BayoTech®

6 Things Every Hydrogen Distributor Should Know

Making Hydrogen Easy®

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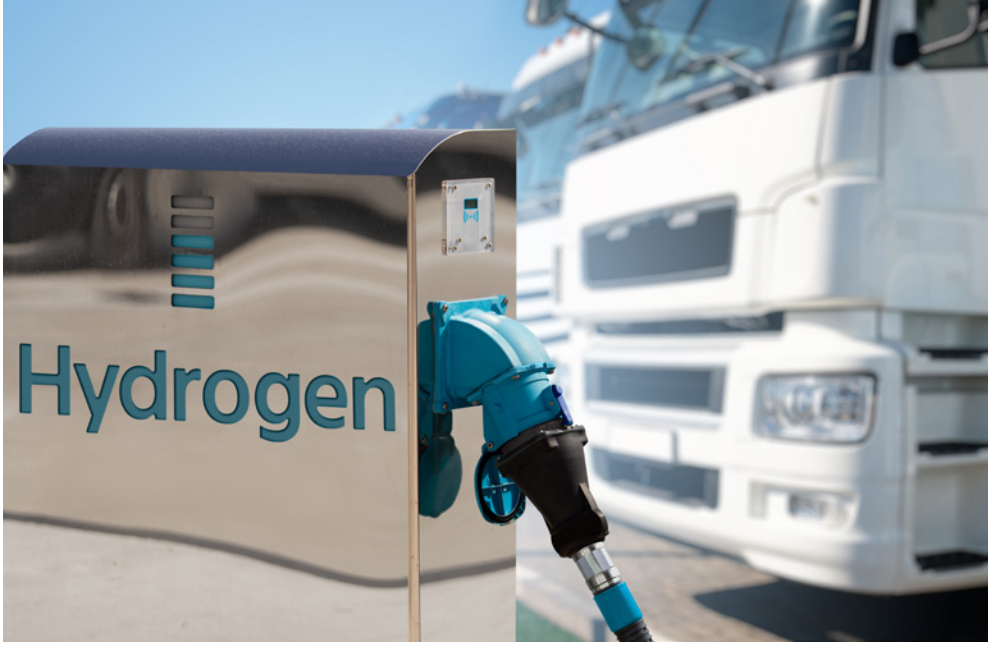
Unraveling the Mysteries of Hydrogen: 6 Key Questions Answered

Hydrogen continues its upward trajectory as a viable source of clean energy, gaining significant momentum over the past decade. To sustain this push, and to ensure the commercial viability of hydrogen, we must have reliable and cost-effective methods to deliver to end users such as industrial facilities, power generators or fueling stations. This means the industry must find efficient ways to move hydrogen by road. There's no extensive pipeline system for hydrogen like there is for natural gas, and development of one is far down the road—if it is ever developed at all.

If you are an industrial gas distributor, you know that one of the biggest challenges to hydrogen transport is its low volumetric energy density. Moving hydrogen from centralized production sites over long distances in low-volume steel tube trailers is inefficient and costly. Transportation, storage, and final delivery to the point of use comprise a significant cost and one of the biggest challenges in hydrogen's long-term adoption.

As an industrial gas distributor, your goal is to transport the maximum amount of hydrogen per delivery while remaining compliant with the U.S. Department of Transportation's road weight limits.

As you look to upgrade or expand your hydrogen transport fleet, consider your options. Here are 6 questions to ask yourself to ensure you're maximizing driver efficiency and your bottom line.



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Which Form of Hydrogen Should I Choose?

Hydrogen is usually delivered either as a compressed gas or as a very cold, cryogenic liquid. Each requires specific transport equipment.

For longer distances, hydrogen is transported as a liquid in super-insulated, cryogenic tanker trucks. After liquefaction, the liquid hydrogen is dispensed to delivery trucks and transported to distribution sites where it is vaporized to a high-pressure gaseous product for dispensing.

The alternative to liquid hydrogen is gaseous hydrogen, which is usually delivered by trucks. Because gaseous hydrogen is typically produced at relatively low pressures (20–30 bar), it must be compressed prior to transport. Trucks that haul gaseous hydrogen are called tube trailers. Gaseous hydrogen is compressed to pressures of 180 bar (~2,600 psig) or higher into long cylinders which are stacked on the trailer that the truck hauls.

Hydrogen is often distributed using compressed gas trailer trucks for distances under 300 kilometers, while liquid hydrogen trailers are used for longer distances and larger volumes. It's important to remember that both methods have advantages and disadvantages. However, transporting hydrogen in gaseous form can be cheaper and safer than using the liquid alternative, regardless of distance.

TYPES OF HYDROGEN CYLINDERS

When it comes to compressed hydrogen cylinders, there's a wide range available.
Knowing the best cylinder type for your application is essential.

TYPE I

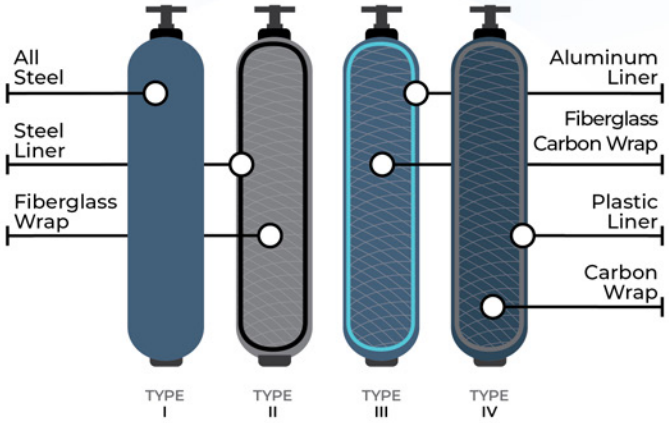
Type I cylinders are comprised entirely of steel or aluminum with no outer wrapping. These cylinders are low in cost and are designed for pressures up to 175 bar (aluminum) or 200 bar (steel).

APPLICATIONS
Stationary Industrial Use, Storage

TYPE II

Type II cylinders are all-metal tanks hoop-wrapped with a carbon fiber resin. Due to the wrapping material, the cylinders can withstand pressures of 300 bar.

APPLICATIONS
Stationary Industrial Use, Storage



TYPE III

Type III cylinders have a thin aluminum inner liner heavily wrapped in a composite material such as fiberglass or carbon fiber. This allows for lighter overall weight and higher-pressure storage. Pressure limits can reach up to 700 bar.

APPLICATIONS
Vehicles, Stationary Industrial Use, Storage, High-Pressure Fueling

TYPE IV

Type IV cylinders are comprised of a plastic inner liner made of composite material and wrapped in carbon fiber. These lightweight cylinders can reach pressures up to 700 bar but provide a lower overall pressure release.

APPLICATIONS
Vehicles, Stationary Industrial Use, Storage, Low-Pressure Fueling

Hydrogen Trailers

Hydrogen trailers are either high-pressure gaseous or cryogenic liquid hydrogen transports used to move hydrogen from production points to end users.

Gaseous hydrogen tube trailers use high-pressure composite cylinders or steel cylinders to contain and transport hydrogen. These trailers consist of multiple cylinders manifolded together. Liquid hydrogen trailers are costly and specialized, used to keep the very low-temperature hydrogen cold and mitigate evaporation.

Hydrogen trailers employ a variety of compressed hydrogen cylinders that provide a range of pressure types. These range from Type I to Type IV. Each allows for different pressure ranges and comes in various sizes. The most commonly used cylinder type for hydrogen transport is Type III.

Users appreciate the lighter weight and higher pressure compared to Type I and II cylinders, which results in an increased capacity for the same size cylinder. Type III tanks can also offer quicker refuelling times compared to Type IV cylinders.

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Have I Accurately Estimated My Operational Needs?

To choose the most cost-effective transportation method for gaseous hydrogen, it's essential to consider your specific operational needs. **Storage capacity** and **discharge rate** are the two critical factors that determine your requirements.

Steel Cylinders

Composite Cylinders

Storage Capacity

Consider the amount of hydrogen you will need delivered and the frequency of delivery based on your current or future storage requirements. This will also help you determine what pressures you will need the hydrogen delivered in.

Steel Cylinders

Today, compressed gaseous hydrogen is primarily transported using a traditional steel-tube trailer. However, these trailers use heavy steel cylinders only capable of pressures less than 200 bar to carry approximately 380 kilograms of hydrogen.

Composite Cylinders

Composite cylinders provide a lightweight, high-pressure package for storing compressed gases with a pressure up to 7,500 psig. Compact 27' trailers carrying 500 kilograms of hydrogen are designed to fit tight spaces and are ideal for delivery to hydrogen refuelling stations. Larger 40' and 52' trailers maximize payloads carrying 752 kilograms of hydrogen or more per load for industrial gas delivery.

Composite cylinders are lighter and can hold more hydrogen than steel alternatives. The compactness and efficiency of composite cylinders make them an excellent choice for any storage capacity.

Steel Cylinder Image: https://commons.wikimedia.org/wiki/File:Hydrogen_Tube_Trailer.jpg

Discharge Rates

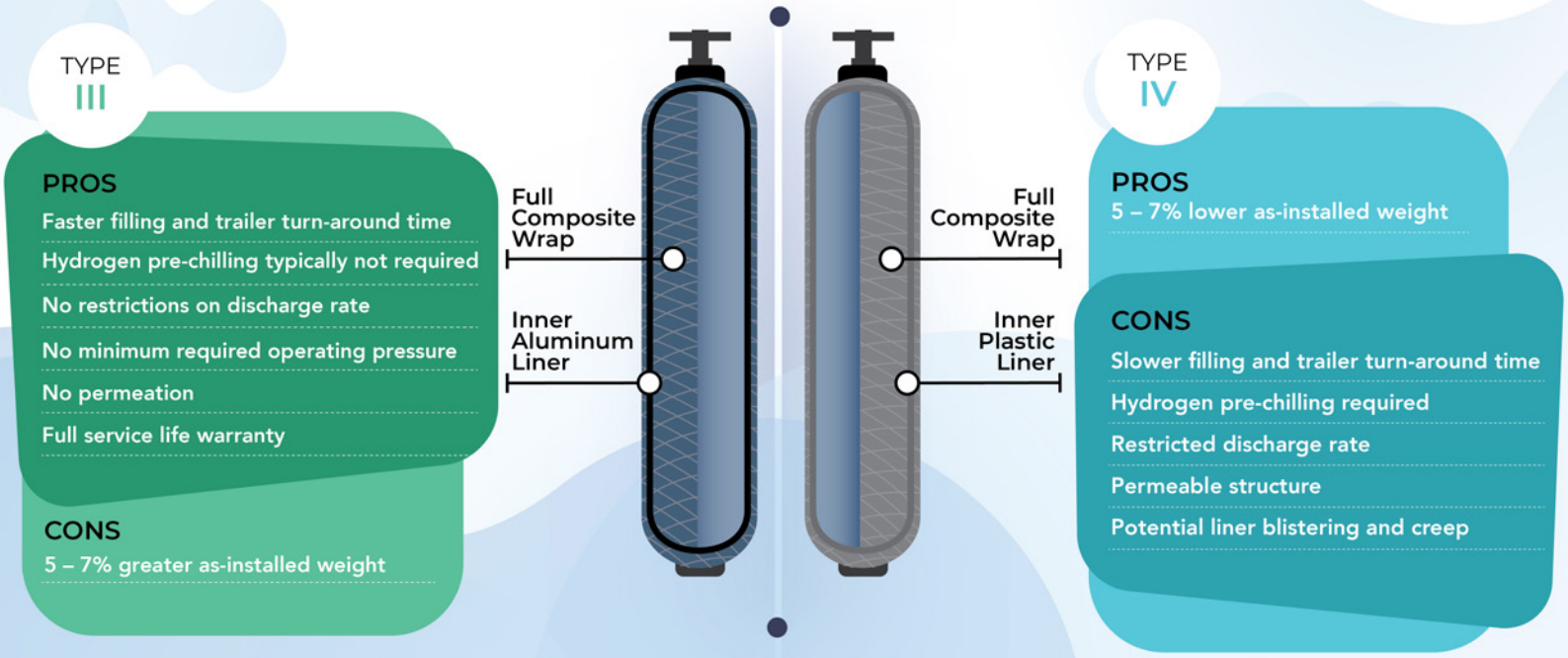
Discharge rates consider the speed you can fill a transport trailer with hydrogen and the speed at which you can dispense that hydrogen from the trailer. During the first process, the gas expands and heats up, while during the second process, it cools down. BayoTech's Type III cylinders have an aluminum lining which dispels the heat better than the plastic liners in Type IV cylinders. That lets you dispense/fill more quickly and save on labor costs.

Using BayoTech's HyFill™ trailers with composite Type-III cylinders, new high-pressure gas trailers in hydrogen service will range from 5,143 psig/350 bar to 7,500 psig/512 bar fill pressures. Since hydrogen is a compressible gas, storing and transporting hydrogen at higher pressures, such as 7,500 psig, increases the payload by three times over older, conventional steel tube-based trailers.

Since Type III cylinders offer flexible discharge rates and fast fill speeds, they are often the best choice for transporting and storing hydrogen. Taking into account the benefits of composite cylinders, we firmly believe that trailers equipped with composite Type III cylinders represent the future of hydrogen transport.

TYPE III VS TYPE IV CYLINDERS

When deciding which type of gaseous hydrogen transport and storage cylinders are right for you, there are two key types that are popular.
Type III and IV cylinders are the workhorses of the industry, but which one is the best choice?



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How Can I Manage the High Costs Of Delivery And Driver Shortages?

Delivery costs continue to increase, while HazMat-endorsed CDL drivers are becoming a scarce commodity. These factors have forced the industry to look at options for improving logistic efficiencies. The best way to deal with high delivery costs and driver shortages is to increase the productivity of hydrogen transport. Here are some suggestions for increasing productivity:

1 Prefer larger payloads

With larger payloads, more sites can be refuelled per trip, thereby lowering transportation costs and maximizing driver productivity.

2 Reduce trailer refills

Take more efficient routes with less refuelling time between deliveries and more time servicing customers.

3 Refill customer storage cylinders directly on-site

Avoid the complicated logistics of swapping and transporting empty cylinder packs. Minimize the overhead costs of cylinder pack inventory.

BayoTech's HyFill™ trailers offer a powerful way to mitigate costs and driver shortages. These high-pressure, high-capacity gas transport trailers move more hydrogen in a smaller and lighter package, maximizing driver productivity. Here's an example:

Consider a distributor currently running two steel-tube trailers to transport 300,000 scf (standard cubic feet) of gaseous hydrogen each month. Once they bring the hydrogen back to their facility, drivers must offload the hydrogen to a high-pressure on-site storage system. From there they receive their customer's empty cylinders in-house, refill them and deliver them back to their customers. This process isn't just costly; it's inefficient.

With BayoTech's HyFill™ trailers carrying up to three times more hydrogen per load than traditional steel-tube trailers, the trailers become an immediate force multiplier for anyone transporting hydrogen. The high-capacity storage of these trailers means that distributors require fewer overall trips to resupply, and they can reduce their trailer inventory to one trailer.

Another key benefit of the HyFill™, compared to Type IV cylinders, is the ability to quickly fill and discharge directly from the trailer at higher pressures. This means a driver can swiftly refill the trailer and deliver hydrogen directly to customers on the return trip. Then the distributor can refill customer cylinders on-site directly from the trailer. This advantage increases driver productivity and operational efficiencies significantly compared to other solutions.

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How Can I Better Manage Hydrogen Deliveries in Small Spaces?

Limited space often presents challenges. Retail refuelling stations located in urban areas are particularly affected by this issue. Large delivery vehicles typically lack sufficient space for all the necessary logistics. Fortunately, there is a solution.

Compact high-pressure trailers, such as the 27’ BayoTech HyFill™ trailer, can move more hydrogen in a smaller and lighter package. These trailers can fit more than 200,000 scf of gaseous hydrogen, which is up to three times more than traditional steel tube trailers. Customer storage cylinders can also be refilled directly on-site, avoiding the complicated logistics of swapping and transporting empty cylinder packs. In addition, navigating streets in the cities with a 27’ trailer is easier compared to a larger 40 or 50-foot conventional tube trailer.

Continuously exploring innovative solutions and updating delivery methods will help industrial gas distributors provide consumers with access to hydrogen in all possible locations.

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How Can We Keep Our Drivers Safe?

While hydrogen transport and use present certain risks, mainly around combustion, safety measures developed over the past 50 years have made hydrogen no more dangerous—and in some ways less dangerous—than other fuels.

By their nature, all fuels have degrees of danger associated with them. The safe use of any fuel focuses on preventing situations where the three combustion factors—ignition source (spark or heat), oxidant (air), and fuel—are present. Over the years, industries have designed fuel systems with appropriate engineering controls and guidelines to enable safe handling and use.

When discussing the safety of hydrogen, it's important to keep these factors in mind:

Using the proper equipment, designed specifically for hydrogen transport, is key. While there are many options available for transport equipment on the market, it's essential to focus on using the safest equipment. Following is a brief discussion on the best and safest options.

Type III Gas Cylinders

Type III gas cylinders are the best and most secure choice for mobile use. They feature a thin and lightweight aluminium liner, fully overwrapped with carbon composite. The cylinders are designed to meet national and international standards and regulations, they are approved for hydrogen usage at high pressure, and they have undergone a rigorous qualification testing regime that includes extreme temperature testing, drop and impact testing, gunfire testing, fatigue cycle, and burst testing. Each cylinder is equipped with a temperature relief device that protects the cylinder in case of a thermal incident.

Ball Valve Design

Ball valves are a crucial component of hydrogen transport trailers, as they provide a safe and reliable means of controlling the flow of hydrogen gas. Unlike other types of valves, ball valves use a spherical ball to regulate the flow of gas, which can be rotated to either allow or block the flow. This design provides a more secure seal than other valves, which reduces the risk of leaks or ruptures that can lead to dangerous accidents.

Fast response, high flow rate, high abuse/impact tolerance, tamper resistance and thermal triggers are all key features to look for in the design of ball valves used in hydrogen transport systems.

Thermal Pressure Relief Devices

A Thermal Pressure Relief Device (TPRD) is designed to safeguard hydrogen tanks and vessels from overheating and overpressure situations. It offers an enhanced safety feature beyond the common pressure relief valves by including temperature control. A glass bulb ruptures when the reaction temperature (usually 102 degrees C) is attained or if the inlet pressure exceeds maximum pressure allowed, causing the hydrogen to be released from the tank through a safety vent within a very brief time.

All BayoTech cylinders are fitted with our patented thermal pressure relief device. They provide a faster reaction time than traditional thermal relief devices and are reliable at any cylinder pressure.

Our proprietary, high-pressure valves provide the most lightweight, reliable, ball valve design for high-pressure cylinder-based gas storage. The ball valve configuration provides extremely high flow rates for both filling and discharging. Furthermore, they're designed for a 2.5x burst strength, considerably higher than the industry norm.

Other Safety Measures

Other crucial safety equipment include emergency shut-off devices, fire extinguishers, and high-pressure tubing and fittings which not only meet but exceed the system pressure required.

Think ahead about possible events which may occur to exclude as many surprises as possible. An example can be an on-road crash that causes a fire. If that happens, the pressure build-up of the hydrogen could rupture the cylinder. Therefore, the hydrogen needs to be quickly vented so it can dissipate into the air.

Always check the crashworthiness and fire resistance of cylinder valves, cylinder support structure, piping support, mechanical connections, and housings.

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How Do I Ensure My Transport Is Reliable?

- **Look for dedicated customer support.** You want a partner that provides responsive support and a technical team to assist you when needed and provide on-site training as expected.
- **Prefer manufacturers that offer longer warranties on equipment.** Product warranties of 15 years demonstrate to station and equipment owners that the manufacturer stands behind its equipment. Additionally, look for a responsive customer support and technical team to assist when needed and provide on-site training expected.
- **Research their reputation.** Look for online reviews or check their track record.
- **Check their certifications.** Ensure that the hydrogen transport partner has all the necessary certifications, such as ISO 9001 for quality management.
- **Ask for references from previous customers.** This will give you a better idea of their level of service and reliability.
- **Evaluate their capacity.** Make sure that the hydrogen transport partner has the necessary infrastructure, equipment, and personnel to produce your order with short lead times.

Consider BayTech as your trusted hydrogen transport partner. BayoTech's HyFill™ hydrogen transport equipment utilizes the most efficient safety features in the industry. With over 700 units delivered, we offer experience, credibility, and a track record of standing behind our products.

Click Here to Read about our 700th Trailer Delivery.

Become A Leader In Clean Energy

For more information or any questions, contact us at **info@bayotech.us**.

JOIN THE HYDROGEN REVOLUTION TODAY!