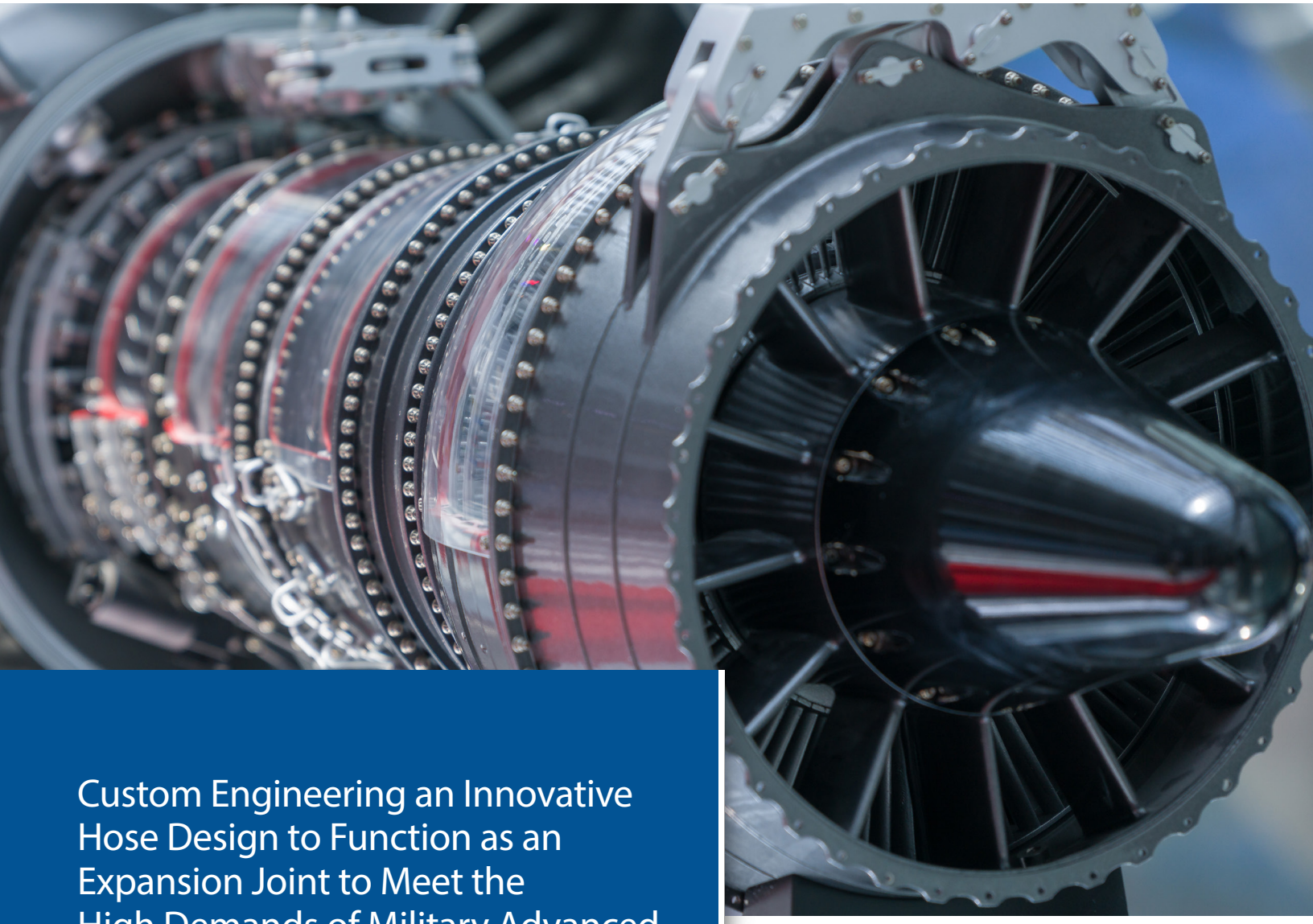
TCH INDUSTRIES
HOSE FOR INDUSTRY

HOSE MASTER



Custom Engineering an Innovative Hose Design to Function as an Expansion Joint to Meet the High Demands of Military Advanced Propulsion Concepts Testing

Figure 1: *Inlet manifold of expansion joint*

Few industries require more product validation and qualification than the military and aerospace sector. Before any new technology is approved by the military's regulatory agencies, they must undergo various levels of technology development, often in a simulated environment. This test environment is designed to push products to their limits in order to ensure they can hold up to the demands of the real world.

Above all else, these tests must be accurate and reliable, delivering boundary conditions for performance and modeling validation and verification. Engineers cannot guarantee the reliability of their products if the testing equipment itself cannot produce accurate, repeatable results. That is why designing functional test equipment is just as important, if not more so, than the products they test.

TCH Industries, a leader in custom hose and fittings, experienced this demanding environment firsthand when one of its customers designed an Advanced Propulsion Concepts test facility for the U.S. military. To validate a new concept, our military has to create a custom testing environment. This environment needed to simulate the high altitudes, fluctuating environments, and extreme pressures and temperatures that the concept would face during normal operation. There was an eight-inch inlet system that would deliver air into the propulsion system to allow for reliable thrust output results. Standard bellows expansion joint designs were not feasible, as they would impart a force under the testing conditions.

With the advanced nature of these challenges, the engineers at TCH Industries realized they needed additional resources to offer a complete design. That is why they partnered with Hose Master, a leader in metal hose and bellows expansion joints. Together, the two companies created a custom U-loop expansion joint design that met all of the requirements of the unique testing environment. By creating an expansion joint that would hold up to military-grade functional testing, TCH and Hose Master enabled our military to validate its Advanced Propulsion Concept.

The High Demands of Military Applications

Functional tests in the military demand more out of engines and propulsion systems than in other sectors, such as the automotive or commercial aircraft industry. Not only will these engines face challenging environments, such as high altitudes and extreme temperatures, but they will also need to perform at top efficiency if a vehicle is meant to cross a map as fast as possible or perform evasive maneuvers in combat.

To become viable, the Advanced Propulsion Concept would need to go through tests that would push the design to the extreme limits it would face out in the field. The design would need to face intense conditions such as:

- ***High pressures up to 750 psi***
- ***A tremendous amount of flow through the eight-inch inlet pipe***
- ***High temperatures up to 1075 degrees Fahrenheit***
- ***Supersonic velocities***
- ***Axial compression up to 1"***

Most importantly, the test apparatus could not apply additional forces on the load cell. If forces were not properly balanced, it would produce inaccurate performance results.

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Design One: The Pressure-Balanced Bellows Expansion Joint

In order to complete its testing design, the military reached out to TCH to develop a custom expansion joint. TCH, well-versed in the requirements of the military sector, accepted the challenge and made an initial design proposal.

TCH's initial design was a pressure-balanced bellows expansion joint. This expansion joint design would eliminate the end thrust forces of the input air by mechanically restraining the forces with equal and opposite force outputs.

However, this caused the system to act like a giant spring due to the compression of the bellows. The system would compress 1 inch due to thermal expansion, which was going to output tens of 1000s of pounds of spring force from the expansion joint on the test cell.

Within the bounds of the bellows-style design, there was no way to completely eliminate forces because of the design's inherent limitations. While it solved the initial problem of unrestrained thrust, it left the massive spring force issue unresolved. This design would create skewed test results because the test fixture would impart force unrelated to the thrust being measured.

Upon reviewing the design considerations with the military, TCH realized they had to pivot and go through another design iteration.

Custom Engineering the Right Solution: The U-Loop Design

Understanding the limits of the bellows-style design of the pressure-balanced expansion joint, TCH realized they needed to think outside the box. Working together on many projects in the past, TCH had a longstanding history of success partnering with Hose Master.

Together, the design engineers at TCH and Hose Master knew that they needed an entirely different type of solution. TCH had the idea of the type of design that was required – a U-loop expansion joint – and worked with Hose Master's design experts to bring it to life.

With direction from TCH, Hose Master developed a custom U-loop manifold design. This design used four U-shaped hose assemblies on the top and four U-shaped hose assemblies on the bottom of the manifold. The manifold design was essentially hose that also acted as an expansion joint, specifically a non-force-inducing expansion joint. All of the forces equaled out to zero since everything that happened on the top happened on the bottom and all lateral forces were contained by the pipe.

Once TCH and Hose Master decided on this custom manifold design, the two companies went through multiple iterations of the design in order to get it right. Iterations include changing the centerline of the hose spacings and changing the branch connections so that they would increase weld efficiencies. These iterations required a high level of collaboration between Hose Master, TCH, and the customer so that everything could be accounted for and no requirements were missed. TCH served as the voice of the customer through this process, ensuring that the design was crafted specifically for the military's system.

Figure 2: *Subassembly of U-loops that join the two manifolds*

The Importance of Expertise

Creating a new expansion joint for the military's testing equipment required a higher degree of expertise and a greater product offering than typical hose and expansion joint suppliers can provide. Many traditional expansion joint makers only make bellows-style expansion joints, which would have been a never-ending design struggle of trying to eliminate forces.

Since Hose Master was both a bellows-style expansion joint manufacturer and a metal hose manufacturer, it was able to utilize the design constraints of one to turn it into another. Combined with TCH's guiding hand, the two companies were uniquely qualified to create this new manifold design. They knew what questions to ask to find the right solution, ensuring that the customer's goals were considered at every step.

Beyond the structure of the design, TCH and Hose Master also had the materials expertise to specify a metal that could stand the 1,075-degree Fahrenheit temperatures of the testing environment. That is why they went with 316H stainless steel. The higher carbon content of 316H stainless steel makes it particularly useful for applications with elevated temperatures, making it the perfect choice for high-temperature testing.

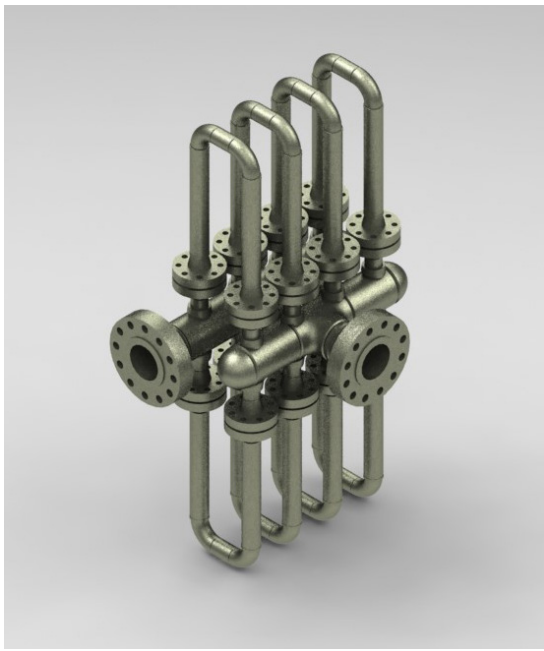

Figure 3: *CAD rendering of expansion joint*

Throughout the design process and at each stage of the final piece, TCH and Hose Master ensured that a high level of quality assurance was met. The viability of the final design was proven through tests such as:

- ***Radiography***
- ***Dye penetrant testing***
- ***Pressure tests***

These tests gave the U.S. military peace of mind knowing that the Advanced Propulsion Concept would be validated in a secure and regulated environment.

Going Beyond

In addition to creating the custom manifold design for the customer, TCH also designed and supplied a silica thermal blanket. Not only did the materials of the joint need to accommodate the extreme temperatures of the testing environment, but the process itself needed to be thermally insulated to keep the process air hot that was going through the system. Since so much heat and air were required, the thermal insulation of the silica blanket made the tests significantly more efficient. Beyond energy savings, the blanket also helped keep the air at higher temps as it went through the system and reached the front of the thruster, improving the process as a whole.

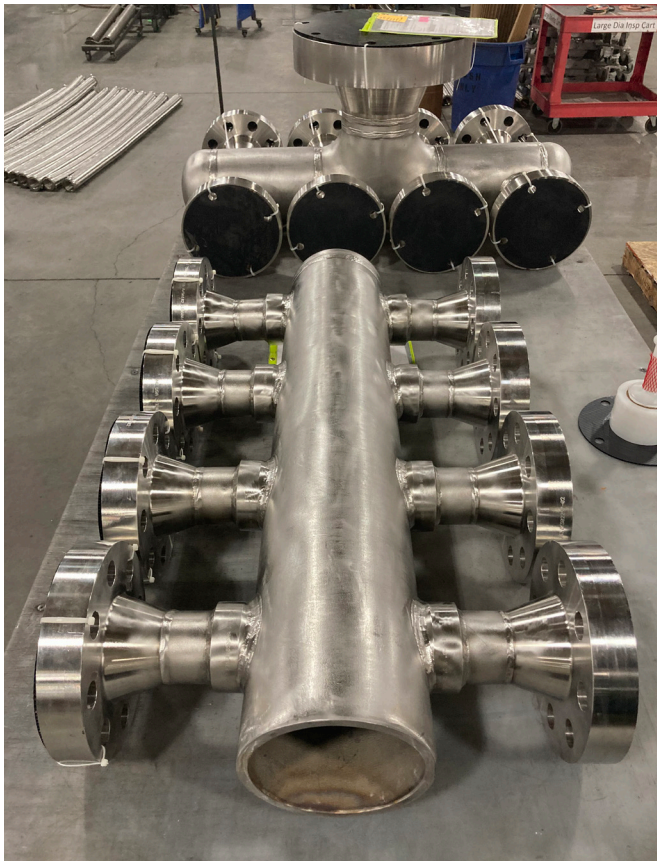

Figure 4: *Inlet and outlet manifolds capped and ready for shipping (outlet side in forefront)*

Enabling Future Innovation

In the military, only the best testing equipment can ensure that innovative new products and technologies see the light of day. By enabling advanced thruster testing, the custom U-loop expansion joint from TCH and Hose Master gave their customer's Advanced Propulsion Concept a chance to innovate in the military, potentially leading to new opportunities and advancement in other products. That domino effect all starts with well-engineered solutions from companies like TCH and Hose Master.

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About TCH Industries

With four decades of experience, TCH Industries is one of the most respected hose fabricators and distributors in the industry. As Hose Pros, TCH has the most knowledgeable inside and outside applications and mechanical engineering team dedicated to proper hose technology and fittings in the region. TCH offers a complete hose shop, delivering hose and fittings for any industrial application. In addition, TCH knows how to apply welding, tube bending, and custom-machined hose components expertise to complete projects seamlessly and efficiently. With the perfect blend of lightning-fast response time, field-proven experience, and design expertise, TCH is the ideal partner for the most difficult applications customers face.

We can accommodate any custom length you require. Just call 1-330-487-5155 and get a quote, or visit tchindustries.com.

About Hose Master

Hose Master is a manufacturer of corrugated and stripwound metal bulk hose and assemblies as well as metal bellows and expansion joints. Hose Master specializes in the custom fabrication of metal hose assemblies. Backed by experienced engineers, ASME IX-certified welders, and cutting-edge technology, Hose Master can design and build any metal hose assembly or expansion joint to suit unique customer requirements. When difficult applications arise, Hose Master's knowledgeable sales team is available to assist on-site or by phone to create a solution. Offering 24-hour emergency service, resources, and value-added products, Hose Master has the tools needed for success. To learn more, call 1-800-221-2319 or visit hosemaster.com.

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