

- pins of fixed connectors;
- open ends of fixed cables, or equivalents.

3.11

thermal response time

time a thermometer takes to respond at a specified percentage to a step change in temperature. To specify the response time, it is necessary to declare the percentage of response, usually $\tau_{0.9}$, $\tau_{0.5}$, or $\tau_{0.1}$, which gives the time for 90 %, 50 % or 10 % of the response. The test medium and its flow conditions have to be specified (usually flowing water and/or flowing air)

3.12

thermoelectric effect

effect of inducing the electro-motive force (EMF) caused by different metals used in the electric circuit of the thermometer and by thermoelectric inhomogeneity of the internal leads at the conditions of temperature gradients along the leads. The induced EMF is measured across the terminals of the thermometer while the thermometer is subjected to a specified temperature

3.13

tolerance

initial¹ maximum allowable deviation expressed as $\Delta t(t)$ in °C from the nominal temperature/resistance relationship $R(t)$

3.14

hysteresis

property of a device or instrument whereby it gives different output values in relation to its input values depending on the directional sequence in which the input values have been applied

[IEC 61298-1, 3.13]

NOTE Hysteresis as defined in IEC 61298-1 can be applied to thermometers by the method described in 6.5.6 of this standard

4 Characteristics

The temperature/resistance relationships and tolerances in this chapter are valid for the sensing resistors at its connecting points. For thermometers, they are valid for the complete thermometer at its terminals.

In the case of two-wire connections, the resistance values of the leads between the connecting point of the resistor and the terminals shall be considered. They may be indicated on the thermometer and shall be subtracted from measured resistances. In some cases, it also may be advisable to consider the temperature coefficient of the lead wires, the geometrical characteristics of the wires and the temperature distribution along their length.

4.1 Temperature/resistance relationships

The temperature/resistance relationships used in this standard are as follows:

For the range –200 °C to 0 °C:

$$R_t = R_0[1 + At + Bt^2 + C(t - 100^\circ\text{C}) t^3]$$

For the range of 0 °C to 850 °C:

¹ First calibration before any use of the resistor or thermometer.

$$R_t = R_0(1 + At + Bt^2)$$

where

R_t is the resistance at the temperature t ;

R_0 is the resistance at $t = 0$ °C.

The constants in these equations are:

$$A = 3.9083 \times 10^{-3} \text{ } ^\circ\text{C}^{-1}$$

$$B = -5.775 \times 10^{-7} \text{ } ^\circ\text{C}^{-2}$$

$$C = -4.183 \times 10^{-12} \text{ } ^\circ\text{C}^{-4}$$

These equations and coefficients have been used to derive the table of resistance values, Table 1, for a platinum resistor of nominal resistance $R_0 = 100 \text{ } \Omega$.

4.2 Resistance values

The temperature/resistance relationship in Table 1 is given for a resistor with nominal resistance of $100 \text{ } \Omega$. For other nominal resistances R_0 , such as; $10 \text{ } \Omega$, $500 \text{ } \Omega$ or $1\,000 \text{ } \Omega$, the table can be used by multiplying the table values with the factor $R_0 / 100 \text{ } \Omega$.

Table 1 – Temperature/resistance relationship, $R_0 = 100.00 \Omega$

t ₉₀ /°C	Resistance at the temperature t ₉₀ /°C										t ₉₀ /°C
	Ω										
	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	
-200	18.52										-200
-190	22.83	22.40	21.97	21.54	21.11	20.68	20.25	19.82	19.38	18.95	-190
-180	27.10	26.67	26.24	25.82	25.39	24.97	24.54	24.11	23.68	23.25	-180
-170	31.34	30.91	30.49	30.07	29.64	29.22	28.80	28.37	27.95	27.52	-170
-160	35.54	35.12	34.70	34.28	33.86	33.44	33.02	32.60	32.18	31.76	-160
-150	39.72	39.31	38.89	38.47	38.05	37.64	37.22	36.80	36.38	35.96	-150
-140	43.88	43.46	43.05	42.63	42.22	41.80	41.39	40.97	40.56	40.14	-140
-130	48.00	47.59	47.18	46.77	46.36	45.94	45.53	45.12	44.70	44.29	-130
-120	52.11	51.70	51.29	50.88	50.47	50.06	49.65	49.24	48.83	48.42	-120
-110	56.19	55.79	55.38	54.97	54.56	54.15	53.75	53.34	52.93	52.52	-110
-100	60.26	59.85	59.44	59.04	58.63	58.23	57.82	57.41	57.01	56.60	-100
-90	64.30	63.90	63.49	63.09	62.68	62.28	61.88	61.47	61.07	60.66	-90
-80	68.33	67.92	67.52	67.12	66.72	66.31	65.91	65.51	65.11	64.70	-80
-70	72.33	71.93	71.53	71.13	70.73	70.33	69.93	69.53	69.13	68.73	-70
-60	76.33	75.93	75.53	75.13	74.73	74.33	73.93	73.53	73.13	72.73	-60
-50	80.31	79.91	79.51	79.11	78.72	78.32	77.92	77.52	77.12	76.73	-50
-40	84.27	83.87	83.48	83.08	82.69	82.29	81.89	81.50	81.10	80.70	-40
-30	88.22	87.83	87.43	87.04	86.64	86.25	85.85	85.46	85.06	84.67	-30
-20	92.16	91.77	91.37	90.98	90.59	90.19	89.80	89.40	89.01	88.62	-20
-10	96.09	95.69	95.30	94.91	94.52	94.12	93.73	93.34	92.95	92.55	-10
0	100.00	99.61	99.22	98.83	98.44	98.04	97.65	97.26	96.87	96.48	0
t ₉₀ /°C	0	1	2	3	4	5	6	7	8	9	t ₉₀ /°C
0	100.00	100.39	100.78	101.17	101.56	101.95	102.34	102.73	103.12	103.51	0
10	103.90	104.29	104.68	105.07	105.46	105.85	106.24	106.63	107.02	107.40	10
20	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.29	20
30	111.67	112.06	112.45	112.83	113.22	113.61	114.00	114.38	114.77	115.15	30
40	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01	40
50	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86	50
60	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69	60
70	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52	70
80	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33	80
90	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13	90
100	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91	100
110	142.29	142.67	143.05	143.43	143.80	144.18	144.56	144.94	145.31	145.69	110
120	146.07	146.44	146.82	147.20	147.57	147.95	148.33	148.70	149.08	149.46	120
130	149.83	150.21	150.58	150.96	151.33	151.71	152.08	152.46	152.83	153.21	130
140	153.58	153.96	154.33	154.71	155.08	155.46	155.83	156.20	156.58	156.95	140
150	157.33	157.70	158.07	158.45	158.82	159.19	159.56	159.94	160.31	160.68	150
160	161.05	161.43	161.80	162.17	162.54	162.91	163.29	163.66	164.03	164.40	160
170	164.77	165.14	165.51	165.89	166.26	166.63	167.00	167.37	167.74	168.11	170
180	168.48	168.85	169.22	169.59	169.96	170.33	170.70	171.07	171.43	171.80	180
190	172.17	172.54	172.91	173.28	173.65	174.02	174.38	174.75	175.12	175.49	190
200	175.86	176.22	176.59	176.96	177.33	177.69	178.06	178.43	178.79	179.16	200
210	179.53	179.89	180.26	180.63	180.99	181.36	181.72	182.09	182.46	182.82	210
220	183.19	183.55	183.92	184.28	184.65	185.01	185.38	185.74	186.11	186.47	220
230	186.84	187.20	187.56	187.93	188.29	188.66	189.02	189.38	189.75	190.11	230
240	190.47	190.84	191.20	191.56	191.92	192.29	192.65	193.01	193.37	193.74	240
250	194.10	194.46	194.82	195.18	195.55	195.91	196.27	196.63	196.99	197.35	250
260	197.71	198.07	198.43	198.79	199.15	199.51	199.87	200.23	200.59	200.95	260
270	201.31	201.67	202.03	202.39	202.75	203.11	203.47	203.83	204.19	204.55	270
280	204.90	205.26	205.62	205.98	206.34	206.70	207.05	207.41	207.77	208.13	280
290	208.48	208.84	209.20	209.56	209.91	210.27	210.63	210.98	211.34	211.70	290
300	212.05	212.41	212.76	213.12	213.48	213.83	214.19	214.54	214.90	215.25	300
310	215.61	215.96	216.32	216.67	217.03	217.38	217.74	218.09	218.44	218.80	310
320	219.15	219.51	219.86	220.21	220.57	220.92	221.27	221.63	221.98	222.33	320

Table 1 (continued)

$t_{90}/^{\circ}\text{C}$	Resistance at the temperature $t_{90}/^{\circ}\text{C}$										$t_{90}/^{\circ}\text{C}$
	Ω										
	0	1	2	3	4	5	6	7	8	9	
330	222.68	223.04	223.39	223.74	224.09	224.45	224.80	225.15	225.50	225.85	330
340	226.21	226.56	226.91	227.26	227.61	227.96	228.31	228.66	229.02	229.37	340
350	229.72	230.07	230.42	230.77	231.12	231.47	231.82	232.17	232.52	232.87	350
360	233.21	233.56	233.91	234.26	234.61	234.96	235.31	235.66	236.00	236.35	360
370	236.70	237.05	237.40	237.74	238.09	238.44	238.79	239.13	239.48	239.83	370
380	240.18	240.52	240.87	241.22	241.56	241.91	242.26	242.60	242.95	243.29	380
390	243.64	243.99	244.33	244.68	245.02	245.37	245.71	246.06	246.40	246.75	390
400	247.09	247.44	247.78	248.13	248.47	248.81	249.16	249.50	249.85	250.19	400
410	250.53	250.88	251.22	251.56	251.91	252.25	252.59	252.93	253.28	253.62	410
420	253.96	254.30	254.65	254.99	255.33	255.67	256.01	256.35	256.70	257.04	420
430	257.38	257.72	258.06	258.40	258.74	259.08	259.42	259.76	260.10	260.44	430
440	260.78	261.12	261.46	261.80	262.14	262.48	262.82	263.16	263.50	263.84	440
450	264.18	264.52	264.86	265.20	265.53	265.87	266.21	266.55	266.89	267.22	450
460	267.56	267.90	268.24	268.57	268.91	269.25	269.59	269.92	270.26	270.60	460
470	270.93	271.27	271.61	271.94	272.28	272.61	272.95	273.29	273.62	273.96	470
480	274.29	274.63	274.96	275.30	275.63	275.97	276.30	276.64	276.97	277.31	480
490	277.64	277.98	278.31	278.64	278.98	279.31	279.64	279.98	280.31	280.64	490
500	280.98	281.31	281.64	281.98	282.31	282.64	282.97	283.31	283.64	283.97	500
510	284.30	284.63	284.97	285.30	285.63	285.96	286.29	286.62	286.95	287.29	510
520	287.62	287.95	288.28	288.61	288.94	289.27	289.60	289.93	290.26	290.59	520
530	290.92	291.25	291.58	291.91	292.24	292.56	292.89	293.22	293.55	293.88	530
540	294.21	294.54	294.86	295.19	295.52	295.85	296.18	296.50	296.83	297.16	540
550	297.49	297.81	298.14	298.47	298.80	299.12	299.45	299.78	300.10	300.43	550
560	300.75	301.08	301.41	301.73	302.06	302.38	302.71	303.03	303.36	303.69	560
570	304.01	304.34	304.66	304.98	305.31	305.63	305.96	306.28	306.61	306.93	570
580	307.25	307.58	307.90	308.23	308.55	308.87	309.20	309.52	309.84	310.16	580
590	310.49	310.81	311.13	311.45	311.78	312.10	312.42	312.74	313.06	313.39	590
600	313.71	314.03	314.35	314.67	314.99	315.31	315.64	315.96	316.28	316.60	600
610	316.92	317.24	317.56	317.88	318.20	318.52	318.84	319.16	319.48	319.80	610
620	320.12	320.43	320.75	321.07	321.39	321.71	322.03	322.35	322.67	322.98	620
630	323.30	323.62	323.94	324.26	324.57	324.89	325.21	325.53	325.84	326.16	630
640	326.48	326.79	327.11	327.43	327.74	328.06	328.38	328.69	329.01	329.32	640
650	329.64	329.96	330.27	330.59	330.90	331.22	331.53	331.85	332.16	332.48	650
660	332.79	333.11	333.42	333.74	334.05	334.36	334.68	334.99	335.31	335.62	660
670	335.93	336.25	336.56	336.87	337.18	337.50	337.81	338.12	338.44	338.75	670
680	339.06	339.37	339.69	340.00	340.31	340.62	340.93	341.24	341.56	341.87	680
690	342.18	342.49	342.80	343.11	343.42	343.73	344.04	344.35	344.66	344.97	690
700	345.28	345.59	345.90	346.21	346.52	346.83	347.14	347.45	347.76	348.07	700
710	348.38	348.69	348.99	349.30	349.61	349.92	350.23	350.54	350.84	351.15	710
720	351.46	351.77	352.08	352.38	352.69	353.00	353.30	353.61	353.92	354.22	720
730	354.53	354.84	355.14	355.45	355.76	356.06	356.37	356.67	356.98	357.28	730
740	357.59	357.90	358.20	358.51	358.81	359.12	359.42	359.72	360.03	360.33	740
750	360.64	360.94	361.25	361.55	361.85	362.16	362.46	362.76	363.07	363.37	750
760	363.67	363.98	364.28	364.58	364.89	365.19	365.49	365.79	366.10	366.40	760
770	366.70	367.00	367.30	367.60	367.91	368.21	368.51	368.81	369.11	369.41	770
780	369.71	370.01	370.31	370.61	370.91	371.21	371.51	371.81	372.11	372.41	780
790	372.71	373.01	373.31	373.61	373.91	374.21	374.51	374.81	375.11	375.41	790
800	375.70	376.00	376.30	376.60	376.90	377.19	377.49	377.79	378.09	378.39	800
810	378.68	378.98	379.28	379.57	379.87	380.17	380.46	380.76	381.06	381.35	810
820	381.65	381.95	382.24	382.54	382.83	383.13	383.42	383.72	384.01	384.31	820
830	384.60	384.90	385.19	385.49	385.78	386.08	386.37	386.67	386.96	387.25	830
840	387.55	387.84	388.14	388.43	388.72	389.02	389.31	389.60	389.90	390.19	840
850	390.48										850

5 General requirements

5.1 Tolerance classes

5.1.1 Temperature range of validity

The temperature ranges of validity of tolerance classes for resistors given in Table 2 are based on the working experience with film and wire resistors showing that in these ranges most resistors can maintain their tolerances and other performance characteristics. The value of $-196\text{ }^{\circ}\text{C}$ was chosen as being close to the boiling point of liquid nitrogen.

5.1.2 Resistors

The tolerance values of resistors are classified in Table 2. These tolerances apply for resistors of any value of R_0 . Where the specified temperature range of a particular resistor is smaller than in this table, this shall be stated.

Table 2 – Tolerance classes for resistors

For wire wound resistors		For film resistors		Tolerance value ^a °C
Tolerance class	Temperature range of validity °C	Tolerance class	Temperature range of validity °C	
W 0.1	–100 to +350	F 0.1	0 to +150	$\pm (0.1 + 0.0017 t)$
W 0.15	–100 to +450	F 0.15	–30 to +300	$\pm (0.15 + 0.002 t)$
W 0.3	–196 to +660	F 0.3	–50 to +500	$\pm (0.3 + 0.005 t)$
W 0.6	–196 to +660	F 0.6	–50 to +600	$\pm (0.6 + 0.01 t)$

^a $|t|$ = modulus of temperature in °C without regard to sign.

5.1.3 Thermometers

The tolerance values of resistance thermometers are classified in Table 3. These tolerances apply for thermometers of any value of R_0 . Where the specified temperature range of a particular thermometer is smaller than in this table, this shall be stated.

Table 3 – Tolerance classes for thermometers

Tolerance class	Temperature range of validity °C		Tolerance values ^a °C
	Wire wound resistors	Film resistors	
AA	–50 to +250	0 to +150	$\pm (0.1 + 0.0017 t)$
A	–100 to +450	–30 to +300	$\pm (0.15 + 0.002 t)$
B	–196 to +600	–50 to +500	$\pm (0.3 + 0.005 t)$
C	–196 to +600	–50 to +600	$\pm (0.6 + 0.01 t)$

^a $|t|$ = modulus of temperature in °C without regard to sign.

5.1.4 Special tolerance classes and special temperature ranges of validity

Tolerances and ranges of validity which differ from values given in Table 2 and Table 3 shall be agreed between manufacturer and user. Recommended special tolerance classes are constructed as multiples or fractions of class B tolerance values. A special tolerance class