LOCTITE®

# HYDROGEN READY
# BONDING, SEALING, AND MONITORING SOLUTIONS

## $H_2$ERE TO PERFORM
## UNDER PRESSURE

**BEYOND** THE BOND


Henkel

Henkel Adhesive Technologies


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# POWERING THE FUTURE *WITH HYDROGEN*

**Hydrogen is emerging as a key pillar in the global transition toward clean, sustainable energy. As a versatile, zero-emission fuel, it plays a crucial role in decarbonizing hard-to-abate sectors such as heavy industry, transportation, and power generation.**

The hydrogen ecosystem encompasses the entire value chain – from production using renewable or low-carbon sources, to storage, distribution, and end use across various applications. By enabling energy resilience, reducing carbon footprints, and supporting circular energy systems, hydrogen is not just an alternative fuel – it's a cornerstone of the future energy landscape.

## 22% OF GLOBAL ENERGY DEMAND[1]

Up to 22% of global energy demand can be met by $H_2$ by 2050.

## UP TO 85 GIGATONS OF $CO_2$ SAVED[2]

Hydrogen plays a key role in the clean energy transition. Up to 85 gigatons of $CO_2$ can be saved cumulatively by 2050.

## UP TO 1.4 TRILLION US DOLLARS[3]

The growth potential of hydrogen by 2050 is gigantic and will create up to two million new jobs worldwide.

1 https://hydrogencouncil.com/wp-content/uploads/2021/11/Hydrogen-for-Net-Zero.pdf
2 https://www.logistik-express.com/deloitte-studie-einsatz-von-gruenem-wasserstoff-kann-bis-2050-einsparungen-von-rund-85-gigatonnen-co2-bringen/
3 https://www.deloitte.com/at/de/issues/climate/hydrogen-outlook-2023.html

# HYDROGEN VALUE CHAIN

**Grey hydrogen is produced from fossil fuels like natural gas through steam methane reforming, emitting significant levels of $CO_2$. Blue hydrogen follows the same process but incorporates carbon capture and storage (CCS) to reduce emissions. Green hydrogen, the cleanest variant, is generated by electrolyzing water using renewable energy sources, resulting in zero carbon emissions.**

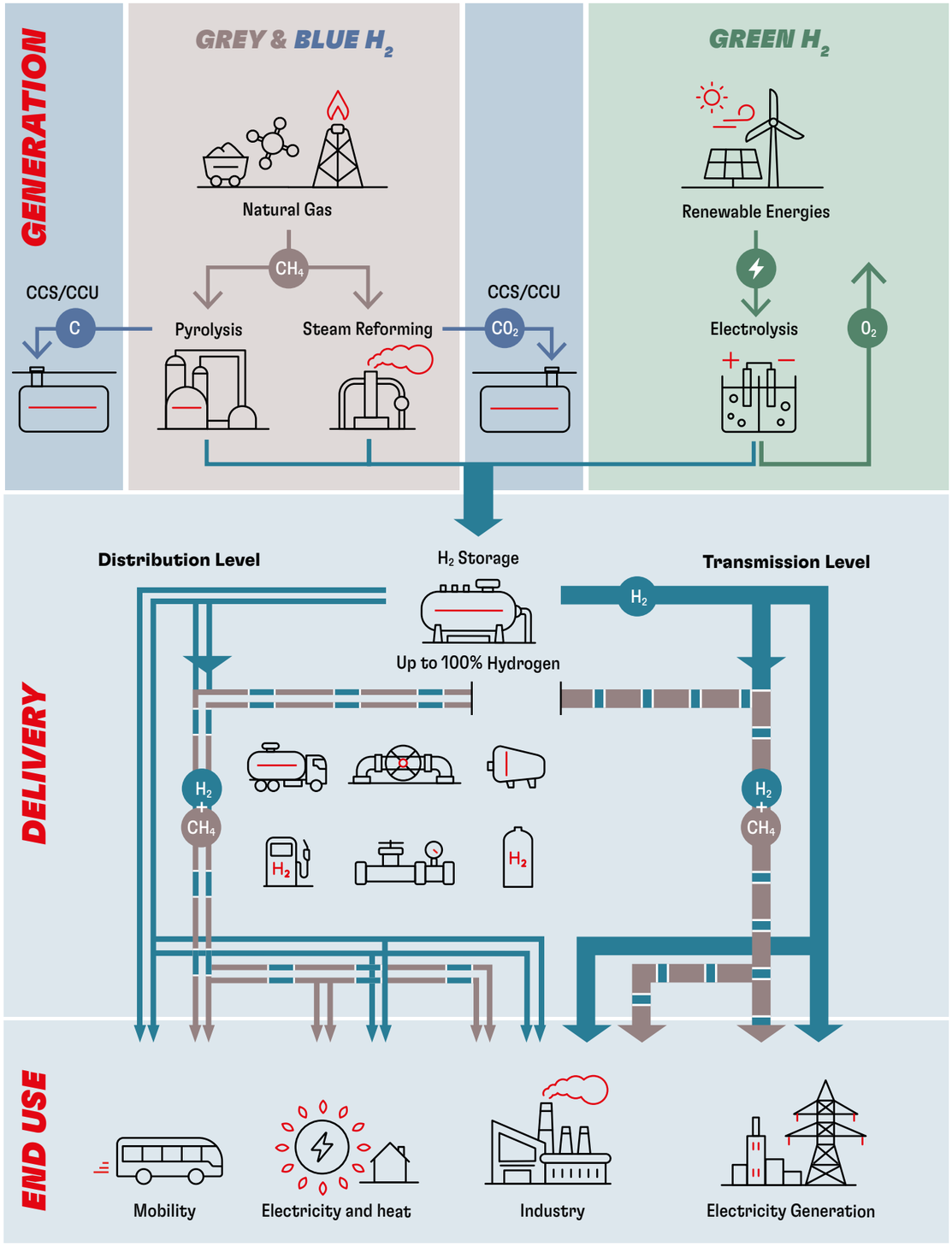
## THE HYDROGEN VALUE CHAIN ENCOMPASSES SEVERAL KEY STAGES:

**Production:**
Hydrogen is produced via methods such as steam methane reforming for grey and blue hydrogen, and electrolysis powered by renewables for green hydrogen.

**Distribution:**
Once produced, hydrogen is transported through pipelines or compressed gas cylinders, or liquefied for shipping, ensuring it reaches various end-use locations.

**Storage:**
Hydrogen is stored in high-pressure tanks or underground caverns, or as metal hydrides, facilitating a steady supply and buffering demand fluctuations.

**End use:**
Hydrogen serves multiple sectors, including transportation (fuel cells), industry (as a feedstock), and energy (power generation), contributing to decarbonization efforts across the economy.



# GREEN HYDROGEN *POWERING A SUSTAINABLE FUTURE*

Hydrogen is a clean, flexible energy carrier that plays a crucial role in the transition to a low-carbon economy. When produced using renewable energy sources – known as green hydrogen – the process creates zero emissions. This makes it especially ideal for decarbonizing hard-to-abate sectors such as heavy industry, long-haul transport, and energy storage.

**By integrating green hydrogen into our energy systems, we can enhance sustainability by reducing reliance on fossil fuels and building a more resilient foundation for the global green transition.**

# OVERCOMING HYDROGEN **MARKET CHALLENGES**

## ENSURING COMPATIBILITY, SAFETY, AND EFFICIENCY

The hydrogen market faces critical challenges, including material compatibility issues like embrittlement, safety concerns due to its flammability, leakage risks, and inefficiencies in storage and distribution systems. Our solutions are designed to tackle these obstacles by enhancing infrastructure compatibility, implementing advanced safety measures, and optimizing efficiency and reliability across the hydrogen value chain. By addressing these key issues, we aim to facilitate a safer and more efficient transition to a hydrogen-powered future.

### SAFETY AND ENVIRONMENT
Leakage, pressure hazards, and hydrogen embrittlement

### COMPATIBILITY
Testing, material compatibility, and approvals

### EFFICIENCY
System efficiency, durability, and automation





**APPLICATIONS**

| | HYDROGEN DEVICES | THREAD SEALING | FLANGE SEALING | THREAD-LOCKING | SMART VALVE |
|---|---|---|---|---|---|
| PRODUCTION | Electrolyzers | ● | ● | ● | |
| | Electrolysis Systems | ● | ● | ● | ● |
| TRANSPORT / TRANSMISSION / STORAGE / DISTRIBUTION | Valves | ● | ● | ● | ● |
| | Compressors | ● | ● | ● | |
| | Pumps | ● | ● | ● | |
| | Pressure Sensors | ● | | | |
| | New $H_2$ Pipelines | | ● | | |
| | Current $CH_4$ Pipelines | | ● | | |
| | Storage Systems | ● | ● | ● | ● |
| | Fuel Stations | ● | ● | ● | ● |
| END USE | Fuel Cells | ● | ● | ● | |
| | Gas Boilers | ● | | ● | |
| | Gas Appliances | ● | | ● | |
| | Engines | ● | ● | ● | ● |
| | Power Generators | ● | ● | ● | ● |
| | Turbines | ● | ● | ● | ● |
| | Ammonia Crackers | ● | ● | ● | ● |
| | Steel Furnaces | | ● | ● | ● |
| | Mobility drivetrains | ● | ● | ● | |

# HYDROGEN READY *SOLUTIONS*

LOCTITE® solutions are engineered to deliver safety, reliability, and high performance, providing secure sealing and locking even under extreme pressures and demanding conditions, thereby supporting our partners in advancing the hydrogen economy.


**01**

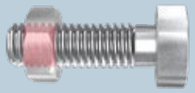
**THREAD SEALING**

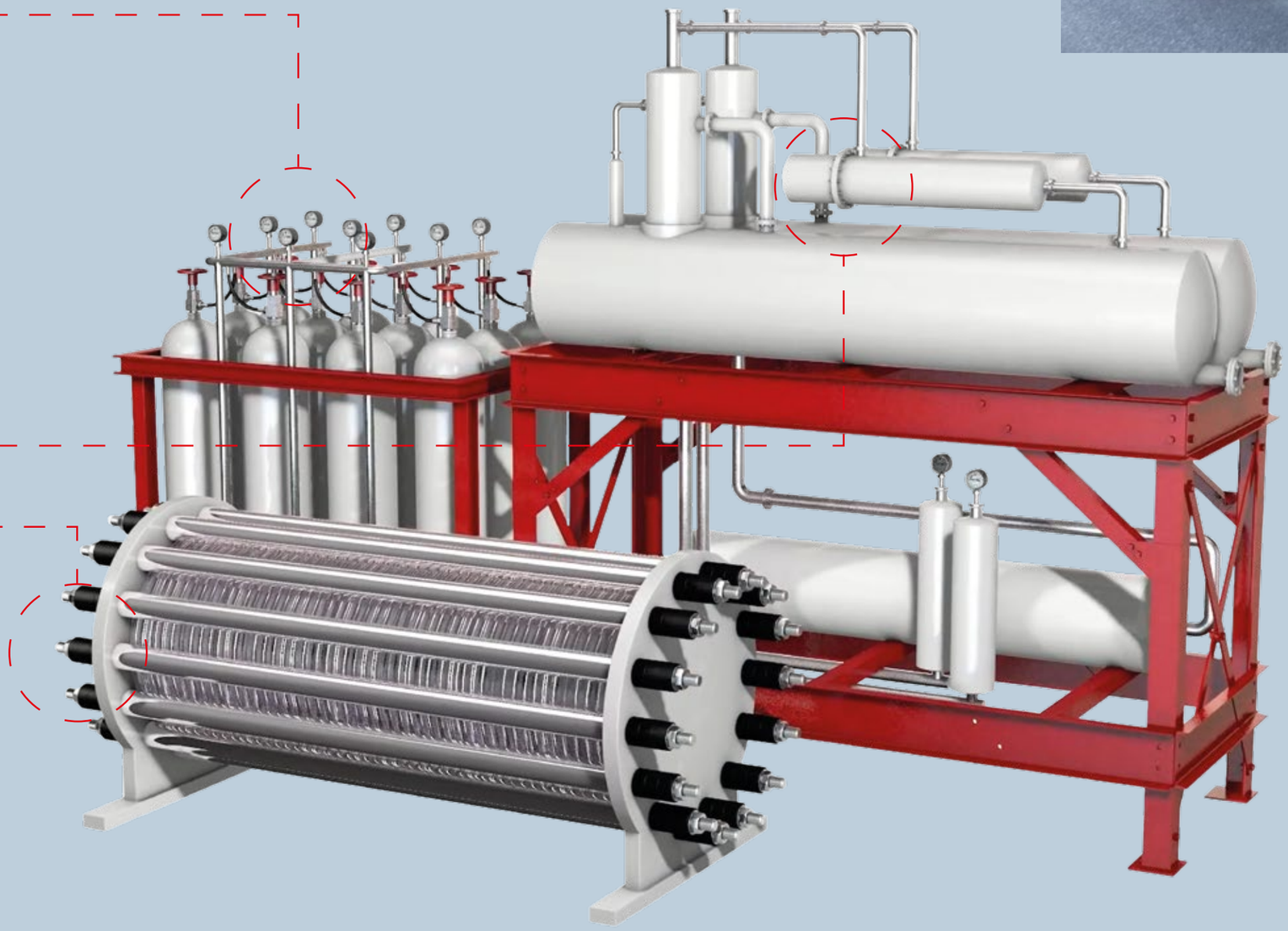
**02**

**FLANGE SEALING**

**03**

**THREADLOCKING**





# HYDROGEN READY THREAD SEALING

## FOR THE SAFE AND RELIABLE PREVENTION OF HYDROGEN GAS LEAKS


Engineered to withstand the challenges of hydrogen environments, LOCTITE Hydrogen Ready Thread Sealing solutions withstand high pressures and meet the performance requirements of KIWA GASTEC QA AR 214 for admixtures up to and including 100% hydrogen gas. Certifications are available in select countries.

Rely on LOCTITE® Hydrogen Ready Thread Sealants to ensure a safe and reliable seal against hydrogen gas leaks while avoiding the complexity and costs associated with other sealing methods, such as seal welding and cone and thread fittings. Engineered to withstand the challenges of hydrogen environments, LOCTITE Hydrogen Ready Thread Sealing solutions meet the performance requirements of KIWA GASTEC QA AR 214 for admixtures up to and including 100% hydrogen gas – certifications are available in select countries.

LOCTITE Hydrogen Ready Thread Sealants are suitable for use on both NPT- and BSPT-style threaded components made of any type of metal, including tough-to-seal stainless steel. The easy-to-apply thread sealants allow for adjustment during assembly and do not shred or tear like tapes, nor shrink like pipe dopes.



In addition to meeting the performance requirements of the KIWA GASTEC QA AR 214 specification, several of our thread sealants have also been tested by third-party labs and proven to seal hydrogen pressures up to 1,500 bar. See results below.


**TABLE 1: Pressure testing results**

| | Kiwa Standard AR 214 | Henkel testing: medium pressure* | Henkel testing: high pressure** |
|---|---|---|---|
| **LOCTITE 55** | ✔ | 150 psi (10.3 bar) | |
| **LOCTITE 567** | ✔ | 450 psi (31 bar) | 7,252 psi (500 bar) |
| **LOCTITE 577** | ✔ | 450 psi (31 bar) | 7,252 psi (500 bar) |
| **LOCTITE 638** | ✔ | | 21,756 psi (1,500 bar) |

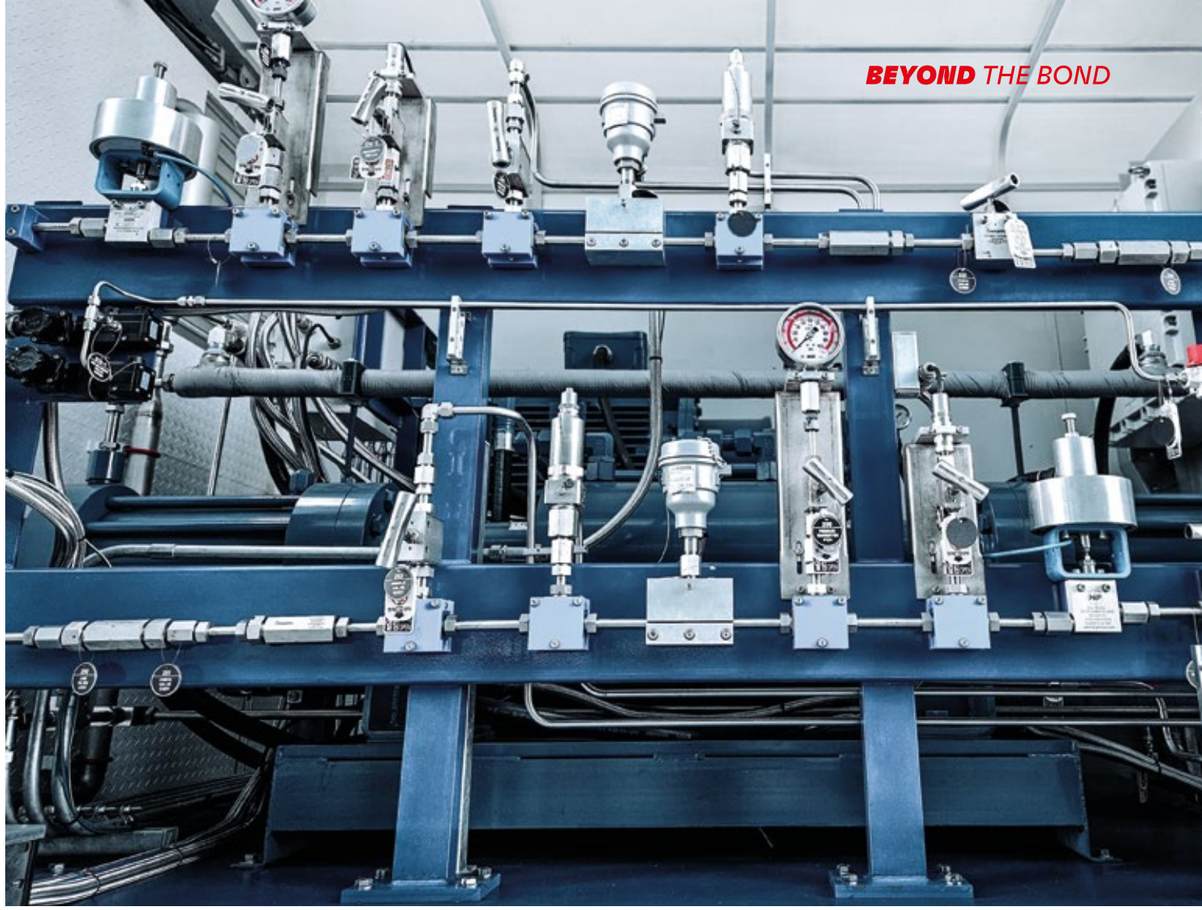
*Test made with a 1/4" NPT and BSPT Pipe Nipple

**Test made with a 1/4" NPT Pipe Nipple

| Thread Sealing solution | Description | Pack size | Part no. (SKU/IDH) |
|---|---|---|---|
| **LOCTITE 55** | White, non-curing thread sealing cord provides immediate full-pressure sealing. Allows for reliable readjustments without leakage. Ideal for BSPT and NPT pipe threads. | | |
| **LOCTITE 567** | White, high-viscosity anaerobic-curing thread sealant paste. Provides instant low-pressure sealing. Seals and locks metal threaded pipes and fittings, but allows for easy disassembly. Ideal for NPT pipe threads. | | |
| **LOCTITE 577** | Yellow, high-viscosity anaerobic-curing thread sealant paste. Provides instant low-pressure sealing. Seals and locks metal threaded pipes and fittings, but allows for easy disassembly. Ideal for BSPT and NPT pipe threads. | | |
| **LOCTITE 638** | Green, medium-viscosity anaerobic-curing adhesive/ sealant with high shear strength. Typically used to retain bearings on shafts, but also ideal for thread sealing and locking applications in high-pressure and/or extreme environments. Ideal for BSPT and NPT pipe threads. | | |

## SUCCESSFUL APPLICATION CASE

# HIGH-PRESSURE HYDROGEN LEAKS ELIMINATED *WITH HIGH-PERFORMANCE, HIGH-STRENGTH SEALANT*



### SITUATION

A leading manufacturer of high-pressure processing equipment was experiencing difficulties in finding a solution to seal the 1/4" and 1/2" AISI 316 stainless steel NPT fittings on a hydrogen compressor that needed to withstand pressures of up to 1,000 bar.
The previously evaluated sealants either failed their pressure requirements or required a long and complex curing process.


### LOCTITE® SOLUTION

LOCTITE 638 high-strength adhesive is a single-component, fast, room-temperature curing adhesive that provides high shear strength.

Typically used to retain cylindrical components, such as bearings on shafts or in housings, LOCTITE 638 is also ideal for thread sealing and/or threadlocking applications that operate in high-pressure and other extreme environments. The anaerobic adhesive cures when confined in the absence of air between close-fitting metal surfaces and prevents loosening and leakage caused by shock and vibration. It cures on most metals without an activator or primer. The product offers high-temperature performance and good oil tolerance and tolerates minor surface contaminants. The product has been deemed hydrogen ready for use on metal fittings only, according to KIWA GASTEC QA AR 214 Class 8. Certifications are available in selected countries.

### BENEFITS

**Enhanced reliability**
due to elimination of all leaks in the field

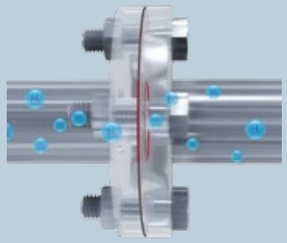
**Increased productivity**
and process time savings due to fast adhesive curing

**Improved end-use equipment safety**
by eliminating the risk of hydrogen leaks

# HYDROGEN READY **FLANGE SEALING**

## FOR THE SAFE AND RELIABLE PREVENTION OF HYDROGEN GAS LEAKS


Tested up to 41 bar of pressurized hydrogen with third-party labs, LOCTITE Hydrogen Ready Flange Sealing solutions have been engineered to withstand the challenges of hydrogen environments and provide reliable, leak-free sealing performance.



Count on LOCTITE® Hydrogen Ready Flange Sealing solutions to ensure a safe and reliable seal against hydrogen gas leaks on rigid metal flanges, while avoiding the compression-set risks, high costs, and inventory complexities associated with pre-formed gaskets.

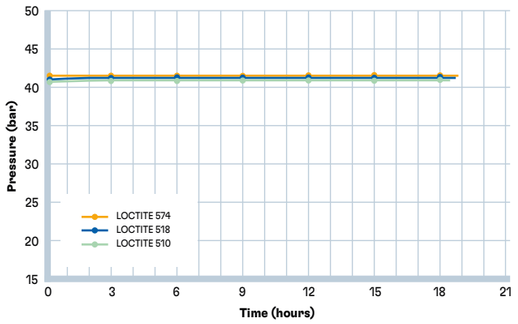
LOCTITE Hydrogen Ready Flange Sealants are self-forming anaerobic-curing liquid gaskets that provide a perfect seal between close-fitting, rigid metal flanges. The easy-to-apply, single-component sealants fill all gaps and surface imperfections between the mating flanges, adding structural stiffness and eliminating micromovement and slipping. They do not shrink, crack, or relax over time.



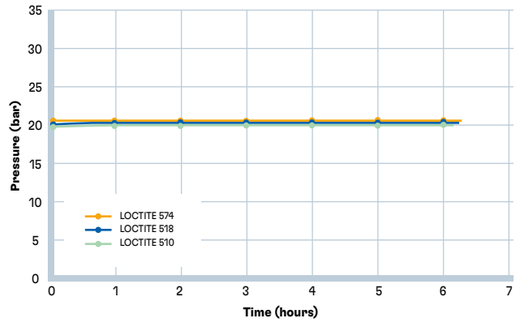
Based on tests conducted by a third-party laboratory, the following LOCTITE Hydrogen Ready Flange Sealants have been proven to provide reliable, leak-free performance against hydrogen. Evaluated on 304 stainless steel raised flanges, the sealed assemblies were pressurized with 100% hydrogen gas and then monitored for pressure drops while at two different pressure and temperature conditions, tested sequentially. No notable pressure drops were detected. Hydrogen pressure tests were conducted sequentially at 41 bar at ambient temperature for 18 hours, followed by 20 bar at 80°C for 6 hours.


### TABLE 2: Pressure testing results

**Flange sealants at 41 bar at ambient temp. for 18 hrs.**




**Flange sealants at 20 bar at 80°C for 6hrs.**

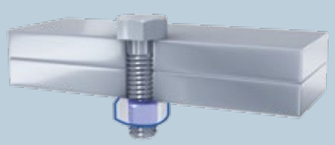



| Flange Sealing Solution | Description | Pack size | Part no. (SKU/IDH) |
|---|---|---|---|
| **LOCTITE 510** | Pink, high-viscosity anaerobic-curing flange sealant for close-fitting, rigid metal flanges. Ideal for steel, stainless steel, and cast iron surfaces. Fills gaps up to 0.25 mm. Provides instant low-pressure seal. Resists temperatures up to 204°C. | | |
| **LOCTITE 518** | Red gel, semi-flexible anaerobic-curing flange sealant for close-fitting, rigid metal flanges. Ideal for steel, stainless steel, and aluminum surfaces. Fills gaps up to 0.25 mm. Provides instant low-pressure seal. Resists temperatures up to 150°C. | | |
| **LOCTITE 574** | Orange, high-viscosity anaerobic-curing flange sealant for close-fitting, rigid metal flanges. Ideal for steel, stainless steel, and cast iron surfaces. Fills gaps up to 0.25 mm. Provides instant low-pressure seal. Resists temperatures up to 150°C. | | |

# THREADLOCKING

## FOR THE SAFE AND RELIABLE PREVENTION OF HYDROGEN GAS LEAKS


Ideal for reliably securing threaded metal fasteners to prevent loosening caused by vibration, thermal cycling, shock loads, and other stresses. Suitable for use on pumps, valves, compressors, motors, and other industrial equipment.




| Threadlocking Solution | Description | Pack size | Part no. (SKU/IDH) |
|---|---|---|---|
| **LOCTITE 243** | Blue, medium-strength threadlocker for securing nuts, bolts, and other threaded metal fasteners. Prevents vibrational loosening yet can be removed using a standard hand tool without heat for easier servicing. Performs reliably on a variety of metals, including stainless steel, aluminum, and plated surfaces. Resists temperatures up to 182°C. | | |
| **LOCTITE 270** | Green, high-strength threadlocker for securing nuts, bolts, studs, and other threaded metal fasteners. For use on parts that are not expected to be disassembled regularly – requires heat to disassemble. Performs reliably on a variety of metals, including stainless steel, aluminum, and plated surfaces. Resists temperatures up to 182°C. | | |
| **LOCTITE 263** | Red, high-strength threadlocker for securing nuts, bolts, studs, and other threaded metal fasteners. For use on parts that are not expected to be disassembled regularly – requires heat to disassemble. Performs reliably on a variety of metals, including stainless steel, aluminum, and plated surfaces. Resists temperatures up to to 182°C. | | |
| **LOCTITE 2400** | Blue, medium-strength threadlocker that carries no hazard symbols or risk or safety phrases. Prevents vibrational loosening yet can be removed using a standard hand tool without heat for easier servicing. Performs reliably on a variety of metals, including stainless steel, aluminum, and plated surfaces. Resists temperatures up to 150°C. | | |
| **LOCTITE 2700** | Green, high-strength threadlocker that carries no hazard symbols or risk or safety phrases. For use on parts that are not expected to be serviced regularly – requires heat to disassemble. Performs reliably on a variety of metals, including stainless steel, aluminum, and plated surfaces. Resists temperatures up to 150°C. | | |

# SURFACE PREPARATION

*ESSENTIAL FIRST STEP FOR RELIABLE SEALING*


## CLEANERS

For best results, it is recommended to thoroughly clean surfaces with an appropriate cleaner before applying sealants or threadlockers, especially when surfaces are heavily oiled or contaminated.


## PRIMERS/ACTIVATORS

Primers are surface-activating agents used to accelerate the curing speed of anaerobic adhesives such as threadlockers, thread sealants, and flange sealants. Ideal for use with inactive or passive metal surfaces or in cold conditions that can slow the curing process.

| Surface Preparation Solution | Description | Pack size | Part no. (SKU/IDH) |
|---|---|---|---|
| **LOCTITE SF 7063 Cleaner** | Solvent-based general purpose cleaner that dries quickly and leaves no residue on the parts. Ideal for cleaning and preparing surfaces prior to adhesive bonding and sealing applications. Removes most greases, oils, lubrication fluids, metal cuttings, and fines from all surfaces. | | |
| **LOCTITE SF 7070 Cleaner** | A non-aqueous, hydrocarbon-based solvent designed for cleaning and degreasing surfaces to be bonded with adhesives. Safe on aluminum, rubber, and most plastics, and will not cause flash rusting on water-sensitive parts. Dries residue-free. | | |
| **LOCTITE SF 7649 Primer/ Activator** | Designed to promote the curing speed of LOCTITE anaerobic adhesives and sealants without any significant loss of joint strength. Especially recommended for applications with passive metals, inert surfaces, or large gaps, or for assembly in cold conditions. | | |






# H₂ERE TO PERFORM *UNDER PRESSURE*

LOCTITE® Pulse

# SMART VALVE



## VALVE FAILURES CAN COST YOUR BUSINESS – AND COMPROMISE SAFETY.

**Failure rate of valves can reach 15% per year.**

- Natural wear and tear: from high usage, aging, fouling, and exposure to harsh environments.
- Human factors: improper calibration, installation, or maintenance, or from exceeding valve specs, can cause malfunctions.
- Creeping failures: Hidden issues lead to unnoticed maintenance costs.
- Safety concerns: Unplanned chemical mixing can cause dangerous reactions, production loss, or equipment damage.
- Internal leakages: inefficiencies, flow disruptions, and pressure issues.

**LOCTITE® Pulse Smart Valve Monitoring offers a more efficient and reliable solution for these challenges.**

## ALWAYS-ON MONITORING FOR CRITICAL VALVES: MAINTAIN FLUID CONTROL AND DETECT INTERNAL LEAKS.

**WIDE COMPATIBILITY:**
Designed for safety, relief, and shutoff valves with pneumatic actuation.

**ALL MEDIA:**
Enhancing various processes for all media.

**QUICK AND EASY ROLLOUT:**
Start monitoring valves in a short time.

**NON-INTRUSIVE:**
Retrofit, with no shutdown required.

**ALWAYS-ON:**
Continuous reporting of failures – 24/7, 365 days a year.

**EASY ACCESS TO DATA:**
Insights are presented and accessible via a web app or API, making it user-friendly for all staff.

# PERFORMANCE AND BEYOND – *TOGETHER*

## $H_2$ERE TO PERFORM *UNDER PRESSURE*

### ENGINEERED FOR SUSTAINABILITY

Our hydrogen-ready solutions are designed to reduce leaks, extend equipment life, and minimize environmental impact—supporting long-term sustainability in critical hydrogen applications.

### IN PARTNERSHIP WITH YOU

We work closely with customers across the hydrogen value chain to understand their challenges and deliver tailored sealing and bonding solutions that enhance safety and reliability.

### INNOVATION AT THE HEART

Backed by decades of research and cutting-edge technology, LOCTITE continuously innovates to meet the demanding requirements of the evolving hydrogen industry.

### EXPERTISE AROUND THE WORLD

With a global network of experts, technical support, and training, we ensure consistent performance and localized service wherever our customers operate.

***BEYOND** THE BOND*



**WATCH THE VIDEO**

LOCTITE

BEYOND THE BOND

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