Tier 4 Maintenance & Troubleshooting Workshop

The Rental Show

February 20, 2016
Kubota CRS

CRS / Common Rail System

ECU (E4)
Sensors and Valves

1. Input and output components of the Kubota CRS are separated into two categories:
   - Sensors
   - Valves

CR ECU – Basic Logic and Function for Fuel Delivery

- Accelerator Opening
- Engine Speed
- Basic Injection Quantity
- Maximum Injection Quantity
- Low Quantity Side Selected
- Corrected Final Injection Quantity
- Injector Actuation Period Calculation
- Intake Air Pressure Correction
- Intake Air Temperature Correction
- Atmospheric Air Pressure Correction
- Ambient Temperature Correction
- Cold Engine Maximum Injection Quantity Correction
- Individual Cylinder Correction Quantity
- Speed Correction
- Injection Pressure Correction
Kubota CRS Engine Training

1. Electrical
2. Regeneration
3. Filters / Lubricants

Emission Regulation and Solutions

<table>
<thead>
<tr>
<th>Component</th>
<th>Regulation</th>
<th>Solution</th>
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<tr>
<td>( CO_2 )</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>( H_2O )</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>( CO )</td>
<td>Tier 3 (Stage IIIA)</td>
<td>CRS</td>
</tr>
<tr>
<td>( C_{pH} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( PM )</td>
<td>Int. Tier 4 (Stage IIIB)</td>
<td>DPF</td>
</tr>
<tr>
<td>( Ash )</td>
<td>before Tier 2 Final Tier 4 (Stage IV)</td>
<td>EGR SCR</td>
</tr>
</tbody>
</table>
## Emission Regulation and Solutions

1. CRS: for CO+HC, PM
2. DPF: for PM
3. SCR: for NOx

<table>
<thead>
<tr>
<th>Tier</th>
<th>Stage</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier II</td>
<td>Stage II</td>
<td>2004</td>
</tr>
<tr>
<td>Tier IIIA</td>
<td>Stage IIIA</td>
<td>2008</td>
</tr>
<tr>
<td>Tier IIIIB</td>
<td>Stage IIIIB</td>
<td>2012</td>
</tr>
<tr>
<td>Tier IV</td>
<td>Stage IV</td>
<td>2015</td>
</tr>
</tbody>
</table>

- **CRS**: Common Rail System
- **DPF**: Diesel Particulate Filter
- **SCR**: Selective Catalytic Reduction

### NOx | Nitrogen Oxides

1. NOx is an inclusive term of Oxidation Products of Nitrogen.
2. It contributes to the Urban Smog and Acid Rain.
3. EGR reduces NOx, but it is not enough for the latest emission requirements.
4. High combustion temperatures (=complete combustion) generates NOx.

- **Trade-off relation with PM**

\[
\begin{align*}
N(\text{Nitrogen}) & \rightarrow NO \rightarrow NO_2 \rightarrow N_2O_4 \rightarrow \text{etc...}
\end{align*}
\]

- **EGR**: Exhaust Gas Recirculation
Kubota Engine Service Distributors

1. For a list of our, please visit: www.kubotaengine.com

Kubota Solutions for Tier 4

1. Common Rail Injection
   - A More Complete and Controlled Combustion Event
     • This prevents excess PM/Soot and other Gases HC’s, CO, NOx...
     • Injection pressures are much higher than mechanical engines, multiple injections – more precise timing

2. Blowby Gas CCB and Tight Manufacturing Tolerances/Process’
   - Blowby Gas and Oil Mist that passes from the cylinder to the crankcase is captured separated and returned to the engine inlet by the closed breather system

3. EGR (Cooled) + Throttle
   - Additional Combustion and Exhaust Temperature Control

4. Aftertreatment DOC+DPF+SCR
   - Reduces Emissions PM, NOx, CO, HC by Catalytic Reaction and Filtering
Common Rail Engine Models

**DOC Only Models Recently Announced**

03 Naturally Aspirated and Turbo Models (3 and 4 Cylinders)

07 Series – Two Basic Models 2.6 and 3.3 Liters Turbocharged

V3800 Turbocharged with TI and SCR Coming Soon

**Common Rail Engine Line Up**

- D1803-CR-E4B
- D1803-CR-T-E4B
- V2403-CR-E4B
- V2403-CR-T-E4B
- V2607-CR-T-E4B
- V3307-CR-T-E4B
- V3800-CR-T-E4B

Electronically Controlled Engine

1. Multiple sensors indicate engine operating status.
2. The ECU controls valves based on the sensors.

**Sensors**

1. Rail Pressure
2. Coolant Temp
3. Crank Position (NE)
4. Cam Position (G)
5. Boost (Turbo only)
6. Barometric Pressure
7. Air Flow
8. Differential Pressure
9. TO
10. T1
11. T2
12. EGR Valve Position
13. Throttle Valve Position
14. Oil Switch

**ECU**

- + Air Intake Temp
- + Fuel Temp (iT4)

**Supply Pump**

**Injector**

**EGR Valve**

**Throttle Valve**

(Denso Only)
Electronically Controlled Engine

1. ACU control electrical valves according to sensor values.
2. ECU and ACU is communicating each other through CAN.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>ECU</th>
<th>Valves</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 sensors</td>
<td></td>
<td>4 actuators</td>
</tr>
</tbody>
</table>

- Sensor:
  1. NOx (Pre)
  2. NOx (Post)
  3. SCR inlet Temp.
  4. DEF Tank Level
  5. DEF Quality
  6. DEF Temp.
  7. DEF Pressure

Engine Control Unit (ECU)

1. 03-Series (Bosch)
2. V3- and 07-Series (Denso)
Barometric Pressure Sensor

1. Senses atmosphere pressure. (low pressure at high altitude.)
2. ECU has the circuit for sensing pressure on the board.
3. ECU uses this value for fuel injection control.

Temperature Sensors

1. Temperature sensors are negative temperature coefficient type.
Pressure Sensors

1. Pressure sensors are linear type.

Coolant Temperature Sensor

1. Cold start-up mode
2. Overheat detection
3. Fuel injection quantity influence
4. Normal range 50 – 100°C
Air Flow Sensor

1. Senses the amount of fresh air into engine.
2. ECU uses this value for EGR valve control and regeneration.

Crank Position (NE) Sensor

1. ECU uses this value for controlling injection timing and sensing engine speed (RPM).
2. Pulsar gear is coupled with Crankshaft, and it shows Piston position.

- Crank Position: crankshaft angle (CA)
- NE: Crank Position Sensor is sometimes called as NE sensor
Cam Position (G) Sensor

2. Piston position

Timing Pulse Chart

1. Typical timing pulse output of crankshaft and camshaft sensors.
**Intake Throttle Valve**

1. During Regeneration control, throttle valve close and decrease intake air quantity.
2. Decreasing intake air quantity increase exhaust gas temp. (DOC catalyst activation)
3. Not linked to accelerator command.

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**High Pressure Fuel System Overview (CRS)**

1. Fuel is compressed to high pressure by the supply pump
2. High pressure fuel is stored in the rail, and distributed to each injector.

- **Supply Pump**
  - compress and delivers fuel to Rail

- **Rail**
  - maintains high pressure fuel

- **Injector**
  - injects fuel into the combustion chamber
Supply Pump

1. compress fuel and send to Rail.
2. quantity of fuel to Rail is regulated by SCV control.

SCV

1. Quantity of fuel output is controlled by time which ECU sends current to the coil.
2. Full open (maximum fuel output) is when current = 0.
Fuel Temperature Sensor

1. Senses fuel temperature at intake side of Supply Pump. (Denso only.)

Supply Pump

1. Feed pump
2. PCV
3. Pressure feed part
4. Delivery valve
Supply Pump

1. The valve closes when electric current is applied.
2. The amount of pressure feed fuel is controlled by the timing when the valve closes.

Fuel Rail | Pressure Sensor and Pressure Limiter

1. Rail sensor and limiter are not serviceable separately.

iT4 V3800CR, 07CR Rail Pressure Limiter
Valve opening pressure: 31,900 PSI (220 MPa)
Valve closing pressure: 7,300 PSI (50 MPa)

03CR Rail Pressure Limiter
Valve opening pressure: 24,700 PSI (170 MPa)
Valve closing pressure: 5,800 PSI (40 MPa)
CRS Injectors

1. Must register the injector compensation codes into the ECU with diagnostic tool, and on the Kubota website.

ID code
when input incorrectly:
P0602 「QR data error」
EGR Valve

1. Control the quantity of circulation gas
2. A check valve to prevent the intake air is discharged from the exhaust side without entering the cylinder.

Differential Pressure Sensor

1. Senses pressure difference before and after DPF.
2. Calculates PM quantity.
Exhaust Gas Temperature Sensors (T0, T1, T2)

Senses exhaust gas temperatures in the DPF muffler.
1. T0 : DOC in
2. T1 : DPF in
3. T2 : DPF out

Regeneration

1. Regeneration
   – A process that catalyzes soot (PM) in the DPF
2. Passive Regeneration
   – Regeneration done strictly by normal exhaust heat due to load
3. Active Regeneration
   – Regeneration controlled by the ECU
Regeneration

1. Inhibit
2. Uninhibit
3. Requirements for regeneration:
   - Neutral
   - Uninhibit
   - Parking brake set
   - Vehicle speed set to zero
   - Engine coolant over 65C (149F)
   - Accelerator pedal has to be 0%
   - Zero active DTCs

Regeneration

1. DPF Filter medium (wall flow) traps PM.
Regeneration

1. Regeneration is a process to change PM into CO₂ by chemical reaction in order to restore filtering function without replacement.
2. Catalyst properties of DPF combine PM with O₂ in exhaust gas to form CO₂ at 550 °C. CO₂ is so small that get out through holes of DPF wall.

Regeneration

To increase exhaust gas temp. to control PM.

1. require engine rpm increasing
2. close throttle valve
3. Post Injection
Post Injection increases T1 temp. for Regen.

The fuel, which is injected after explosion, reached to DOC directly. The fuel on DOC and catalyst of DOC starts catalytic reaction. This reaction heat increase exhaust gas temperature (T1 temp.).

When executed?
1. under Regeneration control (all of Auto, Parked, Manual)
2. T0, T1, T2 reached to specified temperature.
3. Coolant temp. > 65 degC.
**SCR system**

1. SCR catalyst
2. ASC
3. DEF Injector
4. DEF Pump
5. DEF Tank
6. Header Unit
7. DEF Tube (Suction)
8. DEF Tube (Delivery)
9. DEF Tube (Return)
10. Coolant Valve

**Sensors**
1. NOx (Pre)
2. NOx (Post)
3. SCR Inlet Temp.
4. DEF Tank Level
5. DEF Quality
6. DEF Temp.
7. DEF Pressure

**Control Unit**
1. ACU

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**SCR System**

1. The purpose of SCR is to reduce NOx by chemical reaction on SCR catalyst.
2. Urea changes into Ammonia by heat.
3. NOx has reductive reaction with Ammonia by SCR catalyst.
4. Excessive Ammonia changes into N2 by ASC.

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- SCR: Selective Catalytic Reduction
- ASC: Ammonia Slip Catalyst
- Ammonia Slip: exhaustion of excessive NH3 without reaction with NOx
DEF Injector Cooling

After key switch turned off (= engine stopped)
1. DEF is circulated about for 1 – 10 min normally (depend on exhaust gas temp.) to cool down DEF injector.
2. After finishing cooling, DEF is purged for maximum 90 sec (depend on DEF pressure).

* DO NOT DISCONNECT the battery cable for maximum 11.5 min after engine stops

Thaw Control

1. During DEF frozen, engine torque is limited max. 20 % to protect DEF injector.
2. Because DEF pump cannot circulate DEF to DEF injector for cooling.
3. Calculates O-ring temperature in DEF injector with exhaust gas temp., exhaust gas flow rate, ambient temp. and etc..

* Rubber part is the weakest part in DEF injector.
* Under thaw control, engine torque is limited.

- Engine speed
- Fuel injection quantity
- Mass flow rate
- Barometric pressure
- Ambient air temp.
- DPF outlet temp.

Calculates O-ring temp. and decides how much torque to limit
**Operator Inducement**

1. **Reduction Lv.1**: Within 50% of maximum torque, within 60% of engine speed
   - limits engine power and work severely by disabling the function of machine.
2. **Reduction Lv.2**: No available net torque, nearly idle-speed
   - To incent the operator strongly in order to remedy the caused problem by effective disablement of machine.

   1) **Reduction Lv.1** → Repair → Cured
   2) **Reduction Lv.1** → **Reduction Lv.2** → Repair → Cured

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**Diagnostic Trouble Codes**
### Diagnostic Trouble Codes

<table>
<thead>
<tr>
<th>Name</th>
<th>Feed pump circuit abnormality</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 14229 P-Code</td>
<td>P1840</td>
</tr>
<tr>
<td>J1939-73 SPI</td>
<td>523701</td>
</tr>
<tr>
<td>PNI</td>
<td>3</td>
</tr>
<tr>
<td>SPN Name SAE J1939 Table C1</td>
<td>proprietary</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DTC Name</th>
<th>Feed pump circuit open / short to B+</th>
<th>Feed pump circuit short to GND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection Item</td>
<td>Open circuit or B+ short circuit of pump / harness.</td>
<td>GND short circuit of pump / harness.</td>
</tr>
<tr>
<td>DTC Set Preconditions</td>
<td>Battery voltage is normal</td>
<td>Battery voltage is normal</td>
</tr>
<tr>
<td></td>
<td>Feed pump is OFF</td>
<td>Feed pump is ON</td>
</tr>
<tr>
<td>DTC Set parameter</td>
<td>Open circuit or B+ short circuit of harness</td>
<td>GND short circuit of harness</td>
</tr>
<tr>
<td>Time to action or number of error detection</td>
<td>1 sec. or more</td>
<td>1 sec. or more</td>
</tr>
<tr>
<td>Limp Home Action by engine ECU (system action)</td>
<td>Insufficient output or Engine stall</td>
<td>Insufficient output or Engine stall</td>
</tr>
<tr>
<td>Engine Warning Light</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>Recovery from error</td>
<td>Key switch turn OFF</td>
<td>Key switch turn OFF</td>
</tr>
<tr>
<td>Delay time for recovery</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Remark</td>
<td>Go here for DTC assistance...</td>
<td></td>
</tr>
</tbody>
</table>
Diagmaster Tool Kit

1. Check DTCs
2. Data Monitor

OS: Windows XP / 2000 Professional (except 64 bit)
CPU: Intel P 3 or 4 1GHz or more
Memory: 256MB USB 1.1 or 2.0
HDD: Space 100MB
Display: XGA (1024x768)
1. “Diagmaster” is Kubota’s diagnostic software program communicate with the ECU.

### Diagmaster Tool Kit

- **PC**: Driver, Database, Diagmaster
- **Interface**: Firmware
- **ECU**: Sens. & Valves
- **Signal**: order → translated signal → translated order → signal

### Maintenance Information

<table>
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<th>Every</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every 5000 hours</td>
<td>Checking of engine oil level, Checking of fuel level, Checking of coolant level, Checking of fan belt, Checking of DiF/AdBlue® tank</td>
</tr>
<tr>
<td>Every 500 hours</td>
<td>Checking of engine oil level, Checking of fuel level, Checking of coolant level, Checking of fan belt, Checking of DiF/AdBlue® tank</td>
</tr>
<tr>
<td>Every 30 hours</td>
<td>Checking of fuel pipes and clamp bands, Checking of water separator, Checking of radiator hoses and clamp bands, Cleaning of air cleaner element, Adjustment of fan belt tension, Checking of intake air line</td>
</tr>
<tr>
<td>Every 2000 hours</td>
<td>Checking of Evap.</td>
</tr>
</tbody>
</table>
KUBOTA Engine America

DPF Cleaning Program

DPF cleaning currently available through KUBOTA Engine America.

Option 1. Clean DPF Exchange Kit:
All Distributors (through the Essential Service Parts Program) will automatically receive Cleaned DPF Exchange Kits for shelf-ready service.

Option 2. Clean & Return Program:
KEA will offer alternate Clean & Return Program

DPF’s can be shipped to KUBOTA Engine America for cleaning. After cleaning KEA will return The DPF directly to the shipper
Clean DPF Exchange Kit

Clean DPF Exchange Kits shipped through the Essential Service Parts Program will not be assessed a core charge.

Clean & Return

- An alternate Clean & Return Program is available now.

- The DPF cleaning process for Clean & Return Program is the same as Clean DPF Exchange except for:
  
  No core charge
  No direct distributor handling
Clean DPF Exchange Process

1. Distributor purchases Clean DPF Exchange Kit + core deposit
2. Service dealer installs clean DPF
3. Service dealer returns DPF core directly to KEA
4. Core received & evaluated by KEA
5. Credit issued to Distributor

Clean & Return Process

1. Dealer gets pre-authorization from Distributor
2. Distributor provides KEA parts department w/ PO
3. KEA receives dirty DPF and confirms PO receipt from Distributor
4. Distributor is invoiced. Order confirmation sent
5. Dealer completes DPF maintenance
### Return Form

**DPF CORE RETURN**

**Attention:**
This box should only be opened by an authorized DPF cleaning facility.

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### Certificate

**Included in Kit:**
Unique certificate
For each DPF cleaned
Return Instructions

Caution statement:
handle with care

Pre-determination guide

Included in Kit to aid dealer in determining if the core charge/deposit will be refunded
Returnable shipping box