

## P R E F A C E

The present collection comprises 21 sets of ship screw propeller design charts. They are based on the well - known hydrodynamic characteristics of the Wageningen B - screw propeller series obtained from systematic open water model tests . The charts are automatically created using the numerical method and package of computer programmes developed at the Bulgarian Ship Hydrodynamics Centre, Varna . For this purpose, the regression polynomial equations for the serial hydrodynamic coefficients obtained at the Netherlands Ship Model Basin , are used.

For each of the available 21 B - series with systematically varying screw propeller particulars ( number of blades from 2 to 7, blade area ratio from 0.3 to 1.05 and pitch ratio from 0.5 to 1.4 ), two types of charts - " $K_T - J$ " and " $K_Q - J$ " named also "Hull" and "Machine" are built. Their structure allows respective application of the " Naval Architecture " or " Marine Engineering " approaches to the solution of various problems in the design practice . The calculation of the optimum propeller characteristics is realized using the " optimum revolutions line -  $n_{opt}$  " and the " optimum diameter line -  $D_{opt}$  " presented on each chart. The non - dimensional design parameters of Pappel are chosen as parameters of these lines, i.e.  $K_d$ ,  $K_n$  for the " Hull " diagrams, and  $K'_d$ ,  $K'_n$  for the " Machine " diagrams respectively.

The diagrams can be also used for design of modified BB screw propellers, whose hydrodynamic characteristics may be considered identical to those of the original B - series, differing only with their slightly wider blade contour near the tip. This blade contour is more effective for heavier screw propeller loadings which makes this contour preferable for practical purposes . Therefore, the particulars presented in the collection refer to the geometry of the BB - screw propeller series .

The charts are intended for engineering and technical specialists from the shipbuilding industry and the water transport and can be effectively used for solution of a number of problems in the field of screw propeller design and ship performance prediction. The collection can also be used as a handbook when studying " Naval Architecture " and " Marine Engineering " disciplines at the technical high schools and the specialized secondary schools .

## N O T A T I O N

$A_E / A_O$	- propeller expanded area ratio
$A_r, B_r$	- constants
$a_r$	- distance between blade section leading edge and generator line at $r_i / R$
$b_r$	- distance between blade section leading edge and position of maximum thickness at $r_i / R$
$c_r$	- Chord length of blade section at $r_i / R$
$D$	- propeller diameter
$J = \frac{V_A}{nD}$	- propeller advance coefficient
$K_T = \frac{T}{\rho n^2 D^4}$	- propeller thrust coefficient
$K_Q = \frac{Q}{\rho n^2 D^5}$	- propeller torque coefficient
$K_d = DV_A \sqrt{\frac{\rho}{T}}$	- design parameter for the $n_{opt}$ lines of the "hull" charts
$K_n = \frac{V_A}{\sqrt{n}} \sqrt{\frac{\rho}{T}}$	- design parameter for the $D_{opt}$ lines of the "hull" charts
$K'_d = DV_A \sqrt{\frac{75 \rho V_A}{P_D}}$	- design parameter for the $n_{opt}$ lines of the "machine" charts

$$K'_n = \frac{V_A}{\sqrt{n}} \sqrt[4]{\frac{75 \rho V_A}{P_D}}$$

- design parameter for the  $D_{opt}$  lines of the "machine" charts

$n$

- rate of propeller rotation per second

$P / D$

- propeller pitch ratio

$P_D = 2 \pi n Q$

- delivered power at propeller

$Q$

- propeller torque

$r_i / R$

- nondimensional radius of blade section

$R$

- propeller radius

$$Rn = \frac{5nD}{\nu z} \frac{A_E}{A_O}$$

- Reynolds number

$T$

- propeller thrust

$t_r$

- maximum blade section thickness at  $r_i / R$

$V_A$

- propeller speed of advance

$z$

- number of propeller blades

$$\eta_o = \frac{K_T}{K_Q} \frac{J}{2 \pi}$$

- propeller efficiency in open water

$\nu$

- coefficient of water kinematic viscosity

$\rho$

- mass density of water

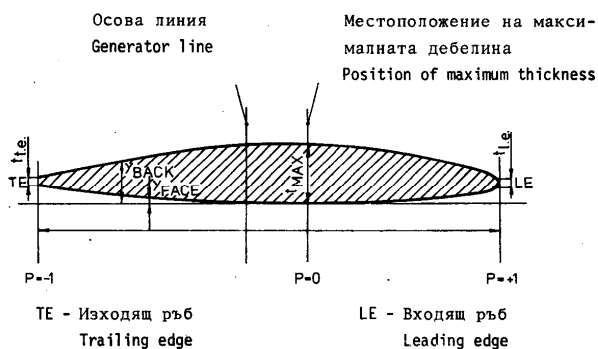
# ГЕОМЕТРИЧНИ ЕЛЕМЕНТИ НА ВАГЕНИНГЕНСКИТЕ BB-0 PARTICULARS OF THE WAGENINGEN BB-SCREW P

## A. РАЗМЕРИ НА ПЕРКИТЕ / DIMENSIONS OF BLADES

$r_t / R$	$\frac{a_r}{D} \cdot z$ $A_B/A_0$	$a_r / c_r$	$b_r / c_r$	$t_r/D=A_r-B_r \cdot z$	
				$A_r$	$B_r$
0.200	1.600	0.581	0.350	0.0526	0.004000
0.300	1.832	0.584	0.350	0.0464	0.003500
0.400	2.023	0.580	0.351	0.0402	0.003000
0.500	2.163	0.570	0.355	0.0340	0.002500
0.600	2.243	0.552	0.389	0.0278	0.002000
0.700	2.247	0.524	0.443	0.0216	0.001500
0.800	2.132	0.480	0.486	0.0154	0.001000
0.850	2.005	0.448	0.498	0.0123	0.000750
0.900	1.798	0.402	0.500	0.0092	0.000500
0.950	1.434	0.318	0.500	0.0061	0.000250
0.975	1.122	0.227	0.500	0.0045	0.000125
1.000	0.000	0.000	0.000	0.0030	0.000000

## B. ОРДИНАТИ НА СЕЧЕНИЯТА НА

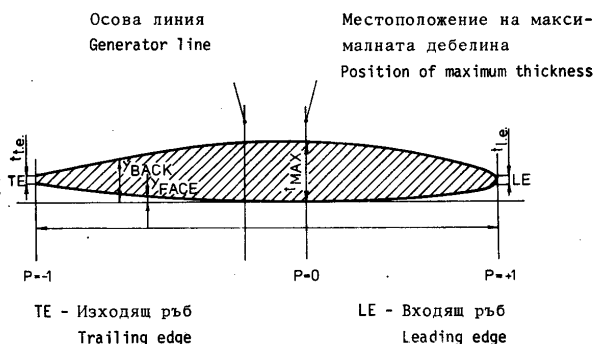
### Геометрични параметри на сеченията Geometric parameters of blade sections



# ТИ НА ВАГЕНИНГЕНСКИТЕ BB-СЕРИИ ГРЕБНИ ВИНТОВЕ THE WAGENINGEN BB-SCREW PROPELLER SERIES

## B. ОРДИНАТИ НА СЕЧЕНИЯТА НА ПЕРКИТЕ / ORDINATES OF BLADE SECTIONS

### Геометрични параметри на сеченията Geometric parameters of blade sections



### Ординати на смукателната страна / Back ordinates

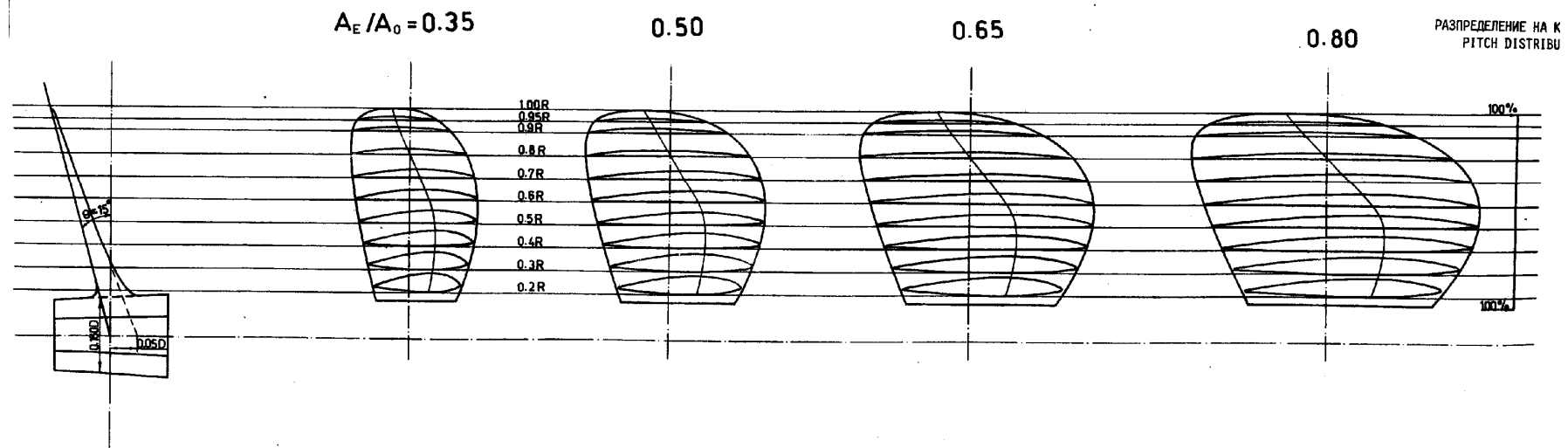
$$y_{back} = (V_1 + V_2) (t_{max} - t_{t.e.}) + t_{t.e.} \quad - P \leq 0$$

$$y_{back} = (V_1 + V_2) (t_{max} - t_{l.e.}) + t_{l.e.} \quad - P > 0$$

### Ординати на нагнетателната страна / Face ordinate

$$y_{face} = V_1 (t_{max} - t_{t.e.}) \quad - P \leq 0$$

$$y_{face} = V_1 (t_{max} - t_{l.e.}) \quad - P > 0$$



$A_E/A_0 = 0.40$

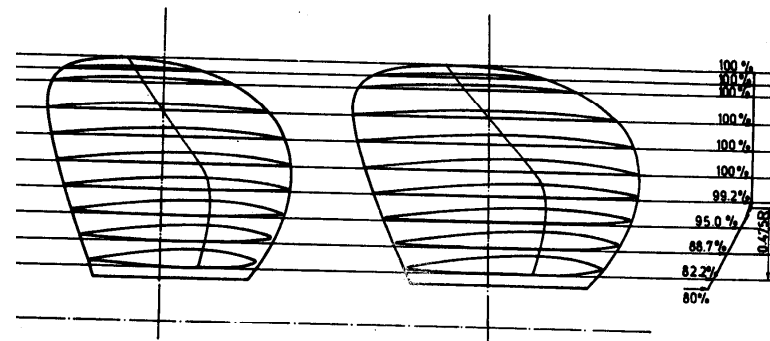
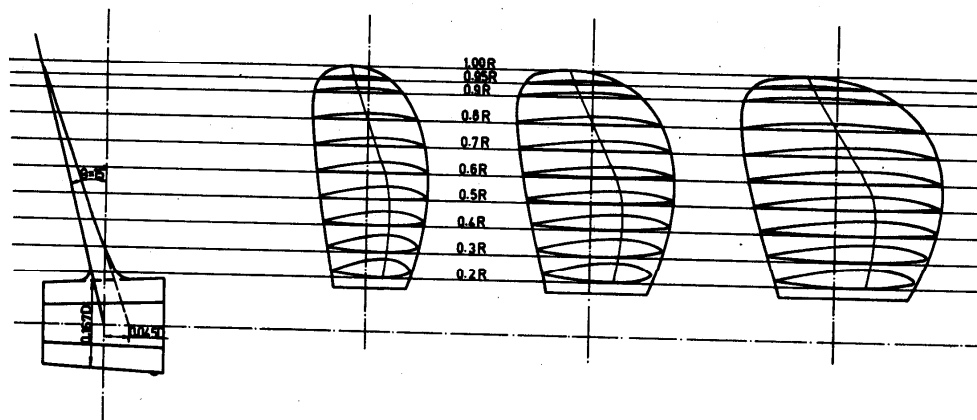
0.55

0.70

0.85

1.00

РАЗПРЕДЕЛЕНИЕ НА КРАЧКАТА  
PITCH DISTRIBUTION



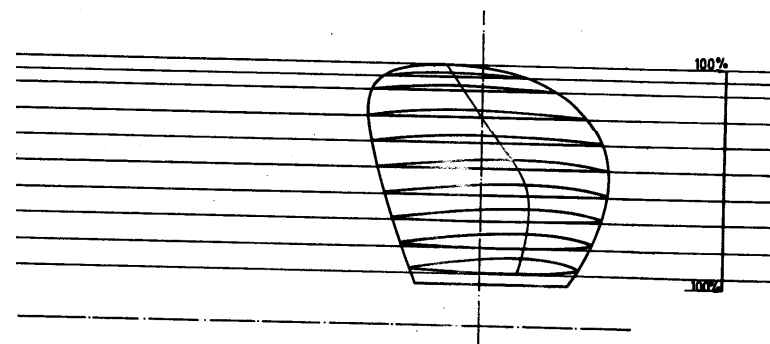
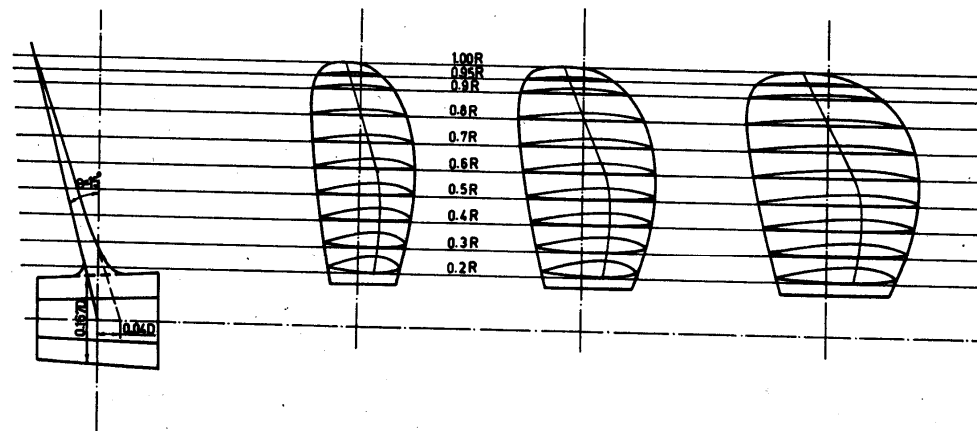
$A_E/A_0 = 0.45$

0.60

0.75

1.05

РАЗПРЕДЕЛЕНИЕ НА КРАЧКАТА  
PITCH DISTRIBUTION



Табулирани стойности на функцията  $V_1$  / Tabulated values of the function  $V_1$

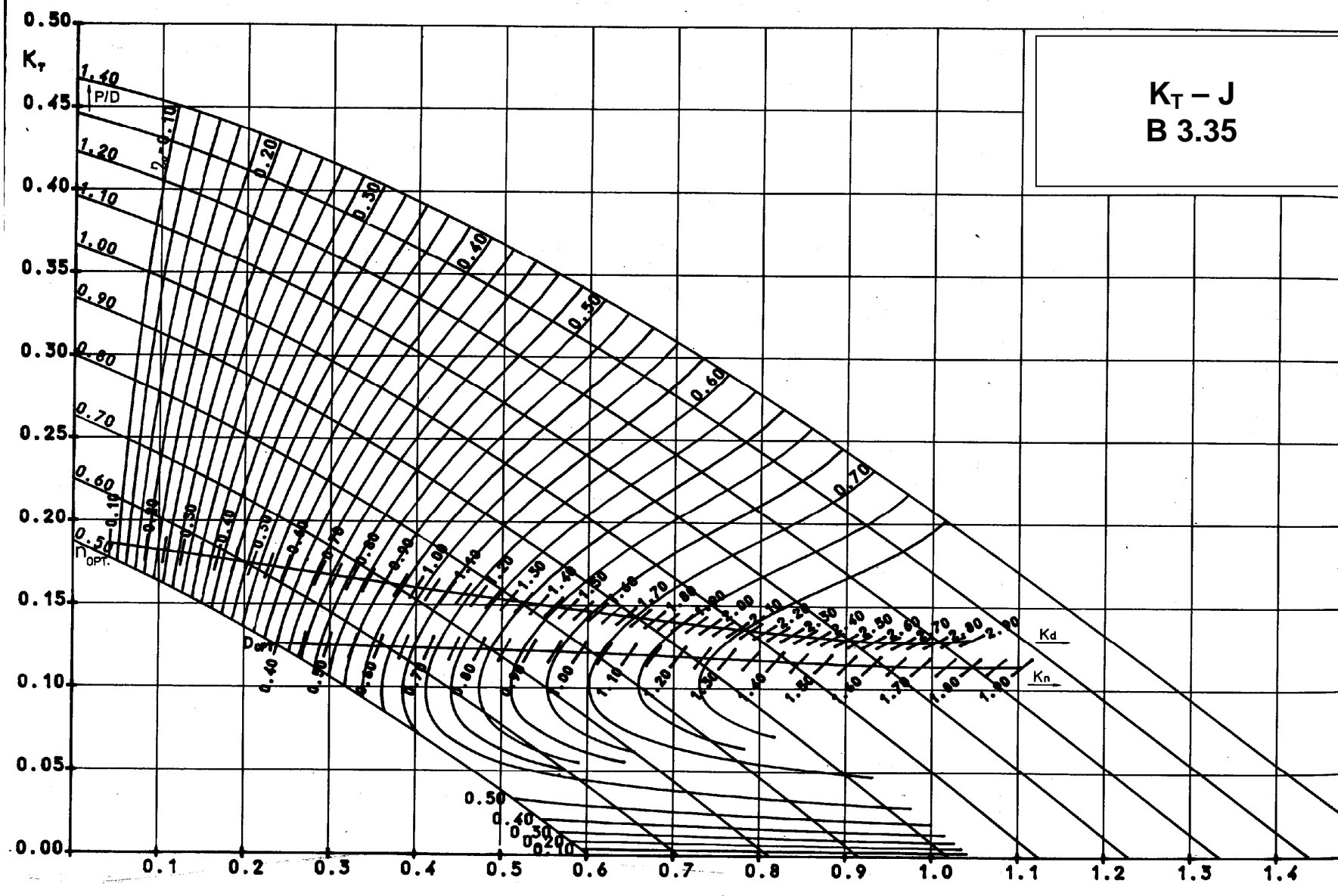
$r_z/R \setminus P$	-1.0	-0.95	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.2	0.	+0.2	+0.4	+0.5	+0.6	+0.7	+0.8	+0.85	+0.9	+0.95	+1.0
0.7-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.0006	0.0022	0.0067	0.0169	0.0382
0.5	0.0522	0.0420	0.0330	0.0190	0.0100	0.0040	0.0012	0.	0.	0.	0.	0.	0.	0.	0.	0.0034	0.0085	0.0211	0.0328	0.0500
0.4	0.1467	0.1200	0.0972	0.0630	0.0395	0.0214	0.0116	0.0044	0.	0.	0.	0.	0.0033	0.0090	0.0189	0.0357	0.0637	0.0833	0.1088	0.1467
0.3	0.2306	0.2040	0.1790	0.1333	0.0943	0.0623	0.0376	0.0202	0.0033	0.	0.0027	0.0148	0.0300	0.0503	0.0790	0.1191	0.1445	0.1760	0.2186	0.2923
0.25	0.2598	0.2372	0.2115	0.1651	0.1246	0.0899	0.0579	0.0350	0.0084	0.	0.0032	0.0224	0.0417	0.0669	0.1008	0.1465	0.1747	0.2068	0.2513	0.3256
0.2	0.2826	0.2630	0.2400	0.1967	0.1570	0.1207	0.0880	0.0592	0.0172	0.	0.0049	0.0304	0.0520	0.0804	0.1180	0.1685	0.2000	0.2353	0.2821	0.3560
0.15	0.3000	0.2824	0.2650	0.2300	0.1950	0.1610	0.1280	0.0955	0.0365	0.	0.0096	0.0384	0.0615	0.0920	0.1320	0.1870	0.2230	0.2642	0.3150	0.3860

Табулирани стойности на функцията  $V_2$  / Tabulated values of the function  $V_2$

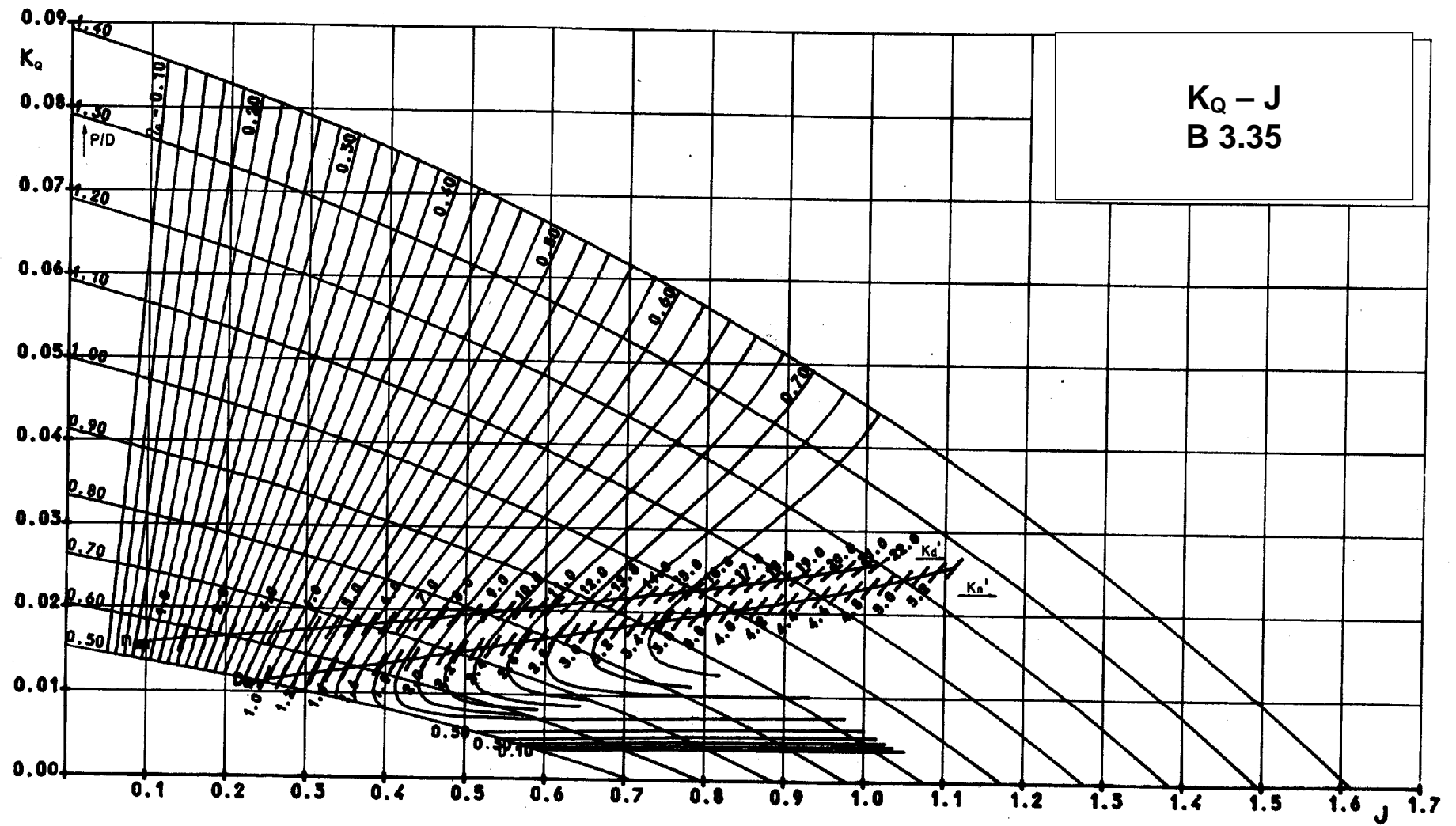
$r_z/R \setminus P$	-1.0	-0.95	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.2	0.	+0.2	+0.4	+0.5	+0.6	+0.7	+0.8	+0.85	+0.9	+0.95	+1.0
0.9-1.0	0.	0.0975	0.1900	0.3600	0.5100	0.6400	0.7500	0.8400	0.9600	1.	0.9600	0.8400	0.7500	0.6400	0.5100	0.3600	0.2775	0.1900	0.0975	0.
0.85	0.	0.0975	0.1900	0.3600	0.5100	0.6400	0.7500	0.8400	0.9600	1.	0.9615	0.8450	0.7550	0.6455	0.5160	0.3660	0.2830	0.1950	0.1000	0.
0.8	0.	0.0975	0.1900	0.3600	0.5100	0.6400	0.7500	0.8400	0.9600	1.	0.9635	0.8520	0.7635	0.6545	0.5265	0.3765	0.2925	0.2028	0.1050	0.
0.7	0.	0.0975	0.1900	0.3600	0.5100	0.6400	0.7500	0.8400	0.9600	1.	0.9675	0.8660	0.7850	0.6840	0.5615	0.4140	0.3300	0.2337	0.1240	0.
0.6	0.	0.0965	0.1885	0.3585	0.5110	0.6415	0.7530	0.8426	0.9613	1.	0.9690	0.8790	0.8090	0.7200	0.6060	0.4620	0.3775	0.2720	0.1485	0.
0.5	0.	0.0950	0.1865	0.3569	0.5140	0.6439	0.7580	0.8456	0.9639	1.	0.9710	0.8880	0.8275	0.7478	0.6430	0.5039	0.4135	0.3056	0.1750	0.
0.4	0.	0.0905	0.1810	0.3500	0.5040	0.6353	0.7525	0.8415	0.9645	1.	0.9725	0.8933	0.8345	0.7593	0.6590	0.5220	0.4335	0.3235	0.1935	0.
0.3	0.	0.0800	0.1670	0.3360	0.4885	0.6195	0.7335	0.8265	0.9583	1.	0.9750	0.8920	0.8315	0.7520	0.6505	0.5130	0.4265	0.3197	0.1890	0.
0.25	0.	0.0725	0.1567	0.3228	0.4740	0.6050	0.7184	0.8139	0.9519	1.	0.9751	0.8899	0.8259	0.7415	0.6359	0.4982	0.4108	0.3042	0.1758	0.
0.2	0.	0.0640	0.1455	0.3060	0.4535	0.5842	0.6995	0.7984	0.9446	1.	0.9750	0.8875	0.8170	0.7277	0.6190	0.4777	0.3905	0.2840	0.1560	0.
0.15	0.	0.0540	0.1325	0.2870	0.4280	0.5585	0.6770	0.7805	0.9360	1.	0.9760	0.8825	0.8055	0.7105	0.5995	0.4520	0.3665	0.2600	0.1300	0.

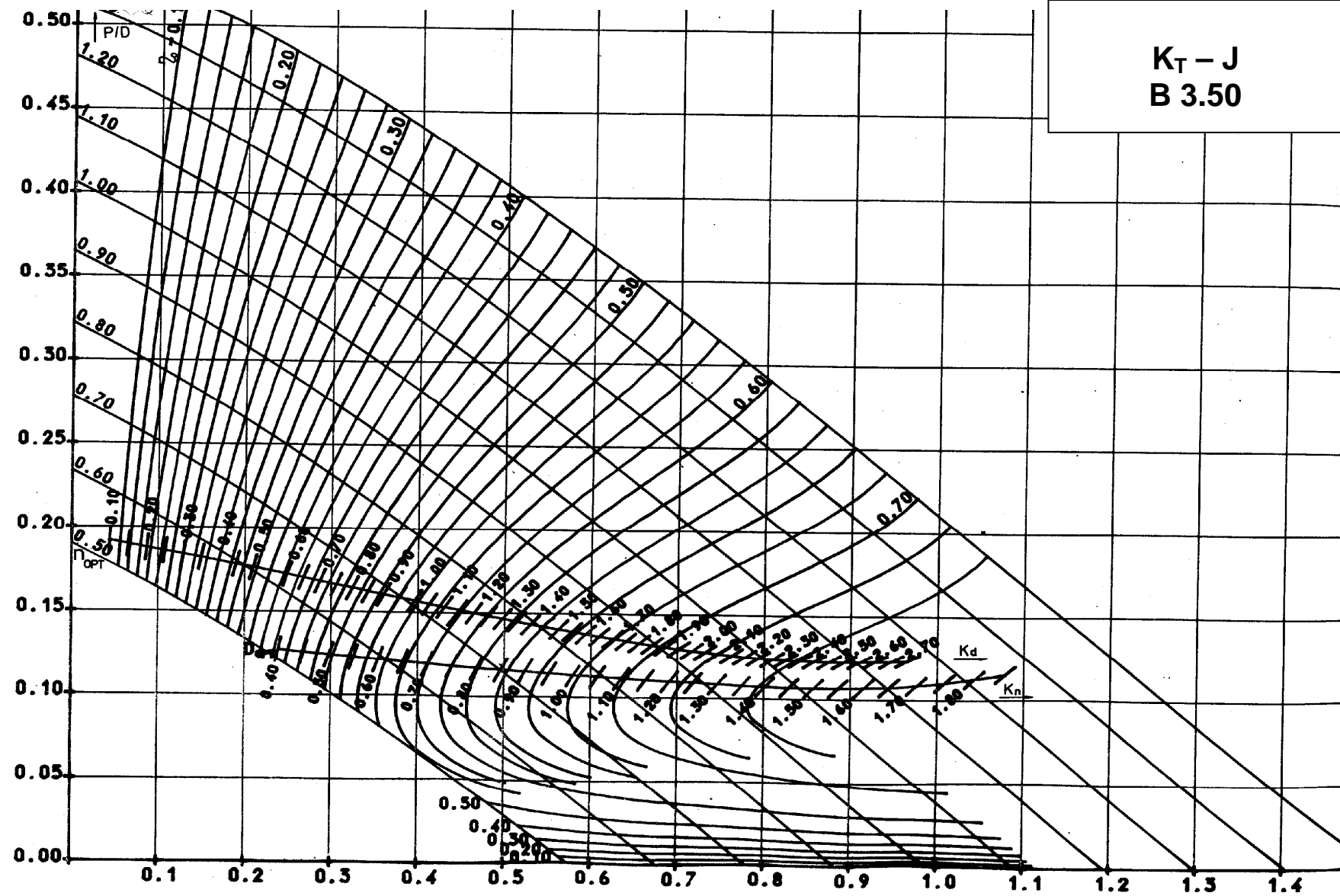
Забележка : Стойностите на дебелините на сеченията при входящите и изходящите ръбове ( $t_{l.e.}$  и  $t_{t.e.}$ ) се избират в съответствие с правилата на класификационните органи или с производствени изисквания.

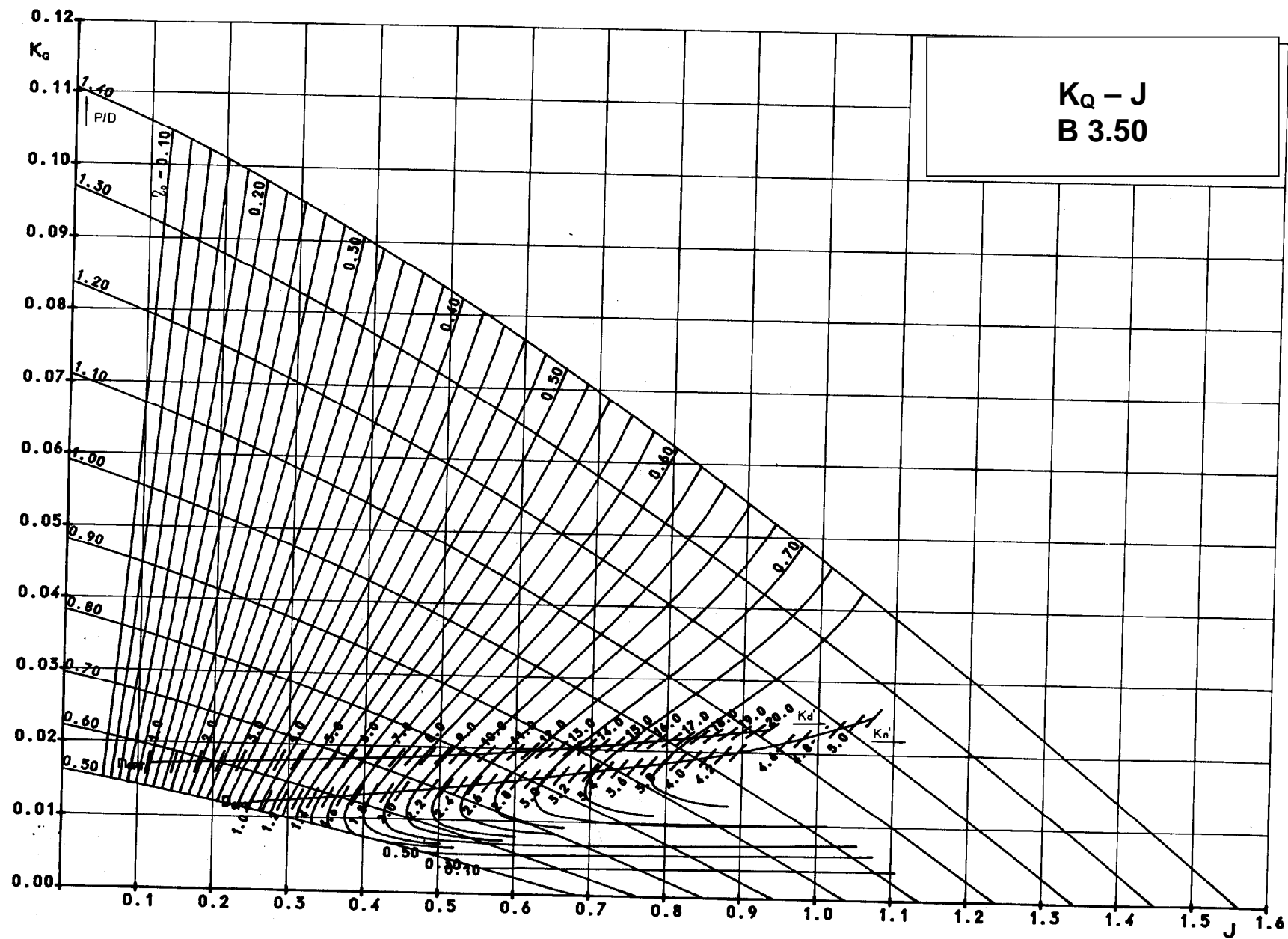
Note : The values of blade section thickness at the leading and trailing edges ( $t_{l.e.}$  and  $t_{t.e.}$ ) are chosen in accordance with rules of classification societies or in accordance with manufacturing requirements .

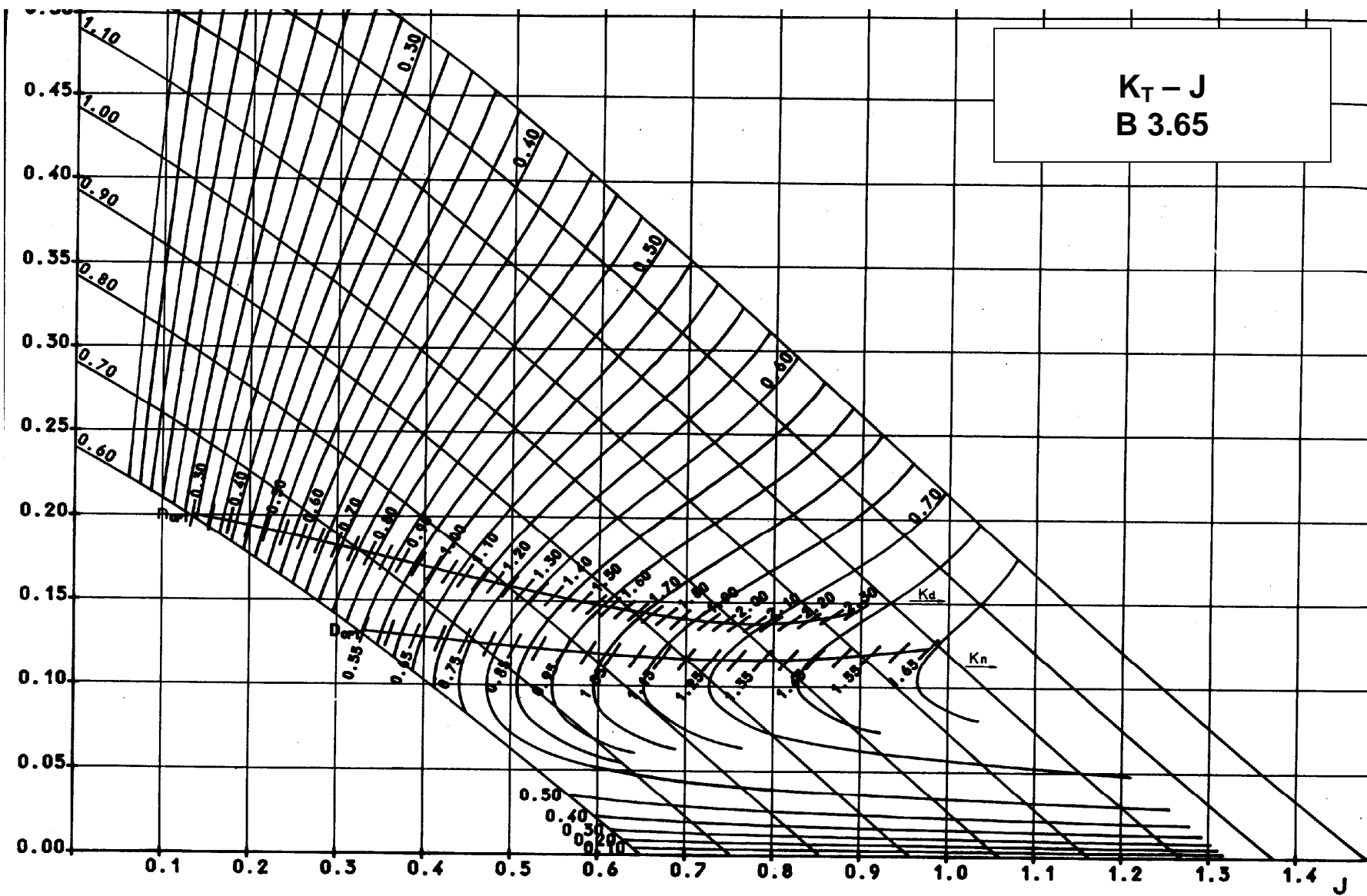


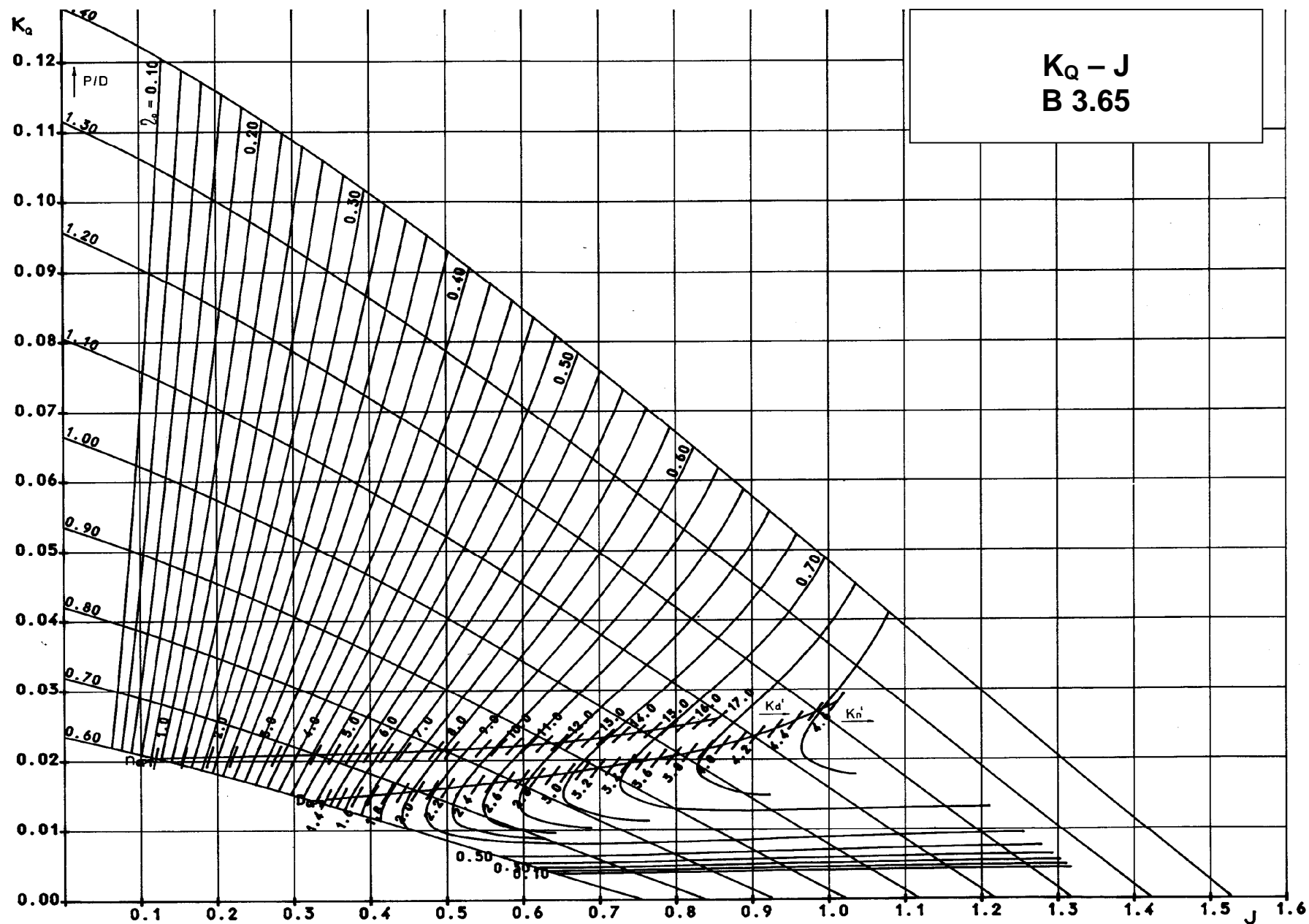


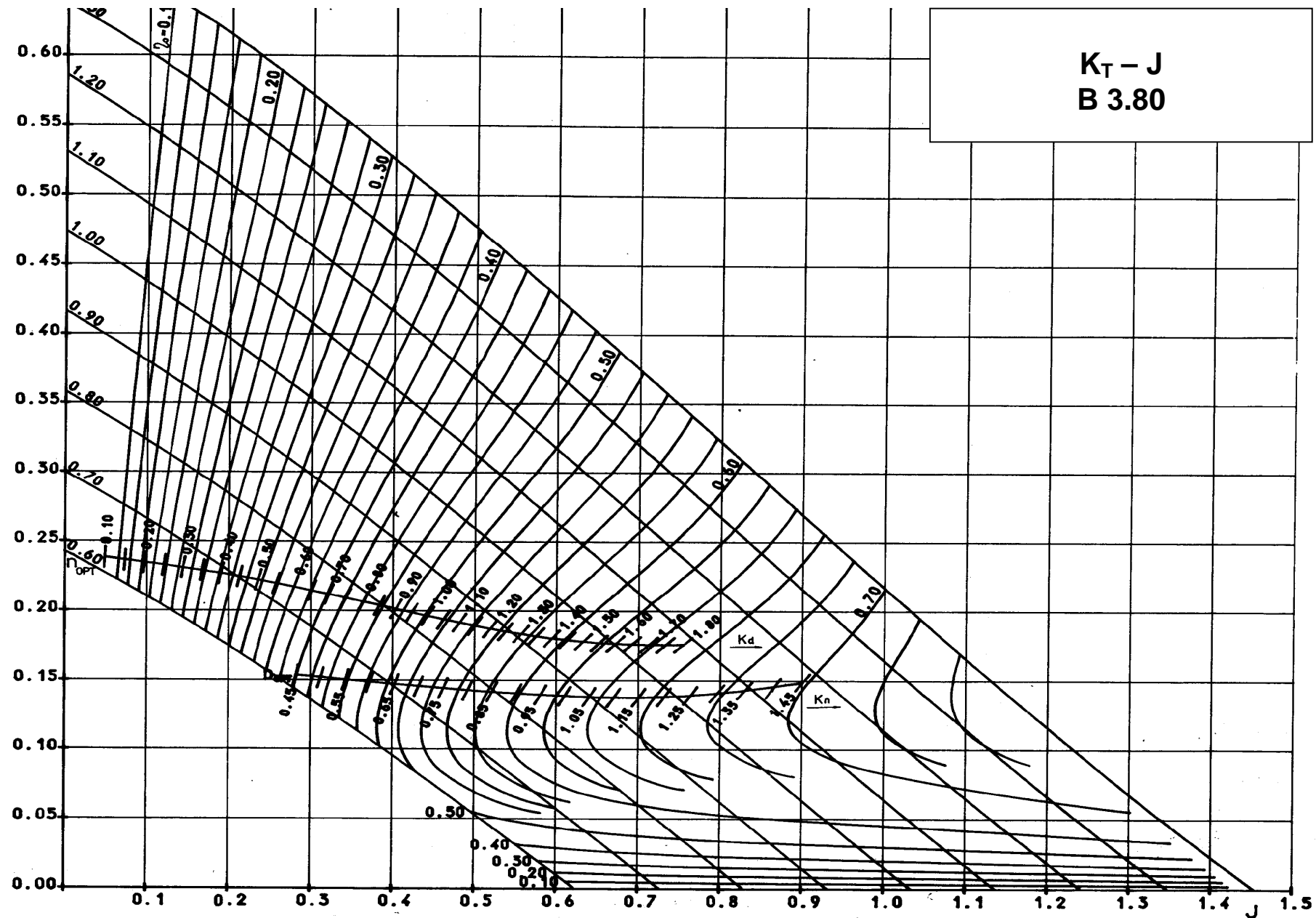


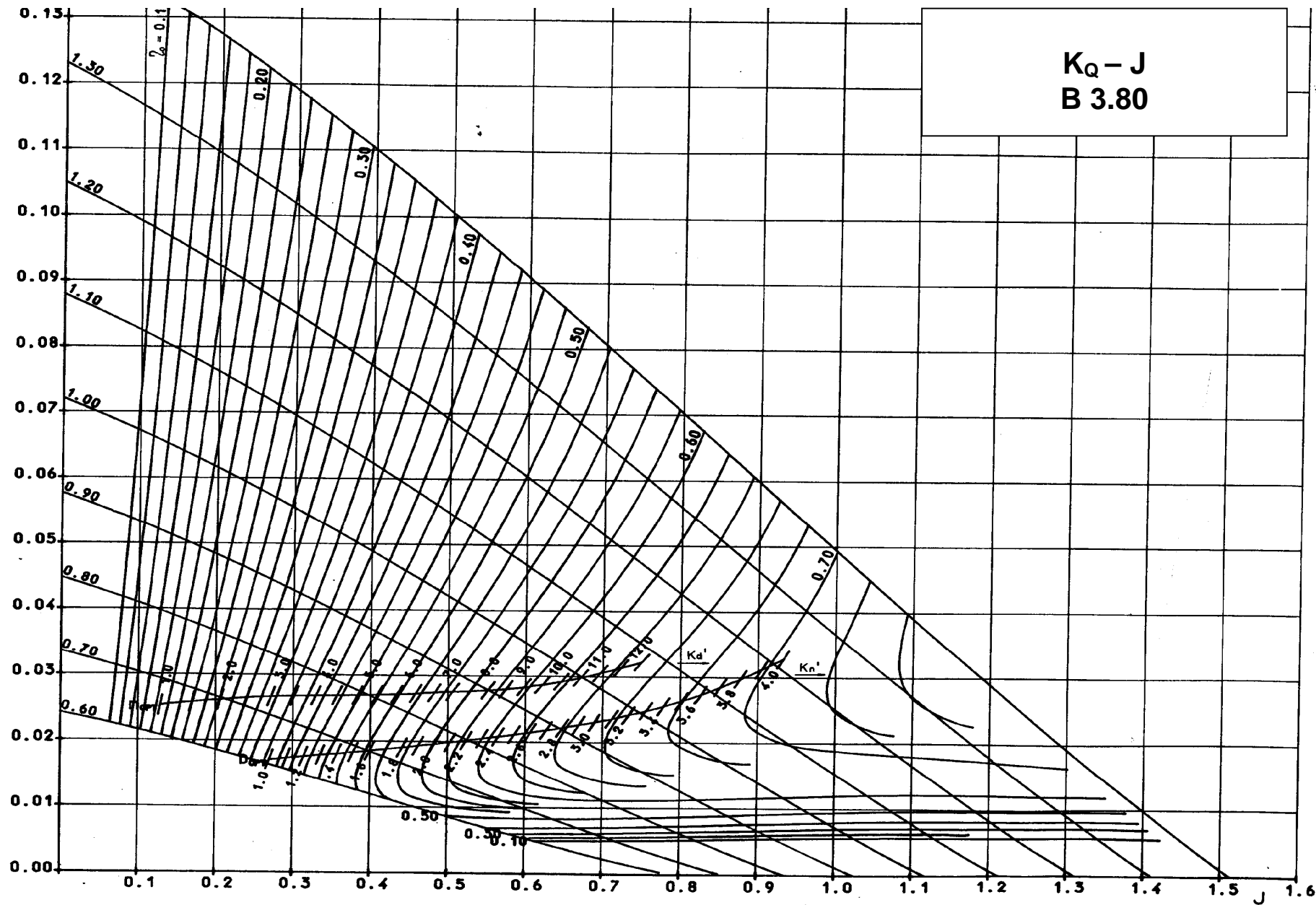


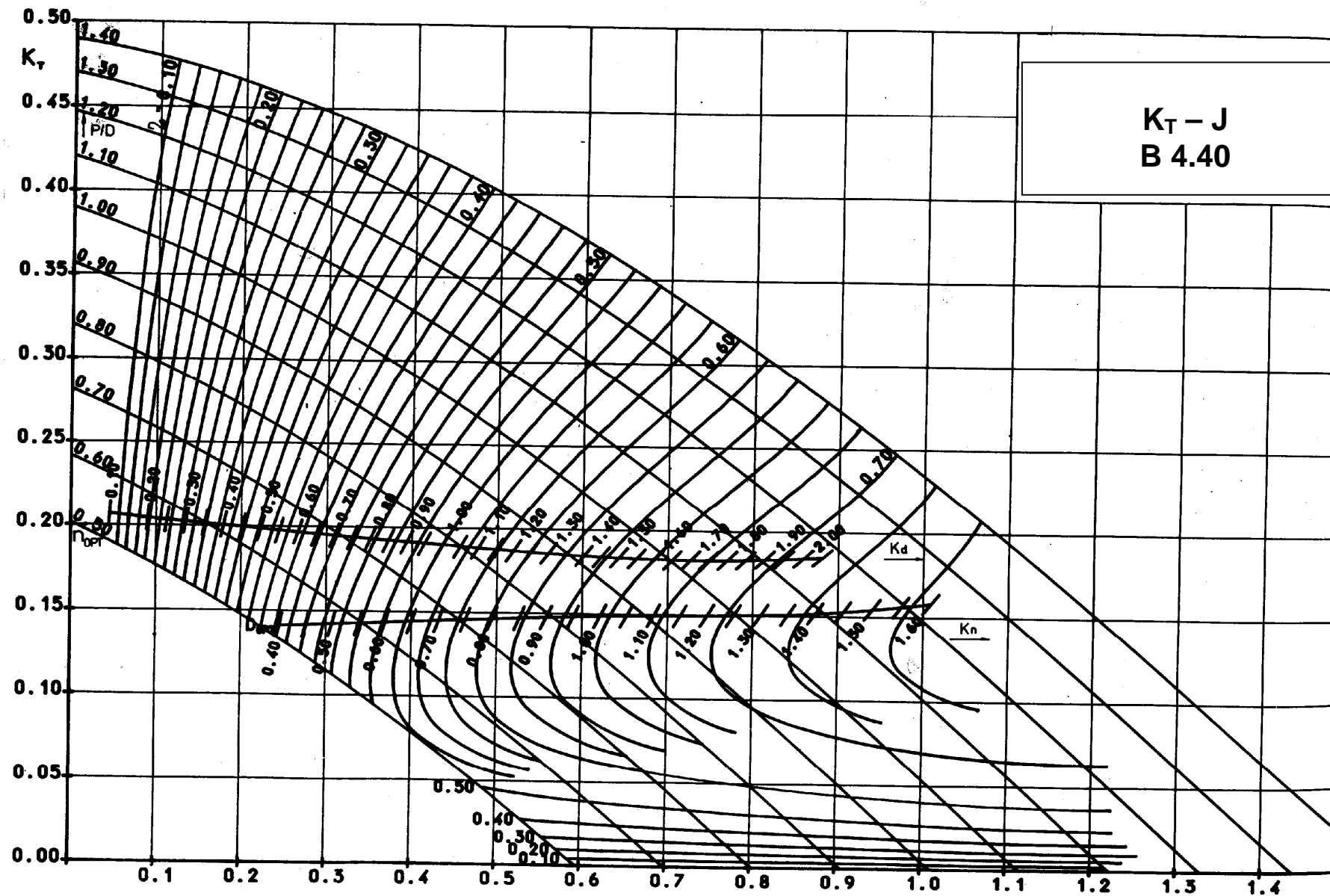




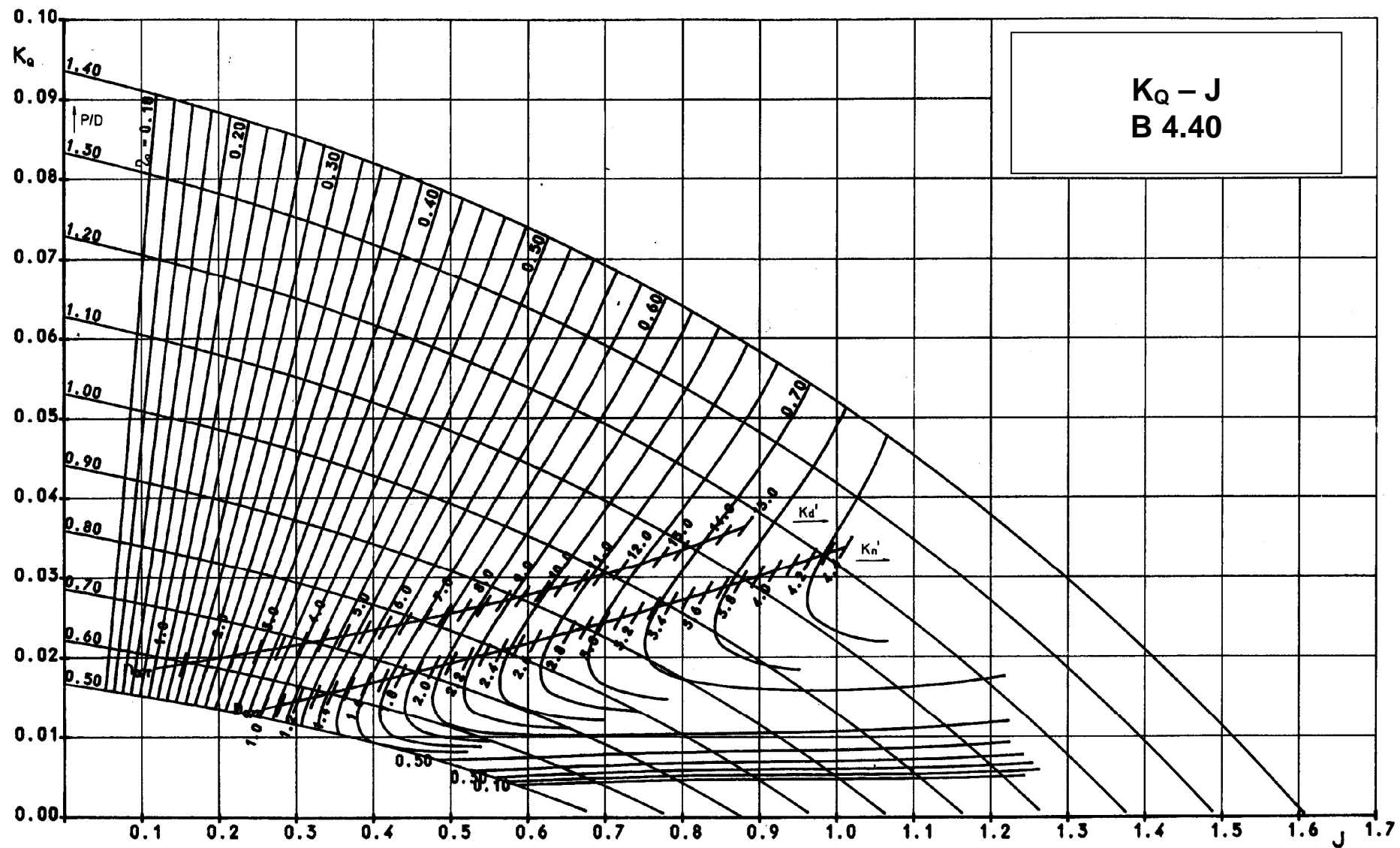




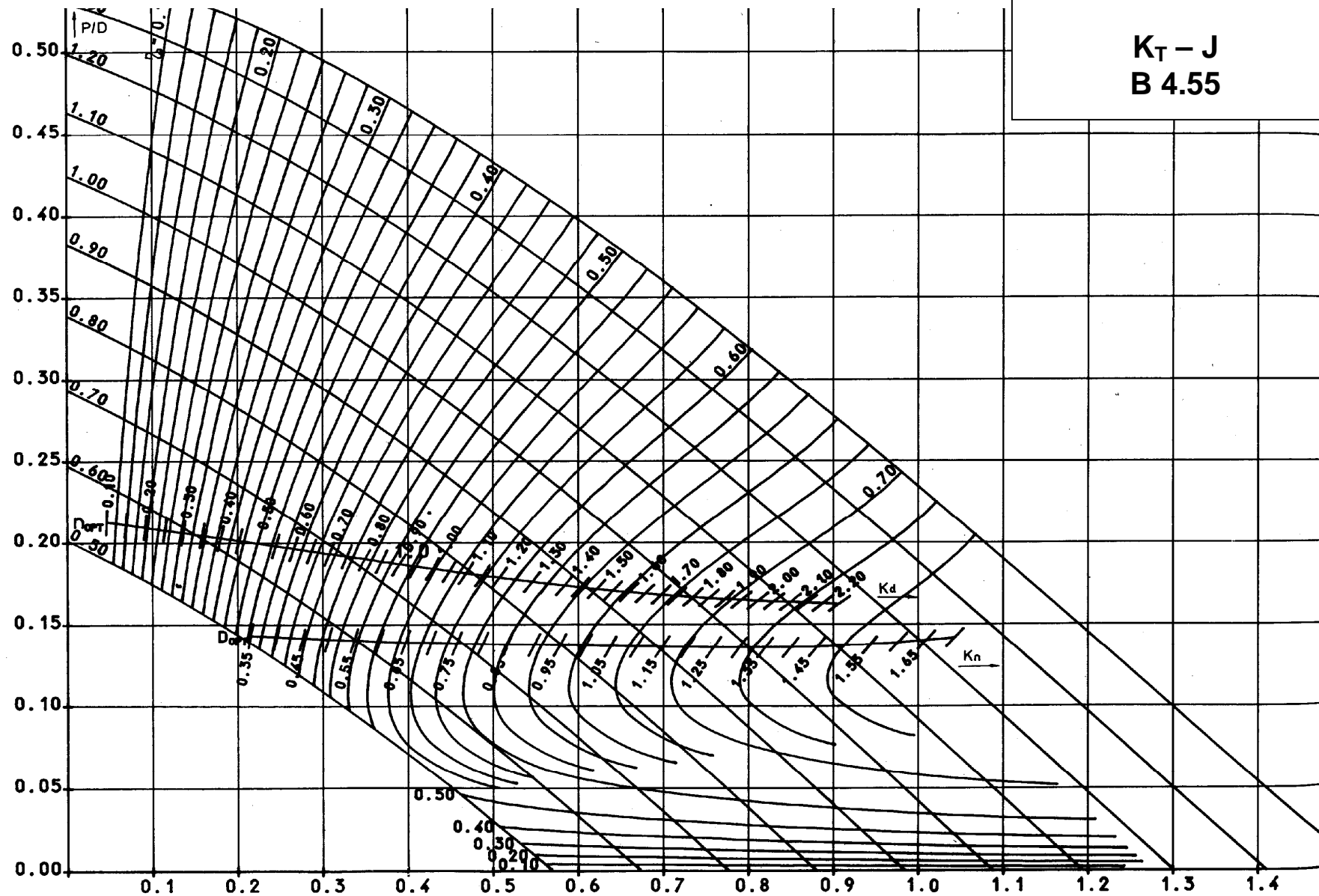


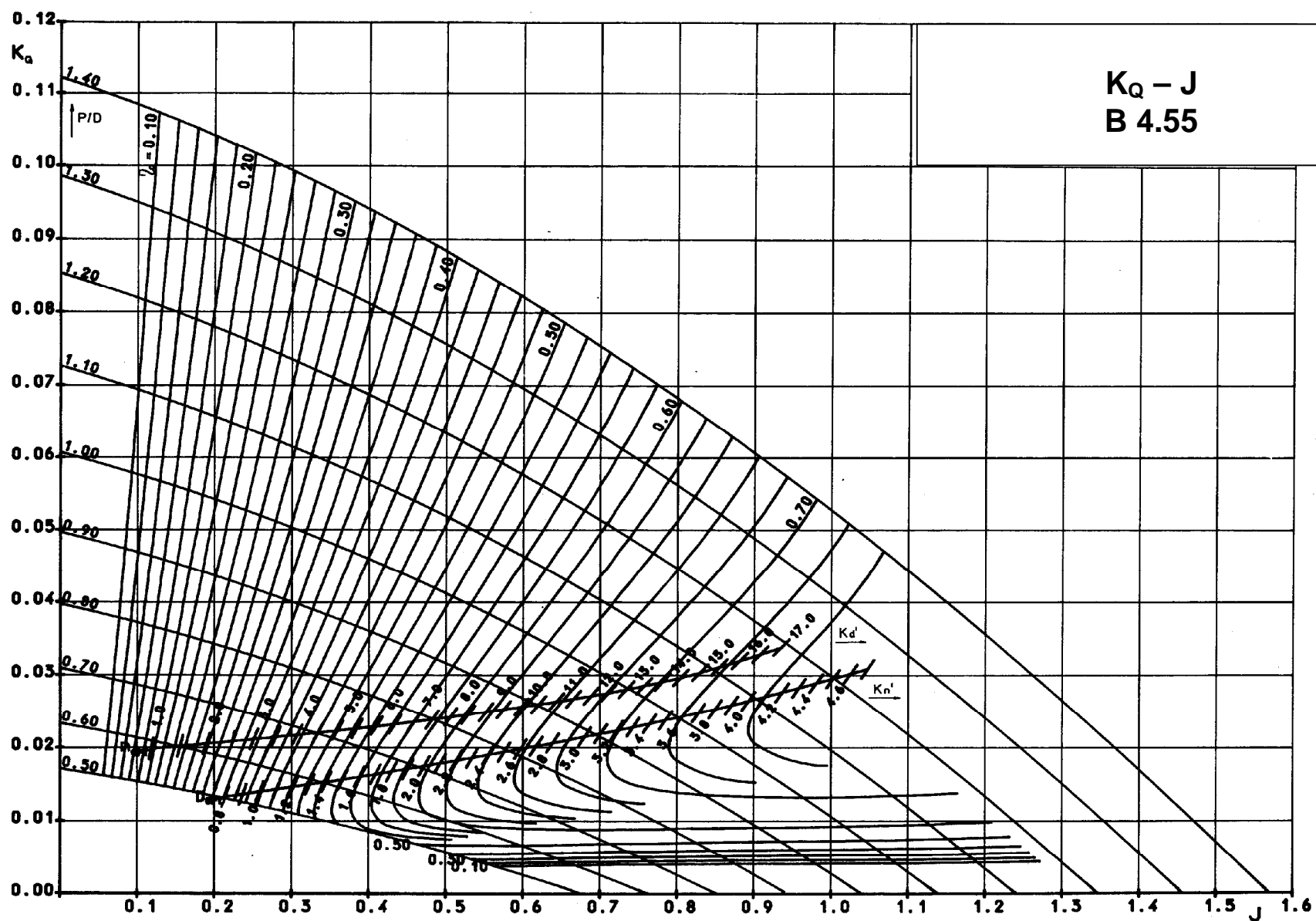


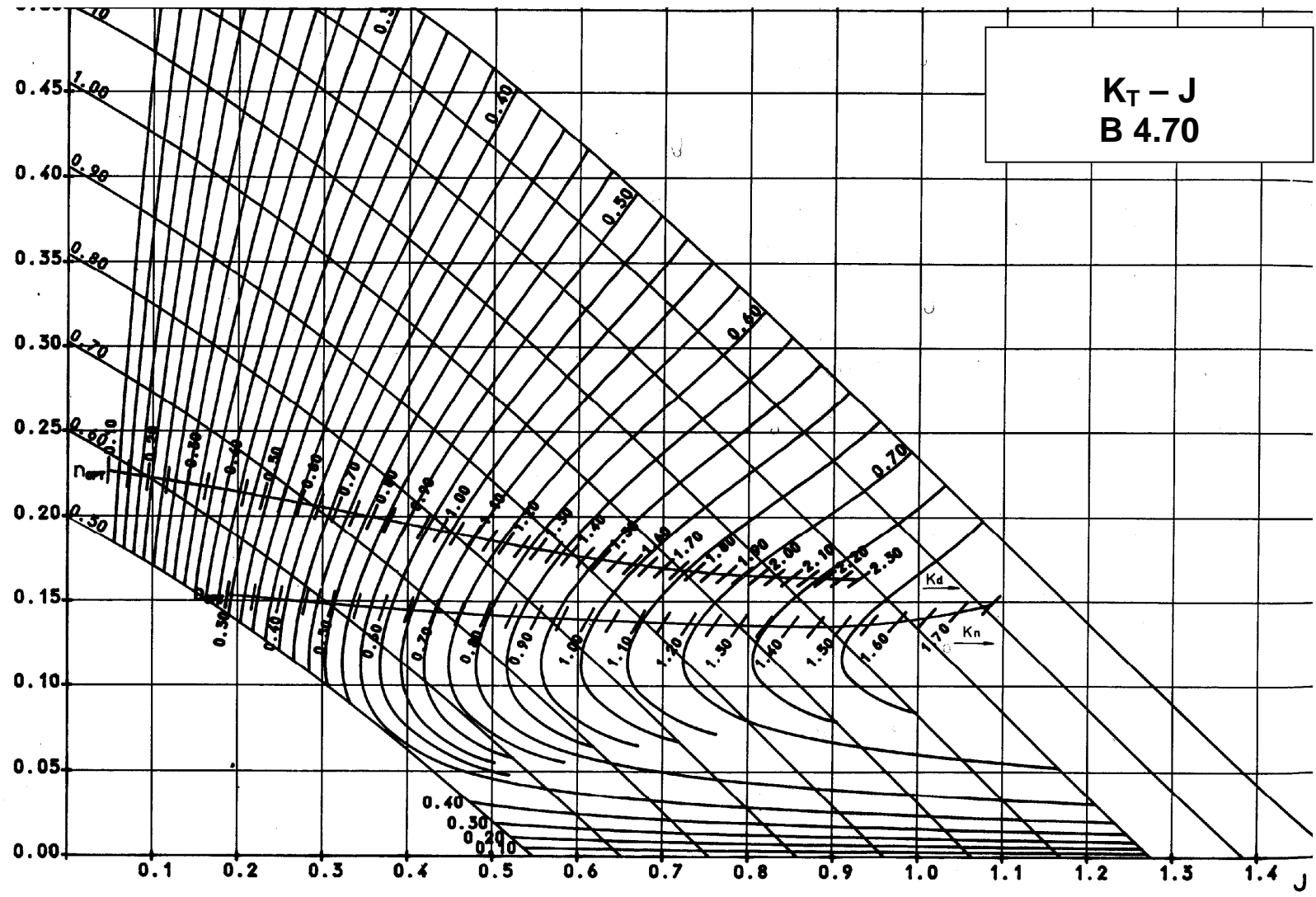


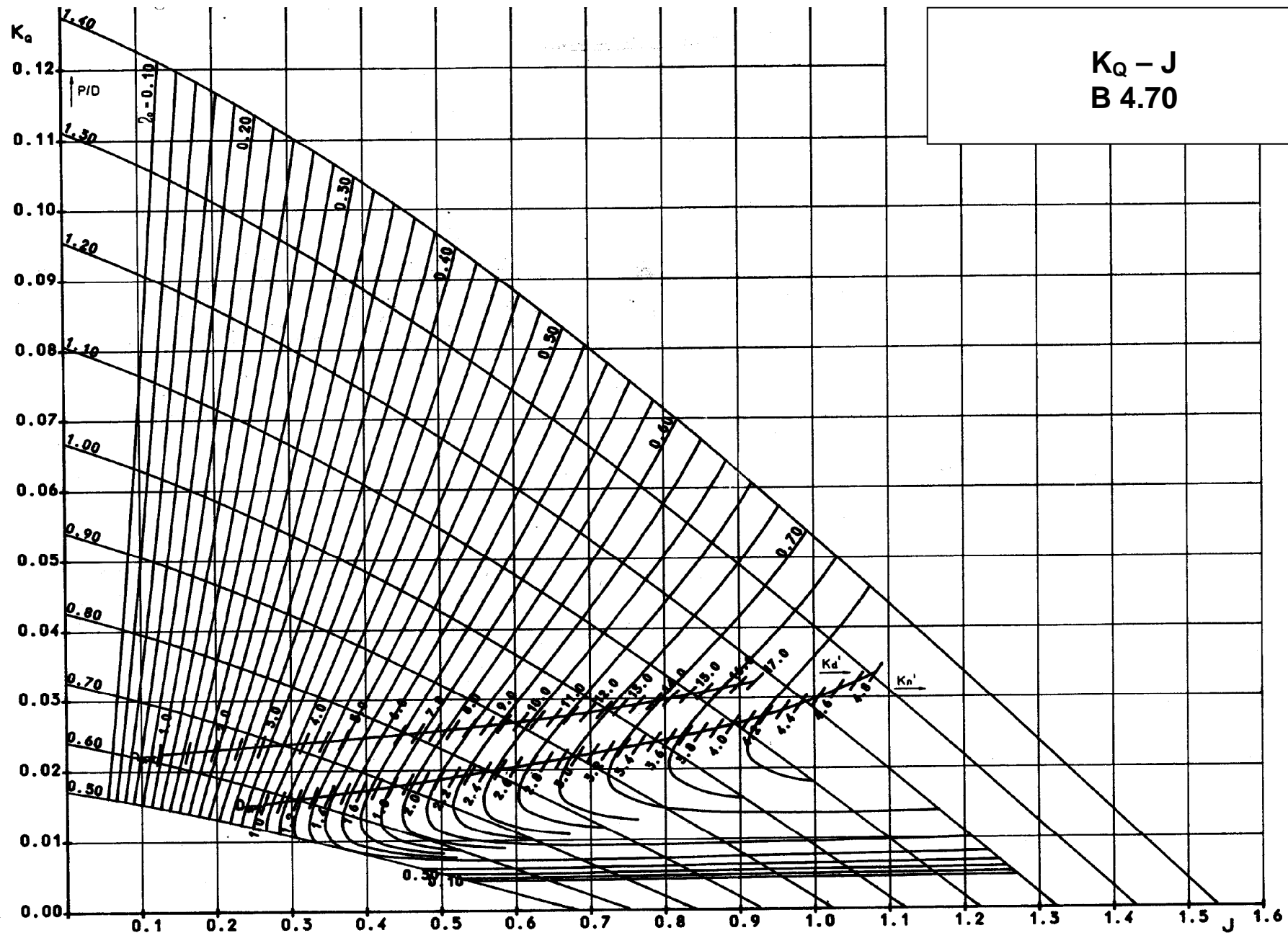


**K<sub>T</sub> – J**  
**B 4.55**

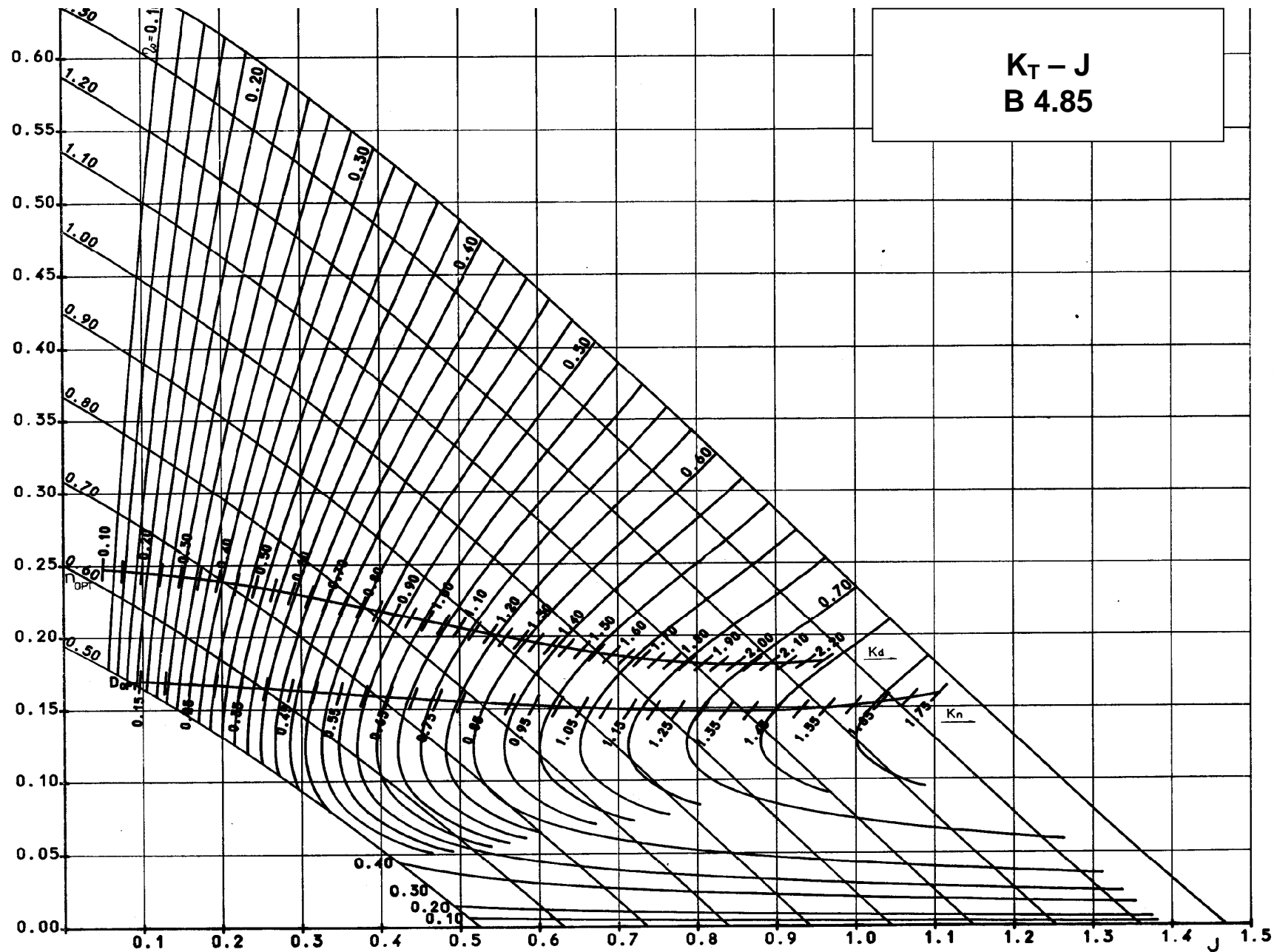


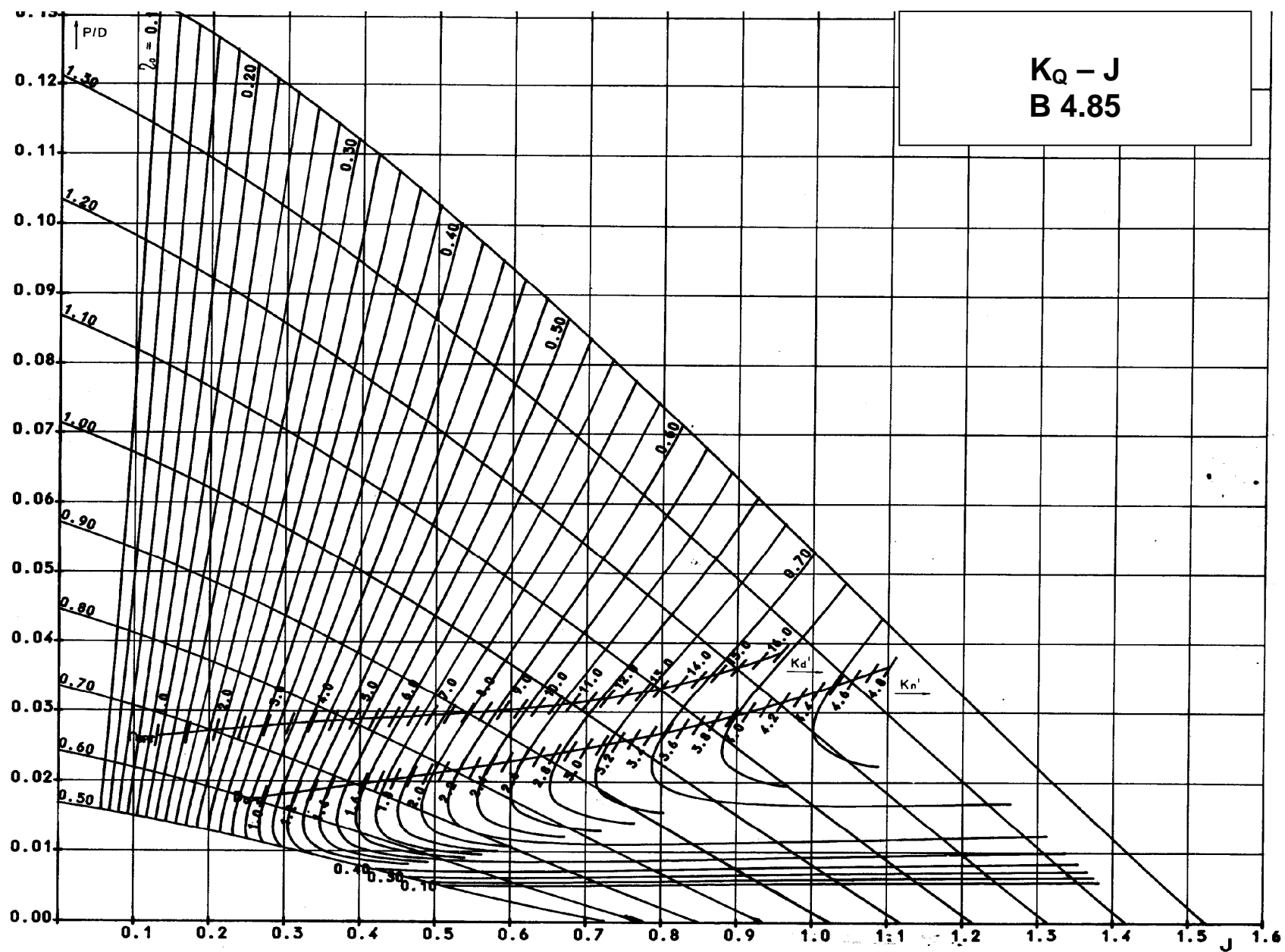


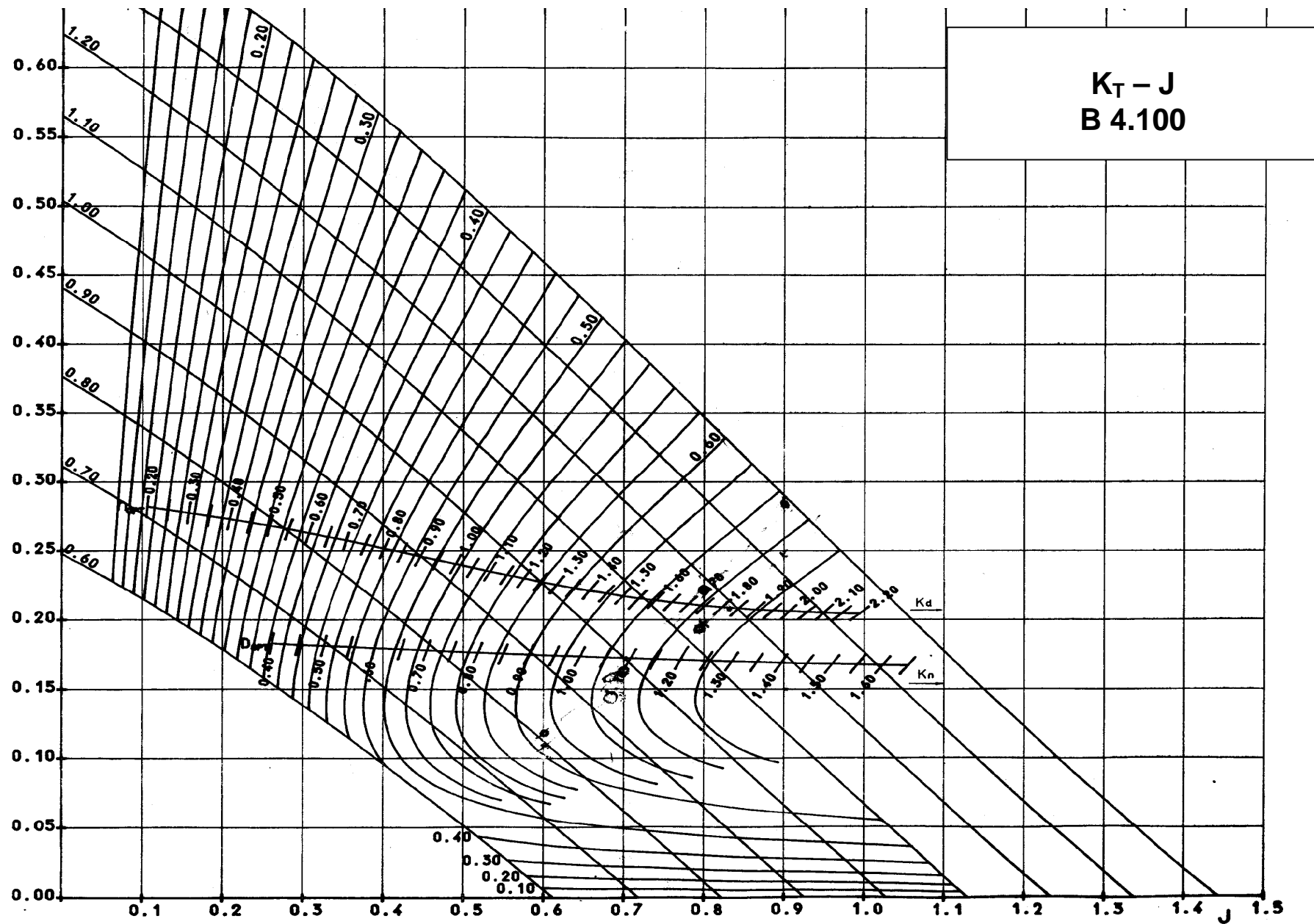




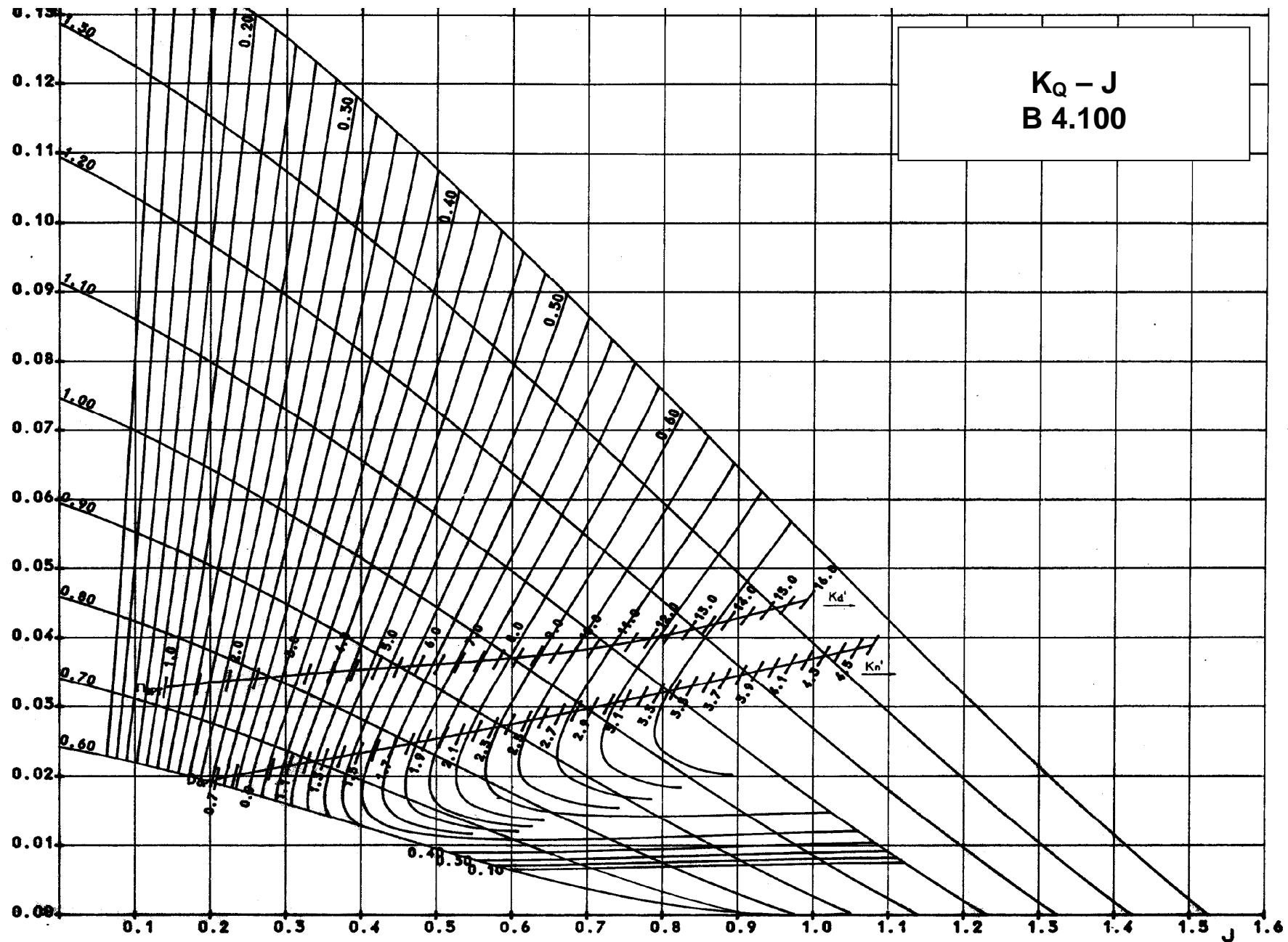
$K_Q - J$   
B 4.70

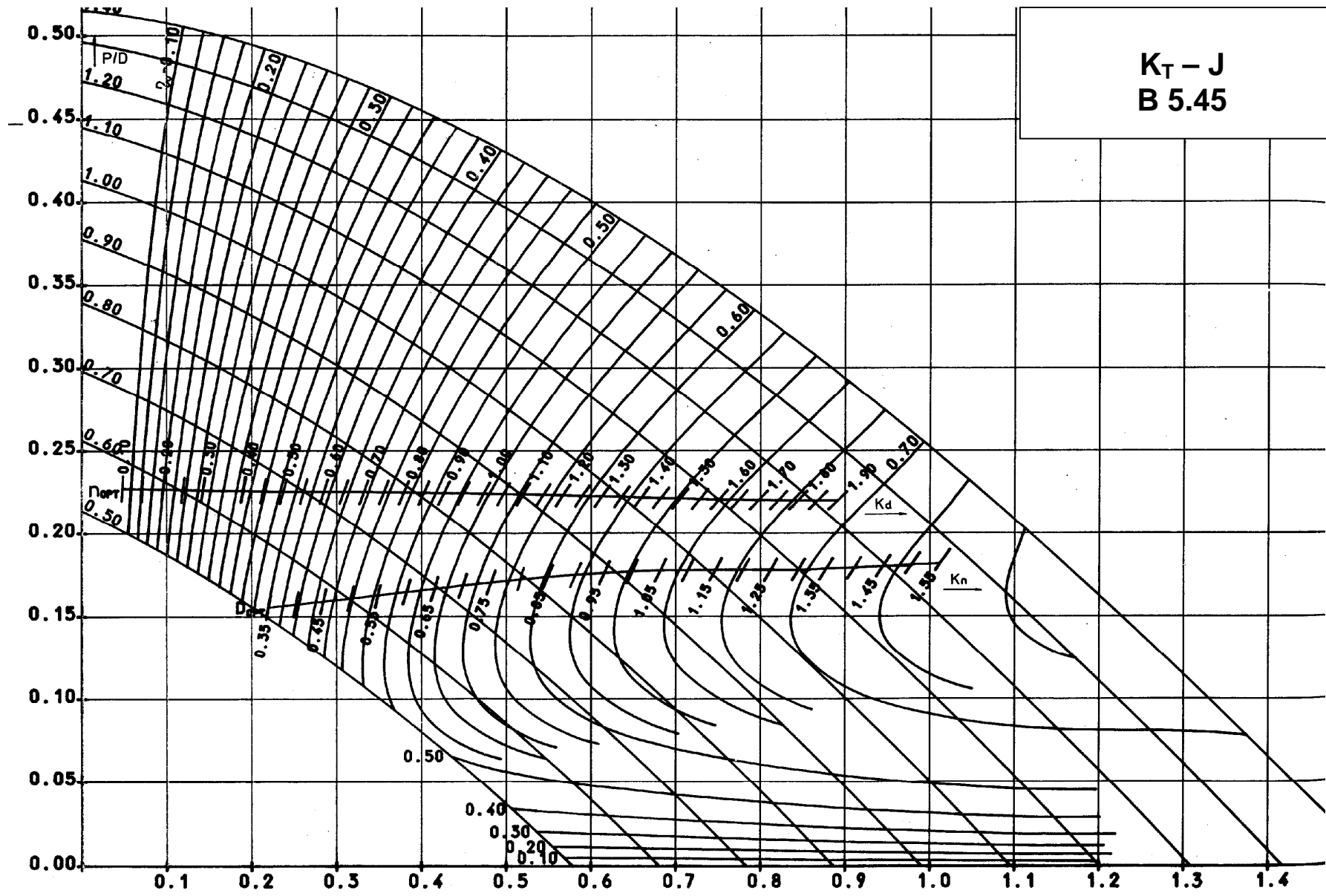




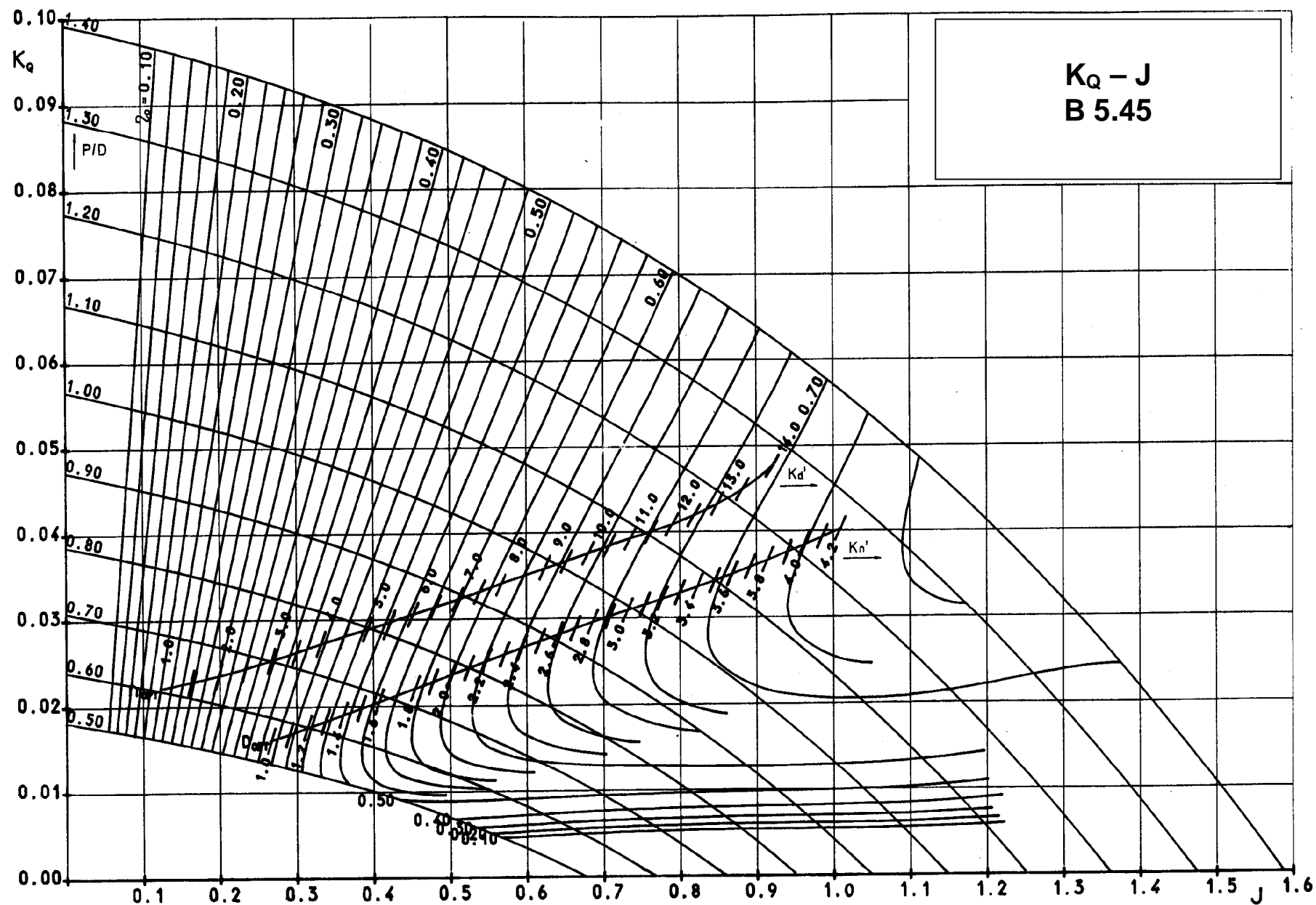








$K_T - J$   
B 5.45



**K<sub>T</sub> – J**  
**B 5.60**

