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Parametric Thermohydraulic Calculations for Advanced Pressurized Water Reactors with the Code HADA-2

M. Cigarini, M. Dalle Donne
Institut für Neutronenphysik und Reaktortechnik

Kernforschungszentrum Karlsruhe

KERNFORSCHUNGSZENTRUM KARLSRUHE
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Parametric Thermohydraulic Calculations for Advanced Pressurized Water Reactors with the Code HADA-2.

M. Cigarini[+] and M. Dalle Donne[+]

+ Delegated from Euratom to Kernforschungszentrum Karlsruhe, Institut für Neutronenphysik und Reaktortechnik

Kernforschungszentrum Karlsruhe GmbH, Karlsruhe

Kernforschungszentrum Karlsruhe GmbH
Postfach 3640, 7500 Karlsruhe 1

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Abstract

The paper describes the improvements introduced in the computer code HADA for the thermohydraulic design of Advanced Pressurized Water Reactors. The main modifications are the use of the water enthalpy, rather than the water temperature, for the equation giving the limitation due to the hot channel factor, and the introduction of a correction factor to ensure that the ratio between the critical heat flux and the hot channel heat flux is always greater than 1.3. About 200 different reactors have been calculated with the improved version HADA-2 of the code. The main results of these calculations are that, in the range of interest, homogeneous and heterogeneous reactors are about equivalent (same net electrical output of the plant for the same ratio between water and fuel rod volume). For the homogenous reactors the optimum designs are for H/d=20 (H=axial pitch of the integral spiral ribs on fuel rod surface, d=diameter of the fuel rod) and for the heterogenous reactors for H/d=35.

Parametrische thermohydraulische Untersuchungen für fortgeschrittene Durckwasser-Reaktoren mit dem Rechenprogramm HADA-2

Zusammenfassung

Der Bericht beschreibt die Verbesserung, die in dem Rechenprogramm HADA zur thermohydraulischen Auslegung von fortgeschrittenen Druckwasser-Reaktoren eingeführt worden sind. Die wichtigsten Änderungen sind die Verwendung von Wasserenthalpie anstelle von Wassertemperatur in der Gleichung, die der Begrenzung aus dem Heißkanalfaktor entspricht und die Einführung eines Korrekturfaktors, so daß das Verhältnis zwischen kritischer Heizflächenbelastung und Heißkanalheizflächenbelastung immer größer als 1.3 ist. Etwa 200 Reaktoren sind mit der verbesserten Version HADA-2 des Rechenprogrammes gerechnet worden. Die Hauptergebnisse dieser Berechnungen sind, daß die homogenen und heterogenen Reaktoren in dem praktisch interessanten Bereich etwa äquivalent

sind (etwa gleiche elektrische Kraftwerknettoleistung für gleiches Verhältnis zwischen Wasser- und Brennstabvolumen). Die optimale Auslegung für die homogenen Reaktoren ist für H/d=20 (H=axiale Steigung der integralen spiralförmigen Rippen auf der Brennstaboberfläche, d=Brennstabdurchmesser) und für die heterogenen Reaktoren fur H/d=35.

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1. Introduction

Since 1980 the Karlsruhe Nuclear Research Center in collaboration with Kraftwerk Union, with the Technical University of Braunschweig and, more recently, with the EIR Nuclear Center at Würenlingen is investigating the possibility of increasing the conversion ratio of a Pressurized Water Reactor in order to improve the uranium utilization /1/. The fuel element is based on UO_2-PuO_2 fuel, where the plutonium vector for the fresh fuel is given by the fuel discharged from a Light Water Reactor. Two types of cores have been considered: a modular core formed by hexagonal fuel elements containing an external blanket with lower enrichment and an internal seed with higher enrichment /2/ and a homogeneous core where all the rods in the core have the same diameter /3/. Results of parametric thermohydraulic calculations for these two types of core configurations have been published /4/. The calculations were performed with the computer code HADA-1 /5/. Since 1982 various improvements have been made to the code HADA-1. In the present paper we shall describe these improvements and present the results of the parametric calculations performed with the improved computer code HADA-2.

2. Improvements to the Computer Code HADA

In its basic structure the program HADA remains the same as that presented in References /4/ and /5/. For the basic equations and the use of the program we refer the reader to the References /4/ and /5/ respectively. Here we will only shortly illustrate the improvements introduced in HADA since the 1982 version of Ref. /4/.

2.1 Hot channel outlet water temperature

In Ref. /4/ the water temperature at the outlet of the core hot channel was calculated as:

$$T_{2H} = T_1 + F_{\Delta H}\, O_P (T_2 - T_1) \qquad (1)$$

and putted equal to the saturation temperature at the core outlet pressure:

$$T_{2H} = f_s(p_2)$$

where T_1 = water temperature at reactor inlet (^oC)
T_2 = average temperature at reactor outlet (^oC)
$F_{\Delta H}$ = hot channel factor for the enthalpy rise in the core
O_P = power plant overpower factor
p_2 = water pressure at reactor outlet (bar)

In the new version of the code these two equations have been replaced by the following:

$$H_{2H} = H_1 + C_{\Delta H} \frac{F_{\Delta H}\, O_P}{K'} (H_2 - H_1) \qquad (3)$$

$$T_{2H} = f(H_{2H}, p_2) \qquad (4)$$

where H_{2H} = water enthalpy at the outlet of the core hot channel (J/kg)
H_1 = water enthalpy at reactor inlet (J/kg)
H_2 = water enthalpy at reactor outlet (J/kg)
$C_{\Delta H}$ = correction factor to take account of the critical heat flux
K' = correction factor to take account of the water flow which bypasses the core

K' accounts for the fact that not all the water of the primary water circuit flows through the core. There are various by-passes to the water core flow, which in a large PWR amount to about 6% of the total water flow /6/, thus K' has been assumed equal to 0.94 for the present calculations.

The factor $C_{\Delta H}$ is determined by iteration. For the first iteration it is put equal to 1. Then the ratio of the critical heat flux to the hot spot heat flux is calculated for the hot channel /4/. If this ratio, generally called DNBR, is less than 1.3, which is usually the required safety margin /7/, the calculation is repeated with a higher value of $C_{\Delta H}$ until the condition

$$DNBR = 1.3 \tag{5}$$

is satisfied.

The use of the water enthalpy, rather than the water temperature, is more consistent with the definition of the hot channel factor $F_{\Delta H}$ /7/. The use of the water temperature is only approximated, because the water specific heat is not constant, especially near the saturation line. Once the enthalpy at the outlet of the hot channel H_{2H} and the pressure p_2 are known, the relative water temperature T_{2H} can be obtained from the functions describing the thermodynamic properties of water (Eq.(4), s. Ref. /8/).
The introduction of the correction factor K' modifies equation (36) of Ref. /4/, which now becomes:

$$M_u = K'M \frac{2n_T A}{2n_T A + (1-K_1)K_2 \frac{\pi}{4} D_{eq}^2} \tag{6}$$

while equations (66) and (78) of Ref. /4/ become respectively:

$$H_{2uS} = H_1 + \frac{H_2 - H_1}{K'K_{2S}} \tag{7}$$

$$H_{2uB} = H_1 + \frac{H_2 - H_1}{K'K_{2B}} \tag{8}$$

For the meaning of the used symbols see the Nomenclature at the end of the paper.

2.2 Pressure drop calculations

Equations (48) and (49) of Ref. /4/, which give the friction factors for the rods with spiral spacers used for the homogeneous cores and the blankets of the heterogeneous cores, are modified by the introduction of the correction factor F_R:

$$\lambda = 0.1317\, F_R \times F \times C\,Re'^{-0.17} \qquad \text{for } 1.9 \times 10^4 \leq Re' \qquad (9)$$

$$\lambda = F_R \times F \times C \left[0.1317\, Re'^{-0.17} + \frac{60}{Re'} - 3.2 \times 10^{-3} \right] \qquad (10)$$

$$\text{for } 2 \times 10^3 \leq Re' < 1.9 \times 10^4$$

The factor F_R accounts for the fact that while the equations (48) and (49) of Ref. /4/ were derived from experiments performed with rods having an average superficial roughness of 2 µm height /9/, the fuel rods used in nuclear reactors may have a greater roughness. For the present parametric reactor calculations an average roughness height of K_R=5 µm on the fuel rod surface has been assumed. According to the equation of Colebrook and White /10/, the correction factor F_R is thus given by:

$$F_R = \left[\frac{1.74 - 2 \log\left(\frac{4\times10^{-6}}{d_h} + \frac{18.7}{Re\sqrt{\lambda/F_R}} \right)}{1.74 - 2 \log \frac{2\,K_R}{d_h} + \frac{18.7}{Re\sqrt{\lambda}}} \right]^2 \qquad (11)$$

In an analogous way the friction factor for the seed rods of the heterogeneous cores, supported by spacer grids placed in discrete axial positions along the core, is given by $\lambda_{TS} \cdot C_S$ where:

$$\lambda_{TS} = \frac{1}{\left[1.74 - 2 \log\left(\frac{2\,K_{RS}}{d_{hS}} + \frac{18.7}{Re_S\sqrt{\lambda_{TS}}} \right) \right]^2} \qquad (12)$$

which replaces equation (70) of Ref. /4/.

In Ref. /4/ the modified drag coefficient of the spacer grid of the seed rods was assumed constant and equal to 7. This rather rough assumption has been improved by taking C_V as a function of the Reynolds number:

$$C_V = 3.5 + \frac{73.14}{Re^{0.264}} + \frac{2.79\times10^{10}}{Re^{2.79}} \quad . \tag{13}$$

Equation (13) has been obtained by fitting the experimental data shown in Ref. /11/. These data refer to a spacer grid with a rounded leading edge. However, when the product $C_V\times\varepsilon^2$ calculated with equation (13) is greater than 2, then the relationship

$$C_V = \frac{2}{\varepsilon^2} \tag{14}$$

replaces equation (13), according to a suggestion given in Ref. /12/.

2.3 Water axial temperature distribution in the core channels

The water axial temperature distribution in the hot coolant channel is calculated, as in the case of the hot channel outlet water temperature (s. chapter 2.1), from the water enthalpy and the pressure:

$$H_{HS}(x) = H_1 + F_{\Delta H}\, O_P\, \frac{H_{2u}-H_1}{2} \left(1 + \frac{\sin\frac{\pi x}{L'_c}}{\sin\frac{\pi L_c}{L'_c}} \right) \tag{15}$$

$$T_{HS}(x) = f(H_{HS}(x), p(x)) \tag{16}$$

Equations (15) and (16) are analogous to equation (3) and (4) and replace equation (82) of Ref. /4/.

Similarly the nominal water temperature axial distribution in the highest rated coolant channels is calculated as:

$$H_N(x) = H_1 + \varphi_{rad}\, O_P \frac{H_{2u}-H_1}{2}\left(1 + \frac{\sin\frac{\pi x}{L'_c}}{\sin\frac{\pi L_c}{\pi L'_c}}\right) \qquad (17)$$

$$T_N(x) = f(H_N(x), p(x)) \qquad (18)$$

Equations (17) and (18) replace equation (109) of Ref. /4/.

2.4 Various substitutions and additions

In the HADA-1 version of the code /4/ the critical heat flux was calculated with an older correlation /13/. In the present version HADA-2 of the code a newer and better critical heat flux correlation especially developed for APWR application, has been used /14/. The factor $C_{\Delta H}$ of equation (3) has been determined on the base of the correlation of Ref. /14/, so that the condition of equation (5) is satisfied. In this way, when the factor $C_{\Delta H}$ is greater than 1, the correlation of Ref. /14/ is an integral part of the core thermo-hydraulic design. In HADA-2 the critical heat flux and the relative DNBR for the critical heat flux correlations WSC-2 /15/, of Edlund /16/ and Columbia-EPRI /17,18/ are calculated and printed as well.

Further parameters of interest are calculated and printed in HADA-2 which were not previously. Namely:

- The total water primary circuit pressure drop:

$$\Delta p_t = 9.80665\times10^{-5}\times H_T\times\rho_1 \qquad (19)$$

- The electrical power of the four primary circuit water pumps:

$$N' = \frac{N}{\eta} \qquad (20)$$

where, for the calculations, the pump efficiency η has been taken equal to 0.774.

- The steam quality X_{DNBR} at the axial position in the hot coolant channel where DNBR is minimum.

3. Calculation Results

3.1 Homogeneous reactors (H/d = 20)

Tables I to IX show the results of the calculations for the homogeneous reactors. The calculations have been performed for the following cases:

p = 0.85 cm	, d = 0.78 ÷ 0.82 cm	(Table I)
p = 0.90 cm	, d = 0.78 ÷ 0.87 cm	(Table II)
p = 0.95 cm	, d = 0.78 ÷ 0.93 cm	(Table III)
p = 1.00 cm	, d = 0.78 ÷ 0.98 cm	(Table IV)
p = 1.05 cm	, d = 0.82 ÷ 1.03 cm	(Table V)
p = 1.10 cm	, d = 0.88 ÷ 1.07 cm	(Table VI)
p = 1.14 cm	, d = 0.94 ÷ 1.10 cm	(Table VII)
p = 1.20 cm	, d = 0.95 ÷ 1.14 cm	(Table VIII)
p = 1.25 cm	, d = 0.95 ÷ 1.09 cm	(Table IX)

Altogether 101 reactors. The symbols in the Tables are the same as those used in the text and they are explained in the Nomenclature. DNBR is the ratio between the critical heat flux and the hot channel heat flux at the axial point where this ratio is a minimum. Four values of DNBR are shown in the tables, namely for the case with inserted control rods and plant overpower factor of 1.12, but for four different critical heat flux correlations, i.e. for the Columbia-EPRI /17,18/, for the Edlund /16/, for the WSC-2 /15/ and for the new KfK correlation /14/ respectively.

V_M/V_F is the ratio between the area occupied by the water (moderator) and by the fuel rods, and "CELL" is the same value for a single unit cell around a fuel rod.

X(BOIL) is the axial distance from the core center where subcooled boiling starts to occur in the highest rated channels. Two values of X(BOIL) are shown, for O_P=1.00 and O_P=1.12 respectively. The value 0 indicates that subcooled boiling occurs starting at the core center or below (that is for negative values of x). The stars indicate that no subcooled boiling occurs in the considered highest rated channels.

Figures 1 to 18 show the results of the calculations in diagrammatic form. Comparing these figures with the corresponding data of the standard German PWR of 1300 MWe one can observe that for the parameters of the APWR:

- The factor $C_{\Delta H}$ based on the KfK critical heat flux correlation of Ref. /14/ is for most of the reactors greater than one. This causes the greatest difference in the results from those given in the previous parametric thermohydraulic study /4/, where $C_{\Delta H}$ was always equal to one. $C_{\Delta H} > 1$ means that the

DNBR limitation is more stringent that the limitation on the average fuel rod linear rating to avoid an unduly high increase of the fuel rod cladding temperature during a LOCA (equation (31) of Ref. /4/). The condition $C_{\Delta H} > 1$ means that not only saturation boiling is not allowed in an APWR, not even at the outlet of the hot channels as it is in the PWR case, but a certain degree of subcooling is required at the outlet of the hot channels to satisfy the condition DNBR $\geq$ 1.3.

- The rod linear power is always lower that for the PWR value (208 W/cm); the reason for this is the smaller p/d ratio and the boundary condition due to reflooding (Eq.(31) of Ref./4/).
- Nevertheless the core power density is higher than in the PWR case (102 W/cm^3) and it increaseswith decreasing fuel rod diameters.
- The water mass flow rate is lower than the PWR value (18800 kg/s).
- The water velocity is higher than for the PWR (4.5 m/s).
- The core height is lower than for the PWR (390 cm).
- Core pressure drops are higher than for the PWR (1.25 bar).
- Inlet and outlet water temperatures are generally lower than the PWR values (291.14 and 326.16^{o} C respectively).
- The primary water pumping power is never higher than 21.2 MW. This means at most about 25% more than the nomimal PWR-pumping power (17 MW). Due to the fact that the primary circuit water pumps can operate at powers 25% higher than the nomimal values, this 25% overpower is considered just acceptable.
- The net electrical plant power decreases rapidly with d especially for low pitches.

- The DNBR (departure from nucleate boiling ratio = ratio between critical heat flux and heat flux in the hot channel) is the smallest in the case inserted control rods and overpower factor equal to 1.12. In this case the DNBR values are practically all equal to 1.3 as required by the condition of equation (5).
- The DNBR's calculated with the other critical heat flux correlations differ quite considerably from the values calculated with the KfK critical heat flux correlation. In our opinion the KfK correlation is the most reliable, because it takes account of the H/d effect on the critical heat flux. This effect is rather strong for the chosen value H/d=20 and it is not considered in the other three correlations. However it seems necessary to perform further critical heat flux experiments for rod bundles simulating the fuel rod assemblies of the chosen APWR reference designs. For our reference design of homogeneous APWR (d=0.95 cm, p=1.14 cm see Ref. /19/) the Columbia-EPRI correlation gives DNBR=1.21, which would still be acceptable due to the relatively low RMS-error which affects this correlation (7.2%) and the fact that this correlation neglects the inprovements in critical heat flux given by the spiral ribs. The Edlund and the WSC-2 correlations give DNBR values of 1.11 and 0.98 respectively (see Table VII).
- The water to fuel rod volume ratio V_M/V_F is an important parameter for the neutronic calculations: the conversion ratio is higher for lower values of V_M/V_F. Fig.16 shows that this parameter decreases with increasing fuel rod diameter d. Of course for a constant d value, V_M/V_F decreases with decreasing values of the fuel rod pitch p.
- Figures 17 and 18 show that for almost all the calculated reactors subcooled (or local) boiling occurs in the highest rated channels over a considerable length of the upper part of the core. This length is of course greater in the case of an overpower factor equal to 1.12. Subcooled boiling is normally allowed in a PWR, even to a greater extent than we have allowed here for the calculated APWR's.

3.2. Heterogeneous reactors (H/d=20)

Tables X to XVI show the results of the calculations for the heterogeneous reactors. The calculations have been performed for the following cases:

d_S = 1.00 cm	q_{vS} = 128 ÷ 148 W/cm^3	(Table X)
d_S = 0.95 cm	q_{vS} = 140 ÷ 164 W/cm^3	(Table XI)
d_S = 0.90 cm	q_{vS} = 148 ÷ 182 W/cm^3	(Table XII)
d_S = 0.85 cm	q_{vS} = 160 ÷ 206 W/cm^3	(Table XIII)
d_S = 0.80 cm	q_{vS} = 180 ÷ 228 W/cm^3	(Table XIV)
d_S = 0.74 cm	q_{vS} = 204 ÷ 272 W/cm^3	(Table XV)
d_S = 0.70 cm	q_{vS} = 228 ÷ 288 W/cm^3	(Table XVI)

Altogether 99 reactors. For each calculated reactor the first four DNBR values are for the seed and the second four values for the blanket. As in the case of the homogeneous reactors the various DNBR values refer to the four different critical heat flux correlations of References /14/ to /18/.

Figures 19 to 48 show the results of the calculations in diagrammatic form. The comparison of these values with the corresponding data of the standard German PWR of 1300 MWe results in conclusions qualitatively similar to those for the homogeneous reactors (see Section 3.1), here we shall discuss only the special features of the results for the heterogeneous reactors.

- The factor $C_{\Delta H}$, based on the KfK critical heat flux correlation of Ref. /14/, is for most of the reactors equal to 1. It is greater than 1 only for a few reactors with d_S=0.74 cm and high power densities, and one reactor at d_S=0.85 cm and a relatively low power density.

- The pitch to diameter ratios of the fuel rods are always higher for the seed than for the blanket (Figures 23 and 24).
- Contrary to the case of the homogeneous reactors, the heterogeneous cores can, in certain cases, be even higher than the PWR (Fig. 27).
- The DNBR's are always greater than 1.3 in the seed (Figures 36 to 39), however, for certain reactors, they can be equal to 1.3 in the blanket for the 12% overpower factor case (Figures 42 and 43). Although the power density in the blanket is only half that in the seed, the DNBR's are lower in the blanket because the fuel rod cluster is much tighter.

3.3. The effect of the variation of the axial pitch of the spiral ribs (H/d)

The ratio H/d of the axial pitch of the six integral spiral ribs on the fuel rod surface, used in the homogeneous core and in the blanket of the heterogeneous core, has an influence on the critical heat flux according to the KfK critical heat flux correlation /14/, therefore the factor $C_{\Delta H}$, when greater than one, depends on H/d. We have, therefore performed a parametric study for the KfK reference designs of the homogeneous and heterogeneous APWR /19/ to investigate the effect of a variation of H/d on the reactor design. The two KfK reference designs of APWR are characterized by the following choices of parameters:

homogeneous reactor: $p = 1.14$ cm, $d = 0.95$ cm, $p/d = 1.2$

heterogeneous reactor: $d_S = 0.74$ cm, $q_{vS} = 245$ W/cm^3, $q_{vB} = 124$ w/cm^3.

The calculations have been performed for the following values of H/d: 15, 20, 25, 30, 35, 40, 45 and 50. Tables XVII and XVIII and Fig. 49 to 65 show the results of the calculations.

The main results are:

- For the homogeneous reactor the factor $C_{\Delta H}$ increases quite rapidly for H/d > 20 and the produced net electrical output of the plant has a maximum by H/d = 20. There is therefore a strong incentive to develop fuel rod claddings with integral spiral ribs with relative short axial pitches (H=20x0.95=19 cm).
- For the heterogeneous reactors the maximum plant electrical power can be reached already at H/d=35. There is no incentive in developing shorter axial pitches of the spiral ribs than H=35x1.109=38.8 cm. Longer axial pitches are of course easier to realize.

4. Conclusions

The computer code HADA for the thermohydraulic design of an Advanced Pressurized Water Reactor has been improved. The two main modifications to the code are:

a) The use of the water enthalpy, rather than the water temperature, for the equation giving the limitation due to the hot channel factor $F_{\Delta H}$.

b) The introduction of the factor $C_{\Delta H}$, which ensures that the minimum value of the ratio between the critical heat flux and the hot channel heat flux (DNBR) is always equal or greater than 1.3.

On the base of this improved version HADA-2 of the code a parametric thermohydraulic study has been performed. The main conclusions of this study are the following:

c) A tighter fuel rod lattice in the core offers the benefit of a smaller water to fuel rod volume ratio V_M/V_F and thus a higher conversion ratio and a better uranium utilization.

This must be paid for by a decrease of the net electrical output of the plant. Fig. 66 shows the ratio V_M/V_F versus the net electrical output of the plant for all the calculated reactors with H/d=20. For a V_M/V_F ratio equal to 0.6, which corresponds roughly to the value of the two (homogeneous and heterogeneous) KfK reference designs /19/, the net electrical output of the plant is about the same for the heterogenous and homogeneous reactors, i.e. 1280 MWe. For lower values of V_M/V_F the net electrical output for the homogeneous reactors may be lower than that of the heterogeneous reactors for the same V_M/V_F, depending on the choice of the fuel rod diameter. This is at variance with what was found in the previous parametric study of Ref. /4/ and it is due to the introduction of the factor $C_{\Delta H}$, which for most of the homogeneous reactors at low V_M/V_F values is greater than one. $C_{\Delta H}$ depends on the chosen critical heat flux correlation (in this case the KfK correlation of Ref. /14/). This shows how important are the critical heat flux experiments for the thermohydraulic design of the APWR.

d) The effect of the ratio H/d of the axial pitch of the six integral spiral ribs on the fuel rod surface, used in the homogeneous core and in the blanket of the heterogeneous core, has been investigated for the KfK reference designs /19/. For the homogeneous reactor the maximum net electrical output of the plant has been obtained for H/d=20, i.e. H=19 cm. This shows that there is a strong incentive to develope fuel rod claddings with integral spiral ribs with relative short axial pitches. For the heterogeneous reactor the maximum net electrical output of the plant can be reached already at H/d=35, i.e. H=38,8 cm.

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Nomenclature

Geometrical Parameters

A = cell water flow area (m^2)

d = fuel rod diameter (m)

d_h = hydraulic diameter of the coolant channel (m)

D_{eq} = equivalent diameter of the core = diameter of the circle which has the same cross section area of the actual core (m)

H = axial pitch of the integral spiral ribs (m)

K_R = average roughness height on the surface of the fuel rods (m)

L_c = core active length (m)

L'_c = core extrapolated length (m)

n_T = total number of fuel rods

p = fuel rod pitch (m)

V_M/V_F = ratio between area occupied by the water (moderator) and the fuel rods.

x = axial distance of the considered section measured from the core center (m)

ε = spacer grid solidity = ratio of the cross section area of the grid to the cross section area of the coolant channel

Water Physical Properties

H_N = nominal water enthalpy in the highest rated core coolant channels (J/kg)

H_{HS} = water enthalpy in the core hot channels (J/kg)

H_1 = average water enthalpy at the inlet of the reactor (J/kg)

H_2 = average water enthalpy at the outlet of the reactor (J/kg)

H_{2H} = water enthalpy at the outlet of the core hot channels (J/kg)

H_{2u} = average water enthalpy at the outlet of the fuel rod coolant channels (J/kg)

ρ = water density (kg/m^3)

Temperatures

T_1 = water temperature at reactor inlet (^oC)

T_2 = average water temperature at reactor outlet (^oC)

T_N = nomimal water temperature in the highest rated coolant channels (^oC)

T_{2H} = water temperature at the outlet of the hot coolant channels (^oC)

T_{HS} = water temperature in the hot coolant channels (^oC)

Other Physical Parameters

H_T = total pressure head of the primary circuit water pumps (m)

M = total water mass flow in the primary circuit (kg/s)

M_u = useful total water mass flow = mass flow of water which actually cools the fuel rods (kg/s)

N(Np) = power required to pump the water in the primary circuit (in the Tables indicated as N_p) (W)

N' = electrical power required to pump the water in the primary circuit (it takes account of the pump efficiency) (W)

p = water pressure (bar)

p_1 = water pressure at reactor inlet (bar)

p_2 = water pressure at reactor outlet (bar)

Q = reactor thermal output (W)

$Q_{el.net}$ = net electrical power of the plant (W)

q_L = average fuel rod linear rating (W/m)

q_v = average volume power density (W/m^3)

u = average water velocity (m/s)

Δp = friction pressure drop caused by the required flow of water through the core (bar)

Δp_t = total water primary circuit pressure drop (bar)

Dimensionless Parameters

C = friction factor correction number for low p/d values (eq.(50) and (51) of Ref. /4/)

C_S = friction factor correction number for bundle geometry (eq. (71) of Ref. /4/)

C_v = modified drag coefficient of the spacer grid

$C_{\Delta H}$ = correction factor to take account of the critical heat flux

DNBR = departure from nucleate boiling ratio = minimum ratio between critical heat flux and heat flux in the hot channel

F = friction factor correction number for spiral ribs (eq. (47) of Ref. /4/)

$F_{\Delta H}$ = hot channel factor for the enthalpy rise in the core

F_R = correction factor for the fiction factor to account for the surface roughness of the fuel rods

K = ratio of the turbine pressure for the APWR case to the turbine pressure for the PWR reference case

K' = correction factor to take account of the water flow which bypasses the core

K_1 = correction factor which takes account of the area occupied by the interface between the fuel elements and by the control and tye rods and their relative cooling water

K_2 = fraction of the "non-useful" cross section area of the core (interface between fuel elements, control and tye rods) occupied by flowing water

Q_P = power plant overpower factor

Q_R = $Q_{el.net}/1300$ MWe

Re = Reynolds number

Re' = modified Reynolds number (eq.(46) of Ref. /4/)

η = efficiency of the primary circuit water pumps

φrad = radial power distribution form factor

λ = friction factor

λ_T = friction factor for flow in a tube

Subscripts

B = relative to the blanket

S = relative to the seed

1 = at the core inlet

2 = at the core outlet

Table I

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 0.850 CM N = 169465

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.780	1.090	157.7	252.0	17676.	7.6	105.	4.08	8.35	268.7	299.7	0.748	2818.	19.34	899.	0.691	1.62	0.91	0.359	0.309	*****	1
											CDH = 1.7230					1.36	1.30	OPF=1.12		*****	
0.790	1.076	154.5	246.9	17512.	7.9	99.	4.52	8.65	262.9	292.3	0.689	2595.	19.64	808.	0.621	1.76	0.92	0.328	0.277	*****	2
											CDH = 1.9657					1.50	1.30	OPF=1.12		*****	
0.800	1.062	151.3	241.8	17346.	8.3	91.	5.01	8.99	255.7	283.0	0.620	2333.	19.93	702.	0.540	1.96	0.92	0.297	0.245	*****	3
											CDH = 2.3169					1.69	1.30	OPF=1.12		*****	
0.810	1.049	148.1	236.7	17219.	8.7	81.	5.51	9.35	246.3	270.8	0.537	2020.	20.25	579.	0.445	2.25	0.93	0.268	0.214	*****	4
											CDH = 2.8757					1.95	1.30	OPF=1.12		*****	
0.820	1.037	144.9	231.5	17174.	9.3	68.	6.00	9.72	234.3	255.0	0.440	1658.	20.60	441.	0.339	2.71	0.93	0.239	0.185	*****	5
											CDH = 3.8357					2.35	1.30	OPF=1.12		*****	

Table II

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 0.900 CM N = 151158

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4	VM/VF -	CELL -	X(BOIL.) CM	
0.780	1.154	171.4	244.3	18003.	6.4	137.	2.75	7.42	286.3	321.5	0.943	3551.	18.21	1208.	0.929	1.25	0.91	0.514	0.468	***** 6
											CDH = 1.1298					1.00	1.30	OPF=1.12		27.
0.800	1.125	165.4	235.9	17726.	6.9	134.	3.33	7.79	281.9	316.6	0.893	3363.	18.62	1128.	0.867	1.32	0.93	0.444	0.396	***** 7
											CDH = 1.2445					1.10	1.30	OPF=1.12		*****
0.810	1.111	162.5	231.6	17551.	7.1	132.	3.67	8.01	279.1	313.4	0.862	3244.	18.85	1077.	0.829	1.37	0.94	0.411	0.361	***** 8
											CDH = 1.3223					1.17	1.30	OPF=1.12		*****
0.820	1.098	159.5	227.3	17347.	7.3	129.	4.07	8.26	275.7	309.5	0.825	3106.	19.08	1019.	0.784	1.42	0.95	0.379	0.328	***** 9
											CDH = 1.4199					1.24	1.30	OPF=1.12		*****
0.830	1.084	156.4	223.0	17120.	7.6	124.	4.51	8.55	271.6	304.6	0.781	2940.	19.31	949.	0.730	1.50	0.95	0.348	0.296	***** 10
											CDH = 1.5506					1.33	1.30	OPF=1.12		*****
0.840	1.071	153.4	218.7	16866.	7.9	118.	5.00	8.87	266.6	298.4	0.728	2743.	19.52	868.	0.668	1.60	0.96	0.318	0.266	***** 11
											CDH = 1.7266					1.44	1.30	OPF=1.12		*****
0.850	1.059	150.4	214.4	16603.	8.2	110.	5.52	9.22	260.2	290.4	0.665	2504.	19.73	771.	0.593	1.74	0.96	0.289	0.236	***** 12
											CDH = 1.9808					1.58	1.30	OPF=1.12		*****
0.860	1.047	147.4	210.1	16353.	8.6	100.	6.08	9.59	252.1	279.9	0.589	2218.	19.92	656.	0.505	1.94	0.97	0.262	0.208	***** 13
											CDH = 2.3705					1.79	1.30	OPF=1.12		*****
0.870	1.034	144.3	205.8	16161.	9.0	86.	6.63	9.98	241.6	266.1	0.499	1877.	20.13	524.	0.403	2.25	0.97	0.235	0.180	***** 14
											CDH = 3.0175					2.09	1.30	OPF=1.12		*****

Table III

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 0.950 CM N = 135666

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.780	1.218	183.1	234.3	18228.	5.7	152.	2.16	7.03	291.4	327.3	1.003	3777.	17.69	1306.	1.005	1.16	0.90	0.660	0.636	8.	15
											CDH =	1.0000				0.88	1.30	OPF=1.12		0.	
0.800	1.187	177.8	227.4	18079.	6.0	154.	2.43	7.20	290.0	325.9	0.987	3715.	17.90	1279.	0.984	1.18	0.93	0.590	0.555	19.	16
											CDH =	1.0302				0.93	1.30	OPF=1.12		12.	
0.820	1.159	172.3	220.4	17881.	6.3	155.	2.80	7.42	287.9	323.7	0.962	3623.	18.17	1239.	0.953	1.22	0.96	0.524	0.480	*****	17
											CDH =	1.0761				0.99	1.30	OPF=1.12		23.	
0.840	1.131	166.7	213.3	17581.	6.7	154.	3.31	7.75	284.9	320.6	0.928	3494.	18.51	1184.	0.910	1.26	0.98	0.459	0.410	*****	18
											CDH =	1.1432				1.07	1.30	OPF=1.12		*****	
0.850	1.118	163.9	209.7	17385.	6.9	153.	3.65	7.95	282.8	318.4	0.905	3407.	18.70	1146.	0.882	1.28	0.98	0.427	0.377	*****	19
											CDH =	1.1908				1.12	1.30	OPF=1.12		*****	
0.860	1.105	161.0	206.0	17155.	7.1	151.	4.02	8.19	280.4	315.8	0.878	3305.	18.89	1103.	0.849	1.31	0.99	0.396	0.346	*****	20
											CDH =	1.2483				1.17	1.30	OPF=1.12		*****	
0.870	1.092	158.2	202.4	16896.	7.4	148.	4.44	8.45	277.4	312.6	0.845	3182.	19.07	1051.	0.809	1.35	1.00	0.367	0.315	*****	21
											CDH =	1.3236				1.23	1.30	OPF=1.12		*****	
0.880	1.080	155.3	198.7	16601.	7.6	144.	4.91	8.74	273.8	308.5	0.806	3036.	19.24	990.	0.761	1.40	1.00	0.338	0.285	*****	22
											CDH =	1.4206				1.30	1.30	OPF=1.12		*****	
0.890	1.067	152.5	195.1	16280.	7.9	138.	5.43	9.07	269.3	303.2	0.759	2857.	19.38	915.	0.704	1.47	1.00	0.310	0.256	*****	23
											CDH =	1.5550				1.39	1.30	OPF=1.12		*****	
0.900	1.056	149.6	191.4	15932.	8.1	130.	5.98	9.42	263.7	296.4	0.702	2642.	19.48	827.	0.636	1.57	1.00	0.283	0.229	*****	24
											CDH =	1.7418				1.51	1.30	OPF=1.12		*****	
0.910	1.044	146.7	187.7	15584.	8.4	120.	6.57	9.79	256.6	287.4	0.632	2380.	19.54	721.	0.554	1.71	1.00	0.256	0.202	*****	25
											CDH =	2.0242				1.67	1.30	OPF=1.12		*****	
0.920	1.033	143.9	184.1	15274.	8.8	106.	7.15	10.19	247.2	275.2	0.548	2062.	19.60	595.	0.458	1.94	1.00	0.231	0.176	*****	26
											CDH =	2.4818				1.91	1.30	OPF=1.12		*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 0.950 CM N = 135666

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4	VM/VF -	CELL -	X(BOIL.) CM	
0.930	1.022	141.0	180.4	15361.	9.4	90.	7.44	10.44	236.4	260.3	0.458	1725.	19.84	466.	0.359	2.29	0.99	0.206	0.151	***** 27
											CDH = 3.2470					2.25	1.30	OPF=1.12		*****

Table IV

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

HOMOGENEOUS CORE

H/D = 20. P = 1.000 CM N = 122438

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.780	1.282	192.9	222.7	18442.	5.3	161.	1.88	6.86	291.9	327.4	1.008	3796.	17.49	1314.	1.011	1.16	0.91	0.805	0.812	0.	28
											CDH = 1.0000					0.82	1.30	OPF=1.12		0.	
0.800	1.250	188.2	217.3	18336.	5.5	164.	2.02	6.94	291.6	327.4	1.006	3787.	17.59	1310.	1.008	1.17	0.94	0.732	0.723	4.	29
											CDH = 1.0000					0.86	1.31	OPF=1.12		0.	
0.820	1.220	183.4	211.7	18186.	5.7	168.	2.22	7.06	291.3	327.3	1.002	3774.	17.73	1305.	1.003	1.17	0.96	0.663	0.640	13.	30
											CDH = 1.0000					0.89	1.30	OPF=1.12		4.	
0.840	1.190	178.3	205.9	18019.	6.0	171.	2.48	7.22	290.3	326.4	0.991	3730.	17.92	1286.	0.989	1.19	0.98	0.597	0.563	21.	31
											CDH = 1.0174					0.94	1.30	OPF=1.12		13.	
0.860	1.163	173.1	199.9	17796.	6.2	173.	2.83	7.43	288.8	325.0	0.974	3668.	18.15	1259.	0.968	1.20	1.00	0.534	0.491	*****	32
											CDH = 1.0437					0.99	1.30	OPF=1.12		22.	
0.880	1.136	167.8	193.8	17498.	6.6	174.	3.29	7.71	286.8	323.1	0.950	3579.	18.42	1220.	0.939	1.22	1.02	0.474	0.424	*****	33
											CDH = 1.0827					1.05	1.30	OPF=1.12		39.	
0.890	1.124	165.1	190.7	17287.	6.8	174.	3.61	7.90	285.3	321.7	0.934	3517.	18.59	1194.	0.918	1.23	1.03	0.443	0.392	*****	34
											CDH = 1.1102					1.09	1.30	OPF=1.12		*****	
0.900	1.111	162.5	187.6	17048.	7.0	173.	3.96	8.12	283.5	320.0	0.914	3442.	18.75	1161.	0.893	1.25	1.03	0.413	0.361	*****	35
											CDH = 1.1453					1.13	1.30	OPF=1.12		*****	
0.910	1.099	159.8	184.5	16780.	7.2	171.	4.36	8.36	281.3	317.8	0.890	3349.	18.90	1122.	0.863	1.27	1.04	0.384	0.332	*****	36
											CDH = 1.1914					1.17	1.30	OPF=1.12		*****	
0.920	1.087	157.0	181.3	16470.	7.4	169.	4.80	8.63	278.7	315.1	0.861	3241.	19.03	1076.	0.827	1.29	1.04	0.356	0.303	*****	37
											CDH = 1.2482					1.22	1.30	OPF=1.12		*****	
0.930	1.075	154.3	178.2	16126.	7.6	164.	5.29	8.93	275.4	311.6	0.825	3108.	19.14	1020.	0.784	1.33	1.04	0.328	0.275	*****	38
											CDH = 1.3242					1.29	1.30	OPF=1.12		*****	
0.940	1.064	151.6	175.1	15742.	7.8	159.	5.82	9.25	271.4	307.1	0.783	2947.	19.20	952.	0.732	1.38	1.04	0.302	0.248	*****	39
											CDH = 1.4257					1.36	1.30	OPF=1.12		*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 1.000 CM N = 122438

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.950	1.053	148.9	171.9	15335.	8.0	151.	6.39	9.60	266.3	301.2	0.730	2748.	19.20	870.	0.669	1.45	1.04	0.276	0.222	*****	40
											CDH = 1.5714					1.46	1.30	OPF=1.12		*****	
0.960	1.042	146.1	168.8	14908.	8.3	140.	6.98	9.97	259.9	293.4	0.666	2508.	19.14	772.	0.594	1.55	1.03	0.252	0.196	*****	41
											CDH = 1.7818					1.59	1.30	OPF=1.12		*****	
0.980	1.020	140.7	162.5	14522.	9.1	111.	7.87	10.58	242.4	270.0	0.508	1911.	19.20	537.	0.413	1.96	1.02	0.204	0.148	*****	42
											CDH = 2.6468					2.04	1.30	OPF=1.12		*****	

Table V

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 1.050 CM N = 111055

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.820	1.280	192.7	201.8	18404.	5.3	177.	1.94	6.90	291.6	327.2	1.006	3786.	17.54	1310.	1.007	1.17	0.96	0.801	0.808	0.	43
											CDH = 1.0040					0.84	1.30	OPF=1.12		0.	
0.840	1.250	188.2	197.1	18308.	5.4	180.	2.08	6.98	291.3	327.0	1.002	3771.	17.64	1303.	1.002	1.18	0.99	0.732	0.723	9.	44
											CDH = 1.0080					0.88	1.30	OPF=1.12		0.	
0.860	1.221	183.6	192.3	18159.	5.7	184.	2.27	7.09	291.0	326.9	0.999	3760.	17.77	1299.	0.999	1.19	1.01	0.666	0.644	18.	45
											CDH = 1.0066					0.91	1.30	OPF=1.12		9.	
0.880	1.193	178.8	187.3	17975.	5.9	188.	2.53	7.24	290.4	326.6	0.992	3735.	17.94	1288.	0.991	1.19	1.03	0.603	0.570	28.	46
											CDH = 1.0122					0.95	1.30	OPF=1.12		14.	
0.900	1.167	173.9	182.1	17739.	6.2	191.	2.87	7.44	289.4	325.8	0.981	3692.	18.14	1269.	0.976	1.20	1.05	0.543	0.501	48.	47
											CDH = 1.0257					1.00	1.30	OPF=1.12		24.	
0.920	1.141	168.8	176.8	17430.	6.5	194.	3.30	7.71	287.9	324.6	0.964	3629.	18.38	1242.	0.955	1.20	1.07	0.485	0.436	*****	48
											CDH = 1.0473					1.05	1.30	OPF=1.12		34.	
0.930	1.129	166.3	174.2	17239.	6.6	194.	3.57	7.86	286.9	323.8	0.953	3588.	18.51	1224.	0.942	1.21	1.07	0.457	0.406	*****	49
											CDH = 1.0620					1.08	1.30	OPF=1.12		44.	
0.940	1.117	163.7	171.5	17000.	6.8	194.	3.90	8.06	285.6	322.6	0.938	3532.	18.65	1200.	0.923	1.21	1.07	0.428	0.376	*****	50
											CDH = 1.0835					1.11	1.30	OPF=1.12		53.	
0.950	1.105	161.2	168.8	16726.	7.0	194.	4.27	8.28	284.0	321.2	0.920	3464.	18.78	1171.	0.901	1.22	1.08	0.400	0.347	*****	51
											CDH = 1.1102					1.14	1.30	OPF=1.12		*****	
0.960	1.094	158.6	166.1	16416.	7.2	192.	4.69	8.53	282.0	319.4	0.899	3383.	18.89	1136.	0.874	1.23	1.08	0.372	0.319	*****	52
											CDH = 1.1440					1.18	1.30	OPF=1.12		*****	
0.970	1.082	156.0	163.4	16073.	7.4	189.	5.14	8.80	279.5	317.0	0.872	3281.	18.98	1093.	0.841	1.24	1.08	0.346	0.292	*****	53
											CDH = 1.1908					1.23	1.30	OPF=1.12		*****	
0.980	1.071	153.4	160.7	15684.	7.6	185.	5.64	9.10	276.6	314.1	0.839	3160.	19.02	1042.	0.801	1.27	1.08	0.320	0.266	*****	54
											CDH = 1.2498					1.28	1.30	OPF=1.12		*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 1.050 CM N = 111055

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.990	1.061	150.8	158.0	15257.	7.8	180.	6.18	9.42	272.9	310.2	0.800	3012.	19.00	979.	0.753	1.30	1.07	0.295	0.240	*****	55
											CDH =	1.3306				1.34	1.30	OPF=1.12		*****	
1.000	1.050	148.2	155.2	14798.	7.9	172.	6.75	9.76	268.2	305.0	0.751	2829.	18.91	903.	0.695	1.35	1.07	0.271	0.216	*****	56
											CDH =	1.4445				1.43	1.30	OPF=1.12		*****	
1.010	1.040	145.6	152.5	14316.	8.1	161.	7.34	10.11	262.4	298.2	0.692	2606.	18.74	812.	0.624	1.43	1.06	0.247	0.192	*****	57
											CDH =	1.6081				1.54	1.30	OPF=1.12		*****	
1.030	1.019	140.4	147.1	13807.	8.9	133.	8.20	10.69	247.1	278.1	0.550	2069.	18.58	597.	0.460	1.72	1.05	0.202	0.146	*****	58
											CDH =	2.2378				1.89	1.30	OPF=1.12		*****	

Table VI

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 1.100 CM N = 101189

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.880	1.250	188.2	179.6	18293.	5.4	197.	2.13	7.02	290.7	326.4	0.995	3747.	17.69	1293.	0.994	1.21	1.04	0.732	0.723	15.	59
											CDH = 1.0217					0.90	1.30	OPF=1.12		5.	
0.900	1.222	183.8	175.4	18136.	5.6	201.	2.32	7.13	290.7	326.6	0.995	3745.	17.81	1292.	0.994	1.20	1.06	0.669	0.647	25.	60
											CDH = 1.0148					0.94	1.30	OPF=1.12		10.	
0.920	1.196	179.2	171.0	17944.	5.9	206.	2.57	7.27	290.3	326.5	0.991	3730.	17.96	1286.	0.989	1.20	1.07	0.609	0.576	36.	61
											CDH = 1.0134					0.97	1.30	OPF=1.12		21.	
0.940	1.170	174.5	166.6	17700.	6.1	210.	2.89	7.46	289.6	326.1	0.984	3703.	18.15	1274.	0.980	1.20	1.09	0.551	0.510	52.	62
											CDH = 1.0169					1.01	1.30	OPF=1.12		26.	
0.960	1.146	169.8	162.0	17388.	6.4	213.	3.31	7.70	288.5	325.5	0.972	3659.	18.36	1255.	0.965	1.19	1.10	0.495	0.448	*****	63
											CDH = 1.0265					1.05	1.30	OPF=1.12		37.	
0.980	1.122	164.9	157.4	16983.	6.7	215.	3.84	8.01	286.9	324.3	0.954	3592.	18.58	1226.	0.943	1.19	1.11	0.442	0.389	*****	64
											CDH = 1.0449					1.10	1.30	OPF=1.12		48.	
0.990	1.111	162.5	155.0	16716.	6.9	215.	4.19	8.22	285.7	323.4	0.941	3541.	18.70	1204.	0.926	1.19	1.12	0.414	0.361	*****	65
											CDH = 1.0607					1.13	1.30	OPF=1.12		54.	
1.000	1.100	160.0	152.7	16415.	7.0	215.	4.57	8.44	284.2	322.2	0.924	3479.	18.79	1177.	0.906	1.19	1.12	0.388	0.334	*****	66
											CDH = 1.0817					1.16	1.30	OPF=1.12		75.	
1.010	1.089	157.5	150.3	16075.	7.2	213.	5.00	8.69	282.4	320.6	0.904	3403.	18.87	1145.	0.881	1.20	1.12	0.362	0.308	*****	67
											CDH = 1.1088					1.19	1.30	OPF=1.12		*****	
1.020	1.078	155.1	148.0	15694.	7.4	211.	5.47	8.96	280.1	318.7	0.880	3312.	18.90	1106.	0.851	1.20	1.11	0.337	0.282	*****	68
											CDH = 1.1437					1.23	1.30	OPF=1.12		*****	
1.030	1.068	152.6	145.6	15277.	7.5	207.	5.97	9.26	277.3	316.0	0.849	3197.	18.87	1057.	0.813	1.22	1.11	0.312	0.258	*****	69
											CDH = 1.1934					1.28	1.30	OPF=1.12		*****	
1.040	1.058	150.1	143.3	14813.	7.7	201.	6.50	9.57	273.9	312.6	0.812	3059.	18.78	999.	0.768	1.24	1.11	0.289	0.234	*****	70
											CDH = 1.2577					1.33	1.30	OPF=1.12		*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 1.100 CM N = 101189

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -		CELL -	X(BOIL.) CM	
1.050	1.048	147.6	140.9	14313.	7.8	193.	7.07	9.90	269.6	308.2	0.768	2891.	18.60	929.	0.714	1.28	1.10	0.266	0.210	*****		71
											CDH = 1.3472					1.40	1.30	OPF=1.12		*****		
1.060	1.038	145.2	138.5	13790.	8.0	183.	7.64	10.23	264.2	302.1	0.713	2683.	18.33	843.	0.648	1.33	1.09	0.243	0.187	*****		72
											CDH = 1.4781					1.49	1.30	OPF=1.12		*****		
1.070	1.028	142.7	136.2	13328.	8.2	169.	8.17	10.55	257.7	294.2	0.648	2442.	18.05	745.	0.573	1.42	1.08	0.222	0.165	*****		73
											CDH = 1.6704					1.62	1.30	OPF=1.12		*****		

Table VII

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 1.140 CM N = 94212

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.940	1.213	182.2	161.9	18048.	5.7	217.	2.45	7.20	290.3	326.3	0.990	3729.	17.90	1285.	0.988	1.21	1.10	0.648	0.622	33.	74
											CDH = 1.0199					0.97	1.30	OPF=1.12		16.	
0.950	1.200	180.0	159.9	17945.	5.8	220.	2.58	7.27	290.2	326.3	0.989	3725.	17.97	1283.	0.987	1.21	1.11	0.619	0.588	38.	75
											CDH = 1.0167					0.98	1.30	OPF=1.12		22.	
0.960	1.188	177.8	157.9	17833.	5.9	222.	2.72	7.36	290.0	326.3	0.987	3718.	18.05	1280.	0.985	1.21	1.11	0.590	0.555	44.	76
											CDH = 1.0153					1.00	1.30	OPF=1.12		22.	
0.980	1.163	173.2	153.9	17562.	6.2	226.	3.07	7.56	289.4	326.1	0.981	3694.	18.23	1270.	0.977	1.20	1.13	0.535	0.492	*****	77
											CDH = 1.0149					1.03	1.30	OPF=1.12		34.	
1.000	1.140	168.6	149.8	17219.	6.4	230.	3.50	7.81	288.4	325.6	0.971	3655.	18.43	1253.	0.964	1.19	1.14	0.482	0.433	*****	78
											CDH = 1.0200					1.07	1.30	OPF=1.12		40.	
1.020	1.118	163.9	145.6	16779.	6.7	233.	4.06	8.13	286.9	324.7	0.954	3592.	18.63	1226.	0.943	1.18	1.15	0.431	0.377	*****	79
											CDH = 1.0331					1.12	1.30	OPF=1.12		52.	
1.040	1.096	159.1	141.4	16173.	7.1	232.	4.81	8.57	284.3	322.8	0.926	3485.	18.79	1180.	0.907	1.17	1.14	0.379	0.325	*****	80
											CDH = 1.0630					1.17	1.30	OPF=1.12		70.	
1.060	1.075	154.4	137.2	15412.	7.4	229.	5.71	9.09	280.4	319.6	0.883	3325.	18.82	1111.	0.855	1.18	1.14	0.330	0.275	*****	81
											CDH = 1.1159					1.24	1.30	OPF=1.12		*****	
1.080	1.056	149.6	132.9	14486.	7.6	219.	6.74	9.68	274.4	314.2	0.819	3085.	18.60	1010.	0.777	1.20	1.13	0.284	0.229	*****	82
											CDH = 1.2121					1.33	1.30	OPF=1.12		*****	
1.090	1.046	147.2	130.8	13963.	7.8	211.	7.29	10.00	270.4	310.2	0.777	2926.	18.36	943.	0.725	1.23	1.12	0.262	0.206	*****	83
											CDH = 1.2882					1.39	1.30	OPF=1.12		*****	
1.100	1.036	144.8	128.7	13408.	7.9	200.	7.86	10.32	265.4	304.8	0.726	2732.	18.02	863.	0.664	1.27	1.11	0.240	0.184	*****	84
											CDH = 1.3953					1.47	1.30	OPF=1.12		*****	

Table VIII

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 1.200 CM N = 85026

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.950	1.263	190.2	152.5	18340.	5.3	228.	2.16	7.05	289.5	324.8	0.980	3690.	17.76	1268.	0.976	1.26	1.11	0.762	0.759	29.	85
											CDH = 1.0590					0.94	1.30	OPF=1.12		17.	
0.960	1.250	188.2	150.9	18269.	5.4	231.	2.23	7.09	289.6	325.1	0.982	3697.	17.80	1271.	0.978	1.25	1.12	0.732	0.723	35.	86
											CDH = 1.0511					0.95	1.30	OPF=1.12		17.	
0.980	1.224	184.2	147.7	18103.	5.6	237.	2.42	7.19	289.8	325.6	0.985	3707.	17.90	1275.	0.981	1.24	1.14	0.675	0.653	41.	87
											CDH = 1.0361					0.98	1.30	OPF=1.12		24.	
1.000	1.200	180.0	144.3	17902.	5.8	242.	2.65	7.32	289.8	326.0	0.985	3708.	18.02	1276.	0.982	1.23	1.15	0.619	0.588	55.	88
											CDH = 1.0246					1.01	1.30	OPF=1.12		30.	
1.020	1.176	175.7	140.9	17655.	6.0	248.	2.95	7.49	289.5	326.1	0.983	3700.	18.17	1273.	0.979	1.21	1.16	0.565	0.526	*****	89
											CDH = 1.0162					1.04	1.30	OPF=1.12		37.	
1.040	1.154	171.4	137.4	17348.	6.3	253.	3.32	7.70	289.0	326.1	0.978	3681.	18.34	1264.	0.973	1.20	1.18	0.514	0.468	*****	90
											CDH = 1.0113					1.07	1.30	OPF=1.12		44.	
1.060	1.132	166.9	133.9	16962.	6.5	257.	3.79	7.97	288.1	325.8	0.968	3646.	18.52	1249.	0.961	1.18	1.18	0.464	0.413	*****	91
											CDH = 1.0111					1.11	1.30	OPF=1.12		51.	
1.080	1.111	162.5	130.3	16477.	6.8	260.	4.38	8.31	286.7	325.1	0.953	3588.	18.67	1224.	0.942	1.16	1.19	0.416	0.361	*****	92
											CDH = 1.0184					1.15	1.30	OPF=1.12		58.	
1.100	1.091	157.9	126.7	15821.	7.1	260.	5.15	8.75	284.2	323.5	0.926	3486.	18.77	1180.	0.908	1.15	1.18	0.367	0.312	*****	93
											CDH = 1.0403					1.19	1.30	OPF=1.12		71.	
1.120	1.071	153.4	123.0	15011.	7.3	256.	6.05	9.26	280.5	320.8	0.886	3335.	18.69	1116.	0.858	1.15	1.17	0.321	0.266	*****	94
											CDH = 1.0818					1.25	1.30	OPF=1.12		96.	
1.140	1.053	148.9	119.4	14033.	7.6	246.	7.06	9.83	274.9	316.1	0.827	3112.	18.32	1021.	0.785	1.16	1.16	0.278	0.222	*****	95
											CDH = 1.1577					1.33	1.30	OPF=1.12		*****	

Table IX

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

H/D = 20. P = 1.250 CM N = 78360

D CM	P/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4		VM/VF -	CELL -	X(BOIL.) CM	
0.950	1.316	197.2	145.8	18531.	5.0	235.	2.00	6.97	288.4	323.2	0.967	3640.	17.70	1246.	0.959	1.29	1.11	0.881	0.909	29.	96
											CDH = 1.1018					0.92	1.30	OPF=1.12		12.	
1.000	1.250	188.2	139.1	18256.	5.4	249.	2.28	7.12	289.1	324.5	0.976	3674.	17.85	1261.	0.970	1.27	1.16	0.732	0.723	50.	97
											CDH = 1.0650					0.98	1.30	OPF=1.12		25.	
1.030	1.214	182.4	134.8	17993.	5.7	258.	2.57	7.28	289.4	325.4	0.980	3691.	18.00	1269.	0.976	1.25	1.18	0.650	0.624	*****	98
											CDH = 1.0399					1.01	1.30	OPF=1.12		32.	
1.050	1.190	178.3	131.8	17771.	5.9	264.	2.83	7.42	289.4	325.8	0.981	3693.	18.12	1270.	0.977	1.23	1.19	0.597	0.563	*****	99
											CDH = 1.0267					1.04	1.30	OPF=1.12		40.	
1.070	1.168	174.2	128.7	17500.	6.1	270.	3.15	7.60	289.2	326.0	0.979	3687.	18.27	1267.	0.975	1.21	1.20	0.547	0.505	*****	100
											CDH = 1.0160					1.07	1.30	OPF=1.12		47.	
1.090	1.147	169.9	125.6	17165.	6.3	276.	3.54	7.83	288.7	326.1	0.975	3669.	18.43	1259.	0.969	1.19	1.21	0.498	0.450	*****	101
											CDH = 1.0082					1.10	1.30	OPF=1.12		48.	

Table X

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 1.000 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
128.	1.345		1.345	200.6	19851	47373	426.7	6.30	18375.	1.97	291.7	1.007	3790.	17.55	1311.	1.17 1.67	0.764	0.691	21.	1
												CDH = 1.0000				1.17 1.42	OPF=1.12		0.	
65.	1.778	1.495	1.189	178.0	27522			4.84		6.91	327.4					1.38 1.48			*****	
																1.27 1.39	OPF=1.12		85.	
130.	1.329		1.329	198.8	20348	48999	417.9	6.37	18136.	2.29	291.2	1.001	3770.	17.77	1303.	1.18 1.67	0.695	0.634	21.	2
												CDH = 1.0000				1.18 1.44	OPF=1.12		10.	
66.	1.742	1.495	1.166	173.7	28651			5.14		7.10	327.2					1.37 1.51			*****	
																1.31 1.43	OPF=1.12		115.	
132.	1.312		1.312	196.8	20871	50629	409.0	6.45	17865.	2.64	290.6	0.995	3746.	17.99	1293.	1.19 1.67	0.636	0.584	31.	3
												CDH = 1.0000				1.19 1.45	OPF=1.12		10.	
67.	1.710	1.492	1.146	169.8	29758			5.43		7.31	327.0					1.36 1.54			*****	
																1.34 1.47	OPF=1.12		*****	
134.	1.295		1.295	194.6	21423	52333	399.6	6.50	17522.	3.08	289.8	0.987	3716.	18.22	1279.	1.20 1.67	0.580	0.537	40.	4
												CDH = 1.0000				1.19 1.46	OPF=1.12		20.	
68.	1.677	1.488	1.127	165.9	30910			5.74		7.56	326.8					1.35 1.56			*****	
																1.38 1.50	OPF=1.12		*****	
136.	1.278		1.278	192.3	22008	54031	390.1	6.56	17144.	3.55	289.0	0.978	3681.	18.42	1265.	1.21 1.67	0.531	0.495	49.	5
												CDH = 1.0000				1.20 1.47	OPF=1.12		29.	
69.	1.648	1.482	1.112	162.6	32023			6.03		7.83	326.5					1.33 1.57			*****	
																1.41 1.53	OPF=1.12		*****	
138.	1.260		1.260	189.7	22632	55770	380.1	6.62	16706.	4.07	287.9	0.967	3640.	18.58	1247.	1.21 1.67	0.487	0.456	57.	6
												CDH = 1.0000				1.21 1.48	OPF=1.12		29.	
70.	1.620	1.476	1.097	159.4	33138			6.31		8.13	326.1					1.32 1.58			*****	
																1.44 1.55	OPF=1.12		*****	
140.	1.242		1.242	187.0	23301	57615	369.2	6.64	16148.	4.71	286.6	0.953	3587.	18.69	1224.	1.22 1.66	0.444	0.417	74.	7
												CDH = 1.0000				1.22 1.50	OPF=1.12		37.	
71.	1.592	1.470	1.083	156.2	34314			6.60		8.49	325.7					1.30 1.58			*****	
																1.47 1.56	OPF=1.12		*****	
142.	1.223		1.223	183.9	24022	59414	358.4	6.69	15605.	5.30	285.2	0.938	3532.	18.70	1200.	1.23 1.65	0.407	0.383	*****	8
												CDH = 1.0000				1.23 1.51	OPF=1.12		45.	
72.	1.568	1.462	1.072	153.6	35392			6.84		8.81	325.2					1.29 1.57			*****	
																1.49 1.57	OPF=1.12		*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 1.000 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL X(BOIL.) / - / CM	
144.	1.203		1.203	180.6	24810	61356	346.2	6.71	14913.	6.00	283.3	0.919	3459.	18.56	1169.	1.23 1.63	0.370	0.348*****	9
												CDH = 1.0000				1.24 1.52		OPF=1.12 52.	
73.	1.543	1.454	1.061	150.8	36546			7.08		9.20	324.6					1.27 1.55		*****	
																1.52 1.57		OPF=1.12*****	
146.	1.183		1.183	176.9	25679	63411	332.4	6.71	14094.	6.77	280.9	0.895	3368.	18.23	1130.	1.22 1.61	0.333	0.314*****	10
												CDH = 1.0000				1.25 1.53		OPF=1.12 58.	
74.	1.518	1.447	1.050	148.1	37732			7.29		9.61	323.8					1.25 1.51		*****	
																1.55 1.56		OPF=1.12*****	
148.	1.161		1.161	172.8	26655	65625	316.6	6.67	13112.	7.59	277.9	0.864	3251.	17.59	1080.	1.22 1.58	0.296	0.279*****	11
												CDH = 1.0000				1.27 1.53		OPF=1.12 71.	
75.	1.494	1.438	1.039	145.4	38970			7.46		10.04	322.8					1.24 1.47		*****	
																1.57 1.54		OPF=1.12*****	

Table XI

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.950 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
140.	1.291		1.359	202.0	21560	51463	390.9	6.21	18466.	1.84	291.9	1.009	3798.	17.47	1315.	1.16 1.66	0.791	0.715	0.	12
												CDH = 1.0000				1.14 1.43	OPF=1.12		0.	
71.	1.705	1.426	1.196	179.2	29903			4.78		6.84	327.5					1.38 1.46			*****	
																1.23 1.39	OPF=1.12		68.	
142.	1.277		1.344	200.5	22037	53035	383.8	6.28	18276.	2.10	291.5	1.004	3782.	17.65	1308.	1.17 1.66	0.727	0.664	10.	13
												CDH = 1.0000				1.15 1.44	OPF=1.12		0.	
72.	1.675	1.426	1.175	175.4	30998			5.04		6.99	327.3					1.37 1.49			*****	
																1.27 1.43	OPF=1.12		77.	
144.	1.263		1.329	198.8	22535	54592	376.7	6.35	18069.	2.38	291.1	1.000	3764.	17.83	1300.	1.18 1.67	0.674	0.619	19.	14
												CDH = 1.0000				1.15 1.44	OPF=1.12		0.	
73.	1.647	1.424	1.157	171.9	32057			5.29		7.15	327.2					1.36 1.51			*****	
																1.30 1.46	OPF=1.12		104.	
146.	1.248		1.314	197.0	23056	56223	369.3	6.40	17811.	2.71	290.5	0.994	3741.	18.03	1290.	1.19 1.66	0.622	0.575	18.	15
												CDH = 1.0000				1.16 1.45	OPF=1.12		9.	
74.	1.619	1.421	1.140	168.5	33167			5.56		7.35	327.0					1.35 1.53			*****	
																1.33 1.49	OPF=1.12*****			
150.	1.219		1.283	193.0	24179	59467	354.4	6.53	17229.	3.45	289.2	0.980	3689.	18.38	1268.	1.21 1.66	0.536	0.501	35.	16
												CDH = 1.0000				1.17 1.47	OPF=1.12		18.	
76.	1.570	1.411	1.112	162.7	35288			6.05		7.77	326.5					1.33 1.55			*****	
																1.38 1.53	OPF=1.12*****			
152.	1.204		1.267	190.8	24788	61137	346.7	6.59	16881.	3.87	288.3	0.971	3657.	18.53	1254.	1.22 1.65	0.498	0.467	43.	17
												CDH = 1.0000				1.18 1.49	OPF=1.12		17.	
77.	1.547	1.406	1.100	160.1	36349			6.29		8.01	326.3					1.32 1.55			*****	
																1.40 1.54	OPF=1.12*****			
154.	1.189		1.251	188.4	25435	62919	338.2	6.63	16434.	4.39	287.3	0.960	3614.	18.65	1236.	1.22 1.65	0.460	0.432	51.	18
												CDH = 1.0000				1.19 1.50	OPF=1.12		25.	
78.	1.523	1.400	1.088	157.3	37484			6.55		8.31	325.9					1.31 1.54			*****	
																1.43 1.55	OPF=1.12*****			
158.	1.156		1.217	183.0	26869	66527	320.7	6.72	15450.	5.46	284.8	0.934	3516.	18.68	1193.	1.23 1.62	0.393	0.371	80.	19
												CDH = 1.0000				1.21 1.51	OPF=1.12		40.	
80.	1.481	1.387	1.068	152.5	39658			6.99		8.90	325.1					1.28 1.51			*****	
																1.47 1.56	OPF=1.12*****			

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.950 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL X(BOIL.) / - / CM	
160.	1.139		1.199	179.9	27674	68525	310.1	6.72	14765.	6.15	282.9	0.914	3443.	18.52	1162.	1.23 1.60	0.359	0.339*****	20
												CDH = 1.0000				1.22 1.52		OPF=1.12 47.	
81.	1.459	1.381	1.057	149.9	40851			7.22		9.28	324.5					1.27 1.48		*****	
																1.49 1.55		OPF=1.12*****	
162.	1.122		1.181	176.5	28558	70564	299.1	6.73	14047.	6.81	280.8	0.893	3363.	18.20	1127.	1.23 1.57	0.327	0.309*****	21
												CDH = 1.0000				1.23 1.53		OPF=1.12 52.	
82.	1.439	1.374	1.048	147.6	42006			7.40		9.63	323.8					1.25 1.45		*****	
																1.52 1.53		OPF=1.12*****	
164.	1.103		1.161	172.7	29541	72752	286.6	6.72	13198.	7.53	278.2	0.866	3262.	17.66	1084.	1.22 1.53	0.295	0.279*****	22
												CDH = 1.0000				1.24 1.53		OPF=1.12 57.	
83.	1.419	1.366	1.038	145.3	43211			7.55		10.01	322.9					1.24 1.40		*****	
																1.54 1.50		OPF=1.12*****	

Table XII

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.900 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
148.	1.270		1.411	206.7	22282	51956	372.7	5.95	18877.	1.28	292.7	1.017	3828.	17.03	1328.	1.13 1.66	1.020	0.901	0.	23
												CDH = 1.0021				1.11 1.41		OPF=1.12	0.	
75.	1.712	1.350	1.268	190.9	29674			4.11		6.51	327.7					1.39 1.35			37.	
																1.11 1.30		OPF=1.12	19.	
150.	1.258		1.398	205.6	22696	53357	367.4	6.01	18781.	1.41	292.6	1.016	3824.	17.13	1326.	1.13 1.66	0.945	0.842	0.	24
												CDH = 1.0000				1.11 1.41		OPF=1.12	0.	
76.	1.684	1.354	1.244	187.3	30661			4.31		6.58	327.7					1.38 1.38			55.	
																1.14 1.33		OPF=1.12	28.	
152.	1.246		1.385	204.5	23124	54819	361.6	6.07	18668.	1.57	292.3	1.013	3815.	17.26	1322.	1.14 1.66	0.875	0.786	0.	25
												CDH = 1.0000				1.11 1.42		OPF=1.12	0.	
77.	1.656	1.357	1.221	183.6	31695			4.52		6.68	327.6					1.38 1.41			81.	
																1.17 1.37		OPF=1.12	36.	
154.	1.235		1.372	203.3	23567	56264	356.0	6.13	18547.	1.73	292.1	1.010	3804.	17.38	1318.	1.15 1.66	0.816	0.738	0.	26
												CDH = 1.0000				1.11 1.43		OPF=1.12	0.	
78.	1.631	1.357	1.202	180.3	32697			4.73		6.77	327.5					1.37 1.44			*****	
																1.20 1.40		OPF=1.12	44.	
156.	1.223		1.359	202.0	24025	57722	350.4	6.19	18412.	1.92	291.8	1.007	3793.	17.52	1313.	1.16 1.66	0.763	0.695	0.	27
												CDH = 1.0000				1.12 1.44		OPF=1.12	0.	
79.	1.606	1.356	1.184	177.2	33697			4.93		6.88	327.4					1.37 1.46			*****	
																1.22 1.42		OPF=1.12	61.	
158.	1.211		1.345	200.7	24501	59256	344.6	6.25	18244.	2.14	291.4	1.004	3779.	17.68	1307.	1.17 1.66	0.711	0.652	0.	28
												CDH = 1.0000				1.12 1.44		OPF=1.12	0.	
80.	1.582	1.355	1.167	174.0	34755			5.16		7.02	327.3					1.36 1.48			*****	
																1.25 1.45		OPF=1.12	69.	
160.	1.199		1.332	199.2	24996	60816	338.8	6.31	18051.	2.40	291.0	0.999	3762.	17.84	1300.	1.18 1.65	0.664	0.613	8.	29
												CDH = 1.0000				1.13 1.45		OPF=1.12	0.	
81.	1.558	1.353	1.152	171.0	35820			5.39		7.16	327.2					1.35 1.49			*****	
																1.28 1.47		OPF=1.12	85.	
162.	1.187		1.319	197.6	25511	62332	333.2	6.37	17858.	2.65	290.6	0.995	3746.	17.99	1292.	1.19 1.65	0.624	0.578	8.	30
												CDH = 1.0000				1.13 1.46		OPF=1.12	0.	
82.	1.537	1.349	1.139	168.4	36821			5.59		7.31	327.0					1.35 1.50			*****	
																1.30 1.49		OPF=1.12	*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.900 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
166.	1.162		1.291	194.1	26611	65507	321.4	6.49	17373.	3.27	289.5	0.983	3702.	18.30	1274.	1.21 1.64	0.548	0.513	24.	31
												CDH = 1.0000				1.14 1.47	OPF=1.12		8.	
84.	1.495	1.341	1.115	163.4	38896			6.03		7.67	326.7					1.33 1.51			*****	
																1.34 1.52	OPF=1.12		*****	
168.	1.149		1.277	192.2	27201	67182	315.1	6.54	17063.	3.65	288.8	0.976	3674.	18.45	1261.	1.22 1.64	0.513	0.481	24.	32
												CDH = 1.0000				1.15 1.48	OPF=1.12		8.	
85.	1.475	1.336	1.104	160.8	39981			6.26		7.89	326.4					1.32 1.51			*****	
																1.36 1.53	OPF=1.12		*****	
170.	1.136		1.263	190.1	27822	68898	308.6	6.58	16710.	4.07	287.9	0.967	3641.	18.58	1247.	1.22 1.63	0.479	0.451	31.	33
												CDH = 1.0000				1.15 1.49	OPF=1.12		15.	
86.	1.455	1.331	1.093	158.4	41076			6.49		8.13	326.1					1.31 1.50			*****	
																1.38 1.54	OPF=1.12		*****	
172.	1.123		1.248	187.9	28479	70576	302.3	6.64	16367.	4.46	287.1	0.958	3608.	18.66	1233.	1.23 1.62	0.449	0.424	38.	34
												CDH = 1.0000				1.16 1.50	OPF=1.12		23.	
87.	1.437	1.326	1.084	156.4	42097			6.68		8.35	325.9					1.30 1.49			*****	
																1.40 1.54	OPF=1.12		*****	
174.	1.110		1.233	185.6	29176	72394	295.1	6.67	15916.	4.97	286.0	0.946	3563.	18.71	1214.	1.23 1.60	0.418	0.395	44.	35
												CDH = 1.0000				1.17 1.51	OPF=1.12		22.	
88.	1.419	1.320	1.074	154.1	43218			6.90		8.63	325.5					1.29 1.47			*****	
																1.42 1.54	OPF=1.12		*****	
176.	1.096		1.218	183.0	29921	74190	288.1	6.73	15476.	5.43	284.8	0.935	3519.	18.68	1194.	1.24 1.59	0.390	0.369	58.	36
												CDH = 1.0000				1.18 1.51	OPF=1.12		29.	
89.	1.402	1.315	1.066	152.2	44269			7.08		8.89	325.1					1.28 1.45			*****	
																1.44 1.53	OPF=1.12		*****	
178.	1.081		1.202	180.3	30721	76155	279.8	6.73	14889.	6.02	283.2	0.918	3457.	18.56	1168.	1.24 1.56	0.361	0.341	*****	37
												CDH = 1.0000				1.19 1.52	OPF=1.12		35.	
90.	1.384	1.309	1.057	150.0	45434			7.28		9.21	324.6					1.27 1.42			*****	
																1.46 1.52	OPF=1.12		*****	
182.	1.051		1.167	174.0	32542	80234	262.4	6.80	13628.	7.17	279.5	0.880	3314.	17.96	1106.	1.23 1.50	0.306	0.289	*****	38
												CDH = 1.0000				1.21 1.52	OPF=1.12		46.	
92.	1.350	1.297	1.041	146.1	47692			7.59		9.82	323.4					1.24 1.34			*****	
																1.50 1.47	OPF=1.12		*****	

Table XIII

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.850 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
160.	1.228		1.445	209.0	23820	54776	338.5	5.77	19144.	1.04	291.2	0.998	3758.	16.89	1297.	1.14 1.71	1.193	1.038	0.	39
												CDH = 1.0584				1.11 1.46	OPF=1.12		0.	
81.	1.676	1.269	1.321	197.8	30956			3.78		6.39	325.5					1.43 1.32			17.	
																1.05 1.30	OPF=1.12		0.	
165.	1.204		1.416	207.1	24793	58137	334.6	5.91	18864.	1.29	292.7	1.017	3831.	17.03	1329.	1.11 1.65	0.997	0.886	0.	40
												CDH = 1.0000				1.08 1.41	OPF=1.12		0.	
84.	1.615	1.284	1.258	189.4	33344			4.21		6.52	327.7					1.38 1.35			33.	
																1.10 1.33	OPF=1.12		17.	
170.	1.179		1.387	204.7	25836	61691	323.1	6.04	18628.	1.62	292.2	1.012	3811.	17.30	1321.	1.13 1.65	0.845	0.765	0.	41
												CDH = 1.0000				1.08 1.43	OPF=1.12		0.	
86.	1.557	1.289	1.209	181.5	35855			4.67		6.71	327.6					1.37 1.41			81.	
																1.16 1.40	OPF=1.12		32.	
176.	1.149		1.352	201.4	27196	66042	309.5	6.20	18254.	2.13	291.5	1.004	3780.	17.67	1307.	1.16 1.64	0.708	0.653	0.	42
												CDH = 1.0000				1.09 1.45	OPF=1.12		0.	
89.	1.496	1.285	1.164	173.4	38846			5.23		7.01	327.3					1.36 1.45			*****	
																1.23 1.46	OPF=1.12		62.	
180.	1.129		1.328	198.7	28181	68999	300.5	6.31	17944.	2.54	290.8	0.997	3753.	17.93	1295.	1.18 1.64	0.635	0.590	0.	43
												CDH = 1.0000				1.10 1.46	OPF=1.12		0.	
91.	1.460	1.279	1.141	168.8	40818			5.59		7.25	327.1					1.34 1.46			*****	
																1.26 1.49	OPF=1.12		83.	
182.	1.119		1.316	197.3	28701	70553	295.8	6.36	17748.	2.79	290.3	0.992	3736.	18.07	1288.	1.19 1.63	0.599	0.560	7.	44
												CDH = 1.0000				1.10 1.46	OPF=1.12		0.	
92.	1.442	1.276	1.130	166.5	41852			5.79		7.39	326.9					1.34 1.47			*****	
																1.28 1.51	OPF=1.12*****			
184.	1.108		1.304	195.8	29241	72035	291.3	6.42	17570.	3.02	289.9	0.988	3720.	18.19	1281.	1.20 1.62	0.570	0.534	7.	45
												CDH = 1.0000				1.11 1.47	OPF=1.12		0.	
94.	1.426	1.272	1.121	164.6	42794			5.95		7.52	326.8					1.33 1.47			*****	
																1.30 1.51	OPF=1.12*****			
186.	1.098		1.292	194.2	29804	73642	286.5	6.47	17332.	3.32	289.4	0.982	3699.	18.32	1272.	1.21 1.62	0.538	0.506	14.	46
												CDH = 1.0000				1.11 1.48	OPF=1.12		0.	
95.	1.408	1.268	1.111	162.4	43838			6.15		7.70	326.6					1.32 1.46			*****	
																1.32 1.52	OPF=1.12*****			

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.850 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR 1/2-3/4	VM/VF -	VM/VF -	CELL X(BOIL.) CM	
188.	1.087		1.279	192.5	30391	75281	281.6	6.51	17067.	3.64	288.8	0.976	3674.	18.45	1261.	1.22 1.61	0.508	0.479	14.	47
												CDH = 1.0000				1.12 1.48	OPF=1.12		7.	
96.	1.392	1.264	1.101	160.3	44890			6.35		7.88	326.4					1.32 1.45			*****	
																1.33 1.52	OPF=1.12		*****	
190.	1.076		1.266	190.7	31005	76850	277.0	6.58	16828.	3.93	288.2	0.970	3652.	18.54	1252.	1.23 1.60	0.483	0.455	21.	48
												CDH = 1.0000				1.12 1.49	OPF=1.12		7.	
97.	1.377	1.259	1.094	158.6	45845			6.51		8.05	326.2					1.31 1.44			*****	
																1.35 1.52	OPF=1.12		*****	
192.	1.065		1.253	188.8	31650	78566	271.8	6.62	16502.	4.31	287.4	0.962	3621.	18.63	1238.	1.23 1.59	0.455	0.430	27.	49
												CDH = 1.0000				1.13 1.49	OPF=1.12		14.	
98.	1.361	1.255	1.085	156.7	46916			6.71		8.26	326.0					1.30 1.43			*****	
																1.37 1.52	OPF=1.12		*****	
194.	1.054		1.240	186.7	32330	80332	266.3	6.66	16136.	4.72	286.5	0.952	3585.	18.69	1223.	1.24 1.57	0.428	0.405	33.	50
												CDH = 1.0000				1.14 1.50	OPF=1.12		13.	
99.	1.346	1.250	1.077	154.7	48002			6.90		8.49	325.7					1.29 1.41			*****	
																1.38 1.51	OPF=1.12		*****	
196.	1.043		1.227	184.5	33048	82041	261.2	6.72	15805.	5.09	285.7	0.943	3552.	18.71	1209.	1.24 1.55	0.405	0.383	39.	51
												CDH = 1.0000				1.14 1.50	OPF=1.12		20.	
100.	1.332	1.245	1.070	153.1	48993			7.06		8.70	325.4					1.28 1.39			*****	
																1.40 1.50	OPF=1.12		*****	
198.	1.031		1.213	182.2	33811	83927	255.1	6.75	15346.	5.57	284.5	0.931	3505.	18.66	1189.	1.24 1.53	0.379	0.359	45.	52
												CDH = 1.0000				1.15 1.51	OPF=1.12		26.	
101.	1.317	1.240	1.062	151.2	50116			7.24		8.96	325.0					1.27 1.36			*****	
																1.41 1.49	OPF=1.12		*****	
200.	1.019		1.198	179.7	34627	85779	249.3	6.81	14923.	5.99	283.3	0.919	3460.	18.57	1169.	1.24 1.51	0.356	0.336	56.	53
												CDH = 1.0000				1.16 1.51	OPF=1.12		31.	
102.	1.304	1.235	1.056	149.7	51152			7.39		9.20	324.6					1.26 1.34			*****	
																1.43 1.47	OPF=1.12		*****	
202.	1.006		1.183	177.0	35507	87726	243.1	6.88	14443.	6.45	282.0	0.905	3408.	18.39	1147.	1.24 1.48	0.332	0.314	*****	54
												CDH = 1.0000				1.17 1.51	OPF=1.12		30.	
103.	1.291	1.230	1.049	148.1	52219			7.52		9.44	324.2					1.25 1.30			*****	
																1.44 1.45	OPF=1.12		*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.850 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL X(BOIL.) / - / CM	
204.	0.993		1.168	174.1	36462	89907	235.3	6.87	13772.	7.05	280.0	0.885	3331.	18.05	1114.	1.23 1.44	0.306	0.289*****	55
												CDH = 1.0000				1.18 1.50		OPF=1.12 35.	
104.	1.276	1.225	1.042	146.1	53445			7.67		9.76	323.5					1.24 1.26		*****	
																1.46 1.41		OPF=1.12*****	
206.	0.979		1.151	170.9	37515	92125	227.5	6.91	13114.	7.59	277.9	0.864	3252.	17.59	1080.	1.22 1.40	0.282	0.266*****	56
												CDH = 1.0000				1.19 1.50		OPF=1.12 40.	
105.	1.262	1.220	1.035	144.4	54610			7.78		10.04	322.8					1.23 1.21		*****	
																1.48 1.37		OPF=1.12*****	

Table XIV

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.800 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL X(BOIL.) / - / CM	
180.	1.158		1.448	209.2	26774	62107	307.0	5.75	19014.	1.09	292.9	1.018	3834.	16.87	1331.	1.09 1.65	1.132	0.995 0.	57
												CDH = 1.0052				1.05 1.41	OPF=1.12	0.	
91.	1.569	1.209	1.298	195.0	35333			3.93		6.40	327.6					1.38 1.29		8.	
																1.03 1.30	OPF=1.12	0.	
184.	1.142		1.428	207.9	27539	64797	300.1	5.84	18882.	1.27	292.8	1.018	3832.	17.01	1330.	1.10 1.64	0.999	0.892 0.	58
												CDH = 1.0000				1.05 1.42	OPF=1.12	0.	
94.	1.528	1.217	1.255	189.0	37258			4.25		6.50	327.7					1.37 1.33		23.	
																1.07 1.35	OPF=1.12	8.	
188.	1.126		1.407	206.4	28341	67546	292.8	5.92	18732.	1.48	292.5	1.015	3820.	17.19	1324.	1.12 1.64	0.892	0.807 0.	59
												CDH = 1.0000				1.05 1.42	OPF=1.12	0.	
96.	1.489	1.220	1.221	183.6	39205			4.56		6.62	327.6					1.36 1.37		44.	
																1.12 1.40	OPF=1.12	22.	
192.	1.110		1.387	204.7	29185	70258	285.7	6.02	18565.	1.71	292.1	1.011	3806.	17.36	1318.	1.13 1.63	0.807	0.738 0.	60
												CDH = 1.0000				1.06 1.43	OPF=1.12	0.	
98.	1.455	1.219	1.194	178.9	41073			4.86		6.76	327.5					1.36 1.40		*****	
																1.15 1.43	OPF=1.12	29.	
196.	1.093		1.366	202.8	30075	73114	278.5	6.11	18349.	2.00	291.7	1.006	3788.	17.58	1311.	1.15 1.62	0.729	0.674 0.	61
												CDH = 1.0000				1.06 1.44	OPF=1.12	0.	
100.	1.422	1.216	1.169	174.3	43039			5.18		6.93	327.4					1.35 1.41		*****	
																1.19 1.47	OPF=1.12	42.	
200.	1.076		1.345	200.6	31017	75923	271.5	6.21	18118.	2.31	291.2	1.001	3768.	17.79	1302.	1.17 1.62	0.666	0.620 0.	62
												CDH = 1.0000				1.07 1.45	OPF=1.12	0.	
102.	1.392	1.211	1.149	170.5	44906			5.48		7.11	327.2					1.34 1.42		*****	
																1.22 1.49	OPF=1.12	54.	
204.	1.059		1.324	198.2	32018	78912	264.3	6.30	17814.	2.71	290.5	0.994	3742.	18.02	1291.	1.19 1.60	0.605	0.567 0.	63
												CDH = 1.0000				1.07 1.46	OPF=1.12	0.	
104.	1.362	1.205	1.130	166.5	46894			5.82		7.34	327.0					1.33 1.42		*****	
																1.25 1.50	OPF=1.12	73.	
208.	1.042		1.303	195.6	33088	81865	257.3	6.41	17495.	3.12	289.8	0.986	3713.	18.23	1278.	1.21 1.59	0.554	0.522 0.	64
												CDH = 1.0000				1.08 1.47	OPF=1.12	0.	
106.	1.335	1.198	1.115	163.2	48777			6.12		7.58	326.7					1.32 1.41		*****	
																1.28 1.51	OPF=1.12	*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.800 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
212.	1.024		1.280	192.7	34238	84914	250.1	6.52	17123.	3.58	288.9	0.977	3679.	18.43	1264.	1.23 1.57	0.507	0.479	6.	65
												CDH = 1.0000				1.09 1.48	OPF=1.12		0.	
108.	1.310	1.190	1.101	160.1	50676			6.42		7.84	326.5					1.31 1.39			*****	
																1.30 1.51	OPF=1.12		*****	
216.	1.006		1.258	189.4	35484	88088	242.7	6.64	16685.	4.10	287.9	0.966	3638.	18.59	1246.	1.24 1.54	0.462	0.437	18.	66
												CDH = 1.0000				1.10 1.48	OPF=1.12		6.	
110.	1.286	1.182	1.088	157.2	52604			6.71		8.14	326.1					1.30 1.36			*****	
																1.33 1.49	OPF=1.12		*****	
220.	0.987		1.234	185.8	36848	91572	234.4	6.72	16073.	4.79	286.4	0.951	3579.	18.70	1220.	1.25 1.51	0.416	0.394	23.	67
												CDH = 1.0000				1.11 1.49	OPF=1.12		12.	
112.	1.261	1.174	1.073	153.9	54724			7.05		8.53	325.6					1.29 1.32			*****	
																1.35 1.47	OPF=1.12		*****	
224.	0.968		1.210	181.7	38359	95131	225.9	6.84	15413.	5.50	284.7	0.933	3512.	18.67	1192.	1.25 1.47	0.374	0.355	34.	68
												CDH = 1.0000				1.12 1.49	OPF=1.12		17.	
114.	1.238	1.166	1.061	151.0	56772			7.34		8.93	325.0					1.27 1.27			*****	
																1.38 1.43	OPF=1.12		*****	
228.	0.947		1.184	177.1	40066	98990	216.4	6.94	14585.	6.32	282.4	0.909	3423.	18.45	1153.	1.24 1.41	0.333	0.315	49.	69
												CDH = 1.0000				1.14 1.49	OPF=1.12		27.	
116.	1.215	1.158	1.050	148.1	58924			7.61		9.37	324.3					1.26 1.21			*****	
																1.40 1.38	OPF=1.12		*****	

Table XV

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.740 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
204.	1.092		1.476	210.6	30136	69615	271.1	5.61	19089.	0.99	293.0	1.019	3838.	16.78	1332.	1.06 1.63	1.219	1.067	0.	70
												CDH = 1.0064				1.01 1.41	OPF=1.12		0.	
104.	1.484	1.124	1.320	197.8	39479			3.81		6.34	327.6					1.37 1.24			0.	
																0.97 1.30	OPF=1.12		0.	
208.	1.079		1.458	209.8	30853	72197	266.1	5.68	18989.	1.11	293.0	1.020	3841.	16.89	1333.	1.07 1.62	1.091	0.969	0.	71
												CDH = 1.0000				1.01 1.41	OPF=1.12		0.	
106.	1.450	1.133	1.280	192.6	41344			4.08		6.41	327.8					1.36 1.28			7.	
																1.01 1.34	OPF=1.12		0.	
212.	1.066		1.441	208.8	31598	74699	260.6	5.76	18898.	1.24	292.8	1.018	3834.	16.99	1330.	1.08 1.62	0.996	0.895	0.	72
												CDH = 1.0000				1.01 1.41	OPF=1.12		0.	
108.	1.420	1.136	1.250	188.3	43101			4.31		6.49	327.8					1.36 1.31			13.	
																1.05 1.38	OPF=1.12		0.	
220.	1.041		1.406	206.3	33181	79869	249.8	5.91	18665.	1.57	292.3	1.013	3814.	17.26	1322.	1.12 1.61	0.842	0.771	0.	73
												CDH = 1.0000				1.02 1.43	OPF=1.12		0.	
112.	1.365	1.135	1.202	180.4	46688			4.79		6.68	327.6					1.35 1.34			37.	
																1.11 1.44	OPF=1.12		19.	
228.	1.015		1.371	203.2	34906	85177	239.5	6.07	18366.	1.98	291.7	1.006	3789.	17.56	1311.	1.16 1.59	0.723	0.672	0.	74
												CDH = 1.0000				1.03 1.44	OPF=1.12		0.	
116.	1.315	1.129	1.165	173.6	50271			5.27		6.92	327.4					1.35 1.35			*****	
																1.16 1.47	OPF=1.12		36.	
236.	0.988		1.335	199.5	36805	90681	229.4	6.25	17983.	2.49	290.9	0.998	3756.	17.90	1297.	1.19 1.56	0.625	0.587	0.	75
												CDH = 1.0000				1.04 1.45	OPF=1.12		0.	
120.	1.271	1.119	1.136	167.7	53876			5.76		7.22	327.1					1.33 1.34			*****	
																1.20 1.49	OPF=1.12		52.	
240.	0.975		1.317	197.4	37833	93620	224.2	6.34	17726.	2.82	290.3	0.992	3734.	18.09	1287.	1.21 1.54	0.579	0.546	0.	76
												CDH = 1.0000				1.04 1.45	OPF=1.12		0.	
122.	1.249	1.113	1.121	164.7	55787			6.03		7.41	326.9					1.33 1.33			*****	
																1.22 1.48	OPF=1.12		62.	
245.	0.958		1.295	194.7	39107	97148	218.1	6.44	17371.	3.27	289.5	0.983	3702.	18.30	1274.	1.23 1.52	0.529	0.501	0.	77
												CDH = 1.0000				1.05 1.46	OPF=1.12		0.	
124.	1.224	1.107	1.106	161.4	58041			6.35		7.67	326.7					1.31 1.30			*****	
																1.25 1.47	OPF=1.12		*****	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

HETEROGENEOUS CORE

H/DB = 20. DS = 0.740 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
248.	0.947		1.279	192.5	40084	99585	213.9	6.54	17144.	3.55	289.0	0.978	3681.	18.42	1265.	1.24 1.50	0.500	0.473	0.	78
												CDH = 1.0000				1.05 1.46		OPF=1.12	0.	
126.	1.209	1.101	1.098	159.5	59501			6.54		7.83	326.5					1.31 1.29			*****	
																1.26 1.46		OPF=1.12	*****	
252.	0.932		1.260	189.7	41327	102831	208.4	6.63	16741.	4.03	288.0	0.968	3644.	18.57	1248.	1.25 1.47	0.460	0.437	5.	79
												CDH = 1.0000				1.06 1.46		OPF=1.12	0.	
128.	1.189	1.095	1.086	156.8	61504			6.82		8.10	326.2					1.30 1.25			*****	
																1.29 1.44		OPF=1.12	*****	
256.	0.918		1.240	186.7	42669	106224	202.5	6.72	16261.	4.58	286.8	0.956	3598.	18.68	1228.	1.26 1.44	0.422	0.401	15.	80
												CDH = 1.0000				1.07 1.46		OPF=1.12	5.	
130.	1.170	1.088	1.075	154.2	63555			7.10		8.42	325.8					1.29 1.22			*****	
																1.31 1.41		OPF=1.12	*****	
260.	0.902		1.219	183.3	44129	109604	196.8	6.84	15793.	5.10	285.7	0.943	3551.	18.71	1208.	1.26 1.40	0.389	0.369	20.	81
												CDH = 1.0000				1.08 1.46		OPF=1.12	10.	
132.	1.153	1.082	1.066	152.0	65475			7.33		8.70	325.4					1.28 1.18			*****	
																1.33 1.37		OPF=1.12	*****	
264.	0.886		1.198	179.6	45739	113410	189.9	6.92	15105.	5.81	283.8	0.924	3480.	18.62	1178.	1.25 1.35	0.352	0.334	28.	82
												CDH = 1.0000				1.09 1.46		OPF=1.12	14.	
134.	1.134	1.075	1.054	149.3	67671			7.60		9.10	324.8					1.26 1.12			*****	
																1.35 1.32		OPF=1.12	*****	
272.	0.851		1.150	170.6	49611	121912	159.0	7.18	13860.	7.30	272.2	0.797	3002.	18.25	975.	1.44 1.33	0.278	0.262	*****	83
												CDH = 1.2219				1.26 1.63		OPF=1.12	*****	
138.	1.097	1.062	1.033	144.0	72301			8.20		9.98	312.9					1.43 1.07			*****	
																1.56 1.30		OPF=1.12	*****	

Table XVI

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.700 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
228.	1.033		1.475	210.6	33682	78559	243.0	5.60	19043.	1.04	293.1	1.021	3845.	16.82	1335.	1.05 1.61	1.144	1.014	0.	84
												CDH = 1.0000				0.98 1.40	OPF=1.12		0.	
116.	1.392	1.076	1.294	194.5	44877			3.99		6.37	327.9					1.36 1.24			0.	
																0.98 1.34	OPF=1.12		0.	
232.	1.022		1.460	209.9	34398	81068	238.5	5.66	18965.	1.15	292.9	1.020	3839.	16.91	1333.	1.06 1.60	1.048	0.939	0.	85
												CDH = 1.0000				0.98 1.41	OPF=1.12		0.	
118.	1.365	1.080	1.264	190.3	46670			4.22		6.43	327.8					1.36 1.27			6.	
																1.01 1.38	OPF=1.12		0.	
236.	1.011		1.445	209.0	35139	83599	234.0	5.73	18876.	1.27	292.8	1.018	3832.	17.02	1330.	1.08 1.60	0.966	0.876	0.	86
												CDH = 1.0000				0.99 1.41	OPF=1.12		0.	
120.	1.340	1.082	1.238	186.4	48460			4.43		6.51	327.7					1.35 1.29			12.	
																1.04 1.41	OPF=1.12		6.	
240.	1.000		1.429	208.0	35906	85994	229.7	5.80	18794.	1.39	292.6	1.016	3825.	17.12	1327.	1.10 1.59	0.905	0.826	0.	87
												CDH = 1.0000				0.99 1.41	OPF=1.12		0.	
122.	1.318	1.080	1.220	183.4	50088			4.62		6.57	327.7					1.35 1.30			23.	
																1.06 1.43	OPF=1.12		6.	
244.	0.989		1.413	206.9	36701	88578	225.4	5.86	18683.	1.54	292.4	1.014	3816.	17.24	1323.	1.11 1.58	0.842	0.774	0.	88
												CDH = 1.0000				0.99 1.42	OPF=1.12		0.	
124.	1.295	1.079	1.200	180.0	51877			4.83		6.66	327.6					1.35 1.31			28.	
																1.09 1.45	OPF=1.12		17.	
248.	0.978		1.398	205.6	37527	91202	221.1	5.93	18558.	1.72	292.1	1.011	3805.	17.37	1318.	1.13 1.57	0.785	0.727	0.	89
												CDH = 1.0000				1.00 1.42	OPF=1.12		0.	
126.	1.273	1.076	1.183	176.9	53675			5.05		6.77	327.5					1.35 1.31			44.	
																1.11 1.46	OPF=1.12		22.	
252.	0.967		1.382	204.3	38386	93673	217.1	6.01	18449.	1.87	291.9	1.008	3796.	17.48	1314.	1.15 1.56	0.741	0.690	0.	90
												CDH = 1.0000				1.00 1.43	OPF=1.12		0.	
128.	1.254	1.072	1.170	174.5	55287			5.23		6.85	327.4					1.34 1.31			*****	
																1.12 1.47	OPF=1.12		27.	
256.	0.956		1.366	202.8	39282	96382	213.0	6.09	18294.	2.08	291.5	1.005	3783.	17.63	1309.	1.17 1.55	0.694	0.649	0.	91
												CDH = 1.0000				1.00 1.43	OPF=1.12		0.	
130.	1.234	1.068	1.155	171.6	57100			5.46		6.98	327.3					1.34 1.30			*****	
																1.15 1.47	OPF=1.12		32.	

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

H/DB = 20. DS = 0.700 CM

QVS / QVB / W/CCM	PS / PB / CM	DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
260.	0.945		1.350	201.2	40217	99145	208.8	6.16	18119.	2.31	291.2	1.001	3768.	17.78	1302.	1.19 1.53	0.649	0.611	0.	92
												CDH = 1.0000				1.01 1.43	OPF=1.12		0.	
132.	1.215	1.064	1.142	168.9	58928			5.69		7.11	327.2					1.33 1.29			*****	
																1.17 1.47	OPF=1.12		37.	
264.	0.934		1.334	199.4	41196	101969	204.7	6.24	17920.	2.57	290.7	0.996	3751.	17.95	1295.	1.21 1.51	0.608	0.574	0.	93
												CDH = 1.0000				1.01 1.43	OPF=1.12		0.	
134.	1.196	1.060	1.129	166.3	60773			5.92		7.26	327.1					1.33 1.27			*****	
																1.18 1.47	OPF=1.12		41.	
268.	0.922		1.318	197.5	42225	104639	200.9	6.34	17752.	2.79	290.4	0.992	3736.	18.07	1288.	1.22 1.50	0.575	0.544	0.	94
												CDH = 1.0000				1.02 1.44	OPF=1.12		0.	
136.	1.180	1.054	1.120	164.4	62414			6.10		7.39	326.9					1.32 1.26			*****	
																1.20 1.46	OPF=1.12		50.	
272.	0.911		1.301	195.4	43308	107608	196.8	6.42	17501.	3.11	289.8	0.986	3714.	18.23	1279.	1.24 1.47	0.538	0.510	0.	95
												CDH = 1.0000				1.02 1.44	OPF=1.12		0.	
138.	1.163	1.049	1.109	161.9	64300			6.34		7.57	326.8					1.32 1.24			*****	
																1.22 1.44	OPF=1.12		*****	
276.	0.899		1.284	193.2	44453	110669	192.5	6.51	17213.	3.47	289.1	0.979	3688.	18.39	1267.	1.25 1.45	0.503	0.477	0.	96
												CDH = 1.0000				1.03 1.44	OPF=1.12		0.	
140.	1.146	1.044	1.098	159.6	66216			6.58		7.78	326.5					1.31 1.21			*****	
																1.23 1.42	OPF=1.12		*****	
280.	0.887		1.267	190.8	45669	113835	188.2	6.59	16880.	3.87	288.3	0.971	3657.	18.53	1254.	1.26 1.42	0.468	0.446	0.	97
												CDH = 1.0000				1.03 1.44	OPF=1.12		0.	
142.	1.130	1.038	1.088	157.2	68166			6.83		8.01	326.3					1.30 1.18			*****	
																1.25 1.40	OPF=1.12		*****	
284.	0.875		1.249	188.1	46968	116889	184.2	6.72	16590.	4.21	287.7	0.964	3629.	18.61	1242.	1.27 1.39	0.440	0.418	5.	98
												CDH = 1.0000				1.04 1.44	OPF=1.12		0.	
144.	1.115	1.032	1.080	155.5	69921			7.02		8.20	326.0					1.29 1.15			*****	
																1.27 1.37	OPF=1.12		*****	
288.	0.862		1.231	185.3	48363	120329	179.5	6.80	16148.	4.71	286.6	0.953	3586.	18.69	1224.	1.27 1.35	0.407	0.387	9.	99
												CDH = 1.0000				1.05 1.44	OPF=1.12		4.	
146.	1.099	1.027	1.070	153.2	71966			7.27		8.49	325.7					1.28 1.11			*****	
																1.28 1.33	OPF=1.12		*****	

Table XVII

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H O M O G E N E O U S C O R E

P/D = 1.200 P = 1.140 CM N = 94212

D CM	H/D -	QL W/CM	QV W/CCM	M KG/S	U M/S	LC CM	DP BAR	DPT BAR	T1 C	T2 C	K -	Q MW	NP MW	QEL MW	QR -	DNBR 1/2-3/4	VM/VF -	CELL -	X(BOIL.) CM	
0.950	15.	180.0	159.9	17595.	5.7	219.	2.99	7.51	290.0	326.8	0.989	3722.	18.17	1282.	0.986	1.19 1.09	0.619	0.588	33.	1
											CDH =	1.0000				0.97 1.41		OPF=1.12	16.	
0.950	20.	180.0	159.9	17945.	5.8	220.	2.58	7.27	290.2	326.3	0.989	3725.	17.97	1283.	0.987	1.21 1.11	0.619	0.588	38.	2
											CDH =	1.0167				0.98 1.30		OPF=1.12	22.	
0.950	25.	180.0	159.9	18330.	5.9	211.	2.32	7.17	287.0	321.9	0.951	3581.	17.95	1221.	0.939	1.30 1.17	0.619	0.588	*****	3
											CDH =	1.1290				1.04 1.30		OPF=1.12	48.	
0.950	30.	180.0	159.9	18567.	5.9	205.	2.18	7.11	284.8	318.8	0.925	3482.	17.95	1178.	0.906	1.37 1.22	0.619	0.588	*****	4
											CDH =	1.2116				1.08 1.30		OPF=1.12	*****	
0.950	35.	180.0	159.9	18717.	5.9	201.	2.09	7.08	283.4	316.6	0.907	3415.	17.94	1150.	0.884	1.42 1.25	0.619	0.588	*****	5
											CDH =	1.2698				1.11 1.30		OPF=1.12	*****	
0.950	40.	180.0	159.9	18814.	5.9	199.	2.04	7.06	282.4	315.2	0.895	3371.	17.94	1131.	0.870	1.45 1.27	0.619	0.588	*****	6
											CDH =	1.3097				1.13 1.30		OPF=1.12	*****	
0.950	45.	180.0	159.9	18883.	5.9	197.	2.00	7.05	281.6	314.2	0.887	3339.	17.94	1117.	0.859	1.47 1.28	0.619	0.588	*****	7
											CDH =	1.3394				1.14 1.30		OPF=1.12	*****	
0.950	50.	180.0	159.9	18932.	5.9	196.	1.97	7.04	281.1	313.5	0.881	3316.	17.94	1108.	0.852	1.49 1.29	0.619	0.588	*****	8
											CDH =	1.3607				1.15 1.30		OPF=1.12	*****	

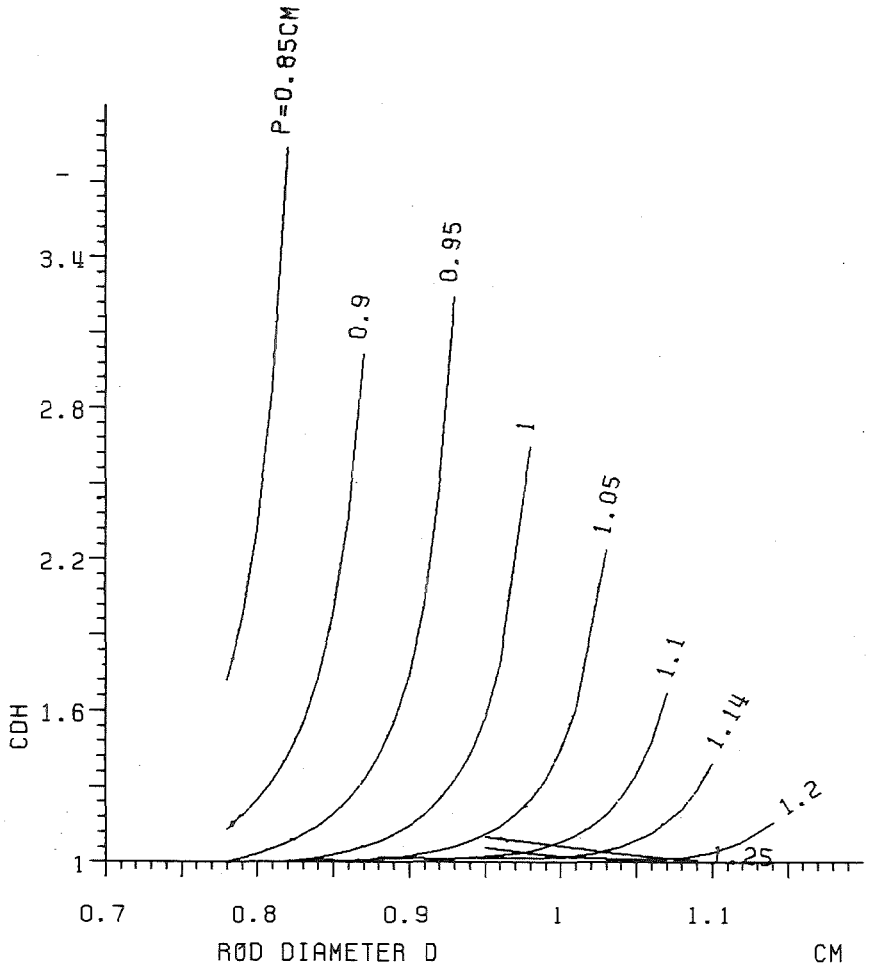
Table XVIII

DNBR 1 COLUMBIA EPRI
2 EDLUND
3 WSC-2
4 DALLE DONNE

H E T E R O G E N E O U S C O R E

DS = 0.740 CM

QVS / QVB / W/CCM	PS / PB / CM	H/DB / DB / CM	PS/DS / PB/DB / -	QLS / QLB / W/CM	NS / NB / -	NT / -	LC / CM	US / UB / M/S	M / KG/S	DP / DPT / BAR	T1 / T2 / C	K / -	Q / MW	NP / MW	QEL / MW	DNBR / 1/2-3/4	VM/VF / -	CELL / -	X(BOIL.) / CM	
245.	0.958	15.	1.295	194.7	39107	96356	218.1	6.44	17371.	3.27	289.5	0.983	3702.	18.30	1274.	1.14 1.52	0.552	0.518	0.	1
												CDH = 1.0000				1.05 1.46	OPF=1.12		0.	
124.	1.233	1.104	1.116	163.6	57249			6.05		7.67	326.7					1.30 1.31			*****	
																1.23 1.66	OPF=1.12*****			
245.	0.958	20.	1.295	194.7	39107	97148	218.1	6.44	17371.	3.27	289.5	0.983	3702.	18.30	1274.	1.14 1.52	0.529	0.501	0.	2
												CDH = 1.0000				1.05 1.46	OPF=1.12		0.	
124.	1.224	1.107	1.106	161.4	58041			6.35		7.67	326.7					1.30 1.30			*****	
																1.25 1.47	OPF=1.12*****			
245.	0.958	25.	1.295	194.7	39107	97506	218.1	6.44	17371.	3.27	289.5	0.983	3702.	18.30	1274.	1.14 1.52	0.519	0.493	0.	3
												CDH = 1.0000				1.05 1.46	OPF=1.12		0.	
124.	1.220	1.108	1.102	160.4	58399			6.50		7.67	326.7					1.29 1.30			*****	
																1.26 1.38	OPF=1.12*****			
245.	0.958	30.	1.295	194.7	39107	97696	218.1	6.44	17371.	3.27	289.5	0.983	3702.	18.30	1274.	1.14 1.52	0.514	0.489	0.	4
												CDH = 1.0000				1.05 1.46	OPF=1.12		0.	
124.	1.218	1.108	1.099	159.8	58589			6.58		7.67	326.7					1.29 1.30			*****	
																1.26 1.33	OPF=1.12*****			
245.	0.958	35.	1.295	194.7	39107	97808	218.1	6.44	17371.	3.27	289.5	0.983	3702.	18.30	1274.	1.14 1.52	0.511	0.487	0.	5
												CDH = 1.0000				1.05 1.46	OPF=1.12		0.	
124.	1.217	1.109	1.098	159.5	58701			6.63		7.67	326.7					1.29 1.30			*****	
																1.27 1.30	OPF=1.12*****			
245.	0.958	40.	1.295	194.7	39107	97729	216.7	6.46	17471.	3.19	289.0	0.977	3679.	18.29	1264.	1.16 1.54	0.513	0.488	0.	6
												CDH = 1.0191				1.06 1.48	OPF=1.12		0.	
124.	1.218	1.108	1.099	159.8	58622			6.62		7.63	325.9					1.31 1.31			*****	
																1.28 1.30	OPF=1.12*****			
245.	0.958	45.	1.295	194.7	39107	97800	215.1	6.46	17508.	3.19	288.4	0.970	3651.	18.32	1251.	1.17 1.55	0.511	0.487	5.	7
												CDH = 1.0381				1.07 1.50	OPF=1.12		0.	
124.	1.217	1.109	1.098	159.6	58693			6.65		7.63	325.1					1.33 1.32			*****	
																1.29 1.30	OPF=1.12*****			
245.	0.958	50.	1.295	194.7	39107	97849	213.9	6.46	17534.	3.18	288.0	0.964	3631.	18.33	1243.	1.18 1.57	0.509	0.486	5.	8
												CDH = 1.0517				1.08 1.51	OPF=1.12		0.	
124.	1.217	1.109	1.097	159.4	58742			6.67		7.64	324.5					1.34 1.33			*****	
																1.30 1.30	OPF=1.12*****			



HOMOGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 1

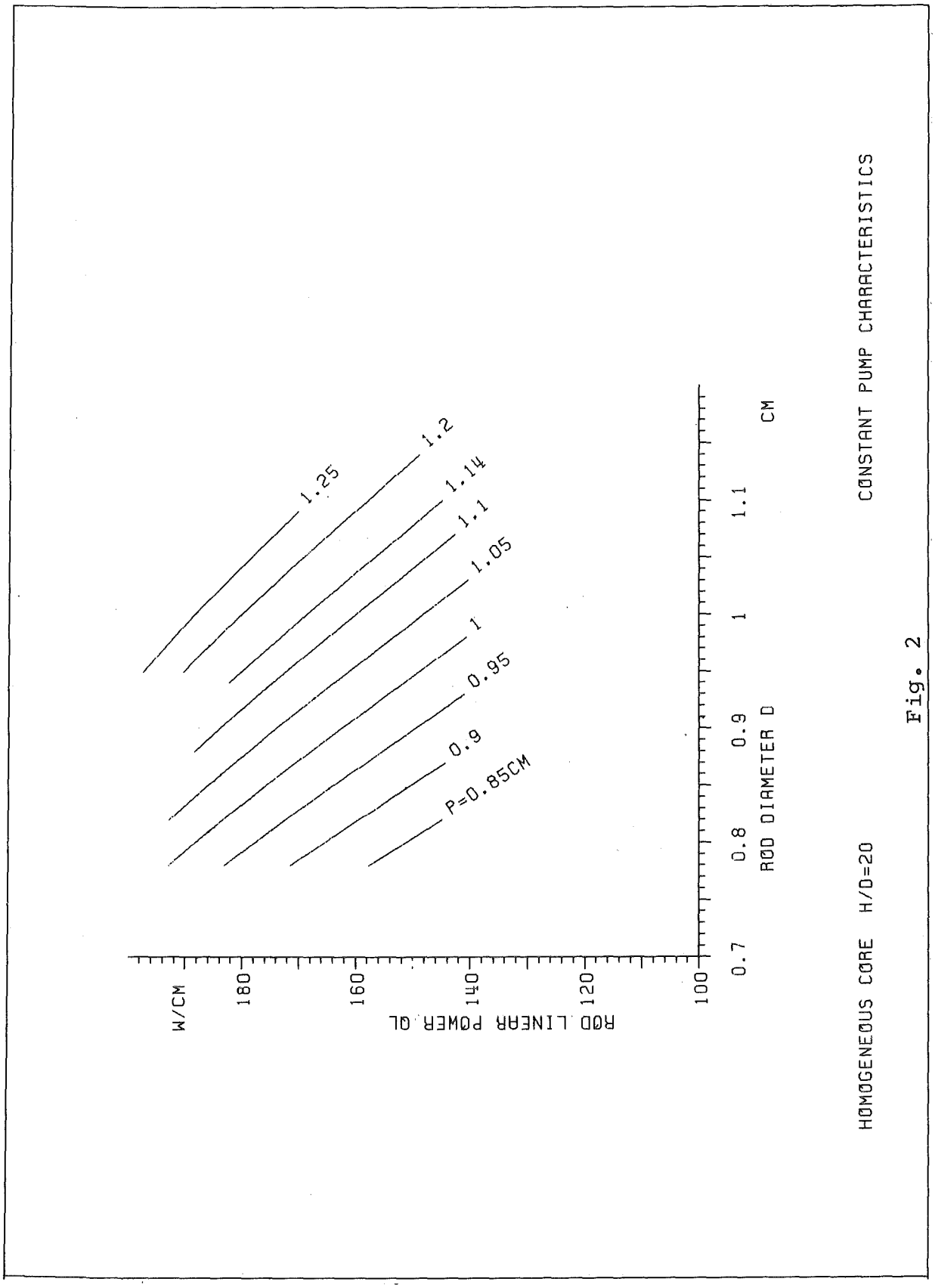

HØMØGENEØUS CØRE H/D=20
CØNSTANT PUMP CHARACTERISTICS
ROD LINEAR POWER QL
W/CM
180
160
140
120
100
0.7
0.8
0.9
1
1.1
CM
RØD DIAMETER D
P=0.85CM
0.9
0.95
1
1.05
1.1
1.14
1.2
1.25

Fig. 2

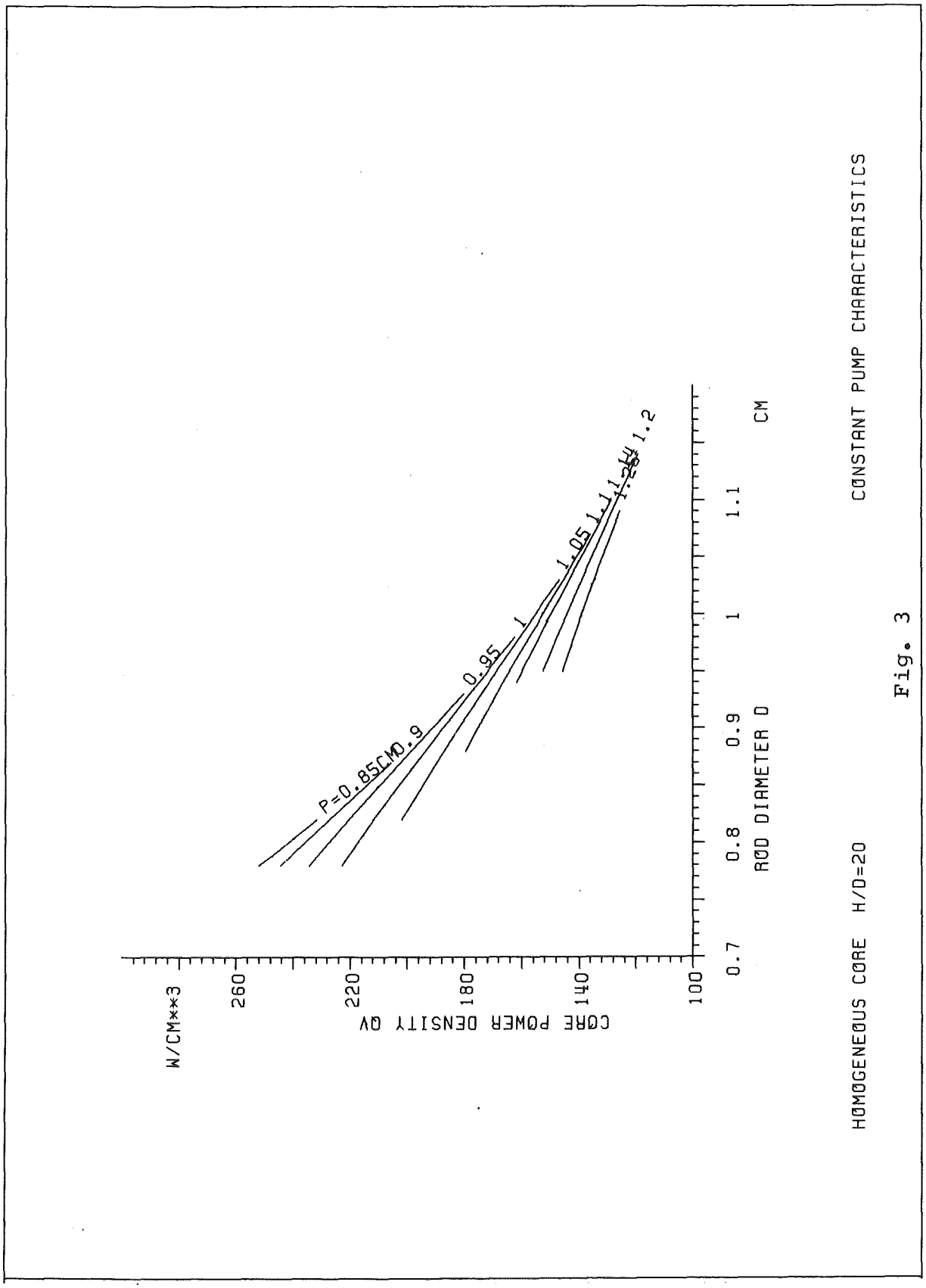
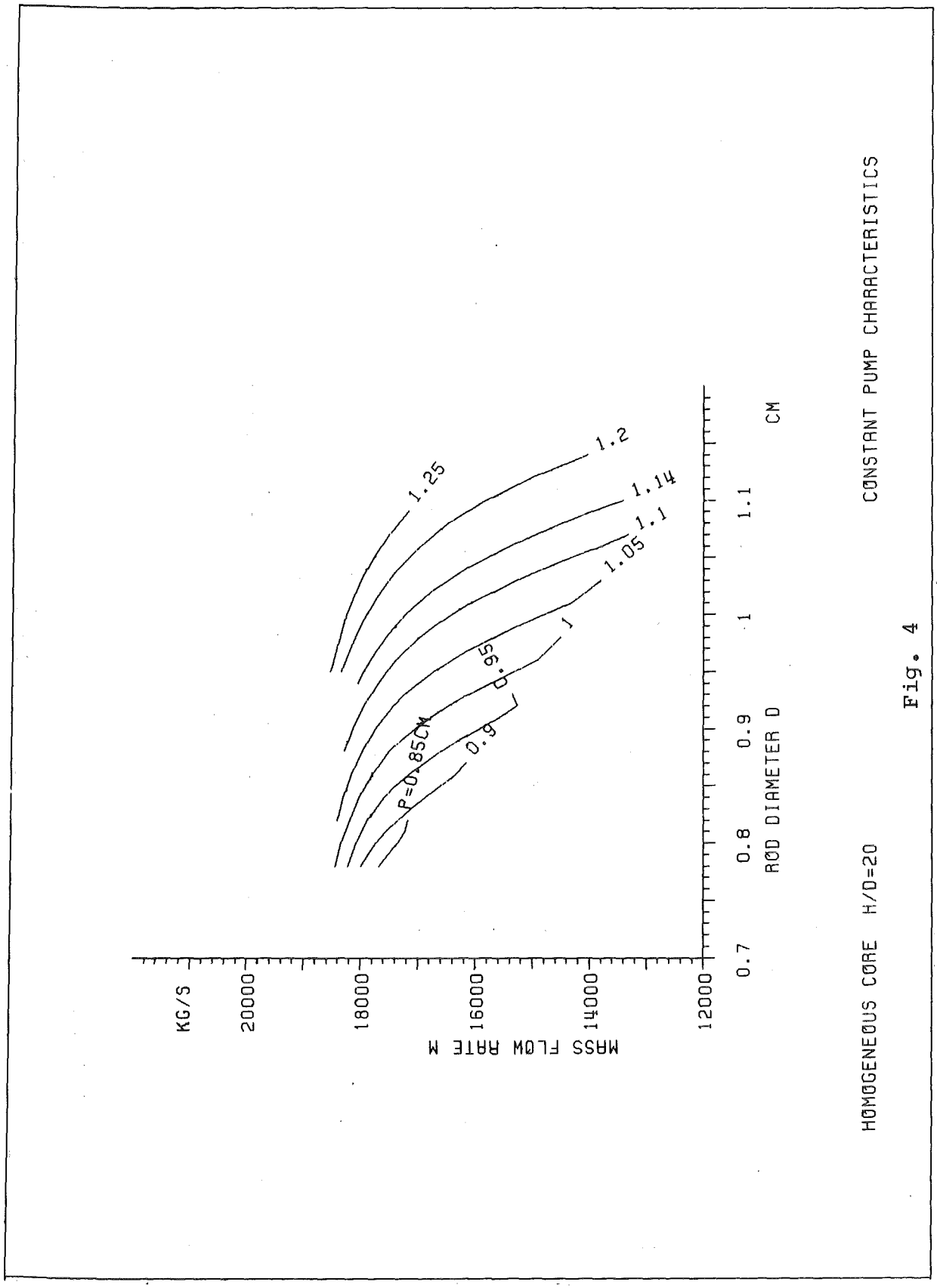

HOMOGENEOUS CORE H/D=20
CONSTANT PUMP CHARACTERISTICS
CORE POWER DENSITY QV
W/CM**3
260
220
180
140
100
0.7
0.8
0.9
1
1.1
CM
ROD DIAMETER D
P=0.85CM0.9
0.95
1
1.05
1.1
1.2

Fig. 3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CØNSTANT PUMP CHARACTERISTICS
MASS FLØW RATE M
KG/S
20000
18000
16000
14000
12000
0.7
0.8
0.9
1
1.1
RØD DIAMETER D
CM
P=0.85CM
0.9
0.95
1
1.05
1.1
1.14
1.2
1.25

Fig. 4

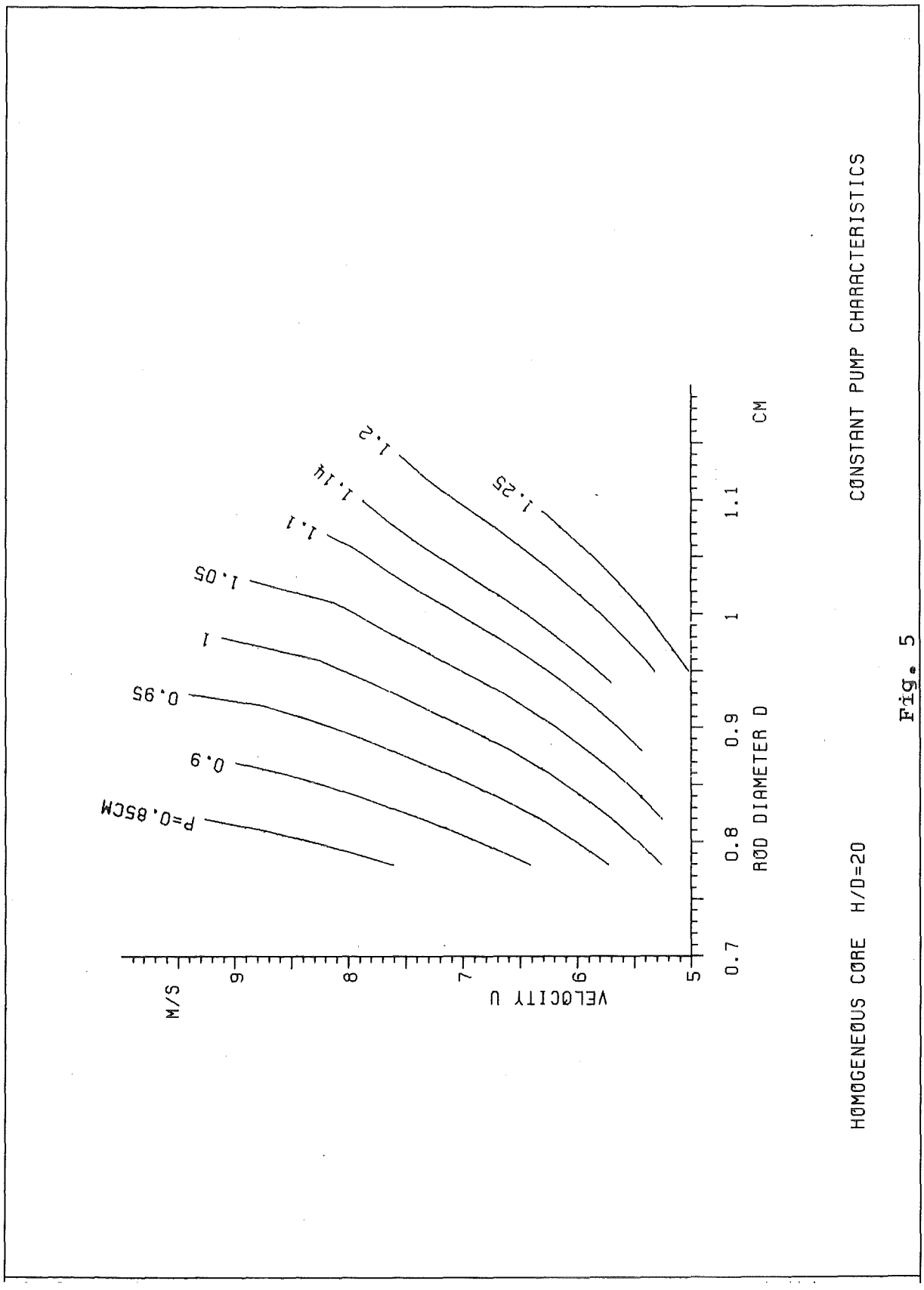
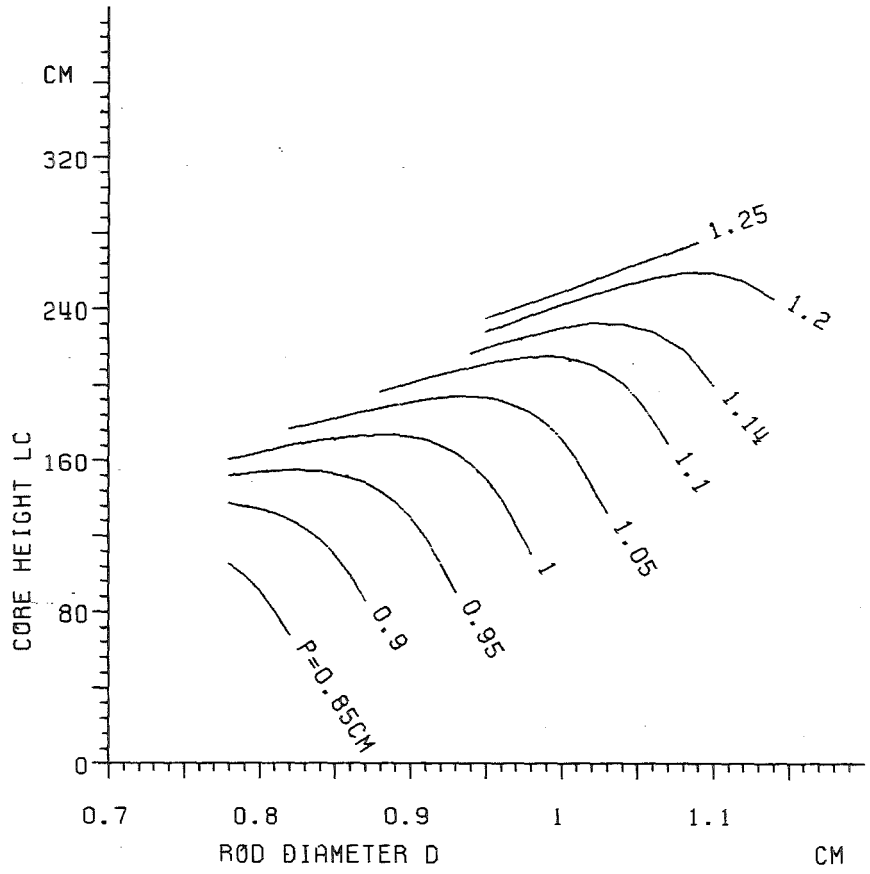

HØMØGENEØUS CØRE H/D=20
CØNSTANT PUMP CHARACTERISTICS
VELØCITY U
M/S
9
8
7
6
5
0.7
0.8
0.9
1
1.1
RØD DIAMETER D
CM
P=0.85CM
0.9
0.95
1
1.05
1.1
1.14
1.2
1.25

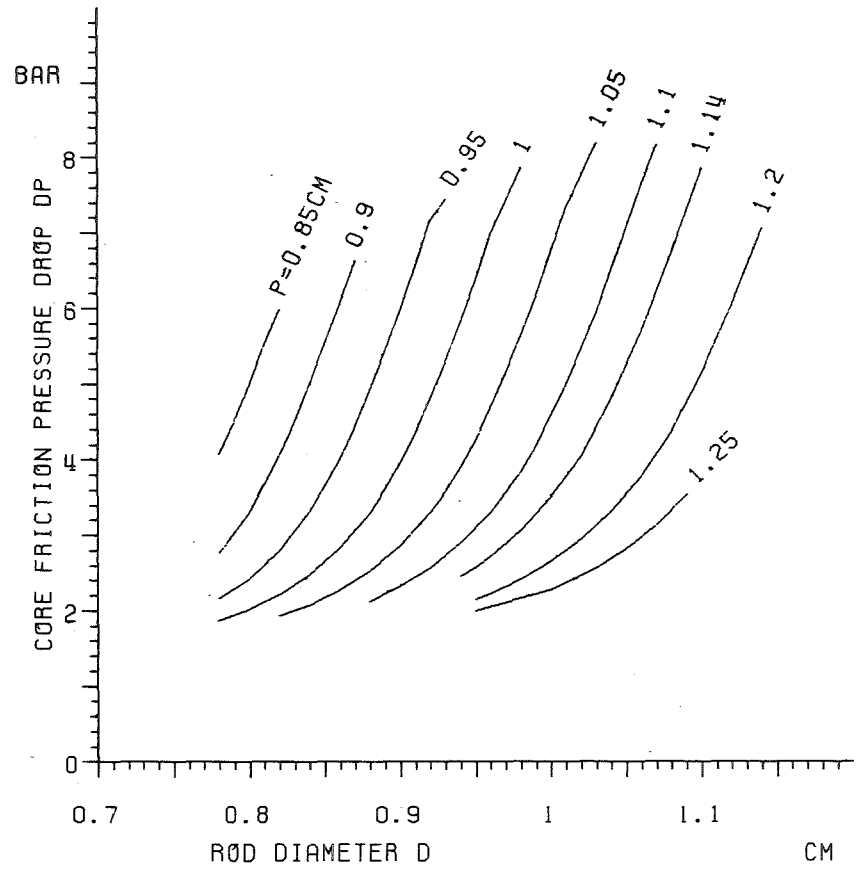
Fig. 5



HOMOGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 6



HOMOGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 7

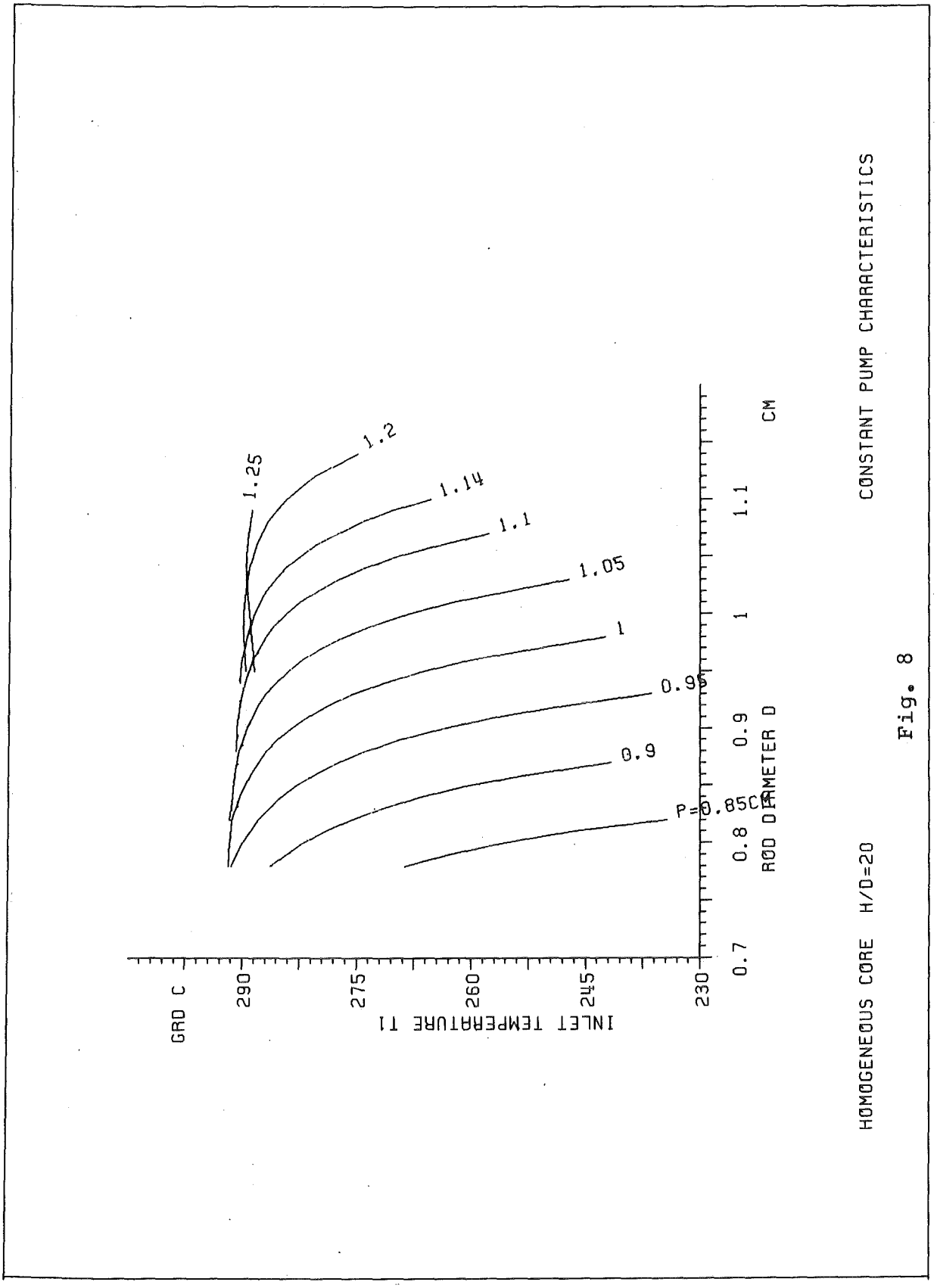

HOMOGENEOUS CORE H/D=20
CONSTANT PUMP CHARACTERISTICS
GRD C
INLET TEMPERATURE T1
290
275
260
245
230
0.7
0.8
0.9
1
1.1
ROD DIAMETER D
CM
1.25
1.2
1.14
1.1
1.05
1
0.95
0.9
P=0.85

Fig. 8

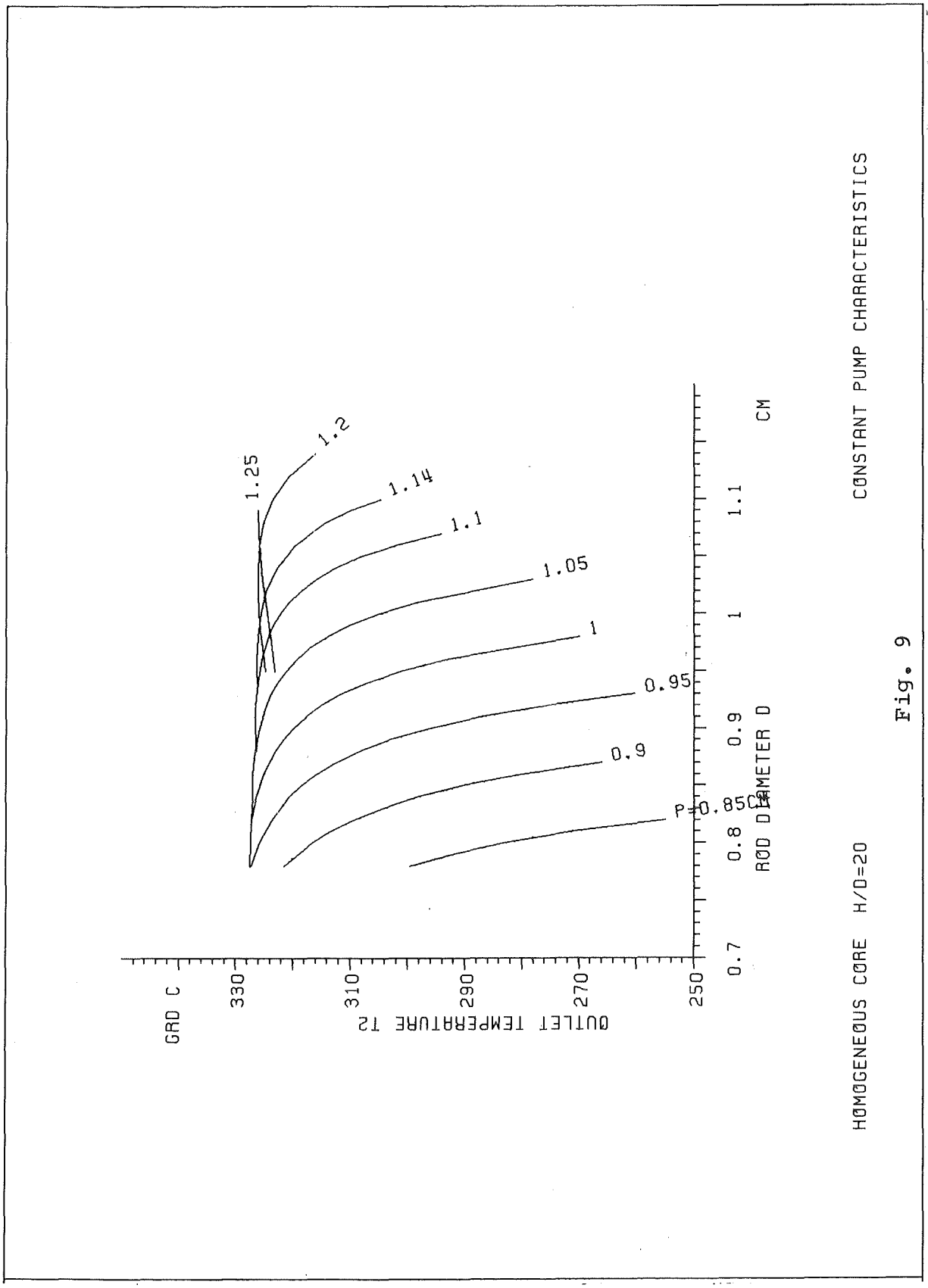
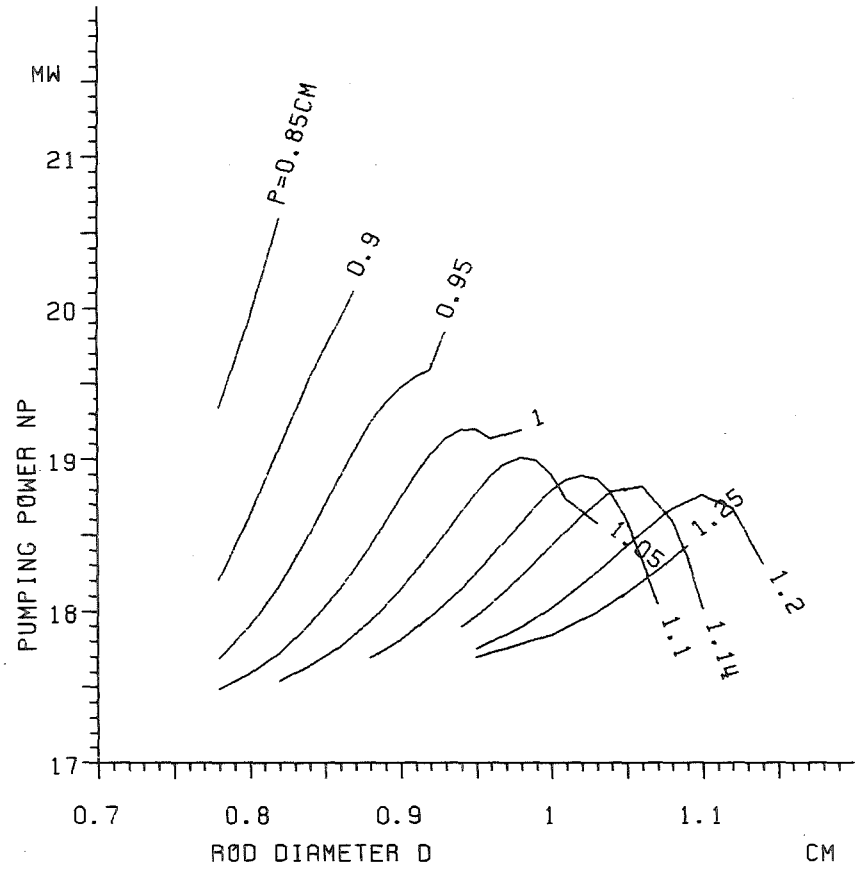

HOMOGENEOUS CORE H/D=20
CONSTANT PUMP CHARACTERISTICS
OUTLET TEMPERATURE T2
GRD C
330
310
290
270
250
0.7
0.8
0.9
1
1.1
CM
ROD DIAMETER D
1.25
1.2
1.14
1.1
1.05
1
0.95
0.9
P=0.85

Fig. 9



HOMOGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 10

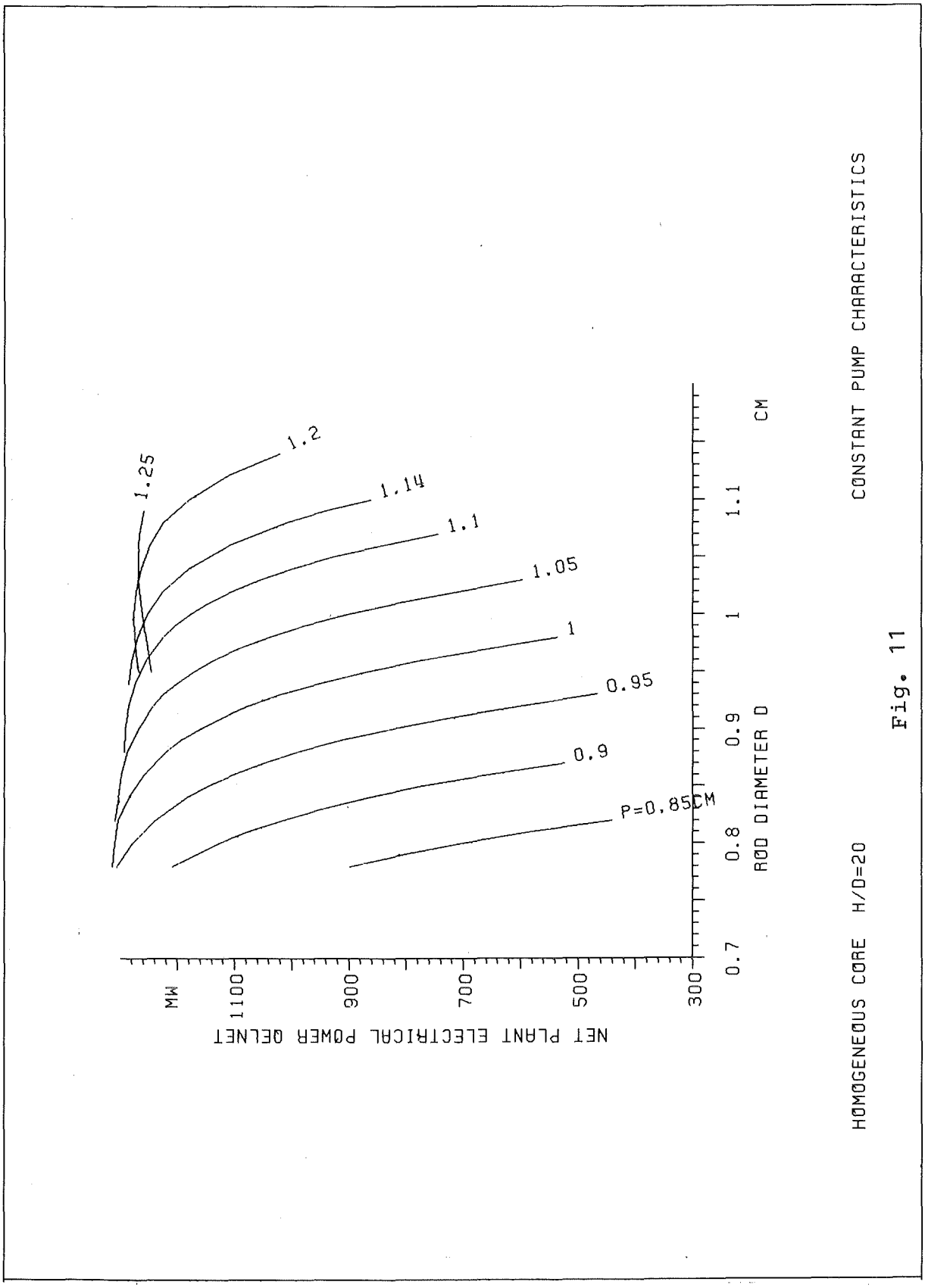
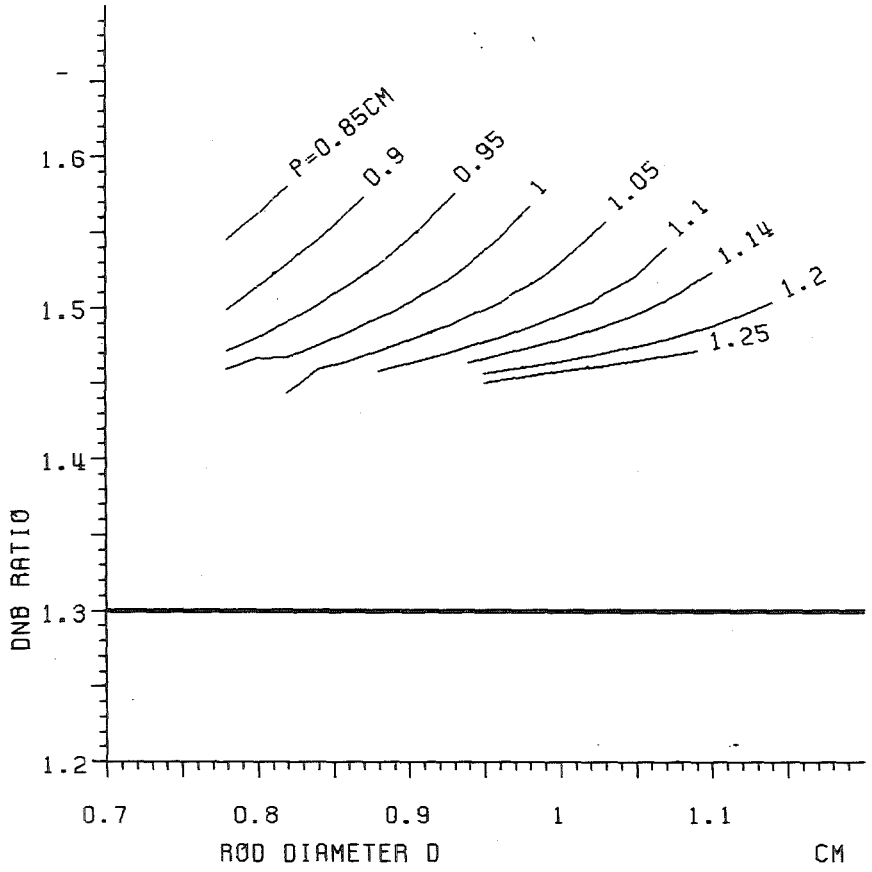

NET PLANT ELECTRICAL POWER DELNET
MW
1100
900
700
500
300
0.7
0.8
0.9
1
1.1
CM
ROD DIAMETER D
1.25
1.2
1.14
1.1
1.05
1
0.95
0.9
P=0.85CM
HOMOGENEOUS CORE H/D=20
CONSTANT PUMP CHARACTERISTICS

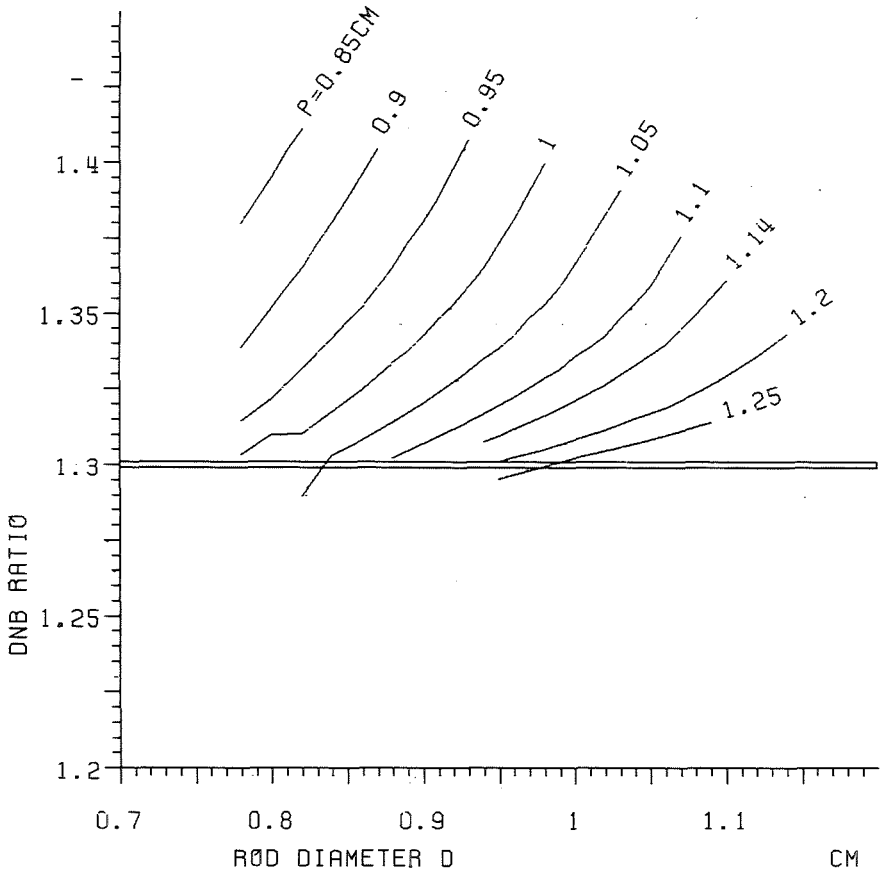
Fig. 11



HOMOGENEOUS CORE H/D=20

OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS

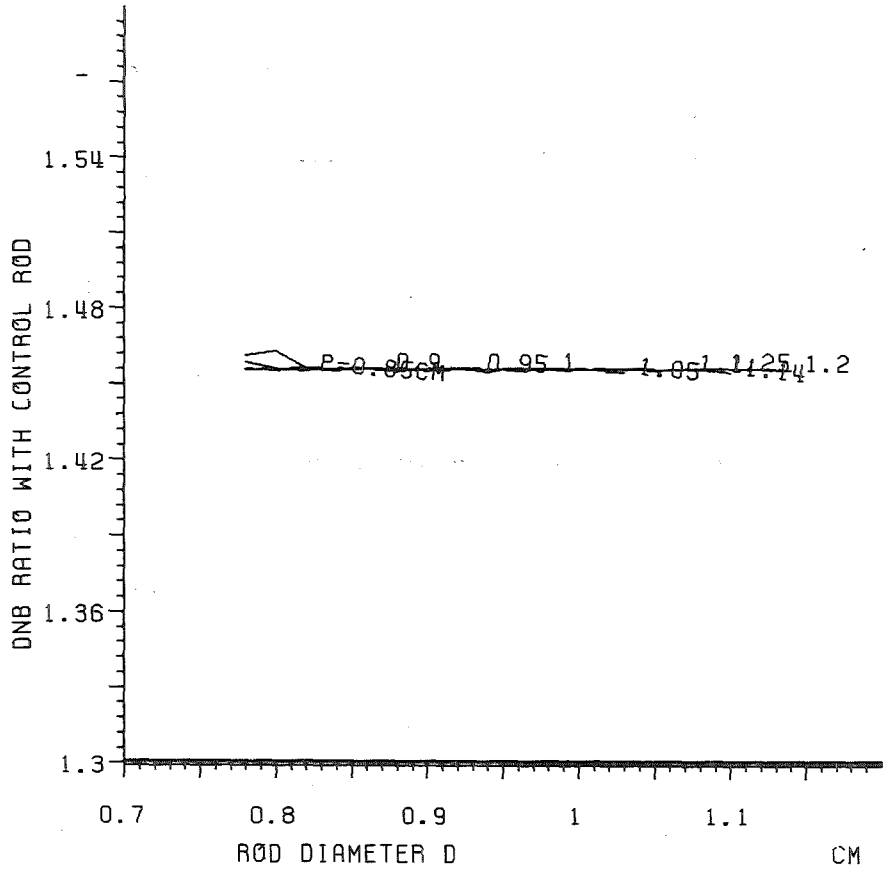
Fig. 12



HOMOGENEOUS CORE H/D=20

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

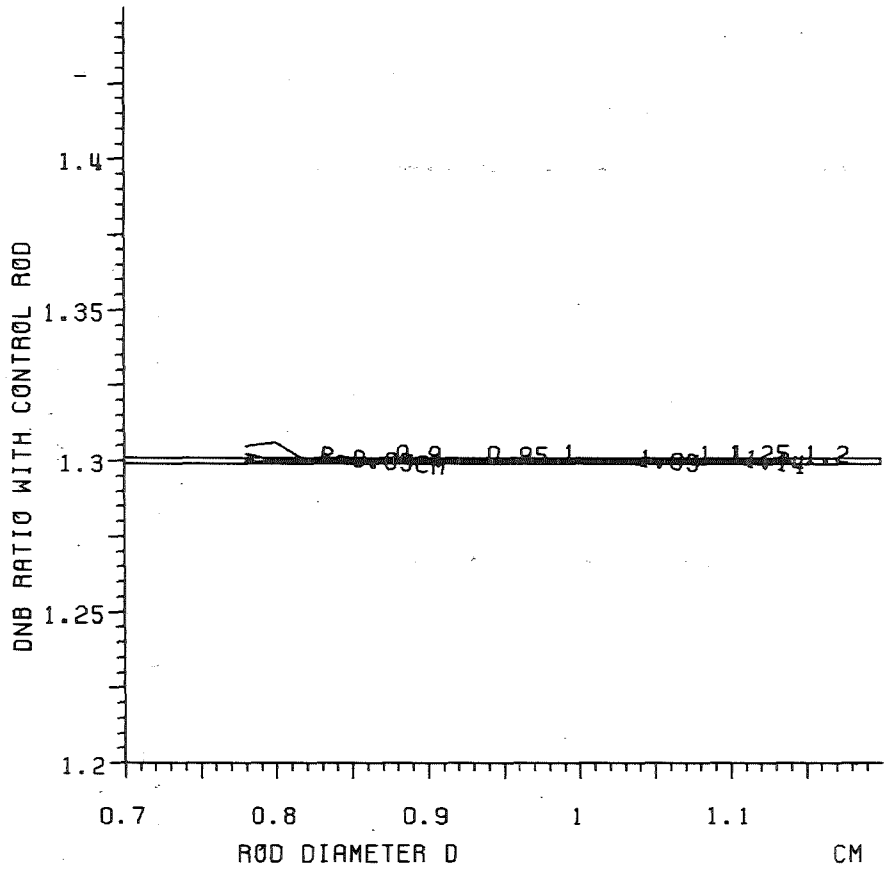
Fig. 13



HOMOGENEOUS CORE H/D=20

OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS

Fig. 14



HOMOGENEOUS CORE H/D=20

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

Fig. 15

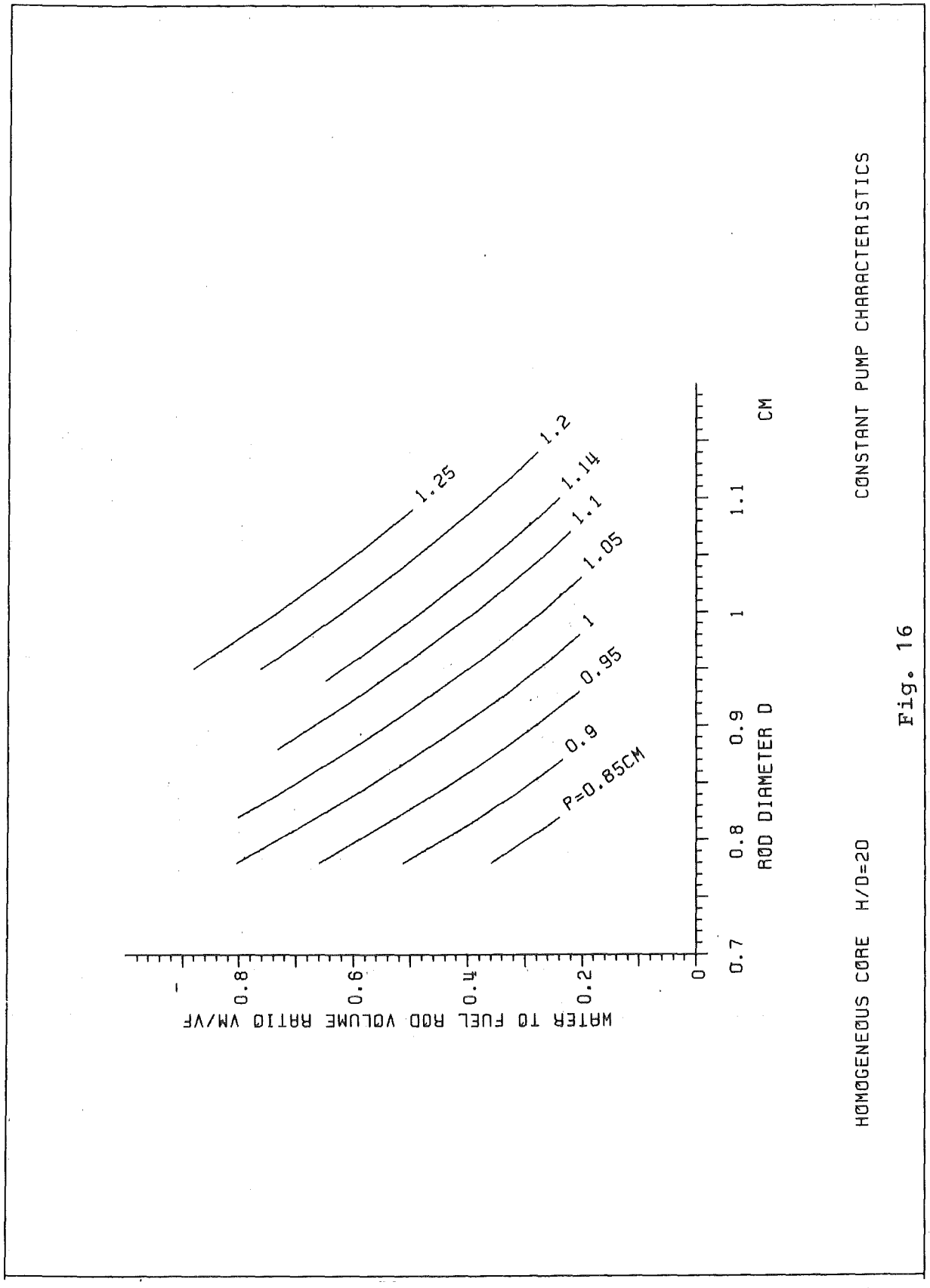
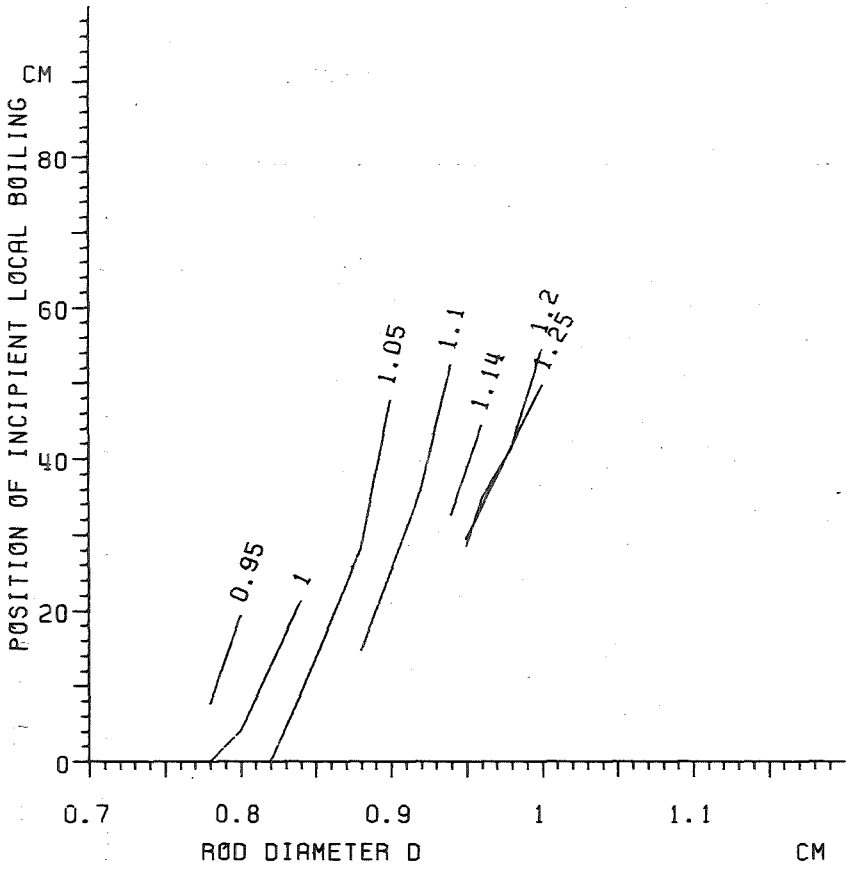

HOMOGENEOUS CORE H/D=20
CONSTANT PUMP CHARACTERISTICS
WATER TO FUEL ROD VOLUME RATIO VM/VF
0.8
0.6
0.4
0.2
0
0.7
0.8
0.9
1
1.1
ROD DIAMETER D
CM
1.25
1.2
1.14
1.1
1.05
1
0.95
0.9
P=0.85CM

Fig. 16



HOMOGENEOUS CORE H/D=20

OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS

Fig. 17

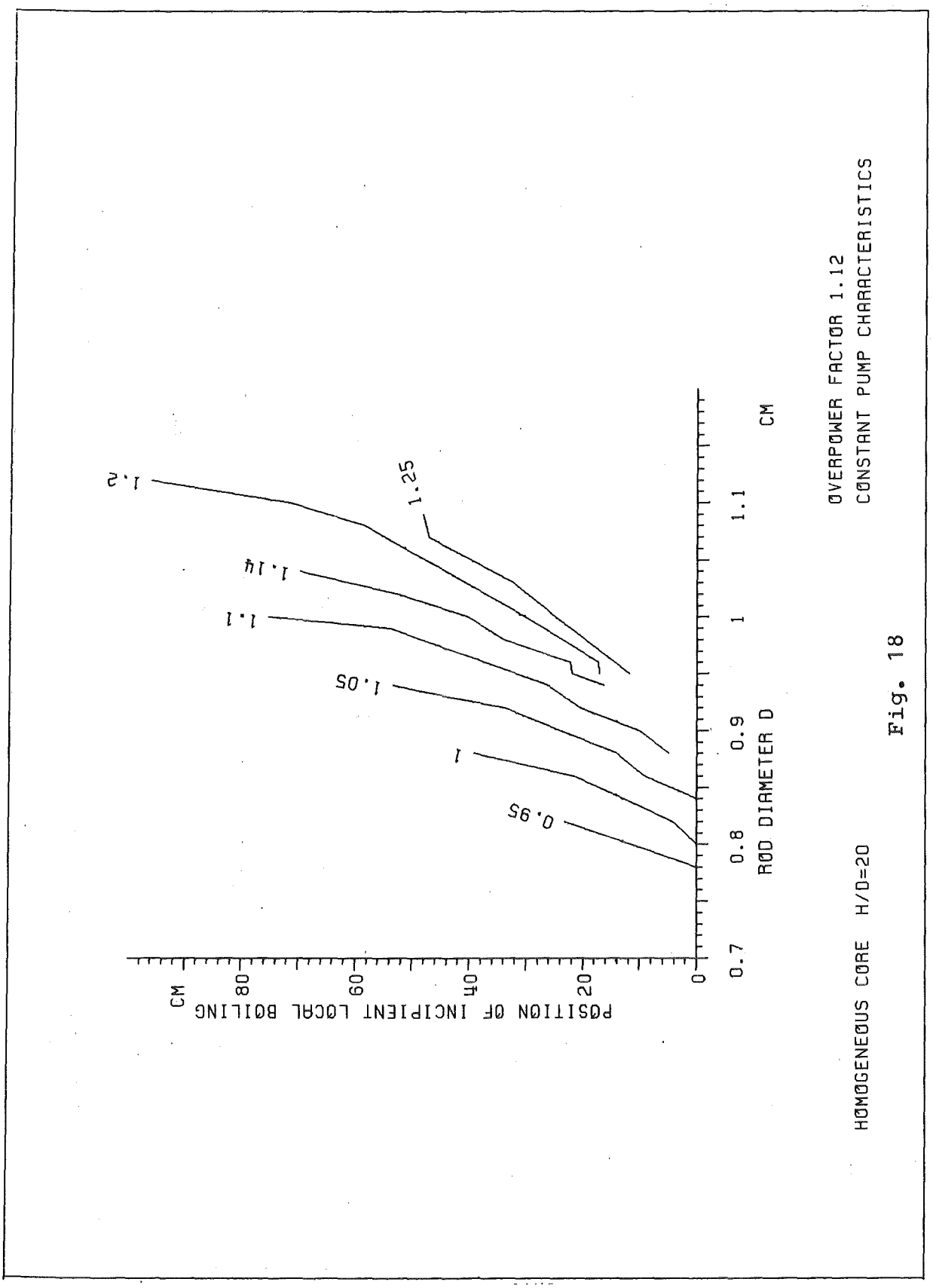
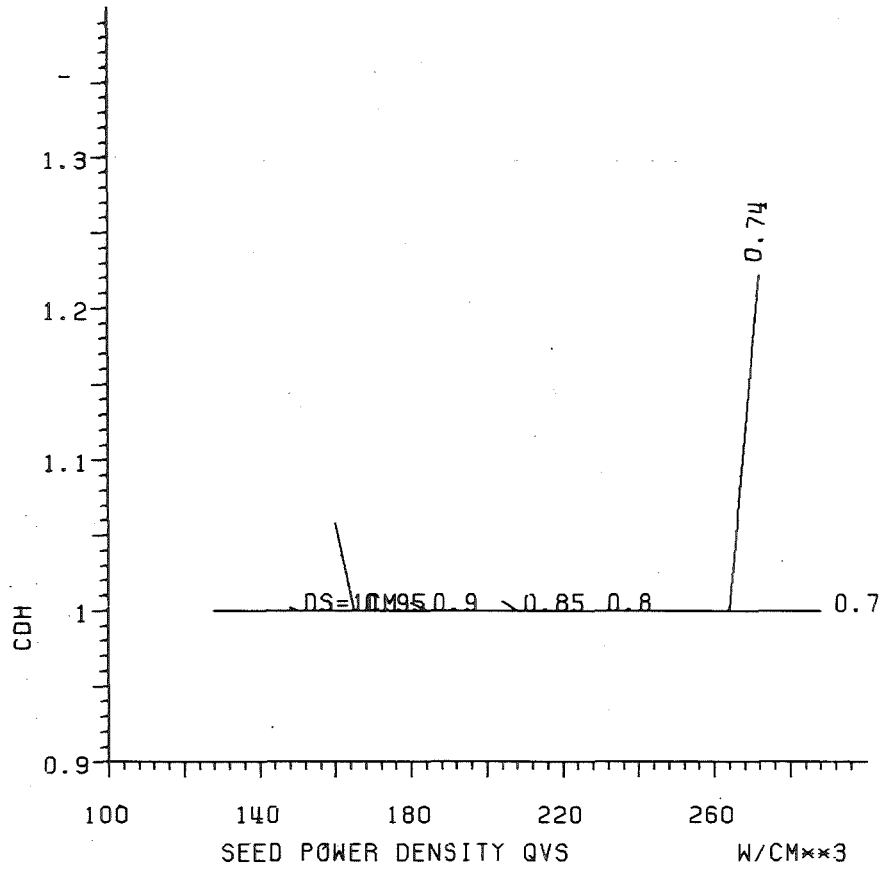

HØMØGENEØUS CØRE H/D=20
CØNSTANT PUMP CHARACTERISTICS
ØVERPØWER FACTØR 1.12
POSITION OF INCIPIENT LOCAL BOILING
CM
0
20
40
60
80
0.7
0.8
0.9
1
1.1
ROD DIAMETER D
CM
0.95
1
1.05
1.1
1.14
1.2
1.25

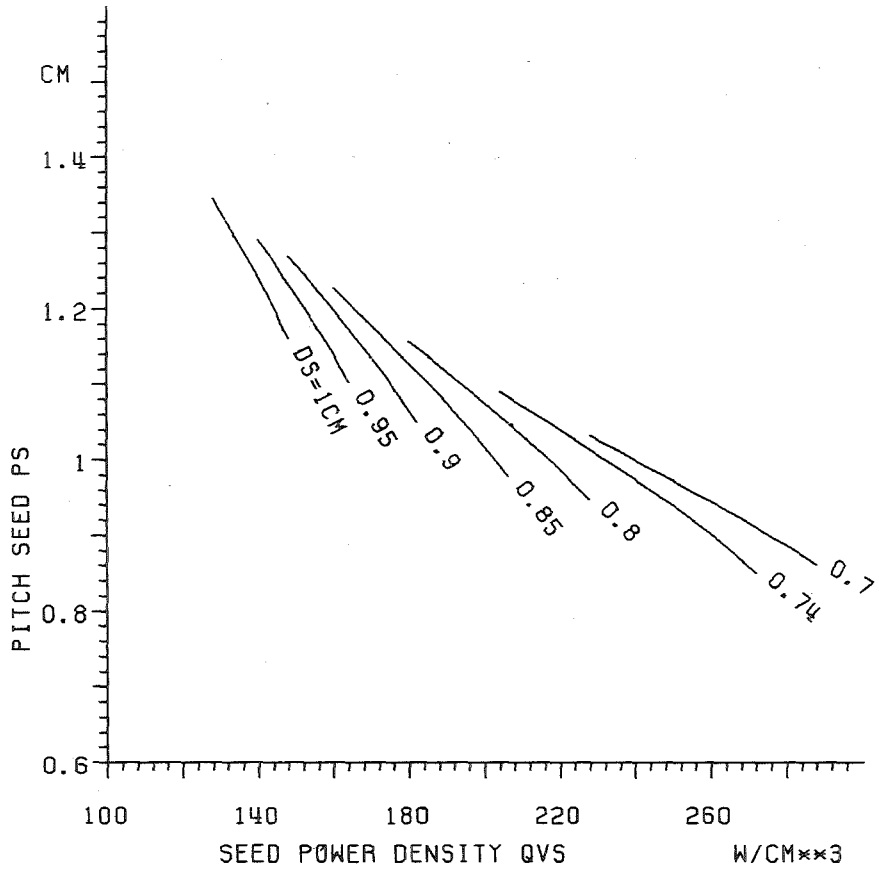
Fig. 18



HETEROGENEOUS CORE H/D=20

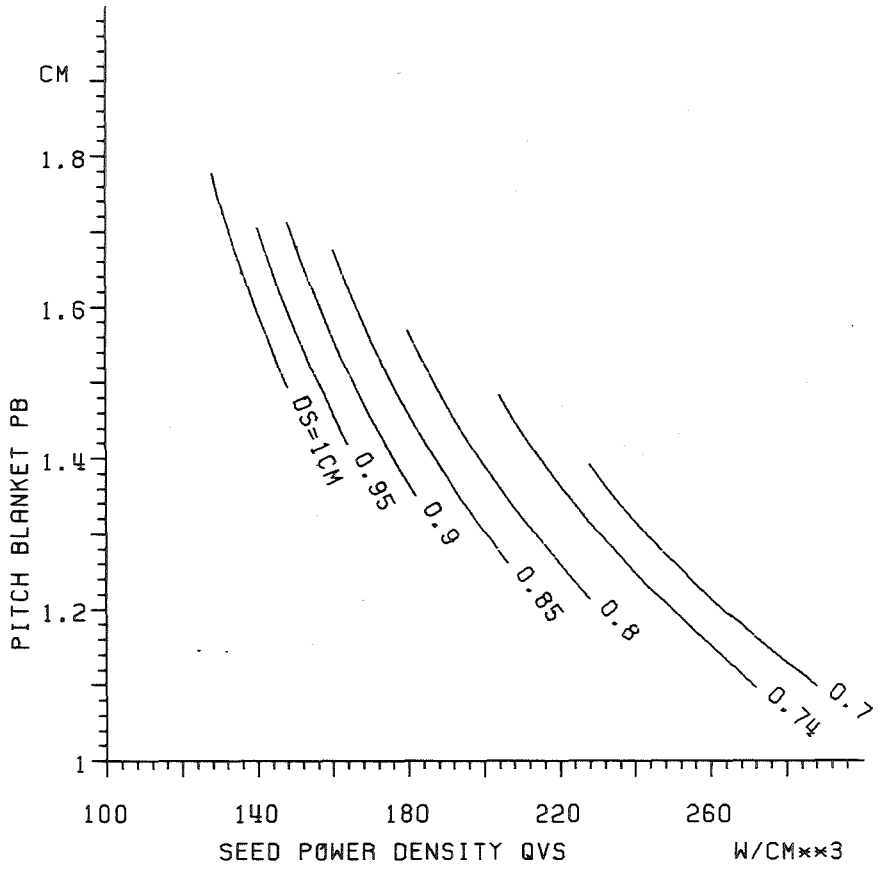
CONSTANT PUMP CHARACTERISTICS

Fig. 19



HETEROGENEOUS CORE H/D=20 CONSTANT PUMP CHARACTERISTICS

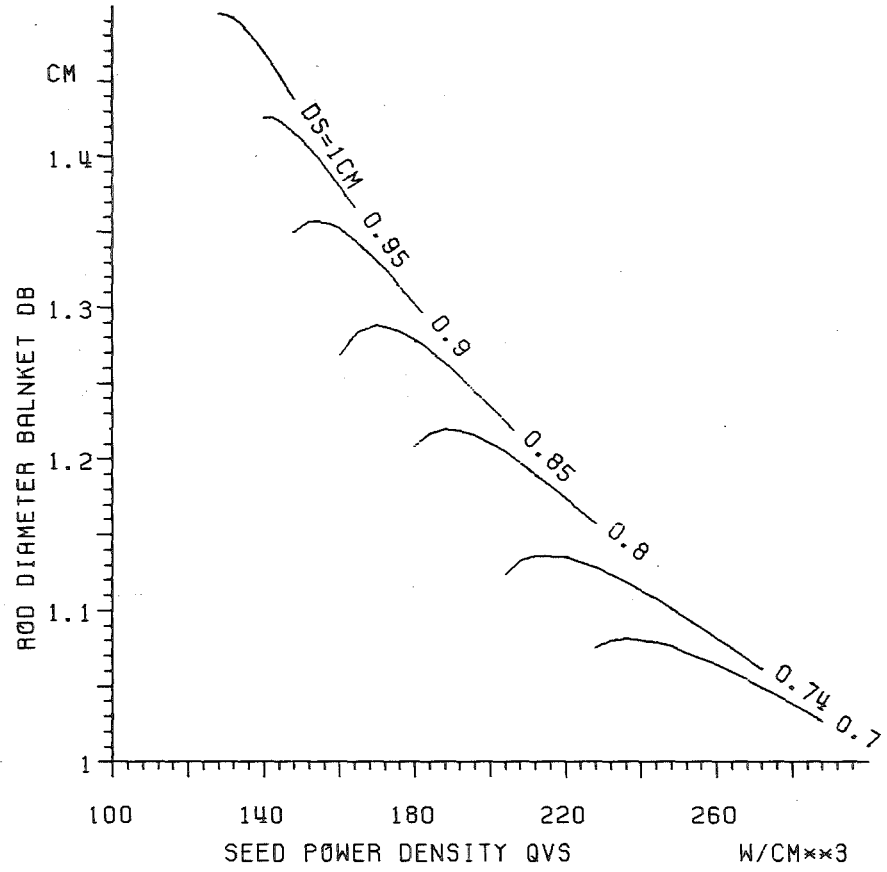
Fig. 20



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

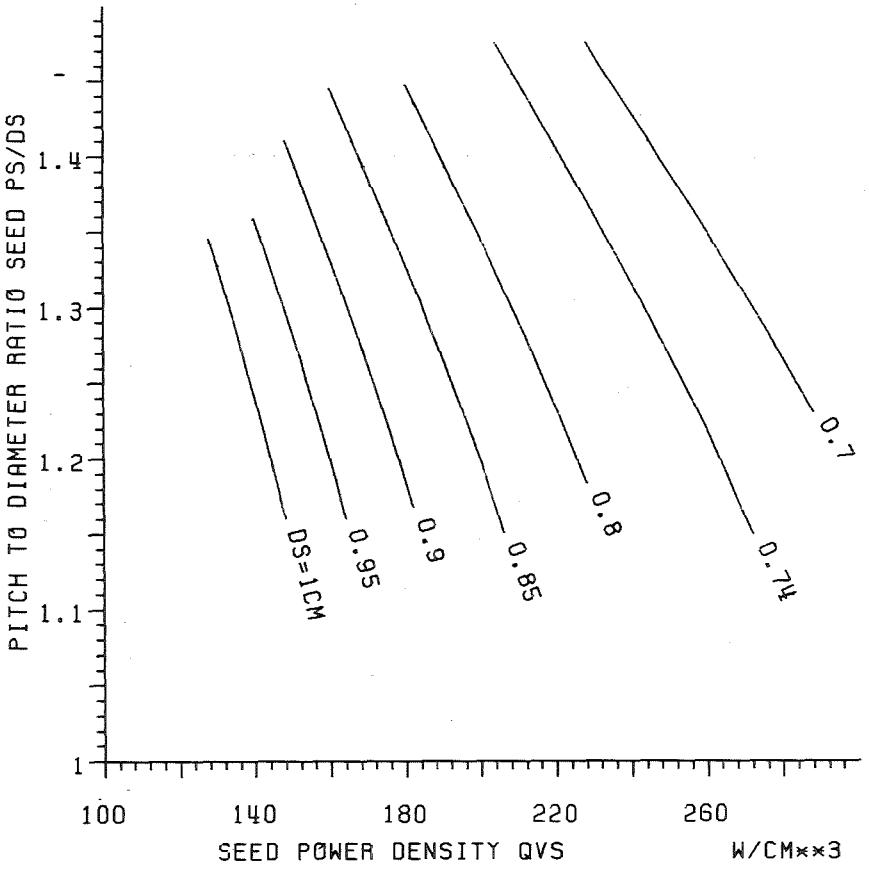
Fig. 21



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

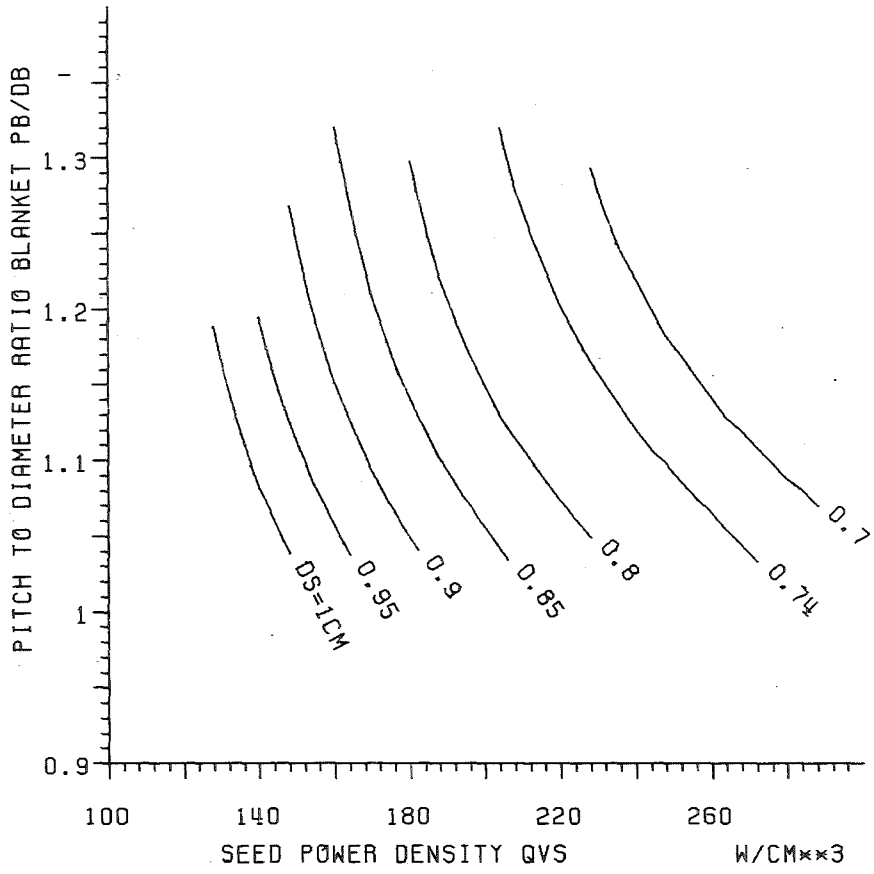
Fig. 22



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

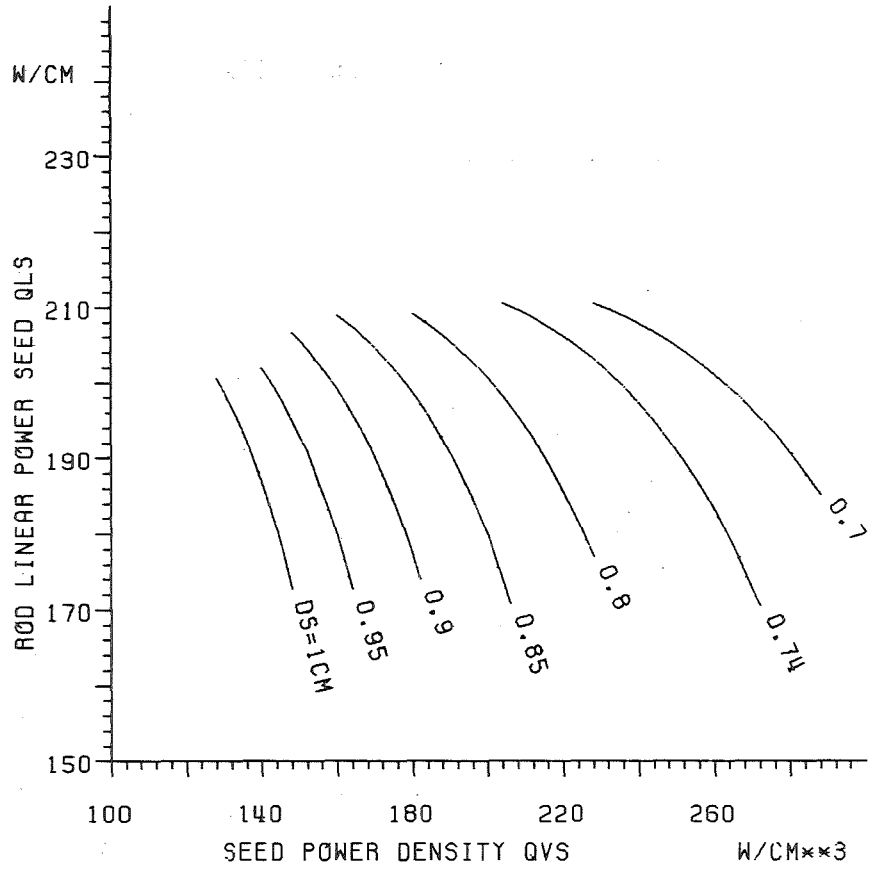
Fig. 23



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 24



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 25

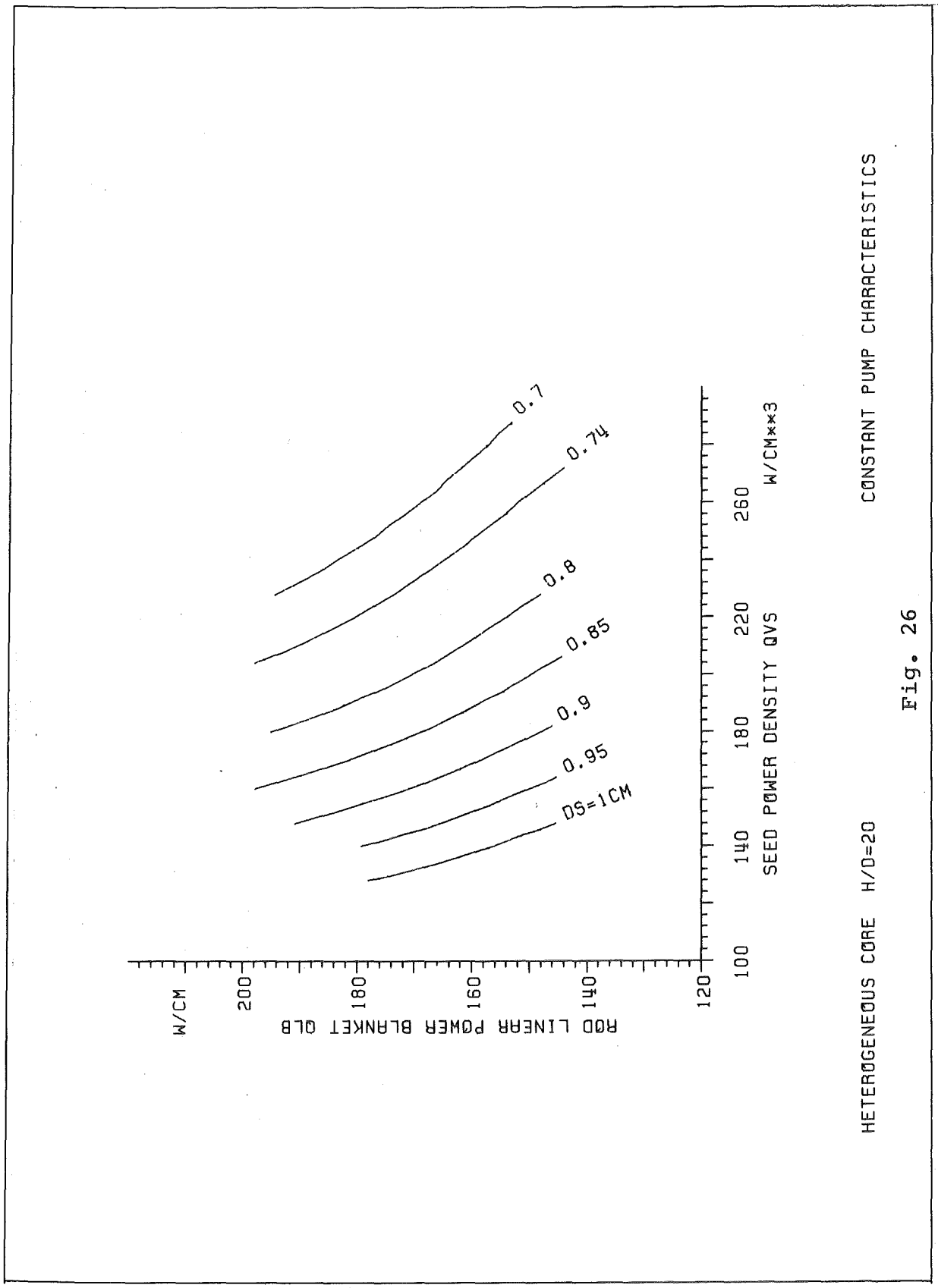
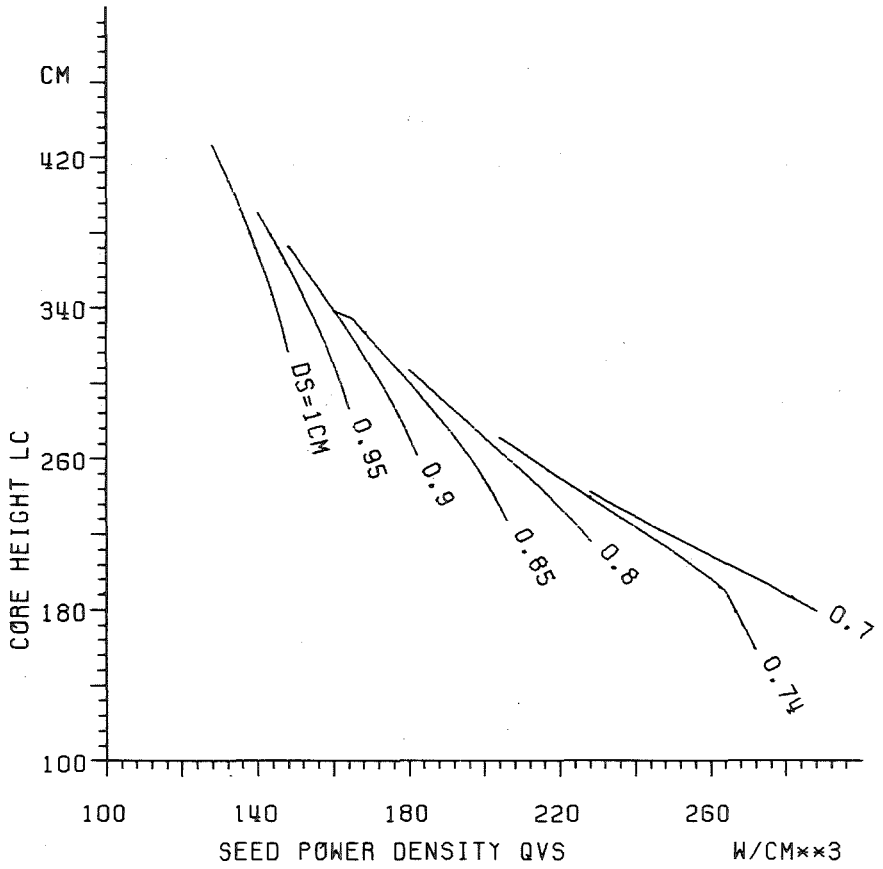

HETERØGENEØUS CØRE H/D=20
CØNSTANT PUMP CHARACTERISTICS
ROD LINEAR PØWER BLANKET ØLB
W/CM
200
180
160
140
120
100
140
180
220
260
SEED PØWER DENSITY ØVS
W/CM**3
0.7
0.74
0.8
0.85
0.9
0.95
DS=1CM

Fig. 26



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 27

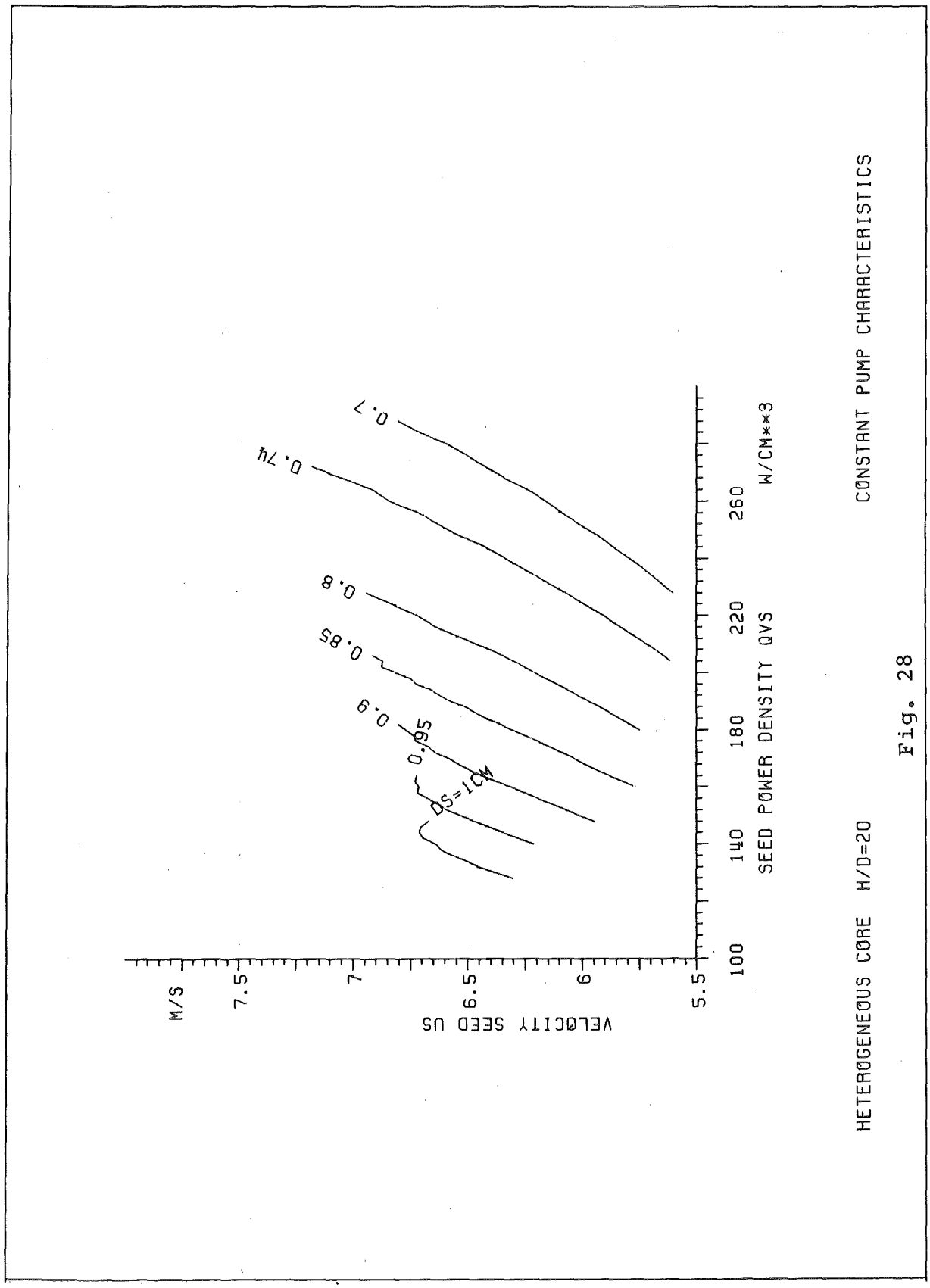

HETERØGENEOUS CØRE H/D=20
CØNSTANT PUMP CHARACTERISTICS
VELOCITY SEED US
M/S
7.5
7
6.5
6
5.5
100
140
180
220
260
SEED PØWER DENSITY QVS
W/CM**3
DS=1CM
0.95
0.9
0.85
0.8
0.74
0.7

Fig. 28

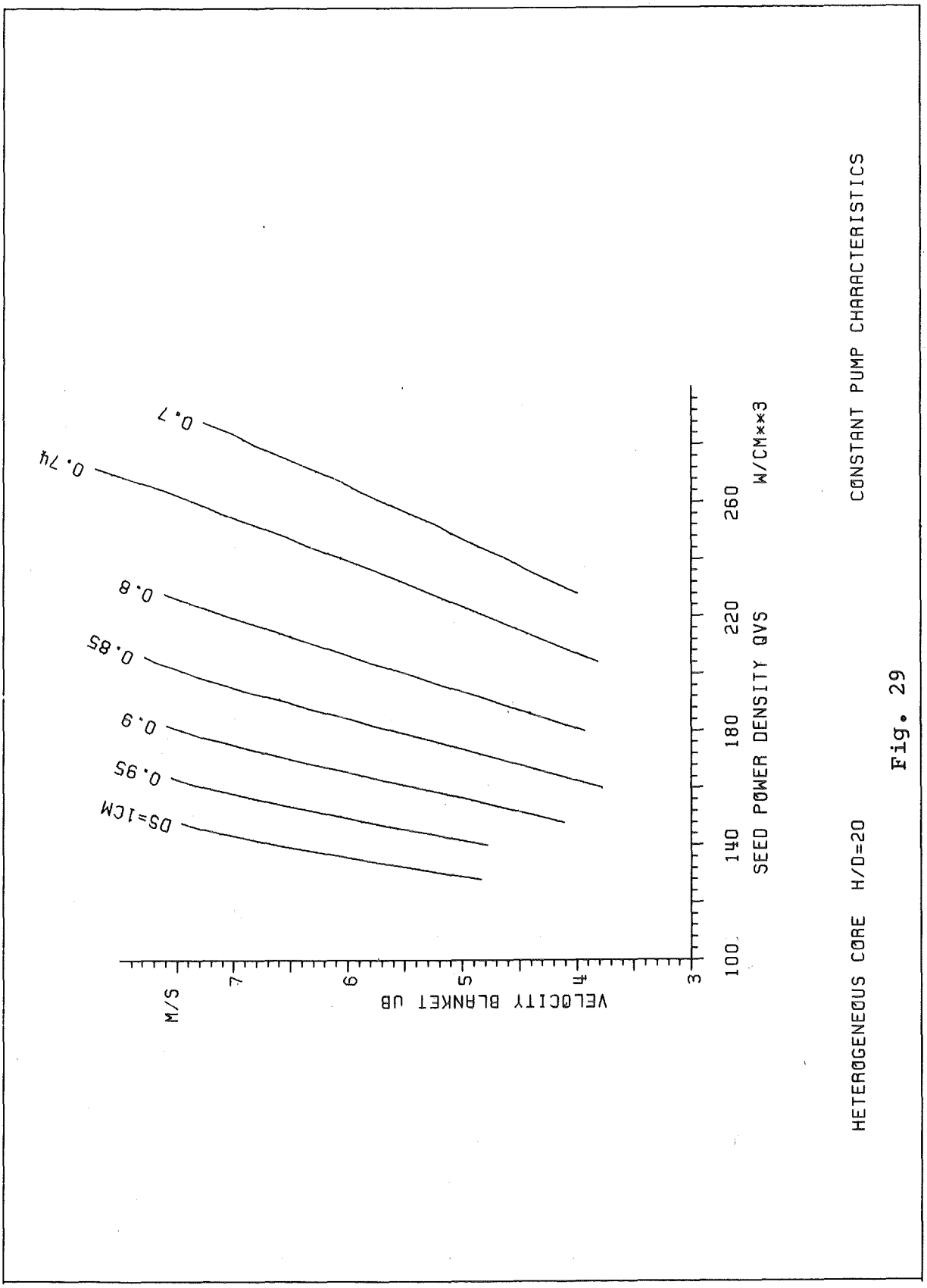

HETERØGENEØUS CØRE H/D=20
CØNSTANT PUMP CHARACTERISTICS
VELØCITY BLANKET UB
M/S
SEED PØWER DENSITY QVS
W/CM**3
100
140
180
220
260
3
4
5
6
7
DS=1CM
0.95
0.9
0.85
0.8
0.74
0.7

Fig. 29

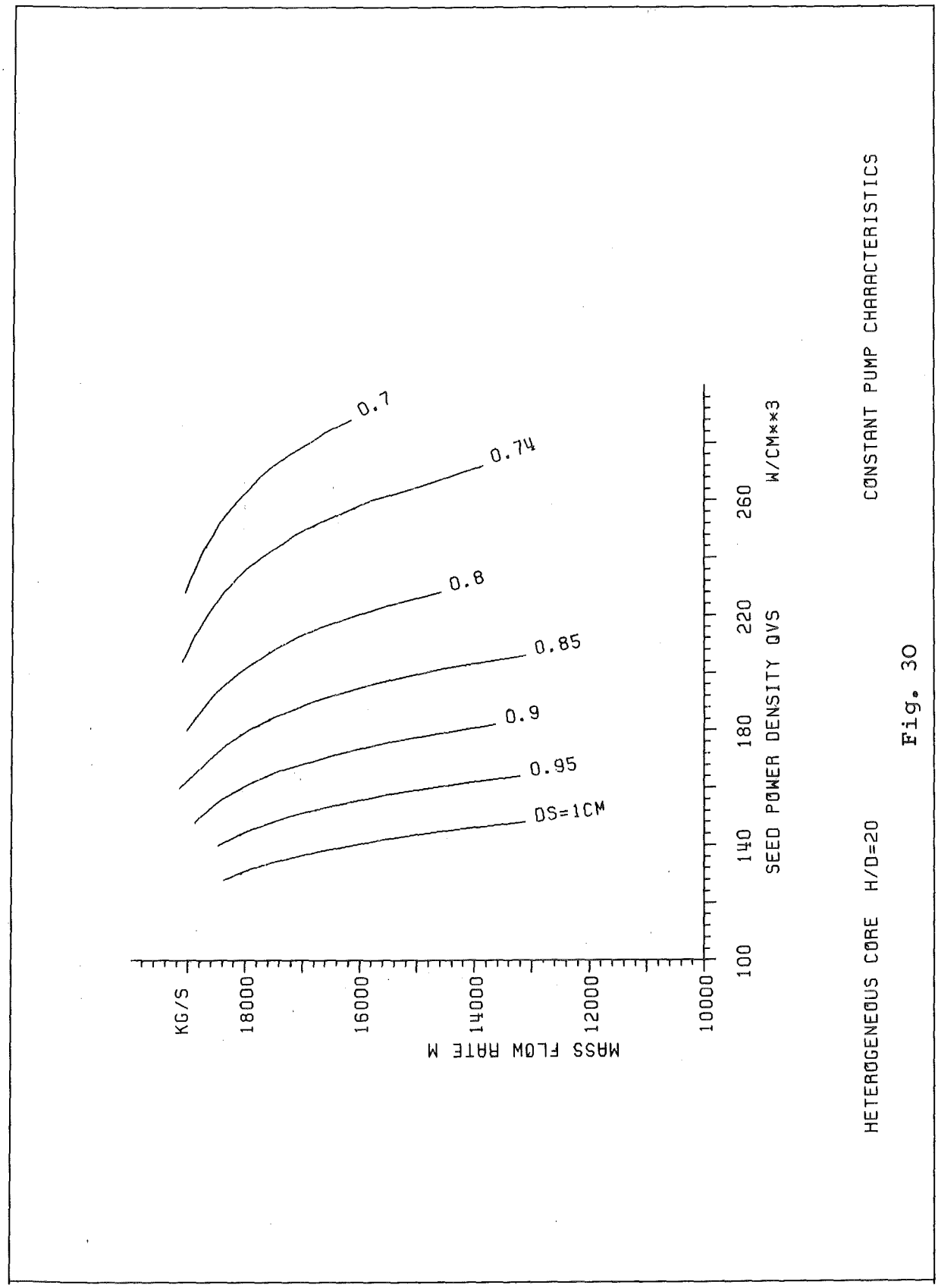
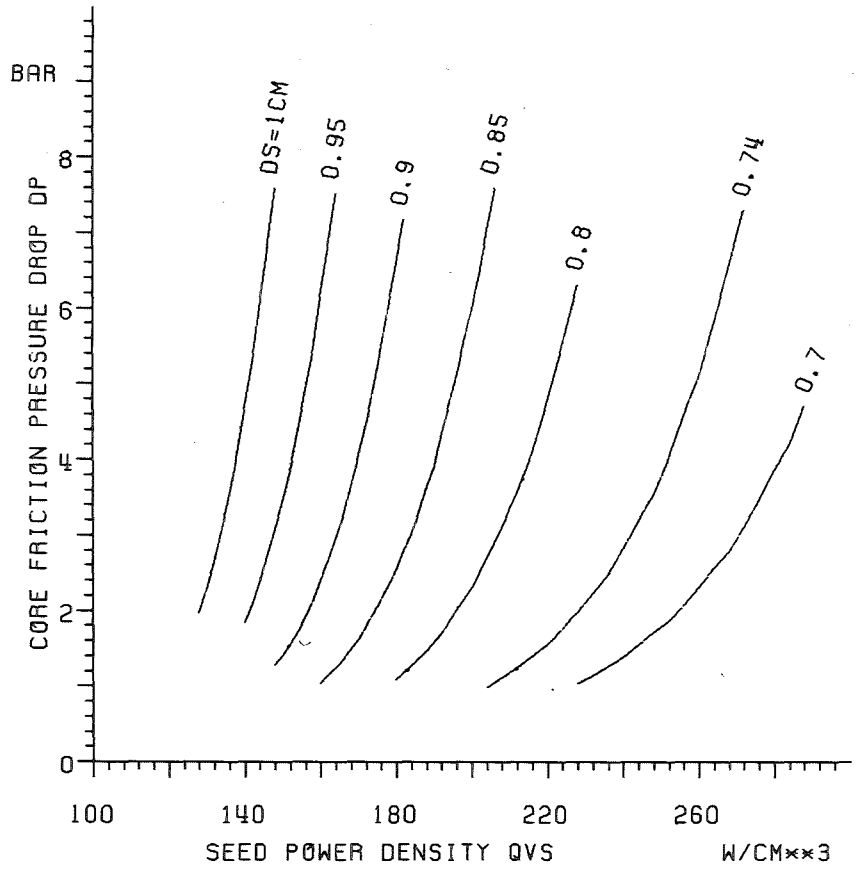

HETEROGENEOUS CORE H/D=20
CONSTANT PUMP CHARACTERISTICS
MASS FLOW RATE M
KG/S
18000
16000
14000
12000
10000
100
140
180
220
260
SEED POWER DENSITY QVS
W/CM**3
0.7
0.74
0.8
0.85
0.9
0.95
DS=1CM

Fig. 30



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 31

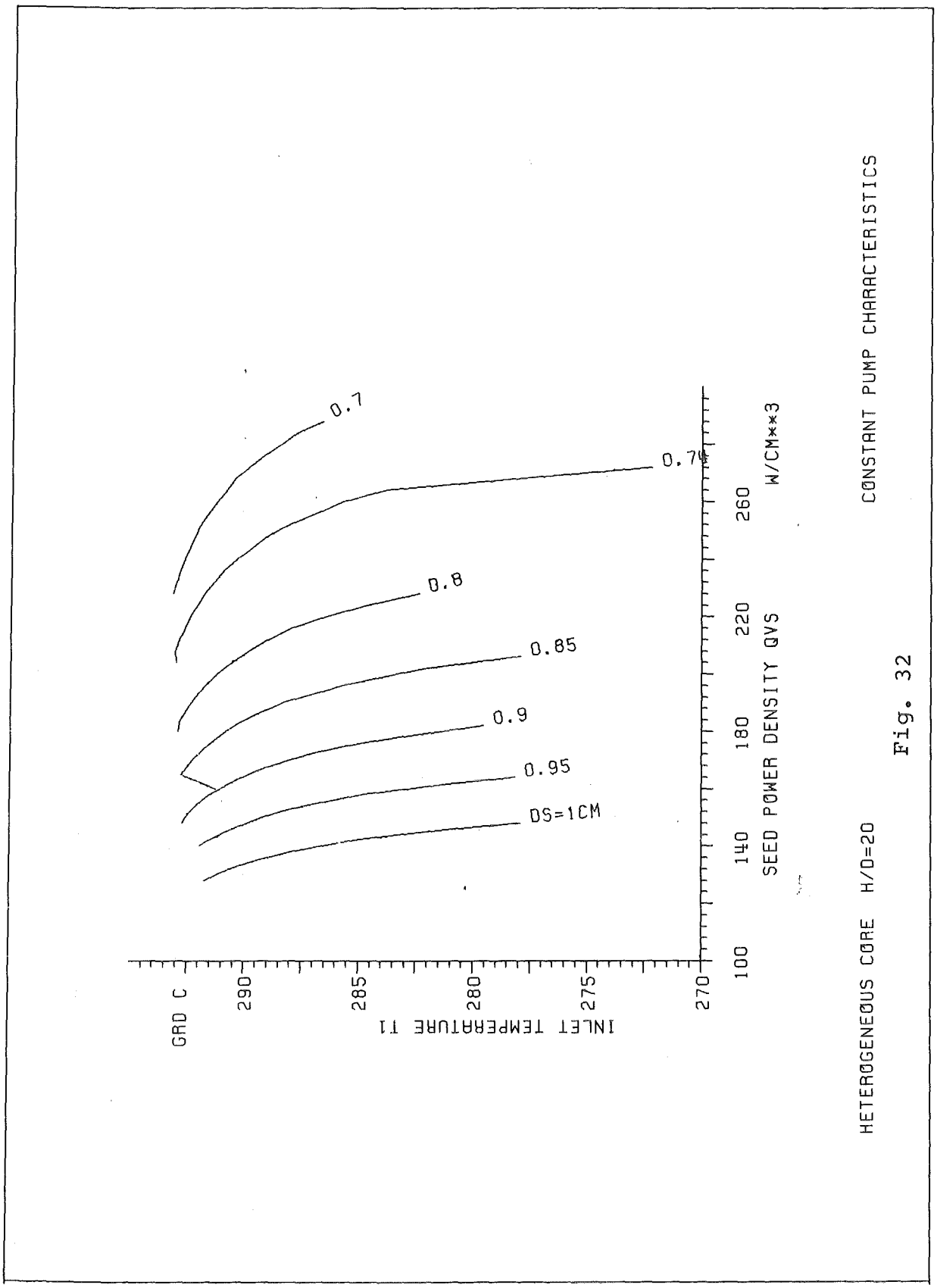
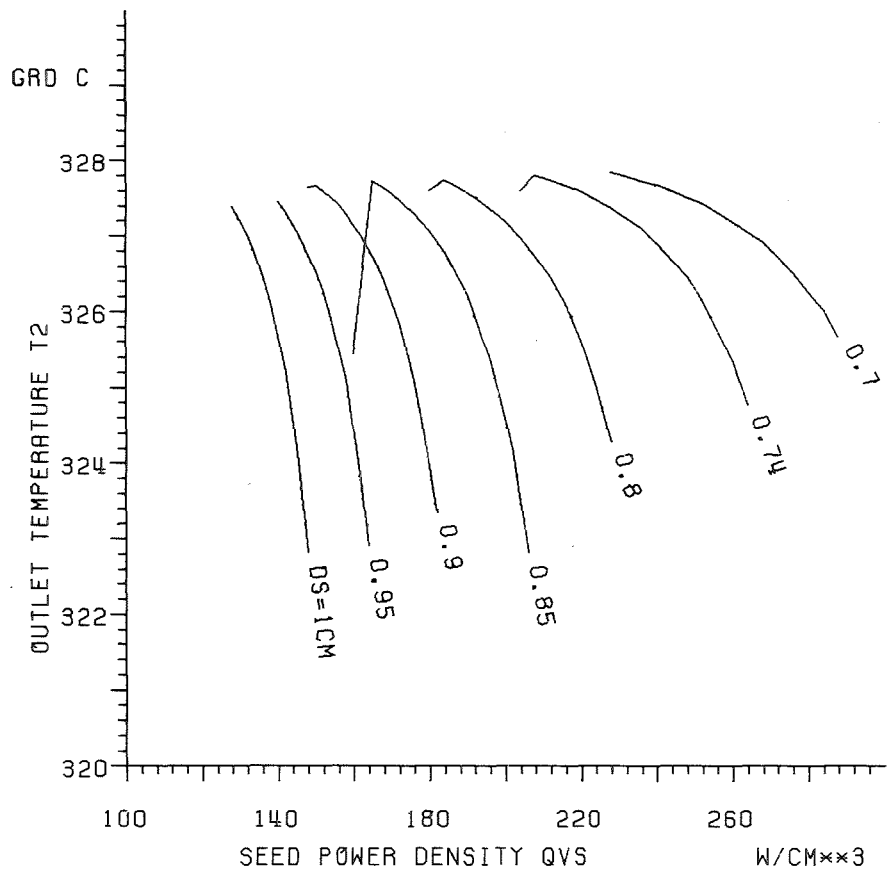
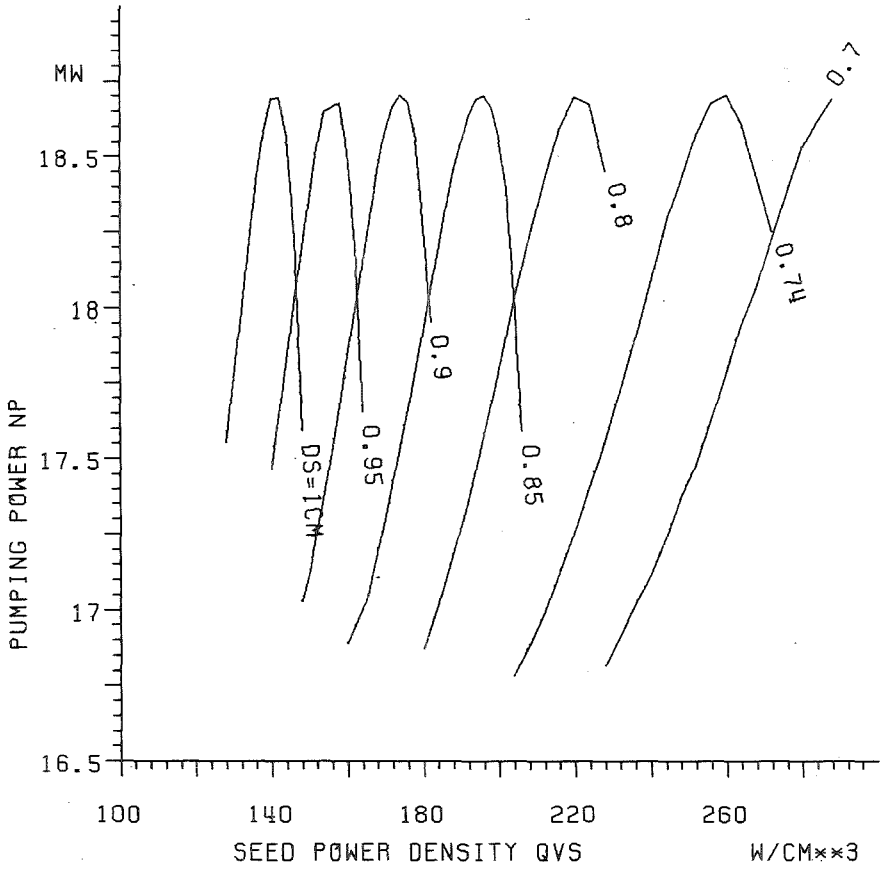

HETERØGENEØUS CØRE H/D=20
CØNSTANT PUMP CHARACTERISTICS
INLET TEMPERATURE T1
GRD C
290
285
280
275
270
SEED PØWER DENSITY QVS
W/CM**3
100
140
180
220
260
0.7
0.7
0.8
0.85
0.9
0.95
DS=1CM

Fig. 32



HETEROGENEOUS CORE H/D=20 CONSTANT PUMP CHARACTERISTICS

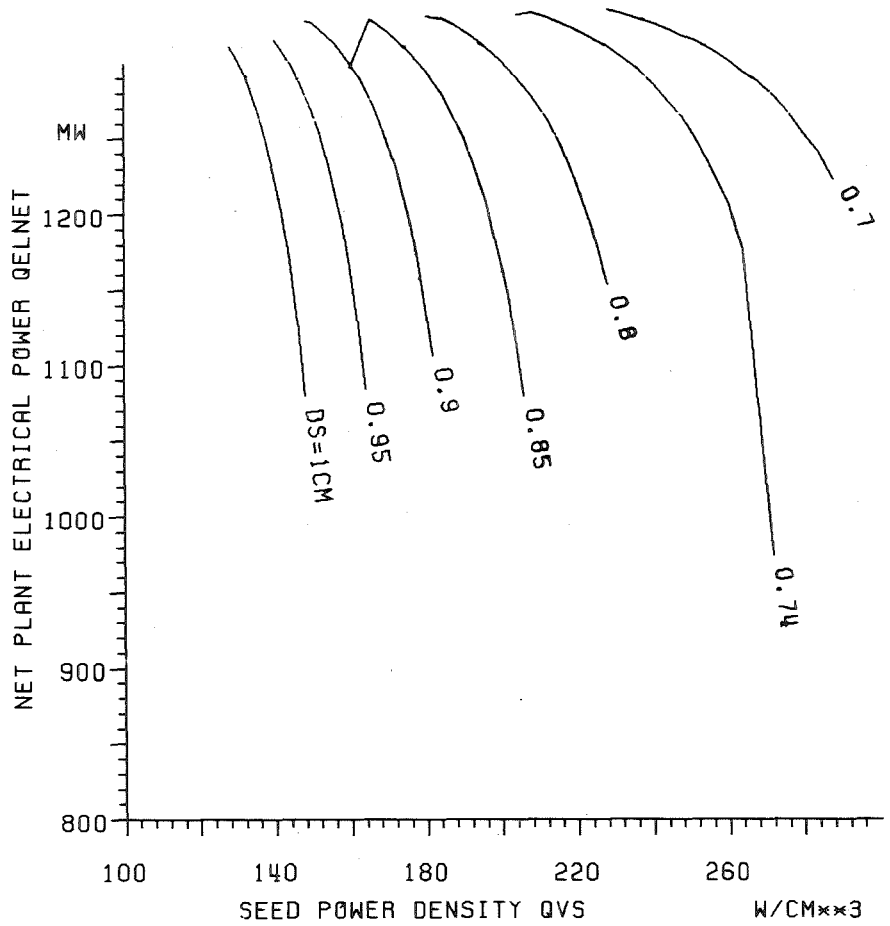
Fig. 33



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

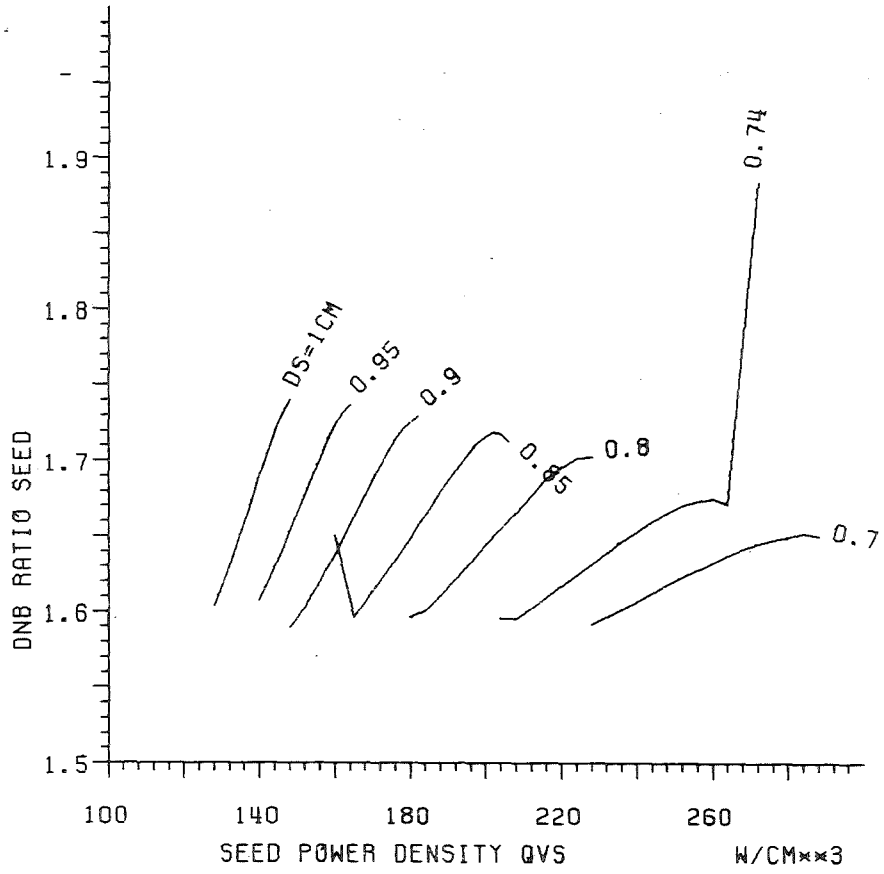
Fig. 34



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

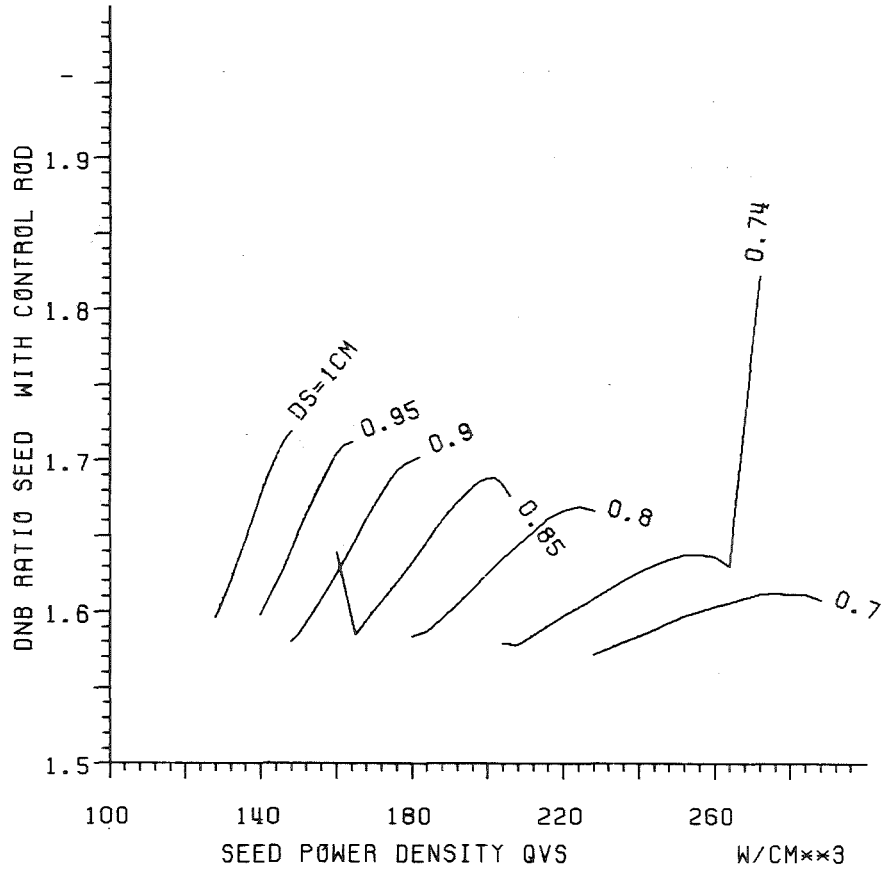
Fig. 35



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS

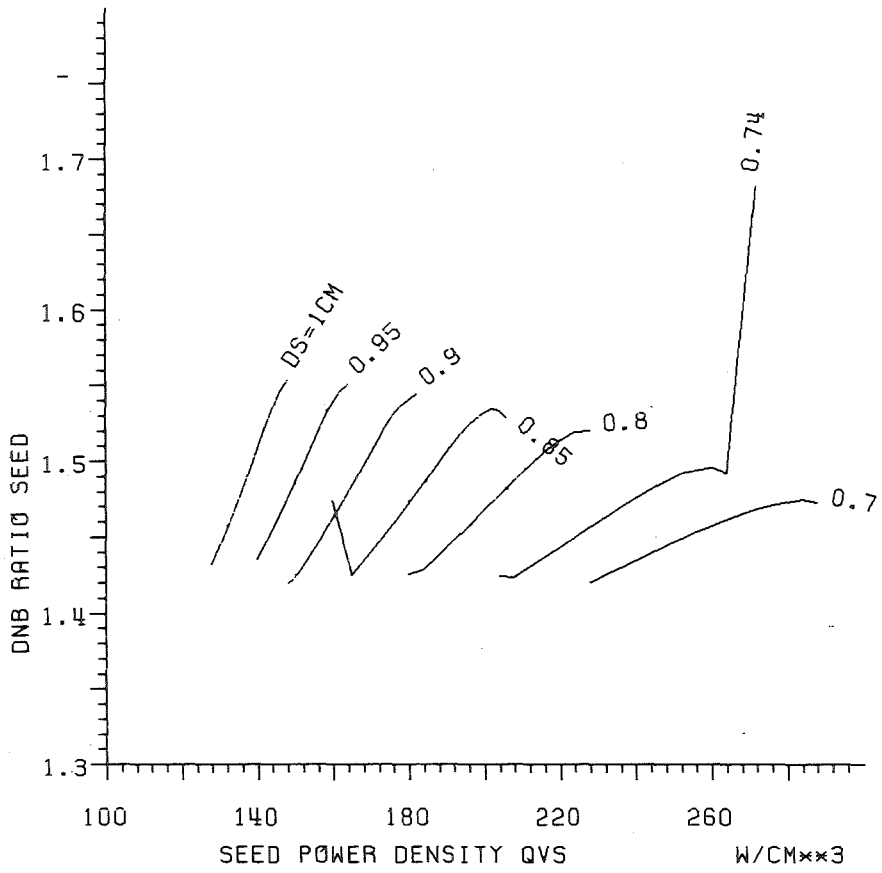
Fig. 36



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS

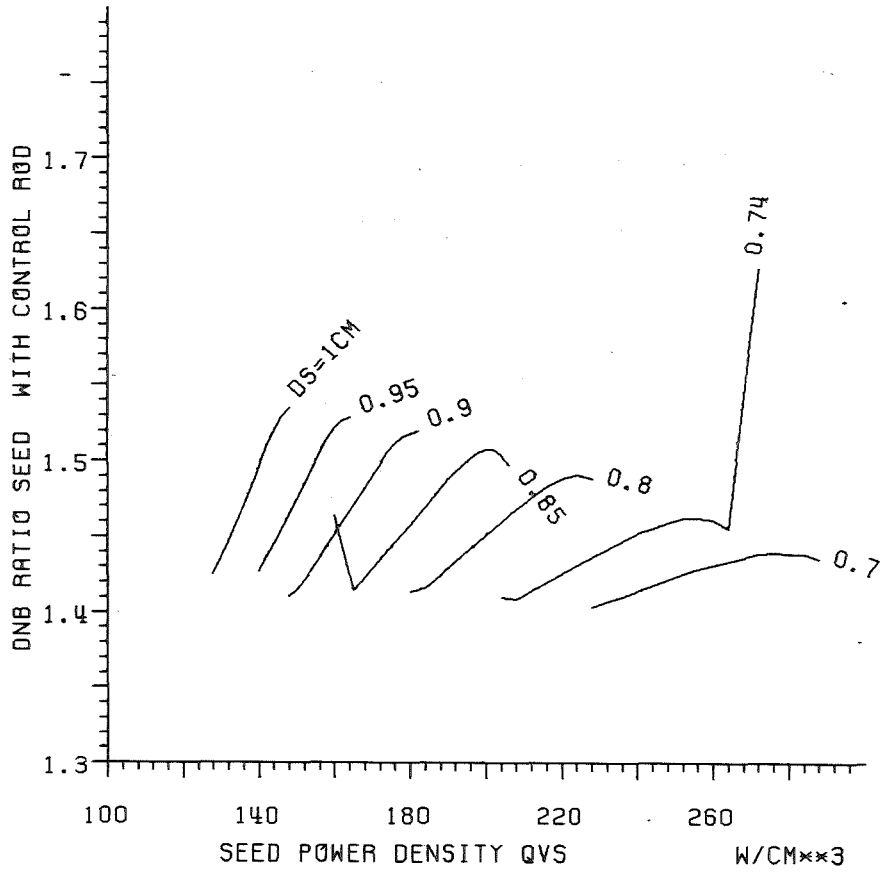
Fig. 37



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

Fig. 38



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

Fig. 39

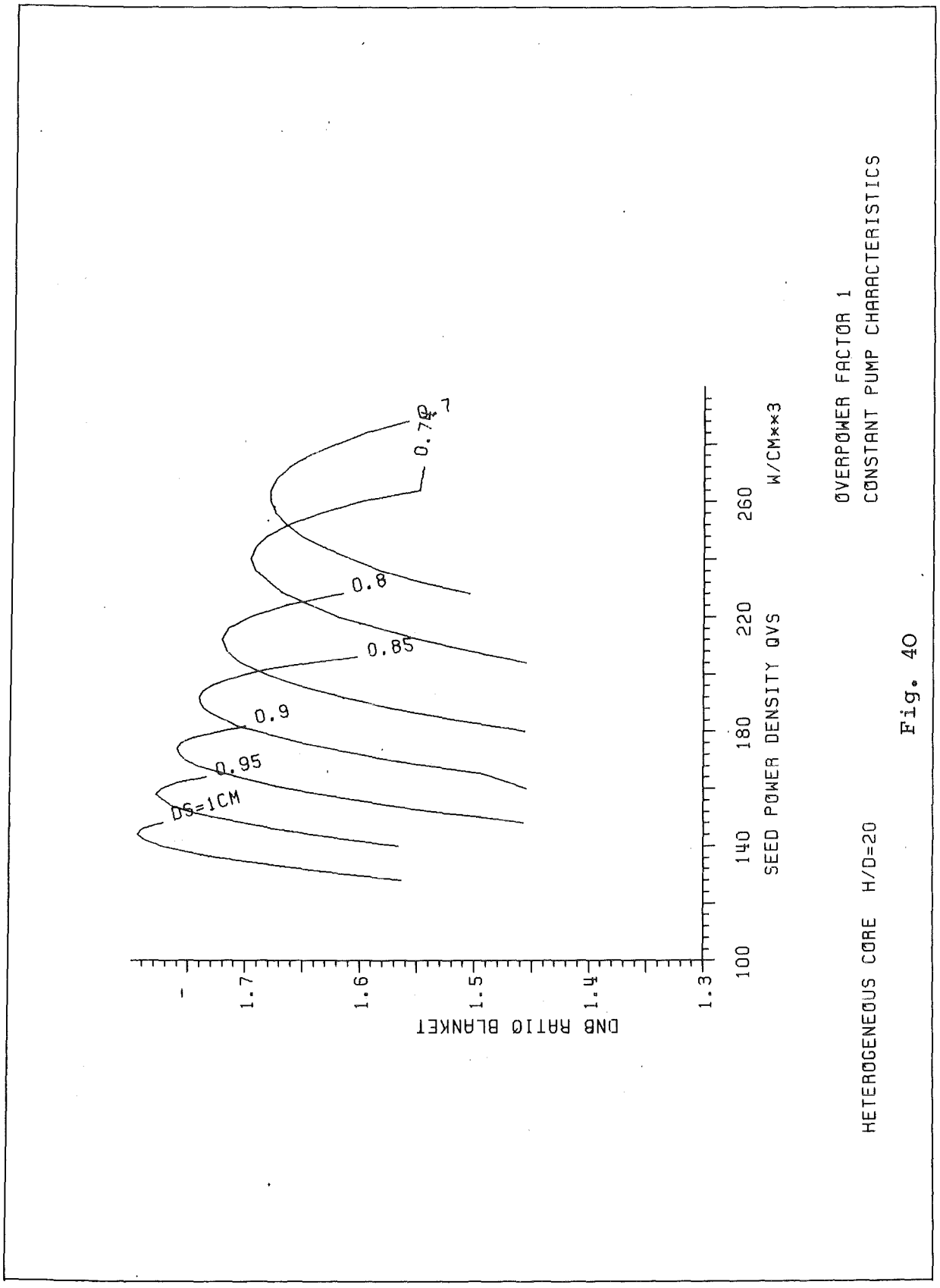
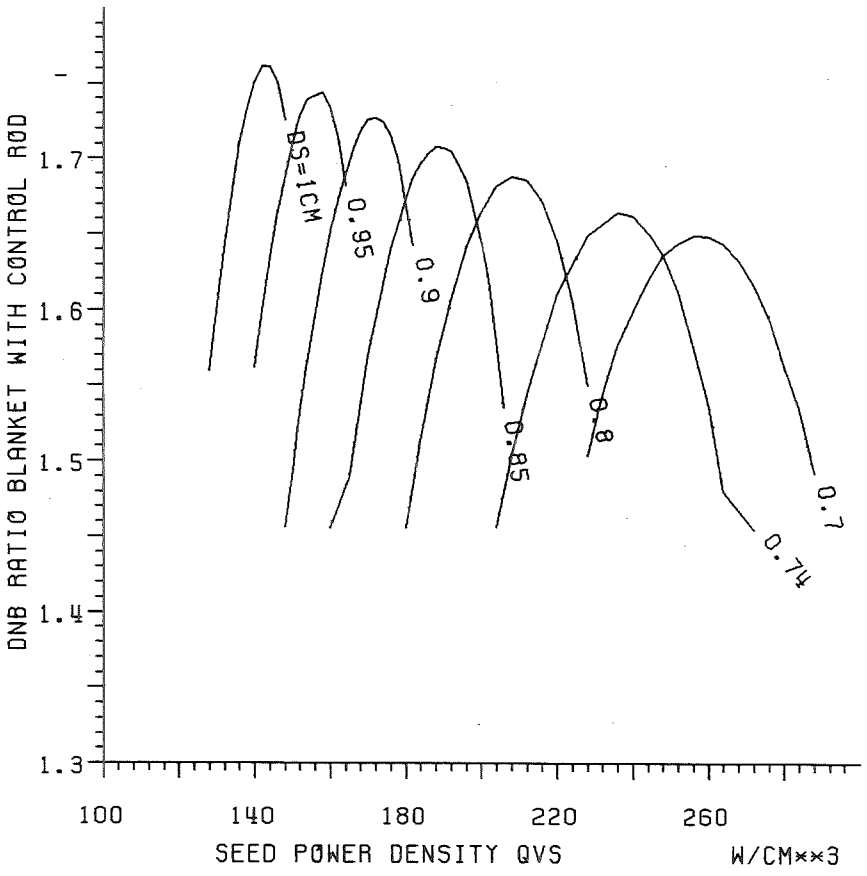

HETEROGENEOUS CORE H/D=20
OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS
DNB RATIO BLANKET
SEED POWER DENSITY QVS
W/CM**3
100
140
180
220
260
1.3
1.4
1.5
1.6
1.7
0.7
0.8
0.85
0.9
0.95
DS=1CM

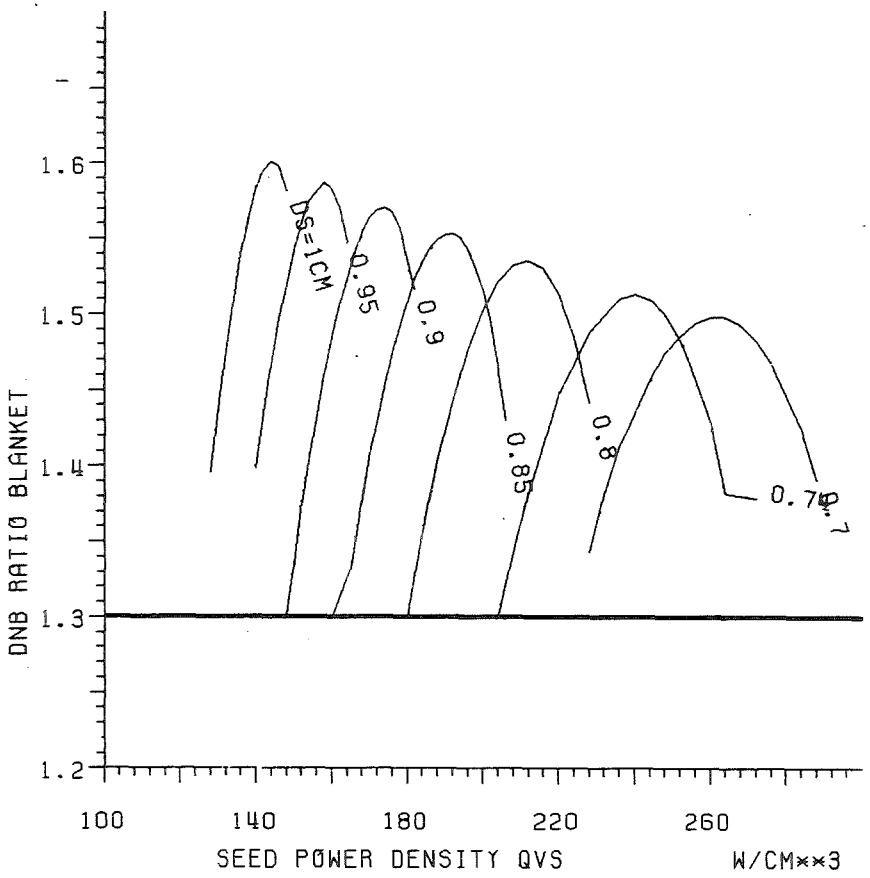
Fig. 40



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS

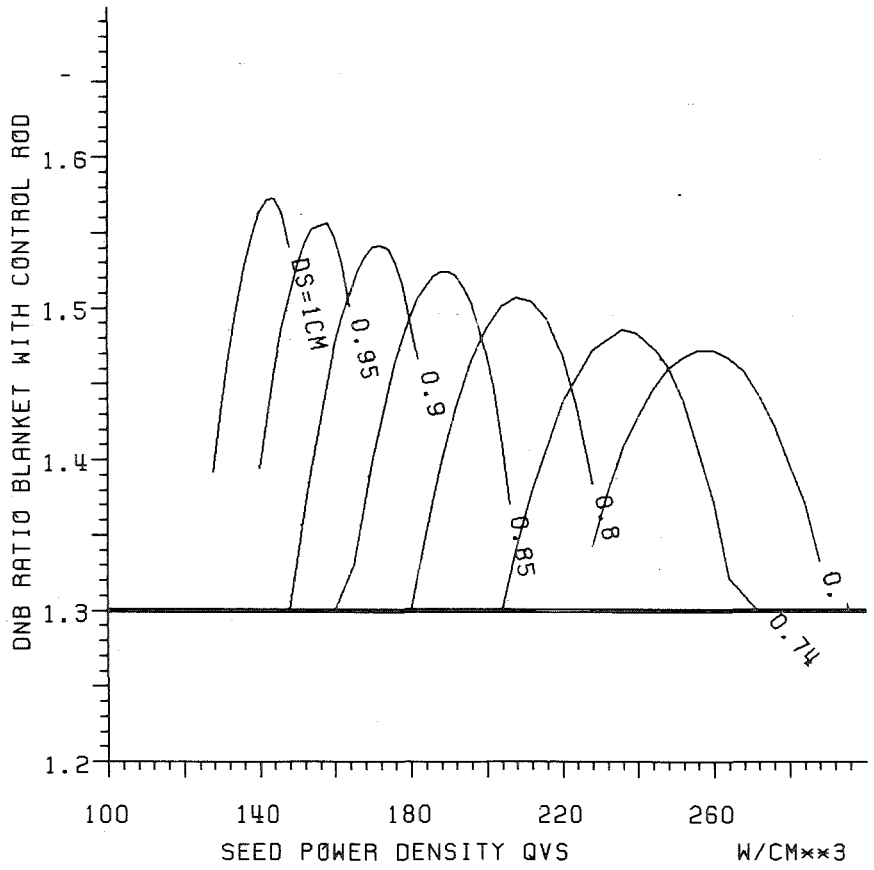
Fig. 41



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

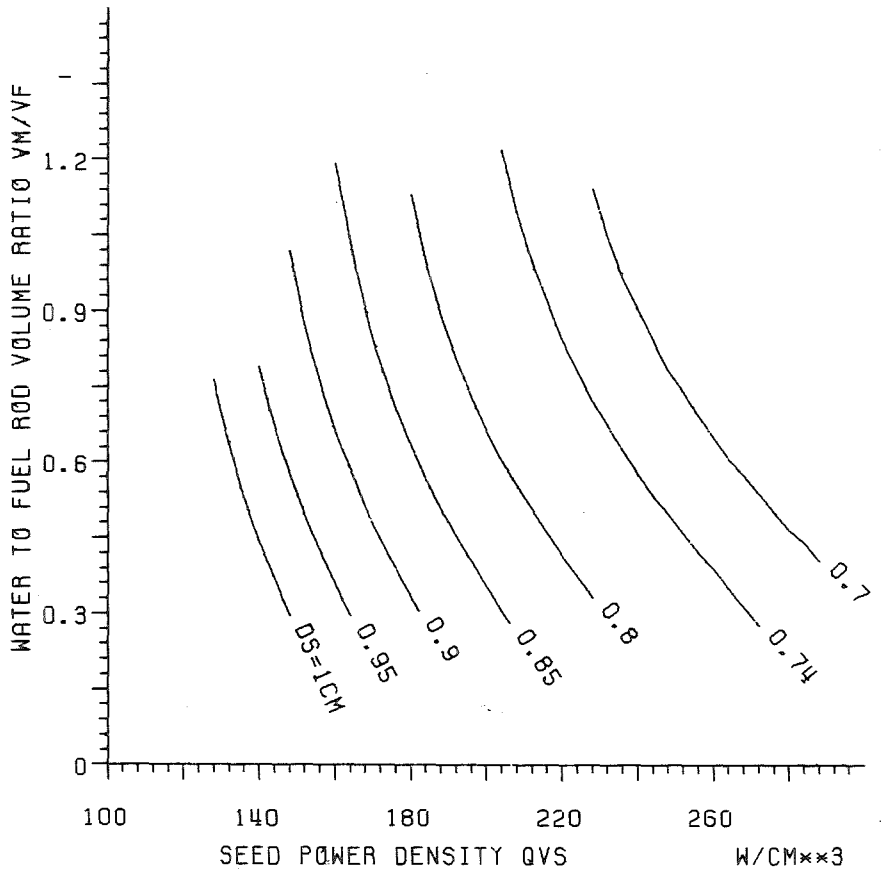
Fig. 42



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

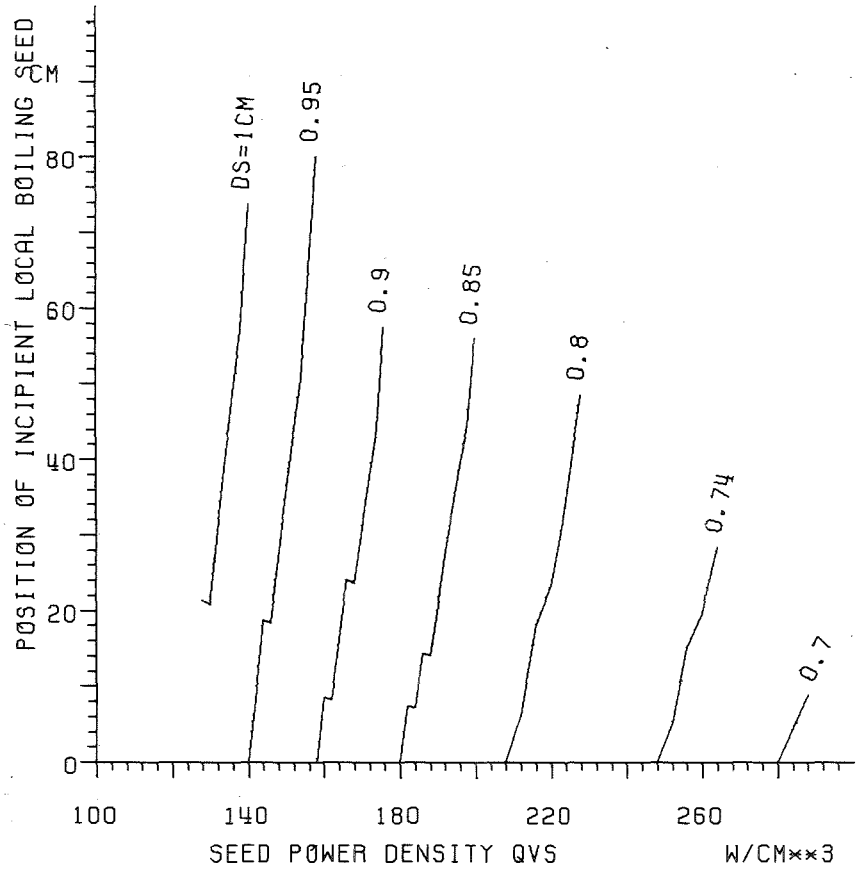
Fig. 43



HETEROGENEOUS CORE H/D=20

CONSTANT PUMP CHARACTERISTICS

Fig. 44



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS

Fig. 45

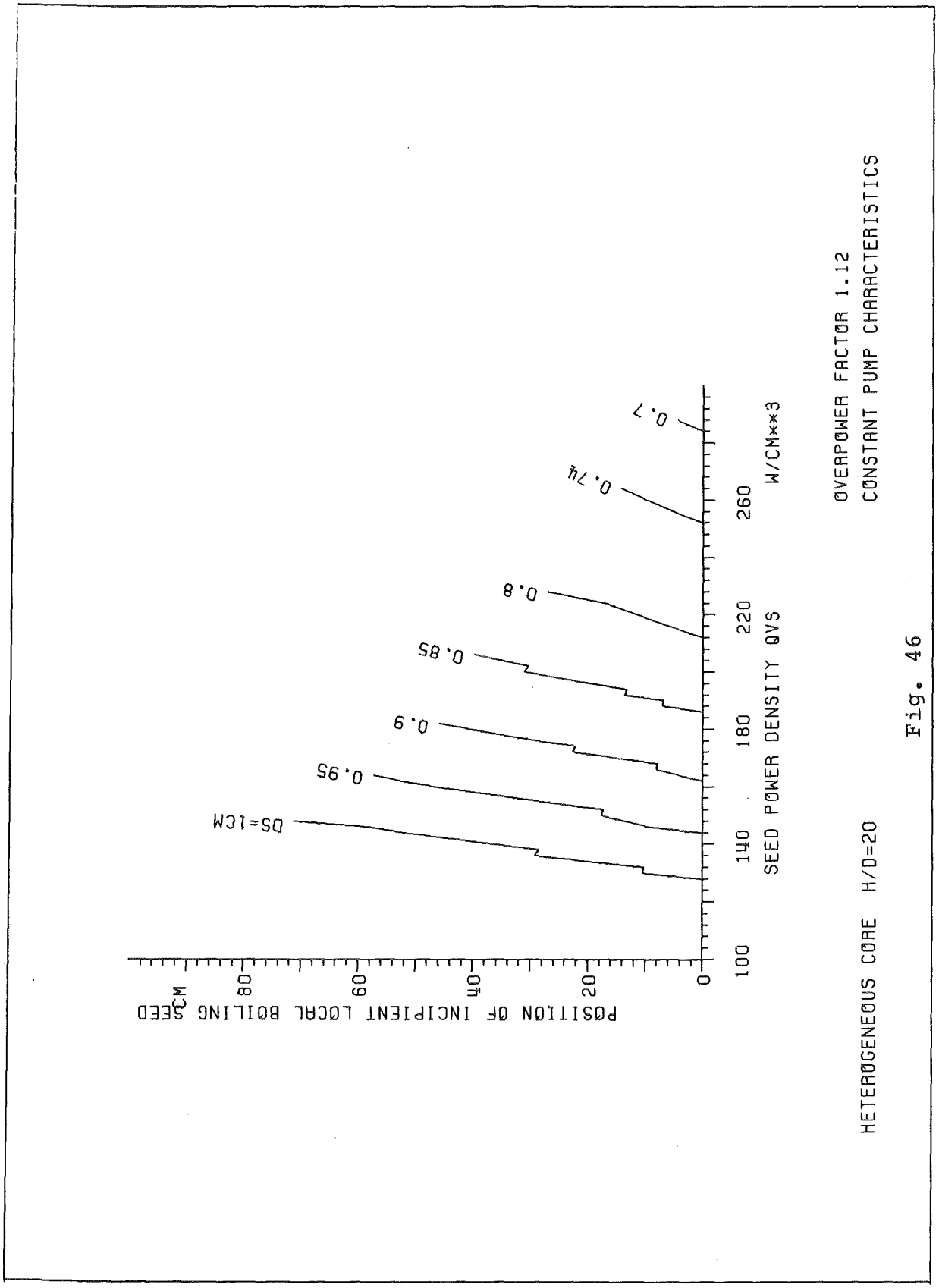
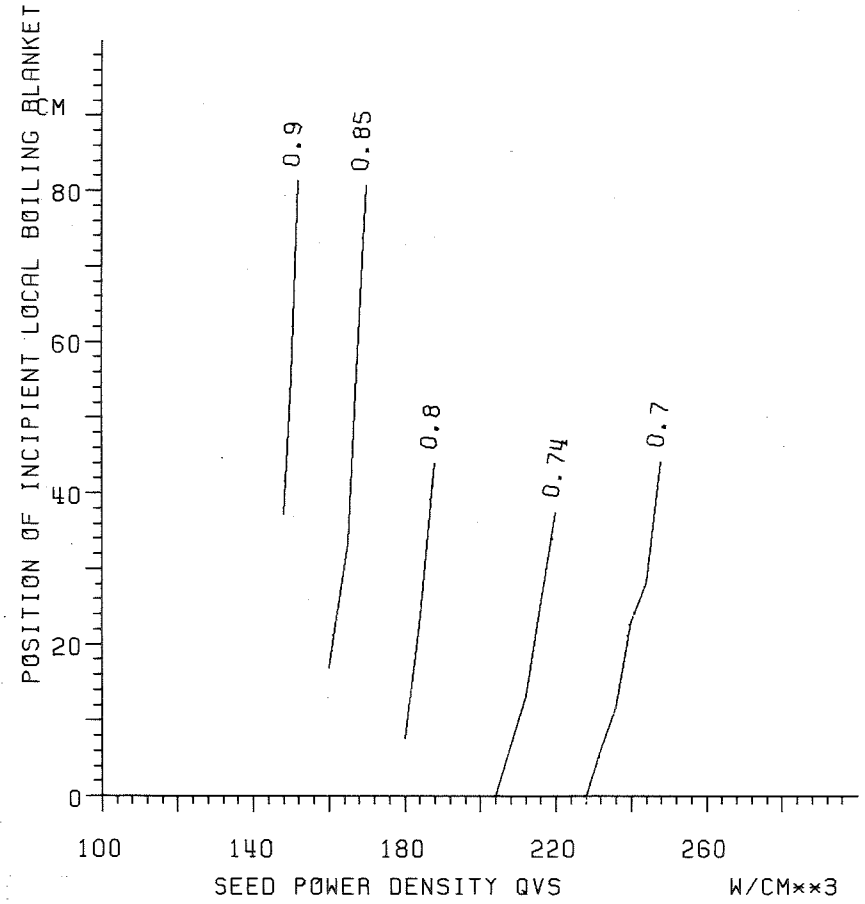

HETEROGENEOUS CORE H/D=20
OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS
POSITION OF INCIPIENT LOCAL BOILING SEED
SEED POWER DENSITY QVS
W/CM**3
100
140
180
220
260
0
20
40
60
80
CM
DS=1CM
0.95
0.9
0.85
0.8
0.74
0.7

Fig. 46



HETEROGENEOUS CORE H/D=20

OVERPOWER FACTOR 1
CONSTANT PUMP CHARACTERISTICS

Fig. 47

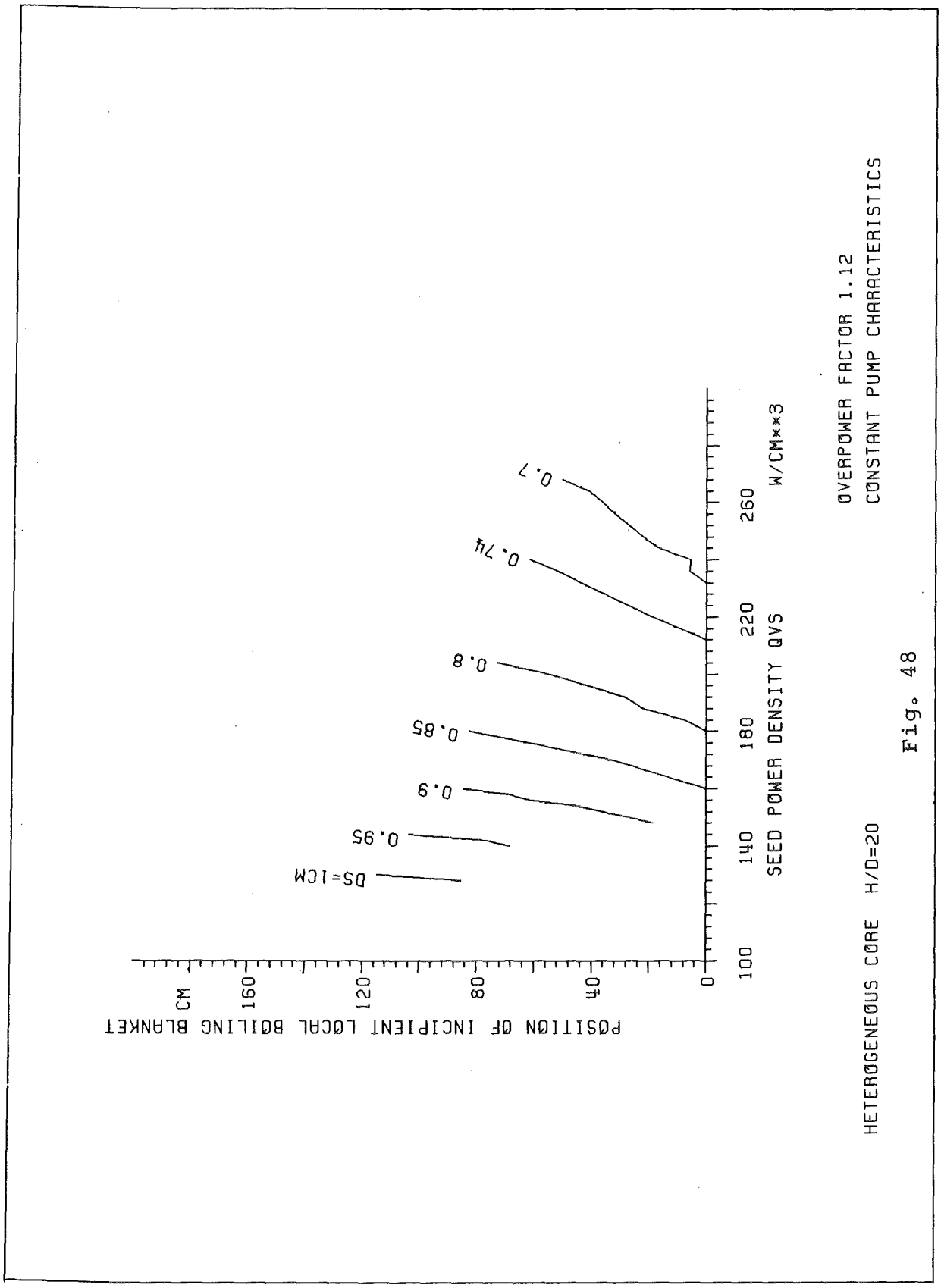

POSITION OF INCIPIENT LOCAL BOILING BLANKET
CM
160
120
80
40
0
100
140
180
220
260
SEED POWER DENSITY QVS
W/CM**3
DS=1CM
0.95
0.9
0.85
0.8
0.74
0.7
OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS
HETEROGENEOUS CORE H/D=20

Fig. 48

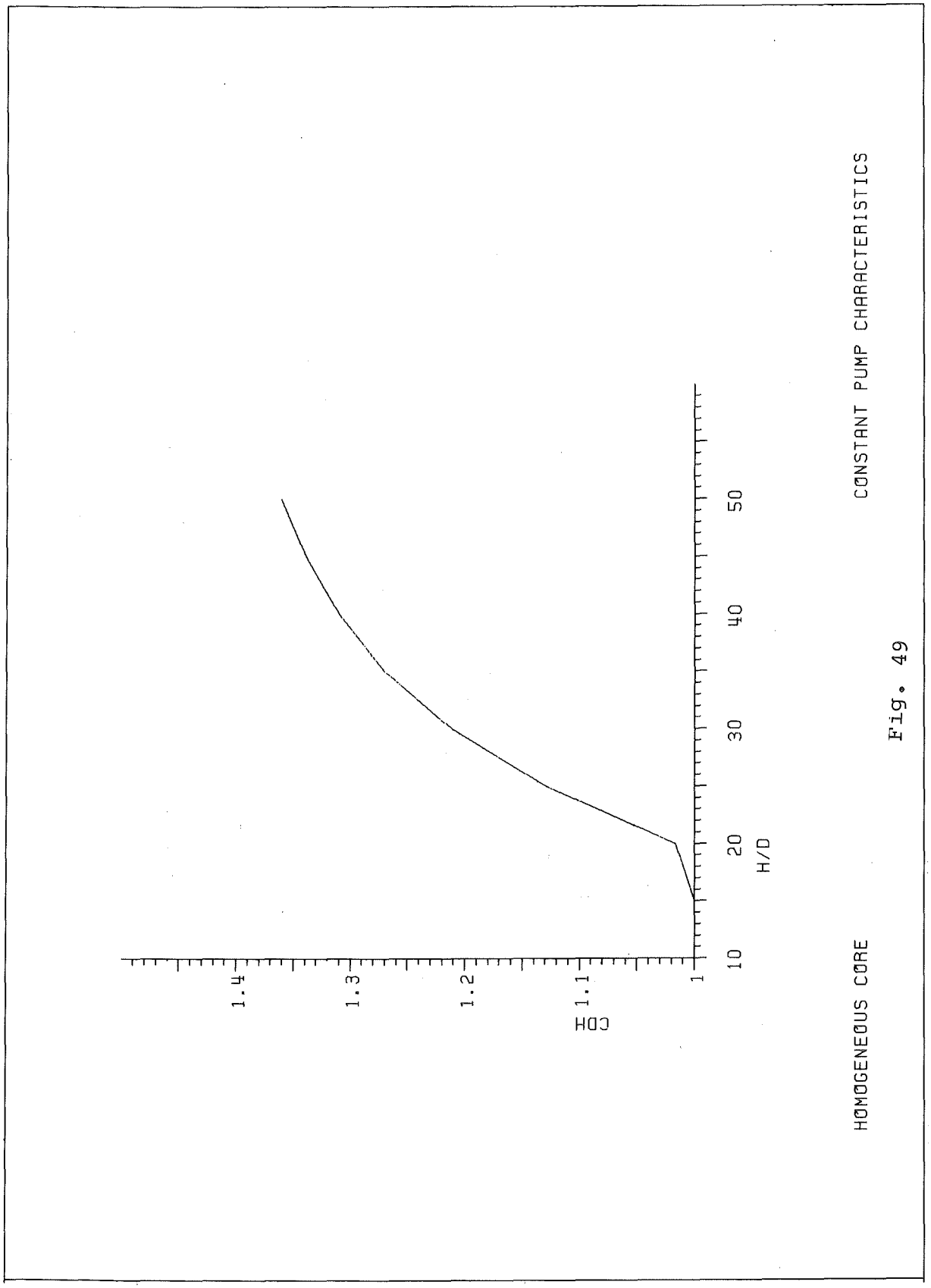

CONSTANT PUMP CHARACTERISTICS
HOMOGENEOUS CORE
CDH
1.4
1.3
1.2
1.1
1
10
20
30
40
50
H/D

Fig. 49

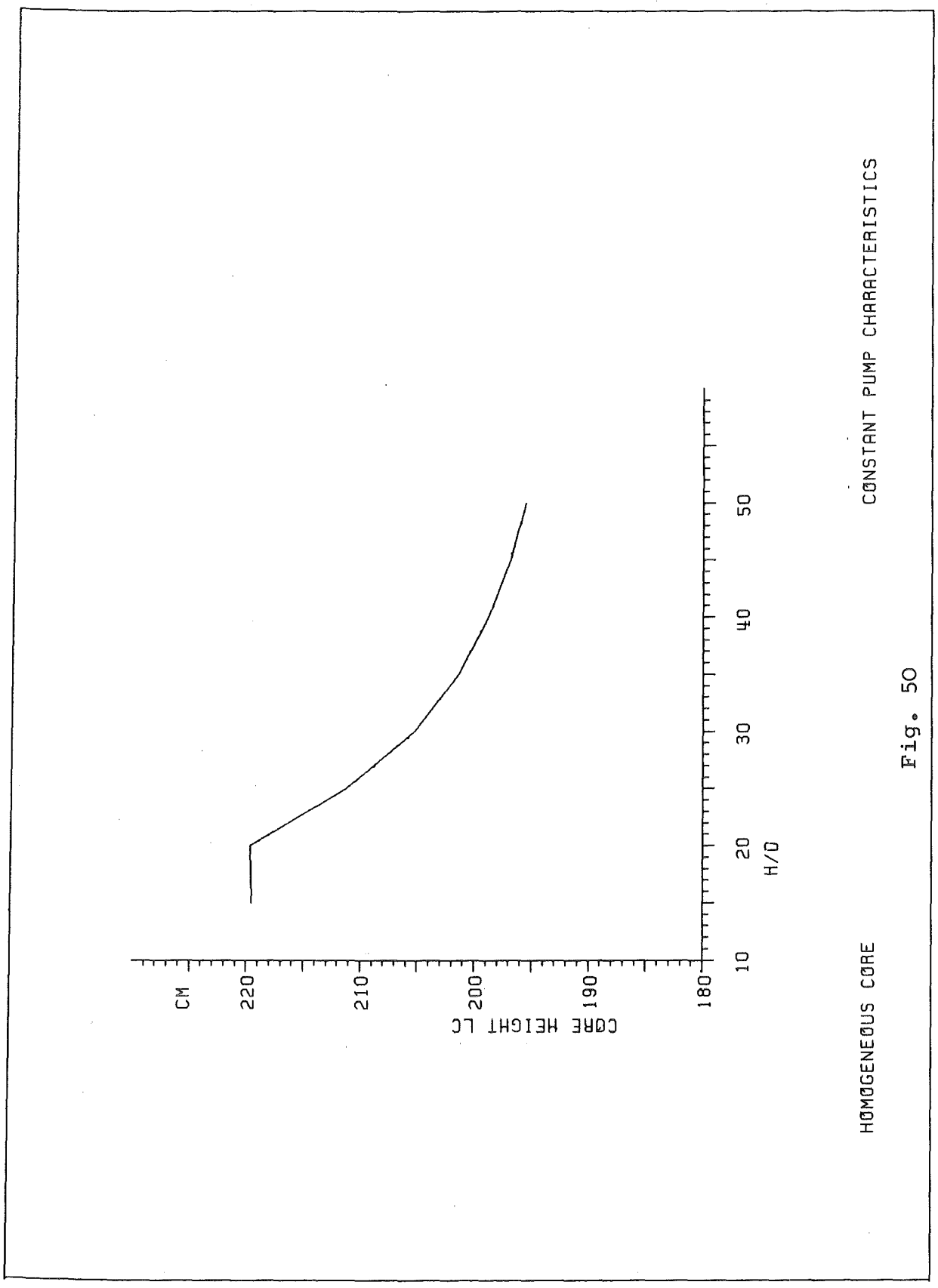

CONSTANT PUMP CHARACTERISTICS
HOMOGENEOUS CORE
CORE HEIGHT LC
CM
220
210
200
190
180
10
20
30
40
50
H/D

Fig. 50

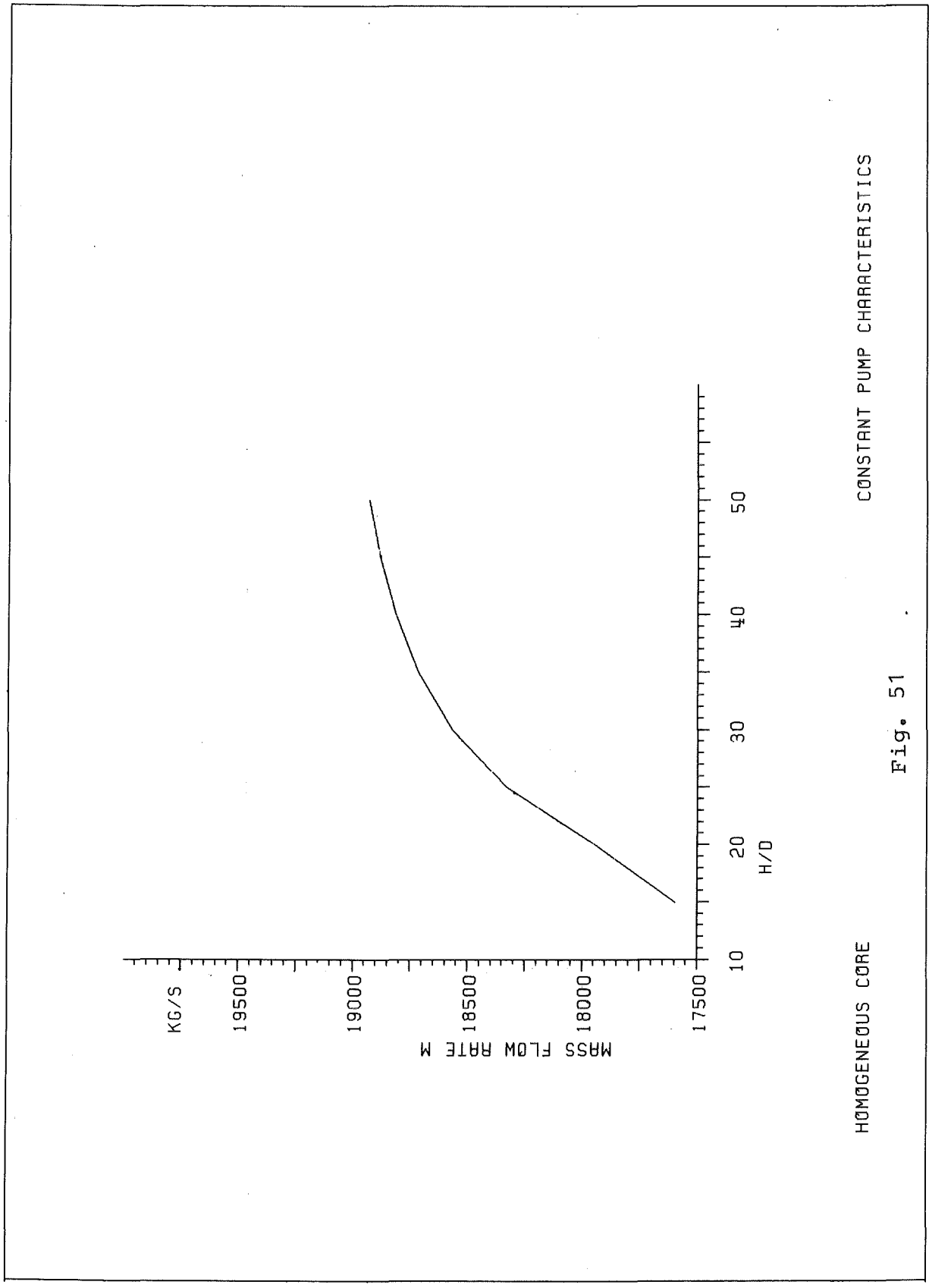

CONSTANT PUMP CHARACTERISTICS
HOMOGENEOUS CORE
MASS FLOW RATE M
KG/S
19500
19000
18500
18000
17500
10
20
30
40
50
H/D

Fig. 51

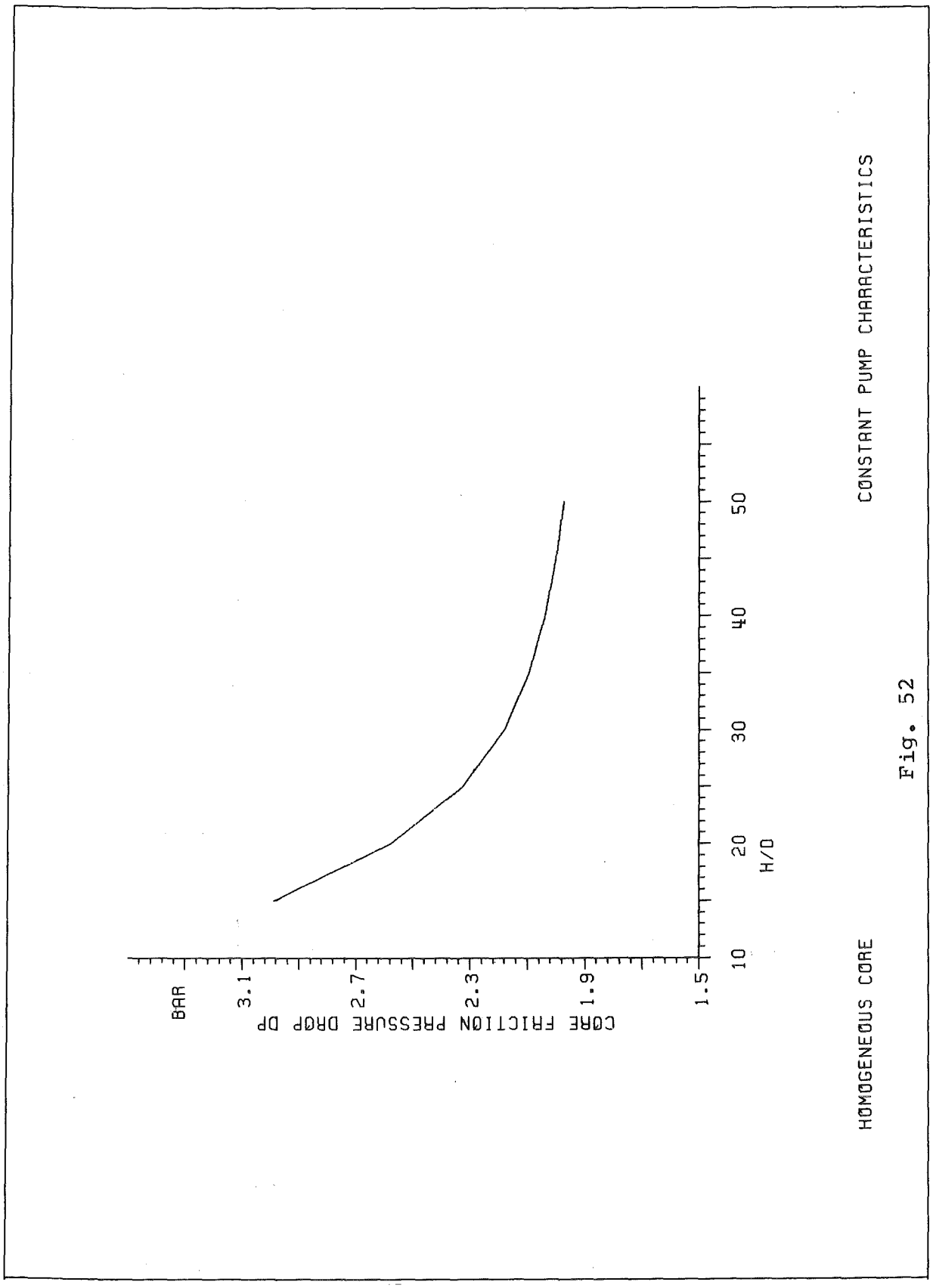

CONSTANT PUMP CHARACTERISTICS
HOMOGENEOUS CORE
CORE FRICTION PRESSURE DROP DP
BAR
3.1
2.7
2.3
1.9
1.5
10
20
30
40
50
H/D

Fig. 52

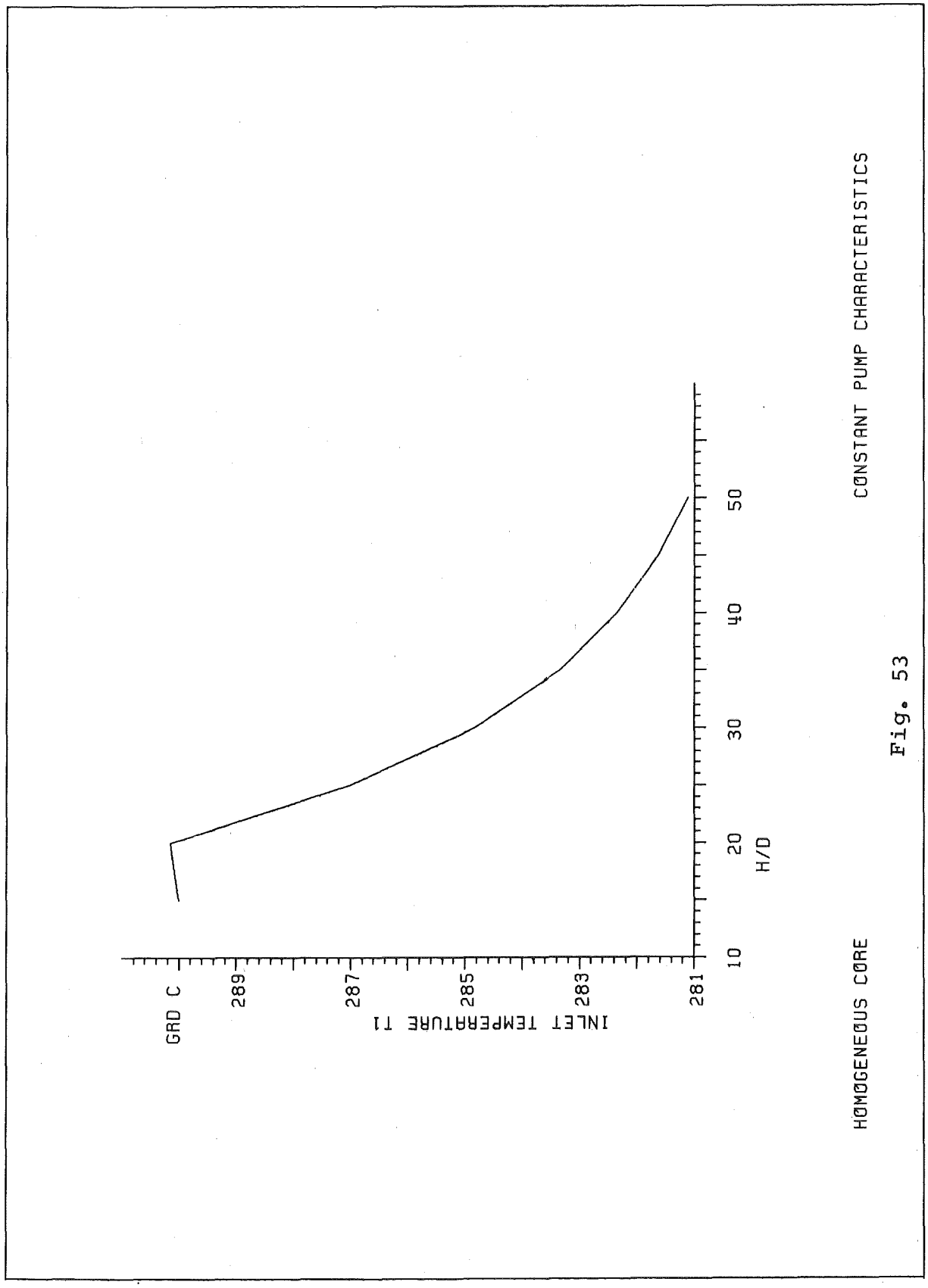
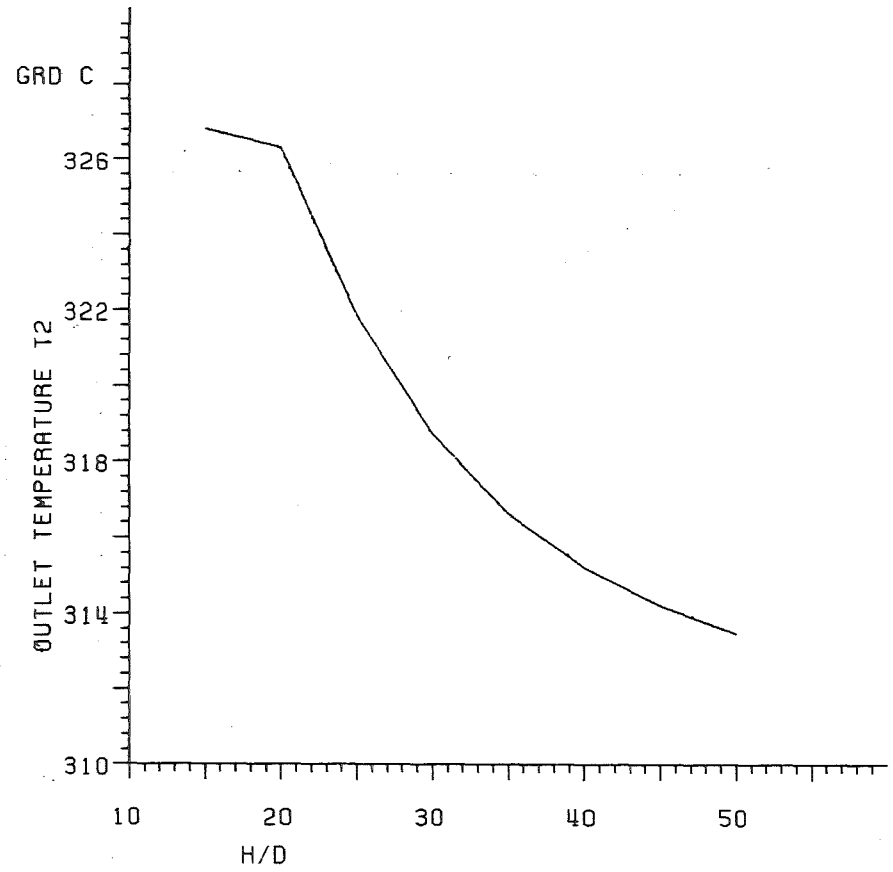

HOMOGENEOUS CORE
CONSTANT PUMP CHARACTERISTICS
INLET TEMPERATURE T1
GRD C
289
287
285
283
281
10
20
30
40
50
H/D

Fig. 53



HOMOGENEOUS CORE

CONSTANT PUMP CHARACTERISTICS

Fig. 54

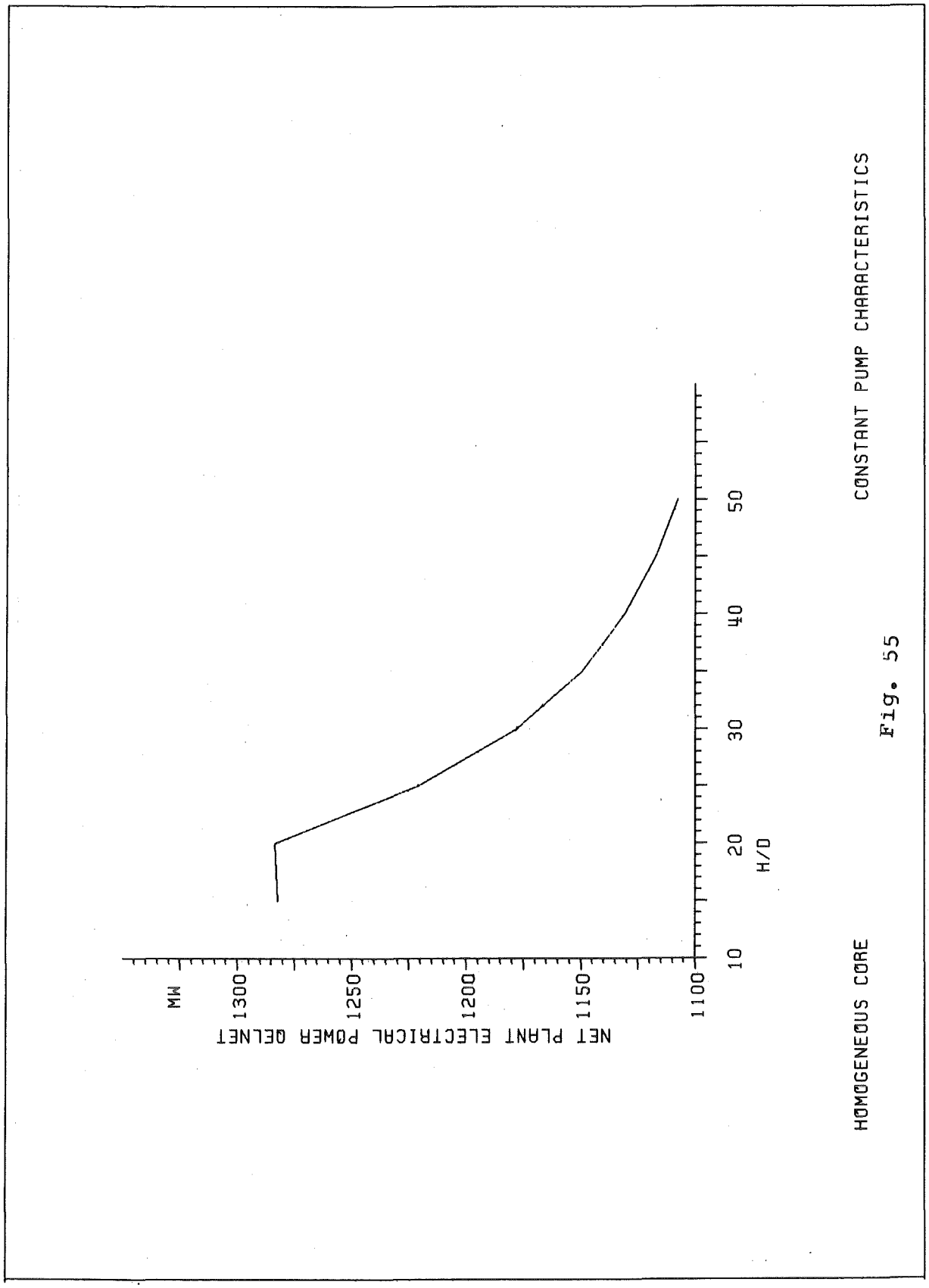
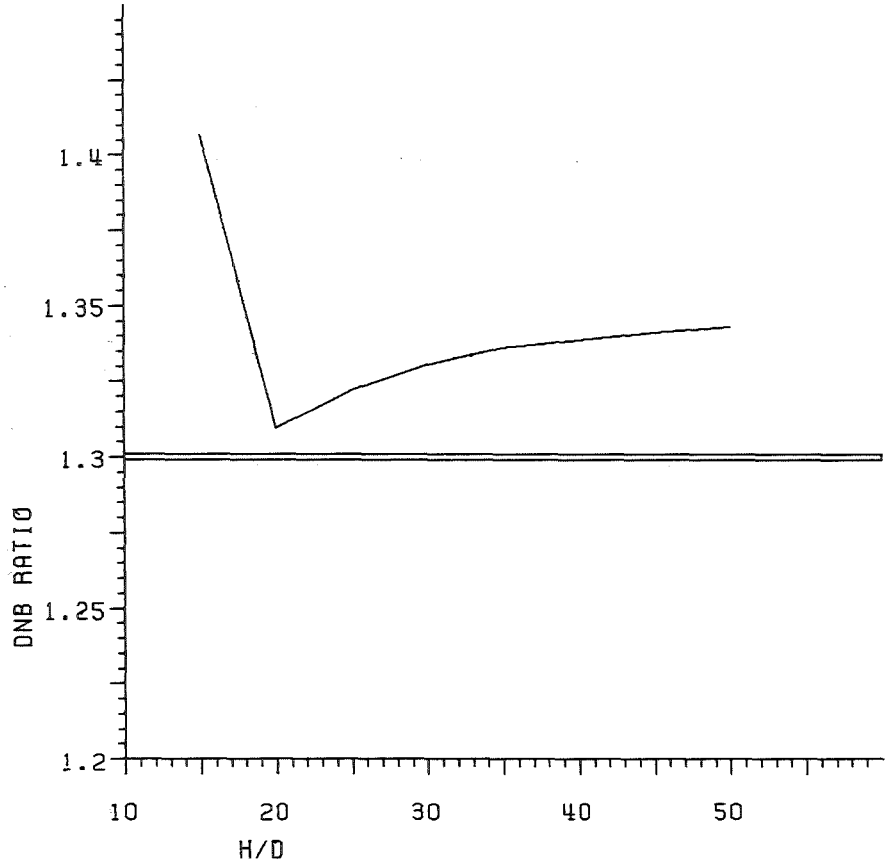

NET PLANT ELECTRICAL POWER DELNET
MW
1300
1250
1200
1150
1100
10
20
30
40
50
H/D
HOMOGENEOUS CORE
CONSTANT PUMP CHARACTERISTICS

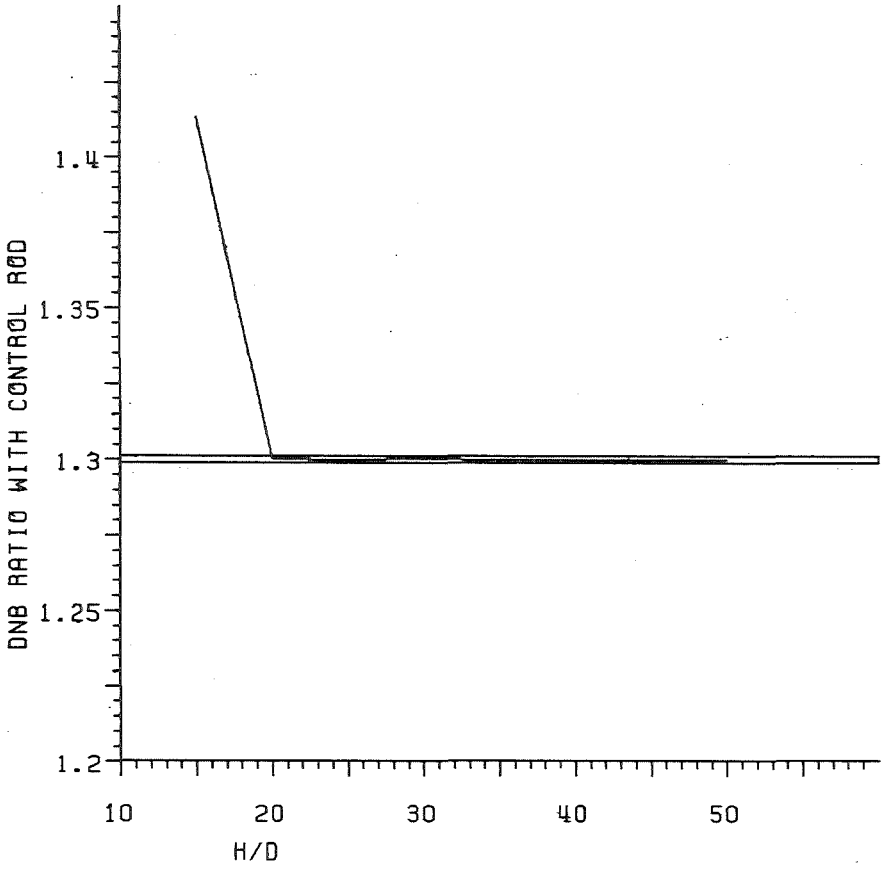
Fig. 55



HOMOGENEOUS CORE

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

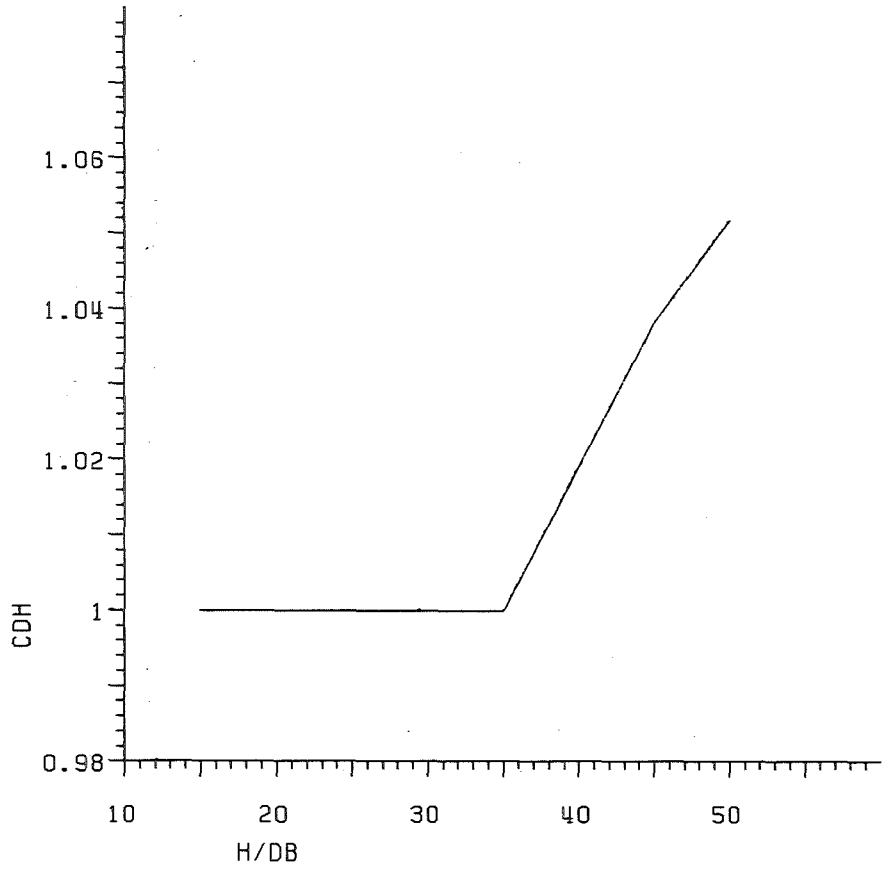
Fig. 56



HOMOGENEOUS CORE

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

Fig. 57



HETEROGENEOUS CORE

CONSTANT PUMP CHARACTERISTICS

Fig. 58

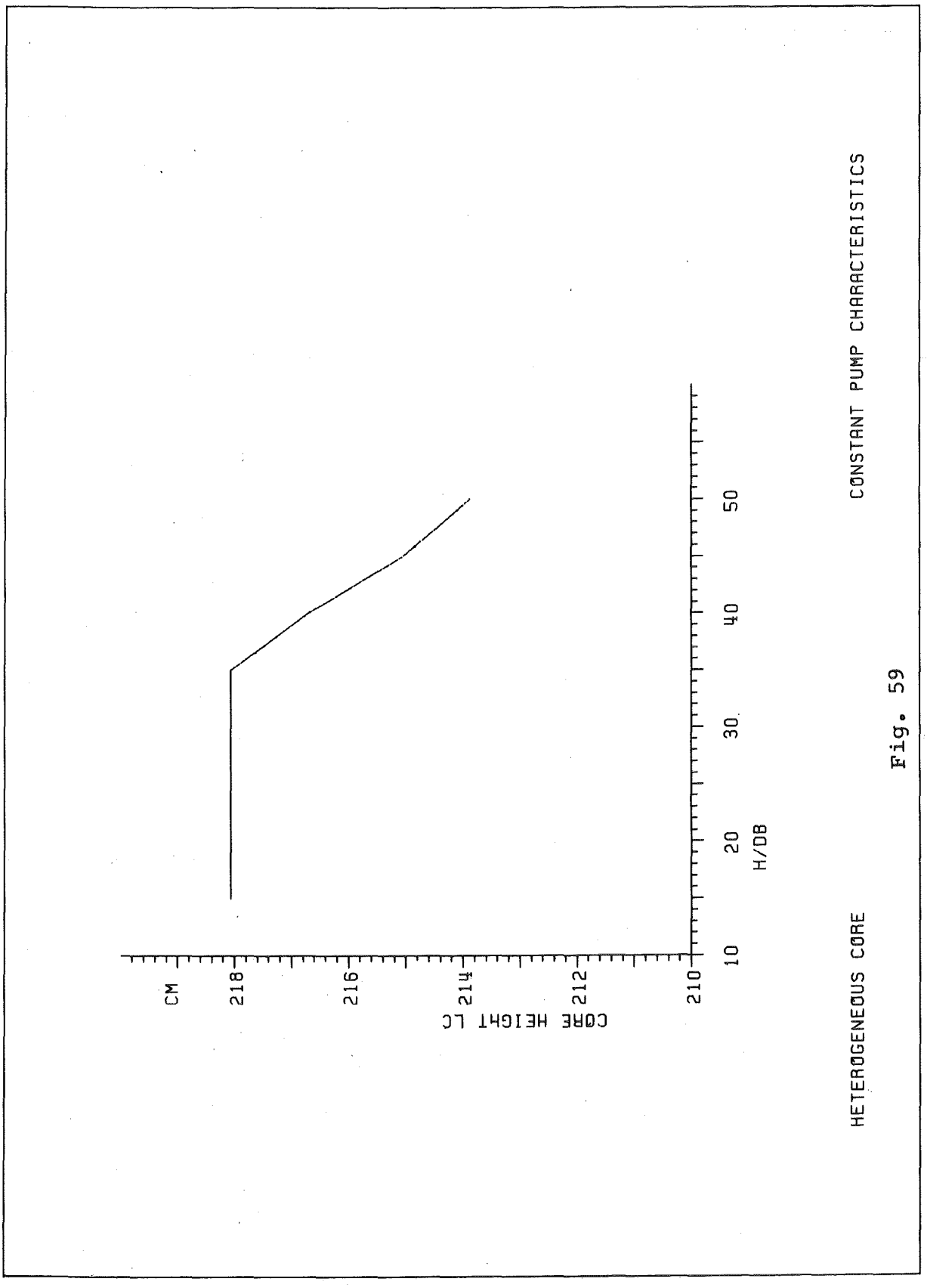
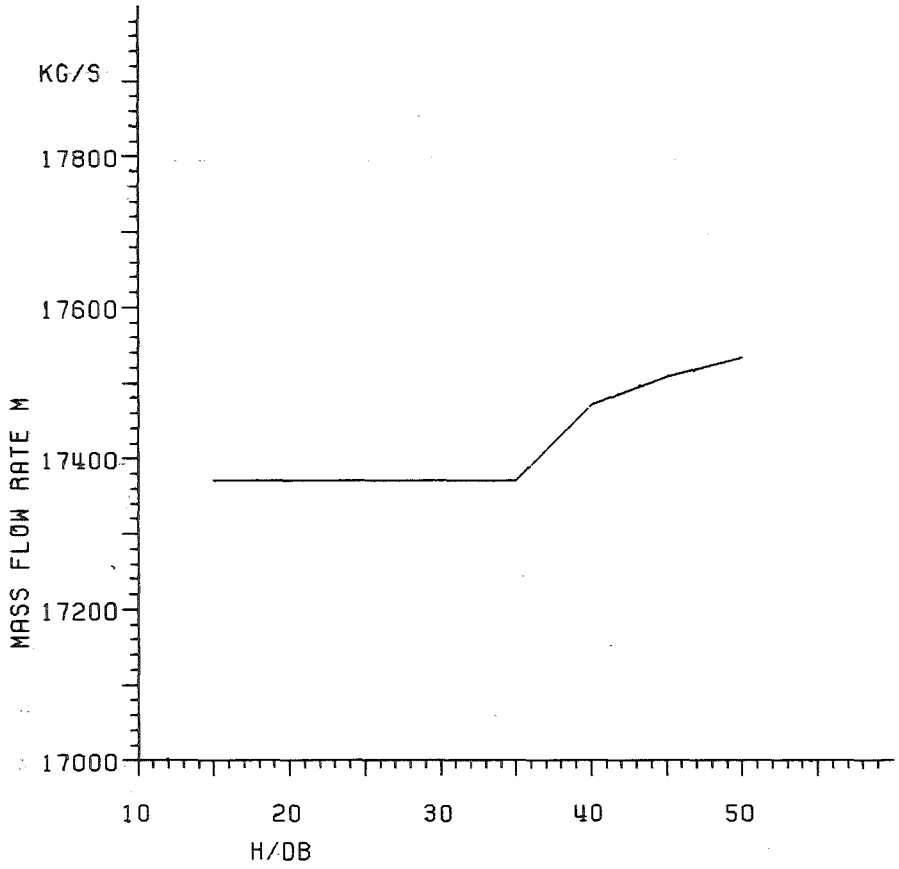

CONSTANT PUMP CHARACTERISTICS
HETEROGENEOUS CORE
CORE HEIGHT LC
CM
218
216
214
212
210
10
20
30
40
50
H/DB

Fig. 59



HETEROGENEOUS CORE

CONSTANT PUMP CHARACTERISTICS

Fig. 60

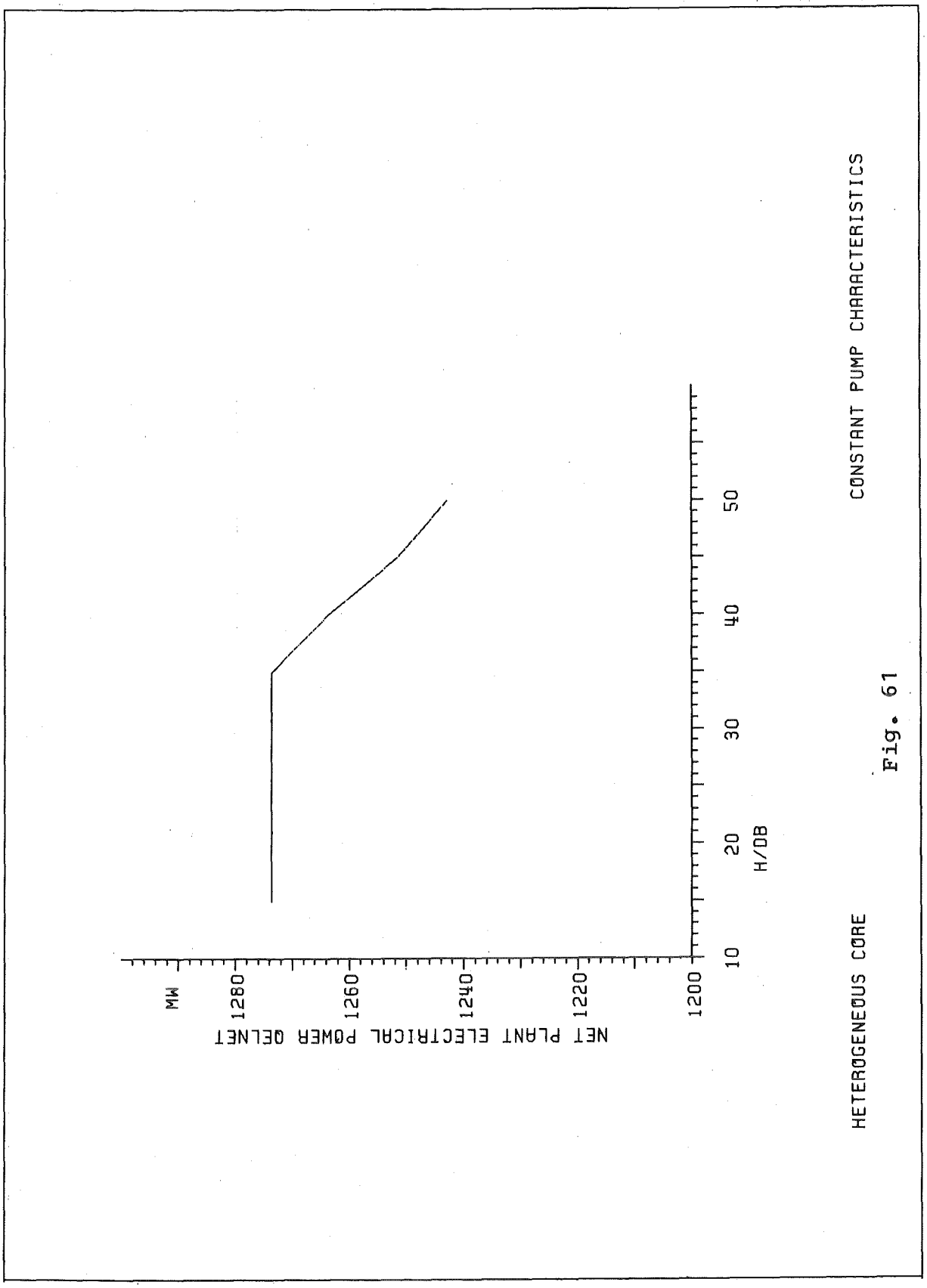
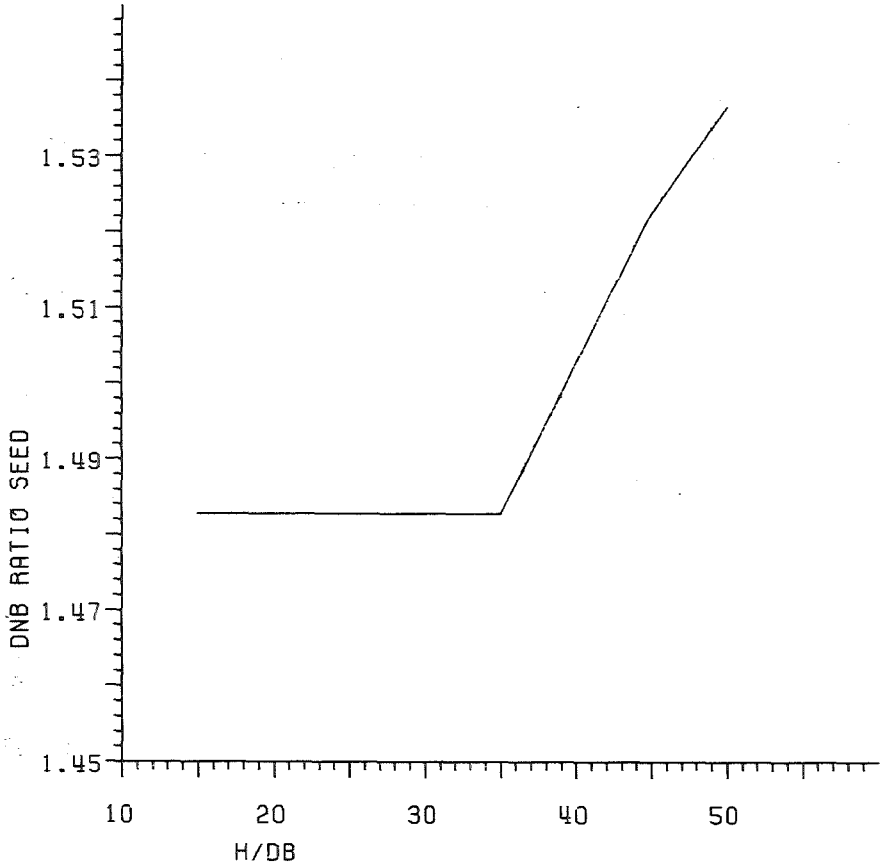

NET PLANT ELECTRICAL POWER DELNET
MW
1280
1260
1240
1220
1200
10
20
30
40
50
H/DB
HETEROGENEOUS CORE
CONSTANT PUMP CHARACTERISTICS

Fig. 61



HETEROGENEOUS CORE

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

Fig. 62

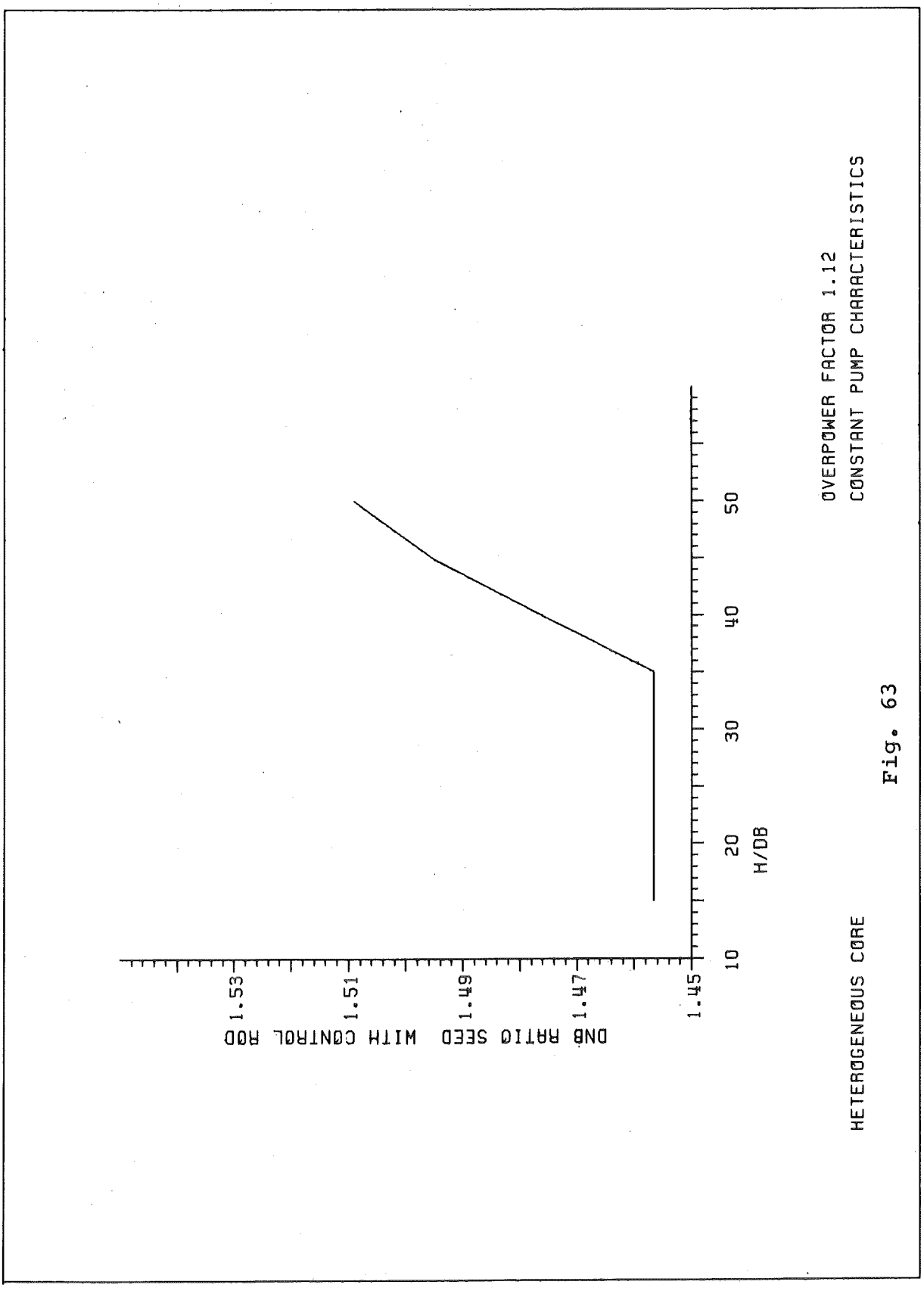
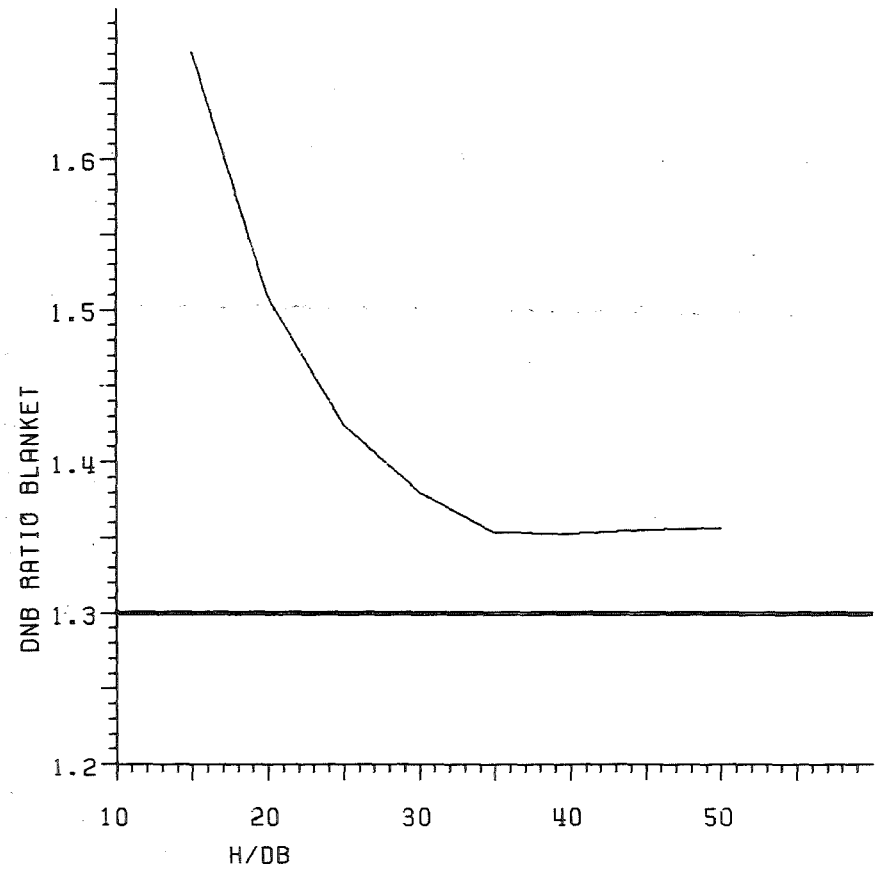

DNB RATIO SEED WITH CONTROL ROD
1.53
1.51
1.49
1.47
1.45
10
20
30
40
50
H/DB
OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS
HETEROGENEOUS CORE

Fig. 63



HETEROGENEOUS CORE

OVERPOWER FACTOR 1.12
CONSTANT PUMP CHARACTERISTICS

Fig. 64

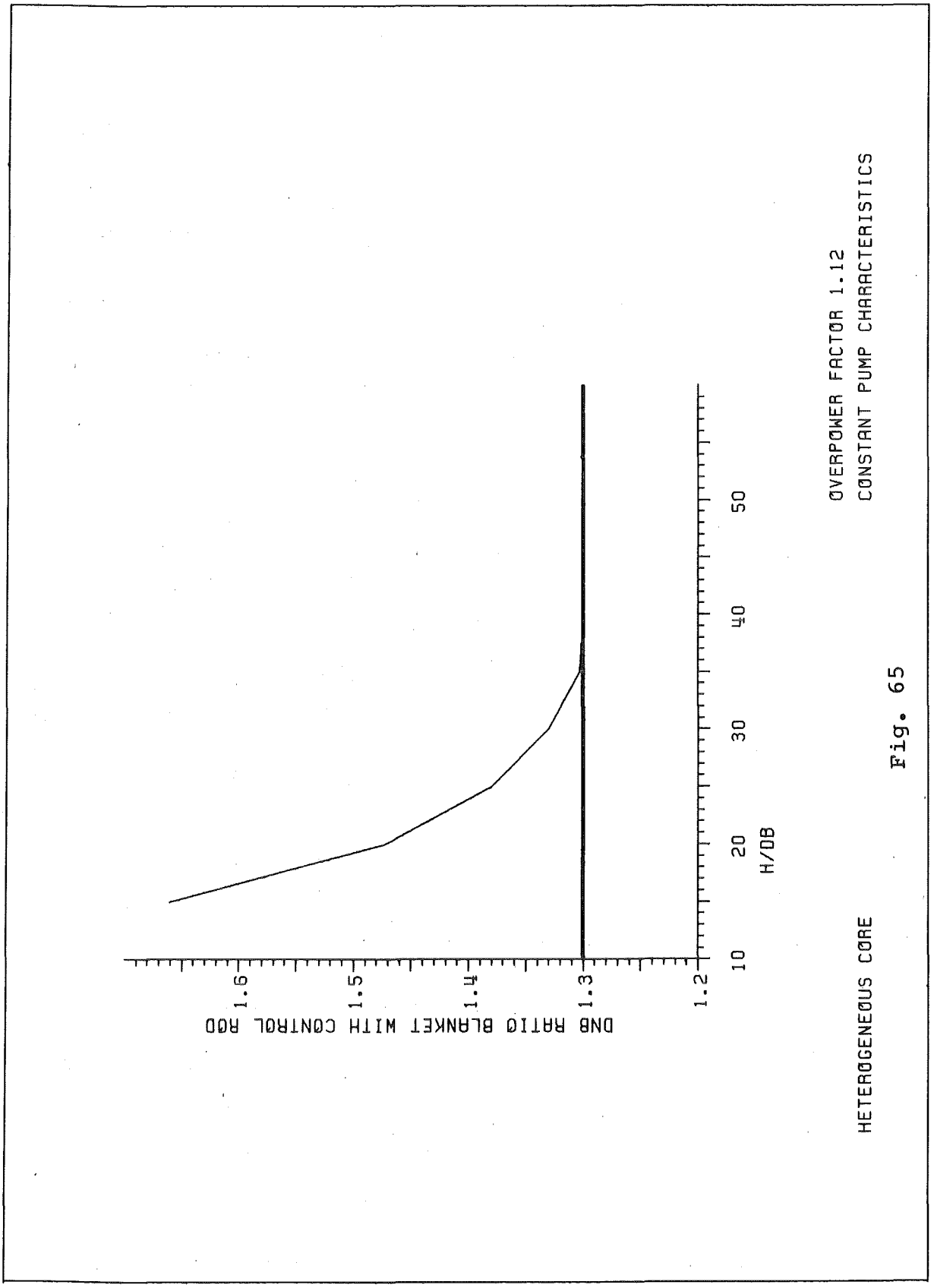

ØVERPØWER FACTØR 1.12
CØNSTANT PUMP CHARACTERISTICS
HETERØGENEØUS CØRE
DNB RATIØ BLANKET WITH CØNTRØL RØD
1.6
1.5
1.4
1.3
1.2
10
20
30
40
50
H/DB

Fig. 65

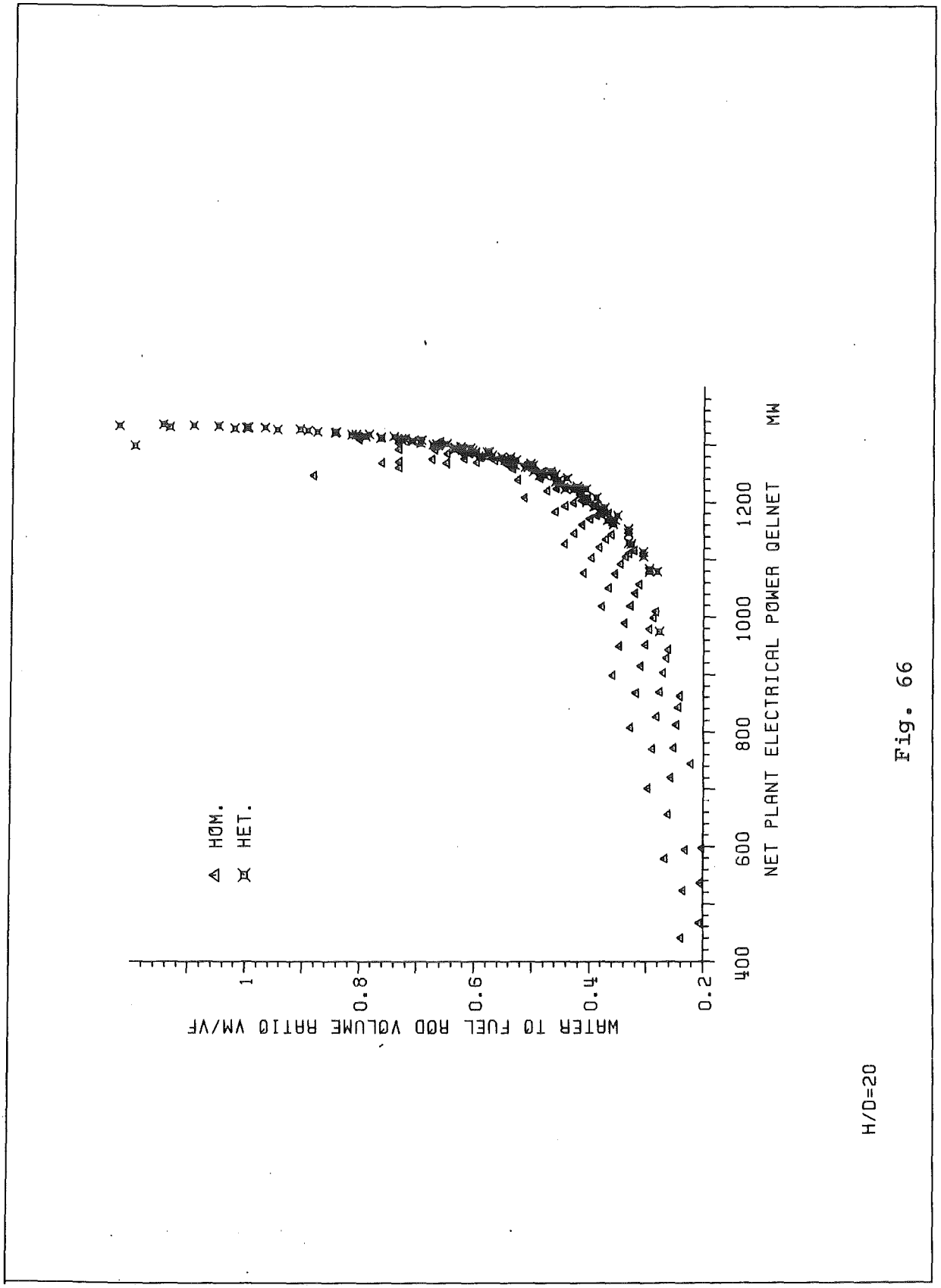

WATER TO FUEL ROD VOLUME RATIO VM/VF
0.2
0.4
0.6
0.8
1
400
600
800
1000
1200
NET PLANT ELECTRICAL POWER QELNET MW
△ HØM.
⋇ HET.
H/D=20

Fig. 66