AMETEK®
SPECIALTY METAL PRODUCTS

finetubes

SuperiorTube







# ENERGY

## High Precision Tubing Solutions for Demanding Power Applications

NUCLEAR • CONVENTIONAL • SOLAR

**HIGH PRECISION TUBES FOR DEMANDING ENVIRONMENTS**

NUCLEAR • CONVENTIONAL • SOLAR



## TUBING EXCELLENCE

With over 70 years of engineering expertise in supplying high precision tubes, Fine Tubes and Superior Tube work closely with customers worldwide developing high specification tubing solutions to help them solve their technical challenges. We manufacture high performance tubes in an ever expanding range of stainless steel, nickel, titanium and zirconium alloys for supercritical and ultra-supercritical nuclear, thermal and solar power applications.

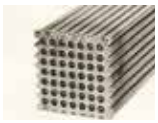
TUBING INNOVATIONS >

## 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:

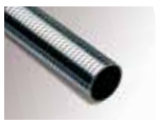
### 1940
Superior Tube supplies tubing for the Manhattan Project, where mankind first learned to control the energy of the atom.

### 1954
Superior Tube manufactures zirconium reactor tubes for the first nuclear powered submarine, the USS Nautilus.



### 1957
Superior Tube supplies cladding to Shippingport Atomic Power Station, the first plant to produce electricity for a civilian population.

### 1960
Superior Tube produces fuel cladding for Argonne National Laboratory's Experimental Breeder Reactor-II.

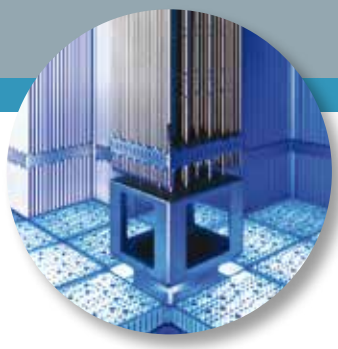


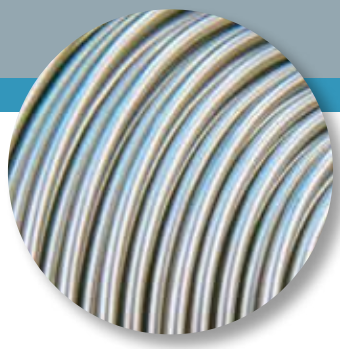
### 1970
Fine Tubes develops 20-25Nb nuclear fuel cladding and supplies for the UK's first generation of Advanced Gas Reactors.

### 2000
The Tennessee Valley Authority's Watts Bar nuclear reactor facility uses Zirconium Zr4 tubing from Superior Tube.

### 2008
Fine Tubes supplies CERN with cooling tubes for the Large Hadron Collider experiment.

### 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:

- Control and Instrumentation
- Control Rod Drive Mechanism
- Fuel Cans or Cladding Tubes
- Flux Thimble Guide Tubes
- Heat Exchangers
- Steam Generators
- Turbine Island Condensers

## 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 welded 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. In collaboration with SENER 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





# MANUFACTURING CAPABILITIES

## 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, welded or welded & redrawn (Weldrawn®) finish.

### SEAMLESS, WELDED, WELDED & REDRAWN

| | |
|---|---|
| **Stainless Steel** | 303Se, 304, 304L, 316, 316L, Vacuum Melted 316L, 321 and 347<br>Duplex S31803, Super Duplex S32750 and S32760 |
| **Nickel** | 200, 201, 211, 230, Monel 400, 600, 625, 690, 718, 750, 800, 825 |

### SEAMLESS ONLY

| | |
|---|---|
| **Titanium** | Ti CP (Grade2) |
| **Zirconium** | Zircaloy2, Zircaloy4 |

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

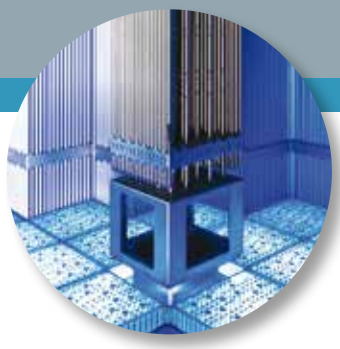
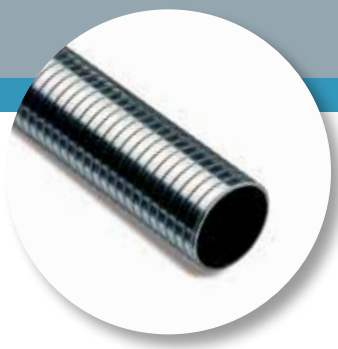
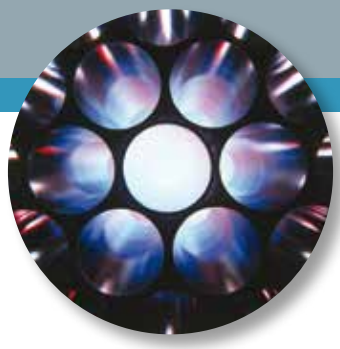
## SUPPLIED FORMS

| | |
|---|---|
| Straight lengths: | Maximum 20 m (65 ft) |
| Coils: | Up to 100 kg (200 lb) or up to 10,000 m (32,808 ft) length with orbital joints |
| Forms: | Straight or 'U' bent |
| Surface Finish: | ID 0.4 micron Ra (16 micro inch Ra) (as drawn)<br>ID 0.1 micron Ra (4 micro inch Ra) (electro-polished) |

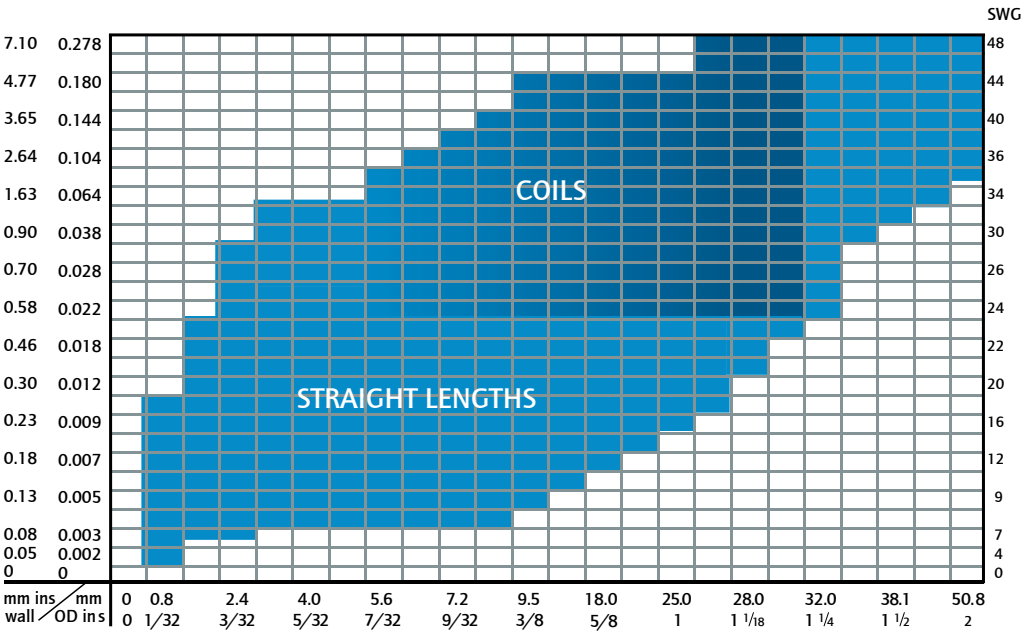
The exceptional performance of our high performance tubing is a reflection of our years of experience with specialty alloys and our state-of-the-art manufacturing processes. Each manufacturing run is custom designed, precision fabricated and finished to exacting specifications.

## 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

## SIZE RANGE




Tubing sizes typical for power applications range from 3 mm (0.1181 in) to 50.8 mm (2 in) OD in seamless, welded, welded & redrawn. Other sizes are available on request, starting from 0.25 mm (0.0098 in) OD.

TUBING QUALITY

## TUBING QUALITY

- RCC-M
- Nadcap (Heat Treatment)
- Nadcap (NDT)
- Nadcap (Welding)
- TUV AD-2000 Merkblatt W0/TRD 100
- 97/23/EC (PED) - TüV
- ISO 9001/AS EN 9100
- 10CFR50 Appendix B
- ASME NQA1
- ANSI/NCSL-Z-540
- ISO 10012
- ISO 14001

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

# SUPERCRITICAL TUBING • GRADE CHARTS

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| 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 | | | |
| STAINLESS STEEL | 303 Se S30323 | 1.4305 | .15 max | 2.0 max | 8.0-11.0 | 17.0-19.0 | | 1 max | | | | 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. |
| | 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. |
| | 316L S31603 | 1.4404 | 0.035 max | 2.0 max | 10.0-13.0 | 16.0-18.0 | bal | 2.0-2.5 | | | | | 7.93 | 0.286 | ANN | 70 | 485 | 25 | 170 | 35 | 200 max | Standard AOD melt austenitic stainless steel grade. |
| | | 1.4435 | | | | | | 2.5-3 | | | | | | | | | | | | | | 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. |
| | 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. |
| | 904L N08904 | 1.4539 | 0.020 max | 2.0 max | 23.0-28.0 | 19.0 -23.0 | bal | 4.0-5.0 | | | | Cu 1.0-2.0 | 8 | 0.289 | ANN | 70 | 485 | 40 | 275 | 35 | 200 max | Stainless steel with higher resistance to general, pitting & crevice corrosion than 316L. |
| | 6Mo S31254 | 1.4547 | 0.020 max | 1.0 max | 17.5-18.5 | 19.5-20.5 | bal | 6.0-6.5 | | | 0.18-0.22 | Cu0.5-1.0 | 8 | 0.289 | ANN | 98 | 675 | 45 | 310 | 35 | 230 max | Super-austenitic stainless steel with good resistance to pitting & crevice corrosion. |
| | 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 | 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 | |
| Ti | CP Grade 2 R50400 | 3.7035 | 0.08 max | | | | 0.30 max | | bal | | 0.03 max | O 0.25 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 | 0.1 max | | | | 0.025 | Zr+Hr 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 | | | | | | | | 0.025 | 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/cm³ | lb/in³ | | 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 | 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 | 0.6 Ma | bal | 19.0-21.0 | 0.7 max | 5.6-6.1 | 1.9-2.4 | | | Co 19.0-21.0 N 0.3-0.6 | 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 | Co 1.0 max | 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 700ºC. |
| | 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 | Cu 0.75 max | 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 | 1.5 max | 30.0-35.0 | 19.0-23.0 | 39.5 min | | 0.15-0.60 | | 0.15-0.60 | Cu 0.75 max | 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 | 1.5 max | 30.0-35.0 | 19.0-23.0 | 39.5 min | | 0.15-0.60 | | 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 | | 0.20 max | 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 DEMANDING ENVIRONMENTS

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## GLOBAL PRESENCE

Through the partnership between U.K.-based Fine Tubes and U.S.-based Superior Tube both companies can offer increased capabilities, leading to significantly reduced lead times, an extended product portfolio, increased global reach and outstanding customer service.

Our tubing experts deliver high precision tubing to customers in over 35 countries worldwide.

In addition to tube mills in the United Kingdom and the United States, we have sales offices in Germany, France, India and the United States as well as an extensive network of partners in Asia, Europe and the Middle East.

Fine Tubes and Superior Tube are collectively a unit of AMETEK, Inc., a leading global manufacturer of electronic instruments and electromechanical devices.

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