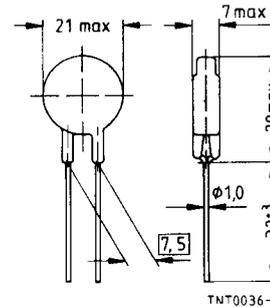


**Applications**

- Switch-mode power supplies
- Soft-start motors, e.g. in vacuum cleaners

**Features**

- Useable in series connections up to 265 V<sub>rms</sub>
- Coated thermistor disk
- Kinked leads of tinned, copper wire
- Wide resistance range
- Available on tape
- UL approval (E69802)



TNT0036-7

**Options**

Resistance tolerance < 20 % available on request

Dimensions in mm  
Approx. weight 4 g

Lower/upper category temperature		- 55/+ 170	°C
Max. power at 25 °C	$P_{max}$	5,1	W
Resistance tolerance	$\Delta R/R_N$	± 20 %	
Rated temperature	$T_N$	25	°C
B value tolerance	$\Delta B/B$	± 3 %	
Dissipation factor (in air)	$\delta_{th}$	approx. 24	mW/K
Thermal cooling time constant (in air)	$\tau_c$	approx. 100	s
Heat capacity	$C_{th}$	approx. 2400	mJ/K

Type	$R_{25}$	$I_{max}$	No of R/T char- acteristic	$B_{25/100}$	$C_T^{(1)}$	$C_T^{(1)}$	Parameters for $R(I)^{(1)}$		Ordering code <b>B57364-</b>
	Ω	(0 65 °C) A					K	μF	
<b>211-8018</b> S 364/1,0/M	1,0	16,0	1202	2800	1000	4000	0,766	- 1,30	S109-M
<b>211-8024</b> S 364/2,0/M	2,0	12,0	1203	2900	1000	4000	0,966	- 1,32	S209-M
S 364/2,5/M	2,5	11,0	1203	2900	1000	4000	1,04	- 1,32	S259-M
S 364/4,0/M	4,0	9,5	1308	3060	1000	4000	1,20	- 1,34	S409-M
<b>211-8030</b> S 364/5,0/M	5,0	8,5	1308	3060	1000	4000	1,29	- 1,34	S509-M
<b>211-8002</b> S 364/10/M	10	7,5	1304	3300	1000	4000	1,55	- 1,37	S100-M

1) For details on the capacitance  $C_T$  as well as on the parameters  $k$  and  $n$  refer to pages 33–35

**2.4 Load derating**

The power handling capability of an NTC thermistor cannot be fully utilized over the entire temperature range. For circuit dimensioning the derating curve given below provides information on the extent to which the current must be reduced at a certain ambient temperature.

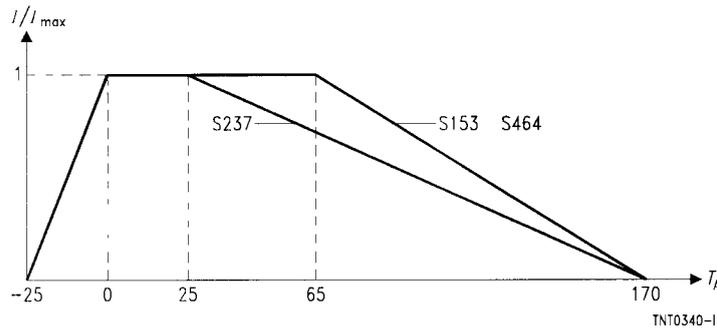


Figure 9  
Derating curve

The  $I_{max}$  values specified in the data sheets denote the maximum permissible continuous current (dc or rms values for sine-shaped ac) in the temperature range 0 °C to 65 °C.

**2.5 Restart**

When the load has been switched off the thermistor slowly cools down. Its resistance increases steadily, but the full resistance value is only reached after 1 to 2 minutes (depending on ambient temperature and type).

It may therefore be useful in some applications to bypass the thermistor during restart. Operation can thus be faster resumed and system performance will not be affected by the thermistor.

**2.6 Dependence of NTC resistance on current**

The resistance effective in the usual current range can be approximated as follows:

$$R_{NTC} = k \cdot I^n \quad 0,3 \cdot I_{max} < I \leq I_{max}$$

- $R_{NTC}$  Resistance value to be determined at current  $I$  [  $\Omega$  ]
- $k, n$  Fit parameter, see individual data sheets
- $I$  Current flowing through the NTC (insert numerical value in A)

The calculated values only serve as an estimate for operation in still air at an ambient temperature of 25 °C.

Note: With the equation above sufficiently accurate results are only obtained for the limited current range stated above.

## Application Notes

### 2.7 Pulse strength

The currents during turn-on are much higher than the rated currents during continuous operation. To test the effects of these current surges S+M uses the following standard procedure:

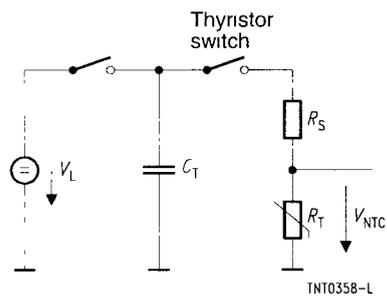


Figure 10

Test circuit for evaluating the pulse strength of an NTC thermistor

$V_L$	Load voltage [ V ]
$C_T$	Test capacitance [ $\mu\text{F}$ ]
$R_S$	Series resistance [ $R_S = 1 \Omega$ ]
$V_{NTC}$	Voltage drop across the NTC under test [ V ]

In the pulse test the capacitor  $C_T$  is discharged via the series resistor  $R_S$  and the NTC thermistor. The load voltage is chosen such that the voltage applied to the thermistor at the start of discharge is  $V_{NTC} = 358 \text{ V}$  (corresponds to  $(230 \text{ V} + \Delta V) \times \sqrt{2}$ ).

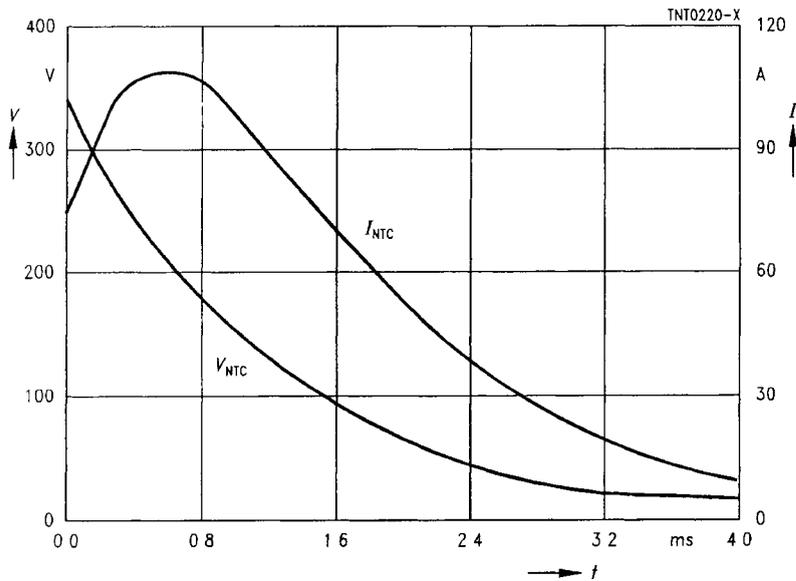


Figure 11  
Pulse strength test · typical curves

The maximum capacitances that can be switched depend on the individual thermistor type and are given in the data sheets

## 2.8 Applications

Inrush current limiters are primarily used in industrial electronics and equipment engineering. Application examples are

Inrush current limiting in fluorescent, projector and halogen lamps, rotational speed limiting in kitchen machines, soft start of motors and switch-mode power supplies etc

S+M thermistors are available in a variety of sizes and rated resistances to optimally match your application. The product line ranges from the small-size S153 with a maximum power of 1.4 W through to the at present largest S464 with a maximum power of 6.7 W. Maximum continuous ac currents of 20 A are reached. Inrush current limiters are presented on pages 76 to 84

## Standardized R/T Characteristics

---

### 1 Introduction

The  $R/T$  characteristics tabulated in the following have been standardized for the resistance value at 25 °C. The actual resistance values of a particular NTC thermistor are obtained by multiplying the ratio  $R_T/R_{25}$  (tabulated value) by the resistance value at 25 °C (specified in the data sheets)

$$R_T = \frac{R_T}{R_{25}} R_{25} \quad (1)$$

Resistance values at intermediate temperatures within the range of the subsequent temperature interval can be calculated by means of the temperature coefficient  $\alpha$

$\alpha$  is inserted in the following equation

$$R_T = R_{T_x} \exp\left[\frac{\alpha_x}{100} (T_x + 273,15)^2 \left(\frac{1}{T + 273,15} - \frac{1}{T_x + 273,15}\right)\right] \quad (2)$$

$R_T$	Resistance value at temperature $T$
$R_{T_x}$	Resistance value at the beginning of the relevant temperature interval
$T_x$	Temperature in °C at the beginning of the relevant temperature interval
$T$	Temperature of interest in °C ( $T_x < T < T_{x+1}$ )
$\alpha_x$	Temperature coefficient at temperature $T_x$

#### Example

Given	Curve 1006
	$R_{25} = 4,7 \text{ k}\Omega$
	$\alpha_5 = 4,4$
Unknown	Resistance at 7 °C ( $R_7$ )

a) Calculation of the resistance value at the beginning of the relevant temperature interval ( $T_x = 5 \text{ °C}$ )

$$R_{T_x} = R_5 = 2,2739 \cdot 4,7 \text{ k}\Omega = 10,6873 \text{ k}\Omega$$

b) Substituting this value into equation (2) yields

$$R_7 = R_5 \exp\left[\frac{\alpha_5}{100} (5 + 273,15)^2 \left(\frac{1}{7 + 273,15} - \frac{1}{5 + 273,15}\right)\right]$$

$$R_7 = 10,6873 \text{ k}\Omega \exp\left[\frac{4,4}{100} \cdot 278,15^2 \left(\frac{1}{280,15} - \frac{1}{278,15}\right)\right]$$

$$R_7 = 10,6873 \text{ k}\Omega \exp[-0,08737] = 10,6873 \cdot 0,9163$$

$$R_7 = 9,7932 \text{ k}\Omega$$

## Standardized R/T Characteristics

### 2 Resistance tolerance

The tolerance range of resistance can be calculated proceeding from the rated temperature and the corresponding rated resistance tolerance (see also chapter 3 1 3)

In practice, the following equation is used

$$\left| \frac{\Delta R_T}{R_T} \right| = \left| \frac{\Delta R_N}{R_N} \right| + \left| \frac{\Delta B}{B} \right| B \left( \frac{1}{T} - \frac{1}{T_N} \right) \quad (3)$$

$|\Delta R_T/R_T|$  Maximum spread of resistance at temperature  $T$  in %  
 $|\Delta R_N/R_N|$  Rated tolerance of resistance value at temperature  $T_N$  (given in data sheet) in %  
 $|\Delta B/B|$  Rated tolerance of  $B$  value (given in data sheet) in %  
 $B$   $B_{25/100}$  value (given in data sheet) in K  
 $T, T_N$  Temperatures in K

#### Example

Given NTC B57820-M561-A5  
 Curve 1009  
 $B_{25/100} = 3930$   
 $B$  value tolerance  $|\Delta B/B| = 1,5 \%$   
 Rated temperature  $T_N = 100 \text{ }^\circ\text{C}$   
 Rated resistance  $R_N = R_{100} = 39,6 \Omega$   
 Resistance tolerance at  $100 \text{ }^\circ\text{C}$   $|\Delta R_N/R_N| = 5 \%$   
 Unknown Resistance value at  $35 \text{ }^\circ\text{C}$  ( $R_T = R_{35}$ )  
 Resistance tolerance at  $35 \text{ }^\circ\text{C}$  ( $|\Delta R_T/R_T| = |\Delta R_{35}/R_{35}|$ )

a) Calculation of reference resistance  $R_{25}$  (required for working with the standardized  $R/T$  curve if the rated temperature is  $25 \text{ }^\circ\text{C}$  this step is omitted) by means of equation (1)

$$R_{100} = \frac{R_{100}}{R_{25}} R_{25} \quad R_{25} = \left( \frac{R_{100}}{R_{25}} \right)^{-1} R_{100}$$

$$R_{25} = \frac{1}{0,070690} 39,6 \Omega = 560,2 \Omega$$

(0,070690 = Factor of curve 1009 at  $100 \text{ }^\circ\text{C}$ )

b) Calculation of resistance value at  $35 \text{ }^\circ\text{C}$

$$R_{35} = \frac{R_{35}}{R_{25}} R_{25} = 0,65726 \cdot 560,2 \Omega = 368,2 \Omega$$

(0,65726 = Factor of curve at  $35 \text{ }^\circ\text{C}$ )

## Standardized R/T Characteristics

---

c) Calculation of resistance tolerance by means of equation (3)

$$\begin{aligned} \left| \frac{\Delta R_{35}}{R_{35}} \right| &= \left[ 5 + 1,5 \cdot 3930 \left( \frac{1}{(35 + 273,15)} - \frac{1}{(100 + 273,15)} \right) \right] \% \\ &= \left[ 5 + 5895 \left| \frac{1}{308,15} - \frac{1}{373,15} \right| \right] \% \\ &= (5 + 5895 \cdot 0,00056529) \% \\ &= 5,0 \% + 3,3 \% = 8,3 \% \end{aligned}$$

If the  $R/T$  characteristics are computer-stored, the resistance tolerances for all temperatures can be easily determined by an appropriate calculation program

### 3 Temperature tolerance

With given resistance tolerance, the temperature tolerance is determined as follows:

$$\Delta T = \frac{1}{\alpha} \frac{\Delta R_T}{R_T} \quad (4)$$

$\alpha$  Temperature coefficient at  $T$  in %/K (see  $R/T$  characteristic)  
 $|\Delta R_T/R_T|$  Resistance tolerance in % at  $T$

The following applies to the example given under point 2

$$\Delta T(100 \text{ }^\circ\text{C}) = \frac{1}{2,9} \cdot 5 \text{ K} = 1,72 \text{ K}$$

$$\Delta T(35 \text{ }^\circ\text{C}) = \frac{1}{4,1} \cdot 8,3 \text{ K} = 2,02 \text{ K}$$

The calculation mode given here is to be regarded as an approximation of actual conditions ( $B$  value temperature-dependent, tolerances symmetrical), nevertheless, the results obtained are sufficiently accurate for practical applications

## Standardized R/T Characteristics

Number	1201		1202		1203		1207	
	$B_{25/100} = 2700 \text{ K}$		$B_{25/100} = 2800 \text{ K}$		$B_{25/100} = 2900 \text{ K}$		$B_{25/100} = 2965 \text{ K}$	
	$R_T/R_{25}$	$\alpha \text{ (%/K)}$						
-55,0	22,708	5,1	27,119	5,5	30,252	5,6	31,68	5,7
-50,0	17,667	4,9	20,748	5,3	22,966	5,4	24,01	5,5
-45,0	13,875	4,7	16,035	5,1	17,612	5,2	18,37	5,3
-40,0	10,995	4,6	12,521	4,9	13,650	5,0	14,19	5,1
-35,0	8,7862	4,4	9,8633	4,7	10,671	4,8	11,06	4,9
-30,0	7,0771	4,3	7,8415	4,5	8,4216	4,7	8,702	4,7
-25,0	5,7435	4,1	6,2836	4,4	6,7001	4,5	6,901	4,6
-20,0	4,6945	4,0	5,0768	4,2	5,3757	4,3	5,517	4,4
-15,0	3,8631	3,8	4,1312	4,1	4,3443	4,2	4,445	4,3
-10,0	3,1994	3,7	3,3866	3,9	3,5376	4,1	3,607	4,1
-5,0	2,6661	3,6	2,7944	3,8	2,8995	3,9	2,948	4,0
0,0	2,2346	3,5	2,3211	3,7	2,3929	3,8	2,426	3,8
5,0	1,8834	3,4	1,9395	3,5	1,9866	3,7	2,008	3,7
10,0	1,5959	3,3	1,6303	3,4	1,6596	3,5	1,673	3,6
15,0	1,3591	3,2	1,3779	3,3	1,3941	3,4	1,402	3,5
20,0	1,1631	3,1	1,1709	3,2	1,1777	3,3	1,181	3,4
25,0	1,0000	3,0	1,0000	3,1	1,0000	3,2	1,0000	3,3
30,0	0,86360	2,9	0,85816	3,0	0,85337	3,1	0,8511	3,2
35,0	0,74898	2,8	0,73986	2,9	0,73170	3,0	0,7279	3,1
40,0	0,65224	2,7	0,64074	2,8	0,63032	2,9	0,6254	3,0
45,0	0,57022	2,7	0,55721	2,8	0,54534	2,9	0,5396	2,9
50,0	0,50040	2,6	0,48657	2,7	0,47384	2,8	0,4676	2,8
55,0	0,44071	2,5	0,42652	2,6	0,41336	2,7	0,4068	2,8
60,0	0,38950	2,4	0,37530	2,5	0,36201	2,6	0,3553	2,7
65,0	0,34538	2,4	0,33141	2,5	0,31822	2,5	0,3114	2,6
70,0	0,30725	2,3	0,29364	2,4	0,28073	2,5	0,2739	2,5
75,0	0,27417	2,2	0,26105	2,3	0,24850	2,4	0,2417	2,5
80,0	0,24539	2,2	0,23280	2,3	0,22069	2,3	0,2140	2,4
85,0	0,22025	2,1	0,20826	2,2	0,19663	2,3	0,1900	2,3
90,0	0,19824	2,1	0,18683	2,1	0,17572	2,2	0,1693	2,3
95,0	0,17890	2,0	0,16809	2,1	0,15750	2,2	0,1512	2,2
100,0	0,16186	2,0	0,15164	2,0	0,14157	2,1	0,1354	2,2
105,0	0,14681	1,9	0,13715	2,0	0,12760	2,1	0,1216	2,1
110,0	0,13347	1,9	0,12436	1,9	0,11531	2,0	0,1095	2,1
115,0	0,12163	1,8	0,11304	1,9	0,10447	2,0	0,09882	2,0
120,0	0,11109	1,8	0,10299	1,8	0,094881	1,9	0,08940	2,0
125,0	0,10167	1,8	0,094040	1,8	0,086371	1,9	0,08106	1,9
130,0	0,093251	1,7	0,086055	1,8	0,078799	1,8	0,07365	1,9
135,0	0,085699	1,7	0,078918	1,7	0,072059	1,8	0,06706	1,9

## Standardized R/T Characteristics

Number	1303		1304		1305		1306	
	$B_{25/100} = 3050 \text{ K}$		$B_{25/100} = 3300 \text{ K}$		$B_{25/100} = 3200 \text{ K}$		$B_{25/100} = 3450 \text{ K}$	
	$R_T/R_{25}$	$\alpha (\%/K)$						
-55,0	34,363	5,8	39,326	5,5	42,131	6,2	49,935	6,3
-50,0	25,827	5,6	30,121	5,4	31,129	5,9	36,640	6,1
-45,0	19,635	5,4	23,164	5,3	23,273	5,7	27,180	5,9
-40,0	15,089	5,2	17,888	5,2	17,592	5,5	20,370	5,7
-35,0	11,712	5,0	13,874	5,1	13,438	5,3	15,416	5,5
-30,0	9,1774	4,8	10,810	5,0	10,366	5,0	11,775	5,3
-25,0	7,2552	4,6	8,4512	4,9	8,1005	4,9	9,0698	5,1
-20,0	5,7835	4,5	6,6612	4,8	6,3856	4,8	7,0497	5,0
-15,0	4,6467	4,3	5,2540	4,7	5,0364	4,7	5,5187	4,8
-10,0	3,7611	4,2	4,1777	4,6	4,0067	4,4	4,3558	4,7
-5,0	3,0547	4,1	3,3309	4,5	3,2217	4,3	3,4609	4,5
0,0	2,4986	4,0	2,6767	4,3	2,6097	4,2	2,7705	4,4
5,0	2,0575	3,8	2,1680	4,1	2,1260	4,0	2,2313	4,3
10,0	1,7051	3,7	1,7683	4,0	1,7438	3,9	1,8098	4,1
15,0	1,4210	3,6	1,4538	3,9	1,4415	3,8	1,4762	4,0
20,0	1,1910	3,6	1,2025	3,8	1,1987	3,7	1,2116	3,9
25,0	1,0000	3,3	1,0000	3,6	1,0000	3,5	1,0000	3,8
30,0	0,85053	3,3	0,83752	3,5	0,84185	3,4	0,82984	3,7
35,0	0,72386	3,2	0,70362	3,4	0,71080	3,3	0,69220	3,6
40,0	0,61897	3,1	0,59417	3,3	0,60317	3,2	0,58042	3,5
45,0	0,53134	3,0	0,50453	3,2	0,51419	3,1	0,48899	3,4
50,0	0,45814	2,9	0,43035	3,2	0,44037	3,1	0,41395	3,3
55,0	0,39637	2,9	0,36798	3,1	0,37824	3,0	0,35197	3,2
60,0	0,34439	2,7	0,31608	3,0	0,32636	2,9	0,30060	3,1
65,0	0,30081	2,7	0,27324	2,9	0,28333	2,8	0,25780	3,0
70,0	0,26372	2,6	0,23718	2,8	0,24697	2,7	0,22197	3,0
75,0	0,23212	2,5	0,20635	2,7	0,21573	2,7	0,19189	2,9
80,0	0,20501	2,5	0,18016	2,7	0,18908	2,6	0,16648	2,8
85,0	0,18150	2,4	0,15843	2,6	0,16649	2,5	0,14498	2,7
90,0	0,16117	2,4	0,13984	2,5	0,14709	2,5	0,12669	2,7
95,0	0,14330	2,3	0,12277	2,5	0,13021	2,4	0,11109	2,6
100,0	0,12775	2,2	0,10804	2,4	0,11560	2,3	0,097717	2,5
105,0	0,11458	2,1	0,095996	2,3	0,10301	2,3	0,086235	2,5
110,0	0,10306	2,1	0,085543	2,3	0,092038	2,2	0,076325	2,4
115,0	0,092752	2,1	0,076380	2,2	0,082442	2,2	0,067760	2,4
120,0	0,083677	2,0	0,068378	2,2	0,074035	2,1	0,060320	2,3
125,0	0,075739	2,0	0,061386	2,1	0,066701	2,1	0,053852	2,2
130,0	-	-	0,055245	2,1	-	-	-	-
135,0	-	-	0,049926	2,0	-	-	-	-

## Standardized R/T Characteristics

Number	1308		1309		2001		2003	
	$B_{25/100} = 3060 \text{ K}$		$B_{25/100} = 3520 \text{ K}$		$B_{25/100} = 3920 \text{ K}$		$B_{25/100} = 3980 \text{ K}$	
	$R_T/R_{25}$	$\alpha$ (%/K)						
-55,0	32,33	5,6	48,460	6,1	87,762	7,1	97,578	7,5
-50,0	24,58	5,4	35,800	6,0	61,922	6,9	67,650	7,2
-45,0	18,85	5,2	26,694	5,8	44,168	6,7	47,538	7,0
-40,0	14,58	5,0	20,085	5,6	31,833	6,5	33,831	6,7
-35,0	11,38	4,9	15,247	5,4	23,173	6,3	24,359	6,5
-30,0	8,947	4,7	11,674	5,3	17,030	6,1	17,753	6,3
-25,0	7,091	4,6	9,0124	5,1	12,621	5,9	13,067	6,0
-20,0	5,663	4,4	7,0136	4,9	9,4515	5,8	9,7228	5,8
-15,0	4,555	4,3	5,5001	4,8	7,1273	5,6	7,3006	5,6
-10,0	3,689	4,1	4,3451	4,6	5,4270	5,5	5,5361	5,5
- 5,0	3,008	4,0	3,4569	4,5	4,1522	5,3	4,2332	5,3
0,0	2,468	3,9	2,7688	4,4	3,2063	5,1	3,2660	5,1
5,0	2,037	3,8	2,2321	4,2	2,5019	4,9	2,5392	5,0
10,0	1,691	3,7	1,8105	4,1	1,9679	4,7	1,9902	4,8
15,0	1,412	3,6	1,4773	4,0	1,5623	4,6	1,5709	4,7
20,0	1,185	3,5	1,2122	3,9	1,2488	4,5	1,2492	4,5
25,0	1,000	3,4	1,0000	3,8	1,0000	4,3	1,0000	4,4
30,0	0,8478	3,3	0,82924	3,7	0,81105	4,2	0,80575	4,3
35,0	0,7221	3,2	0,69105	3,6	0,65930	4,1	0,65326	4,1
40,0	0,6179	3,1	0,57861	3,5	0,53922	4,0	0,53290	4,0
45,0	0,5309	3,0	0,48666	3,4	0,44345	3,9	0,43715	3,9
50,0	0,4581	2,9	0,41110	3,3	0,36674	3,7	0,36064	3,8
55,0	0,3968	2,8	0,34872	3,3	0,30513	3,6	0,29908	3,7
60,0	0,3450	2,8	0,29699	3,2	0,25514	3,5	0,24932	3,6
65,0	0,3011	2,7	0,25390	3,1	0,21457	3,4	0,20886	3,5
70,0	0,2637	2,6	0,21786	3,0	0,18131	3,4	0,17578	3,4
75,0	0,2317	2,6	0,18759	3,0	0,15360	3,3	0,14863	3,3
80,0	0,2042	2,5	0,16208	2,9	0,13064	3,2	0,12621	3,2
85,0	0,1806	2,4	0,14050	2,8	0,11155	3,1	0,10763	3,1
90,0	0,1602	2,4	0,12217	2,8	0,095606	3,0	0,092159	3,1
95,0	0,1425	2,3	0,10656	2,7	0,082347	3,0	0,079225	3,0
100,0	0,1271	2,3	0,093213	2,6	0,071180	2,9	0,068356	2,9
105,0	0,1136	2,2	0,081767	2,6	0,061779	2,8	0,059247	2,8
110,0	0,1019	2,2	0,071922	2,5	0,053799	2,8	0,051531	2,8
115,0	0,09158	2,1	0,063428	2,5	0,046970	2,7	0,044921	2,7
120,0	0,08251	2,1	0,056078	2,4	0,041132	2,6	0,039282	2,7
125,0	0,07451	2,0	0,049702	2,4	0,036141	2,6	0,034387	2,6
130,0	0,06744	2,0	-	-	-	-	0,030186	2,5
135,0	0,06117	1,9	-	-	-	-	0,026650	2,5