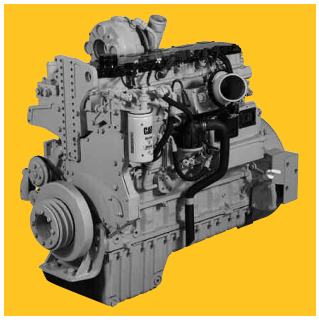
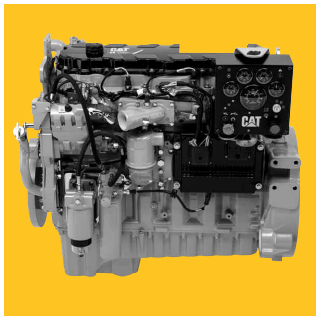
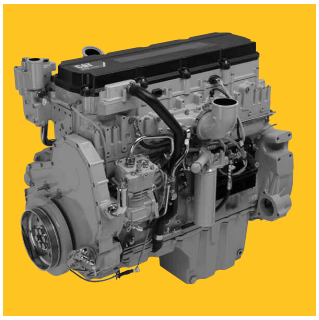
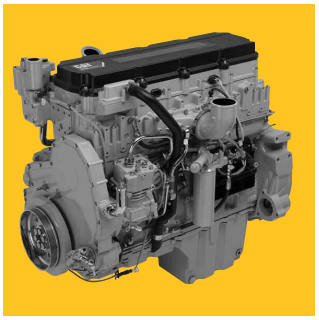
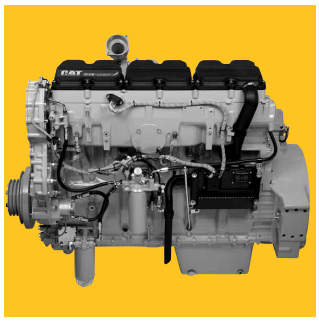
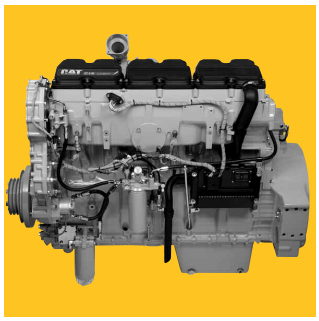
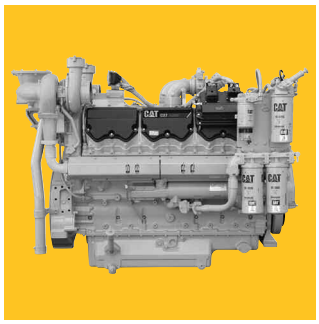
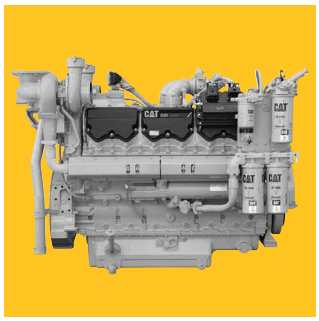
CATERPILLAR®

C7 ACERT® | C9 ACERT | C11 ACERT | C13 ACERT

C7 ACERT®-C32 ACERT INDUSTRIAL ENGINE

electronics application & installation guide

C15 ACERT | C18 ACERT | C27 ACERT | C32 ACERT

INDUSTRIAL

C7 ACERT	(JTF:	100-up)	C13 ACERT	(LGK:	100-up)
C7 ACERT	(JRA:	100-up)	C15 ACERT	(JRE:	100-up)
C9 ACERT	(JSC:	100-up)	C18 ACERT	(WJH:	100-up)
C9 ACERT	(MBD:	100-up)	C27 ACERT	(TWM:	100-up)
C11 ACERT	(GLS:	100-up)	C32 ACERT	(TLD:	100-up)

MACHINE RETROFIT

C15 ACERT	(LHX:	100-up)	C18 ACERT	(RHX:	100-up)

PETROLEUM

C7 ACERT	(C7P:	100-up)	C18 ACERT	(MPE:	100-up)
C9 ACERT	(P9L:	100-up)	C32 ACERT	(SMP:	100-up)

PETROLEUM (CHINA)

C7 ACERT	(K2A:	100-up)
C9 ACERT	(KLW:	100-up)
C11 ACERT	(B5K:	100-up)
C13 ACERT	(A5K:	100-up)
C15 ACERT	(JDK:	100-up)
C18 ACERT	(WJW:	100-up)

LEBH4623-02

Table of Contents

1 Introduction and Purpose

This document is intended to provide the necessary information for correct installation of the following Caterpillar® Industrial engines into off-highway engine applications: C7 ACERT/C9 ACERT, C11 ACERT/C13 ACERT, C15 ACERT/C18 ACERT, C27 ACERT/C32 ACERT.

Engines covered by this publication have an A4 ECU.

NOTE: *The information in this document is subject to change as engine feature requirements are revised and software continues to be developed. In addition, some of the features described in this document are not yet released.*

Contact the Electronic Applications Team via ApplicationSupport@Cat.com for the latest information on software feature release dates.

1.1 Safety

Most accidents that involve product operation, maintenance, and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills, and tools in order to perform these functions properly.

The information in this publication was based upon current information at the time of publication. Check for the most current information before you start any job. Caterpillar dealers will have the most current information.

Improper operation, maintenance, or repair of this product may be dangerous. Improper operation, maintenance, or repair of this product may result in injury or death.

Do not operate or perform any maintenance or repair on this product until you have read and understood the operation, maintenance, and repair information.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are not all inclusive. If a tool, a procedure, a work method, or an operating technique that is not specifically recommended by Caterpillar is used, you must be sure that it is safe for you and for other people. You must also be sure that the product will not be damaged. You must also be sure that the product will not be made unsafe by the procedures that are used.

1.1.1 Welding

WARNING — Welding on a Machine with an Electronic Engine:
Before welding on a vehicle equipped with an electronic engine, the following precautions should be observed.

- **Turn the engine OFF.**
- **Place the ignition key switch in the OFF position.**
- **Disconnect the negative battery cable from the battery. If the vehicle is equipped with a battery disconnect switch, open the switch.**
- **DO NOT use electrical components in order to ground the welder. Do not use the ECU or sensors or any other electronic component in order to ground the welder.**

For more information, refer to Appendix 9 of this document. Appendix 9 provides all relevant engine model Operation and Maintenance Manual and Troubleshooting Guide media numbers. Further information with regard to welding on a machine with an electronic engine is found in these documents.

1.2 Replacement Parts

When replacement parts are required for this product, Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength, and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury, or death.

2 Engine System Overview

All of the engines covered in this document are designed for electronic control. The electronic engine control system consists of the following primary components: Electronic Control Unit (ECU), electronically controlled unit injectors, engine wiring harness, and sensors. The following sections will provide information to better understand the function of the components in the engine control system and basic understanding of electronic engine control.

2.1 Electronic Engine Control

The electronic engine control strategy determines the timing and amount of fuel that is delivered to each cylinder based on the actual and desired conditions at any given time. The objective of the control system is to deliver best performance within emission and engine operating limits. Following are the primary functions performed by the electronic engine control strategy:

2.1.1 Engine Governing

The engine governor determines how much fuel to deliver to each cylinder to respond to changes in operator demand or engine load conditions. Two governing strategies are available: Speed Governor and Min/Max Governor. Governor strategy is selectable through a programmable parameter. Refer to Engine Governor (section 13) for additional information.

2.1.2 Air to Fuel Ratio Control

The control system has full authority over engine fuel delivery. The mechanical fuel/air ratio control is eliminated on an electronically controlled engine. Electronic control of the fuel/air ratio provides optimum performance while limiting emissions.

2.1.3 Injection Timing Control

Injection timing is varied as a function of engine operating conditions to optimize engine performance for emissions, noise, fuel consumption, and driveability.

2.1.4 Torque Rise Shaping

Electronic controls provide increased flexibility to tailor the torque curve over a wide speed range.

2.1.5 Cold Starting Strategy

Before and during cranking, the engine monitors atmospheric pressure, air inlet temperature, and/or coolant temperature. Based on these inputs, the engine executes a complex cold starting strategy that adjusts fuel volume, timing, and starting aids in order to start the engine. Refer to Cold Starting Aid (Section 16) for more information. Also, refer to the Operation and Maintenance Manual and the Troubleshooting Guide for the engine for more information.

2.1.6 Cold Mode Operation

Cold mode operation is activated based on the coolant temperature. The engine power is limited and the low idle speed may be elevated when in cold mode. Refer to the Operation and Maintenance Manual and the Troubleshooting Guide for the engine for more information.

2.1.7 Engine Protection and Monitoring

The engine control system uses the engine sensors to monitor engine operating conditions. Operation outside of customer or factory configured normal operating conditions will cause the engine to employ warning, derate, or shutdown strategies as defined in the engine protection and monitoring strategy. If any of these conditions occurs, an event is logged in the engine ECU. Refer to Engine Monitoring and Protection (section 15) for more information.

2.2 Factory Configuration Parameters

Factory configuration parameters are ECU software settings that affect the emissions, power, and identification of the engine. These parameters are programmed at the factory during engine assembly and test. Emissions control agencies require that the factory setting for these parameters is stamped on the engine information plate and any changes to these settings require that the engine plate be updated along with the change to the ECU setting. The factory configuration parameters must be reprogrammed if the ECU is replaced and/or the engine rating is changed. These parameters do not need to be reprogrammed if the ECU is re-flashed with a latest version of software flash file. Refer to the Factory Configured Parameters section of this document for more information on definition and configuration of each factory-set parameter.

Factory configuration parameters supported:

- Engine Serial Number
- Rating Number
- Full Load Setting (FLS)
- Full Torque Setting (FTS)

Notes on Programming Parameters

1. Changing parameters protected by factory passwords may void Caterpillar warranty. Consult Dealer Support Network contacts before changing these settings.
2. In order for the programmed values to change, the key switch (switched power only) must be cycled off and on.
3. If there is an interlock error (personality module mismatch), then the programmed parameters will not change. It may appear that the parameters are changed, but they will not change until the “personality module mismatch” code is cleared.

2.3 Engine Component Overview

C7 ACERT - C32 Industrial (Equipped w/A4 ECU)			
Factory Wiring	**C7 ACERT/ C9 ACERT**	**C11 ACERT/ C18 ACERT**	**C27 ACERT/ C32 ACERT**
Fuel injector: HEUI injector	x		
Fuel injector: MEUI injector		x	x
High efficiency pump	x		
Speed/timing sensor (cam)	2x	x	x
Speed/timing sensor (crank)		x	x
Compression brake solenoids (optional)		x (C15 ACERT, C18 ACERT)	
Fuel temperature sensor		x	x
Injection actuation pressure sensor	x		
Atmospheric pressure sensor	x	x	x
Boost (intake manifold air) pressure sensor	x	x	x
Intake air temperature sensor	x	x	x
Coolant temperature sensor	x	x	x
Fuel pressure sensor	x	x	x
Oil pressure sensor	x	x	x
Intake air heater	x		

Note: *Petroleum ATEX engine sensors are provided with approved ATEX "pigtail" connections. The exception is the fuel temperature sensor on the C18 ACERT and C32 ACERT that is protected by a guard.*

2.3.1 Engine Control Unit (ECU)

The ECU is generally located on the left rear side of the engine. The ECU has two connectors, one for the Caterpillar engine harness and the other for the customer harness.

2.3.1.1 Engine Connector (120-pin connector, J2/P2)

Engine system and control information is transmitted between the 120-pin connector on the engine ECU and the engine components through the engine harness. The engine harness provides the interface to the following engine components:

- Engine Sensors
- Fuel Injection System

2.3.1.2 Customer Connector (70-pin connector, J1/P1)

Customer control and display information is transmitted between the 70-pin connector on the engine ECU and the customer-installed components through the customer harness. The customer harness provides the interface to the following components:

- Battery
- Data Links
- Customer Components

2.3.2 Software Flash File

If the ECU is correlated to a computer, then the personality module (also known as "flash file") is the software for the computer. The term flash file is derived by the method in which the software is programmed into the ECU — a technology known as flash programming. The flash file contains the operating maps that define the performance and operating characteristics of the engine as well as the Industrial application feature support. Once flashed, the ECU contains the following information to identify the flash file and supported ratings:

- Personality Module PN
- Software Gp Release Date
- Rated Power
- Rated Peak Torque
- Top Engine Speed Range
- Test Spec

The information above can be viewed in the Configuration Parameter screen within the Cat® ET service tool.

2.3.3 Fuel Injector

2.3.3.1 HEUI™ Injector (C7 ACERT and C9 ACERT)

The Hydraulically actuated Electronically controlled Unit Injector fuel system is actuated hydraulically by high pressure engine oil. The HEUI injector contains a solenoid to electrically control the quantity, pressure, and timing of the fuel that is injected. Both positive and negative wires to each solenoid are wired directly back to the ECU. Higher voltages (approximately 70 V) and sharp pulses of relatively high current are used to control the injectors. Injector cables are twisted pairs to minimize emissions of electromagnetic noise. There is no OEM connection to the injectors; however, the OEM should ensure that any systems that are sensitive to electromagnetic radiation are not in proximity to the harness that leads to the injectors.

2.3.3.2 MEUI Injector (C11 ACERT-C32 ACERT)

The Mechanical Electronic Unit Injector (MEUI) fuel system is actuated mechanically by the injector lobe on the camshaft. The electronic control and mechanical actuation provide a level of control of the timing and fuel volume. The timing advance is achieved by precise control of the unit injector timing. Both positive and negative wires to each solenoid are wired directly back to the ECU. Higher voltages (approximately 108 V) and sharp pulses of relatively high current are used to control the injectors. There is no OEM connection to the injectors; however, the OEM should ensure that any systems that are sensitive to electromagnetic radiation are not in proximity to the harness that leads to the injectors.

2.3.4 High Efficiency Pump (C7 ACERT and C9 ACERT, HEUI Only)

The unit injector hydraulic pump is a variable delivery piston pump. The unit injector hydraulic pump supplies a portion of the engine lubrication oil to the HEUI injectors. The high efficiency of the pump combined with the resistance to flow at the unit injectors pressurizes the oil delivered by the pump.

2.3.5 Injection Actuation Pressure Sensor (C7 ACERT and C9 ACERT, HEUI Only)

The IAP sensor is installed in the high pressure oil manifold. The high pressure oil manifold supplies actuation oil in order to power the unit injectors. The IAP sensor monitors injection actuation pressure.

2.3.6 Intake Air Heater (C7 ACERT and C9 ACERT, HEUI Only)

The engines are equipped with an electric heater that is located behind the air inlet elbow. The electric heater has two functions:

- Aid in starting
- Aid in white smoke cleanup during start-up

The intake air heater works in conjunction with the wait-to-start lamp.

NOTE: *If an ether starting aid is used on C7 ACERT or C9 ACERT engines, it must be controlled by the engine ECU so that ether is not injeced while the intake air heater is in use. Refer to section 16.4.*

2.3.7 Fuel Pressure Sensor (C7 ACERT-C18 ACERT Only)

Prior to exiting the fuel filter base, the fuel pressure is sampled by the fuel pressure sensor. The signals that are generated by the sensor are used by the engine control in order to monitor the condition of the engine's injectors. This information is used to adjust the fuel delivery of the engine in order to optimize efficiency and to protect the injectors.

2.3.8 Dual Speed Timing Sensors

The engine speed/timing sensors are used to determine both engine speed and fuel injection timing. The C7 ACERT and C9 ACERT sensors are both triggered by a target wheel on the camshaft. On the C11 ACERT through C32 ACERT, the camshaft position sensor detects information from a target wheel on the camshaft and the crankshaft position sensor detects this information from a target wheel on the crankshaft. Under normal operating conditions the engine monitors one of the position sensors while cranking (camshaft) and one of the position sensors (crankshaft) while running. The design provides for optimized start capability as well as redundancy. Should a failure occur in either of the sensor circuits, the engine can be started and will run with only one sensor.

2.3.9 Compression Brake Solenoids (Option on C15 ACERT and C18 ACERT Only)

Compression brake is an optional feature offered on select C15 and C18 ratings only. There is one compression brake actuator assembly per pair of adjacent cylinders and one control solenoid per brake assembly. The ECU directly drives the solenoid through the engine harness. Contact the Caterpillar Application Support Center for ratings that are approved to use a compression brake. Refer to Exhaust and Compression Brakes (section 10) for more information.

2.3.10 Fuel Temperature Sensor (C11 ACERT-C32 ACERT)

Fuel temperature is measured at the fuel filter base. Fuel is sampled prior to fuel exiting the fuel filter base. Fuel temperature is monitored to adjust fuel rate calculations as part of a fuel temperature power compensation strategy to maintain constant power when fuel temperature exceeds 30° C. Refer to the Fuel Temperature (C11 ACERT-C18 ACERT only) (section 15.1.6) in the Engine Monitoring and Protection section for more information on fuel temperature compensation.

2.3.11 Atmospheric Pressure Sensor

The atmospheric pressure sensor is an absolute pressure sensor measuring crankcase pressure. Both the boost pressure and oil pressure communicated to service tools and over the data link are calculated by subtracting the atmospheric pressure sensor reading. The atmospheric pressure sensor can measure pressures from 0 kPa (0 psi) to 116 kPa (16.8 psi). The engine implements altitude compensation (derate) strategies based partially on input from this sensor.