## GENERAL

These specifications are intended to give the designer information about the intrinsic properties of particular grades of Ferroxcube materials. They relate to test rings with a cross-section of approx. 40mm$^2$ and a magnetic length of approx. 100mm.

In general, components manufactured from these materials conform to these specifications but, owing to variation in size, shape and method of manufacture (e.g. pressing or extruding), these limits cannot always be realised or indeed checked by measurements on the component. Furthermore, specialised components may be manufactured to obtain selected properties, with resulting modification to secondary parameters; for this reason **guaranteed component specifications** are shown in the relevant component data.

## APPLICATION NOTES FOR MANGANESE-ZINC FERROXCUBE ('A' GRADES)

Grade A1 A medium permeability material with relatively low losses, suitable for use at low flux densities at frequencies up to 1MHz. Generally a maintenance grade available in the form of rods and tubes.

Grade A2 This grade is for use in applications involving high flux densities and where core loss and disaccommodation are of secondary importance. It is manufactured in various shapes for industrial and entertainment use for example industrial c.r.o. scanning yokes, c.t.v. convergence cores and r.f. suppressor cores.

Grade A3 Exclusively for the manufacture of yoke rings used in t.v. scanning assemblies.

Grade A4 A relatively high permeability and relatively low loss material for use in inductors and transformers operating at frequencies up to about 1MHz. It is available in the form of E-, I- and U-cores and as rods and toroids.

Grade A5 A versatile material used for a wide range of applications. The manufacture of this material can be varied to provide components for use in:

(i) High quality applications at frequencies below 200kHz and where high stability and low losses are of paramount importance, e.g. in filters and loading coil applications.

(ii) For communication transformers where the lowest frequency to be transmitted is less than 10MHz and where a high permeability with reasonably low material loss is needed.

Grade A7 Grade A8 High permeability materials suitable for pulse applications, where the pulse repetition frequency is less than about 500kHz and for wide band applications where the lowest frequency to be transmitted is less than 1MHz.

Grade A9 Suitable for low frequency power applications where a high operating flux density and low total core loss is required to be maintained at elevated temperatures; e.g. t.v. line output transformers and inverters. This material can be used at frequencies up to 100kHz and is normally available in U-core form.

Grade A10 Complementary to grade A5, this is a low-loss high-stability material for use at frequencies between 200kHz and 2MHz. It is normally available in pot core form.

Grade A13 A very low-loss, high permeability, high-stability material. It is used in the form of pot cores for frequencies up to 300kHz, or in toroidal form for pulse and wideband transformers where the lowest frequency to be transmitted is less than 10MHz.

Grade A15 A very high permeability material suitable for pulse applications where the pulse repetition frequency is less than 500kHz and for wideband applications where the lowest frequency to be transmitted is between 1kHz and 100kHz.

## APPLICATION NOTES FOR NICKEL-ZINC FERROXCUBE ('B' GRADES)

Grade B1 A relatively high permeability material with a high intrinsic resistivity. For use at frequencies up to 1MHz and in applications where the eddy-current loss of a manganese-zinc Ferroxcube becomes unacceptable.

Grade B2 This grade is widely used for applications in the frequency range 500kHz to 2MHz. It is available in a variety of rods, tubes, toroids and blocks.

Grade B4 This grade is for use in the frequency range 5 to 20MHz. It is available in rod, tube, ring and block form.

Grade B5 This grade is for use in the frequency range 20 to 50MHz. It is available in small rod, tube and ring form.

Grade B10 A low-loss high-stability material for use in the frequency range 1 to 15MHz. It is normally available in the form of pot cores for inductor and transformer applications.

Symbols and definitions for ferrite materials and components contained in the Mullard Technical Handbook are in accordance with IEC publication 125.

| Property | | Symbol or expression | Test conditions | | | | Ferroxcube grade | | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | f (kHz) | $\hat{B}$ (mT) | Temp. (°C) | Miscell. | A1 | A2 Note 3 | A3 Note 4 | A4 | A5 | A7 | |
| Initial permeability | Pressing | $\mu_i$ | < 100 | < 0·1 | 25 | — | > 700 | > 1000 | > 800 | > 1200 | > 1150 | > 5000 (+25 to +70°C) | ×1 |
| | Extrusion | | | | | | > 500 | — | — | > 800 | > 900 | — | |
| Amplitude permeability | | $\mu_a$ | < 50 × $10^{-3}$ | 100 | 25 | — | — | — | > 1200 | — | — | — | ×1 |
| | | | | 200 | 25 | | — | — | — | — | — | — | |
| | | | | 250 | 25 | | — | > 1000 | — | — | — | — | |
| | | | | 300 | 25 | | — | — | — | — | — | — | |
| | | | | 320 | 85 | | — | — | — | — | — | — | |
| | | | | 400 | 25 | | — | — | — | — | — | — | |
| Residual plus eddy current loss factor | | $\frac{\tan \delta_{r+e}}{\mu_i}$ | 4 | < 0·1 | 25 | — | — | — | — | — | < 2·5 | < 2·5 | ×$10^{-6}$ |
| | | | 30 | | | | — | — | — | — | < 5 | — | |
| | | | 50 | | | | — | — | — | — | — | — | |
| | | | 60 | | | | < 16 | — | — | < 35 | — | — | |
| | | | 100 | | | | — | — | — | — | < 12 | < 15 | |
| | | | 250 | | | | < 27 | — | — | < 80 | — | — | |
| | | | 450 | | | | < 50 | — | — | < 120 | — | — | |
| | | | 500 | | | | — | — | — | — | — | — | |
| | | | 1000 | | | | — | — | — | — | — | — | |
| Hysteresis coefficient | | I.E.C. $\eta_B = \frac{\tan \delta_h}{\mu \hat{B}}$ | 4 | 0·1 to 1 | 25 | — | — | — | — | — | < 1·5 | < 1·1 | $mT^{-1}$ × $10^{-6}$ |
| | | | 60 | | | | < 9·2 | — | — | < 15 | — | — | |
| | | | 100 | | | | — | — | — | — | — | — | |
| | | Legg $a = \frac{2\pi \tan \delta_h}{\mu \hat{B}}$ | 4 | | | | — | — | — | — | < 0·97 | < 0·69 | $gauss^{-1}$ × $10^{-6}$ |
| | | | 60 | | | | < 5·8 | — | — | < 9·7 | — | — | |
| | | | 100 | | | | — | — | — | — | — | — | |

| Property | Symbol or expression | Test conditions: f (kHz) | Test conditions: $\hat{B}$ (mT) | Test conditions: Temp. (°C) $\theta_1$ | Test conditions: Temp. (°C) $\theta_2$ | Test conditions: Miscell. | Ferroxcube grade: A1 | A2 Note 3 | A3 Note 4 | A4 | A5 | A7 | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature factor | $\frac{\mu_2-\mu_1}{\mu_1\mu_2(\theta_2-\theta_1)}$ | < 100 | < 0·1 | −20 | +25 | — | — | — | — | — | 0 to 2 | — | deg $C^{-1}$ × $10^{-6}$ |
| | | | | +5 | +25 | | — | — | — | — | 0 to 2 | — | |
| | | | | +25 | +55 | | 0 to 2 | — | — | 0 to 4·5 | 0 to 2 | — | |
| | | | | +25 | +70 | | — | — | — | — | 0 to 2 | — | |
| Disaccommodation factor | $\frac{\mu_1-\mu_2}{\mu_1^2}$ | < 100 | < 0·1 | 25 | | $\mu_1$ at 10 min $\mu_2$ at 100 min | < 11·3 | — | — | < 13·2 | < 6·88 | < 1·9 | $\times 10^{-6}$ |
| Curie point | $\theta_c$ | < 100 | < 0·1 | — | | — | > 130 | > 150 | > 150 | > 140 | > 125 | > 140 | °C |
| Saturation flux density | $\hat{B}_{sat}$ | < 50 × $10^3$ | — | 25 | | Peak field strength 0·8 A $mm^{-1}$ | 360 (typical) | > 320 | — | 360 (typical) | 350 (typical) | 420 (typical) | mT |
| | | | | 70 | | | — | — | — | — | — | 340 (typical) | |
| | | | | 85 | | | — | — | — | — | — | — | |
| Power loss density (Total core loss) | $P_m$ | 10 | 200 | 25 | | — | — | < 200 | — | — | — | — | $\mu W\ mm^{-3}$ |
| | | 16 | 100 | 25 | | | — | — | < 100 | — | — | — | |
| | | 16 | 200 | 25 | | | — | — | — | — | — | — | |
| | | 16 | 200 | 85 | | | — | — | — | — | — | — | |
| Resistivity | $\rho$ | d.c. | — | 25 | | — | > 800 | — | — | > 200 | > 800 | > 100 | Ω mm |
| Density | d | — | — | 25 | | — | 4·7 | 4·8 | 4·8 | 4·8 | 4·6 | 4·8 | kg $mm^{-3}$ × $10^{-6}$ |
| Colour code | — | — | — | — | | — | red brown | red red | red orange | red yellow | red green | red violet | — |

NOTES:

(1) 1mT = 10 gauss
(2) For definitions see IEC publication 125
(3) Properties for grades A2 and A9 are measured on a standard 'U' core
(4) Properties for grade A3 are measured on a standard yoke ring
(5) U/C = Under consideration

| Property | | Symbol or expression | Test conditions | | | | Ferroxcube grade | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | f (kHz) | $\hat{B}$ (mT) | Temp. (°C) | Miscell. | A8 | A9 Note 3 | A10 | A13 | A15 | |
| Initial permeability | Pressing | $\mu_i$ | < 100 | < 0·1 | 25 | — | 3500 | — | 600 to 900 | 1850 | 10 000 (+10 to +70°C) | ×1 |
| | Extrusion | | | | | | — | — | — | — | — | |
| Amplitude permeability | | $\mu_a$ | < 50 × $10^3$ | 100 | 25 | — | — | — | — | — | — | ×1 |
| | | | | 200 | 25 | | — | — | — | — | — | |
| | | | | 250 | 25 | | — | — | — | — | — | |
| | | | | 300 | 25 | | — | — | — | — | — | |
| | | | | 320 | 85 | | — | 1000 | — | — | — | |
| | | | | 400 | 25 | | — | 1000 | — | — | — | |
| Residual plus eddy current loss factor | | $\frac{\tan \delta_{r+e}}{\mu_i}$ | 4 | < 0·1 | 25 | — | — | — | — | < 1·2 | < 2·5 | ×$10^{-6}$ |
| | | | 30 | | | | — | — | — | — | — | |
| | | | 50 | | | | — | — | — | — | < 20 | |
| | | | 60 | | | | — | — | — | — | — | |
| | | | 100 | | | | 15 | — | < 8 | < 5 | < 50 | |
| | | | 250 | | | | — | — | — | — | — | |
| | | | 450 | | | | — | — | — | — | — | |
| | | | 500 | | | | < 120 | — | 14 | — | — | |
| | | | 1000 | | | | — | — | 30 | — | — | |
| Hysteresis coefficient | | I.E.C. $\eta_B = \frac{\tan \delta_h}{\mu \hat{B}}$ | 4 | 0·1 to 1 | 25 | — | < 1·9 | — | — | < 1·1 | < 1·1 | mT$^{-1}$ × $10^{-6}$ |
| | | | 60 | | | | — | — | — | — | — | |
| | | | 100 | | | | — | — | 1·84 | — | — | |
| | | Legg $a = \frac{2\pi \tan \delta_h}{\mu \hat{B}}$ | 4 | | | | < 1·2 | — | — | < 0·69 | < 0·69 | gauss$^{-1}$ × $10^{-6}$ |
| | | | 60 | | | | — | — | — | — | — | |
| | | | 100 | | | | — | — | 1·16 | — | — | |

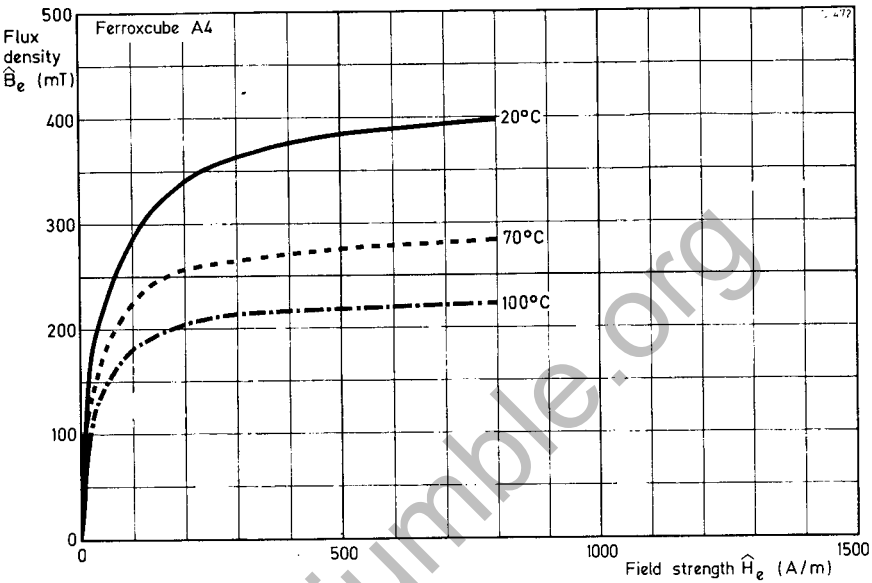
| Property | Symbol or expression | Test conditions: f (kHz) | Test conditions: $\hat{B}$ (mT) | Test conditions: Temp. ( C) | Test conditions: Miscell. | Ferroxcube grade: A8 | A9 Note 3 | A10 | A13 | A15 | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature factor | $\frac{\mu_2-\mu_1}{\mu_1\mu_2(\theta_2-\theta_1)}$ | < 100 | < 0·1 | $\theta_1$ −10 $\theta_2$ +25 | — | 0 to 3 | — | — | — | — | deg C$^{-1}$ × $10^{-6}$ |
| | | | | +5 +25 | | — | — | — | 0·5 to 1·5 | — | |
| | | | | +25 +55 | | — | — | — | 0·5 to 1·5 | — | |
| | | | | +25 +70 | | 0 to 3 | — | 0 to 2·0 | — | — | |
| Disaccommodation factor | $\frac{\mu_1-\mu_2}{{\mu_1}^2}$ | < 100 | < 0·1 | 25 | $\mu_1$ at 10 min $\mu_2$ at 100 min | < 9 | — | < 12 | < 4·28 | < 1·9 | $\times 10^{-6}$ |
| Curie point | $\theta_c$ | < 100 | < 0·1 | — | — | > 130 | > 210 | > 150 | > 130 | > 125 | °C |
| Saturation flux density | $\hat{B}_{sat}$ | < 50 × $10^{-3}$ | — | 25 | Peak field strength 0·8 A mm$^{-1}$ | 380 (typical) | > 450 | 350 (typical) | 340 (typical) | 400 (typical) | mT |
| | | | | 70 | | U C | — | — | — | 300 (typical) | |
| | | | | 85 | | — | > 370 | — | — | — | |
| Power loss density (Total core loss) | $P_m$ | 10 | 200 | 25 | — | — | — | — | — | — | μW mm$^{-3}$ |
| | | 16 | 100 | 25 | | — | — | — | — | — | |
| | | 16 | 200 | 25 | | — | < 180 | — | — | — | |
| | | 16 | 200 | 85 | | — | < 220 | — | — | — | |
| Resistivity | ρ | d.c. | — | 25 | — | 700 (typ) | — | > 1500 | > 1000 | — | Ω mm |
| Density | d | — | — | 25 | — | U C | 4·8 | U/C | 4·6 | 4·9 | kg mm$^{-3}$ × $10^{-6}$ |
| Colour code | — | — | — | — | — | red grey | red white | red brown black | red brown orange | red brown green | — |

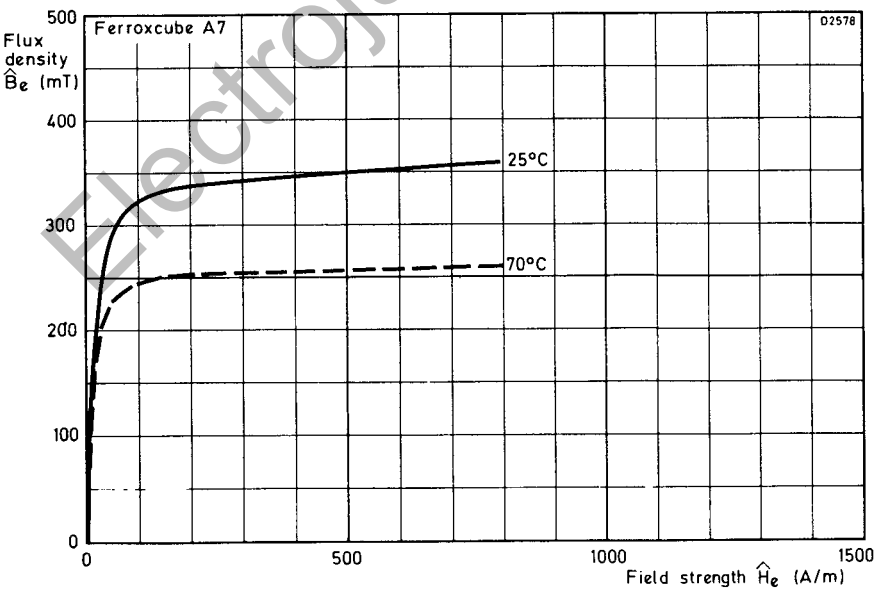
NOTES: (1) 1mT = 10 gauss
(2) For definitions see IEC publication 125
(3) Properties for grades A2 and A9 are measured on a standard 'U' core
(4) Properties for grade A3 are measured on a standard yoke ring
(5) U C = Under consideration

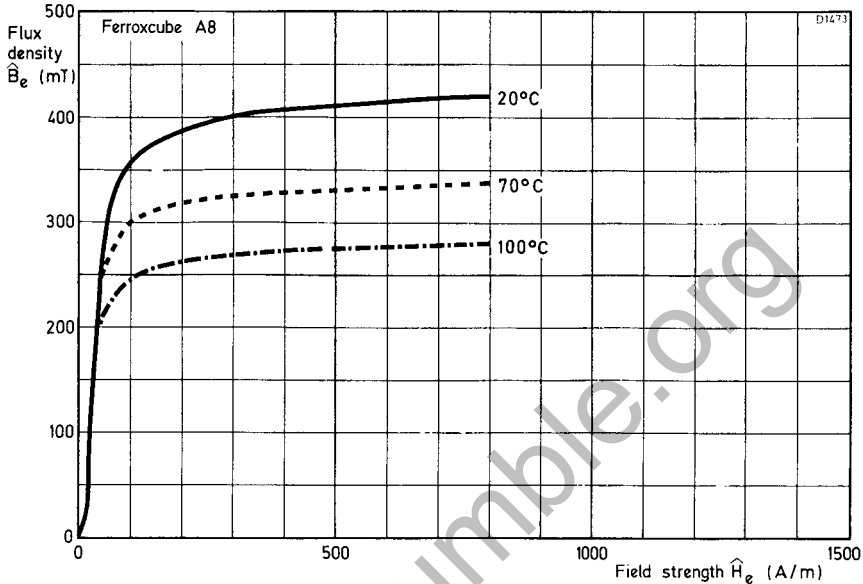
| Property | | Symbol or expression | Test conditions | | | | Ferroxcube grade | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | f (kHz) | $\hat{B}$ (mT) | Temp. (°C) | Miscell. | B1 | B2 | B4 | B5 | B10 | |
| Initial permeability | Pressing | $\mu_i$ | < 100 | < 0·1 | 25 | — | 480 to 720 | 200 to 300 | 40 to 80 | 10 to 20 | 100 to 150 | ×1 |
| | Extrusion | | | | | | > 300 | 150 to 250 | 35 to 60 | 9 to 18 | — | |
| Amplitude permeability | | $\mu_a$ | < 50 × $10^{-3}$ | 100 | 25 | — | — | — | — | — | — | ×1 |
| | | | | 150 | | | — | — | — | — | — | |
| | | | | 250 | | | — | — | — | — | — | |
| Residual plus eddy current loss factor | | $\frac{\tan \delta_{r+e}}{\mu_i}$ | 100 | < 0·1 | 25 | — | < 40 | — | — | — | — | ×$10^{-6}$ |
| | | | 500 | | | | < 80 | < 60 | — | — | — | |
| | | | $10^3$ | | | | < 120 | < 90 | — | — | — | |
| | | | $2 \times 10^3$ | | | | — | < 140 | — | — | — | |
| | | | $5 \times 10^3$ | | | | — | — | < 100 | — | < 50 | |
| | | | $8 \times 10^3$ | | | | — | — | < 130 | — | — | |
| | | | $10 \times 10^3$ | | | | — | — | < 180 | — | < 90 | |
| | | | $30 \times 10^3$ | | | | — | — | — | < 500 | — | |
| | | | $40 \times 10^3$ | | | | — | — | — | < 800 | — | |
| | | | $50 \times 10^3$ | | | | — | — | — | < 1500 | — | |

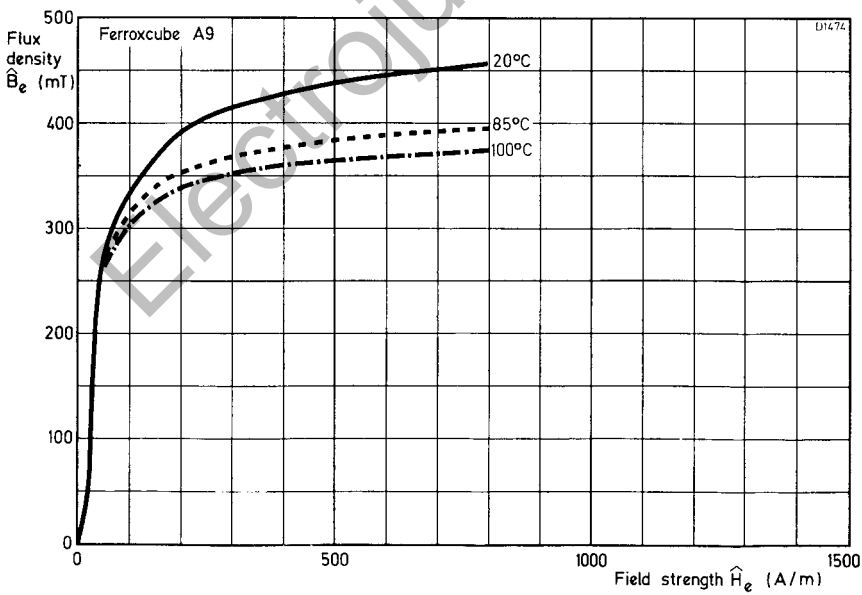
| Property | Symbol or expression | Test conditions | | | | | Ferroxcube grade | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | f (kHz) | $\hat{B}$ (mT) | Temp. (°C) $\theta_1$ | Temp. (°C) $\theta_2$ | Miscell. | B1 | B2 | B4 | B5 | B10 | |
| Temperature factor | $\frac{\mu_2-\mu_1}{\mu_1\mu_2(\theta_2-\theta_1)}$ | < 100 | < 0·1 | 0 | +25 | — | — | — | — | — | 0 to 6 | deg $C^{-1}$ × $10^{-6}$ |
| | | | | +25 | +55 | | 0 to 5 | 0 to 8 | 0 to 15 | 0 to 25 | 4 to 8 | |
| | | | | +25 | +70 | | — | — | — | — | 6 to 12 | |
| Curie point | $\theta_c$ | < 100 | < 0·1 | — | | — | > 125 | > 250 | > 400 | > 500 | > 250 | °C |
| Saturation flux density | $\hat{B}_{sat}$ | < 50 × $10^{-3}$ | — | 25 | | Peak field strength (A $mm^{-1}$) 0·8 | 220 (typical) | 320 (typical) | — | — | — | mT |
| | | | | | | 4 | — | — | 300 (typical) | — | 350 (typical) | |
| | | | | | | 6·4 | — | — | — | 175 (typical) | — | |
| Resistivity | $\rho$ | d.c. | — | 25 | | — | > $10^6$ | > $10^6$ | > $10^6$ | > $10^6$ | > $10^8$ | Ω mm |
| Density | d | — | — | 25 | | — | 4·9 | 4·9 | 4·8 | 4·8 | 4·9 | kg $mm^{-3}$ × $10^{-6}$ |
| Colour code | — | — | — | — | | — | white brown | white red | white yellow | white green | white brown/ black | — |

NOTES: (1) 1 mT = 10 gauss (2) For definitions see IEC publication 125



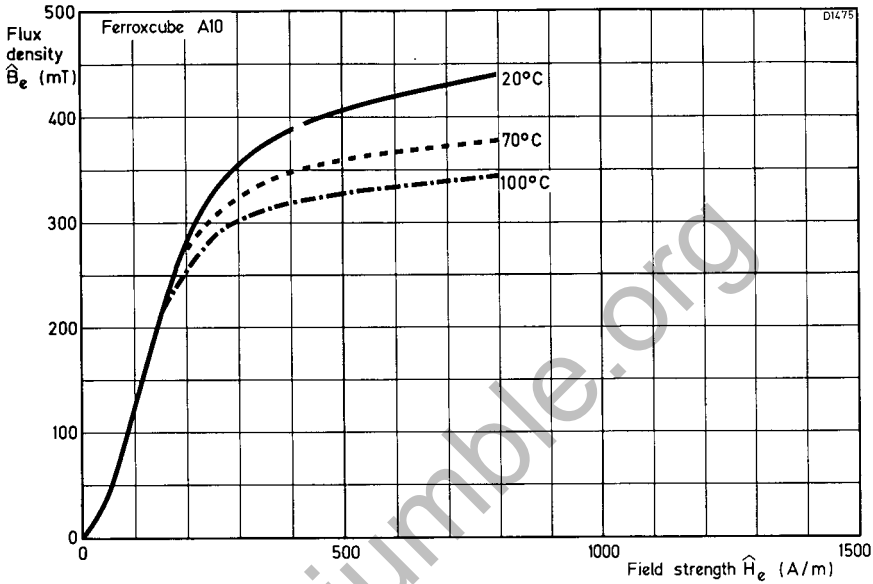



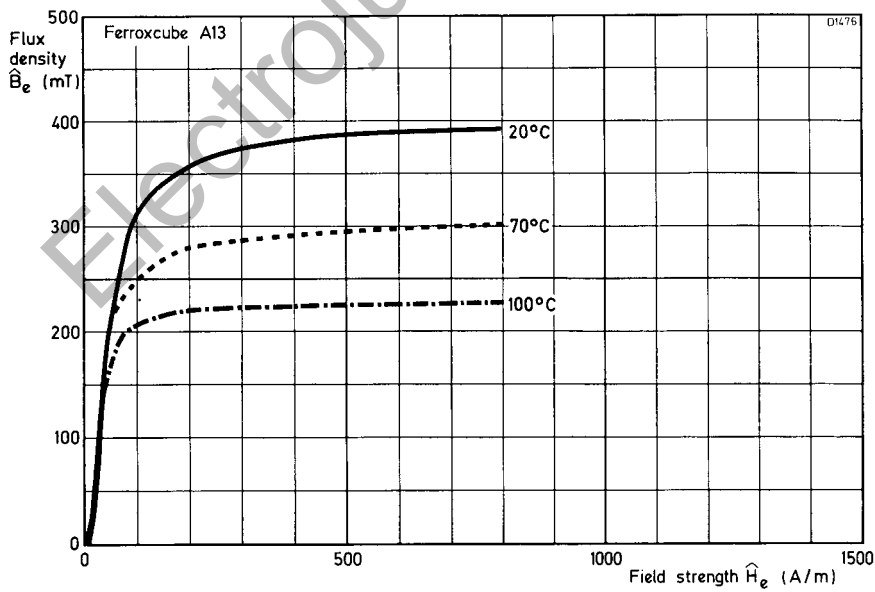


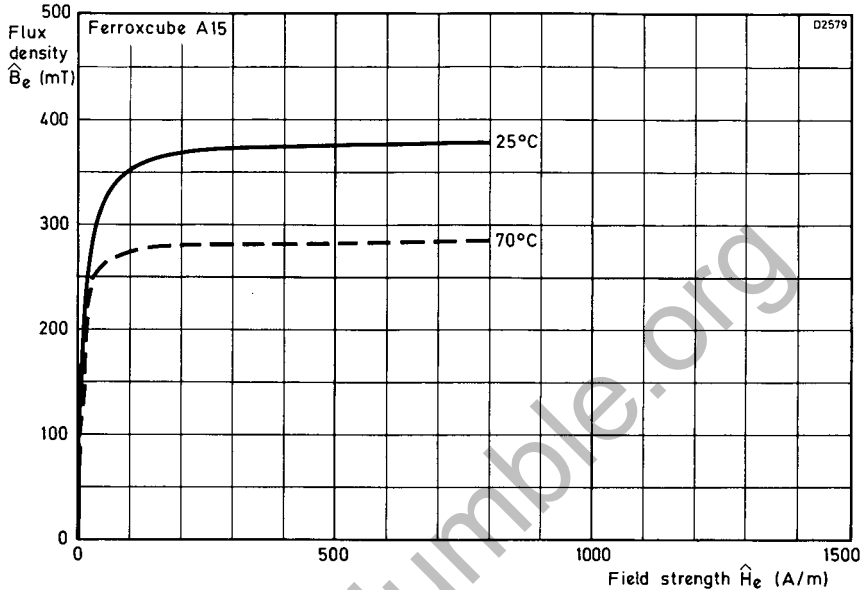



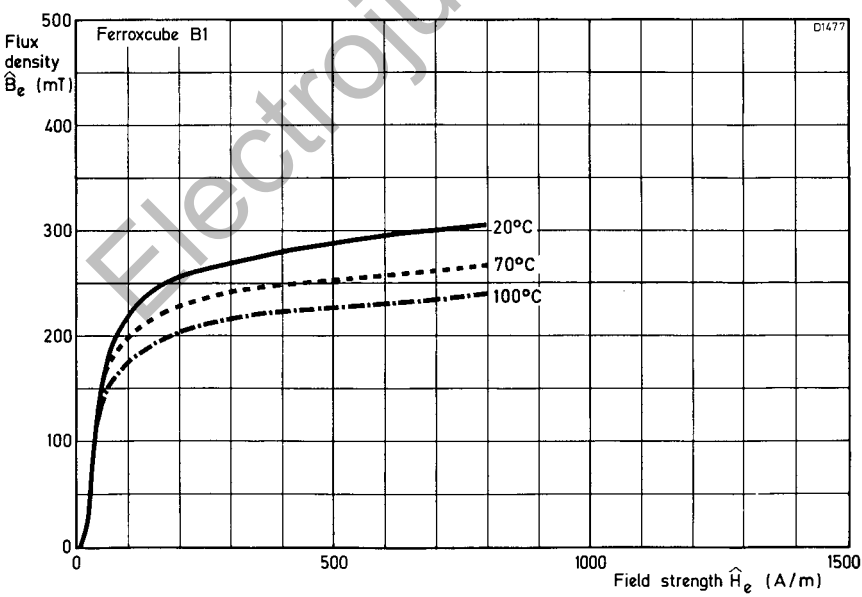



A11



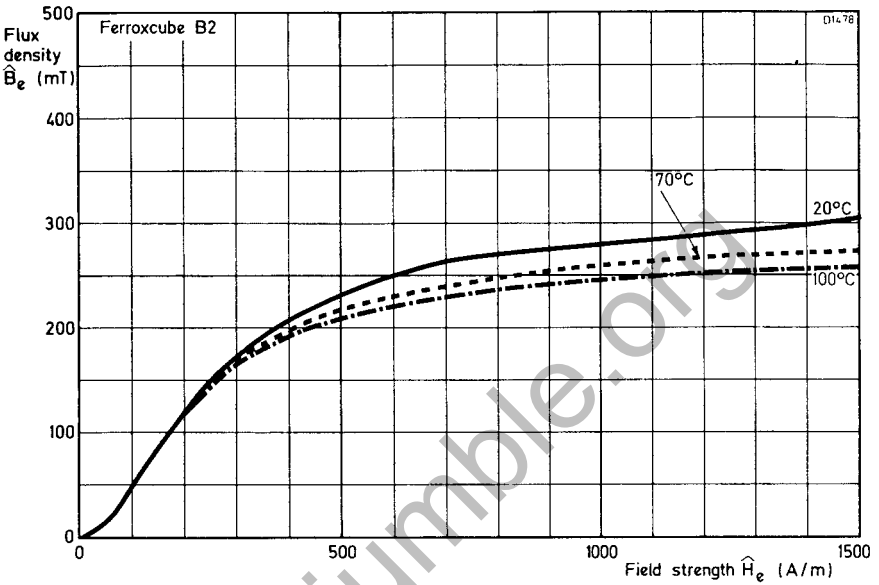



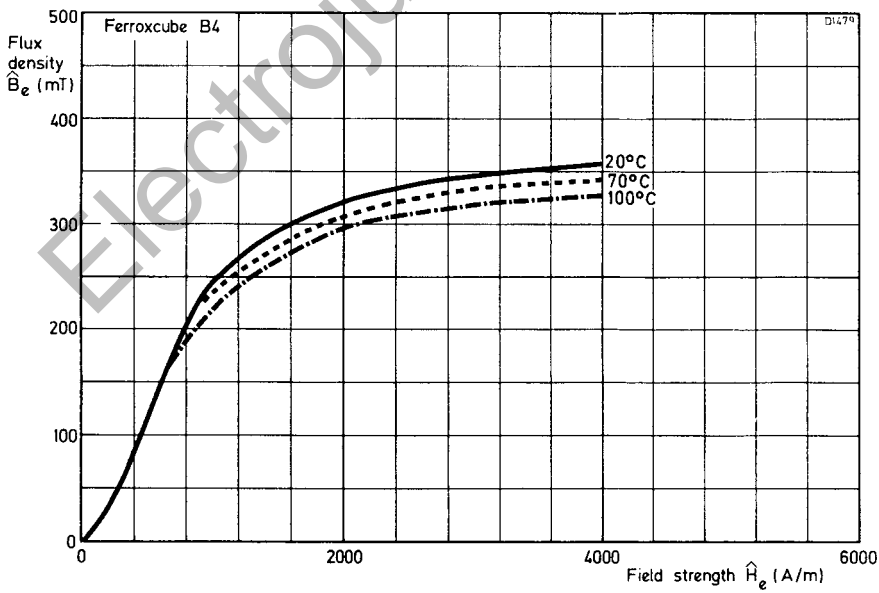


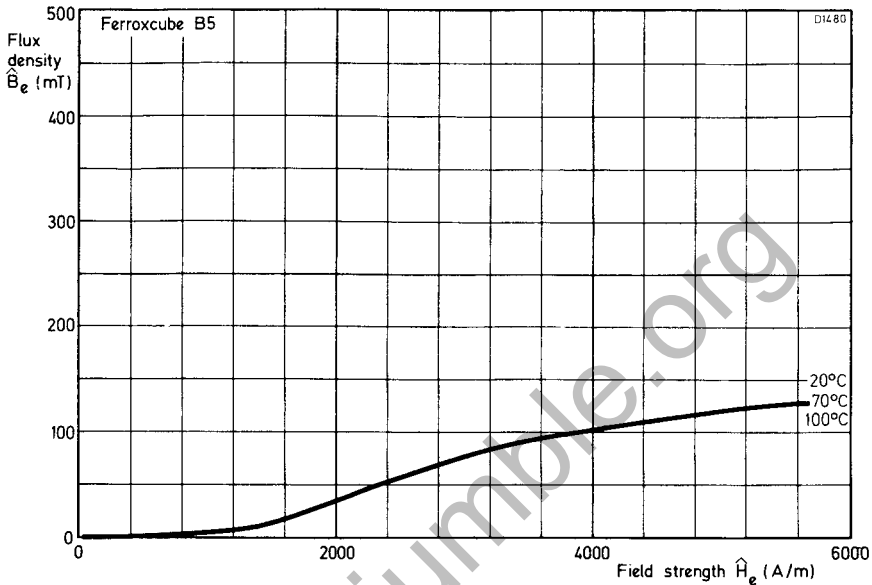



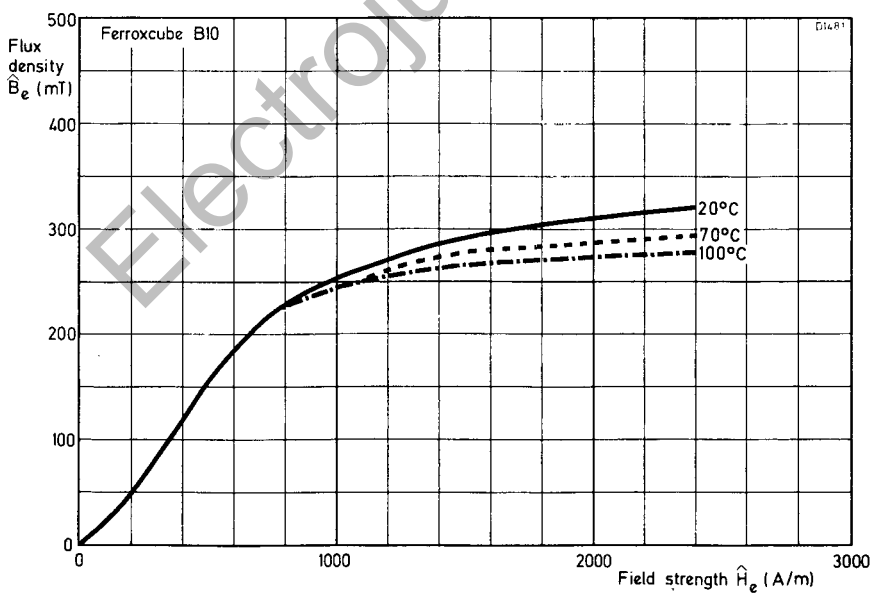



A13








A15