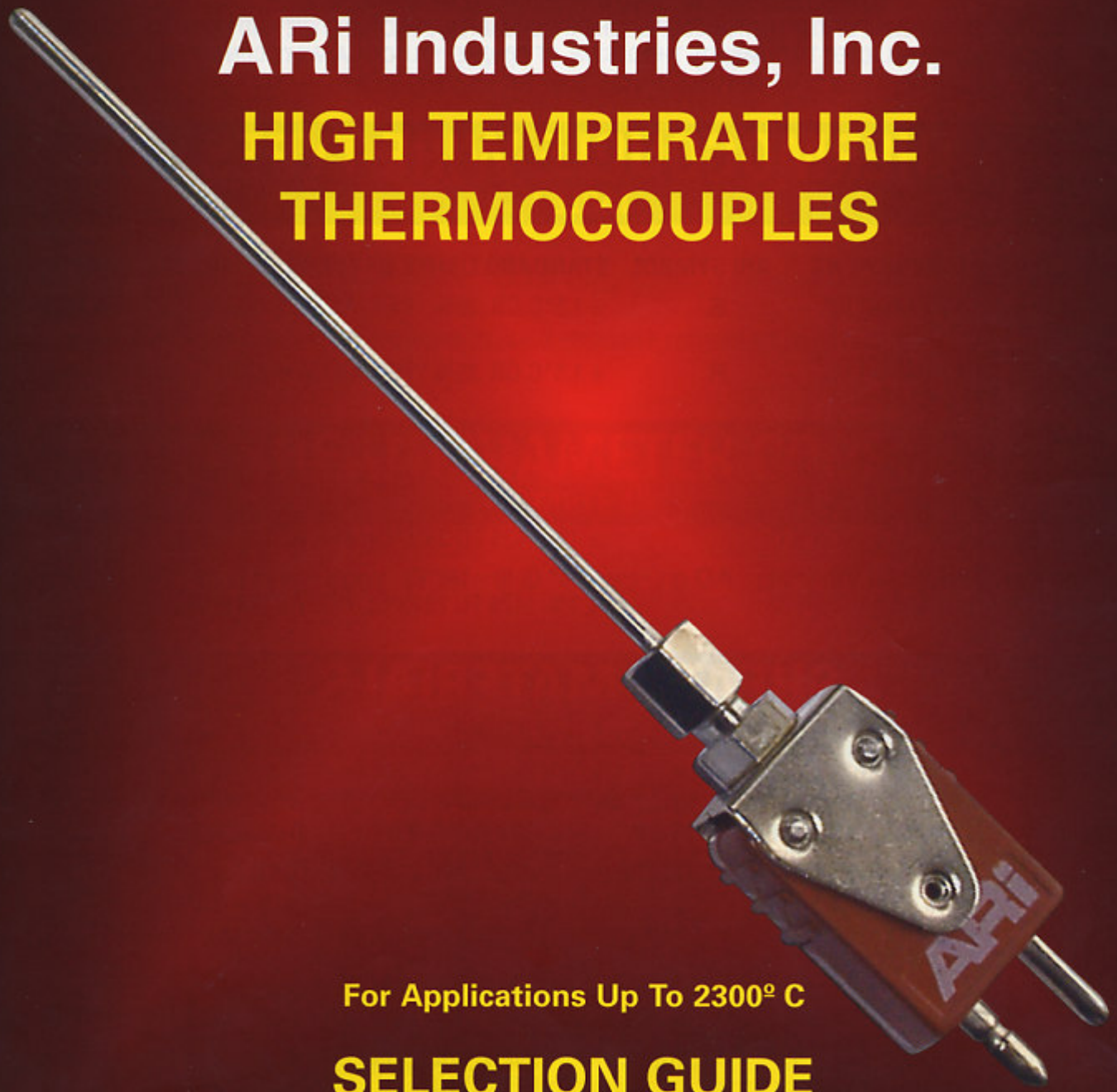
ARi Industries, Inc.

HIGH TEMPERATURE THERMOCOUPLES



For Applications Up To 2300º C

SELECTION GUIDE

BULLETIN 2.0

9/1/01

THERMOCOUPLE SELECTION

ARi HIGH TEMPERATURE THERMOCOUPLES ARE USED IN APPLICATIONS WHERE BASE METAL THERMOCOUPLES CANNOT BE USED BECAUSE OF EXCESSIVE TEMPERATURES OR SEVERE ATMOSPHERES. ARi CAN PROVIDE A WIDE VARIETY OF WIRE COMBINATIONS & SHEATH MATERIALS TO MEET THE HARSHEST DEMANDS. BY SELECTING CERTAIN MATERIALS, TEMPERATURE MEASUREMENTS UP TO 2300° C CAN BE ACHIEVED.

ARi MANUFACTURES IT'S OWN MINERAL INSULATED CABLE AND MANY OF OUR THERMOCOUPLES ARE AVAILABLE IN BENDABLE SHEATHS & LONGER LENGTHS. THIS IN-HOUSE CAPABILITY ENABLES US TO MANUFACTURE A VARIETY OF CUSTOM MATERIAL COMBINATIONS. APPLICATIONS INCLUDE PROCESS CONTROL OF VACUUM FURNACES, GAS FURNACES , HIGH TEMP OVENS AND REACTION FURNACES. PROCESSES INCLUDE SINTERING, ANNEALING AND CARBURIZING.

WHILE MANY PROCESS VARIABLES AFFECT SERVICE LIFE, THERE ARE 2 IMPORTANT CONSIDERATIONS FOR SELECTING THE PROPER THERMOCOUPLE FOR A PARTICULAR APPLICATION. **1.)** WHAT IS THE *TEMPERATURE RANGE* YOU WILL NEED TO MEASURE? **2.)** WHAT IS THE *ATMOSPHERE* THE THERMOCOUPLE WILL BE EXPOSED TO DURING OPERATION? WITH THIS INFORMATION, IT IS POSSIBLE TO USE THESE TABLES TO SELECT A SUITABLE WIRE, SHEATH AND INSULATION COMBINATION. THE PHYSICAL REQUIREMENTS OF THE THERMOCOUPLE (SHEATH DIAMETER, JUNCTION TYPE AND TERMINATION STYLE) CAN THEN BE SELECTED TO COMPLETE THE DESIGN. OF COURSE, YOU CAN ALWAYS CONTACT OUR ARi SALES STAFF FOR HELP IN SELECTING THE PROPER THERMOCOUPLE.

THERMOCOUPLE WIRE TYPES

TABLE 1

THERMOCOUPLE COMBINATIONS	ARI SYMBOL	STANDARD LIMITS OF ERROR	RECOM. TEMP. RANGE
PLATINUM 10% RHODIUM (+) VS. PLATINUM (-) TYPE S	**S**	± 1.5°C OR .25% PER ASTM E-230	0 - 1450°C
PLATINUM 13% RHODIUM (+) VS. PLATINUM (-) TYPE R	**R**	± 1.5°C OR .25% PER ASTM E-230	0 - 1450°C
PLATINUM 30% RHODIUM (+) VS. PLATINUM 6% RHODIUM (-) TYPE B	**B**	± .5% PER ASTM E-230	870 - 1700°C
TUNGSTEN 5% RHENIUM (+) VS. TUNGSTEN 26% RHENIUM (-) TYPE C	**AE**	±4.4° C (0 - 426°C) ± 1% (426 TO 2315°C) PER ASTM E-988	0 - 2200°C
TUNGSTEN 3% RHENIUM (+) VS. TUNGSTEN 25% RHENIUM (-) TYPE D	**AO**	±4.4° C (0 - 426°C) ± 1% (426 TO 2315°C) PER ASTM E-988	0 - 2200°C

SHEATH MATERIALS

TABLE 2

SHEATH TYPE	ARI SYMBOL	RECOM. MAX. TEMP.	MELTING TEMP	ALLOWABLE ENVIRONMENT	STD SHEATH DIAMETERS	MIN.BEND RADIUS
INCONEL 600	**B**	1175°C	1345°C	INERT, VACUUM, OXIDIZING	.040", .062", .125", .188", .250"	5 X DIA.
PLATINUM 10% RHODIUM	**AH**	1550°C	1850°C	INERT, OXIDIZING	.040", .062", .125"	5 X DIA.
TANTALUM	**N**	2200°C	2995°C	INERT, VACUUM	.040", .062", .125"	10 X DIA.
MOLYBDENUM	**O**	2000°C	2620°C	INERT, VACUUM, REDUCING	.062", .125", .188" .250"	DO NOT BEND
NIOBIUM 1% ZIRCONIUM	**AV**	2200°C	2495°C	INERT, VACUUM	.062", .125"	10 X DIA.
COATED MOLYBDENUM	**OCR**	1600°C	2000°C	INERT, OXIDIZING	.125", .250"	DO NOT BEND

INSULATION MATERIALS

TABLE 3

INSULATION TYPE	ARI SYMBOL	RECOM.MAX. OPER. TEMP	APPROX. MELTING TEMP.	COMMENTS
MAGNESIUM OXIDE (MgO)	N	1700°C	2800°C	VERY HYGROSCOPIC AND USED MOSTLY IN COMPACTED SHEATHS
ALUMINA OXIDE (Al_2O_3)	A	1550°C	2040°C	EXCELLENT WITH PLATINUM ALLOYS
HAFNIUM OXIDE (HfO_2)	H	2200°C	2790°C	COMPARABLE TO BERYLLIA OXIDE AND SAFE TO HANDLE
BERYLLIUM OXIDE (BeO) *	B	2200°C	2650°C	EXCELLENT HIGH TEMP THERMAL CONDUCTIVITY AND RESISTIVITY

*BERYLLIUM IS CONSIDERED A TOXIC MATERIAL AND CAN CAUSE HEALTH PROBLEMS IF PARTICLES ARE INHALED.

SHEATH DIAMETER CODES

TABLE 4

SHEATH DIAMETER / LETTER CODE	.040" / A	.062" / B	.125" / D	.188" / E	.250" / F

JUNCTION NUMBER CODES

TABLE 5

SHEATH TYPE	WIRE TYPE LETTER CODE	JUNCTION CODE GROUNDED	JUNCTION CODE UNGROUNDED
INCONEL 600	R, S, & B	(8.1)	9
PLAT 10% RH.	R, S, & B	8	9
COATED MOLY	AE & AO	N/A	(9.3)
TANTALUM	R, S, B, AE, & AO	(8.1)	(9.5)
MOLYBDENUM	R, S, & B	N/A	(9.4)
MOLYBDENUM	AE & AO	N/A	(9.3)
NIOBIUM 1% ZIRC.	AE & AO	(8.1)	(9.5)

STANDARD TERMINATION STYLES

T-91 200°C STD. MALE PLUG

T-107 200°C TRANSITION W/FIBERGLASS INSUL. EXT. WIRE

HI-T-91 427°C HIGH TEMP MALE PLUG

T-14 1/2" BARE WIRE LEADS W/EPOXY SEAL

T-77 200°C TRANS. W/FIBERGLASS INSUL. EXT. WIRE, STD. MALE PLUG

T-99 200°C TRANS. W/FIBERGLASS INSUL. EXT. WIRE WITH ST/ST OVERBRAID

T-37 200°C TRANS. W/EXT. SPRING STRAIN RELIEF, FIBERGLASS INSUL. EXT. WIRE & STD. MALE PLUG

T-31 200°C TRANS. W/EXT. SPRING STRAIN RELIEF, FIBERGLASS INSUL. EXT. WIRE

T-103 200°C TRANS. W/EXT. SPRING STRAIN RELIEF, FIBERGLASS INSUL. EXT.WIRE W/ST/ST OVERBRAID & STD. MALE PLUG

T-191 200°C MINIATURE PLUG

PART NUMBER BREAKDOWN

EXAMPLE: T-107 N -12 B AE (8.1) N -24
(1) (2) (3) (4) (5) (6) (7) (8)

SINCE ALMOST ALL OF OUR THERMOCOUPLES ARE MADE TO YOUR ORDER REQUIREMENTS, WE CAN EASILY SUPPLY ANY MODIFICATION OR CUSTOM DESIGN BASED ON YOUR APPLICATION.

(1) INSERT STYLE NUMBER FROM ABOVE
(2) INSERT INSULATION MATERIAL LETTER CODE FROM TABLE 3
(3) INSERT SHEATH LENGTH (L) IN INCHES
(4) INSERT SHEATH DIAMETER LETTER CODE FROM TABLE 4
(5) INSERT ARi SYMBOL FOR WIRE TYPE FROM TABLE 1
(6) INSERT JUNCTION CODE FROM TABLE 5
(7) INSERT ARi SYMBOL FOR SHEATH MATERIAL FROM TABLE 2
(8) INSERT LENGTH OF EXTENSION WIRE (A) IN INCHES (IF REQ). STANDARD LENGTH OF 16" SUPPLIED IF NOT SPECIFIED.

OPTIONS/MODIFICATIONS

HIGH TEMPERATURE TERMINATION

IN APPLICATIONS WHERE THE COLD END TERMINATION WILL SEE TEMPERATURES IN EXCESS OF 200°C, STANDARD EPOXY SEALS MAY MAY BREAKDOWN CAUSING FAILURE. IN THIS CASE, ARi CAN SUPPLY A CERAMIC CEMENT SEAL WHICH CAN WITHSTAND TEMPERATURES UP TO 450°C. TO SPECIFY THIS OPTION, ADD THE PREFIX **HI-** IN FRONT OF THE PART NUMBER SELECTED.

EXAMPLE: HI-T-107N-12DAE(9.5)N

DUPLEX ELEMENT CONSTRUCTION

MOST THERMOCOUPLE COMBINATIONS WITH AN OUTSIDE SHEATH DIAMETER OF 1/8" OR LARGER ARE AVAILABLE IN DUPLEX ELEMENT CONSTRUCTION (2 SEPARATE MEASURING CIRCUITS IN 1 SHEATH). TO SPECIFY THIS OPTION, ADD THE SUFFIX **.4** AFTER THE STYLE NUMBER, **REPEAT THE JUNCTION CODE A 2ND TIME AND ADD PARENTHESES.**

EXAMPLE: T-91.4N -12FR(9.9)B OR T-91.4B-18DAE(9.3)(9.3)O

MATING JACK

IF REQUIRED WITH ANY OF OUR MALE PLUG TYPE THERMOCOUPLES (T-91, T-191, AND HI-T-91),WE CAN SUPPLY THE APPROPRIATE MATING JACK WITH THE ASSEMBLY. TO SPECIFY THIS MODIFICATION, ADD **(MOD)** AFTER THE PART NUMBER AND SPECIFY **"SUPPLIED WITH MATING JACK".**

ARGON BACKFILL

IN ORDER TO MINIMIZE THE EFFECTS OF ANY RESIDUAL OXIDATION REMAINING INSIDE NON-COMPACTED SHEATH DESIGNS, ARi CAN EVACUATE AND BACKFILL THE SHEATH WITH INERT ARGON GAS PRIOR TO SEALING THE COLD END. TO SPECIFY THIS MODIFICATION, ADD **(MOD)** AFTER THE PART NUMBER AND SPECIFY **"WITH ARGON BACKFILL"** IN THE DESCRIPTION.

SPECIAL LIMITS OF ERROR

THERMOCOUPLES WITH R,S & B CALIBRATIONS MADE WITH MINERAL INSULATED CONSTRUCTION CAN BE SUPPLIED WITH SPECIAL LIMITS OF ERROR TOLERANCES PER ASTM E - 230 OR CLASS 1 PER IEC-584 SUBJECT TO AVAILABILITY OF MATERIAL FROM STOCK. TO SPECIFY THIS MODIFICATION, ADD **(MOD)** AFTER THE PART NUMBER AND SPECIFY **" PER SPECIAL LIMITS OF ERROR"** OR **"PER CLASS 1 TOLERANCE"** IN THE DESCRIPTION.

TEFLON INSULATED EXTENSION WIRES

FOR DESIGNS WHERE EXTENSION WIRE ATTACHMENT IS REQUIRED, ARi CAN SUPPLY MOISTURE RESISTANT TEFLON INSULATED EXTENSION WIRE IN PLACE OF OUR STANDARD FIBERGLASS. OTHER INSULATION TYPES CAN BE SUPPLIED SUBJECT TO AVAILABILITY. TO SPECIFY THIS MODIFICATION, ADD **(MOD)** AFTER THE PART NUMBER AND SPECIFY **"WITH TEFLON INSULATED LEADS"** IN THE DESCRIPTION.

METRIC SIZES

ARi MAINTAINS A WIDE VARIETY OF MINERAL INSULATED CABLE AND TUBING IN STOCK TO MANUFACTURE THERMOCOUPLES WITH METRIC SHEATH DIAMETER REQUIREMENTS. METRIC SIZES ARE SUBJECT TO AVAILABILITY. TO SPECIFY THIS OPTION, **INSERT DECIMAL EQUIVALENT IN PLACE OF THE SHEATH DIAMETER LETTER CODE** OF THE PART NUMBER.

EXAMPLE: FOR 3.0 MM (.118") SHEATH SIZE: T-91N-12(.118)AE(9.3)O

SPECIAL TESTING

SPECIAL NON-DESTRUCTIVE TESTING IS AVAILABLE ON IN-PROCESS AND FINISHED THERMOCOUPLE ASSEMBLIES. TYPE OF TESTS AVAILABLE INCLUDE: THERMOCOUPLE TEMPERATURE CALIBRATION (TEMP VS. EMF), RADIOGRAPHY, LIQUID PENETRANT, HELIUM LEAK, DIMENSIONAL, & INSULATION RESISTANCE. ALL ARi STANDARDS ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST). ARi'S QUALITY MANAGEMENT SYSTEM MEETS THE REQUIREMENTS OF ISO 9002 AS CERTIFIED BY LLOYDS REGISTER QUALITY ASSURANCE.

SPECIAL PRODUCTS

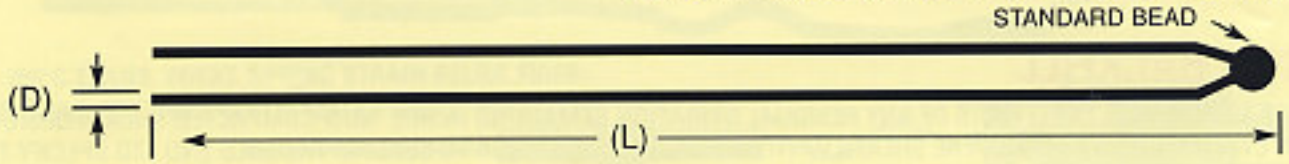
BARE WIRE THERMOCOUPLE ELEMENTS

ARi CAN SUPPLY UN-SHEATHED BARE WIRE THERMOCOUPLE ELEMENTS WHERE QUICK TIME RESPONSE AND ACCURATE TEMPERATURE MEASUREMENTS ARE CRITICAL.

ELEMENTS CAN BE SUPPLIED IN THREE (3) STANDARD DIAMETERS, CUSTOM BUILT TO YOUR LENGTH REQUIREMENTS. TYPE R, S, AND B ARE SUPPLIED WITH A STANDARD BEAD TYPE JUNCTION, WHILE TUNGSTEN RHENIUM TYPES C AND D (ARi TYPE AE AND AO) ARE SUPPLIED WITH OUR PATENTED WIRE WOUND JUNCTION TYPE (9.3).

SPECIFY ARI P/N T-50994 - (L) - (D) - (TYPE)

(L) --- SPECIFY LENGTH IN INCHES
(D)--- SPECIFY WIRE DIAMETER (.010, .020 OR .032)
(TYPE) --- SPECIFY WIRE TYPE (R, S, B, AE OR AO)



CERAMIC PROTECTION TUBE ASSEMBLIES

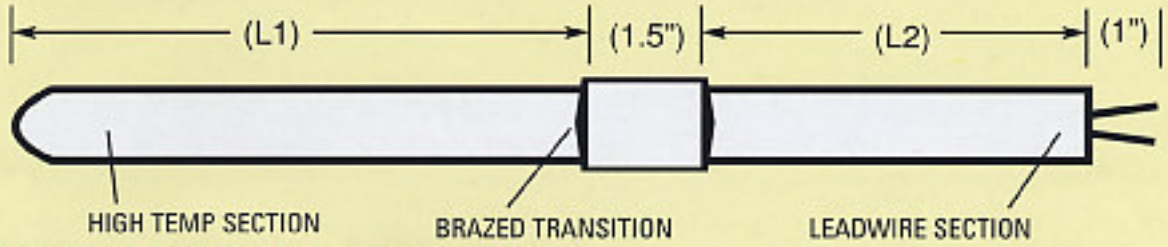
ARi OFFERS A VARIETY OF CERAMIC PROTECTION TUBE ASSEMBLIES FOR APPLICATIONS WHERE EXTREME TEMPERATURES AND ATMOSPHERES ARE TOO SEVERE FOR METAL TUBES. OUR DESIGNS ARE BUILT PER YOUR EXACTING SPECIFICATIONS:

MATERIAL TYPE	GRADE	LETTER CODE	MAXIMUM RECOM. TEMP.	THERMAL SHOCK RESISTANCE	COMMENT
ALUMINA	MIN. PURITY 99.7%	**AL**	1800°C	FAIR	GAS TIGHT. EXCELLENT IN OXIDIZING AND REDUCING ATMOSPHERES
SILICON CARBIDE	MIN. PURITY 75-90%	**SiC**	1400°C	GOOD	VERY HIGH THERMAL CONDUCTIVITY
RECRYSTALLIZED SILICON CARBIDE	MIN. PURITY 99 %	**RSiC**	1600°C	VERY GOOD	GOOD MECHANICAL STRENGTH CAN WITHSTAND UP TO 2000°C IN PROTECTED ATMOSPHERES
HEXOLOY®	SINTERED	**HEX**	1650°C	EXCELLENT	EXCEPTIONAL CORROSIVE / CHEMICAL RESISTANCE IN OXIDIZING /REDUCING ENVIRONMENTS

HEXOLOY® IS A REGISTERED TRADEMARK OF CARBORUNDUM CORP.

TRANSITION STYLE THERMOCOUPLES

WHEN EXOTIC APLICATIONS REQUIRE LONG THERMOCOUPLES WITH EXPENSIVE NOBLE METAL OR REFRACTORY SHEATHS, ARi CAN SUPPLY CUSTOM MADE TRANSITION STYLE THERMOCIOUPLES FOR SUBSTANTIAL COST SAVINGS. THERMOCOUPLES CAN BE SUPPLIED WITH SUITABLE HIGH TEMPERATURE "HOT SECTION" SHEATH AND INSULATING MATERIALS LONG ENOUGH TO REACH A COOLER ZONE IN THE FURNACE OR REACTOR (MAXIMUM 870°C). AT THIS POINT, A BRAZED TRANSITION CAN BE MADE TO A LESS EXPENSIVE THERMOCOUPLE OR COMPENSATING MATERIAL WITH INCONEL 600 OR ST/ST SHEATH. CONTACT ARi FOR SPECIFIC PART NUMBERS AND SPECIFICATIONS.



SPECIAL REFRACTORY SHEATHS

IN ADDITION TO THE SHEATHS LISTED IN TABLE 2, ARi CAN ALSO PROVIDE THE FOLLOWING SHEATHS ON SPECIAL ORDER. CONTACT ARi FOR DIMENSIONS AND AVAILABILITY:

SHEATH TYPE	LETTER CODE	RECOMMENDED MAXIMUM TEMP	MELTING TEMP	COMMENTS
TUNGSTEN	**BC**	2300°C	3410°C	VERY HIGH MELTING POINT AND LOW VAPOR PRESSURE FOR VACUUM APPLICATIONS
MOLYBDENUM 50% RHENIUM	**BE**	2300°C	2550°C	EASILY WELDABLE AND DUCTILE UP TO 2200°C SUITABLE FOR INERT, VACUUM, HYDROGEN , NITROGEN, AND AMONIA ATMOSHERES
UCAR® METAL CERAMIC LT-1 TUBES	**BV**	1371°C	1538°C	SUITABLE FOR VARIOUS MOLTEN METALS AND CORROSIVE GASES
MOLY DISILLICIDE	**BW**	1700°C	VARIES	CAN BE USED IN AIR UP TO 1700°C. SUITABLE FOR HEAT TREATING, SINTERING AND GLASS APPLICATIONS.

SPECIAL COATINGS FOR SHEATHS

IN ADDITION TO THE COATED MOLYBDENUM SHEATH (OCR) SHOWN IN TABLE 2, THE FOLLOWING COATINGS ARE ALSO AVAILABLE:

COATING TYPE	LETTER CODE	MAXIMUM TEMP	COMMENTS
TUNGSTEN (PLASMA SPRAY)	**TPL**	2200°C	FOR RESISTANCE TO GRAPHITE ATTACK IN VACUUM APPLICATIONS. APPLIED TO MOLYBDENUM SHEATH.
BORON NITRIDE	**BN**	1800°C	NON-WETTING WITH MOST MOLTEN METALS AND SLAGS. USE IN OXIDIZING ATMOSPHERES TO 1100°C

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