



# YANMAR 4TNV, Elec.Control.Governor (Tier III)

ENGINE TRAINING for R55-7A, R55W-7A, R80-7A R55-9, R55W-9, R60CR-9, R80CR-9

EDITOR PIETER EVERAERTS



## CONTENT

	PAGE
1] GENERAL	03
2] ELECTRONIC CONTROL SYSTEM (ECO)	06
3] INJECTION PUMP	10
4] EXHAUST GAS RECIRCULATION (EGR)	43
5] COOLANT TEMP SENSOR	45
6] ELECTRICS	47
7] ENGINE VIEW	51
8] ENGINE ERROR CODE SYSTEM	52
9] YANMAR DIAGNOSTIC TOOL	58
10] FUEL PUMP ADJUSTMENT & & REPLACEMENT	61

#### Related manuals:

TNV-ECO-manual.pdf (>Ceres : TNV-SERIES-ECM, part 1) TNV-ECO-diagnostic tool.pdf (>Ceres : TNV-SERIES-ECM, part 2) TNV-ECO-troubleshooting.pdf

TNV-INJ-mechanical.pdf TNV-service-mechanical.pdf

(>Ceres: YANMAR FUEL INJECTION) (>Ceres: YANMAR 3TNV, 4TNV)

> Hyundai Heavy Industries Europe Vossendaal 11 2440 Geel - Belgium Tel 0032 (0)14 56 22 00 Fax 0032 (0)14 56 22 65

Arranged by Pieter Everaerts Instructor HHIE Tel 0032 (0)14 56 22 44 Fax 0032 (0)14 56 22 65 (All listed engines are Yanmar "NV3-Series engines" >> Range 3000...4000cc: all direct injection)



## 1. GENERAL - SPECIFICATION

#### R55(W)-7A

R80-7A

	End	ine mode	4		4TNV	/98-E				4TNV98-Z						
	Engine	classifica	tion			V	M			VM						
1	Туре		_	Vertical,	4-cycle water	r-cooled dies	el engine			Vertical,	4-cycle wate	r-cooled diese	el engine			
2	Combustion system	חכ	_		Direct inje	ection (DI)				Direct injection (DI)						
3	No. of cylin Bore × Stro	nders - oke	n- mm×mm		4 - 98	×110	2260			4 - 98×110 <b>2250</b>						
4	Displacem	ent	l		3.3	18				3.318						
	Rated engi	ine	· -1													
	speed		min <sup>-</sup> '		2100	2200	2300	2400	2500	2000	2100	2200	2300	2400	2500	
	Output	Cont. rating	kW													
5	(Gross) *1	Rated output	kW		37.4	39.0	40.5	42.4	44.0	42.5	44.4	46.3	48.2	50.2	52.1	
	Output	Cont. rating	kW													
	(NET)	Rated output	kW		36.8	38.2	39.7	41.6	43.0	41.9	43.8	45.6	47.4	49.3	51.1	
6	Maximum i speed	idling	min <sup>-1</sup> ±25		2290	2400	2510	2590	2700	2180	2290	2400	2510	2590	2700	
7	Specific fue	əl on	g/kWh	≤224 ≤231				31	≤224 ≤231					31		
8	Exhaust ga	as temp.	°C (°F)		≤610	≤620	≤630	≤640	≤650	≤600	≤610	≤620	≤630	≤640	≤650	
9	Compressi	ion ratio	_		18	.5				18.5						
10	Diesel fuel pressure	injection	MPa (kgf/cm²)		$21.6_{0}^{+1.0}$ ( $220_{0}^{+10}$ )					$21.6_0^{+1.0}$ (220 $_0^{+10}$ )						
11	Main shaft	side	_		Flywhe	el side				Flywheel side						
12	Rotation di	rection	_	Countercl	ockwise (View	wed from flyv	vheel side)			Counterclockwise (Viewed from flywheel side)						
13	Governor		_	Electro	nic governor	All-speed g	overnor)			Electronic governor (All-peed governor)						
14	Aspiration		_		Natural a	spiration				Natural aspiration						
15	Cooling sy	stem	_	L	iquid-Cooled	With Radiat	or			Liquid-Cooled With Radiator						
16	Lubricating	j system		Forced lubr	ication with m	nulti-stage tro	ochoid pump			Forced lubr	ication with n	nulti-stage tro	choid pump			
17	Starting sy	stem	_		Electric	starting					Electric	starting				
18	Charging s	system			Alternator (1	2 VDC/40 A)					Alternator (1	2 VDC/40 A)				
19	Starting aid	device	_		Air heater (12	VDC/500 W	0				Air heater (12	2 VDC/500 W	)			
20	Engine oil pressure	Rated speed	MPa		0.34±0.05 (3.5±0.5)						0.34±0.05	5 (3.5±0.5)				
01	Oil pan	Full	l		10	0.2					10	0.2				
21	capacity	Useful	ł		4.	.5					4	.5				
22	Engine coo capacity	olant	ı		4.2 (Eng	ine only)					4.2 (Eng	ine only)				
23	Cooling far dia. × No. (	n type - of blades	mm	Made by	resin, Pushe	r, F Type - φ	410(A!)×6			Made by	resin, Pushe	r, F Type - ¢4	10(A!)×6			
24	Crank V-pu Fan V-pulk	ulley dia./ ey dia.	mm/mm		φ130 <i>/</i>	/ ¢1 <b>30</b>				φ130 / φ130						

# NV3, adapted (tier III)



Optimization of injection bore diameter→Reduce PM

Electronic control of EGR (exhaust gas recirculation) → to achieve lower NOx



**Electronic Control of Governor (ECO)** 



## 2. ELECTRONIC CONTROL SYSTEM (ECO)



PAGE - 6 -

PAGE - 7 -

YANMAR-'ECO' governor



YANMAR-'ECO' governor



PAGE

- 8 -

Eco-Governor is Yanmar's unique electronics control governor system which has been used for over 10 years mainly on agricultural machines. Yanmar has renewed this system to aplly to all equipment and named it "2G Eco-Governor" which means second generation Eco-Governor. In addition an EGR valve is controlled by this system.

PAGE

-9-



Idling speed control	After heat control	Communication function
Idling speed will be adjusted depending on cooling water temperature	Starting aid devices stay activated after start	Data logging by ECO system Connection for troubleshooting
Engine warm-up time reduced, protection at high idle & less white smoke		Possible to monitor engine performance System diagnosis incl history

# Electronically control rack by ECU

PAGE

- 10 -



3. INJECTION PUMP - RACK CONTROL



CORRECTED PIN LAY OUT FOR CR-68 (ecu main power) AND CR-67 (rack actuator) ON R80-7A

PAGE

- 12 -



The Eco-governor controls the fuel injection quantity by adjusting the rack position of the fuel injection pump. The rack position is converted into voltage by the rack position sensor, and the voltage signal is applied to E-ECU terminal RPS and sent to an AD converter. The AD converter converts the input voltage of 0 to 5 volt into an AD value of 0 to 1023. See **Figure 2-14**.

PAGE

- 13 -

The Eco-governor controls the maximum and minimum rack positions and calculates the load factor on the basis of this AD value.



PAGE - 14 -



INJ. PUMP WITH EL. GOVERNOR (on -7A & -9)

INJ. PUMP WITH MECHANICAL GOVERNOR (on -7)



Engine speed sensor

- magnetic type
  detects eng. speed with 12 pulsers attached to the camshaft

# **Contents**

- 1. Condition of trouble
- 2. Procedure for removing actuator
- 3. Checking for governor-lever
- 4. Checking for actuator
  - (Procedure for checking guide-plate)
- 5. Procedure for installation actuator

# **1.** Condition of trouble

(1) The following trouble occurred.

• The engine doesn't start.

- The load doesn't hang though the engine starts.
- The rotational speed of the engine doesn't go up though the engine starts.

# (2) When you confirm the breakdown lamp

- It blinks seven times.
- It blinks eight times.
- It doesn't light.

(reference) When you use YDT,

code of DTC , Either P1203 or P1211 error code is displayed.

# (3) Execution judgment of confirmation work

The trouble of the actuator thought, when the trouble (1) occurred, and it applies to either of (2).

Please remove the actuator according to the following procedures, and do the confirmation work.

### 3. INJECTION PUMP - TROUBLESHOOTING FOR ACTUATOR & GOVERNOR-LEVER

С



3. INJECTION PUMP - TROUBLESHOOTING FOR ACTUATOR & GOVERNOR-LEVER

PAGE - 18 -

4/19

Procedure for removing actuator
 (1) The look of actuator



PAGE

- 19 -

- 2. Procedure for removing actuator
  - (2) Please remove four bolts.

Because the actuator parts from governor case when loosening a bolt, please hold it by hand while removing it.



PAGE - 20 -

6 / 19

2. Procedure for removing actuator

(3) The actuator is rotated in the direction of the figure below with it pressed against governor case.



PAGE - 21 -

7 / 19

# 2. Procedure for removing actuator

(4) You remove the actuator backward keeping the state of 2-(3). You will be able to remove feeling neither caught nor resistance on the way.Please do it over again from 2- (3) ,when you feel resistance.



3. Checking for governor-lever

(1) You push the governor lever by the finger.





(1)	Rack-restoring assisting spring	(4)	Spacers
(2)	Governor lever	(5)	Governor-lever pin
(3)	Link	(6)	Governor-lever shaft (Eccentric shaft)

When the governor lever doesn't move  $\Rightarrow$  Please exchange pump.

When the governor lever moves (about 5mm) ⇒ Please go to [4. Checking for actuator] 3. INJECTION PUMP - TROUBLESHOOTING FOR ACTUATOR & GOVERNOR-LEVER

#### 9/19

- 4. Checking for actuator
  - (1) Checking for guide plate



# When plate B doesn't rotate

- ⇒The grouting of guide plate is OK.
- ⇒Please install the detached actuator again.

# When plate B rotates

- $\Rightarrow$  The grouting of guide plate is loose. (NG).
- ⇒It is necessary to exchange actuator.
- Please exchange it for the emergency actuator.



PAGE

- 23 -





PAGE

- 24 -

- 5. Procedure for installation actuator
  - (1)O-ring is inserted.



3. INJECTION PUMP - TROUBLESHOOTING FOR ACTUATOR & GOVERNOR-LEVER

- 11 / 19
- 5. Procedure for installation actuator
- (2)-1 You make width across flats of governor lever pin the same direction.





PAGE

- 25 -

5. Procedure for installation actuator

(2)-2 You make width across flats of governor lever pin the same direction.

PAGE

- 26 -



5. Procedure for installation actuator

(3) You insert actuator into governor case.



Direction of the notched portion of the guide plate.



PAGE

- 27 -



5. Procedure for installation actuator

(4)-1 The actuator is rotated in the direction of the figure below with it pressed against governor case.



Important: When you feel resistance even a little at the time of rotating. Please stop it at once. (The actuator is damaged when keeping rotating. Refer to 5-(4)-2)

- 5. Procedure for installation actuator
  - (4)-2 In wrong cases



the notched portion of the guide plate.

- 5. Procedure for installation actuator
  - (4)-3 In correct cases (OK)



OK

- 5. Procedure for installation actuator
  - (5)Please pull the actuator lightly. Please inspect the thing that the actuator cannot be detached from governor case.



5. Procedure for installation actuator

(6)Please fix four bolts.



Socket size: 10mm Tightening torque: 16.5±2.0N·m

PAGE

- 32 -



Socket size: 12mm Tightening torque: 20±2.0N·m

 5. Procedure for installation actuator (7)Please mark it to the actuator.



- (8) Please connect the wire harness.
  - ·Please confirm whether the engine starts
  - (•When the actuator is normal
  - $\Rightarrow$  Please cope with it according to the troubleshooting manual.)

Important: When you exchange it for the emergency actuator Please exchange the Fuel Injection Pump and ECU later.

The fuel injection pump (MP pump) has a CSD valve mechanism that allows the fuel injection timing to advance and the injection quantity to increase, thereby improving the cold start performance of the engine.

The Eco-governor has a solenoid valve CSD where the CSD can be opened or closed with a valve solenoid. The E-ECU opens the CSD valve when the coolant temperature sensor detects that the coolant temperature is 5°C or lower at cold start. The CSD valve closes when the coolant temperature rises to 5°C or five minutes have elapsed after engine started.



PAGE

- 34 -





# **COLD START DEVICE on YANMAR engine R55-7A**

If you dismount the solenoid, you will find a loose spring at the bottom of the solenoid. It is not easy to mount it back if the pump is mounted on the engine.



Fitting for the solenoid, the spring can be found on the bottom when you remove the solenoid.



PAGE



In case of CSD failure, normaly only the solenoid valve (1) needs to be exchanged. All other parts can remain in the FIP! If other parts are or need to be removed as well, the easiest way to mount back is shown in the next slides

- 1. Solenoid Valve CSD (Solenoid)
- 2. Solenoid Spring
- 3. O-Ring 4D1020
- 4. Timer Holder
- Timer Piston
- 6. O-Ring 1016

С

7. Hydraulic Base

- 8. O-Ring 1011
- 9. Timer Spring
- 10. Timer Packing
- 11. Backup-Ring T2P15
- 12. Backup-Ring
- 13. Cap (Timer))







 Insert the timer piston (with some diesel for lubrication)

PAGE

- 39 -



Insert the timer cap



PAGE

- 40 -

# Timer cap installed



PAGE



Finaly mount the solenoid valve. Make sure that the o-ring is mounted correct as shown here. At disassembly the o-ring cán remain seated on the solenoid plunger!

PAGE

- 42 -



If For electronically controlled EGR engine, it is necessary to use fuel with <u>max. 1000 ppm of sulfur</u> III → In case of too much sulfur parts, sulfuric acid can be formed (due to the presence of recycled sulfur dioxide) and cause <u>corrosion</u> on the cylinder liner and other major components

#### Output from ECU to EGR valve:

The EGR valve output is a high-side output. See Figure 2-22.

The EGR valve is driven by a stepping motor. This stepping motor adopts two-phase excitation and requires holding current to keep the valve stopped. "Two-phase excitation" means that the solenoid is supplied with two-phase current and "holding current" does that the solenoid is always energized. The motor of the EGR valve is consequently approx. 24 watt heated even while the engine is at rest.

The E-ECU turns on or off the output transistors in the sequence shown in **Figure 2-22**, thereby driving the solenoids for the stepping motor and opening/closing the EGR valve. The speed of the valve open/close operation depends on the on/off speed of the transistors. The EGR valve opens at 125 pps (pulses per second: the number of steps taken per second) and closes at 250 pps (20 pps for 10 steps before full close).



ECU

7/7



The input characteristics of the coolant temperature sensor are shown in **Figure 2-15**. As in the case of the rack position sensor, the input voltage of 0 to 5 volt is converted into an AD value of 0 to 1023. As is clear from the figure, the thermistor resistance decreases with increasing temperatures.

PAGE

- 46 -

The measurement error of the coolant temperature sensor is approximately  $\pm 3^{\circ}$ C at  $0^{\circ}$ C and  $\pm 6^{\circ}$ C at  $110^{\circ}$ C. The coolant temperature sensor has been designed so that it provides high measurement accuracy at relatively low temperatures to allow low-temperature control of CSD etc.

The E-ECU coverts the input voltage into temperatures by mapping. Connecting a thermistor with different characteristics to the sensor or connecting an unintended load to the thermistor circuit will affect the relationship between input voltage and temperature, resulting in failure to perform correct temperature measurement. Do not connect a coolant temperature sensor other than the Yanmar genuine sensor to terminal TW (E25 - E28) of the E-ECU.





PAGE

- 47 -



## 6a. LOCATION OF YANMAR ECU (& other electric components)

PAGE - 48 -

**R80CR-9** 

## **R80CR-9 (first model)**



Starter Control Starter safety control







When the ECU (engine control unit) detects an active engine fault, the engine fault warning lamp on the cluster lights up and the beeper inside cluster starts beeping



PAGE

- 52 -

In case of simultaneous engine faults, the different beep patterns will appear successively, in order of increasing number of beeps. A complete overview of the engine errors list can be found on next pages

# ENGINE ERROR CODES LIST

6	თ		4	ယ	N		No.
Overspeed	Failure		Rack position sensor failure	Speed sensor failure	Accelerator sensor failure	Coolant tempera- ture sensor failure	Item
Idling engine speed exceeds high idling speed plus 600 min <sup>-1</sup> .	Rack actuator cur- rent is too high. Rack actuator cur- rent is too low. Engine accelerates with minimum rack actuator output. Engine stalls while rack position sensor is failed.	Correlation between rack actu- ator output and rack position exceeds threshold lower limit by 0.16 sec. or more.	Correlation between rack actu- ator output and rack position exceeds threshold upper limit by 0.32 sec. or more.	Engine start signal (E8) is on, but the engine speed is zero. Engine speed decreases by 480 min <sup>-1</sup> or more in 40 ms.	Sensor voltage is 4.6 V or more, or 0.2 V or less.	Sensor voltage is 4.8 V or more, or 0.2 V or less.	Failure detection conditions
Engine stops.	Engline stops.		Engine runs with limited output and speed. (Rack position control is inactive and speed control is active).	[With optional backup speed sensor] Backup speed sensor becomes active; speed is limited to 1800 min <sup>-1</sup> .(Option can change) Backup speed sensor failed: Engine stops. [Without optional backup speed sensor] Engine stops.	[Without optional backup accelerator sensor] Engine runs at 1500 min <sup>-1</sup> . (Option can change) [With optional backup accelerator sensor] Select backup accelerator sensor: No limitation Backup accelerator sensor failure: Engine runs at 1500 min <sup>-1</sup> .(Option can change)	Engine runs with a coolant temperature of 30°C.	Operation when failure occurs
Turn key off.	Turn key off.		Turn key off.	Turn key off.	Correct failure.	Correct failure.	Action/ condition for recovery
Always enable	Always enable		Always enable	Always enable	Default to disable	Always enable	Category
9	ω		7	თ	თ	4	Number of beeps

# ENGINE ERROR CODES LIST

r railure       Power is not shut off.       Engine runs nor         ator relay       Low status is detected even through port is off.       Engine stops.         High status is detected even through port is on.       Engine continue.         0.2 V or less.       Engine continue.         0.2 V or less.       ator sensor is us ator sensor is us 0.2 V or less.         or failure       Oil pressure switch fails to turn on when       Engine runs norr to turn on when	Low status is detected even through port is on. Power is not shut off even though main relay is off. ator relay detected even through port is off. High status is detected even through port is off. Sensor voltage is detected even through port is on. Sensor voltage is dator sensor i ator sensor i at 1500 min <sup>-</sup> Atmospheric canceled. Finite is off. Charge switch fails to turn on when to turn on when	relay High status is Engine detected even through port is off. Low status is detected even through port is on. / failure Power is not shut off even though main relay is off. ator relay Low status is detected even through port is off. High status is detected even through port is off. High status is detected even through port is on. 20.2 V or less. ure 4.6 V or more, or 4.6 V or more, or 0.2 V or less. ure 4.6 V or more, or 4.6 V or more, or 4.6 V or more, or 4.6 V or less. ure 4.6 V or less. ure 5.2 V or less. ator sei or failure 5.2 V or less. ator sei cancele re switch 0il pressure switch fails engine is off. Charge switch fails to turn on when to turn on when Engine	Low status is detected even through port is on.EnginrelayHigh status is detected even through port is off.EnginLow status is detected even through port is on.EnginrailurePower is not shut off even though main relay is off.Enginator relayLow status is detected even through port is off.Enginator relayLow status is detected even through port is off.Enginator relayLow status is detected even through port is off.EnginceleratorSensor voltage is 0.2 V or less.Engin ator s ator s ator sure0.2 V or less.Atmos cancere switchOil pressure switch fails to turn on when engine is off.EnginvitchCharge switch failsEngin	noid valve       High status is detected even through port is off.       Eng         Low status is detected even through port is on.       Eng         relay       High status is detected even through port is off.       Eng         Low status is detected even through port is off.       Eng         vitre       Power is not shut off relay is off.       Eng         ator relay       Low status is detected even through port is off.       Eng         ator relay       Low status is detected even through port is off.       Eng         ure       Sensor voltage is detected even through port is on.       Eng         0.2 V or less.       ator ator 0.2 V or less.       Eng         ure       Oil pressure switch fails to turn on when       Atm         engine is off.       Eng       Eng         urch of the off.       Eng       Eng         brow then       Charge switch fails       Eng         vitch       Charge switch fails       Eng         to turn on when       Eng       Eng	Noid valveHigh status is detected even through port is on.Engin enginNoid valveHigh status is detected even through port is off.EnginImage: Complex Comple	• failureLow status is detected even through port is off.Engine speed(1High status is detected even through port is off.Engine through port is off.Noid valveHigh status is detected even through port is off.Engine through port is off.Image: Complex	munica- tion packets cannot be received.Last valu be received.atilureLow status is detected even through port is off.Engine r speed(1High status is detected even through port is off.Engine r speed(1Noid valveHigh status is detected even through port is off.Engine r speed(1Noid valveHigh status is detected even through port is off.Engine r speed(1Noid valveHigh status is detected even through port is off.Engine r speed(1Image: relayHigh status is detected even through port is off.Engine r speed(1relayHigh status is detected even through port is off.Engine r speed(1ator relayLow status is detected even through port is off.Engine r ator sen ator sen off.calt relaySensor voltage is ator sen of allureEngine r ator sen cancelecalt relayOil pressure switch fails to turn on when engine is off.Engine r ator sen cancelevitchCharge switch fails to turn on whenEngine r	Engine speed decreases by 480 min <sup>-1</sup> or more in 40 ms.Engine speed decreases by 480 ms.munica- tion packets cannot be received.Last value be received.atilureCAN communica- tion packets cannot be received.Last value becomes becomesator relayHigh status is detected even through port is off.Engine r speed(11 main through port is off.relayHigh status is detected even through port is off.Engine r speed(11 speed(11 through port is off.relayHigh status is detected even through port is off.Engine r speed(11 speed(11 through port is off.relayHigh status is detected even through port is off.Engine r speed(11 speed(11 through port is off.relayHigh status is detected even through port is off.Engine r speed(11 speed(11 through port is off.ator relayLow status is detected even through port is off.Engine r speed(11 speed(11 through port is off.ator relayLow status is 
arge switch fails       Engine runs norr         is off.       Engine stops.         ected even       Engine stops.         sected even       ected even         sugh port is off.       Engine continue         h status is       Engine continue         sor voltage is       Engine continue         vor more, or       Ator sensor is us         v or less.       Ator sensor is us         v or less.       ator sensor is us         pressure switch       Engine runs norr         sto turn on when       Engine runs norr         gine is off.       Engine runs norr	/ status is         acted even         /ugh port is on.         veris not shut off       Engine runs         in though main       Engine stops         v status is       ected even         pugh port is off.       Engine stops         v status is       ected even         pugh port is off.       Engine conti         h status is       ected even         pugh port is on.       Engine conti         v or more, or       Main acceler         v or less.       at 1500 min <sup>-</sup> v or less.       at 1500 min <sup>-</sup> pressure switch       Engine runs         sto turn on when       Engine runs         gine is off.       Engine runs	h status is Engine acted even ugh port is off. / status is acted even ugh port is on. ver is not shut off n though main vy is off. Engine acted even ugh port is off. h status is ected even ugh port is on. sor voltage is encel v or more, or v or less. V or less. V or less. turn on when pressure switch s to turn on when gine is off. Engine cancel cancel f. Engine	<i>i</i> status is         acted even         h status is         acted even         yugh port is off.         yugh port is off.         valph port is on.         valph port is off.         valph port is off.         valph port is off.         valph port is off.         varge switch fails	h status is eng acted even sugh port is off. / status is acted even sugh port is off. / status is ected even / status is ected even / status is ected even / though main // though main // though main // though port is off. // thou	h status is socted even uugh port is on. h status is socted even uugh port is off. v status is socted even uugh port is off. v status is socted even uugh port is off. v status is socted even uugh port is off. h status is sected even uugh port is off. v status is sected even uugh port is off. v or more, or v or less. v or less. v or less. v or less. sto turn on when pressure switch fails engin sto turn on when gine is off. h status is sto turn on when gine is off. h status is ected even uugh port is on. h status is sor voltage is v or less. h status is ected even uugh port is on. h status is ected even h status is h status	i status isEngineacted evenspeed(1h status isspeed(1n status isspeed(1acted evensoff.y status issoff.acted evensoff.y soff.soff.y soff.soff.y soff.soff.y soff.soff.y soff.soff.y or more, orsoff.y or lass.ator sery or lass.ator sery or lass.ator sery or lass.soff.pressure switch failsEnginearge switch failsEngine	V communica- received.Last value become received.Last value become received. <i>i</i> status is sected even uugh port is off.Engine r speed(1 <i>i</i> status is sected even uugh port is on. uugh port is on. uugh port is on. vugh port is on. vugh port is on. vugh port is on. vugh port is on. uugh port is on. vugh port is on. vugh port is on. vugh port is on. uugh port is on. vugh port is on. vugh port is on. uugh port is on. vugh port is on. vugh port is on. uugh port is on. vor less.Engine i ator sen to receive ator sen to receive ator sen to turn on when r arge switch failsEngine i Engine i	jine speed reases by 480Last valu Packets cannotV communica- packets cannotLast valu becomes received.v status is ected even sugh port is off.Engine r speed(18h status is ected even sugh port is off.Engine c speed(18h status is ected even sugh port is off.Engine c speed(18v status is ected even sugh port is on.Engine c speed(18v or more, or v or more, or v or less.Engine c ator sens v or less.v or less.Engine c ator sens v or less.arge switch failsEngine r ator sens
Engine stops. Engine continue: ator sensor is us Main accelerator at 1500 min <sup>-1</sup> .(O Atmospheric pre canceled. Engine runs nor	f Engine runs Engine stops Engine conti ator sensor i Main acceler Atmospheric canceled. Engine runs	f Engine Engine Engine ator sei Main ac Atmost cancele	r Englin Englin Englin ator s Malin t Englin Englin	Eng Eng Eng	Engin Engin Engin	Engine Engine Engine Engine Engine Engine Engine Engine Engine ator ser Main ac ancele Engine	Last values become Engine regime regi	Last value becomes Engine r Engine c Engine c Engine c Engine c ator sens Main acc at 1500 r Atmosph cancelec
tops. tops. ontinue or is us elerator elerator elerator elerator	interior interio interior interior interior interior interior interior inte			ine color color filme of the run ine		ומהדיה האסו או דו דו סו מדו	וסבובסשטו או צו צו או מרומב	
nally. s to run while main acceler- ed. sensor failure: Engine runs ption can change) ssure compensation is	normally. s. s. nues to run while main acceler- is used. 1.(Option can change) pressure compensation is	runs with air heater relay being off. runs normally. stops. stops. continues to run while main acceler- nsor is used. ccelerator sensor failure: Engine runs min <sup>-1</sup> .(Option can change) heric pressure compensation is	e runs with air heater relay being off. e runs normally. e stops. e continues to run while main acceler- ensor is used. accelerator sensor failure: Engine runs 20 min <sup>-1</sup> .(Option can change) spheric pressure compensation is	ine continues to run with port being off. ine runs with air heater relay being off. ine runs normally. ine stops. ine stops. ine continues to run while main acceler- sensor is used. n accelerator sensor failure: Engine runs 500 min <sup>-1</sup> .(Option can change) ospheric pressure compensation is	e continues to run with port being off. e runs with air heater relay being off. e runs normally. e continues to run while main acceler- ensor is used. accelerator sensor failure: Engine runs 00 min <sup>-1</sup> .(Option can change) spheric pressure compensation is	runs with limited output(92%) and 800min <sup>-1</sup> ). continues to run with port being off. runs with air heater relay being off. runs normally. runs normally. stops. stops. continues to run while main acceler- is used. continues to run while main acceler- is used. celerator sensor failure: Engine runs min <sup>-1</sup> .(Option can change) heric pressure compensation is	uns with limited output(92%) and 800min <sup>-1</sup> ). continues to run with port being off. uns with air heater relay being off. uns normally. uns normally. uns normally. continues to run while main acceler- isor is used. celerator sensor failure: Engine runs min <sup>-1</sup> .(Option can change) heric pressure compensation is	ie is retained. Backup sensor sactive. uns with limited output(92%) and 300min <sup>-1</sup> ). ontinues to run with port being off. uns with air heater relay being off. tops. tops. tops. tops. tops. itops. elerator sensor failure: Engine runs min <sup>-1</sup> .(Option can change) eric pressure compensation is
correct tail- ure.Or turn key off. Turn key off. > main acceler- ce: Engine runs	Correct fail- ure.Or turn key off. Turn key off. > main acceler- ce: Engine runs	Hay being off. Turn key off. Correct fail- ure.Or turn key off. Turn key off. Turn key off. e main acceler- Correct failure	Jay being off.     Turn key off.       Image: sing acceler- ere: Engine runs     Correct fail- ure.Orturn key off.	port being off. Turn key off. slay being off. Turn key off. Correct fail- ure.Or turn key off. Turn key off. Turn key off. Turn key off.	port being off. Turn key off. slay being off. Turn key off. slay being off. Turn key off. Correct fail- ure.Or turn key off. Turn key off. Turn key off. Turn key off.	utt(92%) and Turn key off. port being off. Turn key off. slay being off. Turn key off. Correct fail- ure.Or turn key off. Turn key off. Turn key off. Turn key off. Correct failure e main acceler- correct failure	p sensor Correct failure ut(92%) and Turn key off. port being off. Turn key off. port being off. Turn key off. Slay being off. Turn key off. ure.Or turn key off. off. Correct fail- ure.Or turn key off. Turn key off. Correct failure e main acceler- Correct failure	p sensor       Correct failure         ut(92%) and       Turn key off.         port being off.       Turn key off.         port being off.       Turn key off.         glay being off.       Turn key off.         slay being off.       Turn key off.         glay being off.       Turn key off.         slay being off.       Turn key off.         glay being off.       Turn key off.         slay being off.       Correct fail-         ure.Or turn key off.       Turn key off.         state off.       Turn key off.         state off.       Turn key off.         state off.       Correct failure         state off.       Correct failure         state off.       Correct failure         state off.       Correct failure
Correct tail- ure.Orturn key disat off. Turn key off. Alwa enat	Correct fail- ure.Orturn key dis off. Turn key off. Alv en	off. Turn key off. De Correct fail- ure.Orturn key d off. De Turn key off. A	off. Turn key off. Defa ena Correct fail- ure.Orturn key off. Defa disa off. Alw ena	off. Turn key off. Alw off. Turn key off. Defa ure.Orturn key off. Defa off. Turn key off. Alw Turn key off. Alw ena	J off.     Turn key off.     Al       off.     Turn key off.     er       off.     Turn key off.     Def       coff.     Correct fail- ure.Orturn key off.     Def       off.     Turn key off.     er       di.     Turn key off.     er	nd Turn key off. Deta goff. Turn key off. Alv off. Turn key off. Alv en off. Correct fail- ure.Orturn key off. Deta ure.Orturn key off. Alv en additional dis off. Alv	Correct failure.     Defa       nd     Turn key off.     Defa       g off.     Turn key off.     dis       g off.     Turn key off.     Alw       off.     Turn key off.     Defa       off.     Turn key off.     ena       off.     Turn key off.     Defa       off.     Turn key off.     Defa       off.     Turn key off.     ena       Turn key off.     ena     ena       off.     Turn key off.     ena	Correct failure.     Defau       nd     Turn key off.     Defau       j off.     Turn key off.     Defau       off.     Turn key off.     enal       off.     Turn key off.     enal       off.     Turn key off.     Defau       off.     Turn key off.     Defau       Image: Correct fail- ure.Or turn key off.     Defau       Off.     Turn key off.     Defau       Image: Correct fail- ure.Or turn key off.     Defau       Image: Correct fail- ure.Or turn key off.     Defau       Image: Correct fail- ure.Or turn key off.     Defau       Image: Correct fail- ure all     Defau
Correct tail- Detau ure.Orturn key disab off. Turn key off. Alwa enat	Correct fail- ure.Or turn key dis off. Turn key off. Alv en	ay being off. Turn key off. De e Correct fail- ure.Or turn key d off. A Turn key off. A	ay being off. Turn key off. Defa ena Correct fail- ure.Or turn key off. Defa disa off. Turn key off. Alw ena	ort being off. Turn key off. Alw ay being off. Turn key off. Defa ure.Orturn key off. Defa ure.Orturn key off. Alw off. Alw Ena	ort being off. Turn key off. Al ay being off. Turn key off. Per ay being off. Turn key off. Def ure.Or turn key off. en off. Turn key off. Al en	((92%) and       Turn key off.       Deft         ort being off.       Turn key off.       Alv         ay being off.       Turn key off.       Petr         ay being off.       Turn key off.       Deft         beft.       Turn key off.       Alv	sensor Correct failure. Defa (92%) and Turn key off. Defa dis ort being off. Turn key off. Alw ort being off. Turn key off. Defa ure.Orturn key off. Defa off. Correct fail- en: Turn key off. Alw en: av being off. Alw en:	sensor Correct failure. Defau (192%) and Turn key off. Defau ort being off. Turn key off. Alwa ay being off. Turn key off. Alwa off. Correct fail- ure.Or turn key off. Defau ure.Or turn key off. Alwa enal
off.	Correct fail- ure.Orturn key dis off.	ater relay being off. De e Correct fail- ure.Or turn key d off.	ater relay being off. Turn key off. Defa ena Correct fail- ure.Orturn key off. Defa	ater relay being off. Turn key off. Alw ater relay being off. Turn key off. Defa ure.Orturn key off. Defa	n with port being off. Turn key off. Al er ater relay being off. Turn key off. Def ure.Or turn key off. Def ure.Or turn key di	d output(92%) and Turn key off. Deft dis n with port being off. Turn key off. Alv ater relay being off. Turn key off. Deft ater relay being off. Correct fail- ure.Orturn key dis off. Deft	Backup sensor     Correct failure.     Defa       d output(92%) and     Turn key off.     Defa       n with port being off.     Turn key off.     Defa       ater relay being off.     Turn key off.     Alm       ater relay being off.     Turn key off.     Defa       off.     Correct failure.     Defa       off.     Correct failure.     Defa	Backup sensor       Correct failure.       Defa         d output(92%) and       Turn key off.       Defa         d output(92%) and       Turn key off.       Defa         ater relay being off.       Turn key off.       Alw         ater relay being off.       Turn key off.       Defa         off.       Correct fail- ure.Orturn key       Defa         off.       Correct fail- ure.Orturn key       Defa
		heater relay being off. Turn key off. De e	heater relay being off. Turn key off. Defa	run with port being off. Turn key off. Alw ena heater relay being off. Turn key off. Defa ena	run with port being off. Turn key off. Al er heater relay being off. Turn key off. Del	itted output(92%) and Turn key off. Defa dis run with port being off. Turn key off. Alv heater relay being off. Turn key off. Defa en	rd. Backup sensor Correct failure. Defa inited output(92%) and Turn key off. Defa dis run with port being off. Turn key off. Alw heater relay being off. Turn key off. Defa en:	id. Backup sensor       Correct failure.       Defa         nited output(92%) and       Turn key off.       Defa         num with port being off.       Turn key off.       Alw         run with port being off.       Turn key off.       Alw         heater relay being off.       Turn key off.       Defa

# ENGINE ERROR CODES LIST

30 E		29 E	28 [E	27 [F		26 tu	25 O	24 A a(	23 tu	22 C	21 0	20 a E	19 S	No.
-ECU failure	-ECU failure //apping error]	-ECU failure sub CPU failure]	EPROM error]	-ECU failure ROM error]		oolant tempera- ire high alarm	ily water separa- r alarm	ir cleaner block- ge alarm	oolant tempera- ire abnormal	harge failure	il pressure low	-ECU overheat arm	ensor 5V failure	ltem
Sensor voltage is	Map format is invalid.	E-ECU fails to com- municate with sub CPU.	Heading/Writing fails. EEPROM suffers checksum error.	FlashROM suffers checksum error.	when Coolant tem- perature decreases to 110°C. (Option can change)	Coolant tempera- ture is 115°C or higher. Alarm is canceled	Oily water separa- tor switch turns on.	Air cleaner switch turns on.	Coolant tempera- ture switch turns on.	Charge switch fails to turn off when engine is running.	Oil pressure switch fails to turn off when engine is running.	E-ECU temperature exceeds 105°C. Alarm is canceled when E-ECU tem- perature decreases to 100°C. (Option can change)	Monitoring voltage is approx. 0 V. Monitoring voltage is 4.5 V or less. Monitoring voltage is 5.5 V or more.	Failure detection conditions
Engine runs normally.	Engine stops.	Engine runs normally.	Engine runs normally.	Engine stops.		Engine runs normally.	Engine runs normally.(Option can change)	Engine runs normally.(Option can change)	Engine runs normally.(Option can change)	Engine runs normally.	Engine runs normally.(Option can change)	Engine runs normally.(Option can change)	Engine runs normally.	Operation when failure occurs
Correct failure.	Turn key off.	Turn key off.	Turn key ott.	Turn key off.		Correct failure.	Turn key off.	Turn key off.	Turn key off.	Turn key off.	Correct failure.	Correct failure.	Turn key off.	Action/ condition for recovery
Always enable	Always enable	Always enable	Always enable	Always enable		Default to enable	Default to enable	Default to enable	Default to enable	Default to enable	Default to enable	Default to enable	Always enable	Category
4-1	4-1	4-1	4	4-1		ය ර	3-5	3-4	а-а	3-2	3-1	<u>ې</u>	2 <u>.</u> 4	Number of beeps





YANMAR SPN	FMI	Description		
10.15	4	Engine fuel rack position sensor : shorted to low source		
1210	3	Engine fuel rack position sensor : shorted to high source		
	4	Accelerator pedal position sensor "A" : shorted to low source		
	3	Accelerator pedal position sensor "A" : shorted to high source		
	2	Accelerator pedal position sensor "A" ; intermittent fault		
91	1	Accelerator pedal position sensor "A" : below normal operational range (SAE J1843)		
	0	Accelerator pedal position sensor "A" : above normal operational range (SAE J1843)		
	15	Accelerator pedal position sensor "A" : not available (SAE J1843)		
	4	Accelerator pedal position sensor "B" : shorted to low source		
	3	Accelerator pedal position sensor "B" ; shorted to high source		
	2	Accelerator pedal position sensor "B" ; intermittent fault		
29	1	Accelerator pedal position sensor "B" ; below normal operational range (SAE J1843)		
	0	Accelerator pedal position sensor "B" ; above normal operational range (SAE J1843)		
	8	Accelerator pedal position sensor "B" : communication fault		
	15	Accelerator pedal position sensor "B" : not available (SAE J1843)		
	4	Barometric pressure sensor : shorted to low source		
108 3 Barometric pressure sensor : shorted to high source				
	2	Barometric pressure sensor ; intermittent fault		
	4	E-ECU internal temperature sensor ; shorted to low source		
	3	E-ECU internal temperature sensor : shorted to high source		
1136	2	E-ECU internal temperature sensor : intermittent fault		
0 E-ECU internal temperature : too high				
	4	Engine coolant temperature sensor ; shorted to low source		
	3	Engine coolant temperature sensor ; shorted to high source		
110	2	Engine coolant temperature sensor ; intermittent fault		
	0	Engine coolant temperature ; too high		
	4	Sensor 5V ; shorted to low source		
1079	3	Sensor 5V ; shorted to high source		
	2	Sensor 5V; intermittent fault		
	1	E-ECU system voltage : too low		
158	0	E-ECU system voltage : too high		
1078	4	Engine fuel injection pump speed sensor : shorted to low source		
522402	4	Auxiliary speed sensor : shorted to low source		
	4	Engine fuel rack actuator relay : open circuit		
500044	3	Engine fuel rack actuator relay : short circuit		
522241	7	Engine fuel rack actuator relay ; mechanical malfunction		
	2	Engine fuel rack actuator relay ; intermittent fault		
	4	Air heater relay : open circuit		
522243 3 Air heater relay : short circuit				
	2	Air heater relay : intermittent fault		

Fault cod	de de	Description			
YANMAR SPN	FMI	Description			
	4	Cold start device ; open circuit			
522242	3	Cold start device ; short circuit			
	2	Cold start device : intermittent fault			
500054	4	EGR stepping motor "A" : open circuit			
522251	3	EGR stepping motor *A" : short circuit			
500050	4 EGR stepping motor "B": open circuit				
522252	3	EGR stepping motor "B" : short circuit			
500050	EGR stepping motor *C": open circuit				
3 EGR stepping motor "C" : short circuit					
500054	4	EGR stepping motor "D" : open circuit			
522254 3 EGR stepping motor *D" : short circuit					
4 Oil pressure switch ; shorted to low source					
100	1	Oil pressure : too low			
4 Battery charge switch ; shorted to low source					
107	1	Battery charge : charge warning			
522314	0	Engine coolant temperature ; abnormal temperature			
522323	0	Air cleaner : mechanical malfunction			
522329	0	Oily water separator : mechanical malfunction			
190	0	Engine speed ; over speed condition			
	4	Engine fuel rack actuator ; shorted to low source			
638	3	Engine fuel rack actuator ; shorted to high source			
	7	Engine fuel rack actuator ; mechanical malfunction			
639	12	High speed CAN communication ; communication fault			
620	2	E-ECU internal fault : EEPROM check sum error (data set 2)			
630	12	E-ECU internal fault : EEPROM error			
	12	E-ECU internal fault : flashROM check sum error (main software)			
628	2	E-ECU internal fault : flashROM check sum error (data set 1)			
	2	E-ECU internal fault : flashROM check sum error (data set 2)			
1485	4	E-ECU main relay ; shorted to low source			
	12	E-ECU internal fault ; cyclic redundancy check of sub-CPU error			
522727 12 E-ECU internal fault : acknowld		E-ECU internal fault : acknowledgement of sub-CPU error			
	12	E-ECU internal fault : communication with sub-CPU error			
522728	12	E-ECU internal fault : engine map data version error			
500700	12	Immobilizer ; CAN communication fault			
522730	8	Immobilizer ; pulse communication fault			
1202	2	Immobilizer : system fault			

## 9. YANMAR ENGINE DIAGNOSTIC TOOL (YEDST)

The YANMAR Engine Diagnostic Service Tool (YEDST) for the TNV series is software to support troubleshooting and installation/maintenance services for electronic control engines. It runs on personal

computers (PC/AT) running Windows operating system.

Part nr. of Yanmar Engine Diagnostic Tool : XJAU-01062

## PC Requirements PC/AT compatible

- Communication port : USB
- Display resolution : 1024 × 768
- OS

: Windows 2000 Professional SP1, Windows XP Professional, Windows XP Home, Windows XP Tablet PC Edition

Connecting the Yanmar genuine service tool to the E-ECU as shown in **Figure 2-53** allows status monitoring or diagnostic testing as well as the indication of detailed failure information, failure log and freeze frame data.





PAGE

- 58 -



When you mount a new ECU, you need to copy the data from the injection pump to the ECU: the data per injection pump is "individual " and "engine specific.

#### 7.8.1.1 ECU Exchange

O Information that must be copied when replacing the ECU.

- 1) Correction information: ① Pump injection quantity correction value, ② Engine output correction value ()
- 2) Configuration value
- 3) Calibration value
- 4) Tuning value
- 6) Serial number : ① Engine serial number, ② Pump serial number
- 7) Additional information : ① Calibration date (date inside PC), ② Calibration device number (license key)

#### 7.8.1.1.1 Copy from Old ECU

When the ECU program is running normally and the CAN communication functions normally, you can copy the setting values (correction values, etc) from the current (old) controller to the new controller. Follow these steps. —> ... Pump data controller

# 7.8.1.1.2 Writing Data Received from the PDM-

If the ECU is broken and data cannot be read, you can receive data from the PDM and write the correction values to the ECU using the following procedure. First, you need to receive the pump correction data file (pump serial.excp) and the engine correction data file (engine serial.exce) for the model name and serial number of your engine in advance. Note that, in this case, the configuration, calibration, and tuning data are not written. Therefore, you need to reenter each item using the menu. $\longrightarrow$  ...

#### 7.8.1.1.3 Manual Entry

С

If the ECU is broken, data cannot be read, and you cannot receive data from the PDM, you can manually write the correction values to the ECU. In this case, first, you need to obtain the pump correction data and the engine correction data (eg, paper document) for the model name and serial number of your engine in advance from the PDM. Note that, in this case, the configuration, calibration, and tuning data are not written. Therefore, you need to reenter each item using the menu.  $\longrightarrow$  ...

HHIE TRAINING CENTRE

# >> CONFIGURATION MENU (FOR REPLACE OF ECU, PUMP)

**PAGES 44...48 OF** 

**YEDST MANUAL** 

PAGE

- 59 -

When you mount a new injection pump, the data from this pump needs to be written to the ECU: in that case the ECU is updated according to the settings of the new pump

## 7.8.1.2 Replacing the Pump

O Information that must be written when replacing the pump.

- 1) Correction information : (1) Pump injection quantity correction value
- 2) Serial number :  $\widehat{1}$  Pump serial number
- 3) Additional information : ① Calibration date (data inside PC), ② Calibration device number (license key)

### 7.8.1.2.1 Writing Data Received from the PDM

When you replace the pump, you need to receive data from the PDM and write the correction values to the ECU using the following procedure. First, you need to receive the pump correction data file (pump\_serial.excp) for the model name and serial number of your pump in advance.

#### 7.8.1.2.2 Manual Entry

As with replacing the ECU, you can enter data manually.

# >> CALIBRATION MENU (YEDST)

This screen provides the function to calibration (correct) the sensor. You can perform the digital calibration of the reference position for the accelerator position sensor, and check the origin calibration value at the time of

(APS)

injection.

## >> TUNING (YEDST)

This screen provides the function to set engine's low idle rotation, select the torque pattern, and fine-tune the speed governing performance. You can make correction within the range according to the emission regulations.













Before you adjust the pump timing make sure to mark the current position! Also attach a mark sticker on the engine next to the mark on the fuel pump so you can measure how far you adjust the fuel pump.







To be able to adjust the fuel pump you first have to loosen 7 bolts. 3 on the rear support and 4 on the flange at the distribution side. In red line you see the position of 2 of them behind the pump house. These can be reached using a ¼, 14mm socket and extensions as shown in the picture. The nuts and bolts don't have to be removed just loosened.

PAGE

- 62 -



The fuel pump can be tilted to advance or retard the fuel injection moment. To make this possible the 7 bolts used to fixate the pump are provided with slotted holes.

PAGE

- 63 -



To advance the fuel injection you have to turn clockwise when looking to the front of the engine, the delay the fuel injection, turn counter-clockwise.

PAGE

- 64 -



If you like to replace the fuel pump you have to follow the previous steps but this time completely remove the 7 mounting bolts on the pump and the support on the rear of the pump. You also have to disconnect the fuel, oil & electric lines. Be carefull for high pressure when you are disconnecting the fuel lines!

PAGE

- 65 -

are disconnecting the fuel lines! Proceed by removing the fuel pump drive gear cover. Then remove the <u>center nut</u>. NEVER loosen the four <u>flange bolts</u>! They connect the fuel pump drive gear to the flange through slotted holes. When they are loosened the fuel pump drive gear can rotate freely and all references of timing will be lost!





Normally it is enough to put a mark on fuel pump drive gear and idler to be able to reassemble the pump on the correct position after removal. But when the injection pump was mounted in the wrong position or the engine has rotated after removal of the pump there is a more precise way to put everything right on time.

On the crankshaft pully are 3 timing marks, 2 bulges and 1 notch. You have to align this notch to the 0° mark on the distribution cover (TDC cyl.1), make sure that cyl 1 is not only on his TDC but also on compression AND be able to see the "B" mark on the idler in the **middle** (not to high or to low) of the opening from the fuel pump driver cover. These 3 situations combined appear only once every !50! Crankshaft revolutions so a little patience can be helpfull... When you have the engine in this position you can align the "B" mark on the fuel pump drive gear with the "B" mark of the idler and the gears will be positioned perfectly.







PAGE

- 66 -

If you replace the pump you have to calculate the injection timing difference between these pumps:

PAGE

- 67 -

- 1) Remove the old pump and take a note of the timing index recorded in that pump.
- 2) Read the timing on the new pump and calculate the difference between new and old angle.
- 3) Put the pump temporarily on the gear case and install the drive gear accordingly to the ID marks you made earlier. (Tightening torque of installation nut => 113 123 Nm)
- 4) Use the marking on the sticker to adjust the calculated (2) injection angle difference.
- 5) If you have calculated a positive angle correction value, push the fuel pump away from the cylinder block

to delay the injection timing and vice versa to advance the timing in case of a negative value.

Timing-Index difference $ extsf{D} \theta$	Ξ	Timing-Index of New pump $ heta \ 2$	-	Timing-Index of previous pump $\theta \ 1$

#### Calculation Example

Timing-index $\theta 2$	Timing-index θ 1	Timing-index Difference $\Delta \theta$	Fuel pump installation method	
75	70	+5	Advanced injection timing 1 scale to direction of +	<u>JAG Hala</u>
60	70	-10	Delayed injection timing 2 scale to direction of -	To Timing index
70	70	0	Install same position	

**1** scale is equal to Timing-index Difference  $\angle \theta = 5$  and 1 degree at Crank angle.

If there is no timing index on the pump body you can find it in this table buy using the pump ID number.



Pump ID	Timing index
XG05	82
XG10	63
XG12	74
XG13	73
XG16	72
XG17	68
XG18	68
XG20	65
XG21	69
XG22	63
VG22	87
XG24	84
XG24	88
XG20	00
XG27	04
XG28	00
XG29	64
XG33	65
XJ01	63
XJ03	77
XJ04	65
XJ09	77
XJ27	81
XJ32	76
XJ33	86
XJ37	75
XJ41	69
XJ42	69
XJ43	62
XJ44	67
XJ46	65
XJ47	79
XJ48	64
XJ49	68
XJ52	78
XJ53	64
X 154	83
X.I56	70
X.157	69
X 159	65
X IR1	60
XIRR	85
X174	85
×172	00
AJ/2	82
HXLX	74
XK01	61
XK02	64
XK05	81
XK07	78
XK14	64
XK19	64
XK20	68
XK21	67
2 M N 4 4 1	
XK22	65
XK22 XK23	65 64

r anny io	Timing index
XK28	67
XK27	68
XK28	71
XK30	71
XK31	79
XK33	66
XK34	64
XK35	67
XK42	78
XKXB	63
XM01	74
XM 14	63
XM 15	68
XM 16	68
XM17	68
XM 19	60
XM20	62
XM21	73
XM22	73
XM23	84
XM24	80
XM29	71
XM30	84
XN01	74
XN04	60
XN06	81
XN10	63
XN11	63
XN12	75
XN13	63
XN14	67
XN16	65
XN20	65
XN21	63
XN23	64
XN24	62
XN25	63
XN26	66
XN27	63
XN29	66
XN31	64
XN32	66
XN33	64
XN35	66
XN36	67
XN38	67
XN45	70
XN46	63
XN54	65
XNXB	63
XR01	64

Pump ID	Timing index
BT16	32
BT17	52
BT18	57
BT19	54
BT21	52
BT21	50
B122	02
B123	52
BT98	50
BT99	52
TQ87	32
TQ92	53
XS08	48
XS10	46
XS12	49
XS13	46
¥\$14	40
VC10	51
A310	51
XS20	45
XS22	57
XS24	50
XS26	52
XSXD	49
XT03	29
XT04	54
XT06	28
XT10	54
VT11	52
×T12	20
AT 13	28
XI16	45
XI17	51
XT18	55
XT19	49
XT20	55
XT23	48
XT24	53
XT25	54
XT26	53
XT27	52
VT20	54
A120	04
×129	52
XT31	45
XT32	56
XT33	52
XT38	48
XT41	50
XT53	51
XT54	51
XT56	52
XT58	51
XT83	49
VTR4	50
×104	50
AI/1	
X172	46
X173	51
XTXB	51
XTXD	50

END

PAGE - 69 -