Christy Catalytics, LLC
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ISO 9001:2000 Certified

Innovators Of Industrial Ceramic Products

The Christy Companies
St. Louis Missouri USA

The evolution of the Christy companies begins in the late 1800's, with the Laclede-Christy Brick Company, a St. Louis manufacturer of building bricks.

The booming industrial base in St. Louis led to the 1922 spin-off of the Christy Firebrick Company to service the region's steel and aluminum mills, petroleum refineries, glass furnaces and foundries associated with the region's automotive, railroad, aeronautical, and agricultural industries.

An expanding product line of both self-manufactured and distribution products for these industries caused a name change to The Christy Refractories Company (CRC), reflecting not only extended product lines, but geographical coverage as well. CRC was now offering ceramic fiber insulation in several formats, firebrick, castable refractory, and refractory shapes and parts, across the North American continent.

One new product, developed at the suggestion of the Phillips Petroleum Company in 1952, was a spherical ceramic catalyst bed support to replace the angular crushed firebrick Phillips had been using in catalytic petroleum refining processes. The pioneering spherical shape for catalyst support media was not only less expensive to produce, but offered lower power consumption for compression, and reduced dust contamination. This technological advancement grew to become the extended line of Christy PROX-SVERS® inert catalyst and adsorbent support media as we know it today, with products tailored for numerous refining and chemical processes.

By 2004, the quality and associated success of Christy's PROX-SVERS® had taken Christy's market to a global level, with increasing activities in Asia, India, the Middle East, and Latin America, as well as the traditional US and Canadian markets. Additional products of interest to our customer base were added to the portfolio.

The Christy Catalytics LLC (CATCO) was spun off in 2004 to focus on the global petroleum refining, petrochemical processing, and related industries.

Christy maintains a direct sales and marketing staff in our St. Louis headquarters, and an established network of qualified and competent sales agents in most global regions active in the petroleum, petrochemical, gas processing, fertilizer, and steel industries.

The other Christy companies include:

- The Christy Refractories Company (CRC), manufacturing and distributing refractory and insulating products to the original target industries of metals, glass, and ceramics production.
- Christy Minerals Company LLC (CMC), engaged in exploration, mining and processing of refractory and ceramic raw materials
- Christy Industrial Services (CIS), engaged in installation of refractory products in the target industries within the home territory

Although diversified in structure, the four Christy companies still share a common history, and draw upon the technical resources and staff experience assigned to each division.

Christy PROX-SVERS® Inert Catalyst Bed Support Media

The 1952 development of the first **PROX-SVERS®** catalyst bed support (CBS), known as T-22, is described above. This was arguably the first spherical CBS produced. But Christy has never stopped innovating. Christy is staffed with ceramics engineers constantly working on new products in the field of industrial ceramics.

Today, Christy offers four distinct families of CBS, with chemistries and physical properties tailored to specific end uses in the petroleum refining, petrochemical, and gas processing industries. Two of these **PROX-SVERS®** CBS are truly unique, globally, with properties found in no other company's portfolio of CBS.

Our reach is global. Over 50% of **PROX-SVERS®** CBS is shipped into countries other than USA.

The two premier CBS in the **PROX-SVERS®** line are made in Christy's own manufacturing facility in St. Louis Missouri, where we hold tight to proprietary formulas and manufacturing processes. The other two grades are made to our specifications by partner manufacturers around the world.

Severe Duty

For refining purposes, the premier **PROX-SVERS®** grade is our **T-38**. Introduced 10 years ago, it is truly unique in its formula and manufacturing process, resulting in the highest:

- Service temperature rating
- Crushing strength
- Attrition resistance
- Pressure shock resistance
- Thermal shock resistance
- Overall refractoriness

Its development was quite intensive, and in fact incorporated years of effort from Christy's ceramists. **T-38** properties are so robust that it is the *only* CBS media called

out by the licensor of a well-recognized naphtha reforming process. **T-38** is also specifically approved by most major refiners.

Synthesis Gas and Monomer Processing
For synthesis gas processes within the refinery, most notably SMR hydrogen, but also ammonia, methanol, and GTL processes, Christy offers silica-free products **PROX-SVERS® T-46** and **T-99**. Due to their extreme purity and resulting catalytic inertness, these two products are also widely used in monomer processing (ethylene and propylene, for example) where trace metal impurities can kick off undesirable or premature reactions.

PROX-SVERS® T-46 is unique in that it is the sole CBS that can actually get stronger with use.

General Purpose
For less severe applications, Christy offers **PROX-SVERS® T-86**. Like **T-38**, this is a clay-based silica-alumina but without the additives and proprietary production process that distinguish the premier **T-38**. This product is made to our specification in Asia by several partners.

T-86 is similar to offerings by other CBS vendors. Like them, it is not quite as robust as **T-38**, and should be avoided in processes with extremely high temperature or pressure. But, its economy makes it the go-to grade for general or utility purpose, particularly adsorption or filtration units.

We at Christy take pride in our product standards and our justly earned 50-year reputation. While we do outsource some production, we do not merely “buy off the Net”. Rather, we control all outsources with:

- Christy product specifications above and beyond the manufacturer’s own internal specs
- Prototype testing in our own ceramics laboratory
- Periodic on-site inspections and audits of supplier facilities and quality systems
- Rigorous review and approval of the manufacturing partner’s COA before every shipment
- Final QC approval of finished goods in our own ceramics labs

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PROX-SVERS® INERT CATALYST SUPPORT BALLS

TYPICAL CHEMICAL ANALYSIS (wt.%)	T-38	T-46
Alumina, Al_2O_3	30 - 38	92 - 96
Silica, SiO_2	54 – 63	0.3
Calcia, CaO	< 1	4 - 8
Titania, TiO_2	2	< 0.1
Alkalies, $K_2O + Na_2O$	1 – 3	< 0.3
Magnesia, MgO	< 1	< 0.1
Leachable Iron	< 0.001	< 0.02
Leachable Sulphur	None Detected	None Detected
Leachable Chlorides	None Detected	< 0.001

TYPICAL PHYSICAL PROPERTIES	T-38	T-46	
Shape	Spherical	Spherical	
Avg Crush Strength, lbs (kg) *1/16"(1.6 mm)	> 20 (9)	N/Av	
1/8" (3.2 mm)	170 (77)	60 (27)	
1/4" (6.4 mm)	325 (147)	100 (45)	
1/2" (12.7 mm)	675 (306)	450 (204)	
3/4" (19.0 mm)	1500 (680)	710 (322)	
1" (25.4 mm)	2750 (1247)	1150 (521)	
1-1/4" (31.8 mm)	>3000 (1362)	1350 (612)	
1-1/2" (38.1 mm)	>3000 (1362)	1800 (816)	
2" (50.8 mm)	>3000 (1362)	>2000 (907)	
3" (76.2 mm)	N/Av	>2000 (907)	
Loose Fill Packing Density, lbs/ft^3 (kg/m^3)	82 - 88 (1314 - 1410)	≤ 1-1/4" 89 – 98 (1426-1570)	≥ 1-1/2" 95 – 100 (1522-1602)
Apparent Particle Density, lbs/ft^3 (g/cc)	150 (2.4)	220 (3.5)	
Water Absorption, Wt. %	< 1	N/Av	
Hardness, Mohs'	6.5	N/Av	
Maximum Use Temperature, °F (°C)	2500 (1370)	3200 (1760)	
Mean Specific Heat, BTU/ lb-°F	0.25	0.25	
Thermal Shock Resistance (heated to 1500°F and quenched in water)	Passed	Passed	

* T-38 1/16" has a modified chemistry of 25% Al2O3 and 70% SiO2 and a maximum use temperature of 1800°F.

Above data is based on control test results. Individual test results may vary, therefore this data may not be used for specifications.
Average crush strength values are actual pounds required by a press to break individual spheres.

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PROX-SVERS® INERT CATALYST SUPPORT BALLS

TYPICAL DIMENSIONAL TOLERANCES	T-38	T-46
1/16” 1.6 mm	0.7 < ∅ < 3.0mm	----------
1/8" 3.2 mm	1/8 < ∅ < 3/16 3.2 < ∅ < 4.8	1/8 < ∅ < 3/16 3.2 < ∅ < 4.8
1/4" 6.4 mm	3/16 < ∅ < 3/8 4.8 < ∅ < 9.5	----------
† 1/4" A 6.4 mm	----------	3/16 < ∅ < 5/16 4.8 < ∅ < 7.9
† 1/4" B 6.4 mm	----------	5/16 < ∅ < 3/8 7.9 < ∅ < 9.5
3/8" 9.5 mm	1/4 < ∅ < 1/2 6.4 < ∅ < 12.7	1/4 < ∅ < 1/2 6.4 < ∅ < 12.7
1/2" 12.7 mm	3/8 < ∅ < 5/8 9.5 < ∅ < 15.9	3/8 < ∅ < 5/8 9.5 < ∅ < 15.9
5/8" 15.9 mm	1/2 < ∅ < 3/4 12.7 < ∅ < 19.1	1/2 < ∅ < 3/4 12.7 < ∅ < 19.1
3/4" 19.0 mm	11/16 <∅< 13/16 17.5 < ∅ < 20.6	5/8 < ∅ < 7/8 15.9 < ∅ < 22.2
1" 25.4 mm	15/16 < ∅ < $1^{1}/_{16}$ 23.8 < ∅ < 27.0	7/8 < ∅ < $1^{1}/_{8}$ 22.2 < ∅ < 28.6
1 1/4" 31.8 mm	$1^{3}/_{16}$ < ∅ < $1^{5}/_{16}$ 30.2 < ∅ < 33.3	$1^{1}/_{8}$ < ∅ < $1^{3}/_{8}$ 28.6 < ∅ < 34.9
1 1/2" 38.1 mm	$1^{7}/_{16}$ < ∅ < $1^{9}/_{16}$ 36.5 < ∅ < 39.7	$1^{7}/_{16}$ < ∅ < $1^{9}/_{16}$ 36.5 < ∅ < 39.7
2" 50.8 mm	$1^{15}/_{16}$ < ∅ < $2^{1}/_{16}$ 49.2 < ∅ < 52.4	$1^{15}/_{16}$ < ∅ < $2^{1}/_{16}$ 49.2 < ∅ < 52.4
3" 76.2 mm	----------	$2^{15}/_{16}$ < ∅ < $3^{1}/_{16}$ 74.6 < ∅ < 77.8

∅ Average ball diameter.

† These sizes are segregated by pallet and part number. If necessary, both sizes will be shipped to fill an order unless otherwise notified. Should it be specified that these two sizes not be combined, it may affect availability.

Above data is based on control test results. Individual test results may vary, therefore this data may not be used for specifications.

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T-86 PROX-SVERS® INERT CATALYST SUPPORT BALLS

TYPICAL CHEMICAL ANALYSIS (wt. %)	**T-86**
Alumina, Al_2O_3	18 – 23
Silica, SiO_2	70 – 75
Calcia, CaO	< 1
Titania, TiO_2	< 2
Alkalies, $K_2O + Na_2O$	1 – 4
Magnesia, MgO	< 1
Leachable Iron	< 0.001
Leachable Sulphur	None Detected
Leachable Chlorides	None Detected

TYPICAL PHYSICAL PROPERTIES	**T-86**
Shape	Spherical
Avg Crush Strength, lbs (kg) 1/8"(3.2 mm)	100 (45)
1/4" (6.4 mm)	300 (136)
1/2" (12.7 mm)	900 (408)
3/4" (19.0 mm)	>2000 (907)
1" (25.4 mm)	>3000 (1360)
1-1/4" (31.8 mm)	>3000 (1360)
1-1/2" (38.1 mm)	>3000 (1360)
2" (50.8 mm)	>3000 (1360)
Loose Fill Packing Density, lbs/ft^3 (kg/m^3)	81 - 86 (1298 - 1378)
Apparent Particle Density, lbs/ft^3 (g/cc)	143 (2.3)
Water Absorption, wt. %	< 1
Hardness, Mohs'	6.5
Maximum Use Temperature, °F (°C)	1800 (982)
Mean Specific Heat, BTU/ lb-°F	0.25
Thermal Shock Resistance (heated to 1500°F and quenched in water)	Passed

Above data is based on control test results. Individual test results may vary, therefore this data may not be used for specifications.
Average crush strength values are actual pounds required by a press to break individual spheres.
NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY ARE MADE REGARDING THE DATA OR PRODUCTS SHOWN ABOVE.

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T-99 PROX-SVERS® INERT CATALYST BED SUPPORTS

T-99 PROX-SVERS® catalyst bed support media, composed of sintered alpha-alumina with very low impurity levels, are essentially inert in most chemical environments.

The low silica content makes **T-99** an excellent choice for high temperature applications in the presence of high water partial pressures, where silica leaching must be held minimal, such as in reformers for synthesis gas production.

The low level of other impurities makes **T-99** an excellent recommendation for supporting adsorbents used to purify reactive monomers such as ethylene and propylene.

TYPICAL CHEMICAL ANALYSIS (wt.%)	T-99
Alumina, Al_2O_3	99.5
Silica, SiO_2	0.02
Iron, Fe_2O_3	0.02
Soda, Na_2O	< 0.20

TYPICAL PHYSICAL PROPERTIES	T-99	
Shape	Spherical	
Avg Crush Strength, lbs (kg) 1/16" (1.0 – 2.0 mm)	120 (55)	
1/8" (3.2 mm)	400 (181)	
1/4" (6.4 mm)	600 (272)	
5/16" (7.9 mm)	700 (317)	
1/2" (12.7 mm)	2300 (1043)	
3/4" (19.0 mm)	>3000 (1360)	
1" (25.4 mm)	>5000 (2268)	
2" (50.8 mm)	>5000 (2268)	
Loose Fill Packing Density, lbs/ft^3 (kg/m^3)	≤ 1-1/4" 125 – 135 (2003 - 2163)	≥ 1-1/2" 115 - 125 (1842 - 2003)
Apparent Particle Density, lbs/ft^3 (g/cc)	225 (3.6)	
Apparent Porosity, Wt%	≤ 1-1/4" < 1%	≥ 1-1/2" <5%
Maximum Use Temperature, °F (°C)	3272 (1800)	
UOP Attrition Loss, Wt%	< 0.5	
UOP Thermal Shock Resistance	Passed	
UOP Pressure Shock Resistance	Passed	

The above data are based on controlled testing. Individual test results may vary, therefore these data may not be used for specification purposes. Average crush strength values are actual force required by a hydraulic press to break individual spheres.

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Innovators Of Industrial Ceramic Products

PRESSURE DROP CALCULATIONS

THROUGH 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-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 secondary ammonia reformers. T-46 1-1/2", 2" and 3" are also available in a low pressure drop version.
- **T-38 PROX-SVERS** are a vitrified alumina-silica product. Its higher alumina content along with its unique design give it the best strength, impact resistance and resistance to pressure shock conditions of any vitrified inert on the market.
- **T-86 PROX-SVERS** are a vitrified alumina-silica product similar to other well known, low cost vitrified inerts in the market.
- **T-99 PROX-SVERS** are a > 99%, sintered, alpha-alumina product. It is available in porosities ranging from <1% to 20%.

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:

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

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)<10, 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) >1000, 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 Figures I and II, when the Ergun Equation is reduced to the following form:

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

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

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

Values of C are given in Figure 1 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 Figure II.

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., CEP, 48 (2), 89-94 (1952)

FIGURE I

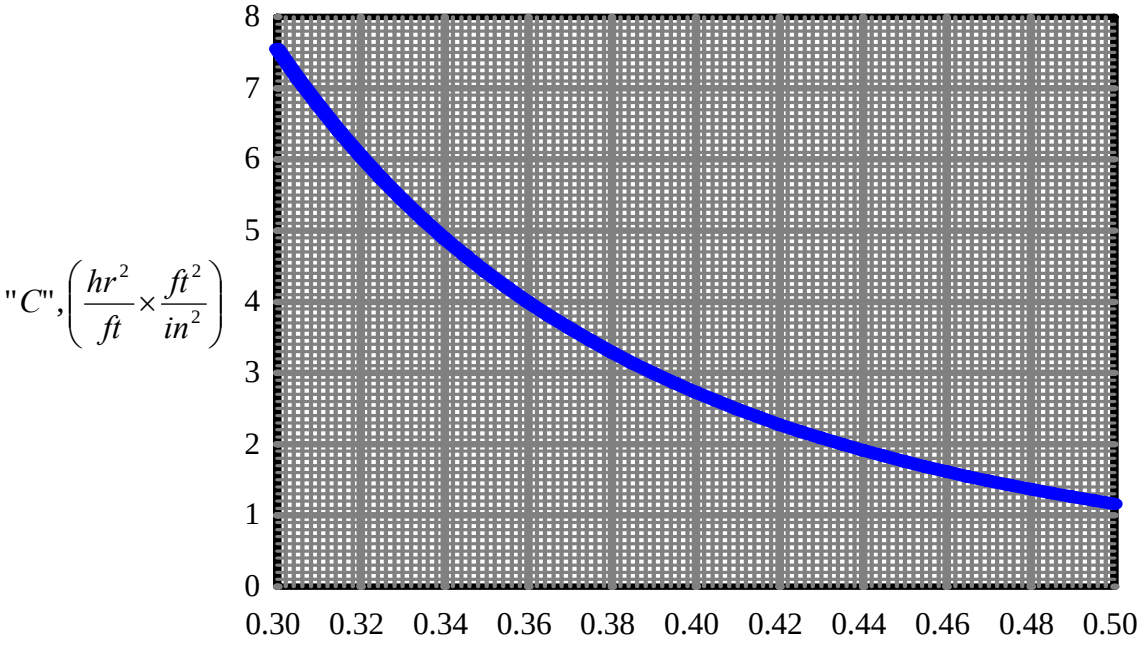
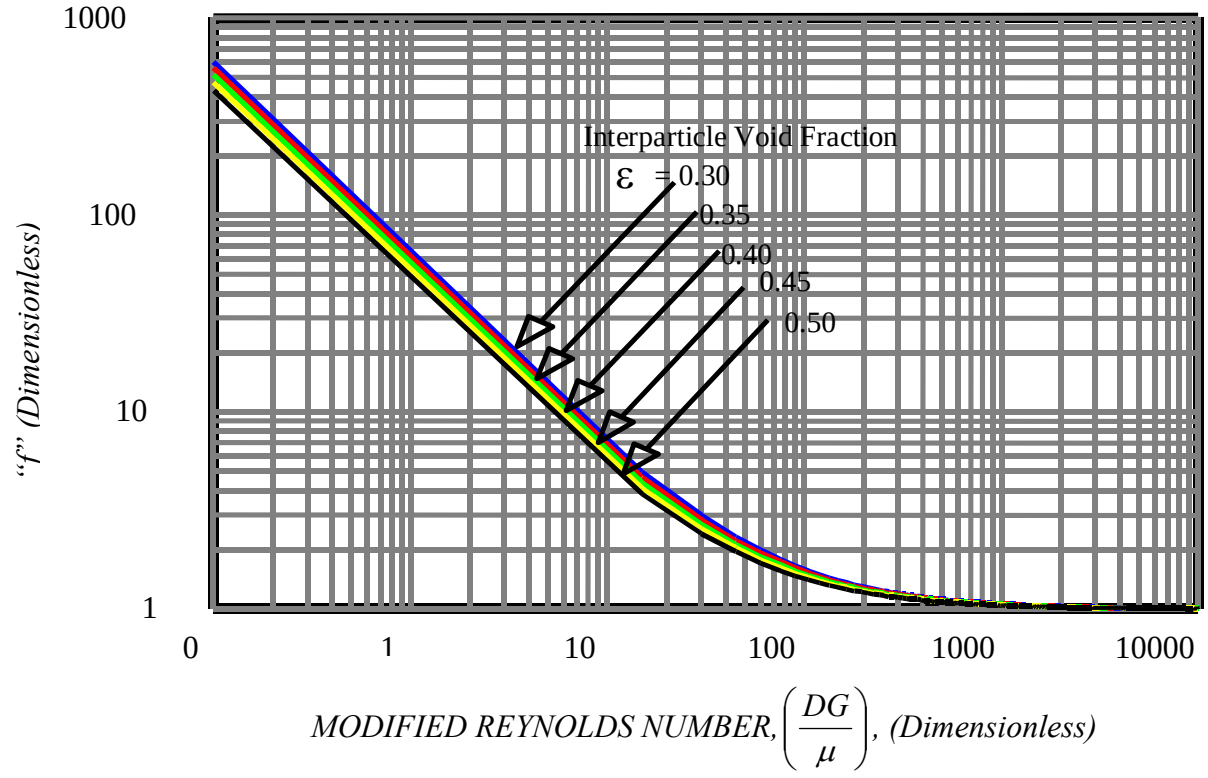


FIGURE II



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

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RECLAIMED CATALYST SUPPORT MEDIA

Some refineries and chemical plants are reusing their previously used catalyst support media. Some are purchasing previously used support media from ex-situ catalyst regeneration companies or metals reclaimers. Although the economics of these practices may be attractive in some situations, users of previously used catalyst support media should be aware of the potential problems:

Catalyst support media tend to exhibit scavenging capacity for various contaminants. Some are installed specifically for trash collection. Some may chemisorb sulfur or chlorine. Some may adsorb heavy metals. The surface trash collection and the sorption phenomena can be reversible when previously used support media are subsequently reused in a different unit, thereby resulting in catalyst poisoning.

Physical properties of catalyst support media, especially vitrified media, previously used in high pressure hydrogen service can be severely degraded. In addition, the vessel unloading and subsequent reclamation processes can degrade physical properties such as crush strength and impact resistance which are key to catalyst support performance. Subsequent reuse can result in excessive breakage to chips and fines and, in turn, cause pressure drop and flow distribution problems within the reactor and plugging problems downstream.

Catalyst support media flushed from a unit or washed following prior use may be contaminated with soda or caustic or other potential catalyst poisons. Unless thoroughly cleaned, many of these poisons are leachable during subsequent reuse, resulting in loss of catalyst activity.

The potential problems associated with the reuse of previously used inert catalyst support media tend to be exacerbated by the way in which these products are handled. Typical handling procedures seem to fly in the face of quality standards such as ISO 9001:2000. Previously used support media are frequently accumulated based only on size and records on prior use tend to be sparse. "Lot analysis" from such accumulations may not represent or may totally mask the potential problems previously used catalyst support media may cause.

It is true that the price of a new charge of inert catalyst support media may appear to be less attractive than the price of previously used material. But it is also true that the price of a new charge of inert catalyst support media is generally very low relative to the price of the catalyst it is purchased to protect, and extremely low relative to the cost of the potential problems which can result from the reuse of previously used inert support media.

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CUSTOM CRAFTED™ HEXAGONAL TARGET TILE

• APPLICATIONS

Christy's high alumina, low silica Hexagonal Target Tiles are used to protect the catalyst in the secondary reformer from being churned by the hydrogen-steam gas stream. The use of tile without holes in the center area is specified by KBR and may be called for by the plant owner. The hexagonal tile area is about 1" to 1-1/2" short of the unit sidewall and partial tile are used to form the periphery of the tile area. A ring of Universal Circle Brick is placed next to the vessel lining and under the periphery hexagonal tile.

• RECENT INNOVATIONS

- Christy's most recent development is the Super Jumbo Hexagonal Tile. This innovation evolved as a result of recent increased production rates, new design burner installations and/or the target tile being placed closer to the burner. The Super Jumbo Hexagonal Tile has both a much larger footprint (16-1/2" inches) and greater mass (49 pounds) which makes the tile less likely to move under extreme process conditions.
- 99% Al_2O_3 for extreme erosion problems. Christy has developed a 99% alumina, high fired mix which offers superior erosion resistance for severe applications.

• ADVANTAGES

- Low Installation Cost
- High Purity, does not poison process stream
- Reduces Hold-Down Support Cost
- Proven in Chemical Processes for 25+ Years
- Faster Installation, due to less pieces

• MATERIAL (contains no SiO_2)

- 95% Aluminum Oxide (general purpose)
- 99% Aluminum Oxide (for superior erosion resistance)

• AVAILABLE SIZES

- Standard 2" thickness
- Jumbo 2-1/2", 3-1/2", & 6" thickness
- Super-Jumbo 3-1/2" thickness
- Universal Circle Brick (9" x 4.5" x 2.5") (23cm x 11.5cm x 6.4cm)

	2" Standard	2.5" Jumbo	3.5" Jumbo	6" Jumbo	3.5" Super
Thickness, in. (cm)	2 (5.1)	2.5 (6.4)	3.5 (8.9)	6.0 (15.2)	3.5 (8.9)
Size, in. (cm)	5-5/16 (13.5)	7-1/2 (19)	7-1/2 (19)	7-1/2 (19)	16-1/2 (42)
Target Area – No Holes	✔	✔	✔	✔	✔
3/8" Holes, Qty	12	N/Av	N/Av	N/Av	N/Av
1/2" Holes, Qty	12	25	25	N/Av	N/Av
5/8" Holes, Qty	12	N/Av	N/Av	N/Av	N/Av
3/4" Holes, Qty	N/Av	14 or 25	14 or 25	N/Av	138
Approx. Weight, lbs (kg)	3.6 (1.6)	7.5 (3.4)	10.5 (4.8)	23 (10.5)	49 (22.2)
No. of Std Tile Per Pc.	1.0	1.8	1.8	1.8	9.1

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PROX-SVERS® INERT SUPPORT MEDIA REFERENCE LIST

PETROCHEMICAL AND REFINING

Agrium
Aguaytia
Air Liquide
Air Products & Chemicals
ArcelorMittal Steel
Arkema
Atlantic LNG
Atlas Methanol
Atofina Chemicals
Aux Sable Liquid Products
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Ballance Nitrogen Nutrients
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BASF-Fina
Badger Licensing
Beaumont Methanol
Bechtel Corp.
Bioko LNG
BP Petroleum
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Burrup Fertilizer
C-F Industries
Cabinda Gulf Oil
Cabot Corp.
Caltex Petroleum
Caribbean Nitrogen
CB&I Howe Baker Engineers
CB&I Lummus
Cherokee Nitrogen
Chevron Phillips Chemical
Chevron
Coffeyville Resources
Colgate Palmolive
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Cos-Mar Company
Daelim
Dakota Gasification
Darwin LNG
Dawood Hercules
Dial Corp.
DSM
Duke Energy/Spectra
E.I. Du Pont de Nemours
Dyno Nobel
Eastman Chemical
Ecopetrol
Egypt Basic Industries
Egyptian LAB
Egyptian LNG
Engro Chemical - Pakistan
ENI
Equistar/Lyondell
Esso
ExxonMobil
FertiNitro
Flint Hills Refining
Formosa Petrochemical
Frontier Refining
Georgia Gulf
Giant Refining
Grace Davison
Green Valley Chemical
Haldor Topsoe
Hellenic Petroleum
Hindustan Petroleum
Holanda Venezuela C.A.
Holly Refining
Honeywell
Hydro Agri Trinidad
Imperial Oil/ESSO
Incitec Pivot
Indian Farmers Fertilizer (IFFCO)
IPSL, Trinidad
Jacobs Engineering
Johnson Matthey
KBR
Koch Nitrogen
Kuwait Nat'l Petroleum
Linde BOC
Lurgi

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Nitrogen 2000
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Texas Eastman
Texas Petrochemicals
Tidewater Polymer
Titan- Malaysia
Tosco Corporation
Total Petroleum
Toyo Engineering (TEC)
Trinidad/Tobago Methanol
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WHITE FUSED ALUMINA LUMPS

TYPICAL CHEMICAL ANALYSIS (wt. %)	
Alumina, Al_2O_3	99.5%
Silica, SiO_2	< 0.10
Calcia, CaO	< 0.05
Ferric Oxide, Fe_2O_3	< 0.05
Alkalies, $K_2O + Na_2O$	< 0.05
Magnesia, MgO	< 0.10

TYPICAL PHYSICAL PROPERTIES	
Specific Gravity	3.77
Bulk Density, lbs./ft.^{3}	220
Loose Fill Density, lbs/ft.^{3}	120-132
Apparent Porosity	7.8%
Melting Point	2040ºC
Specific Heat – cal/gm/ºC at 100ºC	0.217
Coefficient of Linear Expansion 25 - 500ºC 25 - 1000ºC 25 - 1500ºC	 7.58 x 10^{-6}/ºC 8.52 x 10^{-6}/ºC 9.29 x 10^{-6}/ºC
Thermal Conductivity in cal/cm^2/sec/cm/ºC at 200ºC at 600ºC at 1000ºC at 1400ºC	 0.054 0.022 0.015 0.013
Typical Sizes (Call for Other Sizes)	1” x 2” (25x50 mm) 2” x 3” (50x75 mm) 2” x 4” (50x100 mm) 4” x 8” (100x200 mm)

Revised: December 17, 2009