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New Support Media Reduces Operating Costs and Layers in Fixed-Bed Catalyst Applications

Sponsored by: Saint-Gobain NorPro

It has been more than a century since the early days of chemical reactors, when users threw rocks into the unit to hold up the catalyst. Rocks gave way to multiple layers of spherical ceramic media and just recently another option began to take hold.

Pressures on Refineries

Refining is gaining in complexity due to expanding markets, increased regulations and attempts to offset declining profits. Process optimization, therefore, is becoming mandatory in effective refinery planning, turnaround planning, troubleshooting and profit margin analysis and management. Continuous process operations are the norm today, and operational outages severely impact the bottom line.

Refinery engineers have responsibility for a myriad of duties. A large area of their focus is improving operating conditions, which typically sees them putting a substantial focus on managing and optimizing the catalyst performance and processing conditions. With their time spent on this area, they often do not have the time to evaluate cost and performance improvements that support media can bring to their operation. The use of high-quality support media plays an important role in catalyst performance, system efficiency and the potential for reduction of operating costs.

The Role of Support Media

Inert ceramic bed media is widely used in the petrochemical, chemical, fertilizer and natural gas industries. Its main function is to support and maintain catalysts in place within a reactor. Used as both topping and supporting materials for catalysts in reaction vessels, it withstands elevated temperatures and thermal shock (rapid temperature changes) inherent during the chemical reaction process. Support media also resists high pressure common in some environments, is chemically stable and features a low rate of open porosity.

Maintaining optimal catalyst performance depends on support media selection. Created to maximize resistance to erosion and attrition, it also prevents possible catalyst and chemical process contamination. For example, support media should not contain media sulfur, boron, or other catalytic poisons, nor leach out iron, and must positively impact operating costs and keep 24/7 operations in place.

The use of support media should eliminate:

- Unplanned reactor shutdown
- Pressure drop fluctuations
- Process inefficiencies related to breakage, chipping, etc.
- Increased operating costs

Denstone® Support Media Family of Products

For over 70 years Saint-Gobain NorPro has supplied its Denstone® support media for fixed catalyst bed applications in a variety of industries globally.

Known for reliable high-quality and high-performance solutions, Saint-Gobain NorPro's

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Denstone® products retain their physical properties when exposed to wide temperature and pressure fluctuations. Denstone support media avoids fouling or plugging of the catalyst bed and poisoning of the catalyst that can lead to downtime or increased operating costs.

Saint-Gobain NorPro's innovations include an extensive range of Denstone bed support media, including Denstone 57, 2000 and 99. The latest innovation in the Denstone portfolio of support media enables users to maximize reactor performance without sacrificing the Denstone media's consistency and quality that the industry has relied on for decades. Saint-Gobain NorPro is a long-standing manufacturer of spherical bed support media, and now, the first to develop a shaped support media known as Denstone® deltaP®.

Denstone® deltaP® Support Media, Engineered Performance and Value

Saint-Gobain NorPro's quality is engineered into all of its support media products. Spanning formulation design and raw material selection and continuing through process selection and control, building quality into Denstone® deltaP® media is no exception. This revolutionary support media is reshaping how people think about using bed support media.

Denstone® deltaP® is a unique shaped media, that boasts the same chemistry and quality as the spherical support media in the Denstone® media family. It has been engineered to need only two layers of media, versus up to four layers of traditional spherical media. The engineered shape of Denstone deltaP media also allows for users to maintain a lower pressure drop improving operations, but also prevents small catalysts from migrating down through the bed of support media. The fact that fewer layers are required, leaves users with only needing to decide how deep they'd like their layers to be, and which of the three sizes works best for their application based on their reactor design, pressure drop needs, and installation process of the support media.

Figure 1. Denstone® deltaP® support media lowers cost without a performance penalty. There are many advantages to its use in fixed-bed catalyst applications.
Source: Saint-Gobain NorPro

Based on its unique shape, Denstone® deltaP® media provides many performance advantages in fixed-bed catalyst applications:

1) Only two layers of media are used compared to up to four layers of spherical media
2) Increases available space within the reactor allowing for additional catalyst or adsorbent media
3) Reduces fill cost by eliminating the need for expensive small spheres
4) Dramatically reduces pressure drop
5) Fewer media layers translates into faster, simpler installation

Through a combination of reduced initial costs, lower operational costs and increased capacity, Denstone® deltaP® support media improves performance and the user's bottom line.

Denstone® deltaP® Typical Physical Properties

Size (Designation)	Average Diameter		Minimum Crush Strength*		
	Inch	mm	(lb)	(kg)	(N)
			min	min	min
P1	0.453	11.5	500	227	2224
P1.4	0.686	17.4	750	340	3336
P2	1.22	31.0	1500	680	6672

NOTE: Crush strength is the average of the strength in the axial and radial orientations

Table 1. The table displays the typical physical properties of Denstone® deltaP® by each size available.
Source: Saint-Gobain NorPro

Tested and Validated Performance

Extensive testing during its development proves that Denstone® deltaP® support media retains the catalyst particles with minimal migration into or through the support media. During migration testing, a 9 in. layer of Denstone deltaP P1 media was used under a 9 in. layer of 1.6mm molecular sieve. Air was introduced in an upflow direction at a 0.3 m/s velocity and vibration of the column was set at 6.5 KHz for 90 hours. As seen in Figure 2 and Video 1, after the 90 hours, the test showed minimal migration even though Denstone deltaP P1 media, with a typical diameter of 13mm, is larger than traditional 3mm spheres.

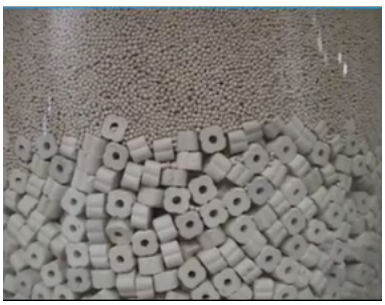
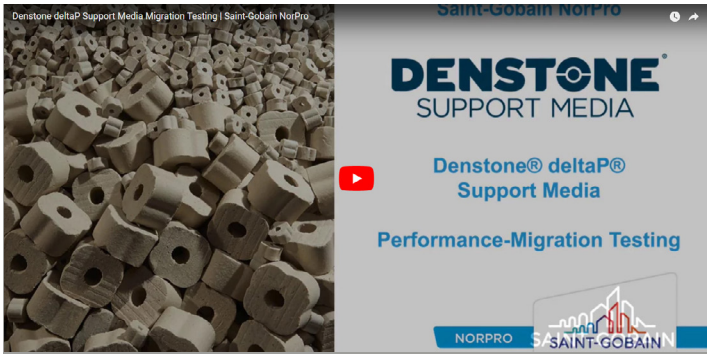


Figure 2. After 90 hours, testing shows Denstone® deltaP® retains catalyst particles with only minimal migration at the side wall.
Source: Saint-Gobain NorPro



Video 1. This video shows the high performance of Denstone® deltaP® support media during a migration test designed to mimic actual process conditions.
Source: Saint-Gobain NorPro

Denstone® deltaP® media has been used for 10 years in various applications in the industry. Customers have used the shaped support media in air separation prepurifiers, natural gas dehydration, hydroprocessing and more. These customers are seeing the benefits of using the shaped media, along with the high quality and reliability that Denstone® spheres are known for.

Customers see performance improvements with Denstone® deltaP® support media

Chevron reduces catalyst migration risk without reducing active catalyst volume

For many years, Chevron has used ceramic spherical support media as catalyst support in their hydroprocessing reactors. At times, they have observed migration of small catalyst particles through the support balls that would partially plug the catalyst support screens at the bottom of the reactor beds. Migrating catalyst can contribute to reactor pressure drop build and in rare cases can lead to catalyst migrating into reactor internals. Multiple layers of appropriately-sized ceramic balls can be used to inhibit catalyst migration, but adding extra support layers can significantly reduce active catalyst volume with subsequent reduction of reactor performance.

To reduce this catalyst migration, Chevron trialed the use of Denstone® deltaP® support media in multiple reactors. Based on these trials, Chevron believes the Denstone deltaP support achieved the goal of reducing catalyst migration without reducing the amount of active catalyst in the reactor. Chevron has stated that the unique shape of the material appears to be more resistant than ceramic balls in preventing catalyst migration.

Chevron utilized two layers of Denstone® deltaP® support media in their reactors – one layer of the P1 size and one layer of the P2 size, during the initial trials. During this time, they found that the larger Denstone deltaP P2 size proved to be very difficult to load and unload using conventional catalyst handling techniques. After several trials, Chevron decided to abandon the use of the larger Denstone deltaP P2 size and continued to use the Denstone deltaP P1 size, which was found to be easily loaded and dumped using normal handling methods.

Chevron then contacted the Saint-Gobain NorPro team and described the difficulties of handling the larger P2 size and proposed the idea of Denstone® deltaP® support media in an intermediate size (smaller than P2 but larger than P1). Saint-Gobain NorPro successfully commercialized an intermediate size of the Denstone deltaP material within two months for further trials in Chevron reactors. The intermediate size is identified as Denstone deltaP P1.4. Chevron has now successfully used the various Denstone deltaP support media sizes in multiple reactors and believes they have achieved our goal of reducing catalyst migration without reducing the volume of active catalyst.

Reduced support media volume leads to more adsorbent and higher performance

The performance of Denstone® deltaP® media was tested in a crude gas dryer, pygas cracker and MAPT reactor by a major European Petrochemical player. Their main goal was to increase the volume of mole-sieve in the reactors in order to upgrade the performance and the run-time of the applications. By utilizing Denstone deltaP media, they were able to reduce the support media layer from 150mm to 100mm, and were able to install an additional 17 percent of adsorbent. With the use of additional adsorbent, the user saw the longer running times and the performance upgrades they were looking for.

Along with the upgraded performance in the vessels, they also saw no negative impact to using the shaped media. Their installation (sock-loading) remained as easy as their previous experience with spherical media. With a highly positive experience, this company would recommend the usage of Denstone® deltaP® media in all other applications, especially in those where a user would want to add more active media into the application.

A Look at Loading and Pressure Drop

Saint-Gobain NorPro makes it easy to select which product and size is right for you, and knows how pressure drop measurements will change in each specific application. By providing interactive online tools, users can select the optimal media size for their application by entering only three inputs, or they can estimate pressure drop based on operating conditions.

Selecting the right size of support media

The Denstone® support media size selection helps identify the best support media configuration for a vessel based on:

- Catalyst size
- Bottom screen opening
- Total support media

Denstone® spherical support media is typically loaded so that the diameter of the media in each layer is no greater than double the diameter of the media in the adjacent layer. Using this 2X concept, the diameter of the spherical support media directly below the catalyst bed should then be no greater than 2X the diameter of the catalyst. The largest support media

size needed is determined by the size of the bottom screen opening.

Denstone® deltaP® media allows for a different type of layering approach, due to its unique shape. With Denstone deltaP support media, you only need two layers of media. When using Denstone deltaP media, size P1 is loaded directly below the catalyst bed in place of the smaller-sized standard spheres. The second layer of the shaped support media would then be size P1.4 or size P2. The choice between the two second layer sizes typically depends on the loading/unloading methods being utilized. If pipes are being used for loading/unloading support media, size P1.4 may work better than size P2, depending on the pipe diameter. The reduction in layers of support media allows reduction in pressure drop and for more catalyst to bte used in the reactor.

Here's how the Denstone® Size Selection Guide tool works. After entering a catalyst diameter of < 3mm, a total height of all bottom support media of 500mm and a bottom screen opening of 0.5mm, calculations will show the recommended layering results of both Denstone® spheres and Denstone® deltaP® media.

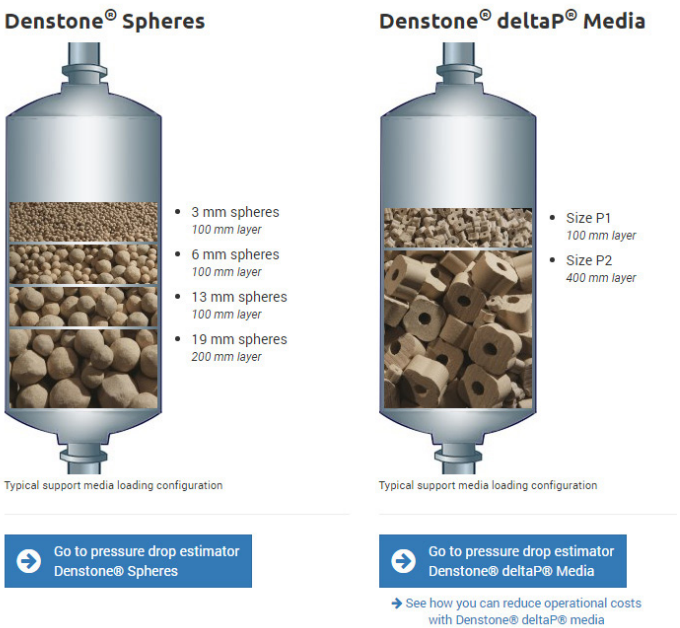


Figure 3. Loading recommendations for Denstone® spheres vs. Denstone® deltaP® provided by the Denstone® Size Selector Guide.
Source: Saint-Gobain NorPro

As seen in Figure 3, the size selector guide shows the layering in both Denstone® spheres and Denstone® deltaP® with the same volume level. While spheres require the use of four layers, Denstone deltaP only requires two layers of support media. Customers can then decide if utilizing deltaP if they'd like to reduce the depth of the layers given their specific application and operational needs. Users can print the selector tool's results as well as email the results to themselves and colleagues. In addition, this data can be automatically populated into the pressure drop estimator, which will allow users to see the impact of the layering depths by product type on their pressure drop.

Estimating Pressure Drop

Pressure drop is important in all applications as it adversely affects the bottom line. When the pressure drop of the unit is high, more energy is required to push the gases and liquids through the unit as there is more pressure differential between top and bottom. As seen in Figure 4, the uniquely-shaped Denstone® deltaP® media provides for a significant reduction in pressure drop when compared with traditional solutions. Whether utilizing a combination of size P1 and P2, or P1 and P1.4, users typically see over a 50% reduction in pressure drop when utilizing Denstone deltaP vs. spherical media.

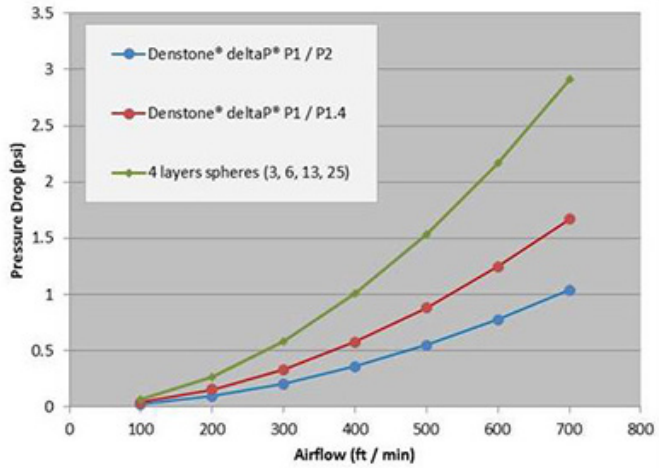


Figure 4: Denstone® deltaP® media pressure drop advantage vs. spherical support media.
Source: Saint-Gobain NorPro

With pressure drop such a critical measure of performance of catalyst bed support media, Saint-Gobain NorPro has created an online tool that allows users to estimate pressure drop based on specific reactor conditions and support bed layering designs. It also provides a comparison between Denstone® deltaP® support media and standard Denstone® ceramic spheres to ensure selection of the best media for the reactor and application.

The Denstone® Pressure Drop Estimator tool simplifies both the calculation of pressure drop and comparison of support media. Specifically, users are asked to input the following information:

- Layers
  - Size support media
  - Layer depth
- Unit Operating Conditions
  - Gas Velocity (ft./min)
  - Operating pressure (PSIg)
  - Average operating temp (°F)
  - Output units (inches H2O, PSI or kPa)

Once the conditions are entered into the tool, the user will then be able to see the pressure drop for Denstone® spheres and how that compares to Denstone® deltaP®. The tool not only provides the total overall pressure drop, but by each layer

in the output unit specified.

For example, utilizing the recommended layering provided by the Denstone® Size Selector tool of the following layer depths:

- Layer 1 : Denstone® size 1/8" (3mm) with a layer depth of 100mm
- Layer 2 : Denstone® size 1/4" (6mm) with a layer depth of 100mm
- Layer 3 : Denstone® size 1/2" (13mm) with a layer depth of 100mm
- Layer 4 : Denstone® size 3/4" (19mm) with a layer depth of 200mm

and Unit Operating Conditions of:

- Gas velocity of 100 ft./min
- Operating pressure of 300 PSIg
- An average operating temp of 150°F
- With PSI as the output unit

The Pressure Drop Estimator tool would show an overall pressure drop of 0.6 PSI for Denstone® spheres and of 0.2 PSI for Denstone® deltaP® as seen in Figure 5. As indicated, there is a substantial improvement in pressure drop when utilizing Denstone deltaP.

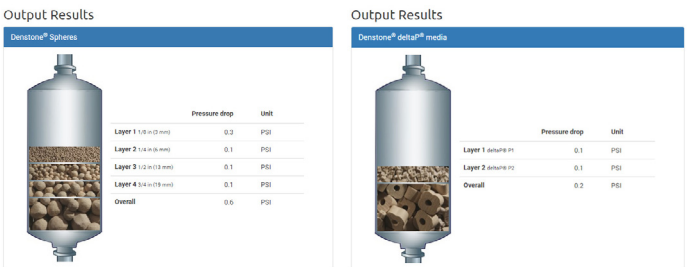


Figure 5. Results from the Pressure Drop Estimator show a significant decrease in pressure drop when utilizing Denstone® deltaP® vs. Denstone® spheres.
Source: Saint-Gobain NorPro

A user can also change inputs to see how their pressure drop would change if their operating conditions were adjusted. Figure 6 shows the variation in pressure drop when gas velocity is adjusted but temperature and operating pressure remain constant.

By utilizing the interactive online tools provided by Saint-Gobain NorPro, a user can clearly see how using Denstone® deltaP® support media would affect layering and pressure drop in their particular application.

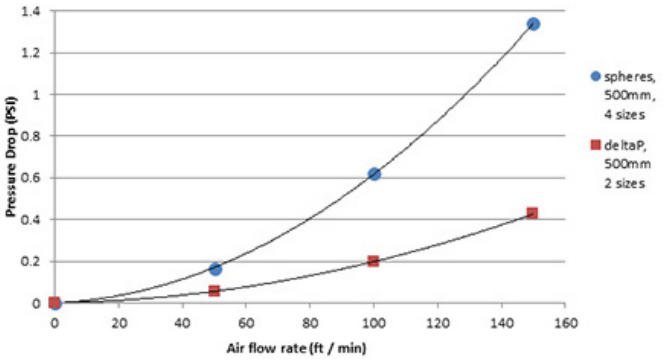


Figure 6. Pressure drop variation when air flow rate is adjusted and all other inputs remain constant.
Source: Saint-Gobain NorPro

Summary

Saint-Gobain NorPro has a long-standing reputation for quality, reliability and the ability to create innovative products that address specific industry challenges. Denstone® deltaP® support media is a continuation of that reputation, delivering a lower fill as well as lower initial and operating costs. While users pay less, they do so without incurring a performance penalty, but rather enjoy a performance advantage.

Saint-Gobain NorPro owns and operates the plants where Denstone® deltaP® support media is manufactured in the United States, Germany and China, allowing you to choose the best media no matter where you are. NorPro processes are validated by such certifications as ISO 9001, ISO 14001 or OHSAS 18001, ensuring a high level of confidence and performance.

As the newest member of the Denstone® family of support media, Denstone® deltaP® is already gaining traction for its high quality, pressure-drop advantage and high reliability, but especially for providing a lower-cost solution and competitive advantages.

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ABOUT SAINT-GOBAIN NORPRO

Saint-Gobain NorPro serves the oil and gas production, refining, petrochemical/chemical, and environmental industries with highly-advanced ceramic based products for fixed bed reactor processing, heat and mass transfer applications, as well as drilling and exploration. Saint-Gobain NorPro has developed into a major international supplier with a distinguished 100+-year history, starting from its humble beginnings as a backyard pottery producer in Akron, Ohio in 1859. The company's evolution started with U.S. Stoneware, then Norton Chemical Process Products (Norton Company), and now as Saint-Gobain NorPro (Saint-Gobain). The company provides technology-driven ceramic solutions – material science knowledge, forming capabilities, and the ability to tailor materials to specific requirements.