REDES ELECTRICAS ORLANDO HERRERA SAS
NIT 900.657.546-4
MANZANA 16 CASA 21 BARRIO BALKANES
Tel: (0571) 3102605759
Espinal - Colombia
orlandoherrera2@yahoo.com

Factura electrónica de venta
No. FE 56

Señores	EMPRESA DE ACUEDUCTO ALCANTARILLADO ASEO DEL ESPINAL ESP		
NIT	890.704.204-7	**Teléfono**	(038) 2390201 - Ext. 000
Dirección	CR 6 7 80 BRR EL CENTRO	**Ciudad**	Espinal - Colombia

Fecha y hora Factura

Generación	11/06/2024, 14:34
Expedición	11/06/2024, 14:34
Vencimiento	26/06/2024

Ítem	Código	Descripción	Cantidad	Vr. Unitario	Vr. Total
1	006	Contrato de mantenimiento No. 17-2024 cuyo objeto es: Mantenimiento correctivo de la planta eléctrica de la PTAP y su respectiva transferencia	1.00	43,920,000.00	52,264,800.00

Total items: 1

Valor en Letras:
Cincuenta y dos millones doscientos sesenta y cuatro mil ochocientos pesos m/cte

Condiciones de Pago:
Pago a crédito - Cuota No. 001 vence el 2024-06-26 por $ 52,264,800.00

Total Bruto	43,920,000.00
IVA 19%	8,344,800.00
Total a Pagar	**52,264,800.00**

bservaciones:

A esta factura de venta aplican las normas relativas a la letra de cambio (artículo 5 Ley 1231 de 2008). Con esta el Comprador declara haber recibido real y materialmente las mercancías o prestación de servicios descritos en este título - Valor. **Número Autorización Electrónica 18764059572381 aprobado en 20231108 prefijo FE desde el número 46 al 500 Vigencia: 12 Meses**
Responsable de IVA - Actividad Económica 4321 Instalaciones eléctricas Tarifa 6*1000
CUFE: 48989d6069cca4eab9066d2fb0a6278d7a834aef4886d9f56d51d0cfd8ad848c19cef3bf8a559a820d1a06e31557ad1a

Fabricante Software y Proveedor tecnológico: Siigo SAS - Nit 830.048.145-8. Nombre Software: Siigo Nube. Firma electrónica: ver en el XML

en línea

DATOS GENERALES DEL APORTANTE

Identificación	dv	Razon Social	Clase Aportante	Sucursal Principal	Direccion	Ciudad-Departamento	Teléfono	Exonerado SENA e ICBF
NIT 900657546	4	REDES ELECTRICAS ORLANDO HERRERA SAS	B - MENOS DE 200 COTIZANTES	ESPINAL	MANZ 16 CASA 21	ESPINAL-TOLIMA	2485789	SI

DATOS GENERALES DE LA LIQUIDACION

Periodo		Clave		Tipo	Fecha		Pago		
Pensión	Salud	Pago	Planilla	Planilla	Limite	Pago	Banco	Dias Mora	Valor
2024-05	2024-06	202406060909S0405085	946829625B	E	2024/06/14	2024/06/06	BANCO AV VILLAS	0	$268,500

LIQUIDACION DETALLADA DE APORTES

EMPLEADO				NOVEDADES																PENSION				SALUD				CCF				RIESGOS				PARAFISCALES				
No.	Identificación		Nombre	ing	ret	tde	tae	tdp	tap	vsp	cor	vst	sln	ige	lma	vac	avp	vct	irl	vlp	Codigo	Días	IBC	Aporte	Codigo	Días	IBC	Aporte	Codigo	Días	IBC	Aporte	Codigo	Días	IBC	Aporte	Días	IBC	Aporte	Exonerado SENA e ICBF	Total Aportes
1	CC	93125933	ARAGON CAMILO	X	X																230301	20	$866,667	$138,700	EPS037	20	$866,667	$34,700	CCF46	20	$866,667	$34,700	14-23	20	$866,667	$60,400	20	$0	$0	SI	$268,500
Total Afiliados(1)																							$866,667	$138,700			$866,667	$34,700			$866,667	$34,700			$866,667	$60,400		$0	$0		$268,500

2024/06/13 02:36 PM

en línea

DATOS GENERALES DEL APORTANTE

Identificación	dv	Razon Social	Clase Aportante	Sucursal Principal	Direccion	Ciudad-Departamento	Teléfono	Exonerado SENA e ICBF
NIT 900657546	4	REDES ELECTRICAS ORLANDO HERRERA SAS	8 - MENOS DE 200 COTIZANTES	ESPINAL	MANZ 16 CASA 21	ESPINAL-TOLIMA	2485789	SI

DATOS GENERALES DE LA LIQUIDACION

Periodo		Clave		Tipo	Fecha		Pago		
Pensión	Salud	Pago	Planilla	Planilla	Limite	Pago	Banco	Dias Mora	Valor
2024-05	2024-06	20240606090950405085	9468296258	E	2024/06/14	2024/06/06	BANCO AV VILLAS	0	$268,500

RESUMEN DE PAGO

RIESGO	CODIGO	NIT	DV	AFILIADOS	VALOR LIQUIDADO	INTERESES MORA	SALDOS E INCAPACIDADES	VALOR A PAGAR
AFP (ADMINISTRADORAS: 1)				1	$138,700	$0	$0	$138,700
PORVENIR	230301	800,224,808	8	1	$138,700	$0	$0	$138,700
ARL (ADMINISTRADORAS: 1)				1	$60,400	$0	$0	$60,400
POSITIVA COMPAÑIA DE SEGUROS	14-23	860,011,153	6	1	$60,400	$0	$0	$60,400
CCF (ADMINISTRADORAS: 1)				1	$34,700	$0	$0	$34,700
CAFASUR	CCF46	890,704,737	0	1	$34,700	$0	$0	$34,700
EPS (ADMINISTRADORAS: 1)				1	$34,700	$0	$0	$34,700
NUEVA E.P.S.	EPS037	900,156,264	2	1	$34,700	$0	$0	$34,700
TOTAL				1	$268,500	$0	$0	$268,500

aportes en línea

Comprobante de Pago

DATOS GENERALES DEL APORTANTE							
Identificación	dv	Razon Social	Clase Aportante	Sucursal Principal	Direccion	Ciudad-Departamento	Teléfono
NIT 900657546	4	REDES ELECTRICAS ORLANDO HERRERA SAS	B - MENOS DE 200 COTIZANTES	ESPINAL	MANZ 16 CASA 21	ESPINAL-TOLIMA	2485789

DATOS GENERALES DE LA LIQUIDACION			
Periodo Pensión	2024-05	Periodo Salud	2024-06
Fecha límite de pago	2024/06/14	Fecha de pago	2024/06/06
Dias de mora	0	Tasa de mora	26.16%

TOTALES	
Valor a pagar	$268,500
Intereses de mora	$0
Saldos e incapacidades	$0
Valor total	$268,500

DATOS DE LA TRANSACCIÓN	
Clave planilla	9468296258
Clave de pago	20240606090950405085
Banco	BANCO AV VILLAS

2024/06/10 02:18 PM

Certificación Bancaria

Bancolombia

Espinal, marzo 12 de 2024

Señor(a)

A quien le pueda interesar

Cordial saludo,

BANCOLOMBIA S.A. se permite informar que **REDES ELECTRICAS ORLANDO HERRERA,** identificado (a) con Nit. No. **900657546,** a la fecha de expedición de esta certificación, tiene con el Banco el siguiente producto:

Nombre Producto	Número Producto	Fecha Apertura	Estado
CUENTA DE AHORROS	411-136975-11	2013/09/26	Activa

Atentamente,

Claudia María Posada Álvarez

Gerente Transformación de Sucursales

* **Importante:** Esta constancia solo hace referencia al producto mencionado anteriormente.
*Si desea verificar la veracidad de esta información, puede comunicarse con la Sucursal Telefónica Bancolombia los siguientes números: Medellín - Local: (57-4) 510 90 00 - Bogotá - Local: (57-1) 343 00 00 - Barranquilla - Local: (575) 361 88 88 - Cali - Local: (57-2) 554 05 05 – Resto del país: 01800 09 12345. Sucursales Telefónicas en el exterior: España (34) 900 995 717 - Estados Unidos (1) 1 866 379 97 14.

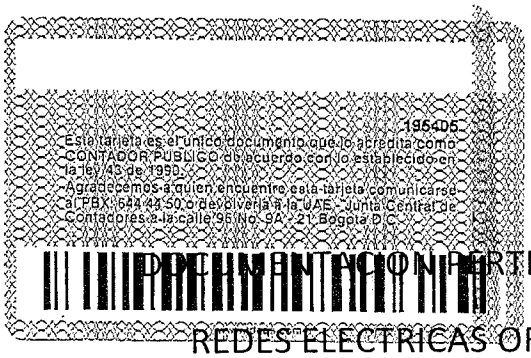




DOCUMENTACION PERTENECIENTE A LA ENTIDAD
REDES ELECTRICAS ORLANDO HERRERA SAS

DOCUMENTACION PERTENECIENTE A LA ENTIDAD

REDES ELECTRICAS ORLANDO HERRERA SAS





DOCUMENTACION PERTENECIENTE A LA ENTIDAD
REDES ELECTRICAS ORLANDO HERRERA SAS

UNIDAD ADMINISTRATIVA ESPECIAL

JUNTA CENTRAL DE CONTADORES

DOCUMENTACION PERTENECIENTE A LA ENTIDAD

Certificado No:

D B 7 2 7 6 7 F A C D F 4 4 5 0

REDES ELECTRICAS ORLANDO HERRERA SAS

LA REPUBLICA DE COLOMBIA

MINISTERIO DE COMERCIO, INDUSTRIA Y TURISMO

UNIDAD ADMINISTRATIVA ESPECIAL

JUNTA CENTRAL DE CONTADORES

DOCUMENTACION PERTENECIENTE A LA ENTIDAD

CERTIFICA A:

QUIEN INTERESE

REDES ELECTRICAS ORLANDO HERRERA SAS

Que el contador público **DIANA PATRICIA MORENO CALDERON** identificado con CÉDULA DE CIUDADANÍA No 65705512 de ESPINAL (TOLIMA) Y Tarjeta Profesional No 194069-T SI tiene vigente su inscripción en la Junta Central de Contadores y desde la fecha de Inscripción.

NO REGISTRA ANTECEDENTES DISCIPLINARIOS * * *

CERTIFICADO DE PAGOS DE SEGURIDAD SOCIAL Y APORTES PARAFISCALES

DIANA PATRICIA MORENO CALDERON, identificada con cédula de ciudadanía No. 65.705.512 de El Espinal, en su calidad de Contador y **ORLANDO HERERA ORJUELA**, identificado con la cédula de ciudadanía No. 93.122.735 de El Espinal, declaran bajo la gravedad de juramento que la entidad **REDES ELECTRICAS ORLANDO HERRERA SAS**, con Nit No. 900.657.546-4, ha efectuado en forma correcta y oportuna durante la ejecución del contrato y a la fecha de la presente certificación, el pago de los aportes correspondientes a la nómina de sus empleados a los Sistema de Salud, Riesgos Profesionales, Pensión y Aportes a las cajas de compensación familiar, Instituto Colombiano de Bienestar Familiar, Servicio Nacional de Aprendizaje "Sena" y Cree cuando a ello haya lugar (artículo 25 Ley 1607 de 2012) y en general los aportes parafiscales que exige la Ley, encontrándose a PAZ Y SALVO por este concepto.

Expedida a los trece (13) días del mes de junio de 2024.

Cordialmente,

Orlando Herrera O

ORLANDO HERRERA ORJUELA
C.C. No. 93.122.735 Espinal Tol.
Gerente General

Diana C. Moreno C.

DIANA PATRICIA MORENO C.
C.C. No. 65.705.512 Espinal
Contador T.P. No. 194069-**T**

DIAN

Formulario del Registro Único Tributario

001

2. Concepto 0 2 Actualización

4. Número de formulario 14997973322

(415)7707212489984(8020) 000001499797332 2

5. Número de Identificación Tributaria (NIT)	6. DV	12. Dirección seccional	14. Buzón electrónico
9 0 0 6 5 7 5 4 6	4	Impuestos y Aduanas de Ibagué 9	

IDENTIFICACIÓN

24. Tipo de contribuyente	25. Tipo de documento	26. Número de Identificación	27. Fecha expedición
Persona jurídica 1			

Lugar de expedición 28. País	29. Departamento	30. Ciudad/Municipio

31. Primer apellido	32. Segundo apellido	33. Primer nombre	34. Otros nombres

35. Razón social
REDES ELECTRICAS ORLANDO HERRERA SAS

36. Nombre comercial	37. Sigla
REDES ELECTRICAS ORLANDO HERRERA	

UBICACIÓN

38. País	39. Departamento	40. Ciudad/Municipio
COLOMBIA 1 6 9	Tolima 7 3	Espinal 2 6 8

41. Dirección principal
MZ 16 CA 21 BRR BALCANES

42. Correo electrónico		
orlandoherrera2@yahoo.com		
43. Código postal	44. Teléfono 1	45. Teléfono 2
	3 1 0 2 6 0 5 7 5 9	

CLASIFICACIÓN

Actividad económica				Ocupación	
Actividad principal		Actividad secundaria		Otras actividades			
46. Código	47. Fecha inicio actividad	48. Código	49. Fecha inicio actividad	50. Código	1	2	51. Código	52. Número establecimientos
4 2 2 0	2 0 1 3 0 9 1 0	4 3 2 1	2 0 1 3 0 9 1 0		3 3 1 2	3 3 2 0		

Responsabilidades, Calidades y Atributos

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
53. Código	5	7	9	1	4	2	4	8	5	2	5	5														

05- Impto. renta y compl. régimen ordinar
07- Retención en la fuente a título de rent
09- Retención en la fuente en el impuesto
14- Informante de exogena
42- Obligado a llevar contabilidad
48 - Impuesto sobre las ventas - IVA
- Facturador electrónico
55 - Informante de Beneficiarios Finales

Usuarios aduaneros										
	1	2	3	4	5	6	7	8	9	10
54. Código										
	11	12	13	14	15	16	17	18	19	20

Exportadores					
55. Forma	56. Tipo	Servicio	1	2	3
		57. Modo			
		58. CPC			

IMPORTANTE: Sin perjuicio de las actualizaciones a que haya lugar, la inscripción en el Registro Único Tributario -RUT-, tendrá vigencia indefinida y en consecuencia no se exigirá su renovación

Para uso exclusivo de la DIAN

59. Anexos SI [ ] NO [X] 60. No. de Folios: 0 61. Fecha 2024 - 03 - 18 / 21 : 28: 10

La información suministrada a través del formulario oficial de inscripción, actualización, suspensión y cancelación del Registro Único Tributario (RUT), deberá ser exacta y veraz; en caso de constatar inexactitud en alguno de los datos suministrados se adelantarán los procedimientos administrativos sancionatorios o de suspensión, según el caso, Parágrafo del artículo 1.6.1.2.6 del Decreto 1625 del 2016. De igual manera al formalizar el trámite el usuario fue informado y acepta la política de tratamiento de datos ley 1581 de 2012.

Firma del solicitante:

Sin perjuicio de las verificaciones que la DIAN realice.

Firma autorizada:

984. Nombre HERRERA ORJUELA ORLANDO

985. Cargo Representante legal Certificado

COPIA NO CERTIFICADO SIN COSTO

Fecha generación documento PDF: 12-06-2024 11:19:02AM

DIAN

Formulario del Registro Único Tributario

001

Espacio reservado para la DIAN

4. Número de formulario: 14997973322

(415)7707212489984(8020) **000001499797332 2**

5. Número de Identificación Tributaria (NIT)	6. DV	12. Dirección seccional		14. Buzón electrónico
9 0 0 6 5 7 5 4 6	4	Impuestos y Aduanas de Ibagué	9	

Características y formas de las organizaciones

62. Naturaleza	2	63. Formas asociativas	1 2	64. Entidades o institutos de derecho público de orden nacional, departamental, municipal y descentralizados	
65. Fondos		66. Cooperativas		67. Sociedades y organismos extranjeros	
68. Sin personería jurídica		69. Otras organizaciones no clasificadas		70. Beneficio	1

Constitución, Registro y Última Reforma

Documento	1. Constitución	2. Reforma
71. Clase	0 4	
72. Número		
73. Fecha	2 0 1 3 0 8 2 6	
74. Número de notaría		
75. Entidad de registro	0 3	
76. Fecha de registro	2 0 1 3 0 9 1 6	
77. No. Matrícula mercantil	0 0 0 0 0 0 7 6 2 2 3	
78. Departamento	7 3	
79. Ciudad/Municipio	2 6 8	
Vigencia		
80. Desde	2 0 1 3 0 8 2 6	
81. Hasta	9 9 9 9 1 2 3 1	

Composición del Capital

82. Nacional	1 0 0 %
83. Nacional público	0 . 0 %
84. Nacional privado	1 0 0 . 0 %
85. Extranjero	0 %
86. Extranjero público	0 . 0 %
87. Extranjero privado	0 . 0 %

Entidad de vigilancia y control

88. Entidad de vigilancia y control

Estado y Beneficio

Item	89. Estado actual	90. Fecha cambio de estado	91. Número de Identificación Tributaria (NIT)	92. DV
1	8 1	2 0 1 4 1 2 3 1		-
2				-
3				-
4				-
5				-

Vinculación económica

93. Vinculación económica	94. Nombre del grupo económico y/o empresarial	95. Número de Identificación Tributaria (NIT) de la Matriz o Controlante	96. DV.

97. Nombre o razón social de la matriz o controlante

170. Número de identificación tributaria otorgado en el exterior	171. País	172. Número de identificación tributaria sociedad o natural del exterior con EP	

173. Nombre o razón social de la sociedad o natural del exterior con EP

COPIA CONTROLADA

DIAN

Formulario del Registro Único Tributario
Representación

001

Espacio reservado para la DIAN

4. Número de formulario: 14997973322

(415)7707212489984(8020) 000001499797332 2

5. Número de Identificación Tributaria (NIT)	6. DV	12. Dirección seccional		14. Buzón electrónico
9 0 0 6 5 7 5 4 6	4	Impuestos y Aduanas de Ibagué	9	

Representación

1

98. Representación	99. Fecha inicio ejercicio representación
REPRS LEGAL PRIN 1 8	2 0 1 3 0 9 1 6

100. Tipo de documento	101. Número de identificación	102. DV	103. Número de tarjeta profesional
Cédula de Ciudadaní 1 3	9 3 1 2 2 7 3 5		

104. Primer apellido	105. Segundo apellido	106. Primer nombre	107. Otros nombres
HERRERA	ORJUELA	ORLANDO	

108. Número de Identificación Tributaria (NIT)	109. DV	110. Razón social representante legal

2

98. Representación	99. Fecha inicio ejercicio representación

100. Tipo de documento	101. Número de identificación	102. DV	103. Número de tarjeta profesional

104. Primer apellido	105. Segundo apellido	106. Primer nombre	107. Otros nombres

108. Número de Identificación Tributaria (NIT)	109. DV	110. Razón social representante legal

3

98. Representación	99. Fecha inicio ejercicio representación

100. Tipo de documento	101. Número de identificación	102. DV	103. Número de tarjeta profesional

104. Primer apellido	105. Segundo apellido	106. Primer nombre	107. Otros nombres

108. Número de Identificación Tributaria (NIT)	109. DV	110. Razón social representante legal

4

98. Representación	99. Fecha inicio ejercicio representación

100. Tipo de documento	101. Número de identificación	102. DV	103. Número de tarjeta profesional

104. Primer apellido	105. Segundo apellido	106. Primer nombre	107. Otros nombres

108. Número de Identificación Tributaria (NIT)	109. DV	110. Razón social representante legal

5

98. Representación	99. Fecha inicio ejercicio representación

100. Tipo de documento	101. Número de identificación	102. DV	103. Número de tarjeta profesional

104. Primer apellido	105. Segundo apellido	106. Primer nombre	107. Otros nombres

108. Número de Identificación Tributaria (NIT)	109. DV	110. Razón social representante legal

COPIA NO CONTROLADA SIN COSTO

DIAN

Formulario del Registro Único Tributario
Estado de la Empresa o Persona

001

Espacio reservado para la DIAN

4. Número de formulario: 14997973322

(415)7707212489984(8020) **000001499797332 2**

5. Número de Identificación Tributaria (NIT)	6. DV	12. Dirección seccional	14. Buzón electrónico
		Impuestos y Aduanas de Ibagué 9	

Estado y beneficio

Item	89. Estado actual	90. Fecha cambio de estado	91. Número de Identificación Tributaria (NIT)	92. DV
1	4 9	2 0 1 3 0 9 1 6		-
2				-
3				-
4				-
5				-
6				-
7				-
8				-
9				-
10				-
11				-
12				-
13				-
14				-
15				-
16				-
17				-
18				-
19				-
20				-
21				-
22				-

COPIA CONTROLADA

REDES ELECTRICAS ORLANDO HERRERA SAS
NIT.: 900-657546-4
REGIMEN COMÚN

ANEXOS:

- Certificados de garantías de baterías
- Manual de operación del control de transferencia digital instalada marca DEEP SEA electronica MODELO: 333 ATS 12V/24B DC SUPPLY, SERIAL: 4737787, REF.: DSE 333
- Manual de mantenimiento del grupo electrógeno de 350kva DIESSEL DOOSAN

ELABORÓ:	ENTIDAD	FECHA	Vo.Bo.
ORLANDO HERRERA O.	REDES ELECTRICAS ORLANDO HERRERA S.A.S.	30-abr.-2024	Orlando Herrera O

APROBÓ:	ENTIDAD	FECHA	Vo.Bo.
YAJAIRA YAZMITH PERDOMO C. SUPERVISORA	EMPRESA DE ACUEDUCTO, ALCANTARILLADO Y ASEO DEL EL ESPINAL ESP	11/06/2024	Yajaira Perdomo

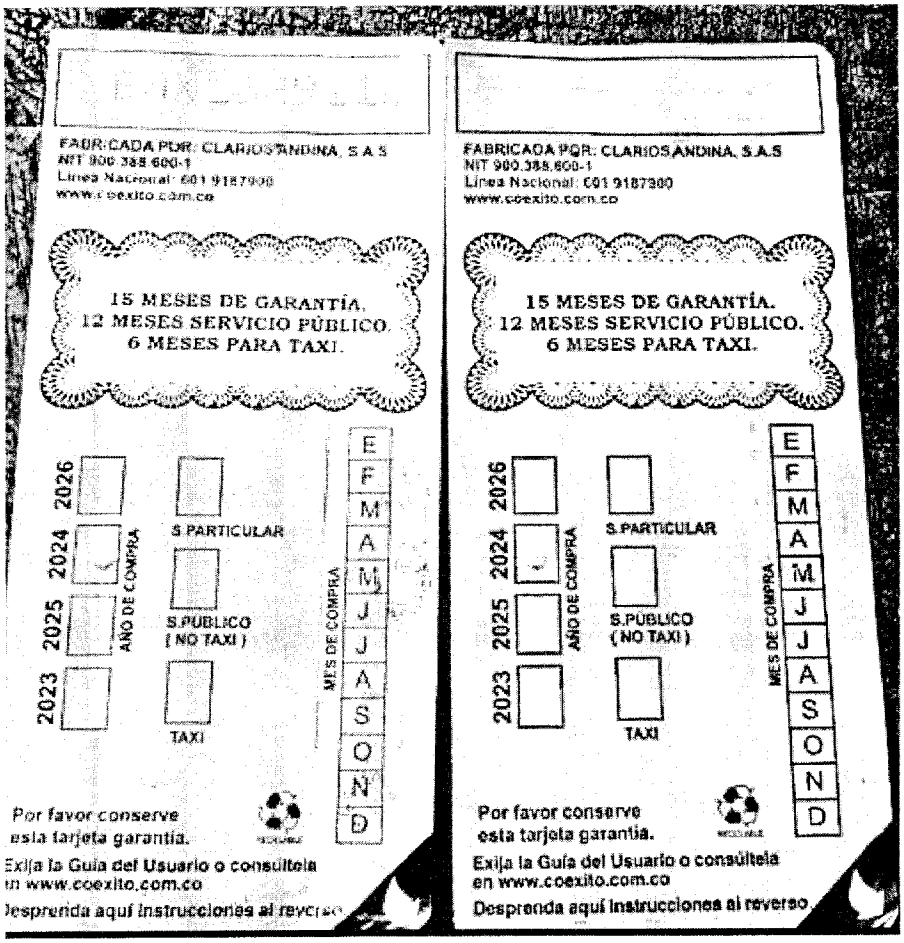
Dirección: Manzana 16 casa 21 Barrio Balkanes El Espinal
Mail: orlandoherrera2@yahoo.com
Cel: 310-2605759

REDES ELECTRICAS ORLANDO HERRERA SAS

NIT.: 900-657546-4

REGIMEN COMÚN

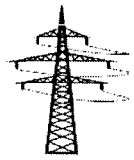
TARJETA DE GRANTIA DE BATERIAS INSTALADAS



Dirección: Manzana 16 casa 21 Barrio Balkanes El Espinal

Mail: orlandoherrera2@yahoo.com

Cel: 310-2605759



REDES ELECTRICAS ORLANDO HERRERA SAS
NIT.: 900-657546-4
REGIMEN COMÚN

Espinal, 04 de junio de 2024

Ingeniera:
YAJAIRA YAZMITH PERDOMO C.
Profesional Universitario 219-02- potabilización de agua y saneamiento hídrico
Empresa de acueducto, alcantarillado y aseo del El Espinal ESP

ASUNTO: INFORME DE EJECUCION DEL CONTRATO DE MANTENIMIENTO No.17 - 2024, objeto: " MANTENIMIENTO CORRECTIVO DE LA PLANTA ELECTRICA DE LA PTAP Y SU RESPECTIVA TRANSFERENCIA "

En cumplimiento a **CLAUSULA SEXTA: CONDICIONES TECNICAS Y OBLIGACIONES DEL CONTRATISTA. – ESPECIFICAS** - Numeral 1. Realizar mantenimiento preventivo a la planta eléctrica ubicadas en la PTAP, realizando el servicio descrito en el numeral 3 Condiciones técnicas del contrato, 2. Realizar un informe detallado del mantenimiento correctivo de la planta eléctrica ubicada en la PTAP, presentando recomendaciones, observaciones y registro fotográfico, y **CLAUSULA QUINTA: FORMA DE PAGO**, me permito presentar el informe de actividades desarrolladas para la certificación de ejecución y entrega a satisfacción del contrato de mantenimiento contratado.

INFORMACION GENERAL DE L CONTRATO DE MANTENIMIENTO

TIPO DE CONTRATO	CONTRATO DE MANTENIMIENTO No.17 -2024
OBJETO	MANTENIMIENTO CORRECTIVO DE LA PLANTA ELECTRICA DE LA PTAP Y SU RESPECTIVA TRANSFERENCIA.
VALOR	CINCUENTA Y DOS MILLONES DOSCIENTOS SESENTA Y CUATRO MIL OCHOCIENTOS PESOS ($52,264,800) M/CTE, Valor incluido IVA.
PLAZO	TRES (03) MESES, CONTADOS A PARTIR DE LA LEGALIZACIBN Y PERFECCIONAMIENTO DE LA MISMA.
CONTRATANTE	EMPRESA DE ACUEDCUTO Y ALCANTARILLADO Y ASEO DEL ESPINAL E.S.P
CONTRATISTA	REDES ELECTRICAS ORLANDO S.A.S

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Cel: 310-2605759

REDES ELECTRICAS ORLANDO HERRERA SAS
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PROPUESTA PRESENTADA Y CONDICIONES TÉCNICAS

GRUPO ELECTROGENO PLANTA ELECTRICA 350KVA - PTAP			
1	***MANTENIMIENTO PREVENTIVO MOTOR DIESSEL DOOSAN***	GLOBAL	1
	Servicio técnico, incluye mantenimiento general, cambio de aceite y filtros, cambio de refrigerante, limpieza general, ajuste de correas, lavado de tanque de combustible, corrección de fugas, mantenimiento motor de arranque y alternador, calibración sistema de inyección, calibración de motor y turbo, despegue de motor y pruebas de funcionamiento; y los siguientes insumos: Refrigerante premezclado compleat, Aceite motor SAE 15w40 API CK-4, Filtro de aire externo PA1885, Filtro combustible Fleetguard FS1212, Filtro aceite MD315 B96 - LF 670 y Baterias		
	MANTENIMIENTO PREVENTIVO GENERADOR ELECTRICO YANAN 350KVA		
	Servicio técnico, incluye (desmonte y montaje de generador para mantenimiento general, cambio de rodamiento, limpieza, pintura con barniz dieléctrico (rotor, estator y excitatriz), ajuste de cableado de potencias y control, ajuste de parámetros de la reguladora de voltaje y pruebas de funcionamiento), y el siguiente insumo: cojinete de rotor nuevo para generador		
	SUMINISTRO E INSTALACION DE <u>CONTROLADOR</u> PARA TRANSFERENCIA DIGITAL DEEPSEA		
	Servicio técnico para instalación del control de transferencia digital marca Deepsea, con protecciones por sobre voltaje, desbalance de voltaje, falla de encendido del generador, falla por frecuencia en planta, censado independiente de las 3 fases, falla por sobrecorriente, desbalance de cargas, salidas y entradas análogas y binarias configurables, página de diagnóstico de acceso fácil a través de PC, muestra un resumen de los estados de salida, además cuenta con línea de comunicación remota Rs485-232 y vía internet. incluye. accesorios, cableado general, relevos, bases, protecciones eléctricas, selectores, terminales, conectores, borneras riel, entre otros, pruebas de funcionamiento y capacitación.		

ACTIVIDADES DESARROLLADAS

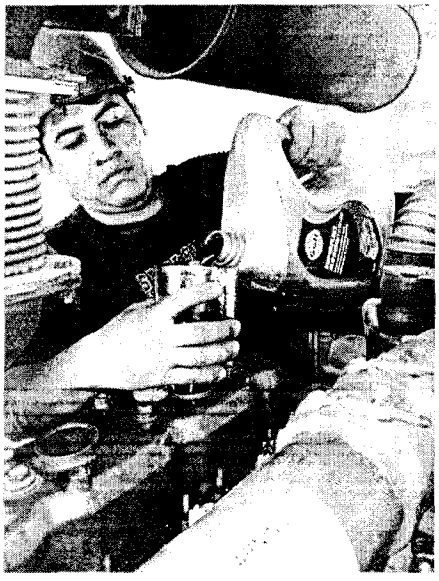
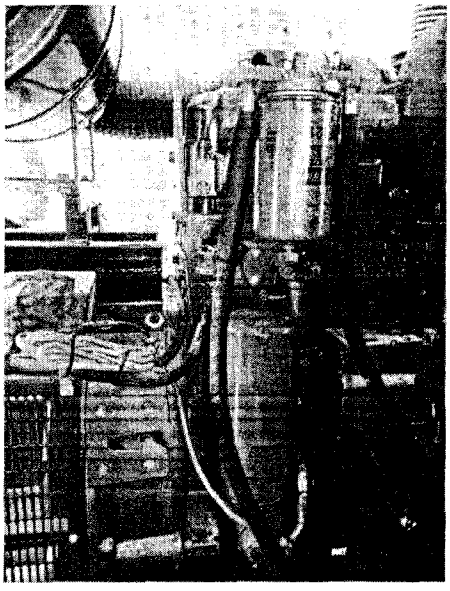
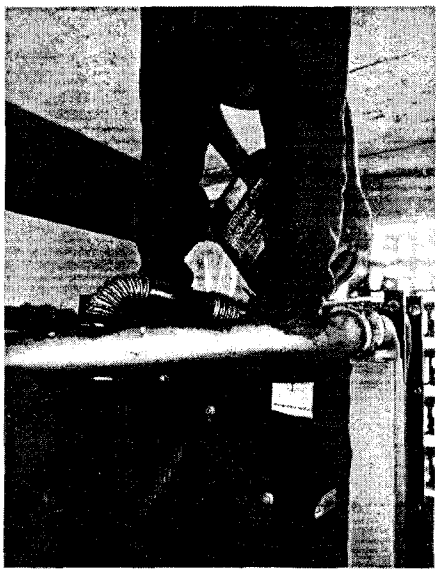
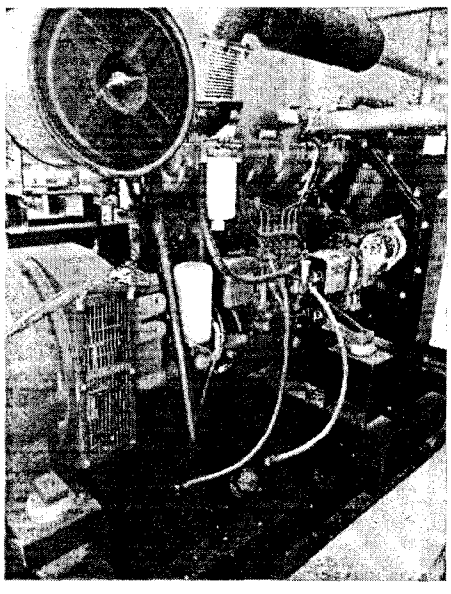
<u>MANTENIMIENTO PREVENTIVO MOTOR DIESSEL CUMMINS DOOSAN</u>

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CAMBIO DE ACEITE DE MOTOR	**FILTROS ACEITE Y COMBUSTIBLE**
	
CAMBIO DE REFRIGERANTE	**AJUSTE DE CORREAS**

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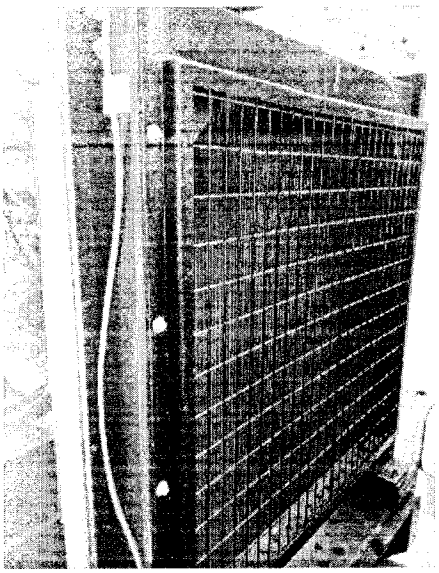
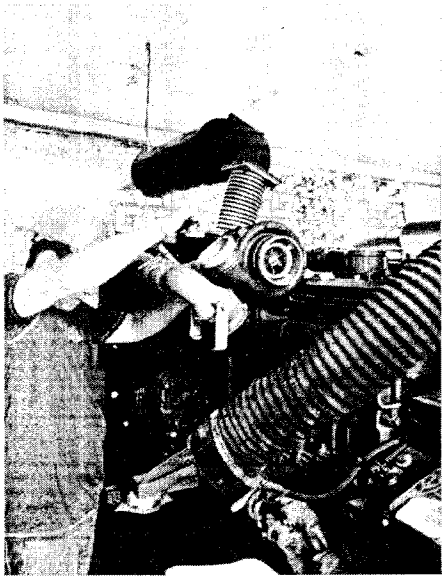
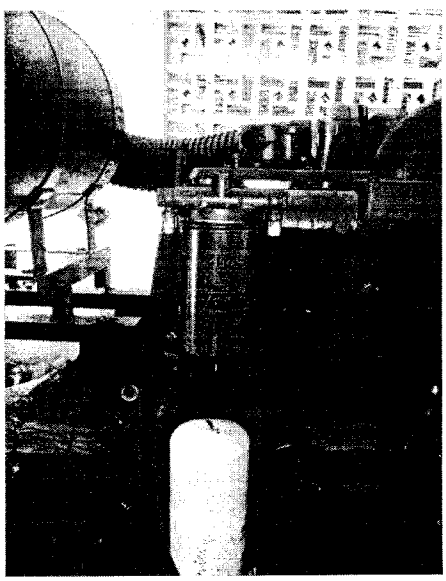
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LIMPIEZA GENERAL	**AJUSTE CORREAS**
	
LAVADO DE TANQUE DE COMBUSTIBLE	**CAMBIO FILTROS COMBUSTIBLE**

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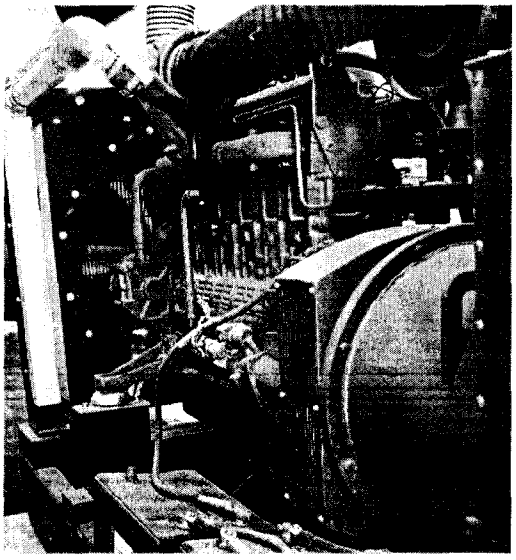
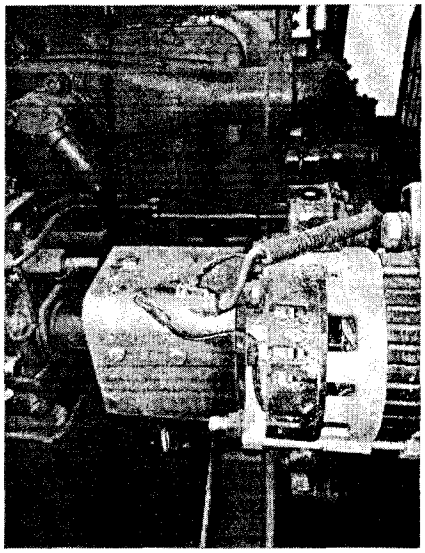
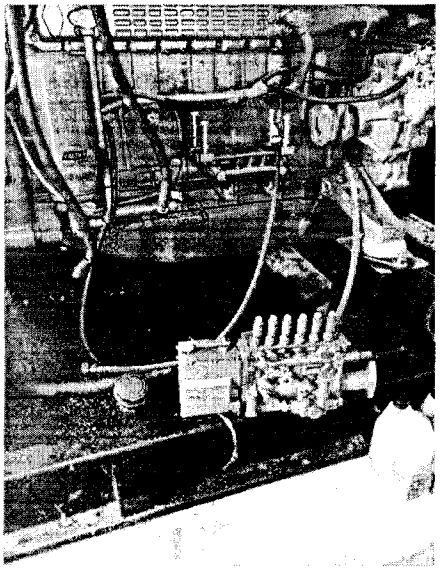
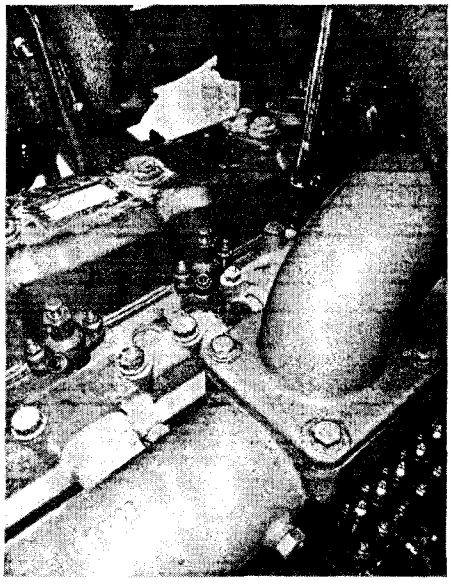
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DIAGNOSTICO ARRANQUE	**DIAGNOSTICO ALTERNADOR**
	
CALIBRACIÓN BOMBA DE INYECCIÓN	**CALIBRACION INYECTORES**

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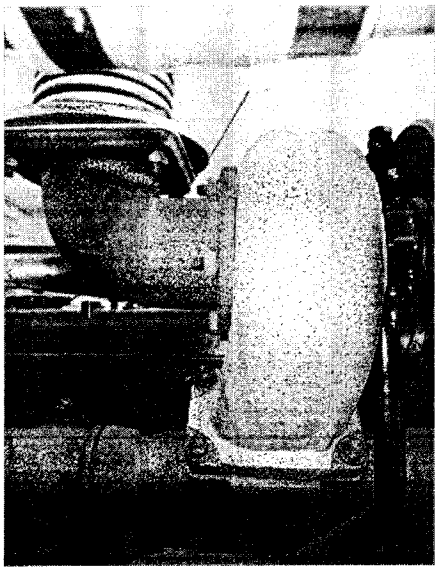
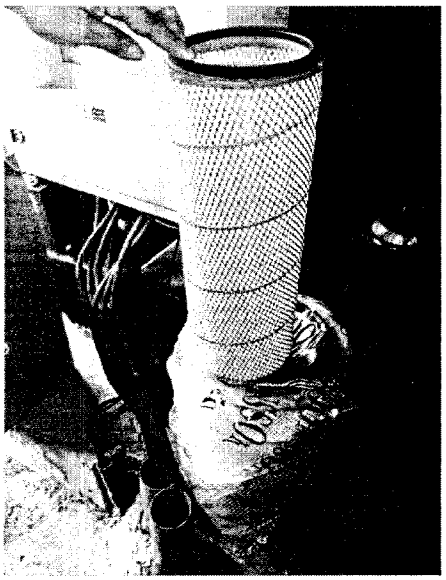
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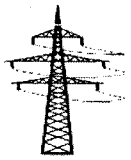
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CALIBRACIÓN DE MOTOR Y TURBO	**CAMBIO FILTROS DE AIRE**
	
CAMBIO DE BATERIAS	**PUESTA EN FUNCIONAMIENTO**

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OBSERVACIONES

Los grupos electrógenos están diseñados para trabajar a su máxima potencia y por eso su correcto cuidado y mantenimiento es esencial para que lo hagan de forma óptima. Todos los equipos deben trabajar al menos a un 50% de su carga de energía, y uso continuado a porcentajes inferiores (< 50%); –a baja carga– es contraproducente y puede tener graves consecuencias cuando un motor funciona con poca, carga no llega a alcanzarse la temperatura ideal de operación del motor.

Efectos negativos de tener un grupo electrógeno a baja carga:

1. Grandes acumulaciones de hollín (carbonilla) en los pistones, en los surcos de los aros de los pistones, las válvulas y el turbocargador. Si después el motor funciona a carga completa los pistones pueden bloquearse por un mal engrase.
2. Las bajas temperaturas darán como resultado una insuficiente combustión del combustible que causará la dilución del aceite lubricante y pérdida de propiedades del mismo, al bajar parte del combustible al aceite.
3. Pulido de las camisas de los cilindros. Desgaste excesivo.
4. El combustible no consumido y el aceite lubricante penetrarán también en el múltiple de escape y eventualmente saldrán a través de las juntas de este, siendo muy evidente –casi escandaloso- por su aspecto quemado, por lo que mancha bastante

Hay que estar en alerta cuando:

1. El motor desprende aceite mezclado con combustible por el colector de escape –incluso por la salida del escape– o por el silenciador.
2. Hay derrame de aceite, goteo de aceite muy oscuro como quemado.
3. Cuando el escape expulsa humo blanco, se aprecia más humo del habitual o sale hollín por la salida del escape al exterior directamente.
4. Las válvulas y tuberías están atascadas por la suciedad (presencia de carbonilla).

RECOMENDACIONES:

1. Si se les da el mantenimiento adecuado, los grupos electrógenos a diésel pueden funcionar con cargas ligeras durante largos períodos sin efectos nocivos. Después de operar a niveles bajos de carga, cada grupo electrógeno afectado debe operar a una carga mayor para aumentar la temperatura y la presión del cilindro, lo que limpia los depósitos de la cámara de combustión. Además, si se espera que la operación de carga baja ocurra regularmente, un plan de mantenimiento más agresivo ayudará a garantizar que no haya un desgaste excesivo de los componentes y que se minimicen las posibilidades de tiempo de inactividad no planificado.

2. Se debe realizar cambio de aceite y filtros cada 250 horas o seis meses por recomendación del fabricante.

3. Encender el grupo electrógeno una vez por semana durante 15 minutos aproximadamente

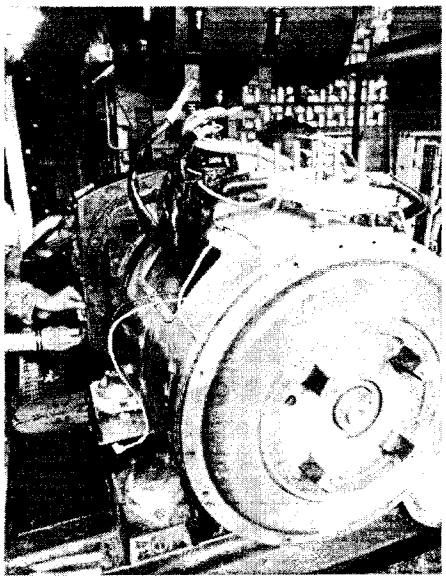
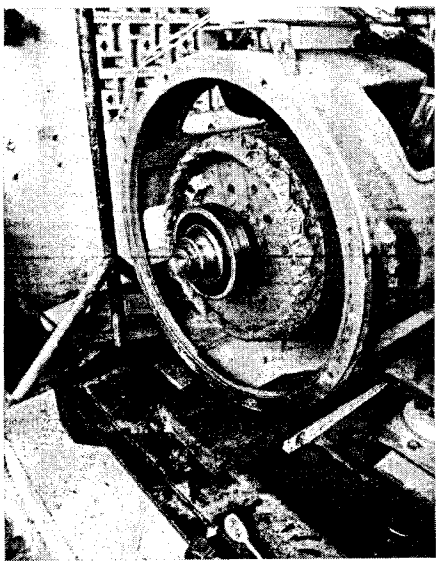
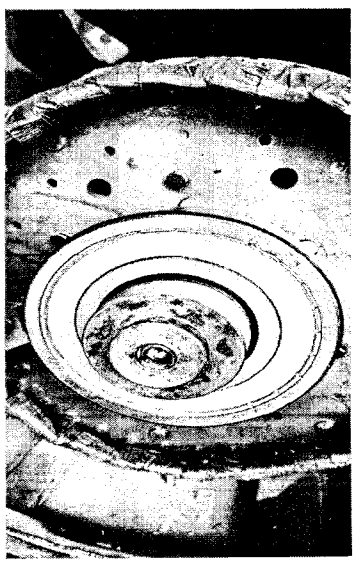
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MANTENIMIENTO PREVENTIVO GENERADOR ELECTRICO YANAN 350KVA

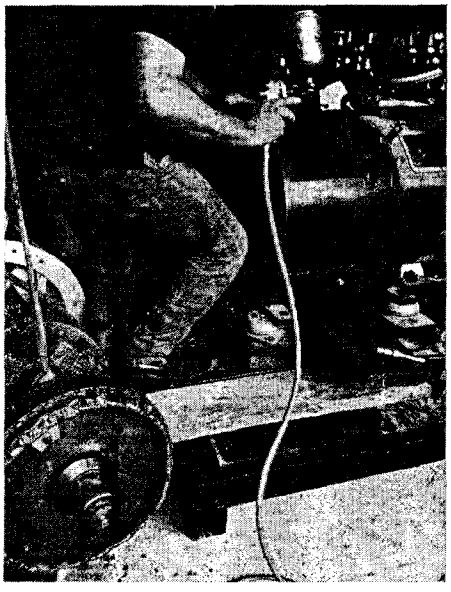
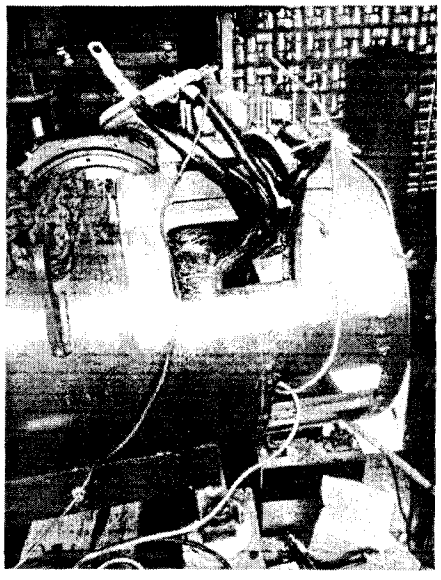
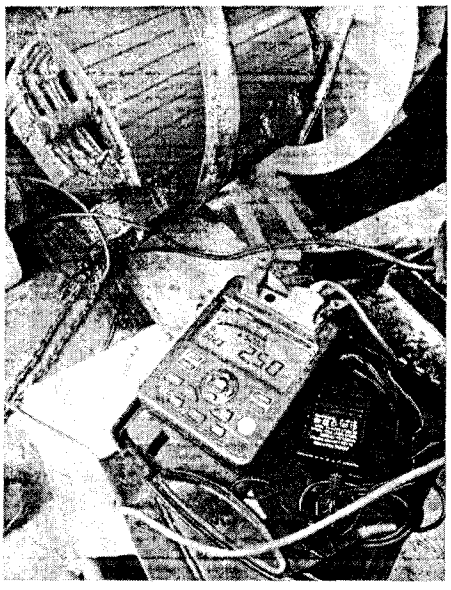
	
DESMONTE DE GENERADOR PARA MANTENIMIENTO GENERAL	MONTAJE DE GENERADOR
	
CAMBIO DE RODAMIENTO	CAMBIO DE RODAMIENTO

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PINTURA CON BARNIZ DIELÉCTRICO (ROTOR, ESTATOR Y EXCITATRIZ)	**PINTURA CON BARNIZ DIELÉCTRICO (ROTOR, ESTATOR Y EXCITATRIZ)**
	
AJUSTE DE CABLEADO DE POTENCIAS Y CONTROL	**AJUSTE DE PARÁMETROS DE LA REGULADORA DE VOLTAJE**

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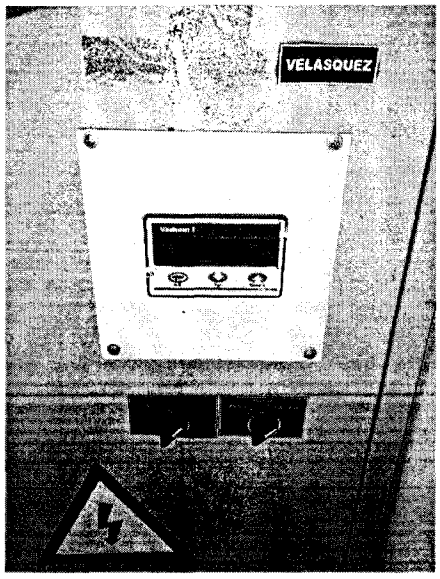
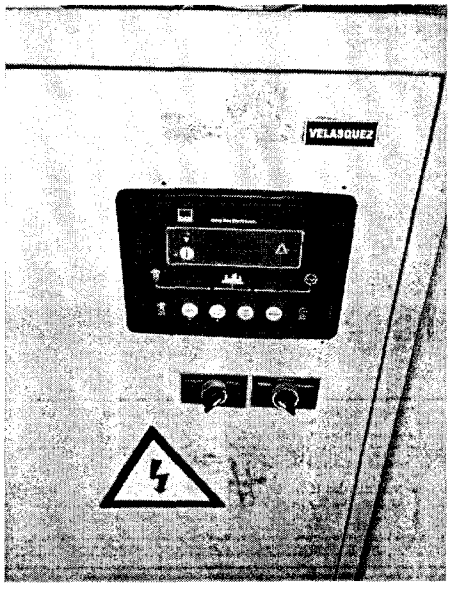
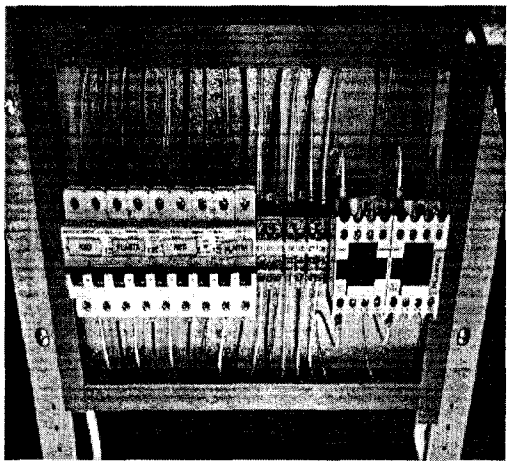
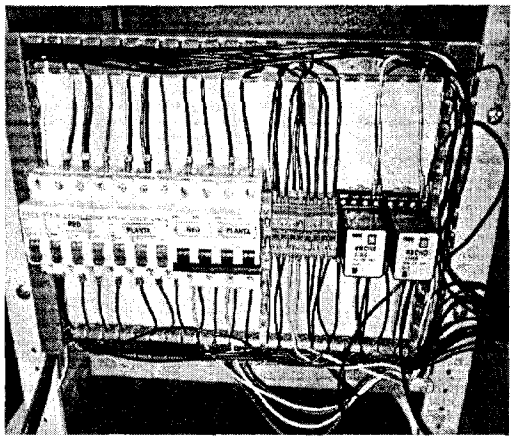
	
PRUEBAS DE FUNCIONAMIENTO	**PRUEBAS DE FUNCIONAMIENTO**

SUMINISTRO E INSTALACION DE CONTROLADOR PARA TRANSFERENCIA DIGITAL DEEPSEA

EL CUAL INCLUYE: protecciones por sobre voltaje, desbalance de voltaje, falla de encendido del generador, falla por frecuencia en planta, censado independiente de las 3 fases, falla por sobrecorriente, desbalance de cargas, salidas y entradas análogas y binarias configurables, página de diagnóstico de acceso fácil a través de PC, muestra un resumen de los estados de salida, además cuenta con línea de comunicación remota Rs485-232 y vía internet. incluye. accesorios, cableado general, relevos, bases, protecciones eléctricas, selectores, terminales, conectores, borneras riel y tranformadores de corriente tipo ventana de 1000/5 amp.

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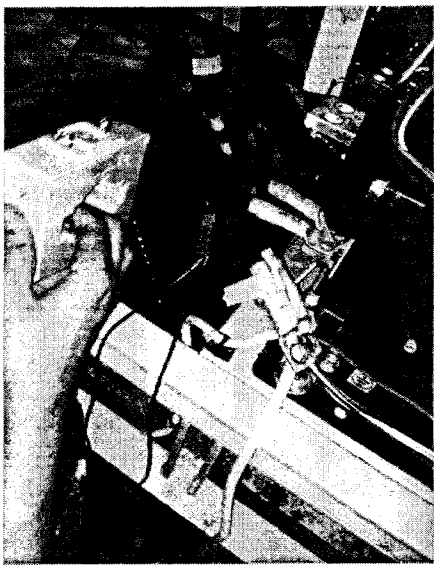
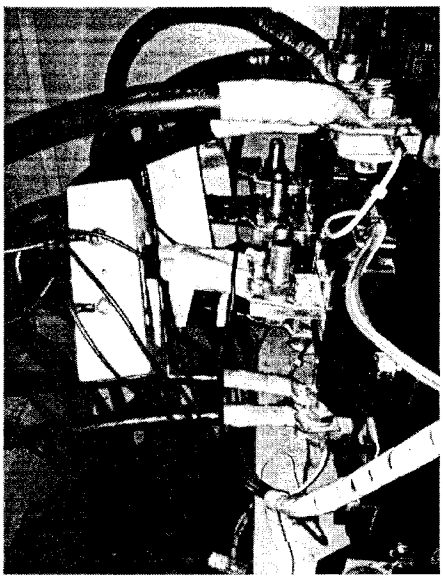
	
CONTROL DE TRANSFERENCIA EXISTENTE	CONTROL DE TRANSFERENCIA DIGITAL MARCA DEEP SEA ELECTRONICA NUEVO
	
ESTADO INICIAL DEL SISTEMA DE TRANSFERENCIA	INSTALACION: PROTECCIONES POR SOBRE VOLTAJE, DESBALANCE DE VOLTAJE, FALLA DE ENCENDIDO DEL GENERADOR Y FALLA POR FRECUENCIA EN PLANTA

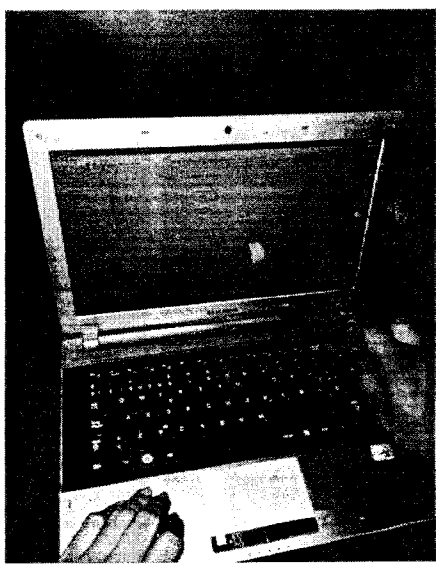
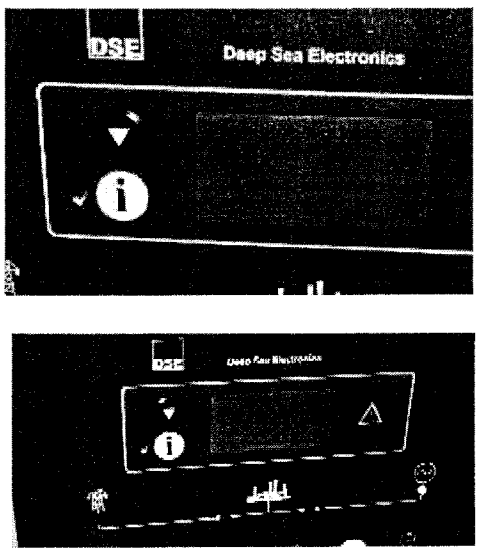
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NO EXISTIEN TRANFORMADORES DE CORRIENTE	**INSTALACION DE TRANFORMADORES DE CORRIENTE DE 1000/5 amp**

	
PARAMETRIZACION DEL CONTROLADOR SUMINISTRADO	**PRUEBAS DE FUNCIONAMIENTO**

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ANEXOS:

- Certificados de garantías de baterías
- Manual de operación del control de transferencia digital instalada marca DEEP SEA electronica MODELO: 333 ATS 12V/24B DC SUPPLY, SERIAL: 4737787, REF.: DSE 333
- Manual de mantenimiento del grupo electrógeno de 350kva DIESSEL DOOSAN

ELABORÓ:	ENTIDAD	FECHA	Vo.Bo.
ORLANDO HERRERA O.	REDES ELECTRICAS ORLANDO HERRERA S.A.S.	30-abr.-2024	Orlando Herrera O

APROBÓ:	ENTIDAD	FECHA	Vo.Bo.
YAJAIRA YAZMITH PERDOMO C. SUPERVISORA	EMPRESA DE ACUEDUCTO, ALCANTARILLADO Y ASEO DEL EL ESPINAL ESP	11/06/2024	Yajaira Perdomo

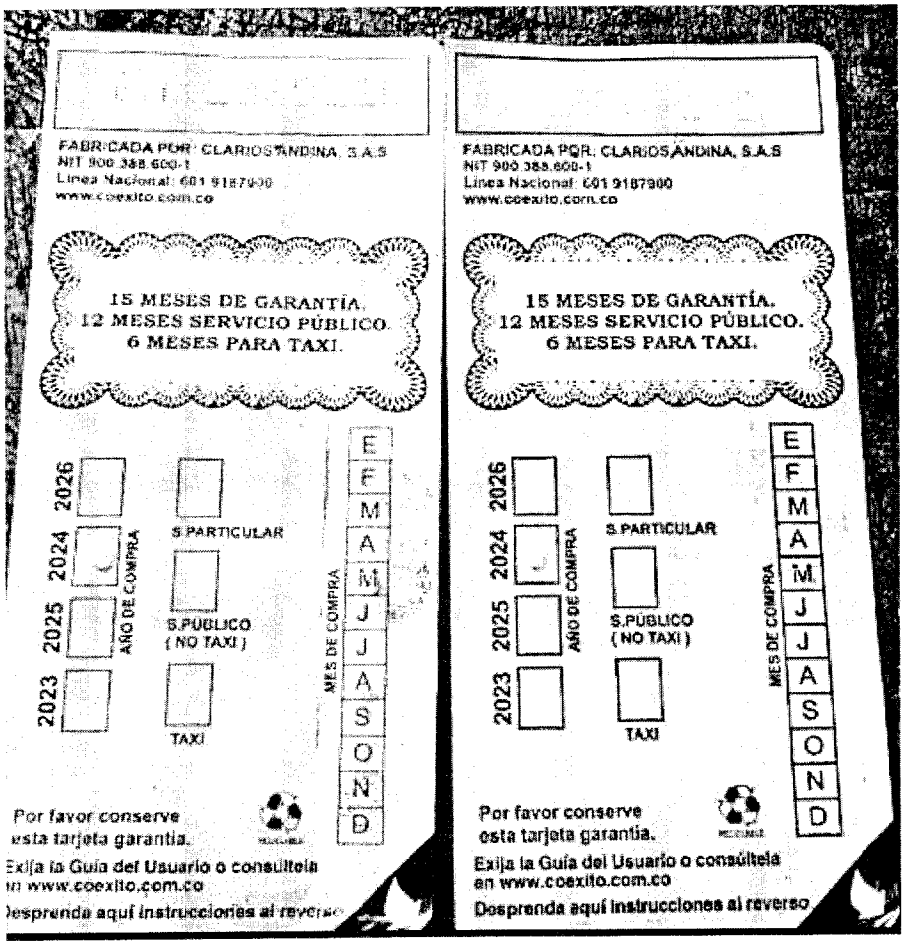
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TARJETA DE GRANTIA DE BATERIAS INSTALADAS

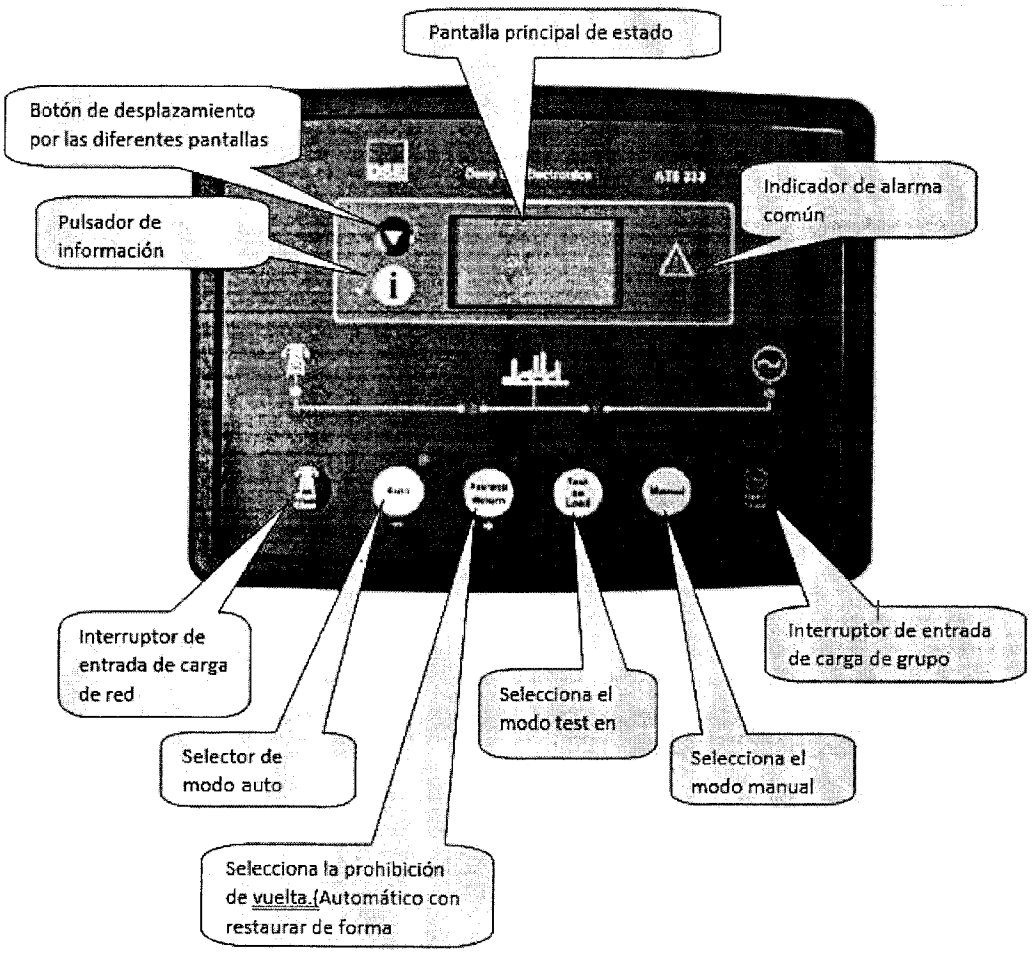


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PROTOCOLO DE FUNCIONAMIENTO DEEPSEA 333

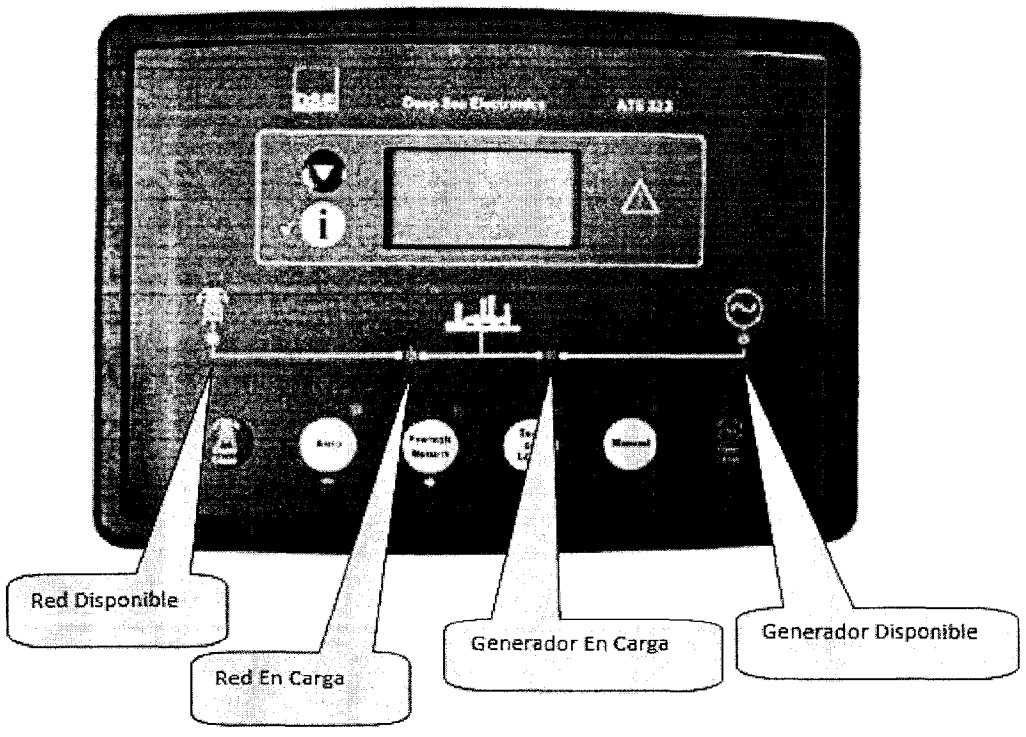


Este botón coloca el módulo en modo "**Automático**". Este modo permite al módulo controlar la función de la conmutación de forma totalmente automática. El módulo monitorea la entrada de arranque remoto y el estado de la alimentación de la red y si aparece una petición de arranque, Dará orden de arranque al generador y lo pondrá en carga.

Tras la eliminación de la señal de arranque remoto, (o que vuelva la red), El módulo transferirá la carga desde el generador hasta la red y quitará la orden de arranque del generador.



Para más detalles, véase la descripción más detallada de "Operación Automática" en este manual.	
Este botón coloca el módulo en modo "Automático" como en el modo anterior, pero no transfiere la carga a la red cuando ésta vuelve. Esta operación a veces es llamada "RESTAURACIÓN MANUAL"	Prohibit Return
Una vez en **Test on Load mode (Test en Modo Carga)** el módulo enviará una orden de arranque al generador y pondrá el generador en carga. El conjunto permanecerá en carga cuando esté en este modo.	Test on Load
Este modo permite el control manual de las funciones ATS. Una vez en modo Manual, el módulo enviará una orden de arranque al generador. Los interruptores se pueden abrir y cerrar usando los botones de transferencia detallados a continuación.	Manual



Este botón cambia entre las diferentes páginas sobre: Estado, Instrumentación, Alarmas, Registro de Eventos, Indicadores LCD.	
Este botón se desplaza por los elementos de la página mostrada en ese momento.	

Pulsando este botón cuando la red está en carga, abrirá el interruptor de carga de red. Pulsando este botón cuando el generador está en carga y la red está dentro de los parámetros previstos, abrirá el interruptor del generador, esperará a que transcurra el retardo de transferencia, tras el cual cerrará el interruptor de red.	
Pulsando este botón cuando el generador está en carga, abrirá el interruptor del generador. Pulsando este botón cuando la red está en carga y el generador está disponible, abrirá el interruptor de la red, esperará a que transcurra el retardo de transferencia y entonces cerrará el interruptor del generador.	

FUNCIONAMIENTO

MODO DE OPERACIÓN AUTOMÁTICA

⚠NOTA: Si una entrada digital configurada como bloqueo de panel está activada, no será posible usar los pulsadores del frontal, (no responderán). La visualización de los instrumentos y registros de enventos no se verán afectados por el bloqueo del panel.

Activar el modo automático presionando el pulsador **Auto.**

El modo automático permitirá al sistema de transferencia operar de forma completamente automática, arrancando y parando el generador sin necesidad de intervención del usuario.

ESPERA EN MODO AUTOMÁTICO

Si se presenta una orden de arranque y no hay una entrada digital activada con inhibición de auto arranque, la orden de arranque comenzará.

La orden de arranque puede venir por una de siguientes causas:

- Fallo de Red
- Activación de una entrada digital que ha sido configurada como arranque remoto.

- Activación del programador horario interno.

SECUENCIA DE ARRANQUE

Para prevenir arranques indeseados, comienza el tiempo de retardo de arranque.

Si todas las órdenes de arranque desaparecen durante el tiempo de retardo de arranque, la unidad volverá a su estado de espera.

Si una orden de arranque está presente cuando termine el tiempo de retardo del arranque, el módulo enviará la orden de arranque al motor.

Si el generador se muestra disponible antes de que el tiempo del temporizador de fallo del generador termine. Esto es indicado en la pantalla LCD, pero la señal de arranque sigue activa.

GENERADOR EN CARGA

Una vez que los parámetros del generador están dentro de los límites, (y la señal de que el generador está dentro de límites) se desactiva el interruptor de red a la carga y después de que el tiempo de transferencia termine, el interruptor de grupo se cierra poniéndolo en carga.

Si todas las señales de arranque desaparecen y no hay entrada presente de inhibición de auto restablecimiento, la secuencia de parada comenzará.

SECUENCIA DE PARADA

El temporizador de retorno funciona para asegurarse de que la orden de arranque ha desaparecido completamente y no es por un corto espacio de tiempo.

Después del tiempo de retardo de vuelta, el interruptor de carga del generador se abre, entonces después del tiempo de transferencia, se cierra el interruptor de carga de la red.

Si aparece otra petición de arranque durante el tiempo de enfriamiento, entonces el generador se volverá a conectar a la carga.

El tiempo de enfriamiento permite desconectar la carga, permaneciendo el generador en marcha durante el tiempo suficiente para que se enfríe antes de pararse. Esto es particularmente importante en motores con turbo.

Después de que termine el tiempo de enfriamiento el generador se detiene.

⚠NOTA: Si se desconecta la alimentación del módulo, este recordará el último modo de funcionamiento. Y volverá a ese estado una vez que la alimentación vuelva a ser conectada.

MODO MANUAL

NOTA: Si una entrada digital configurada como bloqueo de panel está activada, no será posible usar los pulsadores del frontal, (no responderán). La visualización de los instrumentos y registros de enventos no se verán afectados por el bloqueo del panel.

El modo manual permite al usuario arrancar y parar el generador manualmente, y si es necesario cambiar el estado de la carga entre los dispositivos. El modo manual sin carga es activado cuando se presiona el pulsador "**Manual**".

SECUENCIA DE ARRANQUE

NOTA: No hay ningún retardo en este modo de operación.

La orden de arranque se envía al generador a través del relé de salida start/run.

Si el generador aparece como correcto antes de que pase el tiempo de fallo de generador esto se indica en la pantalla LCD, pero la orden de arranque permanece activa.

GENERADOR SIN CARGA

El generador sigue funcionando **FUERA DE CARGA** a no ser que:

- Falle la alimentación de red.
- Se active una entrada programada como fallo de red auxiliar.
- Se active una entrada programada como transferir al generador.
- Apretando los pulsadores del frontal del panel (cuando han sido configurados)

GENERADOR EN CARGA

Una vez que está en carga, el generador permanecerá en este estado a menos que:

- Se active una entrada programada como transferir a la red.
- Apretando los pulsadores del frontal del panel (cuando han sido configurados)
- Cambiando el módulo a modo STOP\RESET O AUTOMATICO. El sistema puede entonces transferir a la red de forma automática si los parámetros de esta son los adecuados.

OPERACIÓN DE TRANSFERENCIA POR PULSADORES

Se suministran dos pulsadores colocados en el frontal para realizar la transferencia de carga en modo manual. El funcionamiento de estos pulsadores puede ser activados/desactivados en al módulo a través del software ¨PC configuración suite¨. Debe revisar el archivo de configuración para ver si ha habilitado los pulsadores.

Presionando este pulsador cuando la red está en carga abrirá el interruptor de red. Presionando este pulsador cuando el generador está en carga y la red está dentro de parámetros, abrirá el interruptor del generador, esperará durante el tiempo de retardo de transferencia y después cerrará el interruptor de red.	
Presionando este pulsador cuando el generador está en carga, abrirá el interruptor del generador. Presionando este pulsador cuando la red está en carga y el generador está disponible, abrirá el interruptor de red, esperará durante el tiempo de retardo de transferencia y entonces cerrará el interruptor del generador.	

SECUENCIA DE PARADA

El generador no parará en este modo de operación.

Para comenzar con la secuencia de parada, el módulo tendrá que ser puesto en AUTOMÁTICO O EN PROHIBICION DE VUELTA.

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DSE333 ATS Control Module

Document Number 057-118

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DSE Model 333 ATS controller Operators Manual

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Amendments since last publication

Amd. No.	Comments

Clarification of notation used within this publication.

NOTE:	Highlights an essential element of a procedure to ensure correctness.
CAUTION!	Indicates a procedure or practice, which, if not strictly observed, could result in damage or destruction of equipment.
WARNING!	Indicates a procedure or practice, which could result in injury to personnel or loss of life if not followed correctly.

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1 BIBLIOGRAPHY

This document refers to and is referred to by the following DSE publications which can be obtained from the DSE website www.deepseaplc.com

DSE PART	DESCRIPTION
053-066	333 installation instructions
057-106	DSE332 / DSE333 Configuration Suite manual

2 INTRODUCTION

This document details the installation and operation requirements of the DSE333 Series modules, part of the DSEUltra® range of products.
The manual forms part of the product and should be kept for the entire life of the product. If the product is passed or supplied to another party, ensure that this document is passed to them for reference purposes.
This is not a *controlled document.* You will not be automatically informed of updates. Any future updates of this document will be included on the DSE website at www.deepseaplc.com

The **DSE 333 series** module has been designed to allow the operator to control the transfer of the load from one supply to another, typically the mains supply and a standby generator.
The user also has the facility to view the system operating parameters via the LCD display.

The **DSE 333** module monitors the supplies, indicating the operational status and fault conditions, automatically transferring the load to the backup supply in case of mains supply failure. The LCD display indicates the status.

The powerful microprocessor contained within the module allows for incorporation of a range of enhanced features:

- *Text based LCD display*
- ***True RMS** Voltage monitoring.*
- *Supply parameter monitoring.*
- *Fully configurable inputs for use as alarms or a range of different functions.*

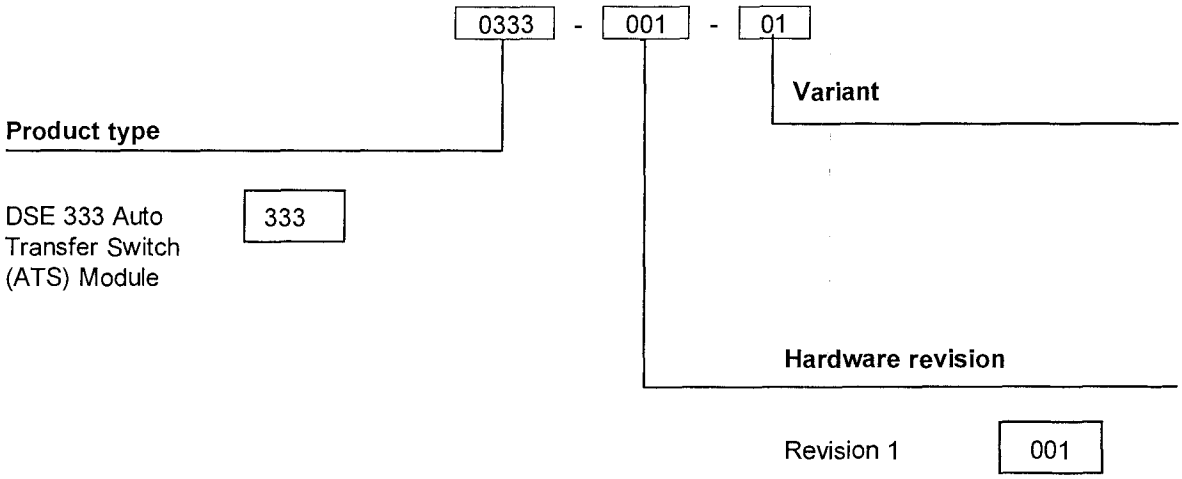
Using a PC and the DSE Configuration Suite software allows alteration of selected operational sequences, timers and alarm trips.

Additionally, the module's integral fascia configuration editor allows adjustment of this information.

A robust plastic case designed for front panel mounting houses the module. Connections are via locking plug and sockets.

3 SPECIFICATIONS

3.1 PART NUMBERING



At the time of this document production, there have been no revisions to the module hardware.

3.1 POWER SUPPLY REQUIREMENTS

Minimum supply voltage	8V continuous, 5V for up to one minute.
Cranking dropouts	Able to survive 0V for 50mS providing the supply was at least 10V before the dropout and recovers to 5V afterwards.
Maximum supply voltage	35V continuous (60V protection for one minute)
Reverse polarity protection	-35V continuous
Maximum operating current Auto mode will all inputs active and all LEDs illuminated	292mA at 12V, 167mA at 24V
Maximum standby current (Stop mode with no active inputs)	101mA at 12V, 66mA at 24V

Plant supply instrumentation display

Range	0V-35V DC (note Maximum continuous operating voltage of 35V DC)
Resolution	0.1V
Accuracy	1% of full scale

3.2 TERMINAL SPECIFICATION

Connection type	Screw terminal, rising clamp, no internal spring
Min cable size	0.5mm² (AWG 24)
Max cable size	2.5mm² (AWG 10)

3.3 MAINS VOLTAGE / FREQUENCY SENSING

Measurement type	True RMS conversion
Sample Rate	5KHz or better
Harmonics	Up to 11th or better
Input Impedance	300K Ω ph-N
Phase to Neutral	15V (minimum required for sensing frequency) to 333V AC (absolute maximum) Suitable for 110V to 277V nominal (±20% for under/overvoltage detection)
Phase to Phase	26V (minimum required for sensing frequency) to 576V AC (absolute maximum) Suitable for 190V ph-ph to 479V ph-ph nominal (±20% for under/overvoltage detection)
Common mode offset from Earth	100V AC (max)
Resolution	1V AC phase to neutral 2V AC phase to phase
Accuracy	±1% of full scale phase to neutral ±2% of full scale phase to phase
Minimum frequency	3.5Hz
Maximum frequency	75.0Hz
Frequency resolution	0.1Hz
Frequency accuracy	±0.2Hz

3.4 INPUTS

3.4.1 DIGITAL INPUTS

Number	10
Arrangement	Contact between input terminal and the module's plant supply negative terminal
Low level threshold	3.2V minimum
High level threshold	8.1V maximum
Maximum input voltage	+60V DC with respect to module's plant supply negative terminal
Minimum input voltage	-2V DC with respect to module's plant supply negative terminal
Contact wetting current	7mA ±1mA
Open circuit voltage	12V ±1V

3.5 OUTPUTS

3.5.1 GENERATOR / MAINS LOADING OUTPUTS A & B

Number	2 (Configurable outputs A & B)
Type	Volts free contacts. Output C Normally closed, Output D Normally open
Rating	8A 250V AC resistive

3.5.2 START/RUN OUTPUT C

Number	1 (Configurable output C)
Type	Volts free normally closed contact
Rating	8A @ 35V

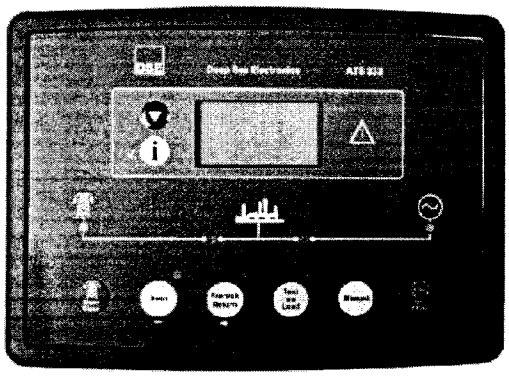
3.5.3 CONFIGURABLE OUTPUTS D & E

Number	2 (Configurable outputs D & E)
Type	Fully configurable, volts free relays. D=change over, E=normally open
Rating	8A @ 250V AC resistive
Protection	Protected against over current & over temperature. Built in load dump feature.

3.6 COMMUNICATION PORTS

USB Port	USB2.0 Device for connection to PC running DSE configuration suite only

3.7 DIMENSIONS AND MOUNTING



3.7.1 DIMENSIONS

216mm x 158mm x 42mm
(8.5" x 6.2" x 1.6")

3.7.2 PANEL CUTOUT

182mm x 137mm
(7.2" x 5.4")

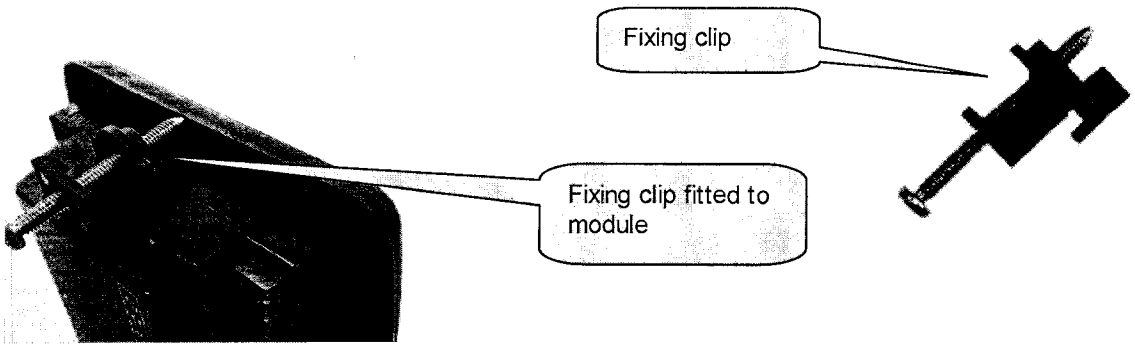
3.7.3 WEIGHT

510g (0.51kg)

3.7.4 FIXING CLIPS

The module is held into the panel fascia using the supplied fixing clips.

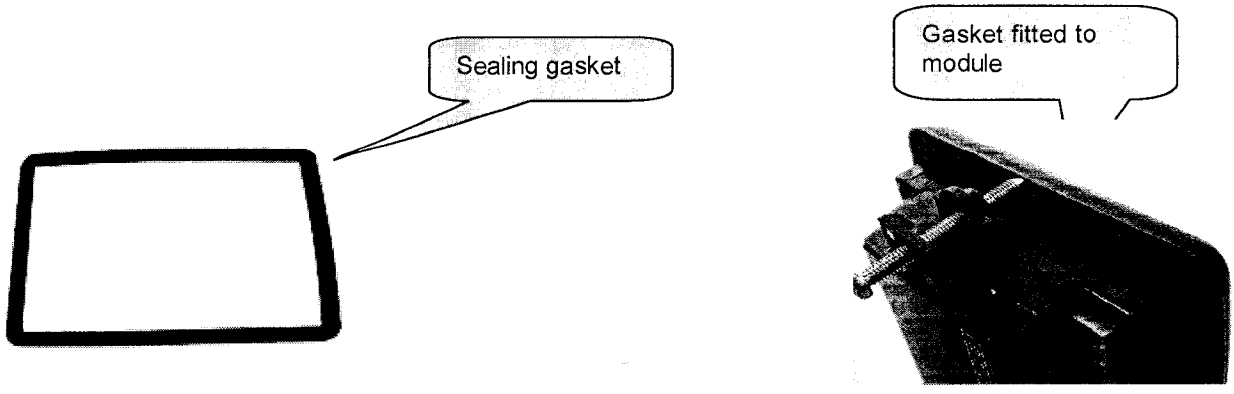
- Withdraw the fixing clip screw (turn anticlockwise) until only the pointed end is protruding from the clip.
- Insert the three 'prongs' of the fixing clip into the slots in the side of the 6000 series module case.
- Pull the fixing clip backwards (towards the back of the module) ensuring all three prongs of the clip are inside their allotted slots.
- Turn the fixing clip screws clockwise until they make contact with the panel fascia.
- Turn the screws a little more to secure the module into the panel fascia. Care should be taken not to over tighten the fixing clip screws.



NOTE:- In conditions of excessive vibration, mount the panel on suitable anti-vibration mountings.

3.7.5 OPTIONAL SILICON SEALING GASKET

The optional silicon gasket provides improved sealing between the 6000 series module and the panel fascia. The gasket is fitted to the module before installation into the panel fascia.
Take care to ensure the gasket is correctly fitted to the module to maintain the integrity of the seal.



3.8 APPLICABLE STANDARDS

BS 4884-1	This document conforms to BS4884-1 1992 Specification for presentation of essential information.
BS 4884-2	This document conforms to BS4884-2 1993 Guide to content
BS 4884-3	This document conforms to BS4884-3 1993 Guide to presentation
BS EN 60068-2-1 (Minimum temperature)	-30°C (-22°F)
BS EN 60068-2-2 (Maximum temperature)	+70°C (158°F)
BS EN 60950	Safety of information technology equipment, including electrical business equipment
BS EN 61000-6-2	EMC Generic Immunity Standard (Industrial)
BS EN 61000-6-4	EMC Generic Emission Standard (Industrial)
BS EN 60529 (Degrees of protection provided by enclosures)	IP65 (front of module when installed into the control panel with the optional sealing gasket) IP42 (front of module when installed into the control panel WITHOUT being sealed to the panel)
UL508 **NEMA rating** (Approximate)	12 (Front of module when installed into the control panel with the optional sealing gasket). 2 (Front of module when installed into the control panel WITHOUT being sealed to the panel)
IEEE C37.2 (Standard Electrical Power System Device Function Numbers and Contact Designations)	Under the scope of IEEE 37.2, *function numbers can also be used to represent functions in microprocessor devices and software programs.* The 333 series controller is device number 11L-333 (Multifunction device protecting Line (generator) – 333 series module). As the module is configurable by the generator OEM, the functions covered by the module will vary. Under the module's factory configuration, the device numbers included within the module are : 2 – Time delay starting or closing relay 30 – annunciator relay 42 – Running circuit breaker 62 – time delay stopping or opening relay 74– alarm relay 81 – frequency relay 86 – lockout relay

In line with our policy of continual development, Deep Sea Electronics, reserve the right to change specification without notice.

4 INSTALLATION

4.1 TERMINAL DESCRIPTION

4.1.1 DC SUPPLY AND OUTPUT C

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	1	DC Plant Supply Input (Negative)	2.5mm² AWG 13	
	2	DC Plant Supply Input (Positive)	2.5 mm² AWG 13	(Recommended Maximum Fuse 15A anti-surge) Supplies the module (2A anti-surge requirement) and all output relays
	3	Output C	1.0mm² AWG 18	Volts free relay normally configured to START/RUN generator (2A rated)
	4	Output C	1.0mm² AWG 18	

4.1.2 OUTPUTS D & E AND FUNCTIONAL EARTH

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	5	Output D Normally Open	1.0mm² AWG 18	Volts free relay change-over relay user configured (2A rated)
	6	Output D Common	1.0mm² AWG 18	
	7	Ouput D Normally Closed	1.0mm² AWG 18	
	8	Output E	1.0mm² AWG 18	Volts free relay user configured (2A rated)
	9	Output E	1.0mm² AWG 18	
	10	System Earth	1.0mm² AWG 18	

4.1.3 DIGITAL INPUTS

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	11	Input A	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	12	Input B	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	13	Input C	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	14	Input D	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	15	Input E	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	16	Input F	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	17	Input G	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	18	Input H	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	19	Input I	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	20	Input J	1.0mm² AWG 18	Configurable input. Connects to plant supply negative
	21	Input K	1.0mm² AWG 18	Generator ready input. Connects to plant supply Positive

4.1.4 LOAD SWITCHING AND GENERATOR SENSING

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	22	Output A	1.0mm² AWG 18	Normally configured to control mains contactor coil (Recommend 10A fuse)
	23	Output A	1.0mm² AWG 18	Normally configured to control mains contactor coil
	24	Output B	1.0mm² AWG 18	Normally configured to control generator contactor coil (Recommend 10A fuse)
	25	Output B	1.0mm² AWG 18	Normally configured to control generator contactor coil
	26	Generator L1 (U) voltage monitoring	1.0mm² AWG 18	Connect to generator L1 (U) output (AC) (Recommend 2A fuse)
	27	Generator L2 (V) voltage monitoring	1.0mm² AWG 18	Connect to generator L2 (V) output (AC) (Recommend 2A fuse)
	28	Generator 31 (W) voltage monitoring	1.0mm² AWG 18	Connect to generator L3 (W) output (AC) (Recommend 2A fuse)
	29	Generator Neutral (N) input	1.0mm² AWG 18	Connect to generator Neutral terminal (AC)

4.1.5 MAINS SENSING

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	30	Mains L1 (R) voltage monitoring	1.0mm² AWG 18	Connect to Mains L1 (R) output (AC) (Recommend 2A fuse)
	31	Mains L2 (S) voltage monitoring	1.0mm² AWG 18	Connect to Mains L2 (S) output (AC) (Recommend 2A fuse)
	32	Mains 31 (T) voltage monitoring	1.0mm² AWG 18	Connect to Mains L3 (T) output (AC) (Recommend 2A fuse)
	33	Mains Neutral (N) input	1.0mm² AWG 18	Connect to Mains Neutral terminal (AC)

4.1.6 CURRENT TRANSFORMERS

Current transformers are fitted in the feed from the transfer switch to the load. They are used to give mains instrumentation when the mains is on load, and generator instrumentation when the generator is on load.

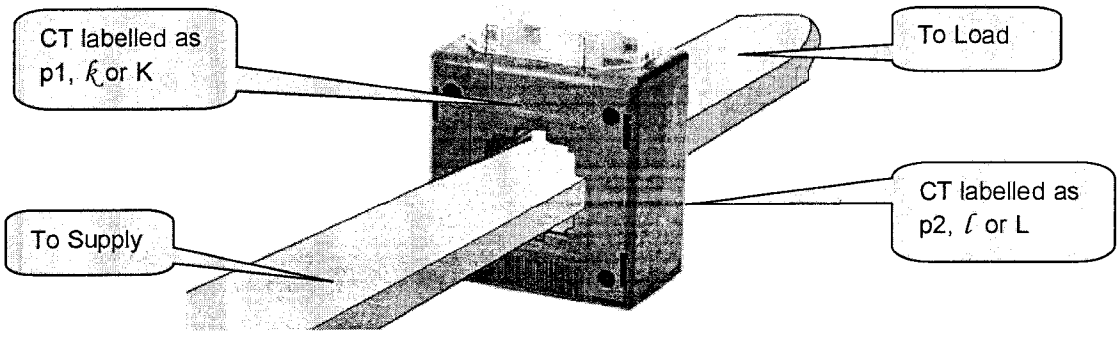
WARNING!:- Do not disconnect this plug when the CTs are carrying current. Disconnection will open circuit the secondary of the C.T.'s and dangerous voltages may then develop. Always ensure the CTs are not carrying current and the CTs are short circuit connected before making or breaking connections to the module.

NOTE:- The DSE333 series module has a burden of 0.5VA on the CT. Ensure the CT is rated for the burden of the DSE333 series controller, the cable length being used and any other equipment sharing the CT. If in doubt, consult your CT supplier.

NOTE:- When not required, the CT function can be disabled using the DSE Configuration Suite PCSoftware.

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	34	I1 Current Transformer	1.0mm² AWG 18	Connect to CT 1 (s1 / k)
	35	I2 Current Transformer	1.0mm² AWG 18	Connect to CT 2 (s1 / k)
	36	I3 Current Transformer	1.0mm² AWG 18	Connect to CT 3 (s1 / k)
	37	Current Transformer common connection	1.0mm² AWG 18	Connect to CT common (s2 / l) 37 & 38 are internally connected to each other.
	38			

NOTE:- Take care to ensure correct polarity of the CT primary as shown below. If in doubt, check with the CT supplier.



This configuration cable is the same as normally used between a PC and a USB printer.

4.1.7 PC CONFIGURATION INTERFACE CONNECTOR

	DESCRIPTION	CABLE SIZE	NOTES
USB	Socket for connection to PC with DSE Configuration Suite PC software.	0.5mm² AWG 20	This is a standard USB type A to type B cable. 

NOTE:- The USB connection cable between the PC and the DSE333 module must not be extended beyond 5m (5yds). For distances over 5m, it is possible to use a third party USB extender. Typically, they extend USB up to 50m (yds). The supply and support of this type of equipment is outside the scope of Deep Sea Electronics PLC.

CAUTION!: Care must be taken not to overload the PCs USB system by connecting more than the recommended number of USB devices to the PC. For further information, consult your PC supplier.

CAUTION!: This socket must not be used for any other purpose.

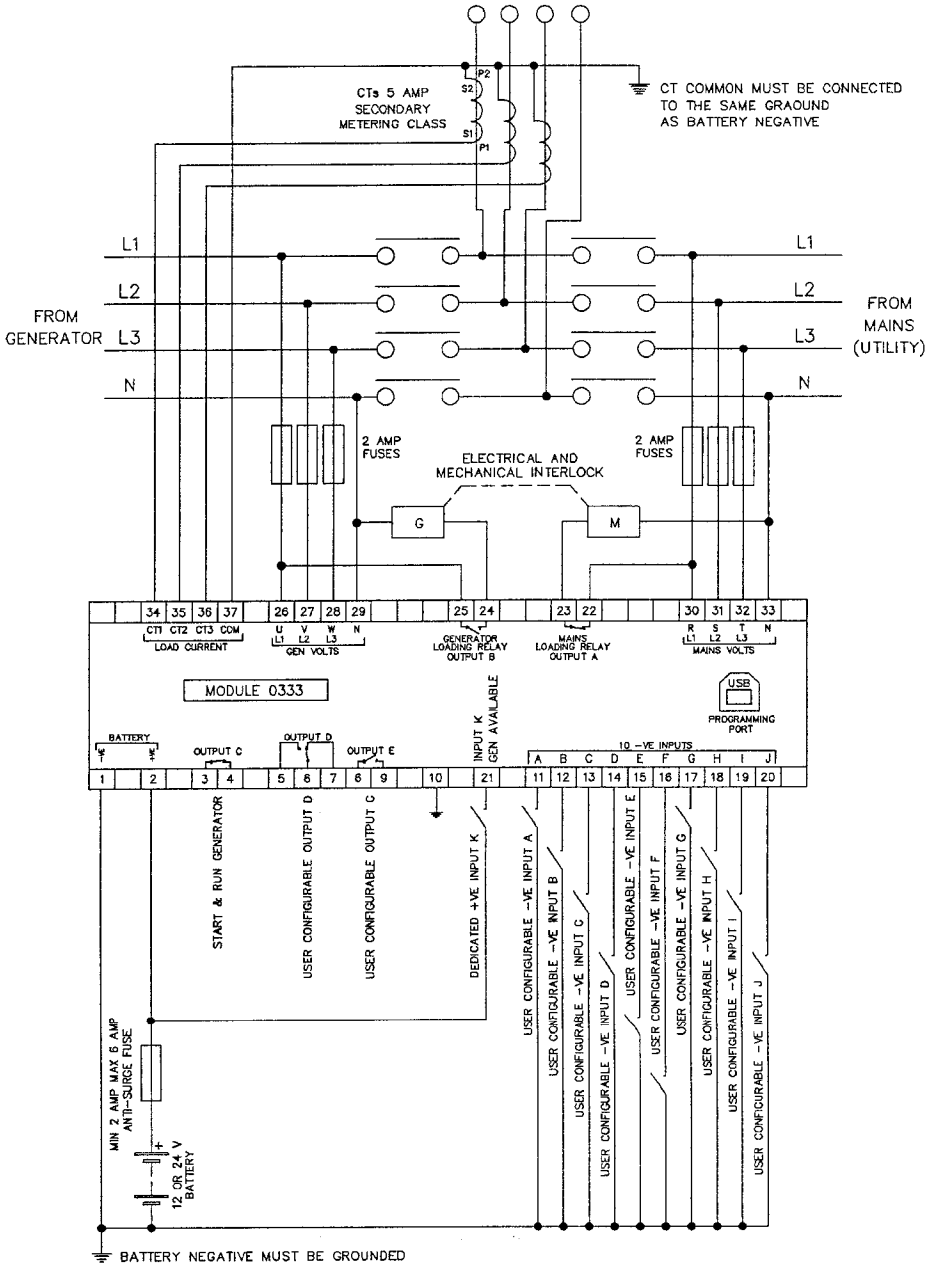
4.2 TYPICAL WIRING DIAGRAM

As every system has different requirements, these diagrams show only a TYPICAL system and do not intend to show a complete system.

Genset manufacturers and panel builders may use these diagrams as a starting point, however you are referred to the completed system diagram provided by your system manufacturer for complete wiring detail.

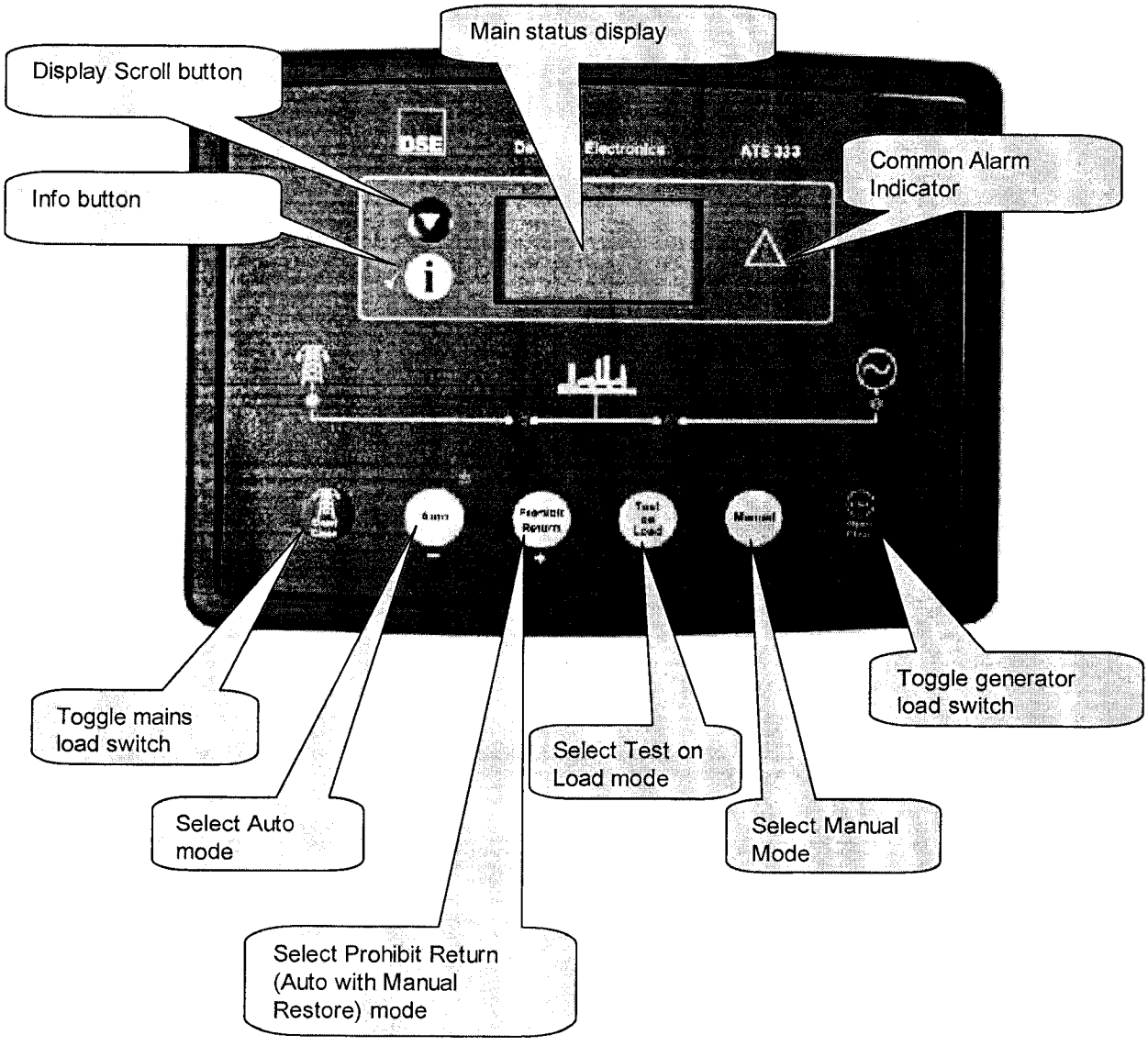
Further wiring suggestions are available in the following DSE publication, available at www.deepseaplc.com.

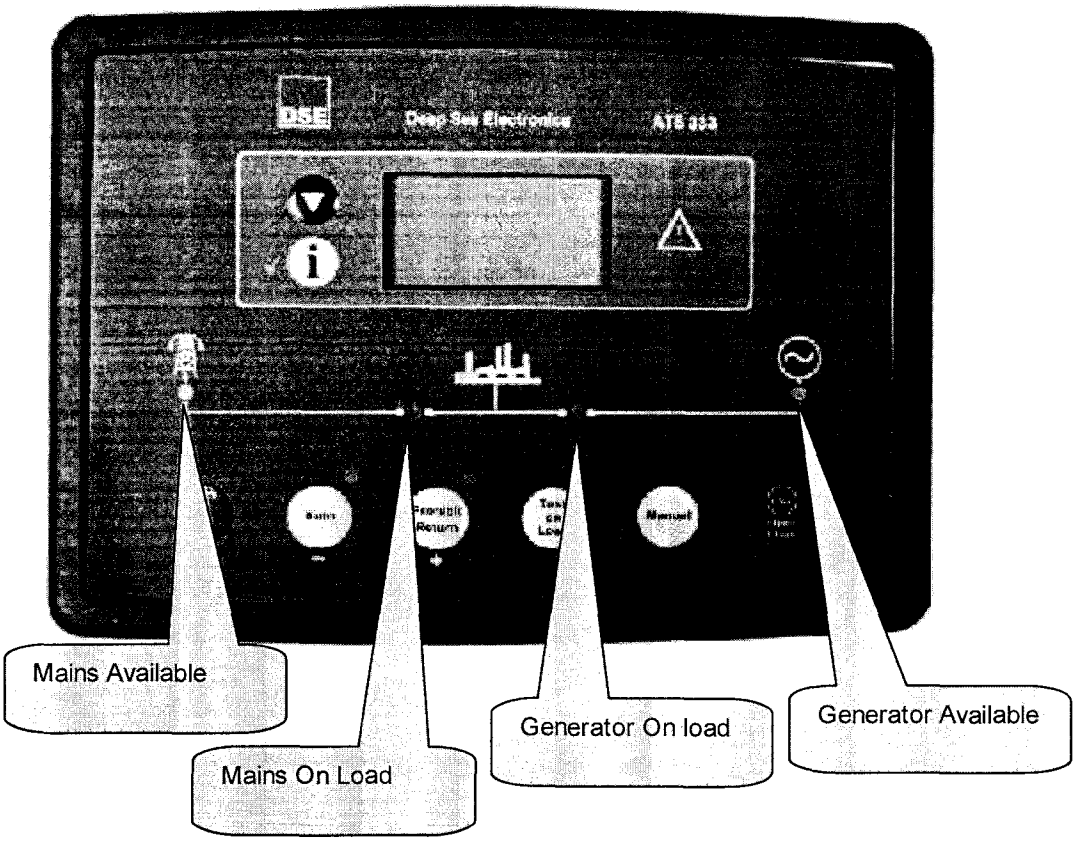
DSE PART	DESCRIPTION
056-022	Breaker Control (Training guide)



5 DESCRIPTION OF CONTROLS

The following section details the function and meaning of the various controls on the module.

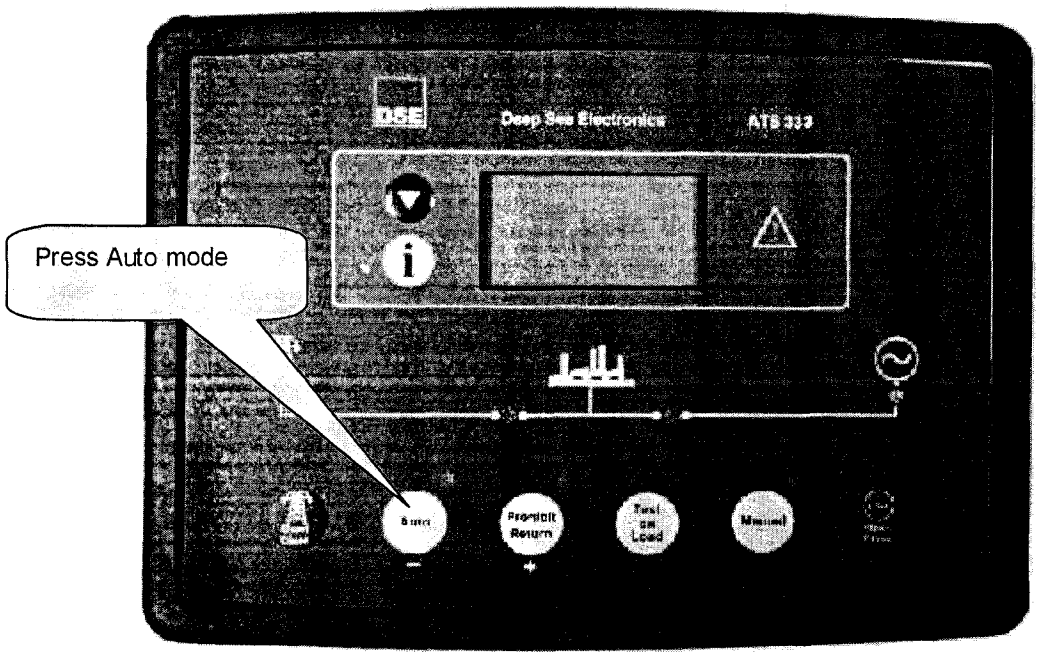



DSE
Deep Sea Electronics
ATS 333
Mains Available
Mains On Load
Generator On load
Generator Available

5.1 QUICKSTART GUIDE

This section provides a quick start guide to the module's operation.

5.1.1 STANDBY OPERATION



NOTE:- For further details, see the section entitled 'OPERATION' elsewhere in this manual.

NOTE:- If module power is removed, it will 'remember' the last operating mode and return to that mode next time power is applied.

5.2 GRAPHICAL DISPLAY

- 4- line, 64 x 132 small Graphic Display with LED Backlight
- Icon and numeric display. Switch to select 'Icon' or 'English' display
- Software controlled contrast
- Mimic of Text insert / 4x indicators via LCD

5.2.1 DISPLAY PAGES

It is possible to scroll to display the different pages of information by repeatedly operating the scroll button 

Once selected the page will remain on the LCD display until the user selects a different page or after an extended period of inactivity, the module will revert to the status display.

When scrolling manually, the display will automatically return to the Status page if no buttons are pressed for the duration of the configurable *LCD Page Timer.*

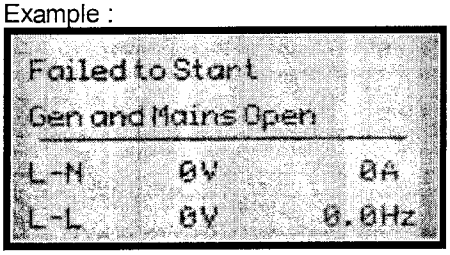
If an alarm becomes active while viewing the status page, the display shows the Alarms page to draw the operator's attention to the alarm condition.

At power up, the display will show the software version, and then display the default display screen, which will display Mains instrumentation.

5.2.1.1 STATUS

Displays current operational status information

Example :

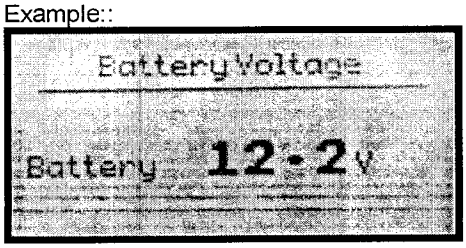


5.2.1.2 INSTRUMENTATION

The instrumentation page contains the following information

Generator Voltage L1-N
Generator Voltage L-L
Generator Frequency
Mains Voltage L1-N
Mains Voltage L-L
Mains Frequency
Load current (A)
Battery Voltage

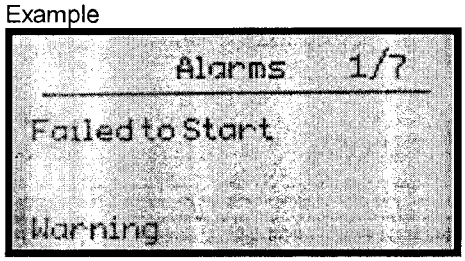
Example::



5.2.1.3 ALARMS

Lists any current alarms

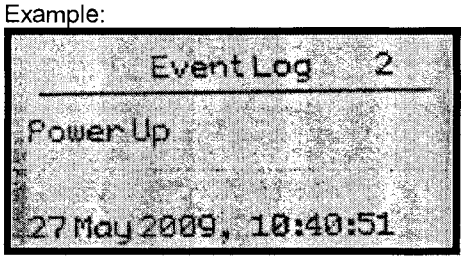
Example



5.2.1.4 EVENT LOG

Displays the entire event log

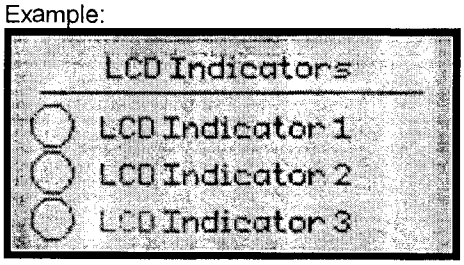
Example:



5.2.1.5 LCD INDICATORS

Shows the status of the configurable LCD indicators

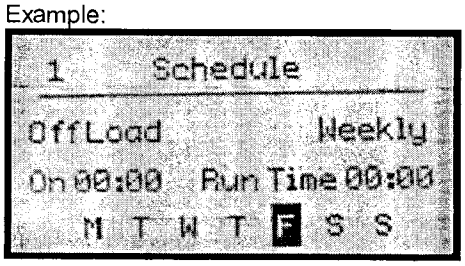
Example:



5.2.1.6 SCHEDULE

Shows the settings of the excercise scheduler

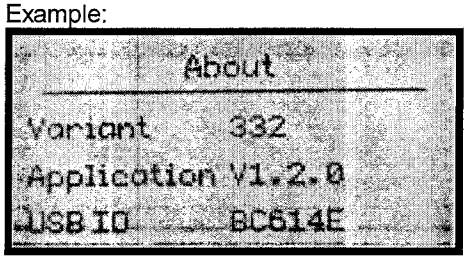
Example:



5.2.1.7 ABOUT

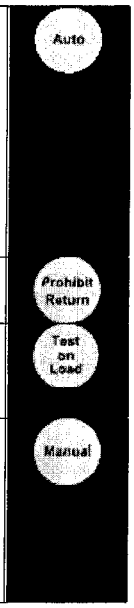
Displays the module firmware versions.

Example:

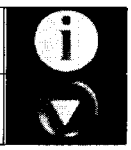


5.3 CONTROLS

5.3.1 MODE SELECTION

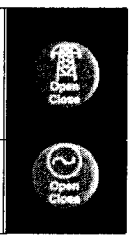
This button places the module into its **'Automatic'** mode. This mode allows the module to control the function of the load switching completely automatically. The module will monitor the *remote start* input and mains supply status and once a start request is made, the set will be placed on load. Upon removal of the starting signal (or the mains supply returns), the module will automatically transfer the load from the generator to the mains and remove the genset starting instruction. *For further details, please see the more detailed description of 'Auto operation' elsewhere in this manual.*	
Operation is as AUTO MODE above but the load is not transferred back to the mains supply when it is reinstated. This function is sometimes called "MANUAL RESTORE"	
Once in **Test on load mode** the module will send a start request to the generator and place the set on load. The set will remain on load when in this mode.	
This mode allows manual control of the ATS functions. Once in **Manual mode** the module will send a start request to the generator. Breakers can be opened and close using the transfer buttons detailed below.	

5.3.2 DISPLAY

This button changes between the various pages About, Status, Instrumentation, Alarms, Event Log, LCD Indicators	
This buttons scrolls through the items in the currently displayed page.	

5.3.3 LOAD SWITCHING CONTROL

Two fascia mounted buttons are provided for load switching operation when in manual mode. These buttons are enabled/disabled in the modules PC configuration Suite so refer to your configuration file to ensure the configuration has enabled the buttons.

Pressing this button when the mains is on load will open the mains load switch. Pressing this button when the generator is on load and the mains is healhty, will open the generator load switch, wait for the duration of the *transfer delay*, then close the mains load switch.	
Pressing this button when the generator is on load will open the generator load switch. Pressing this button when the mains is on load and the generator is available, will open the mains load switch, wait for the duration of the *transfer delay*, then close the generator load switch.	

6 OPERATION

6.1 AUTOMATIC MODE OF OPERATION

NOTE:- If a digital input configured to *panel lock* is active, changing module modes will not be possible. Viewing the instruments and event logs is NOT affected by panel lock.

Activate auto mode by pressing the **Auto** pushbutton.
Auto mode will allow the transfer system to operate fully automatically, starting and stopping the generator as required with no user intervention.

6.1.1 WAITING IN AUTO MODE

If a starting request is made and there is no input present for *Auto Start Inhibit*, the starting sequence will begin. Starting requests can be from the following sources :

- Mains failure
- Activation of an auxiliary input that has been configured to *remote start*
- Activation of the inbuilt exercise scheduler.

6.1.2 STARTING SEQUENCE

To allow for 'false' start requests, the *start delay* timer begins.

Should all start requests be removed during the *start delay* timer, the unit will return to a stand-by state.

If a start request is still present at the end of the *start delay* timer, start signal is given to the generator set by the start/run output.

If the generator fails to become available before the *generator* failure timer expires. This is indicated on the LCD display, but the starting signal remains active.

6.1.3 GENERATOR ON LOAD

Once the generator is measured as being within limits (and the *Auxiliary Generator Ready* signal is received, the mains is removed from the load, and after the *transfer timer* has expired, the generator is placed on load.

If all start requests are removed and there is no input present for *Auto Restore Inhibit*, the *stopping sequence* will begin.

6.1.4 STOPPING SEQUENCE

The *return delay* timer operates to ensure that the starting request has been permanently removed and isn't just a short term removal.

After the return delay timer, the generator load switch is opened, then after the transfer timers, the mains is placed back on load.
Should another start request be made during the cooling down period, the generator will be placed on load.

The *cooling* timer allows the set to run off load and cool sufficiently before being stopped. This is particularly important where turbo chargers are fitted to the engine.

After the *cooling* timer has expired, the set is stopped.

NOTE:- If module power is removed, it will 'remember' the operating mode and return to that mode next time power is applied.

6.2 MANUAL OPERATION

NOTE:- If a digital input configured to *panel lock* is active, changing module modes will not be possible. Viewing the instruments and event logs is NOT affected by panel lock.

Manual mode allows the operator to start and stop the set manually, and if required change the state of the load switching devices. Manual off load mode is active when the **Manual** button is pressed.

6.2.1 STARTING SEQUENCE

NOTE:- There is no *start delay* in this mode of operation.

The start request is sent to the generator via the start/run relay output.

If the generator fails to become available before the *generator failure* timer expires. This is indicated on the LCD display, but the starting signal remains active.

6.2.2 GENERATOR OFF LOAD

The generator will continue run OFF LOAD in this mode unless :

- The mains supply fails
- An input is given for A*uxiliary Mains Failure*
- An input is given for *Transfer to Generator*
- The fascia mounted transfer buttons are pressed (when configured)

6.2.3 GENERATOR ON LOAD

Once on load, the generator will remain on load unless:

- An input is given for *Transfer to Mains*
- The fascia mounted transfer buttons are pressed (when configured)
- The module mode is changed to STOP\RESET or AUTO mode. The system may then transfer back to mains supply automatically if conditions are suitable.

6.2.4 TRANSFER BUTTONS OPERATION

Two fascia mounted buttons are provided for load switching operation when in manual mode. These buttons are enabled/disabled in the modules PC configuration Suite so refer to your configuration file to ensure the configuration has enabled the buttons.

Pressing this button when the mains is on load will open the mains load switch. Pressing this button when the generator is on load and the mains is healhty, will open the generator load switch, wait for the duration of the *transfer delay*, then close the mains load switch.	
Pressing this button when the generator is on load will open the generator load switch. Pressing this button when the mains is on load and the generator is available, will open the mains load switch, wait for the duration of the *transfer delay*, then close the generator load switch.	

6.2.5 STOPPING SEQUENCE

The set will not be stopped in this mode of operation.

To begin the stopping sequence, the module should be placed in the AUTO or PROHIBIT RETURN mode.

NOTE:- If module power is removed, it will 'remember' the operating mode and return to that mode next time power is applied.

6.3 TEST ON LOAD OPERATION

NOTE:- If a digital input configured to *panel lock* is active, changing module modes will not be possible. Viewing the instruments and event logs is NOT affected by panel lock.

Manual mode allows the operator to start and stop the set manually, and if required change the state of the load switching devices. Manual off load mode is active when the **Test on Load** button is pressed.

6.3.1 STARTING SEQUENCE

NOTE:- There is no *start delay* in this mode of operation.

The start request is sent to the generator via the start/run relay output.

If the generator fails to become available before the *generator* failure timer expires. This is indicated on the LCD display, but the starting signal remains active.

6.3.2 GENERATOR ON LOAD

The generator will continue run ON LOAD in this mode unless :

- The generator supply fails – The mains supply is placed back on load if available.
- An input is given for *Transfer to Mains*

6.3.3 STOPPING SEQUENCE

The set will not be stopped in this mode of operation.

To begin the stopping sequence, the module should be placed in the AUTO or PROHIBIT RETURN mode.

NOTE:- If module power is removed, it will 'remember' the operating mode and return to that mode next time power is applied.

6.4 LOAD SWITCHING CONTROL

The following timing diagrams detail the differences between the load switching control options.

6.4.1 BREAKER SCHEME A

NOTE : Generator Closed Auxiliary and Mains Closed Auxiliary inputs do not affect the operation of the load switching in *Breaker Scheme A*

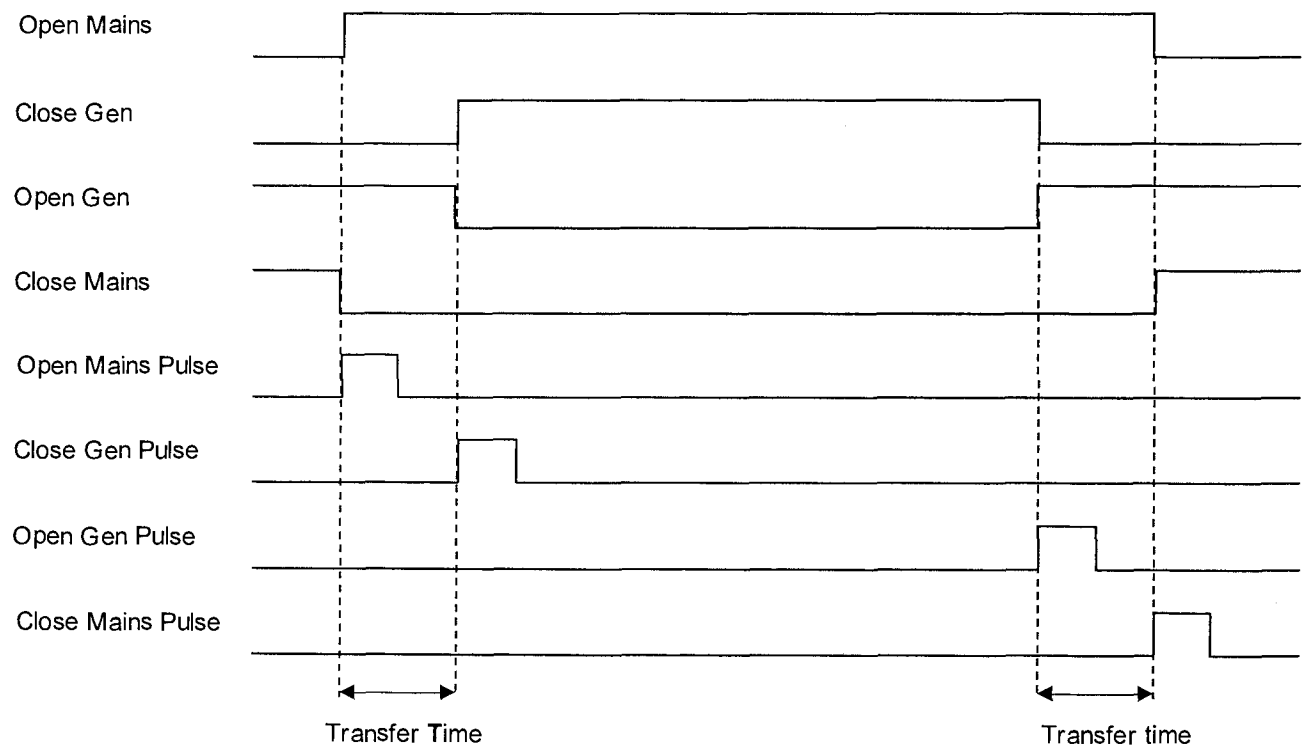
6.4.2 MAINS / GENERATOR LOAD INHIBIT

Activation of an input configured to *mains load inhibit* or *generator load inhibit* inputs cause the corresponding breaker to be opened immediately. No other change in function will occur.
When the input is deactivated the breaker is closed again if appropriate.

6.4.3 LOAD SHEDDING

If an input configured to Load Shed is activated, outputs set to Open Mains and Open Gen will energise, and inputs configured to Close Mains and Close Gen will de-energise. Open Mains Pulse and Open Gen Pulse outputs will only energise if the corresponding supply was on load before application of the Load Shed input.
When the Load Shed input is deactivated, the load will be transferred back to the supply that was disconnected before application of the input.

6.4.4 TIMING DIAGRAM



6.4.5 BREAKER SCHEME B

Breaker Scheme B is intended only for use with certain designs of transfer switch. If you are using contactors, you MUST select Breaker Scheme A.

6.4.5.1 CHECK SYNCHRONISING IS DISABLED

6.4.5.1.1 TRANSFERRING TO GENERATOR

To open the mains breaker the *Open Mains* output energises, it then de-energises when the *Mains Closed Auxiliary* indicates it has successfully opened, or after 1s whichever occurs first.
When the 'Mains Closed Auxiliary' indicates the mains breaker has opened, the *transfer timer* begins.
When the *transfer timer* expires, the module attempts to close the generator breaker by energising the *Open Mains* and *Close Generator* outputs simultaneously, it then de-energises these outputs when the *Generator Closed Auxiliary* input indicates it has successfully closed, or after 1s whichever occurs first.

6.4.5.1.2 TRANSFERRING TO MAINS

To open the generator breaker the *Open Gen* output energises, it then de-energises when the *Generator Closed Auxiliary* indicates it has successfully opened, or after 1s whichever occurs first.
When the 'Generator Closed Auxiliary' indicates the generator breaker has opened, the *transfer timer* begins.
When the *transfer timer* expires, the module attempts to close the mains breaker by energising the *Open Gen* and *Close Mains* outputs simultaneously, it then de-energises these outputs when the *Mains Closed Auxiliary* input indicates it has successfully closed, or after 1s whichever occurs first

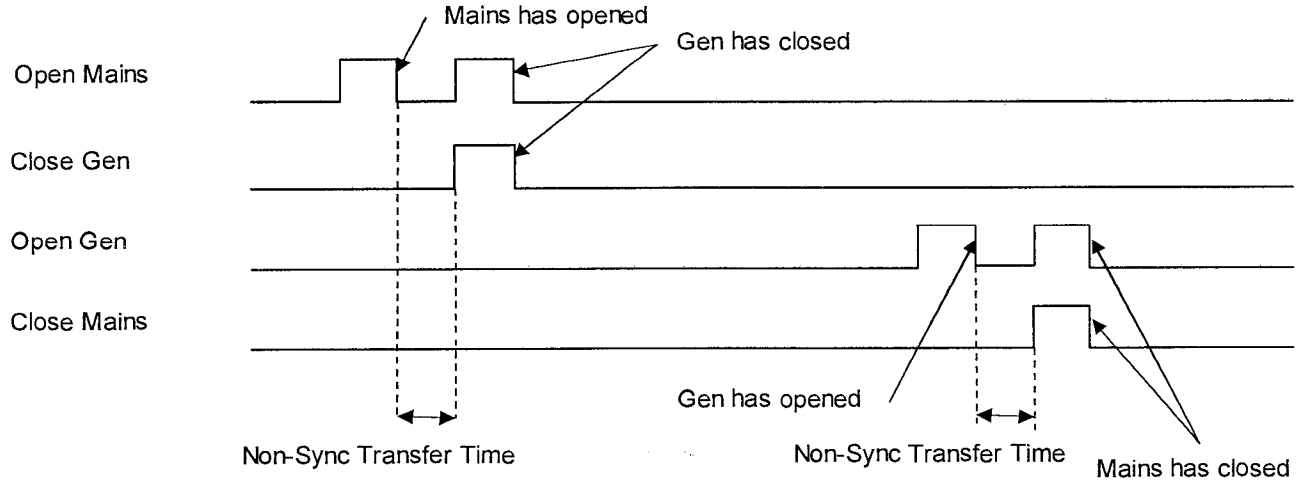
6.4.5.1.3 LOAD SHED INPUT

When the *Load Shed* input is activated while the generator is closed the *Open Gen* output energises, it then de-energises when the *Generator Closed Auxiliary* input indicates that it has successfully opened, or after 1s whichever occurs first.

When the *Load Shed* input is activated while the mains is closed the *Open Mains* output energises, it then de-energises when the *Mains Closed Auxiliary* input indicates that it has successfully opened, or after 1s whichever occurs first.

When the *Load shed* input is de-energised the load will be returned to the supply that was disconnected, providing that supply is healthy.

6.4.5.1.4 TIMING DIAGRAM



6.4.5.2 CHECK SYNCHRONISING IS ENABLED

NOTE : The module waits indefinitely for synchronisation unless the 'Return to programmed transition' function is active in which case after 2 minutes it performs a non-sync transfer as described in the previous section.

NOTE : The transfer time is ignored during a check-sync but is used if the transfer fails and it performs a non-sync transfer.

6.4.5.2.1 TRANSFER TO GENERATOR

When the module is about to transfer from mains to generator it activates the check sync function.
When the mains and generator are within the phase and frequency window the module energises the *Open Mains* and *Close Gen* outputs simultaneously. These outputs are de-energised when the *Generator Closed Auxiliary* input indicates it has successfully closed, or after 1s whichever occurs first.

6.4.5.2.2 TRANSFER TO MAINS

When the module is about to transfer from generator to mains it activates the check sync function.
When the mains and generator are within the phase and frequency window the module energises the *Open Gen* and *Close Mains* outputs simultaneously. These outputs are de-energised when the *Generator Closed Auxiliary* input indicates it has successfully closed, or after 1s whichever occurs first.

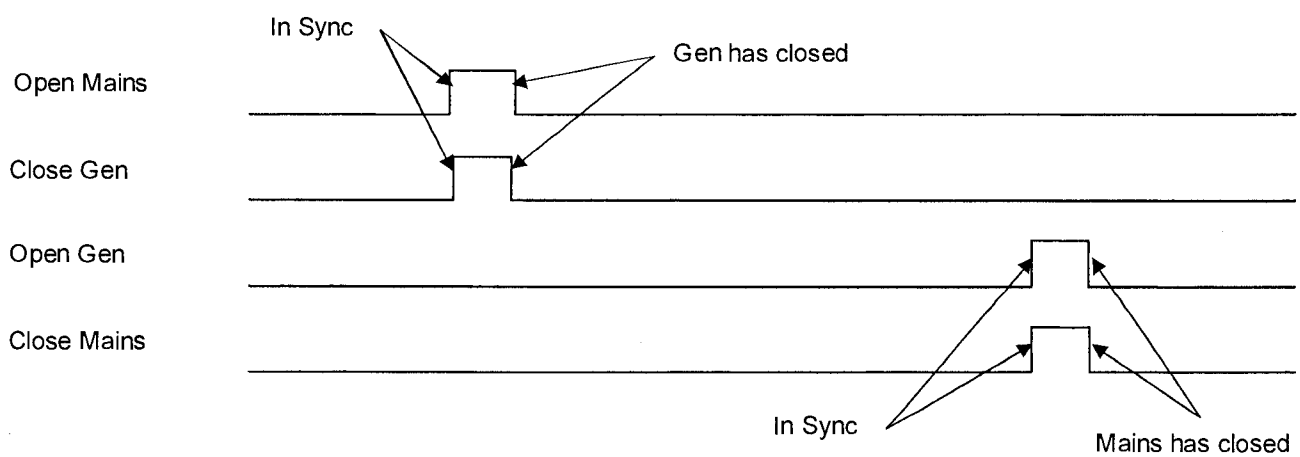
6.4.5.2.3 LOAD SHED INPUT

When the *Load Shed* input is activated while the generator is closed the *Open Gen* output energises, it then de-energises when the *Generator Closed Auxiliary* input indicates that it has successfully opened, or after 1s whichever occurs first.

When the *Load Shed* input is activated while the mains is closed the *Open Mains* output energises, it then de-energises when the *Mains Closed Auxiliary* input indicates that it has successfully opened, or after 1s whichever occurs first.

When the *Load shed* input is de-energised the load will be returned to the supply that was disconnected, providing that supply is healthy.

6.4.5.2.4 TIMING DIAGRAM



7 MODULE DISPLAY

7.1 BACKLIGHT

The backlight will be on if the unit has sufficient voltage on the power connection while the unit is turned on.

7.2 PROTECTIONS

7.2.1 GENERATOR

The 333 ATS module monitors the generator supply to ensure that it remains within configured levels. If the generator supply fails, it is taken off load and the start/run signal is be removed.

Generator failure
The generator has not become available after the period of the *Generator Failure* timer has expired.

Generator Under Voltage shutdown
The generator supply is below the configured *under voltage* trip level

Generator Under Frequency shutdown
The generator supply is below the configured *under frequency* trip level

Failed to reach loading voltage
The generator is running and within under / over voltage trip points, but has failed to reach the configured *Loading Voltage*, hence it is unfit to take load.

Failed to reach loading frequency
The generator is running and within under / over frequency trip points, but has failed to reach the configured *Loading Frequency*, hence it is unfit to take load.

7.2.2 MAINS

Mains alarms signal that the mains supply is out of limits. In AUTO mode, the generator is called to start (if not already running) and will be placed on load when available.
If the mains supply fails while the generator is running in MANUAL mode, the 333 ATS module transfers load to the generator supply.
Should an input configured to *Simulate Mains Available* be active, the mains failure detection is inhibited.

Mains failure
Combined message to indicate the failure of the mains supply or activation of an input configured to *Auxiliary Mains Failure*.

Mains Under Frequency trip
The mains supply is below the configured *Under Frequency* trip level.

Mains Under Voltage trip
The mains supply is below the configured *Under Voltage* trip level.

Mains Over Frequency trip
The mains supply is above the configured *Over Frequency* trip level.

Mains Over Voltage trip
The mains supply is above the configured *Over Voltage* trip level.

7.2.3 PLANT BATTERY

Plant battery alarms are *Warning* alarms only. The module displays the fault but no further action is taken.

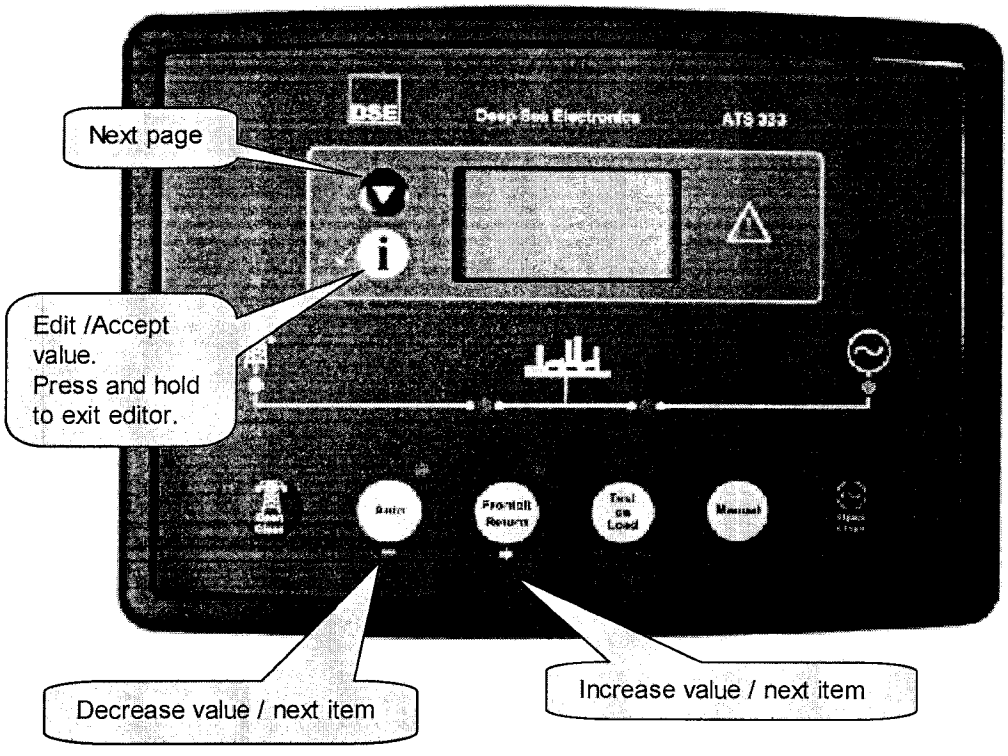
Under Voltage warning
The battery supply is below the configured *Under Voltage* warning level.

Under Voltage warning
The battery supply is above the configured *Over Voltage* warning level.

8 FRONT PANEL CONFIGURATION

This configuration mode allows the operator limited customising of the way the module operates.

Use the module's navigation buttons to traverse the menu and make value changes to the parameters:



8.1 ACCESSING THE FRONT PANEL EDITOR (FPE)

To enter the **'configuration mode'** press both the **DOWN** and **INFO** buttons together.

NOTE:- To exit the front panel configuration editor and activate your changes, press and hold the button. Ensure you have saved any changes you have made by pressing the ✓ button first.

NOTE:- When the editor is visible, it is automatically exited after 5 minutes of inactivity to ensure security.

8.1.1 EDITING A PARAMETER

- Enter the editor as described above.
- Press to select the required 'page' as detailed below.
- Press + to select the next parameter or - to select the previous parameter within the current page.When viewing the parameter to be changed, press the button. The value begins to flash.
- Press + or - to adjust the value to the required setting.
- Press to save the current value, the value ceases flashing.
- Press and hold the button to activate the changs you have made and exit the editor.

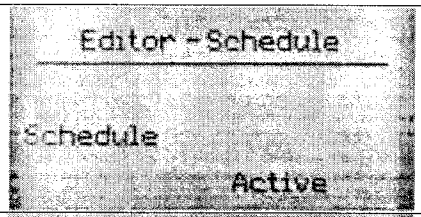
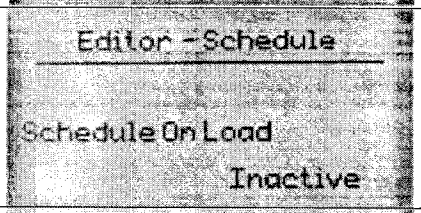
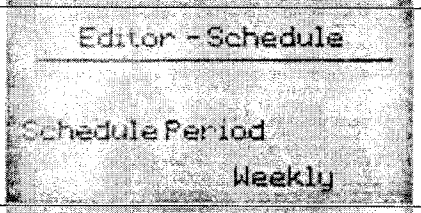
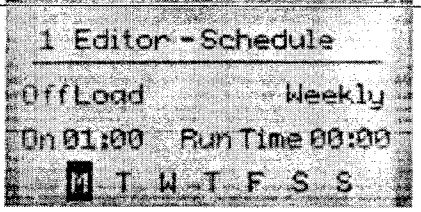
8.2 ADJUSTABLE PARAMETERS (CONFIGURATION EDITOR)

When viewing the configuration editor, Press to select the required 'page' as listed below.

Front Panel Configuration Editor (Factory default settings are shown in bold italicised text)

Page	Parameter as shown on	Values
DISPLAY	Contrast	0% - 100% (***53%***)
	Language	***English*** - Others
	Current date and time	Date month year hh:mm:ss
GENERATOR	Under Voltage Trip	50V – 360V (***184V***)
	Under Frequency Trip	0Hz - 75Hz (***40Hz***)
MAINS	Immediate mains dropout	Active,***Inactive***
	Under Voltage Trip	50V – 360V (***184V***)
	Over Voltage Trip	50V – 360V (***276V***)
	Under Frequency Trip	0Hz - 75Hz (***45Hz***)
	Over Frequency Trip	0Hz - 75Hz (***55Hz***)
TIMERS	Warm Up Time	0 -1hr (***0s***)
	Start Delay	0 - 10hr (***5s***)
	Mains Transient Delay	0 - 30s (***2s***)
	Generator Failed Delay	0 - 1m (***60s***)
	Elevator Delay	0 – 5m (0s)
	Non sync Transfer Time	1 – 10m (**0.7s**)
	Check-sync Transfer Time	1 – 10m (**0.2s**)
	Return Delay	0 - 5hr (***30s***)
	Cool Down Timer	0 - 1hr (***1m***)
	Generator Transient Delay	0 - 30s (**0s**)
	Fail to Stop Delay	0 – 2m (**30s**)
	Scroll Delay	0 – 1hr (**5s**)
	Page Timer	0 – 1hr (**5m**)
SCHEDULE	Schedule	Active, **Inactive**
	Schedule On Load	Active, **Inactive** (only available when Scheduler is active)
	Schedule Period	**Weekly**, Monthly (only available when Scheduler is active)
	Schedule time and date selection (1-16)	Press when editing to select the different parameters within the scheduler.

8.2.1 SCHEDULER SETTING

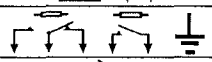
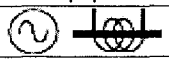
Enter the editor as described above and press the ▼ button to access the Scheduler page. Press ✓ to enter edit mode and use the + / i buttons to make the Schedulle function active. Press ✓ to save your change.	
Press + to move to the next item. Review the current setting and choose if the Scheduler is to perform an 'on load' test (active) or 'off load' test (inactive)	
Press + to move to the next item. Review the current setting and choose if the Scheduler is to perform a weekly schedule (repeats every 7 days) or monthly (repeats every 28 days)	
Press + to move to the next item. Press ▼ to select which schedule entry to edit (there are up to 16 entries indicated by the number in the tope left corner) Press ✓ to edit the schedule. The item being edited flashes. Press + / - to change the flashing item. Press ▼ to move to the next editable value. (On, Day, Run Time etc) Press ✓ to save your change	

9 MAINTENANCE, SPARES, REPAIR AND SERVICING

The DSE333 Series controller is designed to be *Fit and Forget*. As such, there are no user serviceable parts within the controller.
In the case of malfunction, you should contact your original equipment supplier (OEM).

9.1 PURCHASING ADDITIONAL CONNECTOR PLUGS FROM DSE

If you require additional plugs from DSE, please contact our Sales department using the part numbers below.

333 series terminal designation	Plug description	Part No.
1-4 	4 way 5.08mm	007-444
5-10 	6 way 5.08mm	007-446
11-21 	11 way 5.08mm	007-451
22-29 	8 way 7.62mm	007-454
30-33 	4 way 7.62mm	007-171
34-38 	5 way 5.08mm	007-445

9.2 PURCHASING ADDITIONAL FIXING CLIPS FROM DSE

Item	Description	Part No.
	DSE333 / DSE6000 series fixing clips (packet of 4)	020-294

9.3 PURCHASING SEALING GASKET FROM DSE

The optional sealing gasket is not supplied with the controller but can be purchased separately.

Item	Description	Part No.
	DSE333 \ DSE6000 silicon sealing gasket	020-389

10 WARRANTY

DSE provides limited warranty to the equipment purchaser at the point of sale. For full details of any applicable warranty, you are referred to your original equipment supplier (OEM).

11 DISPOSAL

11.1 WEEE (WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT)

Directive 2002/96/EC
If you use electrical and electronic equipment you must store, collect, treat, recycle and dispose of WEEE separately from your other waste.



11.2 ROHS (RESTRICTION OF HAZARDOUS SUBSTANCES)

Directive 2002/95/EC:2006
To remove specified hazardous substances (Lead, Mercury, Hexavalent Chromium, Cadmium, PBB & PBDE's)

Exemption Note: Category 9. (Monitoring & Control Instruments) as defined in Annex 1B of the WEEE directive will be exempt from the RoHS legislation. This was confirmed in the August 2005 UK's Department of Trade and Industry RoHS REGULATIONS Guide (Para 11).

Despite this exemption DSE has been carefully removing all non RoHS compliant components from our supply chain and products.
When this is completed a Lead Free & RoHS compatible manufacturing process will be phased into DSE production.

This is a process that is almost complete and is being phased through different product groups.

12 APPENDIX

12.1 COMMUNICATIONS OPTION CONNECTIONS

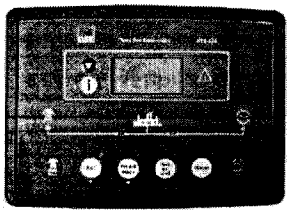
12.1.1 DESCRIPTION

The DSE Configuration Suite software allows the controller to communicate with a PC. The computer connects to the module as shown below and allows easy adjustment of the operating parameters and firmware update of the controller.

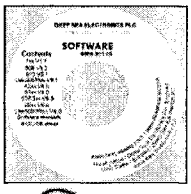
12.1.2 PC TO CONTROLLER (DIRECT) CONNECTION

To connect a 333 ATS module to a PC the following items are required: -

- DSE333 series module

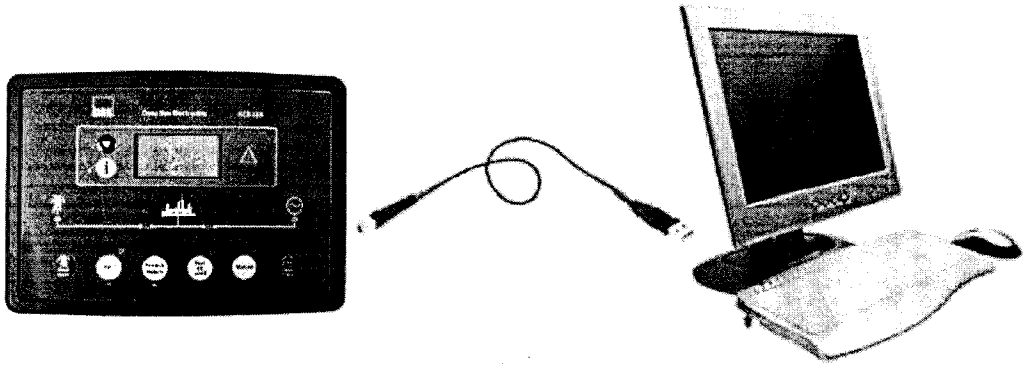


- Configuration Suite software (Supplied on configuration suite software CD or available from www.deepseaplc.com).



- USB cable Type A to Type B.





NOTE:- The DC supply must be connected to the module for configuration by PC.

NOTE:- Refer to DSE Configuration Suite software Manual for further details on configuring the module by PC.

12.2 ENCLOSURE CLASSIFICATIONS

12.2.1 IP CLASSIFICATIONS

333 series specification under BS EN 60529 Degrees of protection provided by enclosures

IP65 (Front of module when module is installed into the control panel with the supplied sealing gasket).
IP42 (front of module when module is installed into the control panel WITHOUT being sealed to the panel)

First Digit		Second Digit	
Protection against contact and ingress of solid objects		Protection against ingress of water	
0	No protection	0	No protection
1	Protected against ingress solid objects with a diameter of more than 50 mm. No protection against deliberate access, e.g. with a hand, but large surfaces of the body are prevented from approach.	1	Protection against dripping water falling vertically. No harmful effect must be produced (vertically falling drops).
2	Protected against penetration by solid objects with a diameter of more than 12 mm. Fingers or similar objects prevented from approach.	2	Protection against dripping water falling vertically. There must be no harmful effect when the equipment (enclosure) is tilted at an angle up to 15°from its normal pos ition (drops falling at an angle).
3	Protected against ingress of solid objects with a diameter of more than 2.5 mm. Tools, wires etc. with a thickness of more than 2.5 mm are prevented from approach.	3	Protection against water falling at any angle up to 60° from the vertical. There must be no harmful effect (spray water).
4	Protected against ingress of solid objects with a diameter of more than 1 mm. Tools, wires etc. with a thickness of more than 1 mm are prevented from approach.	4	Protection against water splashed against the equipment (enclosure) from any direction. There must be no harmful effect (splashing water).
5	Protected against harmful dust deposits. Ingress of dust is not totally prevented but the dust must not enter in sufficient quantity to interface with satisfactory operation of the equipment. Complete protection against contact.	5	Protection against water projected from a nozzle against the equipment (enclosure) from any direction. There must be no harmful effect (water jet).
6	Protection against ingress of dust (dust tight). Complete protection against contact.	6	Protection against heavy seas or powerful water jets. Water must not enter the equipment (enclosure) in harmful quantities (splashing over).

12.2.2 NEMA CLASSIFICATIONS

333 series NEMA Rating (Approximate)
12 (Front of module when module is installed into the control panel with the optional sealing gasket).
2 (front of module when module is installed into the control panel WITHOUT being sealed to the panel)

NOTE: - There is no direct equivalence between IP / NEMA ratings. IP figures shown are approximate only.

1 **IP30**	Provides a degree of protection against contact with the enclosure equipment and against a limited amount of falling dirt.
2 **IP31**	Provides a degree of protection against limited amounts of falling water and dirt.
3 **IP64**	Provides a degree of protection against windblown dust, rain and sleet; undamaged by the formation of ice on the enclosure.
3R **IP32**	Provides a degree of protection against rain and sleet:; undamaged by the formation of ice on the enclosure.
4 (X) **IP66**	Provides a degree of protection against splashing water, windblown dust and rain, hose directed water; undamaged by the formation of ice on the enclosure. (Resist corrosion).
12/12K **IP65**	Provides a degree of protection against dust, falling dirt and dripping non corrosive liquids.
13 **IP65**	Provides a degree of protection against dust and spraying of water, oil and non corrosive coolants.

DOOSAN

950106-00121

Operation & Maintenance Manual

GENERATOR DIESEL ENGINE

DE12T
P126TI
P126TI-1
P126TI-II
PU126TI

Doosan Infracore

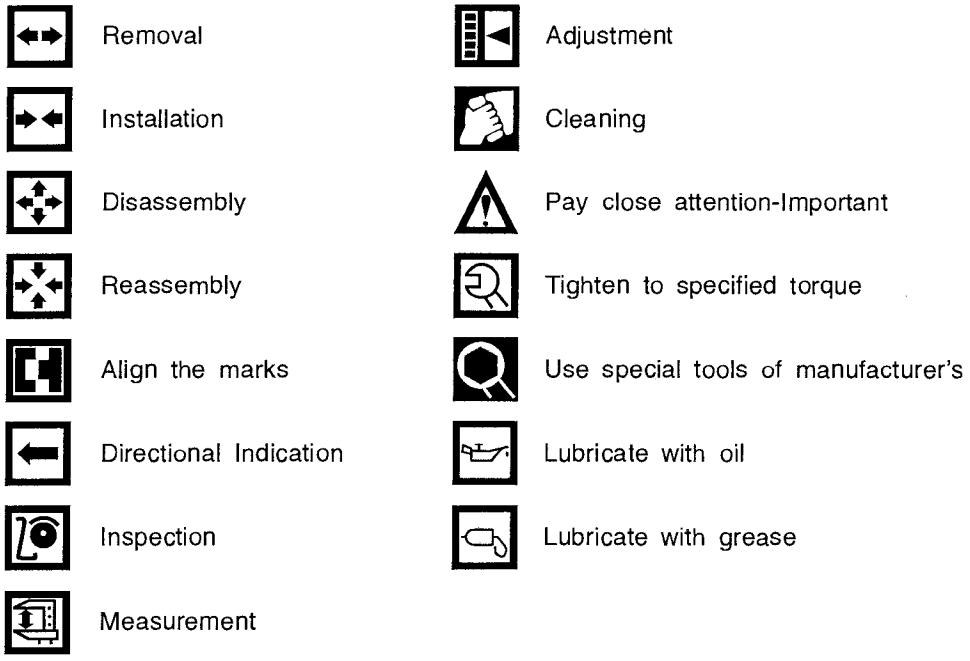
FOREWORD

This maintenance manual is designed to serve as a reference for DOOSAN Infracore (here after DOOSAN's) customers and distributors who wish to gain basic product knowledge on DOOSAN's generator and power unit diesel engines (DE12T, P126TI, P126TI-1, P126TI-II and PU126TI)

These economical and high-performance diesel engines (6 cylinders, 4 strokes, in-line, direct injection type) have been so designed and manufactured to be used for the generator & power unit application. They meet all the requirements such as low noise, fuel economy, high engine speed, and durability.

To maintain the engine in optimum condition and retain maximum performance for a long time, CORRECT OPERATION and PROPER MAINTENANCE are essential.

In this manual, the following symbols are used to indicate the type of service operations to be performed.



During engine maintenance, please observe following instructions to prevent environmental damage;

- Take old oil to an old oil disposal point only.
- Ensure without fail that oil and diesel fuel will not get into the sea or rivers and canals or the ground.
- Treat undiluted anti-corrosion agents, antifreeze agents, filter element and cartridges as special waste.
- The regulations of the relevant local authorities are to be observed for the disposal of spent coolants and special waste.

If you have any question or recommendation in connection with this manual, please do not hesitate to contact our head office, dealers or authorized service shops near by your location for any services.

For the last, the content of this maintenance instruction may be changed without notice for some quality improvement. Thank you.

2015.01.
950106-00121(G)
Doosan Infracore Co., Ltd.

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- **Part & After service center**

1. Safety Regulations

1.1. General Notes

Handling diesel engines and the necessary resources is no problem when the personnel commissioned with operation and maintenance are trained accordingly and use their common sense.

This summary is a compilation of the most important regulations. These are broken down into main sections which contain the information necessary for preventing injury to persons, damage to property and pollution. In addition to these regulations those dictated by the type of engine and its site are to be observed also.



IMPORTANT :
If, despite all precautions, an accident occurs, in particular through contact with caustic acids, fuel penetrating the skin, scalding from oil, antifreeze being splashed in the eyes etc., consult a doctor immediately.



WARNING :
During operating the engine, be careful not to touch the safety guard of cooling fan. Otherwise, by the rotating cooling fan, it can cause serious injuries such as a cutting of fingers to you.



WARNING :
During operating the engine, be careful not to touch the safety guard of v-belt. Otherwise, by the rotating v-belt, it can cause serious injuries such as a cutting of fingers to you.



WARNING :
V-belt safety guard is an optional item at customers. In order to prevent accidents, you should install a v-belt safety guard. If v-belt safety guard is not installed, you should not access to the engine during operating. We will not be responsible for an accidents or injury arising without an installation of v-belt safety guard.



WARNING :
Immediately after stopping the engine or during driving, be careful not to touch a part of turbocharger. Otherwise, due to a hot turbocharger, it can cause you to severe burns. If you need to contact the turbocharger of a hightemperature for maintenance, you contact the turbocharger after enough waiting until be a low temperature.



WARNING :
Immediately after stopping the engine or during driving, be careful not to touch a part of exhaust manifold or heat screen. Otherwise, due to a hot turbocharger, it can cause severe burns to you. In particular, be careful not to touch the heat screen installed on the exhaust manifold because it has also a high temperature.

WARNING :

If you need an emergency engine stop, use a device installed on a generator at first. It is difficult to operate a 'manual emergency stop device' mounted in a fuel pump and it can cause serious burns to you by contact with the exhaust manifold. Therefore, after installing a separate auxiliary cable, use the 'manual emergency stop device'. We will not be responsible for an accidents or injury arising without an installation of separate auxiliary cable.

1.2. Regulations Designed to Prevent Accidents

1.2.1. During commissioning, starting and operation

Before putting the engine into operation for the first time, read the operating instructions carefully and familiarize yourself with the "critical" points, If you are unsure, ask your DOOSAN representative.

- For reasons of safety we recommend you attach a notice to the door of the engine room prohibiting the access of unauthorized persons and that you draw the attention of the operating personal to the fact that they are responsible for the safety of persons who enter the engine room.
- The engine must be started and operated only by authorized personnel. Ensure that the engine cannot be started by unauthorized persons.
- When the engine is running, do not get too close to the rotating parts. Wear close-fitting clothing.
- Do not touch the engine with bare hands when it is warm from operation risk of burns.
- Exhaust gases are toxic. Comply with the installation instructions for the installation of DOOSAN generator diesel engines which are to be operated in enclosed spaces.
  Ensure that there is adequate ventilation and air extraction.
- Keep vicinity of engine, ladders and stairways free of oil and grease.
- Accidents caused by slipping can have serious consequences.

1.2.2. During maintenance and care

- Always carry out maintenance work when the engine is switched off. If the engine has to be maintained while it is running, e.g. changing the elements of change-over filters, remember that there is a risk of scalding. Do not get too close to rotating parts.
- Change the oil when the engine is warm from operation.

CAUTION :
There is a risk of burns and scalding. Do not touch oil drain valve or oil filters with bare hands.

- Take into account the amount of oil in the sump. Use a vessel of sufficient size to ensure that the oil will not overflow.
- Open the coolant circuit only when the engine has cooled down. If opening while the engine is still warm is unavoidable, comply with the instructions In the chapter entitled ìCoolingî.
- Neither tighten up nor open pipes and hoses (lube oil circuit, coolant circuit and any additional hydraulic oil circuit) during the operation. The fluid which flow out can cause injury.
- Fuel is inflammable. Do not smoke or use naked lights in its vicinity. The tank must be filled only when the engine is switched off.
- Keep service products (anti-freeze) only in containers which can not be confused with drinks containers.
- Comply with the manufacturerís instructions when handling batteries.

CAUTION :
Accumulator acid is toxic and caustic. Battery gases are explosive.

1.2.3. When carrying out checking, setting and repair work

- Checking, setting and repair work must be carried out by authorized personnel only.
- Use only tools which are in satisfactory condition. Slip caused by the worn open-end wrench could lead to Injury.
- When the engine is hanging on a crane, no-one must be allowed to stand or pass under it. Keep lifting gear in good condition.
- When checking injectors, do not put your hands under the jet of fuel. Do not inhale at atomized fuel.
- When working on the electrical system disconnect the battery earth cable first. Connect it up again last in prevent short circuits.

1.3. Regulations Designed to Prevent Damage to Engine and Premature Wear

1) Never demand more of the engine than it was designed to yield for its intended purpose. Detailed information on this can be found in the sales literature. The injection pump must not be adjusted without prior written permission of DOOSAN.
2) If faults occur, find the cause immediately and have it eliminate in order to prevent more serious of damage.
3) Use only genuine DOOSAN spare parts. DOOSAN will accept no responsibility for damage resulting from the installation of other parts which are supposedly "just as good".
4) In addition to the above, note the following points.
   - Never let the engine run when dry, i.e. without lube oil or coolant. Use only DOOSAN-approved service products (engine oil, anti-freeze and anticorrosion agent).
   - Pay attention to cleanliness, The Diesel fuel must be free of water. See "Maintenance and care".
   - Have the engine maintained at the specified intervals.
   - Do not switch off the engine immediately when it is warm, but let it run without load for about 5 minutes so that temperature equalization can take place.
   - Never put cold coolant into an overheated engine. See "Maintenance and care".
   - Do not add so much engine oil that the oil level rises above the max. marking on the dip-stick. Do not exceed the maximum permissible tilt of the engine. Serious damage to the engine may result if these instructions are not adhered to.
   - Always ensure that the testing and monitoring equipment (for battery charge, oil pressure, and coolant temperature) function satisfactorily.
   - Comply with instructions for operation of the alternator. See "Commissioning and operation".
   - Do not let the water pump run dry. If there is a risk of frost, drain the water when the engine switched off.

1.4. Regulations Designed to Prevent Pollution

1.4.1. Engine oil, filter element, fuel filter

- Take old oil only to an oil collection point. Take strict precautions to ensure that oil does not get into the drains or into the ground.
- The drinking water supply may be contaminated.
- Oil and fuel filter elements are classed as dangerous waste and must be treated as such.

1.4.2. Coolant

- Treat undiluted anti-corrosion agent and / or antifreeze as dangerous waste.
- When disposing of spent coolant comply with the regulations of the relevant local authorities.

1.5. Notes on Safety in Handling Used Engine Oil

Prolonged or repeated contact between the skin and any kind of engine oil decreases the skin. Drying, irritation or inflammation of the skin may therefore occur. Used engine oil also contains dangerous substances which have caused skin cancer in animal experiments. If the basic rules of hygiene and health and safety at work are observed, health risks are not to the expected as a result of handling used engine oil.



Health precautions

- Avoid prolonged or repeated skin contact with used engine oil.
- Protect your skin by means of suitable agents (creams etc.) or wear protective gloves.
- Clean skin which has been in contact with engine oil.
  - Wash thoroughly with soap and water, A nailbrush is an effective aid.
  - Certain products make it easier to clean your hands.
  - Do not use petrol, Diesel fuel, gas oil, thinners or solvents as washing agents.
- After washing apply a fatty skin cream to the skin.
- Change oil-soaked clothing and shoes.
- Do not put oily rags into your pockets.



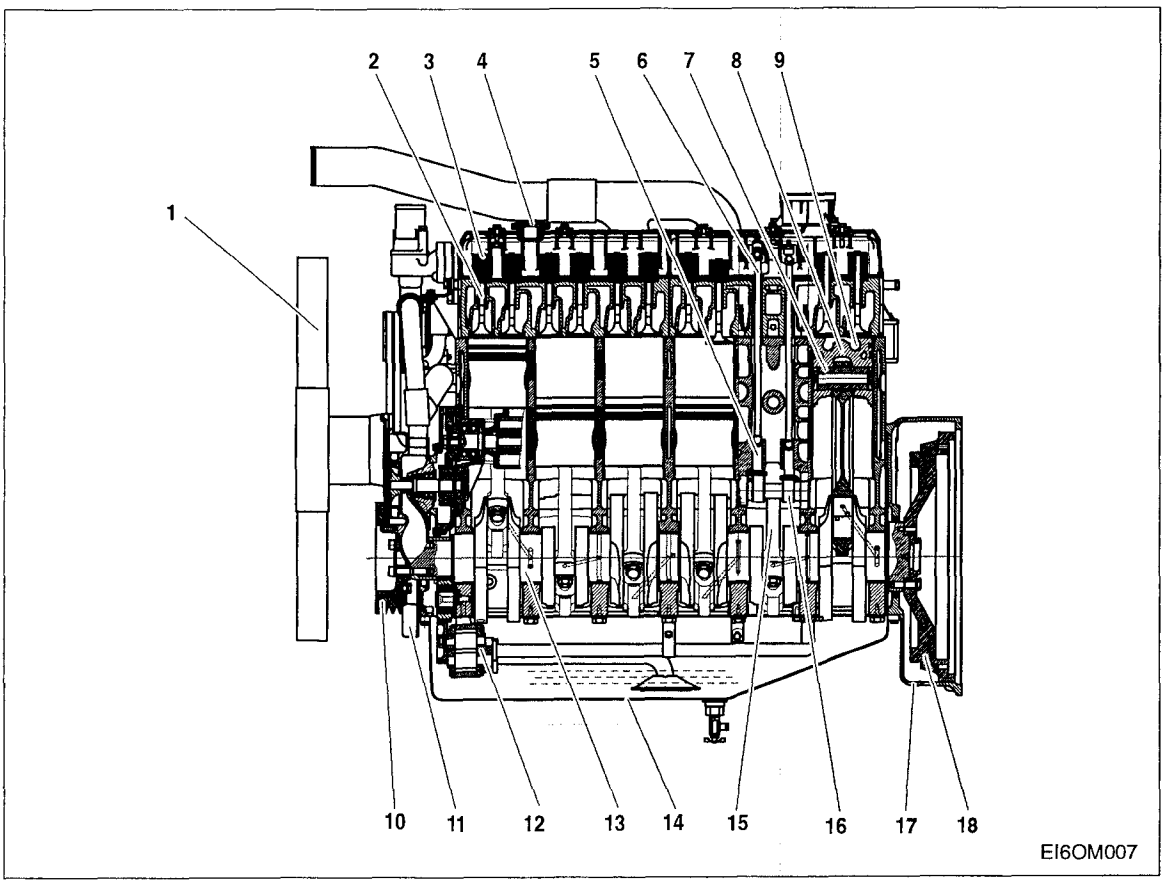
Ensure that used engine oil is disposed of properly.
- Engine oil can endanger the water supply -

For this reason do not let engine oil get into the ground, waterways, the drains or the sewers. Violations are punishable. Collect and dispose of used engine oil carefully.
For information on collection points please contact the seller, the supplier or the local authorities.

2. General Information

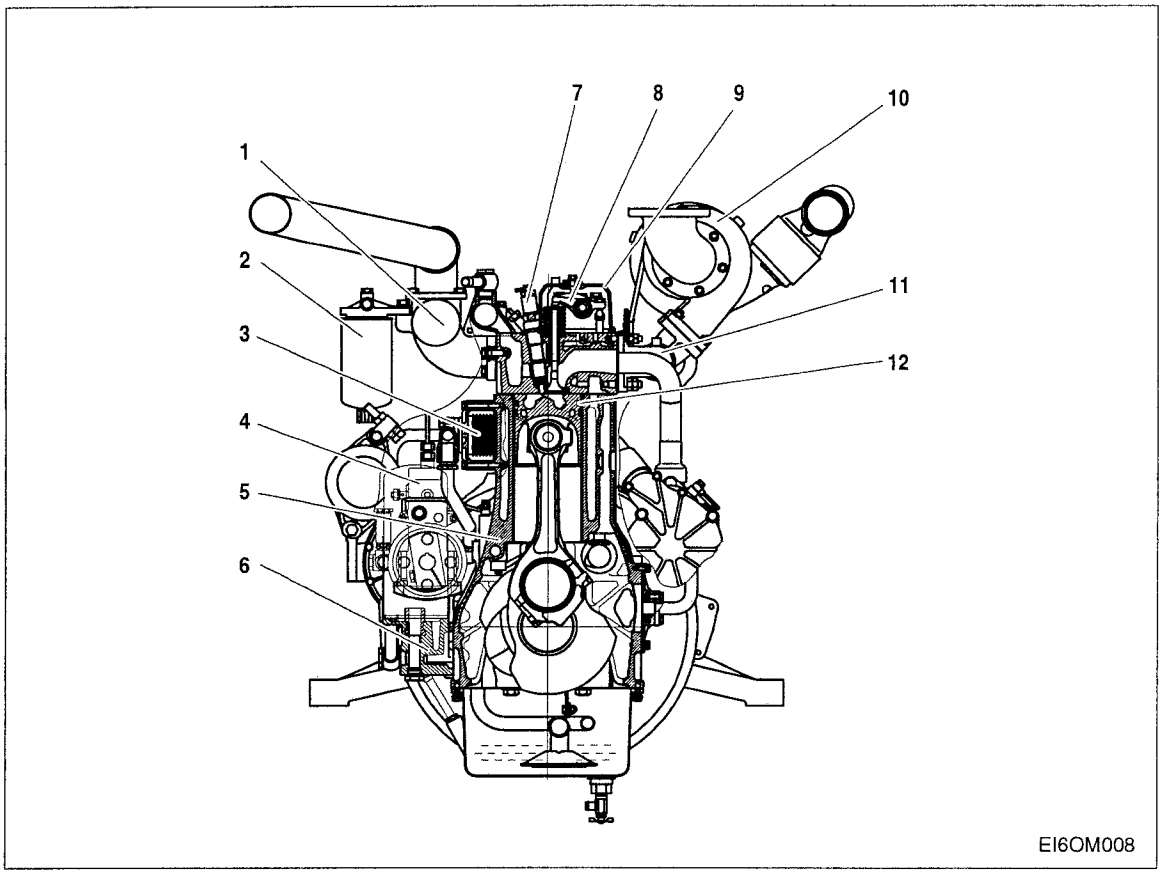
2.1. Engine Assembly

2.1.1. Engine sectional view (longitudinal)



1. Cooling fan
2. Exhaust valve
3. Valve spring
4. Oil filter
5. Tappet
6. Push rod
7. Piston pin
8. Piston
9. Combustion chamber
10. Crankshaft pulley
11. Vibration damper
12. Oil pump
13. Crankshaft
14. Oil pan
15. Connecting rod
16. Camshaft
17. Flywheel housing
18. Flywheel

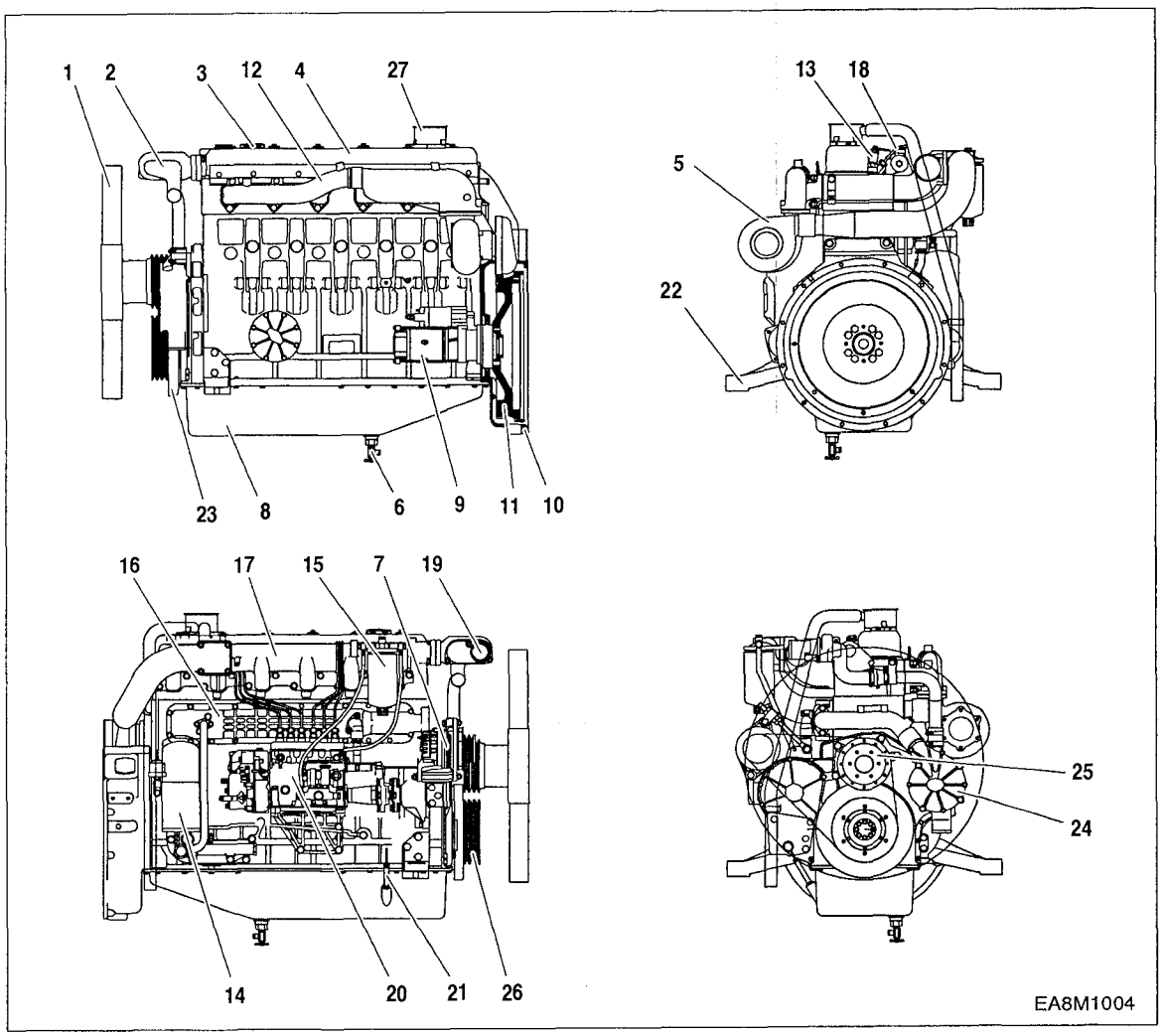
2.1.2. Engine sectional view (Cross)



1. Intake manifold
2. Fuel filter
3. Oil cooler
4. Injection pump
5. Cylinder block
6. Oil filter
7. Injection nozzle assembly
8. Rocker arm
9. Cylinder head cover
10. Turbocharger
11. Exhaust manifold
12. Piston ring

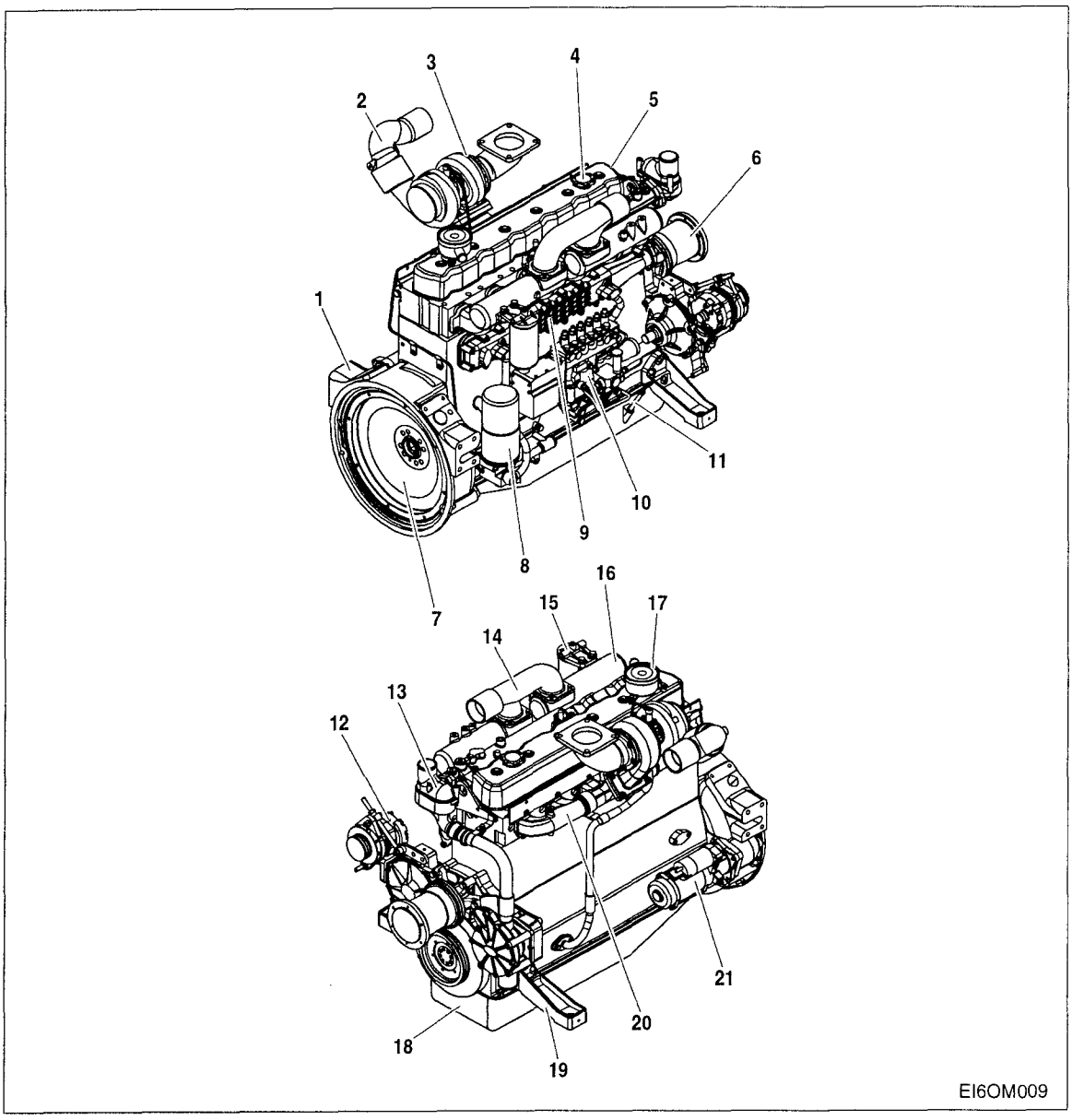
2.1.3. Engine assembly views

1) DE12T



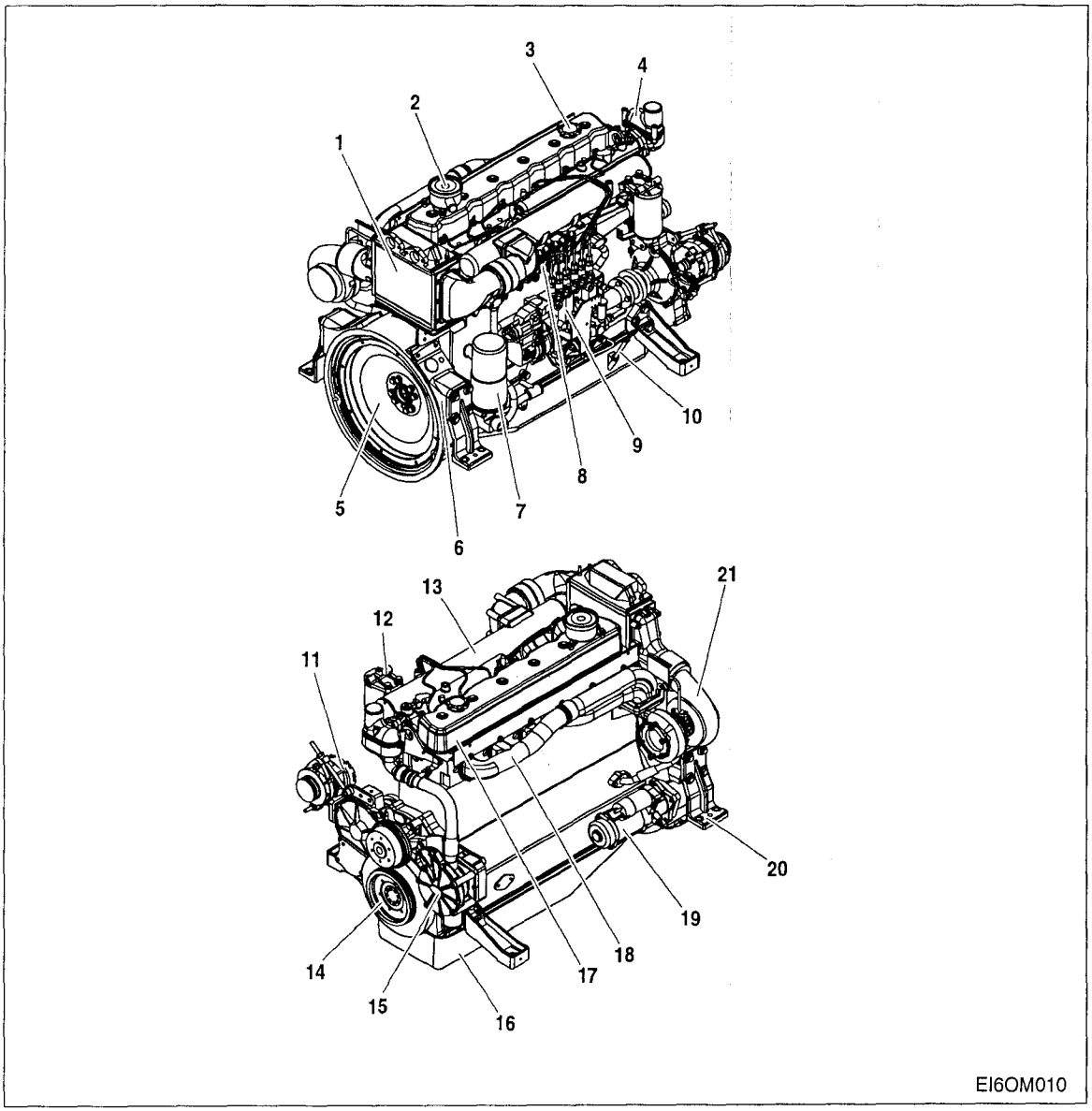
1. Cooling fan
2. Cooling water pipe
3. Oil filler cap
4. Cylinder head cover
5. Turbocharger
6. Oil drain valve
7. Alternator
8. Oil pan
9. Starter
10. Flywheel housing
11. Flywheel
12. Exhaust manifold
13. Injection nozzle assembly
14. Oil filter
15. Fuel filter
16. Oil cooler
17. Intake manifold
18. Injection pipe
19. Thermostat
20. Injection pump
21. Oil level gauge
22. Mounting bracket
23. Vibration damper
24. Water pump
25. Fan drive
26. Crankshaft pulley
27. Breather

2) P126TI / P126TI-1 / P126TI-II / PU126TI



1. Flywheel housing
2. Air pipe to intercooler
3. Turbocharger
4. Oil filter cap
5. Cylinder head cover
6. Cooling fan flange
7. Flywheel
8. Oil filter
9. Oil cooler
10. Injection pump
11. Oil level gauge
12. Alternator
13. Thermostat
14. Air pipe to Intercooler
15. Fuel filter
16. Intake manifold
17. Breather filter
18. Oil pan
19. Mounting bracket
20. Exhaust manifold
21. Starter

3) PU126TI (for Fire Pump)



1. Intercooler
2. Breather filter
3. Oil filter cap
4. Thermostat
5. Flywheel
6. Flywheel housing
7. Oil filter
8. Oil cooler
9. Injection pump
10. Oil level gauge
11. Alternator
12. Fuel filter
13. Intake manifold
14. Crankshaft pulley
15. Water pump
16. Oil pan
17. Cylinder head cover
18. Exhaust manifold
19. Starter
20. Mounting bracket
21. Turbocharger

2.2. Engine Specification

Items \ Engine Model	DE12T	P126TI	P126TI-1	P126TI-II	PU126TI
Engine type	Water-cooled, 4 cycle in-line type Turbo charged	Water-cooled, 4 cycle in-line type Turbo charged & intercooled			
Combustion chamber type	Direct injection type				
Cylinder liner type	Replaceable dry liner				
Timing gear system	Gear driven type				
No. of piston ring	Compression ring 2, oil ring 1				
No. of cylinder-bore x stroke (mm)	4 - 123 x 155				
Total piston displacement (cc)	11,051				
Compression ratio	17.1 : 1				
Engine dimension (length x width x height) (mm)	1,365.5 x 870 x 1,046	1,383 x 870 x 1,207			
Engine weight (kg)	930	910			
Rotating direction (from flywheel)	Counter clockwise				
Fuel injection order	1 - 5 - 3 - 6 - 2 - 4				
Fuel injection timing (B.T.D.C static)	12°	16°	12°	16°	14°
Injection pump type	Zexel in-line "P" type				
Governor type	Mechanical governor type (RSV)	Electric governor type(Ghana Control)			
Injection nozzle type	Multi-hole type (5 hole)	Multi-hole type (5 hole)			
Fuel injection pressure (kg/cm²)	220	1st : 1 60, 2nd : 220			
Compression pressure (kg/cm²)	28 (at 200 rpm)				

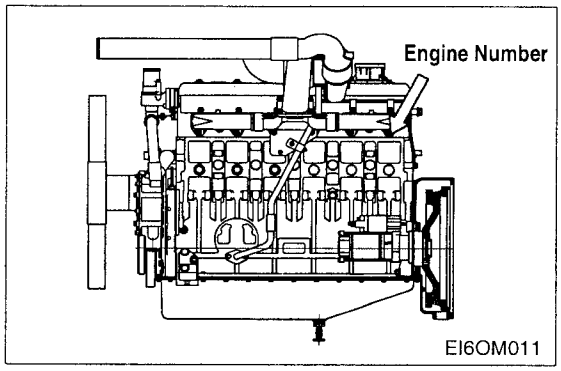
Power (ISO 3046)	condition	50Hz (1,500rpm)	60Hz (1,800rpm)	50Hz (1,500rpm)	60Hz (1,800rpm)	60Hz (1,800rpm)	60Hz (1,800rpm)	50Hz (1,500rpm)	2,100rpm
	Prime	205PS (151kW)	245PS (180kW)	328PS (241kW)	378PS (278kW)	356PS (262kW)	418PS (307kW)	360PS (265kW)	400PS (294kW)
	Stand by	226PS (166kW)	270PS (199kW)	370PS (272kW)	405PS (298kW)	392PS (288kW)	465PS (342kW)	400PS (294kW)	
Intake and exhaust valve clearance (at cold) (mm)	0.3							

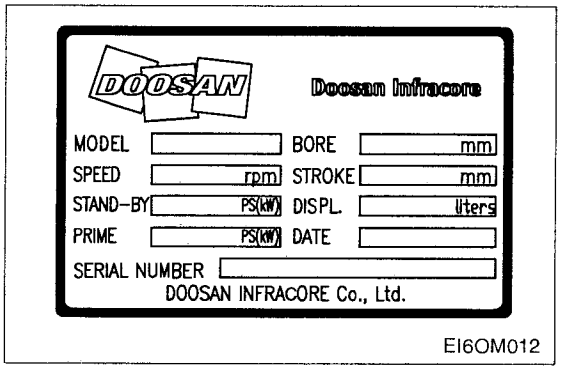
Items \ Engine Model		DE12T	P126TI	P126TI-1	P126TI-II	PU126TI
Intake valve	Open at	18° (B.T.D.C)				
	Close at	34° (A.B.D.C)				
Exhaust valve	Open at	46° (B.B.D.C)				
	Close at	14° (A.T.D.C)				
Lubrication method		Full forced pressure feed type				
Oil pump type		Gear type driven by crankshaft				
Oil filter type		Full-flow, Cartridge type				
Lubricating oil capacity (max./min.) (lit)		23 / 20				
Oil cooler type		Water cooled				
Water pump		Gear driven impeller type				
Cooling Method		Pressurized circulation				
Cooling water capacity (engine only) (lit)		19				
Thermostat type		Wax pallet type (95°C)	Wax pallet type (85°C)			
Alternator voltage - capacity (V - A)		24 - 45				
Starting Motor voltage-output (V-kW)		24 - 6.0				

3. Technical Information

3.1. Engine Model and Serial Number

- The engine model and serial number are located on the engine as illustrated.
- These numbers are required when requesting warranty and ordering parts.





- Engine serial No. (example 1 : DE12T)

EBHOA900001

Serial No.
Production Year (2009)
Engine Model Suffix (EBHOA)

- Engine serial No. (example 2 : P126TI series)

EDIOA900001

Serial No.
Production Year (2009)
Engine Model Suffix (EDIOA ~ EDIOE)

- Engine serial No. (example 3 : PU126TI)

EDIPA900001

Serial No.
Production Year (2009)
Engine Model Suffix (EDIPA ~ EDIPB)

3.2. Engine Type

The Engines DE12T/ P126TI / P126TI-1 / P126TI-II / PU126TI are in-line vertical water-cooled 6-cylinder four-stroke diesel engines with direct injection. DE12T is turbo-charged engine, and P126TI / P126TI-1 / P126TI-II / PU126TI models are turbo-charged and inter-cooled engine.

3.2.1. Cylinder block

The cylinder block is a single piece of alloy cast iron. To increase its stiffness, it is extended to a level below the crankshaft center line. The engine has replaceable dry cylinder liners and individual cylinder heads with struck-in valve seat rings and replaceable valve guides,

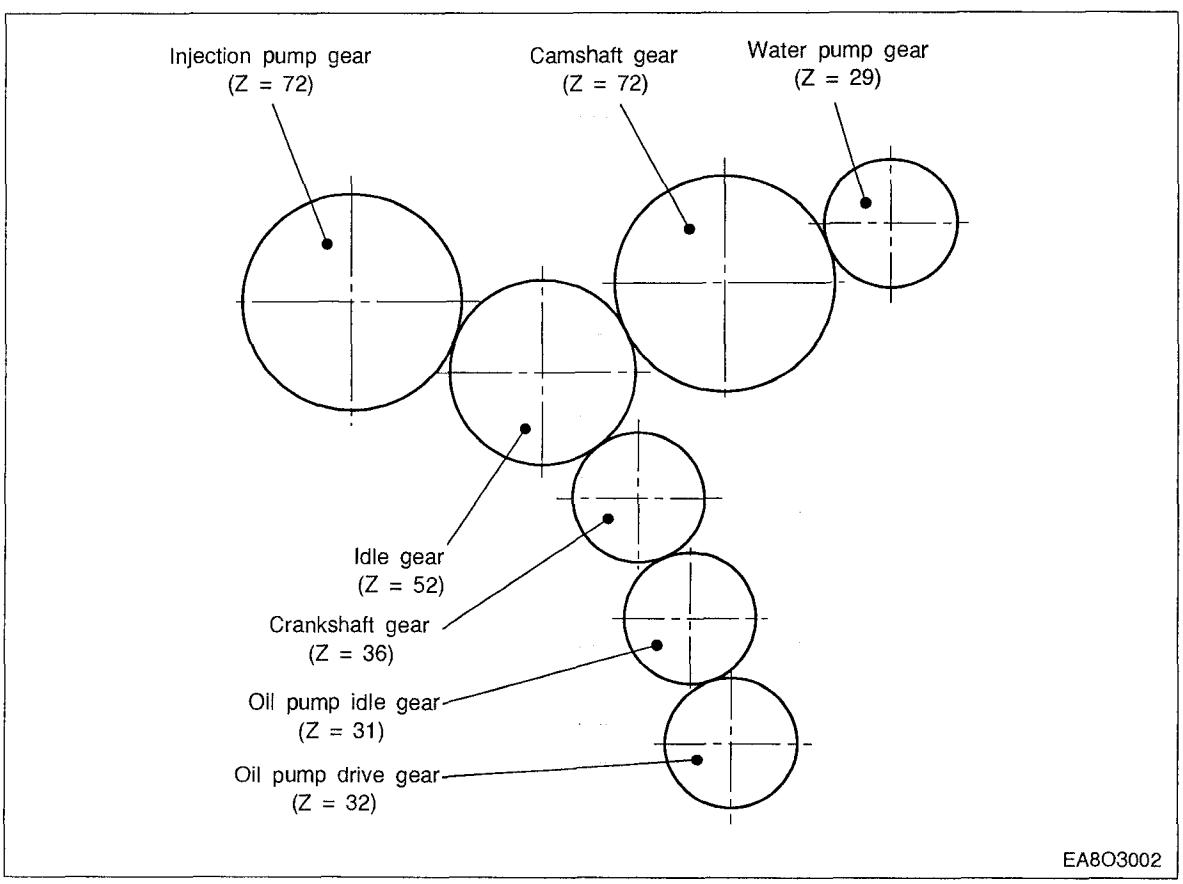
3.2.2. Piston con-rod / crankshaft

The forged crankshaft is a ingrate type (Counterweight is integrated with crank shaft body). Radial oil seal on crankshaft and flywheel are provided to seal the flywheel housing inside penetrations.

The con-rods (connecting rods) are die-forged, diagonally split and can be removed through the top of the cylinders together with the pistons. Crankshaft and connecting rods run in steel-backed lead bronze ready-to fit type bearings.

3.3. Engine Timing

Camshaft, oil pump and injection pump are driven by a gear train arranged at the front end.



3.4. Valves

The overhead valves are actuated via chilled cast iron tappets, push rods and rocker arms from the camshaft.

3.5. Lubrication System

The engine is equipped with force-feed lubrication.

The pressure is produced by a gear pump whose drive gear is in direct mesh with the crankshaft gear at the front end of cylinder block.

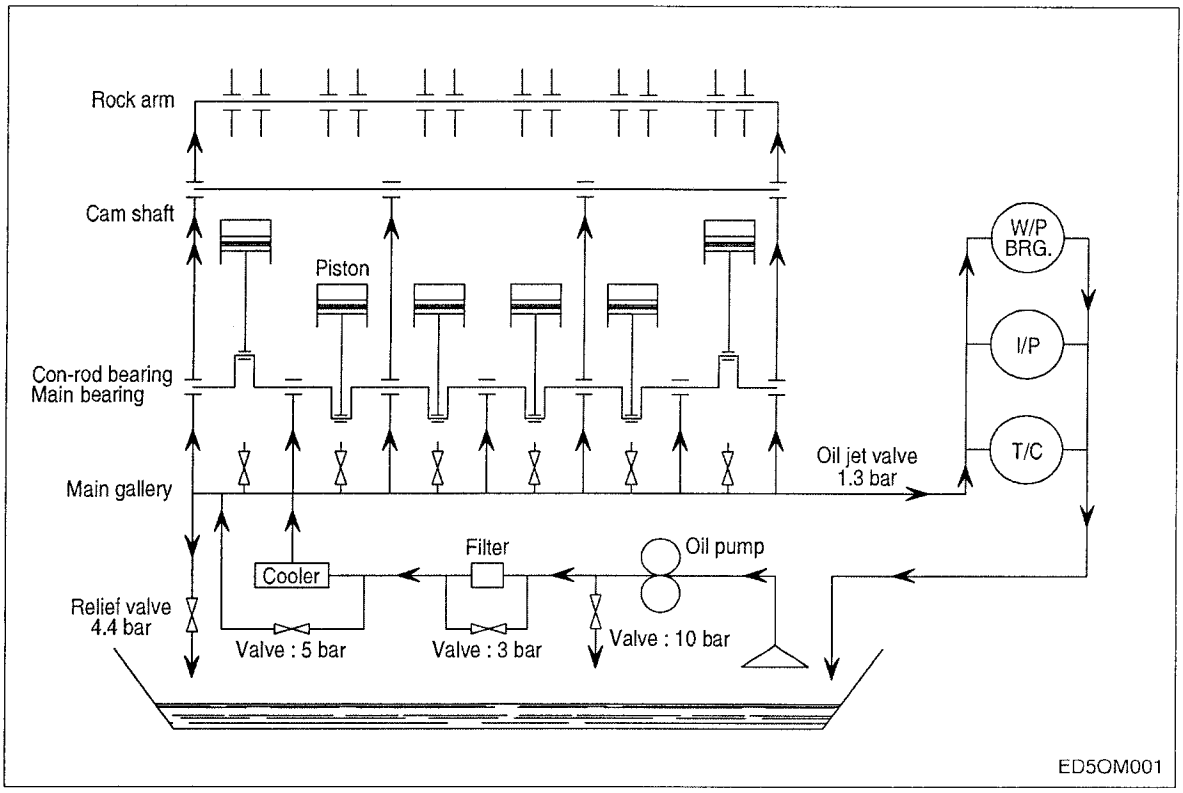
The oil pump draws the oil from the oil sump and delivers it through the oil cooler and oil filter to the main distributor gallery and from there to the main bearings, big-end bearings and camshaft bearings as well as to the small-end bearings and the rocker arms.

The injection pump and the turbocharger are also connected to the engine lubricating system.

The cylinder walls and timing gears are splash lubricated.

Each cylinder has an oil jet provided for cooling the underside of the pistons.

The lube oil is cleaned in a full-flow oil filter.

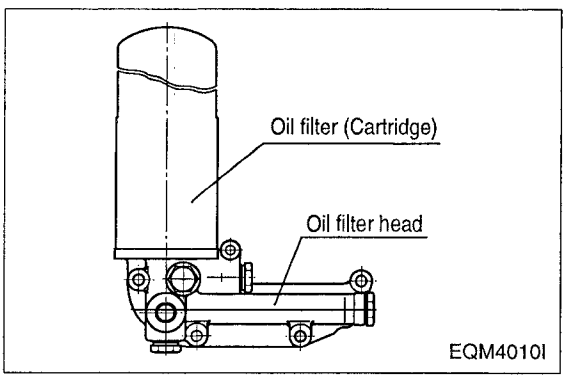


3.5.1. Oil cooler

An oil cooler is provided between the oil filter and the cylinder block. This cooler is a flat tube type with turbulence inserts and operated by the coolant.

3.5.2. Oil filter

Check for oil pressure and oil leaks, and repair or replace the oil filter if necessary. Change the oil filter cartridge simultaneously at every replacement of engine oil.



3.6. Air Cleaner

In case that elements are deformed, damaged or if the air cleaner has a crack, replace it.

By the definite interval, the elements must be cleaned and replaced.

- Cleaning of air cleaner element: Every 200 hours.
- Changing of air cleaner element: Every 400 hours.

3.7. Fuel System

The fuel is delivered by the fuel feed pump via the fuel filter to the injection pump and from there to the injection nozzles.

The fuel is sprayed into the cylinders through nozzles fitted in screw-fit injection nozzle holders in the cylinder heads.

Excessively delivered fuel and leak fuel from the nozzle flow through the return pipe back to the tank.

A strainer is arranged ahead of the fuel feed pump.

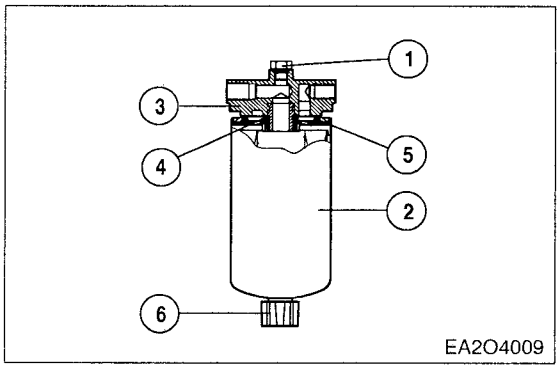
3.7.1. Fuel filter

This fuel filter has two functions not only oil filtering but also water separating.

Before entering the suction chamber of the injection pump, the fuel is cleaned in a strainer of fuel feed pump and a fuel filter.

Drain water in cartridge with loosening the cock under filter manually (6) from time to time.

The fuel filter should be replaced at every 400 hours.



3.7.2. Fuel requirements

DOOSAN marine diesel engines was designed to use Number 2-D diesel fuel or equivalent that meets specification DIN 51601-DK. For maximum fuel economy, Number 2-D fuel whenever possible. When temperatures are below -7 °C (20 °F), use Number 1-D fuel. If Number 1-D fuel is not available, the mixture of one kerosene to two gallons of Number 2-D fuel can be used. Once kerosene has been added, the engine should be run for several minutes to mix the fuel.

3.7.3. How to select fuel oil

Fuel quality is an important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. DOOSAN engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM Designation D975 (grades 1-D and 2-D) have provided satisfactory performance.

The ASTM 975 specification, however, does not in itself adequately define the fuel characteristics needed for assurance of fuel quality.

The properties listed in the fuel oil selection chart below have provided optimum engine performance. Grade 2-D fuel is normally available for generator service. Grade 1-D fuel should not be used in pleasure craft engines, except in an emergency.

Fuel oil selection chart

General Fuel Classification	ASTM Test	No. 1 ASTM 1-D	No. 2 ASTM 2-D	DIN 51601
Gravity,°API #)	D 287	40 ~ 44	33 ~ 37	0.815 ~ 0.855
Flash Point Min. °F (°C)	D 93	100 (38)	125 (52)	131 (55)
Viscosity, Kinematic CST 100 °F (40 °C)	D 445	1.3 ~ 2.4	1.9 ~ 4.1	1.8 ~ 10
Cloud Point °F #)	D 2500	See Note 1)	See Note 1)	See Note 1)
Sulfur Content wt%, Max.	D 129	0.5	0.5	0.15
Carbon Residue on 10%, wt%, Max.	D 524	0.15	0.35	0.1
Accelerated Stability Total Insolubles mg/100 ml, Max. #)	D 2274	1.5	1.5	
Ash, wt%, Max.	D 482	0.01	0.01	
Cetane Number, Min. #)	D 613	45	45	> 45
Distillation Temperature, °F(°C)	D 86			
IMP, Typican #)		350 (177)	375 (191)	
10% Typical #)		385 (196)	430 (221)	
50% Typical #)		45 (218)	510 (256)	680 (360)
90% +)		500 (260) Max.	625 (329) Max.	
End Point #)		550 (288) Max.	675 (357) Max.	
Water & Sediment %, Max.	D 1796	0.05	0.05	0.05

#) Not specified In ASTM D 975

+) Differs from ASTM D 975

NOTE :

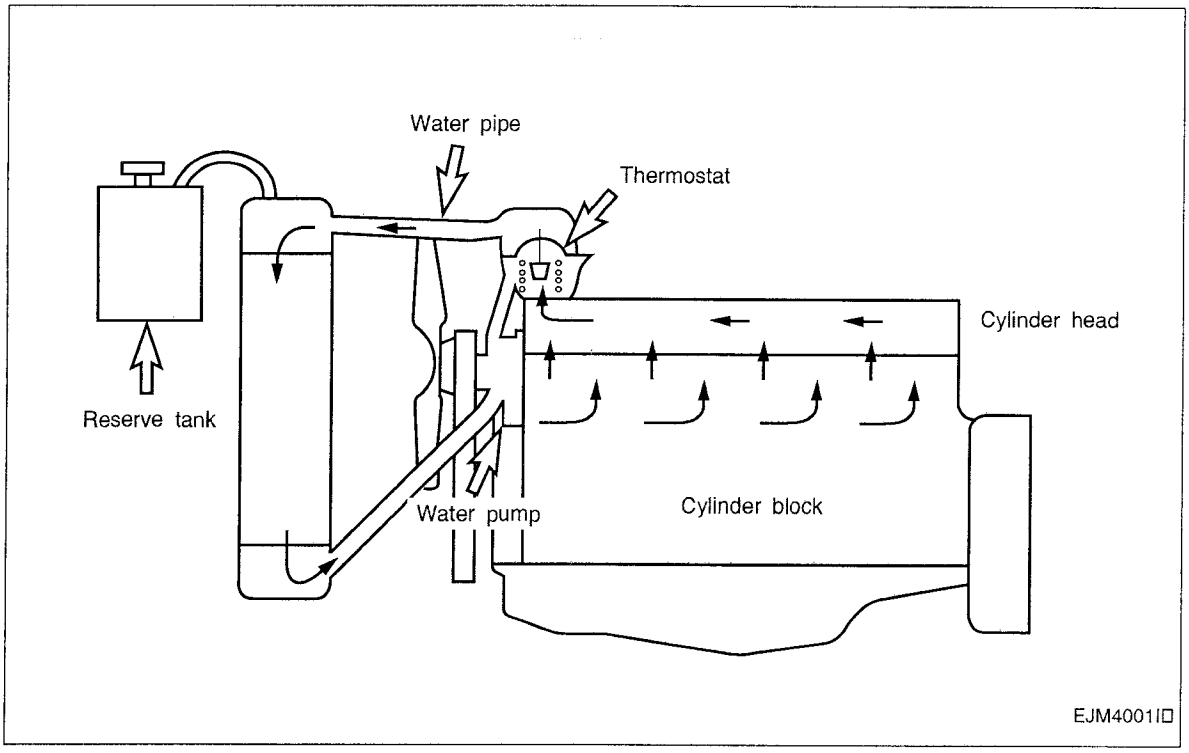
1. The cloud point should be 6°C(10°F) below the lowest expected fuel temperature to prevent clogging of fuel fitters by crystals.

3.8. Cooling System

The engine has a liquid-cooling system. The fresh water pump is a maintenance-free by gear from the crankshaft.

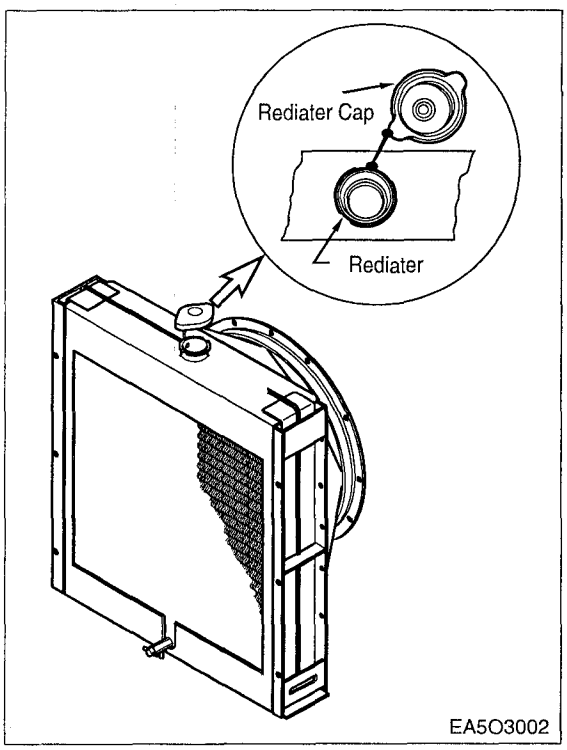
Depending on the agreed extent of delivery and the design of the engine, the coolant circuit can be equipped with temperature monitors which, in the event of loss of coolant, shut the engine down.

- Check the coolant level of the expansion tank by removing the expansion tank filler cap, and add coolant if necessary.
- When injecting antifreeze solution, first drain out the old coolant from the cylinder block and radiator, and then clean them with cleaning solution.
- Be sure to mix soft water with antifreeze solution.



3.8.1. Coolant pressure cap

Check the pressure valve opening pressure using a expansion tank cap tester. Replace the filler cap assembly if the measured valve does not reach the specified limit. (pressure valve opening pressure : 0.5 kg/cm²)



NOTE :
Because it is dangerous to open the pressure cap quickly when coolant is hot, after lowering the inside pressure of the tank by slow-opening at first open it fully.

3.8.2. Cooling water

- Regarding the cooling water that is to be used for engine, the soft water not the hard water must be used.
- The engine cooling water can be used diluting it with antifreezing solution 40% and the additive for rust prevention (DCA4) 3 ~ 5 %.
- The density of above solution and additive must be inspected every 500 hours to maintain it properly.

NOTE :
The proper density control of antifreezing solution and rust preventing additive will be able to prevent the rusting effectively and maintain the stable quality of engine.
For the improper control might give the fatal damage to the cooling water pump and cylinder liners, detail care is needed.

- Since DE12T , P126TI / P126TI-1 and P126TI-II / PU126TI cylinder liner is dry type, particularly the cooling water control should be applied thoroughly.
- The density of antifreezing solution and additive for rust prevention is able to be confirmed by the cooling water test kit. (Fleetguard CC2602M)
- How to use the cooling water test kit
  1) When the cooling water temp. of engine is in the range of 10 ~ 55 °C, loosen the plug for cooling water discharge and fill the plastic cup about a half.

NOTE :
In taking the cooling water sample, if the water in auxiliary tank were taken, it is hard to measure the accurate density. Take the cooling water sample necessarily loosening the cooling water discharge plug.

2) At the state of a test paper soaked in the sampled water, after taking the paper out through water agitation, shake off the water.
3) Wait for about 45 sec. till the color change of test paper.

NOTE :
However, it should not elapse longer than 75 sec, and if it did, the hue would change.

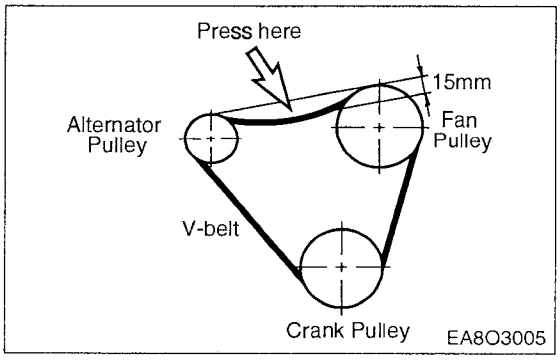
4) Make the numerical value by comparing the test paper which hue has changed with the color list of label on storage bottle.
5) By comparing the hue changed into yellowish green or so with the green color indication of test paper storage bottle, confirm the density. (Then, the density indication must be in the hue range of 33% to 50%).
6) The brown at the middle of test paper and the lower pink color indication represent the additive state for rust prevention, and the proper range is that the meeting numerical value of brown (vertical) and pink color (horizontal) locates in the range of 0.3 to 0.8 at the color list of label on the test paper storage bottle.
7) In case of less than 0.3, replenish the additive for rust prevention (DCA4), and in case of more than 0.8, pour out the cooling water about 50% and then readjust the density after refilling with clean fresh water.

● Amount of Anti-freeze in winter

Ambient Temperature (°C)	Cooling water (%)	Anti-freeze (%)
Over -10	85	15
-10	80	20
-15	73	27
-20	67	33
-25	60	40
-30	56	44
-40	50	50

3.9. V-belt Tension Check and Adjust

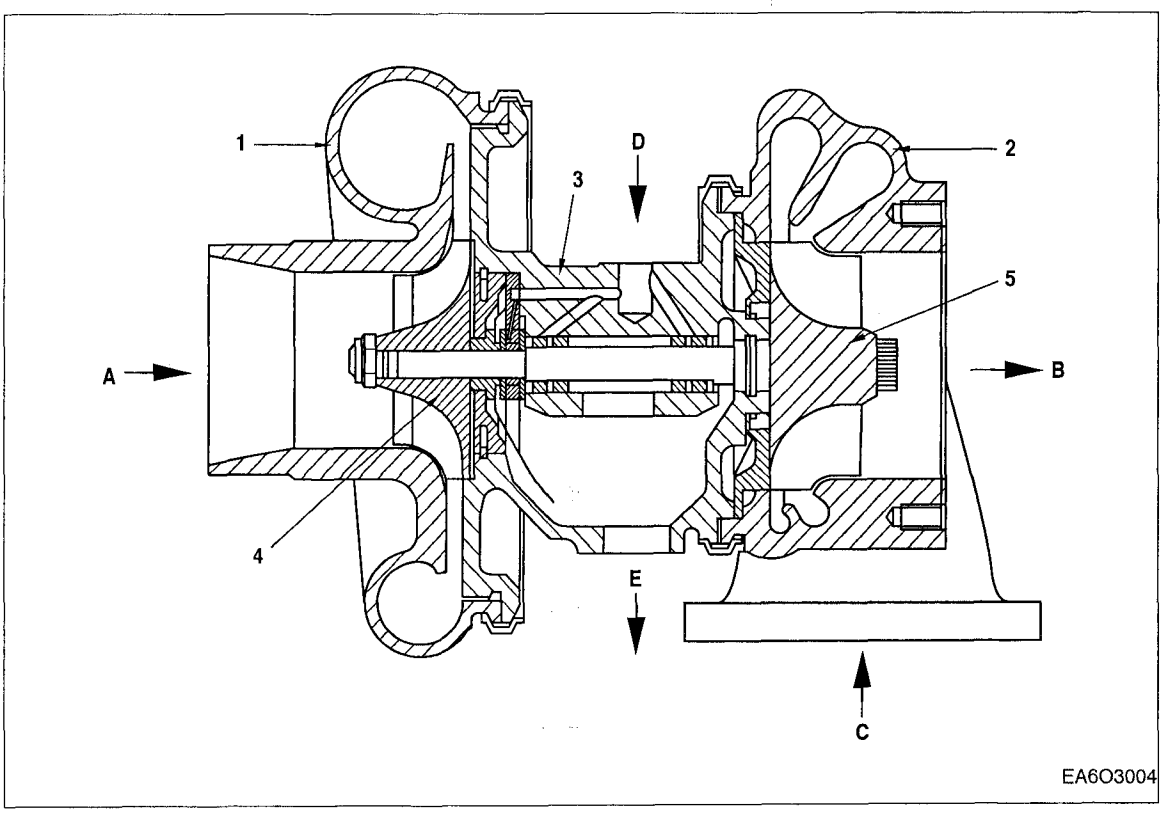
By the finger-pressure the belt is pressed by 10 mm ~ 15 mm between the fan pulley and the alternator pulley in normal condition. For the adjustment of the tension, loosen the adjusting bolts which support the alternator, adjust the tension and tighten the bolts again.



3.10. Turbocharger

The exhaust gases of the engine are passed through the turbine rotor of the turbocharger. Air compressor impeller mounted on the same shaft draws in fresh air and delivers it at a higher pressure to the cylinders.

The turbocharger is naturally air-cooled. Lubrication of the main bearing is by oil under pressure from the engine lubricating system.



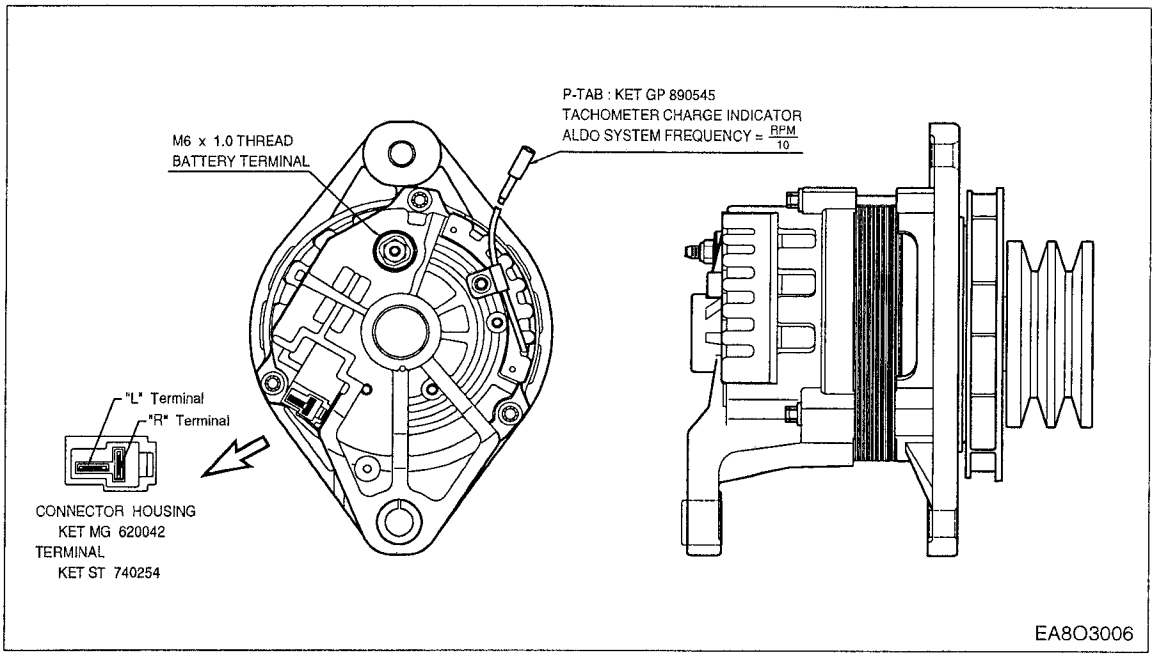
1. Compressor casing
2. Turbine casing
3. Compressor wheel
4. Impeller
5. Turbine

A. Air inlet
B. Gas outlet
C. Gas inlet
D. Oil supply
E. Oil return

3.11. Electrical Equipment

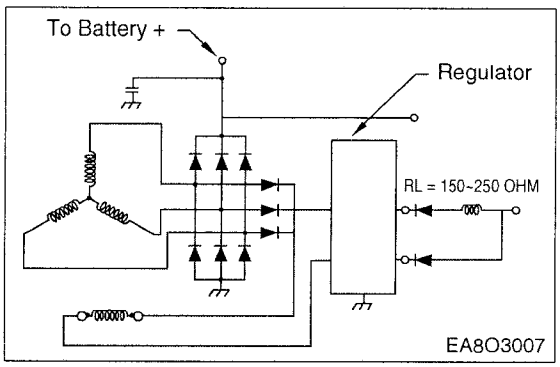
3.11.1. Alternator

The alternator is fitted with integral silicon rectifiers. A transistorized regulator mounted on the alternator body interior limits the alternator voltage. The alternator should not be operated except with the regulator and battery connected in circuit to avoid damage to the rectifier and regulator.



The alternator is maintenance-free, nevertheless, it must be protected against dust and, above all, against moisture and water.

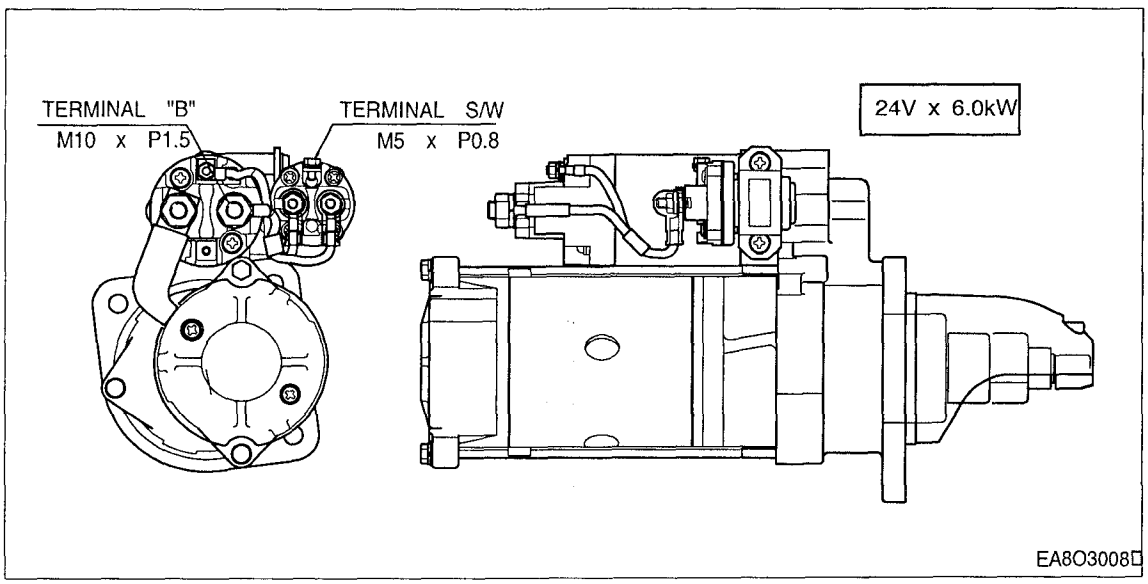
Operate the alternator according to the instructions given in the chapter.



3.11.2. Starter motor

The sliding-gear starter motor is flanged to the rear of the flywheel housing on the left-hand side. When the starting key switch is turned on, the starter motor pinion flies out and engages the ring gear of the flywheel. Then the main contact is closed, current flows, and the engine is started. After the engine starts, the pinion automatically returns to its initial position when the starting key switch is released. Once the engine starts, the starting key switch should be released immediately. Otherwise, the starter motor may be damaged or burned out.

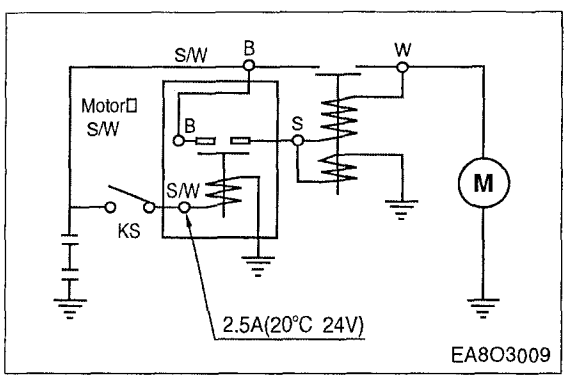
In case of repairing the engine dip the pinion of the starter and ring gear into the fuel and remove the corrosion with brush. After that apply the grease on them to protect the corrosion. Whenever you clean the starter, always pay attention not to occur the electric short due to entering the water.



Always protect starter motor against moisture.

WARNING :

Always disconnect the battery earth cable before starting work on the electrical system. Connect up the earth cable last, as there is otherwise a risk of short-circuits.



4. Commissioning and Operation

4.1. Preparation

At the time of initial commissioning of a new or overhauled engine make sure to have observed the "Technical Information for the installation DOOSAN generator engines".

- Oil filler neck on cylinder head cover
  Before daily starting of the engine, check the fuel, coolant and oil level, replenish if necessary.
  The notches in the dipstick indicate the highest and lowest permissible oil levels
  The oil required in the sump is specified in the "Engine Specification".

NOTE :
The oil required to fill the oil fillers and pipes depends upon the engine and use and must be determined individually at the time of initial commissioning. (Make the Max and Min. marks of the determined quantity on the oil level gauge.)

- Cleanliness
  Ensure outmost cleanliness when handling fuels, lubricants and coolants.

4.2. Breaking-in

4.2.1. Operation of a new engine (Break-In)

Because the sliding surfaces of a new engine are not lapped enough, the oil film can be destroyed easily by overload or overspeed and the engine life-time may be shortened.
Therefore the following things must be obeyed by all means.

Up to the first 50 hours

- Engine should be run at fast idling until the temperature of the engine becomes normal operating condition.
- Overload or continuous high speed operation should be avoided.
- High speed operation with no load should be prevented.
- Abrupt start and stop of the engine should be avoided.
- Engine speed must be under 70% of its maximum speed.
- Maintenance and Inspection must be accomplished thoroughly.

4.2.2. Check points for break-in

During the break-in (the initial running of the engine) period, be particularly observant as follows:

1) Check engine oil level frequently. Maintain oil level in the safe range, between the "min." and "max." marks on dipstick.

NOTE :

If you have a problem getting a good oil level reading on dipstick, rotate dipstick 180° and re-insert for check.

2) Watch the oil pressure warning lamp. If the lamp blinks, it may be the oil pick-up screen is not covered with oil. Check oil dipstick. Add oil to the oil pan, if required. Do not overfill. If level is correct and the status still exists, see your DEALER for possible switch or oil pump and line malfunction.

NOTE :

Oil pressure will rise as RPM increases, and fall as RPM decreases. In addition, cold oil will generally show higher oil pressure for any specific RPM than hot oil. Both of these conditions reflect normal engine operation.

3) Watch the engine water temperature gauge and be sure there is proper water circulation. The water temperature gauge needle will fluctuate if water level in expansion tank is too low.
At the end of the break-in period, remove break-in oil and replace the oil filter. Fill oil pan with recommended engine oil. Refer to following table.

<Engine Oil capacity>

	Oil pan (only)
DE12T	23 liter
P126TI / P126TI-1 / P126TI-II / PU126TI	23 liter

4.2.3. Operating after break-in

When starting a cold engine, always allow the engine to warm up gradually. Never run the engine at full throttle until the engine is thoroughly warmed up. Be sure to check the oil level frequently during the first 50 hours of operation, since the oil consumption will be high until the piston rings are properly seated.

4.3. Inspections after Starting

During operation the oil pressure in the engine lubrication system must be monitored. If the monitoring devices register a drop in the lube oil pressure, switch off the engine immediately.
And the charge warning lamp of the alternator should go out when the engine is running.

- Do not disconnect the battery or pole terminals or the cables!
- If, during operation, the battery charge lamp suddenly lights up, stop the engine immediately and remedy the fault in the electrical system!
- Engine should be stopped if the color, the noise or the odor of exhaust gas is not normal.
- Confirm the following things through warning lamps and gauge panel.

4.3.1. Pressure of lubricating oil

The normal pressure comes up to 1 kg/cm^2 (1.0 bar) at idling and 3 ~ 5 kg/cm^2 (3.0 ~ 4.9 bar) at maximum speed. If the pressure fluctuates at idling or does not reach up to the expected level at high speed, shut down the engine immediately and check the oil level and the oil line leakage.

4.3.2. Temperature of cooling water

The cooling water temperature should be 71 ~ 85°C in normal operating conditions. Abnormally high cooling water temperature could cause the overheating of engine and the sticking of cylinder components. And excessively low cooling water temperature increases the fuel consumption, accelerates the wears of cylinder liners and shortens the engine life-time.

4.4. Operation in Winter Time

Pay special attention to the freezing of cooling water and the viscosity of lubricating oil.

4.4.1. Prevention against the freeze of cooling water

When not using anti-freeze, completely discharge the whole cooling water after engine running. The freeze of cooling water causes the fatal damages of the engine. Because the anti-freeze is used to prevent cooling water from freeze, consult "The amount of anti-freeze".

4.4.2. Prevention against excessive cooling

Drop of thermal efficiency caused by excessive cooling increases fuel consumption, therefore prevent the engine from excessive cooling. If the temperature of coolant does not reach to normal condition (71 ~ 85 °C) after continuous operation, examine the thermostat or the other cooling lines.

4.4.3. Lubricating oil

As cold weather leads to the rise of oil viscosity, engine speed becomes unstable after starting. Therefore the lubricating oil for winter should be used to prevent this unstability. Refer to "Lubricating System Section".

4.5. Tuning the Engine

The purpose of an engine tune-up is to restore power and performance thatís been lost through wear, corrosion or deterioration of one or more parts or components. In the normal operation of an engine, these changes can take place gradually at a number of points, so that itís seldom advisable to attempt an improvement in performance by correction of one or two items only. Time will be saved and more lasting results will be obtained by following a definite and thorough procedure of analysis and correction of all items affecting power and performance.

Economical, trouble-free operation can better be ensured if a complete tune-up is performed once every years, preferably in the spring. Components that affect power and performance to be checked are:

- Components affecting fuel injection ;
  Nozzle, delivery valve, fuel filter, water separator, etc.
- Components affecting Intake & exhaust ;
  Air filter, inter-cooler, turbo, silencer, etc.
- Components affecting lubrication & cooling ;
  Air & oil filter, anti- freeze, etc.

5. Maintenance and Care

5.1. Periodical Inspection and Maintenance

In order to insure maximum, trouble-free engine performance at all times, regular inspection, adjustment and maintenance are vital.

- Daily inspections in below figure should be checked every day.
- The maintenance should be executed thoroughly at regular intervals.
  (Refer to " 7.1. Periodic Inspection Cycle")

5.2. Lubrication System

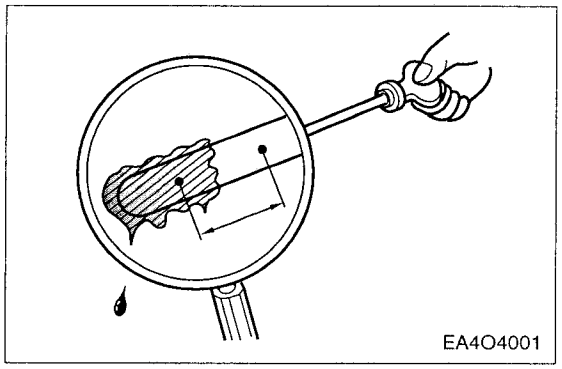
5.2.1. Exchanging of lubrication oil

Engine oil and the oil filter are important factors affecting engine life. They affect ease of starting, fuel economy, combustion chamber deposits and engine wear. Refill and drain oil pan every 50 hours of operation or 6 months whichever occurs first. At the end of the break-in period (50 hours), change the oil sump oil and replace the oil filter.

5.2.2. Oil level

Check the oil level in the engine sump daily with a dipstick.

- The notches in dipstick must indicate the oil level between the max. and the min. permissible.
- The oil level should be checked with the engine horizontal and only after it has been shut down for about 5 minutes.
- Examining the viscosity and the contamination of the oil smeared at the dipstick replace the engine oil if necessary.

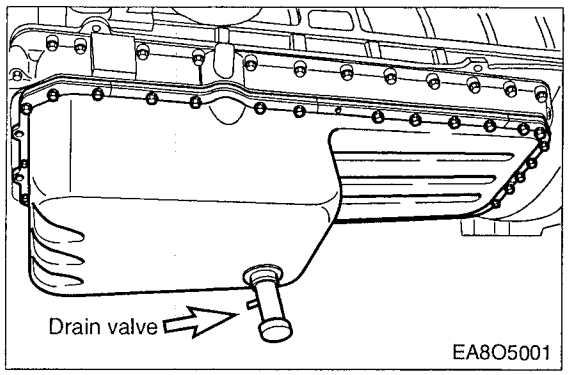


CAUTION :
Do not add so much engine oil that the oil level rises above the max. marking on the dipstick. Over lifting will result in damage to the engine.

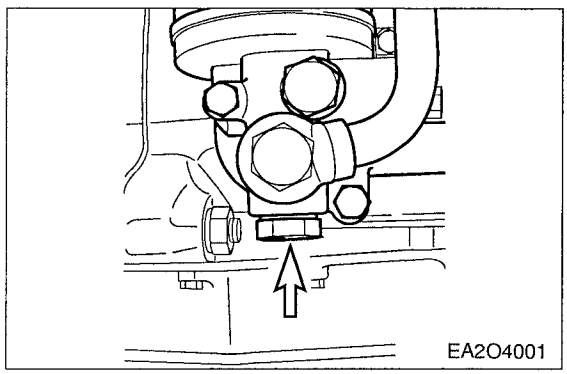
5.2.3. Oil exchange procedure

While the oil is still hot, exchange oil as follows:

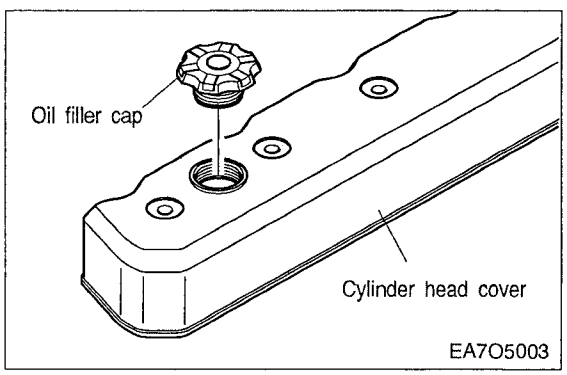
- Take out the oil dip dipstick.
- Remove the drain valve from oil pan and the drain plug form oil filter head, then drain out the engine oil into a container.



- Reassemble the drain valve with the oil pan and the drain plug with oil filter head after draining out the engine oil.

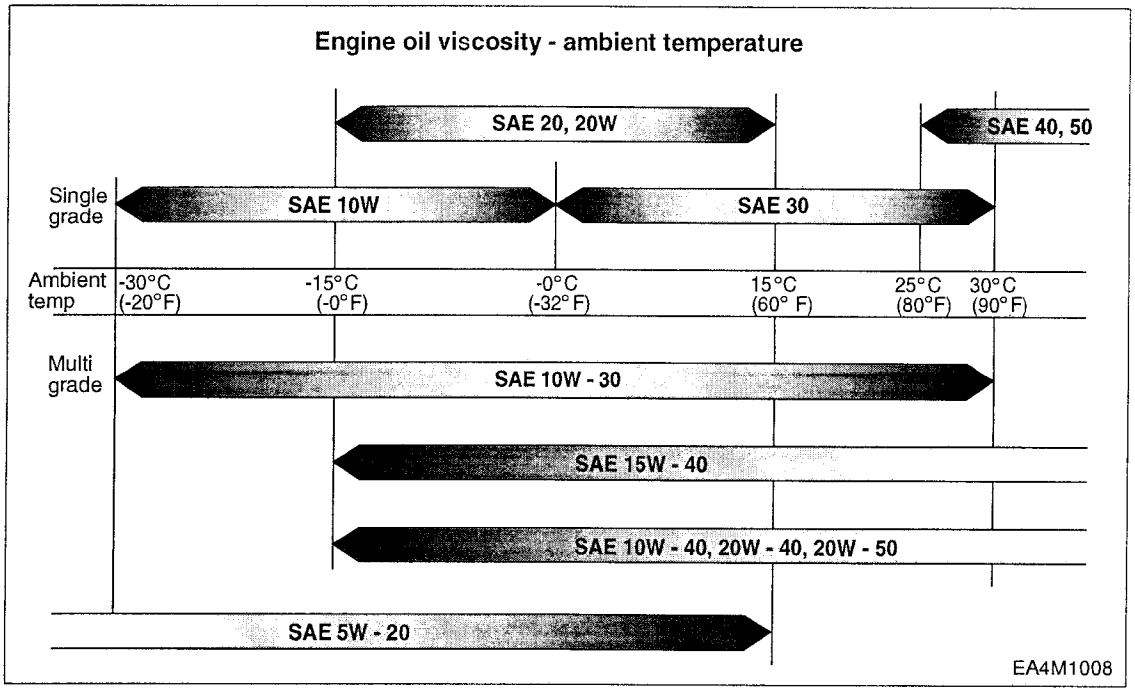


- Refill with new engine oil at the oil filler neck on the head cover and the lubricating oil in accordance with the oil capacity of the engine through oil filler. Be careful about the mixing of dust or contaminator during the supplement of oil. Then confirm that oil level gauge indicates the vicinity of its maximum level.
- For a few minutes, operate the engine at idling in order to circulate oil through lubrication system.
- Thereafter shut down the engine. After waiting for about 10 minutes measure the quantity of oil and refill the additional oil if necessary.



● Recommend of lubricating oil

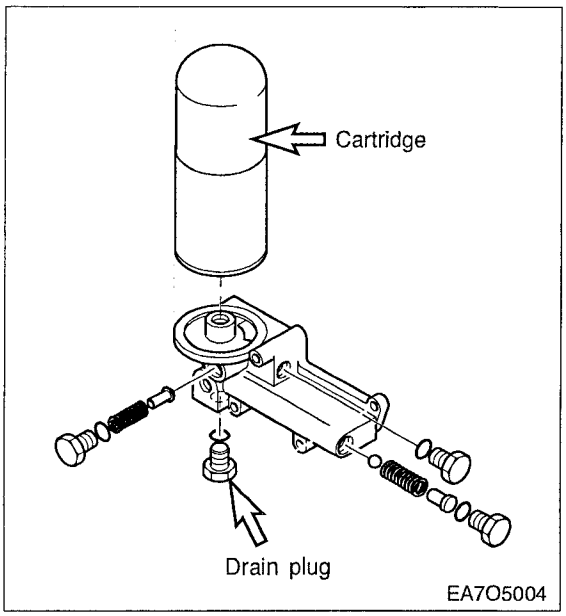
Initial factory filling is high quality break-in oil (API Service CH-4 grade). During the break-in period (50 hours), check the oil level frequently. Somewhat higher oil consumption is normal until piston rings are seated. The oil level should be maintained in the safe range between Min. and Max. mark on the dipstick. To obtain the best engine performance and engine life, Engine oil is specified by API Service, lettered designations and SAE viscosity numbers. If the specified engine oil is not available, use a reputable brand of engine oil labeled for API Service CH-4 and SAE viscosity 15W40 or 10W40. Refer to oil identification symbol on the container.



5.2.4. Replacement of oil filter cartridge

At the same times of oil exchanges, replace the oil filter cartridge.

- Drain engine oil by loosening the drain plug on the filter head.



CAUTION :
Don't forget tightening the drain plug after having drained engine oil.

- Loosen the oil filter by turning it counter- clockwise with a filter wrench.
- With a rag wipe clean the fitting face of the filter body and the oil filter body so that new oil filter cartridge can be seated properly.
- Lightly oil the O-ring and turn the oil filter until sealing face is fitted against the O-ring. Turn 1-1/4 turns further with the filter wrench.

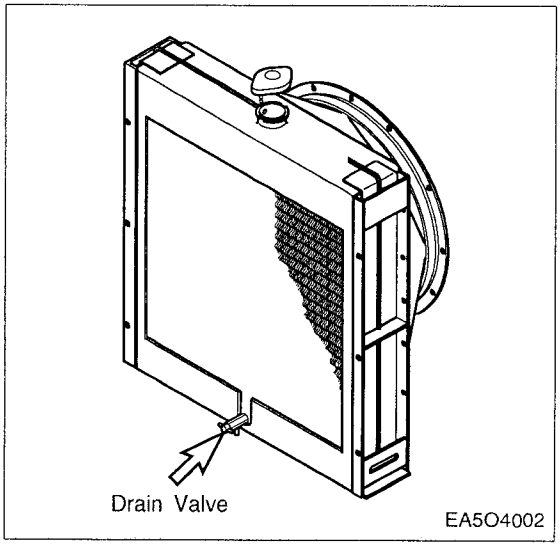
NOTE :
It is strongly advisable to use DOOSAN genuine oil filter cartridge for replacement.

5.3. Cooling System

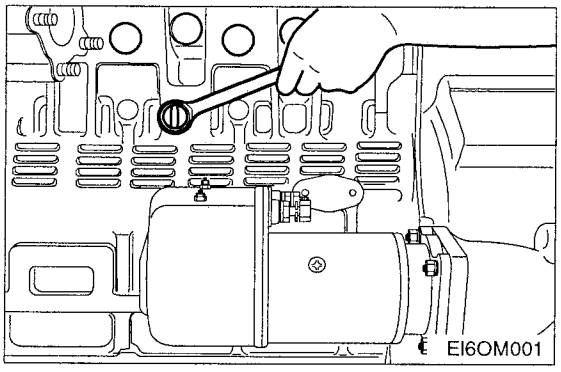
The coolant must be changed at intervals of 1,200 hours operation or six months whichever comes first. If the coolant is being fouled greatly, it will lead an engine overheat or coolant blow off from the expansion tank.

5.3.1. Coolant draining

1) Remove the pressure cap.
2) Open the drain valve at the radiator lower part to drain the coolant as the right figure.



3) Loosen the coolant drain plug. Loosen the coolant drain plug of the cylinder block.



CAUTION :

When removing the pressure filler cap while the engine is still hot, cover the cap with a rag, then turn it slowly to release the internal steam pressure. This will prevent a person from scalding with hot steam spouted out from the filler port.

5.3.2. Cleaning of the cooling system inside circuit (by authorized specialist personnel)

When the cooling system circuits are fouled with water scales or sludge particles, the cooling efficiency will be lowered.

Investigations have shown that in many cases the poor condition of the coolant and /or the cooling system accounts for damage to the water pump mechanical seal, The poor condition of the cooling system is normally due to use of unsuitable or no anti-freezing agents and corrosion inhibitor or defect, not early enough replaced covers for filler neck and working valves.

If twice in a short time the water pump of an engine develops leases or the coolant is heavily contaminated (dull, brown, mechanically contaminated, gray or black signs of a leakage on the water pump casing) clean the cooling system prior to removing that water pump as follows.

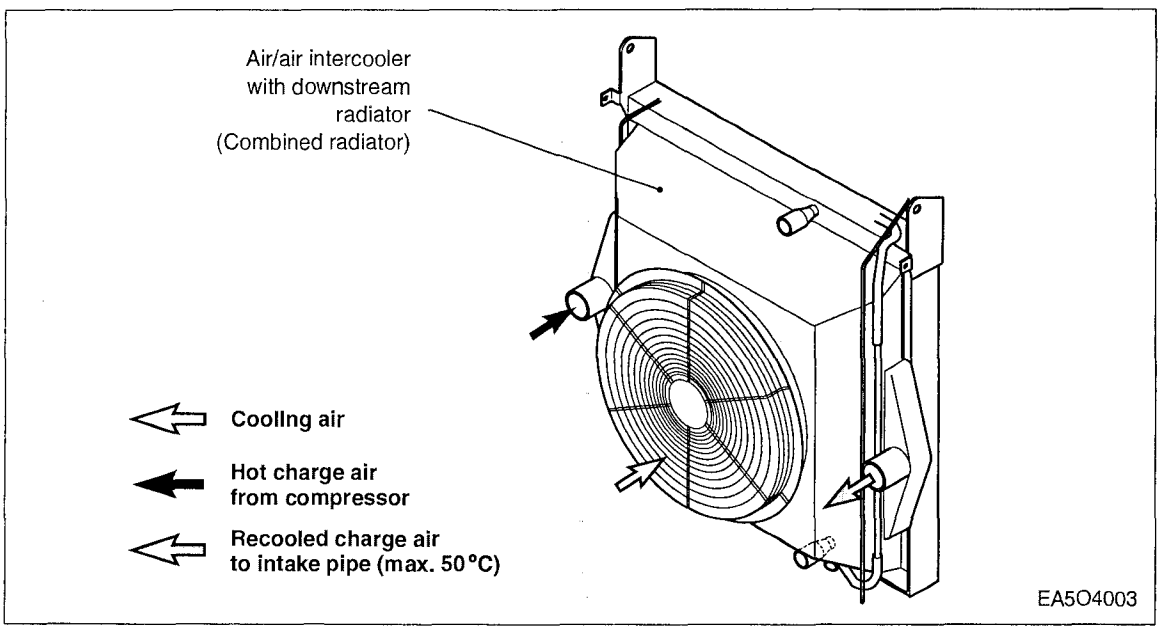
1) Drain coolant.
2) Remove thermostats, so that the whole cooling system is immediately flown through when cleaned.

3) Fill the cooling system with a mixture of potable water and 1.5% by volume of cleaner. (Henkel P3T5175)
4) Warm up engine under load. After a temperature of 60°C is reached, run engine for a further 15 minutes.
5) Drain cleaning fluid.
6) Repeat steps 3) and 4).
7) Flush cooling system.
8) Replace drain plug by drain plug with a bore of 8 mm diameter.
9) Fill cooling system with hot water.
10) Run engine at idle for 30 minutes. At the same time continuously replenish the water leaking from the bore in drain plug by adding fresh water.

Periodically clean the circuit interior with a cleaner.
- Cooling system cleaning interval: Every 1,200 hours.

5.3.3. Intercooler

The intercooler is air to air type and has a large cooling fan capacity. The intercooler life and performance depends on the intake air condition greatly. Fouled air pollutes and clogs the air fins of intercooler. As a result of this, the engine output is decreased and engine malfunction is occurred. So you always check whether the intake air systems like air filter element are worn or polluted.



- Cleaning

  In order to maintain the heat transfer efficiency of the intercooler, it is necessary to clean it at regular intervals.

Cleaning of intercooler fins: Every 600 hours.

5.4. Air Intake System

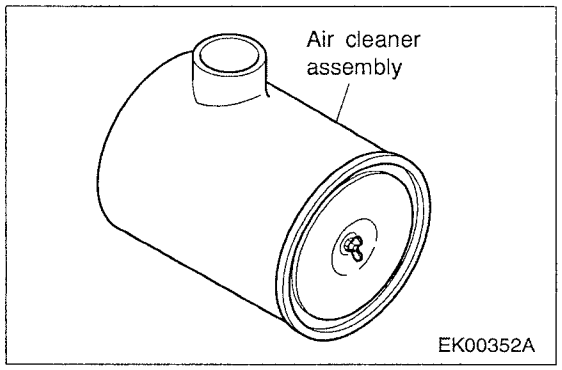
5.4.1. Maintenance (only when engine Is switched off)

Empty the dust bowl (7) regularly. The bowl should never be filled more than halfway with dust.

On slipping off the two clamps (3), the dust bowl can be removed. Take off the cover (6) of the dust bowl and empty.

Be careful to assemble cover and bowl correctly.

There is a recess in the cover rim and a lug on the collector which should register. Where the filter is installed horizontally, watch for "top" mark on cleaner bowl.

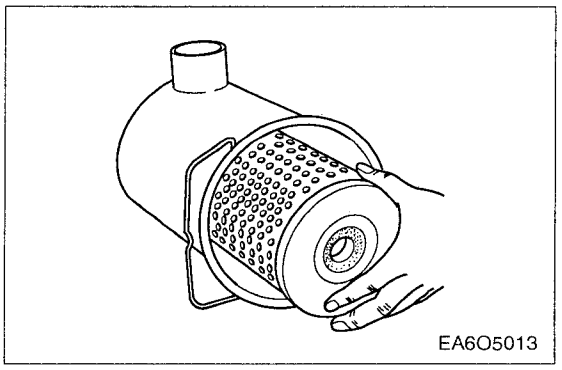


5.4.2. Changing filter element

CAUTION :
Do not allow dirt to get into the clean air end.

On removing the hexagon nut, take out the dirty cartridge and renew or clean.

Wipe the cleaner housing with a damp cloth, in particular the sealing surface for the element.



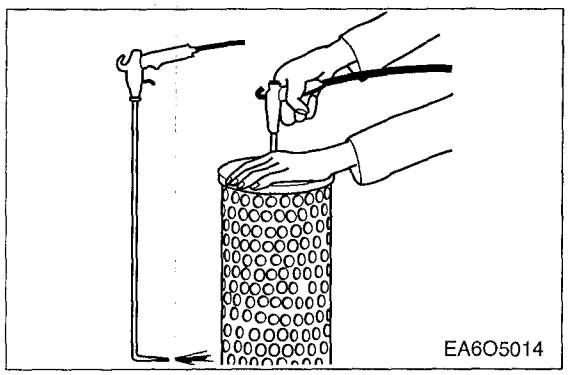
NOTE :
Unless the maximum number of cleanings (up to 5 x) have been done, the filter cartridge should be renewed every two years or 4,000 hours operation.

5.4.3. Cleaning filter elements

- By compressed air (wear goggles)

  For the purpose, the air gun should be fitted with a nozzle extension which is bent 90° at the discharge end and which is long enough to reach down inside to the bottom of the element.

  Moving the air gun up and down, blow out the element from the inside (maximum 500 kPa - 5 bar) until no more dust comes out of the filter pleats.

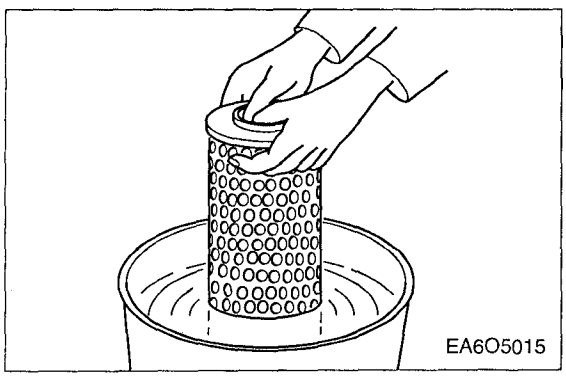


- By washing

  Before washing, the element should be precleaned by means of compressed air, as described above.

  Then allow the element to soak in lukewarm washing solvent for 10 minutes, and then move it to and for in the solvent for about 5 minutes.

  Rinse thoroughly in clean water, shake out and allow drying at room temperature. The cartridge must be dry before it is reinstalled. Never use steam sprayers, petrol (gasoline), alkalis or hot liquids etc. to clean the filter elements.



- Knocking out dirt by hand

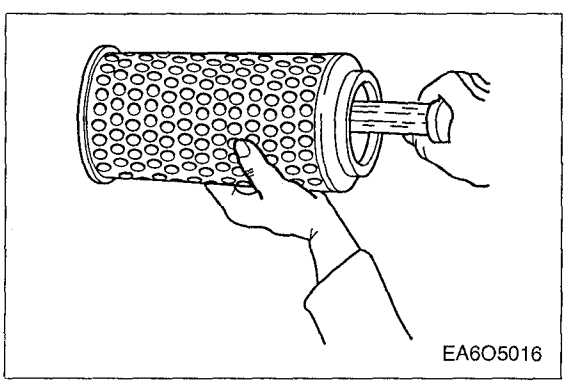
  In emergencies, when no compressed air or cleaning agent is available, it is possible to clean the filter cartridge provisionally by hitting the end disk of the cartridge with the ball of oneís thumb.

  Under no circumstances should the element be hit with a hard object or knocked against a hard surface to loosen dirt deposits.

- Checking the filter cartridge

  Before reinstalling the cartridge, it must be checked for damage e.g. to the paper pleats and rubber gaskets, or for bulges and dents etc. in the metal casket.

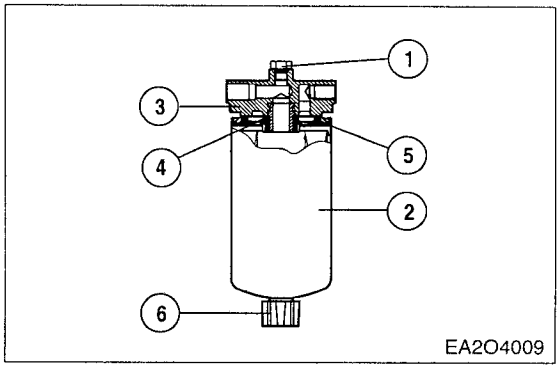
  Cracks and holes in the paper pleating can be established by inspecting the cartridge with a flashlight. Damaged cartridges should not be reused under any circumstances. In cases of doubt, discard the cartridge and install a new one.



5.5. Fuel System

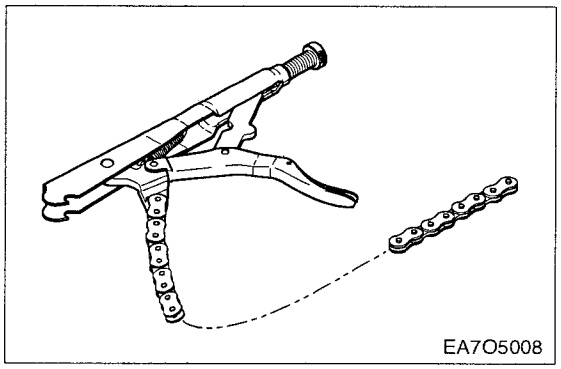
5.5.1. Fuel filter

- After every 200 hour of operation, drain the water and sediment from the fuel-water separator.
- Shut off the engine. Use your hand to open the drain valve (6).
- Turn the valve counter clockwise approximately 2 ~ 3 turns until draining occurs. Drain the filter sump of water until close fuel is visible.
- Turn the valve clockwise to close the drain valve. Do not over tighten the valve, overtightening can damage the threads.



5.5.2. Replacement of fuel filter

- Clean the area around the fuel filter head (3).
- Remove the fuel filter (2) by turning it counter-clockwise with filter wrench. (Discard the used filter.)
- Remove the fuel filter thread adapter seal ring (4).
- Use a clean lint free cloth to clean the gasket surface of the fuel filter head (3).
- Install the new thread adapter seal ring (4) supplied with the new filter.
- Use clean oil to lubricate the filter seal (5), and fill the new filter with clean fuel.
- Install the filter on the filter head (3).
- Tighten the filter until the gasket contacts the filter head surface.
- Tighten the filter on additional one-half to three-fourths of a turn with the filter wrench, on as specified by the filter manufacturer.



NOTE :
Mechanical over tightening of the filter can distort the thread or damage the filter element seal.

5.5.3. Fuel system checks

Fill the tank with the recommended fuel. Keeping tanks full reduces water condensation and helps keep fuel cool, which is important to engine performance.

Make sure fuel supply valves (if used) are open.

To insure prompt starting and even running, the fuel system must be primed with the fuel feed pump manually before starting the engine the first time, or after a fuel filter change.

Refill at the end of each dayís operation to prevent condensation from contaminating the fuel. Condensation formed in a partially filled tank promotes the growth of microbial organisms that can clog fuel filters and restrict fuel flow.

If the engine is equipped with a fuel water separator, drain off any water that has accumulated. Water in fuel can seriously affect engine performance and may cause engine damage. **DOOSAN recommends installation of a fuel water separator on generator units.**

- Air removal of fuel system

  The suction room of fuel injection pump has the function of air removal continuously during the operation through a relief valve.

  In case that the suction room lacks fuel at all, for instance, in case of new installation of injection pump, after loosening the air removing screws of cartridge filter respectively, remove the air by operating the manual pump of fuel supply pump until bubble will disappear.

- Fuel supply pump

  Every time of engine oil replacement, the fuel strainer installed at the fuel supply pump should be removed and cleaned.

5.5.4. Fuel Contamination and water trap

In the generator environment, the most likely fuel contaminants are water and microbial growth (black "slime"). Generally, this type of contamination is the result of poor fuel handling practices. Black ìslimeî requires water in the fuel to form and grow, so the best prevention is to keep water content to a minimum in storage tanks.

If diesel fuel which contains moisture is used the injection system and the cylinder liners / pistons will be damaged. This can be prevented to same extent by filling the tank as soon as the engine is switched off while the fuel tank is still warm (formation of condensation is prevented). Drain moisture from storage tanks regularly. Installation of a water trap upstream of the fuel filter is also advisable.

NOTE :

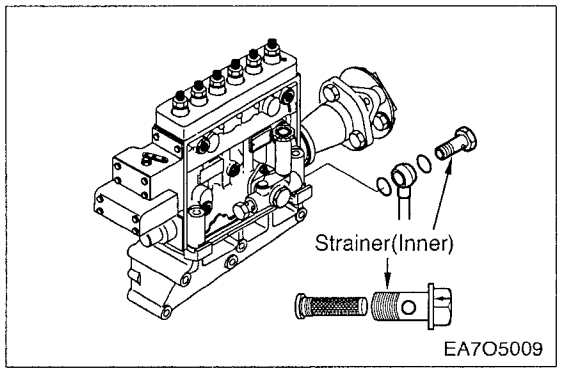
A galvanized steel tank should never be used for fuel storage, because the fuel oil reacts chemically with the zinc coating to form powdery flakes which can quickly clog the fuel filters and damage the fuel pump and injection nozzles.

5.5.5. Priming pump strainer cleaning

Clean the priming pump strainer every 200 operation hours.

The strainer is incorporated in the priming pump inlet side joint bolt.

Clean the strainer with the compressed air and rinse it in the fuel oil.

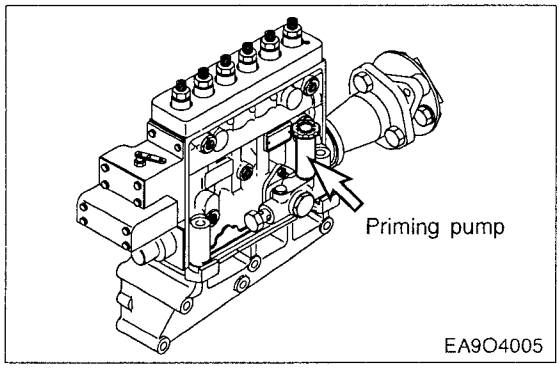


5.5.6. Bleeding the fuel system

Whenever fuel filter is changed or the engine is stopped by cause of the fuel lack, the air of fuel line must be removed as follows.

Bleed the fuel by manually operating the priming pump with fuel filter outlet joint bolt and injection pump bleeder screw loosened.

- Press the feed pump cap repetitively until the fuel without bubbles overflows from the bleeding plug screw.
- After the whole air is pulled out, close the plug screws of the filter and the pump.
- Confirm the resistance of fuel delivery by repetition pressing of the feed pump cap, Pressure and turn the priming pump cap simultaneously to close it.

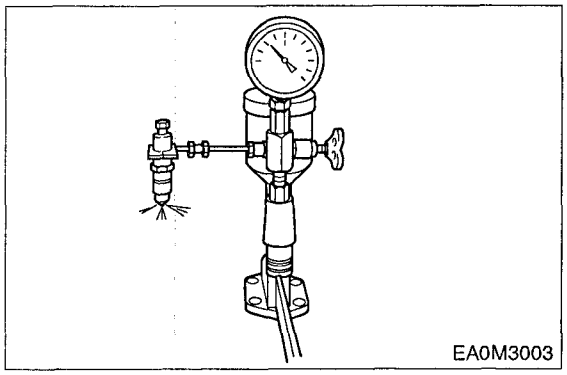


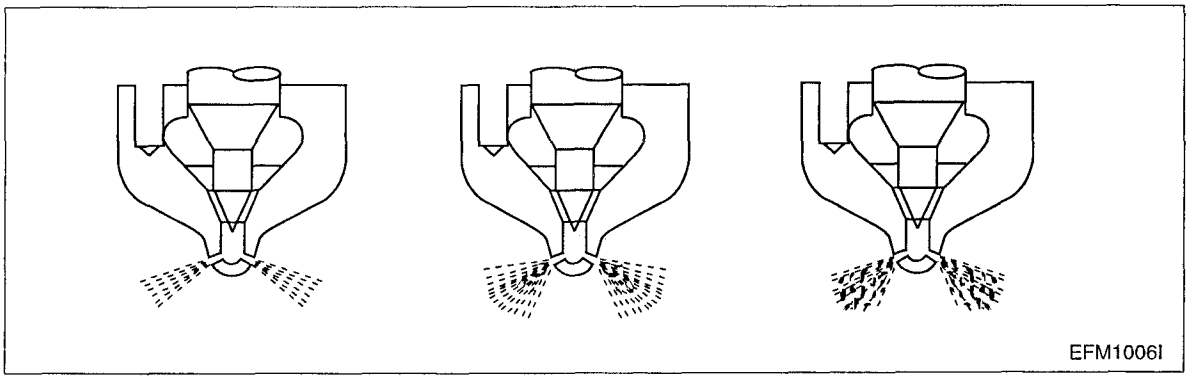
5.5.7. Injection pump

- Check the fuel injection pump housing for cracks or breaks, and replace if damaged.
- Check and see if the lead seal for idling control and speed control levers have not been removed.
- No alterations must be made to the injection pump. If the lead seal is damaged the warranty on the engine will become null and void.
- We strongly recommended that any faults developing in the injection pump should be taken care of by authorized specialist personnel.

5.6. Injection Nozzle Maintenance (by authorized specialist personnel)

The injectors are designed to spray the fuel delivered by the injection pump directly into the spherical combustion chamber in the piston crown. The injector consists of the nozzle and the nozzle holder.
A copper seal fitted to the injector ensures gas-tight seating and good heat dissipation. The opening pressure of the nozzle is adjusted by means of shims at the compression spring.


EA0M3003


EFM1006I

- Install a nozzle to a nozzle tester.
- Check injection pressure, and adjust the nozzle using the adjusting shim if the pressure does not meet the specified limit.
- Check nozzle spray patterns and replace if damaged.

	DE12T	P126TI / P126TI-1 / P126TI-II / PU126TI
Opening pressure	220kg/cm²	1st : 160kg/cm² 2nd : 220kg/cm²

NOTE :
A galvanized steel tank should never be used for fuel storage, because the fuel oil reacts chemically with the zinc coating to form powdery flakes which can quickly clog the fuel filters and damage the fuel pump and injection nozzles.

- When mounting the pipes to the engine take care of good fitness.
- Do not bend pipes to permanent deformation (not for replacing the nozzles either).
- Do not mount any heavily bent pipes.
- Avoid bending the pipes at the ends by more than 2 to 3 degrees.

In case of faults in the injection system which might have resulted in excessive operating pressures, not only the failed part but also the injection line has to be replaced.

5.7. Turbocharger

5.7.1. Maintenance (by authorized specialist personnel)

The turbochargers do not call for any specific maintenance.

The only points to be observed are the oil pipes which should be checked at every oil change for leakage and restrictions. The air cleaners should be carefully serviced.

Furthermore, a regular check should be kept on charge air exhaust gas pipes. Any leakages should be attended to at once because they are liable to cause overheating of the engine.

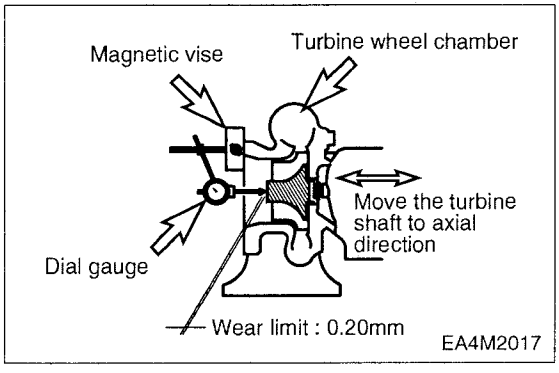
When operating in highly dust or oil-laden atmospheres, cleaning of the air impeller may be necessary from time to time. To this end, remove compressor casing (**Caution : Do not skew it!**) and clean in a non-acid solvent, if necessary using a plastic scraper.

If the air compressor should be badly fouled, it is recommended that the wheel be allowed to soak in a vessel with solvent and to clean it then with a stiff brush. In doing so, take care to see that only the compressor wheel is immersed and that the turbocharger is supported on the bearing casing and not on the wheel.

5.7.2. Special hints

It is recommended that the radial and axial clearances of the rotor be checked after every 3,000 hours operation.

This precaution will enable any wear of the Measuring of axial clearance bearings to be detected in good time before serious damage is caused to the rotor and bearings.



<Measuring rotor axial clearance>

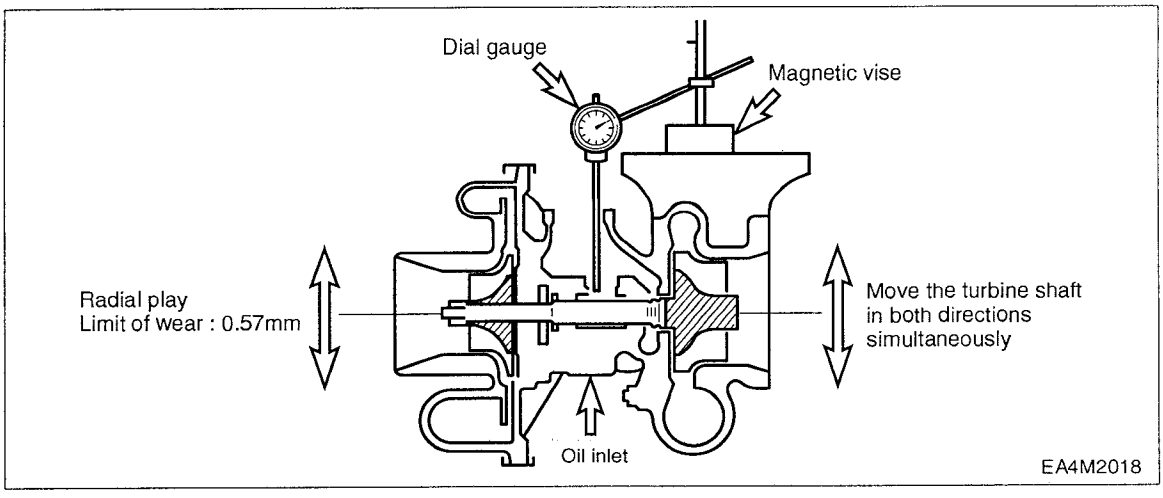
(mm)

Axial clearance	0.2

<Measuring radial clearance>

(mm)

Radial clearance	0.65



6. Checking and Setting

6.1. Adjustment of Valve Clearance

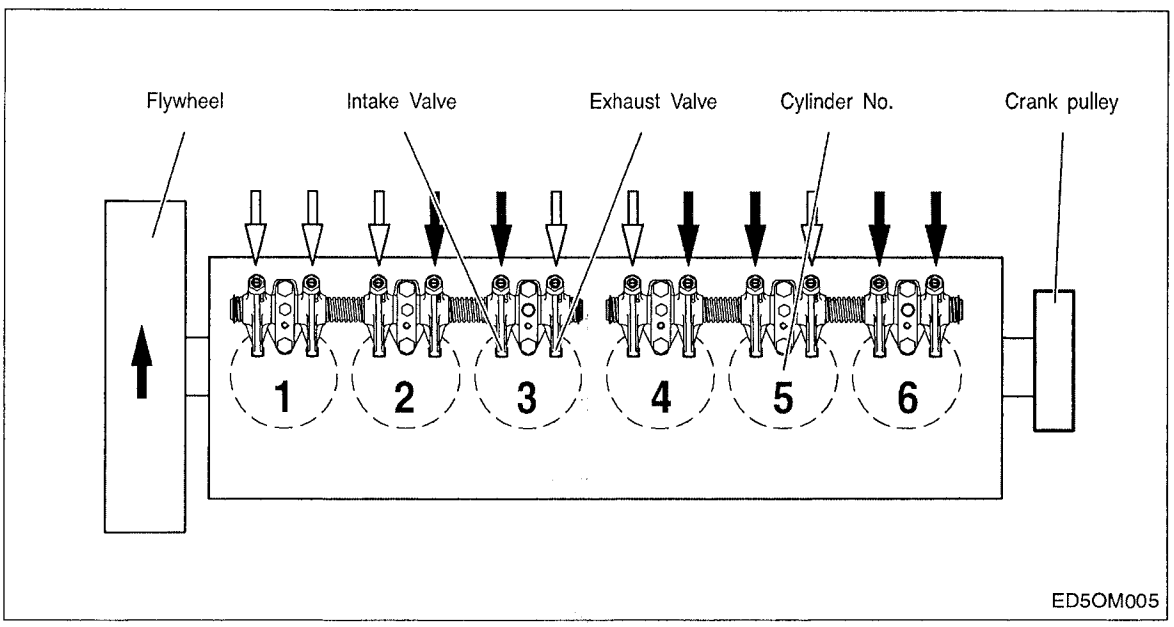
6.1.1. General information

The valve clearances are to be adjusted at the times of the following situations.

- After initial 50 hour's operation.
- When the engine is overhauled and the cylinder heads are disassembled.
- When severe noise comes from valve train.
- When the engine is not normally operated, even though there is no trouble in the fuel system.

6.1.2. Adjusting order of the valve clearance

- Cylinder No. 1 begins from the rear side where the flywheel is mounted but cylinder No. 6 begins from the front side of the engine on the contrary.



Step 1 :

- After letting the cylinder No.6 in the overlap TDC position by turning the crankshaft, adjust the valves corresponding to "⇧" of following figure. At this time cylinder No. 1 should be at the ignition TDC position (O.T).

Step 2 :

- After adjusting upper valves turn the crank pulley 360° to adjust the other valve clearance until the cylinder No. 1 comes to overlap TDC position.
  At this time cylinder No. 6 should be at the ignition TDC position (O.T).
- Adjust the valves corresponding to "⬆" in upper figure.
  After reconfirming the valve clearances, retighten it if necessary.

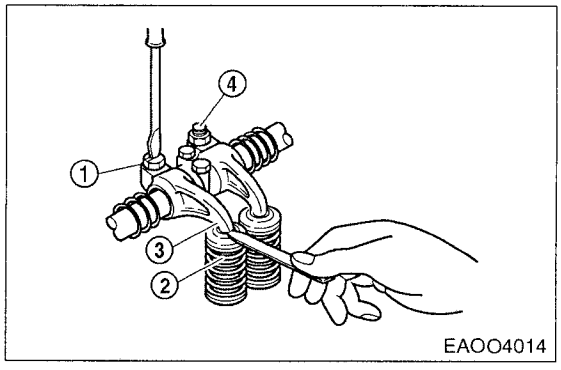
● Loosen the lock nuts of the rocker arm adjusting screws and push the specified feeler gauge and adjust the valve clearance with adjusting screw respectively.

(mm)

Model	Intake Valve	Exhaust Valve
DE12T / P126TI / P126TI-1 / P126TI-II / PU126TI	0.3	0.3

6.1.3. Method of adjusting the valve clearance

1) Loosen the lock-nuts (1) using a ring spanner.
2) Insert a thickness gauge of 0.3mm between valve stem (2) and rocker arm (3).
3) Turn the adjusting bolts (4) using a screw driver until the gauge can be pulled out with some restriction.
4) After the adjustment fix the adjusting bolt not to rotate and tighten the lock-nut at the same time.
5) Measure the clearance one more time and if necessary adjust again.



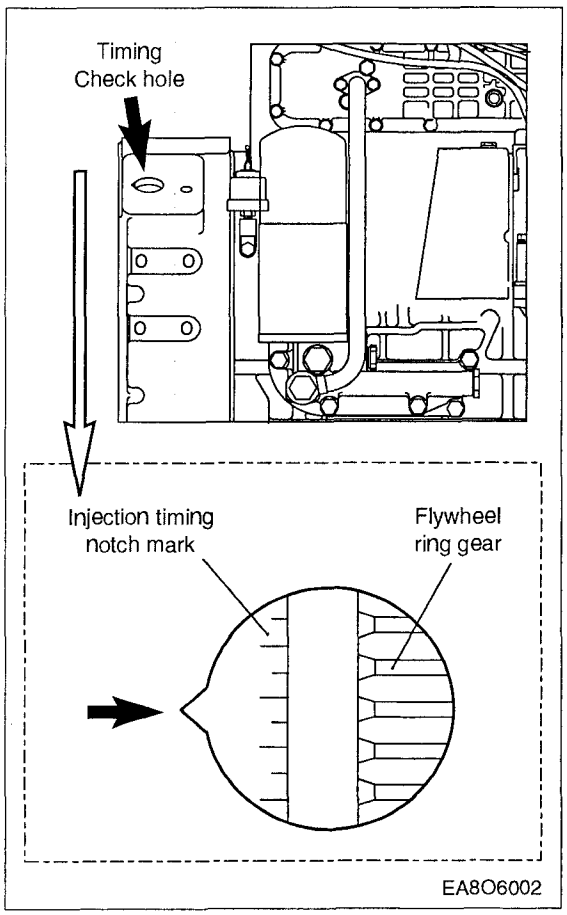
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6.2. Adjustment of Injection Timing

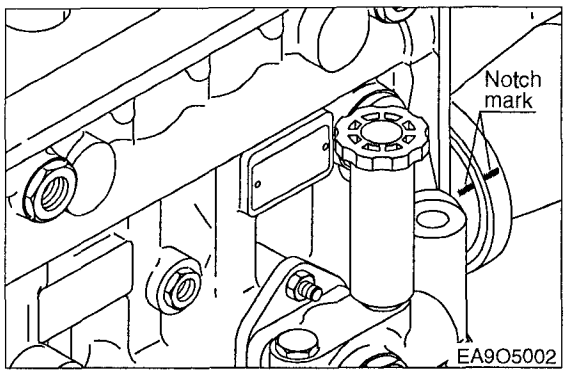
6.2.1. Method of adjusting injection timing

- Turn the flywheel until No. 1 piston is placed in the "OT" position of notch marks on the flywheel, and then turn again the flywheel clockwise until showing the notch mark of the right figure corresponding to the injection timing is aligned with the pointer (↓) on the flywheel housing.

	DE12T / P126TI-1	P126TI / P126TI-II	PU126TI
Fuel injection timing (B.T.D.C static)	12°	16°	14°



- Turn the timer until the notch mark of the indicator plate attached to the fuel injection pump is aligned with the notch mark of the timer.



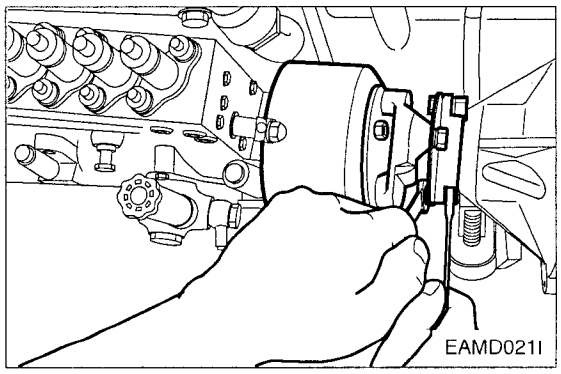
● Tighten the coupling fixing bolts and nuts to specified torque.

Torque	6.0 kg·m

● Tighten the drive shaft connecting flange fixing bolts to specified torque.

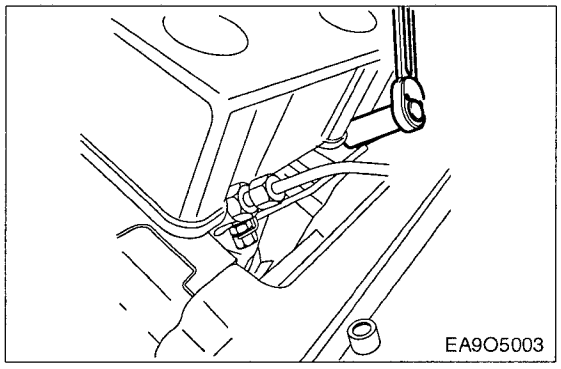
Torque	7.5 ~ 8.5 kg·m

● Install the oil delivery pipe and return pipe.

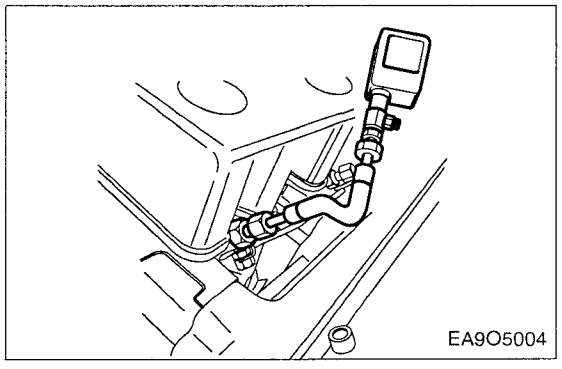


6.3. Cylinder Compression Pressure

1) Stop the engine after warming it up, then remove the nozzle assemblies.



2) Install a special tool (gauge adapter) in nozzle holder hole and connect the compression pressure gauge to the adapter.
3) Cut off fuel circulation, rotate the starter, then measure compression pressure of each cylinder.



Standard value	25 ~ 28 kg/cm²
Limit	24 kg/cm² or less
Difference between each cylinder	Within ± 10%

- Testing conditions : at water temperature of 20°C and speed of 200 rpm (10 turns)

6.4. V-belts

The tension of the V-belts should be checked after every 2,000 hours of operation.

1) Change the V-belts if necessary

If in the case of a multiple belt drive, wear or differing tensions are found, always replace the complete set of belts.

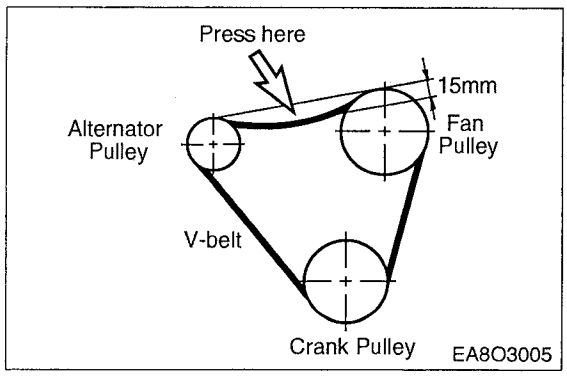
2) Checking condition

Check V-belts for cracks, oil, overheating and wear.

3) Testing by hand

The tension is correct if the V-belts can be pressed in by about the thickness of the V-belt. (no more midway between the belt pulleys)

A more precise check of the V-belt tension is possible only by using a V-belt tension tester.

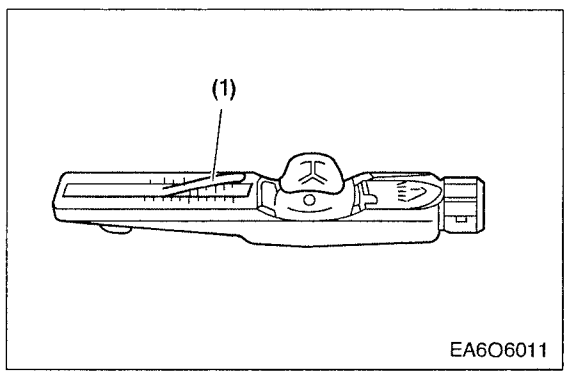


4) Measuring tension

(1) Lower indicator arm (1) into the scale.

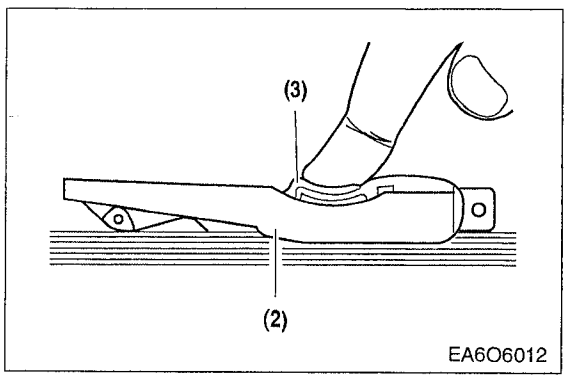
- Apply tester to belt at a point midway between two pulleys so that edge of contact surface (2) is flush with the V- belt.
- Slowly depress pad (3) until the spring can be heard to disengage. This will cause the indicator to move upwards.

  If pressure is maintained after the spring has disengaged a false reading will be obtained!



(2) Reading of tension

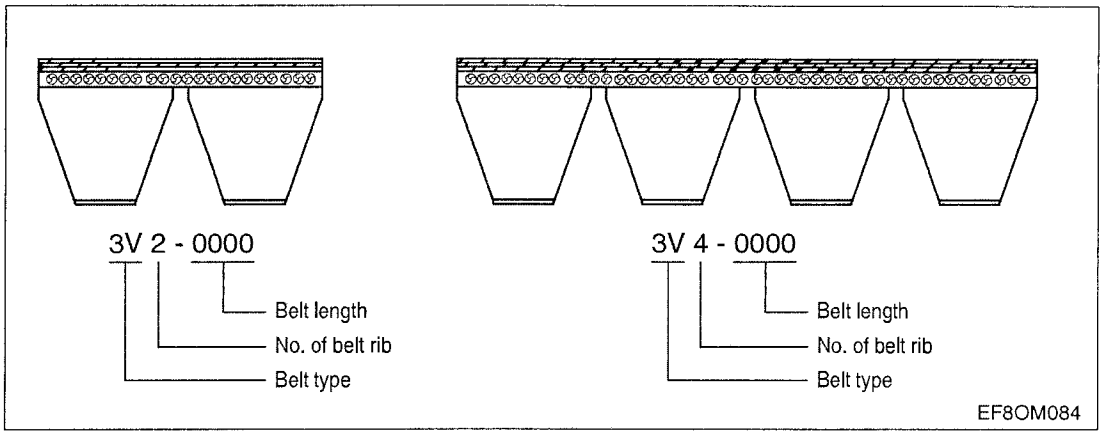
- Read of the tensioning force of the belt at the point where the top surface of the indicator arm (1) intersects with the scale.
- Before taking readings make ensure that the indicator arm remains in its position.



Type	Drive belt width	Tensioning forces on the tester		
		new installation		When servicing after long running time
		Installation	After 10 min. running time	
A	11.8 mm	55 kg	50 kg	45 kg

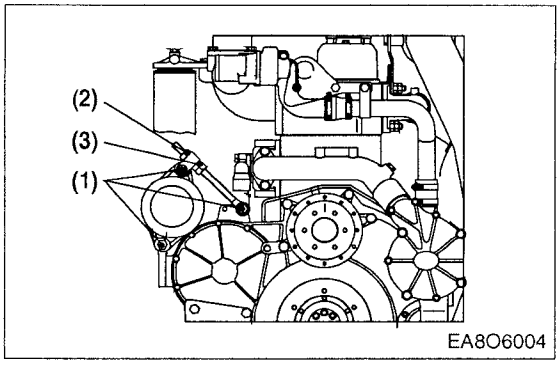
* V-belt of raw edge cogged type

Type	new installation	When servicing after long running time
3V	45 kgf	41 kg



5) Tensioning and changing V-belt

- Remove fixing bolts. (1)
- Remove lock nut. (2)
- Adjust nut (3) until V-belts have correct tensions.
- Retighten lock nut and fixing bolts.



7. Operation Tip

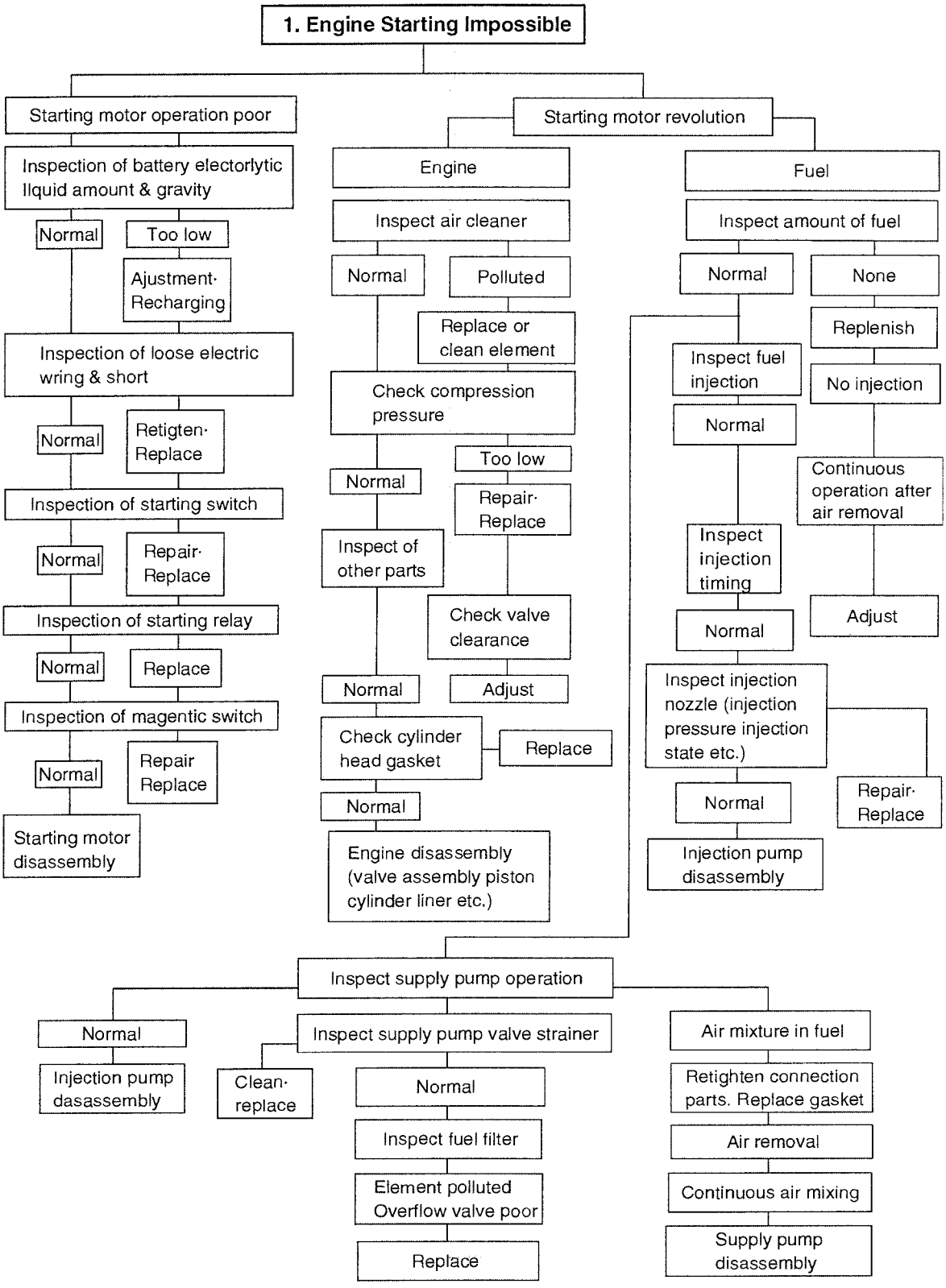
7.1. Periodic Inspection Cycle

○ : Check & adjust ● : Replace

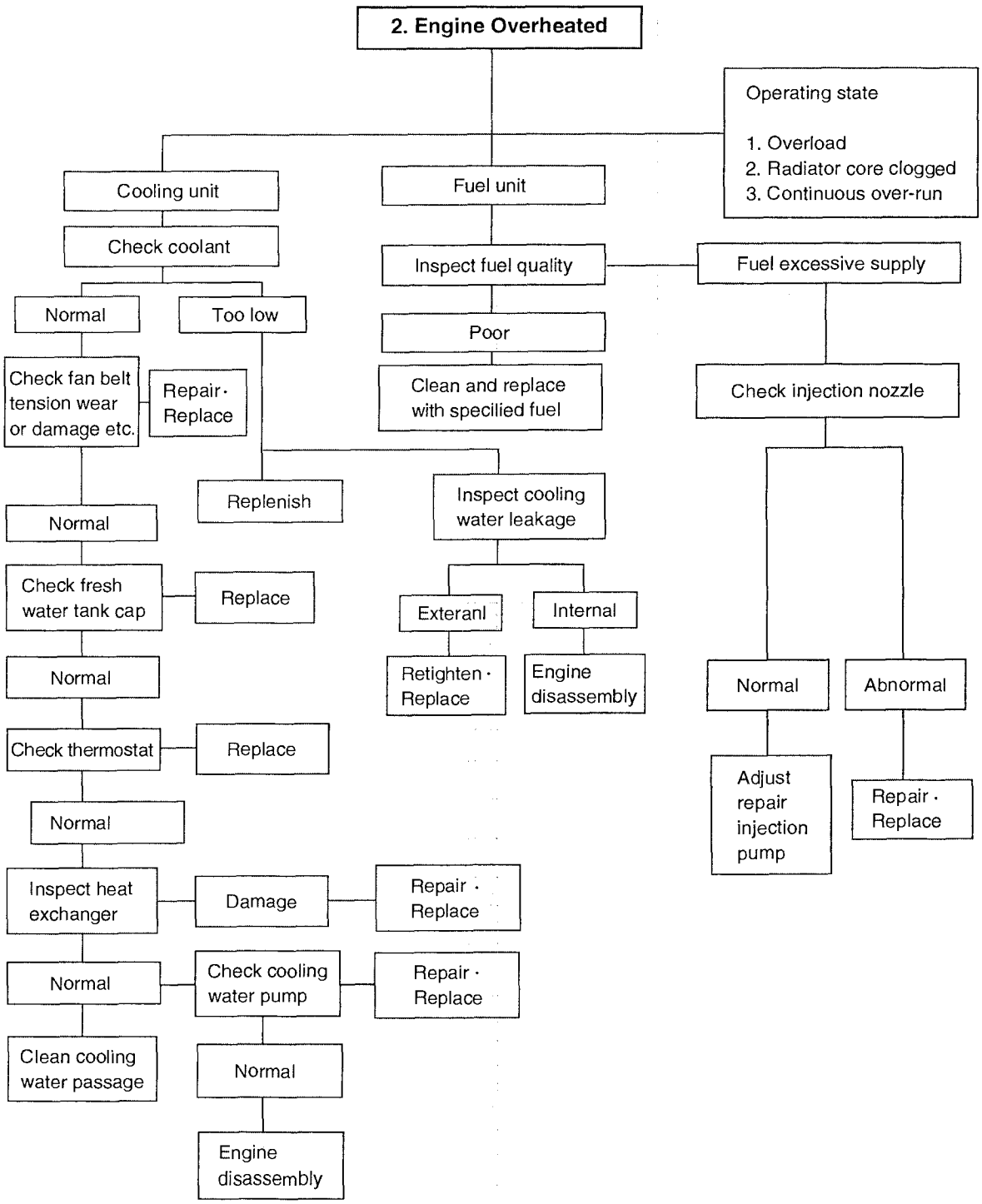
Inspection		Daily	Every 50hrs	Every 200hrs	Every 400hrs	Every 800hrs	Every 1,200hrs	Remark
Cooling System	Check for leakage (hoses, clamp)	○						
	Check the water level	○						
	Change the coolant water						●	
	Adjust the V-belt tension	○						Every 2,000hrs
	Clean the radiator						○	
Lubrication System	Check for leakage	○						
	Check the oil level gauge	○						
	Change the lubricating oil		● 1st	●				
	Replace the oil filter cartridge		● 1st	●				
Intake & Exhaust System	Check the leakage for intercooler (hoses, clamp)	○						
	Clean and change the air cleaner element			○ clean	●			
	Clean the inter-cooler air fins				○			
	Clean the turbo-charger							Every 2,000hrs
Fuel System	Check the leakage fuel line	○						
	Clean the fuel strainer of fuel feed pump						○	
	Remove sediment from fuel tank						○	
	Drain the water in separator			○				
	Drain the water in separator				●			
	Check fuel Injection timing			○				When necessary
	Check the injection nozzles			○				When necessary
Engine Adjust	Check the state of exhaust gas	○						
	Check the battery charging	○						
	Check the compression pressure						○	When necessary
	Adjust Intake/Exhaust valve clearance		○ 1st					When necessary

7.2. Trouble Shooting

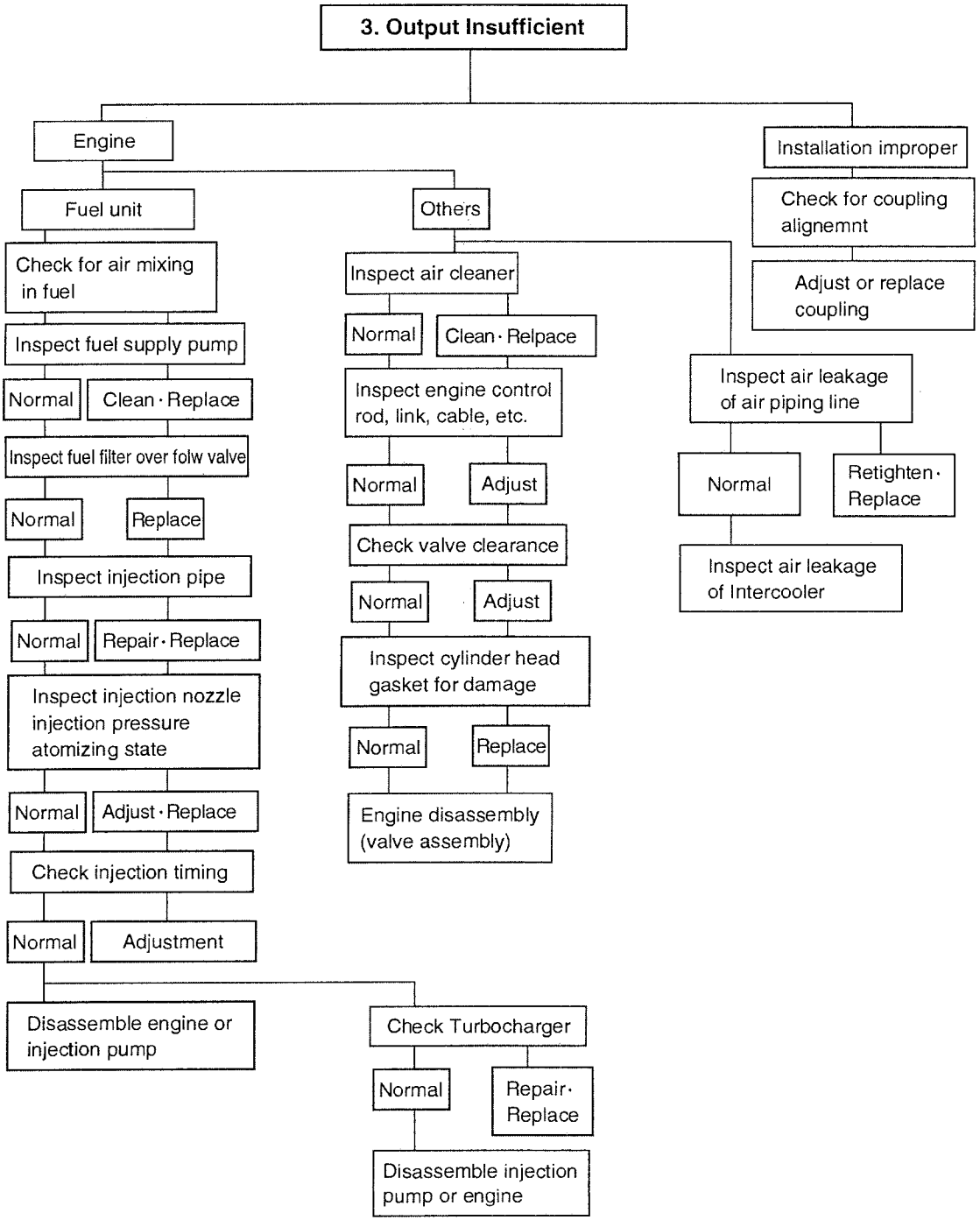
7.2.1. Engine starting impossible



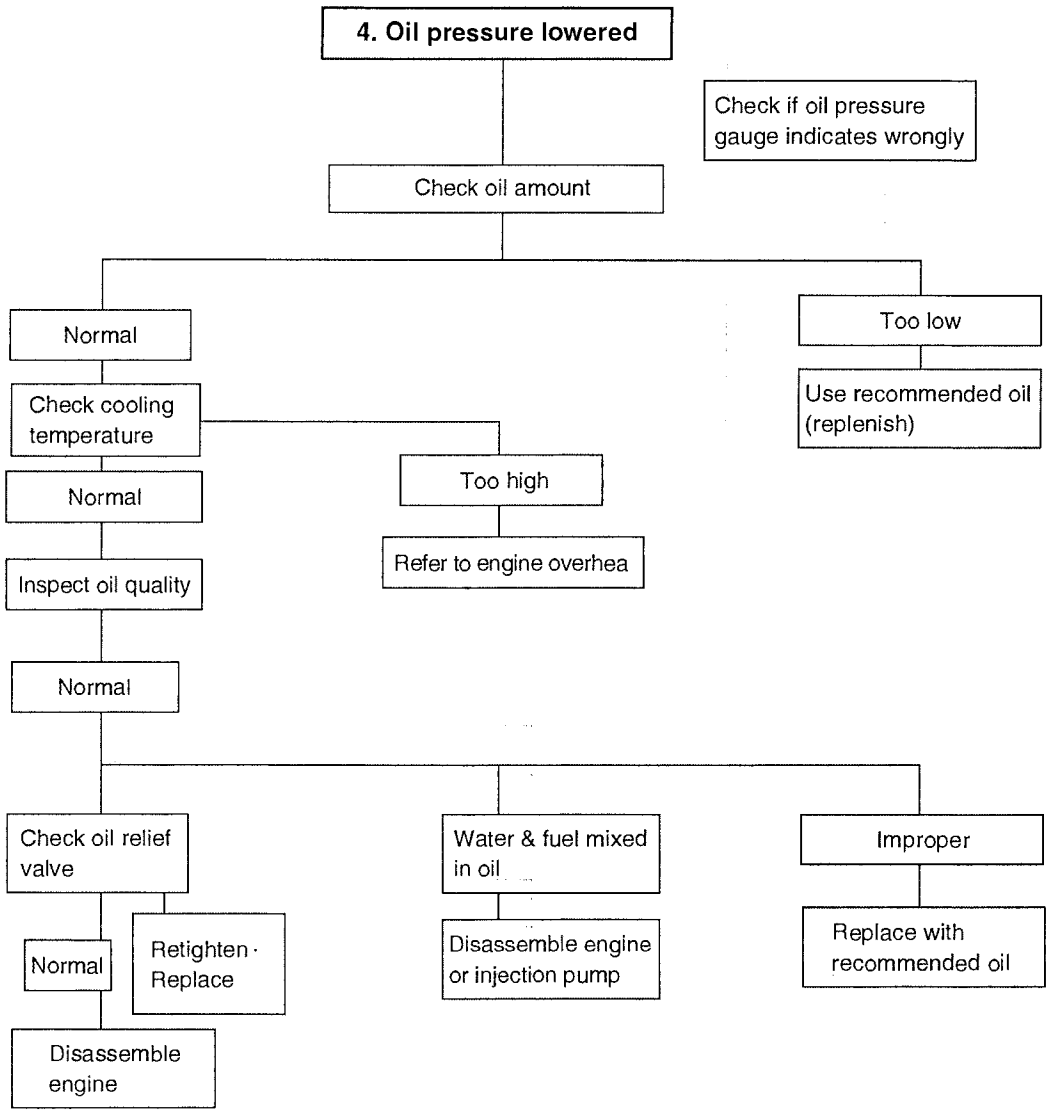
7.2.2. Engine overheated



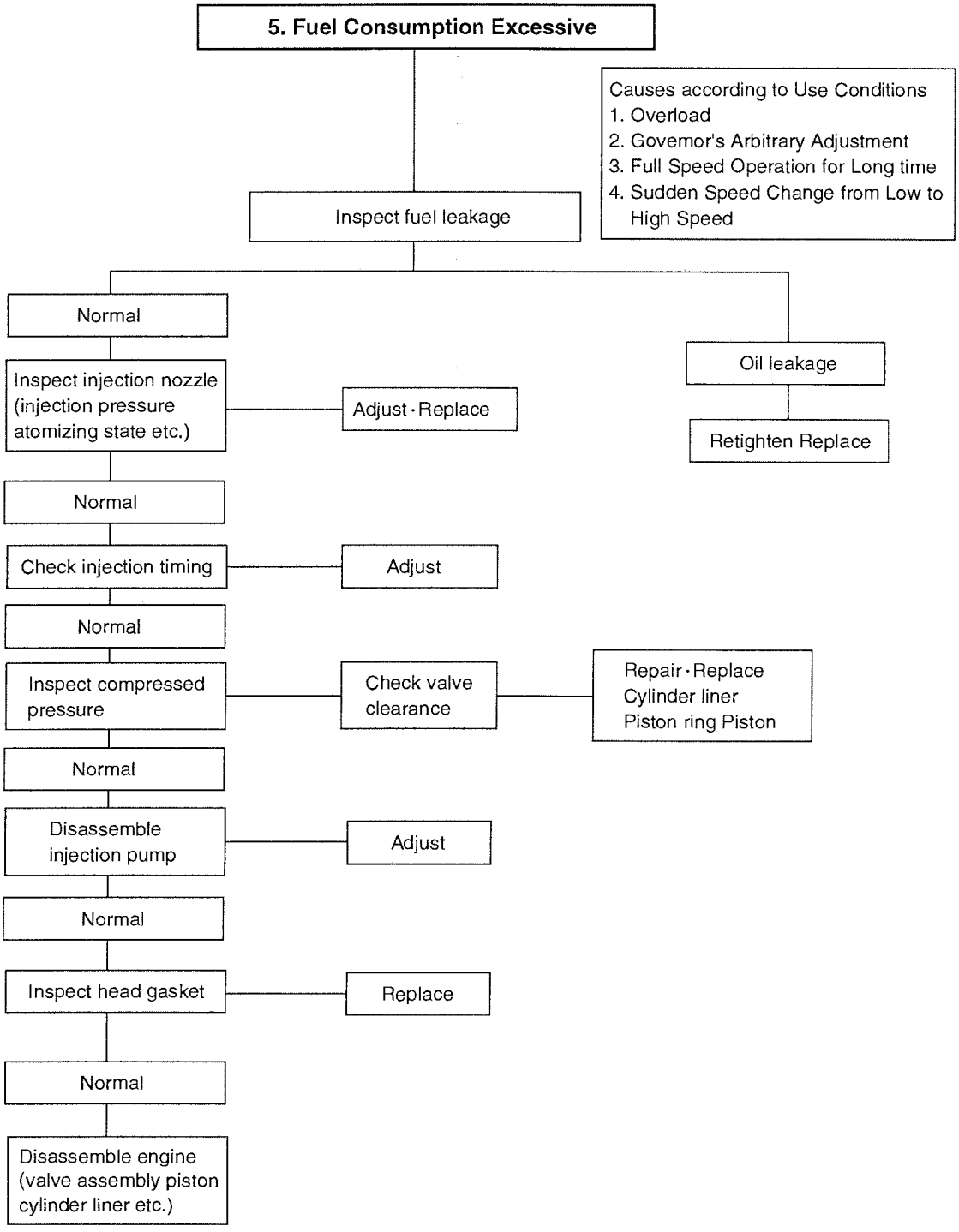
7.2.3. Output insufficient



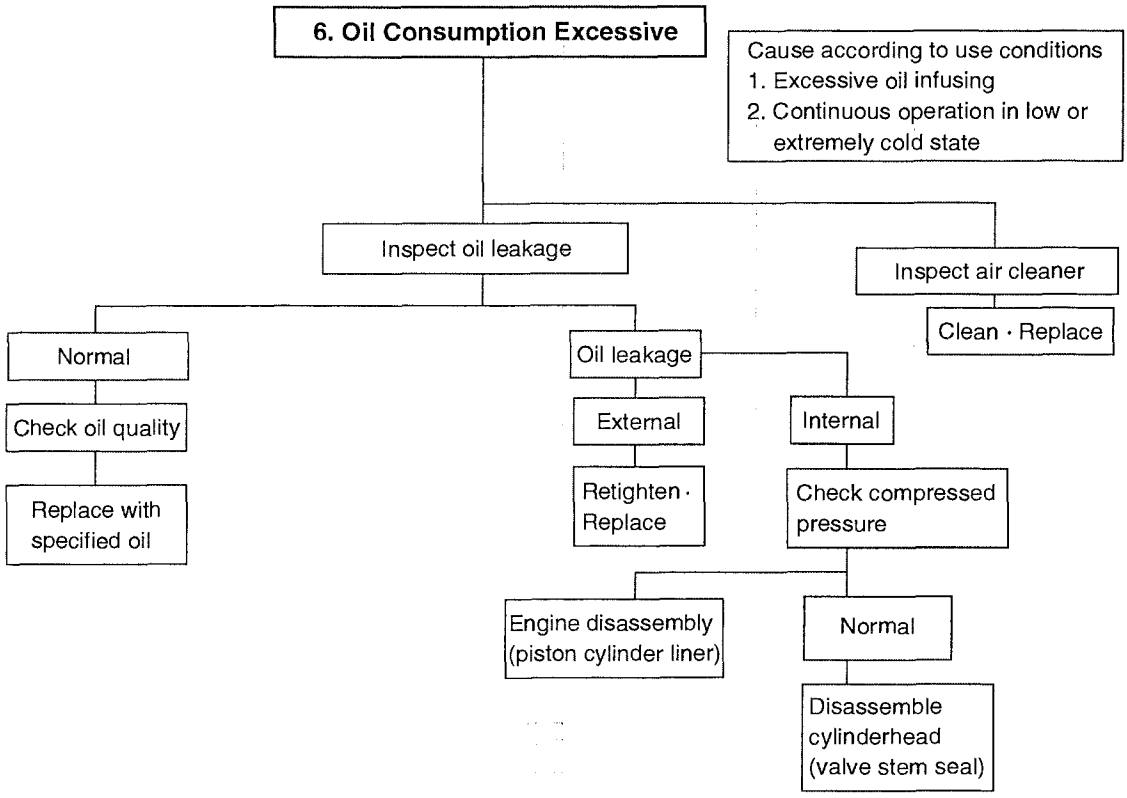
7.2.4. Oil pressure lowered



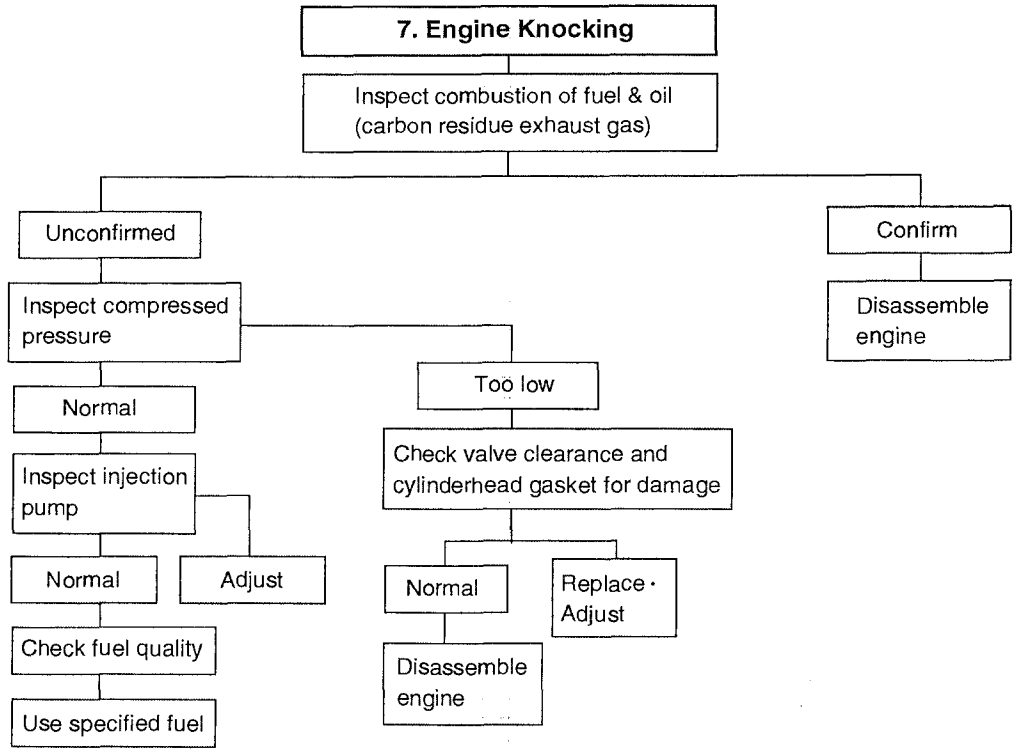
7.2.5. Fuel consumption



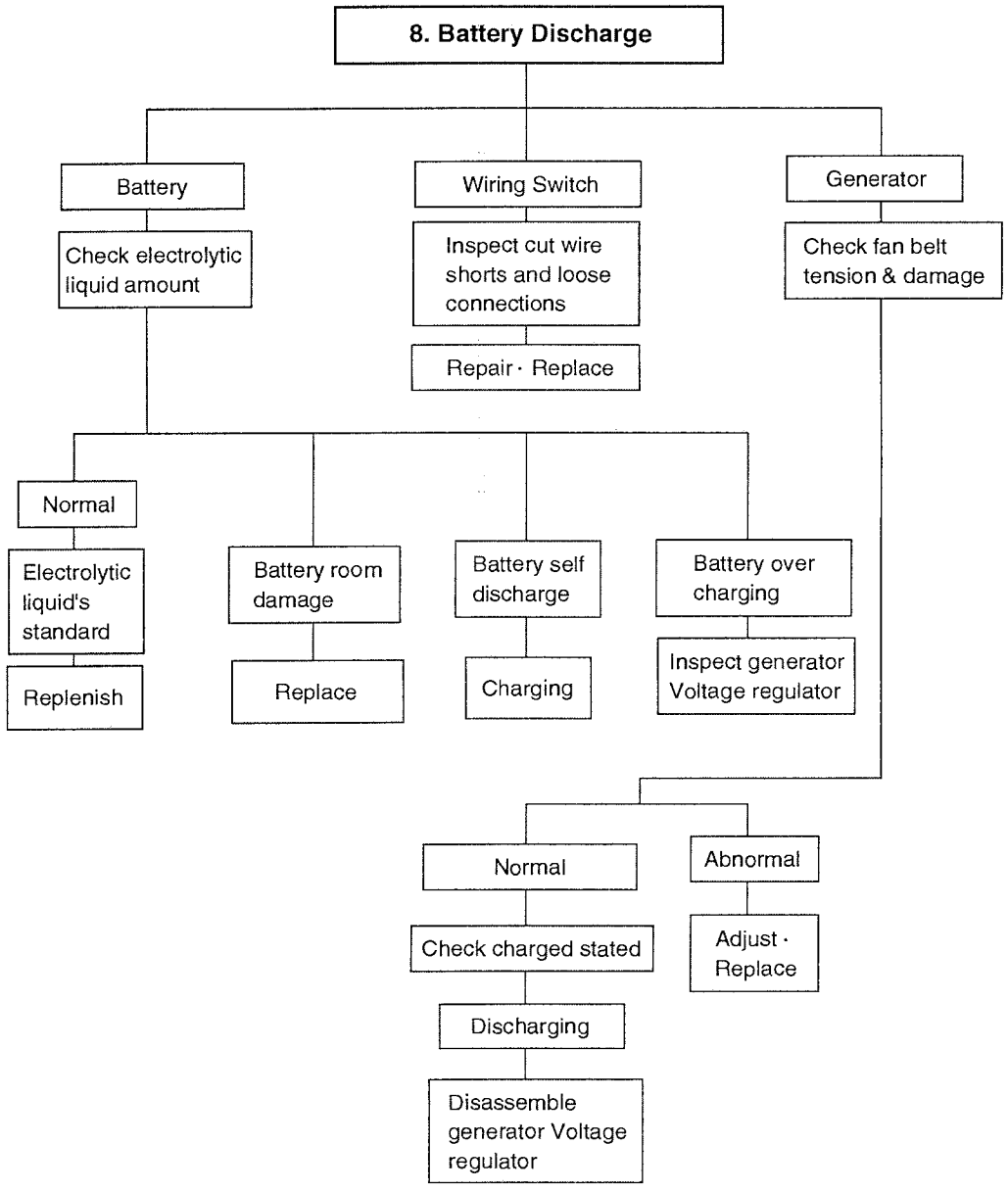
7.2.6. Oil consumption excessive



7.2.7. Engine knocking



7.2.8. Battery discharge



7.3. Causes and Remedies

Condition	Causes	Remedies
1) Starting difficult (1) Compression pressure	● Valveís poor shut, stem distortion ● Valve spring damage ● Cylinder head gasket's leak ● Wear of piston, piston ring or liner	Repair or replace Replace valve spring Replace gasket Adjust
2) Idle operation abnormal	● Injection timing incorrect ● Air mixing at injection pump	Adjust Remove air
3) Engine output insufficient (1) Continuous output insuffi-cient	● Valve clearance incorrect ● Valve tightness poor ● Cylinder head gasket's leak ● Wear, stick, damage of piston ring ● Injection timing incorrect ● Fuel injection amount insufficient ● Nozzle injection pressure improper or stuck ● Supply pump's function lowered ● Fuel pipe system clogged ● Air suction amount insufficient ● Supercharger poor	Adjust Repair Replace gasket Replace piston ring Adjust Adjust injection pump Adjust or replace Repair or replace Repair Clean or replace air cleaner Repair or replace
(2) Output insufficient when in acceleration	● Compression pressure insufficient ● Injection timing incorrect ● Fuel injection amount insufficient ● Injection pump timer's function insufficient ● Nozzle infection pressure, infection angle improper ● Supply pump's function lowered ● Air intake amount insufficient cleaner	Disassemble engine Adjust Adjust injection pump Repair or replace Repair, replace Repair or replace Clean or replace air
4) Overheating	● Engine oil insufficient or poor ● Cooking water insufficient ● Fan belt loosened, worn, damaged ● Cooling water pump's function lowered ● Water temp. regulator's operation poor ● Valve clearance incorrect ● Exhaust system's resistance increased	Replenish or replace Replenish or replace Adjust or replace Repair or replace Replace Adjust Clean or replace
5) Engine noisy	For noises arise compositely such asrota ting parts, lapping parts etc., there is nec essity to search the cause of noises accurately.	
(1) Crankshaft	● As the wear of bearing or crankshaft progress, the oil clearances increase. ● Lopsided wear of crankshaft ● Oil supply insufficient due to oil passage clogging ● Stuck bearing	Replace bearing & grind crankshaft Grind or replace Clean oil passage Replace bearing & Grind

Condition	Causes	Remedies
(2) Con rod and Con rod bearing	● Lopsided wear of con rod bearing	Replace bearing
	● Lopsided wear of crank pin	Grind crankshaft
	● Connecting rod distortion	Repair or replace
	● Stuck bearing	Replace & grind crank-shaft
	● Oil supply insufficiency as clogging at oil passage progresses	Clean oil passage
(3) Piston, piston pin & piston ring	● Piston clearance increase as the wear of piston and piston ring progresses	Replace piston & piston ring
	● Wear of piston or piston pin	Replace
	● Piston stuck	Replace piston
	● Piston insertion poor	Replace piston
	● Piston ring damaged	Replace piston
(4) Others	● Wear of crankshaft, thrust bearing bearing	Replace thrust
	● Camshaft end play increased	Replace thrust plate
	● Idle gear end play increased	Replace thrust washer
	● Timing gear backlash excessive	Repair or replace
	● Vale clearance excessive	Adjust valve clearance
	● Abnormal wear of tappet, cam	Replace tappet, cam
	● Supercharger inner part damaged	Repair or replace
6) Fuel Consumption Exttive	● Injection timing incorrect	Adjust
	● Fuel injection amount excessive	Adjust injection pump
7) Oil Consumption Excessive		
(1) Oil level elevated	● Clearance between cylinder iner & piston	Replace
	● Wear of piston ring, ring groove	Replace piston, piston ring
	● Piston ring's damage, stick, wear	Replace piston ring
	● Piston ring opening's disposition improper	Correct position
	● Piston skirt part damaged or abnormal wear	Replace piston
	● Oil ring's oil return hole clogged	Replace piston ring
	● Oil ring's contact poor	Replace piston ring
(2) Oil level lowered	● Looseness of valve stem & guide	Replace in set
	● Wear of valve stem seal	Replace seal
	● Cylinder head gasket's leak	Replace gasket
(3) Oil leak	● Looseness of connection parts	Replace gasket, repair
	● Various part's packing poor	Replace packing
	● Oil seal poor	Replace oil seal

8. General Information

8.1. General Repair Instructions

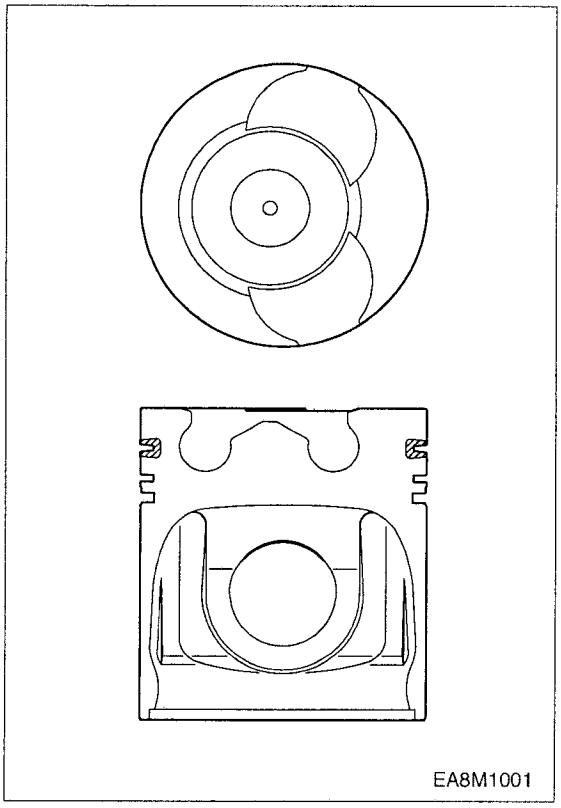
1) Before Performing service operation, disconnect the grounding cable from the battery for reducing the chance of cable damage and burning due to short-circuiting.
2) Use covers for preventing the components from damage or pollution.
3) Engine oil and anti-freeze solution must be handled with reasonable care as they cause paint damage.
4) The use of proper tools and special tools where specified is important to efficient and reliable service operation.
5) Use genuine DOOSAN parts necessarily.
6) Used cotter pins, gaskets, O-rings, oil seals, lock washer and self-lock nuts should be discarded and new ones should be prepared for installation as normal function of the parts can not be maintained if these parts are reused.
7) To facilitate proper and smooth reassemble operation, keep disassembled parts neatly in groups. Keeping fixing bolts and nut separate is very important as they vary in hardness design depending on position of Installation.
8) Clean the parts before inspection or reassembly. Also clean oil ports, etc. using compressed air to make certain they are free from restrictions.
9) Lubricate rotating and sliding faces of parts with oil or grease before installation.
10) When necessary, use a sealer on gaskets to prevent leakage.
11) Carefully observe all specifications for bolts and nuts torques.
12) When service operation is completed, make a final check to be sure service has been done property.

8.2. Engine Characteristics

8.2.1. OMEGA combustion bowl

The OMEGA combustion bowl is a unit designed to perform high efficiency, low emission combustion. As the rim around the combustion bowl port of the upper of the piston has been machined in a smaller size than the interior of the combustion bowl, strong swirl is produced in the combustion bowl and strong squish flow makes the fuel be mixed more sufficiently with air.

Due to the application of OMEGA combustion system and optimal utilization of intake and exhaust port configuration within the cylinder head, the P126TI series, DE12T and PU126TI engines discharge very low level of hazardous exhaust gases such as smoke, nitrogen oxide, hydrocarbon, or carbon monoxide and thus ensure high performance and low fuel consumption.

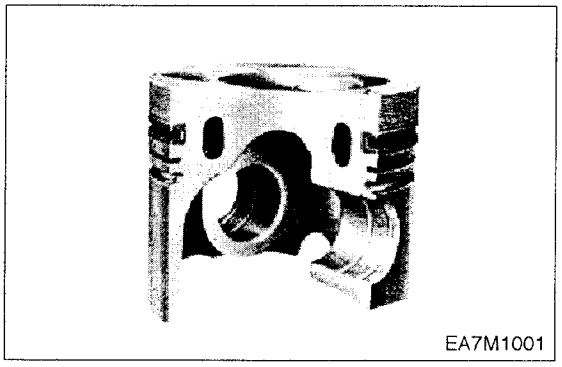


EA8M1001

8.2.2. Oil gallery cooling type piston (P126TI / PU126TI)

Oil gallery cooling is used for the piston of P126TI series and PU126TI engine. When thermal loading is high, piston cooling by means of an oil gallery in the crown is normally necessary to prevent crown cracking and ring sticking. The design of the gallery, the design and location of the oil spray nozzle and the quantity of oil flowing in the gallery are critical in order to achieve the desired temperature reduction.

The cross section shape of the gallery should be designed to achieve sufficient oil movement to maximize cooling efficiency.



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9. Disassembly and Reassembly of Major Components

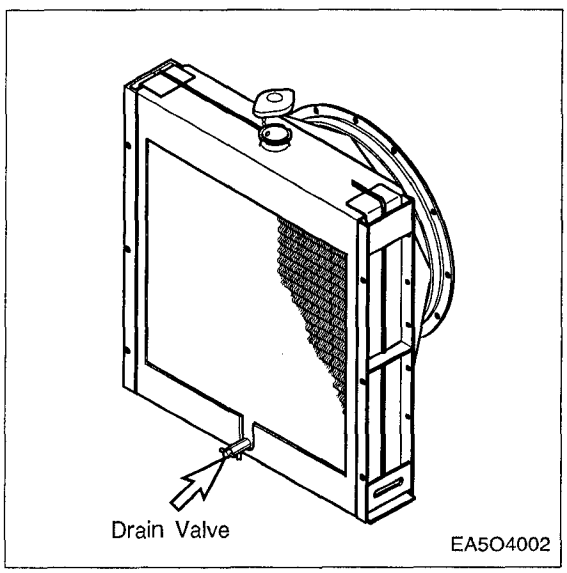
9.1. Disassembly

9.1.1. General precautions

- Maintenance operation should be carried out in a bright and clean place.
- Before disassembly, provide parts racks for storage of various tools and disassembled parts.
- Arrange the disassembled parts in the disassembly sequence and use care to prevent any damage to them.

9.1.2. Cooling water

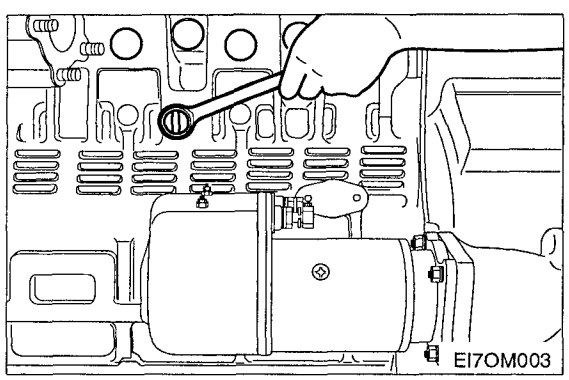
- Remove the radiator cap. Open the drain plug at the radiator lower part to drain the coolant as the right figure.



CAUTION :

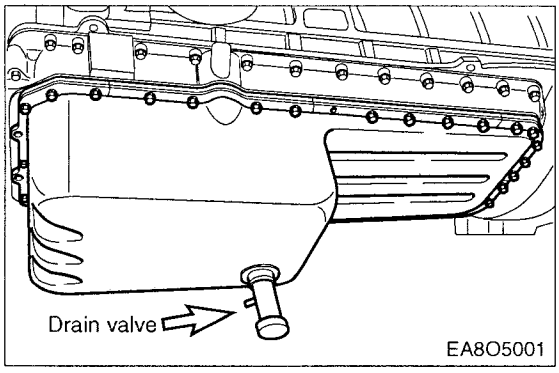
When removing radiator filler cap while the engine is still hot, cover the cap with a rag, then turn it slowly to release the internal steam pressure This will prevent a person from scalding with hot steam spouted out from the filler port.

- Remove the drain plug from the cylinder block and drain out the cooling water into a container.



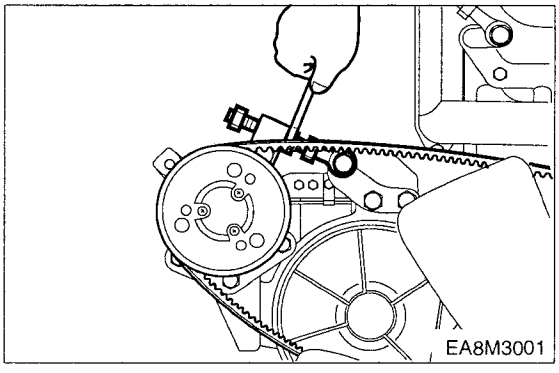
9.1.3. Engine oil

- Take out the oil dipstick.
- Remove the oil drain valve of oil pan and drain out the engine oil into a prepared container.



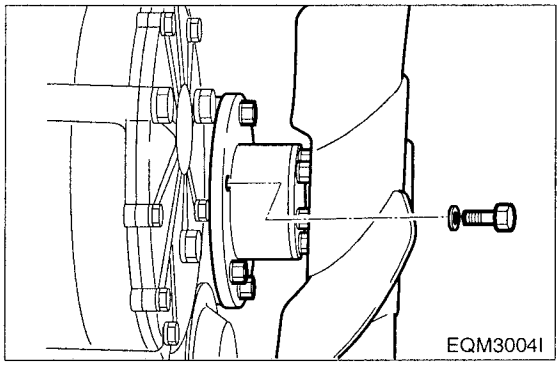
9.1.4. Alternator belt

- Loosen the tension adjusting nut installed on the alternator bracket, and take off the alternator belt.



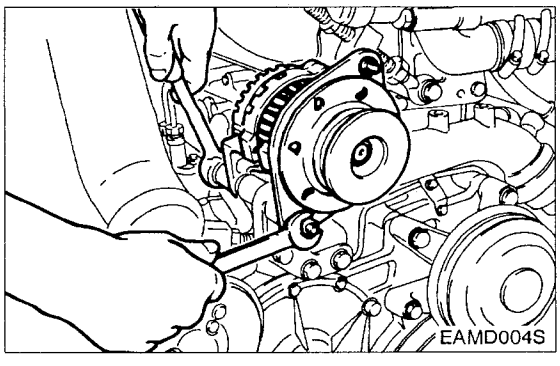
9.1.5. Cooling fan

- Remove the flange fixing bolts, then take off the flange and cooling fan.



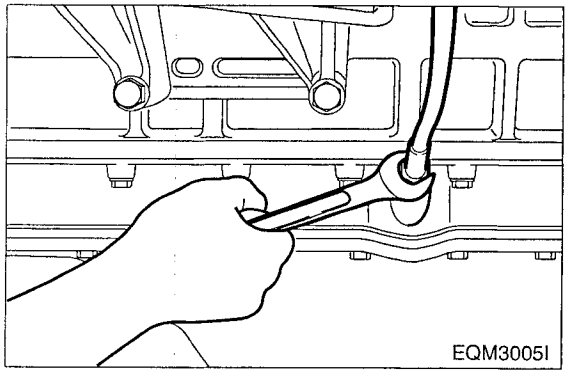
9.1.6. Alternator

- Remove the alternator fixing bolt and disassemble the alternator.
- Remove the tension adjusting bolt and bracket.



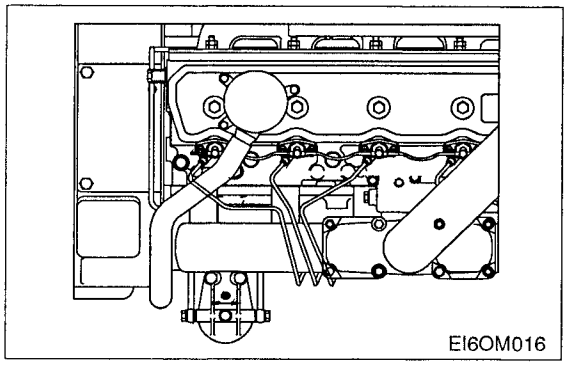
9.1.7. Guide tube of oil level gauge

- Loosen the flange nut installed on the oil pan to remove the guide tube.



9.1.8. Fuel filter

- Remove fuel hoses connected to the fuel injection pump, take off the bracket fixing bolts, then disassemble the fuel filter.

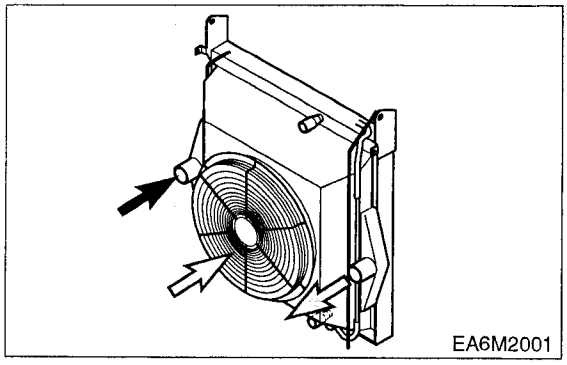


9.1.9. Breather

- Loosen the clamp screw to remove the rubber hose.

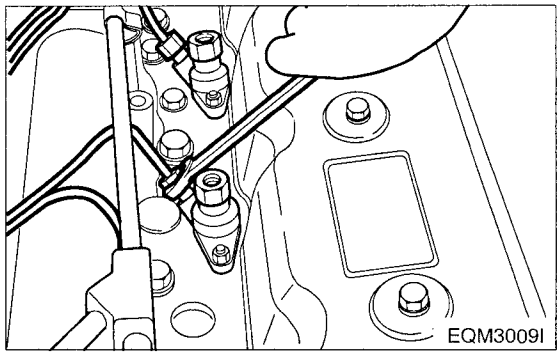
9.1.10. Intercooler

- Tear down the various hoses and air pipes from the inter cooler.
- Remove the intercooler fixing bolts and tear it down.



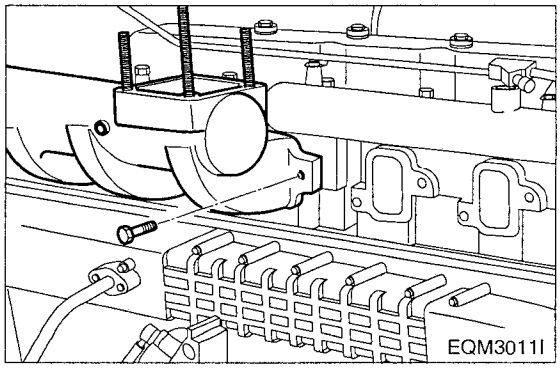
9.1.11. Injection pipe

- Unscrew the hollow screws to disassemble the fuel return pipe.
- Remove the nuts installed on the fuel injection pump and nozzles, then disassemble the injection pipe.



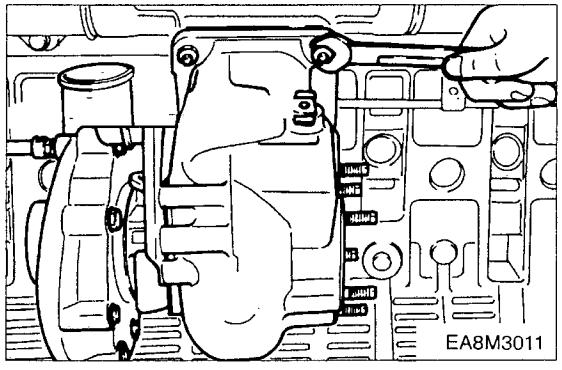
9.1.12. Intake manifold

- Remove the air hose connected to the fuel injection pump.
- Loosen the intake manifold fixing bolts, then disassemble the intake manifold.



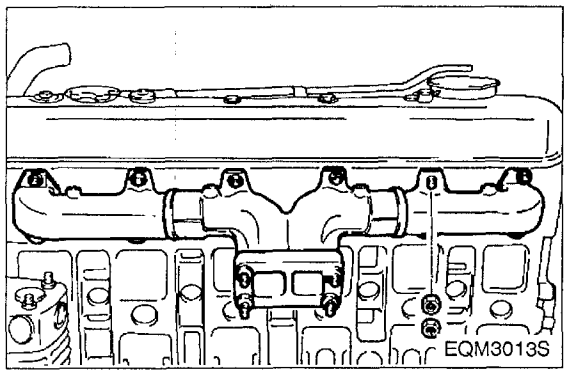
9.1.13. Turbo charger

- Release the clamp screw of the rubber hose connected to the intake manifold, and take off the intake pipes both simultaneously.
- Unscrew the exhaust pip5e bracket fixing bolts, release the nuts installed on the turbocharger, then disassemble the exhaust pipe.
- Remove the turbocharger after removing the oil supply pipe and return pipe and releasing the fixing nuts.



9.1.14. Exhaust manifold

- Release the exhaust manifold fixing bolts, disassemble the exhaust manifold, then remove the heat shield and gasket.

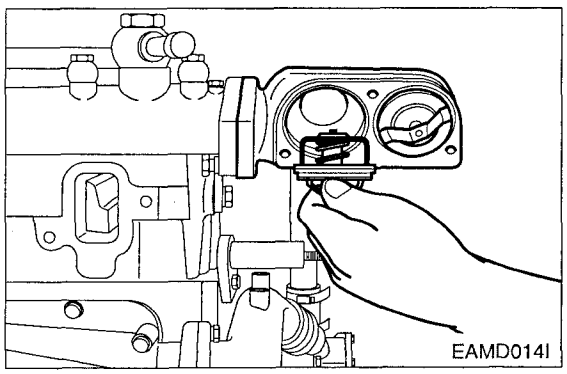


NOTE :

Make sure to release the nuts one after another because the exhaust manifold will be removed if you unscrew two nuts simultaneously.

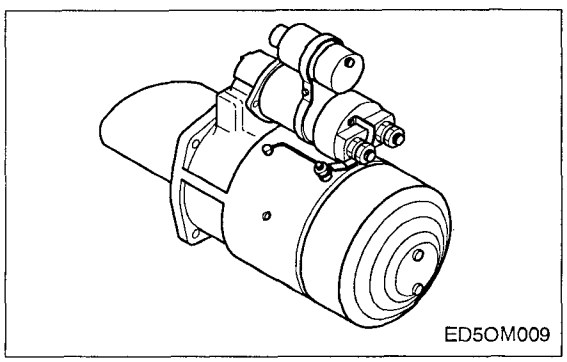
9.1.15. Thermostat

- Remove the by-pass pipe connected to the water pump, unscrew the thermostat fixing bolts, then disassemble the thermostat housing.
- Disassemble the thermostat housing and remove the thermostat.
- Disassemble the water pipe by unscrewing the bolts and nuts installed on the cylinder head.



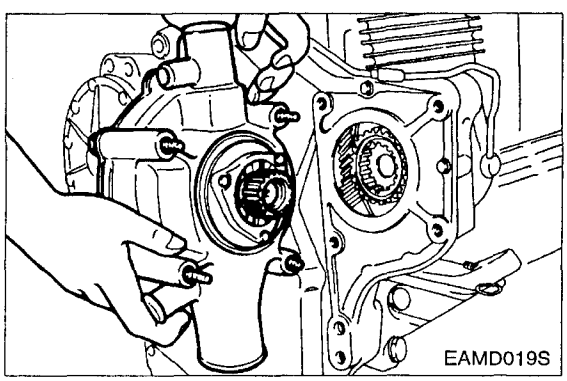
9.1.16. Starter

- Unscrew the starter fixing bolts, then disassemble the starter.



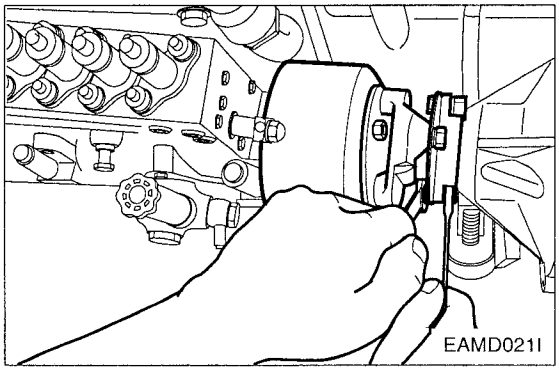
9.1.17. Water pump

- Remove the water pipe connected to the expansion tank.
- Remove the water pipe and hoses connected to the water pump.
- Unscrew the water pump fixing bolts and remove the water pump.



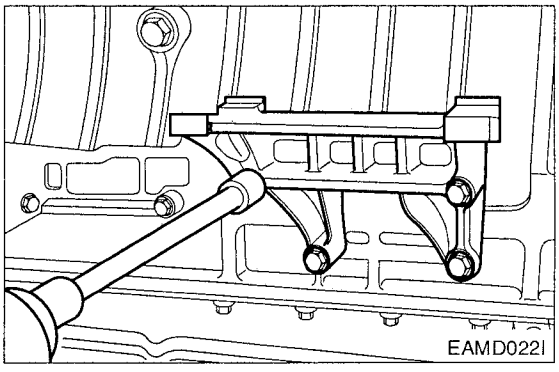
9.1.18. Injection pump

- Remove the oil supply pipe and return pipe connected to the fuel injection pump.
- Unscrew the bolts connecting the coupling and drive shaft, disassemble the injection pump mounting bolts, then detach theinjection pump.



NOTE :
After letting No.1 cylinder to the 'OT' position by turning the crankshaft, disassemble the injection pump.

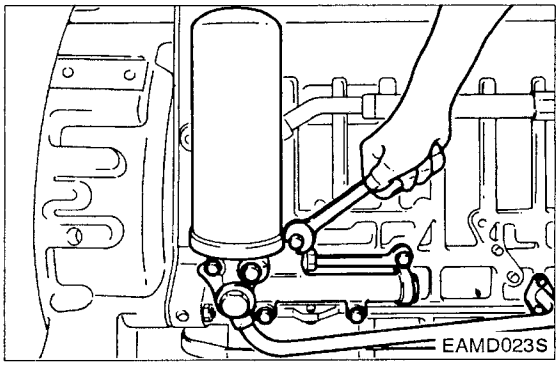
- Release the pump fixing bracket bolts to disassemble the bracket from the cylinder block.



NOTE :
Do not mix the disassembled shims. These should be reassembled to the original position.

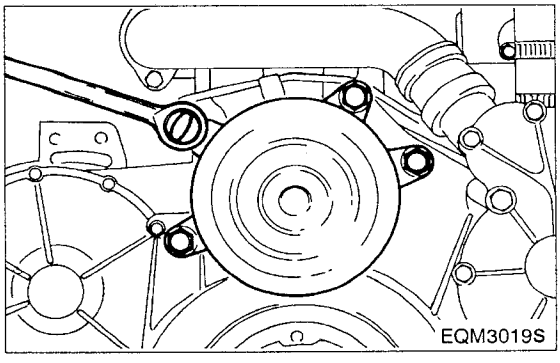
9.1.19. Oil filter

- Using a filter remover wrench, remove the oil filter cartridge.
- Remove the pipe connected to the oil cooler.
- Loosen the oil filter fixing bolts and disassemble the oil filter head from the cylinder block.



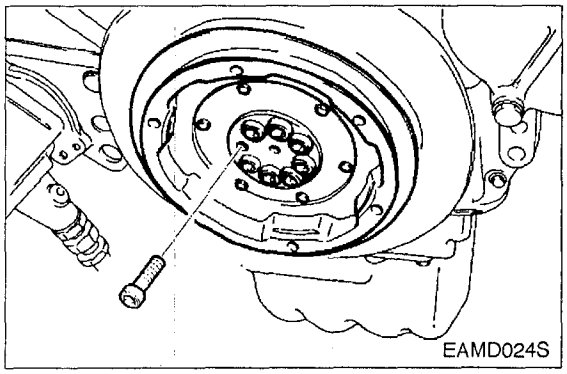
9.1.20. Fan drive pulley

- Remove the bolts and disassemble the fan drive pulley.



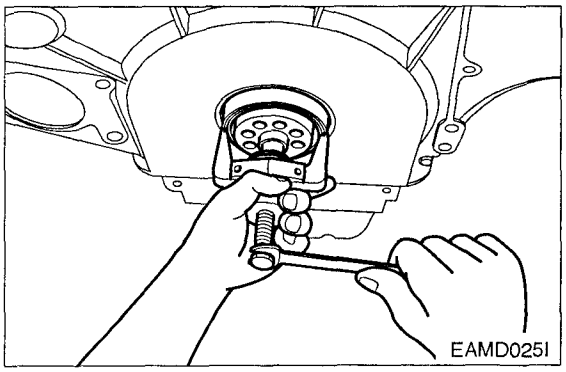
9.1.21. Vibration damper

- Unscrew the pulley fixing bolts and disassemble the pulley-vibration damper assembly.
- Unscrew the vibration damper fixing bolts and disassemble the damper from the pulley.



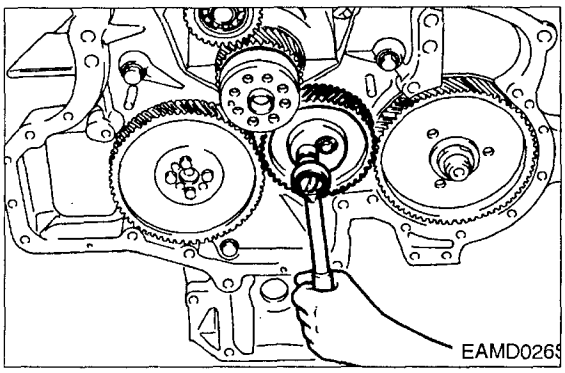
9.1.22. Timing gear case cover

- Disassemble the oil seal using an oil seal removing jig.
- Remove the cover fixing bolts and disassemble the cover from the timing gear case.



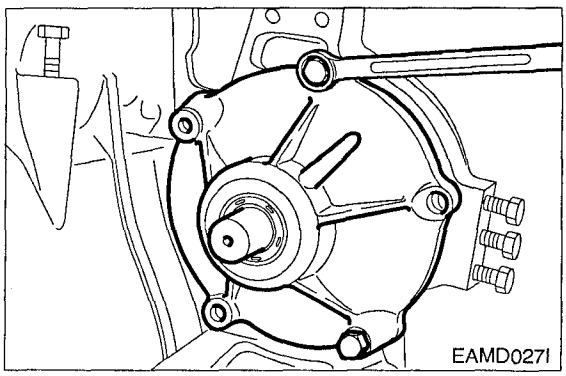
9.1.23. Idle gear

- Unscrew the idle gear fixing bolts and disassemble the thrust washer and idle gear.
- Disassemble the idle gear pin using a rubber hammer to prevent damage to them.



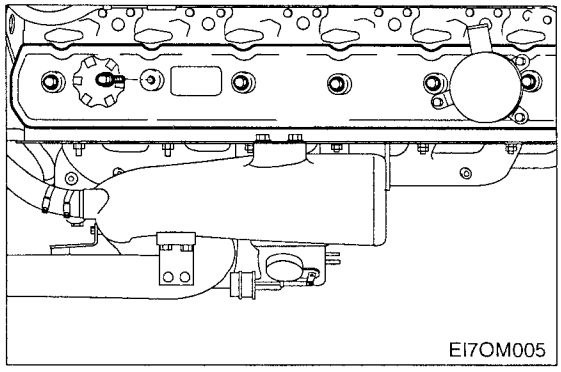
9.1.24. Fuel injection pump drive assembly

- Unscrew the injection pump drive shaft bearing housing fixing bolts and remove the injection pump drive assembly which the shaft, gear, bearings, and housing are put together.



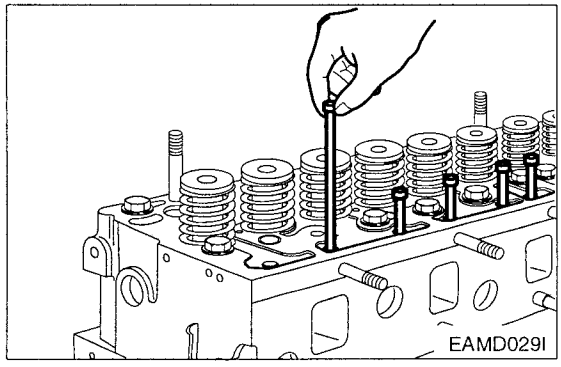
9.1.25. Cylinder head cover

- Unscrew the cover fixing bolts and disassemble the cover.
- Keep the bolts in an assembly state so that the packings and washers may not be lost, and keep the cover packing as assembled with the cover.



9.1.26. Rocker arm assembly

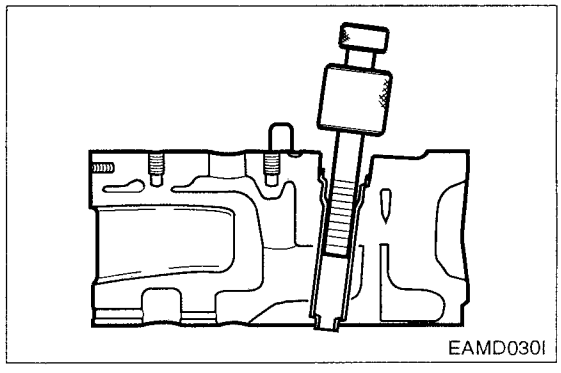
- Unscrew the rocker arm bracket bolts and remove the rocker arm assembly.
- Take off the snap rings to remove the washers and rocker arm, then unscrew the bracket fixing bolts to take off the bracket and springs.
- Take out the push rods.



9.1.27. Injection nozzle

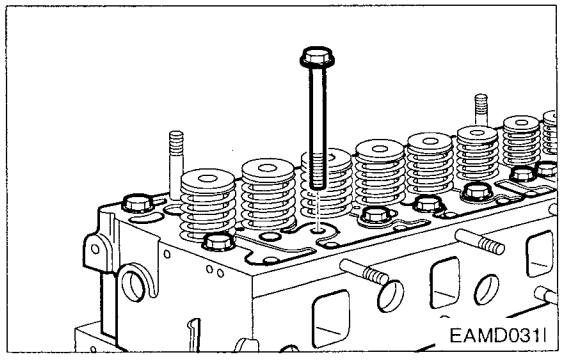
- Take off the injection pipes between the injection pump and injection nozzles.
- Remove the nozzle tube using nozzle tube removing jig.

Do not disassemble injection nozzle unless coolant or gas come out.



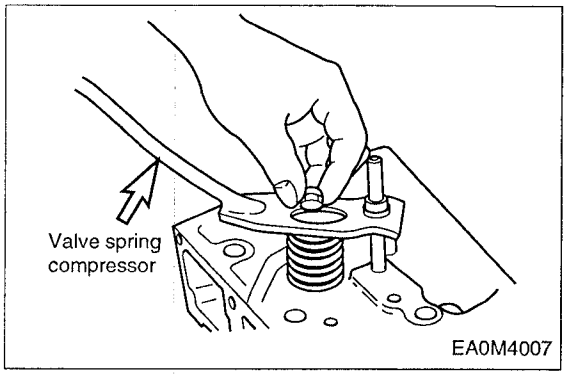
9.1.28. Cylinder head

- Unscrew the cylinder head fixing bolts and take off the cylinder head.
- Remove the cylinder head gasket.



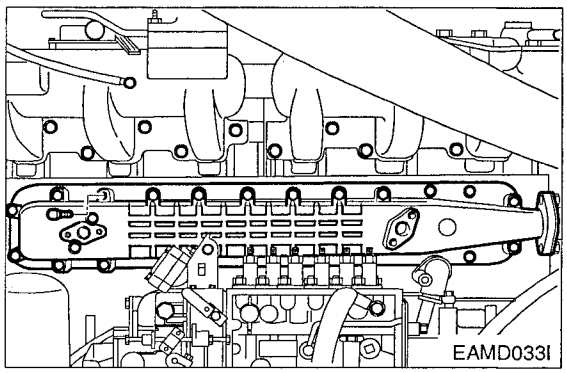
9.1.29. Valve & valve stem seal

- Compress the valve spring retainer using a jig and take off the valve cotter pins.
- Disassemble the valve springs and retainers.
- Take off the valves.
- Remove using a general tool and discard the valve stem seals in order not to be re-used.



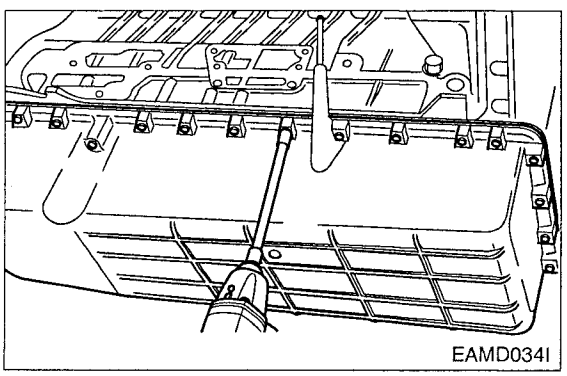
9.1.30. Oil cooler

- Remove the water pipe connected to the water pump.
- Remove the oil pipe connected to the cylinder block.
- Unscrew the oil cooler cover fixing bolts and disassemble the oil cooler assembly from the cylinder block.
- Unscrew the oil cooler fixing bolts and remove the oil cooler from the oil cooler cover.



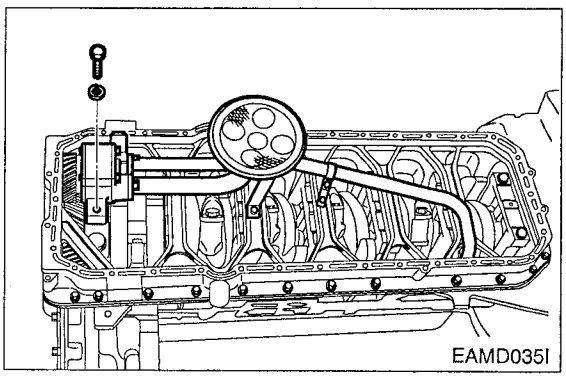
9.1.31. Oil pan

- Stand the engine with the flywheel housing facing the bottom.
- Release the oil pan fixing bolts, remove the stiffeners then disassemble the oil pan.



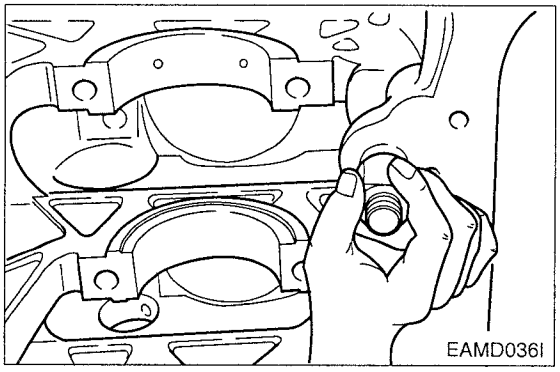
9.1.32. Oil pump & oil pipe

- Unscrew the oil suction pipe bracket bolts, releasing the pipe fixing bolts, then disassemble the oil suction pipe assembly.
- Disassemble the oil pipe feeding oil from the oil pump to the cylinder block.
- Unscrew the oil pump fixing bolts and disassemble the oil pump.



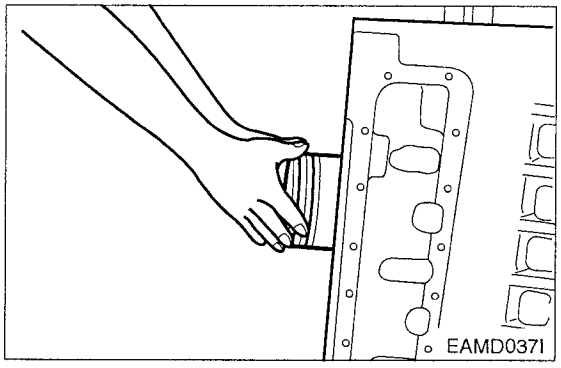
9.1.33. Relief valve

- Disassemble the relief valve.

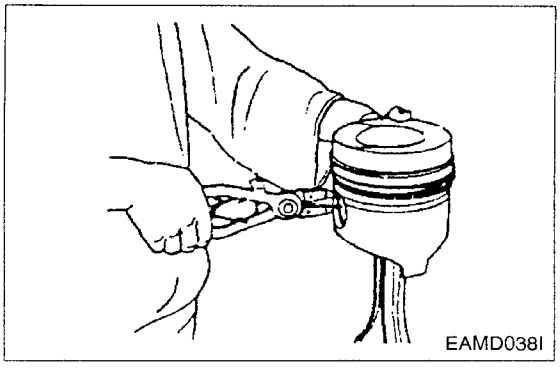


9.1.34. Piston & connection rod

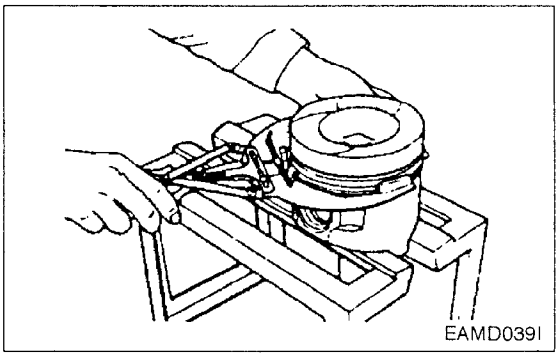
- Disassemble the pistons by two cylinders while turning the crankshaft.
- Unscrew the connecting rod fixing bolts and take off the pistons and connecting rods in the direction of piston.



- Remove the piston pin snap rings, take off the piston pin, then disconnect the connecting rod from the piston.

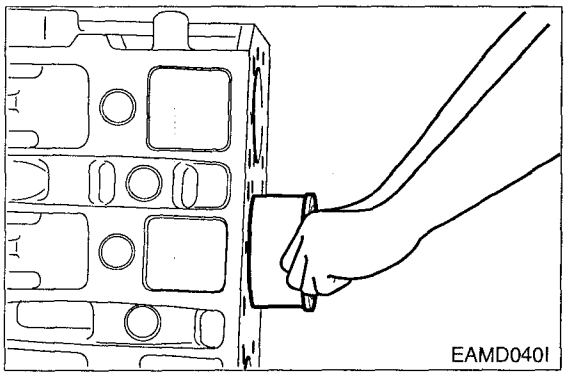


- Disassemble the piston rings using ring pliers.
- Use care not to interchange the disassembled parts and keep them in the sequence of cylinder No.



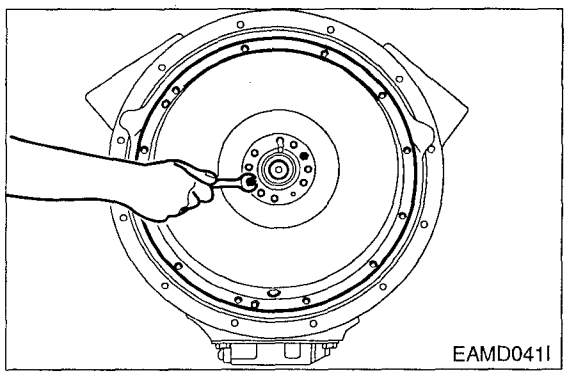
9.1.35. Cylinder liner

- Disassemble the cylinder liner using a liner puller.



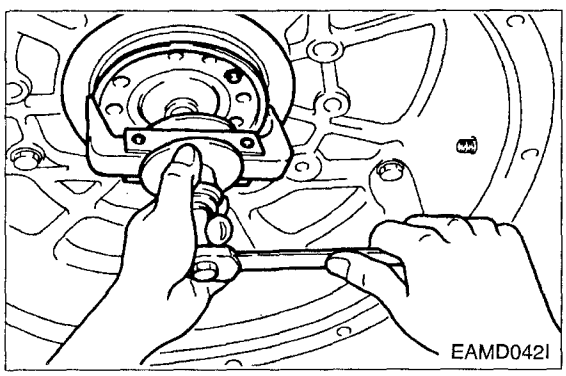
9.1.36. Flywheel

- Position the engine so that the head installing surface of the cylinder block faces down.
- Unscrew the flywheel fixing bolts and fit a dowel pin.
- Install flywheel disassembling bolts in the bolt holes machined on the flywheel, and disassemble the flywheel.



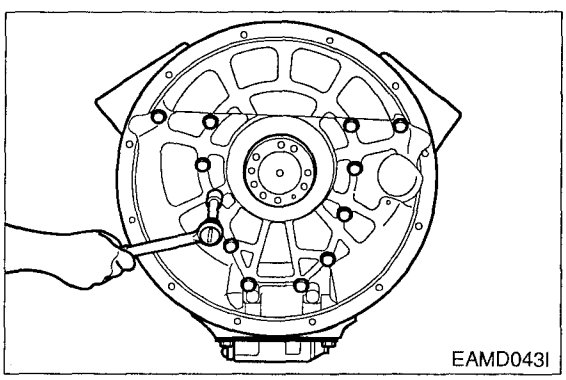
9.1.37. Oil seal

- Take off the rear oil seal using an oil seal disassembling jig.
- If only the inside guide ring is removed, use a special tool to take off the outside seal.



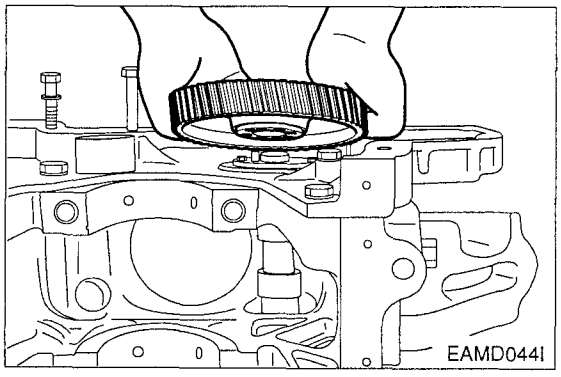
9.1.38. Flywheel housing

- Loosen the housing fixing bolts disassemble the flywheel housing.



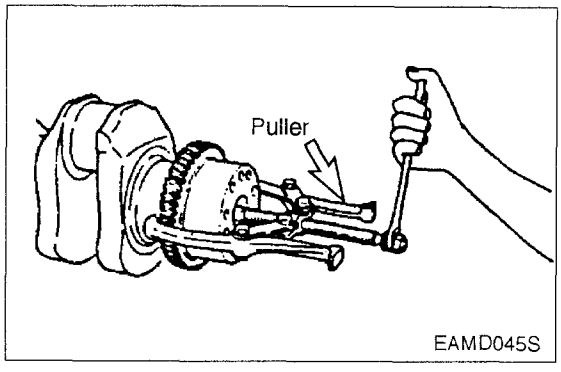
9.1.39. Cam shaft & tappet

- Remove the cam shaft gear.
- Take off the cam shaft gear thrust washer.
- Take out the cam shaft using care not to damage the cam shaft.
- Slide out the tappets by hand.



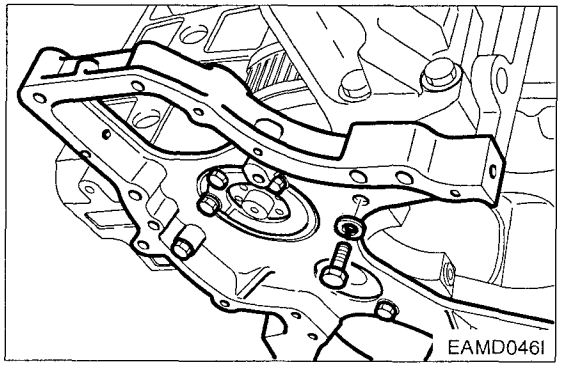
9.1.40. Crankshaft gear & oil pump idle gear

- Loosen the socket head bolts and take out the oil pump idle gear.
- Use a puller to remove the crankshaft gear.



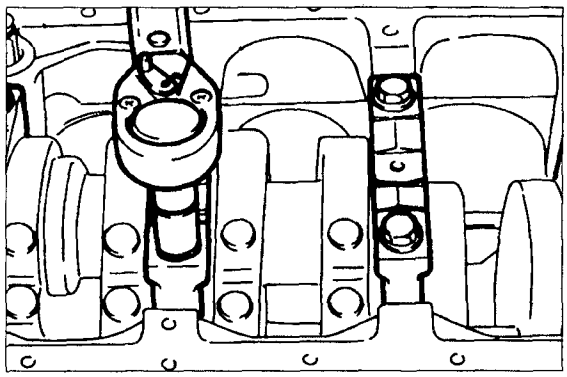
9.1.41. Timing gear case

- Unscrew the case fixing bolts and disassemble the timing gear case.



9.1.42. Crankshaft

- Remove the bolts from bearing caps.
- Remove the main bearing cap fixing bolts in the order of assembling.
- (Remove them in the same way of the cylinder head bolts.)
- Maintain the removed bearing caps in the order of cylinders.
- Temporarily install the bolts at the both side of crankshaft, and lift the shaft with a rope.

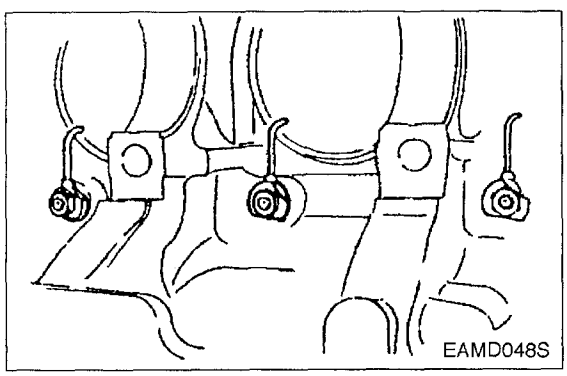


NOTE :

Do not mingle with the metal bearings and bearing caps randomly. To prevent mixing, temporarily assemble the metal bearings to the corresponding bearing caps in turn.

9.1.43. Oil spray nozzle

- Unscrew the fixing bolt and remove the oil spray nozzles.



9.2. Inspection

9.2.1. Cylinder block

1) Clean the cylinder block thoroughly and make a visual inspection for cracks or damage.
2) Replace if cracked or severely damaged, and correct if slightly damaged.
3) Check oil and water flow lines for restriction or corrosion.
4) Make a hydraulic test to check for any cracks or air leaks. (Hydraulic test) :
5) Stop up each outlet port of water/oil passages in the cylinder block, apply air pressure of about 4 kg/cm² against the inlet ports, then immerse the cylinder block in water for about 1 minute to check any leaks. (Water temperature: 70°C)

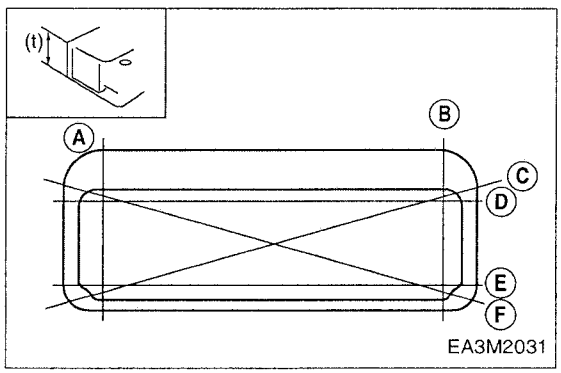
9.2.2. Cylinder head

1) Inspection

- Carefully remove carbon from the lower face of the cylinder head using nonmetallic material to prevent scratching of the valve seat faces.
- Check the entire cylinder head for very fine cracks or damage invisible to ordinary sight using a hydraulic tester or a magnetic flaw detector.

2) Distortion at the lower face

- Measure the amount of distortion using a straight edge and a feeler gauge at six positions (A ~ F) as shown in the right figure.
- If the measured value exceeds the standard value, retrace the head with grinding paper of fine grain size to correct such defect.
- If the measured value exceeds the maximum allowable limit, replace the cylinder head.

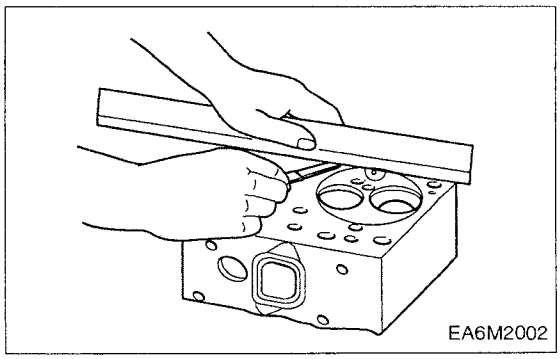


EA3M2031

<Lower face warpage and height>

(mm)

	Standard	Limit
Warpage	0.2 or less	0.3
Thickness : t (reference)	114.95 ~ 115.0	113.9


EA6M2002

3) flatness

Measure flatness of the intake/ exhaust manifolds fitting surfaces on the cylinder head using a straight edge and a feeler gauge.

(mm)

Standard	Limit
0.05	0.2

4) Hydraulic test

Hydraulic test method for the cylinder head is same as that for cylinder block.

9.2.3. Valve and valve guide

1) Valve

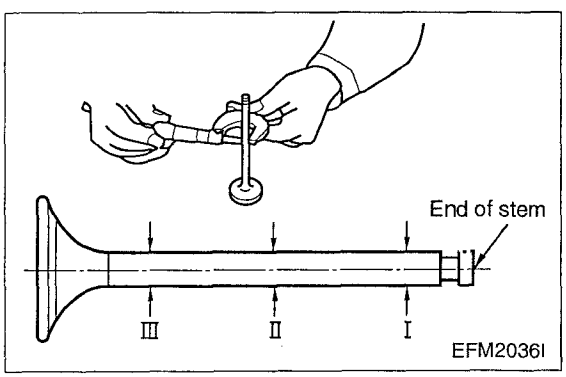
Clean the valves with clean diesel oil, then inspect them as follows:

- Valve stem outer diameter

  Measure the valve stem outer diameter at 3 positions. (top, middle, and bottom) If the amount of wear is beyond the limit, replace the valve.

(mm)

Dimension / Description	Standard	Limit
Intake valve stem	Ø10.950 ~ Ø10.970	Ø10.87
Exhaust valve stem	Ø10.935 ~ Ø10.955	Ø10.84



- Valve seat contacting faces

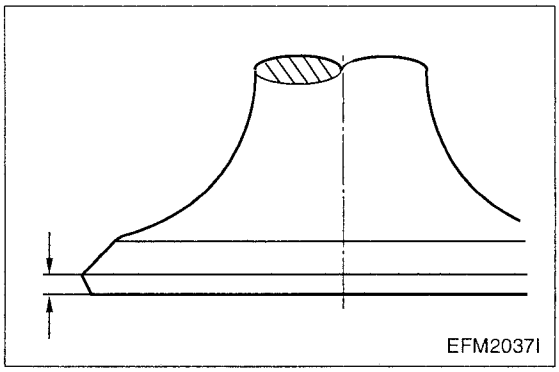
  Check the valve seat contacting faces for scratches or wear, and correct the faces with grinding paper as necessary. Replace if severely damaged.

● Valve head thickness

Measure the valve head thickness, and replace the valve if the measured value is beyond the limit.

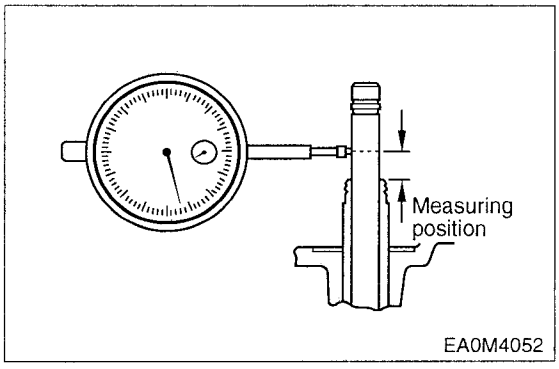
(mm)

Dimension / Description	Standard	Limit
Intake valve	1.5	1 or less
Exhaust valve	1.5	0.9 or less



2) Valve guide

● Install the valve into the valve guide and measure the clearance between them by valve movement. If the clearance is excessive, measure the valve and replace either the valve or the valve guide, whichever worn more.



<Valve stem end play>

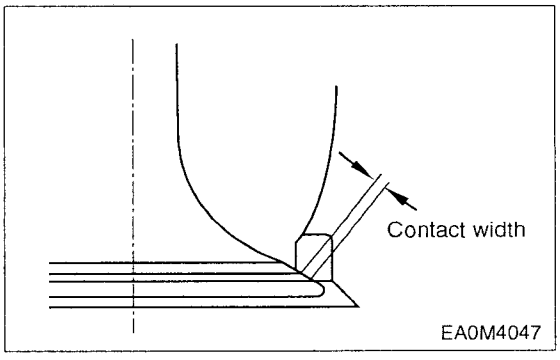
	Standard	Limit
Intake valve	0.04 ~ 0.07	0.2
Exhaust valve	0.06 ~ 0.09	0.25

● Install the valve into the cylinder head valve guide, then check and see if it is centered with the valve seat using a special tool.

3) Valve seat

● Contacting face amount

Measure the contacting face between intake valve and exhaust valve seat for valve seat wear, and replace if the measured value exceeds the specified limit.

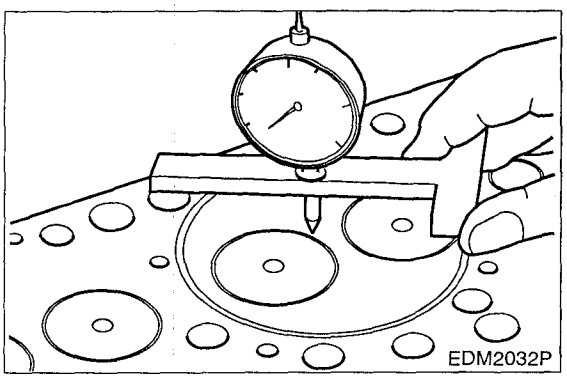


<Valve contact width>

(mm)

Standard	Limit
0 ~ 0.03	0.55

- Install the valve into the valve seat on the cylinder head, and check the amount of depression of the valve from the lower portion of the cylinder head using a dial gauge.

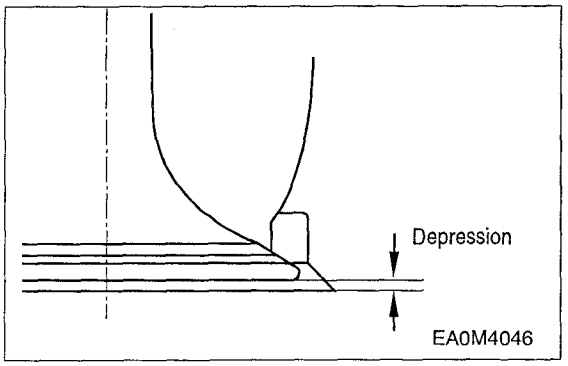


<Valve depression>

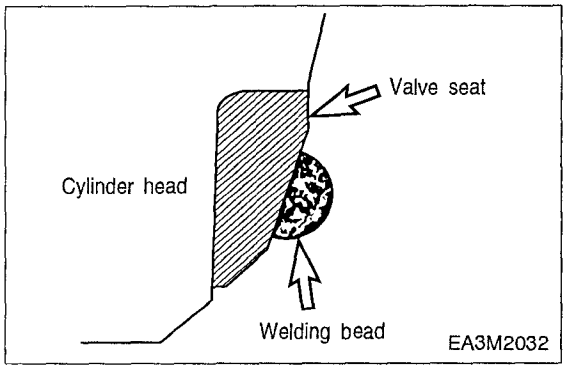
(mm)

	Standard	Limit
Intake & Exhaust	0 ~ 0.3	0.55

If the amount of depression is beyond the specified limit, replace the valve seat.



- For removal of the valve seat, apply arc welding work to two points of valve seat insert, and pull out the valve seat insert with inner extractor.
- For assembling of a new valve seat, by putting it among the dry ices of an ice box previously for about 2 hours for the cold shrinkage, and press it in the cylinder head by a special tool. (bench press)
- Apply the valve lapping compound on the valve head seating face and lap the valve seat by turning it until it is seated in its position, then wipe out the lapping compound.



NOTE :

Clean the valve and cylinder head with light oil or equivalent after the valve seat finishing is completed, and make sure that there are no grinding materials remained.

4) Valve spring

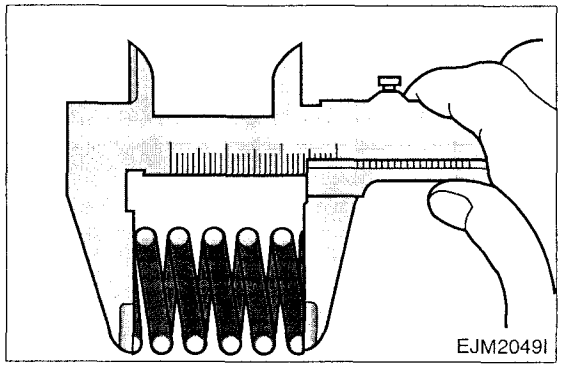
● Visual check

Visually check the exterior of the valve springs for damage, and replace if necessary.

● Valve spring free length

Use a vernier caliper to measure the valve spring free length.

If the measured value is less than the specified limit, the valve spring must be replaced.



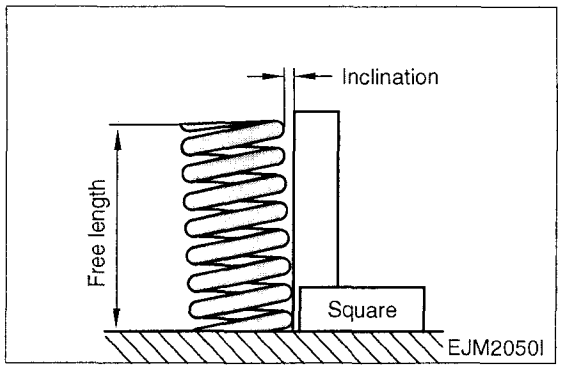
(mm)

Spring free Length		Standard
Intake valve		75.5
Exhaust valve	Inner	65
	Outer	75.5

● Valve spring inclination

Use a surface plate and a square to measure the valve spring inclination.

If the measured value exceeds the specified limit, the valve spring must be replaced.

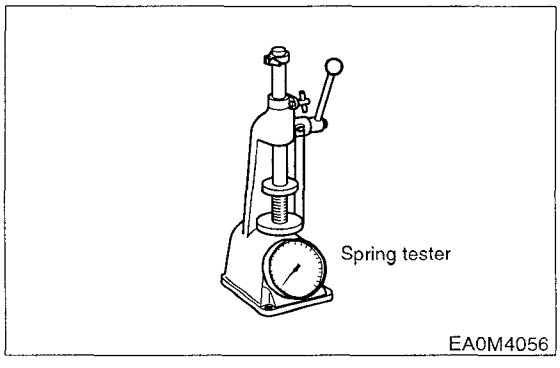


(mm)

	Standard	Limit
Valve spring Inclination	1.0	2.0

● Valve spring tension

Use a spring tester to measure the valve spring tension if the measured value is less than the specified limit, the valve spring must be replaced.



	Set Length		Spring force	Limit
Intake valve	Valve Spring Tension at 37 mm Set Length		61.8 ~ 68.3 kg	61.8 kg
Exhaust valve	Inner	34 mm	36.1 ~ 39.9 kg	36.1 kg

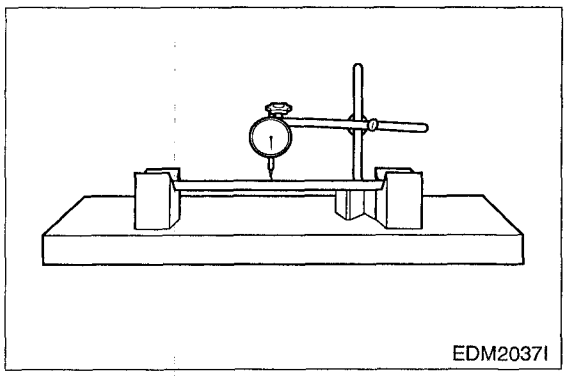
9.2.4. Rocker arm shaft assembly

1) Rocker arm shaft

● Rocker arm shaft run-out

Place the rocker arm shaft on two V blocks and inspect the shaft for bend using a dial gauge.

If the amount of this run-out is small, press the shaft with a bench press to correct the run-out Replace the shaft if the measured value exceeds the limit.



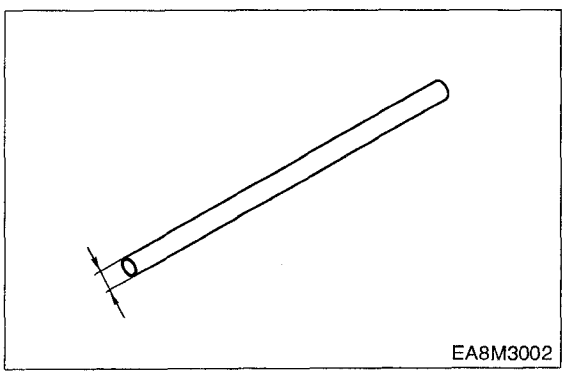
(mm)

Limit	0.2

● Rocker arm shaft diameter

With an outside micrometer, measure the rocker arm shaft diameter at the point where the rocker arms have been installed.

Replace the rocker arm if the amount of wear is beyond the specified limit.



(mm)

Standard	Limit
Ø23.978 ~ Ø23.959	Ø23.75

2) Rocker arm

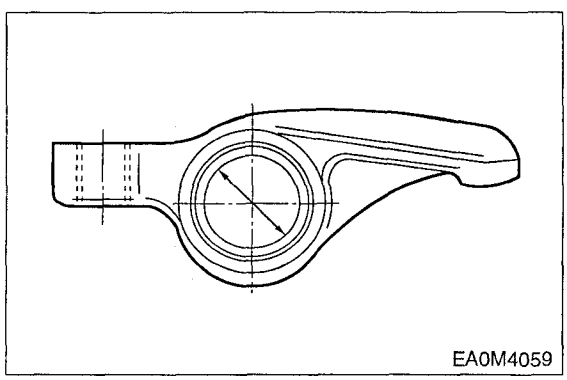
● Visual check

Visually check the face of the rocker arm in contact with the valve stem end for scores and step wear. If the wear is small, correct it with an oil stone or grinding paper of fine grain size. Rocker arm with a considerable amount of step wear should be replaced.

● Diameter of the rocker arm bushing

Measure the inside diameter of the rocker arm bushing with an inside micrometer or vernier calipers, and compare the measured values with the rocker arm shaft diameter.

If the clearance exceeds the limit, replace either bushing or shaft, whichever worn more.



<Clearance>

(mm)

Standard	Limit
0.020 ~ 0.093	0.2

3) Tappet & push rod

● Clearance

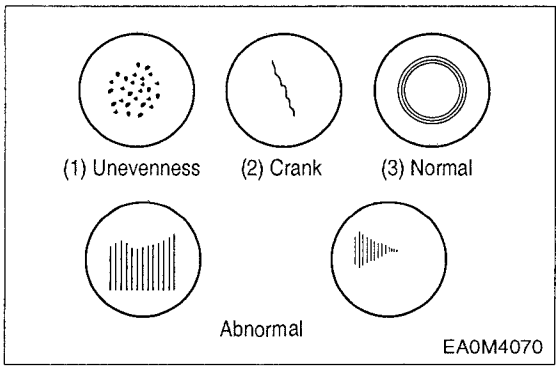
Measure the clearance of the tappet and tappet holes of the cylinder block. If the value is beyond the specified limit, replace tappets.

(mm)

Standard	Limit
0.035 ~ 0.077	0.15

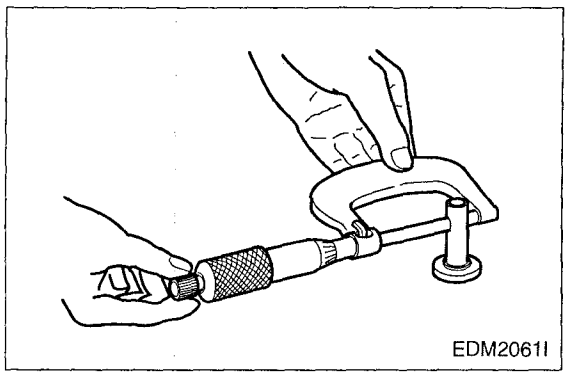
● Visual check of tappet

Visually check the face of the tappets in contact with the cam for pitting, scores or cracks, and replace if severely damaged. If the amount of cracks or pitting is small, correct with an oil stone or grinding paper.



● Outside diameter

With an outside micrometer, measure the tappet outside diameter If the measured value is beyond the limit, replace tappets.


EDM2061I

(mm)

Tappet Dia	Ø19.944 ~ Ø19.965

(mm)

	Standard	Limit
Tappet Clearance	0.035 ~ 0.077	0.15

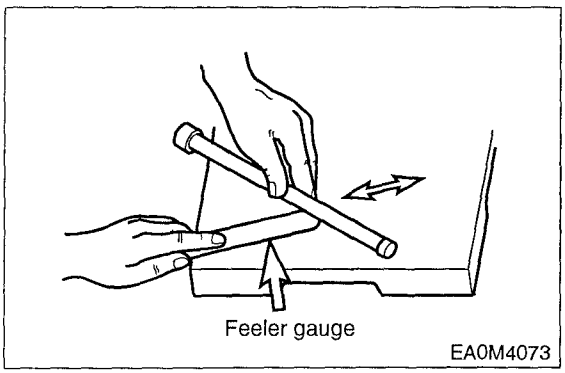
● Push rod run-out

(mm)

Limit	0.3 or less

Use a feeler gauge to measure the push rod run-out.

Roll the push rod along a smooth flat surface as shown in the figure.



EA0M4073

9.2.5. Cam shaft

1) Cam

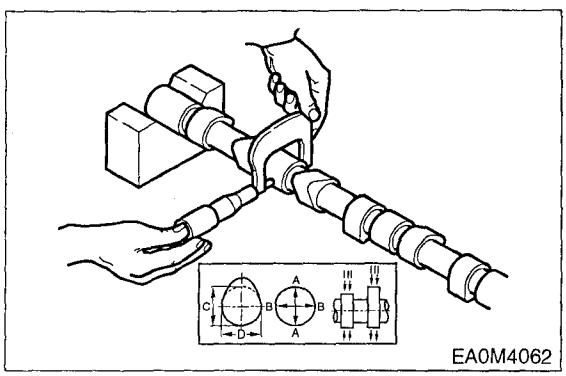
● Cam lobe height

(mm)

	Standard	Limit
Cam journal diameter(A,B)	Ø59.86 ~ Ø59.88	Ø59.52

Use a micrometer to measure the cam journal diameter.

If the measured number is less than the specified limit, the camshaft must replaced.



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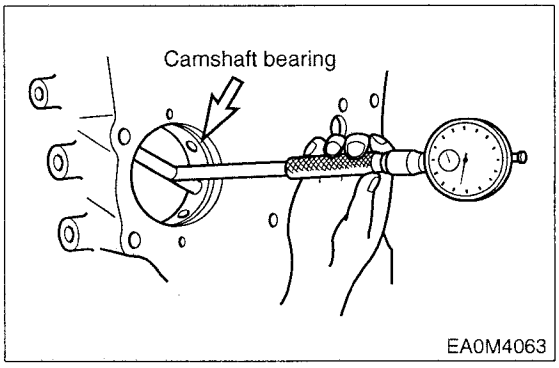
● Cam surface

Use a micrometer to measure the cam journal diameter.

If the measured number is less than the specified limit, the camshaft must replaced.

2) Cam shaft

- Clearance between camshaft journal & camshaft bush
  - With an outside micrometer, measure the camshaft journal diameter.
  - Measure the inside diameter of the camshaft bushing on the cylinder block using a cylinder bore indicator, and compare the measured value with the camshaft outside diameter to determine the clearance.



<Clearance>

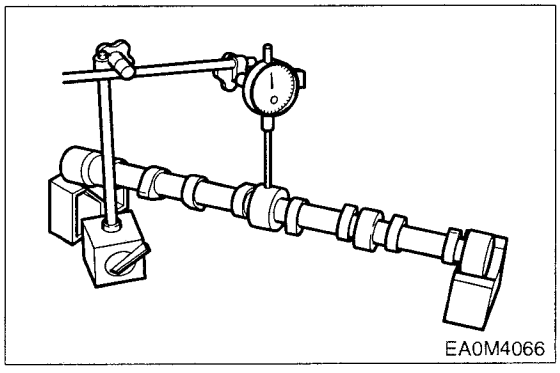
(mm)

Standard	Limit
0.050 ~ 0.128	0.2

Replace the bushing if the measured value is beyond the specified limit.

- Run-out

  Support the camshaft on two V blocks and check for run-out using a dial indicator. Correct or replace the cam shaft if the amount of run-out is beyond the value indicating need for servicing.

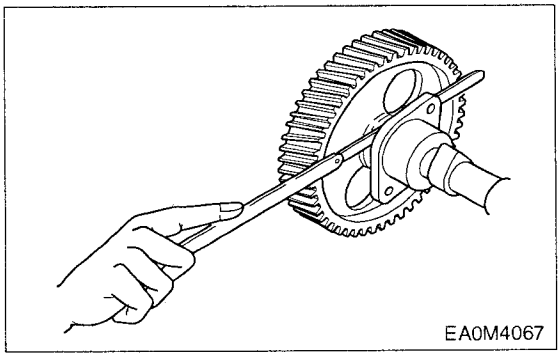


(mm)

Standard	Limit
0.05	0.2

3) Cam shaft & play

- Push the thrust plate toward the cam gear.
- With a feeler gauge, measure the clearance between the thrust plate and camshaft journal.
- If the end play is excessive, replace the thrust plate.



(mm)

Standard	Limit
0.13 ~ 0.27	0.3

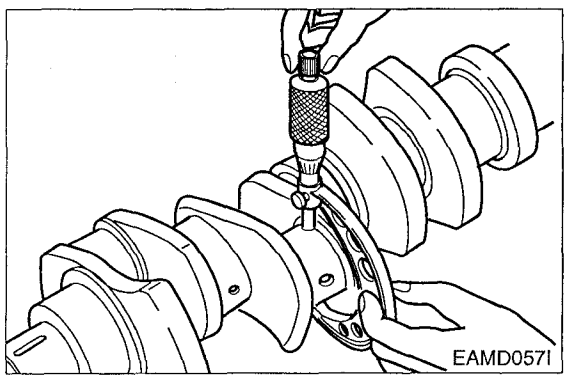
9.2.6. Crank shaft

1) Defect check

- Visually check the crankshaft journal and crank pins for scores or cracks.
- Using a magnetic particle test and color check, inspect the crankshaft for cracks, and replace the crankshaft which has cracks.

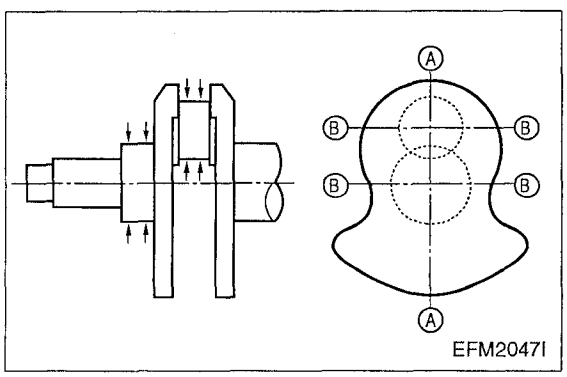
2) Wear

- With an outside micrometer measure the diameter of the crankshaft journals and pins in the directions as shown, and compare the measured values to determine the amount of wear.
- If the amount of wear is beyond the limit, have the crankshaft ground and install undersize bearings. However, if the amount of wear is within the limit, you can correct the wear using an oil stone or oiled grinding paper of fine grain size. (Be sure to use grinding paper which has been immersed in oil.)



(mm)

	Standard	Limit
Journal diameter	Ø95.966 ~ Ø95.988	Ø94.966
Pin diameter	Ø82.966 ~ Ø82.988	Ø81.966



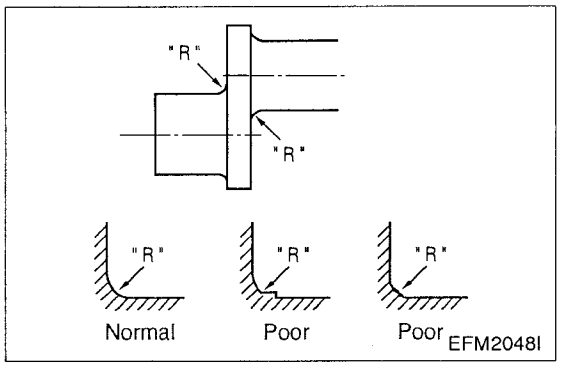
*** Undersize bearings available**

- ◆ Standard
- ◆ 0.25 (Inside diameter is 0.25 mm lesser than the standard size.)
- ◆ 0.50 (Inside diameter is 0.50 mm lesser than the standard size.)
- ◆ 0.75 (Inside diameter is 0.75 mm lesser than the standard size.)
- ◆ 1.00 (Inside diameter is 1.00 mm lesser than the standard size.)

Undersize bearings are available in 4 different sizes as indicated above, and the crankshaft can be reground to the above sizes.

NOTE :

When regrinding the crankshaft as described below, the fillet section ëRí should be finished correctly. Avoid sharp corners or insufficient fillet.



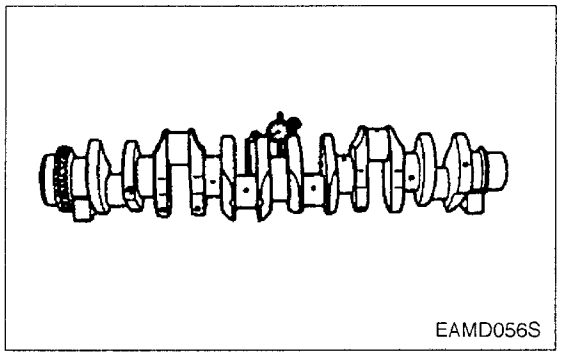
* Standard values of "R"

① Crankshaft Pin "R" : 4.5 $^{0}_{-0.2}$

② Crankshaft journal "R" : 4 $^{0}_{-0.2}$

3) Crankshaft run-out

- Support the crankshaft on V blocks.
- Turn the crankshaft with a dial indicator placed on the surface plate and take the amount of crankshaft run-out.



(mm)

Standard	Limit
0.05	0.1

9.2.7. Crank shaft bearing & connection rod bearing

1) Visual check

Visually check the crankshaft bearing and connecting rod bearing for scores, uneven wear or damage.

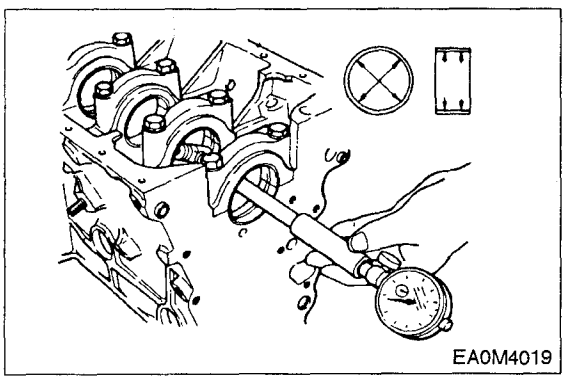
2) Oil clearance between crankshaft & bearing

● Main bearing clearance (Method 1)
Install the main bearing in the cylinder block, tighten the bearing cap to specified torque, then measure the inside diameter.

Torque	30 kg·m

(mm)

Standard Dia.	Ø96.06 ~ Ø96.108


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Compare the two values obtained through measurement of main bearing inside diameter with the outside diameters of crankshaft journals to determine the oil clearance.

<Main bearing oil clearance>

(mm)

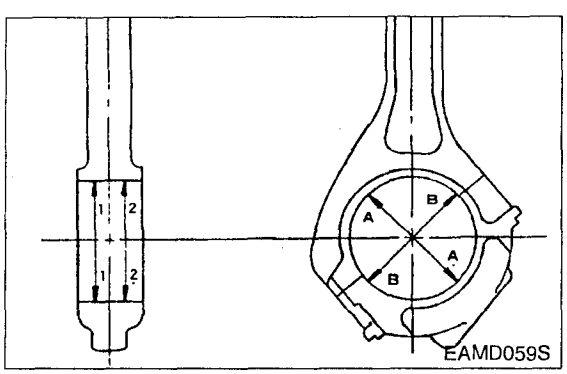
Standard	Limit
0.072 ~ 0.142	0.25

● Connecting rod bearing clearance
Install the connecting rod bearing in the connecting rod bearing cap, tighten the connecting rod cap bolts to the specified torque, then measure the inside diameter.

Torque	28 kg·m

(mm)

Standard Dia.	Ø83.02 ~ Ø83.092

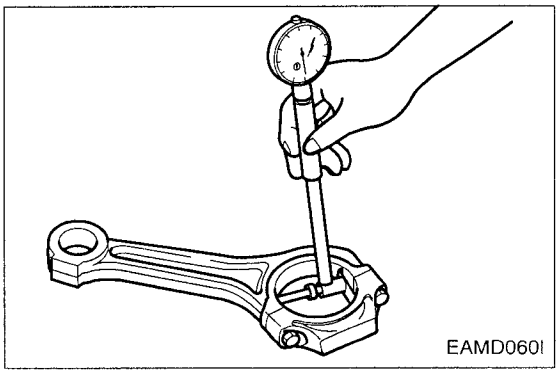


EAMD059S

Compare the two values obtained through measurement of connecting rod bearing inside diameter with the outside diameters of crankshaft pins to determine the oil clearance.

(mm)

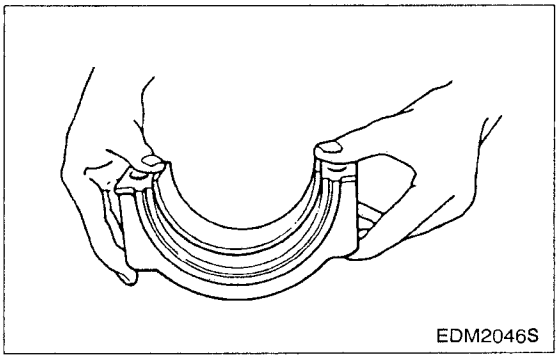
Standard	Limit
0.049 ~ 0.119	0.20

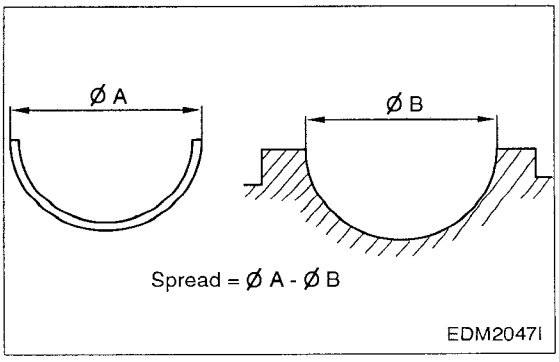


- If the clearance deviates from the specified range, have the crankshaft journals and pins ground and install undersize bearings.
- Connecting rod bearing clearance (Method 2 : with plastic gauge)
  Assemble the crankshaft on the cylinder block and put the plastic gauge on journal and pin of crankshaft and then after assembling bearing cap, tighten the bolts at the specific torque. Again after disassembling the bearing cap by removing the bolts, take out the flatted plastic gauge and measure the width of plastic gauge by means of plastic gauge measuring scale. This is the oil clearance.

3) Bearing spread and crush

- Inspection
  Check to see that the bearing requires a considerable amount of finger pressure at reassembly operation.



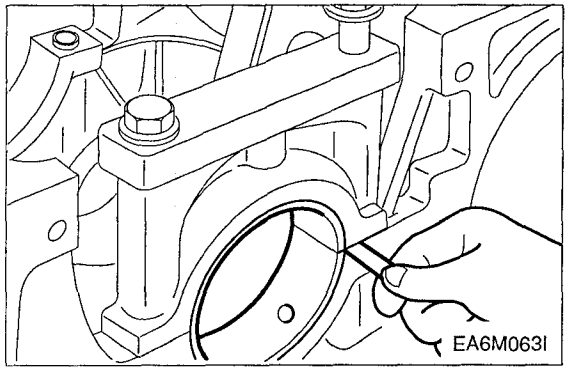


● Crankshaft bearing crush

Install the bearing and cap in the cylinder block, retighten the bolts to specified torque, unscrew out one bolt completely, then measure the clearance between the bearing cap and cylinder block using a feeler gauge.

(mm)

Standard Dia.	0.15 ~ 0.25

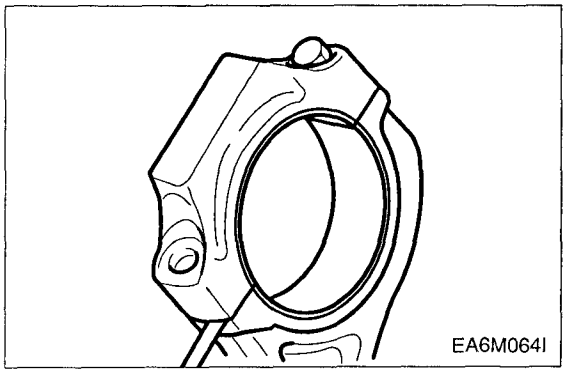


● Connecting rod bearing crush

Install the bearing and cap in the connecting rod big end, retighten the bolts to specified torque, unscrew out one bolt completely, then measure the clearance between the bearing cap and connecting rod big end using a feeler gauge.

(mm)

Standard	0.086 ~ 0.116



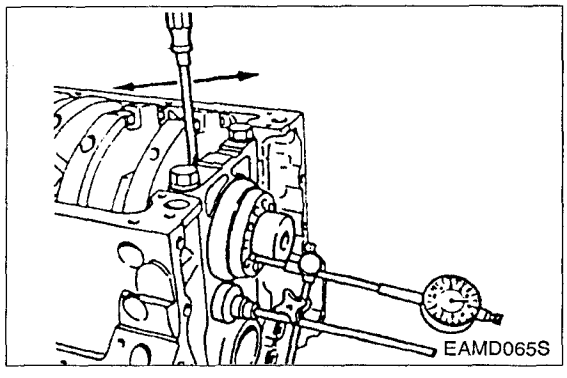
4) crank shaft end play

● Assemble the crankshaft to the cylinder block.

● With a dial gauge, measure crankshaft end play.

(mm)

Standard	Limit
0.15 ~ 0.325	0.5



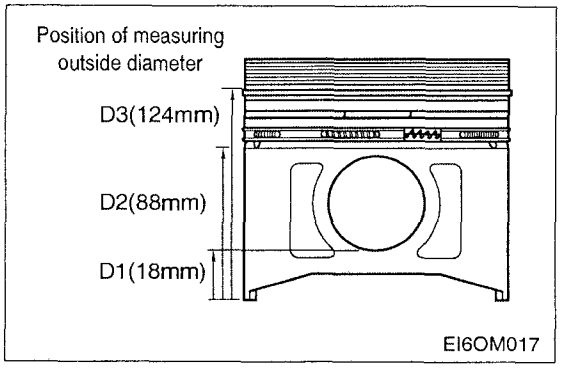
9.2.8. Piston

1) Visual check

Visually check the pistons for cracks, scuff or wear, paying particular attention to the ring groove.

2) Clearance between the piston & cylinder liner

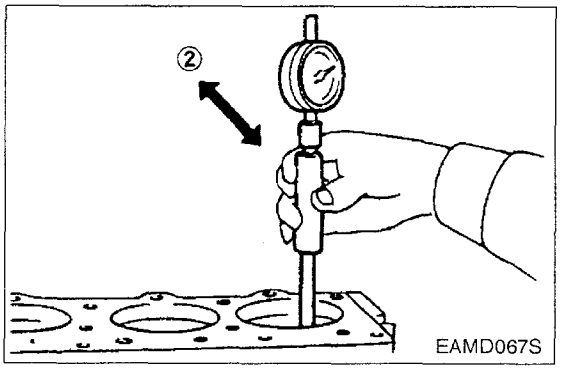
- With an outside micrometer, measure the piston outside diameter at the points D1(18mm), D2(88mm), D3(124mm) away from the lower end of piston skirt in a direction at a right angle to the piston pin hole.



(mm)

Point	Standard Dia.
D1(18mm)	Ø122.870 ± 0.007
D2(88mm)	Ø122.750 ± 0.009
D3(124mm)	Ø122.450 ± 0.010

- Using a cylinder bore gauge, measure cylinder liner inside diameter at 3 points (cylinder top ring contacting face, middle, and oil ring contacting face on BDC) in a direction at an angle of 45. Take the mean value with the largest and smallest values excepted.



(mm)

Standard	Limit
Ø123 ~ Ø123.023	Ø123.223

- The clearance is computed by subtracting the piston outside diameter from the cylinder liner inside diameter. Replace either piston or cylinder liner, whichever damaged more, if the clearance is beyond the specified limit.

<Clearance between piston and liner>

(mm)

Standard	0.114 ~ 0.169

9.2.9. Piston rings

1) Visual check

Replace the piston rings with new ones if detected worn or broken when the engine is overhauled.

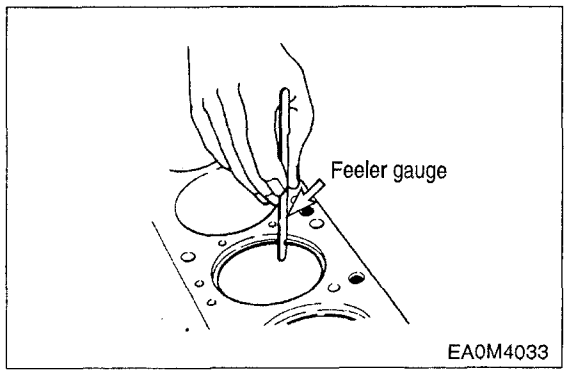
2) Piston ring gap

- Insert the piston ring into the upper portion of the cylinder liner bore so that it is held at a right angle to the cylinder liner wall.
- Measure the piston ring gap with a feeler gauge.

(mm)

	Standard	Limit
Top ring	0.30 ~ 0.45	1.5
2nd ring	1.0 ~ 1.2	2.0
Oil ring	0.30 ~ 0.50	1.5

Replace piston rings with new ones if the gap is beyond the limit

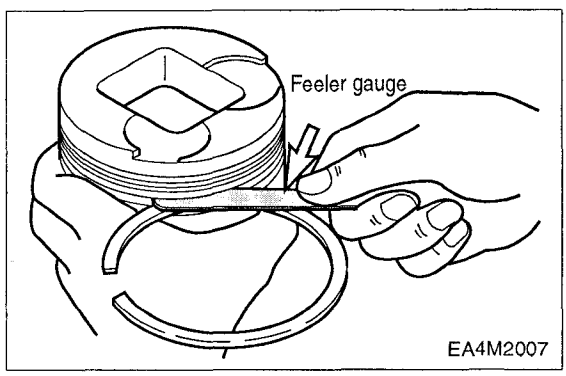


3) Piston ring side clearance

- Fit the compression ring and oil ring in the piston ring groove.
- With a feeler gauge, measure side clearance of each ring, and replace either the ring or piston if the measured value is beyond the specified limit.

(mm)

	Standard	Limit
Top ring	0.105 ~ 0.155	
2nd ring	0.07 ~ 0.102	0.15
Oil ring	0.05 ~ 0.085	0.15



4) Piston ring tension

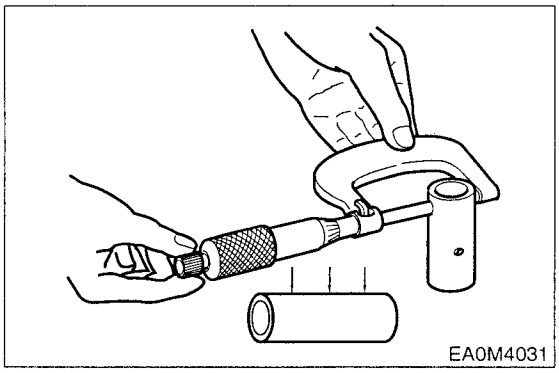
With a tension tester, measure piston ring tension. Replace the piston ring if the measured value is beyond the limit.

	Standard
Top ring	2.27 ~ 3.41 kg
2nd ring	2.0 ~ 3.0 kg
Oil ring	4.03 ~ 5.57 kg

9.2.10. Piston pin

1) Wear

Measure the amount of wear on the piston pin at the points as shown. The measured values are beyond the limit (0.005 mm or greater), replace the pin

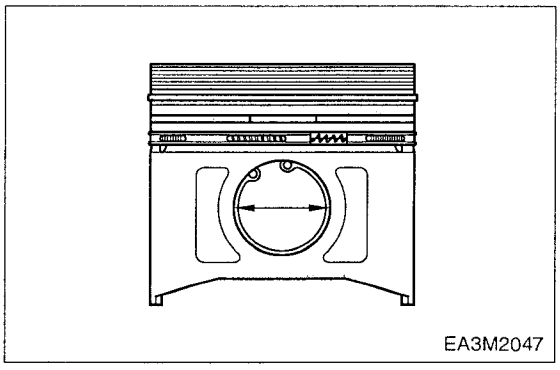


(mm)

Standard	Limit
Ø44.995 ~ Ø45	Ø44.990 or less

2) Clearance

Measure the clearance between the piston pin and connecting rod bushing, and replace either of them, whichever damaged more, if the measured value is beyond the limit.



(mm)

Standard	Limit
0.003 ~ 0.009	0.011

3) Condition check

Check the engaged condition of the piston and piston pin. If it is possible to force the pin into the piston heated with piston heater, the piston is normal.

When replacing the piston, be sure to replace the piston pin together.

9.2.11. Connecting rod

1) Distorsion

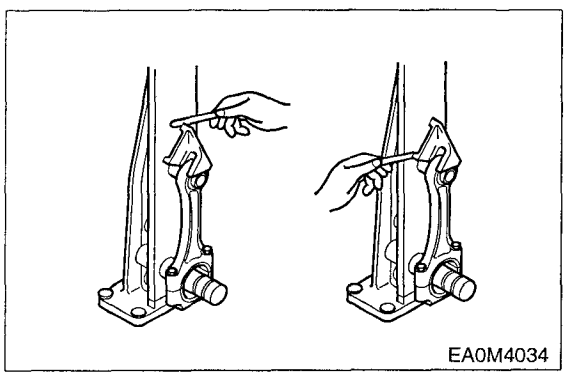
Check the connecting rod for distortion. As shown in the figure below, install the connecting rod to the connecting rod tester, and check for distortion using a feeler gauge. If the connecting rod is found distorted, never re-use it but replace with a new one.

2) Holes alignment (parallelism)

Measure the alignment of the connecting rod piston pin bushing holes with connecting rod big end holes. At this time also, use both connecting rod tester and feeler gauge.

(mm)

Standard	Limit
0.05	0.1 or less



3) Wear

- Assemble the connecting rod to the crankshaft and measure connecting rod big end side clearance using a feeler gauge.
- Assemble the connecting rod to the piston and measure connecting rod small end side clearance.
- If the measured values are beyond the limit, replace the connecting rod.

(mm)

Limit	0.5

9.3. Reassembly

9.3.1. General precautions

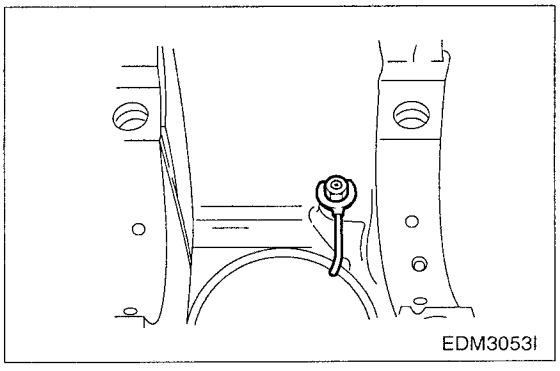
- Wash clean all the disassembled parts, particularly oil and water ports, using compressed air, then check that they are free from restrictions.
- Arrange the general and special tools in order for engine assembly operation.
- To wet each sliding part, prepare the clean engine oil.
- Prepare service materials such as sealant, gaskets, etc.
- Discard used gaskets, seal rings, and consumable parts, and replace with new ones.
- Apply only the specified torque for bolts in the specified tightening order and avoid over-tightening.
- Be sure to check that all the engine parts operate smoothly after being reassembled.
- Check the bolts for looseness after preliminary reassembly.
- After completing the engine reassembly operation, check if there is missing parts or shortage of parts.
- Keep your hands clean during the working.

9.3.2. Cylinder block

Cover the floor of the workshop with wood plate or thick paper to prevent damage to the cylinder head and place the cylinder block with the head fitting surface facing downward.

9.3.3. Oil spray nozzle

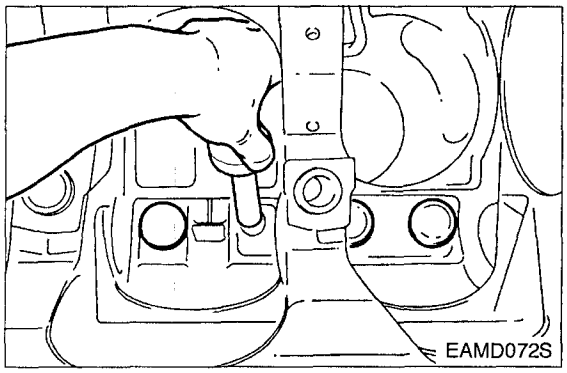
- Tighten and assemble the oil spray nozzle flange with fixing bolts using the spray nozzle jig.



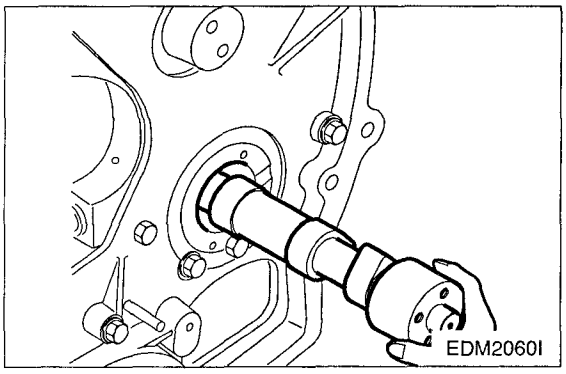
9.3.4. Tappet and cam shaft

- Undercool a new bush with dry ice for about 2 hours and press it into position in the cylinder block using a bench press. After the pressing operation, measure the inside diameter of the cam bush to check if it is not deformed.

- Apply engine oil to the entire face of the tappets and slide them into the tappet holes on the cylinder block.

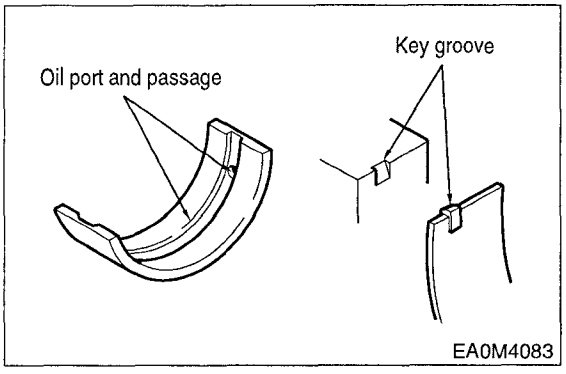


- Wet the cam bush inside diameter and camshaft with oil, and carefully assemble them while turning the camshaft.
- Check to see that the camshaft rotates smoothly.

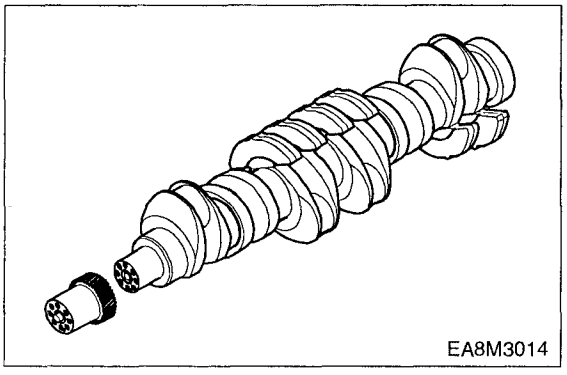


9.3.5. Crankshaft

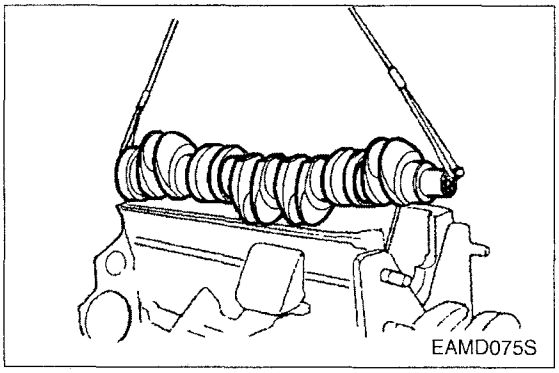
- Install the main bearing machined with two holes in the cylinder block so that the key is aligned with the key groove, then apply oil to the bearing surface.



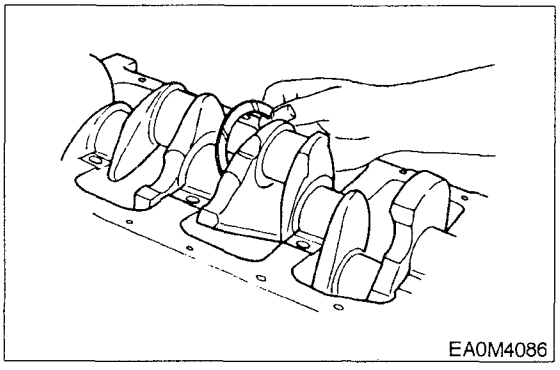
- Heat the crankshaft gear for at least 10 minutes to 120°C, then apply sealant (Loctite # 641) to the inside wall of the heated crankshaft gear evenly before inserting it to the end of crankshaft.



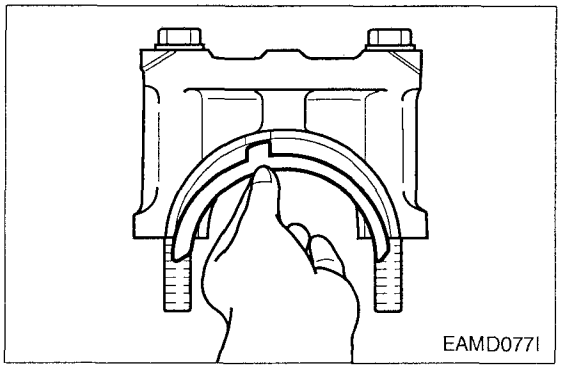
- Semi-tighten a bolt at both sides of the crankshaft, apply engine oil to journals and pins, then assemble the crankshaft with the cylinder block by tightening the fixing bolts.



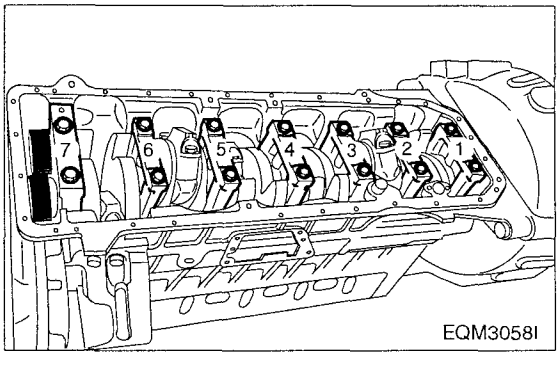
- Install the oiled thrust washers with the oil groove facing outward.



- Install the bearing and thrust washers to the bearing cap and apply oil to the bearing and thrust washers.

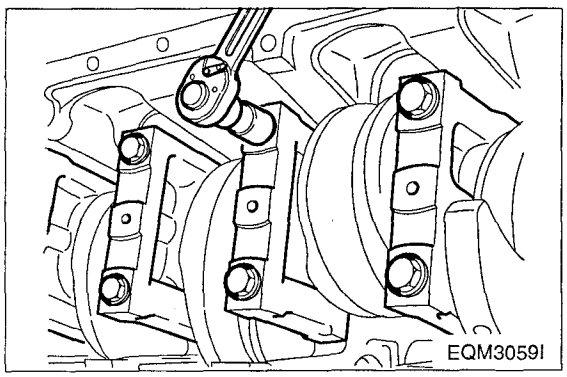


- Install the bearing cap by matching the cylinder block No. with the bearing cap No.



- Apply oil to the entire part of the bearing cap bolts, then tighten in tightening sequence to specified torque.

Torque	30 kg·m



- After semi-tightening both bolts evenly, tighten them diagonally specified torque using a torque wrench as follows.

<Tightening order>

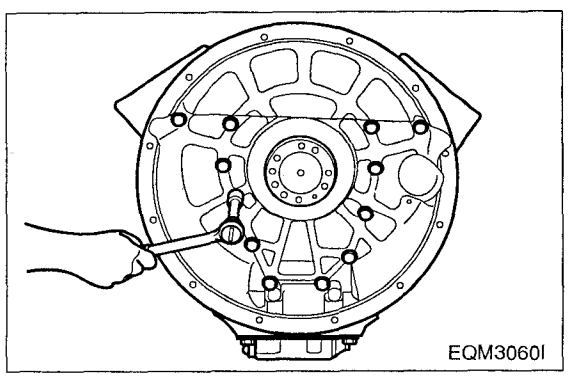
(1) First stage : Coat engine oil over the bolts.
(2) Second stage : Temporary assemble the bolts about 1 ~ 2 threads
(3) Third stage : With impact wrench, tighten up to about 15 kg.m
(4) Fourth stage : With torque wrench, tighten up to about 25 kg.m
(5) Fifth stage : By means of torque wrench, tighten finally in the specified torque. (30 kg·m).

- Tighten the bearing cap in the sequence of 4-3-5-2-6-1-7.
- Check to see that the assembled crankshaft turns smoothly.

9.3.6. Flywheel housing

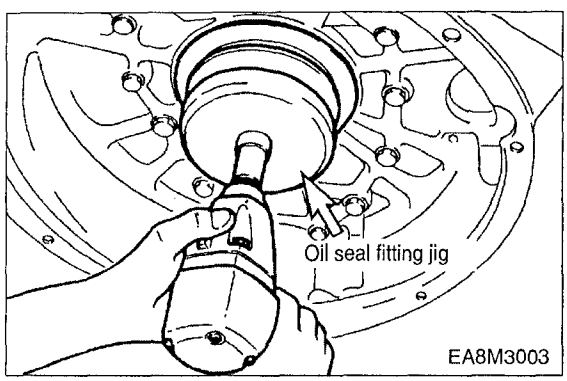
- Temporarily install the guide bar on the cylinder block.
- Apply gasket to the cylinder block.
- Using the dowel pin and guide bar, install the flywheel housing and tighten the fixing bolts in a diagonal sequence to specified torque.

Torque	12 kg·m



9.3.7. Rear oil seal

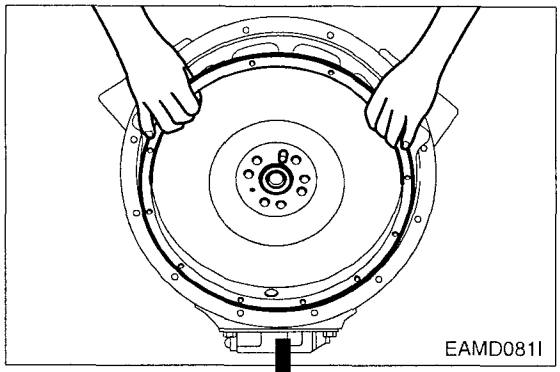
- Apply lubricating oil to the outside of theoil seal and flywheel housing inside diameter and fit them over the crank shaft, then assemble the oil seal using an oil seal fitting jig.

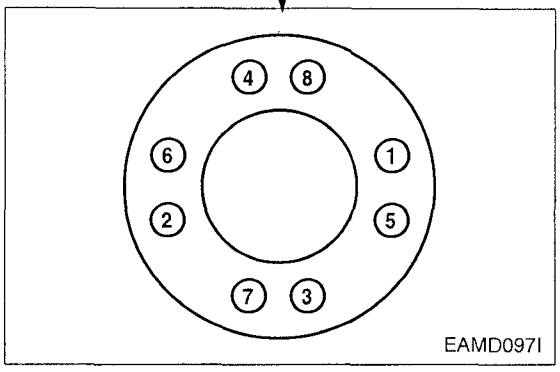


9.3.8. Flywheel

- Install a guide bar into a bolt hole on the crank shaft, and lift the flywheel to align the dowel pin with the pin hole on the flywheel for temporary assembly operation.
- Install bolts in the remaining holes, take out the guide bar, then install a bolt in the hole where the guide bar had been inserted.
- Tighten the fixing bolts using a torque wrench in a diagonal sequence to specified torque.

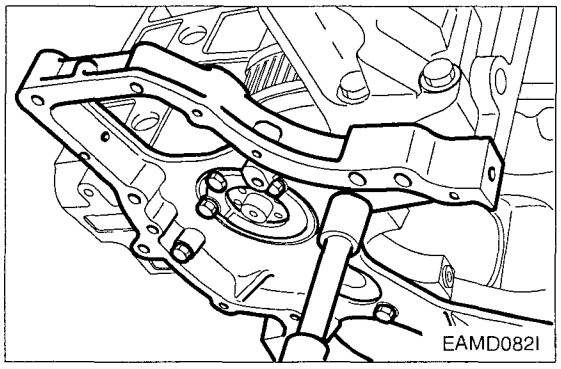
Torque	18 kg·m





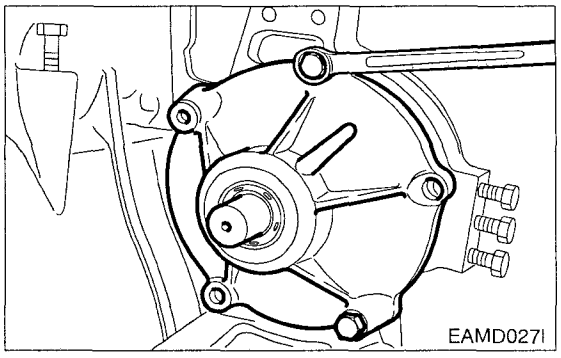
9.3.9. Timing gear case

- Mount gasket using dowel pin on the cylinder block.
- Install the timing gear case by aligning the dowel pin with the dowel pin hole on the timing gear case.



9.3.10. Fuel injection pump drive gear assembly

- Mount gasket by aligning the bolt holes with the pin holes on the bearing housing.
- Tighten up the fixing bolts in the direction of fuel injection pump.

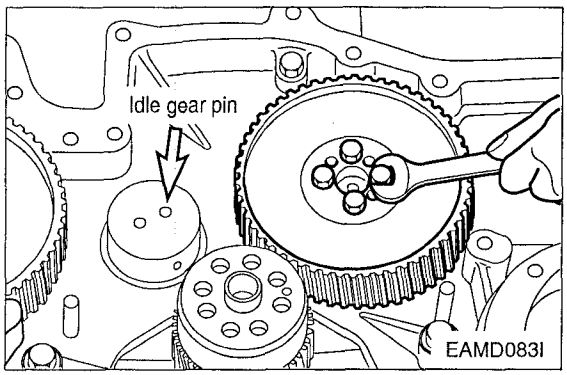


9.3.11. Timing gear

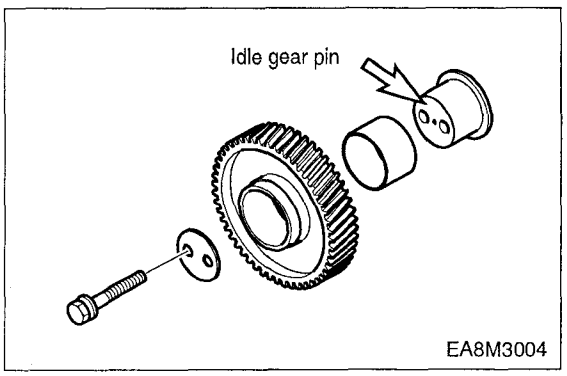
- Install the oil pump idle gear onto the No.7 bearing cap.

- Install a thrust washer over the camshaft and assemble the cam gear by aligning it with camshaft key groove.

Torque	3.1 kg·m



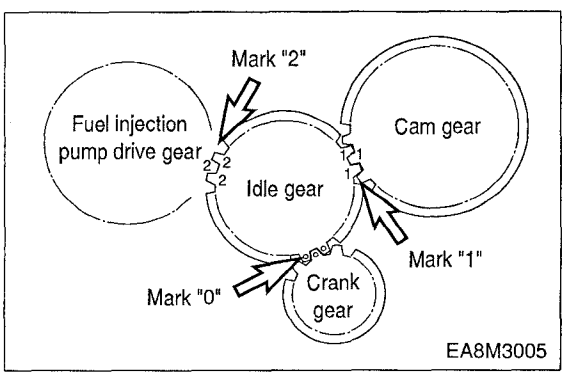
- With the oil port on the idle gear pin facing the cylinder block, install the idle gear pin.



- Install the idle gear by coinciding the marks impressed on the crank gear, cam gear, fuel injection pump drive gear, and idle gear.

- Install a thrust washer on the idle gear and tighten to specified torque.

Torque	7.4 kg·m



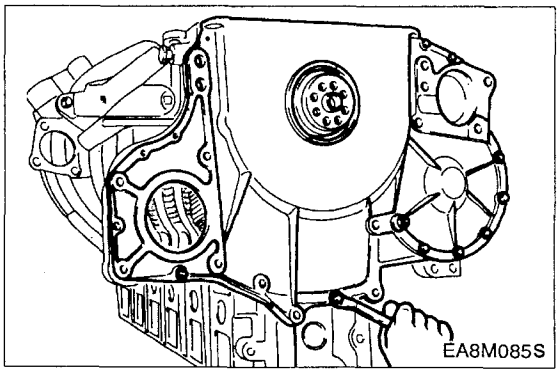
- Check and adjust the amount of backlash between gears using a feeler gauge.

(mm)

Measuring position (between)	Backlash	Limit
Cam gear & idle gear	0.16 ~ 0.28	0.35
Crank gear & idle gear	0.16 ~ 0.28	0.35
Injection pump & idle gear	0.16 ~ 0.28	0.35

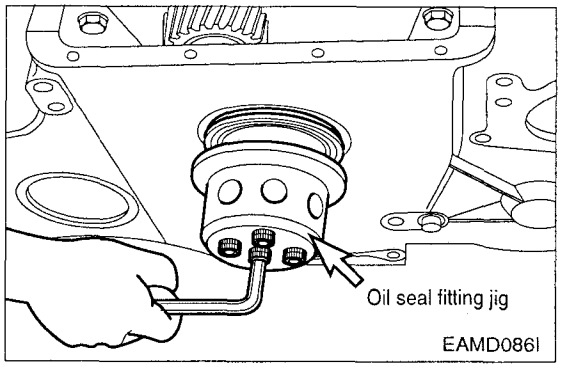
9.3.12. Timing gear case cover

- Install dowel pin on the timing gear case.
- Mount a gasket by aligning the fixing bolt holes with those on the gasket.
- Align the dowel pin with the cover pin hole, then install the cover with light tap.
- Tighten the fixing bolts beginning with the oil pan fitting face.



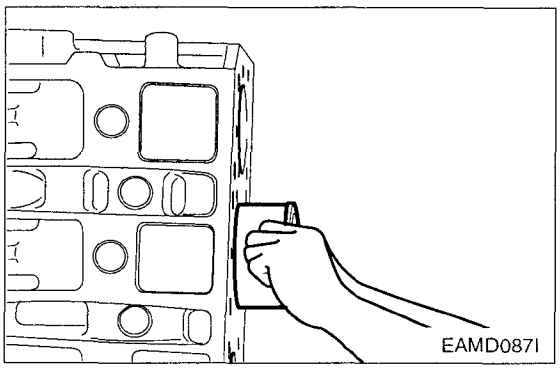
9.3.13. Front oil seal

- Apply lubricating oil to the outside of the oil seal and timing gear case inside diameter and fit them over the crankshaft, then assemble the oil seal using an oil seal fitting jig.



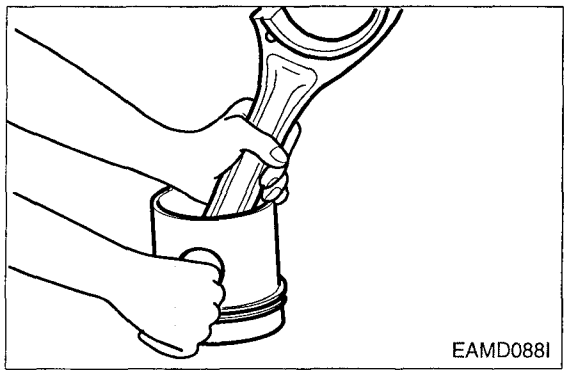
9.3.14. Cylinder liner

- Stand the cylinder block so that the flywheel faces downward.
- Thoroughly clean the liner flange fitting surface and bore inside with compressed air to prevent the entry of foreign substances.
- After the cleaning operation, make the cylinder liner dried up and push it into the cylinder block by hand.
- Wet the liner inside diameter with engine oil.

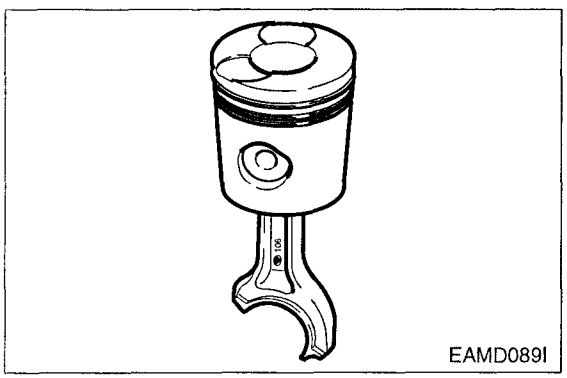


9.3.15. Piston & connecting rod

- Align the piston pin hole with the oiled connecting rod small end and press the piston pin (by lightly tapping with a rubber hammer) to assemble the connecting rod with the piston.


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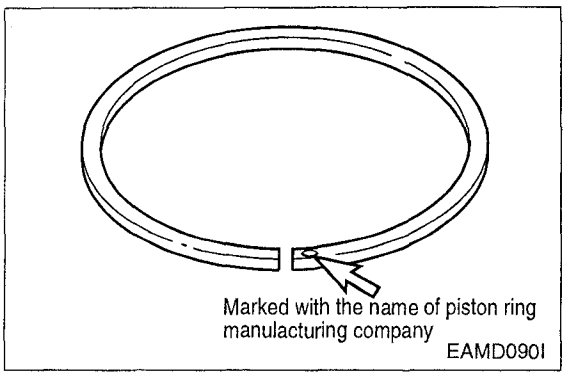
- Noting the direction of the piston, make the longer side (machined with key groove on the bearing) of the connecting rod big end and the mark of "DI" impressed on the inside of the piston face each other in opposite directions. On the piston head surface, the longer side of connecting rod big end is in opposite direction from the valve seating surface as well as in the same direction with the narrow margin of combustion chamber.


EAMD089I

- Install the snap rings and check to see that it is securely assembled.
- Install the piston ring in the piston using piston ring pliers.

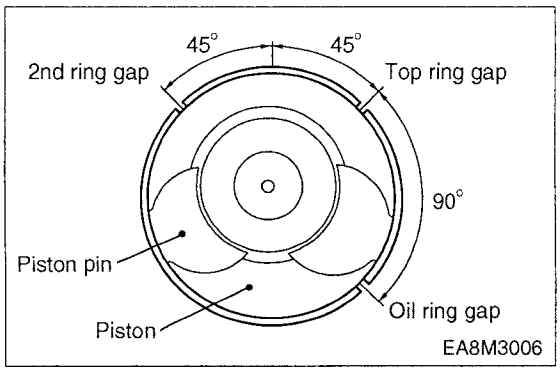
- Identify the mark "Y" or "TOP" on the ring end to prevent the top and bottom of the piston ring is interchanged each other and make the marked top face upward.

NOTE :
Be sure to make the piston ring end marked face("Y" or "TOP") upward.

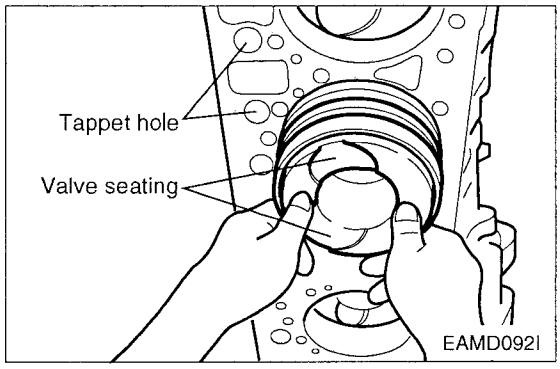


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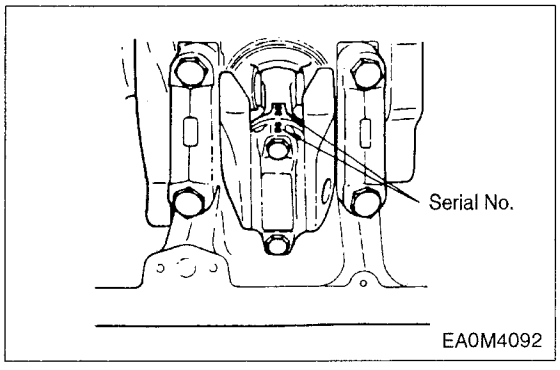
- Adjust the angle among individual piston ring gaps to 90° and fit a piston assembling jig onto the piston, Use care not to match the ring gaps with the pin direction.
- Install the bearing by aligning it with the connecting rod key groove and apply oil to the bearing and piston.



- Position the valve seating surface toward the tappet hole and insert the piston with hand.
  Use care not to damage the cylinder liner and piston, and slightly lift and insert the piston into the cylinder so that the ring may not be damaged by the fillet of the liner.
- Install the bearing in the connecting rod cap and apply oil.



- Make sure that the manufacture serial numbers impressed on the connecting rod cap and connecting rod big end are identical, and install the connecting rod cap by aligning it with dowel pin.

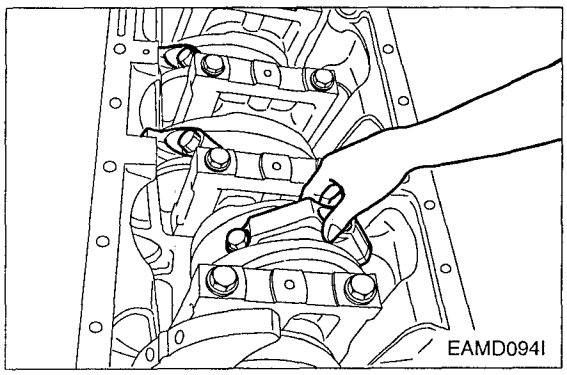


- Wet the fixing bolts with oil, semi-tighten them with hand, tighten them to specified torque using a torque wrench as follows.

<Tightening order>
(1) First stage : Coat engine oil over bolts
(2) Second stage : Temporary screw the bolt about 1 ~ 2 threads
(3) Third stage : With torque wrench, tighten at about 15 kg·m
(4) Fourth stage : With torque wrench, tighten up to about 22 kg·m
(5) Fifth stage : Finally, tighten in the specified torque 28kg.m with torque wrench.

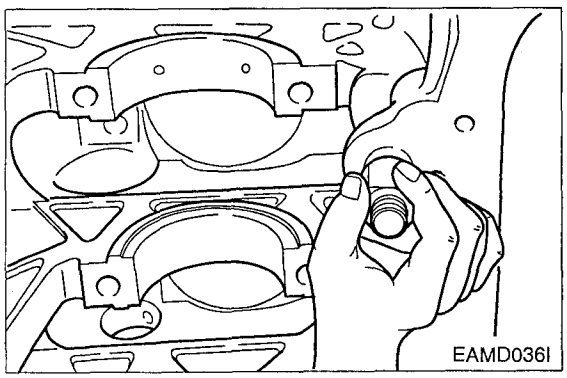
Torque	28 kg·m

- Move the bearing cap with hand, and release and reassemble it if no movement is detected.



9.3.16. Relief valve

- Assemble the relief valve.

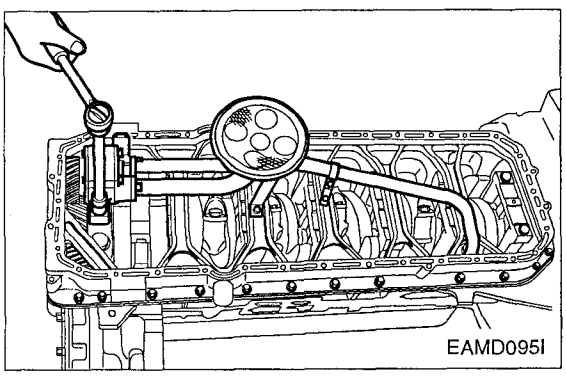


9.3.17. Oil pump and oil pipe

- Install a dowel pin in the No.7 bearing cap, then assemble the oil pump with specified torque.

Torque	4.4 kg·m

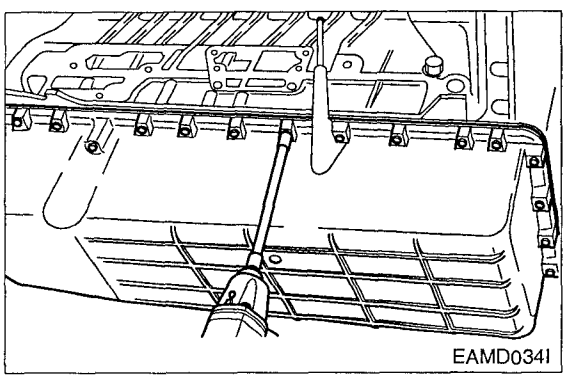
- Assemble the oil suction pipe with the delivery pipe, then install the bracket on the bearing cap.



9.3.18. Oil pan

- Mount gasket and put the oil pan thereon.
- Place stiffeners and tighten bolts.
- Align the bolt holes with gasket holes to prevent damage to the gasket and tighten to specified torque.

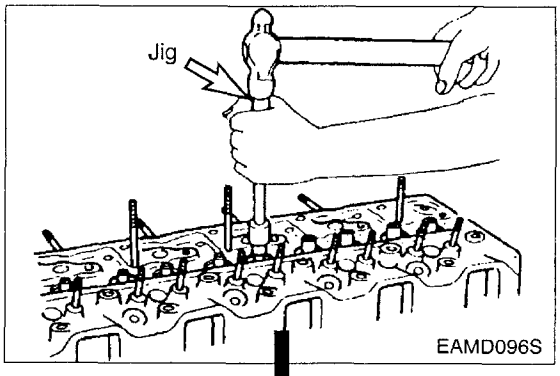
Torque	2.2 kg·m



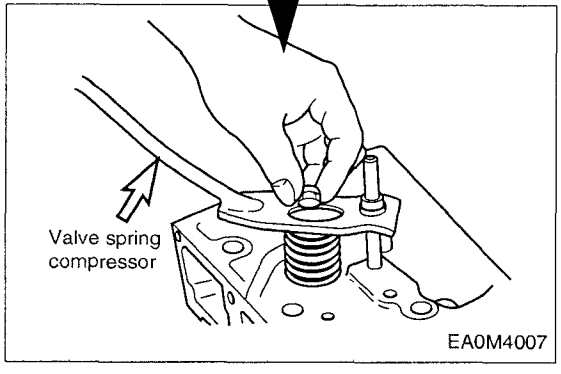
9.3.19. Intake & exhaust valves

- Identify the marks of "IN" and "EX" impressed on the valve head before assembling the valve with the valve head.

- With a valve stem seal fitting jig, assemble the valve stem seal with the valve guide.

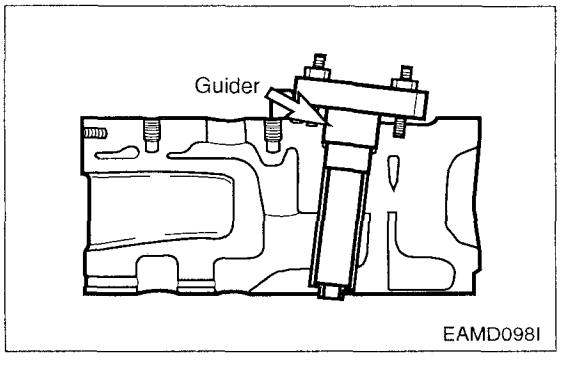


- After installing valve springs and spring retainer, press the retainer with a jig, then install cotter pin.
- Tap the valve stem lightly with a rubber hammer to check that the valve is assembled correctly.



9.3.20. Nozzle tube

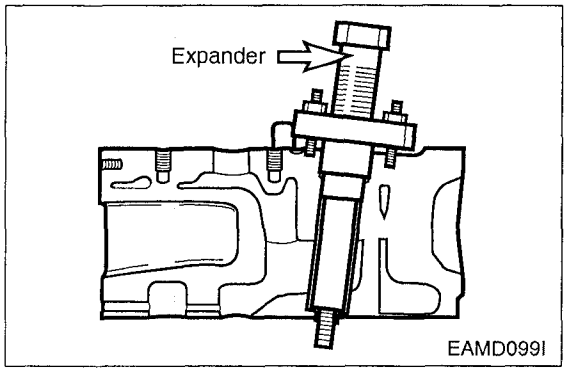
- Apply sealant (LOCTITE # 620) to the nozzle tube and place the O-ring over the cylinder head fitting face on the nozzle tube, then install the nozzle tube in the cylinder head.
- Install a guider of the nozzle tube insert assíy (Guider + Expander) the cylinder head, then tighten the nozzle fixing nuts.



- Apply engine oil to an expander and install it onto the special tool (guider).
- Tighten the bolts until the expander is forced out of the cylinder head bottom.

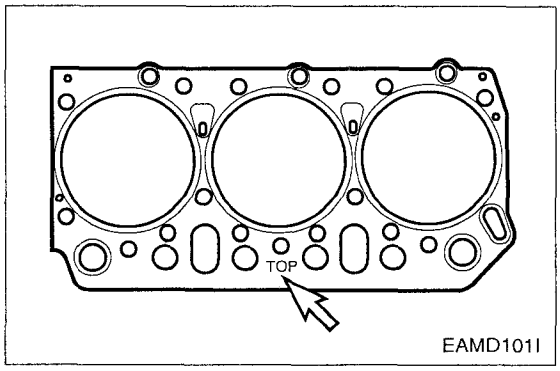
- After mounting the nozzle tube, make a hydraulic test to check for water leaks.

Test pressure	2 kg/cm²



9.3.21. Cylinder head

- Install the injection nozzle fixing stud bolts and water pipe fixing stud bolts.
- Clean the head bolt holes on the cylinder block with compressed air to remove foreign substances and thoroughly clean the gasket fitting face of the cylinder block.
- Install head gasket, with 'TOP' mark facing upward, on the cylinder block by aligning the holes with dowels.



Cylinder Head gasket	Asbestos core type		Semi steel type
	Rubber color : Black		Rubber color : Red
Use bolt	TY 12.9T	TY 10.9T	

- Check the inside of combustion chamber for foreign substances, and carefully mount the cylinder head assembly in the block by aligning the dowel pin with the dowel pin hole. Be careful not to damage the head gasket. If the dowel pin is not in alignment, lift the cylinder head again and then remount it.
- Coat the head bolts with engine oil, then tighten them in proper sequence to the specified torque.

<Cylinder Head Bolts>

	Type1	Type2	Type3 (12.9T)	Type4 (12.9T)	Type5 (10.9T)
Type	TY 12.9T M14 x 1.5 x 153	TY 10.9T M14 x 1.5 x 150	M14 x 1.5 x 153	TY M14 x 1.5 x 150	DL08 M14 x 1.5 x 150
Tighten torque	24.5 kg.m	1st : 6 kg·m 2nd : 180° Finished : 150°	1st : 6 kg·m 2nd : 90°+ 90° Finished : 30°	1st : 7kg·m 2nd : 90°+ 90°	1st : 6 kg·m 2nd : 90°+ 90° Finished : 90°

However, before tightening bolts, align the side face of 2 cylinder heads with parallel. They should be adjusted in a straight line exactly.

<Tightening order of bolts by steps>

(1) First stage : Coat the bolts with engine oil.

(2) Second stage : Tighten 1 ~ 2 threads with hands.

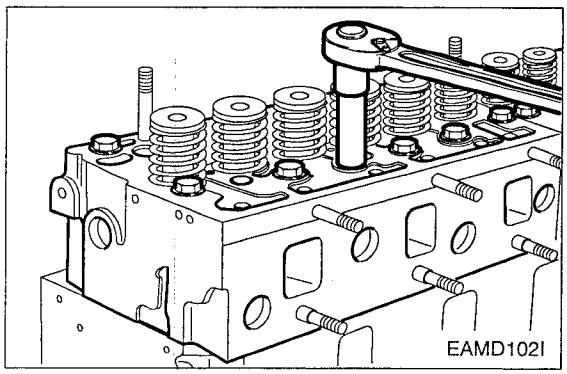
(3) Third stage : Tighten at about 6 kg·m with a wrench.

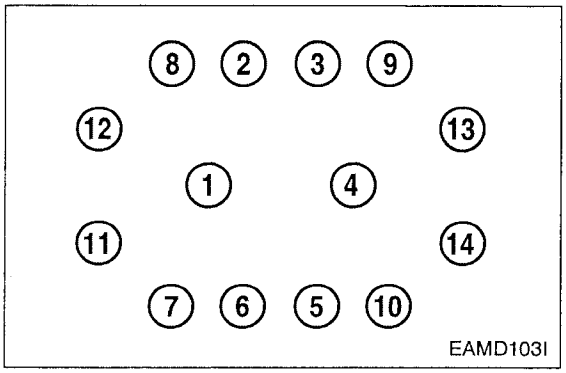
(4) Fourth stage : Tighten at rotating angle method 90° with a wrench.

(5) Fifth stage : Tighten at rotating angle method 90° with a wrench.

(6) Sixth stage : Finally, tighten at rotating angle method 90° with a torque wrench .

Especially, all bolts are tightened simultaneously in each step according to above process as possible.


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EAMD103I

NOTE :

Cylinder head bolts should be replaced by new one after using two or three times because of being loosed as a result of its length too extended. (Limit length 150mm)

- Coat the push rod with engine oil and insert it into the push rod hole.
- Adjust the valve clearance as following guide.

<Guide for valve clearance adjustment>

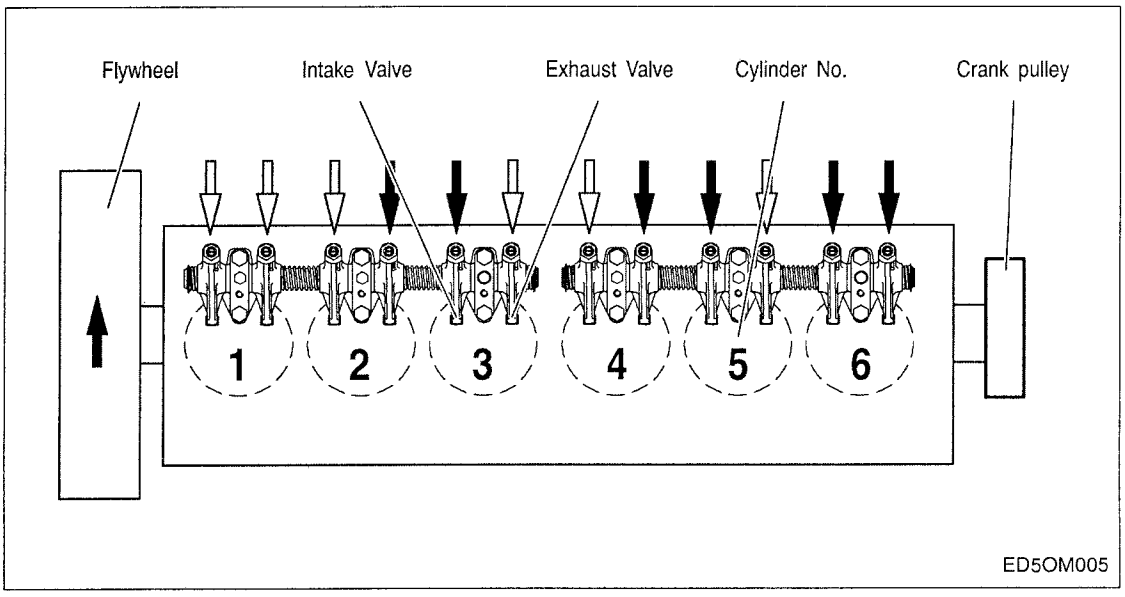
- After letting the #1 cylinder's piston come at the compression top dead center by turning the crankshaft, adjust the valve clearances.
- Loosen the lock nuts of rocker arm adjusting screws and push the feeler gauge of specified value between a rocker arm and a valve stem and adjust the clearance with adjusting screw respectively and then tighten with the lock nut.
- As for the valve clearance, adjust it when in cold, as follow.

(mm)

Model	Intake valve	Exhaust valve
DE12T P126TI series / PU126TI	0.3	0.3

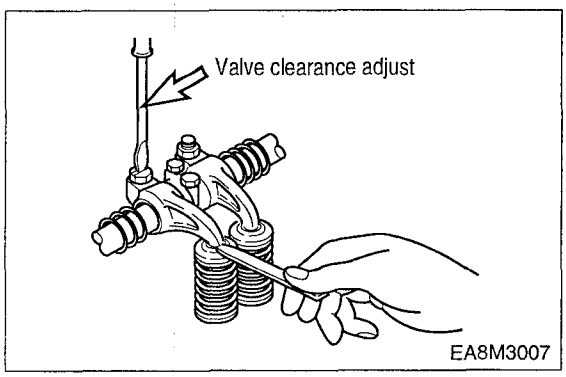
- By cranking the engine, let #6 cylinder's valves overlap.
- In time, adjust the valve clearance corresponding to " ⇧ " of lower lists.
- Adjust the valve clearance corresponding to " ⬆ " of lower lists.
- After reinsuring the valve clearances, retighten if necessary.

- No. 1 Cylinder is located at the side where flywheel was installed.



- Adjust valve clearance with a feeler gauge and tighten the fixing nuts to specified torque.

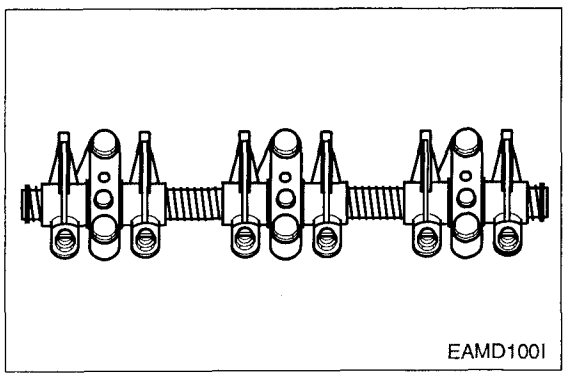
Torque	4.4 kg·m



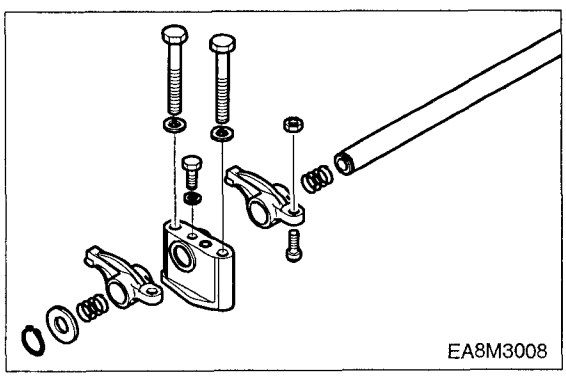
9.3.22. Rocker arm assembly

- Apply lubricating oil to the rocker arm bush and shaft, and assemble the intermediate bracket with the rocker arm using fixing bolts.

Torque	M10(x2) : 4.4 kg·m M8 : 2.2 kg·m



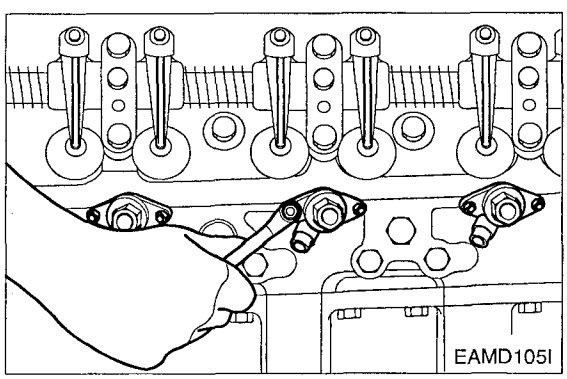
- Semi-install valve clearance adjusting bolts onto the rocker arm.
- Install the spring, rocker arm, bracket, rocker arm, spring, washer, and snap ring in the described sequence.
- Install the rocker arm and bracket in the same direction.



9.3.23. Injection nozzle

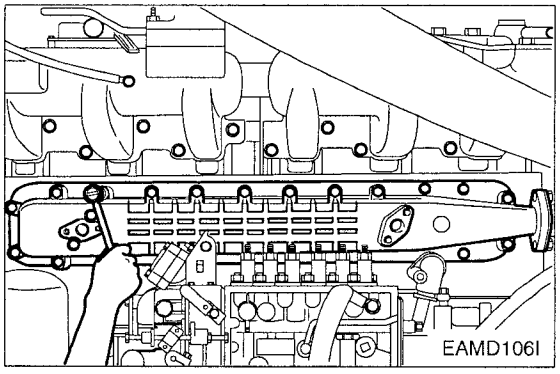
- Install the dust seal with its round portion facing downward.
- Mount a seal ring (0.5 mm) on the seal ring seating surface of the nozzle tube and assemble nozzle holder assembly with the stud bolt with the nozzle pipe installing direction facing outward.
- Be sure to follow the specified torque.

Torque	1.0 kg·m



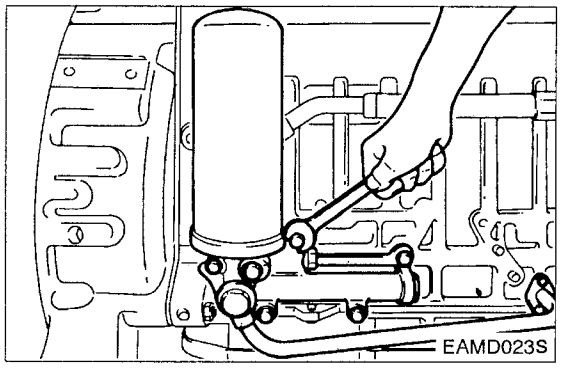
9.3.24. Oil cooler

- Install the oil cooler onto the oil cooler cover.
- Carefully apply the gasket to prevent oil leakage.
- Do not damage the gasket and install the cover onto the cylinder block.
- Connect a connection pipe between the water pump and oil cooler.



9.3.25. Oil filter

- Install the oil filter onto the cylinder block, and tighten the fixing bolts.
- With the hollow screw, assemble the oil pipe connected between the oil cooler and cylinder block.
- Install a connection pipe between the oil cooler and oil filter.
- Install the oil cooler connecting pipe.
- Install packing and assemble the cartridge using a filter wrench.



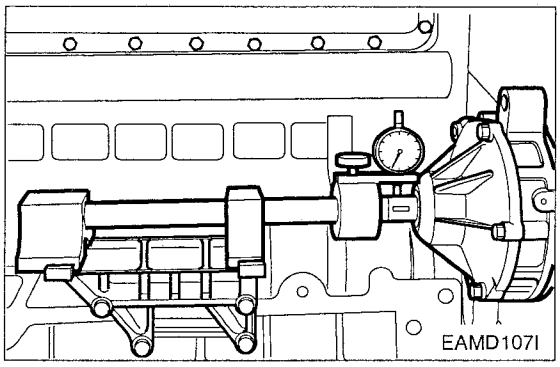
9.3.26. Injection pump

- Install the injection pump bracket in the cylinder block.
- After measuring the amount of run-out with an alignment setting jig, disassemble the bracket, adjust the shims, then reassemble it.

Run out	0.2 or less

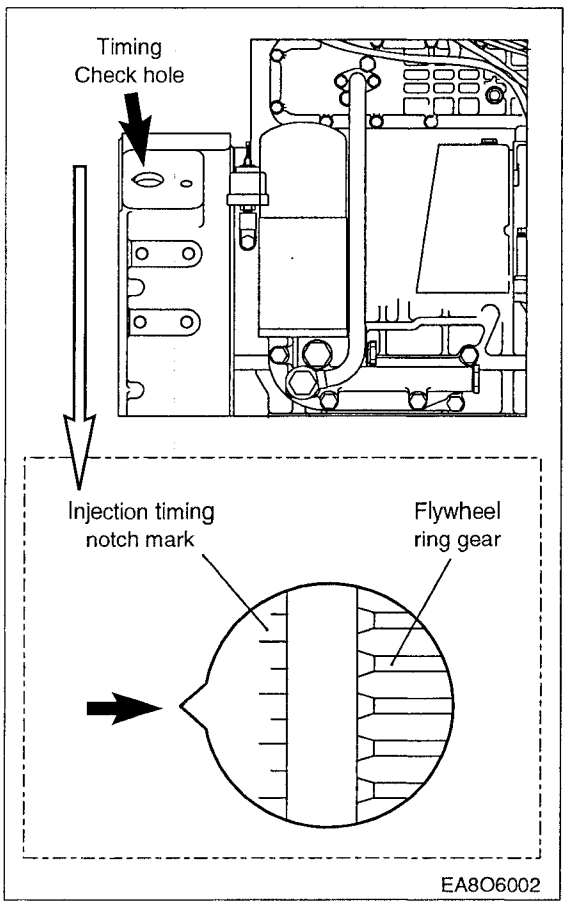
- Mount the top/bottom adjusting shims in the bracket and then mount the fuel injection pump.
- Tighten the fixing bolts in a diagonal sequence to specified torque.

Torque	4.4 kg·m

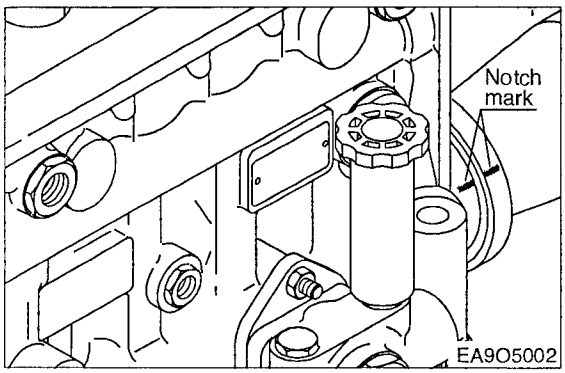


- Turn the flywheel until No. 1 piston is placed in the "OT" position of notch marks on the flywheel, and then turn again the flywheel clockwise until showing the notch mark of the right figure corresponding to the injection timing is aligned with the pointer (↓) on the flywheel housing.

	DE12T / P126TI-1	P126TI / P126TI-II	PU126TI
Fuel injection timing (B.T.D.C static)	12°	16°	14°



- Turn the timer until the notch mark of the indicator plate attached to the fuel injection pump is aligned with the notch mark of the timer.



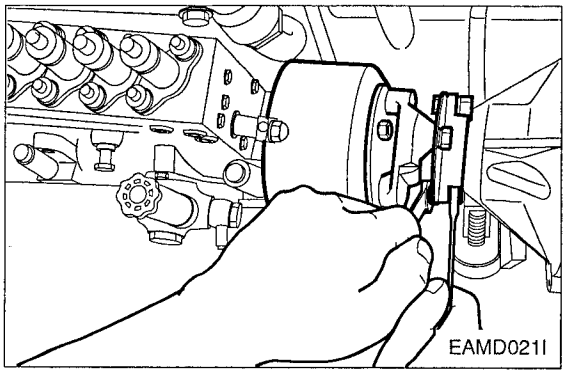
- Tighten the Coupling fixing bolts and nuts to specified torque.

Torque	6.0 kg·m

- Tighten the drive shaft connecting flange fixing bolts to specified torque.

Torque	7.5 ~ 8.5 kg·m

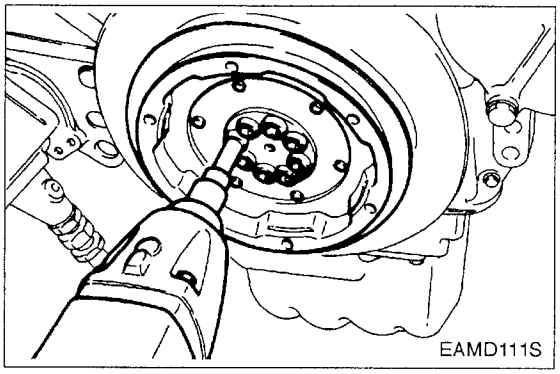
- Install the oil delivery pipe and return pipe.



9.3.27. Vibration damper end pulley

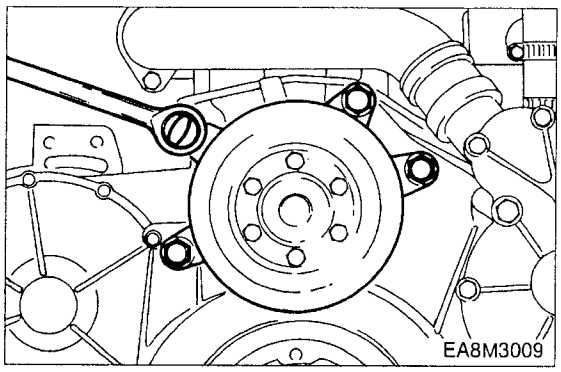
- Install the vibration damper on the crankshaft pulley.
- Install the crankshaft pulley assembly on the crankshaft, then tighten the bolts and thrust washers.

Torque	13.4 kg·m



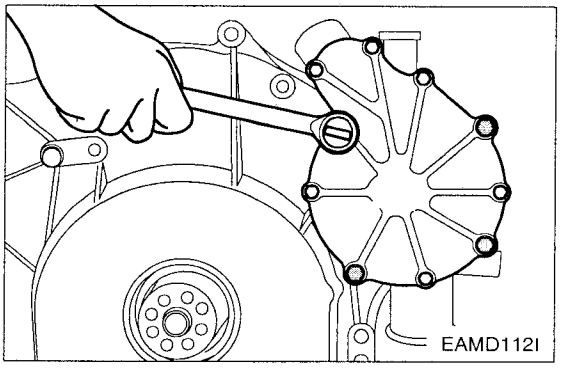
9.3.28. Fan drive pulley

- Install the fan drive pulley onto the timing gear case cover.



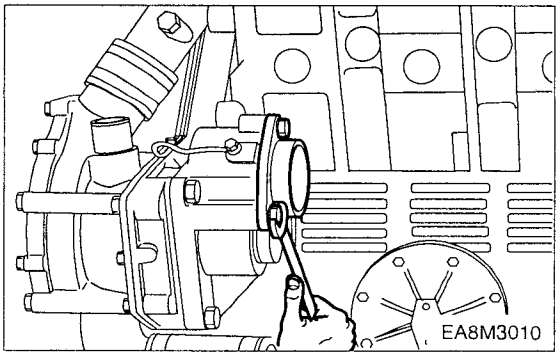
9.3.29. Water pump

- Mount a new O-ring.
- Install the water pump drive pinion over the PTO (power take-off) spline.
- Connect water pipes and by-pass pipe to the water pump.
- Connect a water pipe to the expansion tank.



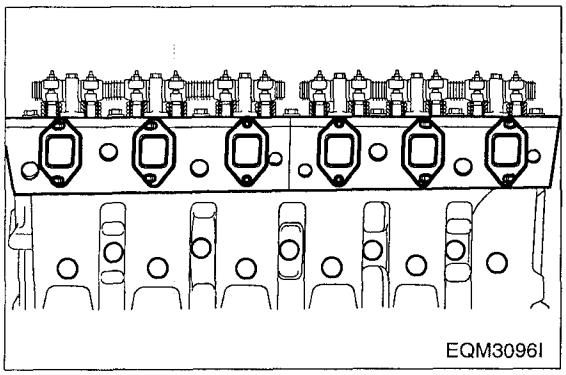
9.3.30. Power take-off

- Assemble the power take-off sub assembly.



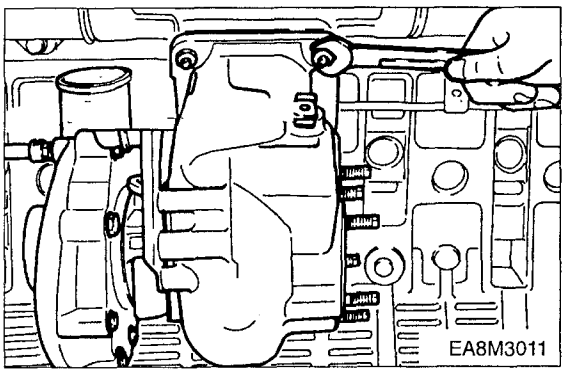
9.3.31. Exhaust manifold

- Install the exhaust manifold gasket over the stud bolts by aligning the gasket with the exhaust port on the cylinder head so that the face and back of the gasket can be positioned correctly.
- Semi-assemble the exhaust manifold and install the heat resisting plate.
- First, install the nuts and then place an additional nut on each of them to prevent looseness.

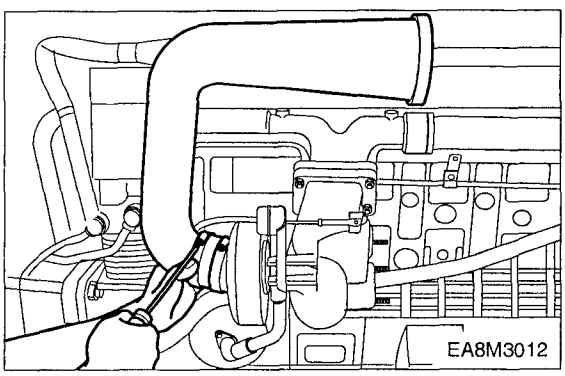

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9.3.32. Turbocharger

- Fit a new gasket over the stud bolts of the exhaust manifold before tightening those turbocharger fixing bolts.
- Install the oil supply pipe and return pipe.

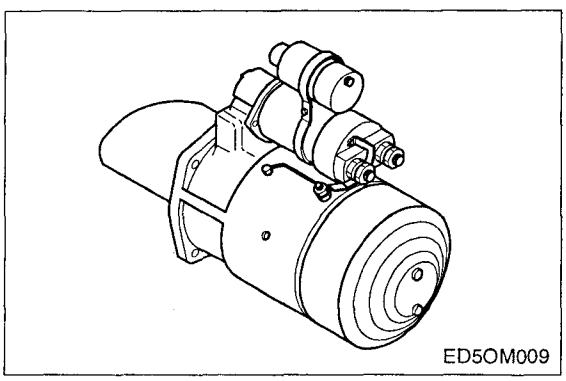

EA8M3011

- Semi-assemble the bracket to the intake pipe, connect a rubber hose between the turbocharger and intake pipe using rubber hose, then assemble the bracket completely.


EA8M3012

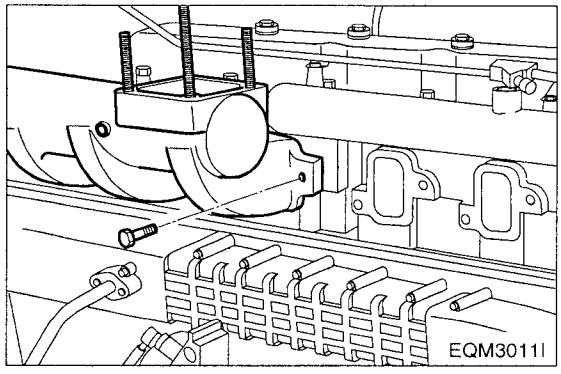
9.3.33. Starter

- Assemble the starter in position on the flywheel housing.


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9.3.34. Intake manifold

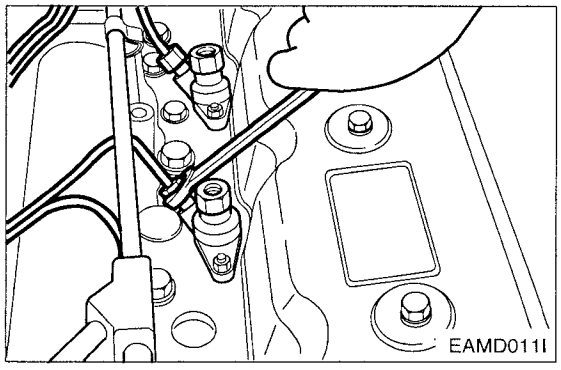
- Fit a gasket on the intake manifold before assembling the intake manifold.



9.3.35. Injection pipe & fuel return pipe

- Assemble the injection pipe according to specified torque as blow

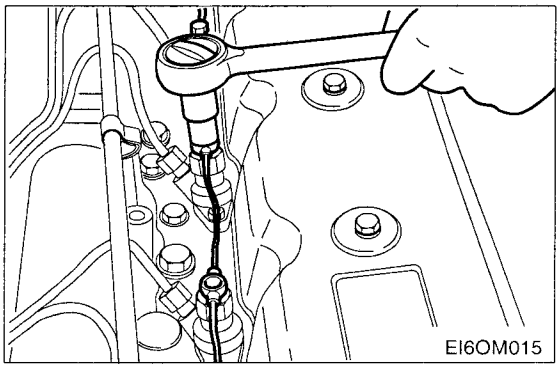
Nut size	Torque
Spanner Dia. 17 mm	3.0 kg·m
Spanner Dia. 19 mm	4.0 kg·m



- Semi-assemble the nuts at both end of the fuel injection pipe and tighten them up one by one to specified torque.

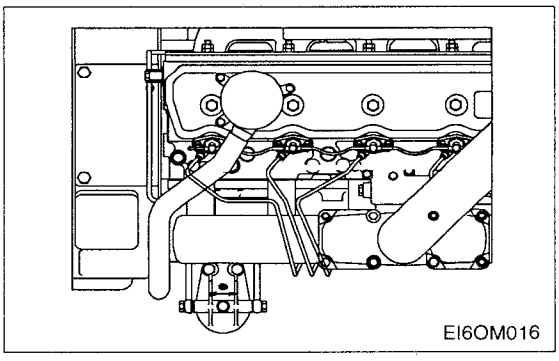
Torque	1 ~ 1.5 kg·m

- Tighten the hollow screws to assemble the fuel return pipe.
- Assemble the fuel return hose on the fuel injection pump.



9.3.36. Fuel filter

- Assemble the fuel filter with the intake manifold.
- Assemble the fuel feed hose according to the direction of an arrow impressed on the fuel filter head so that fuel can be fed in the sequence of **FUEL FEED PUMP → FUEL FILTER → FUEL INJECTION PUMP**.

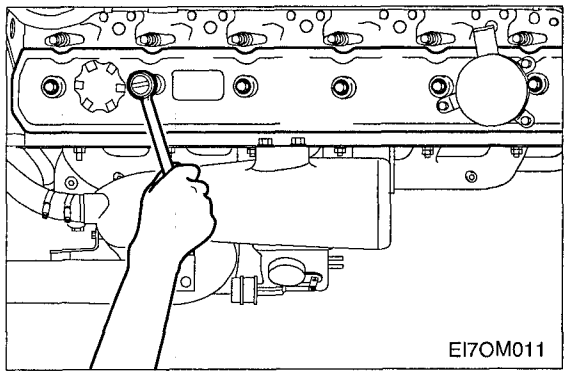


9.3.37. Cylinder head cover

- Assemble the cover packing with the cover, install the cover on the head, then tighten the fixing bolts in sequence to specified torque.

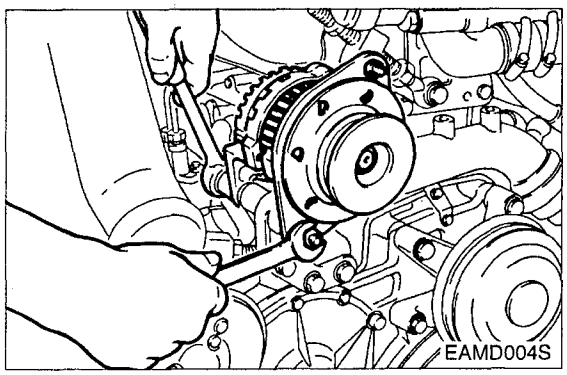
Torque	2.5 kg·m

- Assemble the breather hose with PCV valve.



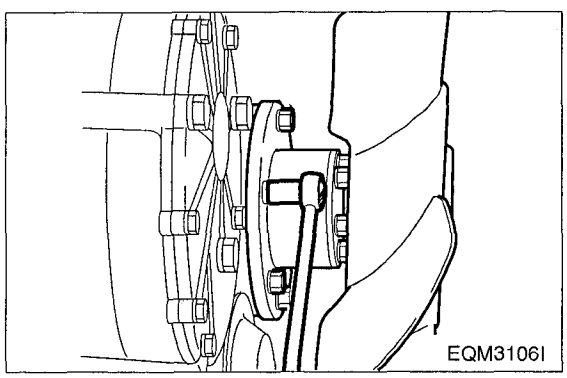
9.3.38. Alternator

- Install the alternator mounting bracket.
- Install the alternator with fixing bolts to the mounting bracket.



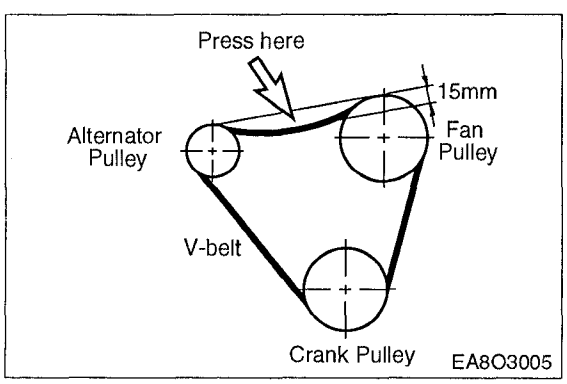
9.3.39. Cooling fan

- Install the cooling fan and flange, then tighten the fixing boltd.



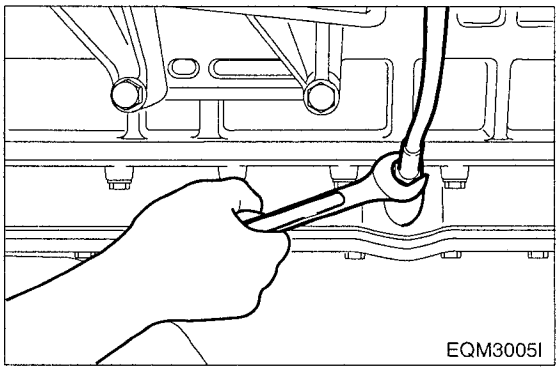
9.3.40. V- belt

- Install the V-belt on the crank pulley, alternator pulley and fan drive pulley.
- Adjust the V-belt tension using the tension adjusting bolt.



9.3.41. Oil level gauge

- Assemble the oil level gauge and guide tube on the oil pan.



9.4. Breaking-in

Refer to "Breaking-in" in chapter of "Commissioning and Operation".

10. Maintenance of Major Components

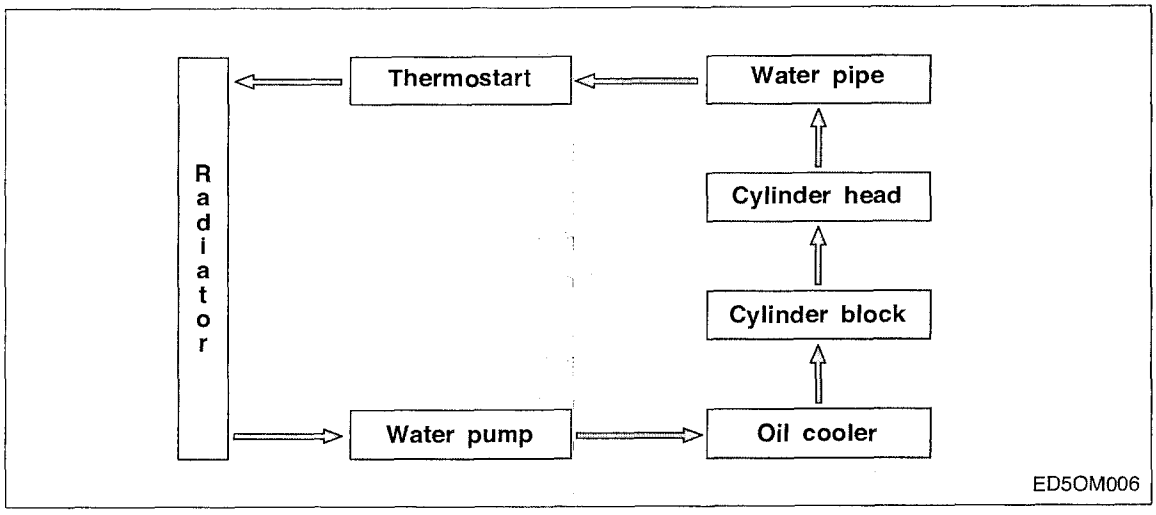
10.1. Cooling System

10.1.1. General information

This engine is water-cooling type. Heat from the combustion chamber and engine oil heat are cooled down by coolant and radiated to the outside, resulting in the normal operation of the engine.

Looking into the cooling system, the water pumped up by the water pump circulates around the oil cooler through the water pipe to absorb the oil heat, and then flows through the water jacket of the cylinder block and water passage of the cylinder head to absorb the heat of the combustion chamber.

The water absorbing the oil heat and combustion chamber heat goes on to the thermostat through the water pipe, and circulates to the water pump if water temperature is lower than the valve opening temperature on the thermostat, while circulating to the radiator at water temperature higher than the valve opening temperature. At the radiator, the heat absorbed in the coolant is radiated to cool down and the coolant recirculates to the water pump.

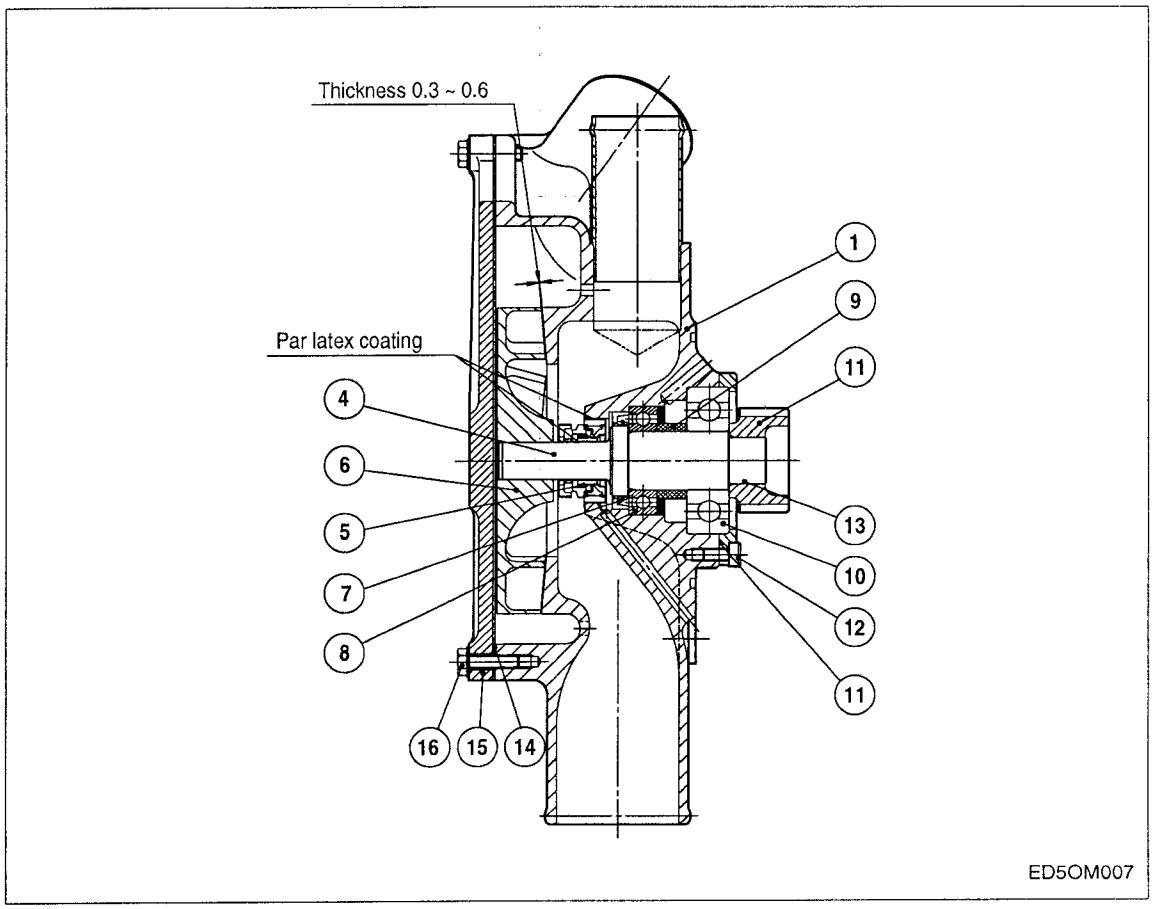


● **Specification**

Item	Specification
1. Water pump	Centrifugal type
type	
Delivery	About 280 liter/min
Pumping speed	2,234 rpm
Pumping back pressure	760 mmHg
2. Thermostat	
Operating temperature	71 ~ 85°C / 83 ~ 95°C
3. Cooling fan and belt	
Fan diameter - Number of blades	Ø755 - 7
Fan belt tension	15mm / deflection by thumb

10.1.2. Water pump

- Loosen the bolt (16) to disassemble the housing cover (15).
- Heat the impeller (6) slightly, then remove it using a puller jig.
- Remove the mechanical seal.
- Unscrew the socket bolt (12) and remove the shaft and bearing assembly from the housing.
- With a press, remove the spline shaft and bearing.
- Reverse the disassembly sequence for reassembly operation.
- Replace the oil seal (7) with a new one at reassembly.
- To reassemble the impeller, maintain a constant gap (0.3 ~ 0.6 mm) between the impeller and pump housing using a feeler gauge.



<Construction of water pump>

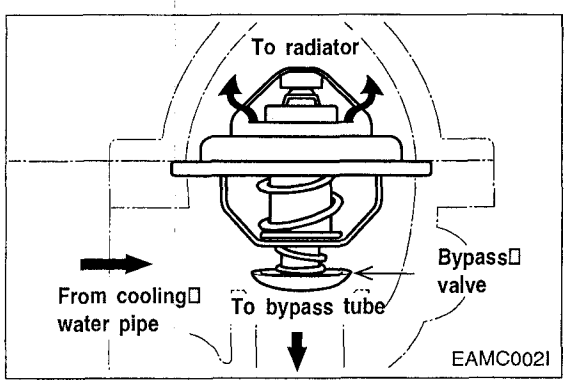
1. Water pump housing
4. Shaft
5. Mechanical seal
6. Impeller
7. Oil seal
8. Ball bearing
9. Spacer
10. Ball bearing
11. Bearing cover
12. Socket bolt
13. Spline shaft
14. Gasket
15. Housing cover
16. Bolt

10.1.3. Thermostat

● **General descriptions and main data**

The thermostat maintains a constant temperature of coolant (71 ~ 85°C / 83 ~ 95°C) and improves thermal efficiency of the engine by preventing heat loss.

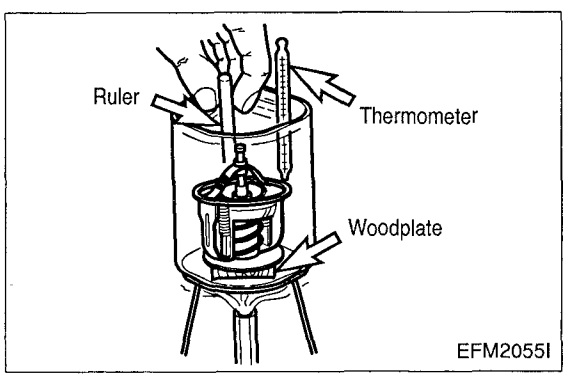
Namely, when the temperature of coolant is low, the thermostat valve is closed to make the coolant bypass to directly enter the water pump; when the coolant temperature rises to open wide the thermostat valve, the bypass circuit is closed and the water passage to the radiator is opened so that the coolant is forced to flow into the radiator.



Item	Specifications	
Type	Wax-pallet type	
Open at	71°C	83°C
Open wide at	85°C	85°C
Valve lift	8 mm or more	

● **Inspecting**

1) Check the wax pallet and spring for damage.
2) Put the thermostat in a container of water, then heat the water slowly and check temperature with a thermometer. If the valve lift is 0.1 mm (starting to open) at temperature of 71°C / 83°C and 8 mm or more (opening wide) at temperature of 85°C / 95°C, the thermostat is normal.



● **Replacing thermostat and precautions for handling**

1) Precautions for handling

The wax pallet type thermostat does not react as quickly as bellows type one to a variation of temperature of coolant. Such relatively slow reaction is mainly due to the large heat capacity of the wax pellet type thermostat. Therefore, to avoid a sharp rise of coolant temperature, it is essential to idle the engine sufficiently before running it. In cold weather, do not run the engine at overload or overspeed it immediately after starting off.

2) When draining out or replenishing coolant, do it slowly so that air is bled sufficiently from the entire cooling system.
3) Replacing thermostat

If the thermostat is detected defective, retrace with a new one.

10.1.4. Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Engine overheating	● Lack of coolant ● Radiator cap pressure valve spring weakened ● Fan belt loosened or broken ● Fan belt fouled with oil ● Thermostat inoperative ● Water pump defective ● Restrictions in water passages due to deposit of scales ● Injection timing incorrect rectly ● Restriction in radiator core ● Gases leaking into water jacket due to broken cylinder head gasket	● Replenish coolant ● Replace cap ● Adjust or replace fan belt ● Replace fan belt ● Replace thermostat ● Repair or replace ● Clean radiator and water passages ● Adjust injection timing cor ● Clean exterior of radiator ● Replace cylinder head gasket
2. Engine overcooling	● Thermostat inoperative ● Ambient temperature too low	● Replace thermostat ● Install radiator curtain
3. Lack of coolant	● Radiator leaky ● Radiator hoses loosely connected or damaged ● Radiator cap valve spring weakened ● Water pump leaky ● Heater hoses loosely connected or broken ● Cylinder head gasket leaky ● Cylinder head or cylinder block cracked	● Correct or replace ● Retighten clamps or replace hoses ● Replace cap ● Repair or replace ● Tighten or replace hoses ● Replace cylinder head gasket ● Replace cylinder head block
4. Cooling system noisy	● Water pump bearing defective ● Fan loosely fitted or bent ● Fan out of balance ● Fan belt defective	● Replace bearing ● Retighten or replace fan ● Replace fan ● Replace fan belt

10.2. Lubricating System

10.2.1. General descriptions and main data

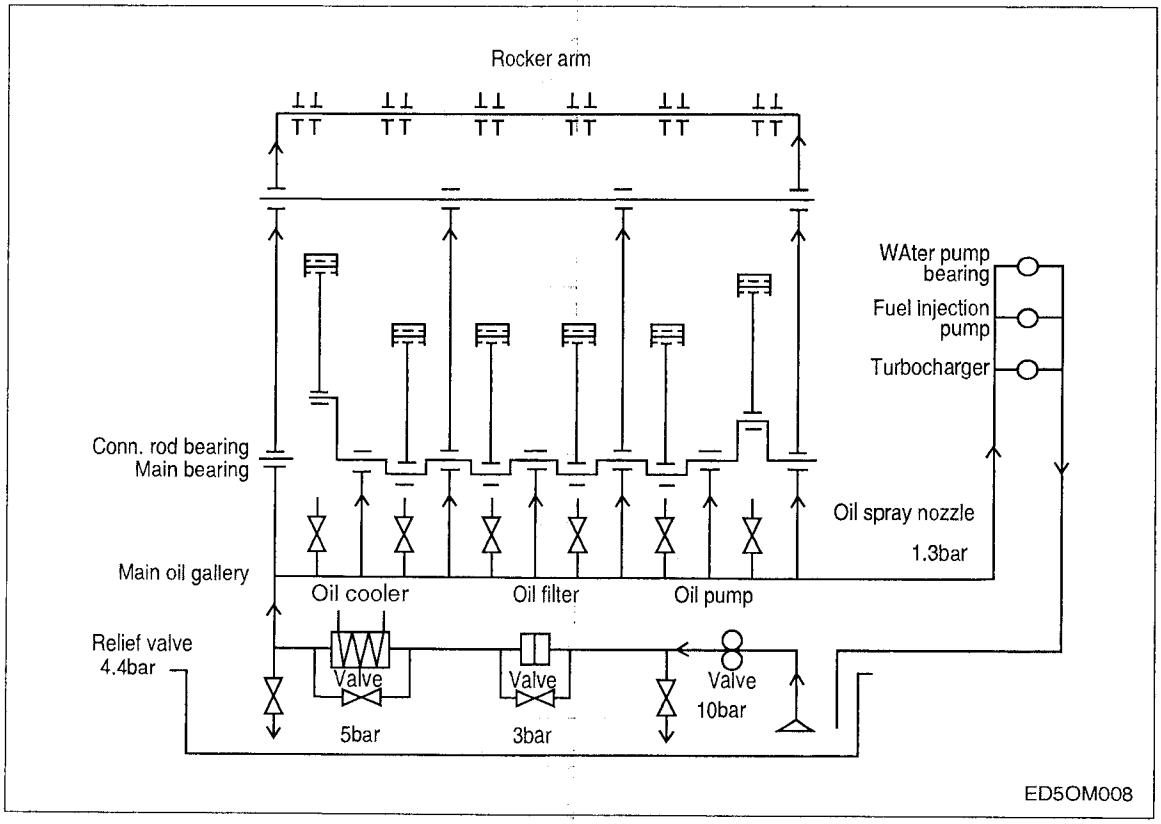
● General descriptions

All the engine oil pumped up from the oil pan by the gear type oil pump is filtrated through the oil cooler and oil filter, and this filtrated oil is forced through the main oil gallery in the cylinder block from where it is distributed to lubricate the various sliding parts, and fuel injection pump in order to ensure normal engine performance.

● Specifications

Item	Specifications	Item	Specifications
Lubricating system	Forced pressure circulation	Oil filter type	Full flow
Oil pump type	Gear type	Bypass for filter element	
Relief valve opening pressure	10 ± 1.5 kg/cm²	Valve opening pressure	1.8 ± 2.3 kg/cm²
Bypass for oil cooler		Bypass for entire oil filter	
Opening pressure	5 + 1 kg/cm²	Valve opening pressure	4.0 ~ 4.8 kg/cm²
Adjusting valve for spray nozzle			
Opening pressure	1.5 ± 1.8 kg/cm²		

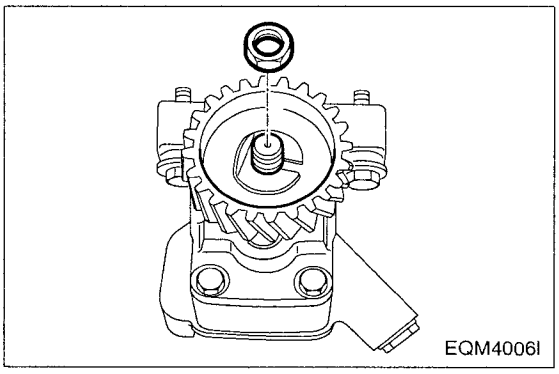
● Diagram of lubricating system



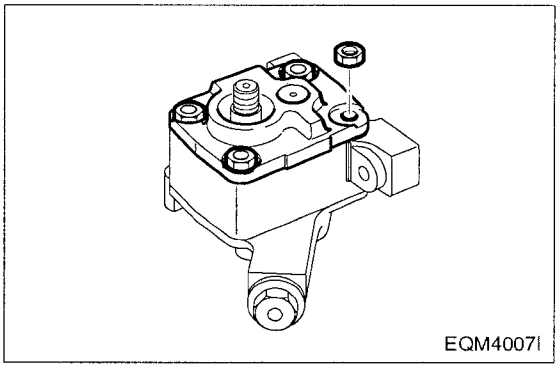
10.2.2. Oil pump

● Disassembly

1) Disassembly of oil pump drive gear
   a) Unscrew the screw and disassemble the oil relief valve.
   b) Unfold the washer for the oil pump drive gear fixing nut and remove the nut.
   c) Disassemble the drive gear.


EQM4006I

2) Remove the oil pump cover fixing nuts and disassemble the oil pump cover.
   The oil pump cover is fixed with the two dowel pins.
3) Disassemble the drive gear and driven gear.

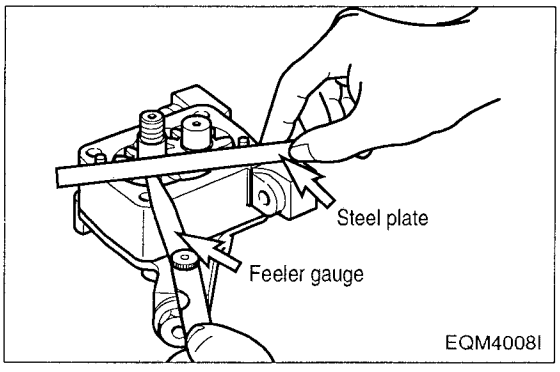

EQM4007I

● Inspection and correction

1) With steel rule and feeler gauge, measure the axial end play of the oil pump gear. Replace if the measured value is beyond the limit.

(mm)

End play	0.025 ~ 0.089

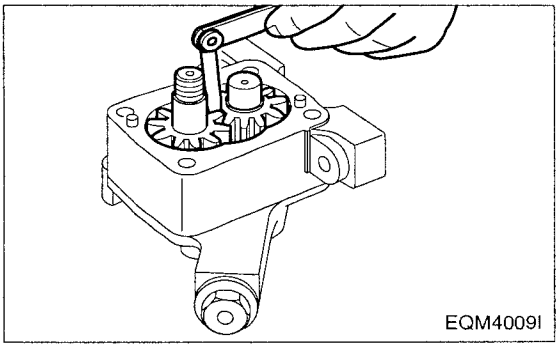


EQM4008I

2) With a feeler gauge, measure the amount of backlash between the oil pump drive gear and driven gear. Replace if the measured value is beyond the limit.

(mm)

Backlash	0.50 ~ 0.64


EQM4009I

3) Measuring clearance between drive shaft and bushing

a) Measure the outside diameters of the drive shaft and driven shaft, and replace if the measured values are less than the limit.

(mm)

Limit	Ø16.95

b) Measure the inside diameter of the pump body bushing to determine the clearance between the bushing and shaft, and compare the measured value with the standard value to determine whether to replace or not.

(mm)

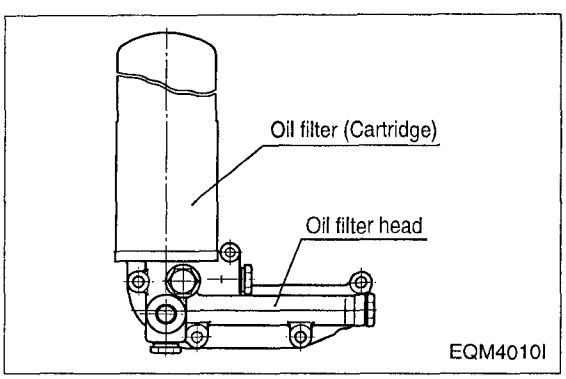
Clearance	0.032 ~ 0.077

● **Reassembly**

1) For reassembly, reverse the disassembly sequence.

10.2.3. Oil filter

The oil filter mounted in this engine is of cartridge type, so it is necessary to replace it with a new one at the specified intervals.



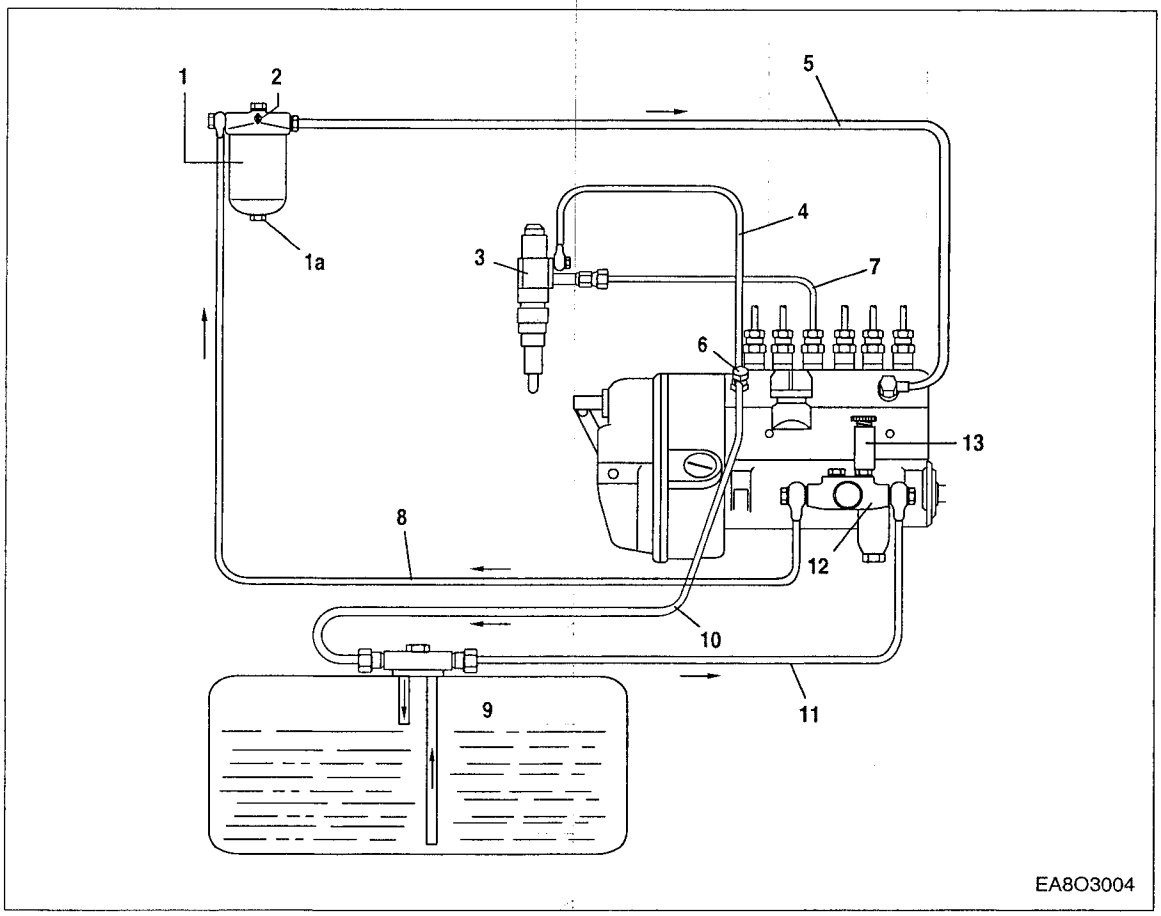
10.2.4. Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Oil consumption excessive	● Poor oil ● Oil seal or packing leaky ● Pistons or piston rings worn ● Cylinder liner worn ● Piston rings sticking ● Valve guide oil seals or valve guides, or valve stem worn	● Use suggested oil ● Replace ● Replace pistons and/or piston rings ● Replace cylinder liner ● Replace pistons and/or piston rings ● Replace
2. Oil pressure too low	● Poor oil ● Relief valve sticking ● Restrictions in oil pump strainer ● Oil pump gear worn ● Oil pump feed pipe cracked ● Oil pump defective ● Oil pressure gauge defective ● Various bearings worn	● Use suggested oil ● Replace ● Clean strainer ● Replace ● Replace ● Correct or replace ● Correct or replace ● Replace
3. Oil deteriorates quickly	● Restriction in oil filter ● Gases leaking ● Wrong oil used	● Replace filter element ● Replace piston rings and cylinder liner ● Use suggested oil

10.3. Fuel Injection Pump

10.3.1. General information of fuel system

The fuel system consists of the fuel tank, injection pump, injection nozzle, fuel filter, and fuel lines such as pipes and hoses necessary to connect those components.



1. Fuel filter
1a. Fuel water drain plug
2. Air bleeding screw (for fuel filter)
3. Injection nozzle
4. Overflow tube
5. Fuel pipe (filter → injection pump)
6. Overflow valve
7. Delivery pipe
8. Fuel pipe (manual pump → filter)
9. Fuel tank
10. Fuel return pipe
11. Suction pipe
12. Feed pump
13. Injection pump

10.3.2. Injection pump

The components relating to the injection pump should be serviced at regular intervals as the plunger and delivery valve may be worn after a given length of time for use and cause the deterioration of the engine.

Make sure that servicing should be performed at the professional maintenance shop as authorized by Bosch or Zexel Company.

For adjustment of fuel injection volume, refer to the 'Specifications of fuel injection pump' described on the following pages.

1) DE12T

(1) Main data and specifications

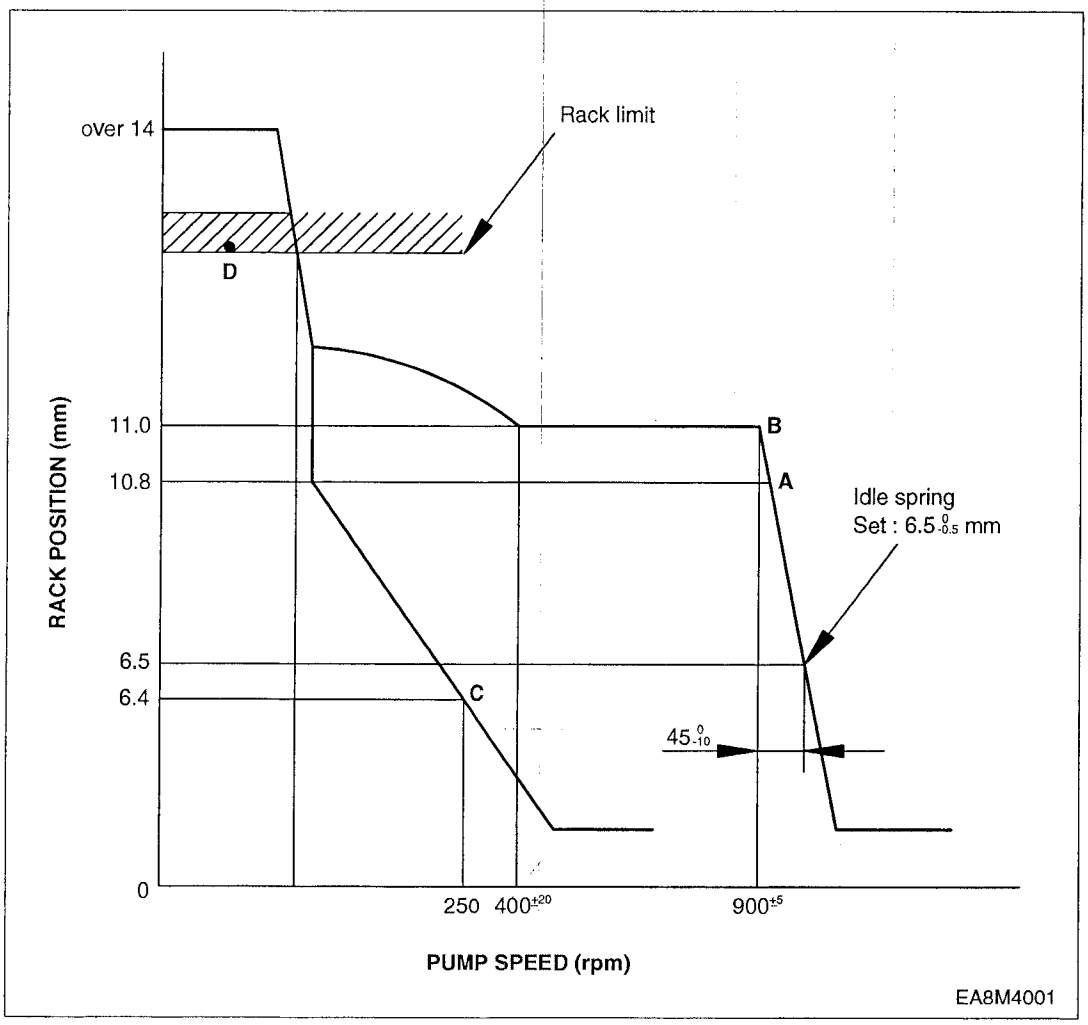
Part No.	: 65.11101-7222 (106672 - 9920)
Model	: NP-PE6P120/720RS3000 (106061 - 7250)
Governor	: NP-EP/RSV200-1200PD36C311 (105407 - 4720)
Timer	: without timer
Plunger	:Ø12, right hand helix 30 lead
Delivery valve	:120 mm^3/st (Ø8 x 2.4 mm)
Fuel feed pump	: NP-FP/K-P (105207 - 1400)
Pre-stroke	: 4.7 mm

(2) Nozzle holder assembly : 65.10101 - 7300 (105160 - 4351)
(3) Nozzle : 65.10102 - 6046 (105029 - 1330)
(4) Injection pipe : 65.10301 - 7004B
(5) Injection order : 1 - 5 - 3 - 6 - 2 - 4
(6) Injection timing : BTDC 12°C
(7) Calibration data

Adjusting point	Rack position (rpm)	Pump speed (rpm)	Injection volume (mm^3 / 1,000 st)	Variation rate (%)	Basic point	Fixing point	Ref.
A	10.8	900	129 ± 2	± 2			
B	11	875	(135) ± 3				
C	Approx. 6.4	250	14.5 ± 1.5	± 15			
D	-	10	193.5 ± 10				

Adjusting point	Content	Specification	Engine Application
Adjusting conditions	Nozzle holder assembly	105780 - 8140	65.10101 - 7300
	Nozzle	105780 - 0000	65.10102 - 6046
	Nozzle holder	105780 - 2080	-
	Opening pressure	175 kg/cm^2	220 kg/cm^2
	Injection pipe	Ø8 x Ø3 - 600 mm	Ø6 x Ø2.2 - 650 mm
	Fuel delivery pressure	1.6 kg/cm^2	-
	Fuel temperature	35 ~ 45 °C	35 ~ 45 °C

(8) Governor adjustment



2) P126TI / P126TI-1 / P126TI-II

(1) Main data and specifications

Part No. : 65.11101 - 7310 (106674-4130 ZEXEL)
Model : NP-PE6P120/700RS3S (106067-6020)
Governor : Ghana Control (DWA-2000)
Plunger & barrel : Ø12, right hand double helix 30 lead
Delivery valve : 90 mm^3/st (Ø7 x 2.35 mm)
Fuel feed pump : NP-FP/KD-PS (105237 - 5470)
Pre-stroke : 3.9 ± 0.05 mm

(2) Nozzle holder assembly : 65.10101 - 7101 (105101 - 852A)
(3) Nozzle : 65.10102 - 6073 (105025 - 285A)
(4) Injection pipe : 65.10301 - 6042A, 65.10301 - 6043A
(5) Injection order : 1 - 5 - 3 - 6 - 2 - 4
(6) Injection timing : P126TI (BTDC 16°) / P126TI-1 (BTDC 12°)

(A) Test condition for injection pump	Nozzle & Holder Ass'y	105101-852A	Opening pressure : 175 kg/cm²
	Injection pipe (ID ,OD ,L)	-	Ø3.0 x Ø8.0 - 600 mm
	Test oil	ISO4113	Temperature :40 ± 5 °C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7101	Nozzle (5 xØ 0.37)
		65.10102-6073	1st pressure : 160 kg/cm² 2nd pressure : 220 kg/cm²
	Injection pipe (ID, OD ,L)	65.10301-6042A 65.10301-6043A	Ø2.2 x Ø6.35 - 650mm

Rack diagram and setting valve at each point

	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Standby power	B		900		260 ± 2	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

3) P126TI (EDIOE)

(1) Main data and specifications

Part No. : 65.11101 - 7310 (106674 - 4130 ZEXEL)
Model : NP-PE6P120/700RS3S (106067 - 6020)
Governor : Ghana Control (DWA-2000)
Plunger & barrel : Ø12, right hand double helix 30 lead
Delivery valve : 90 mm^3/st (Ø7 x 2.35 mm)
Fuel feed pump : NP-FP/KD-PS (105237 - 5470)
Pre-stroke : 3.9 ± 0.05 mm

(2) Nozzle holder assembly : 65.10101 - 7104 (105101 - 853A)
(3) Nozzle : 105025 - 291A
(4) Injection pipe : 65.10301 - 6042A, 65.10301 - 6043A
(5) Injection order : 1 - 5 - 3 - 6 - 2 - 4
(6) Injection timing : BTDC 16°

(A) Test condition for injection pump	Nozzle & Holder Ass'y	105101-853A	Opening pressure : 175 kg/cm²
	Injection pipe (ID ,OD ,L)	-	Ø3.0 x Ø8.0 - 600 mm
	Test oil	ISO4113	Temperature :40 °C ± 5 °C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7104	Nozzle (5 xØ 0.35)
		-	1st pressure : 160 kg/cm² 2nd pressure : 220 kg/cm²
	Injection pipe (ID, OD ,L)	65.10301-6042A 65.10301-6043A	Ø2.2 x Ø6.35 - 650mm

Rack diagram and setting valve at each point

	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm³ / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Standby power	B		900		260 ± 2	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

4) PU126TI

(1) Main data and specifications

Injection pump : 65.11101 - 7310 (106674 - 4130 ZEXEL)
Model : NP-PE6P120/700RS3S (106067 - 6020)
Governor : Ghana Control (DWA-2000)
Fuel feed pump : NP-FP/KD-PS (105237 - 5470)
Cam Lift : 12 mm
Injection timing : BTDC 14° ± 1
Injection order : 1 - 5 - 3 - 6 - 2 - 4
Rotating Direction : Clockwise (Viewed at driving gear side)
Pre-stroke : 3.9 ± 0.05 mm

(2) Calibration data

(A) Test condition for injection pump	Nozzle & Holder Ass'y	105101-8530	Opening pressure : 175 kg/cm²
	Injection pipe (ID ,OD ,L)	-	Ø3.0 x Ø8.0 - 600 mm
	Test oil	ISO4113	Temperature :40 ± 5 °C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7057	Nozzle (5 xØ 0.40)
		65.10102-6050	1st pressure : 160 kg/cm² 2nd pressure : 220 kg/cm²
	Injection pipe (ID, OD ,L)	65.10301-6043A 65.10301-6042A	Ø2.2 x Ø6.35 - 650 mm

Rack diagram and setting valve at each point

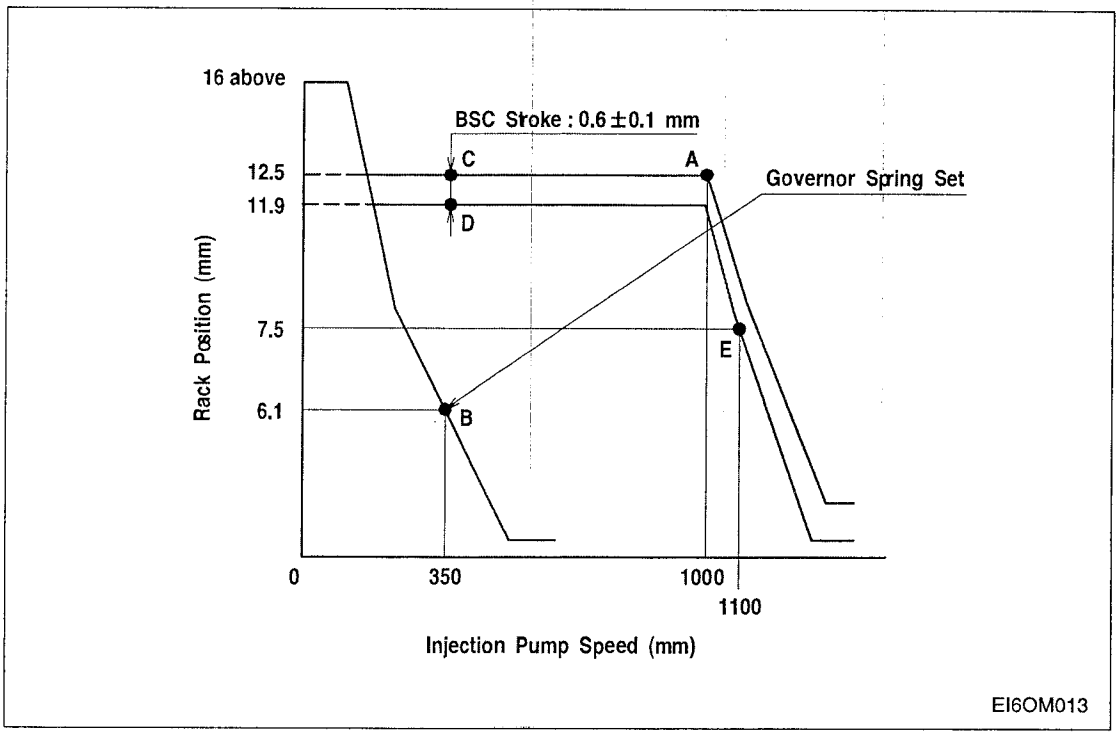
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm³ / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Refer to (3) Rack Diagram	A	12.5	1,000	187 ± 2	-	≤ 675
	B	6.1	350	10 ± 1.5	-	-
	C	12.5	500		-	≤ 675
	D	11.9	500		-	-
	E	7.5	1,100		-	-
			250		-	

Boost pressure dependent full-load stop (boost compensator spring operation point)

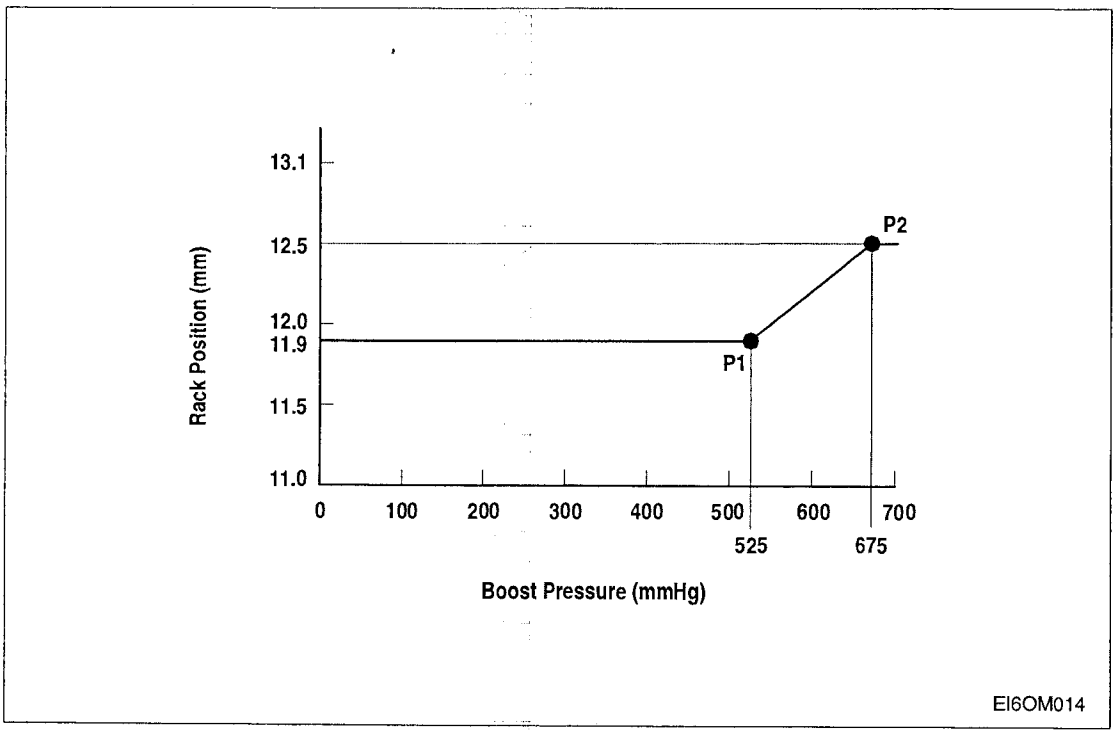
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm³ / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Refer to (4) Boost Pressure	P1	11.9	500	-		525
	P2	12.5	500	-		675
	-	-	-	-	-	

Weight	Weight = 740 g	Lever ratio (min/max)	Min. speed 1:1.2 Max.speed 1:1.2
Governor spring	k = 70.6 mpa	Plunger	Ø12, 30 lead
Idle sub spring	k = 11.8 mpa	Delivery valve retraction volume	2.45 mpa
Start spring	k = 0.098 mpa	Delivery valve opening pressure	k = 8.53 mpa
Boost compensator	k = 8.24 mpa	Delivery valve spring	105237-5470
Adapter spring	k = 63.7 mpa	Feed pump	

(3) Rack Diagram



(4) Boost Compensator Pressure



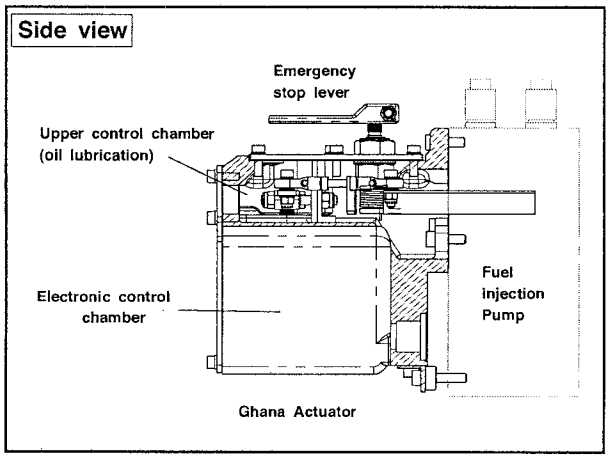
10.3.3. Governor system

10.3.3.1. Actuator

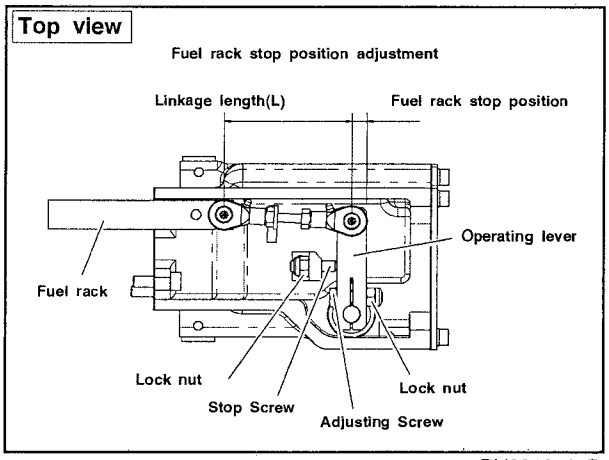
● Actuator Component Parts Function

1. Emergency stop lever: The manual engine stop lever when emergency.
2. Upper control chamber: The cover is install for inside control.
3. Electronic control chamber: The electronic signal operates the operation lever. It is sealed and can not control.
4. Adjusting screw: Adjusting screw is the controlled max. fuel capacity. If the length of the nut is long, the torque is decrease. if the length of the nut is short, the torque is increase.
5. Fuel stop plate: The plate controls the increasing fuel as the preventing movement of adjusting screw.
6. Operation lever: It is the connecting lever to operate the fuel rack.
7. Fuel rack: It controls the fuel capacity of the fuel injection pump connected link lever.

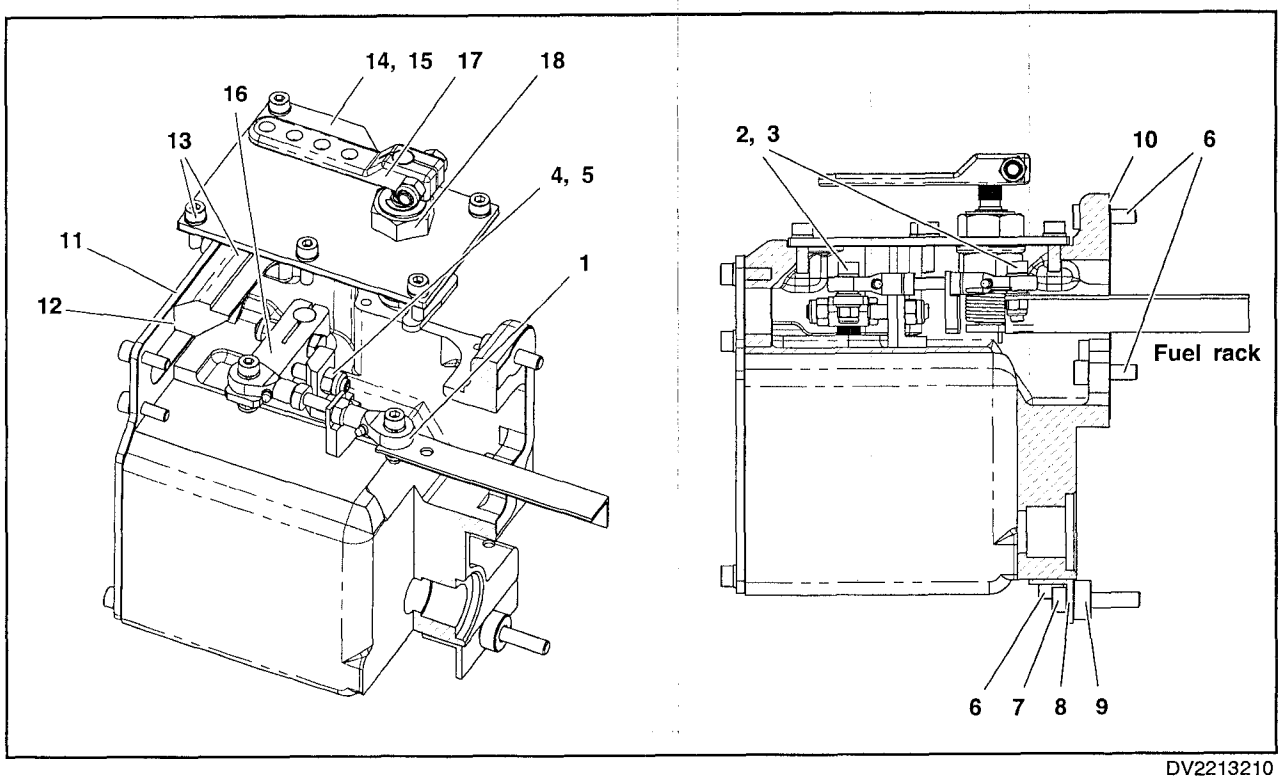
Caution: Adjusting fuel injection pump is critical part for the enfine performance and durability. Only certified professional technicians should repair and maintain engines.



DV2213103B



DV2213104B



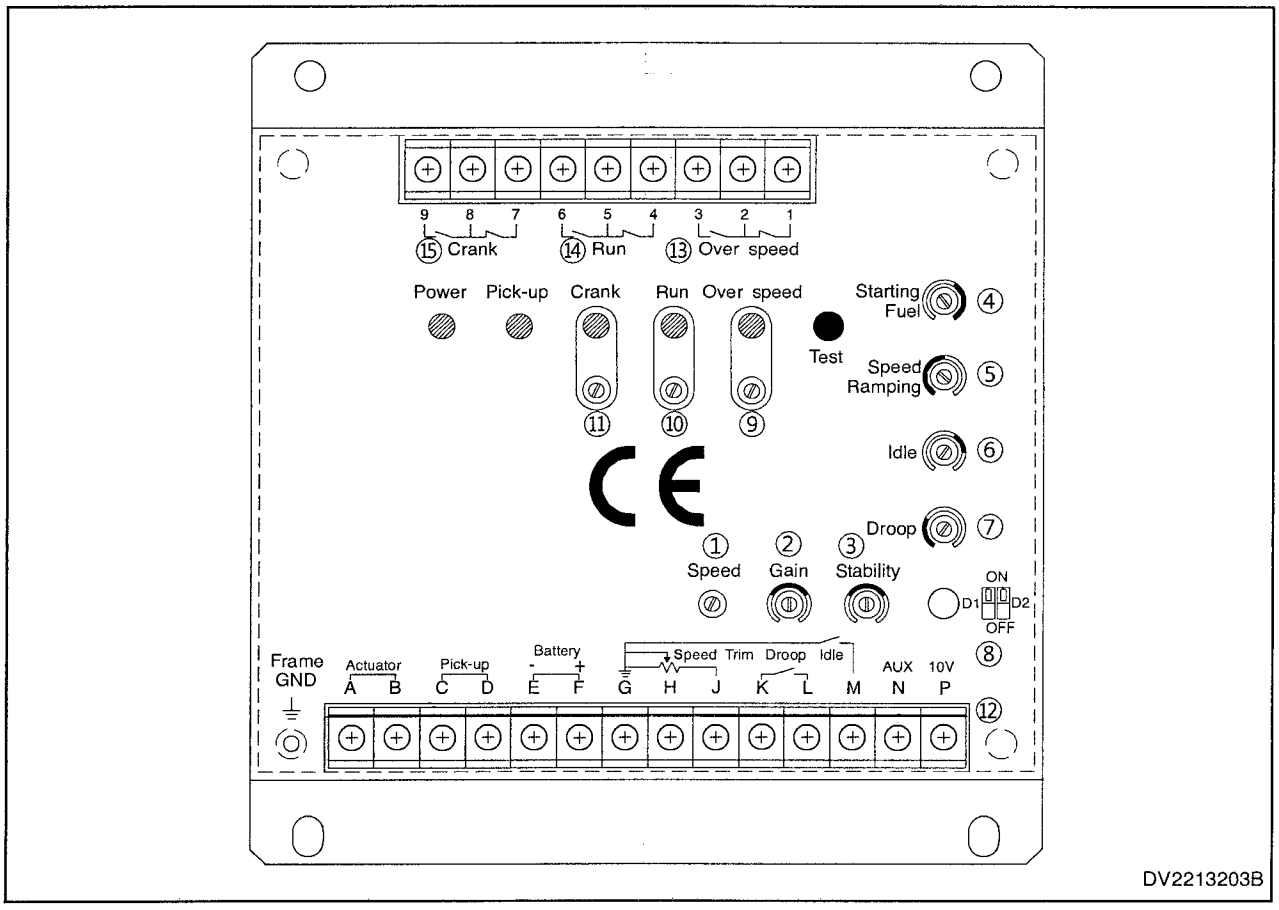
DV2213210

No	Title	Amount	Remarks
1	Ball link ASS"Y	1	M5xL15
2	Screw, Ball link	2	M5xL15
3	Plain Washer	2	ϕ5.5x ϕ14xT1.2
4	Stop Screw	1	M6xL25
5	Lock Nut	1	M6xP1.0
6	Allen Screw (SEMS)	6	M6x22L
7	Allen Screw (SEMS)	2	M6x30L or 18L
8	Mounting Bar	1	
9	Spacer	2	ϕ6.5x ϕ16xT7.4
10	Pump Gasket	1	T 0.5
11	Front Cover	1	T 3.2
12	Front Gasket	1	T0.5
13	Allen Screw	8	
	Seal Screw	4	
14	Top Cover	1	T 3.2
15	Top Gasket	1	T 0.5

No	Title	Amount	Remarks
16	Operating Lever	1	
17	Stop Lever	1	
18	Manual Stop Device ASS'Y	1	

10.3.3.2. Controller system

(DGC-2013 Governor Controller System)



● Description

DGC-2013 Governor Controller Unit is an electronic device designed based on PID algorithm to control engine speed with fast and precise response to transient load changes. The device is available for both single operation (Isochronous mode) and parallel operation (Droop mode).

● Mounting & Warning

DGC-2013 Governor Controller Unit is an electronic device designed based on PID algorithm to control engine speed with fast and precise response to transient load changes. The device is available for both single operation (Isochronous mode) and parallel operation (Droop mode).

1. Mount the controller unit vertically to the surface of a control cabinet, protected from the weather and high humidity, and do not expose the controller unit to the source of radiant heat. Prolonged exposure to moisture (for one month or longer or in case condensation forms) can lead to change in the resistance of internal circuit and failure to reach rated torque. Therefore, make sure that the controller is dry before use.
2. Do not rely exclusively on the governor system electric actuator to prevent overspeed. A secondary shutoff device, such as a fuel solenoid must be used.
3. The setting range indicated on each menu of the control mode is the average range for each engine. It is recommended to set DI engines within each indicated setting range.

EMC (Electromagnetic Compatibility)

To satisfy EMC requirements, the controller unit should be mounted on the grounded metal side, and it is required to use shielded wires for all signal lines and ground all the shields to one of the bolts used to mount the controller.
No product with EMC-related quality issues arising from not following the above instruction will be guaranteed.

● Functions

1. ① Speed: Adjusting the engine speed
2. ② Gain: Adjusting the gain (governing sensitivity)
3. ③ Stability: Adjusting the stability (governing response)
4. ④ Starting Fuel: Adjusting the fuel amount at engine start up
5. ⑤ Speed Ramping: Adjusting the time to reach the rated speed
6. ⑥ Idle: Adjusting the idle speed
7. ⑦ Droop: Adjusting the percentage (%) of droop
8. ⑧ Dip Switch: Adjusting the dip switch
9. ⑨ Over Speed: Adjusting the point when overspeed lamp is on and the relevant relay is activated
10. ⑩ Run Lamp: Adjusting the point when run lamp is on and the relevant relay is activated
11. ⑪ Crank Lamp: Adjusting the point when crank lamp is on and the relevant relay is activated
12. ⑫) TB1: Terminal block for input and output
13. ⑬ TB2: Relay terminal for overspeed mode (capacity - 2A/125VAC).
14. ⑭ TB3: Relay terminal for run mode (capacity - 2A/125VAC).
15. ⑮ TB4: Relay terminal for crank mode (capacity - 2A/125VAC).

● Adjustments

1. The ranges of resistance indicated on the case are applicable only to DI engines.
2. For potentiometer adjustment, use a small sized (-) screw driver. (Be cautious of potentiometers being damaged)
3. Check that all electrical connections are correctly made and terminal screws tightened.
4. Engine Startup
   Connect terminals G and M (with idle switch ON).

1) (4) Starting Fuel

Note) Reason for adjustment: To maximize the fuel efficiency of the engine

* Purpose of adjustment:

Note) Recommended position: Between the 1 and 5 o'clock positions

Note) Possible problems: Between the 7 and 1 o'clock positions → starting problems due to a lack of fuel supply; The 5 o'clock position or above → decreasing fuel efficiency and increasing exhaust emissions at engine start up

2) Turn ⑤ Speed Ramping to between the 9 and 12 o'clock position.

Note) The time to reach the rated speed (run speed) prolongs as turning ⑤ Speed Ramping clockwise (max. over 10 sec)

Note) With ⑤ Speed Ramping biased to counterclockwise direction, a symptom of overshoot or hunting can occur.

3) Start cranking the engine.

5. Rated speed & Idle speed

1) Rated speed adjustment.

Note) After engine startup, remove the connection between terminals G and M (with idle switch OFF)

Note) Under no load condition, adjust Speed. Clockwise): RPM increase/counterclockwise RPM decrease

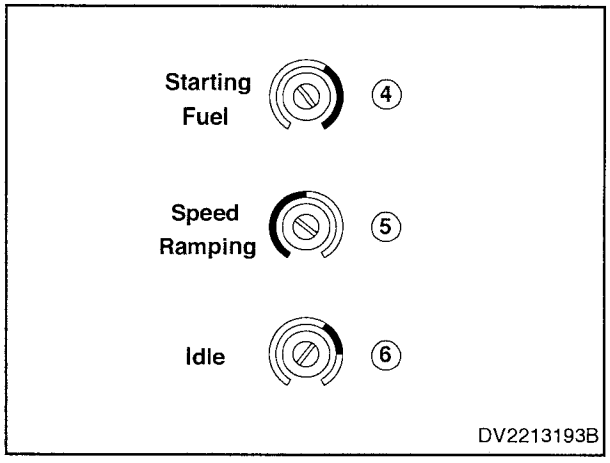
2) Idle speed adjustment

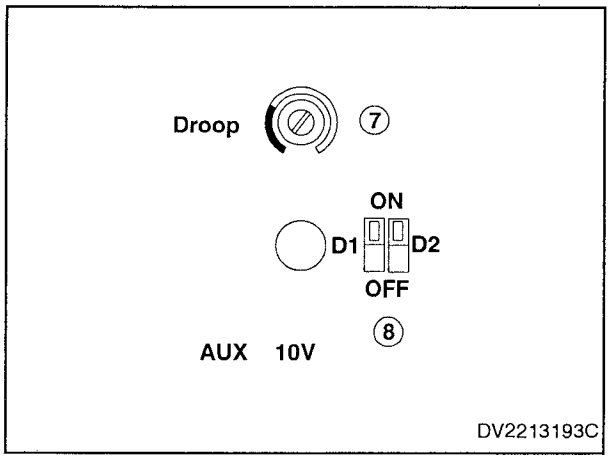
Note) With idle switch ON again, set the engine speed at 800 rpm by ⑥ Idle potentiometer.

Note) Reason for adjustment: To adjust pre-heat levels after engine start up or the initial fuel amount at engine start up

Note) Recommended position: Between the 12 and 3 o'clock positions. Though varying by engine model or rated RPM, it is recommended to set the RPM as 800RPM.

Note) Possible problems: Decreasing cold start performance and the excessive use of fuel during the warm-up phase.





Caution: Idle speed is one of the important factors to determine the characteristics of engine startup. Therefore, it is necessary to adjust the idle speed after rated speed adjustment regardless of the use of "idle mode."

6. Governor performance adjustment

1) Remove the connection between terminals G and M (with idle switch OFF). Once the engine reaches run speed, adjust the performance of governor.

2) Gain adjustment.

Note) Turn ② Gain clockwise until instability develops at no load.

Note) Gradually move ② Gain counterclockwise until stability returns.

Note) Move ② Gain counterclockwise further by around 20 minutes (10°) to ensure stable performance.

7. Stability adjustment.

1) Turn ③ Stability clockwise at no load until instability develops.

2) Gradually move ③ Stability counterclockwise until stability returns.

3) Move ③ Stability counterclockwise further by around 20 minutes (10°) to ensure stable performance.

8. Accessory adjustment

1) Run Lamp ON

Note) At the rated speed, turn ⑩ Run counterclockwise until the Run Lamp is on.

Note) Move ⑩ Run counterclockwise further by 90° to prevent the Run Lamp from flickering.

2) Crank Lamp ON

Note) At the idle speed, turn ⑩ Crank counterclockwise until the Crank Lamp is on.

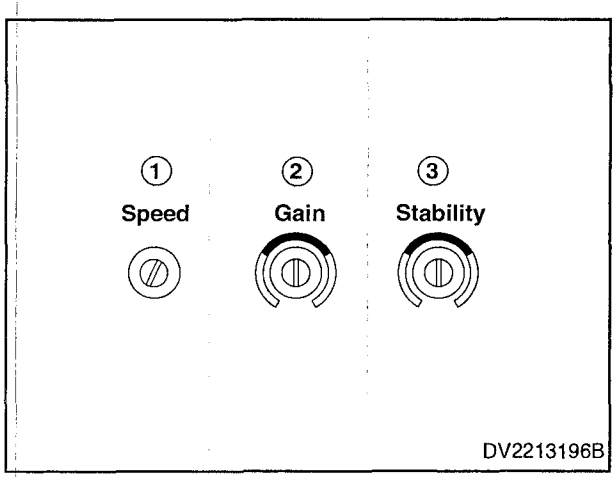
Note) Move ⑩ Crank counterclockwise further by 90° to prevent the Crank Lamp from flickering.

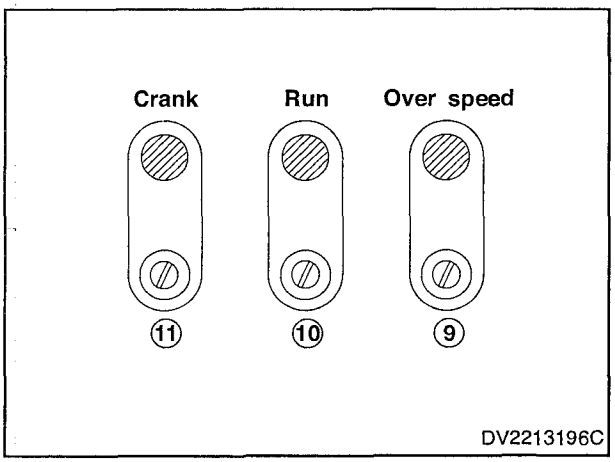
3) Overspeed Lamp ON

Note) At the rated speed, as pressing the Test button, gradually turn ⑨ Over Speed counterclockwise until the Overspeed Lamp is on and the engine is shut off simultaneously.

Note) With the adjustment above, the overspeed function is triggered at around 115% of the rated speed.

Caution: On completion of all the adjustments, start up the engine again to ensure the stable operation at engine startup, at no load, and at load operation, respectively.





9. Starting Fuel Adjustment (to minimize the engine's exhaust smoke)

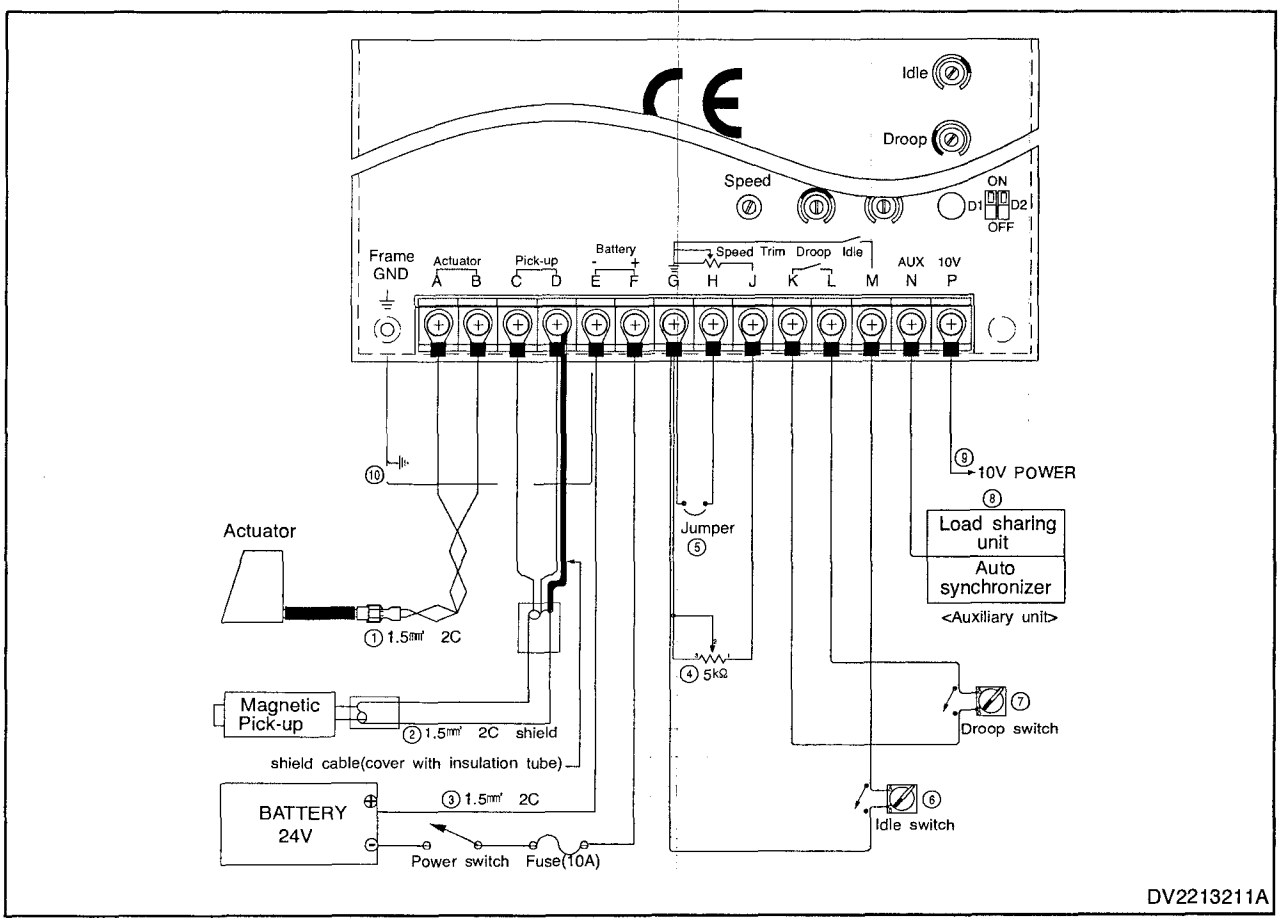
1) Turn on idle speed switch → Set the idlespeed at 800RPM → Turn ④ Starting Fuel counterclockwise until the engine speed begins to fall → Move ④ tarting Fuel clockwise further by 15° to stabilize the engine speed.

Caution: In case the exhaust smoke is not thick, It is recommended to place (4) Starting Fuel at the 5 o'clock position. If (4) Starting Fuel is set too low, It may be hard to start the engine and cause the speed overshoot on engine startup, even resulting in exceeding the preset over-speed value.

10. When the engine won't start

1) If there is no wrong wiring → Return all adjustments to the "factory-set values" → Start up the engine again.

● External Wiring



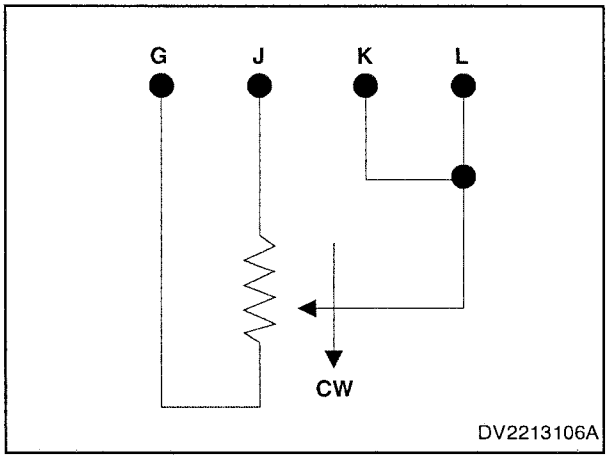
- Wiring to the speed control unit should be as shown in DV2213211A.
- All the cables should be 1.5mm2 or larger and shielded cables should be used for all external connections.
- Other shielded cables not described in DV2213211A should be grounded to the frame.

1. Twisted cables should be used for actuator connections. The normal reading of resistance between terminals A & B should be between 3.5Ω and 4.5Ω.
2. Magnetic speed sensor connections to terminals C and D must be shielded for their entire length. The speed sensor cable should only be connected to terminal D. The shield should be insulated to ensure no other part of the shield comes in contact with engine ground. Otherwise, stray speed signals may be introduced to the speed control unit resulting in instability, etc.
3. Be cautious that the battery's polarity to terminals E and F should not be switched and a 10 amp fuse must be installed between battery (+) and terminal F. After the wiring work, check the voltage between terminals which should be 24VDC (±4V). Ground the terminal E to the frame (wiring (10)).
4. As illustrated in DV2213211A, connecting the optional 5kΩ resistance enables fine adjustment of engine speed within the range of preset speed ±210Hz range.
5. In case of 12V system, or of actuator with current consumption over 5 amp or above, connect terminals G and H.
6. Selector switch, switching over "IDLE mode" and "RUN mode" ON (close): idle mode OFF (open): run rated mode
7. "DROOP" mode selector switch ON (close): DROOP mode OFF (open): Isochronous mode
8. The signal from Auxiliary device for parallel operation system should be connected to terminal N. It is necessary to use the shielded cable for the signal.
9. Accessory power supply: The +10[V] and 20[mA] of current supply, Terminal P, can be utilized to provide power to governor system accessory and for various other purposes.

Caution: Wrong or erroneous wiring and battery voltage can cause fatal damage to the controller.

● Magnetic speed sensor connections

1. With the engine stopped, adjust the gap between the magnetic speed sensor and the ring gear teeth. The gap should not be any smaller than 0.45mm. Usually, backing out the speed sensor by 3/4 turn after touching the ring gear teeth will achieve a satisfactory air gap.
2. The signal from the speed sensor can be measured between C and D in engine operation.
3. Signal VAC 3 or above is required for the controller.



● Remote speed adjustment

1. As illustrated in DV2213106A, a remote speed adjustment potentiometer can be used to adjust the engine speed over specific speed range. Select the desired speed range and the corresponding potentiometer value. When the minimum speed setting is used in remote adjustment mode, the speed drop phenomenon may occur due to instability and load in the system. To maintain engine stability at the minimum speed setting above, a small amount of droop can be added by turning ⑦ Droop counterclockwise. On the other hand, at the maximum speed setting, the governor performance will be near Isochronous regardless of the droop adjustment setting
2. Potentiometer Value by Speed Range

Speed range	Pote tiometer value	Engine RPM for Each Ring Gear		
		160 teeth	152 teeth	146 teeth
900Hz	1K	337rpm	355rpm	370rpm
2,400Hz	5K	900rpm	947rpm	986rpm
3,000Hz	10K	1,125rpm	1,184rpm	1,230rpm
3,500Hz	25K	1,315rpm	1,381rpm	1,438rpm
3,700Hz	50K	1,387rpm	1,460rpm	1,520rpm

3. Factory-set Value

300611-00683	
Overspeed	1,725rpm (No. of teeth = 160)
Run lamp	Maximum CW
Gain	Mid-range (12 O'clock)
Stability	Mid-range (12 O'clock)
Starting Fuel	Full CW[a](Maximum Fuel)
Speed Ramping	9 O'clock
Droop	Full CCW[b] (Minimum)
Adjustment	(No. of teeth = 160)
Speed Adjustment	4,000Hz (1500rpm)
Idle Adjustment	2,133Hz (800rpm)

a. CW: Clockwise
b. CCW: Countclockwise

300611-00684	
Overspeed	2,070rpm (No. of teeth = 160)
Run lamp	Maximum CW
Gain	Mid-range (12 O'clock)
Stability	Mid-range (12 O'clock)
Starting Fuel	Full CW[a](Maximum Fuel)
Speed Ramping	9 O'clock
Droop	Full CCW[b] (Minimum)
Adjustment	(No. of teeth = 160)
Speed Adjustment	4,800Hz (1800rpm)
Idle Adjustment	2,133Hz (800rpm)

a. CW: Clockwise
b. CCW: Countclockwise

300611-00685	
Overspeed	1,725rpm (No. of teeth = 152)
Run lamp	Maximum CW
Gain	Mid-range (12 O'clock)
Stability	Mid-range (12 O'clock)
Starting Fuel	Full CW[a](Maximum Fuel)
Speed Ramping	9 O'clock
Droop	Full CCW[b] (Minimum)
Adjustment	(No. of teeth = 160)
Speed Adjustment	3,800Hz (1500rpm)
Idle Adjustment	2,026Hz (800rpm)

a. CW: Clockwise
b. CCW: Countclockwise

300611-00686	
Overspeed	2,070rpm (No. of teeth = 152)
Run lamp	Maximum CW
Gain	Mid-range (12 O'clock)
Stability	Mid-range (12 O'clock)
Starting Fuel	Full CW[a](Maximum Fuel)
Speed Ramping	9 O'clock
Droop	Full CCW[b] (Minimum)
Adjustment	(No. of teeth = 160)
Speed Adjustment	4,053Hz (1800rpm)
Idle Adjustment	2,026Hz (800rpm)

a. CW: Clockwise
b. CCW: Countclockwise

● Droop parallel Operation mode (Manual paralleling)

- Definition: Engine speed on the decrease against Engine load on the increase.
  DROOP(%) = {(No Load Speed - Full Load Rated Speed) x 100} / Full Load Rated Speed
- Description: Droop is typically used for the load sharing and paralleling of engine driven generators. Without the Droop mode in paralleling system, generators can be overloaded or motorized.
- Application: For DROOP Operation,

1. Close Droop selector switch between terminals K and L.
2. When in Droop operation, the engine speed will decrease as engine load increase. The percentage of droop governing can be varied with ⑦ Droop potentiometer. The higher level of droop is achieved as turning ⑦ Droop clockwise.

- Droop level requirements above 10% are unusual and the minimum droop level to keep the stability of speed droop governor is 2.5% or above.
- After the droop level has been adjusted, the rated engine speed setting may need to be reset. Check the engine speed and adjust the speed setting accordingly.

● Accessory Input (Automatic Paralleling)

- The Auxiliary terminal N accepts input signals from load sharing units, auto synchronizers, and other governor system accessories.
- It is recommended that this connection from accessories be shielded as it is a sensitive input terminal.
- When an accessory is connected to Terminal N, the speed will decrease and the speed adjustment must be reset.
- When operating in the upper end of the control system frequency range, a jumper wire or frequency trim control may be required between Terminals G and J. This increases the frequency range of the speed control to over 7,000Hz.

● Controller LAMP Display (diagnosis)

- Power : When the battery power is connected and inner control power (DC 12V) is achieved, the lap is on and main controller is ready to function.
- Pick Up : When the voltage between terminals C and D is VAC 3.0 or above, the lamp is on.
- Crank : When the engine reaches the preset rated speed (idle speed), the lamp is on and relevant relay is achieved.
- Run : When the engine reaches the preset rated speed (operating speed), the lamp is on and relevant relay is achieved.
- Over Speed : When the engine reaches the preset overspeed, the lamp is on and relevant relay is activated and the power to the actuator is shut off.

● System Troubleshooting (Instability)

1. Fast instability (Hunting)

1) When the position of switch D1 is ON, the differential function is activated.

2. It provides fast transient response against engine speed changes.
3. However, it may generate fast instability being sensitive to external high frequency noise. In this case, place the switch D1 to OFF position and readjust ② Gain and ③ Stability.
4. If instability should be still present, placing D2 to OFF position may help stabilize the engine. Again, readjust ② Gain and ③ Stability for optimum control.
5. Slow instability (Hunting)
   Slow instability can have many causes, most of which are due to wrong setting against the engine characteristics. Adjustment of ② Gain and ③ Stability usually cures most situations
6. If the troubleshooting above is not successful

1) Due to the controller at fault - Replace the controller with new one.
2) Due to the external devices at fault (Actuator, fuel injection device, turbine, etc) rectify the mechanical devices.

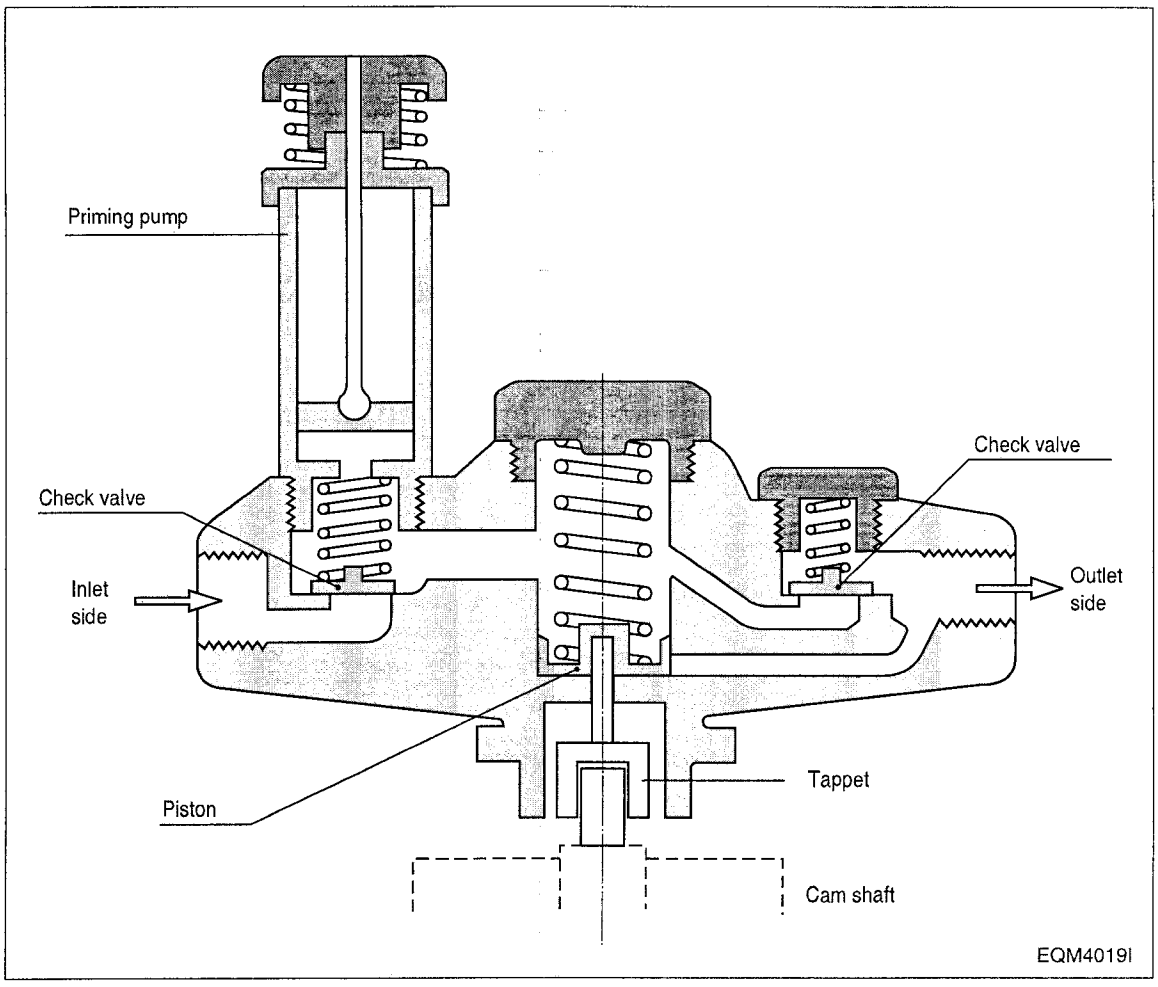
● System inoperative

If the engine governing system does not function, the fault may be determined by performing the voltage tests described in steps 1, 2 and 3. (+) and (-) refer to meter polarity. If normal values should be indicated as a result of following the troubleshooting steps, the fault may be with the actuator or the wiring to the actuator. In that case, check the actuator.

Step	Terminal	When to Take the Reading	Normal readings	Probable Cause of Abnormal Reading	Solution
1	F(+) & E(-)	When the engine stopped	DC 24V		1. Check battery line
					2. Replace battery
2	F(+) & E(-)	When starting the engine	DC 15V or above	1. Low battery voltage	1. Check battery line
				2. Wiring error	2. Replace battery
3	C & D	When the engine stopped	300~1200Ω (tester ohmmeter)	1. Defective speed sensor	1. Check sensor line
				2. Improper or defective wiring to the speed sensor	2. Replace speed sensor
4	C & D	When starting the engine	1.5V or above (tester AC voltmeter)	1. The gap between speed sensor and gear teeth too great.	1. Check sensor line
				2. Defective speed sensor	2. Replace speed sensor
5	A & B	When the engine stopped	3.8~4.5Ω (tester ohmmeter)	1. If the voltage reading is below 3.8Ω => Short	1. Check short/open actuator
				2. If the voltage reading is above 4.8Ω => Open wire	2. Replace actuator
				3. Defective actuator	
6	P(+) & G(-)	KEY S/W ON	DC 9.5~10.5V	Defective speed controller	Replace controller
7	F(+) & A(-)	When starting the engine	DC 9~15V in normal conditions DC 1~3V in abnormal conditions	1. Speed adjustment set too low.	1. Check speed setting
				2. Short/open in actuator wiring	2. Check actuator line
				3. Actuator	3. Replace actuator when found to be defective

10.3.4. Fuel feed pump

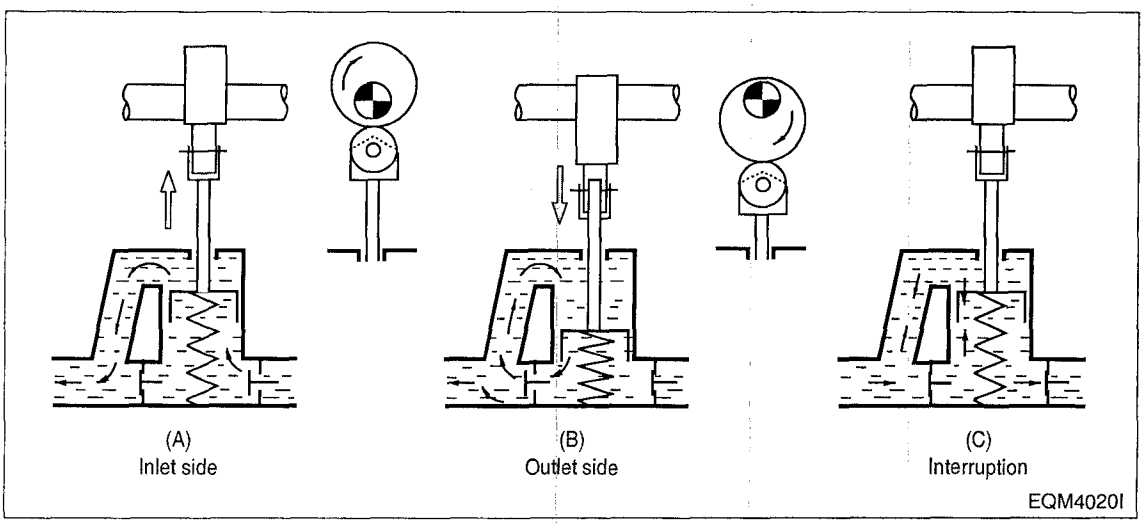
1) General descriptions and construction



The P-type injection pump is mounted with K-ADS or KP type feed pump. These pumps have the same basic construction and operation, and the general descriptions of the KP type pump are given below:

The figures show its construction (right figure) and operation (below figure). The piston in the fuel feed pump is driven by the push rod and tappet via the camshaft of injection pump and performs reciprocating operation to control the suction and delivery of fuel. When the cam reaches the Bottom Dead Center as shown in the figure, the fuel is drawn in through the check valve on the inlet side.

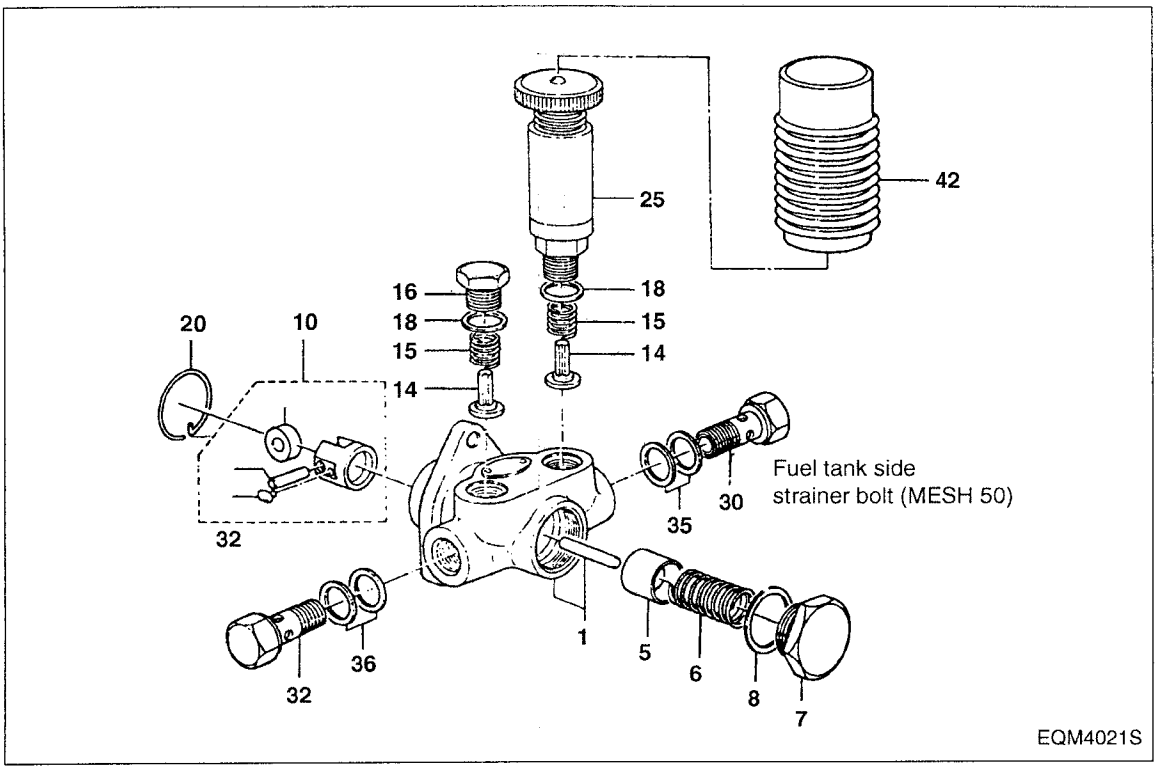
The fuel pressurized as the cam rotates on flows through the check valve on the outlet side as shown in (B). If the feeding pressure increases abnormally, the spring is compressed, resulting in interrupting further delivery of fuel as shown in (C).



This feed pump is mounted with a priming pump designed to permit manual feeding of fuel from the fuel tank with the injection pump mounted in the engine. During the manual feeding operation, air must be bled from the fuel lines.
When using the priming pump, fix it securely to prevent the possible entry of moisture or other foreign substances in the inside of feed pump.

In addition, a strainer is fitted into joint bolt on the inlet side of the fuel feed pump to filtrate any foreign substances possibly mixed in fuel.

2) Disassembly



- Clamp the feed pump with a vise and disassemble the plugs (30, 32), strainer (31) and gaskets (35, 36).
- Take off the priming pump (25), plug (16), both gaskets (18), spring (15), and check valve (14).
- Take off the plug (7), gasket (8), spring (6), and piston (5) on the piston side.
- Pull out the snap ring (20) holding the tappet (10).
- Disassemble the snap ring, then take off the tappet (10) and push rod (1).

3) Inspection

- If the check valve is damaged or scored on its seat face, replace it with a new one.
- Inspect the piston and tappet for damage.
- Replace the push rod if excessively worn, and replace together with the pump housing if required. The inspection for wear should be performed in the same procedure as for suction pressure test described below.

4) Reassembly

- Reassembly operation is performed in reverse order of disassembly. All the gaskets must be replaced with new ones at reassembly.

5) Testing

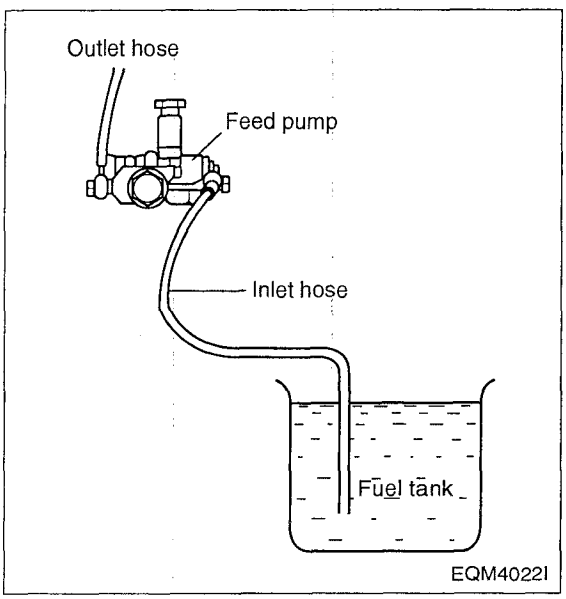
(1) Suction capacity test

Connect one end of a hose to the inlet side of the feed pump and immerse the other end of it into the fuel tank as illustrated.

Hold the feed pump in position about

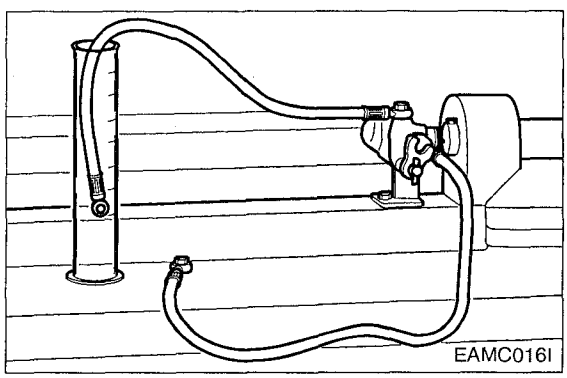
1 m above the level of fuel in the fuel tank.

Operate the tappet at the rate of 100 rpm and check to see if fuel is drawn in and delivered for 40 seconds or so.



(2) Delivery test

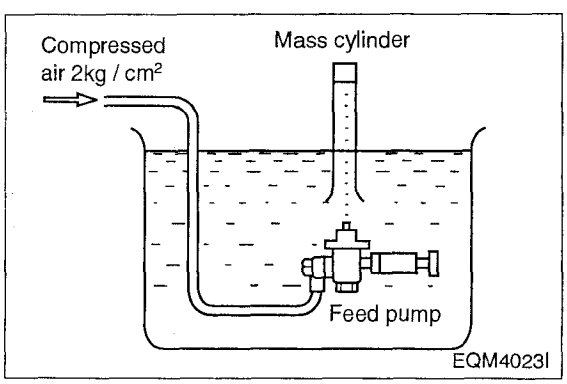
Make a test with the feed pump mounted on a pump tester as illustrated. Operate the pump at the rate of 1,000 rpm and check to see if the pump delivery is more than 405 cc / 15 seconds.



(3) Sealing test

Plug up the delivery port on the feed pump and apply compressed air of 2 kg/cm² into the inlet side.

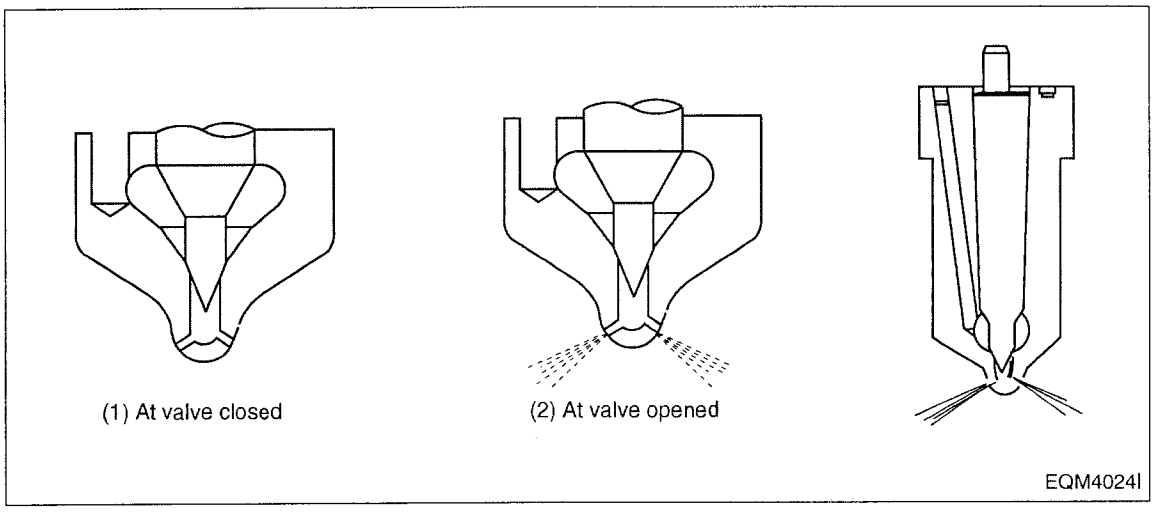
Submerge the feed pump in a container of diesel fuel and check for air leak.



10.3.5. Injection nozzle

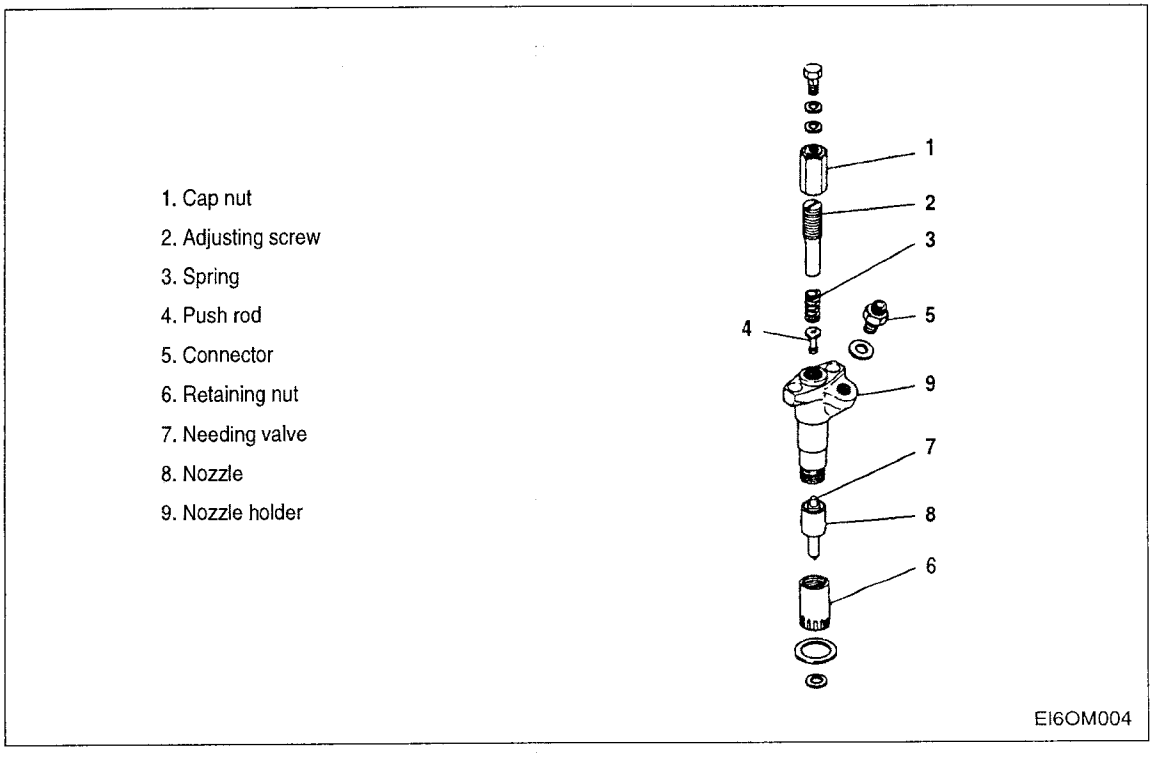
1) General descriptions

Pressurized fuel delivered from the fuel injection pump is sprayed into the combustion chamber past the injection nozzle at proper spray pressure and spray angle, then burnt completely to achieve effective engine performance.



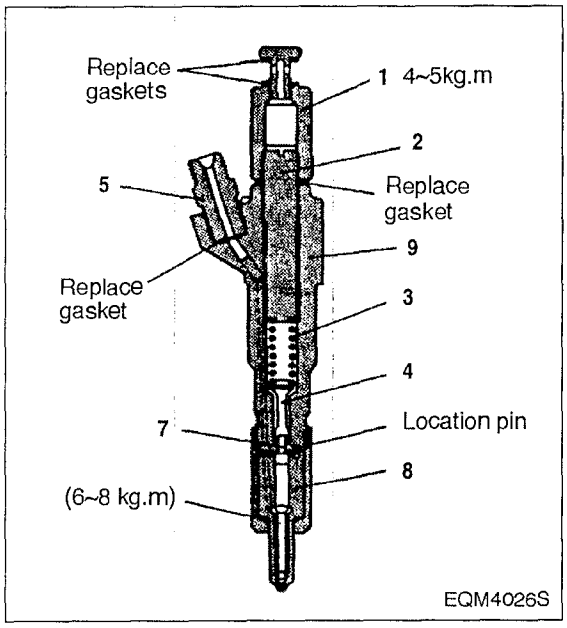
2) 1-spring type

(1) Disassembly



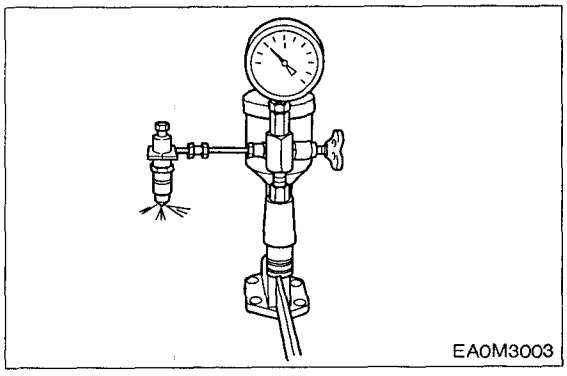
(2) Reassembly

- After removing carbon deposit, submerge the nozzle in diesel oil and clean it.
- Replace all the gaskets with new ones.
- Assemble the parts and tighten them to specified torque.



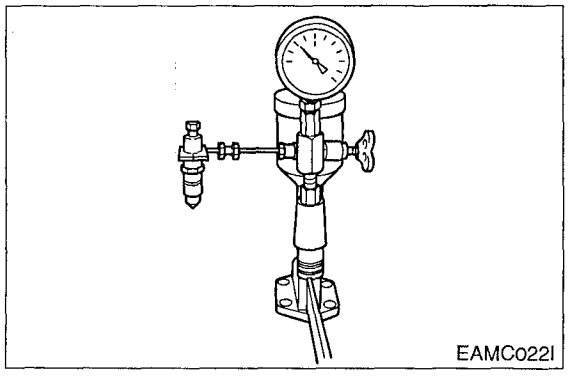
(3) Adjustment

- Remove the cap nut and assemble a nozzle to a nozzle tester.
- With the adjusting screw loosened, operate the nozzle 2 ~ 3 times to bleed it.
- Operate the nozzle tester lever at the specified rate.
- Adjust the injection pressure to the standard pressure using the adjusting screw.
- After adjusting the injection pressure, tighten the cap nut to specified torque.
- Re-check the injection pressure and see if the spray pattern is normal.



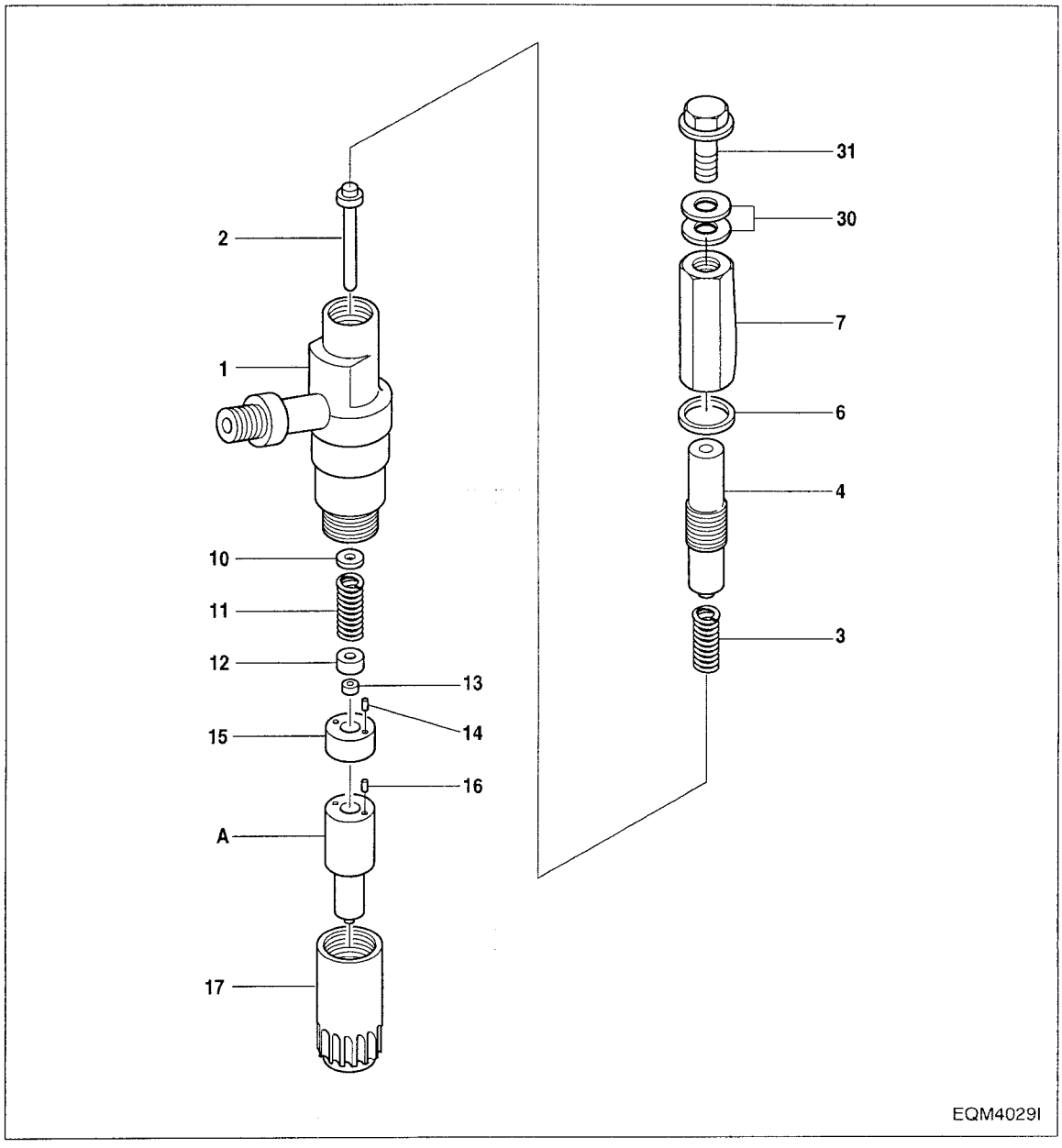
(4) Testing

- With the nozzle assembled to a nozzle tester and pressure of 20 ~ 21 MPa (200 ~ 210 bar) applied, check the nozzle for fuel leakage.



3) 2-spring type

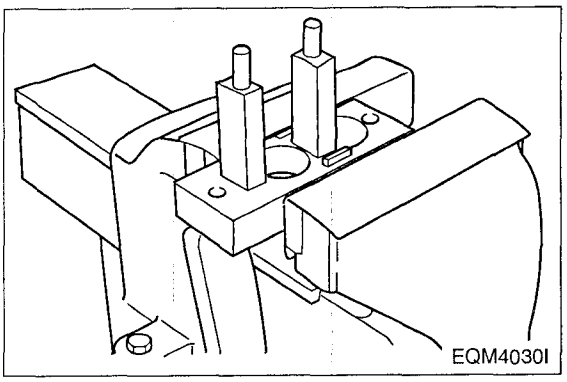
(1) Disassembly



1. Nozzle holder body
2. Push rod
3. Primary spring
4. Adjusting screw
6. Gasket
7. Cap nut
10. Adjusting shim
11. Secondary spring
12. Spring Seat
13. Lift pin
14. Pin
15. Spacer
16. Pin
17. Retaining nut
30 Gasket
31 Eye bolt
A. Nozzle

(2) Inspection and adjustment

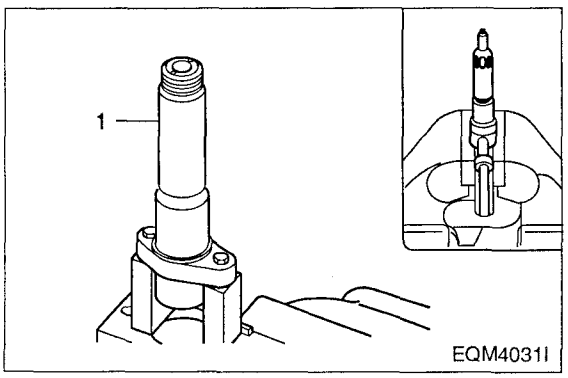
- Adjusting the primary opening pressure. Install the plate of plate assembly (157944-9520) onto a vise.



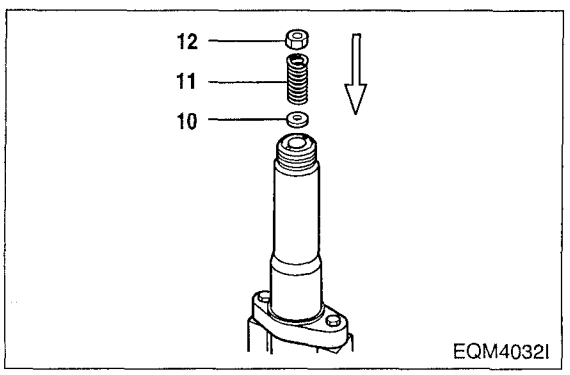
NOTE :

Use the plate assembly (157944-9520) in fixing a nozzle holder having a flange. A nozzle holder without flange should be directly installed onto a vise.

- With the nut, install the two pins on the plate.
- Install the nozzle holder body (1) onto the plate with the cap nut side facing downward.



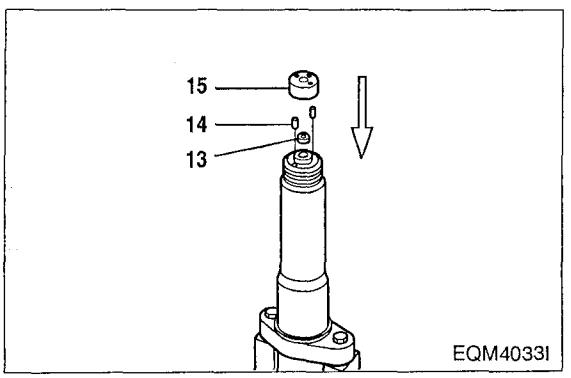
- Assemble adjusting shim (10), secondary spring (11), and spring seat (12) on the nozzle holder body in the order as described.



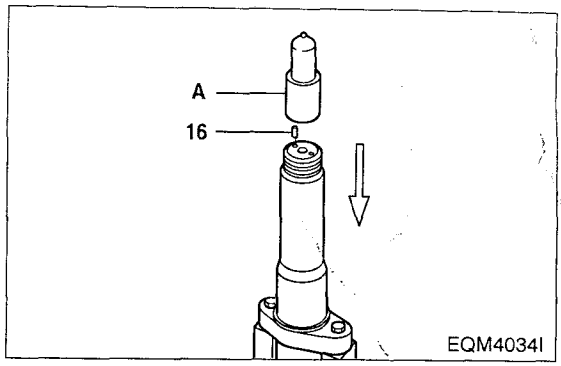
NOTE :

The secondary spring is the same one as the primary spring.

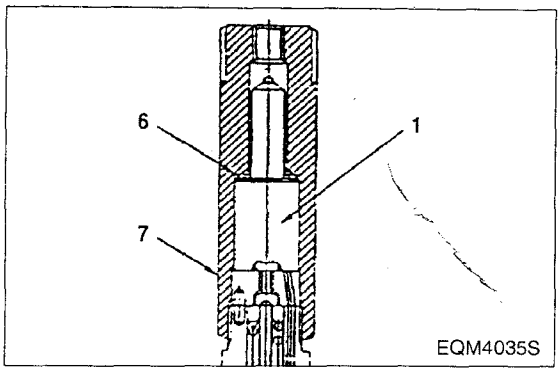
- Assemble the pin (14), lift piece (13), and spacer (15) with the nozzle holder body.



● Install the pin (16) and nozzle (A) onto the spacer.



● After installing the gasket (6:157892-1500) on the nozzle, use the cap nut (7:157892-4000 : SW22 mm) to fix the nozzle onto the nozzle holder.

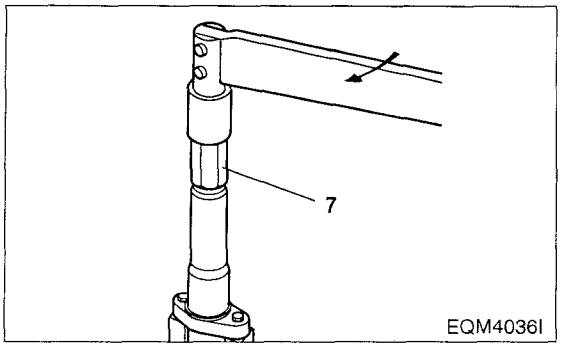


NOTE :
While tightening the cap nut, keep checking to see if the lock pin comes all the way into the nozzle.

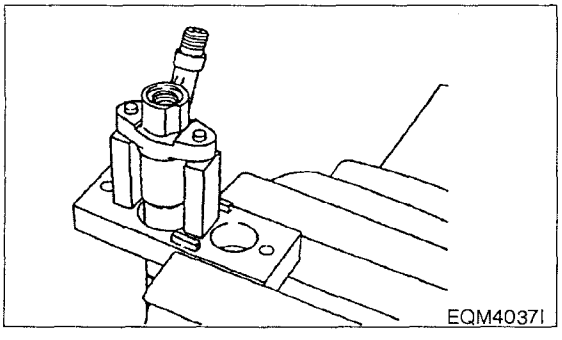
NOTE :
Tighten the retaining nut until it resists hand tightening, then further tighten it using a torque wrench.

● Be sure to follow the specified torque rating when tightening the adjusting retaining nut.

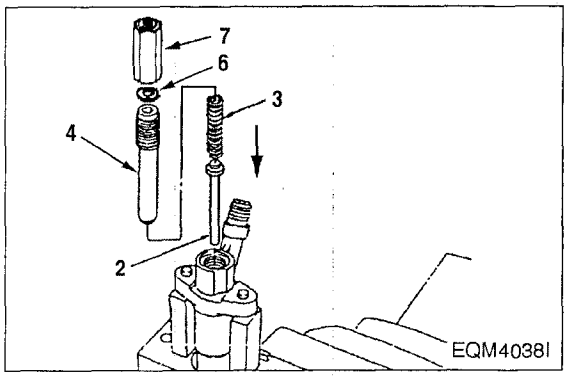
Torque	6.0 ~ 8.0 kg·m



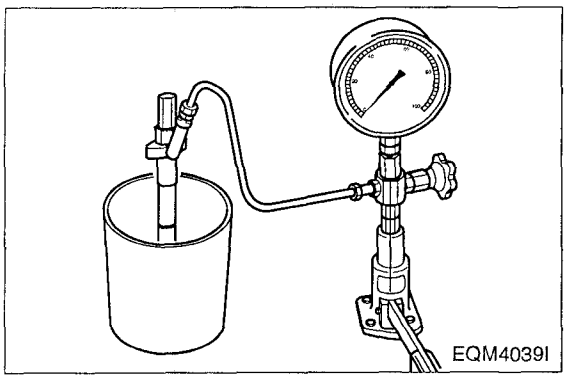
● With the cap nut facing upward, install the nozzle holder on the plate.



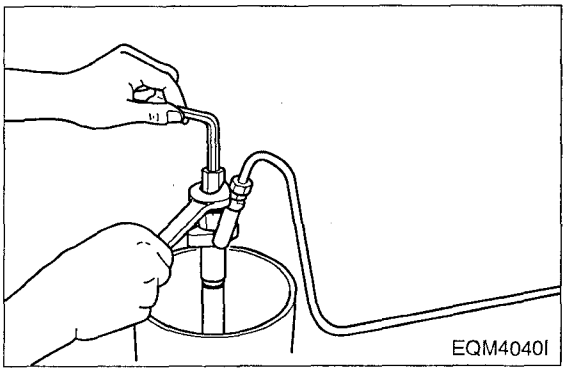
- Assemble the push rod (2), primary spring (3), and adjusting screw (4) on the nozzle holder in the order described.
- Install the gasket (6) and cap nut (7) onto the adjusting screw(4).



- Assemble the nozzle and nozzle holder assembly to the nozzle tester (105785-1010).

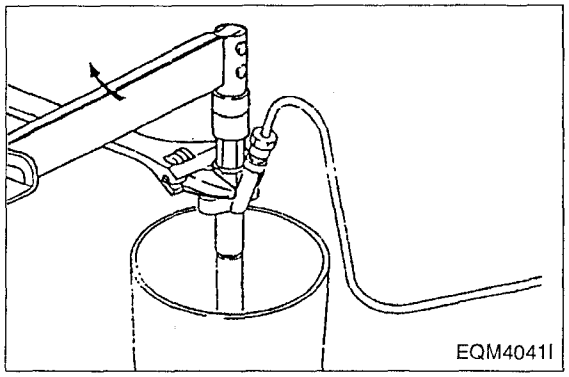


- Adjust the primary opening pressure to the specified pressure using the adjusting screw (4).



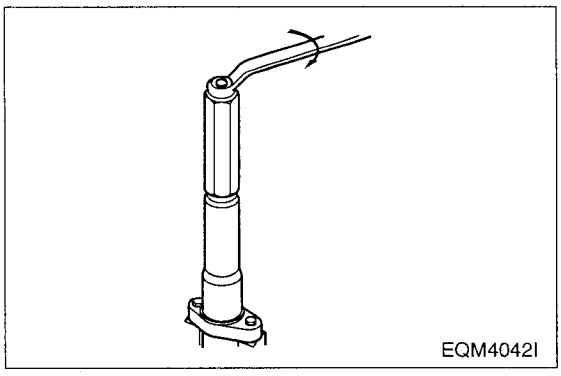
- With a monkey wrench, fix the nozzle holder securely and tighten the cap nut (SW 19mm) to specified torque.

Torque	3.0 ~ 4.0 kg·m

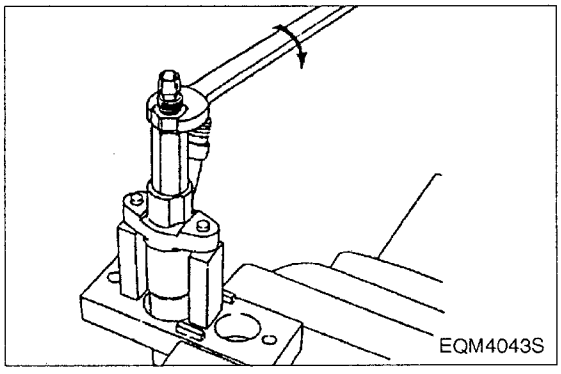


(3) Inspecting the needle valve for full lift

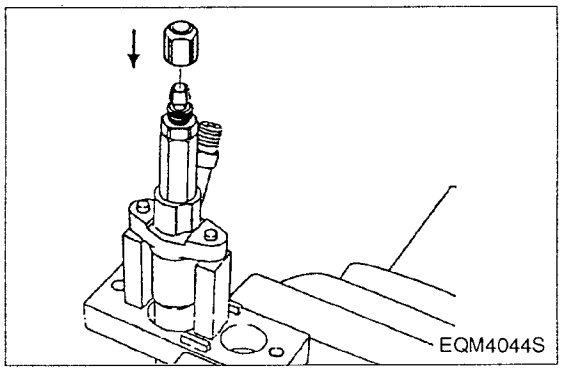
- Install gasket (026508-1140) and plug (157892-1600 : SW12 mm) onto the adjusting retaining nut (157892-1400).



- Install the nozzle holder on the plate with the cap nut facing upward.
- Install the holder(157892-4100 : SW12 mm) into the cap nut.



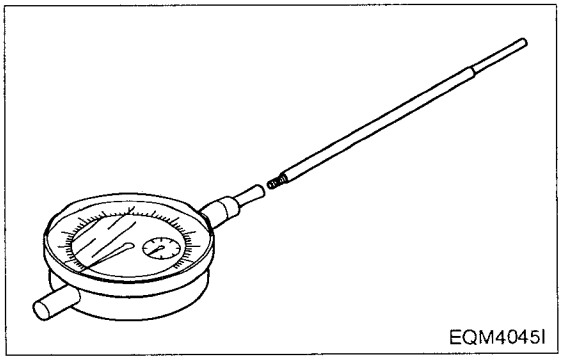
- Install a nut (157892-1000 : SW 17 mm) on the holder.



- Assemble the pin (157892-4200 or 157892-4300) to the dial gauge (157954-3800).

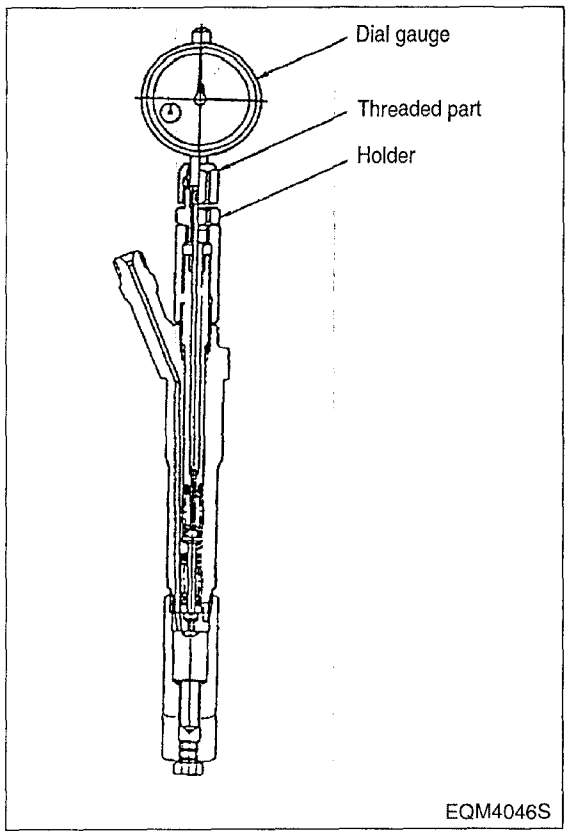
(mm)

Part No.	Limit
157892-4200	160
157892-4300	110



NOTE :
"L" means the length of the pin except the threaded portion.

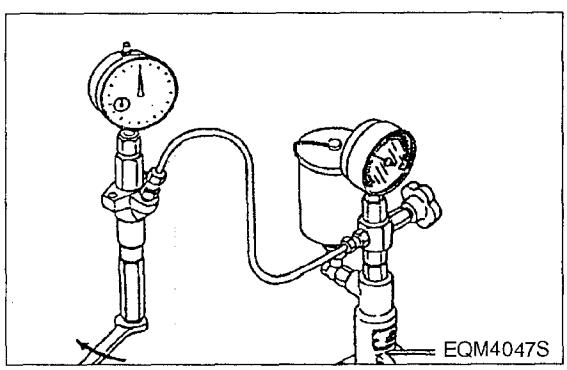
- Install the dial gauge on the holder assembly so that the pin is brought into contact with the upper end of the push rod, then fix the pin with the nut.



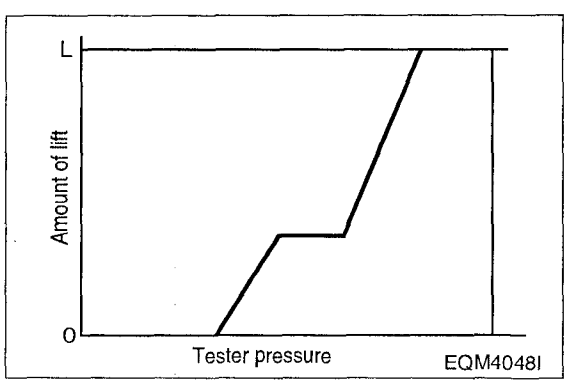
NOTE :
Fix the dial gauge so that a stroke of 2 mm or so can be measured.

NOTE :
Overtightening the nut may cause a sticking of the dial gauge seat.

- Assemble the nozzle and nozzle holder assembly to the nozzle tester and zero the dial gauge.
- Operate the nozzle tester, bleed the retaining nut, and check for fuel leakage.



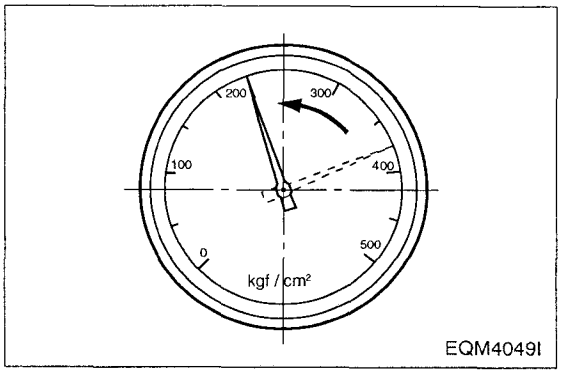
- Operate the nozzle tester and increase the tester pressure up to 350 ~ 450 kgf·cm² in order that the needle valve can be fully lifted. Then, record the full lift value "L".

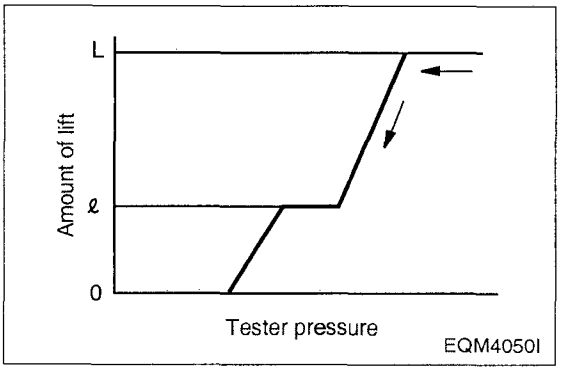


NOTE :
This testing is to be made in order to check the nozzle seat portion for unusual wear or whether the nozzle assembly is a standard item.

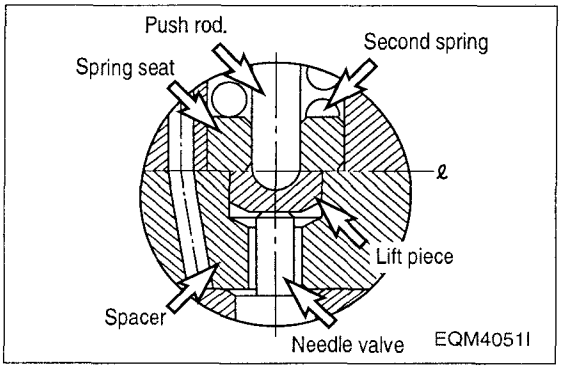
(4) Inspection of pre-lift

- If the nozzle tester handle is released with the needle valve engaged in a full lift condition, the tester pressure drops, being accompanied by decrease in the needle valve lift value (indicated value on the dial gauge).





- Take the indicated value on the dial gauge at the point of time when the secondary spring completes its operation and the needle valve puts an end to descent (the position of needle valve lift value "ℓ" as shown in the above and right figures) and check that the value is within the specified limit.

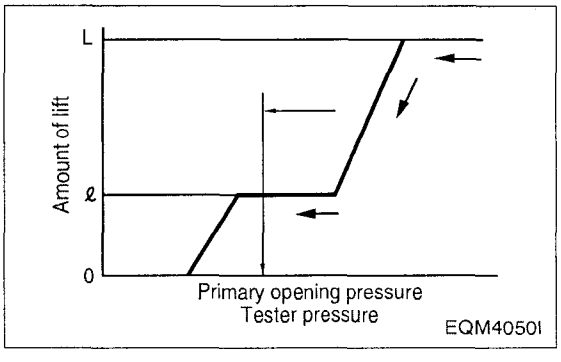


(5) Measuring point for pre-lift

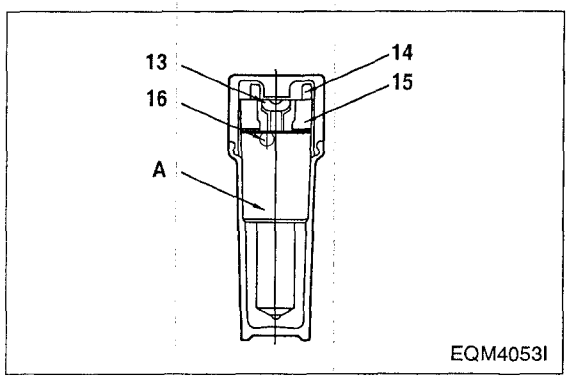
Take the indicated value on the dial gauge at a point of primary opening pressure approx. + 10 kgf·cm².

NOTE :

Locate the point of primary opening pressure approx. +10 kgf·cm² while dropping the pressure.

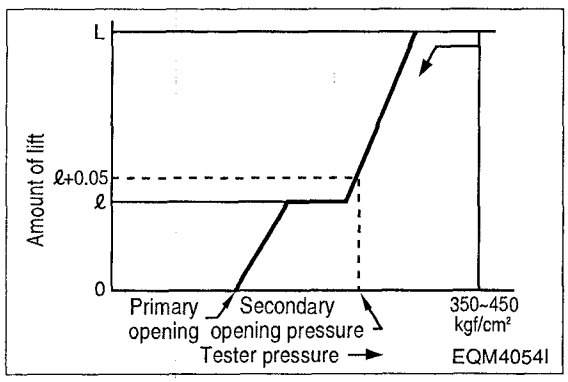


- If the measured pre-lift value deviates from the specified limit, replace the pin (14, 16), lift piece (13), spacer (15), and nozzle assembly (A) with a new "nozzle service kit".

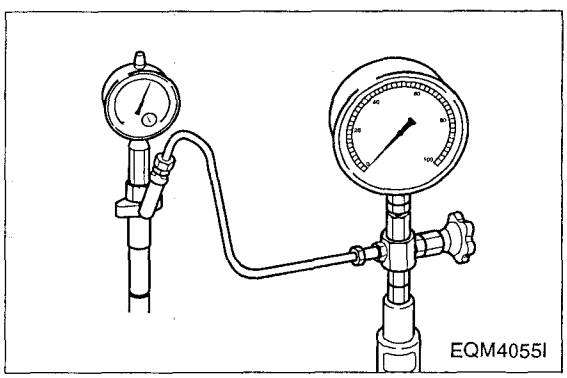


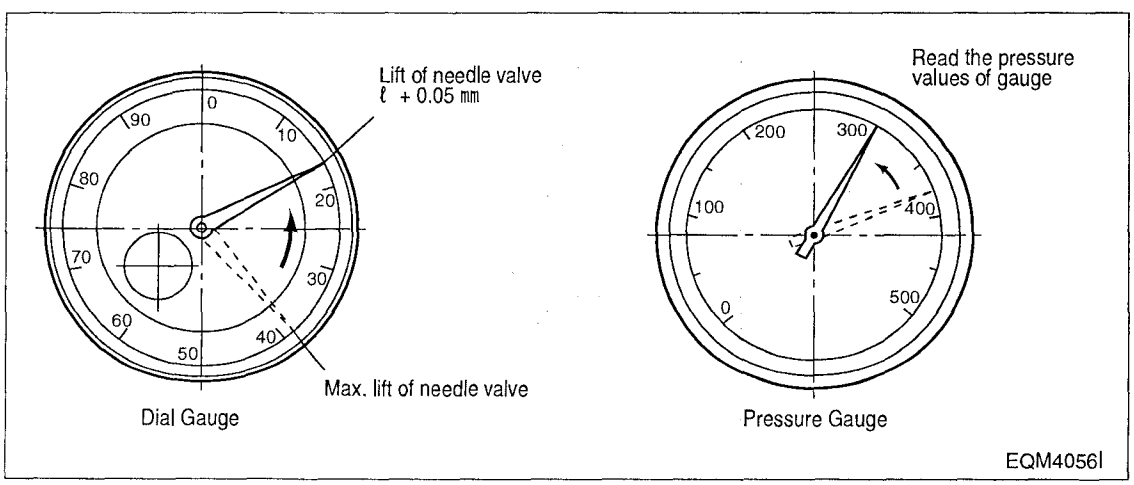
(6) Inspection of secondary opening pressure

- After confirming the pre-lift, operate the nozzle tester and increase the internal pressure up to 350 ~ 450 kgf·cm² to fully lift the needle valve.
- Release the nozzle tester handle to decrease the tester pressure, then take a note of the movements of the dial gauge.



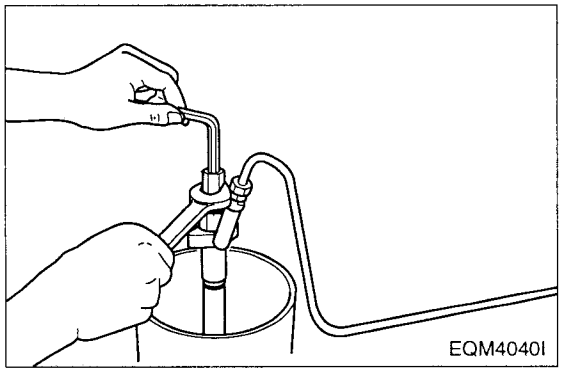
- Take the indicated value on the pressure gauge at the point of time when the needle of the dial gauge indicates the specified needle valve lift value. (In general, pre-lift "ℓ" + 0.05 mm. Refer to following figure).



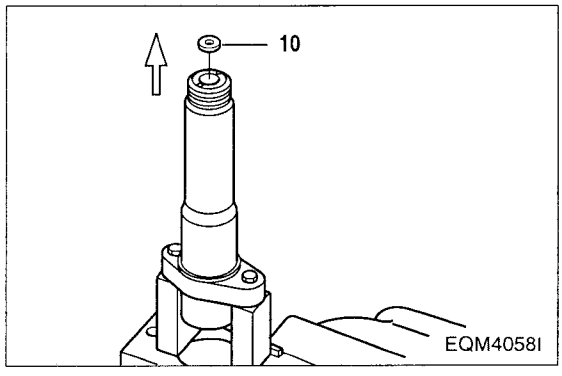


(7) Adjusting secondary opening pressure

- In the event that the measured value deviates from the specified limit, readjust the primary opening pressure if the amount of deviation is small. (to the standard range of the primary opening pressure)
- If the secondary opening pressure is lower than the standard value: Adjust the primary opening pressure up to the top limit of the standard vague, and then measure the secondary opening pressure.
- If the secondary opening pressure is higher than the standard value: In a reverse manner, readjust the primary opening pressure down to the bottom limit of the standard value.



- If the secondary opening pressure still deviates from the specified limit in spite of the readjusting the primary opening pressure, take off the nozzle fixing portion from the nozzle holder and remove the adjusting shim (10).
- If the secondary opening pressure is higher than the standard value, fit a thinner adjusting shim than the existing one.
- After replacing the existing adjusting shim, measure the secondary opening pressure and continue the adjustment until a value satisfying the standard value.



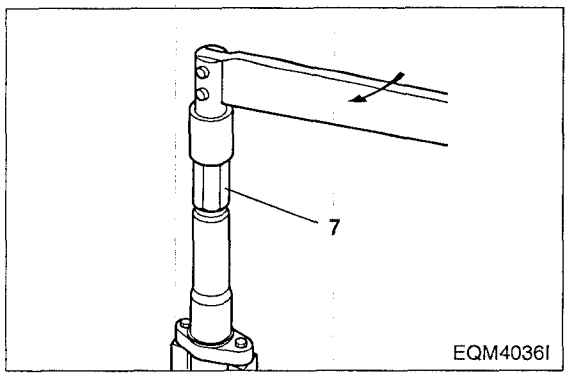
Adjusting shim for secondary opening pressure

(Out diameter = Ø 9.5 , Inner diameter = Ø 4.5)

Part No.	Thickness (mm)	Part No.	Thickness (mm)
1505380-4900	0.40	1505380-5300	0.56
1505380-5000	0.50	1505380-5400	0.58
1505380-5100	0.52	1505380-5500	0.60
1505380-5200	0.54	1505380-5600	0.70

(8) Retaining nut

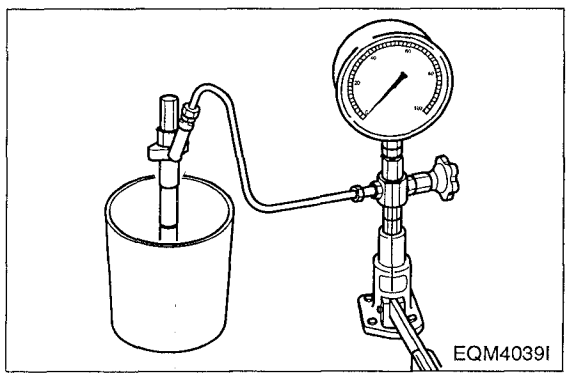
- Take out the dial gauge, nut, holder and gasket from the cap nut (7).
- Remove the adjusting retaining nut and gasket, and install the original retaining nut (SW 19 mm).



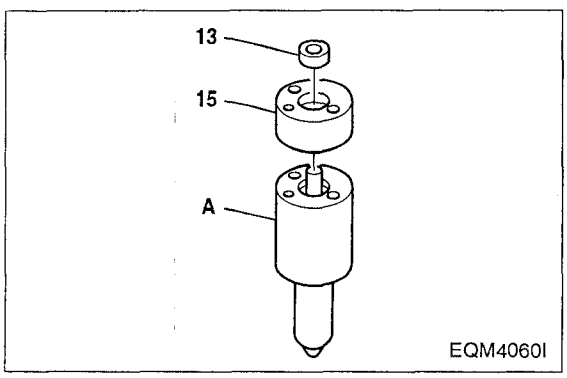
Cap nut Tightening torque	6.0 ~ 8.0 kg·m

(9) Inspection at completion

- Assemble the nozzle holder to a nozzle tester and check the primary opening pressure, spray patterns, oil tightness of seat portion, and oil leakage from each part.



- When replacing the nozzle, replace it with a new "nozzle service kit" integrated with a nozzle, lift piece, and spacer as a complete set.



NOTE :
If only a nozzle is replaced, the amount of pre-lift will deviate from the specified value.

10.3.6. Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Engine won't start		
1) Fuel not being pumped out from feed pump	(1) Fuel pipes clogged or air into pipe line	Correct
	(2) Feed pump valve defective	Replace
	(3) Feed pump piston or push rod sticking	Disassemble, correct
2) Fuel not being injected from injection pump	(1) Fuel filter element restricted	Clean
	(2) Air in fuel filter or injection pump	Bleed
	(3) Plunger and/or delivery valve sticking or defective	Disassemble, correct
3) Fuel injection timing incorrect	(1) Injection pump not properly installed on pump bracket	Check, correct
	(2) Injection pump tappet incorrectly adjusted	Check, correct
	(3) Cams on cam shaft worn excessively	Replace
4) Injection nozzles inoperative	(1) Needle valves sticking	Correct or replace
	(2) Fuel leaking past clearance between nozzle and needle valve	Correct or replace
	(3) Injection pressure incorrect	Adjust
2. Engine starts but stalls immediately	(1) Pipe from feed pump to injection pump clogged or filter clogged	Clean
	(2) Air in fuel	Bleed
	(3) Feed pump delivery insufficient	Disassemble, correct
	(4) Fuel delivery insufficient due to clogging of fuel tank air breather	Replace breather
3. Engine lacks power	(1) Plunger worn excessively	Replace
	(2) Injection timing incorrect	Adjust
	(3) Delivery valves defective	Replace
	(4) Nozzle leaks excessively	Correct or replace
	(5) Nozzle not working normally	Disassemble, correct
4. Engine knocking	(1) Injection timing too fast	Adjust
	(2) Nozzle injection pressure too high	Adjust
	(3) Nozzles not working normally	Disassemble, correct
5. Engine knocks seriously producing excessive exhaust smoke	(1) Injection timing incorrect	Adjust
	(2) Nozzle injection pressure too low	Adjust
	(3) Nozzle spring broken	Replace
	(4) Nozzles not working normally	Replace
	(5) Plungers worn excessively	Adjust
	(6) Delivery valves seat defective	Replace
	(7) Supply of fuel excessively	Check feed pump

Complaints	Possible causes	Corrections
6. Engine output unstable	(1) Supply of fuel insufficient	Check feed pump
	(2) Air in fuel	Bleed
	(3) Water in fuel	Replace fuel
	(4) Operation of plungers unsmooth	Disassemble, correct
	(5) Movement of control rack sluggish	Disassemble, correct
	(6) Nozzles defective	Disassemble, correct
	(7) Injection starting pressure of each barrel incorrect	Adjust
	(8) Automatic timer defective	Disassemble, correct
7. Engine does not reach maximum speed	(1) Nozzles not working normally	Disassemble, correct
	(2) Governor defective	Disassemble, correct
8. Engine idling unstable	(1) Movement of control rod sluggish	Disassemble, correct
	(2) Operation of plungers unsmooth	Disassemble, correct
	(3) Control pinions not engaged with control rod correctly	Disassemble, correct

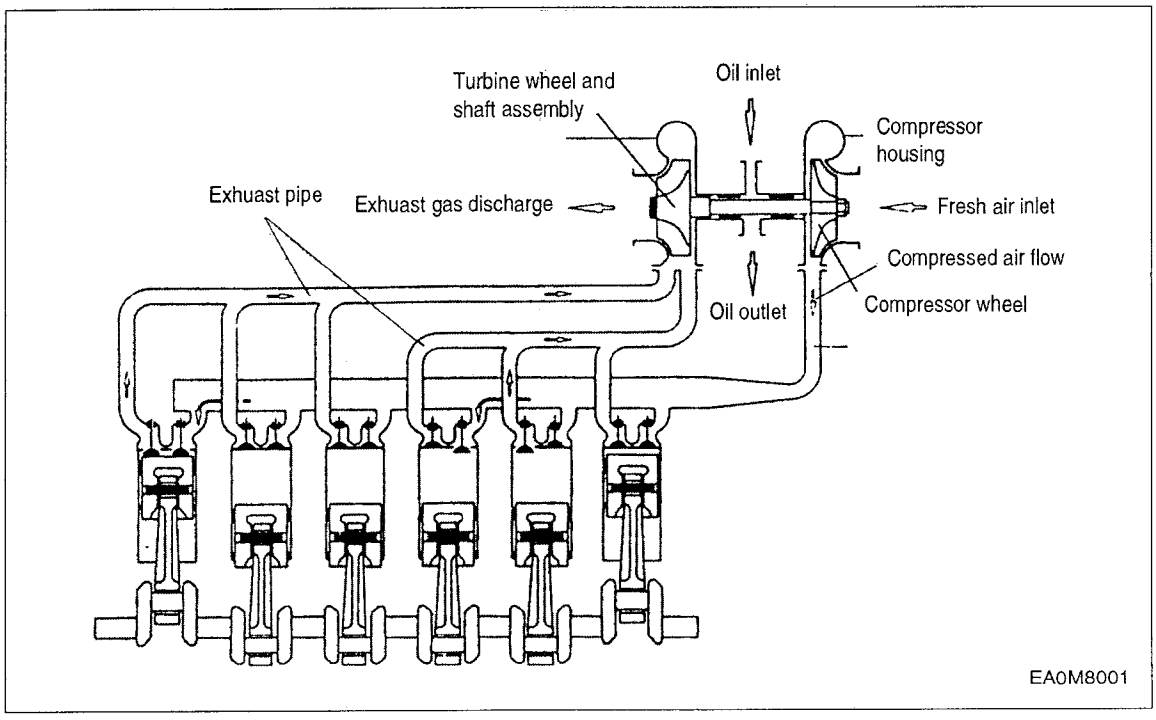
10.4. Turbocharger

10.4.1. Main data and specifications

1) Main data and specifications

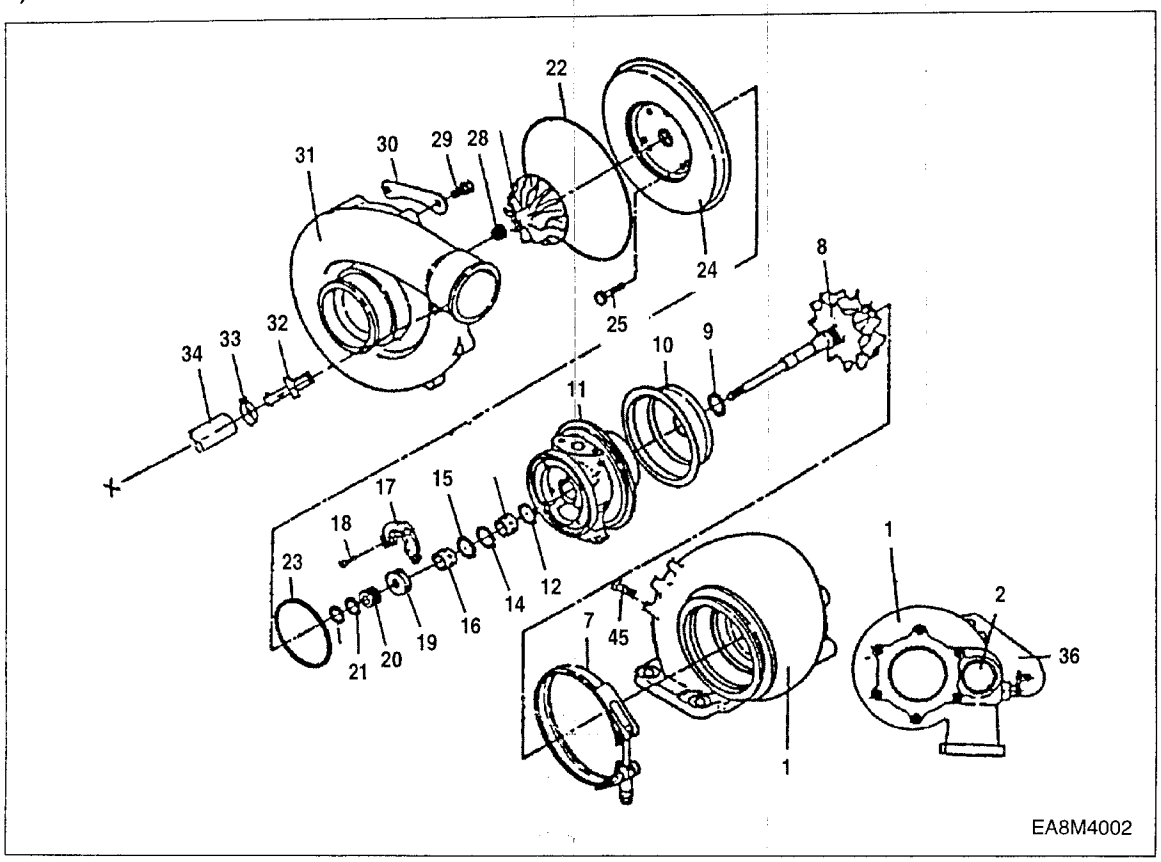
Specification		DE12T	P126TI / P126TI-1 / P126TI-II / PU126TI
Turbocharger Model		Allied Signal T45	Allied Signal TV51
At maximum output	Air pressure at compressor outlet	50 H z: Approx. 1.1 kg/cm^2 60 Hz : Approx. 1.2 kg/cm^2	50 Hz : Approx. 1.5 kg/cm^2 60 Hz : Approx. 1.8 kg/cm^2
	Air suction volume	50 Hz : Approx. 12.5 m^3/min 60 Hz : Approx. 15.0 m^3/min	50 Hz : Approx.18.0 m^3/min 60 Hz : Approx. 23.6 m^3/min
	Speed of turbine revolution	50 Hz : Approx 79.270 rpm 60 Hz : Approx. 86.850 rpm	50 Hz : Approx. 75910 rpm 60 Hz : Approx. 83150 rpm
Maximum allowable speed		110,072 rpm	105,414 rpm
Max. allowable temperature of exhaust gas at turbine inlet		750°C	750°C
Lubricating system		External oil supply	External oil supply
Weight		14 kg	14 kg

2) Operating principle



The turbocharger is a system designed to make use of the engine exhaust gas energy to charge high-density air into the cylinders, thereby to increase the engine output.

3) Construction



1. Turbine housing
2. Plug
5. Crank
7. V-band
8. Wheel
9. Piston ring
10. Wheel shroud
11. Center housing
12. Retainer ring
13. Bearing
14. Retainer ring
15. Retainer ring
16. Bearing
17. Thrust collar
18. Screw
19. Thrust bearing
20. Thrust space
21. Piston ring
22. Seal ring
23. Seal ring
24. Rear plate
25. Bolt
26. Compressor wheel
27. Nut
28. Bolt
29. Clamp
30. Compressor housing
32. Elbow
38. Retainer
45. Bolt

10.4.2. General descriptions

The engine output is determined by the fuel delivery volume and engine efficiency.
To burn the supplied fuel completely to change into effective power for the engine, the volume of air enough to burn the fuel completely should be supplied into the cylinders.
Therefore, the engine output is determined substantially by the cylinder capacity, and a greater volume of compressed air is charged into cylinders of given capacity, the greater engine output can be obtained as a greater volume of air charged into the cylinders burns so much more fuel.
As explained, the compressing of air to supply into the cylinders is called "Supercharging" and the making use of the energy of exhaust gas discharged from the combustion chamber to charge the compressed air into the cylinders is called "Turbocharging".

10.4.3. Functions

1) Turbine

Exhaust gas discharged from the combustion chamber distributes its own energy to the turbine blades while passing the inside of the turbine housing, with the result that the turbine shaft can get rotating force. This is the operating principle of 'turbine', which is mounted with seal rings and heat protector to prevent exhaust gas from affecting the bearings adversely.

2) Compressor

The compressor, which is connected to the turbine over the one and same shaft to form a rotating body, takes in and compresses ambient air with rotating force transmitted from the turbine shaft. Then, the compressed air is delivered to the intake stake. This is the operating principle of the compressor.

3) Bearings

(1) Thrust bearing

The turbine wheel creates thrust force. Therefore, exercise care so that the shaft is not deviated from its the original position due to this thrust.

(2) Journal bearing

This journal bearing of floating type forms a dual oil film on both the inside and outside of the bearing so that the bearing can rotate independently. As the dual oil film plays a role as a damper, the sliding speed of the bearing surface becomes lower than the rotating speed of the shaft, resulting in assurance of stability in its movement.

(3) Sealing-Compressor shaft

The compressor is of a dual construction type composed of seal plate and seal ring to prevent the leak of compressed air or lubricating oil.

10.4.4. Precautions for operation

1) Precautions for operation of engine

The following precautions should be observed when starting, operating, or stopping the engine:

Operations	Precautions	Reasons
When starting the engine	1) Check oil level	
	2) Crank the engine with starter to check the increase in oil pressure(until the needle of pressure gauge starts to move or pressure indicator lamp is actuated) before starting the engine.	2) Abrupt starting of the engine causes the engine to rotate with oil not being distributed not only to each part but also to the turbocharger, resulting in abnormal wear or seizure on the bearing due to insufficient supply of oil.
	3) When having replaced oil, oil filter element, or lubricating parts, or when having stopped the engine for extended period of time, or in a cold place, loosen the oil pipe connections and operate the starter motor until oil is discharged. After completing the operation, be sure to retighten the oil pipe connections portion before starting the engine.	3) In the case of the engine stopped for extended time or in a cold place, oil fluidity within the pipes can be deteriorated.
Immediately after starting	1) Run the engine at idle for 5 minutes after starting off.	1) Applying load abruptly If load is abruptly applied with the engine and turbocharger rotating unsmoothly, such parts that a sufficient amount of oil has not reached can be seized up.
	2) Check each part for leakage of oil, gas, and air, and take proper measure.	2) Leakage of oil, gas, and air (especially, oil leak) causes drop in oil pressure and loss of oil. resulting in seizure of the bearing.
During operation	Check the followings: 1) Oil pressure At idle: 0.8 kg/cm^2 or more At full load: 3.0 ~ 4.8 kg/cm^2 2) If unusual sound or vibration is heard or felt, reduce engine revolutions slowly and locate the cause.	1) Excessively low oil pressure causes unusual wear or seizure of the bearing. Too high pressure causes oil leakage. 2) The engine is operated continuously with unusual sound or vibration not corrected, it can be damaged beyond repair.
When stopping the engine	1) Run the engine at idle for 5 minutes before stopping.	1) If the engine is put to a stop after being operated at high load, heat from the red-hot turbine blades is transmitted to the bearing portion and burns oil to cause seizure of the bearing metal and rotating shaft.

10.4.5. Walk-around check and servicing

As the condition of turbocharger depends greatly on how well the engine is serviced, it is very important to maintain the engine in accordance with the specified maintenance procedure.

1) Intake system

Pay particular attention to the air cleaner when servicing the intake system.

In the case of wet-type air cleaner, if the level of oil surface is lower than specified, cleaning effect is poor; if too high, the cleaner draws in oil to foul the case.

Especially, if the rotor is fouled, the sophisticatedly-tuned balance is broken to create vibration and to cause seizure and unusual wear to the bearing.

Therefore, it is very important to use a good quality air cleaner all the time.

In the case of dry-type air cleaner, it is essential to clean it to reduce intake resistance as much as possible.

2) Exhaust system

Pay particular attention to prevent gas leaks and seizure when servicing the exhaust system because leakage of exhaust gas from discharge pipes, turbocharger fixing portions, etc. lowers charging effect.

As such components as turbine chamber that becomes red-hot during operation use heat resisting steel nuts, do not interchange these nuts with ordinary steel nuts. In addition, apply anti-seizure coating to fixing nuts on the portions as designated.

3) Fuel system

If the full load stopper regulating the maximum injection volume and the maximum speed stopper regulating the maximum speed in the fuel injection pump are adjusted without using a pump tester, the turbocharger rotates at excessively rapid speed and may suffer damage.

Besides of it, if spray pattern from the fuel injection nozzles is bad or the injection timing is incorrect, temperature of exhaust gas rises up to affect the turbocharger adversely. To avoid such trouble, be sure to make a nozzle test.

4) Lubricating system

Pay particular attention to oil quality and oil filter change intervals when servicing the lubricating system. Deteriorated engine oil affects adversely not only the engine but torso the turbocharger.

Suggested engine oils for the turbocharger-mounted engine are as follows:

- SAE 15W30
- API grade CD or CE

10.4.6. Periodical checking and servicing

Make it a rule to check the turbocharger assembly for condition and contamination periodically.

1) Guide for checking the rotor for rotating condition

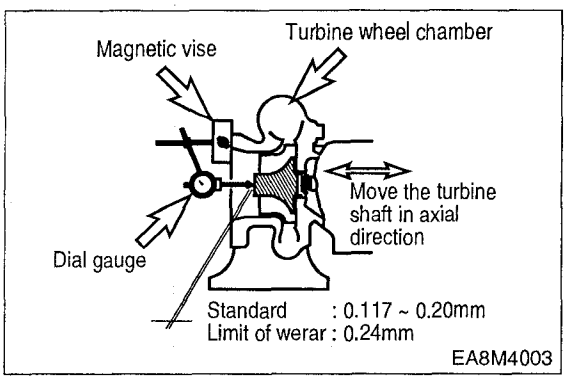
The inspection of the rotor assembly for rotating condition should be performed by the degree of unusual sound. If a sound detecting bar is used, install its tip on the turbocharger housing and increase the engine revolutions slowly. If a high-pitch sound is heard continuously, it means that the rotor assembly is not normal. In this case, as the metal bearing and rotor are likely to be in abnormal conditions, the turbocharger should be replaced or repaired.

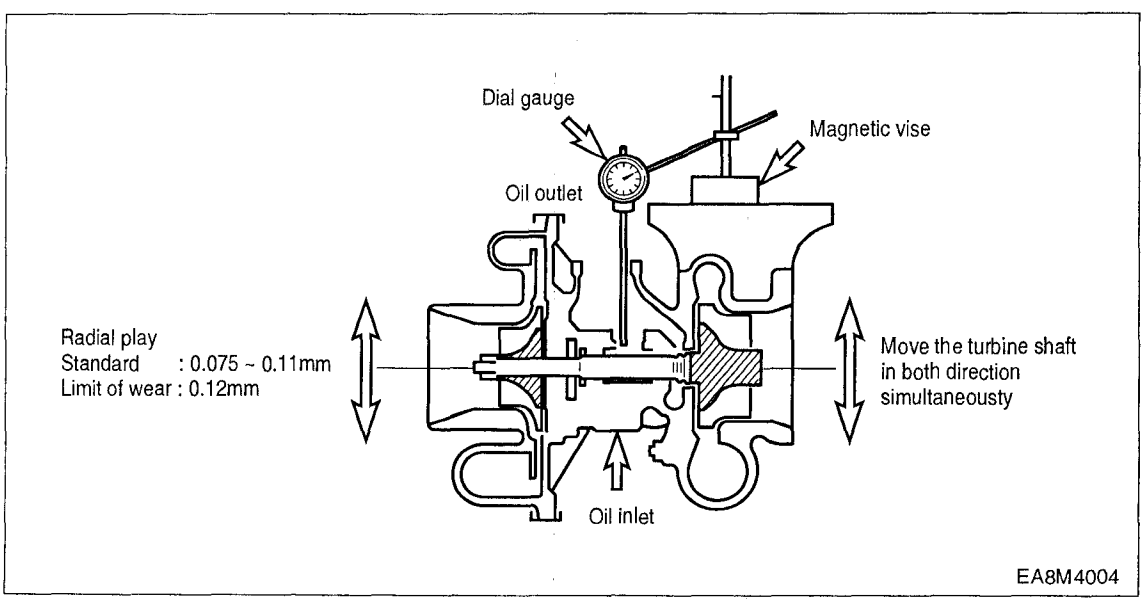
2) Guide for checking rotor end play

Disassemble the turbocharger from the engine, then check the rotor axial play and radial play. When disassembling the turbocharger, be sure to plug the oil inlet and outlet ports with taps, etc.

(1) Rotor axial play

(2) Rotor radial play





(3) If the measured axial and radial plays are beyond the limit of wear, replace or repair the turbocharger.

3) Guide for disassembling/cleaning and checking the turbocharger

First, disassemble the turbocharger from the engine and clean/check it with the oil inlet and outlet plugged with tape and so on.

4) Precautions for reassembling the tarbocharger onto the engine

For reassembly of the turbocharger or handling it after reassembly operation, be sure to observe the following precautions:

Especially, exercise extreme care to prevent foreign matters from entering the inside of the turbocharger.

(1) Lubricating system

- Before reassembling the turbocharger onto the engine, inject new oil in the oil inlet port and lubricate the journal and thrust bearings by rotating them with hand .
- Clean not only the pipes installed between the engine and oil inlet port but also the oil outlet pipe and check them for damage or foreign matters.
- Assemble each joint on oil pipes securely to prevent oil leaks.

(2) Intake system

- Check the inside of the intake system for foreign matters.
- Assemble each joint on the intake duct and air cleaner securely to prevent air leaks.

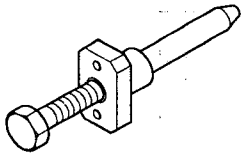
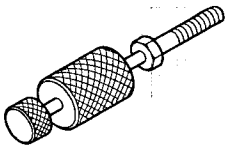
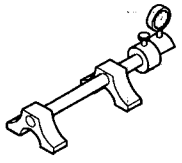
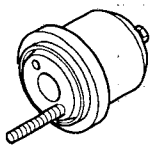
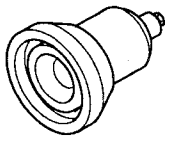
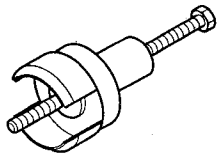
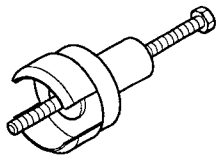
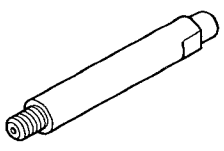
(3) Exhaust system

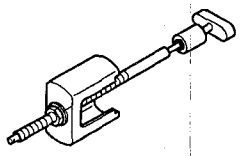
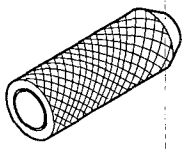
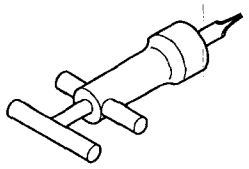
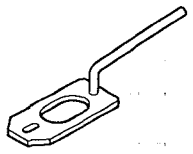
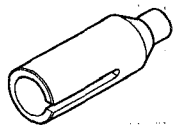
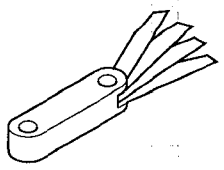
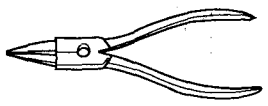
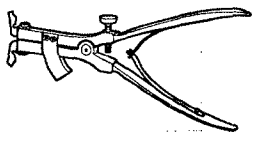
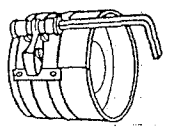
- Check the inside of the exhaust system for foreign matters.
- Be sure to use heat resisting steel bolts and nuts. Do not interchange them with ordinary steel bolts and nuts when performing reassembly operation. Apply anti-seizure coating to the bolts and nuts.
- Assemble each joint on the exhaust pipes securely to prevent gas leaks

10.4.7. Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Excessive black smoke	1) Air cleaner element clogged	Replace or clean
	2) Restrictions in air duct	Check and correct
	3) Leakage at intake manifold	Check and correct
	4) Turbocharger seized up and not rotating	Disassemble/repair or replace
	5) Turbine blades and compressor blades coming in contact with each other or damaged	Disassemble/repair or replace
	6) Exhaust piping deformed or clogged	Check and correct
2. Excessive white smoke	1) Oil leak into turbine and compressor	Disassemble/repair or replace
	2) Worn or damaged seal ring due to excessive wear of bearing	Disassemble/repair or replace
3. Low engine output	1) Gas leak at each part of exhaust system	Check and correct
	2) Air cleaner element restricted	Replace or clean
	3) Turbocharger fouled or damaged	Disassemble/repair or replace
	4) Leakage at discharge port on compressor side	Check and correct
4. Unusual sound contact	1) Rotor assembly coming in contact	Disassemble/Repair or replace
	2) Unbalanced rotation of rotor	Disassemble/Repair or replace
	3) Seized up	Disassemble/Repair or replace
	4) Each joint loosened	Check and correct

11. Special Tool List

No	Part no.	Figure	Tool name
1	DPN-5337		Nozzle tube insert ass'y
2	EF.123-082		Nozzle tube extractor
3	EF.123-015		Injection pump setting ass'y
4	EF.123-173		Oil seal(NOK) insert ass'y (FR)
5	EF.123-194A		Oil seal(NOK) insert ass'y (RR)
6	EF.123-317A		Oil seal(NOK)puller ass'y (FR)
7	EF.123-316A		Oil seal(NOK) puller ass'y (RR)
8	EF.123-347		Cylinder pressure tester adapter

No	Part no.	Figure	Tool name
9	EF.123-087		Cylinder liner puller ass'y
10	EF.123-066		Valve stem seal punch3
11	EU.2-0131		Valve clearance adjust ass'y
12	EF.123.-065		Valve spring press
13	EU.2-0647		Crankshaft gear punch
14	60.99901-0027		Feeler gauge
15	T7610001E		Snap ring plier
16	T7621010E		Piston ring plier
17	EF.120-208		Piston Ring Compressor

Appendix

● Tightening torque for major parts

Major Parts	Screw (Diameter x pitch)	Strength (grade)	Tightening Torque	Remarks
Cylinder head bolt	M14 x 1.5	10.9T	1st : 6 kg·m 2nd : 90° 3rd: 90° Finished : 90° (angle torque)	Dodecagon
Cylinder head cover bolt	M8	8.8T	1.2 kg·m	
Connecting rod bearing cap bolt	M16 x 1.5	12.9T	1st : 15 kg·m 2nd : 22 kg·m 3rd : 30 kg·m	
Crankshaft main bearing cap bolt	M16 x 1.5	12.9T	1st : 15 kg·m 2nd : 25 kg·m 3rd : 30 kg·m	
Balance weight fixing bolt	M14 x 1.5	10.9T	14.0 kg·m	Split type
Flywheel fixing bolt	M14 x 1.5	10.9T	18.0 kg·m	
Crankshaft pulley fixing bolt	M12 x 1.5	12.9T	13.4 kg·m	
Oil spray nozzle	M6	8.8T	1.0 kg·m	

● Tightening torque for injection pump system

Major Parts	Screw (Diameter x pitch)	Strength (grade)	Tightening Torque	Remarks
Injection nozzle holder nut	M6	8.8T	1.0 kg·m	
Injection pump bracket	M10	8.8T	4.4 kg·m	
Injection pump coupling bolt	M10	-	6.0 kg·m	
Injection pump driving gear nut	M24 x 1.5	8.8T	25.0 kg·m	
High pressure injection pipe fixing cap nut	M14 x 1.5	8.8T	3.0 kg·m	
Injection pump delivery valve holder	-	-	13 ~ 14 kg·m	

● Standard bolt tightening torque table

Refer to the following table for bolts other than described above.

	Degree of strength										
	3.6	4.6	4.8	5.6	5.8	6.6	6.8	6.9	8.8	10.9	12.9
	(4A)	(4D)	(4S)	(5D)	(5S)	(6D)	(6S)	(6G)	(8G)	(10K)	(12K)
	Limit value for elasticity (kg/mm²)										
	20	24	32	30	40	36	49	54	64	90	108
	Tightening torque (kg·m)										
M5	0.15	0.16	0.25	0.22	0.31	0.28	0.43	0.48	0.5	0.75	0.9
M6	0.28	0.30	0.45	0.4	0.55	0.47	0.77	0.85	0.9	1.25	0.5
M7	0.43	0.46	0.7	0.63	0.83	0.78	1.2	1.3	1.4	1.95	2.35
M8	0.7	0.75	1.1	1	1.4	1.25	1.9	2.1	2.2	3.1	3.8
M8 x 1	0.73	0.8	1.2	1.1	1.5	1.34	2.1	2.3	2.4	3.35	4.1
M10	1.35	1.4	2.2	1.9	2.7	2.35	3.7	4.2	4.4	6.2	7.4
M10 x 1	1.5	1.6	2.5	2.1	3.1	2.8	4.3	4.9	5	7	8.4
M12	2.4	2.5	3.7	3.3	4.7	4.2	6.3	7.2	7.5	10.5	12.5
M12 x 1.5	2.55	2.7	4	3.5	5	4.6	6.8	7.7	8	11.2	13.4
M14	3.7	3.9	6	5.2	7.5	7	10	11.5	12	17	20
M14 x 1.5	4.1	4.3	6.6	5.7	8.3	7.5	11.1	12.5	13	18.5	22
M16	5.6	6	9	8	11.5	10.5	17.9	18.5	18	26	31
M16 x 1.5	6.2	6.5	9.7	8.6	12.5	11.3	17	19.5	20	28	33
M18	7.8	8.3	12.5	11	16	14.5	21	24.2	25	36	43
M18 x 1.5	9.1	9.5	14.5	12.5	18.5	16.7	24.5	27.5	28	41	49
M20	11.5	12	18	16	22	19	31.5	35	36	51	60
M20 x 1.5	12.8	13.5	20.5	18	25	22.5	35	39.5	41	58	68
M22	15.5	16	24.5	21	30	26	42	46	49	67	75
M22 x 1.5	17	18.5	28	24	34	29	47	52	56	75	85
M24	20.5	21.5	33	27	40	34	55	58	63	82	92
M24 x 1.5	23	25	37	31	45	38	61	67	74	93	103

Others :

1. The above torque rating have been determined to 70% or so of the limit value for bolt elasticity.
2. Tension is calculated by multiplying tensile strength by cross section of thread.
3. Special screws should be tightened to 85% or so of the standard value.

   For example, a screw coated with MoS2 should be tightened to 60% or so of the standard value.

● Maintenance specification table

Unit : mm

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Engine body	Cylinder block & liner	Inside diameter of cylinder liner for wear		Ø123 ~ Ø123.023	Ø123.223	Replace liner	Measure unworn portion beneath the rim of upper side
		Projected portion of liner		0.03 ~ 0.08	-		
		The upper surface of cylinder block for distortion		0.05 / 200	-	Correct with a surface grinder	Per distortion length for 200 mm
		Hydraulic test for 1 minute (kg/cm²)		4	-		
	Cylinder head & valve	Valve seat depression	Intake	0 ~ 0.3	0.55		In case of new valve and seat
			Exhaust	0 ~ 0.3	0.55		
		Height		114.95 ~ 115	113.9	Replace cylinder head	
		Hydraulic test for 1 minute (kg/cm²)		4	-	Replace if leaky	Water temperature 70°C
Major moving parts	Piston	Piston diameter	18mm	Ø122.870±0.007	-		
			88mm	Ø122.750±0.009	-		
			124mm	Ø122.450±0.010	-		
		Clearance between piston and liner		0.109 ~ 0.166	-		
		Width of piston ring grooves	Top ring	3.5	-	Replace piston if groove width is beyond specified value	
			2nd ring	3.060 ~ 3.080	-		
			Oil ring	4.040 ~ 4.060	-		
		Piston projection from cylinder block upper surface		0 ~ 0.12	-		Measure unworn portion beneath the rim of upper side
		Permissible weight difference of each piston		±15 g	Max. 96 g	Replace piston	

Unit : mm

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Piston ring	Piston ring gap	Top ring	0.30 ~ 0.45	1.5		Standard gauge inside diameter : Ø123
			2nd ring	1.0 ~ 1.2	2.0		
			Oil ring	0.30 ~ 0.50	1.5		
		Piston ring groove clearance	Top ring	0.105 ~ 0.155	-	Replace ring or piston	Limit for use if for standard clearance
			2nd ring	0.07 ~ 0.102	0.15		
			Oil ring	0.05 ~ 0.085	0.15		
		Direction of ring gap		-	-	Install ring by 120°	
	Crank shaft	Axial run-out of journal and pin		0.05	0.1	Correct with a grinder	In horizontal and vertical directions
		Outside diameter of journal		Ø95.966 ~ Ø95.988	Ø95	Replace crankshaft	Ø96 g6
		Outside diameter of pin		Ø82.966 ~ Ø82.988	Ø82	Replace crankshaft	Ø83 g6
		Out of round of journal & pin		0.008	0.025		
		Permissible radial run out of journal & pin		0.01	0.03		
		Permissible taper of journal & pin		0.01	0.03		
		Clearance between crankshaft and bearing		0.072 ~ 0.142	0.25	Replace bearing	Measure in the position of crown
		End play of crankshaft		0.15 ~ 0.325	0.5	Replace thrust bearing	
		Run-out of crankshaft		0.05	0.1 or less	Adjust by a press if bent	No.4 bearing (holding no. 1 & 7)
		Balance of crankshaft		60	60 or less	Check dynamic balance	Measure at 400 rpm

Unit : mm

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Crank shaft	Tightening torque of journal bearing cap bolt (kg·m)	30	-	Apply oil to bolt	No foreign matters on bearing cap installing surface
		Journal bearing crush	0.15 ~ 0.25	-		Measure by tightening metal cap & then loosening one stud bolt
		Oil seal for wear	-	-	Replace oil seal if oil leaking	Replace with new one, use shim
	Connecting rod	Clearance between con-rod bearing & crank pin	0.032 ~ 0.102	0.20	Replace bearing	
		End play of con-rod crush	0.22 ~ 0.319	0.5	Replace con.-rod	
		Clearance between small end bush & piston pin	0.050 ~ 0.080	0.12		
		Connecting rod bearing crush height	0.086 ~ 0.116	-		After completing installation of bearing, loosen one stud bolt and measure
		Permissible weight difference of each con-rod	±18 g	-		
		Tightening torque of con-rod bearing cap bolt (kg·m)	28	-	Apply oil to bolt	
	Cam shaft	Outside diameter of cam shaft	Ø59.860 ~ Ø59.880	Ø59.52		Ø60
		Clearance between cam shaft and bush	0.050 ~ 0.128	0.20		
		Axial play of camshaft	0.13 ~ 0.27	0.30	Replace thrust plate	
	Timing gear	Clearance between idle gear shaft and inserting hole	0.025 ~ 0.091	0.15		
		End play of idle gear shaft	0.043 ~ 0.167	0.3	Replace thrust collar	
		Between crank gear & idle gear	0.16 ~ 0.28	0.35	Replace gear	
		Between idle gear & camshaft gear	0.16 ~ 0.20	0.35		

Unit : mm

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Valve system	Valve	Outside diameter of intake valve stem		Ø8.950 ~ Ø8.970	Ø0.02	Replace valve & valve guide	Replace valve guide together when replacing valve
		Outside diameter of exhaust valve stem		Ø8.935 ~ Ø8.955	Ø0.02		
		Clearance between valve stem and valve guide	Intake	0.03 ~ 0.065	0.15	Replace valve & guide	
			Exhaust	0.045 ~ 0.080	0.15	Replace	
		Thickness of valve	Intake	1.5	1 or more	Replace	
			Exhaust	1.5	0.9 or more		
		Perm. radial run-out between valve stem & valve head	Intake	0.04 ~ 0.07	0.2	Replace	
			Exhaust	0.06 ~ 0.09	0.25		
		Clearance between valve guide & cylinder head installing hole		0.01 ~ 0.39	-		Apply oil to valve guide & press in
		Clearance between valve guide & valve spring seat	Intake	22	-		
			Exhaust	22	-		

Unit : mm

Group	Part	Inspection item			Stand value for assembly	Limit for use	Correction	Remark
Valve system	Valve	Intake spring	Free length		75.5	72		
			Spring tension (set length : 37 mm) kg		61.8 ~ 68.3	61.8		
			Straightness (against free length)		1.0	2.0		
		Exhaust spring	Inner	Free length	65	61.75		
				Spring tension (set length : 34mm) kg	36.1 ~ 39.9	36.1	Replace valve spring	
				Straightness (against free length)	1.0	2.0		
			Outer	Free length	75.5	72		
				Spring tension (set length : 37mm) kg	61.8 ~ 68.3	61.8	Replace valve spring	
				Straightness (against free length)	1.0	2.0		
		Valve clearance (at cold)		Intake	0.3	-	Adjust	
				Exhaust	0.3	-		
		Contacting face of valve stem & rocker arm			-	-	Correct or replace if severely pitted on tip of arm and stem	
		Clearance between rocker arm shaft & rocker arm bush			0.020 ~ 0.093	0.25	Replace bush or shaft	
		Rocker arm shaft for wear			Ø23.978 ~ Ø23.959	Ø23.75	Replace	
		Permissible taper of push rod			0.3	-	Replace	
	Tappet	Clearance between tappet & cylinder block			0.035 ~ 0.077	0.1	Replace tappet	
		Outside diameter of tappet			Ø19.944 ~Ø19.965	19.89	Replace tappet	
		Contacting face of tappet & cam			-	-	Replace if excessively worn of deformed	

Unit : mm

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark
Lubricating system	Oil pressure	Oil pressure (normal speed) (kg/cm²)	4.5 or less	3.5	Correct oil leakage and clearance between each part	
		Oil pressure (idling) (kg/cm²)	0.8 ~ 1.4	0.6	Use suggested oil	
	Oil temperature	Max. permissible oil temperature (°C)	-	105		Temperature above this not allowable
		Permissible oil temperature in short time (°C)	-	120		
	Oil pump	Axial play of oil pump gear	0.055 ~ 0.105	-	Replace gear or cover	
		Clearance between gear shaft & oil pump over hole	0.032 ~ 0.068	-		
		Clearance between drive gear bushing & cover hole	0.040 ~ 0.082	-	Replace bushing or cover	
		Outside diameter of gear shaft	Ø16.950 ~ Ø16.968	-	Replace gear	Ø17e7
		Outside diameter of drive gear bushing	Ø27.939 ~ Ø27.960	-	Replace bushing	Ø28e7
		Backlash: Between crank gear & oil pump drive gear	0.15 ~ 0.25	0.8	Adjust backlash	
		Backlash: Between oil pump drive gear & intermediate gear	0.15 ~ 0.25	0.8		
	Valve opening pressure	Oil pressure control valve (kg/cm²)	4.3 ~ 4.7	-	Replace valve	
		By-pass valve for filter element (kg/cm²)	1.8 ~ 2.3	-		
		By-pass valve for full oil filter (kg/cm²)	4.0 ~ 4.8	-		
		By-pass valve for oil cooler (kg/cm²)	5 ~ 6	-		
		Relief valve for oil pump (kg/cm²)	8.5 ~ 11.5	-		
		Control valve for spray nozzle (kg/cm²)	1.5 ~ 1.8	-		
	Oil filter	Oil filter element for damage	-	-	Clean or replace	

Unit : mm

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark
Cooling system	Radiator	Radiator & water pump for corrosion, damage & improper connecting	-	-	Correct or replace	
		Test for leakage (air pressure) (kg/cm²)	1.0	-	Submerge in water and replace if air bubbles found	
		Pressure valve for opening pressure (kg/cm²)	0.5	-		
		Negative pressure valve for opening pressure (kg/cm²)	0.2	-		
	Water pump	Delivery volume l / min - Pumping speed 2,234 rpm - Operating temp. 71 ~ 85 °C - Back pressure : 1 kg/cm²	Approx. 280 ℓ	-		
		Clearance between pump impeller & pump body	0.3 ~ 0.6	-	Replace if contacted impeller & pump body	
	Cooling water temp	Operating temperature (permissible temp.) (°C)	90 ~ 95	95	Temperature above this not allowable	
		Permissible temperature in a short time (°C)	103	103		
	Thermostat	Thermostat opening temperature (°C) (under atmospheric pressure)	83	-	Replace if defective	
		Full operating temp. (°C)	95 or lower	-		Stroke : min. 8 mm

Unit : mm

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark
Fuel System	Piping and the other	Fuel pipe, injection pipe & Nozzle holder for damage, cracks, loose-ness, bad packing	-	-	Correct or replace	
		Fuel filter element for damage	-	-	Clean or replace	
	Injection pressure of injection nozzle (kg/cm^2)		220	-	Adjust by shim	1st : 160, 2nd : 220
	Opening pressure of overflow valve (kg/cm^2)		1.6	-	Replace valve	
	Height of projected nozzle on the cyl. head (mm)		4.3	-	Replace cylinder head and nozzle	
	Clearance between injection pump coupling and cou pling (mm)		0.2 ~ 0.4	-		
Inspection at completion	Running-in the engine		-	-	Refer to supplement "running-in"	Retighten head bolt after running in
	Cylinder pressure	Cylinder compression pressure of cylinder (kg/cm^2)	25 ~ 28	24 or less	Overhaul the engine	
		Compression pressure difference of each cylinder	±10% or less against average	-	Correct	at 200 rpm or more (20°C)