RT-flex Training

Service Aspects
Goals of chapter “Operation and Service”: 

- Trainees will know to operate their RT-flex engine in a safe and economical way
- Trainees will be able to perform trouble shooting and basic maintenance work on the RT-flex engine
RT-flex, Operation and Service

General remarks

Things to consider during normal operation:

- The flex parts of the engine requires different treatment than used on conventional engines.
- However, for the mechanical parts in general refer to the manuals, your knowledge as an engineer and to common sense.
- On the following pages some important hints and tricks are listed but is not limited to.
Please note that the tips, hints and remarks mentioned hereafter are just some possibilities to solve a problem based on experiences with real situations.

However, the manuals delivered with the RT-flex engine and on-site given instructions from engine maker prevails these chapters.

Remember that even at engine standstill, there is probably pressure remaining in the rails.

**Depressurise the rails and pipes before starting to work on them!**
Visual checks on daily rounds

- The top covers of the rail unit lift up easily, so look inside daily and check for leaks, etc.

- Regularly inspect the fuel pump regulating racks. Does it move freely on all pumps? The rod can be pushed to a lower position, the other pumps will automatically compensate.

- Fuel-, Servo- und Control oil pumps, valves, distribution blocks, pipe connections, etc. have to be checked daily for possible leaks.
Working on Pumps, valves and rail unit

- Before starting any work on pumps, valves or rail unit make sure that there is no residual pressure
After overhaul works in or around the rail unit and/or supply unit

- Make use of the simulation possibilities of WECS-9520 and flexView.

- Once the control oil pumps are running, the **exhaust valves** can be **manually open and closed**. This proves that they work properly and leakages can be detected.

- To check the ICU, fuel pipes and injectors the function "Injection venting" which will trigger all injection rail valves on-off for 30 seconds. This procedure can be used to vent air from the newly assembled parts. Oil will flow through them and warm them up. Possible leaks can be seen.
Do not use water washing devices anywhere near any electronic unit!

No welding work within 2 meters around a switched-on electronic units!
FCM-20 modules

- The FCM-20 installed in E90 as “Online-Spare” can be installed in any E95 box.

- Make sure that ALL FCM-20’s in the store have the same software version loaded than the ones used on the engine.
WECS-9520

- The electronic units of the WECS-9520 system shall always be kept on, there is no need to switch it off the electronic units in port. But it is recommended to turn off power when unplugging sockets from modules and during welding works on the engine.

- Power supply to a single cylinder can be cut off even with running engine, after switching back on the cylinder it will boot and start working.
Protection guards

- The E95 boxes have to be protected against damage by using the protection guards.
Protection against unexpected alarms

- To avoid a slow-down / shut-down released by accidentally pushed lever, protect it with a cover.
Trace heating of rail unit, supply unit and rising pipes (all fuel parts):

- To avoid sticking HFO, the trace heating shall be on at all times, specially in port. The fuel inside rising pipes and rail does not circulate and must be kept warm.

- To avoid starting difficulties, it is recommended to turn on the heating at least 4 hours before engine starting.

- All rail unit covers shall be kept close.

**WARNING:** When changing over from bunker to MDO, the trace heating must by all means be stopped early enough to avoid overheating of the diesel oil.
Oil treatment

- Some of the hydraulic components are very sensitive and require clean oil. It avoids operational troubles and prolongs their lifetime.

- The automatic filter is a good and efficient provider of clean oil. Should the filter indicate high differential pressure all the time, this can be an indicator for a problem with the main bearing oil treatment.

- Only in real emergency cases the automatic filter must be switched over to its by-pass side.
Function test of main starting valve

- The two solenoid valves are normally activated together for high availability.

- From time to time a function test should be carried out by disabling one of the valves, starting the engine and repeating using the other valve.

The valves can be disabled by pulling their plugs or via the “User” page of the flexView.

Instead of starting the engine, a “slow turning” or “air run” can be done.
Special measures in emergency cases:

In case of a heavy internal or external fuel leakage of the ICU, which cannot be fixed immediately, the fuel supply from fuel rail to the corresponding ICU can be shut off. The screw plug tool (Nr. 94585) can be installed instead of the venting plug shown in the sketch. The control oil supply and return can be shut in a similar way.

If for any other reason the injection of a unit needs to be stopped, this can be done manually through the WECS-9520 user interface (user parameter) plus unplugging the ICU rail valves.

The ICU itself MUST NOT be opened since without it can not be reassembled without special tools.
Injection unit, “quantity piston stuck in end position”

- “Sticking” does not always mean that the piston got physically seized. It mostly happened due to rail valve failed, fuel quantity sensor failed, FCM failure, cold control oil, etc.

- Very often the piston starts working again after a while with warm oil or after depressurizing the fuel rail.

- Normally replacing the ICU is NOT need.

Remind the very high fuel pressure before working on the ICU or fuel rail unit !!
Venting of fuel oil rail:

- After a major overhaul or to fill up an empty fuel oil system, venting has to be done.
- The venting plug in one ICU per rail must be slackened. Running the booster pump fills the rail with fuel while air and foam escapes from the plug.
- Some engine types have the possibility to pressurise the fuel rail via servo oil system.
- Venting can also be done via flexView under “User”.
Detection of leakages:
Internal leakages of ICU’s and high pressure injection pipes (on each rail unit half) are monitored by one leakage sensor. In order to find out whether the leakage actually comes from the ICU or an injection pipe, the plugs on the connection flanges can be slightly unscrewed.

In order to locate a probable leaking ICU, observe the injection time on all units, observe exhaust gas temperatures after cylinders, or run the engine with reduced load (i.e. < slow down speed) and cut off the injection of all units (one by one). If the leakage stops after a certain unit was cut off, this ICU can be suspected.

Only Wärtsilä approved workshops are allowed to overhaul ICU’s!
Emergency operation:

In case of fuel pressure regulation failure (e.g. actuator failure), resulting in a constantly too high fuel pressure, the max. opening pressure can be reduced in order to remove load from fuel pump etc.

A good value will be between 600-700 bar.
Exhaust Valve Drive
Special measures in emergency cases:

If the injection of a certain cylinder is cut off, the exhaust valve has to remain operational.

In case of a heavy leakage of exhaust valve actuator, actuator pipe or valve drive, the servo oil supply can be shut off by installing plug (Tool Nr. 94586). The main bearing oil supply can easily be interrupted by a shut-off valve as well. In such a case, the engine is operated with a closed exhaust valve and cut-off injection. Additionally, you can disconnect the exhaust valve sensor plug from the cylinder cover to prevent alarms from exhaust valve monitoring system.
Blocking of exhaust valve:

If a cylinder cooling water leakage into combustion space occurs, the engine shall be operated with an open exhaust valve. Therefore the valve is moved open manually by user parameter (will close by itself after a short time!), and pins Nr. 94259 can be inserted.

Of course the injection has to be cut off as well!
Non-closing of Exhaust Valves

- According to the manual, prior to starting the oil pumps, spring air has to be supplied. If the engine is at standstill for a while with pumps running but without air, there is a possibility to block the exhaust valves in open position.

- To release the exhaust valves the jammed oil in the pipe has to be drained via the venting screws.

- Please observe the sequence of the starting-up procedure described in the manuals.
Lifting a fuel pump:

In normal operation, all fuel pumps deliver roughly the same quantity. If a pump is defective, it will be detected by the Alarm System (temperature reduction at HP-outlet pipe). The regulating linkage position will be higher than normal at a given fuel command. In such cases, the affected pumps need to be cut out mechanically by lifting the roller from the cam by eccentric shaft tool. This can only be done at engine standstill.

With one pump cut out, the engine can still be operated at high load and regular service speed. The more pumps are cut out, the more the maximal load is limited.
Remark: With leaky non-return valves, a pressure can be build up itself in the plunger space of the fuel pumps leading to an increased load on the cut-out tool. Tins must be prevented by means of taking the following measures:

- Remove the high pressure pipe from the cut-out fuel pump
- Fit blank flange “8” (tool 94569) to fuel pump.
- Fir blank flange “15” (tool 94569a) to intermediate fuel accumulator.
Special measures in emergency cases:

In case of one or all electronic actuator fail, the corresponding linkage stays in position or moves to full output position. The remaining working actuators will compensate the regulation for the failed one.

A torsional spring on each regulating shaft will pull the linkage to full output, if the affected actuator has no torque force anymore (electric power loss). In addition, spacers can be installed on regulating rack of affected pump. Depending on, how many pumps are fixed in max. position, the fuel rail pressure cannot be regulated properly anymore. A constantly higher fuel rail pressure will result. The emergency overpressure regulating valve will limit the max. pressure accordingly. For long term operation, the opening pressure of that one must be reduced.

When internal actuator faults occur, the position is kept on actual position.
The crank angle signal is absolutely indispensable for engine operation. At least one of the sensors must be working. If one fails, WECS-9520 can detect the failure and will keep working with the healthy signal (plausibility check). In case both sensors fail, the engine will stop without delay.

There is no emergency operation possible without at least one CA sensor!
Crank angle sensors and –drive

- The crank angle sensor drive has to be checked for proper lubrication. Check daily if the lube oil pipe feels warm. If not, the fine orifice at the inlet to the housing may be clogged.

- Open the cover every few months and look inside.
  - Are the belts OK and with correct tension?
  - Is there any dirt or oil?
  - Do sensor wheels have play?
The sensor can be exchanged easily. With the flywheel at 0.0°, the two red lines on the sensor must be flush. If not, the toothed belt is one or more teeth off its position and has to be slackened again, so the sensor wheel can be turned freely until the two red lines are flush. Then the belt has to be pre-tensioned with a given force of approx. 3.5 kg (35 N), max. 4.5 kg. Also the complete sensor drive can be exchanged.

- Standard on-board spare parts: 2 Sensors with belts and screws, 1 complete drive unit assembled.
- The belts have to be exchanged after a while (estimated lifetime 3 ~ 5 years).
- The belts must be free of oil!
Correct assembly of the crank angle sensors and -drive is indispensable for the operational safety.

Sensor pulley, dropped off side ring: Consequence of over tightened belt.
Fitting of shaft encoder

1. Turn crank shaft to TDC of cylinder 1

2. Insert shaft encoder into the guide of the bearing housing. Fasten screws slightly.

3. Push shaft encoder (with black holder plate!) inwards

4. Check whether the holder plate moves freely in the bearing housing

Apply Molykote to sliding surface!
Cylinder No 1 must be at its actual, physical TDC during the whole installation process! (This is NOT necessarily corresponding with the TDC signal "tooth"…. !)

Fitting of toothed belt

1. Lay toothed belt onto the gear wheels in the position where the two red marks of the gear wheels are flush. (The wheel of the sensor is freely movable….)

2. Push shaft encoder outwards till belt is slightly tensioned. Slightly tighten the screws. Re-check if red marks are flush!

3. Align toothed belt in running direction and apply spring balance

4. Tension the belt slightly with the balance, loosen the screws and apply approx. 3.5 kg (35 N), max. 4.5 kg. Tighten the screws.
5. Turn the crankshaft for several turns to let the toothed belt find its running track.

6. If the belt tension has slackened, repeat the tensioning procedure. Check the belt tension according the figure below.

7. Adjust and bend locking plates.

8. Tighten all screws and lock them.

It is important to re-check tension after several engine revs. It will mostly become a bit slack as consequence of alignment on the wheels.

Visual check for belt tension see sketch: Belt teeth in TDC and BDC of wheel must rest in ground.
They are separated from the crankshaft by a special coupling. They create an exact digital signal of the actual crankshaft position (0….360°) The CA sensors have a resolution of 0.1°

The spring loaded coupling absorbs all longitudinal and axial movement of the crankshaft. It drives a shaft which is supported by two ball bearings. The bearings are oil lubricated. From the shaft a toothed belt drives each sensor.

Shielded BUS cables transmit the signals to the WECS-9520 control.

CA-Sensor, complete with holder and cable.

The two red lines must be in line when cylinder 1 is in TDC.
The most important tools for trouble shooting on flex problems are:

- **Control Diagram**
- **Alarm-log**, indications of actual values
- **Wiring diagrams** of WECS-9520 (E87, E85, E90, E95, E94, E96, etc.)

With flexView trend lines can be used to find out if a value is unstable. The journal of the flexView shows directly the cause of the alarm.
Combination of Alarms

- Some situations create not one but a series of alarms. Since this can be confusing, the first one that came up is probably the root cause.

- Logical sense may still be required to pinpoint the exact source of trouble. The current situation has to be analyzed. Has somebody done some work on the engine or the auxiliaries? Switched on or off some equipment?
Replacing parts

- It is NOT recommended just to replace parts with unclear status with new ones (used but probably OK). Try to find out the status by e.g.
  - exchanging an FCM-20 module with one from an other cylinder
  - exchanging a rail valve with one from an other cylinder

- Exchanging components with one from an other cylinders makes it very clear if a component is faulty or not. But check first that else is controlled by these components.
Sensor fail alarms that go on and off

- Power supply to sensor and the cable connections to be checked
- Faulty sensors to be changed at next opportunity.
- If a faulty sensor cannot be changed immediately, it is better to disconnect it, otherwise it might disturb the function of the control system.

The following sensors can be disconnected:

- fuel quantity sensors
- exhaust valve stroke sensors
- rail pressure transmitters
- crank angle sensor (the other one has to be operational !)
Bosch-Rexroth servo oil pump controller card LED indication:

**Inputs:**
- DI1 Shows engine running direction (lit when astern)
- DI2 Unused
- DI3 Unused
- DI4 Unused
- DI5 Unused
- DI6 Enable (should always be lit)
- DI7 Unused
- DI8 Unused

**Outputs:**
- DO1 Swivel angle control is active
- DO2 Pressure control is active. Should be active when engine is running
- DO3 Power control active
- DO4 Unused
- DO5 No external fault (e.g. cable break detected somewhere). Lit when no fault (low active)
- DO6 Lit when pressure is greater than 10 bar
- DO7 Lit when Swivel angle is greater than 10%
Control oil pumps

- RT-flex96C-B with Bosch pumps only:
  The software that controls these pumps makes them run BOTH when engine is stopped. If required, they can be stopped in port by switching off the main breakers.

- Engines with Dynex pumps:
  Only one control oil pump runs in port.

Do **NOT forget** to switch them on again when on stand-by.
Adjusting the fuel linkage:

- The stop screws on the brackets shall only prevent the lever / shaft to strike the actuators mechanical end-stops. They shall not stop the actuator in its electrical travel range!

- With actuators switched off, mount the levers on the serrated shafts such that you will have approx. the same clearance at both ends. Then adjust and lock stop bolts so that they barely touch the levers in the mechanical end position.

- Install the connecting rods between lever and fuel rack linkage. Adjust the rod length so that the min. and max. position of the fuel pump racks can be reached with approx. same distance left between actuator lever and the stop bolts on min and on max side. This gives you a proper distribution of actuator- and fuel rack stroke. Single pumps can be fine-adjusted for equal stroke on the fork-levers, if it is required.

- Power on the actuator and use the emergency stop button for further testing. Bring engine into no-shutdown condition (Fuel press. = 0 bar, actuators go to max. position 100%). For changing actuator position to 0% press emergency stop button.

- Check that linkage positions with the above mentioned outputs at 0% and 100% set the rack to the proper output and do not cause actuator faults or touching any stop bolts.

**Warning:**
Never switch on the el. power to the Woodward actuators, if the linkage is disconnected. Severe risk of injury and actuator damage!
Internal hard stops allow 75° travel!
Electrical stops (BIAS) at 3° and 73°
Effective travel = 70°
External hard stops at ~0.5° and ~74.5°
Inertia = 19 for size IV; 15 for size I
At 0% position demand, pump rack must be in zero position with little (~1mm) clearance!
Adjust connecting rod length accordingly!
Rail Valve

Since rail valves are very sensitive to dirt, the contact surface MUST NEVER be wiped off!

- They have to be mounted that the nameplate is not upside down.
- The plugs are coded and do not fit to the wrong socket.
Level switches

- Horizontally installed level switches of “tuning fork” type have to have the oscillating blades in vertical position.
Parts which need regular inspection, overhaul or have to be exchanged (1):

- **Fuel pumps**: plunger
  - **Exchange**

- **Fuel pumps regulating rack**: bearings
  - **Exchange**

- **Servo oil pumps**: roller bearings, plungers, regulating valve, sealing
  - **Overhaul**

- **Control oil pumps**: plunger units
  - **Exchange**

- **Camshaft**: cam surface and fuel pump rollers
  - **Inspection & Overhaul**

- **Automatic filter
  - **Overhaul**

- **Fuel pressure regulating valve, shutdown valve
  - **Overhaul**
Parts which need regular inspection, overhaul or have to be exchanged (2):

- **Injection control unit**: inspection and overhaul  
  - **Overhaul** *)

- **Hydraulic hoses**  
  - **Inspection & exchange**

- **Crank angle sensor and drive**: belts, shaft sealing, sensor  
  - **Inspection**

- **FCM-20 modules**  
  - **Exchange**

*) To be done by Wärtsilä Switzerland or authorized workshop only!

Wärtsilä has established an exchange based service for complete ICU’s, in case an ICU is considered to be malfunctioning or damaged, or if it is time for an regular overhaul (~24’000 - 36’000 running hrs).
ICU, VCU and FCM-20 MUST NOT be opened by non-authorized persons!! Any warranty would be void! Overhaul of ICU and VCU requires special tools and must be carried to at Wärtsilä Switzerland or authorized repairers only.

Servo oil pumps (Bosch or Dynex) can partly be opened, following the respective makers' instructions.

It is strongly recommended to leave such overhaul works to shore workshops where absolutely clean conditions are given.
FCM-20 Electronic Modules:

- FCM-20 modules can not be repaired but exchanged very easily.
- Reduce engine power to below slowdown level, switch off power supply to the concerned unit (a slow-down will be initiated), remove all attached plugs, unscrew the retaining bolts and remove the module.
- Don not bend the cables more than necessary, do not disconnect cables from their plugs.
- The FCM-20 installed in E90 as “Online-Spare” can be installed in any E95 box to replace a faulty FCM-20.
- Note: Make sure that ALL FCM-20’s in the store have the same software version loaded as the ones used on the engine.
FCM-20 electronic modules

- Switching off two neighbour modules #[1 & 2] or #[3 & 4] or #[last and 2nd last] at the same time is not allowed with running engine!

- If necessary (no spares), exchange modules between cylinder units to have at least one of these paired FCM groups working.

- Also do not switch off more than one cylinder unit at the time of those that control servo oil pumps (FCM #3 thru 5 or up to #8, depending on number of pumps) when engine is running.

- Fitting in a new one goes visa-versa. After switching the power back on, the cylinder unit will start working after a few seconds.
Sensors:

- Crank angle, rail pressure PT, injection quantity piston, exhaust valve position, etc. can be exchanged easily.
Wiring:

- **Loose or broken cables** can stop a cylinder or simply cause a sensor-alarm.
- Defects on the wiring cannot be detected easily and the following points have to be observed:
  - Wires have to be laid in a cable duct, secured with cable retainers to avoid faults by vibrations
  - Wires must not be criss-crossed but running in parallel, not scouring on other elements
- Regularly check and retighten terminals in all boxes
- For wirings marked as shielded in the diagrams, shielded cable **MUST** be used. The shield must be connected to the mass only on the end defined in the diagram
- For data transmission, special shielded Bus-cables must be used
- “L” (low-power/sensitive) and “H” (high-power) **wires** have to kept separate and always guided separately to avoid signal interferences.
Bus cabling:

- Check regularly all terminal bars for loose connections.
- In general only class approved, shielded cables must be used.
- For any of the bus systems, only special $120\,\Omega$ bus cables must be used! (Bus- or Data cables with $110\,\Omega$ to $130\,\Omega$)
- At each end of a bus cable there **MUST** be a terminator resistor of $120\,\Omega$!
- Bus cables **MUST NEVER** be connected as “star-connection” (parallel) but only in serial! Not even for an emergency repair!
Mostly malfunctions appear because of wrong or missing signals from or to the control system, caused by:

- loose cable connections, sensor targets or links
- badly crimped cable-end sockets
- clogged inlet ports at pressure-sensors, transmitters and switches
- sensor exposed to excessive vibrations, heat, dirt, moisture or abnormal wear
- earth faults
- short circuits
- broken wires
- noisy signals (EMC)
- wrong sensor type
- wrong parameters or scaling of sensors
- false connections
- low power supply
The screen is separated in two pages, which can be selected individually, for convenient access and monitoring of failures, indications, engine processes and parameters. For safety reasons, access to parameters on the ADJUST page is locked with a password to allow changes for authorized persons.

In the following there are some examples, how to use the flexView Trends for troubleshooting:
These pages indicate all related data for the energizing times (On-Time) of the rail valves, the feedback currents for the end trigger measured values (open close inject / return) and the measured deadtimes between injection/exhaust commands and start of real executions.
**flexView** User & Adjust pages

- The user page allows to set FQS, select VIT and Heavy Sea Modes, Common start valve test modes and to switch off the injection on single cylinders.

- Further Injection venting and exhaust valve manual test commands can be selected.

- The Adjust page allows to change miscellaneous parameters, to artificially optimize injection timing for ICUs with disconnected FQ sensors and it allows the user to modify the injection timing and the exhaust valve closing within a certain range for balancing the cylinder loads.
**flexView** Using Trends for troubleshooting

In the following there are some examples, how to use the flexView Trends for troubleshooting:

- **Crank angle sensor check:**
  - For evaluation of the crank angle sensors you can simply open the CA Sensor trend from the View menu and run the *TrendView* together with the turning gear.
  - While both sensor curves are matching above each other, any drop-outs of a sensor are visible on the screen.
  - To see both curves, add an offset to one of the signals to shift its curve below or above the first.
**flexView**  Using Trends for troubleshooting

Injection quantity feedback signals:

- Some of the injection curve data can as well be evaluated from the indications on the Inject page:

- But for certain error conditions the fast trend of the injection curve is necessary for determining the malfunction:
If a disturbed feedback signal is within the range of 4-20 mA, the WECS can not recognize the erratic signal condition. For such a failure the Injection Curve in the Service menu is used for investigating the signal shape and to determine, if the sensor is working correctly:

- A normal signal has got a clear curve shape and no spikes or interference.
- Spikes in the signal shape would mean accelerations of the piston that are impossible, clear proof for a Sensor failure.

Here 2 examples for disturbed faulty exhaust valve curves:
## External WECS Failures

<table>
<thead>
<tr>
<th>Indication on AMS system</th>
<th>Countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td>WECS Power Supply Failure</td>
<td>Check all breakers in the E85 box. With Bosch pumps, check additionally breakers in E87 box. Else check breakers in ESB /MSB on the 220(110) VAC supplies. If breakers can’t be reset, check for short circuits in the 24VDC output systems, by isolating separately.</td>
</tr>
<tr>
<td>Servo Oil Pump #n Flow Dynex pumps only</td>
<td>Check the plugs on the IFM flow sensor and on the compensator of the Dynex solenoid for loose cables /damage. Check/adjust pump output if required. Alarm must not be active below ~30% engine load or corresponding speed, else settings in AMS are wrong.</td>
</tr>
<tr>
<td>Common Rail General Leakage Drive end LS3444A Free end LS3445A</td>
<td>Carefully open RU cover to check source of leakage. WARNING: High pressure fuel- or oil leaks can be dangerous and injure eyes and skin. Wear safety equipment! If no leakage traceable: Check the limit switch for proper wiring /power supply. Remove sensor from measurement drum and make sure sensor ends /drum are free from dirt or obstruction. Trace heating working?</td>
</tr>
<tr>
<td>Fuel Pipe Leakage Alarms: Drive end LS3446A Free end LS3447A</td>
<td>Check the separate leakage pipes on the cyl. covers and from the ICUs of the respective rail. Evaluate co alarms (inj. timing etc) for troubleshooting. Check the ICU for damage. Renew leaking injectors, repair leaking pipes / pipe connectors. Check limit switch / sensor drum / trace heating if no real leakage.</td>
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## External WECS Failures

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<tr>
<td>Fuel Supply Unit Leakage LS3426A</td>
<td>Carefully check on the test-valves at SU free end if source is&lt;br&gt;• Safety valve (replace valve)&lt;br&gt;• Fuel pump (repair /exch. Pump)&lt;br&gt;• Rising pipes to RU (lap pipe seats or exchange)&lt;br&gt;• Fuel regulating valve (adjust/exchange valve)&lt;br&gt;<strong>WARNING:</strong> High pressure fuel- or oil leaks can be dangerous and injure eyes and skin. Wear safety equipment!&lt;br&gt;If no leakage traceable: Check the limit switch for proper wiring /power supply. Remove sensor from measurement drum and make sure sensor ends /drum are free from dirt or obstruction. Trace heating working?</td>
</tr>
<tr>
<td>Servo Oil Supply Unit Leakage LS2055A</td>
<td>Carefully open the cover for the s/o pumps to trace the cause.&lt;br&gt;<strong>WARNING:</strong> With HP/LP pipe cracks the amount of leak-oil is immense with running engine. If possible, stop engine before access. Exchange / repair damaged parts.&lt;br&gt;If no leakage traceable: Check the limit switch for proper wiring /power supply. Remove sensor from measurement drum and make sure sensor ends /drum are free from dirt or obstruction.</td>
</tr>
<tr>
<td>Control Oil Supply Unit Leakage RT-flex 84T/96 only LS2058A</td>
<td>Carefully open the cover for the c/o pumps to trace the cause.&lt;br&gt;<strong>WARNING:</strong> High pressure oil leaks can be dangerous and injure eyes and skin. Wear safety equipment or stop engine/motor drives. Exchange / repair damaged parts or tighten union joints.&lt;br&gt;If no leakage traceable: Check the limit switch for proper wiring /power supply. Make sure sensor end is free from dirt.</td>
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## External WECS Failures

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<tr>
<td>Fuel Pump Outlet Temp Monitoring</td>
<td>If separate pump outlet pipe is too cold with HFO operation, pump might be damaged. Carefully check fuel pumps on SU for noise, wear, etc. If in doubt stop the engine and check the running gear visually to make sure roller guides and housings are not damaged. CAUTION: Neglecting the fault might end up in major cam damage! Exchange damaged pump or lift up roller guide before restarting. Refer to instruction manuals. Alarm can also appear if limits in AMS don’t fit to current fuel condition. Might need to be adopted for current bunker fuel. Insulate the outlet pipes to prevent E/R fans from cooling them. Sensor on pipe might be damaged.</td>
</tr>
<tr>
<td>TE3431A - TE3438A</td>
<td></td>
</tr>
<tr>
<td>Fuel Pump Actuator Failure</td>
<td>Check actuator power supply and safety diodes in E85 box terminals. Make sure actuator lever can move freely and is not limited in the output stroke by setscrews or else. Analog setpoint from FCM available? Alarm appears if corresp. FCM is switched off. Check LED code below actuator cover for fault reason, refer to Woodward manual for details. Exchange actuator if required. New actuators need to have correct configuration / parameters for proper operation.</td>
</tr>
<tr>
<td>A1 XS5046A</td>
<td></td>
</tr>
<tr>
<td>A2/AB XS5048A</td>
<td></td>
</tr>
<tr>
<td>B1 XS5047A</td>
<td></td>
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<tr>
<td>B2 XS5049A</td>
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### Alarm Card Indication

<table>
<thead>
<tr>
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<th>Countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge Air pressure 1(2), meas. fail. FCM 3(4) Al2 ✶ 1x FCM 3(4) Al2 (on): short circuit</td>
<td>Check charge air transmitter 1, (transmitter 2) Voltage supply 24V available on plug? FCM-20 #3 (4) switched off? Check cabling to E95.03 (04) In case of short circuit, check cables with multimeter against each other and against ground, exchange cables if required. Disconnect plug X27 from FCM3(4). If red LED remains on, exchange FCM module.</td>
</tr>
<tr>
<td>Servo Oil Pressure, Sensor 1(2), Meas. Fail. FCM 1(2) Al2 ✶ 1x FCM 1(2) Al2 (on): short circuit</td>
<td>Check respective signals on operator interface. Check servo oil p- transmitter 1(2) in RU: Voltage supply 24V available on plug? FCM-20 #1 (2) switched off? Check cabling to E95.01 (02) In case of short circuit, check cables with multimeter against each other and against ground, exchange cables if required. Disconnect plug X27 from FCM1(2). If red LED remains on, exchange FCM module.</td>
</tr>
<tr>
<td>Fuel Rail pressure, sensor 1(2), Meas. Fail. FCM 3(4) Al1 ✶ 1x FCM 3(4) Al2 (on): short circuit</td>
<td>Check respective signals. Check fuel p- transmitter 1 (transmitter 2) in RU: Voltage supply 24V available on plug? FCM-20 #3 (4) switched off? Check cabling to E95.03 (04) In case of short circuit, check cables with multimeter against each other and against ground, exchange cables if required. Disconnect plug X25 from FCM3(4). If red LED remains on, exchange FCM module.</td>
</tr>
</tbody>
</table>
### Passive Failures

#### Alarm Card Indication

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
<th>Countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exh. Valve # n Position Meas. Fail.</strong>&lt;br&gt;FCM n ExD / ExF * 1x&lt;br&gt;FCM n ExD / ExF (on) : short circuit</td>
<td>Check plug on cyl. cover box, sensor cabling and power supply. Change sensor if necessary. If failure appears intermittent, faulty sensor can provisionally be disconnected in cyl. cover box, until repair is possible. In case of short circuit, check cables with multimeter against each other and against ground, exchange cables or sensor if required. Disconnect plug X24 from FCM#(n). If red LED remains on, exchange FCM module.</td>
</tr>
<tr>
<td><strong>Any FCM-20 Module, Cyl. Identification lost</strong>&lt;br&gt;FCM n ID (on)</td>
<td>Cylinder remains in operation, but after any new restarting (powering up) of the FCM-20 module the cylinder is cut-off. Check address wiring in corresponding E95 box on plug X25.</td>
</tr>
<tr>
<td><strong>Start Pilot valve #n loop fail.</strong>&lt;br&gt;FCM n Start V/v (on)</td>
<td>Check plugs on interconnection at cylinder cover and on solenoid valve. Replace solenoid valve if necessary Check cabling for short circuits or interruptions. If both solenoid and cabling are 100% ok, exchange FCM module.</td>
</tr>
<tr>
<td><strong>MODBUS FCM #n Failure</strong>&lt;br&gt;FCM 1-4 ModBus (dark)</td>
<td>If MODBUS LED is not blinking, check plug X23 and connections in SIB E90 for proper wire connections and terminating resistors. Check other end of MODBUS (Propulsion Control, Alarm Monitoring System) for failures, power supply, bus connection etc. Replace module if failure only on one module.</td>
</tr>
</tbody>
</table>
## Passive Failures

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
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</tr>
</thead>
</table>
| Module FCM #00 Fail    | Check plugs X22 and X23 for proper wire connections. Can appear if operator flexView SW is connected and fails to read all data (e.g. too many trends running). Try cycling the el. power supply to module.  
If required, replace online spare module. |
| FCM 0 Fail            |                 |
| CAN M (Module-) Bus #n Fail. | Check plug X22 for proper wire connections and terminating resistors. Check wiring and unit on other end of CAN M-bus (Propulsion Control, Manual Control Panel, Bosch pumps) for failures, power supply, bus connection etc. Can appear on FCM #03, if operator flexView SW is connected and fails to read all data (e.g. too many trends running). |
| FCM n CAN M           |                 |
| CAN S (System-) Bus Fail, FCM #n | Check plugs X22 and X23 for proper wire connections.  
Replace module if failure only on one module.  
If more modules show this failure, check the CAN S-Bus wiring in all E95 boxes and terminating resistors. |
| FCM n CAN S1/2        |                 |
| Crank Angle #1(2) Failure | Active, if crank angle sensor is failing or FCM-20 # (last and last-1) are switched off.  
If failure appears on all active modules, check CA-sensor 1(2) and replace if necessary.  
Else check SSI-bus terminating resistors on X22 /23 in E95.01.  
If failure on single modules, check plugs X22 and X23 for proper wire connections. Replace module if required.  
If on a successive group of FCMs: Check SSI bus wiring from highest failing cyl. number to next higher cylinder without alarm. |
| FCM n SSI CA1/2       |                 |
### Special Passive Failure Combinations

<table>
<thead>
<tr>
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<th>Countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td>WECS CAN/SSI BUS Conn. FAIL #n</td>
<td></td>
</tr>
<tr>
<td>FCM n CAN S1 🟢</td>
<td></td>
</tr>
<tr>
<td>FCM n SSI CA1 🟢</td>
<td></td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>FCM n CAN S2 🟢</td>
<td></td>
</tr>
<tr>
<td>FCM n SSI CA2 🟢</td>
<td></td>
</tr>
<tr>
<td><strong>Plug X22 or X23 are disconnected on affected FCM.</strong></td>
<td></td>
</tr>
<tr>
<td>Crank Angle #1(2) Supply Failure</td>
<td></td>
</tr>
<tr>
<td>FCM #(all) CA PF CA1 🟢</td>
<td></td>
</tr>
<tr>
<td>FCM-20 # (last-1) BinOut 🟢</td>
<td></td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>FCM #(all) CA PF CA2 🟢</td>
<td></td>
</tr>
<tr>
<td>FCM-20 # (last) BinOut 🟢</td>
<td></td>
</tr>
</tbody>
</table>
| **Short circuit on CA sensor power supply. Disconnect affected sensor from E96. If fault recovers, exchange CA sensor, else check power supply cabling and sockets in E96 box.**  
**Check cables between E96 and last / last-1 FCM for short circuits.**  
**Disconnect plug X26 from affected FCM#(last/last-1).**  
**If red Bin Out LED remains on, exchange FCM module.** |
### Common Failures

#### Alarm Card Indication

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
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</tr>
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<tbody>
<tr>
<td>Charge Air pressure 1&amp;2, Meas. Fail</td>
<td>Check charge air transmitter 1 and 2, Voltage supply 24V available on plug? Check wiring in E12 junction box. Check cabling on X27 and “Analog In” LEDs on FCM-20 #3 and 4.</td>
</tr>
<tr>
<td>FCM 3+4 Al2 1x</td>
<td></td>
</tr>
<tr>
<td>Charge Air pressure, Meas. Fail diff hi</td>
<td>Compare both charge air pressure indications with charge air gauge pressure indication to determine erratic sensor. Check wiring in E12 junction box. Check cabling on X27 and “Analog In” LEDs on FCM-20 #3 and 4. Replace or rescale sensor if necessary.</td>
</tr>
<tr>
<td>FCM 3+4 Al2 2x</td>
<td></td>
</tr>
<tr>
<td>Control Oil Pressure, Meas. Fail</td>
<td>Check wiring on FCM-20 #5, X25 plug and on sensor in rail unit. Sensor or sensor cable defective? In case of short circuit, check cables with multimeter against each other and against ground, exchange cables if required. Disconnect plug X25 from FCM #5. If red LED remains on, exchange FCM module.</td>
</tr>
<tr>
<td>FCM 5 Al1 1x</td>
<td></td>
</tr>
<tr>
<td>FCM 5 Al1 (on) : short circuit</td>
<td></td>
</tr>
<tr>
<td>Control Oil Pressure Low</td>
<td>At least 1 pump running? (2nd should start in case of low pressure) Main oil supply and pressure after automatic filter OK? Leakage or shut-off cock for oil drain open? Retaining valves 3.73 properly adjusted? El. power to pump drives ok?</td>
</tr>
<tr>
<td>FCM 5 Al1 4x</td>
<td></td>
</tr>
<tr>
<td>Alarm Card Indication</td>
<td>Countermeasures</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Control oil pump 1(2), fail.</td>
<td>Check on main switchboard: Breaker on? Overload trip? Current sensing relays in starter box ok (Bosch Pump only)? Is pump hot? Check cables from ctrl. oil pump starter box to E90 SIB and FCM-20 #3 (4) X15. If pumps are running but no pressure, check control oil block and components, see co-alarms.</td>
</tr>
<tr>
<td>FCM 3(4) Bin Out * 1x</td>
<td></td>
</tr>
<tr>
<td>FCM 3(4) Bin Out ○ (on)</td>
<td>In case of short circuit, check cables with multimeter against each other and against ground, exchange cables if required. Disconnect plug X15 from FCM3(4). If red LED remains on, exchange FCM module.</td>
</tr>
<tr>
<td>Servo Oil press. 1+2 Meas. Fail</td>
<td>Check servo-oil rail pressure transmitter 1 and 2, Check cabling on X27 and “Analog In” LEDs on FCM-20 #1 and 2. Voltage supply 24V available on plugs?</td>
</tr>
<tr>
<td>FCM 1+2 Al2 * 1x</td>
<td></td>
</tr>
<tr>
<td>Servo Oil pressure, meas. Fail. Diff. hi</td>
<td>Compare both servo-oil rail pressure indications, if possible change engine load through a wider range and verify which sensor does not follow up linearly to the changing servo oil pressure. Check cabling on X27 and “Analog In” LEDs on FCM-20 #1 and 2. Replace sensor if necessary.</td>
</tr>
<tr>
<td>FCM 1+2 Al2 * 2x</td>
<td></td>
</tr>
</tbody>
</table>
## RT-flex, Operation and Service

### Common Failures

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Servo Oil Pressure hi</strong>&lt;br&gt;FCM 1+2 AI2 ⋆ 3x</td>
<td>DYNEX pump: Controller valve on pump not adjusted (after overhaul). Wrong Parameters set in flexView software. BOSCH pumps: Check electronic controller card indications for troubleshooting.</td>
</tr>
<tr>
<td><strong>Servo Oil Pressure lo</strong>&lt;br&gt;FCM 1+2 AI2 ⋆ 4x</td>
<td>Oil pressure after automatic filter OK? Control signal and cables to DYNEX / Bosch pumps OK? Check BOSCH controller card indications for troubleshooting. Safety valve 4.23 open? Ctrl oil supply to Bosch pumps OK? Drain from collector block 4.72 open or inlet valves for servo oil rail closed? Can appear shortly during engine start, if more than one pump / control fails or switched off. Can also indicate severe failure in hydr. exhaust control parts. If a servo oil pump is much cooler than the others while engine is running, carrier sleeve on drive shaft is broken.</td>
</tr>
<tr>
<td><strong>Servo Oil pump #n, No flow</strong>&lt;br&gt;FCM 3,4…8 PWM ⋆ 2x</td>
<td>Pipe crack? Flow sensor failing (Dynex pumps only) Check local swash plate indication (Bosch Rexroth only) Refer also to co-alarms for troubleshooting(e.g. servo oil pressure low).</td>
</tr>
</tbody>
</table>
# RT-flex, Operation and Service

## Common Failures

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Servo Oil pump #n, Failure</strong></td>
<td>DYNEX: Check cabling between pumps and E95. Check plug connection on solenoid. Exchange press. Ctrl. v/v if necessary. BOSCH: Check indication on corresponding controller card Power Supply 24Vdc ok? Any of FCM-20 #3 - #8, CAN M-Bus failing or switched off? Check pump feedback signals and proportional valve. Analyze LED indications on card. If required, exchange Bosch card with neighbour card to determine, if card is defective.</td>
</tr>
<tr>
<td><strong>FCM 3,4…8 PWM ✶ 1x</strong></td>
<td></td>
</tr>
</tbody>
</table>

| **Injection Quantity #n, Meas. Fail** | Check feedback of quantity sensor, check plug for tight fit. Make sure measuring sleeve is properly mounted on fuel quantity piston. Check plug/cabling between E95 and injection quantity sensor for earth faults, if “InQ” LED on corresponding FCM-20 shows red failure indication. Replace sensor or disconnect plug temporarily, if feedback is instable and no spares available. |
| **FCM n InjQ ✶ 1x** | |
| **FCM n InjQ ✦ (on): Short circuit** | |

| **Inj. #n timing fail.** | Injection time on cylinder deviates from other cylinders. Cracked, seized or stuck injection nozzles? Injector pipe leakage? (co-alarm inj. pipe leakage?) Too low opening pressure of injector valve? Rail valve failure (see on times for inject valves) Time too long can be caused by seized ICU. |
| **FCM n InjQ ✶ 5x (time too short)** | |
| **FCM n InjQ ✶ 6x (time too long)** | |
# Common Failures

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Fuel Rail Pressure 1+2, Meas fail FCM 3+4 Al1 ⚫ 1x</td>
<td>Check fuel rail pressure transmitter 1 and 2, Check cabling on X25 and “Analog In” LEDs on FCM-20 #3 and 4. Voltage supply 24V available on plugs?</td>
</tr>
<tr>
<td>Fuel Rail Pressure, Meas. Fail diff Hi FCM 3+4 Al1 ⚫ 2x</td>
<td>Compare both fuel rail pressure indications, if possible change engine load to range, where fuel rail pressure varies with load (e.g. 15-20% or 70-80%) and verify which sensor does not follow up linearly. Check cabling on X25 and “Analog In” LEDs on FCM-20 #3 and 4. Replace sensor if necessary.</td>
</tr>
<tr>
<td>Fuel Rail pressure Hi FCM 3+4 Al1 ⚫ 3x</td>
<td>Check fuel pressure regulating linkage for free movement. Check if fuel pressure actuators (Woodward) are switched on and working. Check for fuel actuator alarms in alarm monitoring system. Can appear during short nervous manoeuvring, if engine is repeatedly started and stopped without having any fuel release in between. If alarms come up every time the engine speed is reduced, check that all fuel pump racks are in no-delivery position, when actuator output is 0%. Adjust fuel rack if necessary.</td>
</tr>
</tbody>
</table>
## Alarm Card Indication and Countermeasures

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
<th>Countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Rail pressure lo</td>
<td>Check fuel pressure regulating linkage for free movement. Check if fuel pressure actuators (Woodward) are switched on and working. Check for fuel actuator alarms in alarm monitoring system. Is fuel supply pressure ok (7-10 bar)? Is there a leakage alarm pending? Em. regulating valve releases fuel (= bearing oil supply to valve not ok or valve seat seized)? Temp monitoring alarm from fuel pump? Check non return valves in intermediate accumulator and fuel pumps Check safety valves in supply unit or rail unit (size0 &amp;1)</td>
</tr>
<tr>
<td>FCM 3+4 Al1 4x</td>
<td>Drive belt shifted or slack? When flywheel is at TDC#1, both sensors must show 0°CA. Adjust sensor offset parameter or belt position, if required. If only on one cylinder: Check SSI bus wiring on FCM-20 plugs X22 and X23. Replace FCM-20, if necessary;</td>
</tr>
</tbody>
</table>
### Alarm Card Indication

| TDC signal, fail | Check TDC-Pickup for correct cabling and correct distance to flywheel tooth. Measure voltage supply and signal. Replace sensor if necessary. Check wiring in E95.05 on X27 and LED indication on FCM-20 #5. In case of short circuit, check cables with multimeter against each other and against ground, exchange cables or sensor if required. Disconnect plug X27 from FCM5. If red LED remains on, exchange FCM module. |
| FCM 5 BI1 * 1x | |
| FCM 5 BI1 (on): Short circuit | |

| Crank Angle, TDC lo shift | CA sensor belts shifted? TDC offset wrongly adjusted? Intermittent TDC sensor fault? |
| FCM 5 BI1 * 2x CA1 lo shift | |
| FCM 5 BI1 * 4x CA2 lo shift | |

| Crank Angle, TDC hi shift | CA sensor belts shifted? TDC offset wrongly adjusted? Intermittent TDC sensor fault? |
| FCM 5 BI1 * 3x CA1 hi shift | |
| FCM 5 BI1 * 5x CA2 hi shift | |
## Cylinder Failures

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<thead>
<tr>
<th>Alarm Card Indication</th>
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<tbody>
<tr>
<td>Exh valve #n fail.</td>
<td>Exhaust rail valve failure (on time &gt;3 ms)? If on all cylinders: Air spring pressure too high? Check non-return valve of bearing oil supply to actuator pipe =&gt;(RT-flex96C, old design 60C, 58T-B only) Check if orifice in VCU is choked. =&gt;(not with RT-flex96C or old design 60C, 58T-B) Mechanical failure of exh. v/v / -drive or partition device?</td>
</tr>
<tr>
<td>FCM n ExD * 2x Late / not opening</td>
<td></td>
</tr>
<tr>
<td>Exh valve #n fail.</td>
<td>If on all cylinders: Air spring pressure too high? Check non-return valve of bearing oil supply to actuator pipe =&gt;(RT-flex96C, old design 60C, 58T-B only) Check if orifice in VCU is choked. =&gt;(not with RT-flex96C or old design 60C, 58T-B) Mechanical failure of exh. v/v / -drive or partition device?</td>
</tr>
<tr>
<td>FCM n ExD * 3x Early closing</td>
<td></td>
</tr>
<tr>
<td>Exh valve #n fail.</td>
<td>Exhaust rail valve failure (on time &gt;3 ms)? Air spring pressure too low? Check non-return valve in air spring supply pipe. Mechanical failure of exh. v/v / -drive or partition device?</td>
</tr>
<tr>
<td>FCM n ExD * 4x Late / not closing</td>
<td></td>
</tr>
<tr>
<td>Exh valve #n fail.</td>
<td>Air spring pressure too low? Check non-return valve in air spring supply pipe. Exhaust valve drive seized or valve stem fretting on guide bush !</td>
</tr>
<tr>
<td>FCM n ExD * 5x Clos. deadtime too long</td>
<td></td>
</tr>
</tbody>
</table>
## Cylinder Failures

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
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</thead>
<tbody>
<tr>
<td>Injection qty piston #n fail</td>
<td>Rail valve failure (return on time &gt;3 ms)? Check feedback of quantity sensor, check plug for tight fit. Make sure measuring sleeve is properly mounted on inj. qty piston. Replace sensor or disconnect plug temporarily, if feedback is instable and no spares available. Fuel viscosity too high? Steam trace heating off? If not recovering: Try short manual opening of fuel SHD-valve with red solenoid lever. Can hint on seized quantity piston, ICU needs to be replaced.</td>
</tr>
<tr>
<td>FCM n InjQ 2x Late / no return</td>
<td></td>
</tr>
<tr>
<td>Injection qty piston #n fail</td>
<td>Rail valve failure (inject on time &gt;3 ms)? Check feedback of quantity sensor, check plug for tight fit. Make sure measuring sleeve is properly mounted on inj. qty piston. Replace sensor or disconnect plug temporarily, if feedback is instable and no spares available. Fuel viscosity too high? Steam trace heating off? Can hint on seized quantity piston, ICU needs to be replaced.</td>
</tr>
<tr>
<td>FCM n InjQ 3x No movement</td>
<td></td>
</tr>
<tr>
<td>Injection qty piston #n fail</td>
<td>Rail valve failure (retrun on time &gt;3 ms)? Check feedback of quantity sensor, check plug for tight fit. Make sure measuring sleeve is properly mounted on inj. qty piston. Replace sensor or disconnect plug temporarily, if feedback is instable and no spares available. Fuel viscosity too high? Steam trace heating off? Can hint on seized quantity piston, ICU needs to be replaced.</td>
</tr>
<tr>
<td>FCM n InjQ 4x Stuck in max. position</td>
<td></td>
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<th>Alarm Card Indication</th>
<th>Countermeasures</th>
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</thead>
<tbody>
<tr>
<td>Module FCM #n Fail.</td>
<td>Check CAN S Bus LEDs on module. If red indication, check plugs X22 and X23 for proper wire connections. Replace module if module doesn’t recover after power cycling.</td>
</tr>
<tr>
<td>FCM n Fail (on)</td>
<td></td>
</tr>
<tr>
<td>Injection #n Cut-off No LED code</td>
<td>Manual (user-) cut-off or automatic cut-off indication Refer to co-alarms in case of automatic cut-off.</td>
</tr>
<tr>
<td>Both Crank Angle Sensors, TDC lo shift</td>
<td>TDC offset wrongly adjusted? Intermittent TDC sensor fault? CA sensor drive damaged? CA Sensor belts both shifted? Possibility of shifted crankshaft?</td>
</tr>
<tr>
<td>FCM 5 BI1 2x CA1 lo shift</td>
<td></td>
</tr>
<tr>
<td>FCM 5 BI1 4x CA2 lo shift</td>
<td></td>
</tr>
</tbody>
</table>
## Rail Pressure Failures

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<tr>
<th>Alarm Card Indication</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Control Oil Pressure Very Low</td>
<td>At least 1 pump running? (2nd should start in case of low pressure) Main oil supply and pressure after automatic filter OK? Leakage or shut-off cock for oil drain open? El. power to pump drives ok?</td>
</tr>
<tr>
<td>FCM 5 Al1 5x</td>
<td></td>
</tr>
<tr>
<td>Servo Oil Pressure Very Low</td>
<td>Oil pressure after automatic filter OK? Control signal and cables to DYNEX / Bosch pumps OK? Check BOSCH controller card indications for troubleshooting. Leakages on servo oil double wall rising pipes SU =&gt; RU? Safety valve 4.23 open? Ctrl oil supply to Bosch pumps OK? Drain from collector block open or inlet valves for servo oil rail closed? Can appear shortly during engine start, if more than one pump / control fails or switched off. Can also indicate severe failure in hydr. exhaust control parts. If a servo oil pump is much cooler than the others while engine is running, carrier sleeve on drive shaft is broken.</td>
</tr>
<tr>
<td>FCM 1+2 Al2 5x</td>
<td></td>
</tr>
<tr>
<td>Fuel Rail Pressure Very Low</td>
<td>Check fuel pressure regulating linkage for free movement. Fuel pressure actuators (Woodward) are switched on and working? Check for fuel actuator alarms in alarm monitoring system. Is fuel supply pressure ok (7-10bar)? Is there a leakage alarm pending? Regulating valve 3.06 releases fuel (=&gt; bearing oil supply to valve not ok, valve seat damaged)? Shut-off cocks at intermediate accumulator or rail inlet still closed after repair works?</td>
</tr>
<tr>
<td>FCM 3+4 Al1 5x</td>
<td></td>
</tr>
<tr>
<td>Charge Air Overpressure</td>
<td>Reduce M/E power; Take countermeasures according to T/C manual. Check waste gate control, if engine is equipped with waste heat recovery system.</td>
</tr>
<tr>
<td>FCM 3+4 Al2 3x</td>
<td></td>
</tr>
</tbody>
</table>
## Critical Failures

<table>
<thead>
<tr>
<th>Alarm Card Indication</th>
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</tr>
</thead>
</table>
| Crank angle / TDC Hi shift 1+2 | TDC offset wrongly adjusted?  
Intermittent TDC sensor fault?  
CA sensor drive damaged?  
CA Sensor belts both shifted?  
Possibility of shifted crankshaft? |
| FCM 5 BI1 ★ [3x + 5x] |  
Check entire CA sensor drive and E96 box for damage.  
Also active if both FCM-20 #(last) and #(last-1) are switched off  
(No clock-masters!). [Last => highest cylinder number]  
Check LED indication on FCM-20 modules.  
If failure on all FCM-20 modules:  
Check SSI-bus terminating resistors on X22 /23 in E95.01.  
If failure comes up on single modules only, check wiring on plugs X22 and X23 for proper connections. Replace module if required. |
| Crank angle 1+2, Fail. |  
FCM n SSI CA1 + CA2 ○ |  
Engine was overspeeding (more than 115% nominal RPM).  
Rough weather? => Reduce RPM;  
Check for separate alarms from TDC- or CA-sensors or FCM-20 modules.  
If alarm appears together with one of the other two critical faults (see above), this alarm is only consequence of these other faults. |