White Paper

Acceptance Testing Procedures for Aerospace Hydraulic Components

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ideas taking flight

As the complexity of flight systems and components used in the development of today's commercial and military aircraft increases, so does the number of components that need to be thoroughly tested to ensure system reliability, serviceability, and support. The proper testing of each component during development is especially crucial for in-flight critical applications because a failure of even the smallest component can have catastrophic results. Additionally, applications in these types of industries often have complex hydraulic components, use exotic fluids, or need to have fail-safe functionality in high-pressure environments, which creates even more complicated test scenarios. Oftentimes, companies perform these mission-critical tests using an independent firm or with manually intensive methods in their test labs. However, in the aerospace industry, where it is critical to monitor and track all of the test data for each component used in a system throughout the entire development process using very specific and regulated methods, it would be better to use a more automated in-house solution that can ensure all tests are performed correctly and all data is properly recorded. This whitepaper will discuss the options available to manufacturers for performing these types of tests and will also show you why a customized system executing an acceptance testing procedure (ATP) may be the best choice for your organization.

Customized Test Systems Executing Automated ATP's Versus Standard Flow Benches

Hydraulic components used in mission-critical applications are typically quite complex and require difficult test sequences to verify functionality under all operating conditions. Two of the most common approaches for developing a complex hydraulic test stand include using a customized test system executing automated ATP's or a standard flow bench. Let's take a deep dive into both of these options.

Automated ATP test systems and standard flow benches are both test station options that can supply hydraulic flow and pressure to test various hydraulic components. Generally, Automated ATP test systems have multiple pressure, tank, and drain connections, while flow benches only have one of each connection per test station. Automated ATP systems also have control valves integrated into a control system to operate the unit under test (UUT) for sequencing or to simulate final operation, as well as valves to reverse the port flows from the pressure to the tank connections to eliminate multiple connects/disconnects during testing. Standard flow benches typically do not have these additional valves and connections. Additionally, standard flow benches are designed to perform tests using one type of fluid, either red oil or Skydrol for aerospace applications, while Automated ATP systems can be designed to handle multiple fluids.

With an Automated ATP system, fluid temperatures are generally controlled in real time during the test to ensure they meet actual operational conditions, while most standard flow benches don't allow for changes to dwell times or variations in temperature set points during testing without manual intervention. Automated ATP systems control the UUT and are always supplied with a data acquisition (DAQ) system at some level. The collected data is typically charted to show performance characteristics and can identify when performance deviates from the predefined operational parameters. Standard flow benches

usually do not have control over the UUT and only top-of-the-line benches include a DAQ system. Additionally, using a purpose-built Automated ATP system, test engineers can build multiple test stations that can be independently controlled through a common control and data acquisition system. They can also perform complex test sequences or test multiple UUT's on subassemblies where each UUT has different requirements to be tested to. Overall, using an Automated ATP system, test engineers can use specific test sequences and/or components or connections to perform tests with greater accuracy and less involvement from the operator than they could using a standard flow bench.

What is the Best Option for Our Company?

Since every company has varying test requirements and budgets, there are three modes of operation available for ATP test systems—manual, semi-automatic, and fully automatic. There are quite a few considerations to make when it comes to deciding which solution is best for your company including the following:

- What would be the consequence of an operator error made during testing? Some aerospace components are extremely costly, and it may be critical to minimize hands-on operator involvement.
- How complex is the ATP you are testing to and how much intervention is required from the operator to execute the test.
- How many parts are you testing per year and what is the throughput of your test station? The more parts you test, the more personnel you need to perform the tests, and the more test stations you may need. Additionally, if some tests take a significant amount of time to perform, you may have a fairly low throughput per test station and may require more stations.
- How skilled do you need your test station operators to be? As you require more skills from your test station operators, their required wages will typically increase.

Some additional considerations include test system repeatability, consistent documentation, the ability to digitally archive results, and increased accuracy. Let's take a look at the pros and cons of the three ATP system options available and how each one could address these considerations.

Manual ATPs

Manually operated ATPs are the least expensive option available but these systems require the highest level of operator involvement. A manual ATP system has various valves to control test flows, pressures, and flow directions that need to be manually set by the operator. To start the test procedures, the operator configures the test stand and starts the first test. To keep the test sequence moving, the operator may either have a computer next to the stand that provides a digital instruction sheet or a hardcopy of a process workflow sheet that outlines the steps the operator needs to perform manually in order to conduct the test.

The tests may also require the operator to connect and/or disconnect multiple fluid connections. Not only does this take additional time, but it could pose a potential hazard to

the operators by exposing them to hazardous fluids and pressurized components that could cause injury while changes are being made or visual inspections for failures are being performed. Additionally, operators typically need to manually adjust hydraulic pressures, flow rates, flow paths, and other parameters and manually record the resultant data during the test procedure. Overall, using a manual test stand is more time consuming, less accurate, has higher safety risks, and is more prone to human error than the more automated options.

Semi-Automatic ATPs

Semi-automatic ATPs provide a level of automation that helps reduce the possibility of operator errors occurring. Much like with a manual test stand, operators still need to configure the test stand and prompt the system to move on to the next test sequence throughout the ATP, which can pose potential safety risks to the operators if they are required to manually change or inspect connections that involve hazardous fluids. However, there may be some level of automation for setting hydraulic pressures and flow rates during the testing. These systems may also include integrated pressure transducers, thermocouples, fluid contamination sensors, and other sensors that can quickly and dynamically identify component failures and provide feedback to the control system for setting and maintaining test operational parameters.

Typically, the biggest level of automation in semi-automatic test stands is usually at the data recording stage. Rather than an operator manually recording test results, each value is typically automatically recorded into the test data sheet after a test is complete. While this option costs a little more than a manual test stand, it can reduce the possibility of costly errors that occur when operators read analog gauges and enter inaccurate data into the DAQ system. Semi-automatic test stands typically include additional safety features and can provide higher throughputs than manual test stands.

Fully Automatic ATPs

Fully automatic test stands provide the highest level of safety for operators and protection against potential costly user errors by eliminating direct operator interaction with the system and UUTs while testing is being performed. The only interaction the operator has with the system is at the beginning when he or she places the UUT into the system and connects the fluid conductors to begin the testing. All pressure, flow, and temperature settings and sequences and the actuation of the UUT are done automatically. And, like the semi-automatic systems, these systems also include integrated pressure transducers, thermocouples, fluid contamination sensors, and other sensors that quickly and dynamically identify component failures and provide feedback to the control system for setting and maintaining test operational parameters.

Additionally, throughout the testing, all data is automatically recorded into the ATP data sheet. This is a key feature of an automated ATP system because the requirements for ATP reports in the aerospace industry are very specific and require exact duplication for format, font, and layout. Any variation in the recreation or documentation of the results in the report can cause the UUT to be rejected.

Developing the Right Automated ATP System for Complex Testing Requirements

As a result of the highly complex nature and sophisticated documentation required for the mission-critical application components used in the aerospace industry, most companies can substantially benefit from working with a third-party test solution developer to create their test system. Hiring a company that specializes in test system development for the most critical aspects of your components is key. Many of today's test system manufacturers are still trying to get by with general purpose flow benches with analog gauges, manual valves for pressure and flow settings, and limited pressure capabilities. Aircraft hydraulic systems are pushing from 5,000 psi operational pressures to 6,000 psi and proof pressure tests are climbing above 8,000 psi, which means general purpose test systems just won't do anymore. Additionally, many companies don't have the experience or don't want to take on the risk involved with designing a test system that involves these high pressures or specialty fluids.

The engineering staff Genuen has extensive experience developing turnkey systems that leverage off-the-shelf technologies for the aerospace industry and specializes in hydraulic test stand solutions. This experience has allowed Genuen engineers to work with all types of specialty fluids common in the aerospace industry, including fire-resistant Skydrol and red oils, and to develop test stands with operation pressures that exceed 10,000 PSI. Genuen fully understands that each component of an aircraft needs to be stringently tested and that proper documentation needs to be provided with each part. Additionally, Genuen can develop solutions that can handle multiple fluids, something that few other companies can do, thus reducing the overall number of testers, required floor space, and total test cost for companies.

Making the Most of Your ATP System

Companies developing complex hydraulic components, especially those used in aerospace applications, need to ensure their parts can operate in some of the harshest environments. With the right ATP test system, manufacturers can ensure the safety and quality of their components while also experiencing tremendous business benefits. For example, significant reductions in operating costs can be made by minimizing operator involvement by integrating automation throughout the testing process. Automation can also help minimize the potential risks that can result in costly component damage or operator safety hazards from manually intensive testing. These systems can also help operators more easily identify potential failure modes early in the development process to ensure the end user receives compliant components free of defects. Additionally, with Automated ATP test systems, test accuracy can be improved to a less than 1 percent error rate and manufacturers can implement better data recording procedures, which provides end users with the highest level of assurance that their components are built to last, even in the most stringent operating modes.