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CABLE - FUSIBLE LINK – PRIMARY - THICK WALL FLAME RESISTANT

1.0 General

1.1 Purpose of the Standard

This standard defines low tension primary cable made with stranded bare copper conductor and insulated with a crosslinked polyethylene insulation.

1.1.2 Purpose of the Material

The cable defined in this standard is used for fusible link applications, where heat resistance, abrasion resistance and flame resistance are desired.

1.2 Scope

1.2.1 Application

This standard is for use in automotive wire harness fusible link applications. This standard is limited in its application to those drawings or engineering illustrations which call out this standard number, or which refer to this standard within some other standard or specification.

1.2.2 Coverage of this Standard

This standard defines the construction and physical requirements of the cable.

1.2.3 Correlation to other Standards

The cable described in this standard meets or exceeds the dimensional, abrasion, and pinch requirements of SAE J1128 type SXL and meets or exceeds all the requirements of SAE J156.

2.0 Requirements

Note: In the following sections metric values are not always direct conversions of the English values, For metric tables (AWG) is for reference only.

2.1 Material Characteristics

2.1.1 Construction

This cable shall be built up as follows in Table 1 for the various gauge sizes.

Table 1

	Size-AWG	22	20	18	16	14
	Insulation Preferred Color	White	Orange	Gray	Dark Blue	Red
	Core (bare copper)	7/30	7/28	19/.0092	19/29	19/27
<D>	Circ Mil Area (min)	672	1072	1537	2336	3702
	Cond. Dia (Ref Only) (in.)	0.030	0.038	0.046	0.057	0.071
	Nom. Ins. Wall (in.)	0.030	0.030	0.030	0.030	0.030
	Mimimum Wall (in)	0.026	0.026	0.026	0.026	0.026
<D>	Minimum O.D. (in.)	0.086	0.094	0.102	0.113	0.127
<D>	Maximum O.D. (in.)	0.096	0.106	0.114	0.129	0.139

	Size-AWG	12	10	8	6
	Insulation Preferred Color	Black	Dark Green	Light Blue	None
	Core (bare copper)	19/25	19/23	19/21	37/21
<D>	Circ Mil Area (min)	5833	9343	14810	28835
	Cond. Dia (Ref Only) (in.)	0.090	0.113	0.143	0.200
	Nom. Ins. Wall (in.)	0.030	0.030	0.043	0.043
	Minimum Wall (in)	0.026	0.026	0.030	0.030
<D>	Minimum O.D. (in.)	0.144	0.177	0.214	0.266
<D>	Maximum O.D. (in.)	0.164	0.199	0.244	0.306

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	Size – Metric mm^2	0.35 (22)	0.5 (20)	0.8 (18)	1.0 (16)	2.0 (14)
	Insulation Preferred Color	White	Orange	Gray	Dark Blue	Red
	Core (bare copper)	7/.25	7/.31	19/.23	19/.28	19/.36
<D>	Cond. Area (min) (mm^2)	0.315	0.508	0.760	1.130	1.850
	Cond Dia. (Ref Only) (mm)	0.76	0.95	1.160	1.410	1.810
	Nom. Ins Wall (mm)	0.76	0.76	0.76	0.76	0.76
	Minimum Wall (mm)	0.66	0.66	0.66	0.66	0.66
<D>	Minimum O.D. (mm)	2.18	2.39	2.59	2.87	3.22
<D>	Maximum O.D. (mm)	2.44	2.69	2.90	3.28	3.53

	Size – Metric mm^2	3.0 (12)	5.0 (10)	8.0 (8)	13.0 (6)
	Insulation Preferred Color	Black	Dark Green	Light Blue	None
	Core (bare copper)	19/.45	19/.57	19/.72	37/.72
<D>	Cond. Area (min) (mm^2)	2.91	4.65	7.75	12.3
	Cond Dia. (Ref Only) (mm)	2.27	2.87	3.62	5.08
	Nom. Ins Wall (mm)	0.76	0.76	1.09	1.09
	Minimum Wall (mm)	0.66	0.66	0.75	0.75
<D>	Minimum O.D. (mm)	3.66	4.50	5.43	6.76
<D>	Maximum O.D. (mm)	4.17	5.05	6.20	7.77

2.1.2 Conductor

The copper conductor must be uniformly annealed and have a clean finish. The cross-sectional area of stranded conductors shall not be less than the values specified in section 2.1.1, which allows for the effects of stranding. The conductors shall conform to ASTM B3. The cross-sectional area may be verified by measuring actual strand sizes or by using the weight method in ASTM B263 with a calculated factor to account for the twist loss.

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2.1.3 Insulation

2.1.3.1 Insulation Specifications

A thermosetting insulation, homogeneous in character, shall be placed concentrically within commercial tolerance about the conductors. The insulation shall adhere closely to, but strip readily from the conductor without fracturing any strands, leaving the conductor in suitable condition for termination.

<D> The outside diameter of the finished cable shall be measured at five separate cross-sections, spaced approximately 2 inches (50 mm) apart and rotated approximately 90 deg between readings, with an optical device accurate to at least .001 inch (.02 mm). Other devices of equal or greater accuracy may be used; however, in case of a dispute, the optical device shall be the referee. A minimum of 3 readings separated by approximately 60 deg shall be taken at each cross-section and averaged to determine the outside diameter for that cross-section. The mean of the five readings shall determine the cable diameter. All 5 cross-sectional readings must fall within the max and min requirements of section 2.1.1.

The minimum wall thickness measured at any cross section shall not be less than 80% of the nominal wall thickness with a mean of not less than 90% of the nominal wall thickness from five readings at 16 inch (400 mm) intervals using the equipment described above.

2.1.3.2 Insulation Cross-Link Test

Cure completeness can be tested by bending a 24 inch (600 mm) sample of finished cable a minimum of 135 deg around a .25 inch (6 mm) mandrel and placing the mandrel and cable against a hot plate, preheated to 437°F - 527°F (225°C - 275°C), with a force of 1.0 - 1.5 lbs (5 -7 newtons) for 5 - 6 seconds. Do not rub or scrape the cable against the hot plate. After removal of the cable from the hot plate, verify that the copper conductors are not visible through the insulation where the cable made contact with the hot plate and that the sample passes the dielectric requirements of section 2.2.2.

2.1.4 Identification

Identification shall be in accordance with the requirements of section 2.1.5. For the purpose of stock identification, use one of the following options:

A. Solid color wire with the legend "Fusible Link" (1/64" min high characters) printed every 3 inches (76 mm), using contrasting color lettering to the base color.

B. Solid color or striped wire with contrasting color band(s) or dots located every 1 to 3 inches (25 to 76 mm).

2.1.5 Color

2.1.5.1 Single Color Wire

The colors of the cable shall match the colors listed in Table 1 as set forth by Munsell Color Notations. The wire color may be dyed or painted on the insulation. The applied color shall withstand the oil soak of section 2.3.5, and 100 hours of 100% condensing humidity at 212° F (100° C) without changing from its original color range as defined by Table 1. The coloring shall not crack or separate from the cable when subjected to the cold bend test of section 2.3.3.

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2.1.5.2 Two Color Wire

Identification of cable is obtained by a solid base color with single or double continuous stripes of a second color extending laterally or spirally along the conductor 180 deg apart. Stripe color must be readily distinguishable from the base color on all size conductors but need not match the color reference of
Table 1.

Note:

1. Comparison must be made by a person with normal color sensitivity, under cool white fluorescent lighting. The surface being inspected and the tolerance set must be in the same plane. Cable samples must be placed flat, overlapping the color standard.

2. Color Tolerance Reference Sets are available from SAE, 400 Commonwealth Drive, Warrendale PA 15096.

2.2 Performance Requirements of the Material

2.2.1 High Temperature

2.2.1.1 Long Term

Withstand a temperature of 100 ± 2° C for 3000 hours (125 days) as described in the procedure listed in section 2.3.1.

2.2.1.2 Short Term

Withstand a temperature of 125 ± 2°C for 240 hours (10 days) as described in the procedure listed in section 2.3.1.

2.2.2 Dielectric

After immersion in a 5% salt solution for 5 hours and while still immersed, withstand 1 kV (rms) at 50 - 60 Hz for one minute without puncture of the insulation as described in section 2.3.2.

2.2.3 Cold Bend

After maintaining a temperature of –40 ± 3°F (-40 ± 2°C) for 3 hours, and while still at this low temperature, pass the cold bend test of section 2.3.3 without revealing any cracks or splits, then pass the dielectric test of section 2.3.2.

2.2.4 Flame

The sample shall be suspended taut at 45 deg to a horizontal plane over a flame for 15 seconds. After removal of the flame, the sample shall extinguish in less than 1 second as described in the procedure listed in section 2.3.4.

2.2.5 Fluid Compatibility

Meet the fluid compatibility requirements specified in Table 3 per the method described in section 2.3.5.

2.2.6 Abrasion

Meet the abrasion requirements specified in Table 4 per the method of section 2.3.6.

2.2.7 Pinch

Meet the pinch requirements specified in Table 4 per the method of section 2.3.7.

2.2.8 Elongation

Minimum initial elongation of 200% and a minimum elongation of 125% after being aged for 240 hours (10 days) at 257 ± 3° F (125 ± 2°C) per method of section 2.3.8.

2.2.9 Fusible Link Testing

Cable shall meet all the requirements of SAE J156, with the additional requirement in the Short Circuit test that after the fusible link opens, the flame shall extinguish in less than 1 second.

2.3 Method of Testing

Note: General Test Conditions - Test samples for all tests shall be preconditioned for at least 24 h at a room temperature of 73 ± 5°F (23 ± 3°C). Unless otherwise specified, all tests shall be conducted at this same temperature.
Ovens - Unless otherwise specified, when an oven is required, it shall be a hot air oven. The air contained in the oven shall be completely changed at least 8 times but not more than 20 times per hour at the specified temperature.

2.3.1 High Temperature Test

A. One inch (25 mm) of the insulation shall be removed from each end of a 24 inch (610 mm) sample. The sample shall be suspended around a cylindrical mandrel specified in Table 2 with a weight attached to each end of the sample and placed in a circulating air oven at temperature and times specified in 2.2.1.

B. Allow the sample to cool to room temperature. Remove the weights and bend the sample in the reverse direction > 180 deg around the mandrel specified in Table 2 at a rate not to exceed one turn per minute. Perform the dielectric test of section 2.3.2.

Table 2, Bend Test

Gauge Size	High Temperature Test Mandrel Diameter (in)	(mm)	Suspension Weight (lb)	(kg)	Bend Test and Cold Test Mandrel Diameter (in)	(mm)	Suspension Weight (lb)	(kg)
22	1.0	25	0.5	0.22	1.0	25	1.0	0.44
20	1.0	25	0.5	0.22	1.0	25	1.5	0.68
18	1.0	25	0.5	0.22	1.0	25	1.5	0.68
16	2.0	50	1.0	0.45	1.0	25	1.5	0.68
14	3.0	75	1.0	0.45	3.0	75	3.0	1.40
12	3.0	75	2.0	0.91	3.0	75	3.0	1.40
10	4.0	100	2.0	0.91	5.0	125	3.0	1.40
8	4.0	100	2.0	0.91	5.0	125	5.0	2.27
6	5.0	125	2.5	1.14	6.0	150	7.0	3.18

2.3.2 Dielectric Test

Remove 1 inch (25 mm) of insulation from a 24 inch (610 mm) long sample of finished cable and twist the two ends together. The loop thus formed shall be immersed in salt water [5% NaCl by weight] at room temperature so that not more than 6 inches (150 mm) of each end of the sample protrudes above the solution. After 5 hours of immersion and while still immersed, the sample shall withstand the application of 1 kV (rms) at 50 - 60 Hz between the conductor and the salt solution for one minute without puncture of the insulation.

2.3.3 Cold Bend Test

Remove 1 inch (25 mm) of insulation from a 24 inch (610 mm) long straight sample of finished cable. The sample shall be placed in a cold chamber at a temperature and times specified in section 2.2.3. With the cable still at this low temperature, using the weight and mandrel specified in Table 2, wrap the sample around the mandrel a minimum of 180 deg at the uniform rate of one turn in 10 seconds. When using a revolving mandrel, fasten one end of the sample to the mandrel. The sample shall not reveal any visible cracks or splits. Return the sample to room temperature and perform the dielectric test of section 2.3.2.

2.3.4 Flame Test

Suspend a taut 24 inch (610 mm) sample of cable at 45 deg angle, within a partial enclosure which allows a flow of sufficient air for complete combustion but is free from drafts, over a natural gas Bunsen burner having a 1/2 inch (13 mm) inlet, a nominal bore of 3/8 inch (10 mm), and a length of about 4 inches (100 mm) above the primary inlets. Adjust the burner to produce a 4 inch (100 mm) flame with an inner cone one half its height. The tip of the inner cone shall be applied to the center of the cable for 15 seconds.

2.3.5 Fluid Compatibility Test

Ref. SAE J1128. Remove 1 inch (25 mm) of insulation from each end of 40 inch (1000 mm) samples of finished cable. A separate sample shall be used for each fluid. The original outside diameter shall be measured using the procedure described in section 2.1.3.1. The area of the sample to be subjected to the bend test shall be immersed in the fluid shown in Table 3 for a period of 20 (+1, -0) hour. After removal from the fluid, remove excess fluid from the sample and then condition the sample for 4 hours at room temperature. After conditioning, the outside diameter of the cable shall again be measured using the procedure in section 2.1.3.1. The mean of the diameter readings taken after conditioning shall be compared to the mean of the original diameter readings. The maximum diameter change shall be in accordance with Table 3. The conditioned sample shall be wrapped around a mandrel as specified in Table 2 for a minimum of 180 deg at a uniform rate of one turn in 10 seconds. A visual inspection shall reveal no cracks or splits. If no exposed conductor is visible, subject the sample to the dielectric test specified in section 2.3.2.

Table 3, Fluid Compatibility

Name	Fluid	Test Temp °C	Maximum OD Change %
Engine Oil	ASTM D471, IRM-902	50 ± 3	15
Gasoline	ASTM D471, Ref. Fuel C	23 ± 5	15
Ethanol	85% Ethanol + 15% ASTM D471, Ref. Fuel C	23 ± 5	15
Diesel Fuel	ASTM D471, 90% IRM 903 + 10% p-xylene	23 ± 5	15
Power Steering	ASTM D471, IRM-903	50 ± 3	30
Auto Trans	Citgo # 33123, SAE J311	50 ± 3	25
Engine Coolant	50% Distilled Water + 50% Ethylene Glycol	50 ± 3	15
Battery Acid	H_2SO_4 Specific Gravity = 1.260 ± .005	23 ± 5	5

2.3.6 Abrasion Test

Ref. SAE J1128 Type SXL. Remove one inch (25 mm) of the insulation from one end of a 36 inch (910 mm) sample of the finished wire. Place the sample taut, without stretching, between the cable clamps as shown in SAE J1128.

Using the weight support bracket and weight specified in Table 4, the sample shall then be subjected to the abrasion test with 10 mm conductive strips perpendicular to the edge of the sandpaper spread over a maximum of every 75 mm shall be used to abrade the insulation. After each reading the specimen shall be moved 2 inches (51 mm) and rotated clockwise 90 deg. Eight readings shall be obtained for each sample. Each test shall be performed using only those areas of the tape not previously used. Four readings shall be obtained for each sample the mean shall define the abrasion resistance of the cable under test.

NOTE: Use Norton Garnet R516 Tape; 150J Grit Paper (Red).

2.3.7 Pinch Test

Ref. SAE J1128. Remove one inch (25 mm) of insulation from one end of a 36 inch (910 mm) sample of finished cable. Place the sample taut, without stretching, across a 1/8 inch (3 mm) diameter steel bar and subjected to the force of a weighted steel anvil. Increasing weight shall be applied to the steel anvil at a rate of 5 lb (2.3 kg) per minute with a lever advantage of 10. At the moment the insulation is pinched through, the 1/8 inch (3 mm) diameter rod will contact the sample conductor and the test shall stop. The weight in the receptacle shall then be recorded. After each reading the specimen shall be moved 2 inches (50 mm) and rotated clockwise 90 deg. Four readings shall be obtained for each sample. The average (arithmetic mean) shall define the pinch resistance of the cable under test. See Table 4.

Table 4, Abrasion and Pinch Resistance

Gauge Size	Minimum Abrasion Resistance		Abrasion Weight Support Bracket	Abrasion Weight		Minimum Pinch Resistance	
	(in)	(mm)		(lb)	(kg)	(lb)	(kg)
22	18	450	A	1.0	0.45	12	5.5
20	22	550	A	1.0	0.45	18	8.2
18	28	700	A	1.0	0.45	20	9.1
16	33	850	A	1.0	0.45	22	10
14	39	1000	B	1.0	0.45	25	11
12	20	500	B	3.0	1.36	27	12
10	24	600	B	3.0	1.36	33	15
8	35	900	B	3.0	1.36	36	16
6	10	250	C	8.8	4.0	N/A	N/A

2.3.8 Elongation Test

A straight specimen, of sufficient length to permit installation in the grips used in the test, shall have the copper conductor removed. Parallel gauge marks shall be located perpendicular to the longitudinal axis at 1 inch (25 mm) on either side of the center of the specimen. The distance between the grips of the test machine shall be 4 inches (100 mm). The rate of travel shall be 2 inches (50 mm) per minute, and shall be uniform at all times.

Calculate Elongation by:

$$\text{Elongation, \%} = (L - L_0) \ / \ L_0 \times 100$$

Where: L = Observed distance between gauge marks on the specimen at rupture.
L_0 = Original distance between gauge marks = 2 inch (51 mm).

Discard results on specimens that break outside the gauge marks and retest.

3.0 Control

3.1 Shipping Container

All Wire shall be shipped on non-returnable reels or containers as specified on purchase requisitions. Each reel or container shall be tagged to show the following:

Manufacturer's Name
Date of Manufacture
Amount in Feet
Color(s)
Order Number
Date of Shipment
Yazaki North America Spec Number, Gauge, and Change Letter Level.

Material shall only be purchased from those sources appearing on the Engineering Approved Source List (EASL), included as an addendum to this standard.

3.2 Material

3.2.1 Insulation

Only virgin materials are to be extruded for this material application. Commercially reprocessed materials are not to be used. All insulation materials utilized shall be lead-free. The finished insulated conductor shall contain no, and be manufactured without the use of, chloroflurocarbons (CFCs) or any known ozone depleting substance.

3.3 Supplier Accountability

The supplier shall not ship materials whose compositions, characteristics, or properties differ from samples submitted to and approved by Yazaki North America, Inc. No more than one strand break per thousand feet will be allowed.

4.0 Contacts

Questions concerning this standard should be directed to Yazaki North America, EDS Engineering / Engineered Materials Development.

5.0 References

5.1 ASTM Standard

ASTM B3 --- Standard Specification for Soft or Annealed Copper Wire
ASTM B263 --- Method for Determination of Cross-Sectional Area of Standard Conductors
ASTM D471 --- Standard Test Method for Rubber Property – Effect of Liquids

5.2 SAE Specifications

SAE J156 --- Fusible Links
SAE J1127 --- Low Tension Battery Cable
SAE J1128 --- Low Tension Primary Cable

6.0 Engineering Approved Source List

SUPPLIER	SUPPLIER CODE	ADDITIONAL INFORMATION
Champlain Cable Corporation 175 Hercules Drive Colchester, VT 05446 (802) 654-4200	Radox-FL	

7.0 Bibliography

By entering the names of the approvers listed below, the writer is stating that the approver has reviewed this Material Standard AS SUBMITTED and concurs with its contents.

Date Standard Originally (Initially) Issued: February 22, 2001
Department Name / Number: EDS Engineering / Engineered Materials Development / 8711.
Current Contact / Phone: V. Neng Kue / (734) 983-3146
Alternate Contact / Phone: Mike Chopp / (734) 983-3180

Date of Change: March 22, 2002
Change Level: B
Description of change:

* Department name change in Title Block and Bibliography
* Section 6.0: Add supplier code product name
* Grammatical corrections.

RADXL FLK

Fusible Link Wire
-40 - 105°C

RADXL FLK is a high performance wire designed specifically for fusible-link applications. Fuse-link wires are designed to "open" a circuit when extreme overload occurs. A Fusible link is not intended to replace a fuse, instead, it is to be used in conjunction with a fuse. It is primary used in high amperage applications especially battery cables. RADXL FLK is designed to protect the wiring harnesses and circuit from a direct electrical short. When there is a direct electrical short, the fuse-link wire will heat to a high temperature and melt the conductor without creating a fire or dripping hot melt insulation.

The high temperature performance and fluid resistance of FLK means it will survive the harsh engine compartment environment. Superior abrasion and pinch resistance ensures durability. Irradiation cross-linked insulation will not melt or catch on fire and will prevent the melted copper conductor from escaping. Normal current flow will not generate enough heat to warn the wire up. Normal current flow does not result in significant voltage drop.

FXL processes very well on automated high speed cut and strip equipment. The end result is a fuse-link wire that performs safely time after time.

Benefits and Features

Fluid Resistant
–40°C to 105°C Temperature Range
Superior Processing
Will not Melt
Will Not Start a Fire
Retains melted copper conductor

Applications

Including but not limited to:
Battery Cables
Power Distribution
Starter wires

Part Number	Standard Conductors Bare Copper	Nom. Dia of Conductor		Insulation Thickness		Nom. OD		Finished Weight (lbs/mft)	AWG size Circuit Protection
		in.	mm.	in.	mm.	in.	mm.		
RADXL-FLK20-XX	20 (7/28)	.038	0.97	.030	.76	.099	2.51	6.83	16
RADXL-FLK18-XX	18 (19/.0092)	.045	1.19	.030	.76	.106	2.69	9.54	14
RADXL-FLK16-XX	16 (19/29)	.057	1.83	.030	.76	.121	3.07	12.63	12
RADXL-FLK14-XX	14 (19/27)	.071	1.85	.030	.76	.133	3.38	17.72	10
RADXL-FLK12-XX	12 (19/25)	.090	2.27	.030	.76	.154	3.91	26.45	8
RADXL-FLK10-XX	10 (19/23)	.112	2.84	.030	.76	.188	4.78	39.45	6
RADXL-FLK8-XX	8 (19/21)	.143	3.62	.043	1.09	.229	5.82	60.56	4
RADXL-FLK6-XX	6 (37/21)	.200	5.08	.043	1.09	.286	7.26	106.58	2

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RADXL FLK

Property / Attribute			SAE J-1128 TXL Req.	RADXL FLK 16 AWG Typical Performance
Flex Life				
Flex Test	Per Modified ISO 14572		NA	NA
Dielectric Strength				
Dielectric Test	Wet Dielectric after 5 hour soak		1 kV 1 min.	5 kV 30 min.
Flame Resistance				
Flame Test	Flame test 45o angle, 15 seconds		<15	<1
Thermal Performance				
Cold Bend	4 hours at temperature no cracks / breakdown		-40^{0}C	-40^{0}C
Temperature Rating	240 Hours @180^{0}C heat aging		125^{0}C	125^{0}C
Temperature Rating	3000 Hours @150^{0}C		100^{0}C	105^{0}C
Mechanical Properties				
Tensile	Minimum psi		No Requirement	1676
Elongation	Minimum %		200	243
Abrasion	Sand Paper Resistance Length cm.		850	2818
Abrasion	Scrape Cycles		None	NA
Pinch	Pounds		22	28
Fusiblelink Testing				
Short Circuit	SAE J156		No Flame	No Flame
Fluids				
Engine Oil	ASTM D471, IRM-902	50 +/-3 ^{0}C	15% Max.	1.30%
Gasoline	ASTM D471 Ref. Fuel C	23 +/-5 ^{0}C	15% Max.	5.90%
Ethanol	85% Ethanol + 15% ASTM D471, Ref. Fuel C	23 +/-5 ^{0}C	15% Max.	2.20%
Diesel Fuel	ASTM D471, 90% IRM-903 + 10% p-xylene	23 +/-5 ^{0}C	15% Max.	5.00%
Power Steering	ASTM D471, IRM-903	50 +/-3 ^{0}C	30% Max.	2.80%
Auto Transmission	Citgo #33123 SAE-J311	50 +/-3 ^{0}C	25% Max.	3.50%
Engine Coolant	50% Ethylene Glyco + 50% distilled Water	50 +/-3 ^{0}C	15% Max.	3.00%
Battery Acid	H_2SO_4 Specific Gravity = 1.260 +/- .005	23 +/-5 ^{0}C	5% Max.	<.2%

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