

Case Studies: Leak testing

Fuel Pipe Helium Leak Test System

Client: Leading Global Aerospace Technology Company

Part: Fuel Pipes for the Aerospace Sector

Machine supplied: Helium leak test system

Throughput: 15 parts per hour

Test Methods: High-Pressure Proof Test (210 bar) + Helium Mass Spectrometry

The Challenge

A leading global aerospace technology company needed production acceptance testing for composite fuel pipes across multiple part variants with different diameters and lengths. The test requirements included:

- High-pressure proof testing to 210 bar to verify structural integrity
- Helium leak detection to aerospace sensitivity levels (typically 1×10^{-9} mbar-l/s)
- Part traceability with RFID and barcode data integration
- Throughput of 15 parts per hour across multiple variants
- Automated testing to eliminate operator variability

Composite fuel pipes require both pressure testing (to confirm they can withstand operating pressures) and helium leak testing (to detect minute leak paths that could allow fuel vapour escape or contamination ingress).

The Solution

TQC designed and built a dual-test system combining high-pressure proof testing with helium mass spectrometry leak detection. The system uses a drawer-style test chamber with automated sequencing that performs pressure testing first, followed by helium leak detection on passed parts. Multi-variant tooling accommodates different pipe configurations without changeover delays.



Technical Overview

System Architecture

The fixture is based on TQC 's Series 20 drawer concept, adapted for high-pressure testing and helium leak detection. The drawer mechanism allows safe loading and unloading outside the test chamber while providing automated transfer into the sealed test environment.

Load/Unload Station: The operator positions the fuel pipe in the tooling and secures two end clamp units that seal the pipe ends and provide pressure/helium supply connections.

Automated Carriage: A powered carriage moves the loaded tooling from the load/unload position into the test chamber. This automated transfer eliminates manual handling near the high-pressure test area.

Test Chamber with Automated Door: The test chamber closes and seals automatically once the tooling is positioned. The chamber isolates the test from ambient conditions and contains helium during leak testing.

Multi-Variant Tooling

The tooling system accommodates different pipe diameters and lengths through adjustable end clamps and flexible positioning:

End Clamp Units: Each clamp seals the pipe end, provides pressure connection, and allows helium fill. The clamps adjust to different pipe diameters within the variant range.

Variable Length Accommodation: The tooling positions pipes of different lengths within the test chamber while maintaining proper sealing and pressure connections.

Quick Changeover: Variant changes require only adjustment of the end clamps, not complete tooling replacement, enabling efficient production of mixed part runs.

Test Sequence

The system performs two sequential tests automatically:

1. High-Pressure Proof Test (up to 210 bar)

Purpose: Verify the structural integrity of the composite pipe and confirm it can withstand operating pressures without failure.

Method:

- Pipe is filled with hydraulic fluid or high-pressure air
- Pressure is increased to the specified proof pressure (up to 210 bar)
- Pressure is held for a defined dwell time
- System monitors for pressure drop that would indicate structural failure
- If proof test fails, the part is rejected and helium test is bypassed

Why This Comes First: Proof testing eliminates gross failures before the time-consuming helium leak test. A pipe that fails proof test would also fail leak testing, so performing proof test first saves time.

2. Helium Mass Spectrometry Leak Test

Purpose: Detect minute leak paths (permeation, porosity, seal defects) that could allow fuel vapour escape or contaminant ingress.

Method:

- Test chamber is evacuated to high vacuum (typically $<10^{-4}$ mbar)
- Pipe interior is filled with helium tracer gas
- Mass spectrometer continuously monitors the chamber vacuum for helium molecules
- Any helium escaping from the pipe is detected and quantified
- Leak rate is compared to acceptance criteria (typically 1×10^{-9} mbar·l/s for aerospace fuel systems)

Advantages of Helium Mass Spectrometry:

- Sensitivity: Detects leaks 1000× smaller than pressure decay methods
- Speed: Test completes in seconds once vacuum is established
- Quantitative: Provides actual leak rate measurement, not just pass/fail
- Helium Efficiency: High vacuum method uses minimal tracer gas compared to accumulation techniques
- No Contamination: Helium is inert and leaves no residue

Control and Data Management

PC-Based Control System: A dedicated PC controls all test sequencing, pressure regulation, vacuum control, and data acquisition. The interface provides:

- Circuit mimic display showing system status in real time
- Test parameter setup for different part variants
- Live pressure and leak rate monitoring
- Pass/fail determination and result logging

Traceability Integration: The system uses RFID readers and barcode scanners to:

- Identify parts at load station
- Link test results to specific serial numbers
- Prevent testing of unauthorised parts
- Enable automated data export to customer quality systems

Safety Interlocks: Light guards at the load/unload station and chamber door interlocks prevent operator access during high-pressure testing and chamber evacuation.

System Specifications

- Test Chamber: Drawer-style with automated door and sealing
- Proof Test Pressure: Up to 210 bar
- Proof Test Medium: Hydraulic fluid or high-pressure air
- Leak Test Method: Helium mass spectrometry (high vacuum)
- Vacuum Level: $<10^{-4}$ mbar (typical)
- Leak Detection Sensitivity: 1×10^{-9} mbar·l/s
- Tracer Gas: Helium (inert, low viscosity)
- Throughput: 15 parts per hour (including load, test, unload)
- Tooling: Multi-variant with adjustable end clamps
- Carriage Travel: Automated transfer between load and test positions
- Traceability: RFID and barcode integration
- Control: PC-based with circuit mimic display
- Operator Interface: Floor-standing fixture with light guard protection
- Part Variants: Multiple diameters and lengths without tooling change



If you have an application that could benefit from TQC's expertise in helium leak testing, please contact us by email or phone via the contact details

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