Juniper Engines Inc.

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JUNIPER 2.4L LPG ENGINE & FUEL SYSTEM SERVICE MANUAL

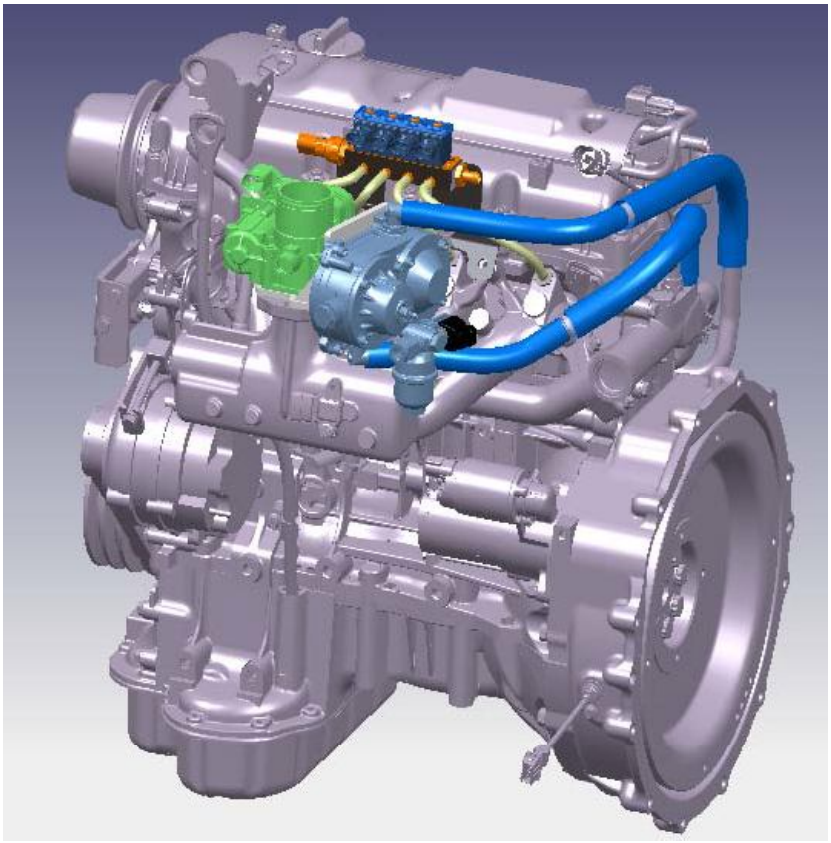

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TABLE OF CONTENTS

Figure 6: Disassembled Liquid-phase Filter

Filter & Shutoff Valve – Option 2, Advance Fuel Components (AFC):

- Manufactured by AFC
- 12Vdc, 12 Watts

Filtering element:

- Resin-impregnated cellulose element
- 40 micron nominal
- 98% filtering efficiency

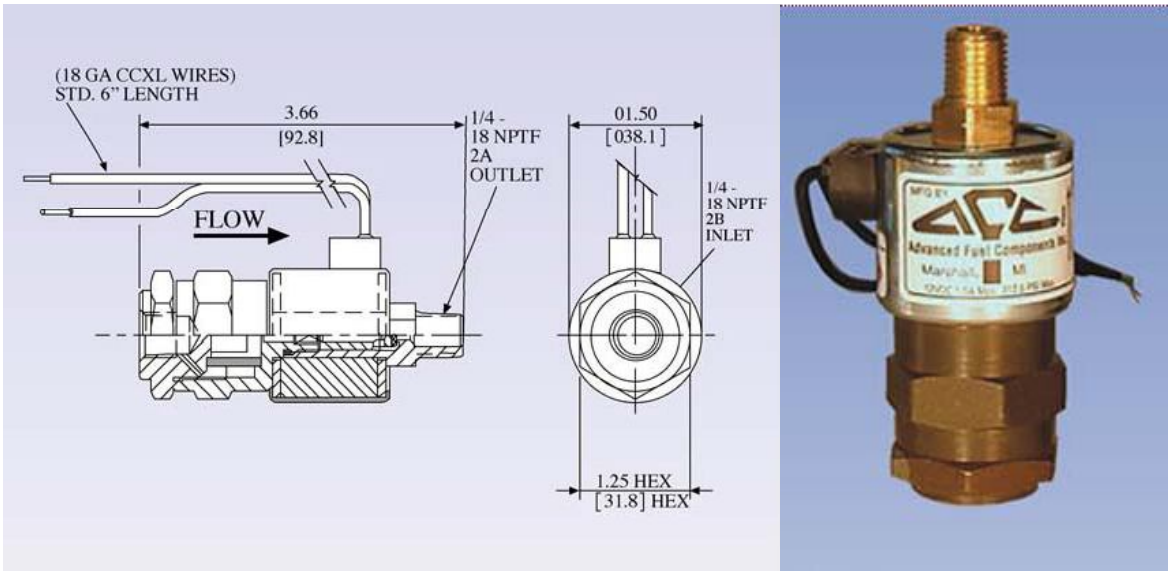

Figure 7: Alternate Liquid-phase Filter & Shutoff Valve

Fuel Rail

The fuel rail is designed and manufactured by OMVL SpA. The rail includes the fuel supply manifold, four fuel injectors, four injector solenoids, fuel supply outlet nozzles and a pressure/temperature sensor. The fuel rail is mounted on the top or beside the engine near the intake manifold. Individual hoses from each nozzle connect the rail to the inlet manifold, immediately upstream of the inlet valve for each cylinder. Fuel rail characteristics are as follows:

- Coil resistance (at 20°C): 2.9 - 3.4 Ohms
- Interface: IP54, Tyco SuperSeal 2-way connectors
- Opening time (driven at 13.5 Vdc, gas @ 200KPa, 20°C): 2.7 ms
- Speed-up current (for 3.24 ms at 13.5 Vdc, gas @ 200 kPa, 20°C): 1.8A
- Hold current (driven at 11 kHz, 13.5 Vdc, gas @ 200 kPa, 20°C): 1A
- Static flow rate per injector (air at 200 kPa, 20°C, 2.5 mm nozzle): 2.47g/s ± 5%
- Max working pressure: 600 kPa
- Burst pressure: 1000 kPa
- Working temperature: -40 - 120°C
- Sensor: integrated Sensata pressure & temperature
- Homologations: ECE110-00 0035 03, ECE67R-01 010100 03, ECE10R-02 4008 00, UL558
- Weight: 0.55 kg
- Durability: over 500 million cycles

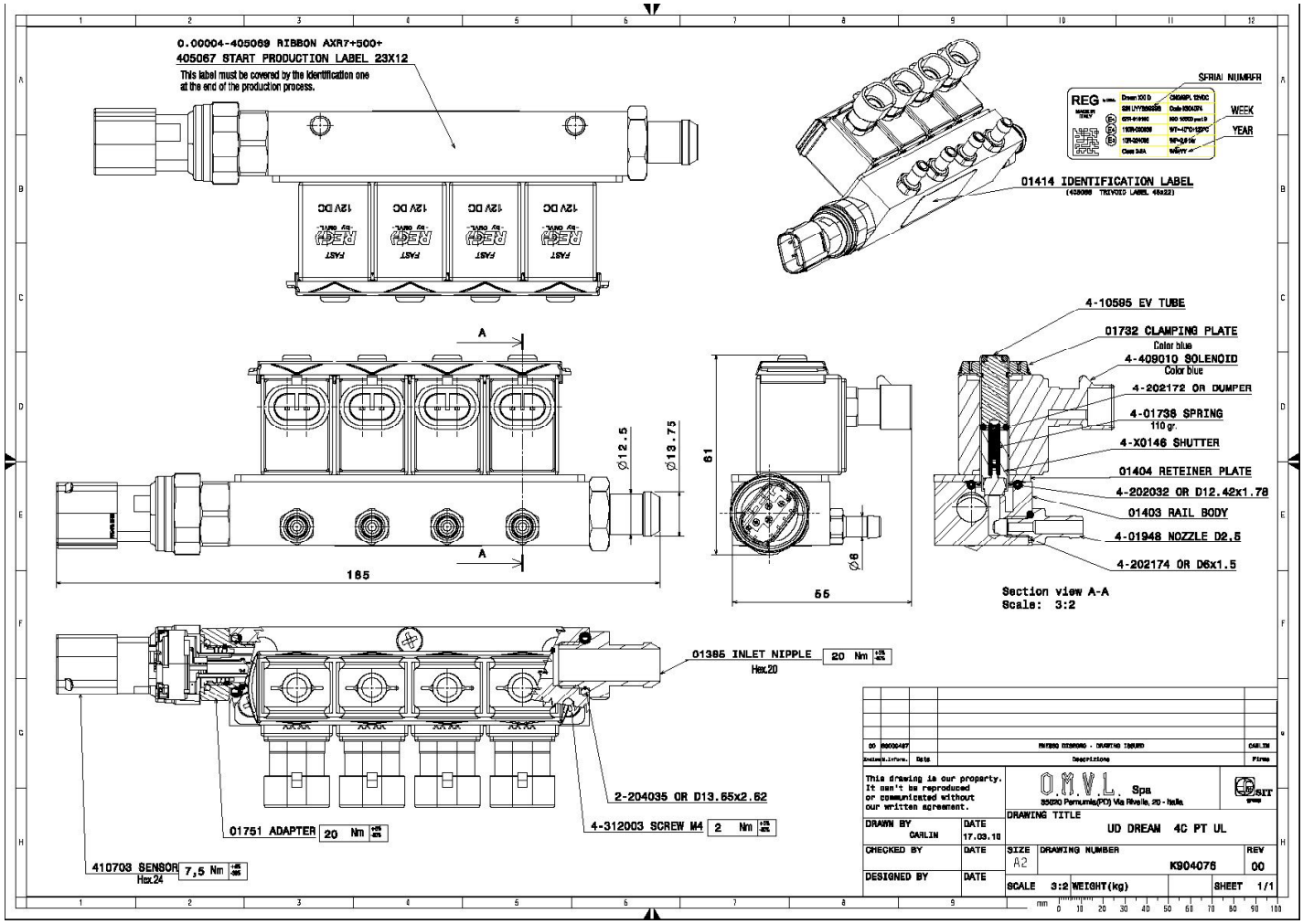

Figure 8: MPI Fuel Rail

Gaseous Fuel Filter

The fuel filter is used to remove small particles and liquids from the LPG vapor. The filter is installed between the vaporizer and the fuel rail. The filter specifications are as follows:

- LPG/CNG gaseous phase filter, class #2
- Flow rate: 55Kg/hr (air) @ 160KPa
- Max working pressure: 450 KPa (compliant to ECE110, class #2)
- Burst pressure: > 7000KPa
- Temperature range: -40-120°C (compliant to ECE110)
- Material: zinc plated steel, FeP04 (UNI5866-66)
- Filtering element:

- Paper cartridge (un-serviceable)
  - Minimum filtering size: 7µm
  - Filtering surface: 327cm2
  - Particle filtration efficiency:
  - Particles smaller than 3µm: 30-50%
  - Particles bigger than 3µm, smaller than 30µm: 85-98%
  - Particles bigger than 30µm: 98%
- Durability: dependant on fuel quality
- Homologations: ECE110R-000041, ECE67R-010105

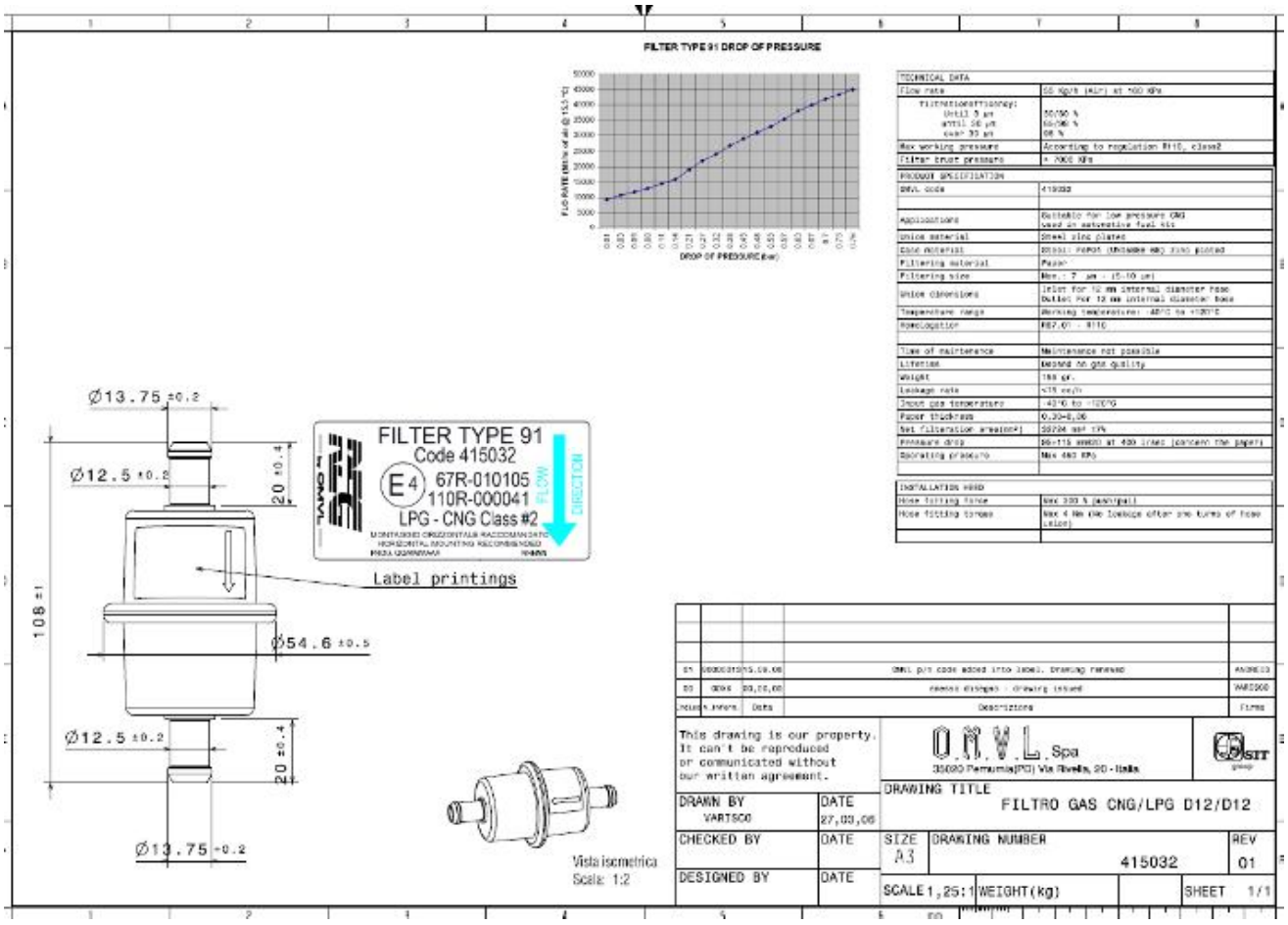

Figure 9: Gaseous Fuel Filter

Engine Control Unit

The Juniper mono-fuel Engine Control Unit (ECU) is a micro-controller based module that is capable of controlling a spark-ignited internal combustion engine with up to four cylinders. The Juniper UCU has control algorithms to achieve:

- Maximum torque
- Desired drivability:
  - speed governing, within the whole range of accepted load
  - no stalling at idle speed, within the whole range of accepted load
  - transient management
- CARB 2010 compliant emissions
- Key Word Protocol 2000 CAN-bus On-Board Diagnostics for off-road applications.
- Safety features compliant to R67, R110 and basic safety for Drive-By-Wire chain, such as:
  - de-power all gas shut-off valves within 5 seconds from engine stall
  - Inhibit gas shut-off valves, in case of electric fault
  - Inhibit outputs while the system is powered off
  - No uncontrolled driving of the throttle body in any condition

Gas fuelling is controlled by a speed density model; the ECU drives four ignition coils, the drive-by-wire chain (foot pedal position sensors, electronic throttle body, throttle-position sensors), gas shut-off solenoid valves as well as application-specific loads.

The ECU implements algorithms for cranking, warm-up, closed-loop injection control, drivability in transients, speed governing, rpm limiting and specified safety features.

Those algorithms are controlled by a set of parameters, stored into ECU memory; the parameters can be modified using a dedicated calibration software (PC-based).

The Juniper mono-fuel ECU has on-board diagnostics that monitor and detect:

- electric failures or malfunctions of all input sensors
- electric failures or malfunctions of all output actuators
- electric failures of most wiring connections
- most electric failures of ECU itself
- fault conditions that negatively impact emissions

The specified on-board diagnostics are compliant with:

- SAE J 1979: E/E Diagnostic test modes.
- ISO 14230-4 Keyword Protocol 2000, Part 4: Requirements for emission-related systems.
- Proprietary KWP2000 ISO14230 protocol over CAN-bus protocol.

ECU Key features:

Micro-controller	• Hitachi 32 bit, 80MHz • MB flash memory • 48 kB SRAM
Inputs	• Foot-pedal position sensors • Throttle position sensors • Intake air temperature sensor • Manifold air pressure sensor • CAM shaft position sensor • Crank shaft angle sensor • Engine coolant temperature sensor • Oil pressure switch • Pre-cat and post-cat oxygen sensors • Gas temperature sensor • Gas pressure sensor • Vehicle speed sensor input • 2 spare inputs (speed selection control)
Optional inputs	• Pressure reducer temperature sensor • Level sensor in multi-valve or high pressure sensor • Knock sensor
Outputs	• High-pressure solenoid valve • 4 gas injectors • 4 ignition coils • Throttle body control • 2 oxygen sensors heater PWM outputs • Check-engine lamp output (MIL) • Load relay output • 2 spare 5V analog PWM output (fuel and temperature gauges…) • 2 spare 12V PWM outputs (relays, speed gauge)
Optional outputs	• Oil pressure warning lamp output • Tank shutoff solenoid valve in multi-valve • Low pressure solenoid valve • Instrumentation (hour counter)
Communication lines	• Diagnostic CAN line (KW2000) • Internal calibration CAN line

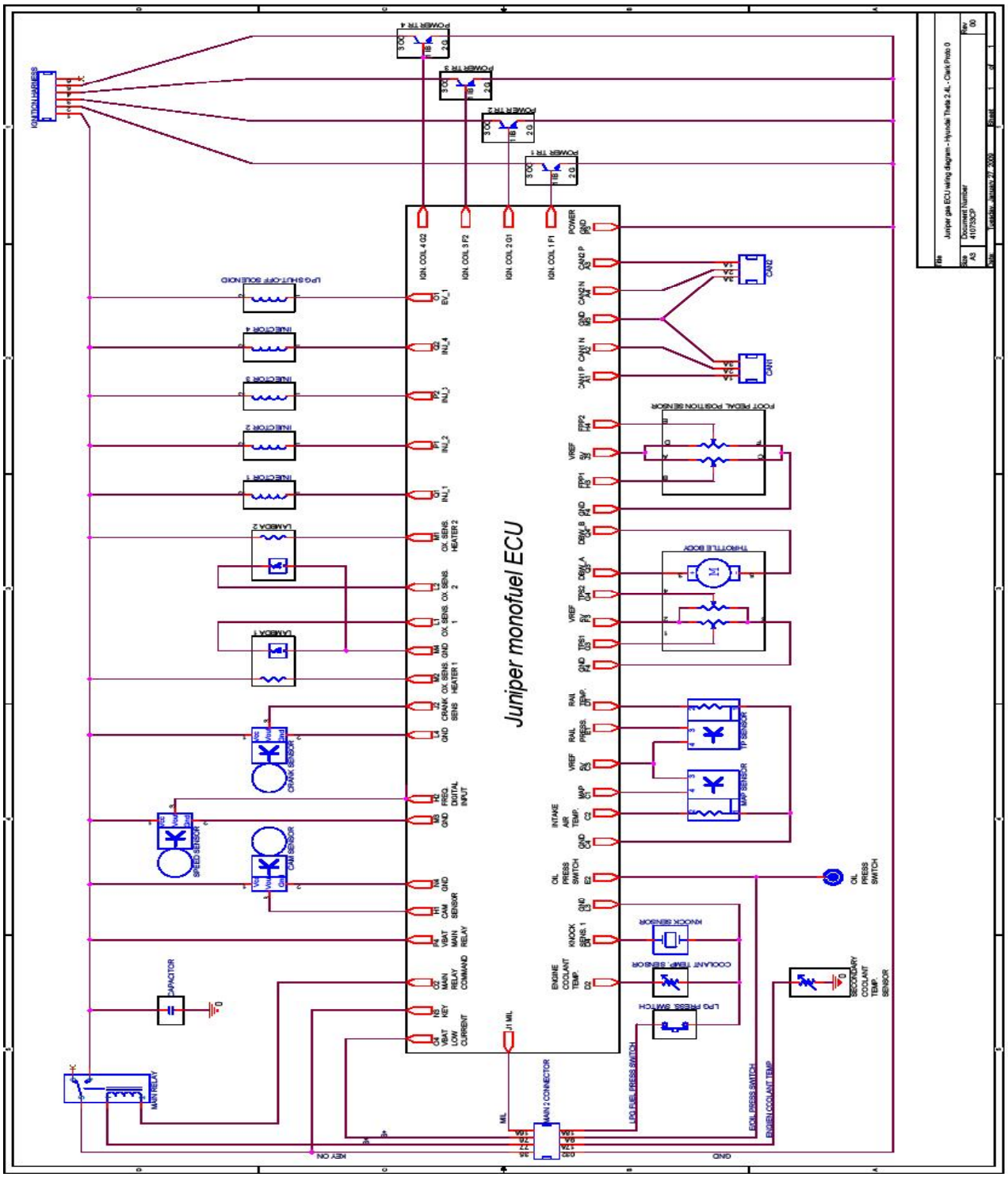

Figure 10: Juniper Engine Control Schematic

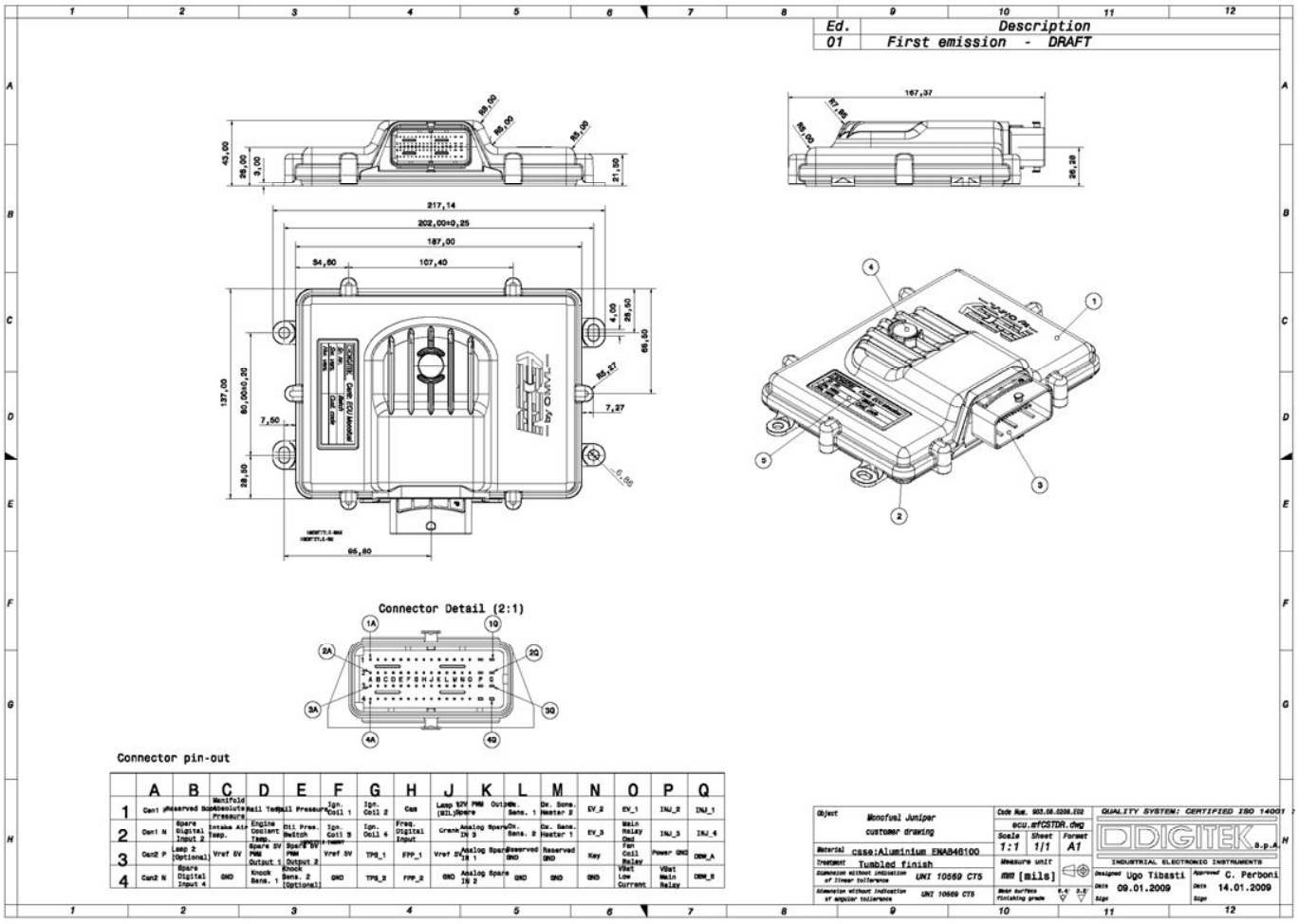

Figure 11: Juniper Engine Control Unit

Wire Harness

Juniper is providing a wire harness to connect the ECU to the various sensors and control devices. The harness also connects to customer supplied sensors, the dash-board display and the vehicle battery.

Two distinct harnesses will be supplied – one for the USA market and one for trucks shipped outside of the USA. The difference is due to the requirements for a post-catalyst oxygen sensor for the EPA certified engines. The wire harness schematic is shown in Figure 12.