

## PC-Based Turbo Charger Engine Quality Verification System

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**The Challenge:** Developing a system for production spin testing of turbo chargers, including monitoring steady state parameters and vibration limits.

**The Solution:** Providing a system that controls the test equipment in real time, monitors critical parameters, collects data, and indicates a pass/fail status to the operator.

### Introduction

As an OEM to the automotive industry and other engine manufacturers, IHI Turbo America (parent company: Ishikawajima-Harima Heavy Industries Co., Ltd.) produces a variety of turbo chargers, ranging from a super-compact model for automobiles and motorcycles to a full-sized model for large marine diesel engines. IHI takes pride in producing highly dependable machinery for the "Big Three" automotive manufacturers. Turbo chargers improve the efficiency and power of automobiles.

**IHI Turbo America saved roughly 50 percent of the cost of implementing this system by using National Instruments LabVIEW RT.**

IHI Turbo America guarantees every turbo that goes out the door. Therefore, quality control is an essential part of their business, and they test every product that they produce. The company needed an automated system for evaluating the quality of their turbo chargers for a new production line. After evaluating several companies, they chose Datappli, a National Instruments Alliance Program Select Integrator member, to create a turnkey electronic and software testing system.

### System Requirements

The test system needed to clamp the turbo charger in position, bring it up to test speed at 80,000 rpm, analyze the vibration, stop the part, and release it. During the test, we needed to monitor the axial and vertical

clamps and other critical variables. If any clamps released during a test, the emergency stop (e-stop) needed to be immediate, with no delays due to the operating system. The cycle time needed to be one minute or less of the entire test.

If the clamps or other critical variables in the test system did not function properly, the part could self-destruct during the test, and/or other test functions could pose significant safety issues. For example, if the seal on the test door failed, results could be catastrophic.

Part of spin testing is to verify that the part has been balanced correctly. If the part is out of balance, it can self-destruct. At the required speed, the part must not vibrate outside a given set of parameters.

The functional test system had several requirements:

- Test cycle time of less than one minute to meet production rate requirements
- A dependable emergency stop (e-stop) based on a stable, real-time operating system – the high test speeds of the system required reliable safety
- Accurate vibration testing
- Reliable control of test equipment – clamping, bringing up to 80,000 rpm, testing, stopping, unclamping

### NI-Based System

We chose National Instruments LabVIEW RT to control this process in real time. Safety was a primary concern; and with LabVIEW RT, we are assured that if Windows crashes, the test keeps running. Using LabVIEW RT for our entire system reduced complexity and provided easier, interactive debugging. We did not need to write separate control routines in different languages. We wrote the program in LabVIEW, compiled and downloaded the code to the RT Series DAQ board – no changes required. We also chose several hardware components for the system.

### Digital Control

We selected the RT Series DAQ board as a low-cost alternative to a programmable logic controller (PLC) to provide dependable real-time e-stop control. We required an operating system that did not have the latencies that

### Production Test/Automotive

- LabVIEW RT Development System
- Sound and Vibration Toolkit
- DSA board
- RT Series Data Acquisition
- SCXI

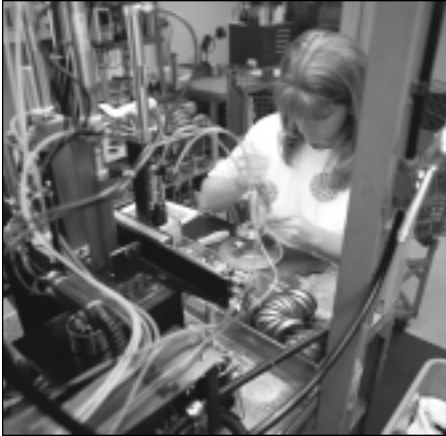


*IHI Turbo America Turbo Charger Engine Quality Verification System uses National Instruments LabVIEW RT and hardware.*

normally occur in the Windows operating system. Also, if Windows NT does crash, the RT Series board is stable and continues to operate. System delays that could affect emergency stops were not acceptable. All digital inputs and outputs are connected to the National Instruments RT Series DAQ board. During a test if any clamps fail or the door to the test chamber is opened, the e-stop is immediately triggered. Because the RT Series board does not rely on the Windows operating system, the timing is deterministic – there is never a delay before the e-stop is triggered. The digital control engine, for sequencing the clamping and unclamping of the part and opening or closing valves, is downloaded to the RT Series board and communicates with the main program on Windows using shared memory.

### Vibration Testing

Vibration data is acquired using a National Instruments DSA board with a built-in anti-aliasing filter and ICP® power for the accelerometer. We selected the DSA board because of the high signal-to-noise ratio, and because the accelerometer connects directly to the terminal block. Because this solution does not require a separate power supply for the accelerometer or an external anti-aliasing filter, we have less equipment to purchase and less equipment to install and troubleshoot. The DSA board provided us with ease of assembly



*IHI Turbo America guarantees every turbo that they make.*

and eliminated the need to wire several pieces of equipment together. The DSA board was initially a more expensive buy, but overall we saved cost by eliminating the additional equipment, time, and effort needed to assemble and debug the end product.

We analyzed the vibration data using National Instruments LabVIEW Sound and Vibration Toolkit. This toolkit provides tools for calibrating the accelerometer, converting voltage data to scaled data, and analyzing the scaled data. The toolkit saved several days of programming and debugging by eliminating the need to write the tools ourselves. We simply created a screen to handle programming and debugging of the desired functions. We reduced programming time from days to just hours.

### PID Control

We used stand-alone proportional integral derivative (PID) controllers for controlling oil temperature, oil pressure, air pressure, and turbo speed. We sent commands and set points using RS-485, which freed computer time for sequencing, data acquisition, and analysis.

### Data Acquisition

We needed to fulfill several criteria for our data acquisition system.

- We chose an E Series board and SCXI signal conditioning for excellent thermocouple conditioning. We used other channels with filtering to reduce noise.
- The data acquisition engine provides continuous acquisition of data throughout the test. The data is sampled at 1,000 samples/s, which is averaged down to 10 samples/s.
- We continuously monitor critical channels, such as oil flow rate (high indicates a leak) and oil pressure (low indicates a problem). If any channel exceeds its limits, the test is shut down immediately.
- A control engine provides the sequencing for running the test once the part is properly clamped. It starts oil flowing through the part for lubrication, and then brings the turbo charger up to an operating speed of about 80,000 rpm. Once the speed has stabilized, data is averaged for 15 seconds, and the part is tested for excessive vibration. After testing, the rotation is stopped, and the oil is blown out of the turbo.

### Manual Control Screen

We provided a manual control screen for experimenting with parameters to optimize the test sequence. Using the controls on the screen, it is possible to go through the entire test sequence. A real-time graph displays calibrated values for a selected channel, providing immediate feedback while tuning the PID parameters. The user can also monitor all the channels to see if the pass/fail criteria are adequate.

### Results

Datappli provided a cost-effective solution based on the National Instruments hardware and software platform. The system is fast, accurate, and provides a simple operator

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interface requiring minimal operator training. IHI Turbo America saved roughly 50 percent of the cost of implementing this system by using National Instruments LabVIEW RT. LabVIEW RT and RT Series hardware can be an efficient and effective replacement for PLCs in this application. The complicated controls necessary in this turbo charger test system would not have been possible on a PLC.

Datappli is quoting a second system at IHI Turbo America (similar to this system) to replace a manually operated test system. The objective of IHI Turbo America is to save time and greatly increase test accuracy. The current manual system has inherent problems with human interaction, affecting the accuracy of test results. Paul Dykstra, Project Engineer for IHI Turbo America, comments, "We see many applications for LabVIEW on the shop floor – and that's pretty exciting." ✦

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