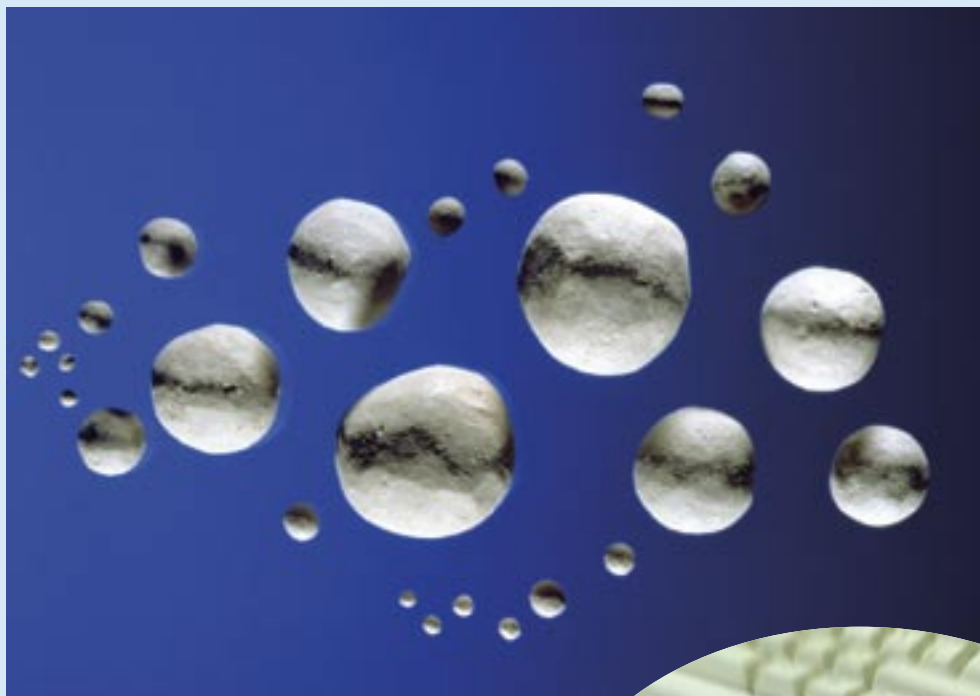


Denstone® Support Media



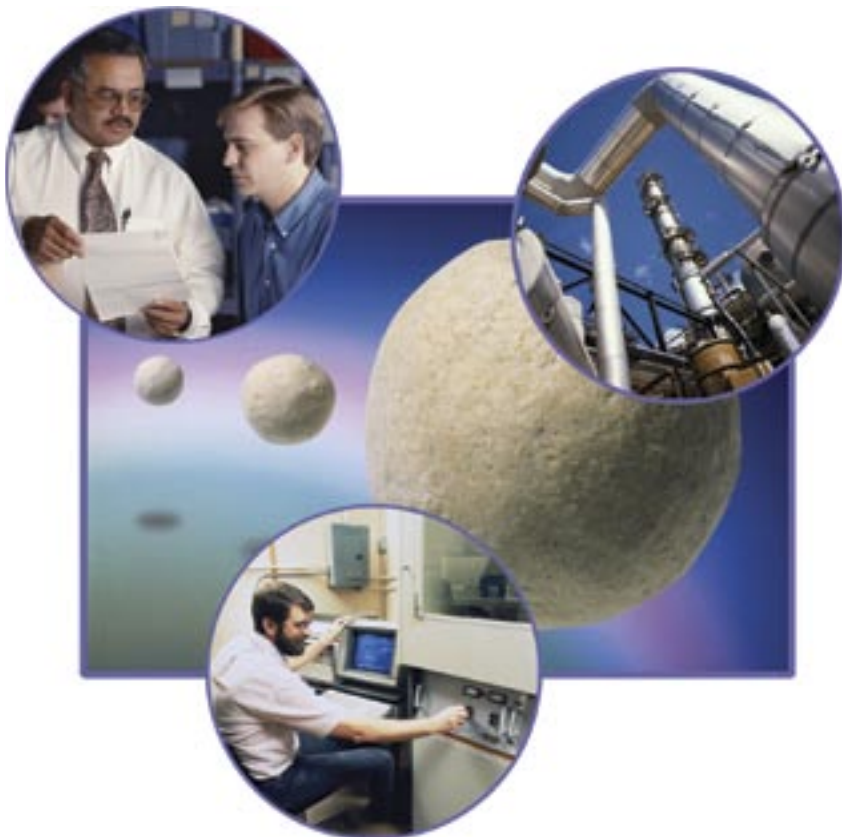
About Us

Saint-Gobain NorPro, formerly known as Norton Chemical Process Products, has a distinguished history of engineering excellence in offering traditional and high-technology products and services for use in various refining, chemical, petrochemical, gas processing and environmental applications. With more than 100 years of experience serving these markets worldwide, Saint-Gobain NorPro is the world leader in ceramic catalyst bed support technology and has set the industry standard with such products as Denstone® support media.

Saint-Gobain NorPro is headquartered in Stow, Ohio, USA, with manufacturing facilities located in Arkansas, Texas, Tennessee, China and Germany. Saint-Gobain NorPro has a worldwide staff of engineers, ceramists, chemists and other technical specialists dedicated to solving each client's problem, wherever they may arise.

Saint-Gobain NorPro is a wholly-owned subsidiary of Compagnie de Saint-Gobain, a multinational corporation with headquarters in Paris. A world leader in engineered materials, Saint-Gobain consists of more than 1,200 companies in 46 countries, with annual sales over €31 billion.

Saint-Gobain companies lead the world in a number of engineered materials' market segments, including advanced ceramics, abrasives, insulation, containers and building materials.



The Industry Standard

Tested, Tried and True

Saint-Gobain NorPro set the industry standard for quality and structural integrity over 60 years ago with the introduction of Denstone® support media for fixed catalyst bed applications. Today, we offer the most extensive range of ceramic support media products in the industry. Our manufacturing technologies have been selected and perfected over many years to yield seamless monolithic spheres which will not split, crack, or spall in use. The non-spalling, non-dusting properties of Denstone support media prevents fouling or plugging of the catalyst bed.

Will Not Plug Catalyst Bed

NorPro™ Denstone® patented support media technology ensures seamless, monolithic spheres which eliminates splitting and spalling.

Benefit: Plugging of the catalyst bed is prevented, optimizing the process efficiency by keeping the pressure drop low and the catalyst activity high.



Denstone® Media
Cross section of Denstone® support media vs. competitors

High Thermal Shock Resistance

Unique NorPro™ technology yields support media with a high thermal shock resistance.

Benefit: Denstone supports will retain their physical properties when exposed to thermal cycling. Poor quality spheres will break, chip or spall, leading to adverse process efficiency and increased operating costs.

Will Not Contaminate

Denstone media are engineered to maximize resistance to attrition and thus minimize the possibility of catalyst contamination.

Benefit: Contamination of catalyst is prevented, extending the catalyst's active life, and reducing operating costs.

Will Not Poison Catalyst

Denstone support media are free of sulfur, boron and other common catalytic poisons. Manufactured Denstone® media have a leachable iron content, expressed as Fe_2O_3 , of less than 0.1%. Furthermore, analysis of Denstone® media boiled in 10% hydrochloric acid for 64 hours indicates a leachable iron content of less than 0.005% by weight. Tests establish that leachable chlorides and sulfur are each less than 1 ppm by weight for both crushed and uncrushed Denstone media.

Benefit: No catalyst poison is introduced to the process, allowing the catalyst to perform optimally and thus avoiding severe cost implications such as plant shut downs, catalyst replacement and re-installation and loss of throughput.

Denstone® 57 Support Media

Denstone® 57 support media are the most widely used support media in the world. With their unparalleled consistency and reliability, Denstone 57 support media remain the industry standard.

Clean Fuels: A New Standard

Clean Fuel standards have raised the bar in process optimization. When every component is critical, why entrust your process to a low-quality support media? Select the product you can trust - Denstone support media from Saint-Gobain NorPro. Whether you are installing a new reactor or revamping an existing one, Denstone support media are the support media of choice. The high quality raw materials and controlled processing means that the Denstone product is not susceptible to the spalling, cracking, or splitting experienced with lesser quality support media. Denstone support media ensure that your catalyst won't suffer premature catalyst replacement.

Dehydration/Desulfurization

Saint-Gobain NorPro is a world-leader in providing high-technology ceramics used in the purification of natural gas and other feedstreams. In fact, our Denstone® 57 media are the leading adsorbent and desiccant bed support media in the industry. With a wide range of available sizes, the most consistent properties, and a quality program certified to ISO-9001:2000, Saint-Gobain NorPro is the smart choice in bed support media for adsorbents, molecular sieve, and silica gel, as well as for catalysts used in desulfurization of sour feedstreams by the Claus process.

Regardless of the type of molecular sieve your process employs: 3A for dehydration, 4A for natural gas drying, or 5A for H₂S and CO₂ removal, Denstone 57 bed support media are the optimum choice for reliable, worry-free performance.

Hydroprocessing

Hydroprocessing subjects support media to a demanding environment. Denstone bed support media were developed to provide optimal performance in all hydroprocessing conditions. Our industry standard Denstone 57 ceramic support media are the preferred option for most hydroprocessing applications.



Denstone® 2000 Support Media

Denstone® 2000 support media revolutionized the industry with unmatched impact resistance, thermal shock, crush strength and survivability. This outstanding combination of properties make Denstone 2000 support media the product of choice for more severe hydroprocessing applications, such as hydrocracking, or when an extra degree of reliability is desired.

Clean Fuels: Hydrocracking

If hydrocracking is a part of your process strategy for meeting Clean Fuels targets, then Denstone® 2000 support media are the product of choice for maximizing performance. Denstone® 2000 support media are the only media developed specifically for hydrocracking applications. Its patented formulation coupled with state of the art manufacturing techniques results in high crush strength and an engineered microstructure which enables it to survive rapid depressurization and thermal shock - conditions present in high pressure hydrocracking operations.

In order to demonstrate the superiority of Denstone 2000 support media, a battery of six tests were conducted to compare media strength and resiliency of Denstone 2000 media to competing products.

Superior Impact Resistance

Two types of impact energy typically cause media failure: Breakage can occur due to the impact of the support media being dropped onto

a stationary surface, which generally occurs during loading. Breakage also occurs when weight impacts upon the media, most often during shipping and handling, or when other media are dropped on top of the media.

Fractured media can, in turn, increase pressure drop due to channeling and plugging of the catalyst bed. In addition, chips or fines can foul the catalyst, decreasing operating efficiency and ultimately increasing operating costs.

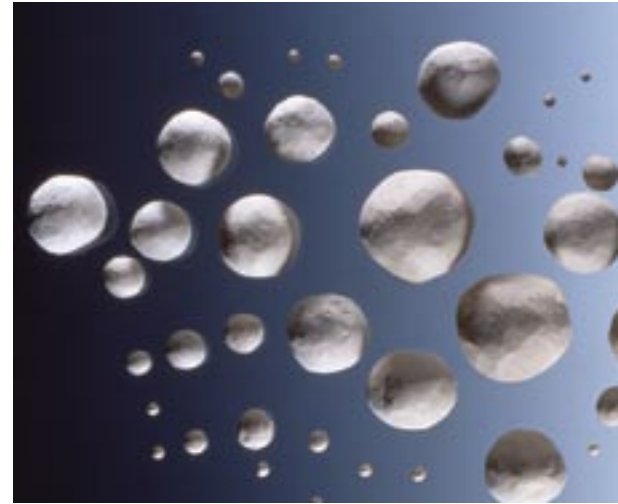
The free fall drop test showed Denstone 2000 ceramic support media to be superior, surviving 100% of the free fall drop vs. 30% of a competing support media.

The ASTM D-3029 impact test demonstrated that Denstone 2000 support media sustained 76% higher impact force over the competing support media.

Stands Up Better to Thermal Shock

Even gradual changes in temperature, whether moderate or extreme, can weaken support media. Cycling conditions common in fixed-bed catalytic applications weaken the supports over time and make them increasingly susceptible to breakage or chipping.

Denstone 2000 support media retained their compressive strength edge over competitive media even after being heated to 427° C (800° F), then quenched with water at room temperature. The test was repeated



using support media heated to 815° C (1500° F), with Denstone 2000 support media demonstrating a 61% compressive strength advantage over the competition.

Excellent Compressive Strength

Compressive strength is a key indicator of proper media processing: low crush strength indicates an inhomogeneous microstructure, internal cracks or fines that can cause the media to break or chip when subjected to thermal cycling. Conversely, a high compressive strength indicates that the media's low flaw population and uniform microstructure will provide the strength necessary to remain intact even under demanding conditions.

Denstone® 2000 ceramic support media demonstrated 61% greater crush strength than a competing support media. (ASTM C-515)

Denstone® Ceramic Support Media Typical Physical Properties

Survival in Rapid Depressurization Tests

A hydrocracking reactor experienced an extreme and rapid drop in pressure. Already weakened by repeated thermal cycling, the support media shattered. The catalyst migrated downward through the broken support media. Within a short time, the refiner was forced to shut down the unit for an emergency change out. The tremendous time, effort and expense involved could have been avoided had the refiner used a support media that could withstand rapid depressurization. That is why Saint-Gobain NorPro developed Denstone® 2000 and the severe procedure to test it.

After being heated to 454° C (850° F) at 10.3 Mpa (1500 psi) hydrogen, then depressurized instantly to ambient pressure, only Denstone 2000 ceramic support media remained 100% intact, compared to only 25% survival of the competing support media.

Unique In-House Testing Capabilities

Don't be misled by general claims regarding survivability under depressurization. Only Saint-Gobain NorPro verifies **every single production batch** of support media for the ability to survive this rapid depressurization, as simulated by in-house autoclave testing.

Denstone® 57 Support Media

Size/ Nominal Size		Crush Strength		
mm	Inch	(lbs) min	(kg) min	(N) min
3	1/8	50	22.7	223
6	1/4	120	55	540
10	3/8	200	90	883
13	1/2	370	170	1668
16	5/8	500	230	2256
19	3/4	950	430	4218
25	1	1400	635	6229
38	1-1/2	2000	900	8829
50	2	2000	900	8829

Typical Chemical Composition	min%	max%
SiO ₂	64.0	75.0
Al ₂ O ₃	19.0	26.0
Fe ₂ O ₃	-	1.7
TiO ₂	-	1.5
CaO	-	0.7
MgO	-	0.5
Na ₂ O	-	2.9
K ₂ O	-	4.8
Al ₂ O ₃ +SiO ₂	90.0	96.0

• Leachable Iron	≤ 0.1 %
• Apparent Porosity by Weight d ≥ 10mm	≤ 0.4 %
• Apparent Porosity by Weight d=6mm	≤ 1.0 %
• Apparent Porosity by Weight d=3mm	≤ 3.0 %
• Operating Temperature	max. 1000°C

Denstone® 2000 Support Media

Size/ Nominal Size		Crush Strength		
mm	Inch	(lbs) min	(kg) min	(N) min
3	1/8	50	22.7	223
6	1/4	160	72.5	711
10	3/8	250	113	1109
13	1/2	500	227	2227
16	5/8	600	273	2678
19	3/4	1050	477	4679
25	1	1750	795	7799
38	1-1/2	2000	900	8829
50	2	2000	900	8829

Typical Chemical Composition	min%	max%
SiO ₂	61.0	77.0
Al ₂ O ₃	18.0	26.0
Fe ₂ O ₃	-	1.7
TiO ₂	-	1.5
CaO	-	1.0
MgO	-	1.0
Na ₂ O	-	2.0
K ₂ O	-	6.0
Al ₂ O ₃ +SiO ₂	90.0	96.0

• Leachable Iron	≤ 0.1 %
• Apparent Porosity by Weight	2-6 %
• Autoclave Survival Rate	≥ 99 %
• Operating Temperature	max. 1000°C

Denstone® 99 High - Alumina Support Media

Denstone® 99 High-Alumina Support Media

Size/ Nominal Size		Crush Strength		
mm	Inch	(lbs) min	(kg) min	(N) min
3	1/8	110	50	491
6	1/4	220	100	981
10	3/8	440	200	1962
13	1/2	1322	600	5886
19	3/4	2202	1000	9810
25	1	3083	1400	13734
38	1-1/2	3965	1800	17658
50	2	4846	2200	21582

Typical Chemical Composition	min%	max%
SiO ₂	-	0.2
Al ₂ O ₃	99.0	-
Fe ₂ O ₃	-	0.2
TiO ₂	-	0.57
CaO	-	0.1
MgO	-	0.1
Na ₂ O	-	0.25
K ₂ O	-	0.1

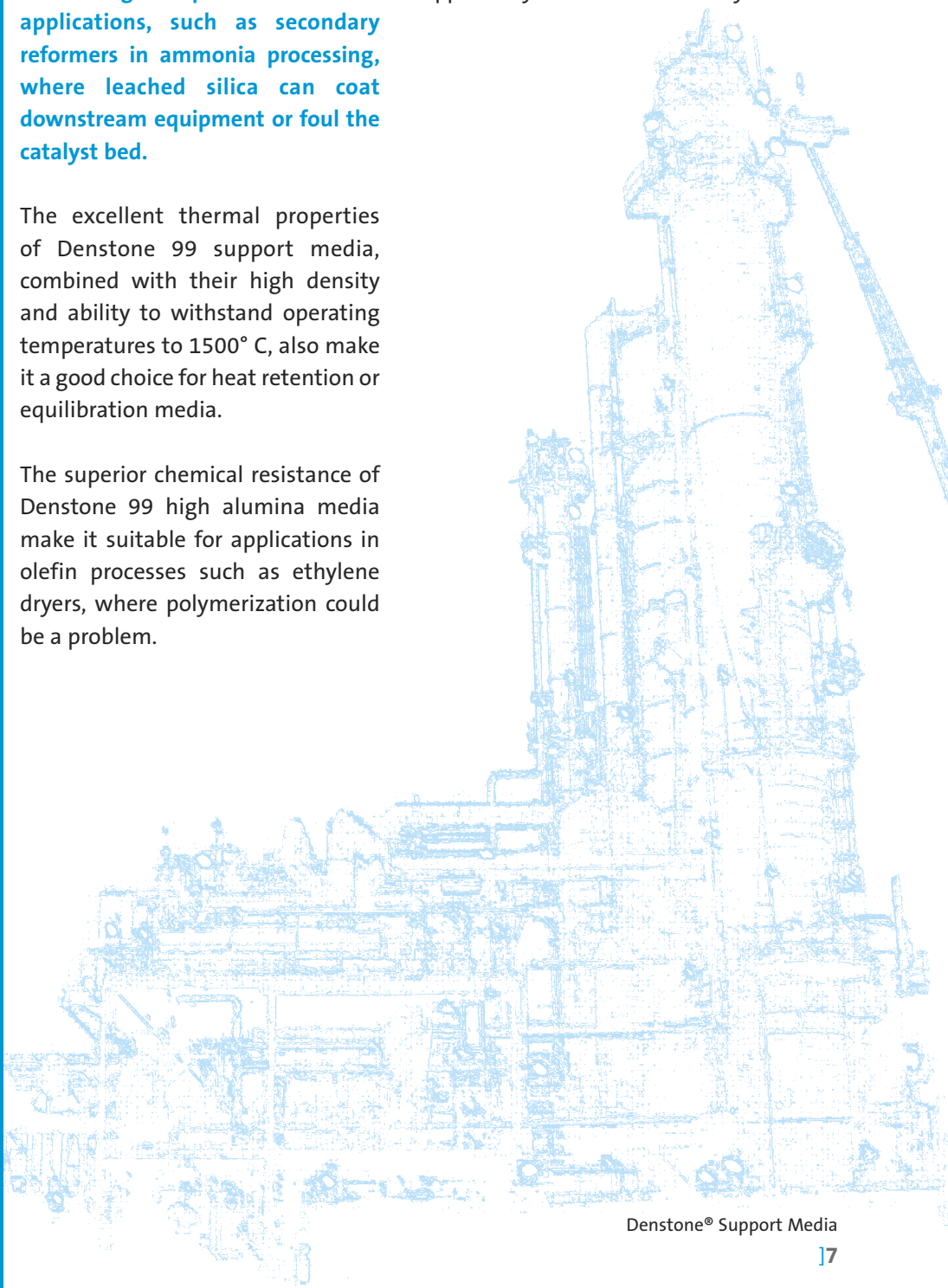
- Leachable Iron ≤ 0.01 %
- Apparent Porosity by Weight ≤ 7.0 %
- Operating Temperature max. 1500°C

Denstone® 99 high-alumina support media are 99+% alpha alumina and a maximum of 0.2 wt% SiO₂. Its high-alumina content, low silica and high strength make this product ideal for high-temperature and steam applications, such as secondary reformers in ammonia processing, where leached silica can coat downstream equipment or foul the catalyst bed.

The excellent thermal properties of Denstone 99 support media, combined with their high density and ability to withstand operating temperatures to 1500° C, also make it a good choice for heat retention or equilibration media.

The superior chemical resistance of Denstone 99 high alumina media make it suitable for applications in olefin processes such as ethylene dryers, where polymerization could be a problem.

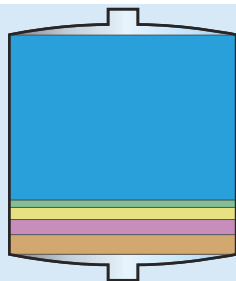
NorPro™ Denstone® 99 high-alumina support media are available in sizes ranging from 50 mm (2 inch) for extra weight and hold-down capability, down to 3 mm (1/8 inch) to support very small diameter catalysts.



Typical Applications of Denstone® Support Media

Desiccant Dryer

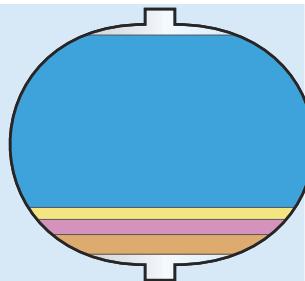
A typical desiccant dryer uses a 1.5 mm (1/16 in.) extrudate molecular sieve. A 5 cm (2 in.) depth of 3 mm (1/8 in.) Denstone® spheres are placed directly under the molecular sieve.



- Catalyst
- 5 cm (2 in.) layer - 3 mm (1/8 in.) spheres
- 8 cm (3 in.) layer - 6 mm (1/4 in.) spheres
- 10 cm (4 in.) layer - 13 mm (1/2 in.) spheres
- 13 cm (5 in.) layer - 19 mm (3/4 in.) spheres

Hydrocracker

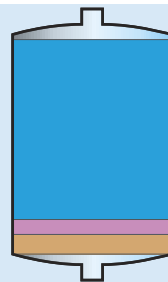
In typical petroleum processes using a 3 mm (1/8 in.) diameter, extrudate catalyst, the bed is identical to the one described above, except that the catalyst can be placed directly on top of 6 mm (1/4 in.) Denstone® spheres. The catalyst is then supported by 6 mm (1/4 in.) Denstone® support spheres, followed by layers of 13 mm (1/2 in.) and 19 mm (3/4 in.).



- Catalyst
- 8 cm (3 in.) layer - 6 mm (1/4 in.) spheres
- 10 cm (4 in.) layer - 13 mm (1/2 in.) spheres
- 13 cm (5 in.) layer - 19 mm (3/4 in.) spheres

Petrochemical Reactor

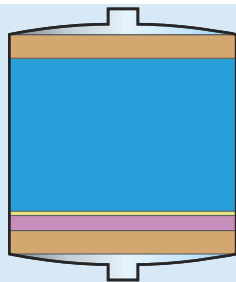
In petrochemical applications such as oxidation reactions, larger catalysts - typically 6 mm (1/4 in.) diameter - are used.



- Catalyst
- 10 cm (4 in.) layer - 10 mm (3/8 in.) spheres
- 13 cm (5 in.) layer - 19 mm (3/4 in.) spheres

Hydrotreater / Downflow Reactor

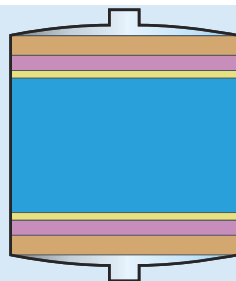
These petroleum processes can use catalyst as small as 1.3 mm (1/20 in.) in diameter. Frequently, downflow reactors use larger Denstone® spheres at top because they have the mass necessary to prevent the top of the bed from being dished out by the inlet velocity of the gas impinging on the bed's surface.



- 15 cm (6 in.) layer - 25 mm (1 in.) spheres
- Catalyst
- 3 mm (1/8 in.) layer - spheres
- 10 cm (4 in.) layer - 10 mm (3/8 in.) spheres
- 15 cm (6 in.) layer - 19 mm (3/4 in.) spheres

Upflow Reactor

When it is necessary to prevent catalyst bed fluidization, spheres are graded in reverse order on top of the bed. The sphere size depends upon the size of the catalyst. To provide sufficient mass to prevent fluidization, at least 22.9 cm (9 in.) of Denstone® support media are installed atop the bed.



- 13 cm (5 in.) layer - 19 mm (3/4 in.) spheres
- 10 cm (4 in.) layer - 13 mm (1/2 in.) spheres
- 5 cm (2 in.) layer - 6 mm (1/4 in.) spheres
- Catalyst
- 5 cm (2 in.) layer - 6 mm (1/4 in.) spheres
- 10 cm (4 in.) layer - 13 mm (1/2 in.) spheres
- 13 cm (5 in.) layer - 19 mm (3/4 in.) spheres

A Denstone® Media for Every Process



Process	Preferred Support
Petroleum Refining	
Hydrocracking	Denstone 2000
Hydrotreating	Denstone 57/2000
Hydrogenation	Denstone 57/2000
Reforming	Denstone 57/2000
Isomerization	Denstone 57
Claus Reactors	Denstone 57/2000

Petrochemical	
Hydrogenation	Denstone 57/2000
Hydrotreating	Denstone 57/2000
Oxidation	Denstone 57/2000
Absorbers	Denstone 57/2000
Desulfurizers	Denstone 57/2000
Molecular Sieve	Denstone 57/2000
Separations	Denstone 57/2000
Ethylene Cracking and Drying	Denstone 99
Polymerization	Denstone 99

Process	Preferred Support
Ammonia Plants	
Desulfurizers	Denstone 99
Secondary Reformers	Denstone 99
Low Temperature Shift	Denstone 99
High Temperature Shift	Denstone 99
Methanator	Denstone 99

Natural Gas Processing	
Dryers	Denstone 57/2000
LPG Treaters	Denstone 57/2000
LNG Prepurifiers	Denstone 57/2000
Claus Reactors	Denstone 57/2000

Acid Plants	
Separations	Denstone 57/2000

Industrial Gases	
Air Prepurifiers	Denstone 57/2000
Dryers	Denstone 57/2000

Process Control

Breakage is the chief problem experienced with common ceramic supports. Fractured support media can plug the catalyst bed, which increases pressure drop and ultimately decreases efficiency. Similarly, attrition can foul the catalyst bed or block downstream filters. There are a number of causes for breakage in lesser quality support media: loading and unloading, thermal shock, thermal cycling, and rapid depressurization - conditions which are not uncommon in today's demanding services. Shutting down a reactor due to support media failure is very costly. Pre-qualification of raw materials, as well as multiple in process controls, ensures that the customer gets a support media on which he can rely.

Pre-Qualification

Whether mined or refined, Saint-Gobain NorPro qualifies the optimum raw materials well in advance of manufacturing. In the case of mined materials, extensive testing of core samples from the mine site identifies specific areas of prime reserves to guarantee a consistent supply far into the future. Standard raw material tests are conducted in both our laboratories and the suppliers' to confirm data accuracy.

Lot Qualification

Our pre-qualification procedure ensures that only the most consistent starting materials are utilized; but we do not stop there. Each shipment of raw material must pass additional testing before we accept it at the manufacturing site.

Proactive Process Adjustments

When our testing does reveal subtle changes in raw material composition, our technical knowledge and experience with the relationships between material characteristics and final product properties allows us to apply Predictive Process Control to fine-tune the blend at the front end of the process to guarantee a consistent, high-quality ceramic support media.

ISO Certification

All Saint-Gobain NorPro manufacturing locations are certified to ISO 9001:2000.

Process Checks

Saint-Gobain NorPro follows documented procedures at every stage of the manufacturing cycle to ensure consistent final product quality.

In Process Controls

In process controls are in place for each of the following areas:

- Mixing
- Forming
- Drying
- Firing
- Screening
- Packaging
- Shipping

Finished Product Tests

The following tests are performed on all products:

- Crush strength
- Size
- Shape
- Chemical composition
- Apparent porosity
- Appearance
- Autoclave depressurization test (Denstone 2000 media only)

Special Tests

Special tests are performed on products designed for highly demanding applications:

- Thermal shock
- Thermal cycling
- Thermal compression
- Free-fall drop
- Impact resistance



When No Standard Product Will Do

Decades of experience developing and manufacturing the optimal support media makes Saint-Gobain NorPro uniquely qualified to provide custom products for particularly difficult or unusual applications. Ask us about co-development partnerships and custom engineered products. No matter what your application, no matter where you are, you will find us an exceptionally responsive resource.

Other Exceptional Products for Fixed Bed Applications

Saint-Gobain NorPro offers a unique top bed solution that includes a macroporous ceramic media that effectively filters particulate matter from the feed stock, thus protecting the catalyst bed from fouling and subsequent pressure drop buildup. In fact, over 100 actual field applications prove that MacroTrap® guard bed media keep catalyst reactors

running longer without the need for costly skimming operations.

For more information on MacroTrap® guard bed media, request brochure GB-1.

Products for Mass and Heat Transfer

Saint-Gobain NorPro is a global leader in the production of ceramic products for mass transfer and heat transfer applications. Our technical accomplishments in developing materials and products for improved performance have mirrored the industry's most important advances for more than 40 years.

For more information on NorPro mass transfer and heat transfer products, request brochure CPIAA-1.

Catalyst Carriers Tailored to Meet Your Needs

Saint-Gobain NorPro engineers and manufactures catalyst carriers to meet your specific process needs

for size, shape, porosity and surface area.

For more information on NorPro™ catalyst carrier capabilities, request brochure CAT-3.

Proppants for Oil and Gas Recovery

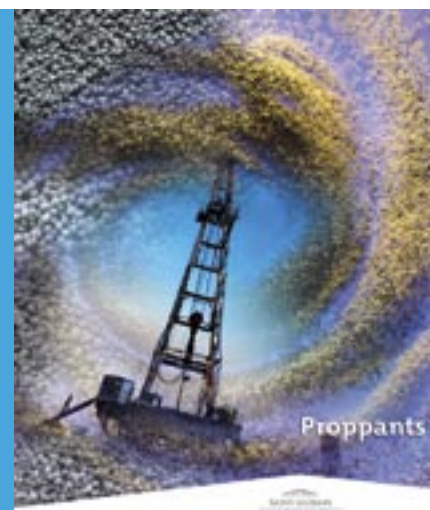
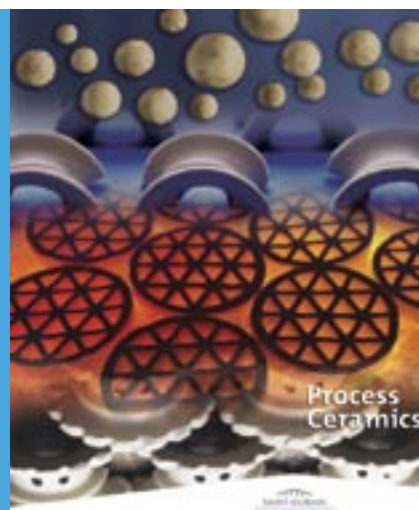
Proppants are used in the hydraulic fracturing of oil and gas wells to increase oil and/or gas production, and Saint-Gobain Proppants is known throughout the world for its ceramic proppant technology. Details of our technology and products are available by visiting:

www.proppants.saint-gobain.com

Website

Visit the Saint-Gobain NorPro website for a complete line of products, markets and applications, as well as a library for brochures, flyers and technical papers:

www.norpro.saint-gobain.com





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The information herein does not constitute a guarantee or warranty. The Saint-Gobain NorPro warranty is set forth in its standard terms and conditions which govern sales of Saint-Gobain NorPro products. The standard terms are set forth in Saint-Gobain NorPro quotations and acknowledgements and are also available on request.

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