combination of strength & oxidation resistance.	
	Alloy 625 N06625	2.4856	0.10 max	0.5 max	bal	20.0- 23.0	5.0 max	8.0- 10.0	0.40 max	3.15- 4.15				0.40 max	8.44	0.305	ANN	120	827	60	414	30	260 max	Nickel alloy with high strength, excellent fabricability. Superior resistance to corrosive environments of unusual severity as well as to high-temperature effects such as oxidation & carburization.	
	Alloy 690 N06690	2.4642	0.05 max	0.05 max	58 min	27.0- 31.0	7.0- 11.0							Cu 0.50 Si 0.50	8.19	0.296	ANN	84	586	34	240	30	200 max	Excellent resistance to many corrosive aqueous media & high temperature atmospheres.	
	Alloy 718 N07718	2.4668	0.08 max	0.4 max	50.0- 55.0	17.0- 21.0	bal	2.80- 3.30	0.65- 1.15	4.75- 5.50				0.20- 0.80	8.19	0.296	HT	185	1275	150	1034	12	331 min	Age hardenable, high-strength nickel alloy with excellent corrosion resistance and formability. Used at temperatures up to 700°C.	
	Alloy X750 N07750	2.4669	0.08 max	1.0 max	70.0 min	14.0- 17.0	5.0- 9.0		2.25- 2.75	0.70- 1.20				0.40- 1.00	8.25	0.298	HT	160	1103	100	689	20	260-360	High temperature strength performance.	
	Alloy 800 N08800	1.4876	0.15 max	1.5 max	30.0- 35.0	19.0- 23.0	39.5 min		0.15- 0.60					0.15- 0.60	8	0.289	ANN	75	517	30	207	30	200 max	Resistant to stress corrosion & good in aqueous media.	
Alloy 800H N08810	1.4876	0.05- 0.10 max	1.5 max	30.0- 35.0	19.0- 23.0	39.5 min		0.15- 0.60					0.15- 0.60	8.08	0.292	ANN	75	517	30	207	30	200 max	Excellent high temperature creep resistance, combined with oxidation and carburisation resistance.		
Alloy 800HT N08811		0.06- 0.10 max	1.5 max	30.0- 35.0	19.0- 23.0	39.5 min		0.15- 0.60					Al + Ti 0.85-1.20	7.94	0.287	ANN	75	517	30	207	30	200 max	Similar corrosion properties to A800 & 800H with significantly high creep-rupture strength.		
Alloy 825 N08825	2.4858	0.05 max	1.0 max	38.0- 46.0	19.5- 23.5	bal	2.5- 3.5	0.6-1.20					Cu 1.5-3.0	8.1	0.292	ANN	85	586	35	241	30	209 max	Excellent corrosion resistance in both oxidising and reducing environments. Good resistance to chloride stress-corrosion cracking and pitting.		

## HIGH PRECISION TUBES FOR CRITICAL NUCLEAR APPLICATIONS



### ABOUT AMETEK SPECIALTY METAL PRODUCTS

AMETEK Specialty Metal Products (SMP) is a division of AMETEK, Inc. a leading global manufacturer of electronic instruments and electromechanical devices with annual sales in 2020 of more than \$4.5 billion.

AMETEK has 16,500 colleagues at more than 150 operating locations, and a global network of sales, service and support locations in 30 countries around the world.

The Specialty Metals division consists of five businesses and operating facilities in the United States and the United Kingdom. All are proven experts in the manufacture of advanced metallurgical products including high precision tube, precision metal strip, water atomized powders, ultra-thin foil, shaped wire, engineered components, thermal management materials, and roll-bonded clad plate.

These high performance metal products are used around the world for critical applications in a range of industries including aerospace, automotive, defense, electronics, industrial, medical, nuclear, and oil and gas.



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