Waukesha 12V-AT25GL Case Study

By Loran Novacek

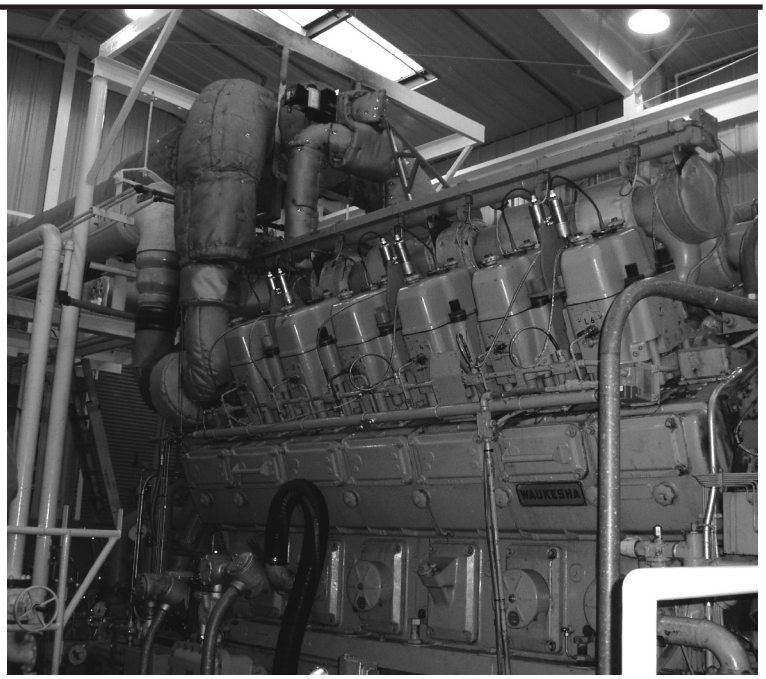
Background Information
Since the original installation in 1993, Natural Gas Pipeline (NGPL) has been experiencing excessive downtime on a Waukesha 12V-AT25GL natural gas engine located at their Station 206 Storage Facility, St. Elmo, IL. This was found to be a result of chronic reliability issues with the OEM turbocharger and air-fuel ratio controls. During NGPL's 2005 storage injection season, the engine operated no more than 100 hours at any one stretch of time without a shutdown. This was due primarily to engine turbocharger management and / or air / fuel ratio. The operating season yielded less than 2000 total hours. Normally the unit would be expected to operate in the 4000-5000 hours / season range with minimal shutdowns during this time.

Enginuity took the expertise and knowledge gained on emissions reduction projects previously performed on slow-speed two and four stroke cycle engines, as well as recent conversions on White-Superior 2400 and other high-speed four stroke cycle engines, and applied this to the Waukesha ATGL series engine.

Enginuity approached NGPL with a solution to retrofit the engine with a new control philosophy. The new control philosophy covered: air / fuel ratio, pre-combustion chamber fuel, engine speed, and ignition. Given that NGPL was already utilizing a Siemens S505 PLC for engine load, speed and monitoring purposes, Enginuity recommended leaving this in place and adding Enginuity's combustion control strategy and any necessary I/O to the PLC for the new engine controls.

Analysis:
Capital Cost - $50,000
Enginuity provided major hardware: Main fuel control valve, pre-combustion fuel control valve, wastegate valve and an ignition system. In addition, Enginuity provided construction oversight, controls and engine commissioning including measuring exhaust emissions to verify compliance with the current air permit.

Variable Costs
In addition to the capital cost, NGPL requested that they install the new control hardware and perform the software programming modifications, both tasks with guidance from Enginuity. Since turbocharger surge had been occurring over the last several years, the intercooler fins on the airside had been damaged causing large pressure drops and low flow rates. Therefore, NGPL also decided to replace the intercooler to increase the flow rate and decrease the pressure drop.



Evaluation of Alternatives
Prior to Enginuity discussing a new control philosophy, NGPL looked at installation of new higher flow Waukesha turbochargers along with a turbocharger control management (TCM) system. The new turbochargers and TCM system were expensive and only addressed the turbocharger system. One of NGPL's primary concerns for operation was the manual adjustment of air / fuel ratio.

Scope of Work
Engine speed is no longer controlled via the electro-hydraulic governor and therefore the throttle plate, governor, linkage and hand throttle were removed in favor of a main fuel system flow control valve. Engine speed is digitally controlled by a fuel flow control device creating a much more stable engine speed under loaded and unloaded conditions. Additionally, engine startup was improved by controlling the time fuel is delivered to the carburetor and the amount of fuel delivered.

NGPL removed the old turbocharger control management system, which included a spring-loaded wastegate dump valve and a Fisher bypass control valve. The dump valve relieved exhaust gas around the turbocharger to prevent high engine loading conditions. The bypass control valve relieved pressure around the throttle plate in an effort to control turbocharger surge. In exchange, a pneumatically controlled exhaust only wastegate was installed to bypass exhaust gas around each turbocharger. Controlling the turbine side of the turbocharger directly affects the compressor output; ultimately affecting the air / fuel charge in the combustion chamber. Part of Enginuity's combustion control strategy includes an air / fuel ratio algorithm, which manages air / fuel ratio in the combustion chamber by adjusting the air manifold pressure to a calculated set point, thus maintaining exhaust emissions compliance.

The old pre-combustion chamber fuel supply system was removed in favor of a digitally controlled fuel flow valve. The speed switch, solenoid valve, supply piping, and Fisher 95 were removed and replaced with a digitally controlled flow control valve that precisely maintains the fuel to the pre-combustion chambers over the entire operating range from initial startup to full load full speed conditions. In addition to the air / fuel ratio algorithm, Enginuity's combustion control strategy includes an algorithm to properly adjust the pre-combustion chamber pressure over the entire operating range.

Finally, Enginuity recommended an Altronic CPU-95 ignition system to accurately control the spark ignition timing. Enginuity recommended the CPU-95 to provide the ability to have an input signal for varying ignition timing control, varying energy levels to the ignition coils for prolonged spark plug life and ignition diagnostics to aid the operators and technicians in troubleshooting ignition system related issues.

The new engine controls were adjusted for proper engine operation at startup and shutdown, loading, unloading, and general operation. During full load and full speed conditions Enginuity tuned the air / fuel ratio to meet the existing air permit requirements while allowing for a sufficient margin of compliance.

Results
As a result, the unit meets the existing air permit requirements, speed is more stable, engine loading/unloading is without turbocharger surge and the unit operates without air / fuel and turbocharger control related shutdowns. To date, the engine has operated more than 3000 hours and NGPL is extremely pleased with the operation of the engine. They have experienced no shutdowns due to the new engine controls. The engine is now the first engine on and the last engine off, just as originally intended when the engine was installed back in 1993.

ACKNOWLDEGEMENTS
Bob Brasel, Area Supervisor – Natural Gas Pipeline – St. Elmo Storage Facility, St. Elmo, IL