CHRISTY® CATALYTICS

A WORLD LEADER IN INDUSTRIAL CERAMIC PRODUCTS

4641 McRee Avenue | Saint Louis, MO 63110 USA | P 314.773.7500 | F 314.773.8371 | www.christycatalytics.com

PRESSURE DROP CALCULATIONS THROUGH FIXED BEDS OF PROX-SVERS® CATALYST SUPPORT BALLS

PROX-SVERS® inert catalyst support balls are used for support and hold-down of catalyst and absorbent beds and to improve flow distribution.

FOR SUPPORT OF CATALYST AND ABSORBENT BEDS..................................

- A layer of PROX-SVERS above the mechanical grid assures retention of the relatively small particles comprising the catalyst or absorbent bed; or

- Filling the complete vessel head space below the bed with PROX-SVERS eliminates the need for a mechanical support structure, permitting simpler vessel design and easier vessel filling and dropout operations.

FOR HOLD-DOWN ABOVE CATALYST AND ABSORBENT BEDS..................

- A layer of PROX-SVERS on top of the bed serves as a buffer to prevent particle movement and subsequent attrition which can result during heat and flow surges; or

- Filling the vessel head space above the bed with PROX-SVERS eliminates all movement and assures bed integrity in event of sudden depressurization, equipment failures, or operating mishaps.

PROX-SVERS inert catalyst support balls provide a stable packing which retain uniform properties and are available in diameters ranging from 1/16" to 3" and in five types:

- **T-38 PROX-SVERS** are a vitrified alumina-silica ceramic ball. Its higher alumina content along with its unique design give it the best strength, impact resistance and resistance to pressure shock conditions of any ceramic ball on the market.
- **T-86 PROX-SVERS** are a vitrified alumina-silica ceramic ball similar to other well known, low cost ceramic balls on the market.
- **T-99 PROX-SVERS** are a > 99%, sintered, alpha-alumina alumina ball.
- **T-46 Alumina PROX-SVERS** are a high purity 95% alumina, chem bonded composition containing less than 0.3% silica. T-46 is designed specifically for the synthesis gas industry.

CALCULATION OF PRESSURE DROPS

The Ergun Equation*, commonly used to calculate pressure drop through catalyst packed beds, can be used to calculate pressure drop through bed sections packed with PROX-SVERS inert catalyst support balls. Satisfactory results are obtained for both gas and liquid systems.

The Ergun Equation can be written as follows:

$$\frac{\Delta P}{L} = 150 \frac{\mu G}{k g \rho D^2} \frac{(1-\varepsilon)^2}{\varepsilon^3} + 1.75 \frac{G^2}{\kappa g \rho D} \frac{(1-\varepsilon)}{\varepsilon^3}$$

Where ΔP = pressure drop, lb./in.^{2}, or psi
L = depth of the packed bed, ft.
$G = \rho V$ = mass velocity, lb./hr.-ft.^{2}
V = superficial linear velocity, ft./hr.
ρ = fluid density, lb/ft.^{3}
μ = fluid viscosity, lb./hr.-ft.
(centipoise x 2.42 = lb./hr.-ft.)
(centistokes x 0.3876 x density, lb./ft.^{3} = lb./hr.-ft.)
D = effective particle diameter, ft.
ε = interparticle void fraction, dimensionless
g = gravitational constant, 4.17 x 10^8 lb.-ft./lb.-hr.^{2}
k = conversion factor, 144 in.^{2}/ft..^{2}

Pressure drops are correlated in terms of ($\Delta P/L$), the pressure drop per unit length of packing. The term, ($\Delta P/L$), is usually expressed as "psi per foot of packing".

The first term on the right side of the Ergun Equation corresponds to the Blake-Kozeny Equation for laminar flow. Laminar flow exists when (DG/μ) (1/1-ε) and under these conditions the second term on the right can be ignored. The second term corresponds to the Burke-Plummer Equation for turbulent flow. When (DG/μ) (1/1-ε) the first term can be ignored. The term, (DG/μ), or its equivalent, ($D\rho V/\mu$), is a modified Reynolds Number.

Pressure drops can be calculated rapidly, using <u>Figures I and II</u>, when the Ergun Equation is reduced to the following form:

$$\frac{\Delta P}{L} = \frac{f C G^2}{\rho D} \times 10^{-10}$$

Where $C = \frac{1.75 \times 10^{10}}{144 g} \left(\frac{1-\varepsilon}{\varepsilon^3} \right)$

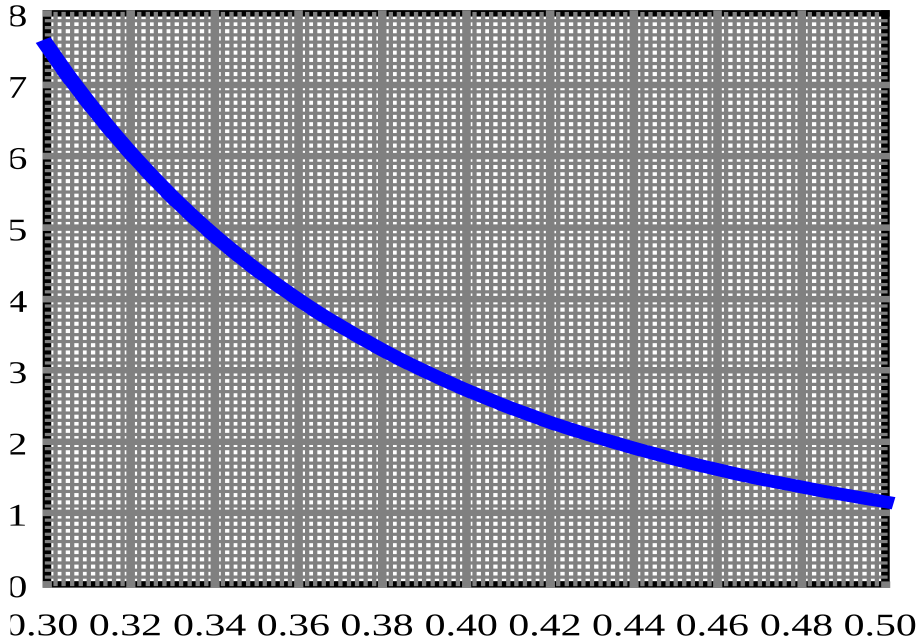
$$f = 1 + \frac{150}{1.75} \left(\frac{DG}{\mu} \right)^{-1} (1-\varepsilon)$$

Values of *C* are given in <u>Figure 1</u> for ε in the range 0.30 to 0.50. Values of f as a function of modified Reynolds Number, (DG/μ), for selected values of ε, are given in <u>Figure II</u>.

Typical values of void fraction, ε, and effective particle diameter, *D*, for PROX-SVERS inert catalyst support balls of various sizes are presented in the accompanying table.

*Ergun, S., <u>CEP</u>, <u>48</u> (2), 89-94 (1952)

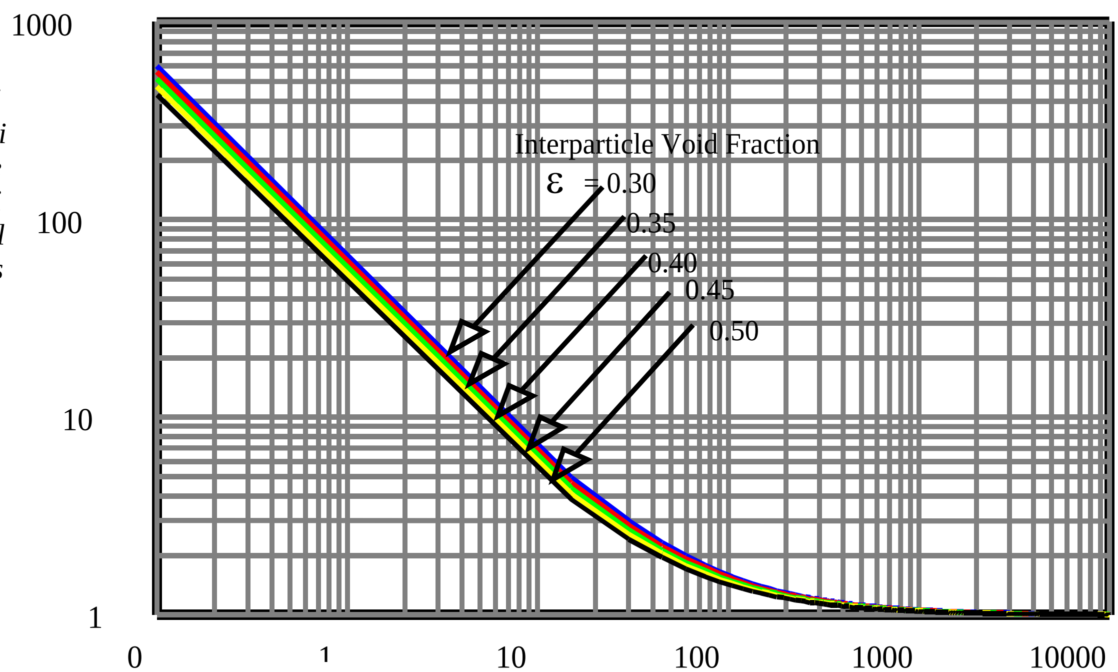
FIGURE I



$"C", \left(\frac{hr^2}{ft} \times \frac{ft^2}{in^2}\right)$

INTERPARTICLE VOID FRACTION, ϵ, (Dimensionless)

FIGURE II



"f" (Dimensionless)

MODIFIED REYNOLDS NUMBER, $\left(\frac{DG}{\mu}\right)$*, (Dimensionless)*

Ergun Constants for PROX-SVERS® Inert Catalyst Support Balls

Nominal Diameter (Inch)	Tolerance		"*D*" Effective Diameter (Feet)	"ε" Void Fraction (Dimensionless)
	Larger Than (Inch)	Smaller Than (Inch)		
1/8	1/8	3/16	0.013	0.40
1/4	3/16	3/8	0.023	0.42
3/8	1/4	1/2	0.031	0.43
1/2	3/8	5/8	0.041	0.43
5/8	1/2	3/4	0.051	0.44
3/4	5/8	7/8	0.062	0.45
1	7/8	1-1/8	0.082	0.45
1-1/4	1-1/8	1-3/8	0.104	0.46
1-1/2	1-3/8	1-5/8	0.125	0.46
2	1-7/8	2-1/8	0.167	0.46
3	2-7/8	3-1/8	0.250	0.46

REVISED: Dec, 2010