

Properties of PZT piezoelectric ceramics
-Hard PZT

NO.	Property	Symbol	P41	P42	P43-A	P43-B	P44	P48	P44-L1	P44-L2	P44-L5	P81	P81-F	
1	Coupling Coefficients	k_n	0.56	0.58	0.62	0.64	0.62	0.56	0.63	0.64	0.63	0.55	0.58	
		k_3	0.33	0.34	0.36	0.37	0.36	0.33	0.37	0.37	0.37	0.36	0.32	0.33
		k_{33}	0.68	0.69	0.70	0.72	0.73	0.65	0.72	0.73	0.73	0.73	0.68	0.70
		kt	0.49	0.50	0.48	0.49	0.48	0.46	0.49	0.49	0.49	0.49	0.48	0.50
		k_{15}	0.61	0.63	0.66	0.68	0.69	0.64	0.68	0.68	0.68	0.62	0.65	0.67
2	Dielectric constant (1kHz)	ϵ^T_{r3}	1100	1280	1600	1700	1500	1275	1300	1450	1450	1050	950	
		ϵ^1_{r1}	1450	1700	2200	2450	1800	1700	1600	1650	1600	1400	1260	
3	Poisson's ratio	σ	0.30	0.31	0.32	0.33	0.33	0.31	0.31	0.31	0.32	0.31	0.29	
4	Young's modulus of elasticity ($10^{10}N/m^2$)	Y^E_1	9.0	8.9	8.2	8.0	8.7	8.7	8.0	8.0	8.2	9.0	9.2	
5	Dielectric Loss Factor (1kHz)	$tg \delta$	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.003	0.003	
6	Elastic Constants ($\times 10^{-12}m^2/N$)	S^E_{11}	12.0	11.5	13.5	13.9	13.0	12.0	13.1	12.8	12.8	11.2	11.2	
		S^E_{12}	-3.9	-3.9	-4.3	-4.4	-4.1	-3.9	-4.2	-4.1	-4.1	-4.1	-3.6	-3.6
		S^E_{33}	15.3	15.0	17.0	18.0	16.9	15.0	17.0	16.5	16.5	16.2	14.7	14.7
		S^E	35.5	36.0	37.5	37.9	39.0	36.0	38.7	38.2	38.2	35.5	33.0	33.0
		S^D_{11}	11.0	11.0	11.5	11.5	11.0	10.5	11.0	11.0	11.0	11.0	10.0	10.0
		S^D_{12}	-5.0	-5.0	-6.3	-6.5	-5.5	-5.0	-6.0	-6.0	-6.0	-5.5	-5.0	-5.0
		S^D_{33}	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
		S^D	21.0	21.0	20.0	20.0	20.5	21.0	20.5	20.5	20.5	21.5	19.0	19.0
7	Piezoelectric Charge (Displacement Coefficients) ($\times 10^{-12}C/N$)	d_{15}	460	500	550	600	550	460	500	500	400	430	430	
		d_{31}	-110	-130	-160	-170	-150	-120	-140	-150	-145	-110	-105	
		d_{33}	260	290	340	370	350	290	340	350	345	260	270	
8	Piezoelectric Voltage Coefficient	g_{31}	-11.5	-11.0	-11.0	-11.0	-11.0	-11.0	-12.0	-11.5	-11.0	-11.0	-12.0	
		g_{33}	27.5	25.0	25.0	25.0	25.5	25.0	26.0	25.5	24.5	25.0	25.0	
		g_{15}	32.5	32.0	34.0	34.0	33.5	32.0	35.0	35.0	33.0	32.5	32.5	
9	Mechanical Quality Factor	Q_M	1000	1100	1100	1100	800	1100	1300	1300	2000	1300	1250	
10	Frequency Constants($\pm z \cdot m$)	N_d	2280	2260	2100	2120	2190	2280	2150	2170	2200	2350	2290	
		N_1	1650	1650	1520	1530	1580	1650	1550	1550	1600	1700	1650	
		N_3	2000	2050	2000	2020	2000	2020	1950	1960	2000	2050	2020	
		N_t	2350	2350	2300	2350	2350	2350	2300	2350	2350	2350	2350	2300
11	Density ($\times 10^3 kg/m^3$)	ρ	7.55	7.60	7.80	7.80	7.70	7.60	7.90	7.90	7.70	7.65	7.70	
12	Curie Point($^{\circ}C$)	T_c	320	310	300	290	310	300	330	320	320	310	310	
13	Safe operating temperature($^{\circ}C$)	/	110	110	100	100	110	110	120	120	120	110	110	
14	Ageing rate per decade(%)	A_{Nd}	1.3	1.3	1.0	1.2	1.2	1.3	1.2	1.2	1.2	1.3	1.3	
		A_{kp}	-2.3	-2.0	-1.5	-1.6	-1.8	-2.0	-1.5	-1.5	-1.5	-1.5	-2.0	-2.0
		A_e	-4.5	-4.5	-4.0	-4.0	-4.5	-4.5	-2.5	-2.5	-2.5	-2.5	-4.0	-4.0
15	The relative change rate of temperature(%) ($-10 \rightarrow +25^{\circ}C$, $+25^{\circ}C \rightarrow +50^{\circ}C$)	$\Delta N_d/N$	1.0	1.5	0.7	1.0	1.0	1.5	1.0	1.0	1.0	1.5	1.5	
		$\Delta \epsilon / \epsilon$	9.5	9.5	9.0	9.0	9.0	9.5	6.0	7.0	7.0	9.0	9.0	
16	Dielectric Properties in High Electric Field $T=25^{\circ}C$ $E=400V$	$tg \delta$	0.020	0.020	0.040	0.040	0.030	0.020	0.020	0.030	0.020	0.010	0.010	
		$\Delta \epsilon / \epsilon$	0.11	0.13	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.10	0.10
17	coercive field ($KV/cm @ T=25^{\circ}C$)	E_c	8.00	9.00	12.00	12.50	8.00	9.50	12.00	12.20	12.50	12.10	12.10	