

# Material Data

## SPECIFIC PARAMETERS OF THE STANDARD MATERIALS

		Soft PZT materials						Hard PZT materials						Lead-free materials	
		Unit	PIC151	PIC255/ PIC252 <sup>1)</sup>	PIC155	PIC153	PIC152	PIC181	PIC184 <sup>2)</sup>	PIC144 <sup>2)</sup>	PIC241	PIC300	PIC110	PIC050 <sup>3)</sup>	PIC700 <sup>2)</sup>
<b>Physical and dielectric properties</b>															
Density	$\rho$	g/cm <sup>3</sup>	7.80	7.80	7.80	7.60	7.70	7.80	7.75	7.95	7.80	7.80	5.50	4.7	5.6
Curie temperature	$T_c$	°C	250	350	345	185	340	330	295	320	270	370	150	>500	200 <sup>4)</sup>
Relative permittivity	in the polarization direction ⊥ to polarity	$\epsilon_{33}^T/\epsilon_0$	2400	1750	1450	4200	1350	1200	1015	1250	1650	1050	950	60	700
		$\epsilon_{11}^T/\epsilon_0$	1980	1650	1400			1500	1250	1500	1550	950		85	
Dielectric loss factor	$\tan \delta$	10 <sup>-3</sup>	20	20	20	30	15	3	5	4	5	3	15	<1	30
<b>Electromechanical properties</b>															
Coupling factor	$k_p$		0.62	0.62	0.62	0.62	0.48	0.56	0.55	0.60	0.50	0.48	0.30		0.15
	$k_t$		0.53	0.47	0.48			0.46	0.44	0.48	0.46	0.43	0.42		0.40
	$k_{31}$		0.38	0.35	0.35			0.32	0.30	0.30	0.32	0.25	0.18		
	$k_{33}$		0.69	0.69	0.69		0.58	0.66	0.62	0.66	0.64	0.46			
	$k_{15}$			0.66				0.63	0.65		0.63	0.32			
Piezoelectric charge coefficient	$d_{31}$		-210	-180	-165			-120	-100	-110	-130	-80	-50		
	$d_{33}$	10 <sup>-12</sup> C/N	500	400	360	600	300	265	219	265	290	155	120	40	120
	$d_{15}$			550				475	418		265	155		80	
Piezoelectric voltage coefficient	$g_{31}$		-11.5	-11.3	-12.9			-11.2	-11.1	-10.1	-9.8	-9.5			
	$g_{33}$	10 <sup>-3</sup> Vm/N	22	25	27	16	25	25	24.4	25	21	16	-11.9		
<b>Acousto-mechanical properties</b>															
Frequency coefficients	$N_p$		1950	2000	1960	1960	2250	2270	2195	2180	2190	2350	3150		
	$N_1$		1500	1420	1500				1640	1590	1590	1590	1700	2300	
	$N_3$	Hz · m	1750		1780				2010	1930		1550	1700	2500	
	$N_t$		1950	2000	1990	1960	1920	2110	2035	2020	2140	2100			
Elastic compliance coefficient	$S_{11}^E$		15.0	16.1	15.6				11.8	12.7	12.4	12.6	11.1		
	$S_{33}^E$	10 <sup>-12</sup> m <sup>2</sup> /N	19.0	20.7	19.7				14.2	14.0	15.5	14.3	11.8		
Elastic stiffness coefficient	$C_{33}^D$	10 <sup>10</sup> N/m <sup>2</sup>	10.0		11.1				16.6	14.8	15.2	13.8	16.4		
Mechanical quality factor	$Q_m$		100	80	80	50	100	2000	400	1000	400	1400	250		
<b>Temperature stability</b>															
Temperature coefficient of $\epsilon_{33}^T$ (in the range -20 °C to +125 °C)	$TK \epsilon_{33}$	10 <sup>-3</sup> /K	6	4	6	5	2	3	5			2			
<b>Time stability</b> (relative change of the parameter per decade of time in %)															
Relative permittivity	$C_\epsilon$			-1.0	-2.0					-4.0			-5.0		
Coupling factor	$C_k$			-1.0	-2.0					-2.0			-8.0		

Recommended operating temperature:  
50 % of Curie temperature.

- 1) Material for the Multilayer tape technology. Matrix of coefficients on request
- 2) Preliminary data, subject to change
- 3) Crystalline material
- 4) Maximum operating temperature

The following values are valid approximations for all PZT materials from PI Ceramic:

Specific heat capacity:  
WK = approx. 350 J kg<sup>-1</sup> K<sup>-1</sup>

Specific thermal conductivity :  
WL = approx. 1.1 W m<sup>-1</sup> K<sup>-1</sup>

Poisson's ratio (lateral contraction):  
 $\sigma$  = approx. 0.34

Coefficient of thermal expansion:  
 $\alpha_3$  = approx. -4 to -6 × 10<sup>-6</sup> K<sup>-1</sup>  
(in the polarization direction, shorted)  
 $\alpha_1$  = approx. 4 to 8 × 10<sup>-6</sup> K<sup>-1</sup>  
(perpendicular to the polarization direction, shorted)

Static compressive strength:  
> 600 MPa

The data was determined using test pieces with the geometric dimensions laid down in EN 50324-2 standard and are typical values.

All data provided was determined 24 h to 48 h after the time of polarization at an ambient temperature of 23±2 °C.

A complete coefficient matrix of the individual materials is available on request. If you have any questions about the interpretation of the material characteristics please contact PI Ceramic (info@piceramic.de).