

Properties of PZT piezoelectric ceramics
—Soft PZT

NO.	Property	Symbol	P33	P33-HA	P33-HC	P33-HG	P51	P52	P52-HB	P52-HF	P52-LC	P52-HD	K148	GF	C10	
1	Coupling Coefficients	k_p	0.67	0.64	0.59	0.67	0.66	0.69	0.69	0.72	0.72	0.69	0.69	0.67	0.62	
		k_{31}	0.39	0.38	0.34	0.39	0.39	0.40	0.40	0.42	0.43	0.40	0.40	0.39	0.36	
		k_{33}	0.72	0.74	0.69	0.76	0.76	0.75	0.76	0.75	0.77	0.76	0.76	0.72	0.76	
		kt	0.49	0.48	0.48	0.48	0.50	0.50	0.49	0.48	0.54	0.50	0.46	0.48	0.50	
2	Dielectric constant (1kHz)	ϵ	1850	1800	1650	1750	2500	3500	3650	2800	3800	5700	2500	1300	700	
		ϵ	1900	2100	2100	1950	2400	5100	4100	3800	3300	6000	2900	1170	685	
3	Poisson's ratio	σ	0.35	0.38	0.40	0.35	0.36	0.29	0.31	0.25	0.28	0.35	0.31	0.33	0.34	
4	Young's modulus of elasticity ($10^{10}N/m^2$)	Y_{11}^E	6.5	7.0	7.0	6.5	5.9	5.6	5.7	5.8	6.0	6.5	6.3	6.3	6.4	
5	Dielectric Loss Factor (1kHz)	$tg \delta$	0.020	0.020	0.020	0.020	0.020	0.020	0.025	0.020	0.020	0.030	0.020	0.020	0.030	
6	Elastic Constants ($\times 10^{-12}m^2/N$)	S_{11}^E	15.0	14.5	13.5	15.3	15.5	16.5	17.0	16.5	16.5	14.6	17.3	16.0	13.3	
		S_{12}^E	-4.8	-4.6	-4.2	-4.9	-5.0	-5.2	-5.4	-5.3	-4.2	-4.7	-5.5	-5.1	-4.2	
		S_{13}^E	20.0	19.0	17.0	21.0	21.0	22.0	24.0	22.5	21.0	18.0	23.0	21.0	18.9	
		S_{55}^E	/	/	/	/	/	/	/	/	/	/	/	/	64.2	/
		S_{11}^D	12.7	12.5	11.7	13.0	13.2	13.7	14.1	13.8	13.5	12.3	14.3	13.6	11.5	
		S_{12}^D													-7.5	
		S_{13}^D	9.3	8.8	9.0	9.0	8.5	9.6	9.8	9.8	8.2	7.7	9.7	9.5	8.0	
		S_{55}^D	24.0	22.0	22.5	20.9	20.3	24.5	23.2	25.1	20.5	22.0	21.7	48.7	18.8	
7	Piezoelectric Charge (Displacement Coefficients) ($\times 10^{-12}C/N$)	d_{15}	600	570	440	710	800	840	990	850	1000	1050	830	560	700	
		d_{31}	-190	-180	-150	-190	-220	-290	-300	-270	-330	-410	-250	-170	-104	
		d_{33}	450	420	370	450	550	700	700	650	780	830	580	410	350	
8		g_{31}	-11.8	-11.3	-10.3	-12.5	-10.2	-9.2	-9.2	-10.8	-10.0	-8.0	-11.4	-14.4	-16.7	
		g_{33}	26.5	25.0	24.0	26.0	24.0	19.0	20.3	21.5	21.0	15.0	24.0	34.0	40.0	
		g_{15}	33.7	34.8	32.0	37.8	32.8	26.0	28.8	28.6	35.0	16.5	34.8	27.5	42.0	
9	Mechanical Quality Factor	Q_M	90	85	90	80	75	70	60	70	50	70	70	75	70	
10	Frequency Constants (Hz·m)	N_d	2010	2030	2130	1980	1990	1900	1900	1880	1850	1900	1870	1950	2110	
		N_1	1450	1460	1540	1430	1430	1380	1370	1350	1350	1430	1350	1410	1530	
		N_3	1850	1890	1880	1860	1930	1810	1810	1760	1900	1880	1800	1880	1980	
		N_t	2310	2300	2330	2300	2310	2260	2260	2250	2320	2200	2210	2200	2350	
11	Density ($\times 10^3kg/m^3$)	ρ	7.80	7.85	7.80	7.90	7.80	7.85	7.80	8.00	7.95	8.20	7.90	7.80	7.90	
12	Curie Point (°C)	T_c	340	360	365	340	290	210	210	210	220	150	300	380	350	
13	Safe operating temperature (°C)	/	130	150	150	130	120	90	90	90	110	70	120	320	250	
14	Ageing rate per decade (%)	A_{Nd}	0.07	0.20	0.20	0.07	0.35	0.10	0.35	0.35	/	/	0.36	0.10	0.10	
		A_{kp}	-0.20	-0.15	-0.15	-0.20	-0.40	-0.37	-0.25	-0.25	/	/	-0.35	-0.20	-0.10	
		A_{ϵ}	-0.3	-0.1	-0.1	-0.4	-1.5	-1.4	-2.0	-2.0	/	/	-1.4	-0.1	-0.1	
15	The relative change rate of temperature (%) (-10—+25°C, +25°C—+50°C)	$\Delta N_d/N$	0.1	0.1	0.1	0.2	1.5	2.0	2.0	2.0	/	/	1.5	-0.06	-0.05	
		$\Delta \epsilon / \epsilon$	15	13	13	16	20	40	40	40	/	/	30	0.70	1.00	
16	Coercive field (KV/cm@T=25°C)	E_c	12.30	15.40	16.60	11.10	10.90	8.20	8.20	9.10	8.00	8.00	10.00	12.00	16.00	