# TECHNICAL REPORT

# IEC 909-2

First edition
1992-11

## Electrical equipment – Data for short-circuit current calculations in accordance with IEC 909 (1988)

*Matériel électrique – Données pour le calcul des courants de court-circuit conformément à la CEI 909 (1988)*

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En ce qui concerne la terminologie générale, le lecteur se reportera à la CEI 50: *Vocabulaire Electrotechnique International* (VEI), qui se présente sous forme de chapitres séparés traitant chacun d'un sujet défini. Des détails complets sur le VEI peuvent être obtenus sur demande. Voir également le dictionnaire multilingue de la CEI.

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Pour les symboles graphiques, les symboles littéraux et les signes d'usage général approuvés par la CEI, le lecteur consultera:

- la CEI 27: *Symboles littéraux à utiliser en électrotechnique*;
- la CEI 417: *Symboles graphiques utilisables sur le matériel. Index, relevé et compilation des feuilles individuelles*;
- la CEI 617: *Symboles graphiques pour schémas*.

et pour les appareils électromédicaux,

- la CEI 878: *Symboles graphiques pour équipements électriques en pratique médicale*.

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- **IEC Bulletin**
- **IEC Yearbook**
  Published yearly
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  Published yearly with regular updates

## Terminology

For general terminology, readers are referred to IEC 50: *International Electrotechnical Vocabulary (IEV)*, which is issued in the form of separate chapters each dealing with a specific field. Full details of the IEV will be supplied on request. See also the IEC Multilingual Dictionary.

The terms and definitions contained in the present publication have either been taken from the IEV or have been specifically approved for the purpose of this publication.

## Graphical and letter symbols

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications:

- IEC 27: *Letter symbols to be used in electrical technology*;
- IEC 417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets*;
- IEC 617: *Graphical symbols for diagrams*;

and for medical electrical equipment,

- IEC 878: *Graphical symbols for electromedical equipment in medical practice*

The symbols and signs contained in the present publication have either been taken from IEC 27, IEC 417, IEC 617 and/or IEC 878, or have been specifically approved for the purpose of this publication.

## IEC publications prepared by the same technical committee

The attention of readers is drawn to the end pages of this publication which list the IEC publications issued by the technical committee which has prepared the present publication.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

# ELECTRICAL EQUIPMENT – DATA FOR SHORT-CIRCUIT CURRENT CALCULATIONS IN ACCORDANCE WITH IEC 909 (1988)

## FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

This Technical Report has been prepared by IEC Technical Committee No. 73: Short-circuit currents.

The text of this report is based on the following documents:

| CD | Report on Voting |
|---|---|
| 73(SEC)39 | 73(SEC)46 |

Full information on the voting for the approval of this report can be found in the Voting Report indicated in the above table.

This report is a Technical Report of type 3 and is of a purely informative nature. It is not to be regarded as an International Standard.

# ELECTRICAL EQUIPMENT – DATA FOR SHORT-CIRCUIT CURRENT CALCULATIONS IN ACCORDANCE WITH IEC 909 (1988)

## SECTION 1: GENERAL

### 1.1 Scope and object

This Technical Report comprises data collected from different countries to be used when necessary for calculating short-circuit currents in accordance with IEC 781 and IEC 909.

Generally, electrical equipment data are given by the manufacturers on the name plate or by the electricity supplier. In some cases, however, the data may not be available. The data presented in this report may be applied for calculating short-circuit currents in low-voltage systems if they are in accordance with typical equipment employed in the user's country. The collected data and their evaluation may be used for medium or high voltage planning purposes and also for comparison with data given by manufacturers. For overhead lines the electrical data may be calculated from the physical dimensions.

### 1.2 Reference documents

IEC 38: 1983, *IEC standard voltages.*

IEC 50, *International Electrotechnical Vocabulary (IEV).*

IEC 781: 1989, *Application guide for calculation of short-circuit currents in low-voltage radial systems.*

IEC 909: 1988, *Short-circuit current calculation in three-phase a.c. systems.*

## SECTION 2: DATA FOR ELECTRICAL EQUIPMENT

### 2.1 General

The data presented are necessary for the calculation of short-circuit currents. In general data are presented in the form of curve sheets. For each type of equipment a table is presented, giving data as examples and explanatory notes and additional comments on the supplied data. In all 15 National Committees gave information. Information received is listed in table 1.

In some cases, average values or characteristic trends as function of rated power, rated voltage, etc. are given.

Table 1 – Information received from National Committees

| National Committee | Number of answers to questionnaire tables | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Australia | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Austria | 10 | 11 | 4 | 1 | 8 | 7 | — |
| Bulgaria | 4 | 15 | 6 | 6 | 14 | 11 | 28 |
| China | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Czechoslovakia | 8 | 5 | — | 3 | 9 | 5 | 68 |
| Denmark | 8 | 18 | 1 | 2 | 8 | 15 | — |
| ex-GDR | 23 | 28 | 9 | 6 | 8 | — | 20 |
| Germany | 21 | 26 | 2 | 2 | 5 1) | 13 2) | 19 |
| Hungary | 7 | 16 | 3 | 5 | 9 | 8 | 9 |
| Italy | 25 | 16 | 4 | 6 | 26 | 9 | 11 |
| Japan | 12 | 10 | 7 | 7 | 7 | 9 | 3 |
| Norway | 9 | 10 | 4 | 3 | 9 | 8 | 10 |
| UK | — | 11 | 1 | 5 | — | — | — |
| USA | 110 | 10 | 1 | — | — | 10 | 20 |
| ex-USSR | 12 | 6 | 3 | 5 | 4 | — 3) | 10 |
| | 255 | 188 | 51 | 57 | 113 | 101 | 204 |

1) Additional data for low and medium voltage overhead lines.

2) Additional data for low voltage cables.

3) Data for busbars.

## 2.2 Data on typical synchronous machines

In figure 1 the subtransient reactance of 50 Hz and 60 Hz synchronous turbogenerators, motors, condensers and salient pole generators is plotted as a function of the rated power.

In figure 2 the rated voltage and power factor of 50 Hz and 60 Hz synchronous turbogenerators, salient pole generators and motors are plotted as a function of the rated power.

In figure 3 the unsatured and satured reactances for 50 Hz and 60 Hz turbogenerators are plotted as a function of the rated power.

Data are also given for the zero-sequence reactance. It is recommended that the relationship $X_{(0)}/X''_{d} = 0,5$ be used.

Characteristic data for synchronous machines are listed in table 2.

Table 2 - Actual data of typical synchronous generators, condensers and motors

| No. | Type[1] | Rated apparent power | Rated voltage and deviation[2] | | Power factor | Relative values of reactances | | | | | DC time constant | Notes | National Committee |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $S_{rG}$ | $U_{rG}$ | $\pm p_G$ | $\cos\varphi_{rG}$ | $x_d$[3] | $x_{dsat}$[4] | $x''_d$ | $x_{(2)}$[6] | $x_{(0)}$[7] | $T_a$[5] | | |
| | - | MVA | kV | % | - | - | - | - | - | - | s | | |
| 1 | TG2 | 100 | 10,5 | ±5 | 0,80 | 1,77 | 1,45 | 0,134 | – | – | 0,246 | 50 Hz | Germany |
| 2 | TG2 | 125 | 10,5 | ±5 | 0,80 | 2,13 | 1,87 | 0,16 | 0,18 | 0,08 | 0,46 | 50 Hz | ex-GDR |
| 3 | TG2 | 180 | 10,5 | ±5 | 0,90 | 1,83 | 1,77 | 0,25 | 0,23 | 0,14 | 0,48 | 50 Hz | Austria |
| 4 | TG2 | 353 | 18,0 | ±5 | 0,85 | 2,264 | 2,17 | 0,167 | 0,204 | 0,089 | 0,194 | 50 Hz | China |
| 5 | TG2 | 388,9 | 17,5 | ±5 | 0,90 | 2,42 | 2,188 | 0,203 | 0,202 | 0,099 | 0,250 | 50 Hz | Australia |
| 6 | TG2 | 64 | 13,8 | ±5 | 0,85 | 1,865 | 1,865 | 0,179 | 0,170 | 0,104 | 0,220 | 60 Hz | USA |
| 7 | SG20 | 290 | 18 | ±5 | 0,90 | 1,03 | 0,96 | 0,22 | 0,22 | 0,14 | 0,36 | 60 Hz | Japan |
| 8 | SG14 | 48 | 10 | ±5 | 0,90 | 0,78 | – | 0,160 | 0,170 | 0,05 | 0,16 | 50 Hz | Italy |
| 9 | SM2 | 1,45 | 10 | +5<br>−10 | 0,90 | 1,63 | – | 0,166 | 0,166 | 0,046 | 0,04 | 50 Hz | ex-USSR |
| 10 | SM3 | 3,4 | 4,0 | ±5 | 0,80 | 2,675 | 2,675 | 0,249 | 0,303 | – | 0,116 | 60 Hz | USA |
| 11 | SC10 | 40 | 13,8 | ±5 | 0 | 1,33 | 1,33 | 0,119 | 0,129 | – | 0,1425 | 60 Hz | USA |
| 12 | SC6 | 100 | 10,5 | ±5 | 0 | 1,78 | 1,60 | 0,20 | 0,25 | 0,095 | 0,57 | 50 Hz | Czechoslovakia |

1) TG2: Two-pole turbogenerator.
SG: Salient pole generator.
SC: Salient pole synchronous condenser.
SM: Synchronous motor.

2) $U_G = U_{rG}(1 \pm \frac{p_G}{100})$.

3) Unsaturated synchronous reactance.

4) Saturated synchronous reactance.

5) DC time constant for three-phase terminal short circuit.

6) Negative-sequence reactance.

7) Zero-sequence reactance.

## 2.3 Data on typical transformers, two-winding, three-winding and auto-transformers

In figure 4 the rated short-circuit voltage is plotted as a function of the rated power for power station generator transformers with or without tap-changer.

An average value for the rated short-circuit voltage is given by

$$u_{kr} = 8 + 0{,}92 \ln S_{rT}$$

where $S_{rT}$ is the rated power in MVA. (Values of $S_{rT}$ lie between 3 MVA and 1 000 MVA.) From the curve sheet it can be seen that the following average values for $u_{kr}$ may be used:

$S_{rT}$ 1 - 10 MVA: $u_{kr} \approx 9$ %
$S_{rT}$ 10 - 100 MVA: $u_{kr} \approx 11$ %
$S_{rT}$ 100 - 1 000 MVA: $u_{kr} \approx 13$ %

In figure 5 the rated short-circuit voltage of network transformers is plotted as a function of the rated power. For low-voltage transformers 4 % and 6 % are commonly used.

Excluding auto-transformers, the following average values may be used:

$S_{rT}$ 1 - 100 MVA: $u_{kr} \approx 12$ %
$S_{rT}$ 100 - 1 000 MVA: $u_{kr} \approx 14$ %

In general $u_{kr}$ values for auto-transformers are lower.

The $u_{kr}$ for network transformers in the UK is, on average, twice as large as those reported from other countries.

The relationship $\dfrac{X_{(0)}}{X_{(1)}}$ for two- and three-winding network transformers is as follows:

For YN d-transformers: 0,8-1,0
For Y zn-transformers: 0,1
For YN yn0 d-transformers: 1,5-3,2

In tables 3A, 3B and 3C, characteristic data for two-winding, three-winding and auto-transformers are listed.

Table 3A - Actual data of typical two-winding transformers (NT-network, PT = power station)

| No. | Rated apparent power | Rated voltage | | Rated short-circuit voltage | | Winding connection symbol | Side of earthing connection | Zero-sequence reactance | Tap-changer | | | Notes | National Committee |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_{rT}$ | $U_{rTHV}$ | $U_{rTLV}$ | $u_{kr}$ | $u_{Rr}$ | HV LV | | $X_{(0)}/X_{(1)}$ | $\pm p_T$ | $u_{k+}$ | $u_{k-}$ | | |
| | MVA | kV | kV | % | % | - | - | - | % | % | % | | |
| 1 | 0,63 | 20 | 0,4 | 6,0 | 1,2 | Dyn5 | LV | ≈1 | ±5 | off load | | 50 Hz, 3 limb, NT | ex-GDR |
| 2 | 24 | 33 | 11 | 24,2 | 1,12 | YNyn0 | HV, LV | 0,7 | ±10 | 24,1 | 25,3 | 50 Hz, 3 limb, NT | UK |
| 3 | 31,5 | 112 | 22,2 | 12,8 | 0,37 | YNd5 | HV | ≈1,0 | ±18 | 13,9 | 10,5 | 50 Hz, NT | Germany |
| 4 | 80 | 121 | 6,3 | 10,5 | – | YNd5 | HV | 0,71 | 2x2,5 | – | – | 50 Hz, 3 limb, NT | Bulgaria |
| 5 | 500 | 400 | 132 | 26,1 | 0,30 | YNynd5 | HV, LV | ≈1,6 | ±13 | | | 50 Hz, NT | Denmark |
| 6 | 20 | 138 | 13,2 | 10,58 | 0,49 | Dyn 1 | LV | ≈0,93 | +2,5<br>–7,5 | | | 60 HZ, 3 limb, PT | USA |
| 7 | 180 | 110 | 10,5 | 12,0 | 0,221 | Yd11 | | 0,78 | ±12 | | | 50 Hz, PT | Austria |
| 8 | 25 | 132 | 6,3 | 10,5 | | YNd11 | HV | 1,0 | | | | 50 Hz, 3 limb, PT | Hungary |
| 9 | 780 | 230 | 21,0 | 15,3 | 0,2 | YNd5 | HV | 0,7-0,9 | ±15 | 16,7 | 14,3 | 50 Hz, PT | Germany |
| 10 | 390 | 350 | 23,0 | 15,92 | 0,554 | YNd1 | HV | 1,0 | +10<br>–15 | 16,7 | 15,5 | 50 Hz, 3 limb, PT | Australia |

Table 3B - Actual data of typical three-winding transformers

| No. | Rated voltages | | | Rated apparent powers | | | Rated short-circuit voltages (related to A) | | | Connection symbol | Zero-sequence reactances related to side A (HV-side) | | | Notes | National Committee |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $U_{rTA} = U_{rTHV}$ | $U_{rTB} = U_{rTMV}$ | $U_{rTC} = U_{rTLV}$ | $S_{rTAB}$ | $S_{rTAC}$ | $S_{rTBC}$ | $u_{krAB}$ | $u_{krAC}$ | $u_{krBC}$ | HV MV LV | $X_{(0)A}$ | $X_{(0)B}$ | $X_{(0)C}$ | | |
| | kV | kV | kV | MVA | MVA | MVA | % | % | % | – | Ω | Ω | Ω | | |
| 1 | 34,5 | 13,8 | 13,8 | 7,5 | 7,5 | 7,5 | 3,65 | 3,58 | 7,96 | YN d1, d1 | – | – | – | 60 Hz, 3 limb | USA |
| 2 | 110 | 38,5 | 6,3 | 31,5 | 31,5 | 31,5 | 10,5 | 17,5 | 6,5 | YN yn0, d11 | +6,13 | +17,23 | +18,24 | 50 Hz, 3 limb | China |
| 3 | 120 | 22 | 11 | 25 | 16 | 16 | 11,0 | 14,5 | 3,5 | YN yn0, d11 | +99 | – | +3,15 | 50 Hz, 3 limb | Hungary |
| 4 | 230 | 63 | 20 | 125 | 42 | 42 | 11,7 | 10,6 | 5,9 | YN yn0, d11 | +124,6 | – | +5,74 | 50 Hz, 5 limb | ex-GDR |
| 5 | 239 | 130 | 13,8 | 94 | 94 | 94 | 11,79 | 11,31 | 12,44 | YN yn0, d11 | +32,39 | +39,23 | +36,31 | 50 Hz, 3 limb | Italy |
| 6 | 400 | 230 | 30 | 600 | 150 | 150 | 17,5 | 16,5 | 11,3 | YN yn0, d5 | 50,5 | –3,8 | +125,3 | 50 Hz, 5 limb | Austria |

Table 3C - Actual data of typical autotransformers with and without tertiary winding

| No. | Rated voltages | | | Rated apparent powers | | | Rated short-circuit voltages | | | Connection symbol | Zero-sequence reactances related to side A (HV-Side) | | | National Committee |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $U_{rTA} = U_{rTHV}$ | $U_{rTB} = U_{rTMV}$ | $U_{rTC} = U_{rTLV}$ | $S_{rTAB}$ | $S_{rTAC}$ | $S_{rTBC}$ | $u_{krAB}$ | $u_{krAC}$ | $u_{krBC}$ | HV MV LV | $X_{(0)A}$ | $X_{(0)B}$ | $X_{(0)C}$ | |
| | kV | kV | kV | MVA | MVA | MVA | % | % | % | – | Ω | Ω | Ω | |
| 1 | 132 | 66 | 11 | 60 | 60 | 10 | 11,0 | 27,5 | 79,0 | Y yn0, d1 | +61,6 | +4,19 | +1049,8 | Australia |
| 2 | 230 | 121 | 6,6<br>38,5 | 200 | 200 | 100 | 11,0 | 32,0 | 20,0 | Y auto, d11 | +30,4 | 0 | +54,2 | ex-USSR |
| 3 | 230 | 130 | – | 250 | 250 | – | 11,6 | – | – | YN yn0 | +24,55 | – | – | Italy |
| 4 | 235 | 165 | – | 300 | 300 | – | 7,0 | – | – | YN yn0 | +13 | – | – | Denmark |
| 5 | 400 | 132 | 18 | 250 | 75 | 75 | 14,6 | 12,2 | 7,1 | YN yn0, d11 | +10,11 | –7,71 | +159,1 | Hungary |
| 6 | 400 | 121 | 10 | 250 | 100 | 100 | 12,9 | 13,1 | 6,3 | YN yn0,d1 | +95,7 | –13,1 | +113,9 | Czechoslovakia |
| 7 | 400 | 231 | 30 | 660 | 198 | 198 | 10,2 | 13,5 | 10,6 | III, d5[1)] | +24,35 | +0,35 | +84,65 | Germany |

[1)] Three separate poles.

## 2.4 Data on typical overhead lines, single and double circuits

The positive-sequence impedance may be calculated from conductor data such as cross section and conductor centre-distances (see IEC 909).

The effective resistance per unit length is:

$$R'_{L} = \frac{\rho}{q}$$

where

$q$ is the cross section

$\rho$ is the resistivity

$$\rho = \frac{1}{54}\ \frac{\Omega\ \mathrm{mm}^2}{\mathrm{m}} \text{ for copper and } \rho = \frac{1}{34}\ \frac{\Omega\ \mathrm{mm}^2}{\mathrm{m}} \text{ for aluminium}$$

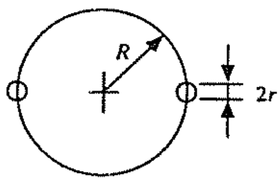
The positive–sequence reactance may be calculated from line data.

For single conductor lines equation (1) is valid (see figure 6):

$$X'_{(1)L} = \frac{\omega\,\mu_0}{2\pi}\left(0{,}25 + \ln\frac{d}{r}\right) \qquad (1)$$

$$d = \sqrt[3]{d_{L1L2} \cdot d_{L1L3} \cdot d_{L2L3}} \quad \text{and } r = \text{conductor radius}$$

For bundle conductor lines equation (2) is valid (see figure 7):




$$X'_{(1)L} = \frac{\omega\,\mu_0}{2\pi}\left(\frac{0{,}25}{\mathrm{n}} + \ln\frac{d}{r_B}\right) \qquad (2)$$

$r$ and $d$ as above, $r_B = \sqrt[\mathrm{n}]{\mathrm{n}r \cdot R^{\mathrm{n}-1}}$ n = number of conductors.

$R$ is the radius in the circle on which the conductors are placed, see figure above.

The zero-sequence impedances are referred to an earth resistivity of $\rho$ = 100 Ωm and therefore to an equivalent depth of current return of $\delta$ = 930 m (50 Hz) or $\delta$ = 850 m (60 Hz).

For single circuit (I) lines without earth wire:

$$\underline{Z}'^{\,I}_{(0)} = \frac{\rho}{\mathrm{n}q_{\mathrm{n}}} + 3\omega\frac{\mu_0}{8} + \mathrm{j}\omega\frac{\mu_0}{2\pi}\left[\frac{1}{4\mathrm{n}} + 3\ln\frac{\delta}{\sqrt[3]{r_B d^2}}\right] \qquad (3)$$

For single circuit (I) lines with one earth wire (D):

$$\underline{Z}'^{\mathrm{ID}}_{(0)} = \underline{Z}'^{\mathrm{I}}_{(0)} - 3\,\frac{\underline{Z}'^{2}_{\mathrm{LD}}}{\underline{Z}'_{\mathrm{D}}} \qquad (4)$$

with $\underline{Z}'_{\mathrm{D}} = R'_{\mathrm{D}} + \omega\,\frac{\mu_0}{8} + \mathrm{j}\omega\,\frac{\mu_0}{2\pi}\left[\frac{\mu_{\mathrm{D}}}{4} + \ln\frac{\delta}{r_{\mathrm{D}}}\right]$

$\underline{Z}'_{\mathrm{LD}} = \omega\,\frac{\mu_0}{8} + \mathrm{j}\omega\,\frac{\mu_0}{2\pi}\,\ln\frac{\delta}{d_{\mathrm{mLD}}}$

$d_{\mathrm{mLD}} = \sqrt[3]{d_{\mathrm{L1D}} \cdot d_{\mathrm{L2D}} \cdot d_{\mathrm{L3D}}}$

$\mu_{\mathrm{D}}$ depends on material and structure of the earth wire.

For single circuit (I) lines with two earth wires (D1, D2):

$$\underline{Z}'^{\mathrm{ID1D2}}_{(0)} = \underline{Z}'^{\mathrm{I}}_{(0)} - 3\,\frac{\underline{Z}'^{2}_{\mathrm{LD1D2}}}{\underline{Z}'_{\mathrm{D1D2}}} \qquad (5)$$

with $\underline{Z}'_{\mathrm{D1D2}} = \frac{R'_{\mathrm{D}}}{2} + \omega\,\frac{\mu_0}{8} + \mathrm{j}\omega\,\frac{\mu_0}{2\pi}\left[\frac{\mu_{\mathrm{D}}}{8} + \ln\frac{\delta}{\sqrt{r_{\mathrm{D}} d_{\mathrm{D1D2}}}}\right]$

$\underline{Z}'_{\mathrm{LD1D2}} = \omega\,\frac{\mu_0}{8} + \mathrm{j}\omega\,\frac{\mu_0}{2\pi}\,\ln\frac{\delta}{d_{\mathrm{mLD1D2}}}$

$d_{\mathrm{mLD1D2}} = \sqrt[6]{d_{\mathrm{L1D1}}\, d_{\mathrm{L2D1}}\, d_{\mathrm{L3D1}}\, d_{\mathrm{L1D2}}\, d_{\mathrm{L2D2}}\, d_{\mathrm{L3D2}}}$

For double circuit (II) lines with one earth wire (D), zero-sequence impedance per circuit (with both circuits in parallel) is:

$$\underline{Z}'^{\mathrm{IID}}_{(0)} = \underline{Z}'_{(0)} + 3\underline{Z}'_{\mathrm{LM}} - 6\,\frac{\underline{Z}'^{2}_{\mathrm{LD}}}{\underline{Z}'_{\mathrm{D}}} \qquad (6)$$

with $\underline{Z}'_{\mathrm{LM}} = \omega\,\frac{\mu_0}{8} + \mathrm{j}\omega\,\frac{\mu_0}{2\pi}\,\ln\frac{\delta}{d_{\mathrm{LM}}}$

$d_{\mathrm{mL1M1}} = \sqrt[3]{\mathrm{D}_{\mathrm{L1M1}} \cdot \mathrm{D}_{\mathrm{L2M2}} \cdot \mathrm{D}_{\mathrm{L3M3}}}$

$d_{\mathrm{mL1M2}} = \sqrt[3]{\mathrm{D}_{\mathrm{L1M2}} \cdot \mathrm{D}_{\mathrm{L3M1}} \cdot \mathrm{D}_{\mathrm{L2M3}}}$

$d_{\mathrm{LM}} = \sqrt[3]{d^{2}_{\mathrm{mL1M2}} \cdot d_{\mathrm{mL1M1}}}$

For double circuit (II) lines with two earth wires (D1, D2), zero–sequence impedance per circuit (with both circuits in parallel) is:

$$\underline{Z}'^{\,\mathrm{IID1D2}}_{(0)} = \underline{Z}'^{\,\mathrm{I}}_{(0)} + 3\,\underline{Z}'_{\mathrm{LM}} - 6\,\frac{\underline{Z}'^{\,2}_{\mathrm{LD1D2}}}{\underline{Z}'_{\mathrm{D1D2}}} \qquad (7)$$

for $\underline{Z}'_{\mathrm{LM}}$, $\underline{Z}'_{\mathrm{LD1D2}}$, $\underline{Z}'_{\mathrm{D1D2}}$, see above equations (5) and (6).

In case of multiple lines the coupling of the zero-sequence impedances between the different conductors must be considered.

In table 4 characteristic data for overhead lines are given. For type of line and number of circuits, see figure 8.

Table 4 - Actual data of typical overhead lines (single and double circuit 50 and 60 Hz) per circuit

| No. | Type of line/number of circuits (see figure 8) | Voltage $U_n$ | Conductors/ subconductors number Material $q_n$ | Earth-wire ground-wire number Material $q_n$ | Geometric data (see clause 2.4 and figure 8) $r$ / $r_B$ | $d$ / $d_{LM}$ | $d_{mL1M2}$ / $d_{mL1M1}$ | $d_{D1D2}$ | $d_{mLD}$ / $d_{mLD1D2}$ | Positive-sequence impedance $Z'_{(1)} = R'_{(1)} + jX'_{(1)}$ | Zero-sequence impedance $Z'_{(0)} = R'_{(0)} + jX'_{(0)}$ | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | – | kV | mm² | mm² | mm | m | m | m | m | Ω/km | Ω/km | |
| 1 | A/1 | 0,38 | 1 x Al 95 | – | 6,25 | 0,6 | – | – | – | 0,31 + j0,302 | 0,63 + j0,941 | Austria |
| 2 | B/1 | 20 | 1 x Cu25 | – | 3,15 | 1,23 | – | – | – | 0,746 + j0,396 | 0,854 + j1,643 | Italy |
| 3 | D/1 | 66 | 1 x Al/St condor | Al/St No 25 | 13,86 | 3,77 | – | 3,0 | 4,9 | 0,072 + j0,365 | 0,410 + j0,882 | Norway |
| 4 | F/1 | 110 | 1 x Al/St 240/40 | 1 x St 50 | 10,95 | 4,06 | – | – | 10,8 | 0,119 + j0,387 | 0,309 + j1,382 | Germany |
| 5 | C/1 | 110 | 1 x Al/St 185/25 | 1 x St 50 | 9,2 | 4,61 | – | – | 4,33 | 0,156 + j0,395 | 0,370 + j1,34 | Bulgaria |
| 6 | C/1 | 132 | 1 x Al/St 525/68 | 1 x Al/St 138/68 | 15,8 | 5,81 | – | – | 12 | 0,061 + j0,387 | 0,202 + j0,931 | Denmark |
| 7 | E/1 | 220 | 1 x Al/St 291/37,2 | 2 x St50 | 11,75 | 6,39 | – | 5,8 | 6,99 | 0,108 + j0,411 | 0,352 + j1,242 | China |
| 8 | C/* | 220 | 1 x Al/St 400/51 | 1 x St70 | 13,75 | 8,0 | – | – | 11,6 | 0,075 + j0,420 | 0,250 + j1,340 | ex-USSR |
| 9 | G/2 | 220 | 2 x Al/St 240/40 | 1 x Al/St 240/40 | 10,95<br>66,2 | 6,24<br>15,3 | 15,8<br>14,4 | – | 16,3 | 0,06 + j0,299 | 0,273 + j1,479 | Germany |
| 10 | K/2 | 275 | 4 x Al/St 610/79,4 | 2 x AS 160 | 17,1<br>304 | 9,85<br>13,74 | 16,39<br>12,60 | 13,0 | 16,84 | 0,015 + j0,239 | 0,111 + j1,708 | Japan (50 Hz) |
| 11 | K/2 | 380 | 2 x Al/St 680/85 | 1 x Al/St 240/40 | 18,0<br>48,9 | 11,5<br>19,1 | 19,2<br>23,2 | – | 21,6 | 0,0215 + j0,303 | 0,243 + j1,400 | Austria |
| 12 | D/1 | 500 | 4 x Al/St 291/37,2 | 2 x Al/St 120/22 | 11,75<br>197,3 | 17,64 | – | 24,0 | 18,08 | 0,031 + j0,286 | 0,233 + j0,715 | Australia |
| 13 | K/2 | 500 | 4 x Al/St 814/56 | 2 x Al/St 150/87 | 38,4<br>287,3 | 15,13<br>21,16 | 25,23<br>19,38 | 20,4 | 26,92 | 0,009 + j0,304 | 0,356 + j1,224 | Japan (60 Hz) |

Resistance at a temperature of 20 °C.
*) Special design. Two separate lines in one single right-of-way.

## 2.5 Data on typical low- and high-voltage cables

The impedances of low- and high-voltage cables depend on national techniques and standards and may be taken from textbooks or the manufacturer's data.

The positive-sequence resistance value for high-voltage cables may, as a first approximation, be calculated according to formula $R'_L = \rho/q_n$ (see clause 2.4). This also applies for low-voltage Cu cables with cross sections 4 mm$^2$ to 240 mm$^2$ and low-voltage Al cables 16 mm$^2$ to 300 mm$^2$.

The positive-sequence reactances for low-voltage cables according to German Standards are shown in figure 9 for four, three and a half and three conductor cables of the following types:

Type A: Cable with copper (aluminium) conductors, insulation of thermoplastic material based on PVC and a protective covering in the form of a sheath of thermoplastic material based on PVC [N(A)YY].

Type B: Cable with copper (aluminium) conductors, insulation of thermoplastic material based on PVC, concentric copper conductor, helically applied, and a protective covering in the form of a sheat of thermoplastic material based on PVC [N(A)YCWY].

Type C: Belted cable with copper (aluminium) conductors, a mass-impregnated paper insulation for conductors (and belt), a smooth extruded aluminium sheath, protective covering with an embedded layer (e.g. lapped) of elastomer tape or plastic film and a sheath of thermoplastic material based on PVC [N(A)KLEY].

Type D: Cable with copper (aluminium) conductors, a mass-impregnated paper insulation for conductors (and belt), lead sheat with steel tape armouring and an outer serving of fibrous material [N(A)KBA].

In figure 10 the positive-sequence reactance is plotted for medium-voltage cables (IEC 38) of the non-radial and radial field types with three conductors.

For high-voltage cables (>36 kV), the positive-sequence reactance varies with design, laying, cross section and voltage. Data received indicate a variation from 0,1 to 0,19 Ω/km. The ratio $X_{(0)}/X_{(1)}$ also varies depending on the design and the current return. The $X_{(0)}/X_{(1)}$ variation for cables without metallic sheath and without earth return is 0,3 to 0,8 and for cables with metallic sheath and earth return 0,25 to 3,7.

Figures 11 and 12 give a general survey of the positive-sequence reactance $X'_{(1)}$ and the ratios $R_{(0)}/R_{(1)}$ and $X_{(0)}/X_{(1)}$ for low-voltage cables (type A, B, C, D, with copper (figure 11) and aluminium (figure 12) conductors).

The different return circuits are:

a: return circuit by fourth conductor;

b: return circuit by fourth conductor and sheath;

c: return circuit by fourth conductor and earth (100 Ωm);

d: return circuit by fourth conductor, sheat and earth (100 Ωm).

Special values depending on $q_n$ are given in the figures 13 to 20. The cables are according to German standards.

In table 5 characteristic data of 50 Hz cables are given.

## Table 5 - Actual data of typical electric cables

| No. | Rated voltage $U_r$ 1) | Conductors | | Cross section and type 2) | Type of cable 3) | Assemb. of cores 4) | Shield (sheath) | | Positive sequence impedance | Current return 7) | Zero-sequence impedance | Notes | Country |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number | Material | | | | Type 5) | Material | $\underline{Z}'_{(1)} = R'_{(1)} + jX'_{(1)}$ 6) | | $\underline{Z}'_{(0)} = R'_{(0)} + jX'_{(0)}$ 6) | | |
| | kV | – | – | $mm^2$ | – | – | – | – | Ω/km | – | Ω/km | | |
| 1 | 0,6/1 | 4 | Al | 240/220 rST | NR | 3 1/2 | – | – | 0,129 + j0,04 | 4th + E | $4{,}2 \cdot R'_{(1)} + j4{,}6X_{(1)}$ | | Czechoslovakia |
| 2 | 6/10 | 1 | Cu | 120 rST | R | SC | W + T | Cu | 0,16 + j0,116 | S + E | – | N2YSY | Hungary |
| 3 | 10 | 3 | Cu | 240 rST | NR | TC | M | Pb | 0,088 + j0,069 | S + E | j0,242 | | China |
| 4 | 22 | 3 | Cu | 120 rST | NR | TC | FW | Cu | 0,153 + j0,104 | S + E | – | DKAB | Norway |
| 5 | 50 | 1 | Al | 500 r | R | SC | W | Cu | 0,084 + j0,11 | S + E | 0,456 + j0,156 | | Denmark |
| 6 | 110 | 1 | Cu | 240 H0 | R | SC | M | Pb/Al | 0,079 + j0,12 | S + E | 0,51 + j0,30 | oil pressure | Germany |
| 7 | 132 | 3 x 1 | Cu | 220 rH0 | R | SC | M | Pb | 0,084 + j0,12 | S | 0,58 + j0.061 | | Italy |
| 8 | 275 | 1 | Cu | 1400 sST | R | SC | M | Al | 0,0131 + j0,146 | S + E | 0,047 + j0,047 | | Japan |
| 9 | 330 | 3 | Cu | 1200 sH0 | R | SC | M | Al | 0,0205 + j0,188 | S + E | 0,0719 + j0,0566 | | Australia |
| 10 | 380 | 1 | Cu | 1200 sST | R | SC | M | Al | 0,018 + j0,188 | S | 0,047 + j0,070 | | Austria |

1) Line-to-line voltage.
2) r = round, H0 = hollow, s = sector form, ST = stranded.
3) R = radial field, NR = non-radial field.
4) SC = single core, TC = three (or more) core cable.
5) T = tapes, W = wires, M = metallic sheaths.
6) AC resistance at 20 °C.
7) S = in the shield, E = earth, 4th = fourth conductor.

## 2.6 Data on typical asynchronous motors

The ratio locked rotor current to rated current $I_{LR}/I_{rM}$ is different for low- and medium-voltage motors. For low-voltage motors the average value is approximately 6,7 in the range 2 kW to 300 kW per pair of poles. The average value for medium-voltage motors is approximately 5,5 in the range 30 kW to 6 MW per pair of poles.

In figure 21 the ratio $I_{LR}/I_{rM}$ is plotted as a function of the active power per pair of poles.

The product of power factor and rated efficiency ($\cos\varphi_{rM} \cdot \eta_r$) is plotted as a function of the active power per pair of poles ($P_{rM}/p$) in figure 22.

In table 6 actual data of asynchronous motors are given.

## 2.7 Busbars

Actual data of low-voltage distribution busbars 50 Hz are given in table 7.

Table 6 - Actual data of typical asynchronous motors

| No. | Rated power $P_{rM}$ | Rated voltage $U_{rM}$ | Rated current $I_{rM}$ | Efficiency (rated) $\eta_r$ | Power factor $\cos\varphi_{rM}$ | Ratio $\frac{I_{LR}}{I_{rM}}$ | Rotation speed r.p.m. $n_r$ | Number of pairs of poles $p$ | D.C. Time constant $T_a$ | Country |
|---|---|---|---|---|---|---|---|---|---|---|
| | kW | kV | A | – | – | – | 1/min | – | s | |
| 1 | 45 | 0,380 | 80 | 0,92 | 0,89 | 7,14 | 2950 | 1 | | Bulgaria |
| 2 | 200 | 0,380 | 370 | $\eta_r \cdot \cos\varphi_{rM}$ = 0,82 | | 6,4 | – | 2 | 0,013 | Czechoslovakia |
| 3 | 250 | 6,0 | 29 | 0,94 | 0,89 | 5,3 | 2973 | 1 | 0,05 | Germany |
| 4 | 500 | 6,0 | 62 | 0,942 | 0,83 | 5,8 | 741 | 4 | 0,053 | ex-GDR |
| 5 | 1000 | 6,0 | 121 | 0,985 | 0,85 | 5,0 | 590 | 5 | 0,031 | ex-USSR |
| 6 | 3150 | 6,0 | 380 | $\eta_r \cdot \cos\varphi_{rM}$ = 0,80 | | 5,2 | – | 6 | 0,064 | Czechoslovakia |
| 7 | 6000 | 6,0 | 660 | 0,972 | 0,90 | 5,5 | 1490 | 2 | – | Italy |
| 8 | 315 | 6,0 | 36,5 | 0,942 | 0,88 | 6,2 | 1794 | 2 | – | Norway, 60 Hz |
| 9 | 6000 | 6,6 | 595 | 0,969 | 0,910 | 4,5 | 1776 | 2 | 0,055 | Japan, 60 Hz |
| 10 | 9698 | 6,6 | 963 | 0,961 | 0,917 | 6,23 | 1190 | 3 | 0,0968 | USA, 60 Hz |

## Table 7 - Actual data of distribution busbars

| No. | Rated voltage | Rated current | Conductors | | | Material sheath | Current return | Positive-sequence impedance | Zero-sequence impedance | Country |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number | Material | Cross section | | | | | |
| | kV | A | – | – | $mm^2$ | – | – | Ω/m | Ω/m | – |
| 1 | 0,38/0,66 | 1250 | 3 | Al | 1120 | Al | S + E | 0,038 + j0,0163 | 0,0882 + j0,0689 | ex-USSR |
| 2 | 0,38/0,66 | 1600 | 3 | Al | 1280 | Al | S + E | 0,0297 + j0,0143 | 0,0672 + j0,0555 | ex-USSR |
| 3 | 0,38/0,66 | 3200*) | 3 x 2 | Al | 2650 | Al | S + E | 0,0101 + j0,00495 | 0,0735 + j0,0392 | ex-USSR |

*) Split bar 2 x 1600 A.

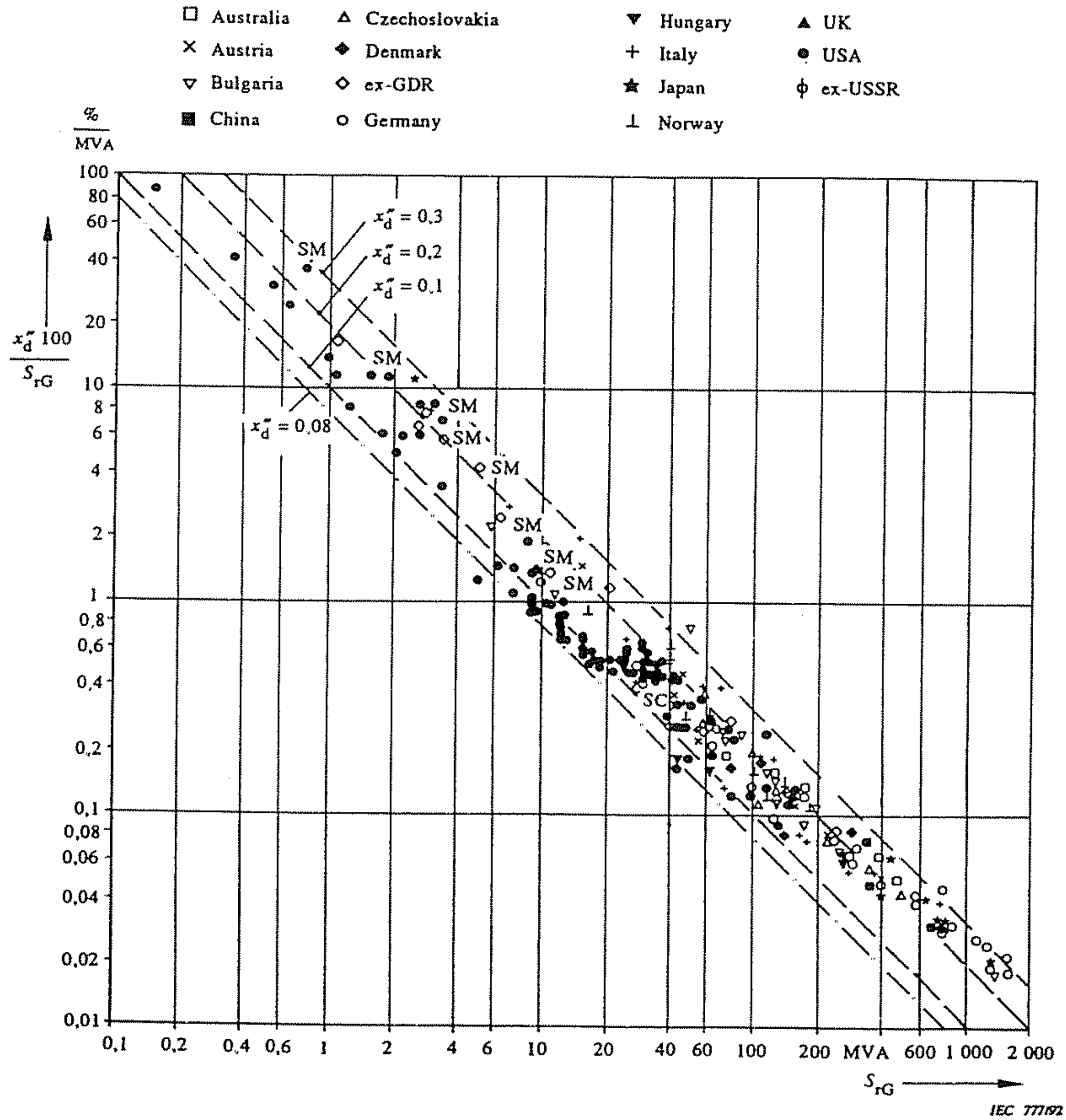



Figure 1 - Subtransient reactance of synchronous machines (motors SM, condensers SC, turbogenerators and salient pole generators) 50 Hz and 60 Hz

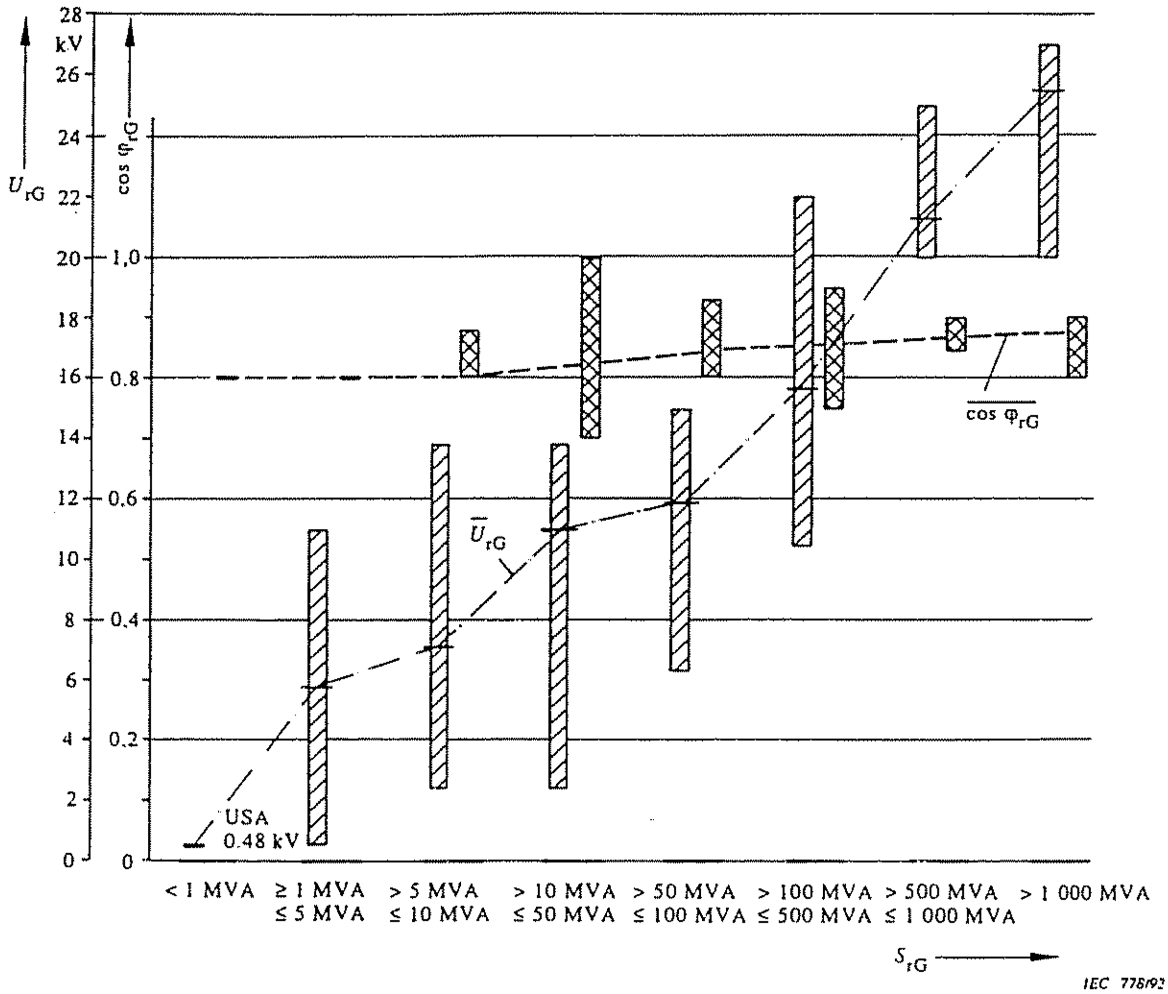
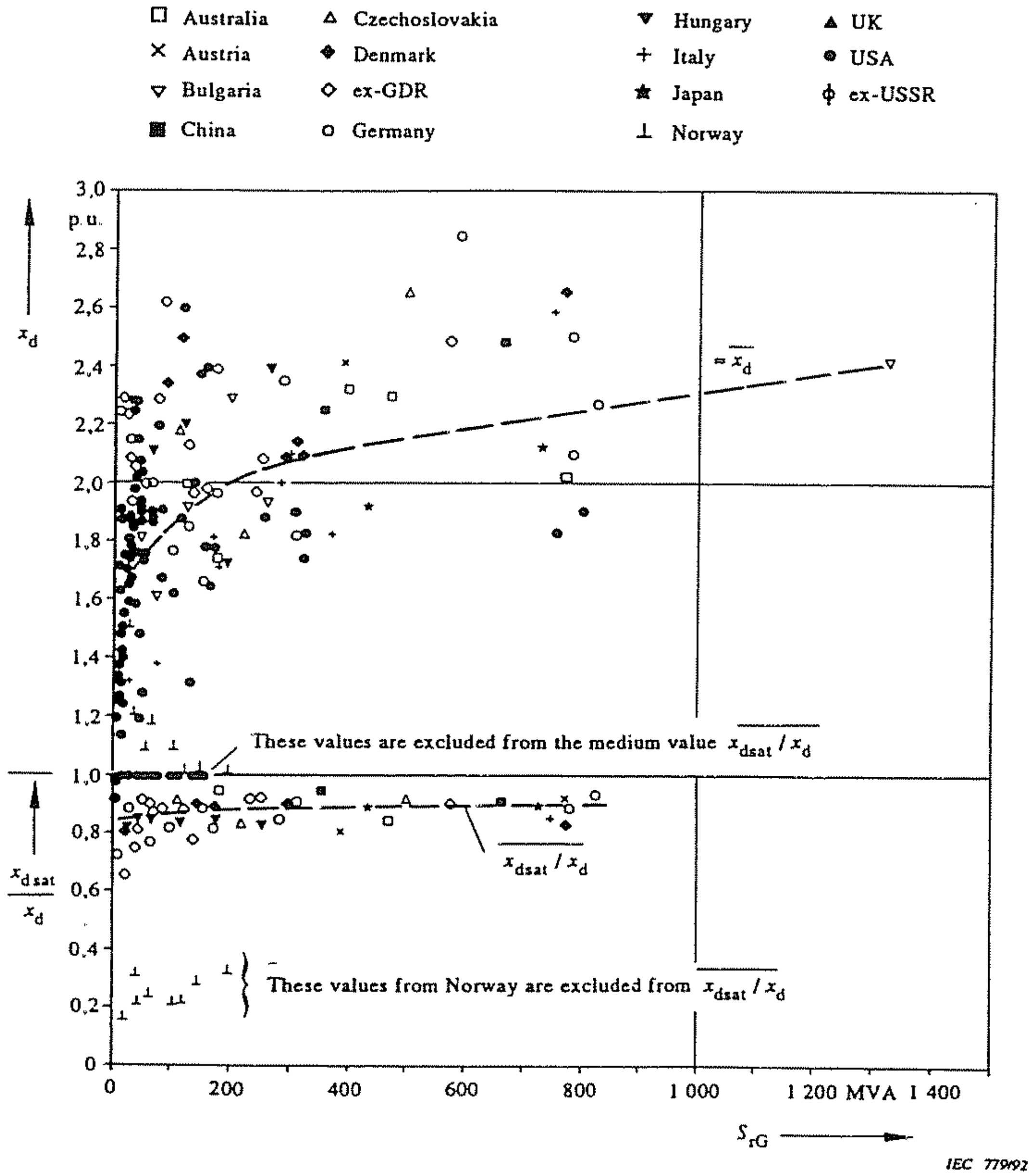


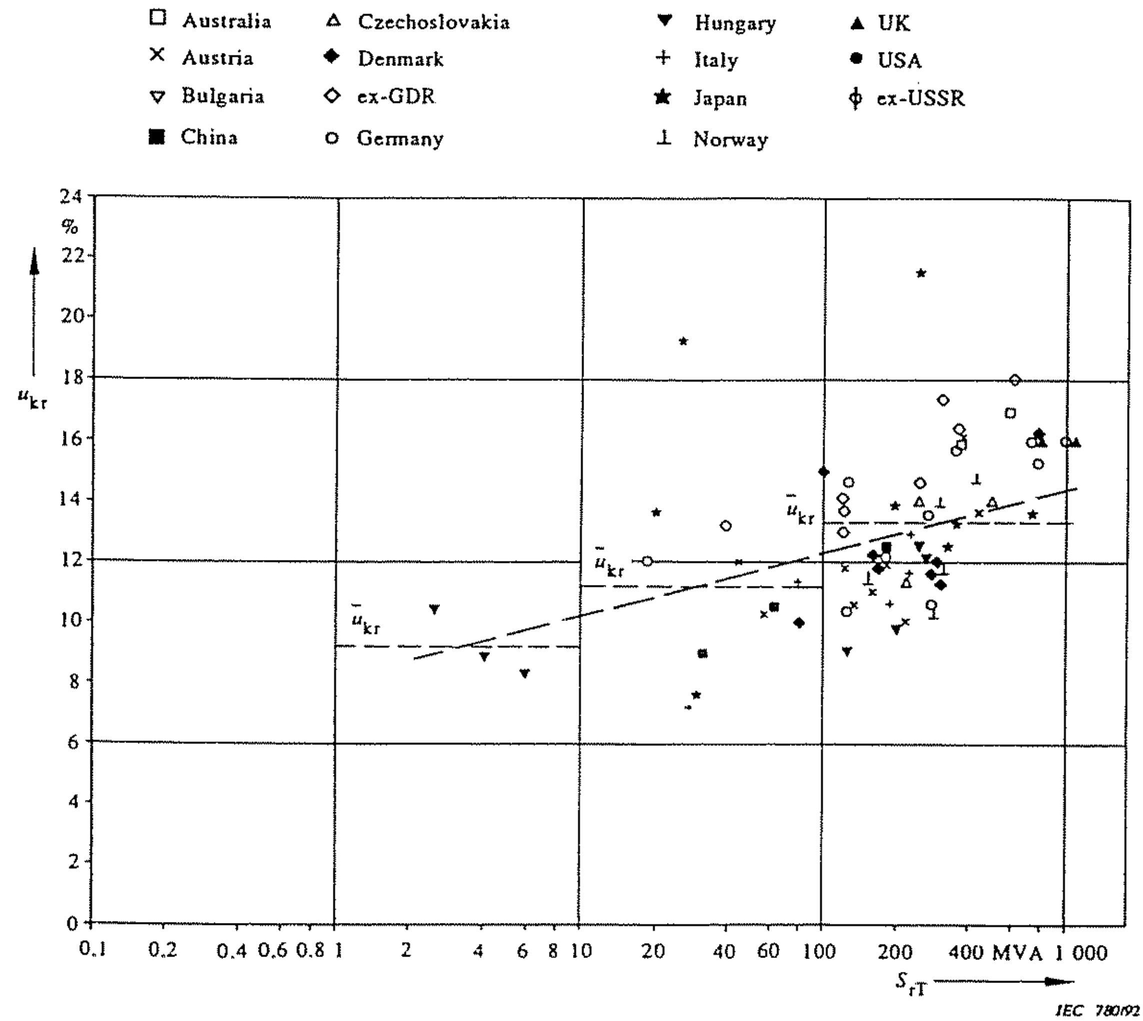

Figure 2 - Rated voltage $U_{rG}$ and rated power factor $\cos\varphi_{rG}$ of synchronous machines (motors, condensers, turbogenerators and salient pole generators) 50 Hz and 60 Hz




$x_d$ = Unsaturated reactance.

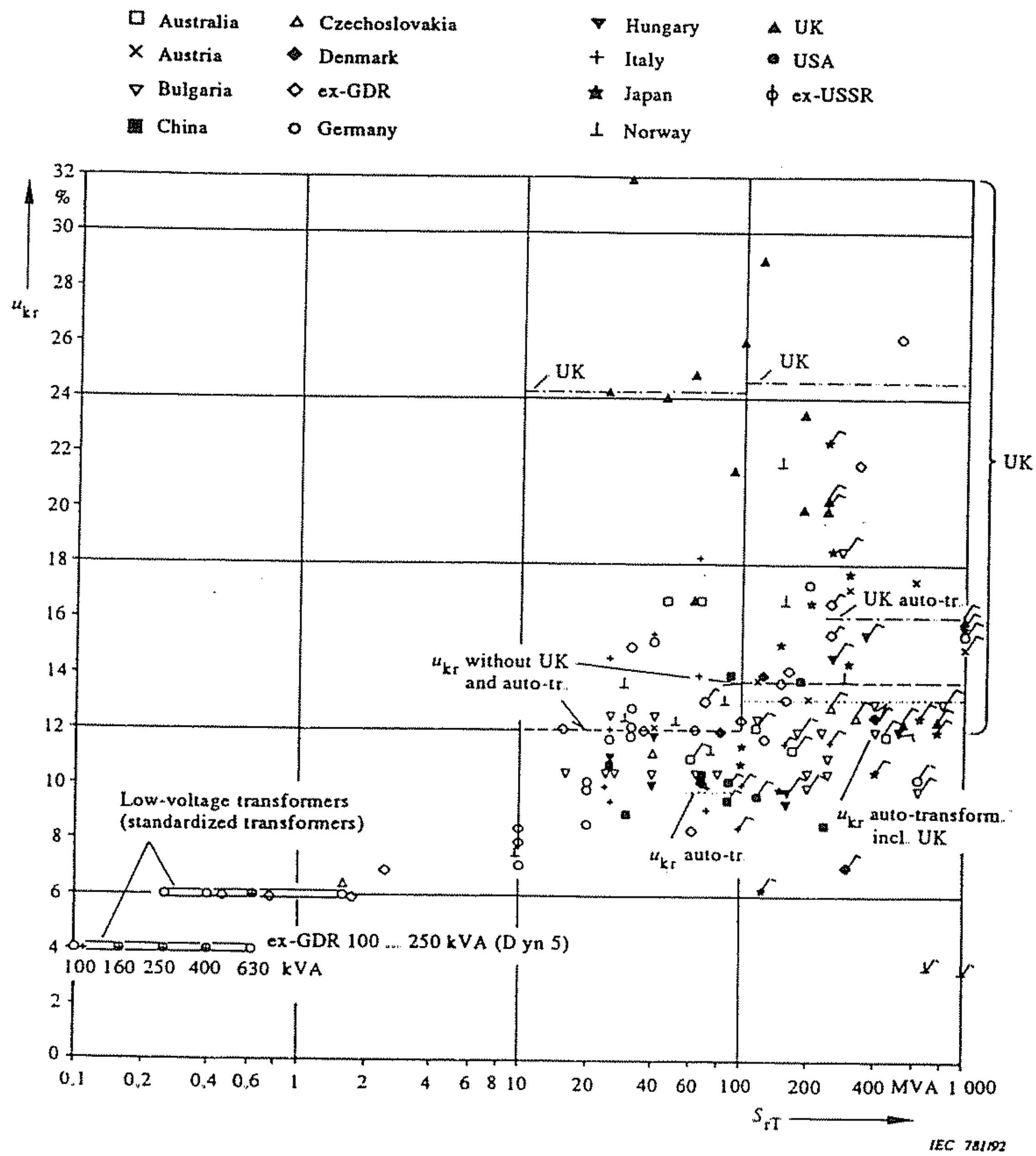
$x_{d\,sat}$ = Saturated reactance.

Figure 3 - Unsaturated and saturated synchronous reactances of two-pole turbogenerators 50 Hz (n = 3 000 min$^{-1}$) and 60 Hz (n = 3 600 min$^{-1}$)




$u_{kr} \approx 8 + 0{,}92 \ln S_{rT}$ for transformers $S_{rT}$ = (3...1 000) MVA

Figure 4 - Rated short-circuit voltage $u_{kr}$ of power station generator transformers (PT) with or without tap-changer

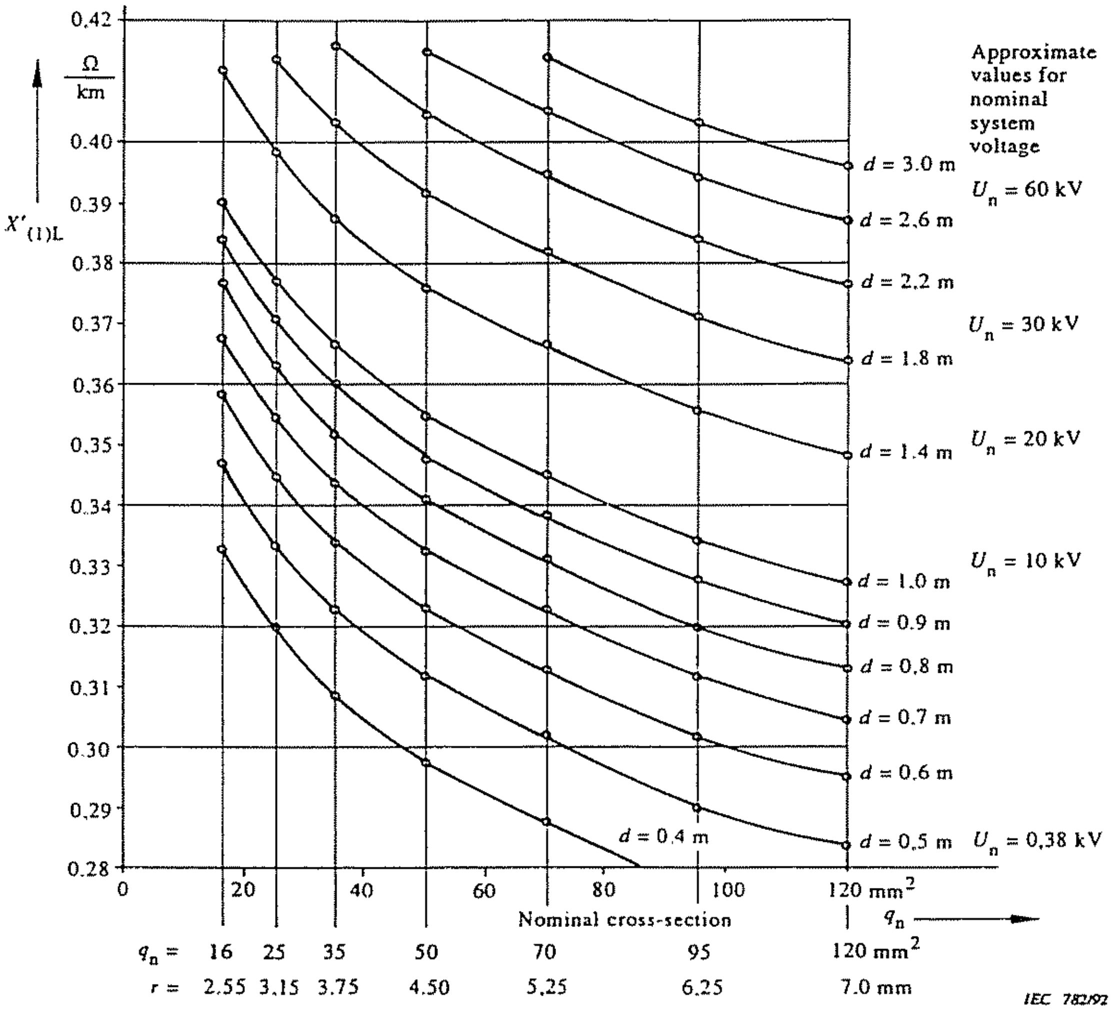



□, ×, ▽, ■ a.s.o. Three-winding transformers $u_{krAB} = f(S_{rTAB})$.

□́, ×́, ▽́, ■́ a.s.o. Three-winding auto-transformers $u_{krAB} = f(S_{rTAB})$.

UK: United Kingdom.

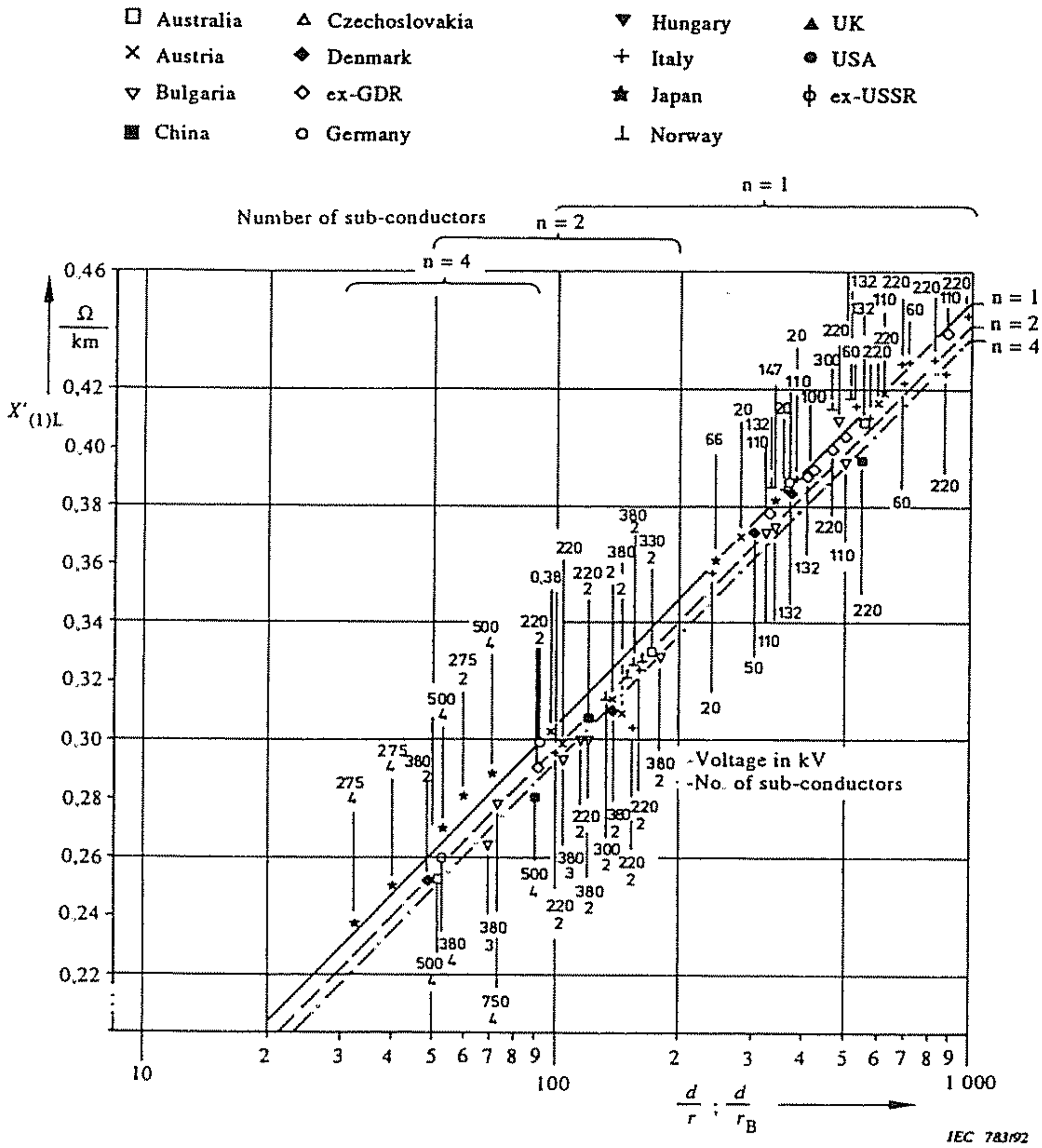
Figure 5 - Rated short-circuit voltage $u_{kr}$ of network transformers




Calculated values: $X'_{(1)L} = \omega \frac{\mu_0}{2\pi} \left(\frac{1}{4} + \ln\frac{d}{r}\right)$

with $d = \sqrt[3]{d_{L1L2} \; d_{L1L3} \; d_{L2L3}}$

Figure 6 - Positive-sequence reactance $X'_{(1)L}$ of low-voltage and medium-voltage overhead lines 50 Hz, Cu or Al. For 60 Hz these values must be multiplied by 1,2




Calculated values:

———— n = 1 $X'_{(1)L} = \omega \frac{\mu_0}{2\pi} \left( \frac{1}{4n} + \ln \frac{d}{r_B} \right)$

– – – – n = 2 $d = \sqrt[3]{d_{L1L2}\, d_{L1L3}\, d_{L2L3}}$

–·–·–·– n = 4 $r_B = \sqrt[n]{n r R^{n-1}}$

Figure 7 - Positive-sequence reactance $X'_{(1)L}$ of overhead lines 50 Hz (60-Hz-values converted to 50 Hz)

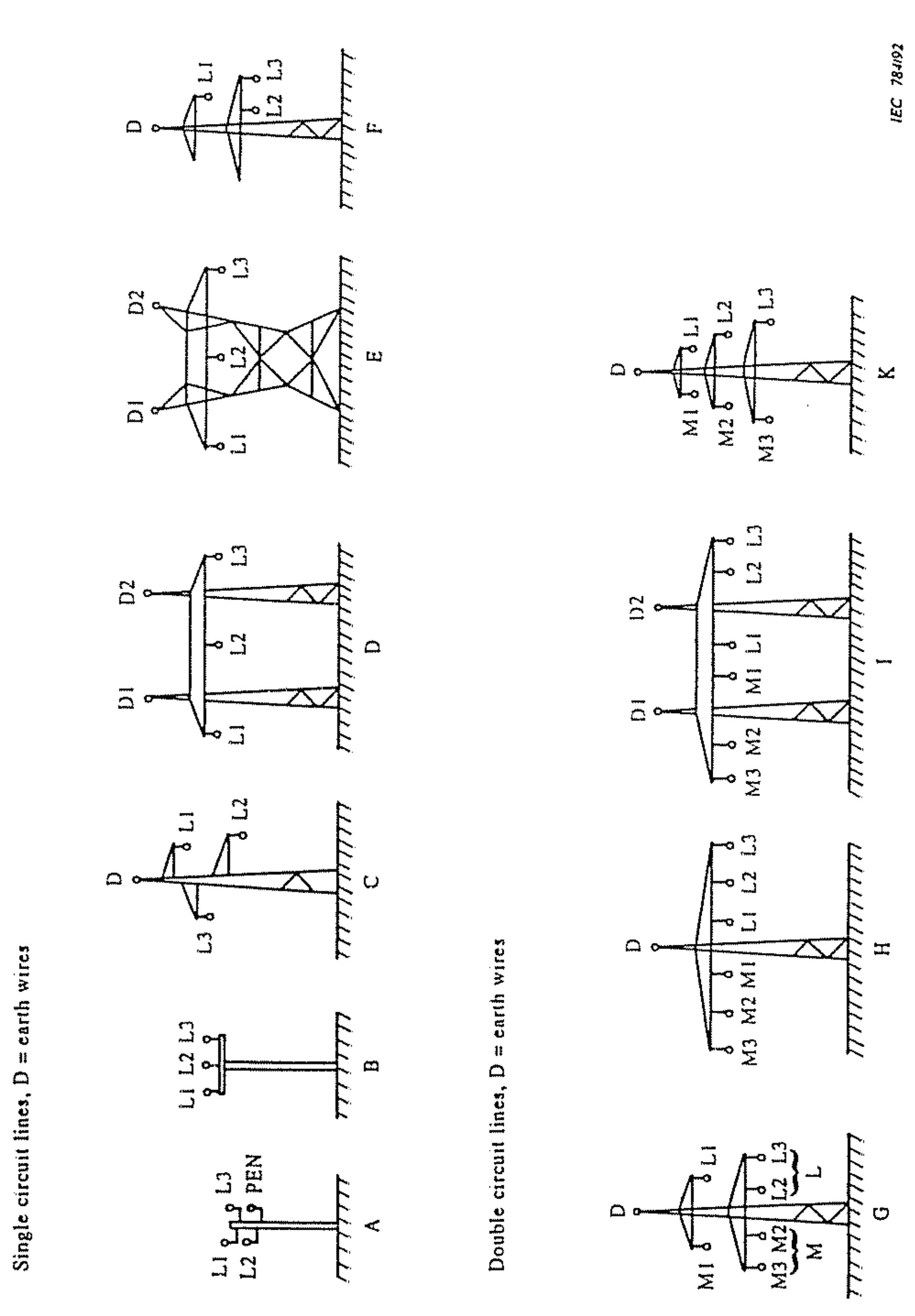



Figure 8 - Type of line

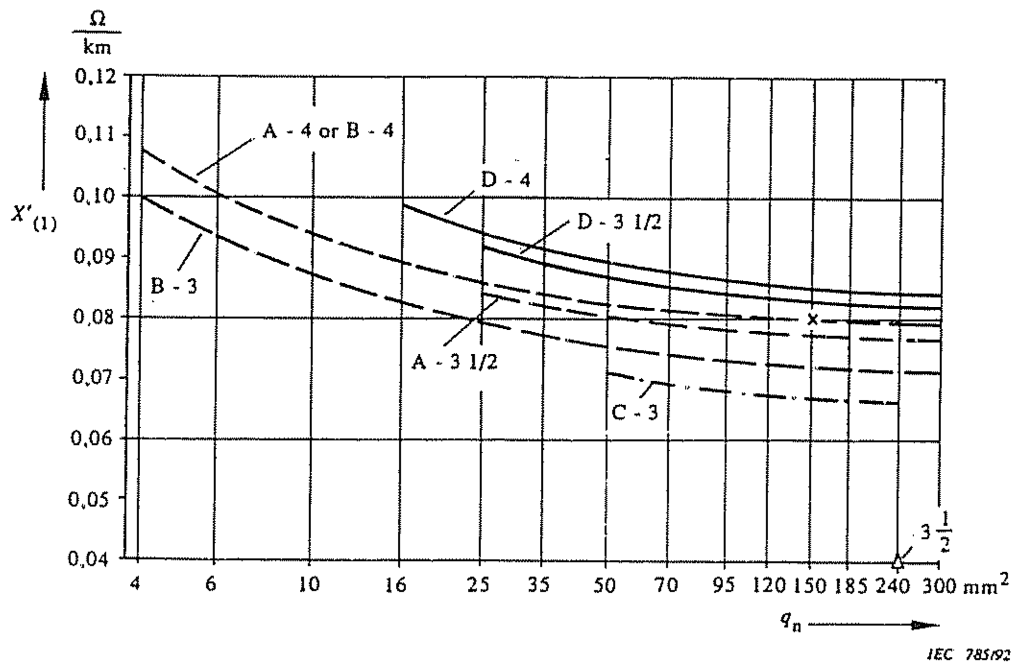
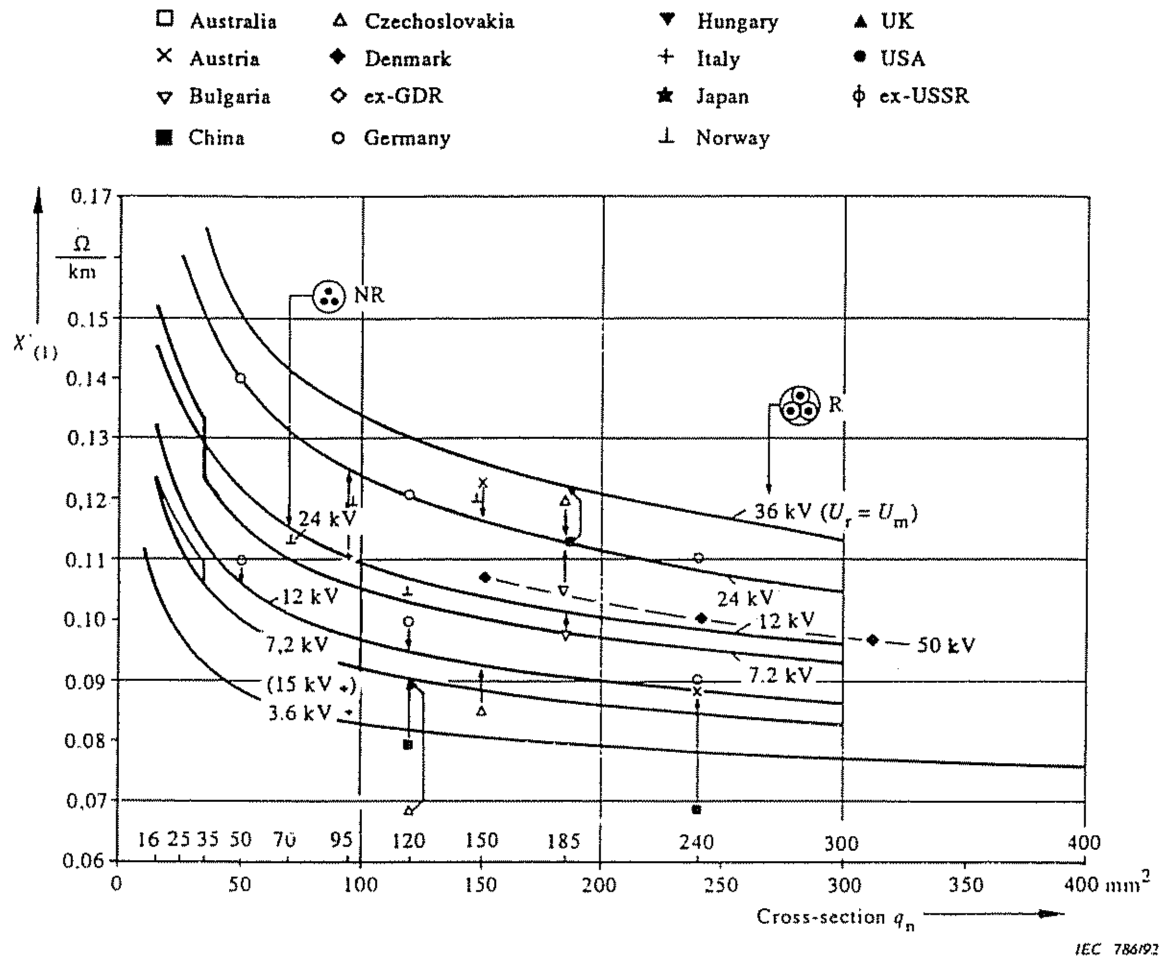



Figure 9 - Positive-sequence reactance $X'_{(1)}$ of low-voltage cables Cu or Al, 50 Hz (Germany), for different types of cables A, B, C, D, see clause 2.5. Three, three and a half and four conductor cables




NR: Non-radial field cables with three conductors.
R: Radial field cables with three conductors.

Figure 10 - Positive-sequence reactance $X'_{(1)}$ of medium-voltage cables, 50 Hz

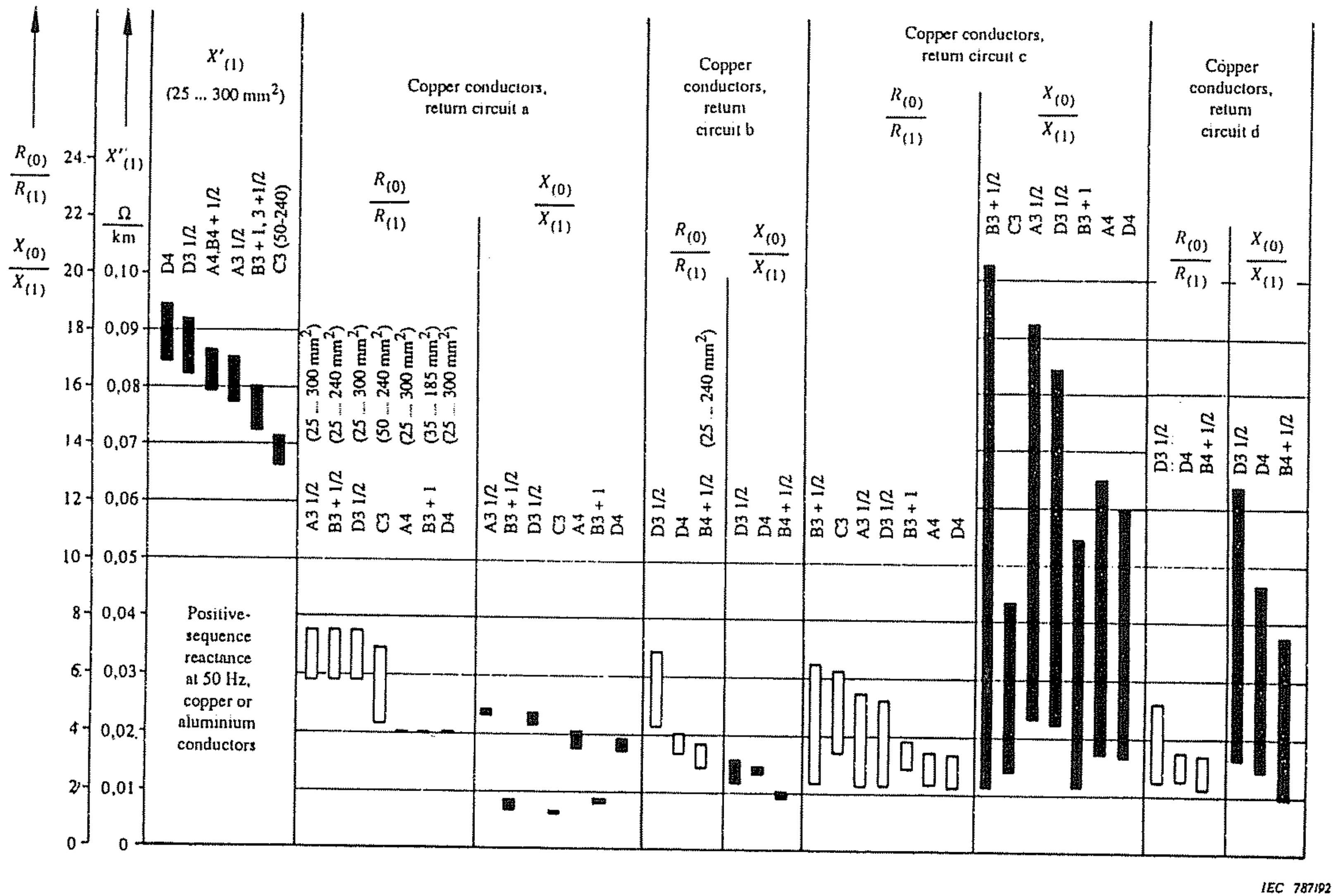



Figure 11 - Low-voltage cables 0,6/1 kV, positive-sequence reactance $X'_{(1)}$ and ratios $R_{(0)}/R_{(1)}$ and $X_{(0)}/X_{(1)}$. Copper conductors and return circuits a, b, c, d (see clause 2.5)

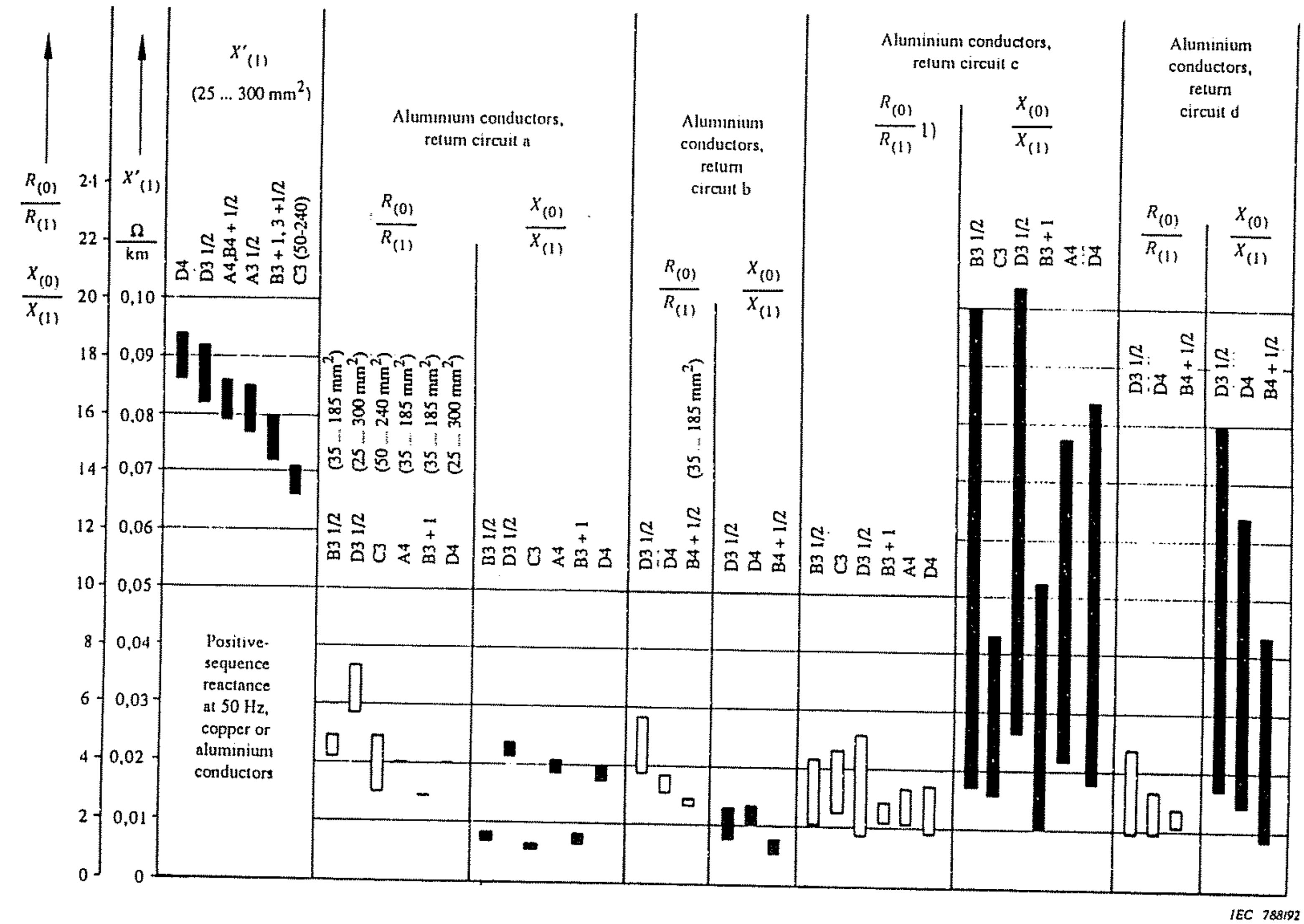
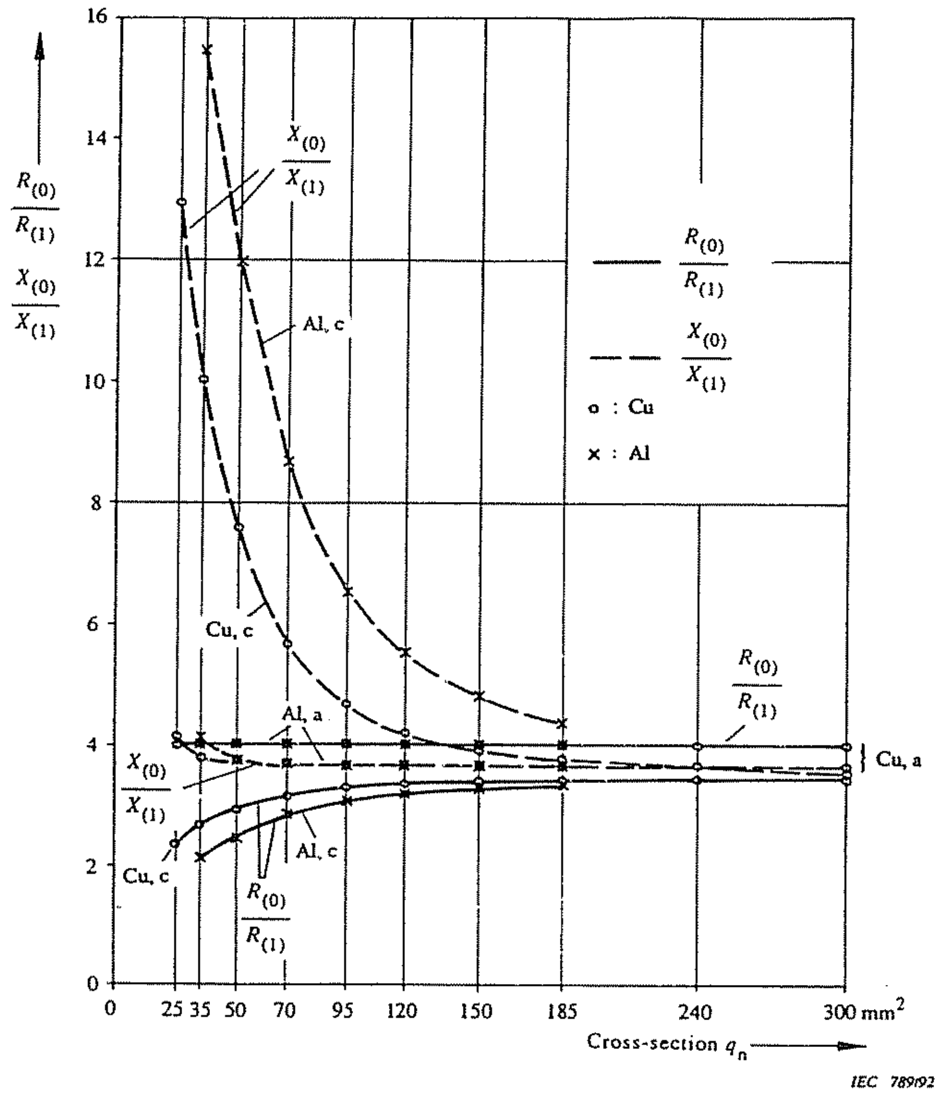
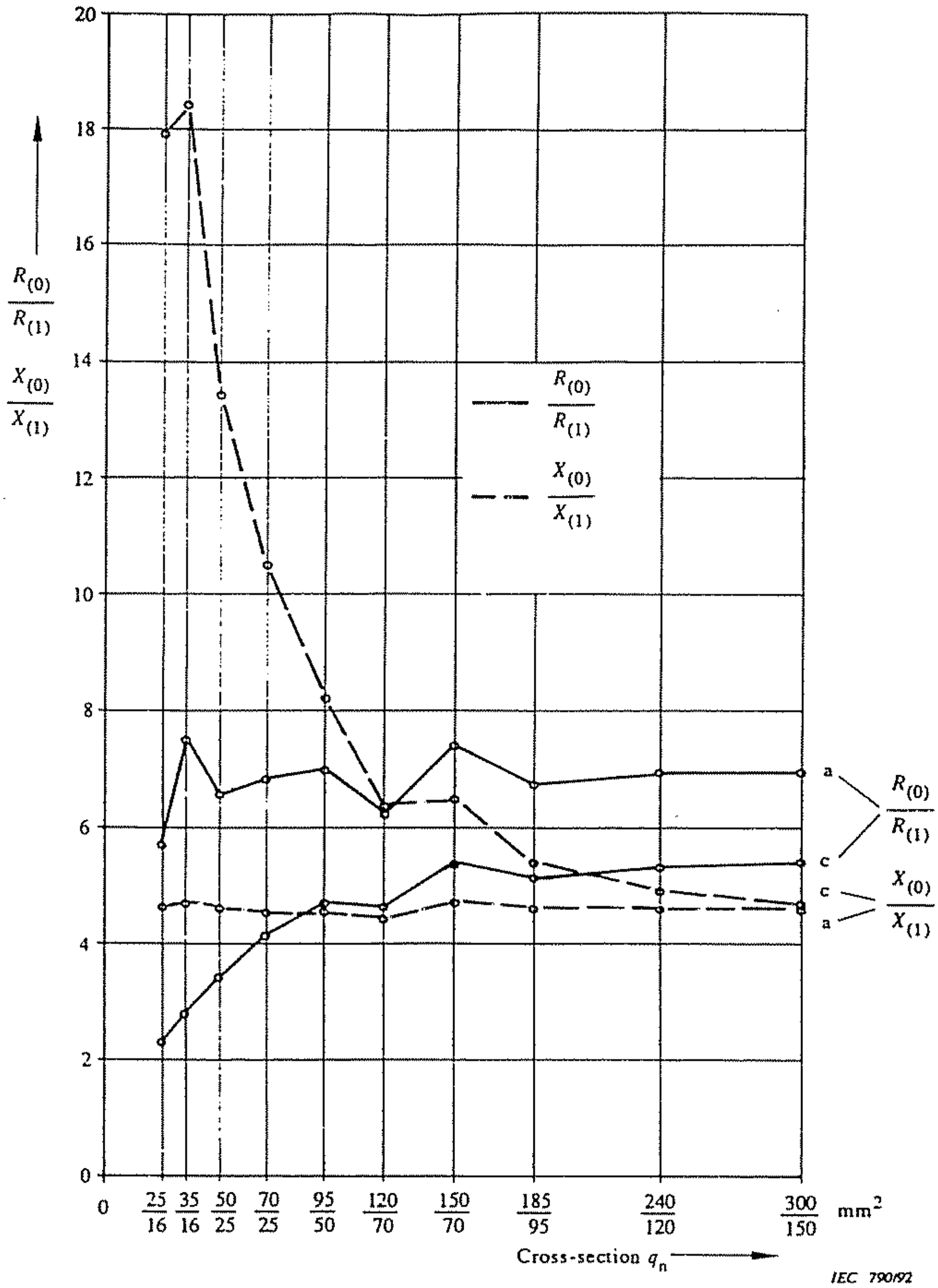



Figure 12 - Low-voltage cables 0,6/1 kV, positive-sequence reactance $X'_{(1)}$ and ratios $R_{(0)}/R_{(1)}$ and $X_{(0)}/X_{(1)}$. Aluminium conductors and return circuits a, b, c, d (see clause 2.5)




a: Return circuit by fourth conductor.
c: Return circuit by fourth conductor and earth.

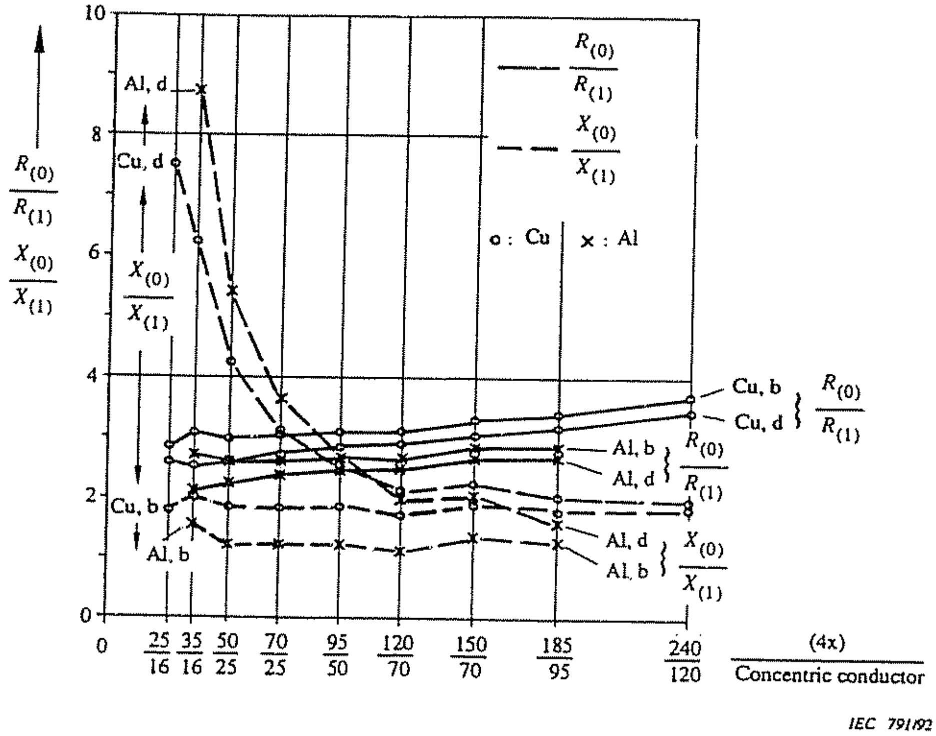
Figure 13 - Low-voltage cables 0,6/1 kV, type A, with four conductors Cu or Al (Germany), $R_{(0)}/R_{(1)}$, $X_{(0)}/X_{(1)}$




a: Return circuit by fourth conductor

c: Return circuit by fourth conductor and earth

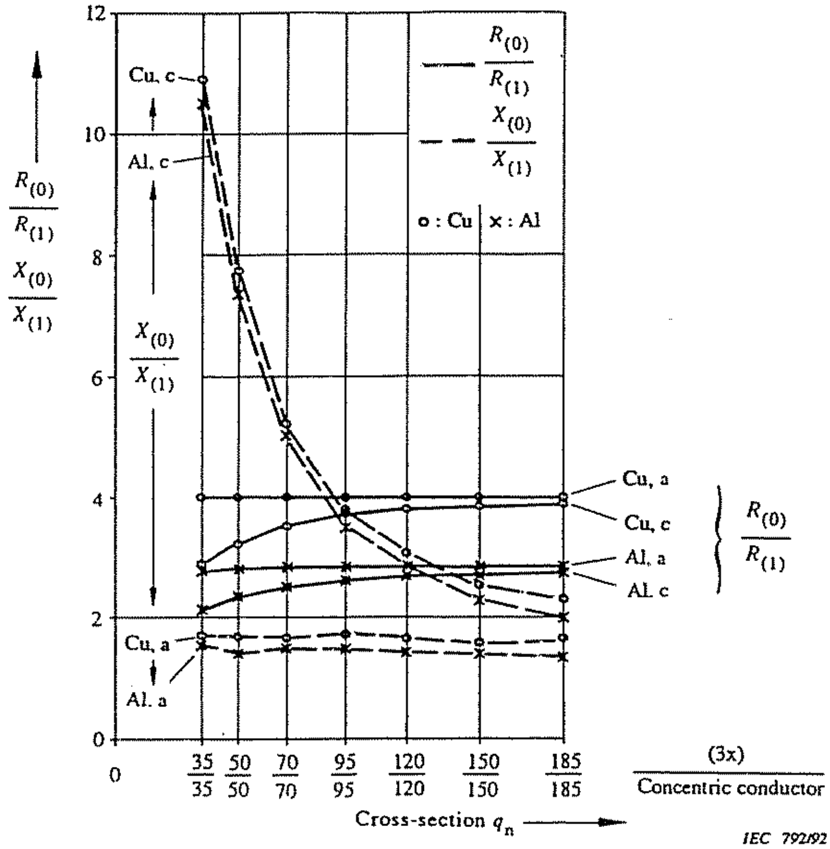
Figure 14 - Low-voltage cables 0,6/1 kV, type A, with three and a half copper conductors (Germany), $R_{(0)}/R_{(1)}$, $X_{(0)}/X_{(1)}$




b: Return circuit by fourth conductor and concentric conductor.

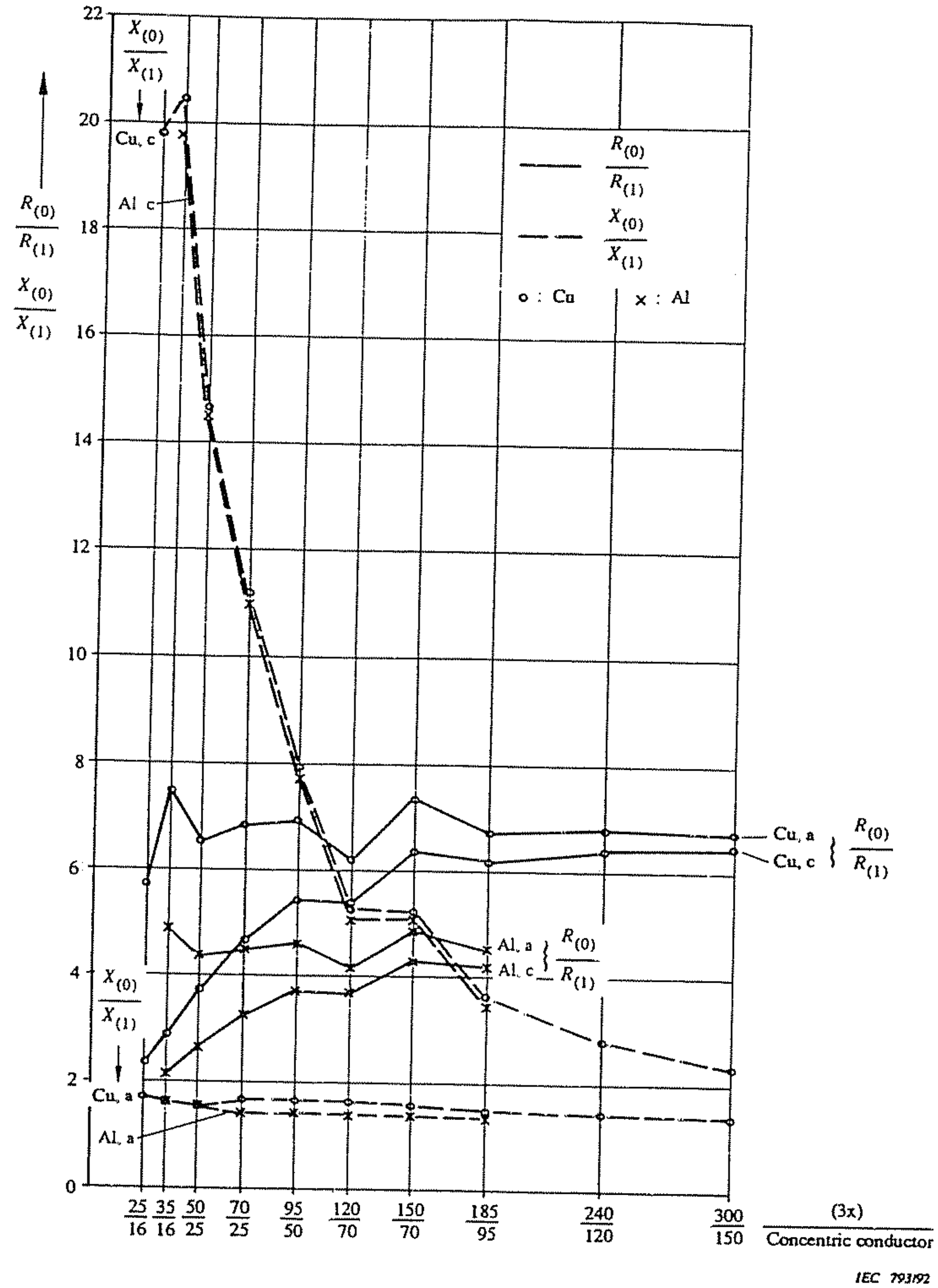
d: Return circuit by fourth conductor, concentric conductor and earth.

Figure 15 - Low-voltage cables 0,6/1 kV, type B, with four conductors Cu or Al and a concentric conductor Cu (Germany), $R_{(0)}/R_{(1)}$, $X_{(0)}/X_{(1)}$




a: Return circuit by concentric conductor.
c: Return circuit by concentric conductor and earth.

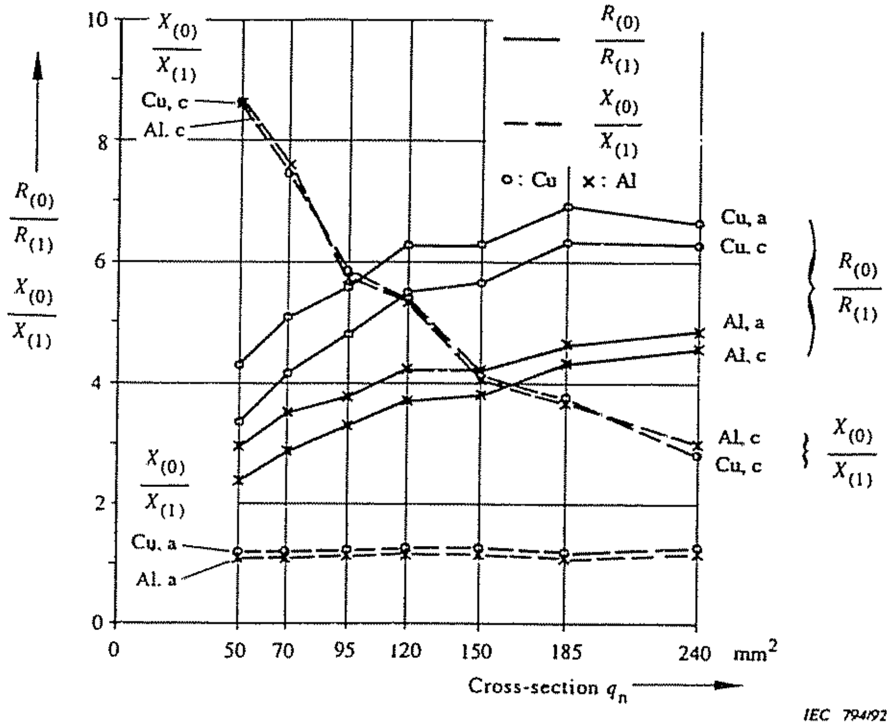
Figure 16 - Low-voltage cables 0,6/1 kV, type B, with three conductors Cu or Al and a concentric conductor Cu (Germany), $R_{(0)}/R_{(1)}$, $X_{(0)}/X_{(1)}$. The concentric conductor has the same cross-section as the main conductor




a: Return circuit by concentric conductor.

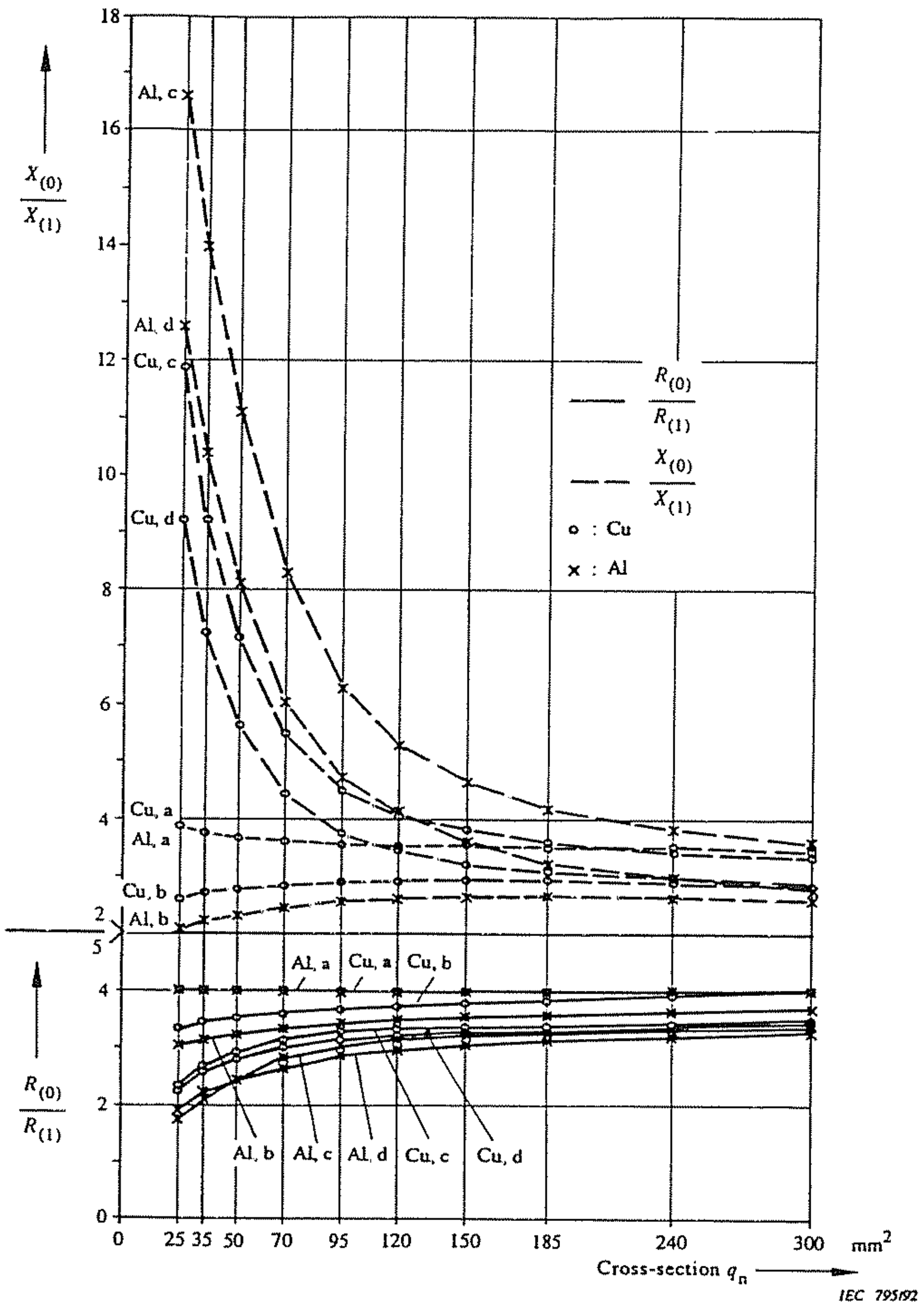
c: Return circuit by concentric conductor and earth.

Figure 17 - Low-voltage cables 0,6/1 kV, type B, with three conductors Cu or Al and a concentric conductor Cu (Germany), $R_{(0)}/R_{(1)}$, $X_{(0)}/X_{(1)}$. The concentric conductor has half the cross-section of the main conductor



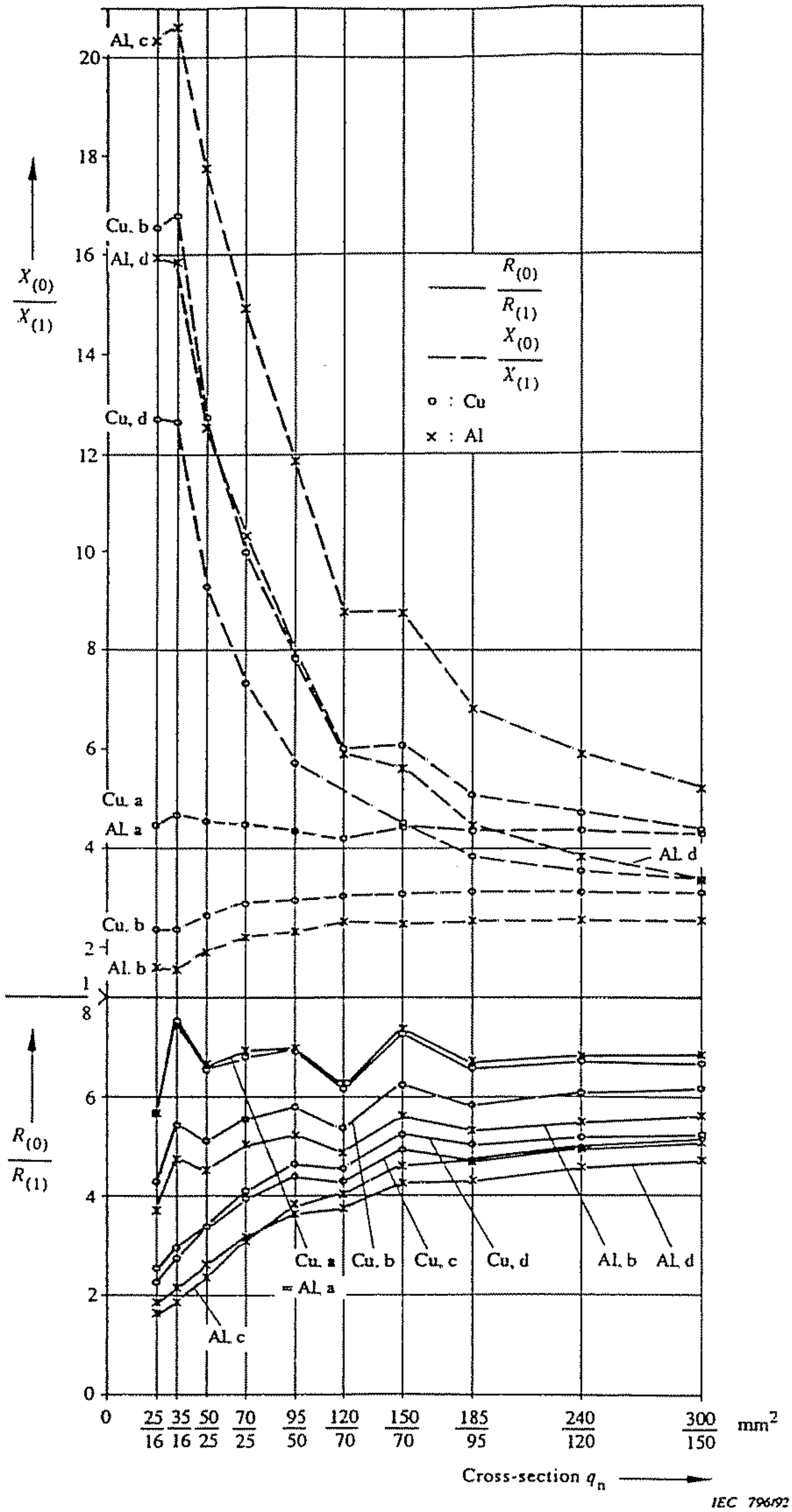

a: Return circuit by sheath
c: Return circuit by sheath and earth

Figure 18 - Low-voltage cables 0,6/1 kV, type C, with three conductors Cu or Al and an aluminium sheath (Germany), $R_{(0)}/R_{(1)}$, $X_{(0)}/X_{(1)}$




a: Return circuit by fourth conductor.
b: Return circuit by fourth conductor and sheath.
c: Return circuit by fourth conductor and earth.
d: Return circuit by fourth conductor, sheath and earth.

Figure 19 - Low-voltage cables 0,6/1 kV, type D, with four conductors Cu or Al and a lead sheath with steel armouring (Germany), $R_{(0)}/R_{(1)}$, $X_{(0)}/X_{(1)}$




a, b, c, d as in figure 19.

Figure 20 - Low-voltage cables 0,6/1 kV, type D, with three and a half conductors Cu or Al and a lead sheath with steel armouring (Germany), $R_{(0)}/R_{(1)}$, $X_{(0)}/X_{(1)}$

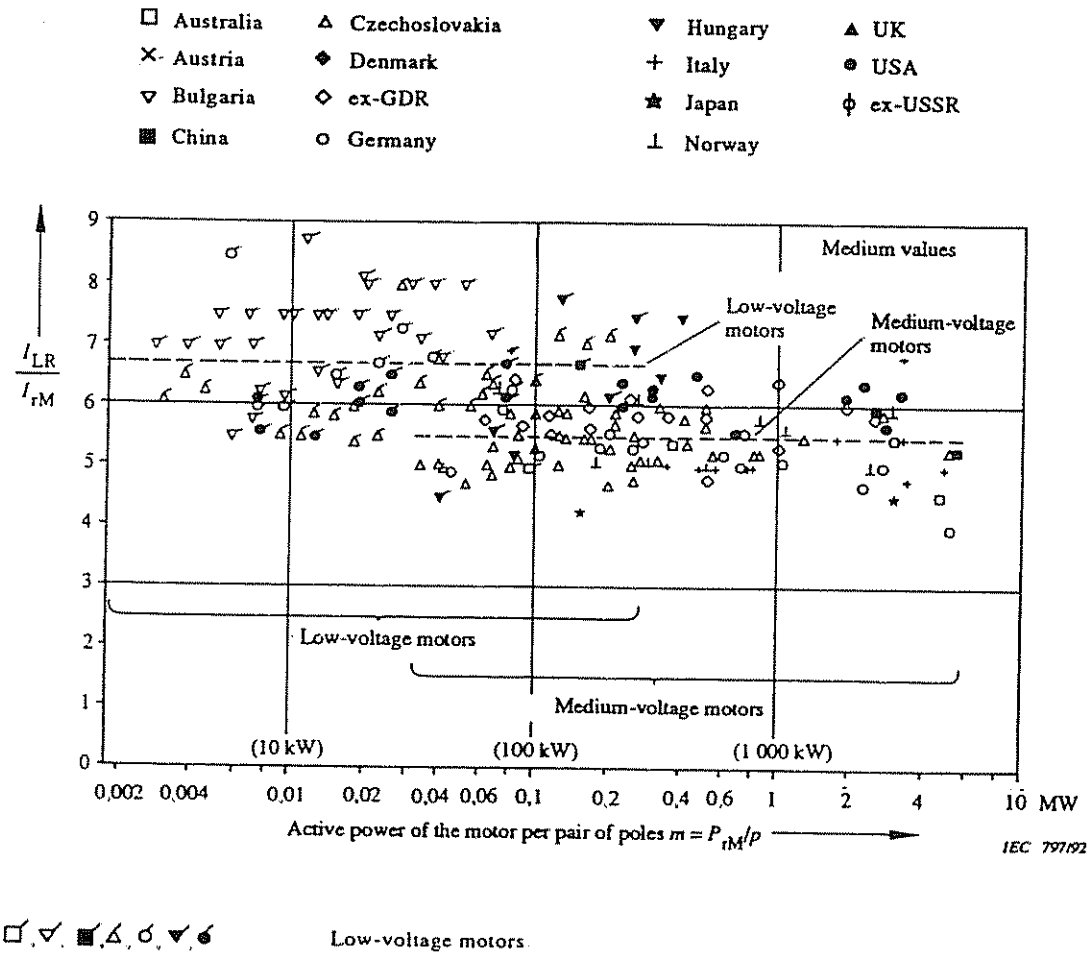



Figure 21 - Locked-rotor currents $I_{LR}/I_{rM}$ of low-voltage and medium-voltage asynchronous motors, 50 Hz and 60 Hz

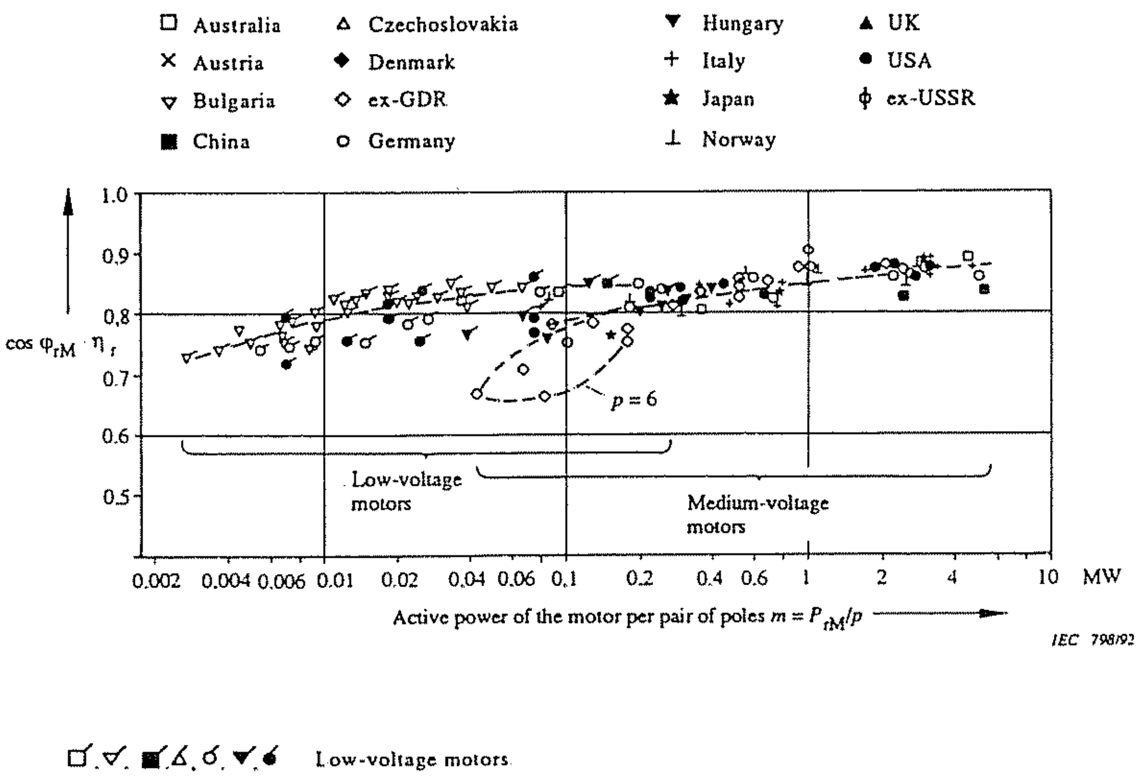



Figure 22 - Product cos $\varphi_{rM} \cdot \eta_r$ of low-voltage and medium-voltage asynchronous motors, 50 Hz and 60 Hz

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3.
This standard was purchased from:

. . . . . . . . . . . . . . . . . . . . . . . . .

4.
This standard will be used (check as many as apply):

- ☐ for reference
- ☐ in a standards library
- ☐ to develop a new product
- ☐ to write specifications
- ☐ to use in a tender
- ☐ for educational purposes
- ☐ for a lawsuit
- ☐ for quality assessment
- ☐ for certification
- ☐ for general information
- ☐ for design purposes
- ☐ for testing
- ☐ other . . . . . . . . . . . . . . . . . .

5.
This standard will be used in conjunction with (check as many as apply):

- ☐ IEC
- ☐ ISO
- ☐ corporate
- ☐ other (published by . . . . . . . . . . )
- ☐ other (published by . . . . . . . . . . )
- ☐ other (published by . . . . . . . . . . )

6.
This standard meets my needs (check one):

- ☐ not at all
- ☐ almost
- ☐ fairly well
- ☐ exactly

7.
Please rate the standard in the following areas as (1) bad, (2) below average, (3) average, (4) above average, (5) exceptional (0) not applicable:

- ☐ clearly written
- ☐ logically arranged
- ☐ information given by tables
- ☐ illustrations
- ☐ technical information

8.
I would like to know how I can legally reproduce this standard for:

- ☐ internal use
- ☐ sales information
- ☐ product demonstration
- ☐ other . . . . . . . . . . . . . . . . . . . .

9.
In what medium of standard does your organization maintain most of its standards (check one):

- ☐ paper
- ☐ microfilm/microfiche
- ☐ mag tape
- ☐ CD ROM
- ☐ floppy disk
- ☐ on line

9A.
If your organization currently maintains part or all of its standards collection in electronic media please indicate the format(s).

- ☐ raster image
- ☐ full text

10.
In what medium does your organization intend to maintain its standards collection in the future (check all that apply):

- ☐ paper
- ☐ microfilm/microfiche
- ☐ mag tape
- ☐ CD ROM
- ☐ floppy disk
- ☐ on line

10A.
For electronic media which format will be chosen (check one):

- ☐ raster image
- ☐ full text

11.
My organization is in the following sector (e.g. engineering, manufacturing)

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

12.
Does your organization have a standards library:

- ☐ Yes
- ☐ No

13.
If you said yes to 12 then how many volumes:

. . . . . . . . . . . . . . . . . . . . . . . . .

14.
Which standards organizations published the standards in your library (e.g. ISO, DIN, ANSI, BSI, etc.):

. . . . . . . . . . . . . . . . . . . . . . . . .

15.
My organization supports the standards-making process by (check as many as apply):

- ☐ buying standards
- ☐ using standards
- ☐ membership in standards organizations
- ☐ serving on standards development committees
- ☐ other . . . . . . . . . . . . . . . . . .

16.
My organization uses (check one):

- ☐ French text only
- ☐ English text only
- ☐ Both English/French text

17.
Other comments:

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

18.
Please give us information about you and your company

name: . . . . . . . . . . . . . . . . . . . . . . . .

job title: . . . . . . . . . . . . . . . . . . . . . .

company: . . . . . . . . . . . . . . . . . . . . .

address: . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

No. employees at your location: . . . . . . . .

turnover/sales: . . . . . . . . . . . . . . . . . .

## Publications de la CEI préparées par le Comité d'Etudes n° 73

60781 (1989) Guide d'application pour le calcul des courants de court-circuit dans les réseaux à basse tension radiaux

60865: — Courants de court-circuit – Calcul des effets

60865-1 (1993) Partie 1: Définitions et méthodes de calcul

60865-2 (1994) Partie 2: Exemples de calcul

60909 (1988) Calcul des courants de court-circuit dans les réseaux triphasés à courant alternatif

60909-1 (1991) Partie 1: Facteurs pour le calcul des courants de court-circuit dans les réseaux alternatifs triphasés conformément à la CEI 60909

60909-2 (1992) Matériel électrique – Données pour le calcul des courants de court-circuit conformément à la CEI 60909 (1988)

60909-3 (1995) Partie 3: Courants durant deux court-circuits monophasés simultanés séparés à la terre et courants de court-circuit partiels s'écoulant à travers la terre

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61660-1 (1997) Partie 1: Calcul des courants de court-circuit

61660-2 (1997) Partie 2: Calcul des effets

## IEC publications prepared by Technical Committee No. 73

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60865:— Short-circuit currents – Calculation of effects

60865-1 (1993) Part 1: Definitions and calculation methods.

60865-2 (1994) Part 2: Examples of calculation.

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