

Protection Tubes

Protection Tubes are used to protect sensors, usually thermocouples, against contaminating atmospheres and/or mechanical damage. Closed at one end, they usually incorporate some means by which the tube, sensor and connection head are assembled and mounted into the process. The Protection Tube material is selected on the basis of the environment to which the sensor assembly will be subjected. The table included in this Product Reference Guide lists materials commonly used for various applications.



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GENERAL

Ceramic Protecting Tubes are dense, fine grained, nonporous compositions that remain gas tight even at temperatures near their melting point. Ceramic tubes are generally used at high temperatures with platinum type thermocouples. However, their use with base metal thermocouples is prevalent in atmospheres harmful to metal tubes and not subjected to mechanical abuse.

Ceramic tubes will sag at high temperatures, so if they are installed horizontally and used above their sagging temperatures, they should be fully supported. Sag temperature is the temperature at which the tube will sag 1/4" in one hour. Ceramics will retain moisture at room temperature. This moisture may become trapped in the ceramic and cause the destruction of the tube when it is thermally shocked. It is recommended that ceramic tubes be preheated to approximately 400°C (750°F) in order to drive off this moisture before subjecting them to high heat.

SPECIFICATIONS

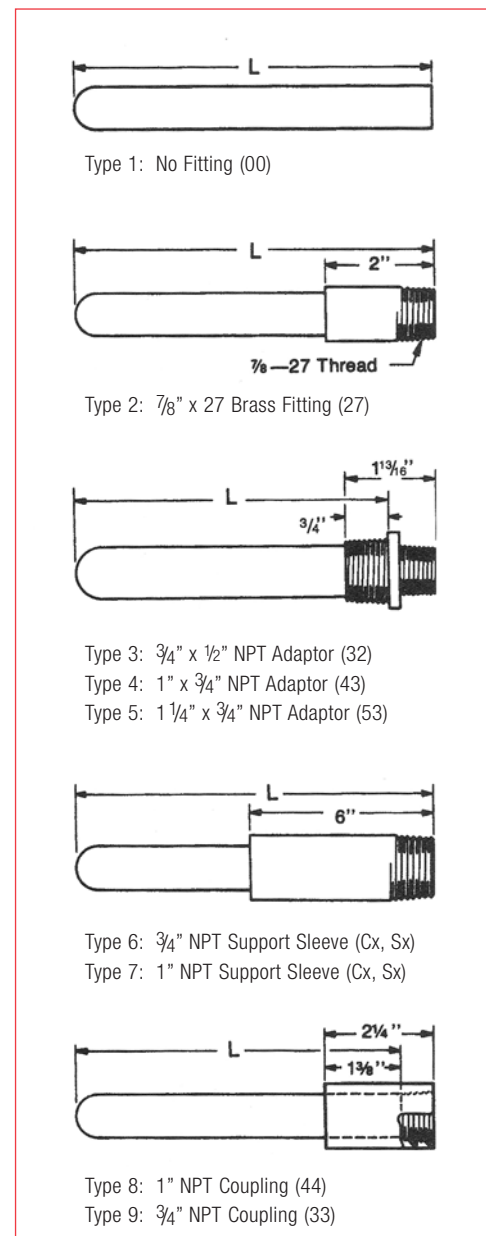
PROPERTY	ALUMINA	MULLITE
Composition	99.8% Al ₂ O ₃	60% Al ₂ O ₃ , 38% SiO ₂
Specific Gravity	3.8	2.8
Flexural Strength	345 MPa	185 MPa
Compressive Strength	2000 MPa	1300 MPa
Coeff of Thermal Exp (1200°C)	9x10 ⁻⁶ / °C	5x10 ⁻⁶ / °C
Max Service Temperature	1950°C/3540°F	1700°C/3100°F
Approx Sag Temperature**	1600°C (2900° F)	1500° C (2730°F)
Thermal Conductivity (1200°C)	8 W / m°C	4 W / m°C
Thermal Shock Resistance	Good	Good
Permeability	Gas tight	Gas tight
Hardness	9 mohs	7.5 mohs

** 1 1/4" empty tube suspended across 18"

Alumina (Al₂O₃) tubes have excellent thermal shock and strength characteristics and are virtually chemical resistant. Alumina is compatible with platinum thermocouples for long term use in reducing or oxidizing atmospheres and should be used at temperature above 1200°C (2200°F).

Mullite (3Al₂O₃, 2SiO₂) tubes have good thermal shock and strength characteristics and are chemically resistant. These lower cost tubes can be used with platinum thermocouples for short term applications in oxidizing atmospheres, or where mechanical failure would likely occur. Exposure to silica, which can be reduced from mullite, will contaminate platinum thermocouples at temperatures above 1200°C (2200°F).

FITTINGS



STANDARD CONFIGURATIONS*

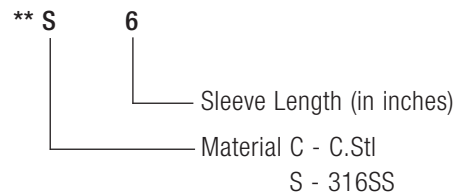
SIZE		FITTING TYPE	PART NUMBER		
O.D.	I.D.		MULLITE	ALUMINA	FITTING
3/8"	1/4"	1	CP-0604-00	AP-0604-00	-
		2	CP-0604-27	AP-0604-27	00-2026-00
		3	CP-0604-32	AP-0604-32	00-2025-32
11/16"	7/16"	1	CP-1107-00	AP-1107-00	-
		2	CP-1107-27	AP-1107-27	00-2026-00
		3	CP-1107-32	AP-1107-32	00-2025-32
		4	CP-1107-43	AP-1107-43	00-2025-43
		6	CP-1107-S6**	AP-1107-S6**	P-31640-12-6
1"	3/4"	9	CP-1107-33	AP-1107-33	00-2021-66
		1	CP-1612-00	AP-1612-00	-
		5	CP-1612-53	AP-1612-53	00-2025-53
		7	CP-1612-S6**	AP-1612-S6**	P-31640-16-6
1 1/4"	1"	8	CP-1612-44	AP-1612-44	00-2021-88
		1	CP-2016-00	-	-

Standard lengths are 12 to 48" in 6" increments.

*Other sizes and configurations available. If the desired arrangement cannot be configured using standard part number, add Option "SP" and describe in detail.

OPTIONS

- OO – Open ended tube
- FG – Adjustable flange (requires support sleeve Type 6 or 7)**
- SP – Special configuration (describe in detail)



ORDERING INFORMATION

Specify: (PART NUMBER) – (LENGTH "L" in inches) – OPTION

Example: AP-1107-32-24.0-00 identifies a 24" long alumina tube (1 1/16" OD x 7/16" ID) with a 3/4" x 1/2" NPT mounting fitting.

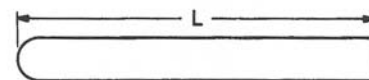
GENERAL

Hexoloy protection tubes are made from sintered alpha (SA) silicon carbide. They are impermeable to gases at pressures up to 4500 psig and their fine grain structure provides high strength and excellent resistance to abrasion and corrosion (50% harder than tungsten carbide). Useable to working temperatures of 1650°C (3000°F), Hexoloy tubes are characterized by excellent thermal conductivity properties, which provide high thermal transfer and rapid response times (10 times silicon nitride; 3 times stainless steel). Its low thermal expansion results in high creep resistance and high resistance to thermal shock (10 x alumina oxide). Hexoloy contains no free silicon, which provides superior chemical resistance in both reducing and oxidizing environments. It is non-toxic, therefore suitable for use in food and drug service. Hexoloy cannot be used where there is iron present. When used with platinum thermocouples, a ceramic (alumina) liner tube is required. Hexoloy becomes conductive at high temperatures.

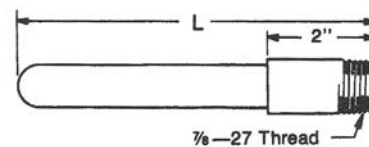
SPECIFICATIONS

PROPERTY	HEXOLOY
Composition	99.1% SiC
Specific Gravity	3.1
Flexural Strength	460 MPa
Compressive Strength	3900 MPa
Coeff of Thermal Exp (1200°C)	4.5x10 ⁻⁶ mm / mm / °C
Max Service Temperature	1650°C (3000°F)
Thermal Conductivity (1200°C)	30 W /m°C
Thermal Shock Resistance	Excellent
Permeability	Gas tight
Hardness	9.5 mohs
Acid Resistance	Excellent

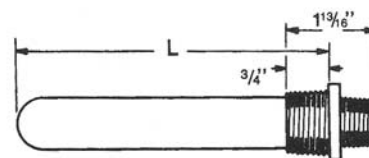
FITTINGS



Type 1: No Fitting (00)



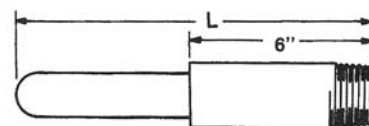
Type 2: 7/8" x 27 Brass Fitting (27)



Type 3: 3/4" x 1/2" NPT Adaptor (32)

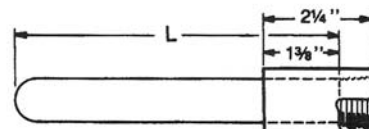
Type 4: 1" x 3/4" NPT Adaptor (43)

Type 5: 1 1/4" x 3/4" NPT Adaptor (53)



Type 6: 3/4" NPT Support Sleeve (Cx, Sx)

Type 7: 1" NPT Support Sleeve (Cx, Sx)



Type 8: 1" NPT Coupling (44)

Type 9: 3/4" NPT Coupling (33)

STANDARD CONFIGURATIONS*

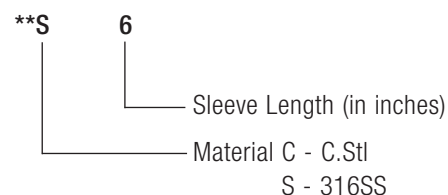
SIZE		FITTING TYPE	PART NUMBER	
O.D.	I.D.		SA SIC	FITTING
3/8"	1/4"	1	SA-0604-00	-
		2	SA-0604-27	00-2026-00
		3	SA-0604-32	00-2025-32
5/8"	3/8"	1	SA-1006-00	-
		2	SA-1006-27	00-2026-00
		3	SA-1006-32	00-2025-32
		4	SA-1006-43	00-2025-43
		6	SA-1006-S6**	P-31640-12-6
		9	SA-1006-33	00-2021-66
3/4"	1/2"	1	SA-1208-00	-
		2	SA-1208-27	00-2026-00
		3	SA-1208-32	00-2029-32
		4	SA-1208-43	00-2025-43
		6	SA-1208-S6**	P-31640-12-6
		8	SA-1208-33	00-2021-66
1"	1/2"	1	SA-1608-00	-
		5	SA-1608-53	00-2026-53
		7	SA-1608-S6**	P-31640-16-6
		8	SA-1608-44	00-2021-88

Standard lengths are 6 to 48" in 6" increments.

*Other sizes and configurations available. If the desired arrangement cannot be configured using standard part number, add Option "-SP" and describe in detail.

OPTIONS

- 00 – Open ended tube
- FG – Adjustable flange (requires support sleeve Type 6 or 7)**
- SP – Special configuration (describe in detail)
- CL – Hexoloy collar



ORDERING INFORMATION

Specify: (PART NUMBER) – (LENGTH "L" in inches) – OPTION

Example: SA-1006-32-24.0-00 identifies a 24" long SA tube (5/8" OD x 3/8" ID) with a 3/4" x 1/2" NPT mounting fitting.

GENERAL

Silicon Carbide (SiC) tubes are highly resistant to flame and gases. These tubes are usable to temperatures of 1650°C (3000°F) and are characterized by high thermal conductivity, excellent thermal shock properties and good resistance to most corrosive liquids including molten aluminum.

Since silicon carbide tubes are porous, they are used as a secondary protection against extreme temperature, abrasive atmospheres and direct flame impingement. Primary mullite or alumina tubes are required when noble metal thermocouples are used with silicon carbide tubes. This double tube arrangement often doubles the life of the thermocouple for less than a third increase in the cost of the assembly.

PART NUMBER

PART NUMBER	FIG	DIMENSIONS
SP-2816-NC	1	1 3/4" OD x 1" ID
SP-2816-BC	2	
SP-2816-SC	3	

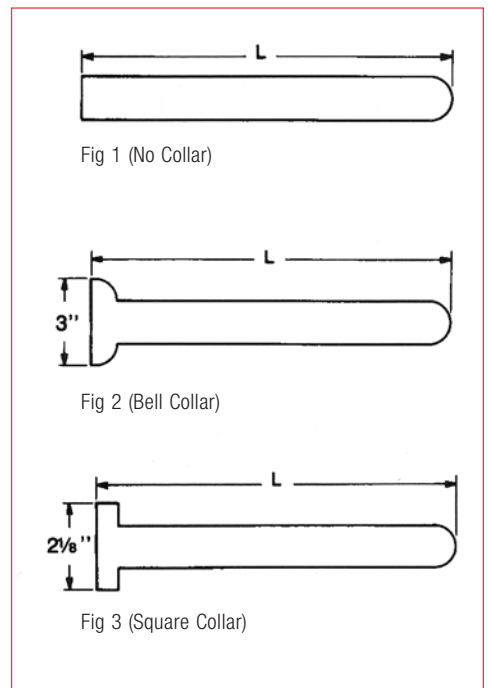
Standard lengths are 12 to 48" in 6" increments.

Tubes cannot be cut.

Other lengths must be ordered as specially cast items.

SPECIFICATIONS

PROPERTY	SILICON CARBIDE
Composition	86% SiC, 12% SiO ₂
Specific Gravity	2.6
Flexural Strength	55 MPa
Compressive Strength	400 MPa
Coeff of Thermal Exp (1200°C)	4 x10 ⁻⁶ mm / mm / °C
Max Service Temperature	1500°C (2730°F)
Thermal Conductivity (1200°C)	15 W /m°C
Thermal Shock Resistance	Good
Permeability	14% Porosity
Hardness	9 mohs
Acid Resistance	Good



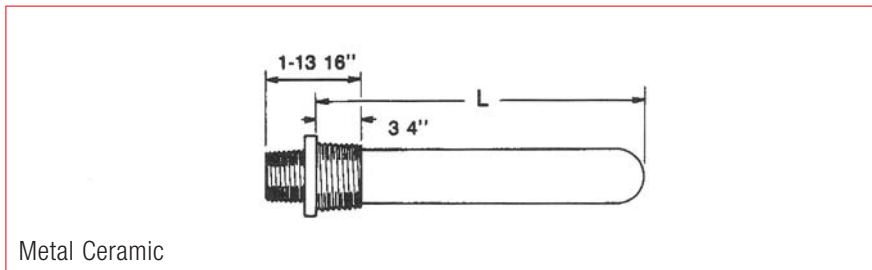
ORDERING INFORMATION

Specify: (PART NUMBER) – (LENGTH “L” in inches) – OPTION

Example: SA-2816-SC-24-0 specifies a square collar tube 24” long.

LT-1 METAL CERAMIC PROTECTION TUBES

Metal-Ceramic tubes are a combination of chromium and alumina for use at temperatures up to 1370°C (2500°F). They provide excellent oxidation resistance, thermal conductivity comparable to that of stainless steel, good resistance to wetting by most molten metals, excellent resistance to wear and abrasion at high temperatures and are gas tight at high temperatures. A primary alumina tube is recommended when used in conjunction with platinum thermocouples.



Metal Ceramic

PART NUMBER	MTG THRP	DIMENSIONS
MP-21075-00	None	7/8" O.D. x 5/8" I.D.
MP-21075-43	1" NPT	
MP-21075-53	1 1/4" NPT	

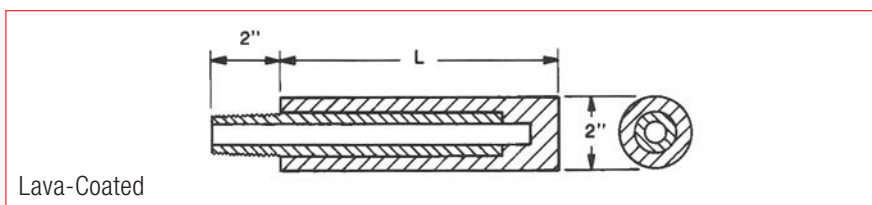
SPECIFICATIONS

PROPERTY	LT-1
Composition	71% Cr 23%, Al ₂ O ₃
Specific Gravity	5.8
Flexural Strength	340 MPa
Compressive Strength	760 MPa
Coeff of Thermal Exp (1200°C)	9 x10 ⁻⁶ mm / mm / °C
Max Service Temperature	1370°C (2500°F)
Thermal Conductivity (1200°C)	30 W /m°C
Thermal Shock Resistance	Good*
Permeability	Gas tight
Hardness	34 Rc

* Avoid extreme thermal shock or gradients, mechanical shock and impact.

LAVA-COATED PROTECTION TUBES

Lava-coated protection tubes provide excellent thermal conductivity for quick response to temperature changes. They comprise silicon carbide/graphite isostatically formed around a threaded pipe. These tubes are designed for monitoring the holding and melting temperatures of aluminum and other nonferrous alloys up to 1250°C (2280°F).



Lava-Coated

PART NUMBER	MTG THD	DIMENSIONS
LP-3210-08	1/2" NPT	2" O.D. x 1/2"
LP-3210-12	3/4" NPT	2" O.D. x 3/4"

ORDERING INFORMATION

Specify: (PART NUMBER) – (LENGTH "L" in inches) – OPTION

Example: MP-21075-43-24 specifies a LT-1 metal ceramic tube, 24" long with a 1" NPT mounting bushing.

SIALON PROTECTION TUBES

Sialon is a high-strength ceramic with superior heat and abrasion resistance characteristics. These tubes have high thermal shock resistance and can be used at temperatures up to 1250°C (2280°F). They are chemically inert and resistant to corrosion and chemical attack. They are not wetted by non-ferrous metals and are ideal for use in molten aluminum.

PART NUMBER	MTG THD*	DIMENSIONS
SL-1810-00	None	1.1" O.D. x .63" I.D.
SL-1006-00	None	.63" O.D. x .40" I.D.
SL-0804-00	None	.50" O.D. x .25" I.D.

Maximum length: 60"

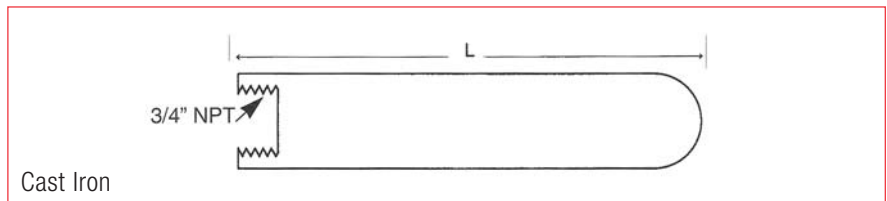
*Mounting fittings as required can be provided.

SPECIFICATIONS

PROPERTY	SIALON
Composition	SiN + Al ₂ O ₃
Specific Gravity	3.24
Compressive Strength	700 MPa
Coeff of Thermal Exp (1200°C)	3 x 10 ⁻⁶ mm / mm / °C
Max Service Temperature	1250°C (2280°F)
Thermal Conductivity (1200°C)	38 W /m°C
Thermal Shock Resistance	Excellent
Permeability	Gas tight
Hardness	90 HrA

CAST IRON PROTECTION TUBES

Cast Iron is a low cost material used in molten aluminum and aluminum alloy applications and also has good resistance to acid and caustic solutions. It has good thermal conductivity and shock resistance. Maximum working temperatures of 800°C (1470°F) reducing; 700°C (1300°F) oxidizing.



PART NUMBER	MTG THD	DIMENSIONS
MP-11097	3/4" Female	1 5/8" O.D. x 7/8" I.D.
*MP-12097	3/4" Female	1 5/8" O.D. x 7/8" I.D.

*Ceramic-coated

A ceramic coated cast iron tube is also available. The coating is non-wetting and adds resistance to deformation and oxidation while providing protection against solution attack during continuous immersion in molten aluminum, zinc or lead.

ORDERING INFORMATION

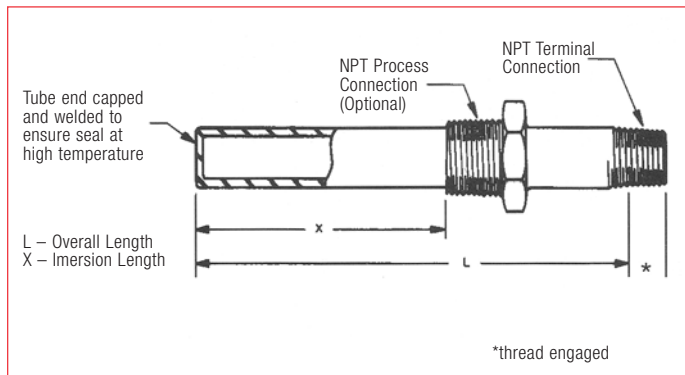
Specify: (PART NUMBER) – (LENGTH "L" in inches) – OPTION

Example: MP-12097-24.00 specifies a ceramic coated cast iron protection tube, 24" long.

GENERAL

Metal tubes offer good mechanical protection for base metal thermocouples up to 1150°C in oxidizing atmospheres. All metals are porous above 870°C, so it may be necessary to provide a ceramic primary tube to protect the thermocouple from detrimental vapors.

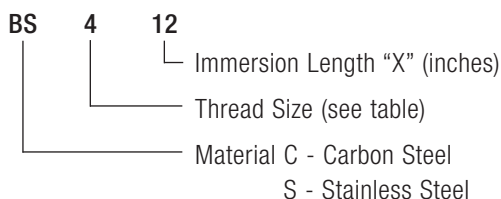
Most metal protection tubes are made from standard schedule 40 pipe in 1/2", 3/4" and 1" pipe sizes. (Other sizes and schedules are available.) Standard pipe size metal tubes have one end closed and welded. This proves satisfactory for pressures up to 75 psi.



OPTIONS

- O O – None
- O P – Open ended tube (Closed end is standard)
- F G – Adjustable mounting flange
- B X – Welded mounting bushing

Example



MATERIAL	SIZE	PART NUMBER
Carbon Steel	1/2"	MP-10540-08
	3/4"	MP-10540-12
	1"	MP-10540-16
304 SS	1/2"	MP-30440-08
	3/4"	MP-30440-12
	1"	MP-30440-16
310 SS	1/2"	MP-31040-08
	3/4"	MP-31040-12
	1"	MP-31040-16
316 SS	1/2"	MP-31640-08
	3/4"	MP-31640-12
	1"	MP-31640-16
446 SS	1/2"	MP-44640-08
	3/4"	MP-44640-12
	1"	MP-44640-16
Inconel 601	1/2"	MP-60140-08
	3/4"	MP-60140-12
	1"	MP-60140-16
Hastelloy B-3	1/2"	MP-HSB40-02
	3/4"	MP-HSB40-12
	1"	MP-HSB40-16
Hastelloy C-22	1/2"	MP-HSC40-08
	3/4"	MP-HSC40-12
	1"	MP-HSC40-16
Hastelloy X	1/2"	MP-HSX40-08
	3/4"	MP-HSX40-12
	1"	MP-HSX40-16

Sch 80 also available (eg MP-60180-12 specifies a 3/4" Sch 80 Inconel Protection Tube)
* .69" OD x .092" wall

MOUNTING THREAD	SIZE CODE	MAXIMUM PIPE SIZE
3/4" NPT	3	1/2"
1" NPT	4	3/4"
1 1/4" NPT	5	1"
1 1/2" NPT	6	1 1/4"

ORDERING INFORMATION

Specify: (PART NUMBER) – (LENGTH "L" in inches) – OPTION

Example: MP-31640-08-24-BS412 specifies a 1/2", Sch 40, 316 SS tube, 24" long, with a 1" SS mounting bushing welded 12" from the hot end.

APPLICATION DATA

MATERIAL	CHARACTERISTICS
Mullite	Up to 1500°C (2750°F). Has good thermal shock resistance but low mechanical shock resistance. For barium chloride salt baths to 1290°C (2350°F). Should be mounted vertically or supported if horizontal. For high temperature applications in ceramic and heat treating.
Alumina	Up to 1870°C (3400°F) when properly supported. Fair resistance to thermal and mechanical shock. Superior resistance to reducing atmospheres. Applications similar to mullite including induction melting, vacuum furnaces and glass manufacturing. Impervious to gases at high temperatures. Good resistance to thermal shock.
Silicon Carbide	Up to 1650°C (3000°F). For secondary protection tube with alumina or mullite primary tube. (Silica-bonded) For brick and ceramic kilns, steel soaking pits, molten non-ferrous metals. Can withstand direct flame impingement.
Hexoloy (SA SiC)	Up to 1650°C (3000°F) in oxidizing or reducing atmospheres. Superior thermal shock resistance. Exceptional resistance to erosion, abrasion and wear. Suitable for corrosive liquids & gases, acids & alkalis, at high temperature. Good for applications with flame impingement. A ceramic liner tube is required for use with noble metal thermocouples.
Sialon	Up to 1250°C (2280°F). Superior heat and abrasion resistance characteristics. High thermal shock resistance. Ideal for molten aluminum.
Sapphire	Up to 1900°C (3450°F). High thermal conductivity. Fair thermal shock resistance. Non-wetting in most metals or glass. Chemically inert.
Boron Nitride	Up to 2800°C (5070°F) in inert or reducing atmospheres; 985°C (1800°F) in oxidizing. Properties include high thermal conductivity, low thermal expansion, high strength with excellent resistance to thermal shock. Resists wetting by most molten metals.
Beryllium Oxide	Up to 2200°C (4000°F) in oxidizing or reducing atmospheres. Excellent resistance to thermal shock. Fair resistance to mechanical shock.
Quartz	Up to 1090°C (2000°F). Excellent resistance to thermal shock. For use in molten gold and silver.

MELTING TEMPERATURE OF METALS (°C/°F)

Graphite*	3725/6740	Zirconium	1852/3366	Copper	1083/1981
Tungsten	3410/6170	Platinum	1769/3217	Gold	1063/1945
Tantalum	2995/5425	Titanium***	1668/3035	Silver	961/1761
Molybdenum	2610/4730	Palladium	1550/2822	Aluminum	660/1220
Iridium	2455/4450	Iron****	1510/2750	Magnesium	650/1202
Niobium	2468/4474	Cobalt	1455/2723	Zinc	420/787
Rhodium	1966/3571	Nickel	1453/2647	Lead	327/621
Vanadium**	1900/3450	Beryllium	1280/2336	Cadmium	321/609
Chromium	1875/3407	Manganese	1245/2273	Tin	232/449

MELTING TEMPERATURE OF ALLOYS (°C/°F)

304 SS	1400/2550	Carbon Steel	1515/2760	Monel 400	1350/2460
316 SS	1375/2505	Inconel 600	1415/2575	Hastelloy C	1370/2500
446 SS	1425/2600	Inconel 601	1370/2495	Hastelloy X	1357/2470

* Sublimes

** ±45/25

*** ±10/18

**** ±5/9

APPLICATION DATA

MATERIAL	CHARACTERISTICS
Carbon Steel (C1018)	Up to 540°C (1000°F) in non-oxidizing environments. Main areas of usage are galvanizing pots, molten babbitt metal, molten magnesium, molten zinc, petroleum refinery applications such as dewaxing and thermal cracking. Not suitable for brass, bronze or copper.
Type 304L SS	Up to 900°C (1650°F) under oxidizing conditions. Has generally good oxidation and corrosion resistance in a wide range of industrial environments. Good mechanical properties from -185 to 790°C (-300 to 1450°F). Main areas of usage: chemicals, food, plastics, petroleum.
Type 310 SS	Up to 1150°C (2100°F) under oxidizing conditions. Has high elevated temperature strength and scale resistance. Power plant boiler tubes to 980°C (1800°F) are the main areas of application.
Type 316L SS	Up to 930°C (1700°F) under oxidizing conditions. Same area of application as 304 plus improved resistance to acids and pitting corrosion.
Type 446 SS	Up to 1090°C (2000°F) under oxidizing conditions. Excellent high temperature corrosion and oxidation resistance. Main areas of application are: hardening; nitriding and annealing furnaces; salt baths and molten lead; tin and babbitt metal; sulphurous atmospheres. Not suitable for carburizing atmospheres. Other areas are: steel soaking pits; tinning pots; waste heat boilers; ore roasters; cement exit flues; boiler tubes to 980°C (1800°F); asphalt mixing; incinerators to 1090°C (2000°F); glass tank flues.
Inconel 601	Up to 1260°C (2300°F) under oxidizing conditions. For reducing conditions, lower maximum temperature to 1040°C (1900°F). Some resistance to sulphurous atmospheres. Main areas of application; carburizing, annealing and hardening furnaces; cyanide salt baths; blast furnace downcomers; steel soaking pits; waste heat boilers; ore roasters; cement exit flues; incinerators; glass tank flues. Do not use in vacuum furnaces. Susceptible to intergranular attack by prolonged heating in the temperature range 540 - 760°C (1100 - 1400°F).
Nickel	Up to 1100°C (2100°F) under oxidizing conditions. Must not be used in sulphur atmospheres above 540°C (1100°F). Applications include: potassium cyanide salt baths; brines; caustics; high temperature chemical exposure.
Cast Iron	Up to 700°C (1300°F) in oxidizing conditions. Main area of usage is in molten non-ferrous metals; daily whitening is recommended. Can be used to 870°C (1600°F) under reducing conditions. Ceramic coated cast iron protection tubes provide additional protection for continuous use in molten aluminium, lead or zinc.
Lava-Coated	Up to 1250°C (2280°F). Main use is for monitoring the holding and melting temperatures of aluminum and other non-ferrous metals.
Metal-Ceramic (LT-1)	Up to 1370°C (2500°F) in oxidizing conditions. Main areas of usage are: molten copper-based alloys to 1150°C (2100°F); blast furnace and stack gases to 1315°C (2400°F); sulphur burners to 1090°C (2000°F); cement kilns to 1200°C (2200°F); chemical reactors to 1370°C (2500°F). Good for boiling sulphuric acid (97%). A ceramic primary tube is required for use with noble metal thermocouples. Good resistance to mechanical and thermal shock.
Kanthal A-1	Up to 1260°C (2300°F) in oxidizing conditions. Good high temperature sulphur resistance. For use in molten copper.
Hastelloy B-3	Up to 815°C (1500°F) in vacuum or inert atmospheres; 540°C (1000°F) in air. Excellent resistance to pitting and stress-corrosion cracking. Suitable for most chemical processes. Excellent corrosion resistance to hydrochloric, sulphuric (60% max), phosphoric and acetic, and hydrogen chloride gas.
Hastelloy C-22	Up to 1040°C (1900°F) in oxidizing atmospheres. Excellent corrosion resistance to many chemical environments including ferric, hydrofluoric, nitric and other mineral acids, cupric chlorides, hypochlorite, chlorine dioxide and wet chlorine gas.
Hastelloy X	Up to 1200°C (2200°F) in oxidizing atmospheres. Good high temperature strength and oxidation resistance. Resists attack by sulphur compounds. Resists stress-corrosion cracking in petrochem industry applications.

Inconel is a trademark of International Nickel
 Kanthal A-1 is a trademark of Kanthal Ltd
 Hastelloy is a trademark of Haynes International Inc

Pyrosil D is a trademark of Tyco Thermal Controls
 Hexoloy is a trademark of Carborundum
 LT-1 is a trademark of Union Carbide

The following information is offered as a guide to the selection of materials. Caution should be exercised when applying the materials below to specific applications. Thermo-Kinetics assumes no responsibility for the information supplied herein.

HEAT TREATING

Annealing (<740°C)	304SS
Annealing (>740°C)	INC601, 446SS
Carburizing	INC601
Hardening (<815°C)	304SS
Hardening (<1090°C)	INC601, 446SS
Hardening (>1090°C)	Alumina
Lead Hardening	446SS
Salt Bath (Cyanide)	INC601, 446SS
Salt Bath (Neutral)	INC601, 446SS
Salt Bath (High Speed)	Alumina
Quench Oil	C.Stl, 304SS

IRON & STEEL

Billet Heating (<1100°C)	INC601, 446SS
Billet Heating (>1100°C)	Alumina
Blast Furnace	
Downcomer	INC601, 446SS
Stove Dome	SiC, Hex
Hot Blast- Main	INC601, Hex, 310SS
Stove Trunk	INC601, 310SS
Stove Outlet Flue	Hex
Brazing	Alumina
Bright Anneal (Batch)	INC601, 310SS
Bright Anneal (Continuous)	INC601, Alumina, 310SS
Forge Furnaces	Alumina, SiC
Galvanizing	C.Stl, SiC
Palm Oil	304LSS
Pickling Tanks	Lead, SiC, Teflon, C22
Soaking Pits (<1100°C)	INC601, SiC, LT-1, 446SS
Soaking Pits (>1100°C)	Alumina, SiC, LT-1
Tinning	C.Stl, 446SS
Vacuum Melting (<1750°C)	Alumina
Vacuum Melting (>1750°C)	Beryllium Oxide
Waste Heat Boilers	INC601, 446SS, 310SS

CEMENT KILN

Hot End (Clinker) (<1400°C)	Alumina
Cool End - Flue (<1100°C)	LT-1, 446SS, 310SS
Clinker Cooler (<650°C)	INC601

POWER

Boiler Tubes	310SS, 446SS
Flue Gas	446SS, C22
Preheaters	446SS
Steam Lines	316SS
Water Lines	C.Stl

GLASS

Forehearth & Feeders	Pt Thimble on Alumina
Lehrs	340SS, 316SS, INC601
Roof	Alumina, LT-1
Tank Roof & Walls	Alumina
Tank Flues	446SS

NON-FERROUS METALS

Aluminum (Molten)	Sialon, Lava C, Hex, CCCI
Aluminum (Heat Treating)	C.Stl, 304LSS
Aluminum (Annealing)	C.Stl
Aluminum (Billet Heating)	INC 601, 446SS, 310SS
Babbitt	446SS
Brass, Bronze (Molten)	LT-1, SiC
Copper	LT-1, SiC, Kanthal
Lead	446SS, SiC
Tin	C.Stl, SiC
Smelting & Ore	INC601, 446SS, SiC
Zinc	446SS, SiC, Sialon, 310SS, Hex

CERAMICS

Dryers (<450°C)	304LSS
Kilns-Brick (<1200°C)	Alumina, SiC, Mullite
Vitreous Enamelling (<1100°C)	INC601, 310SS
Grinding Wheels	304SS
Abrasive Grits (<1250°C)	Alumina, Mullite
Porcelain Pottery (<1300°C)	Alumina, Mullite

FOOD / MEAT

Baking Ovens	304LSS, 316LSS
Char, Kilns, Sugar	446SS
Cooking - Fruits, Veg, Meats	304LSS, 316LSS
Smokehouses	304LSS, 316LSS

GAS

Producer Gas	INC601, 446SS
Water Gas (Carburator)	INC601, 446SS
Water Gas (Superheater)	INC601, 446SS
Tar Stills	C.Stl, 304LSS

PETROLEUM

Bridgewall	446SS, INC601
Sulphur Burners	446SS, LT-1
Dewaxing	310SS, 316SS
Fractionating Columns	310SS, 316SS
Reaction Chambers	310SS, 316SS
Thermal Catalytic Units	310SS, 316SS
Towers	310SS, 316SS
Transfer Lines	310SS, 316SS

MISC

Incineration	LT-1, SiC, C22
Reactors	LT-1, Hex
Asphalt Mixing	C.Stl, 446SS
Sulphur Burners	446SS, LT-1
Ore Roasters	INC601, 446SS, 310SS
Paper Digesters	316SS, 446SS

C. Stl = Carbon Steel Hex = Hexoloy SA Lava C = Lava Coated C22 = Hastelloy C-22 CCCI = Ceramic Coated C.I.

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