



Idaho Laboratories Corporation

MANUFACTURING AND SERVICES

Mineral Insulated Cable

Mineral Insulated Cable



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Dimensions for our most common Mineral Insulated Cable design for thermocouples is in the table below. Further designs can be accessed at the links below.

Standard Design						
Diam.	Diameter Tolerance	Wall	Wire Diameter			
			2 wire	4 wire	6 wire*	8 wire*
.500"	+.003"/-.003"	.064"	.098"	.080"	.051"	.040"
.375"	+.003"/-.0025"	.048"	.074"	.060"	.038"	.030"
.313"	+.003"/-.0025"	.040"	.061"	.050"	.032"	.025"
.250"	+.003"/-.0025"	.032"	.049"	.040"	.026"	.020"
.188"	+.002"/-.0025"	.024"	.037"	.030"	.019"	.015"
.125"	+.001"/-.0015"	.016"	.025"	.020"	.013"	.010"
.063"	+.0015"/-.002"	.008"	.012"	.010"	n/a	n/a
.040"	+.001"/-.002"	.005"	.008"	.006"	n/a	n/a
.032"	+.001"/-.001"	.004"	.006"	n/a	n/a	n/a
.020"	+.001"/-.001"	.003"	.004"	n/a	n/a	n/a

*may not be available in all desired options

For diameters not listed, please use the following formulas to determine the information you require:

O.D. tolerance = +/- .001" [0.025mm] or +/- 1%, whichever is greater.

Wall thickness = 12% of the O.D. [+/-15% tolerance]

Conductor diameter: 20% of the O.D. [+/-15% tolerance] for 2 wire [single] mineral insulated cable. Duplex material is 16% of the O.D. [+/-15% tolerance]

The sheath of the standard MI cable can withstand an external pressure of 60,000 psi (4218 kg/cm²) as tested at .062" diameter.

Haynes HR 160 Sheath

We offer MI cable with a Haynes Alloy HR160 sheath material to meet your special requirements. This material has an Inconel liner to protect the thermoelements.

The table below contains the dimensions.

Diam.	HR 160 Outer Sheath	Inconel 600 Liner	Tolerance	Wire Diameter		Insulation	
				2-wire	4-wire	2-wire	4-wire
.125"	.018"	.008"	+/-0.002"	.019"	.016"	.012"	.011"
.188"	.027"	.011"	+/-0.002"	.030"	.024"	.017"	.016"
.236"	.033"	.014"	+/-0.002"	.037"	.030"	.022"	.020"
.250"	.035"	.015"	+/-0.002"	.040"	.032"	.023"	.021"
.313"	.044"	.019"	+/-0.003"	.049"	.039"	.029"	.026"
.375"	.053"	.023"	+/-0.003"	.059"	.047"	.035"	.032"
.500"	.071"	.030"	+/-0.003"	.078"	.063"	.047"	.042"

Heavy Wall MI Cable

This page describes our heavy wall and Haynes Alloy HR160(TM) sheath MI cable. These are some of the less common designs we carry. If you have something in mind, please contact us to discuss the possibilities. We are here to help you! Other designs can be accessed at the links below.

Heavy Wall (when the normal material is just not enough)

Heavy Wall – the sheath material is thicker (~2X) than our Standard material. This allows you to weld to the sheath material with less risk of burning through the side of the probe.

Dual Wall – this design has 2 separate sheath materials. You can choose either the same material for both sheaths, or go with a composite design in some cases. For some alloys, this is the only option available. *Exact dimensions for this design depend upon the sheath material desired.*

Alternate Designs						
Diam.	HEAVY Wall			EQUAL Wall		
	Wall	2-wire	4-wire	Wall	2-wire	4-wire
.500"	.120"	.069"	.055"	.080"	.080"	.074"
.375"	.090"	.052"	.041"	.060"	.060"	.056"
.313"	.075"	.043"	.034"	.050"	.050"	.046"
.250"	.060"	.035"	.028"	.040"	.040"	.037"
.236"	.057"	.033"	.026"	.038"	.038"	.035"
.188"	.045"	.026"	.021"	.030"	.030"	.028"
.125"	.030"	.017"	.014"	.020"	.020"	.019"
.093"	.023"	.013"	.010"	.014"	.014"	.013"
.063"	.015"	.009"	-	.010"	.010"	.009"
.040"	-	-	-	.006"	.006"	.006"
.032"	-	-	-	.005"	.005"	-
.020"	-	-	-	.003"	.003"	-

**Dimensions for Dual Wall depend on sheath material required. Please contact us with your specific requirements.*

We offer MI cable with a Haynes™ Alloy HR160 outer sheath. This material is usually made in Type K or N, and has the dimensions below.

Diam.	HR 160 Outer Sheath	Inconel 600 Liner	Tolerance	Wire Diameter		Insulation	
				2-wire	4-wire	2-wire	2-wire
.125"	.018"	.008"	+/--.002"	.019"	.016"	.012"	.011"
.188"	.027"	.011"	+/--.002"	.030"	.024"	.017"	.016"
.236"	.033"	.014"	+/--.002"	.037"	.030"	.022"	.020"
.250"	.035"	.015"	+/--.002"	.040"	.032"	.023"	.021"
.313"	.044"	.019"	+/--.003"	.049"	.039"	.029"	.026"
.375"	.053"	.023"	+/--.003"	.059"	.047"	.035"	.032"
.500"	.071"	.030"	+/--.003"	.078"	.063"	.047"	.042"

RTD Conductor Cable

We offer RTD or pass-through cable in 2, 3, 4, 6, and 8 wire configurations. The Standard wall/wire dimensions are listed below.

Other designs are available upon request, so please ask us if you do not see what you need!

RTD Cable Construction

WIDE-SPACE Construction (C43 Design)			
Diameter	Wall	Wire	Bolt Circle
.375"	.050"	.030"	.198"
.313"	.041"	.025"	.165"
.250"	.033"	.020"	.132"
.188"	.025"	.015"	.099"
.125"	.017"	.010"	.066"

WIDE-SPACE Construction (C44 Design)			
Diameter	Wall	Wire	Bolt Circle
.375"	.033"	.033"	.221"
.313"	.028"	.028"	.185"
.250"	.022"	.022"	.148"
.188"	.017"	.017"	.111"
.125"	.011"	.011"	.074"

Normal Construction (C45 Design)			
Diameter	Wall	Wire	Bolt Circle
.375"	.060"	.028"	.184"
.313"	.050"	.023"	.153"
.250"	.040"	.019"	.123"
.188"	.030"	.014"	.092"
.125"	.020"	.009"	.061"

Normal 4-wire Material

Normal Construction (C42 – 4 wire)			
Diameter	Wall	Wire	Bolt Circle
.375"	.044"	.062"	.145"
.313"	.037"	.051"	.121"
.250"	.030"	.041"	.097"
.188"	.022"	.031"	.073"
.125"	.015"	.021"	.048"

Small Diameter Cable

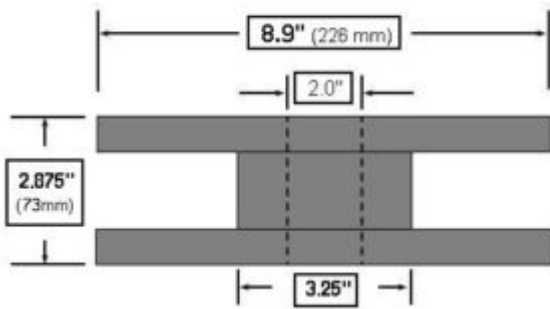
Small Diameter MI Cable:

We have retooled, adding a new furnace dedicated solely to small diameter cable. This means shorter lead times for our customers, and better quality as well. The new equipment was built especially for MI cable ranging from .010" up to .040" (in addition to the other products up to .750" [3/4"] diameter). With this additional capacity, we can make small diameter cable in a few weeks!



Please ask us how we can meet your needs.

The small diameter cable ships on a spool as dimensioned below.



Heater Cable

Heater Cable Information

Standard design heater cable specifications:

- Sheath alloy 600 or equivalent with an annealed bright surface finish
- Insulation high purity MgO 99.4% minimum and a 70% nominal compaction density.
- Conductor(s): either single (1) or dual (2) nickel / chrome alloy wire(s) with an electrical resistance of 620 to 650 ohms/circular mil. foot. The change in resistance at 2000 degrees F is less than 14%.
- Room temperature insulation resistance for mineral insulated heater cable over .062" outside diameter is 10,000 megohms at 500 vdc. For cable with a smaller outside diameter than .062", the resistance is 5000 megohms at 50 vdc measured from wire to wire or wire to sheath.
- The mineral insulated heater cable may be coiled around a mandrel that is 4 times the sheath diameter (tighter coils or bends are not recommended if maximum life is to be expected).

The safe watt density for mineral insulated heater cable, in still air applications, is 30 watts per square inch. Higher watt densities are possible in certain applications.

Maximum recommended applied voltages:

Diameter	Voltage*
.032" to .040"	50*
.062" to .092"	120*
.125" and larger	240*

*In some applications this voltage may vary.

Tube & Pipe

The following table shows the various sizes and styles of tubing offered by Idaho Labs.

Standard Tube and Pipe		
Tube Material	Available Diameters (OD)	Recommended Upper Temperature
304 / 304L	Tube: .125" to .750" Pipe: 1/2" sched 40	1650 °F
310	Tube: .125" to .750" Pipe: 1/2" sched 40	2100 °F
316 / 316L	Tube: .062" to .750" Pipe: 1/2" sched 40	1650 °F
321	Tube: .250" to .750" Pipe: 1/2" sched 40	1600 °F
347	Tube: .250" to .750" Pipe: 1/2" sched 40	1500 °F
446	.125" to .313"	2100 °F
Haynes™ 188	.156" to .250"	2100 °F
Haynes™ 230	.125" to .250"	2100 °F
Haynes™ Hastelloy C-276	.125" to .750"	2000 °F
Haynes™ Hastelloy X	.125" to .750"	2200 °F
Haynes™ HR-160 Alloy	1/2" SCH 40 ONLY	2150 °F
Incoloy 800	.125" to .375"	2000 °F
Incoloy 825	PIPE ONLY	
Incoloy 600	Tube: .062" to .500" Pipe: 1/2" sched 40	2150 °F
Incoloy 601	Various Sizes	2150 °F continuous; 2300 °F intermittent
Incoloy 625	.188" to .500"	1800 °F
Incoloy 718	.156" to .313"	1200 °F
Incoloy X750	.375" to .500"	1500 °F
Molybdenum	.062" to .250"	Melting Point: 4730 °F, 750 °F in air
Monel 400	.250" to .500"	1000 °F
Nickel 200 / 201	.055" to .500"	Application Specific
Platinum / Rhodium Alloy	Various Sizes to .250"	100% Pt – 2700 °F Pt10%Rh – 2825 °F Pt20%Rh – 3000 °F
Tantalum	.063" to .250"	In air – 800 °F In vacuum – 4375 °F
Titanium	.050" to .375"	In air – 800 °F Max Temp – 3135 °F

Thermocouple Wire & Rod

The following table shows the most common thermocouple alloys offered by Idaho Labs Corp. We offer these as both annealed and hard-drawn / machineable for applications where machining is required.

Thermocouple Wire Offered by Idaho Laboratories Corporation	
Wire Type	Available Diameters (OD)
Type K	From .032" to .609"
Type J	From .032" to .250"
Type E & T	From .064" to .313"
Type N	From .064" to .188"
Type C	From .005" to .020"
Platinum (Type R, S, & B)	From .005" to .051"
Platinel II	From .005" to .020"

Unfortunately Nickel / Nickel Moly (Type M) has been discontinued.

We also offer a large selection of resistance wire such as Nichrome 80.

Thermocouple Wire & Rod

Ohms per circular mil foot						
(a constant)						
		585	800	356	721	308
Wire Diameter (inches)	AWG	Type K	Type N	Type J	Type E	Type T
.460	0000	.00276	.00378	.00168	.00341	.00146
.4096	000	.0035	.0048	.0021	.0043	.0018
.3648	00	.0044	.0060	.0027	.0054	.0023
.3249	0	.0055	.0076	.0034	.0068	.0029
.2893	1	.0070	.0096	.0043	.0086	.0037
.2576	2	.0088	.0121	.0054	.0109	.0046
.2294	3	.0111	.0152	.0068	.0137	.0059
.2043	4	.0140	.0192	.0085	.0173	.0074
.1819	5	.0177	.0242	.0108	.0218	.0093
.162	6	.0223	.0305	.0136	.0275	.0117
.1443	7	.0281	.0384	.0171	.0346	.0148
.1285	8	.0354	.0484	.0216	.0437	.0187
.1144	9	.0447	.0611	.0272	.0551	.0235
.1019	10	.0563	.0770	.0343	.0694	.0297
.0907	11	.0711	.0972	.0433	.0876	.0374
.0808	12	.0896	.1225	.0545	.1104	.0472
.072	13	.113	.154	.069	.139	.059
.0641	14	.142	.195	.087	.175	.075
.0571	15	.179	.245	.109	.221	.094
.0508	16	.227	.310	.138	.279	.119
.0453	17	.285	.390	.173	.351	.150
.0403	18	.360	.493	.219	.444	.190
.0359	19	.454	.621	.276	.559	.239
.032	20	.571	.781	.348	.704	.301
.0285	21	.720	.985	.438	.888	.379
.0254	22	.907	1.240	.552	1.118	.477
.0226	23	1.15	1.57	.697	1.412	.603
.0201	24	1.45	1.98	.881	1.785	.762
.0179	25	1.83	2.50	1.11	2.25	.961
.0159	26	2.31	3.16	1.41	2.85	1.22
.0142	27	2.90	3.97	1.77	3.58	1.53
.0126	28	3.68	5.04	2.24	4.54	1.94
.0113	29	4.58	6.27	2.79	5.65	2.41
.010	30	5.85	8.00	3.56	7.21	3.08
.0089	31	7.39	10.10	4.49	9.10	3.89
.008	32	9.14	12.50	5.56	11.27	4.81
.0071	33	11.60	15.87	7.06	14.30	6.11
.0063	34	14.74	20.16	8.97	18.17	7.76
.0056	35	18.65	25.51	11.35	22.99	9.82
.005	36	23.40	32.00	14.24	28.84	12.32

Platinum/Noble Metals

We offer platinum wire thermocouple materials, including Type S, Type R, Type B, and Platinel II alloys. The most common diameter is .020" (24 gauge), though other diameters are available. The table below outlines availability for the most common sizes. Because platinum and platinum thermocouple alloys are precious metals, the price fluctuates daily following the market. Please ask us if you need a quote to be valid for more than 24 hours.

- Type "R" is a 100% Platinum vs. Platinum/13% Rhodium Alloy
- Type "S" is a 100% Platinum vs. Platinum/10% Rhodium Alloy
- Type "B" is a Platinum/6%Rhodium vs. Platinum/30% Rhodium Alloy
- Platinel II™ is an alloy designed to mimic Type K thermocouples while providing a much higher usable temperature.

Diam.	Gauge	Material Availability			
		Type R	Type S	Type B	Platinel II
.005"	36	X	X	X	X
.010"	30	X	X	X	
.0159"	26	X	O	X	
.0179"	25	X	O		
.020"	24	X	X	X	X
.025"	22	O	O		
.032"	20	X	X	X	
.040"	18	O	O	O	O
.0508"	16	O	O	O	

O – Limited availability. Other diameters are available upon request.

X – Generally available from STOCK. Materials are subject to prior sale.

Standard Design Multipoint Thermocouples

Standard Composite Sheath Thermocouples

Sheath Materials Available:

Standard – Platinum/Rhodium (10% or 20% Rh), with Alloy 600 (aka Inconel™ 600)

Special Order – Molybdenum, Hastelloy X & C-276, Nickel 200, 310SST, 321SST, others (consult us)

Standard calibrations: R, S, B. Base metal designs also available (K, J, E, T, N)

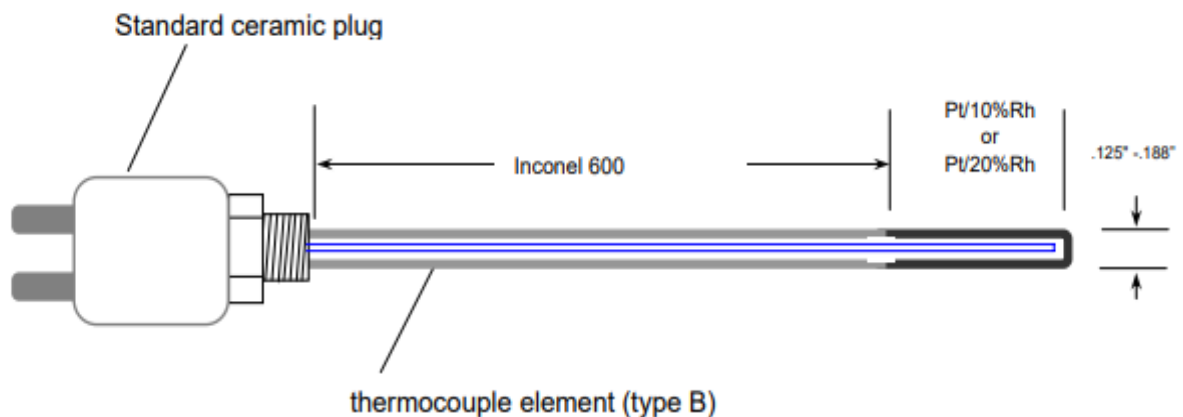
Common Diameters: .125" and .188" are the most commonly used.

Junction Types Available: Ungrounded only with Platinum-tipped thermocouples

Terminations available: ceramic (high-temperature) plug, bare wires, and transition.

Example: Compacted MgO Style (Type B platinum alloy element)

Sheath Material: Platinum/10%Rhodium alloy, and Inconel 600 composite.



Standard Design Multipoint Thermocouples

Sheath Materials Available:

Standard - SST 304, SST 316, Alloy 600 (aka Inconel™ 600)

Special Order - Hastelloy C-276, Hastelloy X, Nickel 200, 310SST, 321SST, others (consult factory)

Standard calibrations: K, J, E, T, N

Junction types available: grounded or ungrounded **Note:** Junction locations are measured from the bottom of the transition housing. The junction location tolerance is typically +/- the diameter of the sheath.

Standard transition sizes:

Number of points	Transition diameter and length
2 - 3	1/2" x 4"
4 - 5	3/4" x 4"
6 - 7	1" x 4"
8 - 12	1" x 6"
13 - 16	1 1/2" x 6"
17 - 20	2" x 6"
21 - 25	2 3/8" x 6"
26 - 30	2 3/8" x 8"

Standard sheath diameter and maximum number of points:

Diameter	Number of points
.062"	4
.092"	7
.125"	12
.188"	24
.250"	30
.313"	30

Maximum available lengths:

Diameter	Length
.062"	20 feet
.092"	20 feet
.125"	100 feet
.188" to .375"	110 feet

Additional information:

- Insulation resistance of mineral insulated cable prior to junctioning > 100 megohms at 50 vdc at room temperature.
- Standard limits of error or special limits of error are available.
- Sheath hardness is furnished in the 1/4 hard condition unless requested.
- Units longer than 8 feet will be shipped in a coil.
- Transitions are epoxy filled with 350°F resin.

Reduced Tip Thermocouples

STANDARD SPECIFICATIONS:

- Reduced tip is annealed after swaging process.
- Taper angle 3 to 4 degrees per side (6 to 8 degree included angle)
- Normal tolerances and specifications
 - MgO compaction: 70% minimum.
 - Reduced tip diameter tolerance: +/- .003"
 - Reduced tip length tolerance: +/- .125" (measured from tip to start of taper)

Note: Special dimensions and tolerances available upon request. Please ask us.

COMMON REDUCTIONS AVAILABLE:

CABLE Diameter	TIP Diameter	Max. Taper Length	Avg. Taper Length
.375"	.250"	1.30"	1.022"
	.188"	1.80"	1.529"
.250"	.188"	.60"	.507"
	.125"	1.20"	1.022"
.188"	.125"	.60"	.515"
	.092"	.90"	.785"
.125"	.092"	.30"	.270"
	.062"	.60"	.515"
.062"	.040"	.20"	.180"
.040"	.020"	.20"	.164"

TYPES OF REDUCED TIPS

Bullet Tip



Standard Reduced Tip (specify reduced length)



FORMULA for TAPER SECTION LENGTH: (3.5 degree angle)

$$\text{TAPER LENGTH} = [(\text{START O.D.} - \text{FINAL O.D.}) / 2] \times 16.35$$

If you have a design that you require, please do not hesitate to send a drawing for our review. We will usually respond within 24 hours.

Part Number System Idaho Labs Thermocouples

EXAMPLE:

125-Ks-I600-H-EW-UNG-24"IM-MP

(A)-(B)-(C)-(D)-(E) - (F) - (G) - (H) (OTHER)

The first five (5) sections of the part number ("A" to "E") describe the mineral insulated cable to be used. The others ("F" thru "Other") describe the thermocouple design and components.

A. NOMINAL OUTSIDE DIAMETER OF SHEATH (in thousandths of an inch).

A two (2) number description is denotes a dual diameter probe.

EXAMPLE: 062/125-XXXXXXXXXX is .062" at the tip, the balance of the immersion length will be .125" diameter.

B. TYPE OF THERMOCOUPLE CALIBRATION:

1. Follows the ANSI system for "normal" calibrations, and uses special characters for non-standard types.

EXAMPLE: XXX-M-XXXXXXXXXX

The -M- designates a Nickel / Nickel-Moly thermocouple, also known as Alloy 19 vs. Alloy 20.

2. This area also designates the number of conductors.

EXAMPLE: XXX-K-XXXXXXXXXX is two (2) wire. XXX-KK-XXXXXXXXXX is four (4) wire.

XXX-KKK-XXXXXXXXXX denotes six (6) wires.

3. An "s" after the calibration letter designates special limits of error wire calibration.

(NOTE: special limits of error platinum/rhodium alloys will be called out in the (other) category to avoid confusion with four-wire "S" calibration.)

4. A number in brackets () will call out the conductor diameter if required.

EXAMPLE: XXX-R(020)-XXXXXXXXXX designates 24 awg (.020"diameter) wire.

C. SHEATH MATERIAL or MATERIALS (for composite sheath TC's):

EXAMPLE: XXX-X-AL2O3HF-XXXXXXXXXX calls for a hard-fired aluminum oxide ceramic sheath.

EXAMPLE: XXX-X-P10R/I600-XXXXXXXXXX calls for a Platinum /10% Rhodium sheath on the tip, and the balance of the probe will be Inconel Alloy 600.

D. DESCRIPTION OF THE INSULATION PURITY: Choose from either High-Purity or Standard Purity.

EXAMPLE: XXX-X-XXXX-H-XXXXXX

The letter -H- designates a high purity MgO of 99.4% minimum. If no letter is used in this area the insulation is standard purity MgO with a minimum purity of 96.4%

E. SPECIAL DESCRIPTION AREA: This is left blank unless needed.

EXAMPLE: XXX-X-XXXX-X-EW-XXXXXXXXXX

The -EW- is a call out for mineral insulated cable that has equal wall and wire thickness.

F. JUNCTION INFORMATION: Choose the type of junction based on the application.

EXAMPLES:

- **GND** - grounded junction where the wires are welded into sheath.
- **UNG** - isolated or ungrounded junction: the junction is electrically isolated from the sheath.
- **UNC/UNG** - the wire pairs are welded together and are not in contact with other pairs or the sheath.
- **EXP** - the wires are welded together and extend past the end of sheath. Usually the insulation is sealed to prevent contamination from entering the probe (the seal material depends on the application).

Part Number System Idaho Labs Thermocouples

EXAMPLE:

125-Ks-I600-H-EW-UNG-24"IM-MP

(A)-(B)-(C)-(D)-(E) - (F) - (G) - (H) (OTHER)

The first five (5) sections of the part number ("A" to "E") describe the mineral insulated cable to be used. The others ("F" thru "Other") describe the thermocouple design and components.

A. NOMINAL OUTSIDE DIAMETER OF SHEATH (in thousandths of an inch).

A two (2) number description is denotes a dual diameter probe.

EXAMPLE: 062/125-XXXXXXXXXX is .062" at the tip, the balance of the immersion length will be .125" diameter.

B. TYPE OF THERMOCOUPLE CALIBRATION:

1. Follows the ANSI system for "normal" calibrations, and uses special characters for non-standard types.

EXAMPLE: XXX-M-XXXXXXXXXX

The -M- designates a Nickel / Nickel-Moly thermocouple, also known as Alloy 19 vs. Alloy 20.

2. This area also designates the number of conductors.

EXAMPLE: XXX-K-XXXXXXXXXX is two (2) wire. XXX-KK-XXXXXXXXXX is four (4) wire.

XXX-KKK-XXXXXXXXXX denotes six (6) wires.

3. An "s" after the calibration letter designates special limits of error wire calibration.

(NOTE: special limits of error platinum/rhodium alloys will be called out in the (other) category to avoid confusion with four-wire "S" calibration.)

4. A number in brackets () will call out the conductor diameter if required.

EXAMPLE: XXX-R(020)-XXXXXXXXXX designates 24 awg (.020"diameter) wire.

C. SHEATH MATERIAL or MATERIALS (for composite sheath TC's):

EXAMPLE: XXX-X-AL2O3HF-XXXXXXXXXX calls for a hard-fired aluminum oxide ceramic sheath.

EXAMPLE: XXX-X-P10R/I600-XXXXXXXXXX calls for a Platinum /10% Rhodium sheath on the tip, and the balance of the probe will be Inconel Alloy 600.

D. DESCRIPTION OF THE INSULATION PURITY: Choose from either High-Purity or Standard Purity.

EXAMPLE: XXX-X-XXXX-H-XXXXXX

The letter -H- designates a high purity MgO of 99.4% minimum. If no letter is used in this area the insulation is standard purity MgO with a minimum purity of 96.4%

E. SPECIAL DESCRIPTION AREA: This is left blank unless needed.

EXAMPLE: XXX-X-XXXX-X-EW-XXXXXXXXXX

The -EW- is a call out for mineral insulated cable that has equal wall and wire thickness.

F. JUNCTION INFORMATION: Choose the type of junction based on the application.

EXAMPLES:

- **GND** - grounded junction where the wires are welded into sheath.
- **UNG** - isolated or ungrounded junction: the junction is electrically isolated from the sheath.
- **UNC/UNG** - the wire pairs are welded together and are not in contact with other pairs or the sheath.
- **EXP** - the wires are welded together and extend past the end of sheath. Usually the insulation is sealed to prevent contamination from entering the probe (the seal material depends on the application).

Calibration Standards

Calibration Standards

Description: Calibration standard type "S" Platinum 10% Rhodium vs. pure Platinum. Reference grade wire certified to ITPS-90 is used to manufacture each standard. Each standard will be calibrated against an N.I.S.T. traceable thermocouple. Temperature vs. emf data will be furnished with each standard, as well as complete documentation traceable to the N.I.S.T. standard. Recalibration services are offered for standards manufactured by Idaho Labs Corp or other companies.

Specifications:

- Wire size 24 awg .5mm (.020")
- Standard immersion length is 600mm (24"). Other lengths are also available.
- Insulation is provided by a high purity, hard fired, aluminum oxide insulator which is 3.2mm (.125") diameter. A closed end protection tube is offered if desired. This ceramic is 6.35mm (.250") outside diameter.
- The non-sensing end of the standard can be furnished with a variety of terminations. Some of the options available are:
 - a. Compensating alloy male plug with a tube adapter clamped to the protection tube.
 - b. Transition fitting to compensating alloy flexible lead wire.

Note: To achieve the highest accuracy, a transition fitting using the same type "S" wire as the standard should be used up to the ice point. From the ice point, flexible copper leads will be used.

Calibration standard with compensated plug



Calibration standard with compensated lead wire



Wire Loop Resistance

Loop Resistance (Ohms per foot) For Thermocouple Wire of Various Diameters

Ohms per circular mil foot (a constant)		585	800	356	721	308
Wire						
Diameter (inches)	AWG	K	N	J	E	T
.460	0000	.00276	.00378	.00168	.00341	.00146
.4096	000	.0035	.0048	.0021	.0043	.0018
.3648	00	.0044	.0060	.0027	.0054	.0023
.3249	0	.0055	.0076	.0034	.0068	.0029
.2893	1	.0070	.0096	.0043	.0086	.0037
.2576	2	.0088	.0121	.0054	.0109	.0046
.2294	3	.0111	.0152	.0068	.0137	.0059
.2043	4	.0140	.0192	.0085	.0173	.0074
.1819	5	.0177	.0242	.0108	.0218	.0093
.162	6	.0223	.0305	.0136	.0275	.0117
.1443	7	.0281	.0384	.0171	.0346	.0148
.1285	8	.0354	.0484	.0216	.0437	.0187
.1144	9	.0447	.0611	.0272	.0551	.0235
.1019	10	.0563	.0770	.0343	.0694	.0297
.0907	11	.0711	.0972	.0433	.0876	.0374
.0808	12	.0896	.1225	.0545	.1104	.0472
.072	13	.113	.154	.069	.139	.059
.0641	14	.142	.195	.087	.175	.075
.0571	15	.179	.245	.109	.221	.094
.0508	16	.227	.310	.138	.279	.119
.0453	17	.285	.390	.173	.351	.150
.0403	18	.360	.493	.219	.444	.190
.0359	19	.454	.621	.276	.559	.239
.032	20	.571	.781	.348	.704	.301
.0285	21	.720	.985	.438	.888	.379
.0254	22	.907	1.240	.552	1.118	.477
.0226	23	1.15	1.57	.697	1.412	.603
.0201	24	1.45	1.98	.881	1.785	.762
.0179	25	1.83	2.50	1.11	2.25	.961
.0159	26	2.31	3.16	1.41	2.85	1.22
.0142	27	2.90	3.97	1.77	3.58	1.53
.0126	28	3.68	5.04	2.24	4.54	1.94
.0113	29	4.58	6.27	2.79	5.65	2.41
.010	30	5.85	8.00	3.56	7.21	3.08
.0089	31	7.39	10.10	4.49	9.10	3.89
.008	32	9.14	12.50	5.56	11.27	4.81
.0071	33	11.60	15.87	7.06	14.30	6.11
.0063	34	14.74	20.16	8.97	18.17	7.76
.0056	35	18.65	25.51	11.35	22.99	9.82
.005	36	23.40	32.00	14.24	28.84	12.32

Insulation Resistance of Mineral Insulated Cable

Insulation Resistance of Mineral Insulated Cable

The following information is compiled from published technical references and taken from actual testing performed at Idaho Laboratories Corporation. Actual results will vary. **The following information should be used as a guide only.**

The table below refers to three common mineral oxides: Aluminum Oxide, Magnesium Oxide, and Hafnia Oxide when used as electrical insulation in mineral insulated cable with a metallic sheath. The insulation resistance will vary with purity, types of impurities in the ceramic, compaction, thickness of insulation, and temperature.

The approximate electrical resistances of these ceramics in mineral insulated cable are listed below. These values are averaged from many sources and should be used for comparison only. Resistance is in ohms/mm of insulation thickness with an applied voltage of 10 to 500 vdc for short lengths of mineral insulated cable. These are the maximum values observed. Inspection values for longer lengths or thinner insulation thickness will be reduced.

Temperature	Al ₂ O ₃	MgO 99.4%	MgO 96.4%	HfO ₂
25°C	100,000 meg	100,000 meg	10,000 meg	10,000 meg
400°C	10,000 meg	10,000 meg	1,000 meg	10,000 meg
800°C	10 meg	10 meg	1 meg	10,000 meg
1000°C	1 meg	1 meg	25 kilo	8,200 meg
1200°C	25 kilo	25 kilo	10 kilo	170 meg
1500°C	10 kilo	10 kilo	1,000 ohms	3 meg

The use of MgO and Al₂O₃ at temperatures above 1300°C for compacted mineral insulated cable is not advised. The rapid loss of insulation resistance at these elevated temperatures is pronounced. If these materials are required, the insulation thickness should be increased.

The maximum temperature limit for Hafnia oxide is approximately 2500°C. The upper temperature limit for an assembly will be determined by the maximum temperature limits of the individual components. Example: cable made with a 316 SST sheath will have a maximum service temperature of 900°C while the ceramic insulation will have a higher rating.

Compaction density of the ceramic will greatly affect insulation resistance. The values listed above are with maximum densities, obtained only by swaging. Lesser compaction densities obtained by drawing usually produce insulation resistances decreased by one decade (ie 1×10^{-1}).

Mineral Insulated Cable Part Number System

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Mineral insulated cable (MIC) consists of three basic components.

Sheath: The outside covering which shields and protects the conductors and insulation from harm or contamination. This metal sheath is compacted around the inner components and is in direct contact with the insulation. The unique property of MIC, as compared to a simple tube with wires inserted inside, is the great flexibility of this design. The normal MIC can be coiled around a mandrel that is 4 times the diameter of the cable. In some applications, it is possible to coil MIC around a mandrel that is 2 times the diameter of the cable.

Insulation: The most common material furnished is magnesium oxide (MgO). Typical compaction density is between 70% to 75%. ILC furnishes MgO insulation in three purity grades:

- **Low Purity:** Commercial grade having a minimum purity of 96.4%.
- **High Purity:** Used in applications above 1700° F. This insulation has a minimum purity of 99.4%. We also offer this material that meets ASTM E1652 Table 1 requirements.
- **Ultra High Purity:** This insulation has a minimum purity of 99.8%. This grade meets the requirements of ASTM E-235 and ASTM E-2181.

Other ceramic insulating materials such as alumina oxide (Al_2O_3) and hafnia oxide (HfO_2), which has a temperature rating of 2500°C, are also available upon request.

Conductor(s): Thermocouple cable commonly contains 2 wires. There are normally 1 to 8 wires placed in MIC. The most common conductors are nickel alloys used as thermocouples, resistance heating alloys, or conductor alloys.

For a single pair of thermocouple wires, a single letter is used. For multiples, add another letter. Duplex is "KK", triplex is "KKK", etc. We offer up to 9 pairs inside a single cable. Our standard construction is parallel.

Duplex Cable Options – Adjacent (Parallel) and Alternating (Diagonal) Cable



Figure 1: **Parallel construction** of the Duplex (4-wire) Thermocouple Cable. This is the standard configuration made at Idaho Labs.



Figure 2: **Diagonal Construction** of Duplex Cable. The red circles denote negative wires. This configuration is available upon request. Known as alternating or "DIAG".

The red circles show the location of the negative thermocouple wires

Example of MIC part number system:

250-KKS-316-H-HW-DIAG

(a) (b) (c) (d) (e)

- (a) Outside diameter of sheath in thousandths of an inch
- (b) Calibration or type of conductors, quantity of conductors, and limits of error
- (c) Sheath material
- (d) Insulation material
- (e) Special information (multiple requirements separated by dashes)

This part number describes a cable that has a diameter of 1/4", a type "K" calibration, four wire (duplex), special limits of error. The sheath alloy is 316 stainless steel. The insulation is high purity MgO. The next two letters designate a special construction of heavy wall thickness. The final section "DIAG" references the alternating positive and negative wire configuration.

Idaho Laboratories Corporation



WE OFFER SOLUTIONS

SPECIALTY THERMOCOUPLES

We offer many different styles of specialty and multipoint thermocouples; the optimized multipoint (OMP), the proprietary C317/C329 and standard multipoint probes. We also offer other specialty probes including different sheath materials (ceramic, exotic metals, and super alloys), reduced tip thermocouples, and x-ray quality junctions. The HTIR-TC (High-Temperature Irradiation Resistant thermocouple is the newest addition to our repertoire. It was proven in the AGR 5-6-7 test cycle in the Advanced Test Reactor at Idaho National Laboratories to withstand 1500°C for over 6 months with almost no drift (~1%).

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SELECTION

We excel at specialty, exotic & multi-point thermocouples, as well as thermocouples for the nuclear industry. We offer mineral insulated thermocouple cable, platinum and noble metal thermocouple wire, custom thermocouples, and mineral insulated heaters for almost any application.

TESTING

Do you need PMI (positive material identification) of your finished parts, or have lost traceability on some materials? We can solve that. With our SciAps XRF analyzer, we can distinguish between the hardest alloys. Differentiating between 304, 321, 316, and 347 is no problem. We also offer X-ray services. Backed by our in-house ASNT Level III RT and in-house equipment, fast turn-around is possible. Helium leak testing and visible dye penetrant (PT) are also offered.

QUALITY

Do you need a supplier for aerospace or nuclear quality parts? We can help with that. We have recently completed supplier audits to NQA-1 and AS9100 requirements. Our NQA-1 audit team can help provide the assurance that your requirements are understood and will be met.



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