

## Engineering & Manufacturing Capabilities

VPE provides the metallurgical services, engineering, and contract manufacturing expertise our customers require to meet their demanding performance, cost, and lead-time goals. We work closely with OEMs, suppliers, and technology integrators to create the most efficient and effective compact heat exchangers. Depending on your objectives, we can develop a unit to your exact specifications or design a custom system that achieves your desired performance requirements.



[www.vpei.com](http://www.vpei.com)

## Advantages of Working with VPE

- Over 40 years of diffusion bonding experience.
- Design and manufacturing with engineering assistance.
- Tested and proven manufacturing processes.
- Redundant and burst capacity facility for fast turn and reliable sourcing.
- State-of-the-art technical facilities.
- Large-assembly diffusion bonding experience and facility.
- Developed supply chain.
- 150,000 sq. ft. of design, lab, quality assurance and production space.



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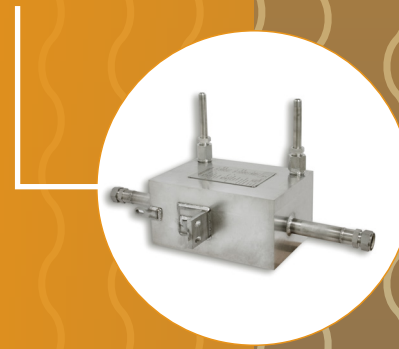
## Quality Assurance Certifications & Registrations

VPE is committed to meeting customer quality and on-time delivery expectations through practicing continuous improvement, and by operation of an effective Quality Management System.

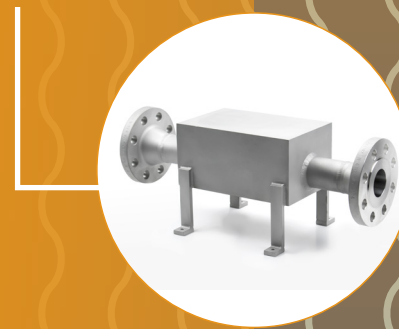
- ISO 9001
- AS9100
- ITAR registered
- Numerous Supplier-Specific Certifications

VPE can manufacture "U" or "UM" stamped heat exchangers that meet requirements of the ASME Boiler and Pressure Vessel Code

H2PC® | Hydrogen Pre-Cooler | (Gen 3)



H2PC® | Hydrogen Pre-Cooler | (Gen 2)

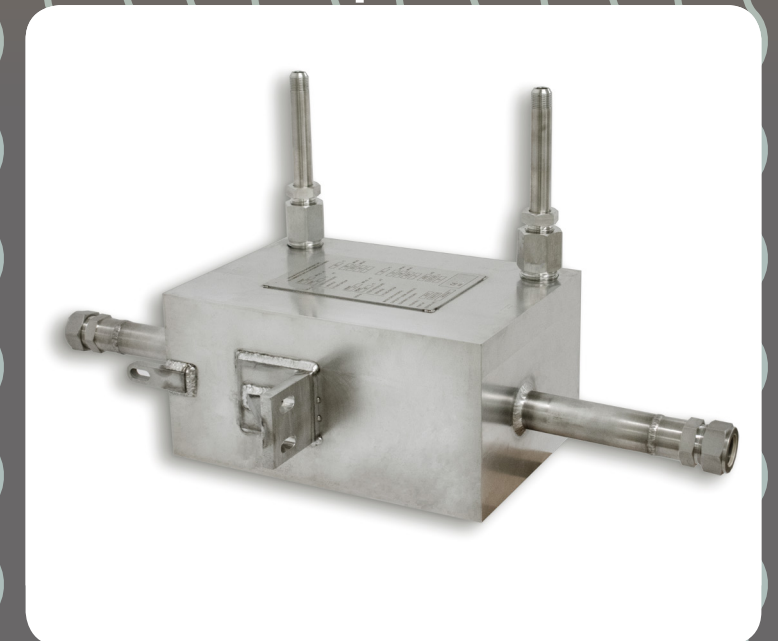


## For Use in Stationary and Mobile Hydrogen Fuel Stations

VPE offers various size compact Hydrogen Pre-Cooling Heat Exchangers (H2PC®) and Hydrogen recuperators for different hydrogen fill rates.

VPE's heat exchangers meet  
SAE J2601 specifications.

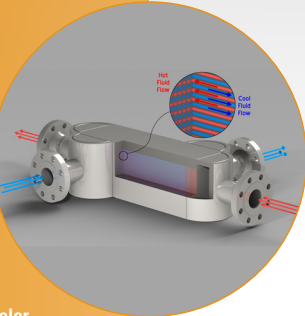
# H2PC®: The most efficient & effective compact heat exchangers.



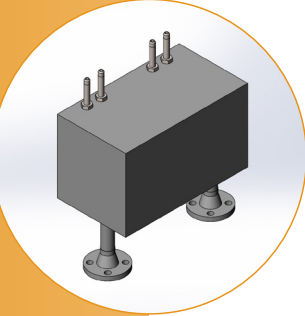
H2PC® | Hydrogen Pre-Cooler  
Butt Welded Hydrogen line



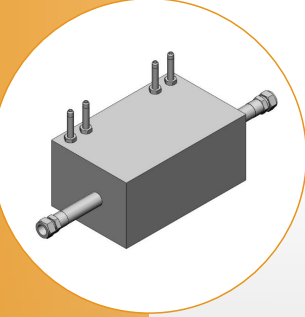
H2PC® | Hydrogen Pre-Cooler | Process



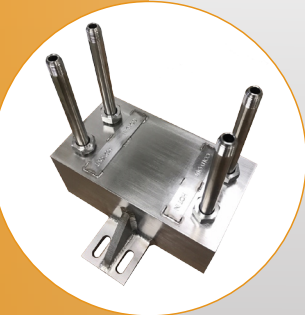
H2PC® | Hydrogen Pre-Cooler  
Butt Welded Hydrogen line - different nozzle  
orientation for the coolant side



H2PC® | Hydrogen Pre-Cooler  
double dispensing options



Hydrogen Recuperator  
for mobile fuel stations



## Hydrogen Pre-Cooling Micro-channel Heat Exchangers (H2PC®s)

VPE has applied sophisticated Diffusion Bonded Micro-channel Heat Exchanger (MCHE) algorithms, in conjunction with diffusion bonding know-how and advanced manufacturing techniques in these highly efficient, compact Hydrogen Pre-Cooling Heat Exchangers. Perfected over four decades, our proven diffusion bonding process ensures parent material strength throughout the core of the heat exchanger. This allows us to produce compact heat exchangers ideally suited for extreme pressure and temperature applications.

### Features and Benefits

- Diffusion bonded to create a solid heat exchanger core without gaskets, interlayer or brazing.
- Highly compact construction for productive use of small spaces relative to other configurations.
- Savings through low weight and fluid inventory.
- A core designed to handle the maximum of the two stream design pressures at the highest temperature, enabling enhanced safety.
- Highly resistant to vibrations and catastrophic failure modes.
- Close approach temperatures in counter flow configuration.

### Advantages of H2PC®s Compared to Alternative Heat Exchangers

	Alternative	VPE Pre-Cooler MCHE
<b>Physical Size</b>	Large mass and Volume (typical block is 27 ft³)	Small mass & volume (high heat transfer area / volume ratio)
<b>Cooling Energy Overhead</b>	Large cooling overhead (large thermal mass)	Small cooling overhead (small thermal mass)
<b>B2B Fill Capability</b>	HX size increases with number B2B fills	Virtually infinite
<b>Packaging / Footprint</b>	Large footprint	Small foot print. Sizes range from hand-held size for mobile fueling to those that fit stationary fueling cabinets.
<b>Cost</b>	Purchase cost low, shipping & installation cost high	Capital cost well below alternative. Low shipping and installation cost provide additional savings.

### Design and operating features for VPE's H2PC® models

Models	H2PC1	H2PC2	H2PC4	H2PC8	H2PC10	H2PC12
<b>Hydrogen fill rates in kg/min (SAE J 2601 and beyond) – covering forklift, light duty vehicles, heavy duty trucks, busses, trains etc)</b>	< 1	~ 2	~ 4	~ 8	~ 10	~ 12
<b>Number of hydrogen side dispenser line – options. Various nozzle orientation - easily configurable</b>	Single	Single	Single and dual	Single and dual	Multiple	Multiple
<b>Typical operating inlet temperature range</b>	20 °C to 65 °C					
<b>Operating exit temperature range (depending on customer application)</b>	0 °C to -40 °C [Hydrogen recuperators use cold side hydrogen inlet at -196 °C]					
<b>Heat exchanger design temperature (MAX / MIN)</b>	100 °C / -196 °C					
<b>Operating pressure range</b>	350 barg - 950 barg					
<b>Heat Exchanger design pressure in barg</b>	500 (for 350 Operating); 1000 - 1275 (for > 700 operating)					
<b>Typical coolant types used</b>	Syltherm XLT, R744 (CO2), Freezium-60, d-limonene, dynalene HC, Temper 60, Therminol D12, glycol-water mix, liquid nitrogen and other refrigerants					
<b>Typical hydrogen side connection types</b>	-Medium pressure cone and threaded fittings (e.g. Maximator type) -Pipe butt welded nozzle option is also available					
<b>Typical coolant side connection type</b>	Swagelok (straight and elbows), ANSI Flanges (CI 150 RF, CI 300 RF)					
<b>Typical MTTF<sub>D</sub> and design life</b>	- MTTF <sub>D</sub> > 50 years, based on 24 hrs operation for 365 days in a 3-min. cycle operation -Can handle very high-pressure cycle fatigue					
<b>Typical material of construction</b>	SS 316L (UNS 31603)					
<b>Certifications</b>	<ul style="list-style-type: none"> <li>• ASME U &amp; UM Stamps</li> <li>• PED compliant with CE marking</li> </ul>					