

Q&A

Enter your question

Submit

### About the presenter



**Chuck Hayes** is a 30-year veteran of Swagelok Company, a world leader in the development of fluid system products, assemblies, and services. He has spent the last 25 years developing a wide range of fluid system products and the past 20 years focused exclusively on fitting technology for alternative fuel applications. Chuck currently holds 7 patents in the US and numerous patents internationally.

He is an active member of CSA (Canadian Standards Association Group) committees for both CNG and Hydrogen and has recently been the chair of HGV (Hydrogen Gas Vehicles) 4.10 for fittings. Chuck also sits on ISO-TC97 (Technical Committee) and participates in international working groups. During his time as Principal Applications Engineer for the transportation market, Chuck has supported numerous on-vehicle platform development projects globally.

Today, he concentrates most of his time on the development of hydrogen mobility solutions for both infrastructure and on-vehicle applications. Outside of work, Chuck has been an active leader in the Boy Scouts of America movement and serves as Scoutmaster for a troop that has recently welcomed 2 of the first female Eagle Scouts in the nation. He also runs an Explorer Scouts post focused on engineering with local high school students at Swagelok.






## Introduction

- The clean transportation landscape (vehicle pressure classes)
- The challenges of H<sub>2</sub> as a fuel
- Characteristics of high-performance H<sub>2</sub> fuel system fittings

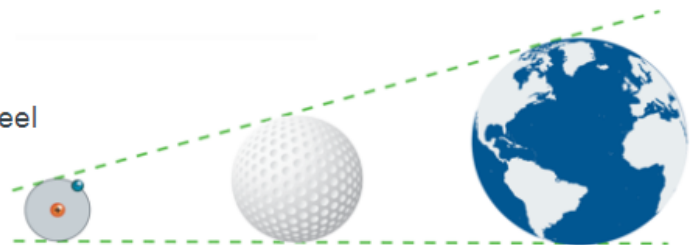


## The clean transportation landscape

	Current EV	H2 Advantages
 Driving Range	<ul style="list-style-type: none"> <li>• 100 – 300 miles</li> <li>• Not compatible for HD/long haul vehicles</li> </ul>	<ul style="list-style-type: none"> <li>• 300+ miles on a single refill</li> <li>• 1000+ miles for HD/long haul vehicles</li> </ul>
 Refueling Time	<ul style="list-style-type: none"> <li>• Can range from 3 – 12 hours</li> </ul>	<ul style="list-style-type: none"> <li>• &lt;4 minutes for light duty vehicles</li> <li>• &lt;15 minutes for heavy duty vehicles</li> </ul>
 Costs	<ul style="list-style-type: none"> <li>• High price</li> <li>• Short service life</li> <li>• Replacement cost + disposal</li> </ul>	<ul style="list-style-type: none"> <li>• Increased efficiency</li> <li>• Lower total cost of ownership</li> </ul>

## The unique nature of H2

- H2 is among the smallest molecules in nature, which makes H2 fluid system containment challenging
- Critical performance for leak-tight tube fitting connections
  - Safety
    - Escaping gas poses safety risks
    - End-users interact with dispenser during refueling
  - Efficiency
    - Effective utilization of all H2
    - No waste
- Hydrogen embrittlement
  - H2 molecules can diffuse into stainless steel
  - Pressure and time can produce fissures
  - 316/316L materials are critical



## Why fittings matter

Operating conditions for H<sub>2</sub> fuel system components are inherently challenging

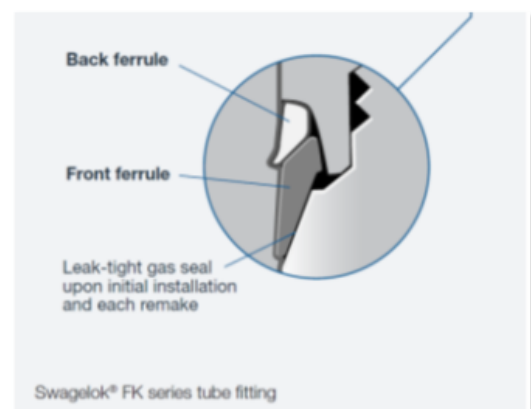
- **Pressure:** To achieve desired density, H<sub>2</sub> must be stored in on-vehicle tanks at 250 – 700 bar
- **Stress and vibration:** Systems must be able to withstand fast speeds, bumpy roads, and inclement weather conditions
- **Safety:** Refueling stations must be safely operable by the average consumer
- **Maintenance:** Ability to easily remake leak-free joints during servicing
- **Net:** Quality design and materials are critical as tube fittings must deliver leak-tight performance that lasts for years—or decades.



© 2021 Swagelok Company

## Performance characteristics: gas seal tightness

- Gas seal tightness is critical for safety, reliability, and efficiency
- Challenge/solution
  - Size of H<sub>2</sub> molecule can make traditional fitting designs ineffective
  - Seal along a single line of contact OK for general industrial uses
  - Ideal design
    - Incorporates 2 contact zones along longer sealing surfaces
    - Contact surfaces angled for optimized stress level and seal
    - Two-ferrule solution
      - Front ferrule creates long line of contact
      - Back ferrule grips tubing and creates surface seal
      - Long, precisely machined front ferrule makes gas seal more reliable and tighter



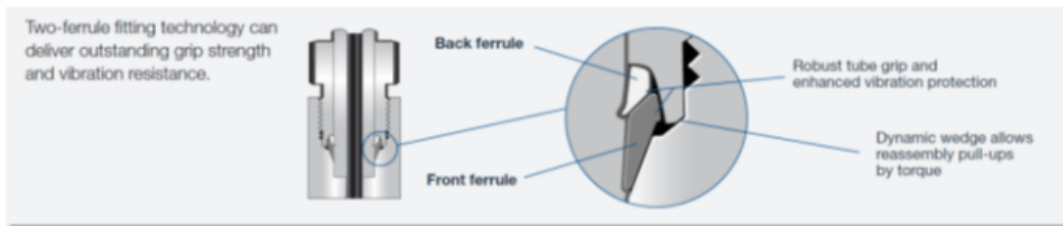
© 2021 Swagelok Company

7

## Performance characteristics: tube grip strength

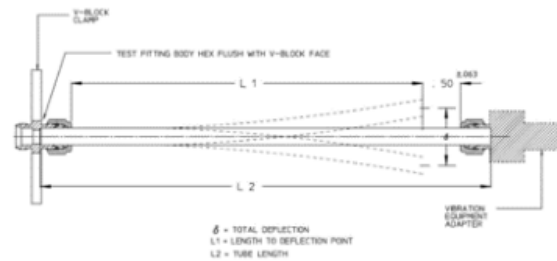
**Tube grip strength:** The persistent force at which a fitting grips the tube.

- For H2 fuel system applications, tube grip strength must withstand high pressures (generation, transport, storage, and dispensing), and the intense vibrations of a moving vehicle.
- Traditional fitting connections (cone & thread, NPT, and O-ring face seals) may not be able to maintain an effective tube grip or seal
- Two-ferrule solution
  - Two low-temperature, case-hardened ferrules will:
    - Hinge and collet into the tubing
    - Create a seal with a pressure rating of up to 1050 bar (15 229 psi)



## Performance characteristics: vibration resistance

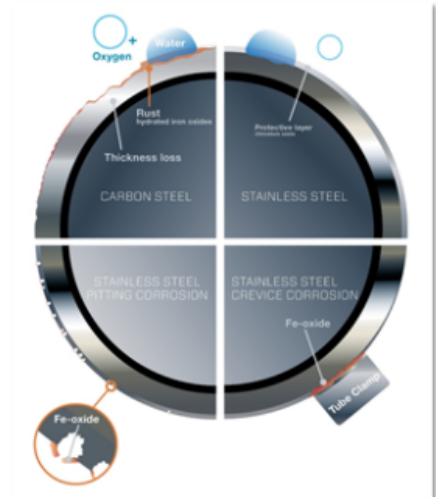
- Tube connections on moving vehicles are subject to more shock and vibration than a stationary fluid system application (rotary and planar forces)
- Two-ferrule solution
  - “Spring back” allows for slight movement without compromising tube grip and force
  - Two-ferrule mechanical grip fitting can withstand dynamic vibration conditions in either on-vehicle or infrastructure applications
  - Also, spring back enables fitting connections to tolerate expansion and contraction of metallic alloys through a wide range of temperatures (-40°C to 85°C)



## Performance characteristics: material integrity

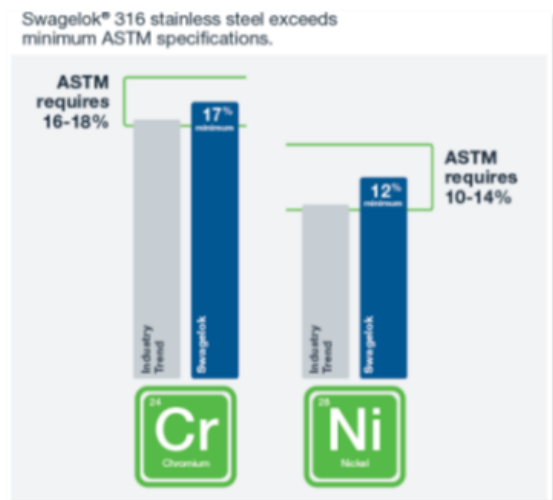
Corrosion: A loss of material in a metal surface when a metal atom is oxidized by a fluid.

- Corrosion in H2 fuel system tubing reduces wall thickness
- Both on-vehicle and infrastructure are subject to adverse weather
- And “H2 embrittlement” can further compromise lesser-quality alloys
- Only higher-quality 316/316L stainless can reliably withstand these challenges



## Performance characteristics: material integrity

- 316/316L stainless steel alloys (contribution to material integrity)
  - Nickel (stabilizes crystal structure of steel)
  - Chromium (corrosion resistance)
  - Molybdenum (corrosion resistance)
- Combatting H2 embrittlement and corrosion
  - Higher concentrations of Ni and Cr provide greater ductility
  - ASTM requirements for 316 stainless
    - >12% Cr
    - >10% Ni



## Performance characteristics: ease of installation and maintenance

- The ramp-up of H<sub>2</sub> fuel system on-vehicle and infrastructure adoption requires simple, fast, easy, and repeatable installation processes
- Challenges for traditional cone and thread fittings
  - Require specialized tools, materials, and lubricants
  - Tubes must first be properly coned and threaded
  - Added complexity
    - Collar threaded onto tubing
    - Gland nut inserted into the fitting body

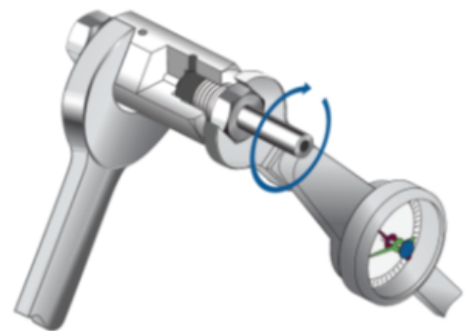


Traditional Cone and Thread Fitting Design

## Performance characteristics: ease of installation and maintenance

### Two-ferrule solution

- Mechanical grip fittings can be installed 5x faster
- High functionality yields reliable first-time, leak-tight seals
- Significantly reduces rework and overall cost of maintenance (total cost of ownership)
- Other advantages:
  - 1) simpler installation
  - 2) fewer installation errors
  - 3) consistent, reliable performance over time
  - 4) no special tools or materials required





Swagelok

## A solution designed specifically for H2: Swagelok FK series fittings

FK series fittings deliver these essential performance characteristics

- Seal tightness
- Grip strength
- Vibration resistance
- Material integrity
- Ease of installation



FK series fittings are available for your hydrogen fuel system needs.

Swagelok

## A solution designed for H2: Swagelok FK series fittings



### Designed for leak-tight performance

- Compatible with a variety of tubing types and materials
- Low-temperature case-hardened ferrules
- Hinging-colleting action
- Reliable tube grip and vibration resistance



## A solution designed for H<sub>2</sub>: Swagelok FK series fittings



### Certifications/type approvals (H35/H70 pressure classes)

- EC-79
- HGV 3.1
- EIHP certified

POWERED BY  
ON24

## A solution designed for H<sub>2</sub>: Swagelok FK series fittings



### Material compatibility

- 316/316L stainless steel
- 12% minimum nickel (strength)
- 17% minimum chromium (resists corrosion and H<sub>2</sub> embrittlement)

POWERED BY  
ON24



## A solution designed for H2: Swagelok FK series fittings

---



### Simple and easy installation

- Patented, two-piece design
- Preassembled cartridge ensures proper installation
- Components are released only after the nut is threaded
- Install up to five times faster than traditional cone and thread fittings with no special tooling

POWERED BY  
ON24

## A solution designed for H2: Swagelok FK series fittings

---



### Backed by our full suite of service offerings

- Specialized training
- On-site evaluations
- Design and assembly services
- And much more

POWERED BY  
ON24

## Wrap-up

---

- The long-term viability of H2 mobility market depends on the safety, reliability, and durability of vehicles and infrastructure
- Selecting and specifying the right components for critical systems can help
- Swagelok FK series fittings are an optimal choice for today and tomorrow
- Interested in learning more? [Contact your local authorized Swagelok sales and service center.](#)

The Swagelok logo is located in the top right corner of the slide. It consists of the word "Swagelok" in a blue, sans-serif font.The "POWERED BY ON24" logo is located in the bottom right corner of the slide. It features the text "POWERED BY" in a small font above "ON24" in a larger, bold font, all in white.

## Questions?

---

The Swagelok logo is located in the bottom right area of the slide. It consists of the word "Swagelok" in a blue, sans-serif font.The "POWERED BY ON24" logo is located in the bottom right corner of the slide. It features the text "POWERED BY" in a small font above "ON24" in a larger, bold font, all in white.

---

This webinar has concluded. Thank you for engaging with us.