in-active Safety Standard (Safety standard no longer included in the reaffirmation process acc. sec. 5.2 of the procedural statutes)

SAFETY STANDARDS

of the

Nuclear Safety Standards Commission (KTA)

KTA 3102.3

Reactor Core Design of High-Temperature Gas-Cooled Reactors

Part 3: Loss of Pressure through Friction in Pebble Bed Cores

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Comment:

In these English translations of KTA-Safety Standards the words shall, should and may are used with the following meanings:

shall indicates a mandatory requirement,

should indicates a requirement[1] to which exceptions are allowed. However, the exceptions shall be substantiated during the licensing procedure,

may indicates a permission and is, thus, neither a requirement (with or without exceptions) nor a recommendation: recommendations are worded as such, e.g., "it is recommended that ....".

The word combinations basically shall/shall basically are used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. These exceptions - other than in the case of should - are specified in the text of the safety standard.

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1 Please note that in the case of IAEA NUSS standards and ANSI standards, the word "should" indicates a mere recommendation.

KTA 3102.3

Reactor Core Design of High-Temperature Gas-Cooled Reactors

Part 3: Loss of Pressure through Friction in Pebble Bed Cores

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PLEASE NOTE:

Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger No. 44a on March 4,1988. Copies may be ordered through the Carl Heymanns Verlag KG, Gereonstr. 18-32, D-5000 Köln 1.

Nuclear Safety Standards Commission (KTA)

Federal Republic of Germany

Introduction

(1) The Safety Standard KTA 3102 "Reactor Core Design for High-Temperature Gas-Cooled Reactors" comprises the entire field of core design. Within the scope of the thermodynamic and flow-mechanical core design of high-temperature gas-cooled reactors, the following areas are dealt with:

Part 1: Calculation of the Material Properties of Helium

Part 2: Heat Transfer in Spherical Fuel Elements

Part 3: Loss of Pressure through Friction in Pebble Bed Cores

Part 4: Thermohydraulic Analytical Model for Stationary and Quasi-Stationary Conditions in Pebble Bed Cores

Part 5: Systematic and Statistical Errors in the Thermohydraulic Core Design of the Pebble Bed Reactor

(2) The reactor core of a high-temperature gas-cooled reactor which is considered in Part 3, consists of a heaped bed of pebbles of identical diameter. The loss of pressure through friction in pebble bed cores is part of the total loss of pressure in the primary circuit. It is primarily taken into account in the de sign of the ventilators and thus in the design of sufficient cooling of the reactor core. The following is a specification of an empirical correlation for the coefficient of loss of pressure through friction; this correlation will be used to calculate the loss of pressure through friction in pebble beds in order to design the cooling of the reactor core.

I Scope

This safety standard applies to the calculation of the loss of pressure through friction in a heaped bed of pebbles of identical diameter within the following scope:

Reynolds number Re	$10^0 < \mathrm{Re}/(\mathrm{l} - \varepsilon) < 10^5$
Porosity of the bed	0.36 < e < 0.42
Diameter ratio D/d	D/d values above the limiting curve in accordance with **Figure 1-1**
Height of bed H	H > 5 d

The following equation shall be used for the Reynolds number Re:

$$\mathrm{Re} = \frac{(\dot{m}/A)d}{\eta}$$

2 Symbols Used

A vessel cross section

d diameter of the pebbles forming the bed

D diameter of the vessel enclosing the bed

H height of the bed

ΔH height of the bed layer being considered

Δp loss of pressure through friction in the bed layer being considered

m mass flow of the gas in the bed

ε porosity of the bed, i.e. the relation between the empty volume in the bed and the total volume of the bed

η dynamic viscosity of the gas

ρ density of the gas

Ψ coefficient of loss of pressure through friction

Re Reynolds number

3 Calculation Equations

The following equation shall be used to calculate the loss of pressure through friction Ap in a layer of height AH of a pebble bed:

$$\frac{\Delta p}{\Delta H} = \Psi \cdot \frac{1-\varepsilon}{\varepsilon^3} \cdot \frac{1}{d} \cdot \frac{1}{2\rho} \cdot \left(\frac{\dot{m}}{A}\right)^2 \qquad (3\text{-}1)$$

The coefficient of loss of pressure through friction shall be determined in accordance with the following empirical correlation:

$$\Psi = \frac{320}{\left(\frac{\mathrm{Re}}{1-\varepsilon}\right)} + \frac{6}{\left(\frac{\mathrm{Re}}{1-\varepsilon}\right)^{0.1}} \qquad (3\text{-}2)$$

The value of Ψ as a function of Re/(1 - ε) is Shown in **Figure 3-1**.

The dynamic viscosity n of the gas shall be determined for the arithmetic mean value of the surface temperature of the pebble and the gas temperature, the density ρ of the gas shall be determined at the gas temperature.

The uncertainty range of the correlation in accordance with equation (3-2) is ± 15% within the scope of application, with a confidence level of 95%.

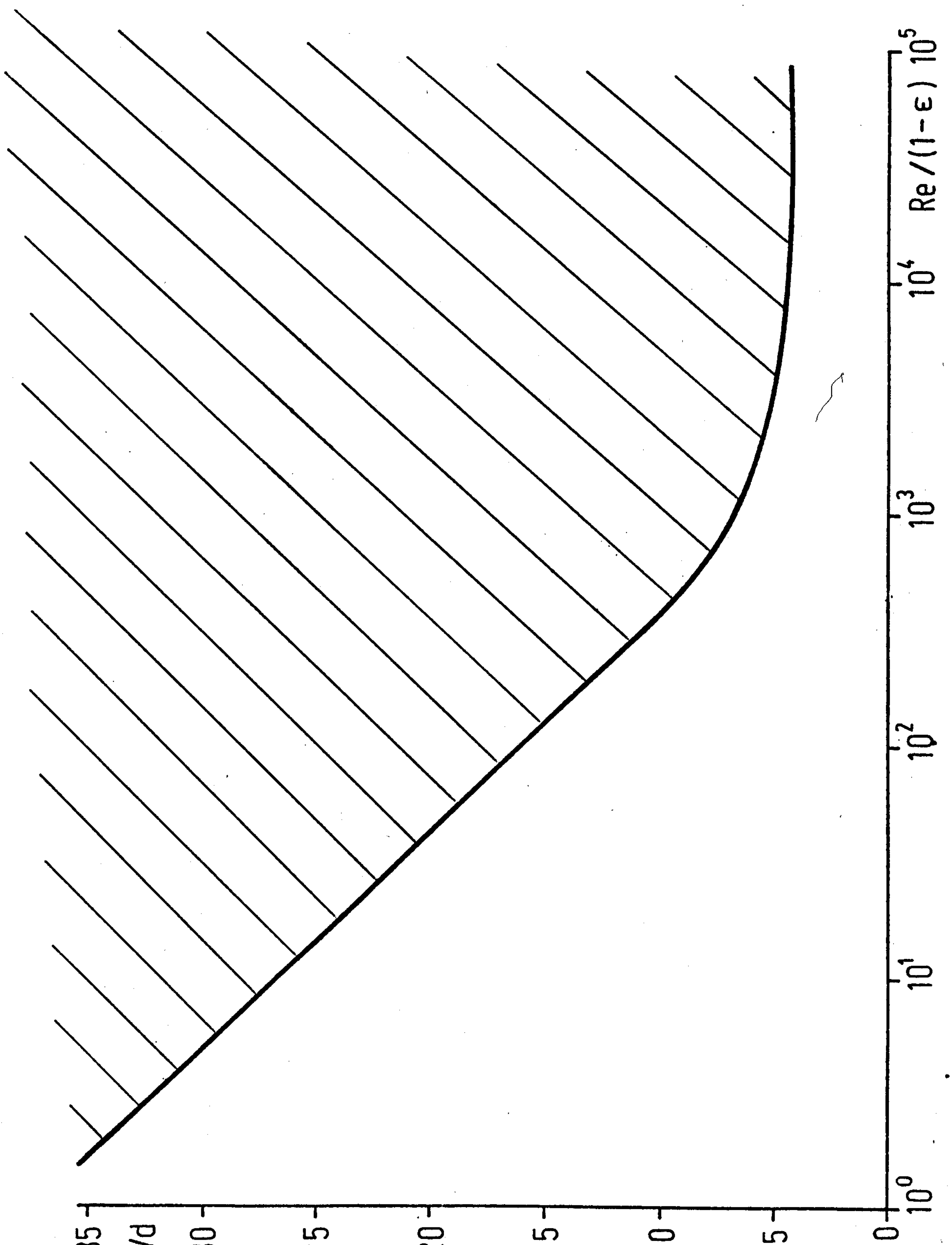

Figure 1-1: Limiting curve of the diameter ratio D/d as a function of the modified Reynolds number Re/(1-ε) (D/d values above the limiting curve)

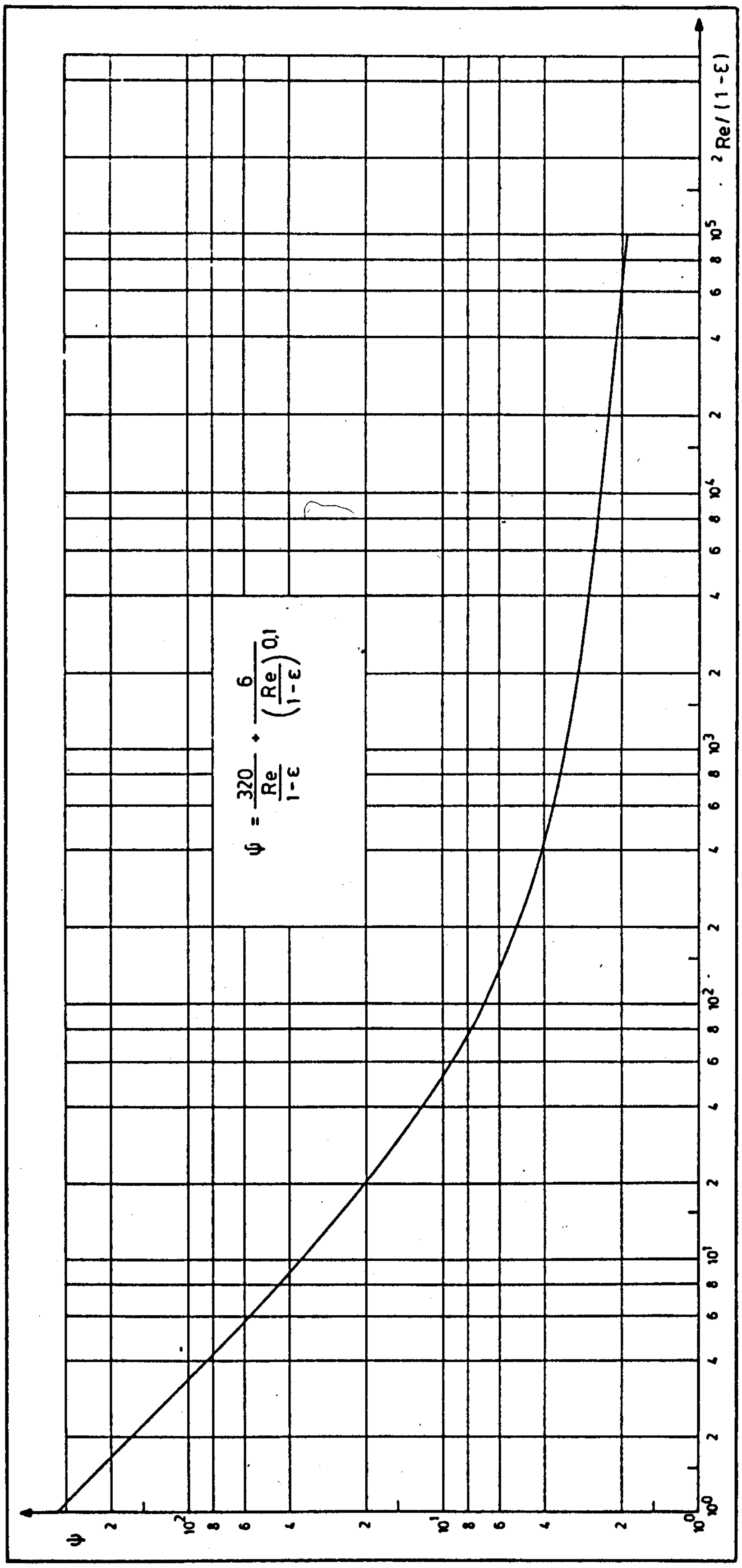

Figure 3-1: Coefficient of loss of pressure through friction Ψ as a function of the modified Reynolds number Re/(1 - ε)