Hitachi Construction Machinery Co., Ltd.

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ZX200-5G • 200LC-5G • 210H-5G • 210LCH-5G • 210K-5G • 210LCK-5G HYDRAULIC EXCAVATOR TECHNICAL MANUAL TROUBLESHOOTING TTDCD-EN-00

PART NO. TTDCD-EN-00

HITACHI

Reliable solutions

Technical Manual

Troubleshooting

ZX

200-5G
200LC-5G
210H-5G
210LCH-5G
210K-5G
210LCK-5G

Hydraulic Excavator

Service Manual consists of the following separate Part No.

Technical Manual (Operational Principle)	: Vol. No.TODCD-EN
Technical Manual (Troubleshooting)	: Vol. No.TTDCD-EN
Workshop Manual	: Vol. No.WDCD-EN
Engine Manual	: Vol. No.EDCD-EN

INTRODUCTION

To The Reader

This manual is written for an experienced technician to provide technical information needed to maintain and repair this machine.

- Be sure to thoroughly read this manual for correct product information and service procedures.

- If you have any questions or comments, at if you found any errors regarding the contents of this manual, please contact using “Service Manual Revision Request Form” at the end of this manual. (Note: Do not tear off the form. Copy it for usage.):
  - Publications Marketing & Product Support Hitachi Construction Machinery Co. Ltd.
  - TEL: 81-29-832-7084
  - FAX: 81-29-831-1162
  - E-mail: dc@hitachi-kenki.com

Additional References

Please refer to the other materials (operator’s manual, parts catalog, engine technical material and Hitachi training material etc.) in addition to this manual.

Manual Composition

This manual consists the Technical Manual, the Workshop Manual and the Engine Manual.

- Information included in the Technical Manual:
Technical information needed for redelivery and delivery, operation and activation of all devices and systems, operational performance tests, and troubleshooting procedures.

- Information included in the Workshop Manual:
Technical information needed for maintenance and repair of the machine, tools and devices needed for maintenance and repair, maintenance standards, and removal / installation and assemble / disassemble procedures.

- Information included in the Engine Manual:
Technical information needed for redelivery and delivery and maintenance and repair of the machine, operation and activation of all devices and systems, troubleshooting and assemble / disassemble procedures.

Page Number

Each page has a number, located on the center lower part of the page, and each number contains the following information:

Example:

- Technical Manual: T 1-3-5

T	Technical Manual
1	Section Number
3	Group Number
5	Consecutive Page Number for Each Group

- Workshop Manual: W 1-3-2-5

W	Workshop Manual
1	Section Number
3	Group Number
2	Sub Group Number
5	Consecutive Page Number for Each Group

Safety Alert Symbol and Headline Notations

In this manual, the following safety alert symbol and signal words are used to alert the reader to the potential for personal injury of machine damage.

This is the safety alert symbol. When you see this symbol, be alert to the potential for personal injury.
Never fail to follow the safety instructions prescribed along with the safety alert symbol.
The safety alert symbol is also used to draw attention to component/part weights.
To avoid injury and damage, be sure to use appropriate lifting techniques and equipment when lifting heavy parts.

CAUTION:
Indicated potentially hazardous situation which could, if not avoided, result in personal injury or death.

IMPORTANT:
Indicates a situation which, if not conformed to the instructions, could result in damage to the machine.

NOTE:
Indicates supplementary technical information or know-how.

Units Used

SI Units (International System of Units) are used in this manual. MKSA system units and English units are also indicated in parentheses just behind SI units.

Example: 24.5 MPa (250 kgf/cm^2, 3560 psi)

A table for conversion from SI units to other system units is shown below for reference purposes.

Quantity	To Convert From	Into	Multiply By
Length	mm	in	0.03937
	mm	ft	0.003281
Volume	L	US gal	0.2642
	L	US qt	1.057
	m^3	yd^3	1.308
Weight	kg	lb	2.205
Force	N	kgf	0.10197
	N	lbf	0.2248
Torque	N·m	kgf·m	0.10197
Pressure	MPa	kgf/cm^2	10.197
	MPa	psi	145.0
Power	kW	PS	1.360
	kW	HP	1.341
Temperature	°C	°F	°C×1.8+32
Velocity	km/h	mph	0.6214
	min^{-1}	rpm	1.0
Flow rate	L/min	US gpm	0.2642
	mL/rev	cc/rev	1.0

NOTE: The numerical value in this manual might be different from the above-mentioned table.

SYMBOL AND ABBREVIATION

Symbol / Abbreviation	Name	Explanation
TO	Technical manual (Operational principle)	Technical manual (Operational Principle).
TT	Technical manual (Troubleshooting)	Technical manual (Troubleshooting).
T/M	Technical manual	Technical manual.
W, W/M	Workshop manual	Workshop manual (Removal and Installation, Disassembly and Assembly).
MC	Main Controller	Main controller. MC controls the engine, pump, and valve according to the machine operating condition.
ECF	Engine Controller	Engine controller. ECF controls EC motor according to the machine operating condition.
GSM	Global System for Mobile communications controller	Communication controller. GSM is a type of wireless communication system, is used in more than on 100 countries around Europe and Asia, and becomes the factual global standards of the mobile telephone.
GPS	Global Positioning System	Global positioning system.
CAN	Controller Area Network	CAN communication. CAN is a serial communications protocol internationally-standardized by ISO (International Organization for Standardization).
A/C	Air Conditioner	Air conditioner.
OP, OPT	Option	Optional component.
MPDr.	Maintenance Pro Dr.	MPDr. is software that troubleshooting, monitoring, and adjustment.
A/I	Auto-Idle	Auto-idle.
WU	Warming-Up	Warming-up.
Li	Low (Slow) Idle	Slow idle engine speed.
ATT	Attachment	Attachment. Attachment is optional parts such as breaker, crusher, and pulverizer in this manual.
HI, Hi	High	Travel fast position.
LO, Lo	Low	Travel slow position.

(Blank)

Recognize Safety Information

- These are the **SAFETY ALERT SYMBOLS**.
  - When you see these symbols on your machine or in this manual, be alert to the potential for personal injury.
  - Follow recommended precautions and safe operating practices.

SA-688

Understand Signal Words

- On machine safety signs, signal words designating the degree or level of hazard - DANGER, WARNING, or CAUTION - are used with the safety alert symbol.
  - **DANGER** indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
  - **WARNING** indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
  - **CAUTION** indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.
  - **DANGER or WARNING safety signs** are located near specific hazards. General precautions are listed on **CAUTION safety signs.**
  - Some safety signs do not use any of the designated signal words above after the safety alert symbol are occasionally used on this machine.

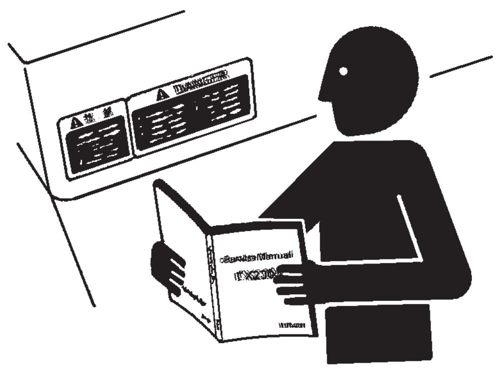
SA-1223

- To avoid confusing machine protection with personal safety messages, a signal word **IMPORTANT** indicates a situation which, if not avoided, could result in damage to the machine.

- ***NOTE***: indicates an additional explanation for an element of information.

Follow Safety Instructions

- Carefully read and follow all safety signs on the machine and all safety messages in this manual.
- Safety signs should be installed, maintained and replaced when necessary.
  - If a safety sign or this manual is damaged or missing, order a replacement from your authorized dealer in the same way you order other replacement parts (be sure to state machine model and serial number when ordering).
- Learn how to operate the machine and its controls correctly and safely.
- Allow only trained, qualified, authorized personnel to operate the machine.
- Keep your machine in proper working condition.
  - Unauthorized modifications of the machine may impair its function and/or safety and affect machine life.
  - Do not modify any machine parts without authorization. Failure to do so may deteriorate the part safety, function, and/or service life. In addition, personal accident, machine trouble, and/or damage to material caused by unauthorized modifications will void Hitachi Warranty Policy.
  - Never attempt to modify or disassemble the inlet/exhaust parts and the muffler filter. Avoid giving shocks on the muffler filter by striking elements with other objects or dropping the elements. Failure to do so may affect the exhaust gas purifying device, possibly damaging it or lowering its performance.
  - Do not use attachments and/or optional parts or equipment not authorized by Hitachi. Failure to do so may deteriorate the safety, function, and/or service life of the machine. In addition, personal accident, machine trouble, and/or damage to material caused by using unauthorized attachments and/or optional parts or equipment will void Hitachi Warranty Policy.
- The safety messages in this SAFETY chapter are intended to illustrate basic safety procedures of machines. However it is impossible for these safety messages to cover every hazardous situation you may encounter. If you have any questions, you should first consult your supervisor and/or your authorized dealer before operating or performing maintenance work on the machine.



SA-003

Prepare for Emergencies

- Be prepared if a fire starts or if an accident occurs.
  - Keep a first aid kit and fire extinguisher on hand.
  - Thoroughly read and understand the label attached on the fire extinguisher to use it properly.
  - To ensure that a fire extinguisher can be always used when necessary, check and service the fire extinguisher at the recommended intervals as specified in the fire extinguisher manual.
  - Establish emergency procedure guidelines to cope with fires and accidents.
  - Keep emergency numbers for doctors, ambulance service, hospital, and fire department posted near your telephone.

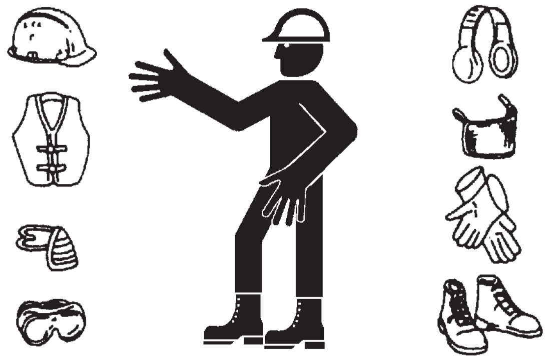
SA-437

Wear Protective Clothing

- Wear close fitting clothing and safety equipment appropriate to the job.

  You may need:
  A hard hat
  Safety shoes
  Safety glasses, goggles, or face shield
  Heavy gloves
  Hearing protection
  Reflective clothing
  Wet weather gear
  Respirator or filter mask.

  Be sure to wear the correct equipment and clothing for the job. Do not take any chances.
  - Avoid wearing loose clothing, jewelry, or other items that can catch on control levers or other parts of the machine.
- Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating the machine.



SA-438

Protect Against Noise

- Prolonged exposure to loud noise can cause impairment or loss of hearing.
  - Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortably loud noises.

SA-434

Inspect Machine

- Inspect your machine carefully each day or shift by walking around it before you start it to avoid personal injury.
  - In the walk-around inspection be sure to cover all points described in the "Inspect Machine Daily Before Starting" section in the operator’s manual.

SA-435

General Precautions for Cab

- Before entering the cab, thoroughly remove all dirt and/or oil from the soles of your work boots. If any controls such as a pedal is operated while with dirt and/or oil on the soles of the operator's work boots, the operator's foot may slip off the pedal, possibly resulting in a personal accident.
- Do not leave parts and/or tools lying around the operator's seat. Store them in their specified locations.
- Avoid storing transparent bottles in the cab. Do not attach any transparent type window decorations on the windowpanes as they may focus sunlight, possibly starting a fire.
- Refrain from listening to the radio, or using music headphones or mobile telephones in the cab while operating the machine.
- Keep all flammable objects and/or explosives away from the machine.
- After using the ashtray, always cover it to extinguish the match and/or tobacco.
- Do not leave cigarette lighters in the cab. When the temperature in the cab increases, the lighter may explode.

Use Handholds and Steps

- Falling is one of the major causes of personal injury.
  - When you get on and off the machine, always face the machine and maintain a three-point contact with the steps and handrails.
  - Do not use any controls as hand-holds.
  - Never jump on or off the machine. Never mount or dismount a moving machine.
  - Be careful of slippery conditions on platforms, steps, and handrails when leaving the machine.
  - Never get on and off the machine with tools in your hands.

SA-439

Adjust the Operator's Seat

- A poorly adjusted seat for either the operator or for the work at hand may quickly fatigue the operator leading to misoperations.
  - The seat should be adjusted whenever changing the operator for the machine.
  - The operator should be able to fully depress the pedals and to correctly operate the control levers with his back against the seat back.
  - If not, move the seat forward or backward, and check again.
  - Adjust the rear view mirror position so that the best rear visibility is obtained from the operator’s seat. If the mirror is broken, immediately replace it with a new one.

SA-378

Ensure Safety Before Rising from or Leaving Operator's Seat

- Before rising from the operator's seat to open/close either side window or to adjust the seat position, be sure to first lower the front attachment to the ground and then move the pilot control shut-off lever to the LOCK position. Failure to do so may allow the machine to unexpectedly move when a body part unintentionally comes in contact with a control lever and/or pedal, possibly resulting in serious personal injury or death.
- Before leaving the machine, be sure to first lower the front attachment to the ground and then move the pilot control shut-off lever to the LOCK position. Turn the key switch OFF to stop the engine.
- Before leaving the machine, close all windows, doors, and access covers and lock them up.

Fasten Your Seat Belt

- If the machine should overturn, the operator may become injured and/or thrown from the cab. Additionally the operator may be crushed by the overturning machine, resulting in serious injury or death.
  - Prior to operating the machine, thoroughly examine webbing, buckle and attaching hardware. If any item is damaged or worn, replace the seat belt or component before operating the machine.
  - Be sure to remain seated with the seat belt securely fastened at all times when the machine is in operation to minimize the chance of injury from an accident.
  - We recommend that the seat belt be replaced every three years regardless of its apparent condition.

SA-237

Move and Operate Machine Safely

SA-426

- Bystanders can be run over.
  - Take extra care not to run over bystanders. Confirm the location of bystanders before moving, swinging, or operating the machine.
  - Always keep the travel alarm and horn in working condition (if equipped). It warns people when the machine starts to move.
  - Use a signal person when moving, swinging, or operating the machine in congested areas. Coordinate hand signals before starting the machine.
  - Use appropriate illumination. Check that all lights are operable before operating the machine. If any faulty illumination is present, immediately repair it.
  - Ensure the cab door, windows, doors and covers are securely locked.
  - Check the mirrors and the monitor in the CAB for problems.
    If there is, replace the problem part (s) or clean the mirror, camera and the monitor.
    Refer to Rear View Monitor section on the cleaning of the camera and the monitor in the operator's manual.

Operate Only from Operator's Seat

SA-444

- Inappropriate engine starting procedures may cause the machine to runaway, possibly resulting in serious injury or death.
  - Start the engine only when seated in the operator's seat.
  - NEVER start the engine while standing on the track or on ground.
  - Do not start engine by shorting across starter terminals.
  - Before starting the engine, confirm that all control levers are in neutral.
  - Before starting the engine, confirm the safety around the machine and sound the horn to alert bystanders.

Jump Starting

SA-032

- Battery gas can explode, resulting in serious injury.
  - If the engine must be jump started, be sure to follow the instructions shown in the “OPERATING THE ENGINE” chapter in the operator’s manual.
  - The operator must be in the operator’s seat so that the machine will be under control when the engine starts. Jump starting is a two-person operation.
  - Never use a frozen battery.
  - Failure to follow correct jump starting procedures could result in a battery explosion or a runaway machine.

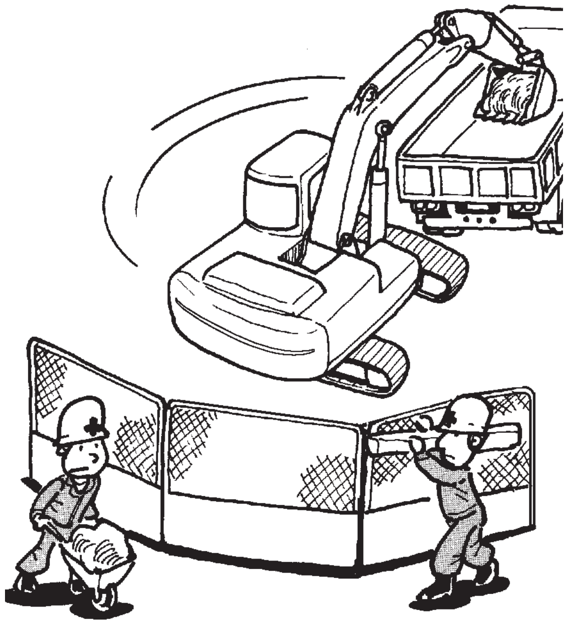
Keep Riders off Machine

SA-379

- Riders on machine are subject to injury such as being struck by foreign objects and being thrown off the machine.
  - Only the operator should be on the machine. Keep riders off.
  - Riders also obstruct the operator’s view, resulting in the machine being operated in an unsafe manner.

Precautions for Operations

- Investigate the work site before starting operations.
  - Be sure to wear close fitting clothing and safety equipment appropriate for the job, such as a hard hat, etc. when operating the machine.
  - Clear all persons and obstacles from area of operation and machine movement.
    Always beware of the surroundings while operating.
    When working in a small area surrounded by obstacles, take care not to hit the upperstructure against obstacles.
  - When loading onto trucks, bring the bucket over the truck beds from the rear side. Take care not to swing the bucket over the cab or over any person.



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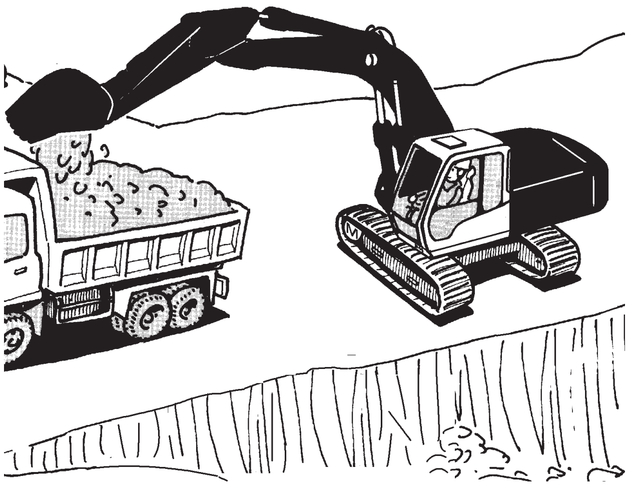
Investigate Job Site Beforehand


SA-380

- When working at the edge of an excavation or on a road shoulder, the machine could tip over, possibly resulting in serious injury or death.
  - Investigate the configuration and ground conditions of the job site beforehand to prevent the machine from falling and to prevent the ground, stockpiles or banks from collapsing.
  - Make a work plan. Use machines appropriate to the work and job site.
  - Reinforce ground, edges and road shoulders as necessary. Keep the machine well back from the edges of excavations and road shoulders.
  - When working on an incline or on a road shoulder, employ a signal person as required.
  - Confirm that your machine is equipped with a FOPS cab before working in areas where the possibility of falling stones or debris exist.
  - When the footing is weak, reinforce the ground before starting work.
  - When working on frozen ground, be extremely alert. As ambient temperatures rise, footing becomes loose and slippery.
  - Beware the possibility of fire when operating the machine near flammable objects such as dry grass.

- Make sure the worksite has sufficient strength to firmly support the machine.
  When working close to an excavation or at road shoulders, operate the machine with the tracks positioned perpendicular to the cliff face with travel motors at the rear, so that the machine can more easily evacuate if the cliff face collapses.
- If working on the bottom of a cliff or a high bank is required, be sure to investigate the area first and confirm that no danger of the cliff or bank collapsing exists. If any possibility of cliff or bank collapsing exists, do not work on the area.
- Soft ground may collapse when operating the machine on it, possibly causing the machine to tip over. When working on soft ground is required, be sure to reinforce the ground first using large pieces of steel plates strong and firm enough to easily support the machine.
- Note that there is always a possibility of machine tipping over when working on rough terrain or on slopes. Prevent machine tipping over from occurring. When operating on rough terrain or on slopes:
  - Reduce the engine speed.
  - Select slow travel speed mode.
  - Operate the machine slowly and be cautious with machine movements.



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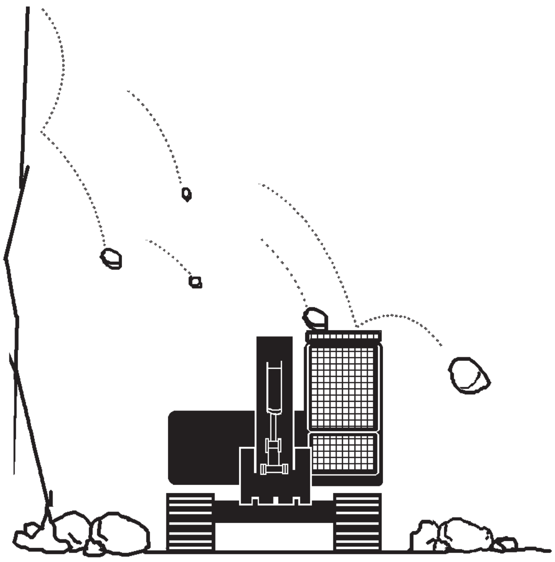
Install OPG Guard

In case the machine is operated in areas where the possibilities of falling stones or debris exist, equip Hitachi OPG guard.
Consult your authorized dealer for installing the OPG guard.
The guard can be compliant with ROPS standards depending on the machine specifications.
In order not to impair operator protective structure:
Replace damaged ROPS or OPG guard. Never attempt to repair or modify the guard.

ROPS: Roll Over Protective Structure
OPG: Operator Protective Guard



SA-490

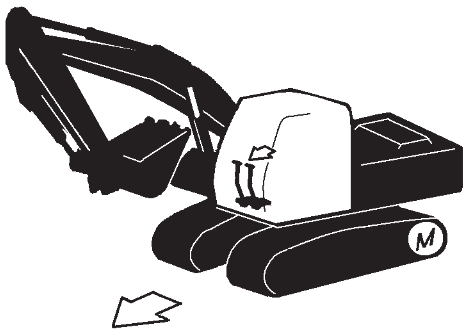
Provide Signals for Jobs Involving Multiple Machines

- For jobs involving multiple machines, provide signals commonly known by all personnel involved. Also, appoint a signal person to coordinate the job site. Make sure that all personnel obey the signal person's directions.

SA-481

Confirm Direction of Machine to Be Driven

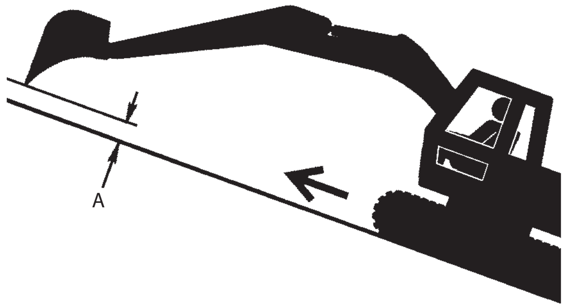
- Incorrect travel pedal/lever operation may result in serious injury or death.
  - Before driving the machine, confirm the position of the undercarriage in relation to the operator's position. If the travel motors are located in front of the cab, the machine will move in reverse when travel pedals/levers are operated to the front.



SA-491

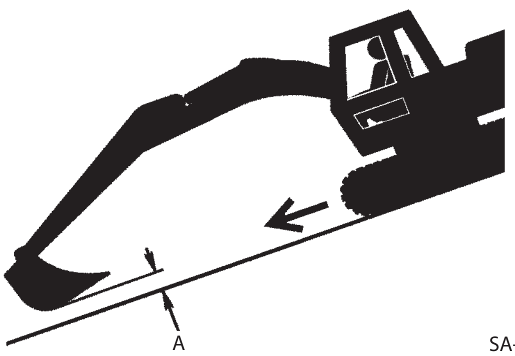
Drive Machine Safely

- Before driving the machine, always confirm that the travel levers/pedals direction corresponds to the direction you wish to drive.
  - Be sure to detour around any obstructions.
  - Avoid traveling over obstructions. Soil, fragments of rocks, and/or metal pieces may scatter around the machine. Do not allow personnel to stay around the machine while traveling.



SA-657

- Driving on a slope may cause the machine to slip or overturn, possibly resulting in serious injury or death.
  - Never attempt to ascend or descend 35 degrees or steeper slopes.
  - Be sure to fasten the seat belt.
  - When driving up or down a slope, keep the bucket facing the direction of travel, approximately 0.2 to 0.3 m (A) above the ground.
  - If the machine starts to skid or becomes unstable, immediately lower the bucket to the ground and stop.
  - Driving across the face of a slope or steering on a slope may cause the machine to skid or turnover. If the direction must be changed, move the machine to level ground, then, change the direction to ensure safe operation.



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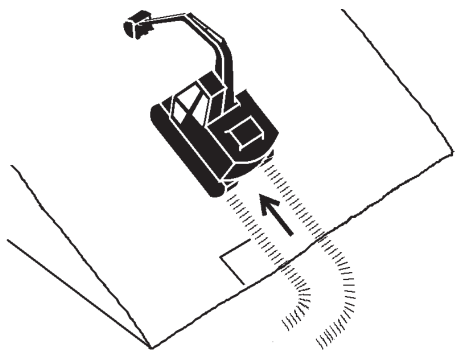

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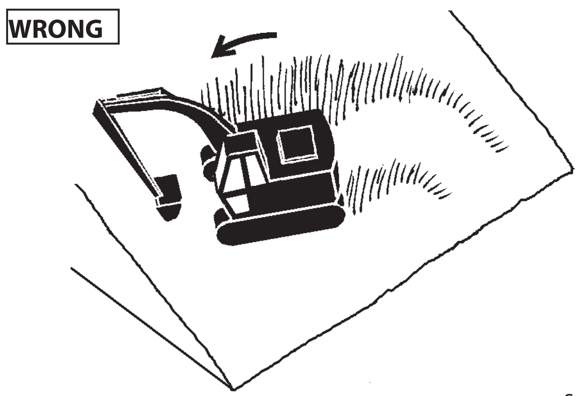
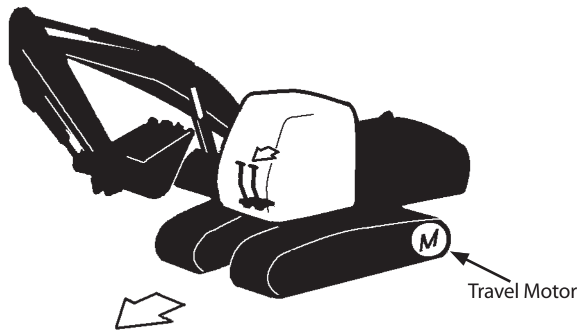


SA-590

- Avoid swinging the upperstructure on slopes. Never attempt to swing the upperstructure downhill. The machine may tip over. If swinging uphill is unavoidable, carefully operate the upperstructure and boom at slow speed.
- If the engine stalls on a slope, immediately lower the bucket to the ground. Return the control levers to neutral. Then, restart the engine.
- Be sure to thoroughly warm up the machine before ascending steep slopes. If hydraulic oil has not warmed up sufficiently, sufficient performance may not be obtained.
- Use a signal person when moving, swinging or operating the machine in congested areas. Coordinate hand signals before starting the machine.
- Before moving machine, determine which way to move travel pedals/levers for the direction you want to go. When the travel motors are in the rear, pushing down on the front of the travel pedals or pushing the levers forward moves the machine forward, towards the idlers. An arrow-mark seal is stuck on the inside surface of the side frame to indicate the machine front direction.
- Select a travel route that is as flat as possible. Steer the machine as straight as possible, making small gradual changes in direction.
- Before traveling on them, check the strengths of bridges and road shoulders, and reinforce if necessary.
- Use wood plates in order not to damage the road surface. Be careful of steering when operating on asphalt roads in summer.
- When crossing train tracks, use wood plates in order not to damage them.
- Do not make contact with electric wires or bridges.
- When crossing a river, measure the depth of the river using the bucket, and cross slowly. Do not cross the river when the depth of the river is deeper than the upper edge of the upper roller.
- When traveling on rough terrain, reduce engine speed. Select slow travel speed. Slower speed will reduce possible damage to the machine.
- Avoid operations that may damage the track and undercarriage components.
- During freezing weather, always clean snow and ice from track shoes before loading and unloading machine, to prevent the machine from slipping.



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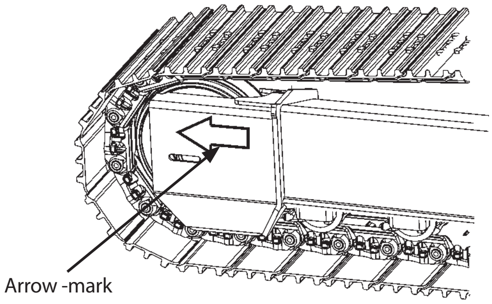

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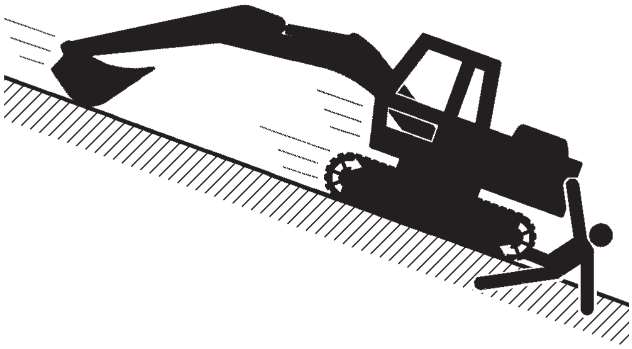
SA-011

Avoid Injury from Rollaway Accidents

- Death or serious injury may result if you attempt to mount or stop a moving machine.

  To avoid rollaways:
  - Select level ground when possible to park the machine.
  - Do not park the machine on a grade.
  - Lower the bucket and/or other work tools to the ground.
  - Turn the auto-idle switch OFF and the power mode switch E or P.
  - Run the engine at slow idle speed without load for 5 minutes to cool down the engine.
  - Stop the engine and remove the key from the key switch.
  - Pull the pilot control shut-off lever to LOCK position.
  - Block both tracks and lower the bucket to the ground. Thrust the bucket teeth into the ground if you must park on a grade.
  - Position the machine to prevent rolling.
  - Park at a reasonable distance from other machines.



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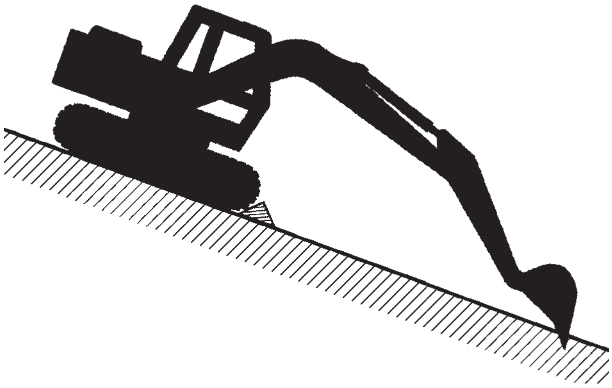
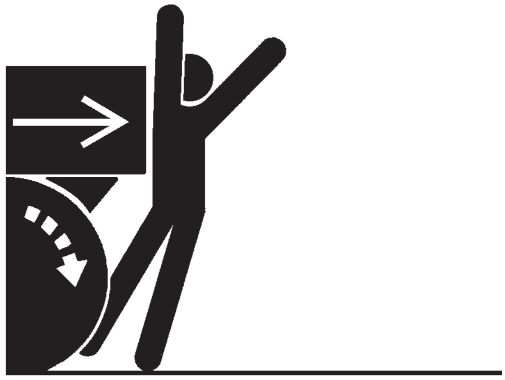


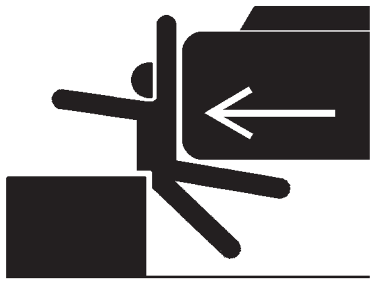
SA-2273

Avoid Injury from Back-Over and Swing Accidents

- If any person is present near the machine when backing or swinging the upperstructure, the machine may hit or run over that person, resulting in serious injury or death.
  To avoid back-over and swing accidents:
  - Always look around BEFORE YOU BACK UP AND SWING THE MACHINE. BE SURE THAT ALL BYSTANDERS ARE CLEAR.
  - Keep the travel alarm in working condition (if equipped). ALWAYS BE ALERT FOR BYSTANDERS MOVING INTO THE WORK AREA. USE THE HORN OR OTHER SIGNAL TO WARN BYSTANDERS BEFORE MOVING MACHINE.
  - USE A SIGNAL PERSON WHEN BACKING UP IF YOUR VIEW IS OBSTRUCTED. ALWAYS KEEP THE SIGNAL PERSON IN VIEW.
    Use hand signals, which conform to your local regulations, when work conditions require a signal person.
  - No machine motions shall be made unless signals are clearly understood by both signalman and operator.
  - Learn the meanings of all flags, signs, and markings used on the job and confirm who has the responsibility for signaling.
  - Keep windows, mirrors, and lights clean and in good condition.
  - Dust, heavy rain, fog, etc., can reduce visibility. As visibility decreases, reduce speed and use proper lighting.
  - Read and understand all operating instructions in the operator's manual.



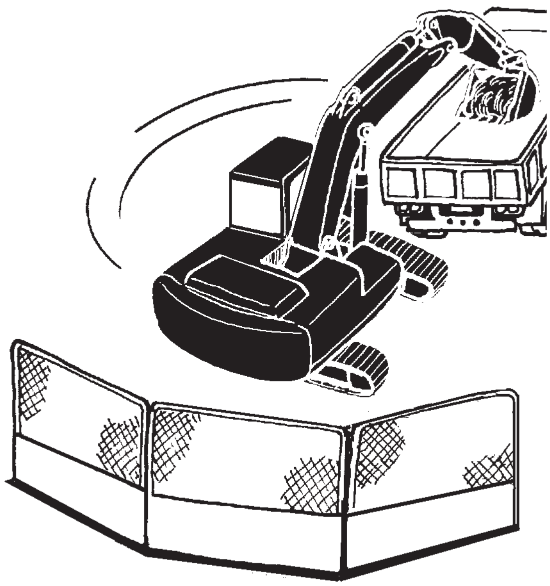
SA-383



SA-384

Keep Person Clear from Working Area

- A person may be hit severely by the swinging front attachment or counterweight and/or may be crushed against an other object, resulting in serious injury or death.
  - Keep all persons clear from the area of operation and machine movement.
  - Before operating the machine, set up barriers to the sides and rear area of the bucket swing radius to prevent anyone from entering the work area.



SA-386

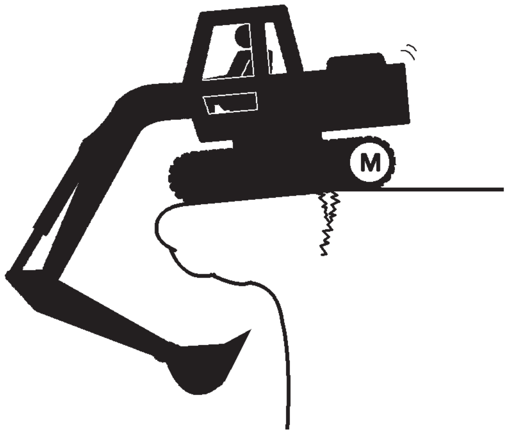
Never Position Bucket Over Anyone

- Never lift, move, or swing bucket above anyone or a truck cab.
  Serious injury or machine damage may result due to bucket load spill or due to collision with the bucket.

SA-487

Avoid Undercutting

- In order to retreat from the edge of an excavation if the footing should collapse, always position the undercarriage perpendicular to the edge of the excavation with the travel motors at the rear.
  - If the footing starts to collapse and if retreat is not possible, do not panic. Often, the machine can be secured by lowering the front attachment, in such cases.



SA-488

Avoid Tipping

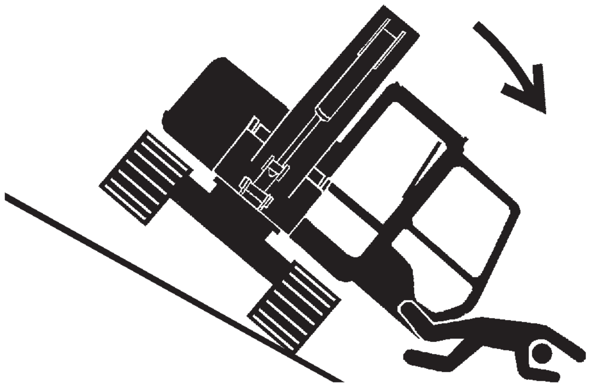
DO NOT ATTEMPT TO JUMP CLEAR OF TIPPING MACHINE --- SERIOUS OR FATAL CRUSHING INJURIES WILL RESULT

MACHINE WILL TIP OVER FASTER THAN YOU CAN JUMP FREE

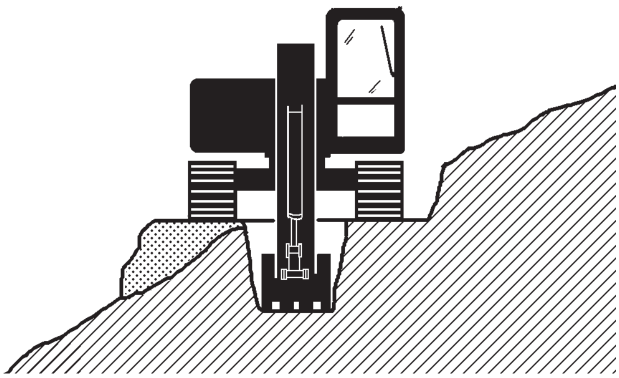
FASTEN YOUR SEAT BELT

- The danger of tipping is always present when operating on a grade, possibly resulting in serious injury or death.
  To avoid tipping:
- Be extra careful before operating on a grade.
  - Prepare machine operating area flat.
  - Keep the bucket low to the ground and close to the machine.
  - Reduce operating speeds to avoid tipping or slipping.
  - Avoid changing direction when traveling on grades.
  - NEVER attempt to travel across a grade steeper than 15 degrees if crossing the grade is unavoidable.
  - Reduce swing speed as necessary when swinging loads.

- Be careful when working on frozen ground.
  - Temperature increases will cause the ground to become soft and make ground travel unstable.



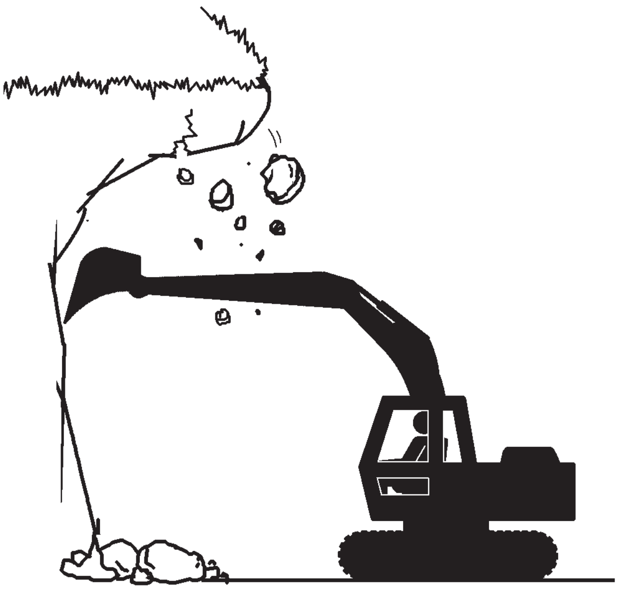
SA-012



SA-440

Never Undercut a High Bank

- The edges could collapse or a land slide could occur causing serious injury or death.



SA-489

Dig with Caution

- Accidental severing of underground cables or gas lines may cause an explosion and/or fire, possibly resulting in serious injury or death.
  - Before digging check the location of cables, gas lines, and water lines.
  - Keep the minimum distance required, by law, from cables, gas lines, and water lines.
  - If a fiber optic cable should be accidentally severed, do not look into the end. Doing so may result in serious eye injury.
  - Contact your local "diggers hot line" if available in your area , and/or the utility companies directly. Have them mark all underground utilities.

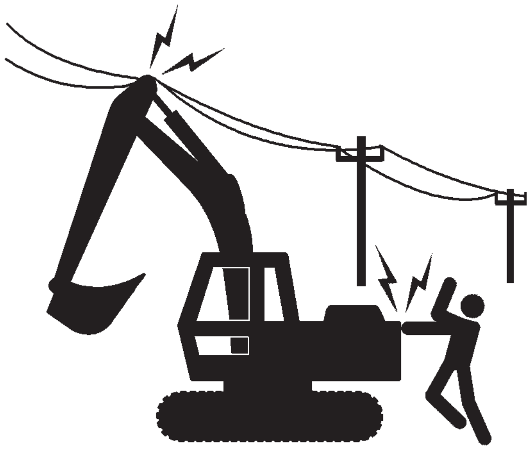
SA-382

Operate with Caution

- If the front attachment or any other part of the machine hits against an overhead obstacle, such as a bridge, both the machine and the overhead obstacle will be damaged, and personal injury may result as well.
  - Take care to avoid hitting overhead obstacles with the boom or arm.

SA-389

Avoid Power Lines



SA-381

- Serious injury or death can result if the machine or front attachments are not kept a safe distance from electric lines.
  - When operating near an electric line, NEVER move any part of the machine or load closer than 3 m plus twice the line insulator length.
  - Check and comply with any local regulations that may apply.
  - Wet ground will expand the area that could cause any person on it to be affected by electric shock. Keep all bystanders or co-workers away from the site.

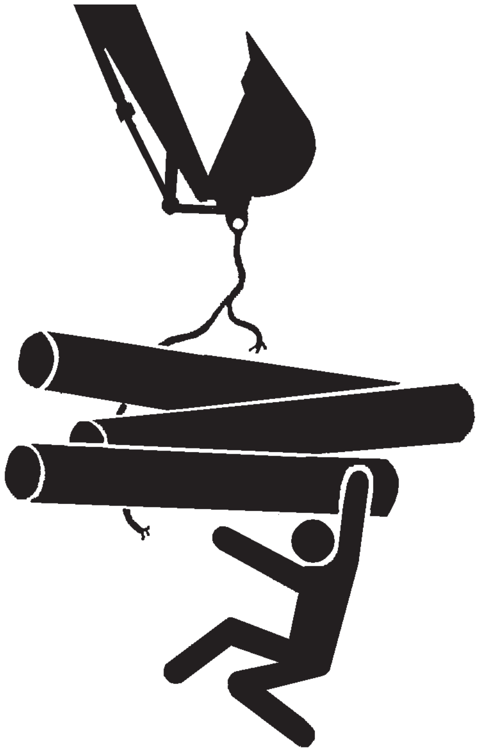
Precautions for Lightning

SA-1088

- The machine is vulnerable to lightning strikes.
  - In the event of an electrical storm, immediately stop operation, and lower the bucket to the ground. Evacuate to a safe place far away from the machine.
  - After the electrical storm has passed, check all of the machine safety devices for any failure. If any failed safety devices are found, operate the machine only after repairing them.

Object Handling

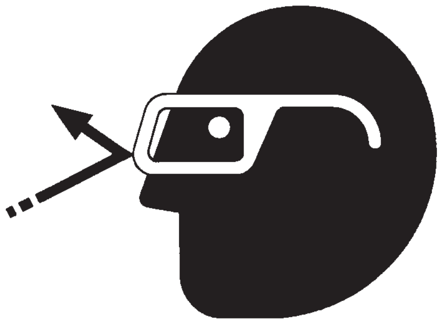
- If a lifted load should fall, any person nearby may be struck by the falling load or may be crushed underneath it, resulting in serious injury or death.
  - When using the machine for craning operations, be sure to comply with all local regulations.
  - Do not use damaged chains or frayed cables, sables, slings, or ropes.
  - Before craning, position the upperstructure with the travel motors at the rear.
  - Move the load slowly and carefully. Never move it suddenly.
  - Keep all persons well away from the load.
  - Never move a load over a person's head.
  - Do not allow anyone to approach the load until it is safely and securely situated on supporting blocks or on the ground.
  - Never attach a sling or chain to the bucket teeth. They may come off, causing the load to fall.



SA-014

Protect Against Flying Debris

- If flying debris hit eyes or any other part of the body, serious injury may result.
  - Guard against injury from flying pieces of metal or debris; wear goggles or safety glasses.
  - Keep bystanders away from the working area before striking any object.
  - Always close the front windows, doors, door windows and the overhead window when operating the machine.



SA-432

Park Machine Safely

To avoid accidents:
- Park machine on a firm, level surface.
- Lower bucket to the ground.
- Turn auto-idle switch OFF and power mode switch E or P.
- Run engine at slow idle speed without load for 5 minutes.
- Turn key switch to OFF to stop engine.
- Remove the key from the key switch.
- Pull the pilot control shut-off lever to the LOCK position.
- Close windows, roof vent, and cab door.
- Lock all access doors and compartments.

SA-390

Handle Fluids Safely–Avoid Fires

- Handle fuel with care; it is highly flammable. If fuel ignites, an explosion and/or a fire may occur, possibly resulting in serious injury or death.
  - Do not refuel the machine while smoking or when near open flame or sparks.
  - Always stop the engine before refueling the machine.
  - Fill the fuel tank outdoors.

- All fuels, most lubricants, and some coolants are flammable.
  - Store flammable fluids well away from fire hazards.
  - Do not incinerate or puncture pressurized containers.
  - Do not store oily rags; they can ignite and burn spontaneously.
  - Securely tighten the fuel and oil filler cap.

SA-018

SA-019

Transport Safely

- Take care the machine may turn over when loading or unloading the machine onto or off of a truck or trailer.
  - Observe the related regulations and rules for safe transportation.
  - Select an appropriate truck or trailer for the machine to be transported.
  - Be sure to use a signal person.
  - Always follow the following precautions for loading or unloading:

1. Select solid and level ground.
2. Always use a ramp or deck strong enough to support the machine weight.
3. Turn auto-idle switch OFF and turn mode switch to PWR or ECO position.
4. Always select the slow speed mode with the travel mode switch.
5. Never load or unload the machine onto or off a truck or trailer using the front attachment functions when driving up or down the ramp.
6. Never steer the machine while on the ramp. If the traveling direction must be changed while the ramp, unload the machine from the ramp, reposition the machine on the ground, then try loading again.
7. The top end of the ramp where it meets the flatbed is a sudden bump. Take care when traveling over it.
8. Place blocks in front of and behind the tires. Securely hold the machine to the truck or trailer deck with wire ropes.

SA-395

Be sure to further follow the details described in the TRANSPORTING section in the operator's manual.

Practice Safe Maintenance

SA-028

To avoid accidents:
- Understand service procedures before starting work.
- Keep the work area clean and dry.
- Do not spray water or steam inside cab.
- Never lubricate or service the machine while it is moving.
- Keep hands, feet and clothing away from power-driven parts.

Before servicing the machine:
1. Park the machine on a level surface.
2. Lower the bucket to the ground.
3. Turn the auto-idle switch off.
4. Run the engine at slow idle speed without load for 5 minutes.
5. Turn the key switch to OFF to stop engine.
6. Relieve the pressure in the hydraulic system by moving the control levers several times.
7. Remove the key from the key switch.
8. Attach a "Do Not Operate" tag on the control lever.
9. Pull the pilot control shut-off lever to the LOCK position.
10. Allow the engine to cool.

SA-527

- If a maintenance procedure must be performed with the engine running, do not leave the machine unattended.
- If the machine must be raised, maintain a 90 to 110° angle between the boom and arm. Securely support any machine elements that must be raised for service work.
- Inspect certain parts periodically and repair or replace as necessary. Refer to the section discussing that part in the "MAINTENANCE" chapter in the operator's manual.
- Keep all parts in good condition and properly installed.
- Fix damage immediately. Replace worn or broken parts. Remove any buildup of grease, oil, or debris.
- When cleaning parts, always use nonflammable detergent oil. Never use highly flammable oil such as fuel oil and gasoline to clean parts or surfaces.
- Disconnect battery ground cable (–) before making adjustments to electrical systems or before performing welding on the machine.

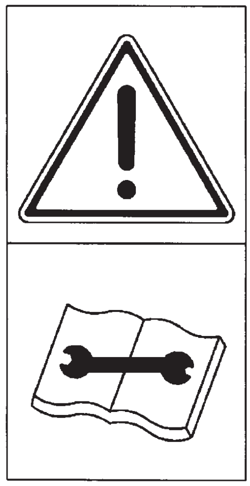
- Sufficiently illuminate the work site. Use a maintenance work light when working under or inside the machine.
- Always use a work light protected with a guard. In case the light bulb is broken, spilled fuel, oil, antifreeze fluid, or window washer fluid may catch fire.

SA-037

Warn Others of Service Work

- Unexpected machine movement can cause serious injury.
  - Before performing any work on the machine, attach a "Do Not Operate" tag on the control lever.
    This tag is available from your authorized dealer.

SS3076175



SS2045102

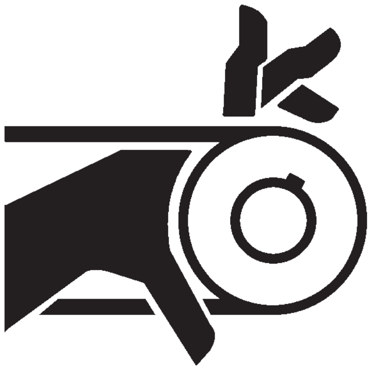
Support Machine Properly

- Never attempt to work on the machine without securing the machine first.
  - Always lower the attachment to the ground before you work on the machine.
  - If you must work on a lifted machine or attachment, securely support the machine or attachment. Do not support the machine on cinder blocks, hollow tires, or props that may crumble under continuous load. Do not work under a machine that is supported solely by a jack.

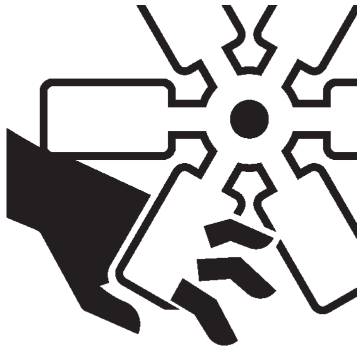
SA-527

Stay Clear of Moving Parts

- Entanglement in moving parts can cause serious injury.
  - To prevent accidents, care should be taken to ensure that hands, feet, clothing, jewelry and hair do not become entangled when working around rotating parts.



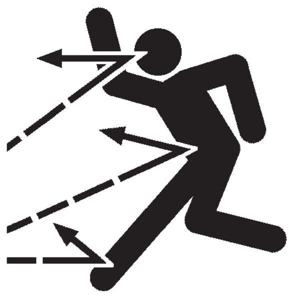
SA-026



SA-2294

Prevent Parts from Flying

- Grease in the track adjuster is under high pressure.
  Failure to follow the precautions below may result in serious injury, blindness, or death.
  - Do not attempt to remove GREASE FITTING or VALVE ASSEMBLY.
  - Do not attempt to remove grease fitting securing cover.
  - As pieces may fly off, be sure to keep body and face away from valve.
  - Never attempt to disassemble the track adjuster. Inadvertent disassembling of the track adjuster may cause the parts such as a spring to fly off, possibly resulting in severe personal injury or death.

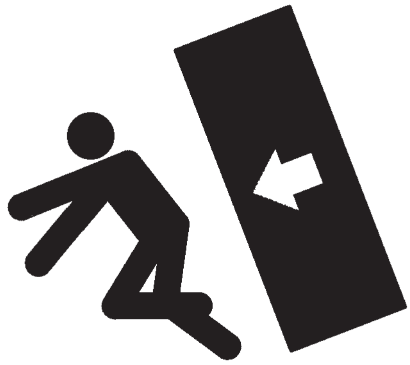


SA-344

- Travel reduction gears are under pressure.
  - As pieces may fly off, be sure to keep body and face away from AIR RELEASE PLUG to avoid injury.
  - GEAR OIL is hot. Wait for GEAR OIL to cool, then gradually loosen AIR RELEASE PLUG to release pressure.

Store Attachments Safely

- Stored attachments such as buckets, hydraulic hammers, and blades can fall and cause serious injury or death.
  - Securely store attachments and implements to prevent falling. Keep children and bystanders away from storage areas.



SA-034

Prevent Burns

Hot spraying fluids:

- After operation, engine coolant is hot and under pressure. Hot water or steam is contained in the engine, radiator and heater lines.
  Skin contact with escaping hot water or steam can cause severe burns.
  - To avoid possible injury from hot spraying water. DO NOT remove the radiator cap until the engine is cool. When opening, turn the cap slowly to the stop. Allow all pressure to be released before removing the cap.
  - The hydraulic oil tank is pressurized. Again, be sure to release all pressure before removing the cap.

SA-039

Hot fluids and surfaces:

- Engine oil, gear oil and hydraulic oil also become hot during operation.
  The engine, hoses, lines and other parts become hot as well.
  - Wait for the oil and components to cool before starting any maintenance or inspection work.

SA-225

Replace Rubber Hoses Periodically

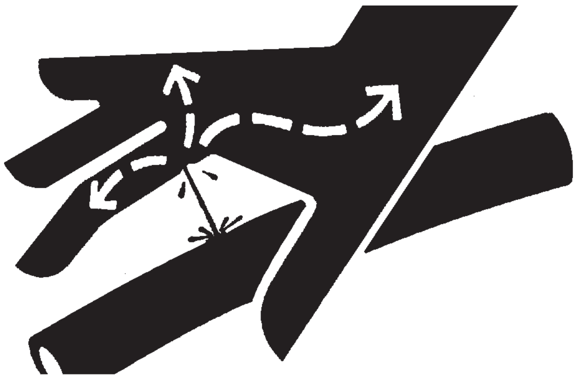
- Rubber hoses that contain flammable fluids under pressure may break due to aging, fatigue, and abrasion. It is very difficult to gauge the extent of deterioration due to aging, fatigue, and abrasion of rubber hoses by inspection alone.
  - Periodically replace the rubber hoses. (See the page of "Periodic replacement of parts" in the operator's manual.)

- Failure to periodically replace rubber hoses may cause a fire, fluid injection into skin, or the front attachment to fall on a person nearby, which may result in severe burns, gangrene, or otherwise serious injury or death.

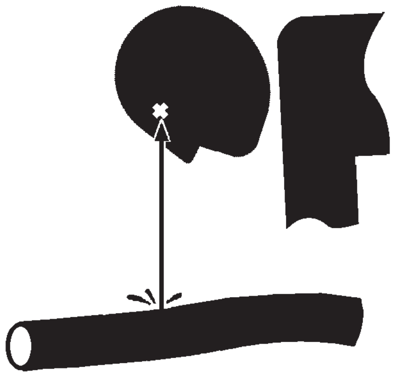
SA-019

Avoid High-Pressure Fluids

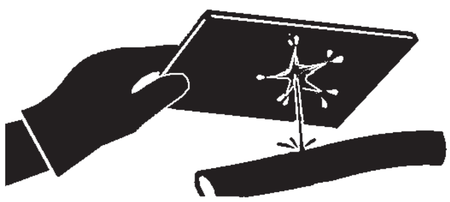
- Fluids such as diesel fuel or hydraulic oil under pressure can penetrate the skin or eyes causing serious injury, blindness or death.
  - Avoid this hazard by relieving pressure before disconnecting hydraulic or other lines.
  - Tighten all connections before applying pressure.
  - Search for leaks with a piece of cardboard; take care to protect hands and body from high-pressure fluids. Wear a face shield or goggles for eye protection.
  - If an accident occurs, see a doctor familiar with this type of injury immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result.



SA-031



SA-292



SA-044

Prevent Fires

Check for Oil Leaks:

- Fuel, hydraulic oil and lubricant leaks can lead to fires.
  - Check for oil leaks due to missing or loose clamps, kinked hoses, lines or hoses that rub against each other, damage to the oil-cooler, and loose oil-cooler flange bolts.
  - Tighten, repair or replace any missing, loose or damaged clamps, lines, hoses, oil-cooler and oil-cooler flange bolts.
  - Do not bend or strike high-pressure lines.
  - Never install bent or damaged lines, pipes, or hoses.
  - Replace fuel hoses and hydraulic hoses periodically even if there is no abnormality in their external appearance.

SA-019

Check for Shorts:

- Short circuits can cause fires.
  - Clean and tighten all electrical connections.
  - Check before each shift or after eight (8) to ten (10) hours operation for loose, kinked, hardened or frayed electrical cables and wires.
  - Check before each shift or after eight (8) to ten (10) hours operation for missing or damaged terminal caps.
  - DO NOT OPERATE MACHINE if cable or wires are loose, kinked, etc.
  - Never attempt to modify electric wirings.

Clean up Flammables:

- Spilled fuel and oil, and trash, grease, debris, accumulated coal dust, and other flammables may cause fires.
  - Prevent fires by inspecting and cleaning the machine daily, and by removing adhered oil or accumulated flammables immediately. Check and clean high temperature parts such as the exhaust outlet and mufflers earlier than the normal interval.
  - Do not wrap high temperature parts such as a muffler or exhaust pipe with oil absorbents.
  - Do not store oily cloths as they are vulnerable to catching fire.
  - Keep flammables away from open flames.
  - Do not ignite or crush a pressurized or sealed container.
  - Wire screens may be provided on openings on the engine compartment covers to prevent flammables such as dead leaves from entering. However, flammables which have passed through the wire screen may cause fires. Check and clean the machine every day and immediately remove accumulated flammables.

Check Key Switch:

- If a fire breaks out, failure to stop the engine will escalate the fire, hampering fire fighting.
  Always check key switch function before operating the machine every day:
  1. Start the engine and run it at slow idle.
  2. Turn the key switch to the OFF position to confirm that the engine stops.
  - If any abnormalities are found, be sure to repair them before operating the machine.

Check Heat Shields:

- Damaged or missing heat shields may lead to fires.
  - Damaged or missing heat shields must be repaired or replaced before operating the machine.
  - If hydraulic hoses are broken while the engine cover is open, splattered oil on the high temperature parts such as mufflers may cause fire. Always close the engine cover while operating the machine.

Evacuating in Case of Fire

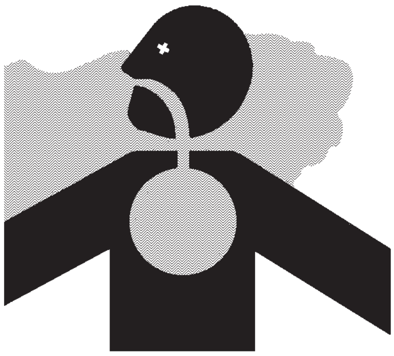
- If a fire breaks out, evacuate the machine in the following way:
  - Stop the engine by turning the key switch to the OFF position if there is time.
  - Use a fire extinguisher if there is time.
  - Exit the machine.
- In an emergency, if the cab door or front window can not be opened, break the front or rear window panes with the emergency evacuation hammer to escape from the cab. Refer to the explanation pages on the Emergency Evacuation Method in the operator's manual.

SA-393

SS-1510

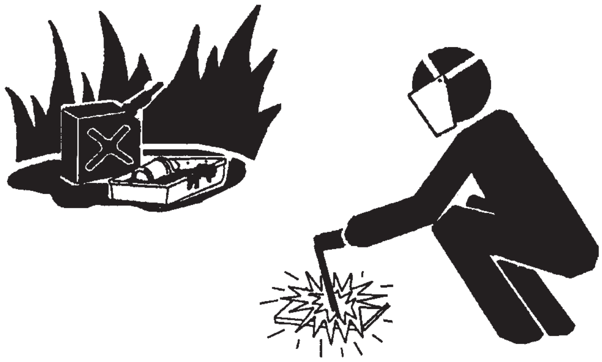
Beware of Exhaust Fumes

- Prevent asphyxiation. Engine exhaust fumes can cause sickness or death.
  - If you must operate in a building, be sure there is adequate ventilation. Either use an exhaust pipe extension to remove the exhaust fumes or open doors and windows to bring enough outside air into the area.



SA-016

Precautions for Welding and Grinding


SA-818

- Welding may generate gas and/or small fires.
  - Be sure to perform welding in a well ventilated and prepared area. Store flammable objects in a safe place before starting welding.
  - Only qualified personnel should perform welding. Never allow an unqualified person to perform welding.
- Grinding on the machine may create fire hazards. Store flammable objects in a safe place before starting grinding.
- After finishing welding and grinding, recheck that there are no abnormalities such as the area surrounding the welded area still smoldering.

Avoid Heating Near Pressurized Fluid Lines

- Flammable spray can be generated by heating near pressurized fluid lines, resulting in severe burns to yourself and bystanders.
  - Do not heat by welding, soldering, or using a torch near pressurized fluid lines or other flammable materials.
  - Pressurized lines can be accidentally cut when heat goes beyond the immediate flame area. Install temporary fire-resistant guards to protect hoses or other materials before engaging in welding, soldering, etc..

SA-030

Avoid Applying Heat to Lines Containing Flammable Fluids

- Do not weld or flame cut pipes or tubes that contain flammable fluids.
- Clean them thoroughly with nonflammable solvent before welding or flame cutting them.

Precautions for Handling Accumulator and Gas Damper

High-pressure nitrogen gas is sealed in the accumulator and the gas damper. Inappropriate handling may cause explosion, possibly resulting in serious injury or death.

Strictly comply with the following items:

- Do not disassemble the unit.
- Keep the units away from open flames and fire.
- Do not bore a hole, do not cut by torch.
- Avoid giving shocks by hitting or rolling the unit.
- Before disposing the unit, sealed gas must be released. Consult your nearest Hitachi dealer.

Remove Paint Before Welding or Heating

SA-029

- Hazardous fumes can be generated when paint is heated by welding, soldering, or using a torch. If inhaled, these fumes may cause sickness.
  - Avoid potentially toxic fumes and dust.
  - Do all such work outside or in a well-ventilated area. Dispose of paint and solvent properly.
  - Remove paint before welding or heating:
  1. If you sand or grind paint, avoid breathing the dust.

     Wear an approved respirator.
  2. If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.

Beware of Asbestos and Silicon Dust and Other Contamination

SA-029

- Take care not to inhale dust produced in the work site. Inhalation of asbestos fibers may be the cause of lung cancer. Inhalation of silicon dust or other contamination may cause sickness.
  - Depending on the work site conditions, the risk of inhaling asbestos fiber, silicon dust or other contamination may exist. Spray water to prevent asbestos fibers, silicon dust or other contamination from becoming airborne. Do not use compressed air.
  - When operating the machine in a work site where asbestos fibers, silicon dust or other contamination might be present, be sure to operate the machine from the upwind side and wear a mask rated to prevent the inhalation of asbestos, silicon dust or other contamination.
  - Keep bystanders out of the work site during operation.
  - Asbestos fibers might be present in imitation parts. Use only genuine Hitachi Parts.

Prevent Battery Explosions

- Battery gas can explode.
  - Keep sparks, lighted matches, and flame away from the top of battery.
  - Never check battery charge by placing a metal object across the posts. Use a voltmeter or hydrometer.
  - Do not charge a frozen battery; it may explode. Warm the battery to 16 °C (60 °F) first.
  - Do not continue to use or charge the battery when electrolyte level is lower than specified. Explosion of the battery may result.
  - Loose terminals may produce sparks. Securely tighten all terminals.
  - Connect terminals to the correct electrical poles. Failure to do so may cause damage to the electrical parts or fire.

- Battery electrolyte is poisonous. If the battery should explode, battery electrolyte may be splashed into eyes, possibly resulting in blindness.
  - Be sure to wear eye protection when checking electrolyte specific gravity.

SA-032

Service Air Conditioning System Safely

- If spilled onto skin, refrigerant may cause a cold contact burn.
  - Refer to the instructions described on the container for proper use when handling the refrigerant.
  - Use a recovery and recycling system to avoid leaking refrigerant into the atmosphere.
  - Never touch the refrigerant.

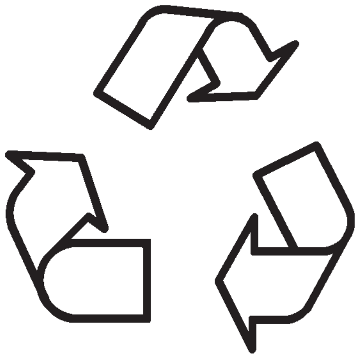
SA-405

Handle Chemical Products Safely

SA-309

- Direct exposure to hazardous chemicals can cause serious injury. Potentially hazardous chemicals used with your machine include such items as lubricants, coolants, paints, and adhesives.
  - A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques.
  - Check the MSDS before you start any job using a hazardous chemical. That way you will know exactly what the risks are and how to do the job safely. Then follow procedures and use recommended equipment.
  - See your authorized dealer for MSDS's (available only in English) on chemical products used with your machine.

Dispose of Waste Properly



SA-226

- Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with HITACHI equipment includes such items as oil, fuel, coolant, brake fluid, filters, and batteries.
  - Use leakproof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them.
  - Do not pour waste onto the ground, down a drain, or into any water source.
  - Air conditioning refrigerants escaping into the air can damage the Earth's atmosphere. Government regulations may require a certified air conditioning service center to recover and recycle used air conditioning refrigerants.
  - Inquire on the proper way to recycle or dispose of waste from your local environmental or recycling center, or from your authorized dealer.

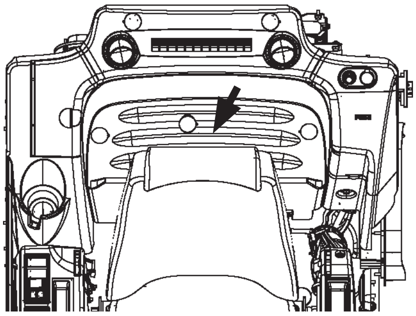
Never Ride Attachment

Never allow anyone to ride attachments or load. This is an extremely dangerous practice.

Precautions for Communication Terminal

Electrical wave transmitted from the communication terminal may cause malfunction of other electronic devices.
Inquire the device manufacturer for electrical wave disturbance upon using an electronic device near the communication terminal.

Precaution for Communication Terminal Equipment



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This machine has a communication terminal equipment emitting electrical waves installed inside a rear tray which is situated at the back of the driver's seat. There is a possibility that a medical device, including an implantable device such as a cardiac pacemaker, would be affected and would malfunction by the electrical waves emitted from the communication terminal equipment.

Any person affixed with a medical device such as the above should not use this machine, unless the medical device and the rear tray are at least 22 centimeters (8.662 inches) apart at all times. If such condition cannot be met, please contact our company's nearest dealer and have the person in charge stop the communication terminal equipment from functioning completely and confirm that it is not emitting electrical waves.

Specific Absorption Rate ("SAR") (measured by 10 g per unit) of communication terminal equipments:

E-GSM900	0.573 W/Kg (914.80 MHz)
DCS-1800	0.130 W/Kg (1710.20 MHz)
WCDMA Band I	0.271 W/Kg (1950.00 MHz)

*This data was measured by having each type of communication terminal equipment, such as the communication terminal equipment used with this machine, and a human body set apart by 3 cm (1.18 inches).
* SAR is a measure of the amount of radio frequency energy absorbed by the body when using a wireless application such as a mobile phone.

In Japan: *Under the Japanese Radio Act and other relevant Japanese regulations, the maximum SAR value is 2 W/kg (as of March 2010).

In EU Member nation: *Under the "Council Recommendation 1999/519/EC 12 July 1999'; the maximum SAR value is 2 W/kg (as of March 2010).

Before Returning the Machine to the Customer

- After maintenance or repair work is complete, confirm that:
  - The machine is functioning properly, especially the safety systems.
  - Worn or damaged parts have been repaired or replaced.

SA-435

SECTION AND GROUP CONTENTS

TECHNICAL MANUAL

(Troubleshooting)

SECTION 4 OPERATIONAL PERFORMANCE TEST

SECTION 5 TROUBLESHOOTING

All information, illustrations and specifications in this manual are based on the latest product information available at the time of publication. The right is reserved to make changes at any time without notice.

SECTION 4

OPERATIONAL PERFORMANCE TEST

CONTENTS

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SECTION 4 OPERATIONAL PERFORMANCE TEST

Group 1 Introduction

Operational Performance Tests

Use operational performance test procedure to quantitatively check all system and functions on the machine.

Purpose of Performance Tests

1. To comprehensively evaluate each operational function by comparing the performance test data with the standard values.
2. According to the evaluation results, repair, adjust, or replace parts or components as necessary to restore the machine's performance to the desired standard.
3. To economically operate the machine under optimal conditions.

Kinds of Tests

1. Base machine performance test is to check the operational performance of each system such as engine, travel, swing, and hydraulic cylinders.
2. Hydraulic component unit test is to check the operational performance of each component such as hydraulic pump, motor, and various kinds of valves.

Performance Standards

"Performance Standard" is shown in tables to evaluate the performance test data.

Precautions for Evaluation of Test Data

1. To evaluate not only that the test data are correct, but also in what range the test data are.
2. Be sure to evaluate the test data based on the machine operation hours, kinds and state of work loads, and machine maintenance conditions.

The machine performance does not always deteriorate as the working hours increase. However, the machine performance is normally considered to reduce in proportion to the increase of the operation hours. Accordingly, restoring the machine performance by repair, adjustment, or replacement shall consider the number of the machine's working hours.

Definition of "Performance Standard"

1. Operation speed values and dimensions of the new machine.
2. Operational performance of new components adjusted to specifications. Allowable errors will be indicated as necessary.

SECTION 4 OPERATIONAL PERFORMANCE TEST

Group 1 Introduction

Preparation for Performance Tests

Observe the following rules in order to carry out performance tests accurately and safely.

THE MACHINE

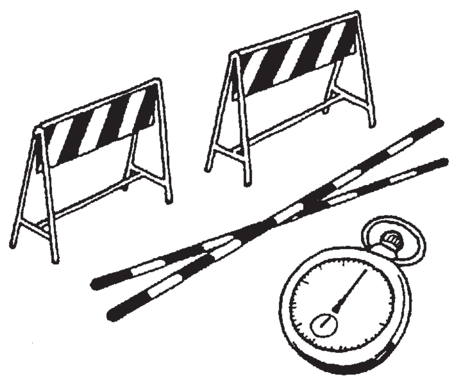
1. Repair any defects and damage found, such as oil or water leaks, loose bolts, cracks and so on, before starting to test.

TEST AREA

1. Select a hard and flat surface.
2. Secure enough space to allow the machine to run straight more than 20 m (65 ft 7 in), and to make a full swing with the front attachment extended.
3. If required, rope off the test area and provide signboards to keep unauthorized personnel away.

PRECAUTIONS

1. Before starting to test, agree upon the signals to be employed for communication among coworkers. Once the test is started, be sure to communicate with each other using these signals, and to follow them without fail.
2. Operate the machine carefully and always give first priority to safety.
3. While testing, always take care to avoid accidents due to landslides or contact with high-voltage power lines. Always confirm that there is sufficient space for full swings.
4. Avoid polluting the machine and the ground with leaking oil. Use oil pans to catch escaping oil. Pay special attention to this when removing hydraulic pipings.



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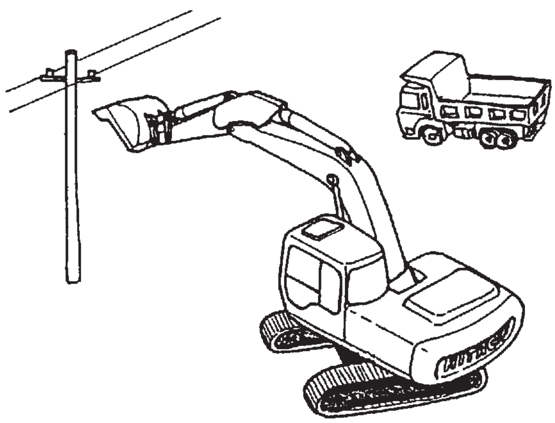
MAKE PRECISE MEASUREMENT

1. Accurately calibrate test instruments in advance to obtain correct data.
2. Carry out tests under the exact test conditions prescribed for each test item.
3. Repeat the same test and confirm that the test data obtained can be produced repeatedly. Use mean values of measurements if necessary.



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Operational Performance Standard Table

The standard Performance values are listed in the table below.
Refer to the Group T4-3 to T4-5 for performance test procedures.
Values indicated in parentheses are reference values.

The following switch positions shall be selected and the hydraulic oil temperature shall be maintained as indicated below as the preconditions of performance tests unless otherwise instructed in each performance test procedure:

- Engine Control Dial : Fast Idle
- Power Mode : PWR
- Auto-Idle Switch: OFF
- Work Mode: Digging Mode
- Hydraulic Oil Temperature : 50±5 °C (122±9 °F)

Performance Test Designation	Performance Standard	Remarks	Reference Page
Engine Speed min^{-1}			T4-3-1
Slow Idle Speed	950±100	Lever in neutral, Value indicated on MPDr.	
Fast Idle Speed (with ECO deactivated)	2150±50	Lever in neutral, Value indicated on MPDr.	
Fast Idle Speed (Heater control: OFF)	2050±50	Lever in neutral, Pilot shut-off lever: UNLOCK position, Value indicated on MPDr.	
Fast Idle Speed (Heater control: ON)	2050 to 2300	Pilot shut-off Lever: LOCK position, Coolant temperature: 5 °C or lower, Value indicated on MPDr.	
Fast Idle Speed (Relief operation)	2000±50	Boom raise relief operation, Value indicated on MPDr.	
Fast Idle Speed (ECO mode)	2000±70	Lever in neutral, Value indicated on MPDr.	
Fast Idle Speed (Travel HP mode)	2000 to 2300	Travel relief operation, Value indicated on MPDr.	
Auto-Idle Speed	1300±50	Value indicated on MPDr.	
Warming-Up Speed	1400±100	Value indicated on MPDr.	

SECTION 4 OPERATIONAL PERFORMANCE TEST

Group 2 Standard

Performance Test Designation	Performance Standard	Remarks	Reference Page
Engine Compression Pressure MPa (kgf/cm^2, psi)	3.04 (31, 565)	Engine speed: 200 min^{-1}	T4-3-4
Valve Clearance (IN, EX) mm	0.4	With the engine cold	T4-3-6
Lubricant Consumption (Rated output) mL/h	50 or less	Hour meter: 2000 hours or less	T4-3-12
Travel Speed sec/10 m			T4-4-1
Fast Speed	6.6±0.6		
Slow Speed	(10.2±1.0)		
Track Revolution Speed sec/3 rev			T4-4-2
Fast Speed	17.2±1.0	LC, LCH: 18.3±1.0	
Slow Speed	26.7±2.0	LC, LCH: 28.4±2.0	
Mistrack (With fast and slow travel speed modes) mm/20 m	200 or less		T4-4-3
Travel Motor Leakage mm/5 min	0		T4-4-4

SECTION 4 OPERATIONAL PERFORMANCE TEST

Group 2 Standard

Performance Test Designation		Performance Standard	Remarks	Reference Page
Swing Speed	sec/3 rev	13.5±1.0	Bucket: empty	T4-4-5
Swing Function Drift Check	mm /180°	1254 or less	Bucket: empty H, LCH: 1368 or less	T4-4-6
Swing Motor Leakage	mm/5 min	0	Bucket: loaded	T4-4-8
Maximum Swingable Slant Angle	deg	25 or more	Bucket: loaded	T4-4-10
Swing Bearing Play	mm	0.2 to 1.25	Allowable limit: 2.0 to 3.05	T4-4-12
Hydraulic Cylinder Cycle Time	sec		2.91 m arm 0.8 m^3 (PCSA heaped) bucket Bucket: empty	T4-4-14
Boom Raise		3.4±0.3	H, LCH: 3.5±0.3	
Boom Lower		2.2±0.3		
Arm Roll-In		3.6±0.3		
Arm Roll-Out		2.7±0.3	H, LCH: 2.8±0.3	
Bucket Roll-In		2.8±0.3		
Bucket Roll-Out		1.9±0.3	H, LCH: 2.0±0.3	

Performance Test Designation		Performance Standard	Remarks	Reference Page
Dig Function Drift Check	mm/5 min		2.91 m arm 0.8 m^3 (PCSA heaped) bucket	T4-4-16
Boom Cylinder	(Maximum Reach Position) (Arm Roll-In Position)	20 or less 5 or less	Bucket: loaded Bucket: empty	
Arm Cylinder	(Maximum Reach Position) (Arm Roll-In Position)	20 or less 15 or less	Bucket: loaded Bucket: empty	
Bucket Cylinder	(Maximum Reach Position) (Arm Roll-In Position)	20 or less 10 or less	Bucket: loaded Bucket: empty	
Bucket Bottom	(Maximum Reach Position) (Arm Roll-In Position)	150 or less 110 or less	Bucket: loaded Bucket: empty	

Group 2 Standard

Performance Test Designation	Performance Standard	Remarks	Reference Page
Control Lever Operating Force N (kgf, lbf)		ISO lever pattern	T4-4-19
Boom Lever	16 (1.6, 3.9) or less		
Swing Lever (HITACHI Lever Pattern: Arm Lever)	13 (1.3, 2.9) or less		
Bucket Lever	13 (1.3, 2.9) or less		
Arm Lever (HITACHI Lever Pattern: Swing Lever)	16 (1.6, 3.9) or less		
Travel Lever	28 (2.8, 6.3) or less		
Control Lever Stroke mm		ISO lever pattern	T4-4-20
Boom Lever	96±10		
Swing Lever (HITACHI Lever Pattern: Arm Lever)	81±10		
Bucket Lever	81±10		
Arm Lever (HITACHI Lever Pattern: Swing Lever)	96±10		
Travel Lever	120±10		
Boom Raise/Swing sec	3.6±0.4	2.91 m arm 0.8 m^3 (PCSA heaped) bucket Bucket: empty	T4-4-21
(Bucket Teeth Height: H) mm	6600 or more	H, LCH: 6200 or more	
Boom Raise/Arm Roll-In sec	(4.3±0.5)	2.91 m arm 0.8 m^3 (PCSA heaped) bucket	T4-4-22

Performance Test Designation	Performance Standard	Remarks	Reference Page
Hydraulic System			
Primary Pilot Pressure MPa (kgf/cm², psi)			T4-5-1
Engine: Fast Idle	$4.0^{+1.0}_{-0.5}$ (40^{+10}_{-5}, 580^{+145}_{-73})	Value indicated on MPDr.	
Engine: Slow Idle	$3.8^{+1.0}_{-0.5}$ (38^{+10}_{-5}, 550^{+145}_{-73})	Value indicated on MPDr.	
Secondary Pilot Pressure MPa (kgf/cm², psi)			T4-5-3
(Engine: Fast Idle (normal) and Slow Idle)	3.4 to 4.0 (34 to 40, 495 to 580)	Value indicated on MPDr. (Control Lever: Full stroke)	
Solenoid Valve Set Pressure MPa(kgf/cm²)	Value indicated on MPDr.±0.2 (2, 29)		T4-5-4
Main Pump Delivery Pressure MPa (kgf/cm², psi)	$0.8^{+1.2}_{-0.5}$ (8^{+12}_{-5}, 115^{+175}_{-73})	In neutral, Value indicated on MPDr.	T4-5-6
Main Relief Valve Pressure MPa (kgf/cm², psi)			T4-5-8
Boom, Arm, Bucket (Relief operation for each)	$34.3^{+2.0}_{-0.5}$ (350^{+20}_{-5}, 4970^{+290}_{-145})	Value indicated on MPDr.	
Power Digging	$38.0^{+2.0}_{-1.0}$ (390^{+20}_{-10}, 5510^{+290}_{-73})	Value indicated on MPDr.	
Relief Pressure (Swing relief operation) MPa (kgf/cm², psi)	$33.3^{+2.3}_{-0.5}$ (340^{+23}_{-5}, 4830^{+335}_{-73})	Value indicated on MPDr.	T4-5-12
Overload Relief Pressure MPa (kgf/cm², psi)		(Reference values at 50 L/min)	T4-5-14
Boom Lower, Arm Roll-In, Bucket Roll-In	$39.2^{+1.0}_{-0}$ (400^{+10}_{-0}, 5680^{+145}_{-0})		
Boom Raise, Arm Roll-Out, Bucket Roll-Out	$39.2^{+1.0}_{-0}$ (400^{+10}_{-0}, 5680^{+145}_{-0})		
Main Pump Flow Rate L/min		Refer to T4-2-6.	T4-5-16
Swing Motor Drainage L/min			T4-5-24
With constant speed	0.2 to 0.5		
With the motor relieved	(2 to 5)		
Travel Motor Drainage L/min			T4-5-26
With the track jacked up	Less than 10	Allowable limit: 10	
With the motor relieved	Less than 15	Allowable limit: 15	

Main Pump P-Q Diagram

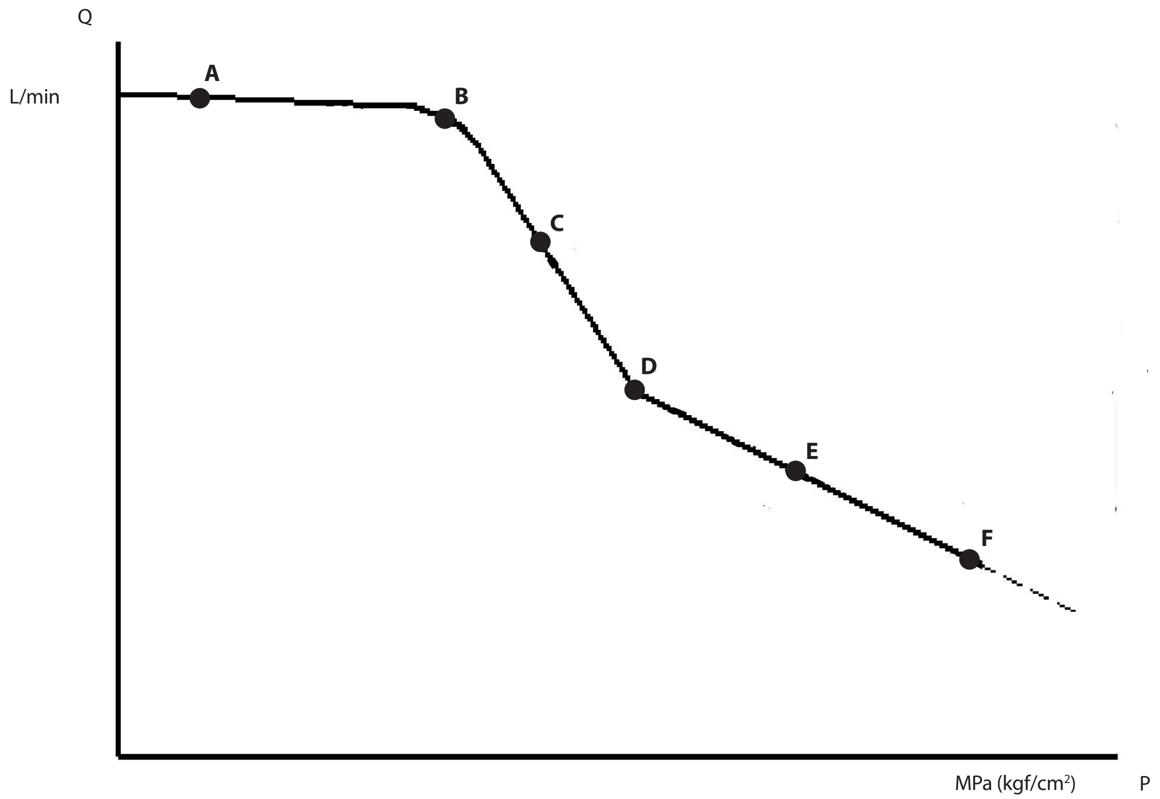
- P-Q Control (Torque Control)
  (Reference: Measured at Test Stand)
  - Rated Pump Speed: 2000 min^{-1} (rpm)
  - Hydraulic Oil Temperature: 50±5 °C (122±9 °F)

NOTE: Refer to T4-5-16.

Points on P-Q Line

	Delivery Pressure MPa (kgf/cm², psi)	Flow Rate L/min (gpm)
A	3.9 (40, 565)	212±3 (55.9±0.79)
B	14.7 (150, 2130)	[210 (55.4)]
C	16 (163, 2320)	196±6 (51.7±1.58)
D	22.0 (224, 3190)	[134 (35.4)]
E	26.0 (265, 3770)	116±6 (30.6±1.58)
F	34.3 (350, 4970)	79±10 (20.8±2.64)

The valve indicated in parentheses is only a reference valve.



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- P-Q Control by Pump Control Pilot Pressure Signal (Reference: Measured at Test Stand)

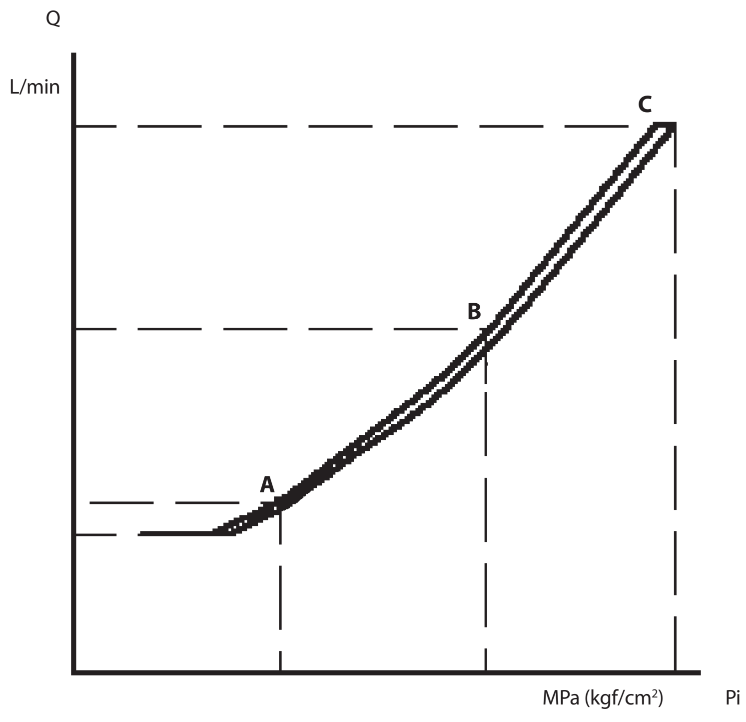
  - Rated Pump Speed: 2000 min^{-1} (rpm)
  - Hydraulic Oil Temperature: 50±5 °C (122±9 °F)

NOTE: Refer to T4-5-18.

Points on P-Q Line

	Pilot Pump Control Pressure MPa (kgf/cm^2, psi)	Flow Rate L/min
A	1.7±0.05 (17±0.5, 245±7.3)	70±2 (18.5±0.53)
B	2.0 (20, 290)	[102 (26.9)]
C	$2.9^{+0.05}_{-0.29}$ ($30^{+0.5}_{-3}$, $420^{+7.3}_{-42}$)	212±3 (55.9±0.79)

The valve indicated in parentheses is only a reference valve.



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Sensor Activating Range

1. Checking Method

- Hydraulic Oil Temperature: 50±5 °C (122±9 °F)
- Unless specified:

Engine Control Dial	Power Mode	Work Mode	Auto-Idle Switch
Fast Idle	PWR	Digging Mode	OFF

- Monitor each sensor by using MPDr..

2. Sensor Activating Range

Sensor	Operation	Specification
Engine Control Dial	Slow Idle	0.3 to 1.0 V
	Fast Idle	4.0 to 4.7 V
EC Sensor	Slow Idle	2.5 to 2.7 V
	Fast Idle	3.3 to 3.7 V
Pressure Sensor	Control Lever: Neutral Pilot Shut-Off Lever: LOCK	0 to 0.1 MPa (0 to 1.0 kgf/cm^2, 0 to 15 psi)
	Control Lever: Full Stroke Pilot Shut-Off Lever: UNLOCK	3.3 to 3.9 MPa (34 to 40 kgf/cm^2, 480 to 565 psi)
Pump Control Pressure Sensor	Control Lever: Neutral	0 to 1 MPa (0 to 10 kgf/cm^2, 0 to 145 psi)
	Control Lever: Full Stroke	2.9 to 3.9 MPa (30 to 40 kgf/cm^2, 420 to 565 psi)
N Sensor	20 °C between GND and SIGNAL	810±240 Ω

MPDr. Monitor Indicating Values

Unless specified, test under the following conditions.
Engine Speed: Fast Idle
Work Mode: Digging Mode
Power Mode : PWR
Auto-Idle Switch: OFF

ECF

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Directed Engine Speed (min^{-1})						
No load	1900					
When relieving arm roll-in	2000					
Actual Engine Speed (min^{-1})						
No load	2050					
When relieving arm roll-in	2000					
EC Sensor Voltage (V)	3.29					
EC Motor Position (step)	353					

MC

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Demand Engine Speed (min^{-1})						
Fast Idle	1900					
Fast Idle (When operating a control lever)	2000					When relieving boom raise
Fast Idle (Travel HP Mode)	2100					When relieving travel
Fast Idle (ECO Mode)	1850					When relieving boom raise
Auto-Idle	1150					
Slow Idle	800					Pilot shut-off lever: LOCK position
Actual Engine Speed (min^{-1})						
Fast Idle	2050					
Fast Idle (When operating a control lever)	2000					When relieving boom raise
Fast Idle (Travel HP Mode)	2100					When relieving travel
Fast Idle (ECO Mode)	1850					When relieving boom raise
Auto-Idle	1300					
Slow Idle	950					Pilot shut-off lever: LOCK position

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Engine Speed Deviation (min^{-1})						
Fast Idle	150					
Fast Idle (When operating a control lever)	0					When relieving boom raise
Fast Idle (Travel HP Mode)	0					When relieving travel
Fast Idle (ECO Mode)	0					When relieving boom raise
Auto-Idle	150					
Slow Idle	150					Pilot shut-off lever: LOCK position
EC Dial (V)						
Slow idle	0.56					
Fast idle	4.42					

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Tgt Pump 1 Flow Rate (L)						
Control lever in neutral	57.5					
Boom raise	37.0					When relieving
Boom lower	-					
Arm roll-in	50.5					When relieving
Arm roll-out	50.5					When relieving
Bucket roll-out	128.0					When relieving
Bucket roll-in	128.0					When relieving
Combined operation of boom raise, arm roll-in, and bucket roll-in	51.5					When relieving
Tgt Pump 2 Flow Rate (L)						
Control lever in neutral	57.5					
Boom raise	37.0					When relieving
Boom lower	-					
Arm roll-in	50.5					When relieving
Arm roll-out	50.5					When relieving
Bucket roll-out	55.5					When relieving
Bucket roll-in	55.5					When relieving
Combined operation of boom raise, arm roll-in, and bucket roll-in	51.5					When relieving

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Tgt Pump 1 Displacement (cm^3)						
Control lever in neutral	28.0					
Boom raise	18.5					When relieving
Boom lower	-					
Arm roll-in	25.5					When relieving
Arm roll-out	25.5					When relieving
Bucket roll-out	64.5					When relieving
Bucket roll-in	64.5					When relieving
Combined operation of boom raise, arm roll-in, and bucket roll-in	26.0					When relieving
Tgt Pump 2 Displacement (cm^3)						
Control lever in neutral	28.0					
Boom raise	18.5					When relieving
Boom lower	-					
Arm roll-in	25.5					When relieving
Arm roll-out	25.5					When relieving
Bucket roll-out	28.0					When relieving
Bucket roll-in	28.0					When relieving
Combined operation of boom raise, arm roll-in, and bucket roll-in	26.0					When relieving

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Pump 1 Delivery Pressure (MPa)						
Control lever in neutral	0.7					
Boom raise	38.0					When relieving
Boom lower	-					
Arm roll-in	34.3					When relieving
Arm roll-out	34.3					When relieving
Bucket roll-out	34.3					When relieving
Bucket roll-in	34.3					When relieving
Combined operation of boom raise, arm roll-in, and bucket roll-in	34.3					When relieving
Pump 2 Delivery Pressure (MPa)						
Control lever in neutral	0.7					
Boom raise	38.0					When relieving
Boom lower	-					
Arm roll-in	34.3					When relieving
Arm roll-out	34.3					When relieving
Bucket roll-out	0.7					When relieving
Bucket roll-in	0.7					When relieving
Combined operation of boom raise, arm roll-in, and bucket roll-in	34.3					When relieving

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Pump 1 Control Pressure (MPa)						
Control lever in neutral	1.0					
Boom raise	3.8					When relieving
Boom lower	-					
Arm roll-in	3.8					When relieving
Arm roll-out	3.8					When relieving
Bucket roll-out	3.8					When relieving
Bucket roll-in	3.8					When relieving
Combined operation of boom raise, arm roll-in, and bucket roll-in	3.8					When relieving
Pump 2 Control Pressure (MPa)						
Control lever in neutral	1.0					
Boom raise	3.8					When relieving
Boom lower	-					
Arm roll-in	3.8					When relieving
Arm roll-out	3.8					When relieving
Bucket roll-out	1.0					When relieving
Bucket roll-in	1.0					When relieving
Combined operation of boom raise, arm roll-in, and bucket roll-in	3.8					When relieving

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Boom Raise Pilot Pressure (MPa)	4.0					When relieving boom raise
Arm Roll-In Pilot Pressure (MPa)	4.0					When relieving arm roll-in
Travel Pilot Pressure (MPa)	4.0					
Front ATT Pilot Pressure (MPa)	4.0					Operate either of boom, arm, bucket, or swing
Swing Pilot Pressure (MPa)	4.0					When relieving swing
ATT 1 Pilot Pressure (MPa)	4.0					When relieving attachment
Arm Roll-Out Pilot Pressure (MPa)	4.0					When relieving arm roll-out
Pumps 1&2 Torque P/S O/P (MPa)	1.94					When relieving arm roll-in
Arm Regen P/S Output (MPa)	3.19					Arm leveling
Pressure Boost P/S Output	3.0					Power boost switch: ON
Digging Regen P/S O/P (MPa)	3.19					When relieving arm roll-in
Auxil Flw Cont P/S Output (MPa)						
Pumps 1&2 Torque P/S O/P FB	374					When relieving arm roll-in
Arm Regen P/S Output FB (mA)	495					Arm leveling
Pressure Boost P/S Output FB (mA)	479					
Digging Regen P/S O/P FB (mA)	495					When relieving arm roll-in

Wiper/Light Controller

Item	Reference Value	Measured Value				Remarks
		First	Second	Third	Average	
Wiper 1 Input (V)						
Wiper 2 Input (V)						

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Engine Speed

Summary:

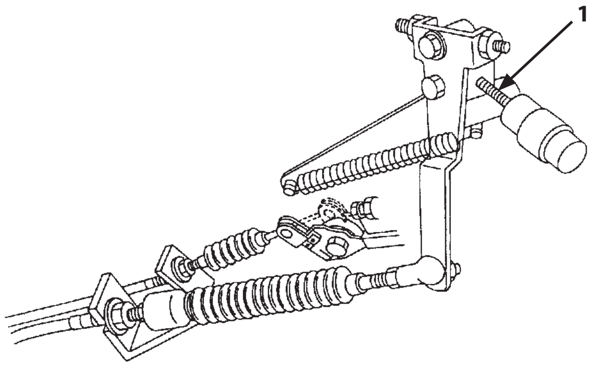
1. Measure the engine speed by using MPDr. or the service menu of monitor. Use a pulse counter when MPDr. or the service menu of monitor is in trouble.
2. Measure the engine speeds in each mode.

NOTE: If the engine speed is not adjusted correctly, all other performance data will be unreliable. Consequently, measure the engine speed before performing all other tests in order to check that the engine speed meets specification.

Preparation:

1. Install MPDr. or select the service menu of monitor. In case a pulse counter is used, disconnect the N sensor connector. Install the pulse counter.
2. Warm up the machine until coolant temperature reaches 50 °C (122 °F) or more, and hydraulic oil temperature is 50±5 °C (122±9 °F).

IMPORTANT: Do not adjust stopper (1) in the governor lever.



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Measurement:

1. Measure the engine speeds as shown in the table.
2. Select the switch positions and the test conditions corresponding to the engine speed to be measured as shown in the table below.
3. In case a pulse counter is used, read the pulse counter and calculate from the following equation.

   Engine speed (min^{-1}) = Pulse number (Hz) × 60/34

Evaluation:

Refer to Operational Performance Standard.

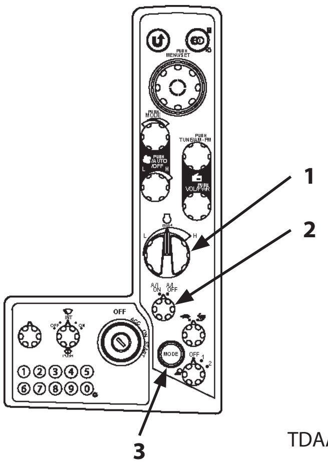
Remedy:

Refer to Troubleshooting B.

NOTE: ECO stands for the auto engine speed reduction system by 100 min^{-1}.

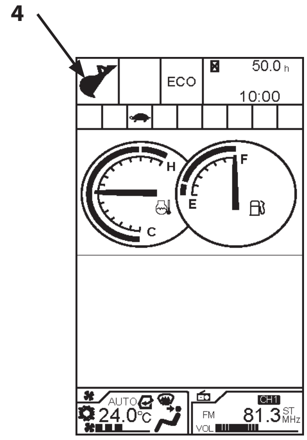
Item	Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode	Test Conditions
Slow Idle	Min. Speed	PWR	OFF	Digging Mode	Move the pilot shut-off lever to the UNLOCK position. Measure engine speed with the control lever in neutral.
Fast Idle (with ECO deactivated)	Max. Speed	PWR	OFF	Digging Mode	Deactivate ECO by using the MPDr. special functions or service menu of monitor. Measure engine speed with the control lever in neutral.
Fast Idle (Heater control: OFF)	Max. Speed	PWR	OFF	Digging Mode	Move the pilot shut-off lever to the UNLOCK position. Measure engine speed with the lever in neutral.
Fast Idle (Heater control: ON)	Max. Speed	PWR	OFF	Digging Mode	Move the pilot shut-off lever to the LOCK position. Engine speed can be measured only when coolant temperature is 5 °C (41 °F) or lower.
Fast Idle (Relief operation)	Max. Speed	PWR	OFF	Digging Mode	Measure engine speed while relieving the boom raise circuit.
Fast Idle (ECO mode)	Max. Speed	ECO Mode	OFF	Digging Mode	
Fast Idle (Travel HP mode)	Max. Speed	Travel HP Mode	OFF	Digging Mode	Measure engine speed while relieving the boom raise circuit.
Auto-Idle	Max. Speed	PWR	ON	Digging Mode	Measure engine speed in 4 seconds after returning the control lever to neutral.
Warming-Up	Min. Speed	PWR	OFF	Digging Mode	Engine speed can be measured only when hydraulic oil temperature is 0 °C (32 °F) or lower.

Switch Panel:



TDAA-05-02-032

Monitor:



TDAA-05-02-060

1- Engine Control Dial
2- Auto-Idle Switch
3- Power Mode Switch
4- Digging Mode

Engine Compression Pressure

Summary:

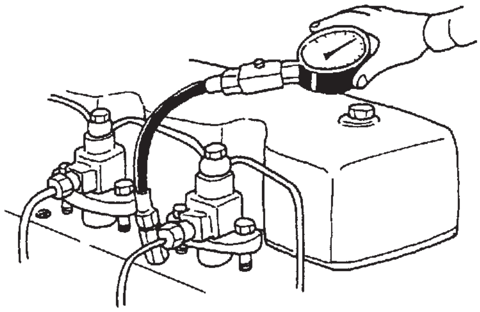
1. Measure compression pressure in the cylinders and check for a decline in engine power.
2. Check exhaust gas color. Keep track of engine oil consumption.
3. Check for abnormalities in the intake system, including the air filter.

Preparation:

1. Confirm that valve clearances are correct.
2. Charges the batteries.
3. Run the engine until the coolant temperature gauge reaches the operating range.
4. Remove all the glow plugs and fuel pipes from each cylinder.

NOTE: If disconnecting the fuel pipes, the pressure continues to increase as fuel blows up in the cylinder.

5. Install a pressure gauge and an adaptor (Isuzu 5-85317-001-0) to the glow plug mounting part. (Sufficiently install them in order to prevent air leakage.)



T105-06-02-001

Measurement:

1. Turn the starter and measure compression pressure of each cylinder.
2. Repeat the measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to the engine shop manual.

(Blank)

Valve Clearance

Summary:

1. Perform the measurement when the engine is cold.
2. Before starting any work, clean the head cover mounting area and avoid contamination in the engine.

Preparation:

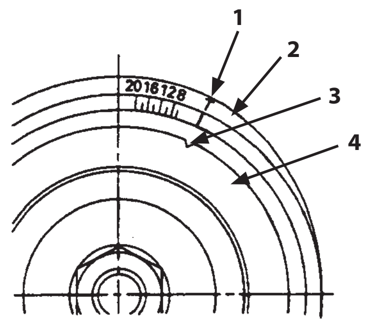
1. Rotate crank pulley (4). Fit top dead center (TDC) mark (3) on crank pulley (4) to top mark (1) located on timing gear case (2) in order to get the top dead center (TDC) in the compression stroke.

NOTE: When rotating crank pulley (4), remove the fan guard. Then, rotate the fan while holding the fan belt. If it is difficult to rotate, remove all glow plugs and release compression pressure.

2. Check if No.1 piston (or No.6 piston) is now positioned at the TDC in the compression stroke.

NOTE: If any clearances on the both ends of the push rods are found, No.1 piston is positioned at TDC in the compression stroke. (If the exhaust valve of No.1 cylinder is pushed down, No.6 piston is positioned at TDC in the compression stroke.)

3. Remove the head cover. Start the measurement from No.1 cylinder or No.6 cylinder positioned at the TDC in the compression stroke.



T157-05-02-002

1- Top Mark
2- Timing Gear Case
3- TDC Mark
4- Crank Pulley

Measurement:

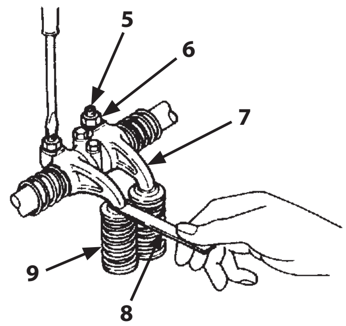
1. Insert thickness gauge (8) into the clearance between rocker arm (7) and valve stem (9) and measure the valve clearance.

NOTE: The cylinders are aligned from No.1 to No.6 in that order, as viewed from the fan side. Injection Order: 1-5-3-6-2-4)

2. When measurement is started from No.1 cylinder, perform the same measurement to all valves indicated with the mark ○ in the table below. (When measurement is started from No.6 cylinder, perform the measurement in the valves shown with mark ×.)

Cylinder No.	No.1		No.2		No.3		No.4		No.5		No.6	
Valve locations	I	E	I	E	I	E	I	E	I	E	I	E
When the measurement is started from No.1 cylinder	○	○	○			○	○			○		
When the measurement is started from No.6 cylinder				×	×			×	×		×	×

3. Rotate the crank shaft 360 °. Fit the TDC mark to the pointer. Continue measurement of other valves in the same way.



T107-02-12-005

5- Adjusting Screw
6- Lock Nut
7- Rocker Arm
8- Thickness Gauge
9- Valve Stem

Evaluation:

Refer to Operational Performance Standard.

Adjustment:

If the measurement results are out of specification, adjust the valve clearance in the same order of measurement.

1. Loosen lock nut (6) on adjusting screw (5) of rocker arm (7). Insert thickness gauge (8) set by specification and adjust adjusting screw (5).
2. After adjustment, tighten lock nut (6). Check the valve clearance after lock nuts (6) are tightened.

   : 25.5±4.9 N·m (2.6±0.5 kgf·m, 19±3.6 lbf·ft)

Nozzle

Summary:

1. Check the injection pressure and the spray pattern by using a nozzle tester.
2. Before starting any work, clean the nozzle holder mounting area and avoid contamination in the engine.

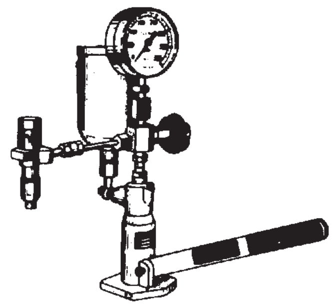
Preparation:

1. Removal of Nozzle Holder

   Remove all nozzles and fuel injection pipes.

2. Installation to Nozzle Tester

   Install the nozzle holder, which was removed from the engine, to the nozzle tester.



T107-06-02-006

Measurement:

CAUTION: The fuel spray from the nozzle may penetrate the skin and results in serious injury. If fuel penetrates into the blood stream, it may cause blood toxication. Do not touch spray directly.

- Injection starting pressure:
  1. After installing a nozzle to the nozzle tester, strongly inject fuel several strokes. While operating the tester at approx. 60 time strokes a minute, measure the fuel injection pressure.
  2. Loosen the lock nut and adjust the pressure by using the adjusting screw. Turning the adjusting screw clockwise increases the pressure. Turning the adjusting screw counterclockwise decreases the pressure.

- Spray pattern:
  1. After installing a nozzle to the nozzle tester, strongly inject fuel several strokes and check the fuel spray pattern. For this test, do not operate the pressure gauge in principle.

- Oil tight condition:
  1. Keep the pressure slightly below the injection pressure. Check for fuel leak from around the nozzle tip.

IMPORTANT: Use clean diesel fuel.

Evaluation:

1. Standard injection starting pressure:

   Refer to Operational Performance Standard.

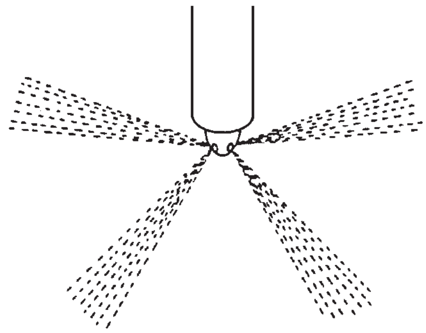
2. Spray pattern:

- No rough and large particle visually confirmed.
- No particle injected aside.
- Intermittent fine spray at initial injection.
- No after-dripping after completing injection.
- Correct spray angle.

3. Oil tight condition:

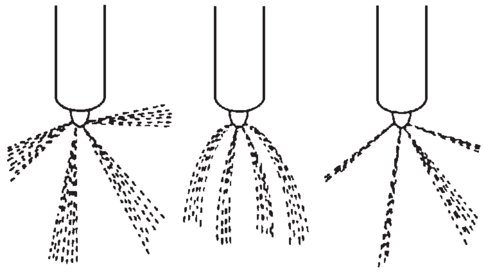
- No fuel leakage.

Correct



T102-02-11-005

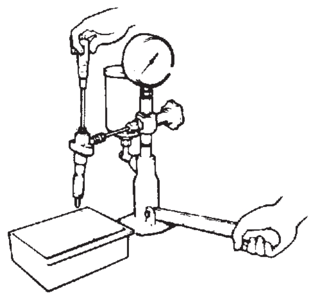
Incorrect



T102-02-11-006

Adjustment:

- Loosen the lock nut and adjust the injection starting pressure by using the adjusting screw. Turning the adjusting screw clockwise increases the pressure. Turning the adjusting screw counterclockwise decreases the pressure.
- After adjustment, tighten the lock nut.



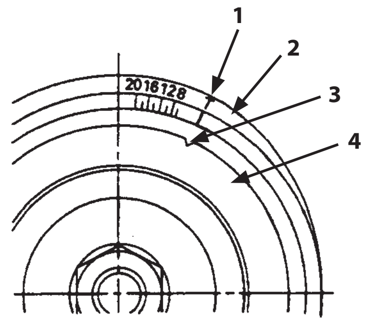
T107-06-02-007

Injection Timing

Inspection:

1. Rotate crank pulley (4) in the engine normal rotation (clockwise). Fit top dead center (TDC) mark (3) of crank pulley (4) to top mark (1) located of timing gear case (2) in order to get the top dead center (TDC) in the compression stroke of No.1 piston.

NOTE: When rotating crank pulley (4), remove the fan guard. Then, rotate the fan while holding the fan belt. If it is difficult to rotate, remove all glow plugs and release compression pressure.



T157-05-02-002

1- Top Mark
2- Timing Gear Case
3- TDC Mark
4- Crank Pulley

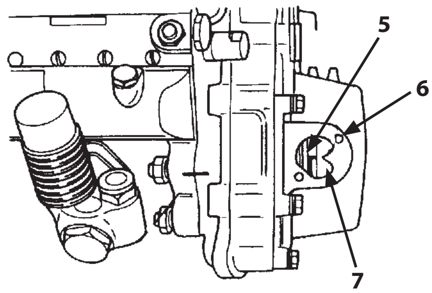
2. Remove sight glass (6) in front of the injection pump. In case concave part (5) of the gear case is fit to matching mark (7) of the injection pump, the injection pump is installed correctly.

NOTE: As matching mark (7) of the injection pump cannot be seen from sight glass (6), check it by using a mirror.

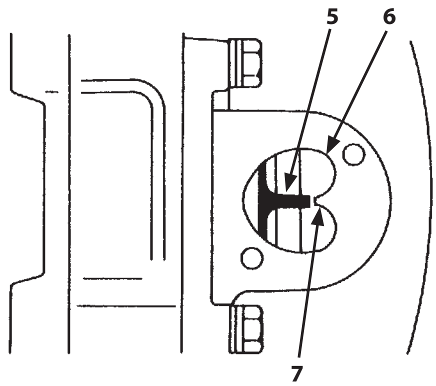
3. Disconnect the injection pipe from No.1 cylinder.
4. Remove the delivery valve holder for No.1 cylinder from the injection pump. Remove the delivery valve and the spring. Install only the delivery valve holder again.

   : 39 to 44 N·m (4 to 4.5 kgf·m, 29 to 32.5 lbf·ft)

5. Rotate crank pulley (4) by approx. 30 ° counterclockwise.



T107-02-12-007



T107-02-12-008

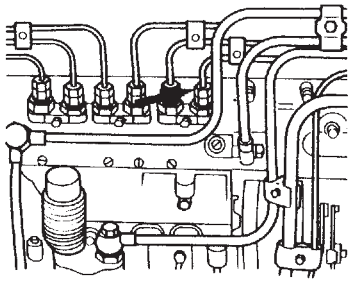
5- Gear Case Convex Part
6- Sight Glass
7- Matching Mark of Injection Pump

6. While supplying fuel with the solenoid fuel feed pump, rotate crank pulley (4) slowly clockwise just until fuel from the top of the delivery valve holder hole stops. This position is Injection Start.
7. Check the angle of timing gear case (2) pointed by top dead center (TDC) mark (3) of crank pulley (4).

Adjustment:

1. Set the angle of timing gear case (2) pointed by top dead center (TDC) mark (3) correctly.

   (10 ° before top dead center (TDC))
2. Loosen the nut which secures the injection pump.
3. Incline the injection pump outside (opposite the cylinder block) in order to advance the injection timing. Incline the injection pump inside (toward the cylinder block) in order to delay the injection timing.



T107-02-12-009

Lubricant Consumption

Checking Method:

1. Place the machine on level firm ground and leave the machine for at least one hour in order to let the lubricant lower to the oil pan when the engine stops. At this time, confirm that the machine is level by using a leveler.
2. Record read-out A (unit: hour) of the hour meter.
3. Replenish the lubricant up to the high-level gauge.
4. Operate the machine for at least 100 hours or until the oil level lowers to the low-level gauge.

IMPORTANT: Keep the machine-leaving time in step 1.

5. Place the machine on level firm ground and leave the machine for at least one hour in order to let the lubricant lower to the oil pan when the engine stops. At this time, confirm that the machine is level by using a leveler.
6. Record read-out B (unit: hour) of the hour meter.
7. Replenish the lubricant up to the high-level gauge while measuring the oil-replenishing volume C (unit: mL).

NOTE: When measuring, use a high-precision measuring cylinder.

8. Determine lubricant consumption from the following equation: Oil replenishing volume (C) [mL] / Operating hours (B-A) [hr]

Evaluation:

Refer to Operational Performance Standard.

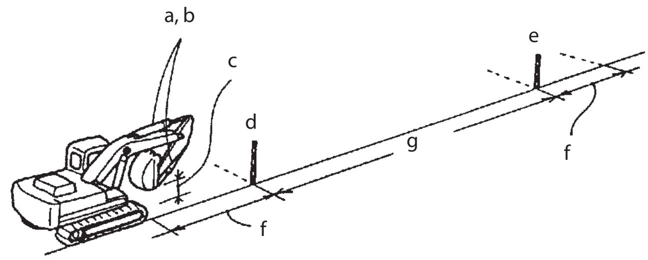
Travel Speed

Summary:

1. Measure the time required for the machine to travel a test track and check the performance of the travel device systems (from main pump to travel motor).

Preparation:

1. Adjust the track sag of both tracks equally.
2. Provide a flat, solid test yard 10 m (33 ft) in length, with extra length of 3 to 5 m (10 to 16 ft) on both ends for machine acceleration and deceleration.
3. With the arm and the bucket cylinders fully extended, hold the bucket 0.3 to 0.5 m (1.0 to 1.6 ft) above the ground.
4. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T105-06-03-001

a - Arm Retract
b - Bucket Tilt-In
c - Bucket Height: 0.3 to 0.5 m (1.0 to 1.6 ft)
d - Start
e - End
f - Acceleration Zone: 3 to 5 m (10 to 16 ft)
g - 10 m (33 ft)

Measurement:

1. Measure the amount of mistracking in both fast and slow travel modes.
2. Select the following switch positions

Travel Mode Switch	Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Slow Mode	Fast Idle	PWR	OFF	Digging Mode
Fast Mode	Fast Idle	PWR	OFF	Digging Mode

3. Start traveling the machine in the acceleration zone with the travel levers to full stroke.
4. Measure the time required to travel 10 m (33 ft).
5. After measuring the forward travel speed, turn the upperstructure 180° and measure the reverse travel speed in the same way.
6. Repeat the measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

Track Revolution Speed

Summary:

1. Measure the track revolution cycle time with the track raised off ground and check the performance of the travel device systems (from main pump to travel motor).

Preparation:

1. Adjust the track sag of both tracks equally.
2. On the track to be measured, put the mark on one shoe by using a piece of chalk or cloth.
3. Raise the track to be measured as illustrated.

CAUTION: Securely support the raised machine using blocks.

4. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

Measurement:

1. Measure on both tracks at slow and fast travel speeds of the machine.
2. Select the following switch positions

Travel Mode Switch	Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Slow Mode	Fast Idle	PWR	OFF	Digging Mode
Fast Mode	Fast Idle	PWR	OFF	Digging Mode

3. Operate the travel control lever of the track to be measured to full stroke.
4. Measure the time required for 3 revolutions after a constant track revolution speed is obtained.
5. Repeat the measurement three times and calculate the mean values.

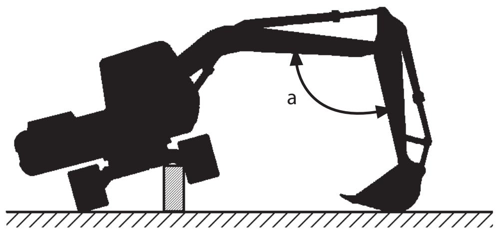
Evaluation:

Refer to Operational Performance Standard.

NOTE: The measurement data obtained through the raised track revolution test may have wide variations. Therefore, the evaluation based on the results obtained from the 10 m travel speed check described before is more recommendable.

Remedy:

Refer to Troubleshooting B.



M104-07-067

a - 90 to 110°

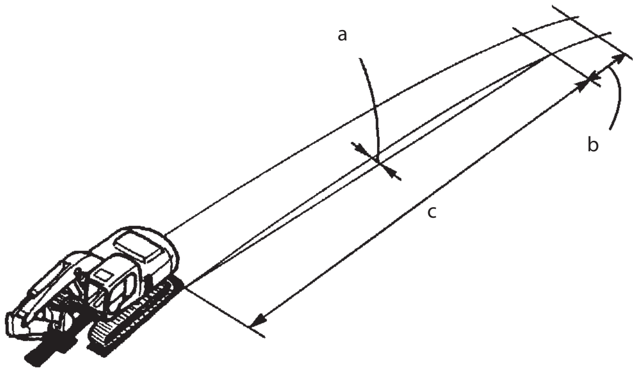
Mistrack Check

Summary:

1. Allow the machine to travel 20 m (65.6 ft). Measure the maximum tread deviation from the tread chord drawn between the travel start and end points and check the performance of travel device systems (from main pump to travel motor).
2. If measured on a concrete surface, the tread deviation has a trend to decrease.

Preparation:

1. Adjust the track sag of both tracks equally.
2. Provide a flat, solid test yard 20 m (65.6 ft) in length, with extra length of 3 to 5 m (10 to 16 ft) on both ends for machine acceleration and deceleration.
3. With the arm and bucket cylinders fully extended, hold the bucket 0.3 to 0.5 m (12 to 20 in) above the ground.
4. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T105-06-03-002

a - Maximum Distance
b - Acceleration Zone: 3 to 5 m (10 to 16 ft)
c - 20 m (65.6 ft)

Measurement:

1. Measure the amount of mistracking in both fast and slow travel modes.
2. Select the following switch positions

Travel Mode Switch	Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Slow Mode	Fast Idle	PWR	OFF	Digging Mode
Fast Mode	Fast Idle	PWR	OFF	Digging Mode

3. Start traveling the machine in the acceleration zone with the travel levers to full stroke.
4. Measure maximum distance between a straight 20 m (65.6 ft) tread chord and the tread made by the machine.
5. After measuring the tracking in forward travel, turn the upperstructure 180° and measure in reverse travel.
6. Repeat the measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

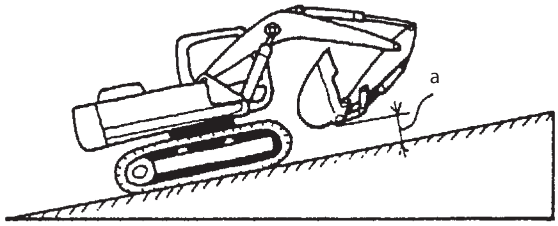
Travel Parking Leakage

Summary:

Measure the parking brake function on a specified slope.

Preparation:

1. Measure on a flat slope with a gradient of 20 % (11.31).
2. With the arm and bucket cylinders fully extended, hold the bucket 0.2 to 0.3 m (8 to 12 in) above the ground.
3. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T105-06-03-004

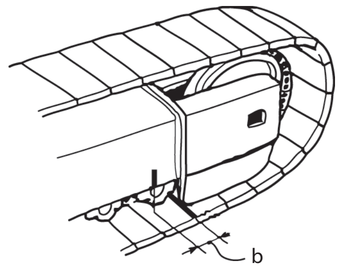
a - 0.2 to 0.3 m (8 to 12 in)

Measurement:

1. Measure the travel parking brake slip amount while parked.
2. Climb the slope and set the travel lever in neutral.
3. Stop the engine.
4. After the machine stops, put the matching marks on track link or shoe, and the track side frame.
5. After 5 minutes, measure the distance between marks on the track link or the shoe and the track frame.

Evaluation:

Refer to Operational Performance Standard.



TDAA-04-04-001

b - Displacement measured after 5 minutes.

Swing Speed

Summary:

Measure the time required to swing three complete turns and check the performance of the swing device systems (from main pump to swing motor).

Preparation:

1. Check lubrication of the swing gear and the swing bearing.
2. Place the machine on flat and solid ground with ample space for swinging. Do not conduct this test on a slope.
3. Fully retract the arm cylinder. Fully extend the bucket cylinder. Hold the boom so that the arm end pin height is the same as the boom foot pin height. Empty the bucket.

NOTE: In case a sufficient space for the measurement is difficult to find, carry out the measurement with the boom fully raised and the arm fully rolled-in.

4. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

CAUTION: Prevent personal injury. Always make sure that the area is clear and that coworkers are out of the swing area before starting the measurement.

Measurement:

1. Select the following switch positions

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

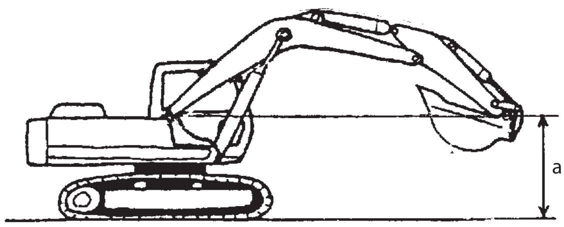
2. Operate the swing control lever fully.
3. Measure the time required to swing 3 turns in one direction.
4. Check in both clockwise and counterclockwise directions.
5. Repeat the measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

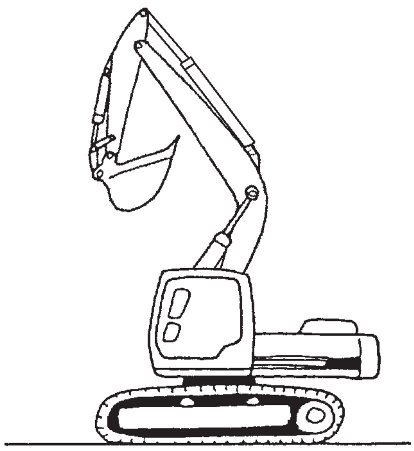
Remedy:

Refer to Troubleshooting B.



T105-06-03-013

a - The height as boom foot pin height



T178-04-03-001

Swing Function Drift Check

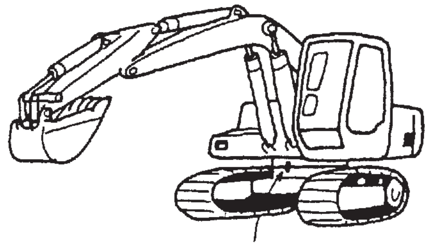
Summary:

1. Measure the swing drift on the swing bearing outer circumference when stopping after a 180° full-speed swing and check the performance of the swing brake valve.
2. The mechanical brake for the swing parking brake is equipped for the swing motor.

Preparation:

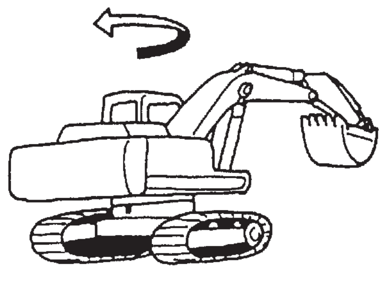
1. Check lubrication of the swing gear and the swing bearing.
2. Place the machine on the flat and solid ground with ample space for swinging. Do not conduct this test on a slope.
3. With the arm cylinder fully retracted and the bucket cylinder fully extended, hold the bucket so that height of the arm end pin is the same as the boom foot pin. Empty the bucket.
4. Put the matching marks on the swing bearing outer circumference (upperstructure side) and the track frame.
5. Turn the upperstructure 180°.
6. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

CAUTION: Prevent personal injury. Always make sure that the area is clear and that coworkers are out of the swing area before starting the measurement.



T105-06-03-008

a - Put the matching marks on swing bearing outer circumference and track frame.



T105-06-03-009

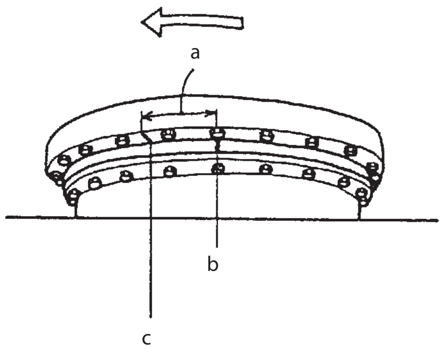
b - Before start the measurement, swing the upperstructure 180°.

Measurement:

1. Select the following switch positions

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

2. Operate the swing control lever fully and return it to the neutral position when the mark on upperstructure aligns with that on track frame after turning the upperstructure 180°.
3. Measure the distance between the two marks.
4. Check in both clockwise and counterclockwise directions.
5. Repeat the measurement three times and calculate the mean values.



T105-06-03-010

a - Measure difference between marks.
b - Mark on Track Frame
c - Mark on Swing Bearing

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

Swing Motor Leakage

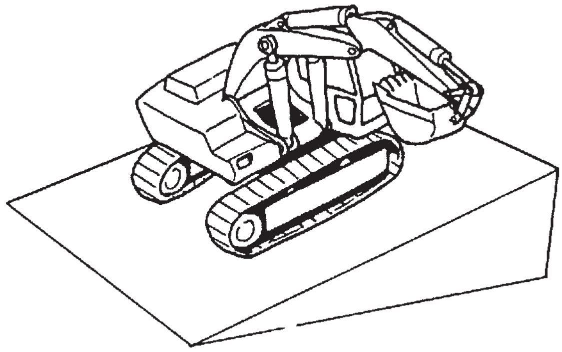
Summary:

1. Measure the upperstructure drift while suspending a load on a specified slope and check the performance of the swing parking brake. (The mechanical brake for the swing parking brake is equipped for the swing device.)

Preparation:

1. Check lubrication of the swing gear and the swing bearing.
2. Load the bucket with either soil or a weight equivalent to the weight standard.

   Weight: 1050 kg (2320 lb)
3. With the arm cylinder fully retracted and the bucket cylinder fully extended, hold the bucket so that height of the arm end pin is the same as the boom foot pin.
4. Park the machine on a smooth slope with a gradient of 26.8 % (15°).
5. Climb a slope and swing the upperstructure to position it 90° to the slope. Put the matching marks on the outer circumference of the swing bearing (upperstructure side) and track frame by using the tape.
6. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



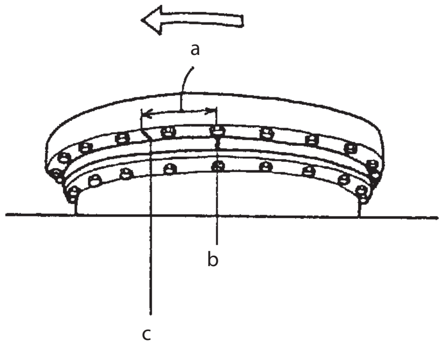
T105-06-03-011

Measurement:

1. Select the following switch positions

Power Mode	Auto-Idle Switch	Work Mode
PWR	OFF	Digging Mode

2. Maintain the engine at slow idle. After five minutes, measure the difference between the marks on the swing bearing outer circumference and the track frame.
3. Check in both clockwise and counterclockwise directions.
4. Repeat the measurement three times and calculate the mean values.



T105-06-03-010

a - Measure difference between marks.
b - Mark on Track Frame
c - Mark on Swing Bearing

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

Maximum Swingable Slant Angle

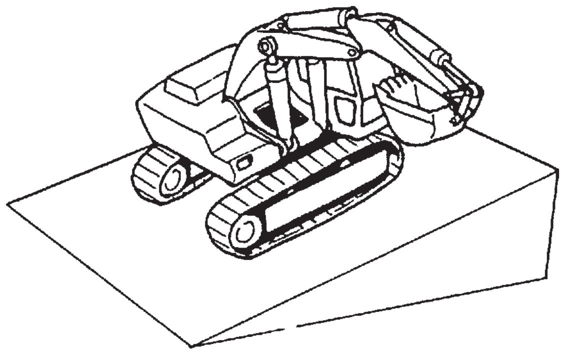
Summary:

1. With the upperstructure swung 90° to the slope, check the maximum slant angle on which the upperstructure can swing to the uphill side.

Preparation:

1. Check lubrication of the swing gear and the swing bearing.
2. Load the bucket with either soil or a weight equivalent to the weight standard.

   Weight: 1050 kg (2320 lb)
3. With the arm cylinder fully retracted and the bucket cylinder fully extended, hold the bucket so that height of the arm end pin is the same as the boom foot pin.
4. Climb a slope and turn the upperstructure 90° to the slope.
5. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T105-06-03-011

Measurement:

1. Select the following switch positions

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

2. Operate the swing lever to full stroke to swing the upperstructure to the uphill side.
3. If the machine can turn, measure the cab floor slant angle.
4. When the machine can swing, increase the slant angle. Check in both clockwise and counterclockwise directions.
5. Repeat the measurement three times.

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

Swing Bearing Play

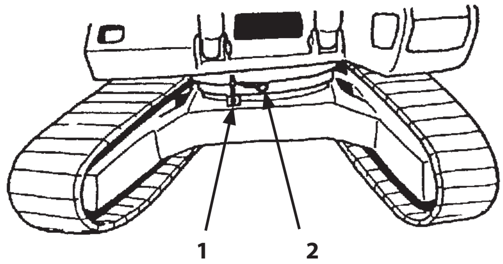
Summary:

1. Measure the swing bearing play and check the wear of the swing bearing races and the balls.

Preparation

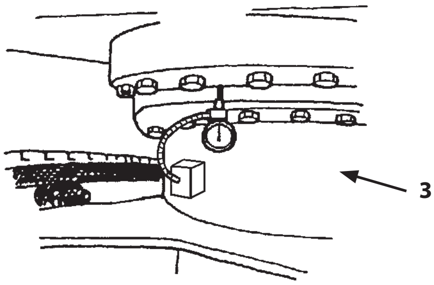
1. Check the swing bearing mounting bolts for looseness.
2. Check lubrication of the swing bearing. Confirm that bearing rotation is smooth without noise.
3. Secure a dial gauge (2) on the round trunk of the track frame by using a magnetic base (1).
4. Position the upperstructure so that the boom aligns with the tracks facing towards the front idlers.
5. Position the dial gauge (2) so that its needle point comes into contact with the bottom surface of the swing bearing outer race.
6. The bucket must be empty.

NOTE: The measured value will vary depending on where the magnetic base (1) is secured. Secure the magnet base onto the round trunk or in a position as close to the swing bearing as possible.



T105-06-03-014

1- Magnetic Base 2- Dial Gauge

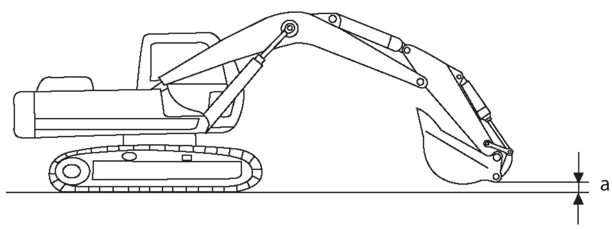


T105-06-03-015

3- Round Trunk

Measurement:

1. With the arm fully retracted and the bucket fully extended, hold the bucket 100 mm (4 in) above the ground. Record dial gauge reading (h1).

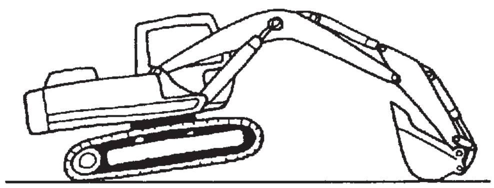


TDAA-04-04-002

a - 100 mm (3.9 in)

2. Lower the bucket to the ground and raise the front idler 0.5 m (20 in) by using the front attachment. Record dial gauge (2) reading (h2).
3. Calculate bearing play (H) from these data (h1 and h2) as follows:

   [H]=[h2]-[h1]



T105-06-03-017

Evaluation:

Refer to Operational Performance Standard.

Hydraulic Cylinder Cycle Time

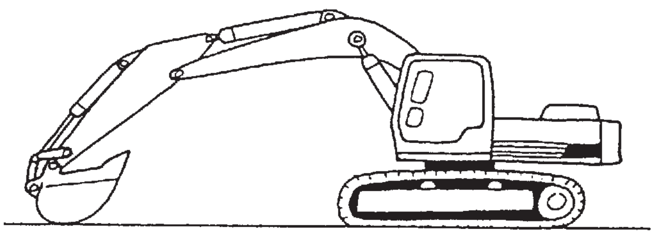
Summary:

1. Measure the cycle time of boom, arm and bucket cylinders and check the performance of the front attachment systems (from main pump to each cylinder).
2. The bucket should be empty.

Preparation:

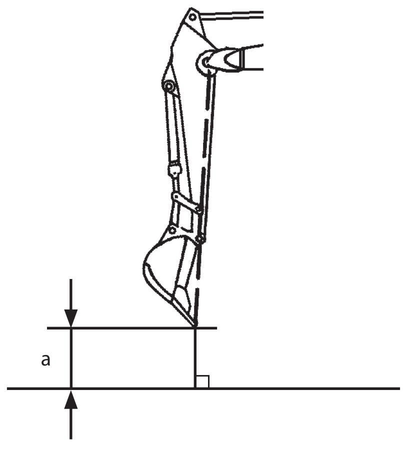
1. Measurement is made for the following positions.

- Measurement of the cycle time of the boom cylinder: With the bucket cylinder fully extended and the arm cylinder fully retracted, lower the bucket onto the ground.



T105-06-03-018

- Measurement of the cycle time of the arm cylinder: Retract or extend the bucket cylinder so that the arm and the bucket teeth are vertical to the ground. Set the arm so that the center of arm operation is vertical. The bucket teeth clearance above the ground is 0.5m (20 in).

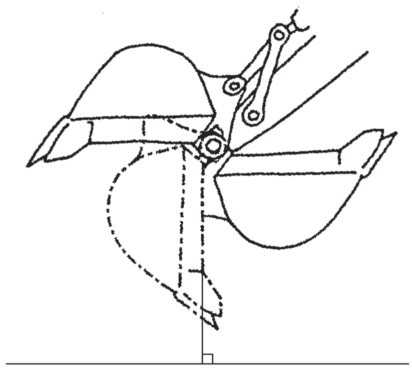


T1V1-04-05-005

a - 0.5 m (20 in)

- Measurement of the cycle time of the bucket cylinder: Adjust the boom and arm cylinders so that the bucket oscillation center faces vertically to the ground.

2. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T105-06-03-020

Measurement:

1. Select the following switch positions

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

2. Measure the cylinder cycle times as follows: (Cylinder full stroke includes cylinder cushioning zone.)

- Measurement of the cycle time of the boom cylinder: Operate the boom control lever to full stroke. Measure the time to raise and lower the boom.
- Measurement of the cycle time of the arm cylinder: Operate the arm control lever to full stroke. Measure the time to roll in and roll out the arm.
- Measurement of the cycle time of the bucket cylinder: Operate the bucket control lever to full stroke. Measure the time to roll in and roll out the bucket.

3. Repeat the measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

Dig Function Drift Check

- Maximum Reach Position

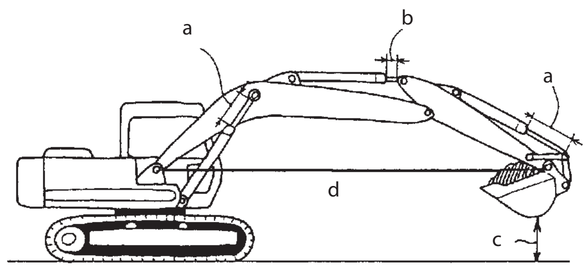
Summary:

1. Measure dig function drift, which can be caused by oil leakage in the control valve and boom, arm and bucket cylinders, with the bucket loaded.
2. When measuring the drift just after cylinder replacement, slowly operate the cylinder for ten minutes and bleed air from the cylinder.

Preparation:

1. Load the bucket with either soil or a weight equivalent to the weight standard.

   Weight: 1050 kg (2320 lb)
2. With the arm cylinder fully retracted and the bucket cylinder fully extended, hold the bucket so that height of the arm end pin is the same as the boom foot pin.
3. Position the arm cylinder and the bucket cylinder with the rod 50 mm (2 in) away from the full stroke end position.
4. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T105-06-03-021

a - Retraced Distance
b - Extended Distance
c - Dig Function Drift Amount
d - height is the same as boom foot pin.

Measurement:

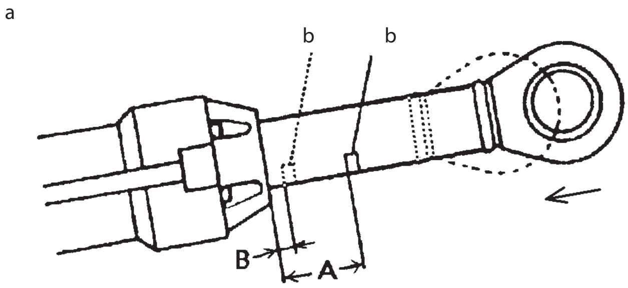
1. Stop the engine.
2. Five minutes after the engine has been stopped, measure the change in position of bottom of the bucket, as well as the boom, arm and bucket cylinders.

   Boom and Bucket Cylinders: Retraction a

   a=A-B

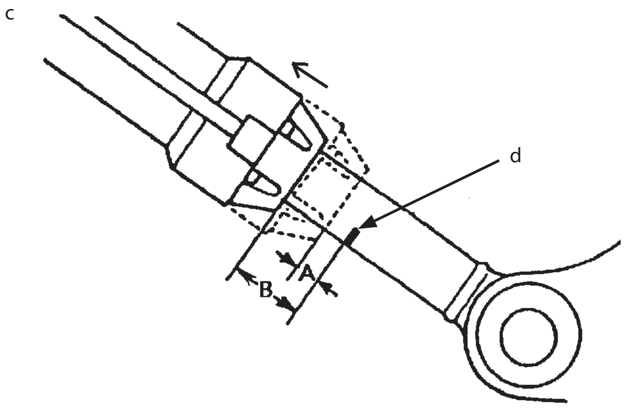
   Arm Cylinder: Extension c

   c=B-A
3. Repeat the measurement three times and calculate the mean values.



T110-06-03-002

a - Boom and Bucket Cylinders: Retraction b - Mark



T110-06-03-001

c - Arm Cylinder: Extension d - Mark

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

- Arm Roll-In position

Summary:

1. Measure dig function drift, which can be caused by oil leakage in the control valve and boom, arm and bucket cylinders.
2. When measuring the drift just after cylinder replacement, slowly operate the cylinder for ten minutes and bleed air from the cylinder.

Preparation:

1. The bucket must be empty.
2. With the arm fully extended and the bucket fully extended, hold the arm end 1 m (40 in) above the ground.
3. Position the arm cylinder and the bucket cylinder with the rod 50 mm (2 in) away from the full stroke end position.
4. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

Measurement:

1. Stop the engine.
2. In five minutes after the engine has been stopped, measure the change in position of bottom of the arm tip, as well as the boom, arm and bucket cylinders.

   Cylinder Retraction b

   b=A-B
3. Repeat the measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

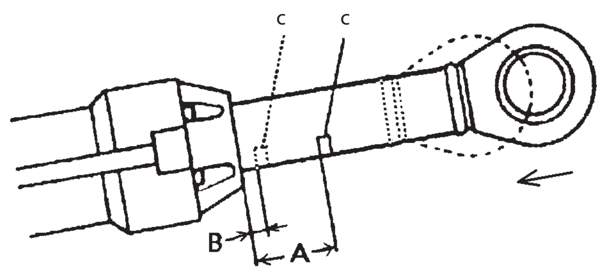
Remedy:

Refer to Troubleshooting B.

T173-04-03-001

a - 1 m (40 in)

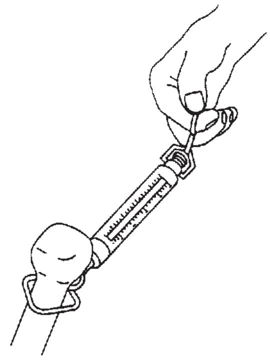
b



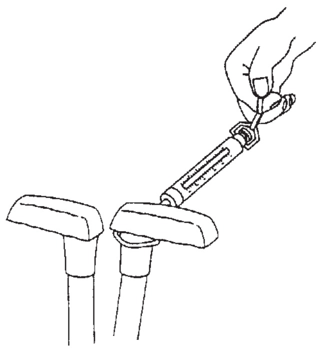
T110-06-03-002

b - Cylinder Retraction c - Mark

Control Lever Operating Force



T107-06-03-003



T107-06-03-004

Summary:

1. Measure a play and operating condition of each control lever.
2. Measure the maximum operating force of the front attachment control lever.
3. Measure the lever stroke at the grip center of each control lever.

Preparation:

1. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

CAUTION: Prevent personal injury. Always make sure that the area is clear and that coworkers are out of the swing area before starting the measurement.

Measurement:

1. Measure the force of each control lever.
2. Select the following switch positions

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

3. In case of boom (raise), arm and bucket control lever, measure the maximum operating force for each with each actuator relieved.
4. In case of boom (lower) lever, measure the maximum operating force with the boom (lower) relieved by raising the machine in a stable area.
5. In case of swing lever, measure the maximum operating force with swing relieved after securing the front attachment to prevent turning.
6. In case of travel lever, raise the track to be measured. Measure the maximum operating force required.
7. Repeat the measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

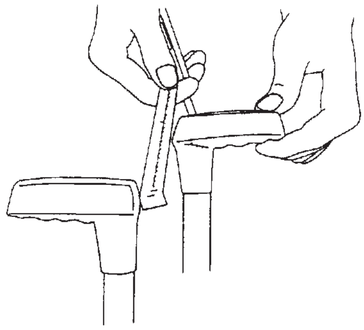
Control Lever Stroke

Summary:

1. Check a play and operating condition and measure each control lever stroke.
2. Measure the lever stroke at the grip center of each control lever.
3. In case lever stroke play is present in the neutral position, add half (1/2) the play present to both side lever strokes.

Preparation:

1. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T107-06-03-005

Measurement:

1. Stop the engine.
2. Measure each lever stroke from neutral to the stroke end of each control lever of boom, arm, bucket, swing and travel.
3. Measure the chord length from neutral to the stroke end.
4. Repeat the measurement three times and calculate the mean values.

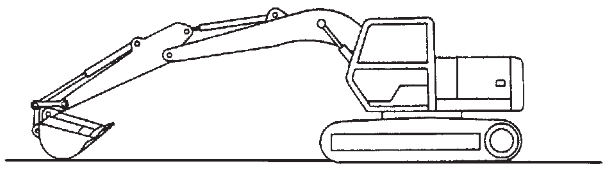
Evaluation:

Refer to Operational Performance Standard.

Combined Operation of Boom Raise / Swing Function Check

Summary:

1. Check boom raise and swing movement and speeds while operating both functions simultaneously.
2. Check if the cylinders do not hesitate while operating the cylinder with the engine running at fast idle.

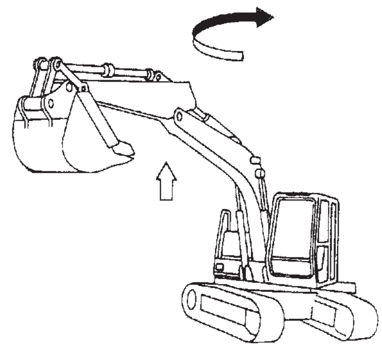


T107-06-03-009

Preparation:

1. With the arm cylinder fully retracted and the bucket cylinder fully extended, lower the bucket onto the ground. Lower the bucket onto the ground. Empty the bucket.
2. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

CAUTION: Prevent personal injury. Always make sure that the area is clear and that coworkers are out of the swing area before starting the measurement.



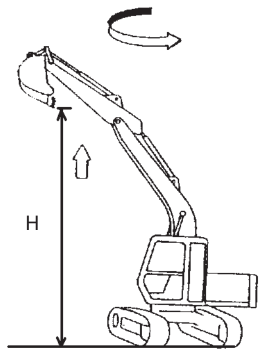
T107-06-03-010

Measurement:

1. Select the following switch positions

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

2. Raise the boom and roll the swing in full stroke at the same time. Measure the time required to turn the upperstructure 90° and height (H) of the bucket teeth. (The bucket should be empty.)
3. Repeat the measurement three times and calculate the mean values.



T107-06-03-011

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

Combined Operation of Boom Raise / Arm Roll-In Function Check

Summary:

1. Check boom raise and arm roll-in movement and speeds while operating both functions simultaneously.
2. Check if the cylinders do not hesitate while operating the cylinder with the engine running at fast idle.

Preparation:

1. Retract the arm cylinder fully and extend the bucket cylinder so that the bucket teeth and arm mounting pin are on a straight line. Adjust the boom cylinder so that the bucket tooth tip height is 0.5 m (1.6 ft) above the ground. Empty the bucket.
2. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

Measurement:

1. Select the following switch positions.

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

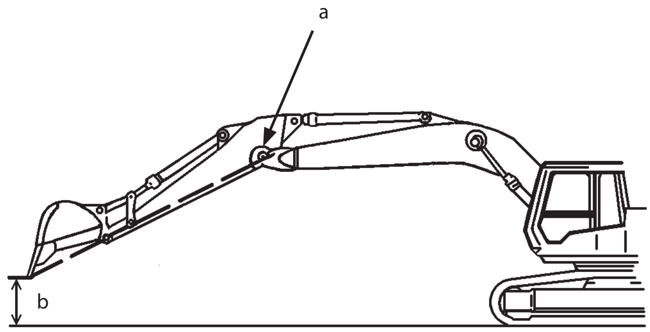
2. Raise the boom and roll the arm in full stroke at the same time.
3. Measure the time required for the arm to reach the stroke end. (The bucket should be empty.)
4. Repeat the measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

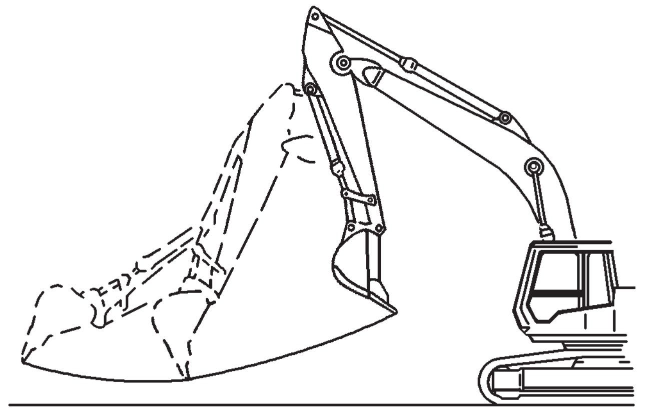
Remedy:

Refer to Troubleshooting B.



T107-06-03-006

a - Arm Mounting Pin
b - 0.5 m (1.6 ft)



T1V1-04-04-001

Primary Pilot Pressure

Preparation:

1. Stop the engine.
2. Push the air bleed valve on top of the hydraulic oil tank and release any remaining pressure.
3. Remove plug (1) from the pilot filter. Install adapter (ST 6069) and pressure gauge (ST 6942) to the pressure check port.

   : 14 mm
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

Measurement:

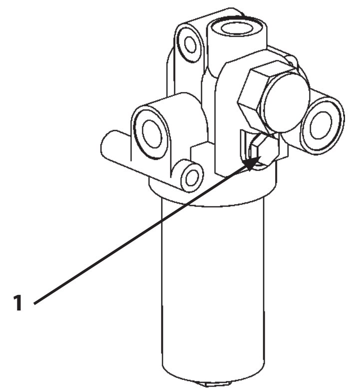
1. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode
Slow Idle	PWR	OFF	Digging Mode

2. Measure pilot pressure in each specified setting above without load.
3. Repeat each measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.



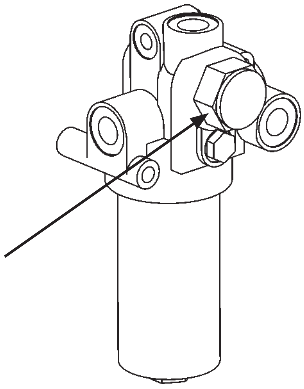
T178-03-07-001

1- Plug

Primary Pilot Pressure Adjustment Procedure

Adjustment:

Adjust relief valve (1) set pressure if necessary.



T178-03-07-001

1. Remove plug (2) from relief valve (1).

   : 22 mm

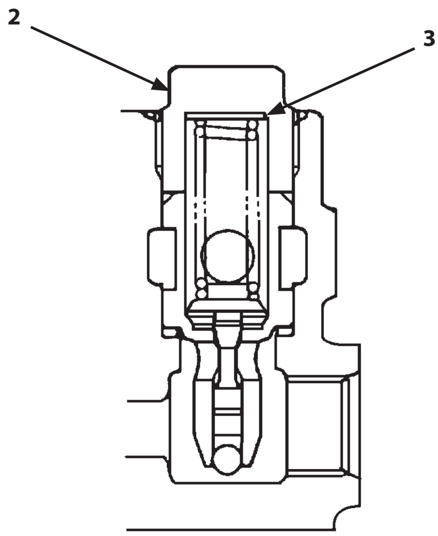
2. Install the estimated number of shims (3).
3. After adjustment, tighten plug (2).

   : 25^{+2} N·m ($2.5^{+0.2}$ kgf·m, $18.4^{+1.5}$ lbf·ft)

4. After adjustment, check the set pressures.

NOTE: Standard Change in Pressure (Reference)

Shim (3) Thickness (mm)	Change in Pressure	
	kPa	(kgf/cm^2, psi)
0.25	78	(0.8, 11.3)
0.5	157	(1.6, 22.8)
1.0	304	(3.1, 44.1)



T111-06-04-004

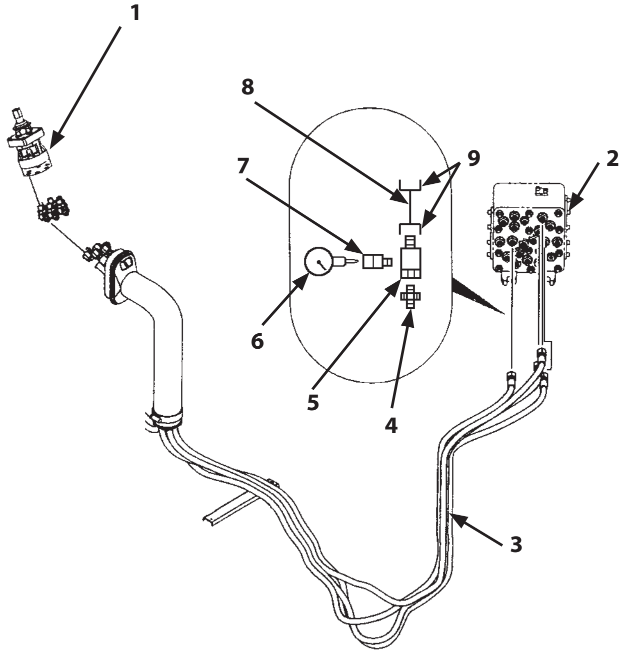
1- Relief Valve
2- Plug
3- Shim

Secondary Pilot Pressure

Preparation:

1. Stop the engine.
2. Push the air bleed valve on top of the hydraulic oil tank and release any remaining pressure.
3. Measure pressure between pilot valve (1) and signal control valve (2). Disconnect pilot hose (3) from the circuit to be measured. Install hose (8) (9/16-18UNF, Length: approx. 400 mm (16 in)) to the signal control valve (2) side. Install tee (5) (4351843), adapter (4) (ST 6460), fitting (7) (ST 6069), coupling (9) (ST 6332), and pressure gauge (6) (ST 6315) between hoses (8).

   : 17 mm, 19 mm
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge (6) connection.
5. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T1F3-04-05-008

1- Pilot Valve
2- Signal Control Valve
3- Pilot Hose
4- Adapter
5- Tee
6- Pressure Gauge
7- Fitting
8- Hose
9- Coupling

Measurement:

1. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode
Slow Idle	PWR	OFF	Digging Mode

2. Measure pilot pressure by using pressure gauge (6) with the corresponding control lever operated to full stroke.
3. Repeat each measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

Solenoid Valve Set Pressure

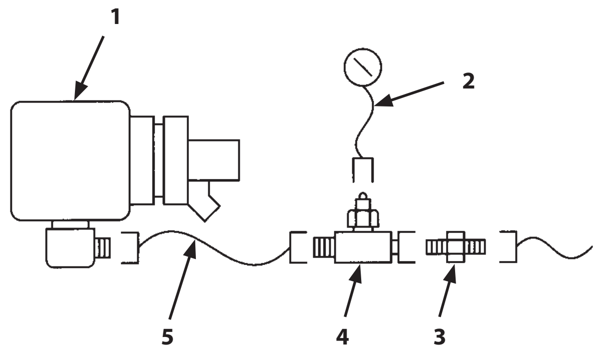
Use MPDr. and a pressure gauge at the same time.

Preparation:

1. Stop the engine.
2. Push the air bleed valve on top of the hydraulic oil tank and release any remaining pressure.
3. Disconnect the hose from the solenoid valve to be measured. Install tee (4) (ST 6451), hose (5) (Parts Number: 4216453), adapter (3) (ST 6461), and pressure gauge (2) (ST 6942).

   : 17 mm, 19 mm, 22 mm

   Connect MPDr. and select the monitoring function.
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



T157-05-04-002

1- Solenoid Valve Unit
2- Pressure Gauge
3- Adapter
4- Tee
5- Hose

Measurement:

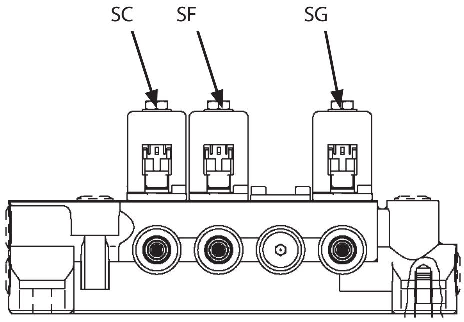
1. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode
Slow Idle	PWR	OFF	Digging Mode

2. Operate as instructed below for each measuring solenoid valve:

- Solenoid Valve SG:
  Turn the power digging switch ON and OFF.
- Solenoid Valve SF:
  Relief combined operation of boom raise and arm roll-in.
- Solenoid Valve SC:
  Combined operation of swing and arm roll-in.

3. Read the values on both MPDr. and the pressure gauge.
4. Repeat each measurement three times and calculate the mean values.



TDCD-03-07-001

Evaluation:

Refer to Operational Performance Standard.

Solenoid Valve Adjustment Procedure

IMPORTANT: As O-ring (8) is damaged and oil leakage may cause, do not loosen adjusting screw (8) excessively.

Do not loosen adjusting screw (6) more than 2 turns.

1. Loosen lock nut (7). Turn adjusting screw (6) and adjust the set pressure.
2. After adjustment, tighten lock nut (7).

   : 13 mm

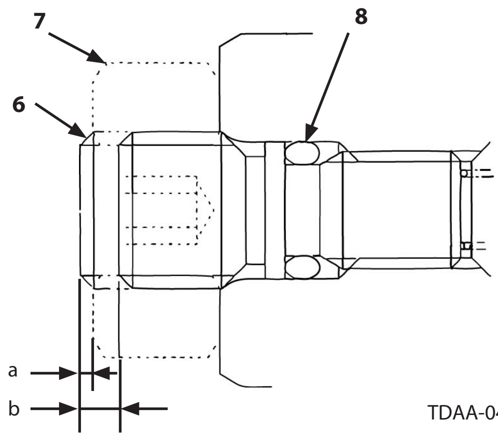
   : 5 N·m (0.5 kgf·m, 3.7 lbf·ft)

   : 3 mm

3. After adjustment, check the set pressures.

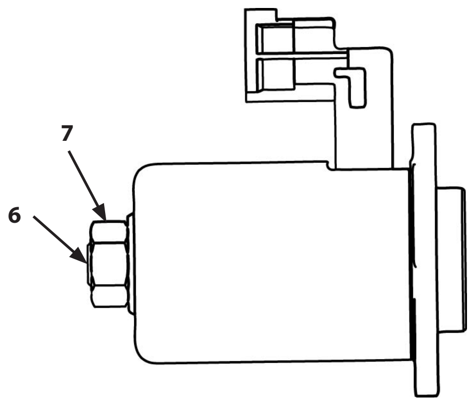
NOTE: Standard Change in Pressure (Reference)

Screw Turns		1/4	1/2	3/4	1
Change in Pressure	kPa	111	222	333	444
	(kgf/cm²)	(1.1)	(2.3)	(3.4)	(4.5)
	(psi)	(16.1)	(32.2)	(48.3)	(64.4)

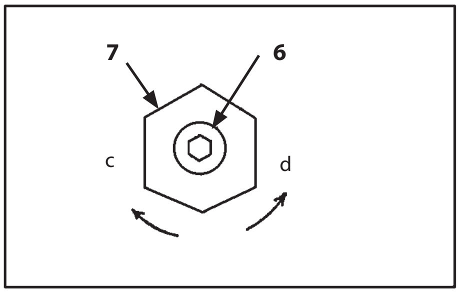


TDAA-04-05-013

a - 0.663 mm (0.026 in)　　b - 2.0 mm



TDAA-04-05-012



W107-02-05-129

c - Pressure Increase　　d - Pressure Decrease

6- Adjusting Screw　　8- O-Ring
7- Lock Nut

Main Pump Delivery Pressure

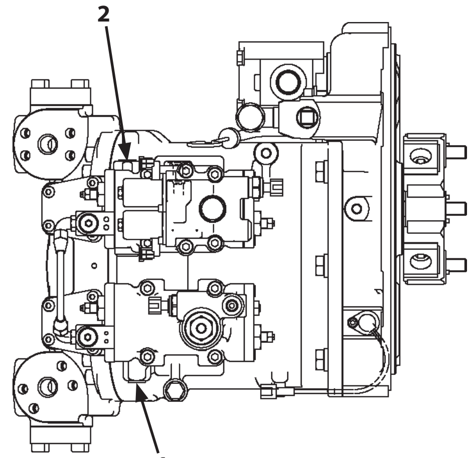
The main pump delivery pressure can also be measured by using MPDr..

Preparation:

1. Stop the engine.
2. Push the air bleed valve on top of the hydraulic oil tank and release any remaining pressure.
3. Remove the plug from delivery pressure check port on the main pump. Install adapter (ST 6069), hose (ST 6943) and pressure gauge (ST 6941).

   : 6 mm

   Connect MPDr. and select the monitoring function.
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



TDCD-03-01-004

1- Pump 1 Delivery Pressure Check Port
2- Pump 2 Delivery Pressure Check Port

Measurement:

1. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

2. Measure pressure with the control levers in neutral without load.
3. Repeat each measurement three times and calculate the mean values.

Evaluation:

Refer to Operational Performance Standard.

Remedy:

Refer to Troubleshooting B.

(Blank)

Main Relief Set Pressure

Summary:

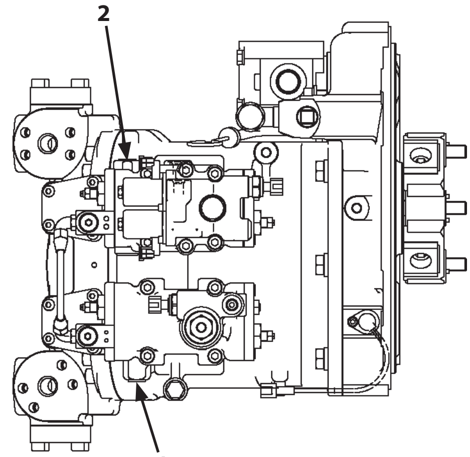
Measure the main relief valve set pressure at the delivery port in main pump. (The main relief set pressure can also be measured by using MPDr..)

Preparation:

1. Stop the engine.
2. Push the air bleed valve on top of the hydraulic oil tank and release any remaining pressure.
3. Remove the plug from delivery pressure check port on the main pump. Install adapter (ST 6069), hose (ST 6943) and pressure gauge (ST 6941).

   : 6 mm

   Connect MPDr. and select the monitoring function.
4. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).



TDCD-03-01-004

1- Pump 1 Delivery Pressure Check Port

2- Pump 2 Delivery Pressure Check Port

Measurement:

1. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

2. As for the bucket, arm, or boom function, operate control levers slowly to the stroke end and relieve each function.
3. As for the swing function, secure the upperstructure so it is immovable. Slowly operate the swing lever and relieve the swing function.
4. As for the travel function, secure the tracks against an immovable object. Slowly operate the travel levers and relieve the travel function.
5. Operate the bucket, arm and boom control levers slowly to the stroke end and relieve each function with the power digging switch pushed. (Measure within eight seconds.)

Evaluation:

Refer to Operational Performance Standard.

NOTE: If the measure pressures for all functions are lower than the specified range, the probable cause is a decrease of main relief valve (1) setting pressure. If relief pressure of a particular function is lower, the probable cause is other than main relief valve.

Main Relief Valve (1) Pressure Adjustment Procedure

In case of pressure adjustment during power digging operation, adjust the high-pressure side of main relief pressure.
In case of pressure adjustment in normal, adjust the low-pressure side of main relief pressure.

High-Pressure Side of Main Relief Pressure Adjustment Procedure

1. Loosen lock nut (3). Lightly tighten plug (2) until plug (2) comes into contact with the end of piston (6). Tighten lock nut (3).

   : 27 mm

   (Plug (2))

   : 20 N·m (2 kgf·m, 15 lbf·ft)

   (Lock Nut (3))

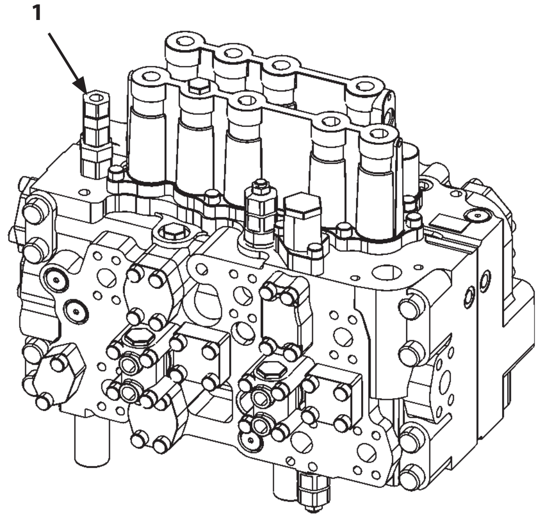
   : 70 to 80 N·m (7 to 8 kgf·m, 52 to 59 lbf·ft)

2. Loosen lock nut (5). Turn plug (4) and adjust pressure until the specified pressure is obtained.

   : 27 mm, 32 mm

   (Lock Nut (5))

   : 80 to 90 N·m (8 to 9 kgf·m, 59 to 66 lbf·ft)



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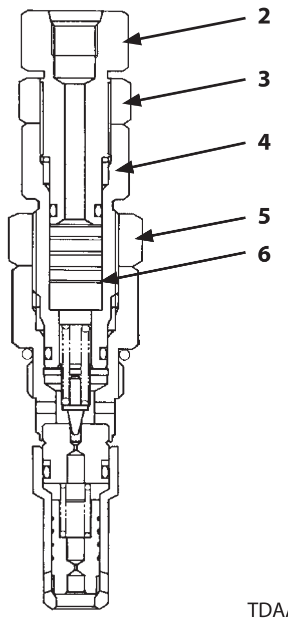
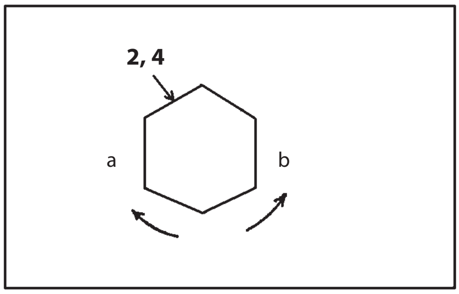


TDAA-04-05-009

1- Main Relief Valve
2- Plug
3- Lock Nut
4- Plug
5- Lock Nut
6- Piston



W107-02-05-127

a - Pressure Increase
b - Pressure Decrease

Low-Pressure Side of Main Relief Pressure Adjustment Procedure

3. Loosen lock nut (3). Turn plug (2) counterclockwise until the specified pressure is obtained. Tighten lock nut (3).

 : 27 mm

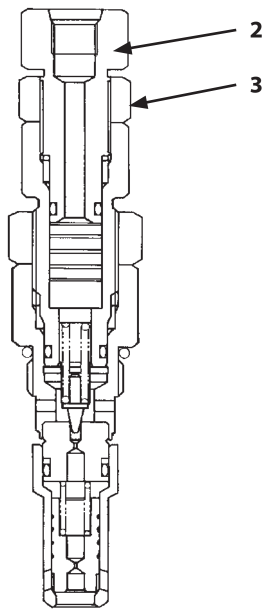
(Lock Nut (3))

 : 60 to 70 N·m (6 to 7 kgf·m, 44 to 52 lbf·ft)

After adjustment, check the set pressures.

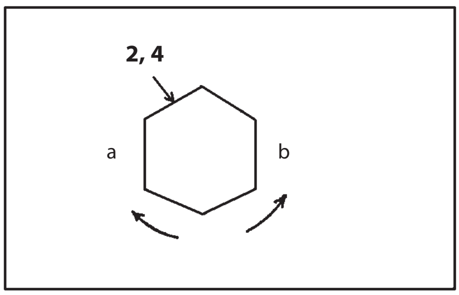
NOTE: Standard Change in Pressure (Reference)

Turns		1/4	1/2	3/4	1
Change in Relief Pressure: Plug (4) (High-Pressure Side)	MPa	7.1	14.2	21.3	28.4
	(kgf/cm^2)	(72.5)	(145)	(217.5)	(290)
	(psi)	(1030)	(2059)	(3089)	(4118)
Change in Relief Pressure: Plug (2) (Low-Pressure Side)	MPa	5.3	10.7	16.0	21.3
	(kgf/cm^2)	(54)	(109)	(163)	(217)
	(psi)	(769)	(1552)	(2320)	(3089)



TDAA-04-05-009

2- Plug   3- Lock Nut



W107-02-05-127

a - Pressure Increase   b - Pressure Decrease

Relief pressure (when relieving swing)

Adjust pressure by changing the number of shims (3).

1. Remove swing relief valve (1).

   : 41 mm

2. Remove plug (6), sleeve (5) and piston (4).

   : 30 mm

3. Install shims (3) between piston (4) and spring seat (2) in order to adjust pressure.
4. After adjustment, install piston (4), sleeve (5) and plug (6).

   : 120 N·m (12 kgf·m, 89 lbf·ft)

NOTE: Replace seals (A, B, C) with new ones.

A: JIS B 2401 G30 1B

B: AS568-023 (Aero-Space Standard)

C: AS568-125 (Aero-Space Standard)

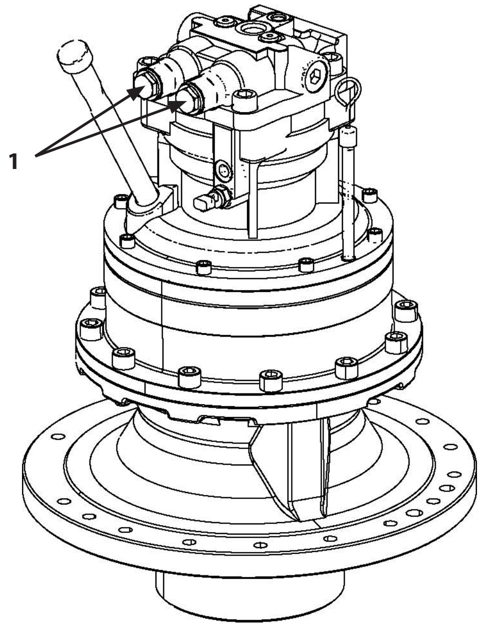
5. Install swing relief valve (1).

   : 180 N·m (18 kgf·m, 133 lbf·ft)

6. After adjustment, check the set pressures.

NOTE: Standard Change in Pressure (Reference)

Shim (3) Thickness (mm)	Change in Pressure	
	kPa	(kgf/cm^2, psi)
0.1	610	(6.3, 88.5)



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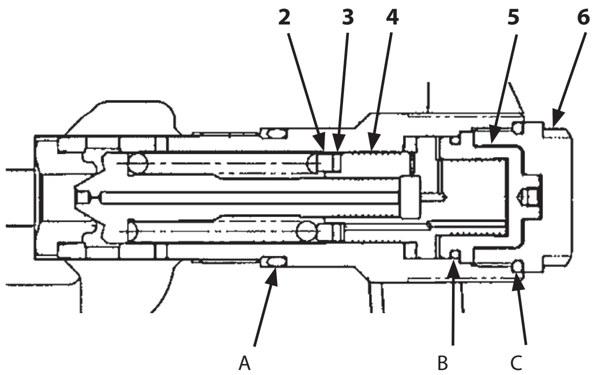


TDAA-04-05-010

1- Swing Relief Valve
2- Spring Seat
3- Shim
4- Piston
5- Sleeve
6- Plug

(Blank)

Overload Relief Valve Set Pressure

Summary:

1. The circuit pressure must be increased by applying an external force while blocking the return circuit from the control valve. This measuring method is hazardous and the results obtained with this method are unreliable.
2. The oil flow rate used to set the overload relief pressure is far less than that used to set the main relief pressure. Therefore, measuring the overload pressure in the main circuit by increasing the main relief set pressure more than the overload valve set-pressure is not a proper method. In addition, main relief valve may be designed to leak a small quantity of oil before reliving. In this case, its pre-leaking start pressure must be increased more than the overload relief valve set pressure.

   However, the pre-leaking start pressure is not always increased more than the overload relief valve set-pressure as the adjustable upper limit of the main relief valve set-pressure is provided.

   Accordingly, the overload relief valve assembly should be removed from the machine and checked on a specified test stand at a correct oil flow rate. Some overload relief valves come in contact with the control valve body to block the oil passage. When this type of overload relief valve is checked, the control valve body must be precisely finished as the test unit. Provide one control valve other than that on the machine as a test kit.
3. If the overload relief valve performance must be checked on the machine, however, measure the main relief pressure while releasing each front function respective to the measuring overload relief valve. And, assume that the overload relief valve is functioning correctly if the obtained main relief pressure is within the specified value range. Measure by using MPDr..

Preparation:

1. Stop the engine.
2. Push the air bleed valve on top of the hydraulic oil tank and release any remaining pressure.
3. Remove the plug from delivery pressure check port on the main pump. Install adapter (ST 6069), hose (ST 6943) and pressure gauge (ST 6941).

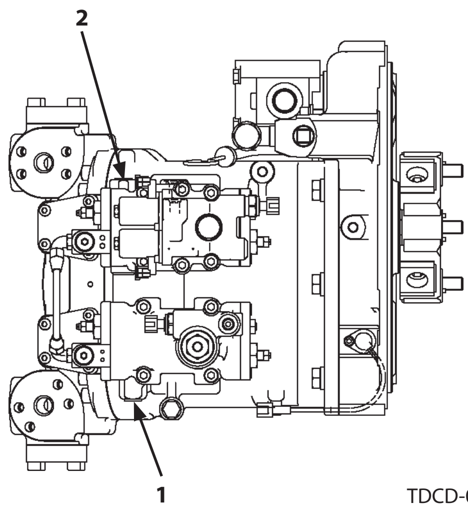
   : 6 mm
4. Connect MPDr. and select the monitoring function. Start the engine. Confirm that no oil leakage is observed at the pressure gauge connection.
5. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F).

Measurement:

1. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

2. Slowly operate the bucket, arm, or boom control levers to the stroke ends and relieve each function.
3. Read pressures on the pressure gauge at this time.
4. Perform the measurement for the bucket, arm, and boom in that order.
5. Repeat each measurement three times and calculate the mean values.



TDCD-03-01-004

1- Pump 1 Delivery Pressure Check Port
2- Pump 2 Delivery Pressure Check Port

Evaluation:

Performance of the overload relief valves are normal if the measured main relief pressures are within the specified value range.
Refer to Operational Performance Standard.

Overload Relief Valve Pressure Adjustment Procedure

NOTE: In principle, adjust the overload relief valve pressure on a test stand.

Loosen lock nut (1) and adjust pressure by using adjusting screw (2).

1. Loosen lock nut (1).

   : 17 mm

2. Turn adjusting screw (2) in order to adjust pressure.

   : 6 mm

3. Tighten lock nut (1).

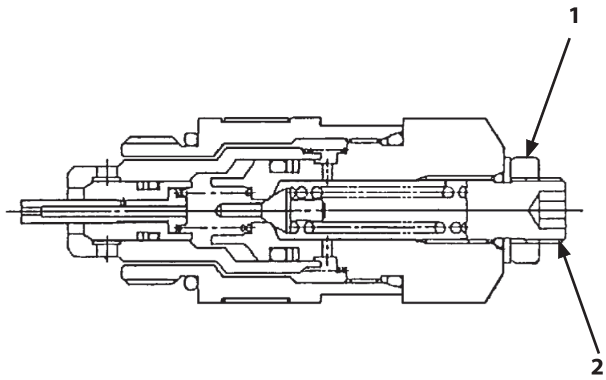
   : 17 mm

   : 30 N·m (3 kgf·m)

4. After adjustment, check the set pressures.

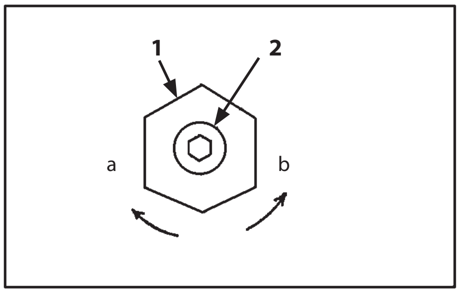
NOTE: Standard Change in Pressure (Reference)

Adjusting Screw (2) Turns		1/4	1/2	3/4	1
Change in Pressure	MPa	5.2	10.6	15.9	21.1
	(kgf/cm^2)	(54)	(108)	(162)	(216)
	(psi)	(770)	(1540)	(2300)	(3070)



TDAA-04-05-011

1- Lock Nut 2- Adjusting Screw



W107-02-05-129

a - Pressure Increase b - Pressure Decrease

Main Pump Flow Rate Measurement

- P-Q Control (Torque Control)

Summary:

Main pump performance is checked by measuring the pump flow rate by using a hydraulic tester installed at the main pump delivery port to be measured. Use MPDr. and a pressure gauge at the same time.

IMPORTANT: This measurement procedure is a simple method. The measured data will be lower by approx. 5 % than the accurately measured value. In order to measure accurately, disconnect the return circuit from the control valve and connect it to the hydraulic oil tank.

Preparation:

1. Stop the engine. Push the air bleed valve and bleed air. Connect a vacuum pump to the oil filler port.

NOTE: Operate the vacuum pump while connecting the pump flow rate test line.

2. Disconnect the main pump delivery hose from the main pump to be measured. Connect pipe (1 or 2) to the main pump delivery port with the removed split flange and bolt.

   : 41 mm

   : 10 mm

3. Install pipe (1 or 2) to hydraulic tester (5) by using test hose (3) and adapter (4). Install adapter (6), joint (7), test hose (8) and flange (9) to hydraulic tester (5).

   : 41 mm

   : 10 mm

4. Install flange (9) and the disconnected hose with split flange (10) and bolt (11).

   : 10 mm

5. Install a pressure gauge to the main pump to be measured. (Refer to "Main Relief Set Pressure".)

   : 6 mm

6. Remove the vacuum pump. Loosen plug (12) on top of the pump casing. Bleed air from the casing until oil only comes out.

   (Pump 1)

   : 27 mm

   (Pump 2)

   : 27 mm

7. Fully open the loading valve of hydraulic tester.
8. Start the engine. Check the pressure gauge connection for any oil leaks. Connect MPDr. and select the monitoring function.

Measurement:

1. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F)
2. Measure the maximum flow rate.
3. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

4. Adjust the relief set pressure of main relief valve in control valve to each pressure point specified along the main pump P-Q curve. (Refer to T4-2-7)
   Slowly restrict the loading valve of hydraulic tester while relieving pressure in the arm roll-in circuit. Measure the flow rates and engine speeds at each pressure point specified in the P-Q curve.
5. Repeat each measurement three times and calculate the mean values.

Evaluation:

1. Convert the measured flow rates to those at the specified engine speed by using the following formula:

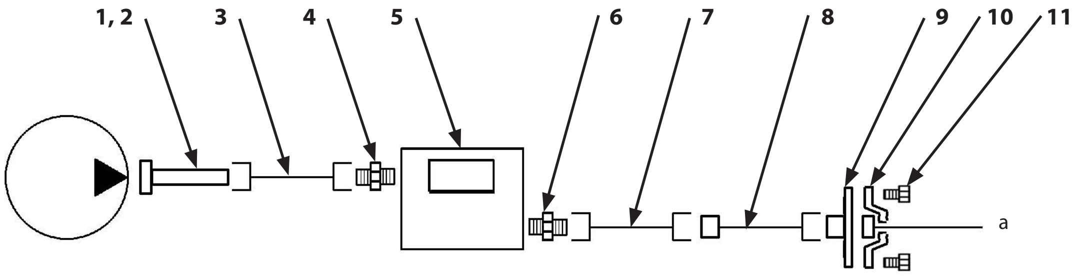
Qc = Ns×Q/Ne

Qc : Converted Flow Rate
Q : Measured Flow Rate
Ns : Specified Engine Speed 2000 min^{-1}
Ne : Measured Engine Speed
Values indicated on MPDr.

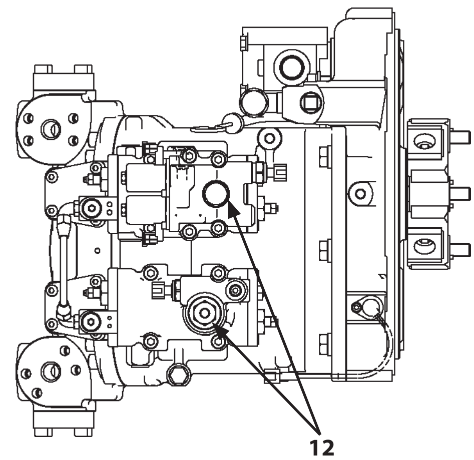
2. Standard Flow Rate

   Refer to Operational Performance Standard.

NOTE: When actually measuring, connect pipe (1 or 2) only to the pump to be measured.



T173-04-04-002



TDCD-03-01-004

a - Main Pump Delivery Hose (To Control Valve)

1- Pipe E (ST 6144)
2- Pipe B (ST 6143)
3- Test Hose (ST 6145)
4- Adapter PF1×UNF1-7/8 (ST 6146)
5- Hydraulic Tester (ST 6299)
6- Adapter PF1×UNF1-7/8 (ST 6146)
7- Joint (ST 6330)
8- Test Hose (ST 6320)
9- Flange (ST 6118)
10- Split Flange (ST 6130)
11- Bolt (ST 6409) (4 Used)
12- Plug

- Pilot Characteristics

Summary:

Main pump performance is checked by measuring the pump flow rate by using hydraulic tester (5) installed at the main pump delivery port to be measured. Use MPDr. and pressure gauge (18) at the same time.

IMPORTANT: This measurement procedure is a simple method. The measured data will be lower by approx. 5 % than the accurately measured value. In order to measure accurately, disconnect the return circuit from the control valve and connect it to the hydraulic oil tank.

Preparation:

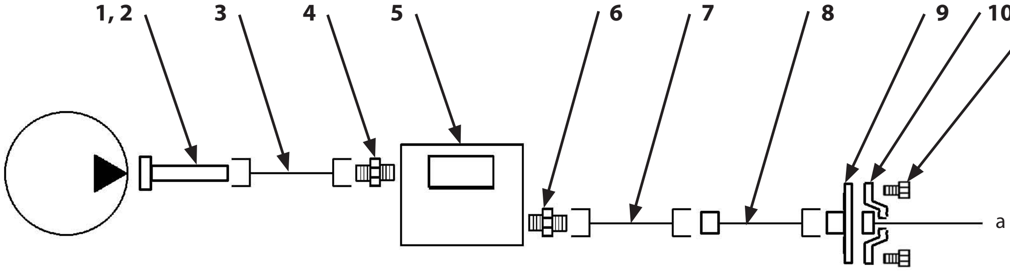
1. While referring to steps 1 to 4 on page T4-5-16, install hydraulic tester (5) to the main pump to be measured.
2. Disconnect the hose from regulator port Pi (21) of the pump to be measured. Install plug (ST 6214) to the removed hose.

   : 6 mm, 19 mm
3. Install adapters (15) (3 used) to pressure reducing valve (16). Remove plug M (23) from the pilot filter. Install adapter (13) and hose (14) to the pilot filter. Install hose (14) to port P1 on pressure reducing valve (16).

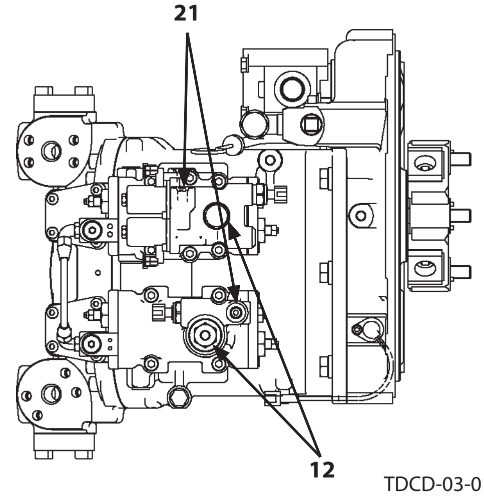
   : 19 mm
4. Install tee (17) to port P2 of pressure reducing valve (16). Connect pressure gauge (18) and hose (14) to tee (17). Connect hose (14) to the regulator.

   : 19 mm
5. Connect hose (19) and adapter (20) to port T of pressure reducing valve (16). Remove Plug L from return pipe (22). Connect hose (19).

   : 19 mm, 22 mm
6. Remove the vacuum pump. Loosen plug M (12) on top of the pump casing. Bleed air from the casing until oil only comes out.
7. Fully open the loading valve of hydraulic tester.
8. Start the engine. Check the connections for any oil leaks.



T173-04-04-002



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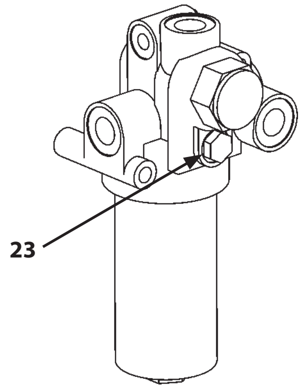
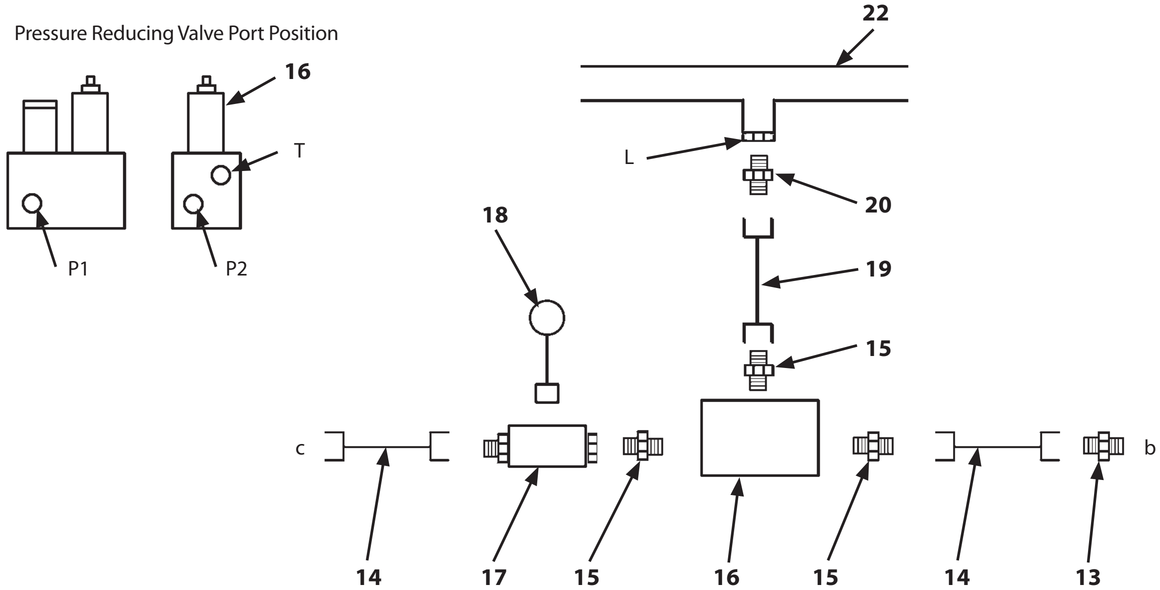


T178-03-07-001



T178-04-04-004

a - Delivery Hose (To Control Valve)
b - To Pilot Filter
c - To Regulator Port Pi (21)

1- Pipe E (ST 6144)
2- Pipe B (ST 6143)
3- Test Hose (ST 6145)
4- Adapter PF1×UNF1-7/8 (ST 6146)
5- Hydraulic Tester (ST 6299)
6- Adapter PF1×UNF1-7/8 (ST 6146)
7- Joint (ST 6330)
8- Test Hose (ST 6320)
9- Flange (ST 6118)
10- Split Flange (ST 6130)
11- Bolt (ST 6409) (4 Used)
12- Plug M (Regulator)
13- Adapter UNF7/16×PF1/4 (ST6099)
14- Hose UNF7/16×UNF7/16 (4334309)
15- Adapter PF3/8×UNF7/16 (4200465)
16- Pressure Reducing Valve (4325439)
17- Tee UNF7/16×UNF7/16×PF1/4 (ST 6451)
18- Pressure Gauge (ST 6931)
19- Hose UNF7/16×UNF7/16 (4334309)
20- Adapter PF3/8×UNF7/16 (4200465)
21- Port Pi
22- Return Pipe
23- Plug M (Pilot Filter)

Measurement:

1. Maintain the hydraulic oil temperature at 50±5 °C (122±9 °F)
2. Measure pump flow rate in response to the external command pilot pressure.
3. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode

4. Adjust the pressure reducing valve set pressure to each pressure point specified along the main pump P-Q curve. (Pilot Characteristics) (Refer to T4-2-8.)

   Measure the flow rates and engine speeds at the pressure points specified in the P-Q curve.
5. Repeat each measurement three times and calculate the mean values.

Evaluation:

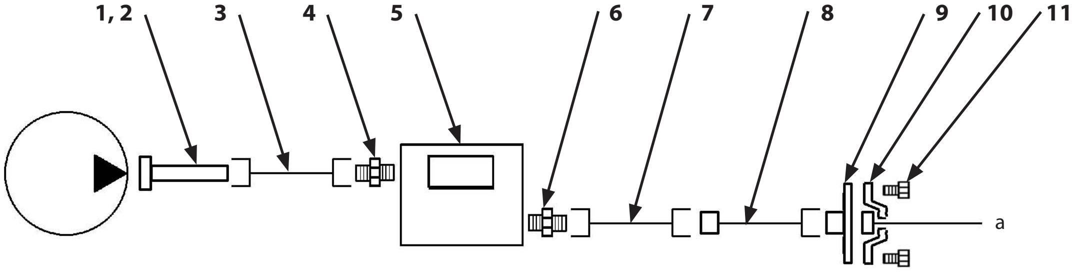
1. Convert the measured flow rates to those at the specified engine speed by using the following formula:

Qc = Ns×Q/Ne
Qc : Converted Flow Rate
Q : Measured Flow Rate
Ns : Specified Engine Speed 2000 min^{-1}
Ne : Measured Engine Speed
Values indicated on MPDr.

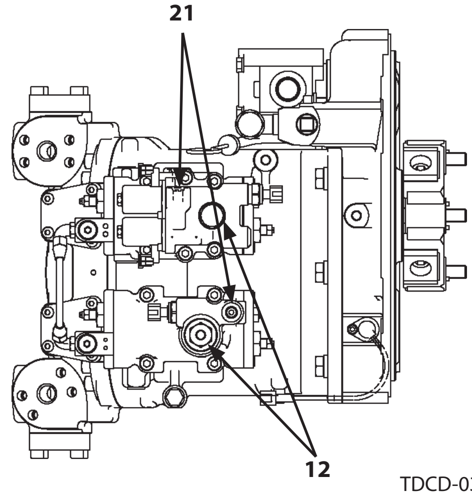
2. Standard Flow Rate

   Refer to Operational Performance Standard.

NOTE: When actually measuring, install pipe (1) (ST 6144) or (2) (ST 6143) only to the pump to be measured.



T173-04-04-002



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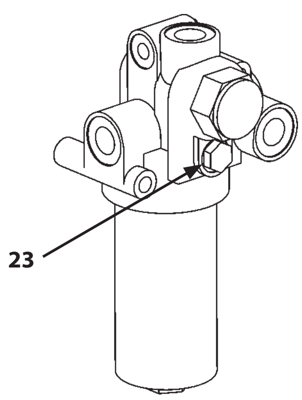
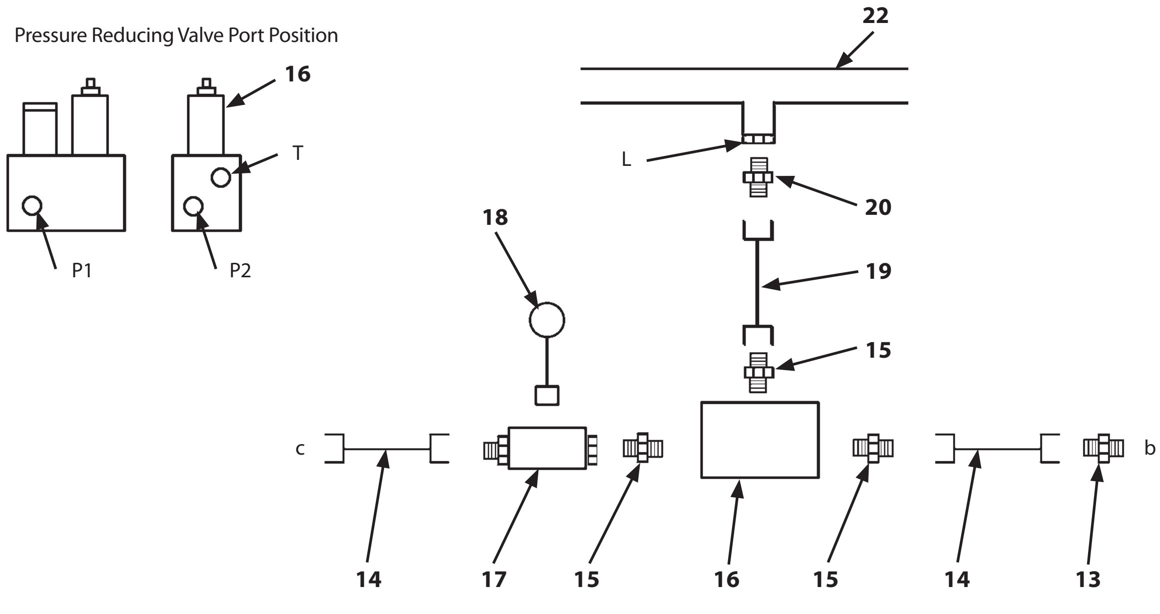


T178-03-07-001

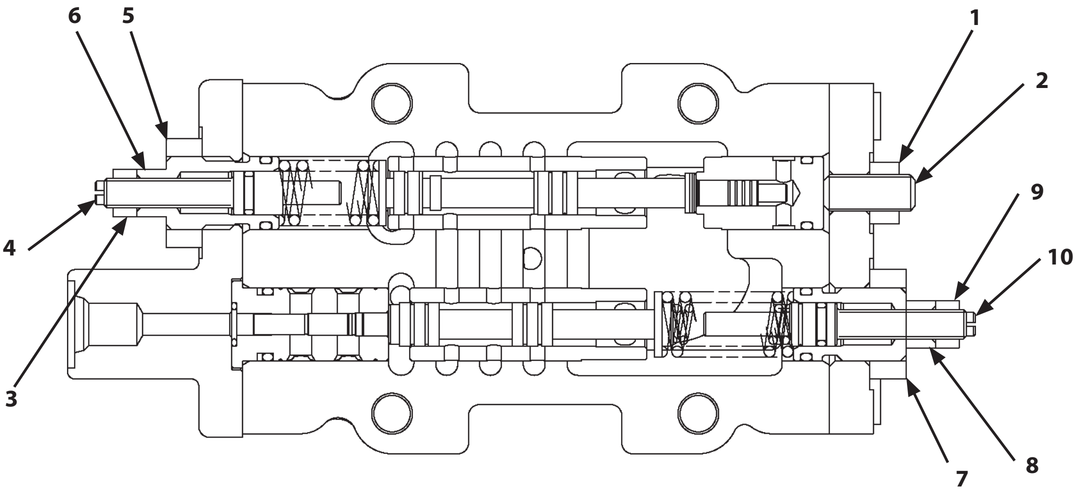


T178-04-04-004

a - Delivery Hose (To Control Valve)
b - To Pilot Filter
c - To Regulator Port Pi

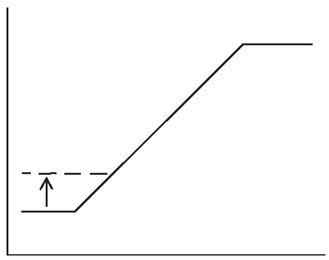
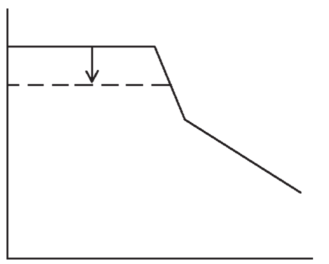
1- Pipe E (ST 6144)
2- Pipe B (ST 6143)
3- Test Hose (ST 6145)
4- Adapter PF1×UNF1-7/8 (ST 6146)
5- Hydraulic Tester (ST 6299)
6- Adapter PF1×UNF1-7/8 (ST 6146)
7- Joint (ST 6330)
8- Test Hose (ST 6320)
9- Flange (ST 6118)
10- Split Flange (ST 6130)
11- Bolt (ST 6409) (4 Used)
12- Plug M (Regulator)
13- Adapter UNF7/16×PF1/4 (ST6099)
14- Hose UNF7/16×UNF7/16 (4334309)
15- Adapter PF3/8×UNF7/16 (4200465)
16- Pressure Reducing Valve (4325439)
17- Tee UNF7/16×UNF7/16×PF1/4 (ST 6451)
18- Pressure Gauge (ST 6931)
19- Hose UNF7/16×UNF7/16 (4334309)
20- Adapter PF3/8×UNF7/16 (4200465)
21- Port Pi
22- Return Pipe
23- Plug M (Pilot Filter)

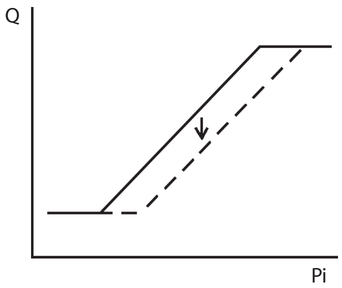
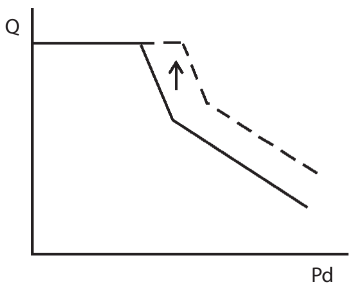
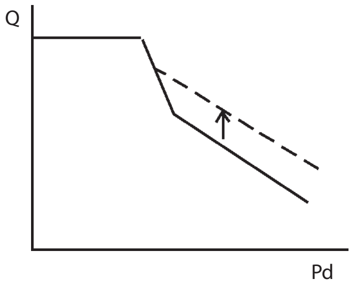
Regulator Adjustment



TDCD-03-01-005

1- Lock Nut (For Minimum Flow Rate)
2- Adjusting Screw (For Minimum Flow Rate)
3- Lock Nut (For Maximum Flow Rate)
4- Adjusting Screw (For Maximum Flow Rate)
5- Lock Nut (For Pilot Pressure Characteristic)
6- Adjusting Screw (For Pilot Pressure Characteristic)
7- Lock Nut (For P-Q Control)
8- Adjusting Screw (For P-Q Control)
9- Lock Nut (For P-Q Control)
10- Adjusting Screw (For P-Q Control)

Adjustment Item	Adjustment Procedure	Remarks
1. Minimum Flow Rate  TDAA-04-05-003	Loosen lock nut (1) and turn adjusting screw (2). Rotating the adjusting screw 1/4 turn clockwise increases the minimum pump flow rate by 6.56 cm^3/rev. (0.4 in^3/rev). : 17 mm : 20 N·m (2 kgf·m, 15 lbf·ft)	Do not turn the adjusting screw more than 2 turns. Securely tighten lock nut (1) after adjustment.
2. Maximum Flow Rate  TDAA-04-05-004	Loosen lock nut (3) and turn adjusting screw (4). Rotating the adjusting screw 1/4 turn clockwise decreases the maximum pump flow rate by 8.22 cm^3/rev. (0.5 in^3/rev). : 13 mm : 10 N·m (1 kgf·m, 7.4 lbf·ft)	Do not turn the adjusting screw more than 2 turns. Do not increase the maximum flow rate. In other words, do not turn the adjusting screw counterclockwise. Securely tighten lock nut (3) after adjustment.

Adjustment Item	Adjustment Procedure	Remarks
3. Pilot Pressure Characteristics  TDAA-04-05-005	Loosen lock nut (5) and turn adjusting screw (6). Rotating adjusting screw (6) 1/4 turn clockwise decreases the flow rate by 13.2 cm^3/rev. (0.8 in^3/rev). : 30 mm : 30 N·m (3 kgf·m, 22 lbf·ft)	Do not turn the adjusting screw (6) more than one turn. When adjusting screw (6) is turned clockwise, the maximum flow rate will also be decreased. In order to maintain the maximum flow rate unchanged, turn adjusting screw (4) counterclockwise twice when adjusting screw (6) is turned once. This ratio of 2 (adjusting screw (4) counterclockwise turn) to 1 (adjusting screw (6) clockwise turn) is to counterbalance. Securely tighten lock nut (5) after adjustment.
4. P-Q Control (Torque Adjustment)  TDAA-04-05-006	Loosen lock nut (7) and turn adjusting screw (8). Rotating the adjusting screw 1/4 turn clockwise increases the flow rate by 15.3 cm^3/rev. (1.0 in^3/rev). : 30 mm : 30 N·m (3 kgf·m, 22 lbf·ft)	Do not turn the adjusting screw more than one turn. Rotate the adjusting screws watching the engine performance. Securely tighten lock nut (7) after adjustment.
5. P-Q Control (Torque Adjustment)  TDAA-04-05-007	Loosen lock nut (9) and turn adjusting screw (10). Rotating the adjusting screw 1/4 turn clockwise increases the flow rate by 3.60 cm^3/rev. (0.2 in^3/rev). : 13 mm : 10 N·m (1 kgf·m, 7.4 lbf·ft)	Do not turn the adjusting screw more than one turn. Rotate the adjusting screws watching the engine performance. Securely tighten lock nut (9) after adjustment.

Swing Motor Drainage

Summary:

1. Measure amount of oil draining from the swing motor while swinging the upperstructure and check the swing motor performance.
2. Secure absolute safety for the measuring persons as well as for the surrounding while measuring.
3. The amount of drain oil from the swing motor will change depending on hydraulic oil temperature.

Preparation:

1. Main hydraulic oil temperature at 50±5 °C (122±9 °F). Rotate the swing motor in order to warm inside of the motor.
2. Stop the engine. Push air bleed valve (1) on top of the hydraulic oil tank and release any remaining pressure.
3. Disconnect the drain hose of the swing motor at the hydraulic oil tank end. Install plug (ST 6213) to the disconnected end on the hydraulic oil tank.

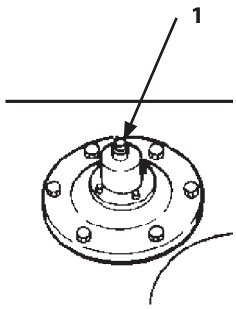
: 19 mm

: 30 N·m (3 kgf·m, 22 lbf·ft)

Preconditions for Measurement:

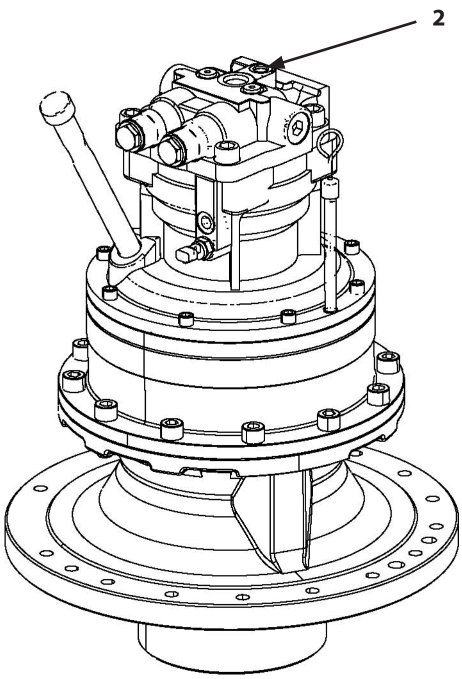
1. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode



TDAA-04-05-008

1- Air Bleed Valve



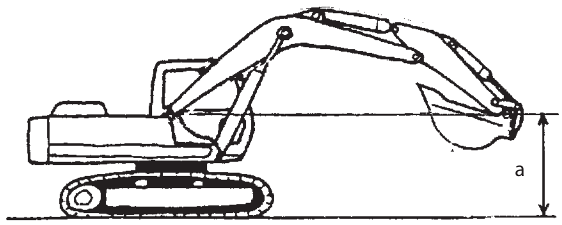
T1V1-01-02-005

2- Drain Hose Connecting Hole

Measurement:

CAUTION: Always make sure that the area is clear and that co-workers are out of the swing area before starting the measurement. Also, take care not to fall off the machine while the measurement.

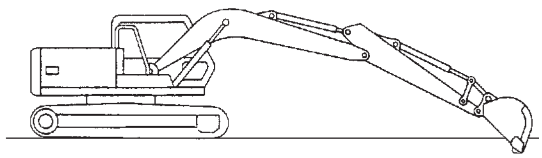
- Amount of Oil Drained While Swinging the Upperstructure
  1. Fully retract the arm cylinder. Fully extend the bucket cylinder. Hold the boom so that the arm tip pin height is the same as the boom foot pin height. The bucket must be empty.
  2. Start the engine. Operate and hold the swing lever full stroke. After the swing speed reaches a constant maximum speed, start draining oil measurement when drain oil starts coming out of the drain hose end.
  3. Repeat the measurement at least three times in both clockwise and counterclockwise directions, and calculate the mean values.
  4. The measuring time should be more than 45 seconds.



T105-06-03-013

a - The same height as boom foot pin height

- Amount of Oil Drained While Relieving Swing Motor Circuit
  1. Thrust the bucket teeth into the ground so that the upperstructure does not rotate.
  2. Start the engine. Operate and hold the swing lever full stroke. Start draining oil measurement when drain oil starts coming out of the drain hose end.
  3. Repeat the measurement at least three times in both clockwise and counterclockwise directions, and calculate the mean values.
  4. The measuring time should be more than 45 seconds.



T107-06-06-005

Evaluation:

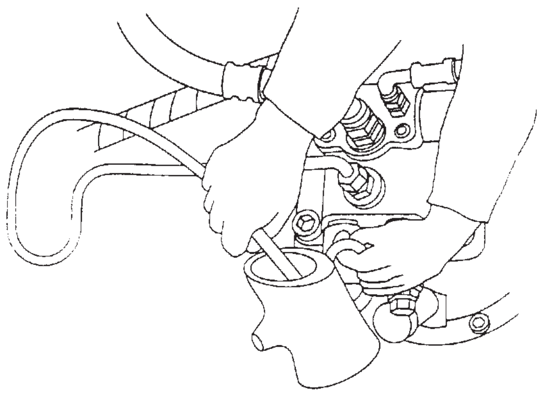
Refer to Operational Performance Standard.

* Conversion of amount of drain oil measured into the per-minute value

First measure amount of drain oil using a calibrated container. Then, convert the measured drain oil into the per-minute value using the formula below:

$\Delta Q = 60 \times q/t$

ΔQ : Amount of drain oil per minute (L/min)
t : Measured time (seconds)
q : Total amount of drain oil (L)



T107-06-05-008

Travel Motor Drainage

Summary:

1. While rotating the travel motor with the track to be measured jacked up, measure amount of oil draining from the travel motor and check travel motor performance.
2. Secure absolute safety for the measuring persons as well as for the surrounding while measuring.
3. Judge travel motor performance from the results including travel speed, mist rack and so on overall.
4. The amount of drain oil from the travel motor will change depending on hydraulic oil temperature.

Preparation:

1. Adjust track sag.

   Track sag specification: 300 to 335 mm (11.8 to 13.2 in)
2. Main hydraulic oil temperature at 50±5 °C (122±9 °F). Rotate the travel motor and warm inside of the motor.
3. Stop the engine. Push air bleed valve (1) on top of the hydraulic oil tank and release any remaining pressure.
4. Disconnect drain hose (2) in the travel motor at the travel motor end. Install plug (ST 6637) to the removed end.

   Connect the drain hose (3/4-16UN) to the travel motor.

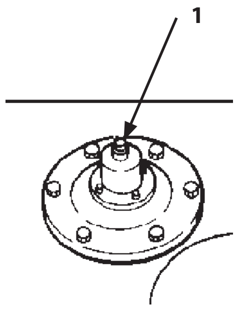
   : 27 mm

   : 80 N·m (8 kgf·m, 59 lbf·ft)

Preconditions for Measurement:

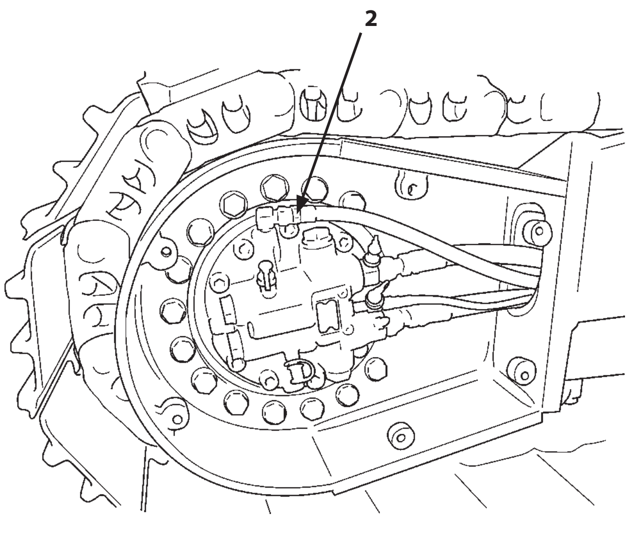
1. Select the following switch positions:

Engine Control Dial	Power Mode	Auto-Idle Switch	Work Mode
Fast Idle	PWR	OFF	Digging Mode



TDAA-04-05-008

1- Air Bleed Valve



M178-07-047

2- Drain Hose

Measurement:

CAUTION: When working around moving parts is unavoidable, pay special attention to ensure that hands, feet, and clothing do not become entangled. Securely support the raised track by using the blocks.

1. Start the engine. Jack up the track to be measured.
2. Rotate the track to be measured. Start drain oil measurement when drain oil starts coming out of the drain hose (1) end.
3. Repeat the measurement at least three times in both forward and reverse directions, and calculate the mean values.
4. The measuring time should be more than 45 seconds.

Evaluation:

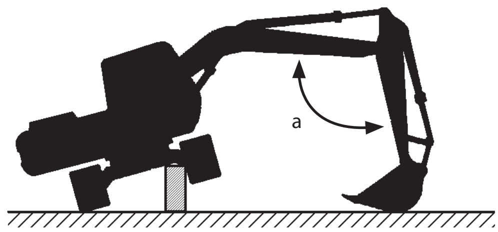
Refer to Operational Performance Standard.

* Conversion of amount of drain oil measured into the per-minute value

First measure amount of drain oil using a calibrated container. Then, convert the measured drain oil into the per-minute value using the formula below:

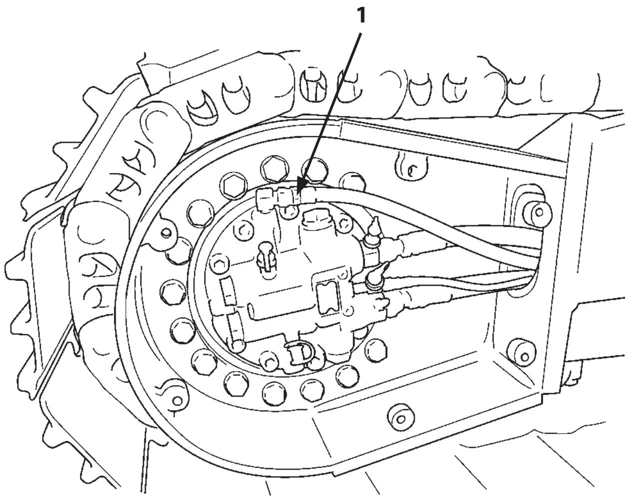
$\Delta Q = 60 \times q/t$

ΔQ : Amount of drain oil per minute (L/min)
t : Measured time (seconds)
q : Total amount of drain oil (L)



M104-07-067

a - 90 to 110°



M178-07-047

1- Drain Hose

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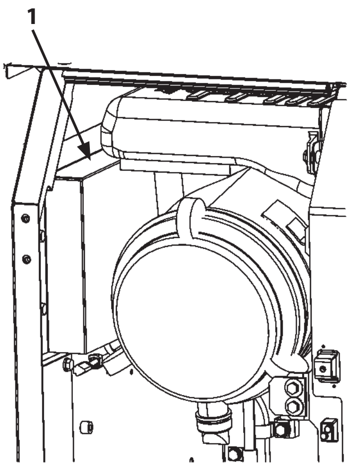
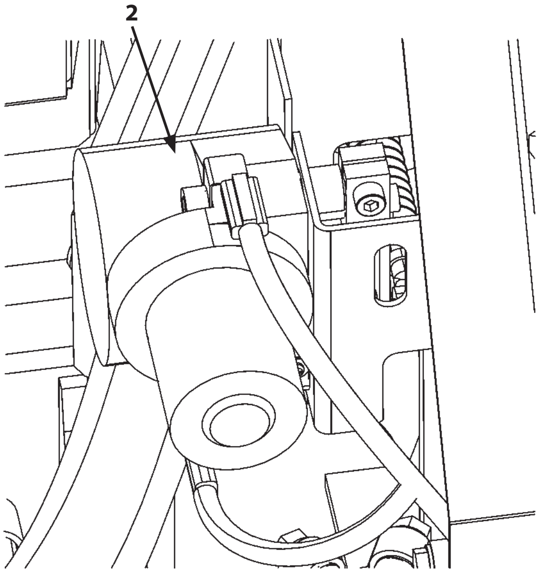
Engine Speed Adjustment and Engine Learning

When ECF (1) fault code 16606 (abnormal EC angle sensor) is displayed or after removing and/or replacing the components as described below for repair and/or inspection, or if error in engine speed is found, readjust engine speed and perform engine learning.

- Removal of the engine, engine control cable, or EC motor (2)
- Replacement of ECF (1)



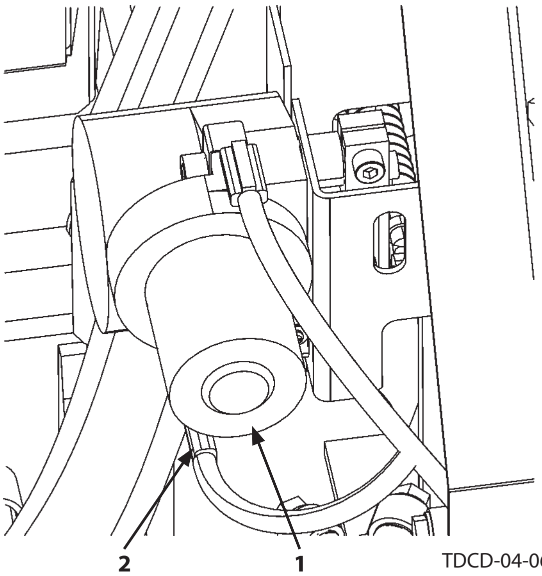
TDCD-01-02-006



TDCD-04-06-001

Inspection of EC Motor

Procedure	Inspection Method	Condition:	Evaluation:	Cause	Remedy
1	Check the EC motor (1) operation.	Key Switch ON	EC motor is operated.	Loose the governor lever holding bolt or EC sensor position is incorrect.	To step 2.
			EC motor is not operated.	Faulty EC motor or ECF.	Replace.
2	Monitor the EC sensor voltage with MPDr.	Key Switch: ON Engine Control Dial: Slow Idle	approx. 2.5 V	Loose the governor lever holding bolt.	Adjustment of Engine Speed.
			Except approx. 2.5 V	EC sensor position is incorrect.	To step 3.
3	Turn the key switch OFF. Disconnect connector (2) of EC motor (1) during EC motor (1) stopping (for 4 seconds).	-	-	-	-
4	After 10 seconds, connect disconnected connector (2). Monitor the EC sensor voltage with MPDr.	Key Switch: ON Engine Control Dial: Slow Idle	approx. 2.5 V	Loose the governor lever holding bolt.	Adjustment of Engine Speed.
			Except approx. 2.5 V	EC sensor position is incorrect.	To step 3.



TDCD-04-06-001

Adjustment of engine speed

1. Turn the key switch to the START position to start the engine.

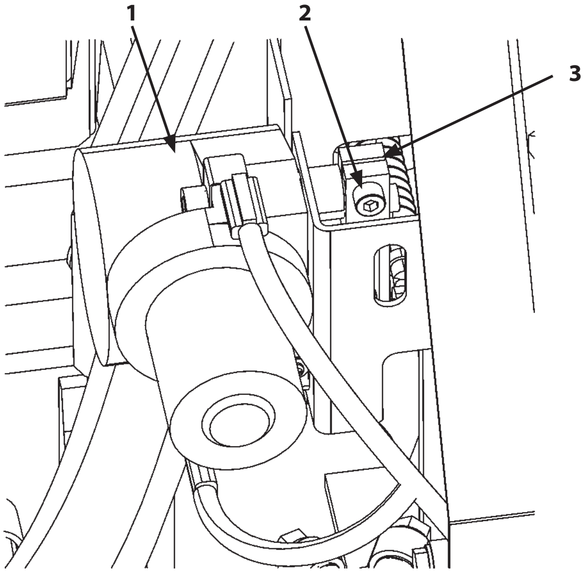
NOTE: Turn the air conditioner OFF.

2. Rotate the engine control dial to the slow idle position. (The output voltage from EC sensor is 2.5 V.)
3. Deactivate ECO control by MPDr..
4. Loosen bolt (2) holding control lever (3) to the EC motor output shaft.
5. While monitoring the actual engine speed with MPDr. or the engine speed meter, adjust control lever (3) so that the minimum speed (slow idle) matches the specification. (Refer to Operational Performance Standard in T4-2)
6. Tighten lever holding bolt (2) to secure control lever (3) to the EC motor (1) output shaft.

   : 30 N·m (3 kgf·m, 22 lbf·ft)

NOTE: Do not lubricate the motor output shaft.

7. Perform engine learning.



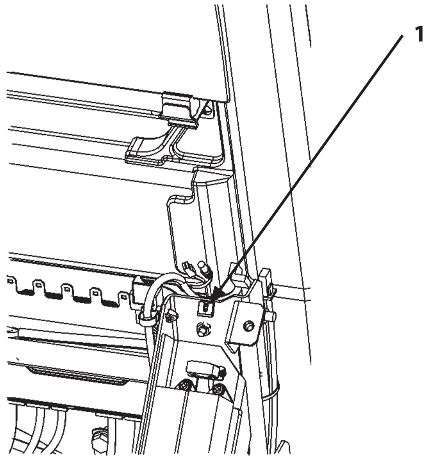
TDCD-04-06-001

Engine Learning

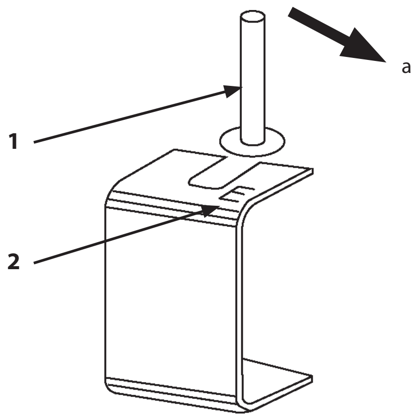
1. Turn the key switch OFF.

NOTE: In case the engine does not stop when the key switch is turned OFF, pull the handle located under the seat to stop the engine.

2. Turn learning switch (1) ON (stamp E (2) side).
3. Turn the key switch ON. Wait for 5 seconds.
4. Turn the key switch OFF. Wait for 5 seconds.
5. Turn learning switch (1) OFF.
6. Check the engine speed.



TDCD-04-06-002



a- Turn the learning switch to stamp E.

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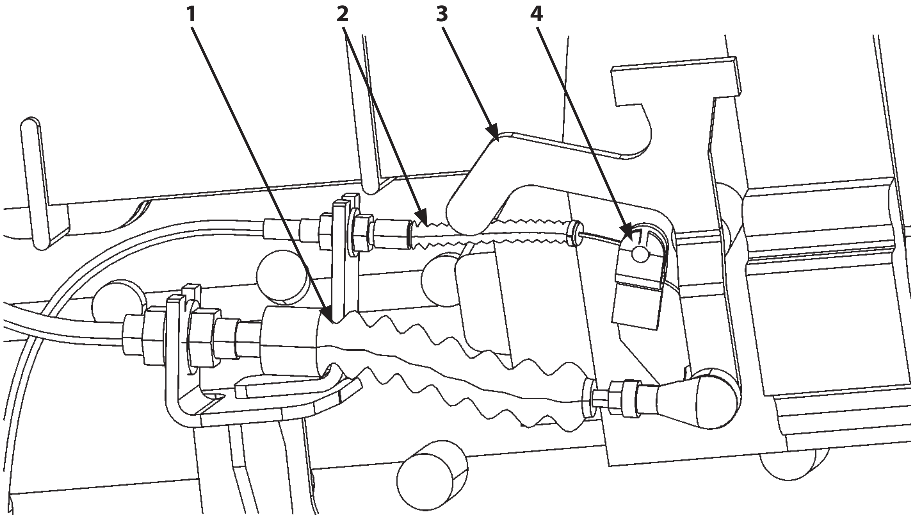
Governor Lever and Fuel Cut Lever Position

Check the governor lever and the fuel cut lever position during cranking.

- Even if starter rotates, engine does not start.

- Governor Lever and Fuel Cut Lever

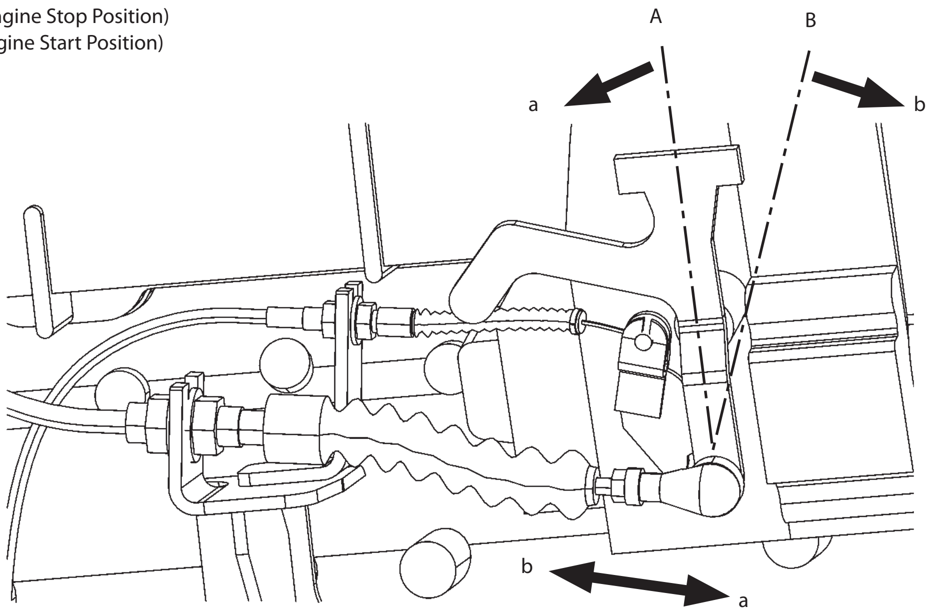


TDCD-04-06-003

1- Governor Cable (From EC Motor)
2- Fuel Cut-Off Cable (Fuel Cut-Off Handle)
3- Governor Lever
4- Fuel Cut Lever

- Governor Lever Position

A- Key Switch OFF (Engine Stop Position)
B- Key Switch ON (Engine Start Position)

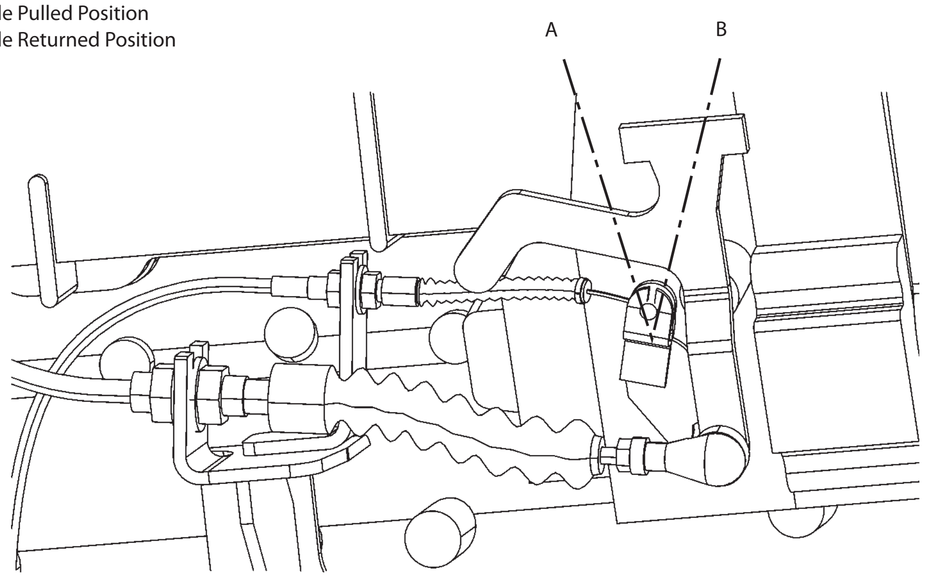


TDCD-04-06-003

a- STOP
b- FULL

- Fuel Cut Lever Position

A- Fuel Cut-Off Handle Pulled Position
B- Fuel Cut-Off Handle Returned Position



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MEMO

MEMO

SECTION 5

TROUBLESHOOTING

CONTENTS

Group 7 Air Conditioner

SECTION 5 TROUBLESHOOTING

Group 1 Diagnosing Procedure

Introduction

Refer to the inspection and troubleshooting procedures after any machine trouble has occurred. The inspection and troubleshooting procedures are presented in an orderly fashion in this section to quickly find the cause of the machine trouble and solution.

The troubleshooting section in this manual consists of seven groups; Diagnosing Procedure, Monitor, e-Service, Component Layout, Troubleshooting A (base machine diagnosis by using fault codes), Troubleshooting B (base machine diagnosis starting with inspection of abnormal operational status), and air conditioner.

- Diagnosing Procedure
  This group explains procedures of troubleshooting and precautions and/or information for the electrical system inspection.

  Example: Fuse Inspection

- Monitor
  This group contains the display screen of monitor and the operating procedures of service menu.

- e-Service
  This group contains as follows. Download data from the monitor controller and Upload. Procedures when starting communication, when installing the communication controller and when replacing the monitor controller. Explanation for the communication system.

- Component Layout

- Troubleshooting A (base machine diagnosis by using fault codes)
  Refer to these procedures if any fault codes are displayed when each controller is diagnosed by using MPDr. (or the service menu of monitor).

IMPORTANT: The monitor controller receives and retains a record of the electrical signal system malfunction of each controller in the form of fault codes by using the CAN communication. In addition, the self-diagnosing function records the electrical signal system malfunction in the form of fault codes

  Example: Fault Code 11000-2: Abnormal EEPROM

- Troubleshooting B (base machine diagnosis starting with inspection of abnormal operational status)
  Refer to troubleshooting B for diagnosis by using trouble symptom.
  Refer to these procedures when no fault codes are displayed after diagnosing the machine by using MPDr. (or the service menu of monitor).

  Example: Even if engine control dial is rotated, engine speed does not change.

- Air Conditioner
  This group explains air conditioner system, troubleshooting, and charge air conditioner with refrigerant.

Diagnosis Procedure

These six basic steps are essential for efficient troubleshooting:

1. Study the system

- Study the machine's technical manuals.
- Know the system and how it works, and what the construction, functions and specifications of the system components are.
  (Construction and functions)

2. Ask the operator
   Before inspecting, get the full story of malfunctions from the operator below.

- Operating condition: How is the machine being used? (Find out if the machine is being operated correctly.)
- Trouble identification: When was the trouble noticed, and what types of work the machine doing at that time?
- Trouble symptom: What are the details of the trouble? Did the trouble slowly get worse, or did it appear suddenly for the first time?
- Trouble history: Did the machine have any other troubles previously? If so, which parts were repaired before?

3. Inspect the machine
   Before starting the troubleshooting procedure, check the machine's daily maintenance points, as shown in the operator's manual.
   Also, check the electrical system, including the batteries, as troubles in the electrical system such as low battery voltage, loose connections and blown fuses will result in malfunction of the controllers, causing total operational failure of the machine.
   If troubleshooting is started without checking for blown fuses, a wrong diagnosis may result, wasting time. Check for blown fuses before troubleshooting.
   Even if a fuse looks normal by visual inspection, a fine crack is difficult to find.
   Always use a circuit tester when checking the fuses.

4. Operate the machine yourself
   Reproduce the trouble on the machine and make sure the actual phenomenon.
   If the trouble cannot be confirmed, stop the engine and obtain further details of the malfunction from the operator. Also, check for any incomplete connections of the wire harnesses corresponding to the trouble.

T107-07-01-001

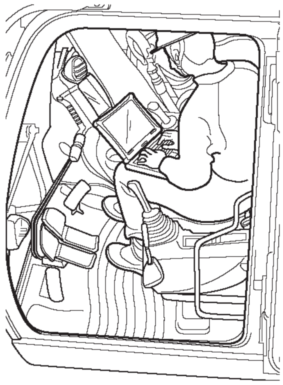
T107-07-01-002

T107-07-01-003

5. Perform troubleshooting

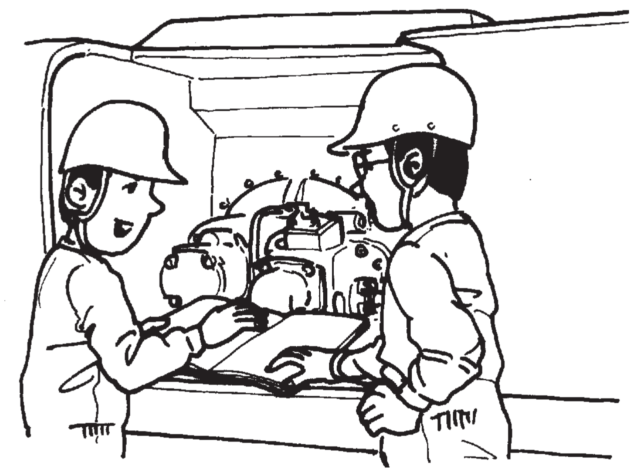
CAUTION: Do not disconnect harnesses or hydraulic lines while the engine is running. The machine may malfunction or pressurized oil may spout, possibly resulting in personal injury. Stop the engine before disconnecting harnesses or hydraulic lines.

Perform diagnosis by connecting MPDr. to the machine or by using the service menu of monitor.
In case any fault code has been displayed by diagnosis by using MPDr. (the service menu of monitor), check the cause of the trouble by referring to Troubleshooting A in this section. In case any fault code has been displayed by diagnosis by using MPDr. (the service menu of monitor), write the fault code. Delete the fault code once and retry self-diagnosis again. If the fault code is displayed again, check the cause of the trouble by referring to Troubleshooting A in this section. After the machine trouble has been corrected, the fault code (displayed by the service menu of monitor) will be deleted. Therefore, in case the problems which are not easily re-predicable are encountered, check the fault code by using MPDr..
In case the fault code is not displayed, check operating condition of each component by referring to Troubleshooting B in this section and by using MPDr. (the service menu of monitor).


TDCD-05-01-002

NOTE: Note that the fault codes displayed do not necessarily indicate machine trouble. The controller stores even temporary electrical malfunctions, such as a drop in battery output voltage or disconnection of the switches, sensors, etc., for inspections. For this reason, the "RETRIAL" is required to erase the accumulated fault codes from the controller memory and to confirm if any fault codes are indicated after the "RETRIAL".

6. Trace possible causes
   Before reaching a conclusion, check the most suspect causes again.
   Try to identify the actual cause of the trouble.
   Based on your conclusion, make a plan for appropriate repairs to avoid consequent malfunctions.



T107-07-01-007

Electric System Inspection

The precautions and information for the electrical system inspection are explained here. The electrical system inspection contains as follows.

- Precautions for Inspection and Maintenance
- Instructions for Disconnecting Connectors
- Fuse Inspection
- Fusible Link Inspection
- Battery Voltage Check
- Alternator Check
- Continuity Check
- Voltage and Current Measurement
- Check by False Signal
- Test Harness

Precautions for Inspection and Maintenance

1. Disconnect the power source.
   Disconnect the harness from the negative terminal side in battery first when taking wire harnesses and connectors off for repair or replacement work. Failure to do so can result in damage to the wire harnesses, fuses and fusible links and, in some cases, cause fire due to short circuiting. In addition, even when the key switch is turned OFF, the controller may be operated for a specified time. Therefore, disconnect the harness from the negative terminal side in battery after setting the key switch to the OFF position and waiting one minute or more.

2. Color coding of wire harnesses.
   As for the color codes of wire harnesses in the electrical system, refer to the table. In cases on the design sheet where two colors are indicated for one wire, the left initial stands for base color, while the right initial stands for marking color.

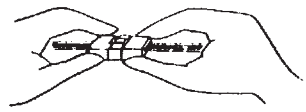
Code	R	W	L	G	Y	B
Color	Red	White	Blue	Green	Yellow	Black
Code	Or	Lg	Br	p	Gr	V
Color	Orange	Light green	Brown	Pink	Gray	Violet

NOTE:

- *Code BW indicates a black base wire with white fine-line marking.*
- *Initials "O" and "Or" both stand for the color orange.*
- *Wires with longitudinal stripes printed on them are not color coded. Do not confuse them with color coded wires.*

3. Precautions for connecting and disconnecting terminal connectors.

- When disconnecting the harnesses, grasp them by their connectors. Do not pull on the wire itself. Release the lock first before attempting to separate connectors, if a lock is provided. (Refer to Instructions for Disconnecting Connector on T5-1-8.)
- The water-resistant connectors keep water out. If water enters them, water will not easily drain from them. When checking the water-resistant connectors, take extra care not to allow water to enter the connectors. In case water should enter the connectors, reconnect only after the connectors are thoroughly dried.
- Before connecting the terminal connectors, check that no terminals are bent (3) or coming off. In addition, as most connectors are made of brass, check that no terminals are rusting (2).
- When connecting terminal connectors provided with a lock, insert them together until the lock "clicks."
- Pull the harness near the connector in order to check if it is correctly connected.



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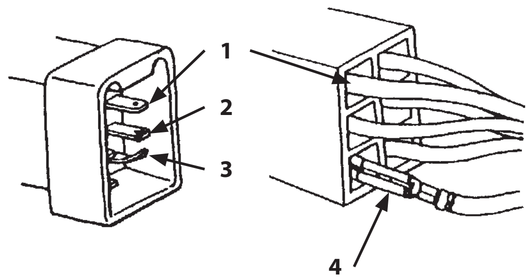


TDAA-05-08-003

1- Correct
2- Rust
3- Incorrect (Deformation)
4- Incorrect (Deformation)

4. Precaution for using a circuit tester.

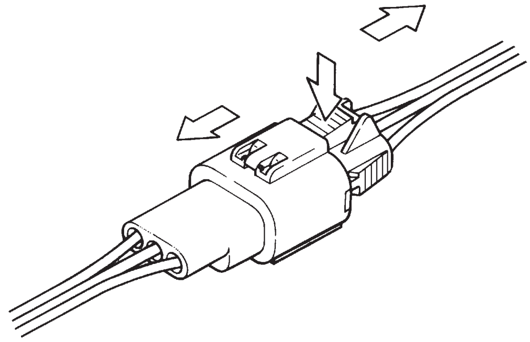
- Before using a circuit tester, refer to the instructions in the circuit tester manual. Then, set the circuit tester to meet the object to be measured, voltage range and current polarity.
- Before starting the connector test, always check the connector terminal numbers, referring to the circuit diagram. When the connector size is very small, and the standard probe size is too large to be used for testing, wind a fine piece of sharpened wire or a pin around the probe to make the test easier.
- When checking the connector by using a circuit tester, insert a tester probe from the harness end of connector in order not to damage the terminal inside connector.

TDAA-05-08-004

Instructions for Disconnecting Connectors

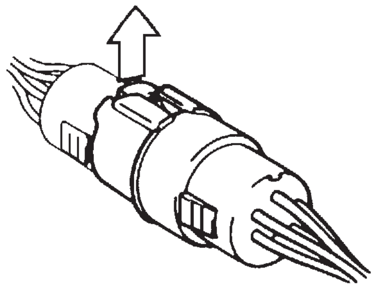
- Push, Unlock, and Separate Type

    - Connectors will not be easily separated even if the lock is pushed while being pulled.
    - The lock is located on female side connector (harness end side).



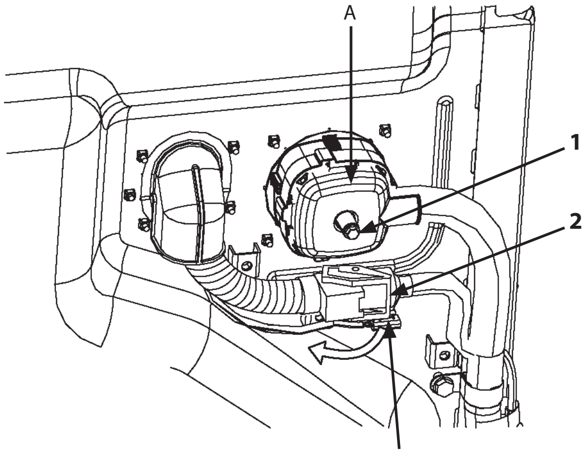
T107-04-05-002

- Raise Lock, Pull, and Separate Type



T107-04-05-003

- Remove Bolt (1) and Remove Type: (A)
- Push Lock and Switch Lever (2) Type: (B)



TDAA-05-08-006

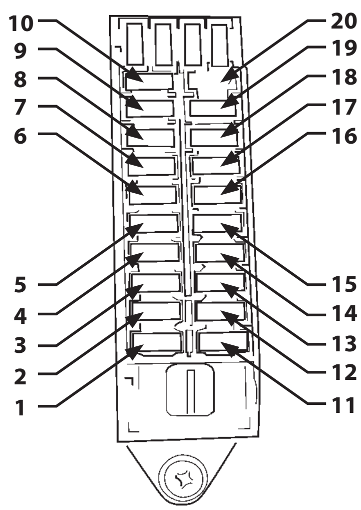
1- Bolt (M8)

2- Lever

Fuse Inspection

Cracks in a fuse are so fine that it is very difficult or impossible to find by visual inspection. Use a circuit tester in order to correctly inspect fuse continuity. Use a circuit tester in order to correctly inspect fuse continuity by following the instructions described below.

1. Set the key switch to the ON position. When the key switch is in the ON position, current from key switch terminal M turns the battery relay ON so that electric power is supplied to all circuits except the glow plug relay circuit. (Refer to the circuit diagram.)
2. Remove the fuse box cover. Set a circuit tester. (Measurement Range: 0 to 30 V)
3. Ground the negative probe of circuit tester to the body. Touch the terminals located away from center of the fuse box with the positive probe of circuit tester one at a time. When normal continuity of a fuse is intact, the circuit tester will indicate 20 to 25 V (battery voltage).



M178-07-034

Fuse No.	Capacity	Connected to
1	20 A	Work Light Relay 1, Work Light Relay 2
2	10 A	Washer Relay, Wiper Motor
3	20 A	Air Conditioner Unit
4	10 A	Pilot Shut-Off Relay, Pilot Shut-Off Solenoid Valve, Security Relay, MC (Solenoid Valve Power)
5	5 A	Option 1, Travel Alarm (Optional)
6	20 A	Option 2, Auto-Lubrication Device (Optional)
7	5 A	Monitor Controller
8	5 A	ECF (Power)
9	10 A	Monitor Controller (Backup Power), Switch Panel, Cab Light, Radio (Backup Power), Security Horn (Power), Security Horn Relay (Power)
10	5 A	MC (Power), GSM (Power), Wiper/Light Controller (Power)
11	10 A	ECF (EC Motor Power)
12	5 A	Wiper/Light Controller, Radio (Power)
13	10 A	Cigar Lighter
14	5 A	Monitor Controller (Power)
15	10 A	Auxiliary (Power)
16	5 A	Glow Plug Relay, QOS Controller
17	5 A	Buzzer, Option, Air Conditioner Unit, Work Light Relay 1, Washer Relay, Wiper Relay, GSM, Monitor Controller, ECF, MC
18	-	-
19	10 A	Horn Relay (Power)
20	5 A	Option 3

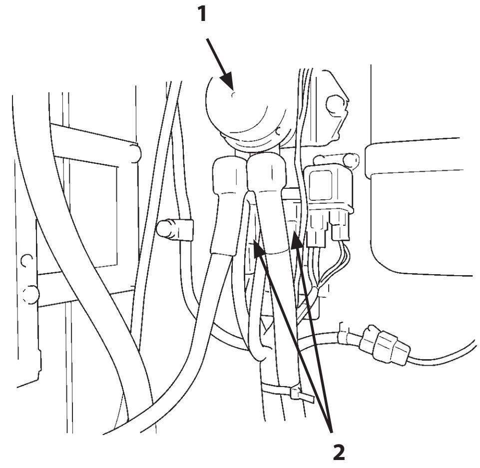
Fusible Link Inspection

Inspection

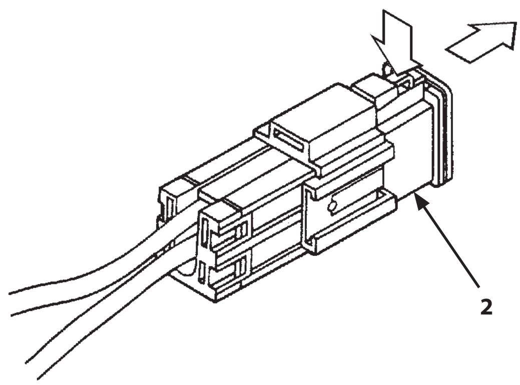
1. Visually inspect fusible link (2).

Replacement

1. Disconnect the negative cable from the battery.
2. Pull out fusible link (2). Replace fusible link (2).
3. Connect the negative cable to the battery.



M178-07-049



T111-04-05-015

1- Battery Relay
2- Fusible Link

Battery Voltage Check

1. Turn the key switch OFF. Check voltage between the battery positive terminal and the body (ground).

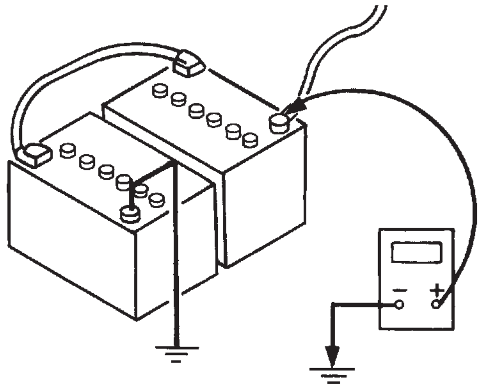
   Normal Voltage: 24 V

NOTE: If voltage is abnormal, recharge or replace the battery.

2. Start the engine. Check voltage between the battery positive terminal and the body (ground).

   Normal Voltage: 26 to 28 V

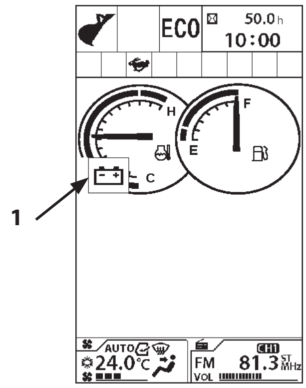
NOTE: If voltage is abnormal, check the charging system.



T162-05-06-005

Alternator Check

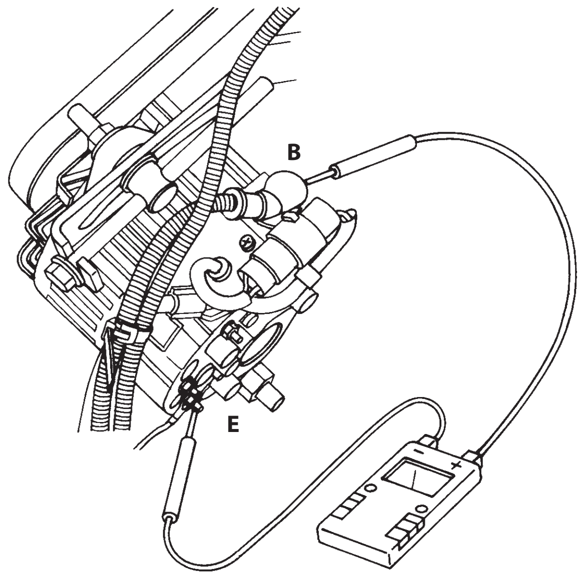
Generally, if the alternator has generated electricity, alternator alarm (1) will disappear. If alternator alarm (1) is displayed while the engine is running, the alternator might be defective.



MDAA-01-043

How to Check Alternator

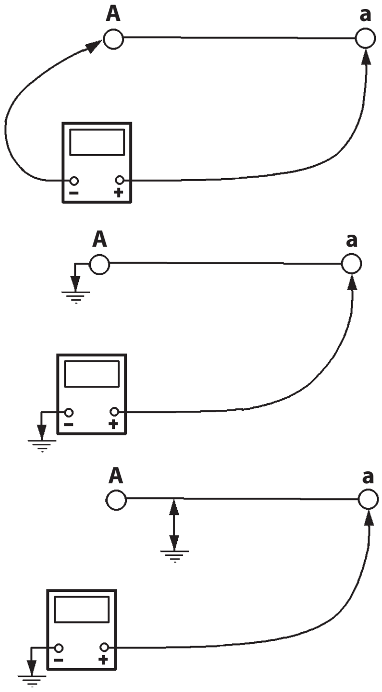
1. Set the key switch to the ON position. Confirm that alternator alarm (1) is displayed.
2. Measure voltage between terminals B and E of the alternator. If the measured voltage is around 24 V, the alternator circuit can be considered normal. If the measured voltage is low, a shortage in battery capacity or looseness of the wire connectors of alternator circuit might be the cause of the malfunction. When voltage is 0 V, the wiring between fuse box and alternator might be loose or disconnected. Also, the alternator cannot generate electricity if the ground line is disconnected.
3. Next, start the engine and measure voltage generated while the alternator rotates. As described above, measure voltage between terminals B and E on the alternator side.
   If voltage is around 28 V, the alternator is operating normally. If the rated voltage is not being generated (around 24 V), there is some trouble with the alternator or the regulator.



T157-07-06-003

Continuity Check

IMPORTANT: Before continuity check, set the key switch to the OFF position.



T107-07-05-003

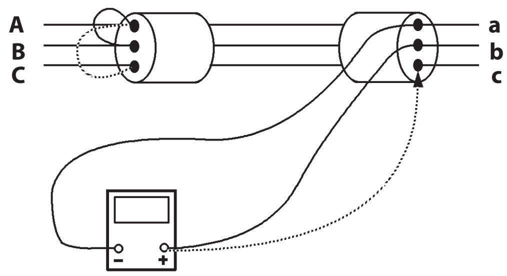
- Single-line continuity check

Disconnect both end connectors of the harness and check continuity between both ends:
  - If the ohm-meter reading is: ∞ Ω = Discontinuity
  - 0 Ω = Continuity

- When the one end connector is far apart from the other, connect one end of connector (A) to the body by using a clip. Then, check continuity of the harness through the body as illustrated.
  - If the ohm-meter reading is: ∞ Ω = Discontinuity
  - 0 Ω = Continuity

- Single-line short-circuit check

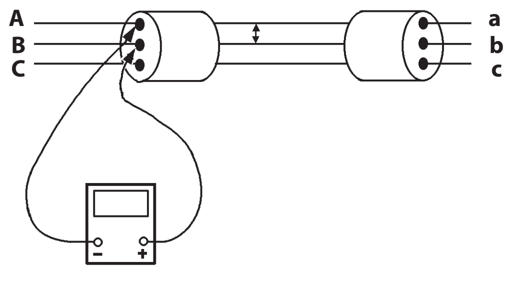
Disconnect both end connectors of the harness and check continuity between one end connector of the harness and the body:
  - 0 Ω = Short-circuit is present.
  - ∞ Ω = No short-circuit is present.



T107-07-05-004

- Multi-line continuity check

Disconnect both end connectors of the harness, and short-circuit two terminals, (A) and (B), at one end connector, as illustrated. Then, check continuity between terminals (a) and (b) at the other connector.
If the ohm-meter reading is ∞ Ω, either line (A) - (a), or (B) - (b) is in discontinuity. To find out which line is discontinued, conduct the single line continuity check on both lines individually, or, after changing the short-circuit terminals from (A) - (B) to (A) - (C), check continuity once more between terminals (a) and (c). By conducting the multi-line continuity check twice, it is possible to find out which line is discontinued. With terminals (A) and (C) short-circuited, check continuity between terminals (a) and (c).
  - 0 Ω = Line (B) - (b) has discontinuity.
  - ∞ Ω = Line (A) - (a) has discontinuity.



T107-07-05-005

- Multi-line short-circuit check

Disconnect both end connectors of the harness, and check continuity between terminals (A) and (B) or (C).
  - 0 Ω = Short-circuit exists between the lines.
  - ∞ Ω = No short-circuit exists between the lines.

Voltage and Current Measurement

Turn key switch ON so that the specified voltage (current) is supplied to the location to be measured. Judge if the circuit is normal by evaluating whether the measured voltage (current) matches the specification.

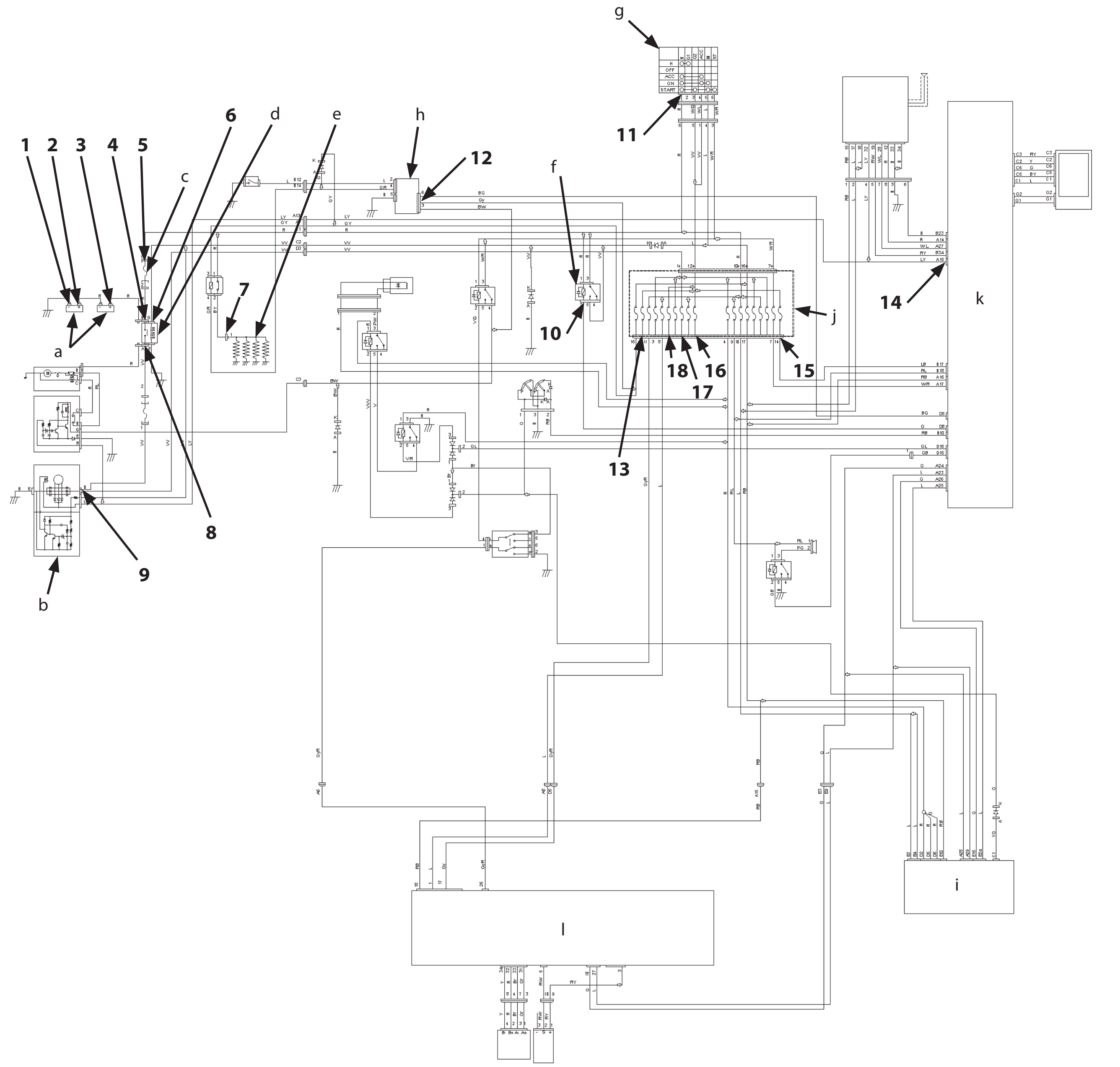
24-Volt Circuit

Start checking the circuit in order up to the location to be measured from either power source or actuator side. Thereby, the faulty location in the circuit will be found.

- Black (negative) probe terminal of circuit tester: To ground to the body
- Red (Positive) probe terminal of circuit tester: To touch the location to be measured

Engine	Key Switch	Location to be Measured		Specification
Electric Power Circuit				
Stopped	OFF	Between (2) and (1):	One Battery	10 to 12.5 V
Stopped	OFF	Between (3) and (2):	One Battery	10 to 12.5 V
Stopped	OFF	Between (3) and (1):	Two Batteries	20 to 25 V
Stopped	OFF	Between (4) and Ground:	Battery Power	20 to 25 V
Stopped	OFF	Between (5) and Ground:	Fusible Link	20 to 25 V
Stopped	OFF	Between (1) and Ground:	Backup Current *1	20 mA or less
Preheating Circuit				
Stopped	ON or START	Between (11) and Ground:	Key Switch	20 to 25 V
Stopped	ON or START	Between (7) and Ground:	Glow Plug *2	20 to 25 V
Stopped	ON or START	Between (12) and Ground:	QOS Controller	20 to 25 V
Charging Circuit				
Fast Speed	ON	Between (9) and Ground:	Alternator (B)/Generating Voltage	26 to 30 V
Fast Speed	ON	Between (8) and Ground:	Battery Relay/Generating Voltage	26 to 30 V
Fast Speed	ON	Between (17) and Ground:	Fuse Box/Generating Voltage	26 to 30 V
Fast Speed	ON	Between (14) and Ground:	Monitor Controller (A15)	13 to 30 V
Surge Voltage Prevention Circuit				
Idle Speed	ON	Between (9) and Ground:	Alternator (B)	26 to 30 V
Idle Speed	ON	Between (10) and Ground:	Load Dump Relay	26 to 30 V
Idle Speed	ON	Between (6) and Ground:	Battery Relay	26 to 30 V
Accessory Circuit				
Stopped	ON	Between (15) and Ground:	Monitor Controller	20 to 25 V
Stopped	ON	Between (16) and Ground:	Wiper/Light Controller, Radio	20 to 25 V
Stopped	ON	Between (18) and Ground:	Auxiliary	20 to 25 V
Stopped	ON	Between (13) and Ground:	Cigar Lighter	20 to 25 V
Stopped	ON	Between (6) and Ground:	Battery Relay	20 to 25 V

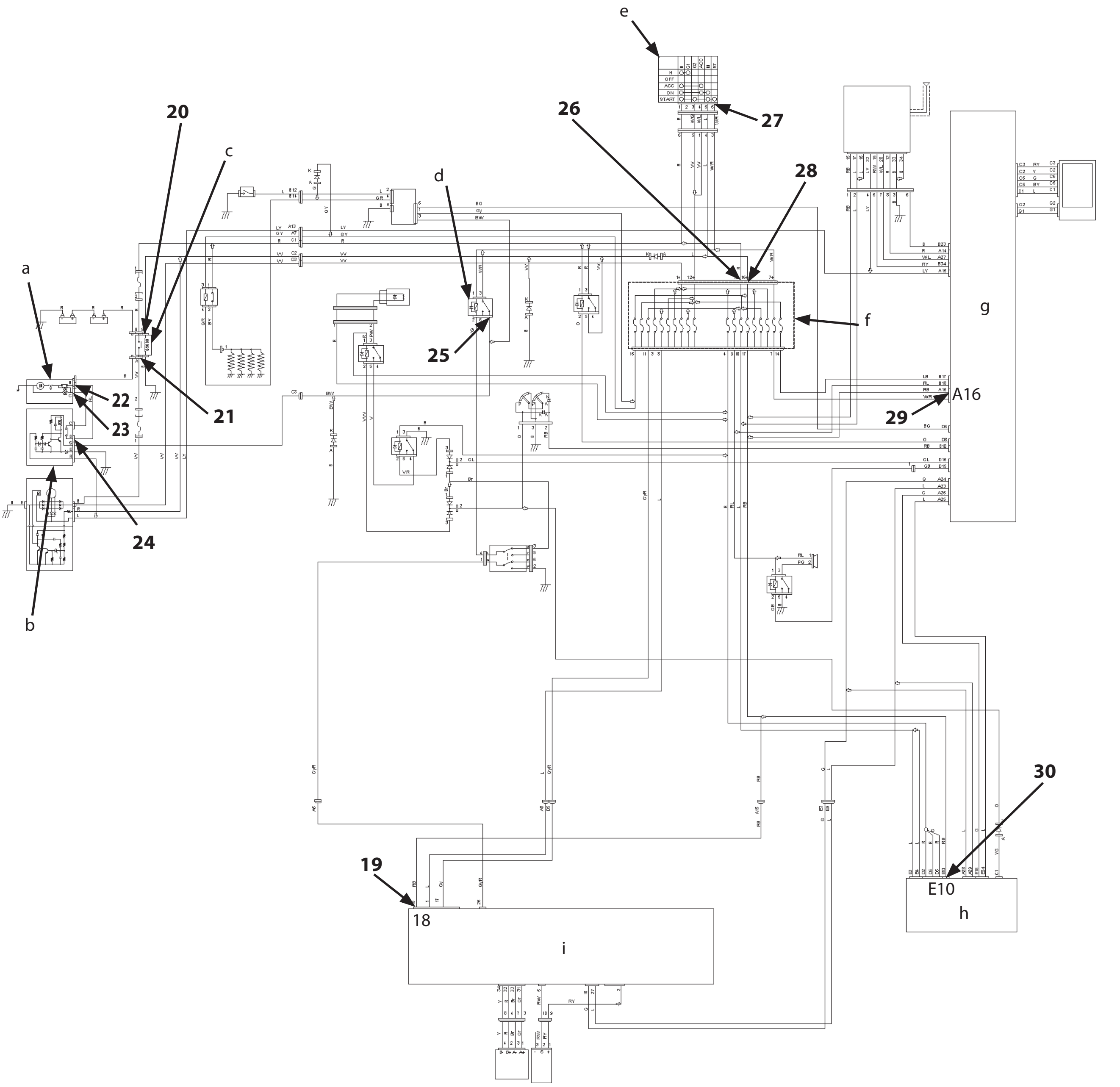
*1 Before measurement, disconnect the negative cable from the battery.
*2 The preheating circuit is operated for the preheating time according to the coolant temperature.



TDCD-05-01-001

a-	Battery	e-	Glow Plug	i-	MC		
b-	Alternator	f-	Load Dump Relay	j-	Fuse Box		
c-	Fusible Link	g-	Key Switch	k-	Monitor Controller		
d-	Battery Relay	h-	QOS Controller	l-	ECF		

Engine	Key Switch	Location to be Measured		Specification
Starting Circuit				
Started	START	Between (20) and Ground:	Battery Relay (Coil)	20 to 25 V
Started	START	Between (21) and Ground:	Battery Relay (Switch)	20 to 25 V
Started	START	Between (22) and Ground:	Starter (B)	20 to 25 V
Started	START	Between (23) and Ground:	Starter (C)	20 to 25 V
Started	START	Between (24) and Ground:	Starter Relay 2 (B)	20 to 25 V
Started	START	Between (25) and Ground:	Starter Cut Relay	20 to 25 V
Started	START	Between (26) and Ground:	Fuse Box	20 to 25 V
Started	START	Between (27) and Ground:	Key Switch	20 to 25 V
Started	START	Between (28) and Ground:	Fuse Box	20 to 25 V
Started	START	Between (29) and Ground:	Monitor Controller (A16)	20 to 25 V
Started	START	Between (30) and Ground:	MC (E10)	20 to 25 V
Started	START	Between (19) and Ground:	ECF (18)	20 to 25 V

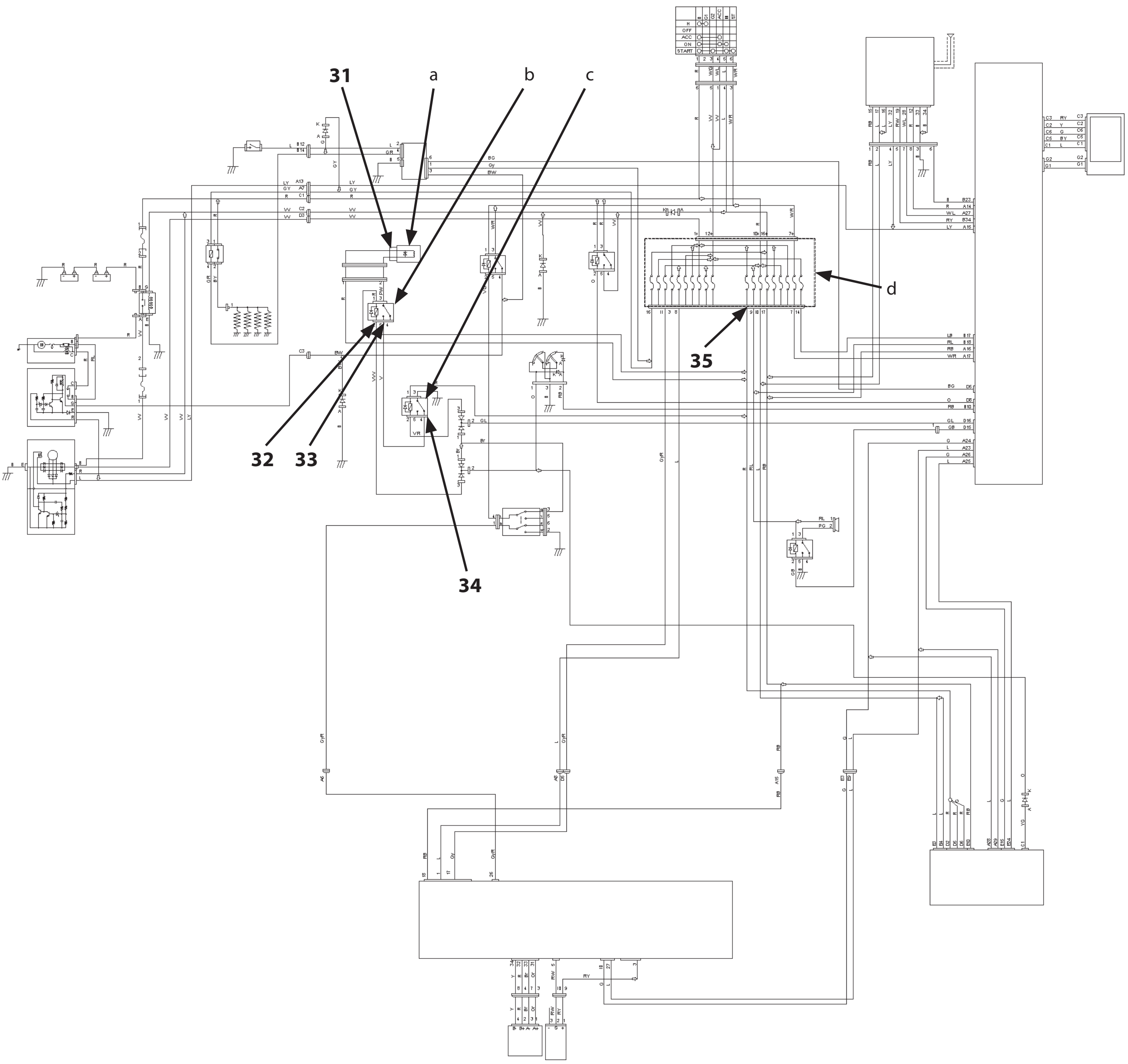


TDCD-05-01-001

a- Starter
b- Starter Relay 1
c- Battery Relay
d- Starter Cut Relay
e- Key Switch
f- Fuse Box
g- Monitor Controller
h- MC
i- ECM

Engine	Key Switch	Location to be Measured		Specification
Pilot Shut-Off Circuit *				
Stopped	ON	Between (31) and Ground:	Pilot Shut-Off Solenoid Valve	20 to 25 V
Stopped	ON	Between (32) and Ground:	Pilot Shut-Off Relay (Coil)	20 to 25 V
Stopped	ON	Between (33) and Ground:	Pilot Shut-Off Relay (Switch)	20 to 25 V
Stopped	ON	Between (34) and Ground:	Security Relay	20 to 25 V
Stopped	ON	Between (35) and Ground:	Fuse Box	20 to 25 V

* Before measurement, set the pilot shut-off lever to the UNLOCK position.



TDCD-05-01-001

a- Pilot Shut-Off Solenoid Valve
b- Pilot Shut-Off Relay
c- Security Relay
d- Fuse Box

5-Volt Circuit

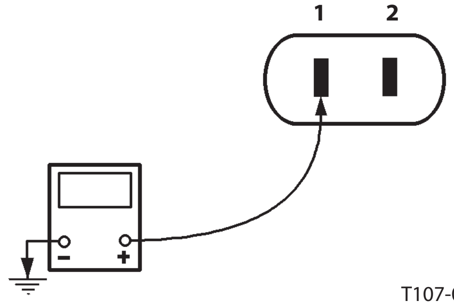
- Voltage between terminal #1 and the body

Disconnect the connector with the key switch OFF. Measure voltage between terminal #1 on the body harness end connector and the body (ground).

- Key Switch: ON
- Black (negative) probe terminal of circuit tester: To ground to the body
- Red (Positive) probe terminal of circuit tester: To terminal #1

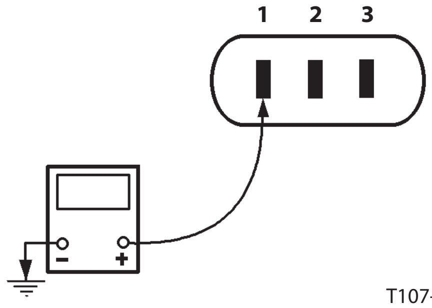
Evaluation: If the measuring voltage is within 5 ± 0.5 volts, the circuit up to terminal #1 is normal.

Two Polarities



T107-07-05-006

Three Polarities



T107-07-05-007

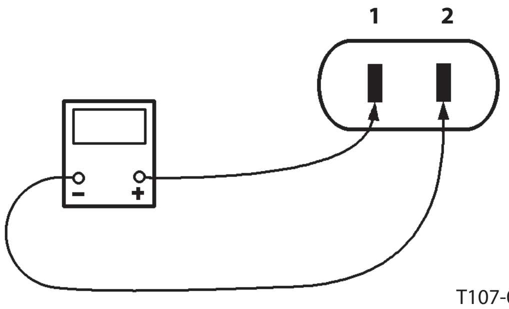
- Voltage between terminal #1 and the ground terminal

Turn OFF the key switch, and disconnect the sensor connector. Measure the voltage between terminal #1 (5 V power supply) on the body harness end connector and the ground terminal (terminal #2 for two-polarities or terminal #3 for three-polarities connector) under the following conditions.

- Key Switch: ON
- Black (negative) probe terminal of circuit tester: To ground terminal (Terminal #2 or #3)
- Red (Positive) probe terminal of circuit tester: To terminal #1

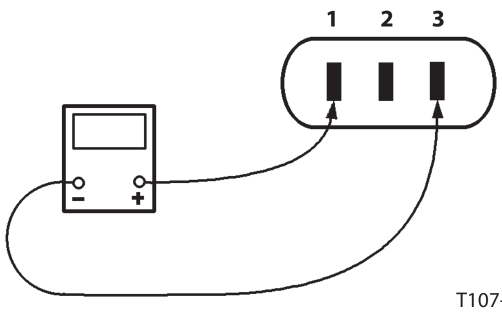
Evaluation: If the measuring voltage is within 5 ± 0.5 volts, the circuit up to terminal #1 or the ground terminal (terminal #2 or #3) is normal.

Two Polarities



T107-07-05-008

Three Polarities



T107-07-05-009

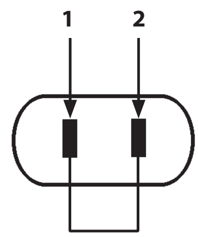
Check by False Signal

Turn the key switch OFF. Disconnect the sensor connector. Turn the key switch ON. Connect terminal #1 (power source) of the body harness end connector to terminal #2 (signal). (Power voltage is used as a false signal.)
Check this state by using the monitor function of MPDr..
When the maximum value is displayed, MC and the circuit up to the body harness end connector are normal. If "ON" is displayed, the pressure switch circuits are normal.

IMPORTANT: Do not connect terminal #1 or #2 to terminal #3 or to the body (ground) when checking a three-polarity connector.

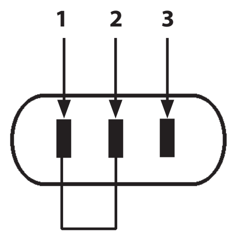
NOTE: Some kinds of sensors can be monitored by the service menu of the monitor.

Two Polarities



T107-07-05-010

Three Polarities



T107-07-05-011

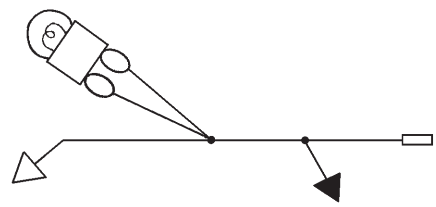
Test Harness

Install a test harness between connectors. Check the circuit condition depending on whether the test harness lamp lights or extinguishes during operation.

- Parts Number 4283594 (ST 7126)

Use in order to check a single-line (discontinuity and/or voltage).
  - During Operation: Light is ON.

Parts Number 4283594 (ST 7126)

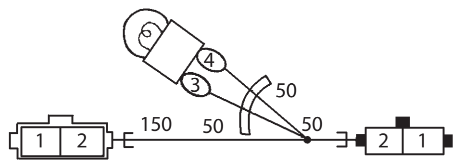


T107-07-05-012

- Parts Number (ST 7226)

Use in order to check the solenoid valve unit circuits.
  - When the corresponding control lever or switch is operated: Light is ON.

Parts Number (ST 7226)

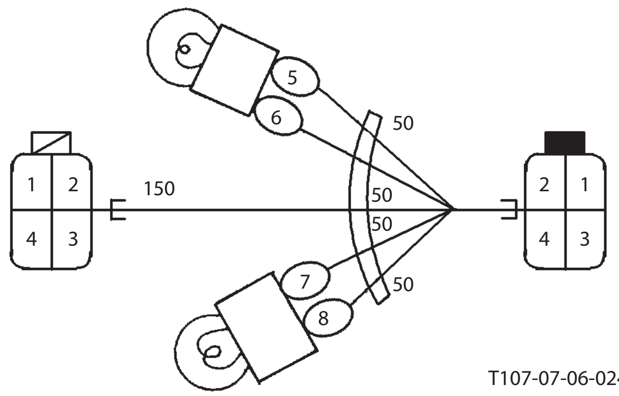


T107-07-06-015

- Parts Number 4274589 (ST 7125)

Use to check the EC motor circuit.
When the engine control dial is rotated:
  - Both lamps ON: Normal
  - Only one lamp ON: Check for continuity of the circuit connected to the lamp OFF.
  - Both lamps OFF: Check the harness together with the relay.

Parts Number 4274589 (ST 7125)

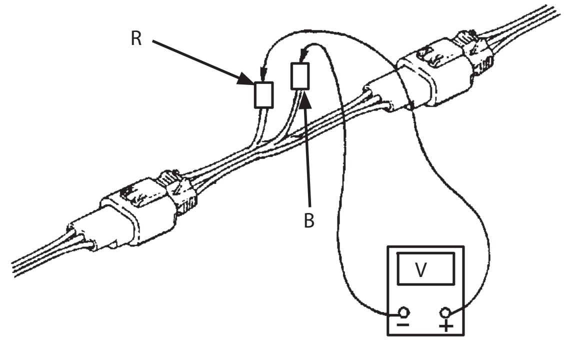


T107-07-06-024

- Parts Number 4284347 (ST 7129)

Use to measure the EC sensor circuit signal line voltage (between terminals #2 and #3).

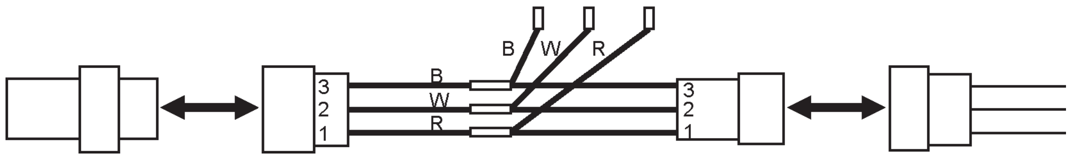
Parts Number 4284347 (ST 7129)



T107-07-03-009

Connect a test harness to the harness end connector of pressure sensor. Check the state of pressure sensor circuit.

- ST 6701 for high-pressure sensor
- ST 6703 for low-pressure sensor

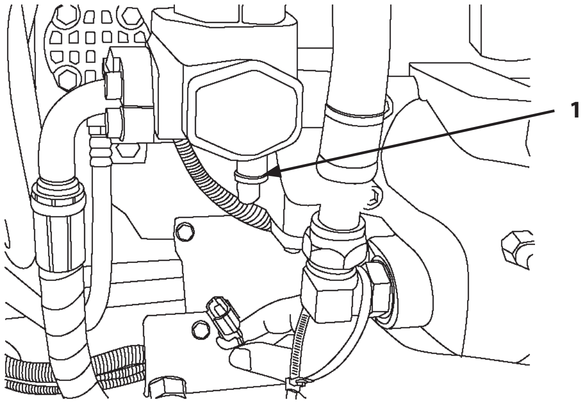


TDAA-05-06-003

Connecting Procedure of Test Harness

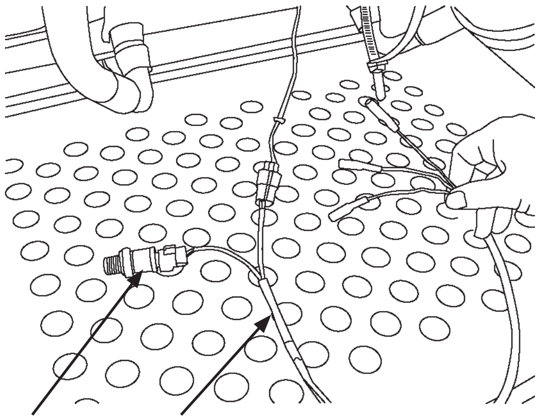
NOTE: The connecting procedures of test harness of pump 2 delivery pressure sensor (1) are explained.

1. Disconnect a connector of pump 2 delivery pressure sensor (1).

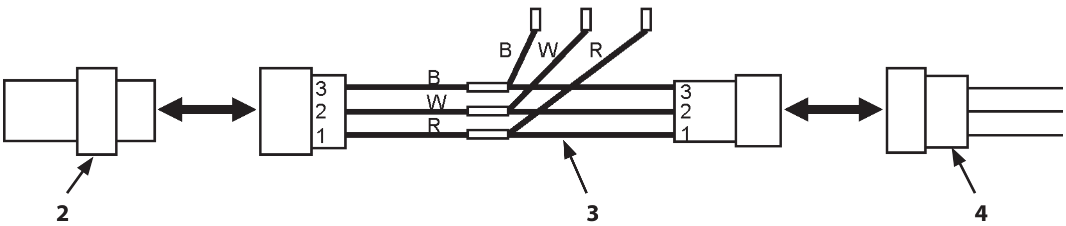


TDAA-05-06-001

2. Connect the male end connector of test harness (3) (ST 6701) to harness end connector (4) of pump 2 delivery pressure sensor (1).
3. Connect dummy sensor (2) equivalent to #4436271 to the female end connector of test harness (3) (ST 6701).



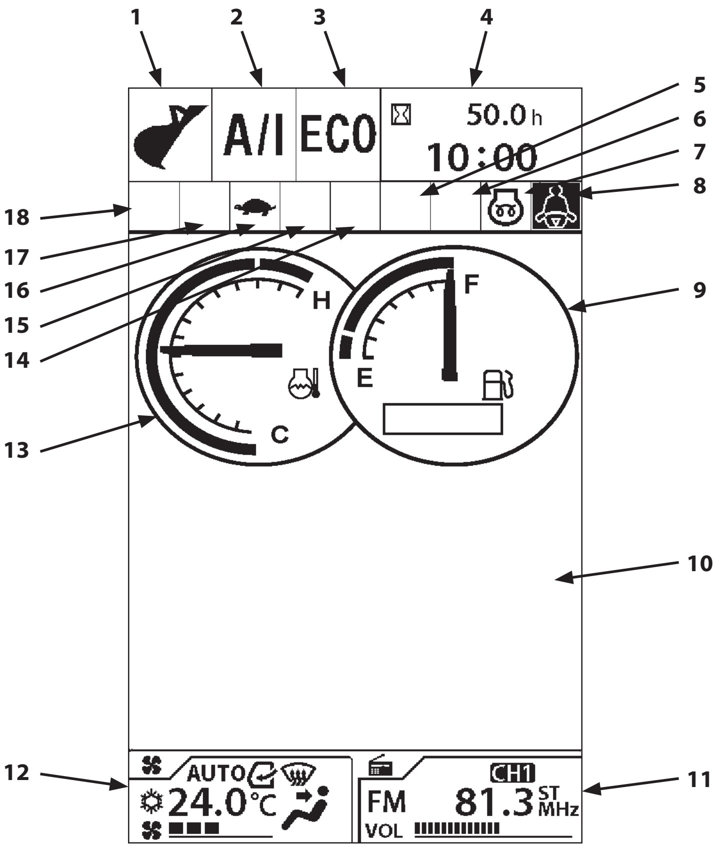
TDAA-05-06-002



TDAA-05-06-003

Outline

Basic Screen



MDCD-01-020

1- Work Mode Display
2- Auto-Idle Display
3- Power Mode Display
4- Clock, Hour Meter
5- Auxiliary
6- Auxiliary
7- Glow Signal Display
8- Seat Belt Alarm
9- Fuel Gauge
10- Logo Display/ Operation Display/ No Display/ Rear View Monitor Display
11- Radio Display
12- Air Conditioner Display
13- Coolant Temperature Gauge
14- Auxiliary
15- Auxiliary
16- Travel Mode Display
17- Auxiliary
18- Auxiliary

Operating Procedures of Service Menu (Built-In Diagnosing System)

IMPORTANT: The service menu (built-in diagnosing system) is provided only for maintenance activity. Do not explain this function to your customers.

The following items can be displayed on the monitor without using MPDr..

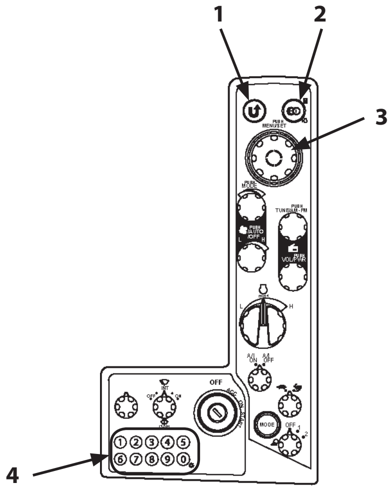
- Troubleshooting:
  Fault code is displayed.
- Monitoring:
  A part of monitor items for MPDr. is displayed.
- Controller Version:
  The controller version is displayed.
- Issued Warning Record:
  Ten alarms which were issued recently are displayed.
- Operation:
  Total operating hours of various hour meters are displayed.
- Communication Terminal Status:
  Information of the communication terminal is displayed.
- Machine Setting:
  The settings are adjusted.
- Monitor Setting:
  All item operations displayed on the monitor are set to enable / disable.

NOTE: Machine Setting and Monitor Setting are not displayed in initialization. When displaying Machine Setting and Monitor Setting, make enable function settings of MPDr..

How to display service menu

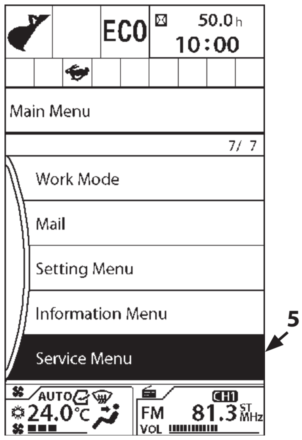
1. Push select / set switch (3) while pushing 9 on TEN-key function (4) with the key switch set in the ON position or the engine running. Therefore, Service Menu (5) is added to the Main Menu screen. (Figure A)
2. Turn select / set switch (3) and select Service Menu (5). When pushing select / set switch (3), the Service Menu screen appears. (Figure B)
3. When pushing back switch (1), the previous screen appears.
4. When pushing return to basic screen switch (2), the basic screen appears.

NOTE: When the basic screen has appeared by using back switch (1) or return to basic screen switch (2), Service Menu (5) on the Main Menu screen is deleted. In case Service Menu is displayed, perform step 1 again.



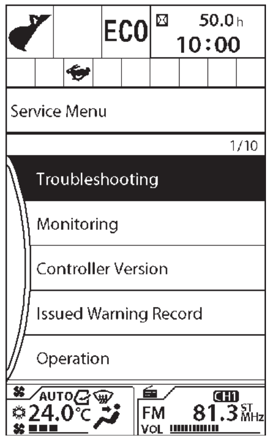
TDAA-05-02-032

A



TDAA-05-02-014EN

B



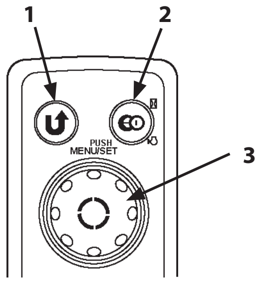
TDAA-05-02-010EN

Troubleshooting

1. Turn select / set switch (3) and select Troubleshooting (4) on Service Menu. When pushing select / set switch (3), the Troubleshooting screen appears. (Figure A)
2. Turn select / set switch (3) and select the controller. When pushing select / set switch (3), the self-diagnostic result of selected controller (fault code) is displayed. (Figure B)

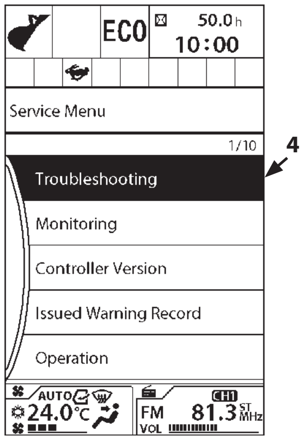
NOTE: Main (MC) (5) is selected as an example here.

3. The past fault codes as well as the current ones are displayed at this time.
4. Turn select / set switch (3), select CLEAR (6), and push select / set switch (3).
5. Therefore, the past fault codes are deleted and only the current fault codes can be displayed. (Figure C)
6. When pushing back switch (1), the previous screen appears.
7. When pushing return to basic screen switch (2), the basic screen appears.

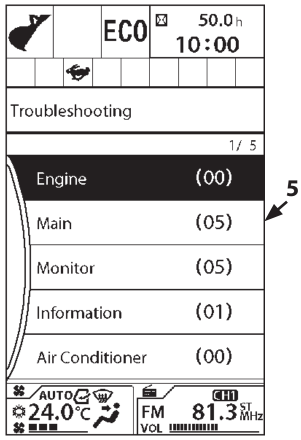


TDAA-05-02-030

A

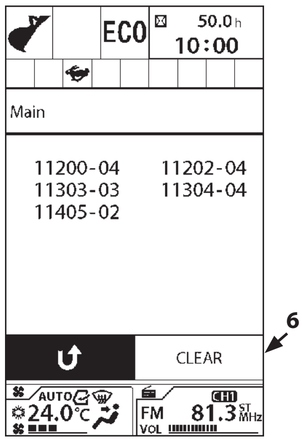


TDAA-05-02-010EN



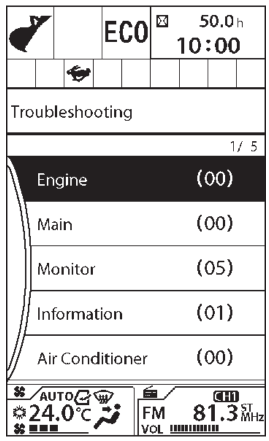
TDAA-05-02-024EN

B



TDAA-05-02-025EN

C



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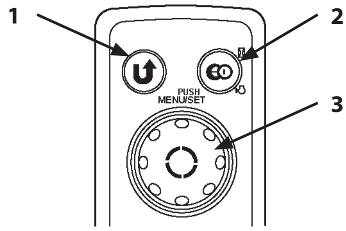
Monitoring

1. Turn select / set switch (3) and select Monitoring (4) on Service Menu. When pushing select / set switch (3), the Monitoring screen appears. (Figure A)
2. Turn select / set switch (3) and select the controller for monitoring. When pushing select / set switch (3), the monitoring items for selected controller are displayed. (Figure B) (Refer to List of Monitoring Item.)
3. Turn select / set switch (3), select the item for monitoring, and push select / set switch (3). (Up to 12 items can be selected.)
4. Push back switch (1) and the Monitoring screen appears. (Figure C)
5. Turn select / set switch (3), select START (5), and push select / set switch (3). (Figure C)

NOTE: START (5) and CLEAR (HOLD) (6) are displayed only when one or more monitoring items are selected. START (5) and CLEAR (HOLD) (6) are not displayed when no monitoring item is selected.



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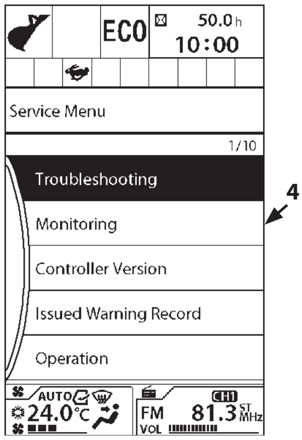

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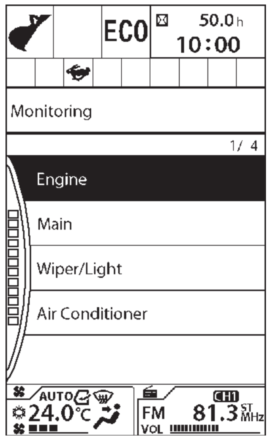
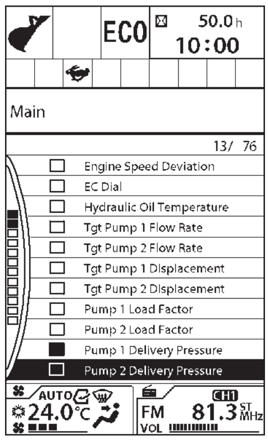
A



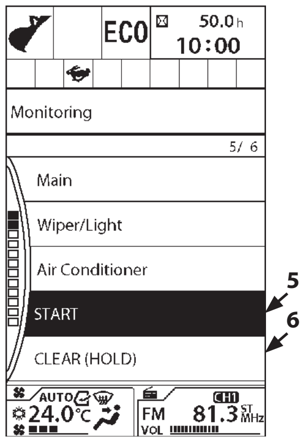
TDAA-05-02-015EN

B



TDCD-05-02-016EN

C

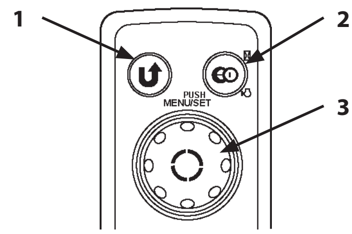


TDAA-05-02-017EN

6. The selected monitoring item is started monitoring. (Figure D)
7. When pushing select / set switch (3) while monitoring, PAUSE (7) is displayed and the monitoring value can pause (be held). (Figure E)
8. When pushing select / set switch (3) again, pausing is stopped.

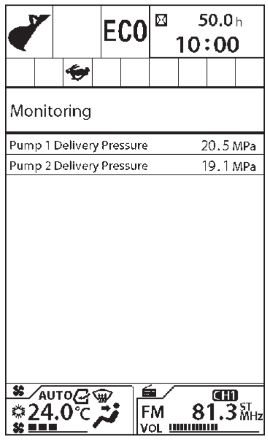
NOTE: Even if the key switch is set to OFF position, the selected monitoring item has been stored. If the selected monitoring item is released, select CLEAR (HOLD) (6) on the Monitoring screen and push select / set switch (3) for a while until START (5) and CLEAR (HOLD) (6) disappear.

9. When pushing back switch (1), the previous screen appears.
10. When pushing return to basic screen switch (2), the basic screen appears.



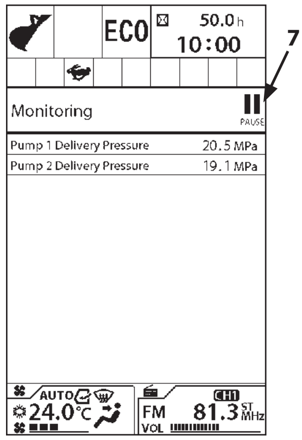
TDAA-05-02-030

D

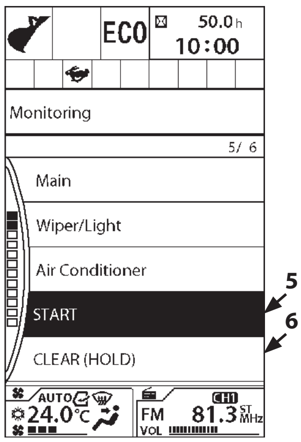


TDAA-05-02-019EN

E



TDAA-05-02-018EN



TDAA-05-02-017EN

List of Monitoring Item

Engine Controller (ECF)

Item	Unit	Data
Actual Engine Speed	min^{-1}	Input signal from N sensor (engine speed sensor)
Directed Engine Speed	min^{-1}	Input signal from engine control dial
EC Sensor Voltage	V	Input signal from EC sensor
EC Motor Position	Step	Input signal from EC motor position
Eng Learning Status	-	Engine learning status
Learning Switch	OFF/ON	Engine learning switch ON/OFF status
Engine Stop Switch	OFF/ON	Engine stop switch ON/OFF status
Coolant Temp (Meter)	°C	Input signal from coolant temperature sensor (Coolant Temperature Gauge)

Main Controller (MC)

Item	Unit	Data
Demand Engine Speed	min^{-1}	Input signal from engine control dial
Actual Engine Speed	min^{-1}	Input signal from ECF
Engine Speed Deviation	min^{-1}	Difference between actual engine speed and requested engine speed
EC Dial	V	Input signal from engine control dial
Hydraulic Oil Temperature	°C	Input signal from hydraulic oil temperature sensor
Tgt Pump 1 Flow Rate	L	Command signal to maximum pump 1 flow rate limit control solenoid valve
Tgt Pump 2 Flow Rate	L	Command signal to maximum pump 2 flow rate limit control solenoid valve
Tgt Pump 1 Displacement	cm^3	Calculation signal from engine speed and input signal from pump 1 delivery pressure sensor
Tgt Pump 2 Displacement	cm^3	Calculation signal from engine speed and input signal from pump 2 delivery pressure sensor
Pump 1 Load Factor	%	Calculation signal from engine speed and input signal from pump 1 delivery pressure sensor
Pump 2 Load Factor	%	Calculation signal from engine speed and input signal from pump 2 delivery pressure sensor
Pump 1 Delivery Pressure	MPa	Input signal from pump 1 delivery pressure sensor
Pump 2 Delivery Pressure	MPa	Input signal from pump 2 delivery pressure sensor
Pump 1 Control Pressure	MPa	Input signal from pump 1 control pressure sensor
Pump 2 Control Pressure	MPa	Input signal from pump 2 control pressure sensor
Boom Raise Pilot Pressure	MPa	Input signal from pressure sensor (boom raise)
Arm Roll-In Pilot Pressure	MPa	Input signal from pressure sensor (arm roll-in)
Travel Pilot Pressure	MPa	Input signal from pressure sensor (travel)
Front ATT Pilot Pressure	MPa	Input signal from pressure sensor (front)
Swing Pilot Pressure	MPa	Input signal from pressure sensor (swing)

Item	Unit	Data
ATT 1 Pilot Pressure*	MPa	Input signal from pressure sensor (auxiliary)
Arm Roll-Out Pilot Pressure*	MPa	Input signal from pressure sensor (arm roll-out)
Pumps 1&2 Torque P/S O/P	MPa	Control signal to torque control solenoid valve
Pump 2 Flw Limit P/S O/P	MPa	Control signal to maximum pump 2 flow rate limit control solenoid valve
Arm Regen P/S Output	MPa	Control signal to solenoid valve unit (SC)
Pressure Boost P/S Output	MPa	Control signal to solenoid valve unit (SG)
Digging Regen P/S O/P	MPa	Control signal to solenoid valve unit (SF)
Pump 1 Flw Limit P/S Output*	MPa	Control signal to maximum pump 1 flow rate limit control solenoid valve
Analog Output 14	MPa	-
Analog Output 15	MPa	-
Analog Output 16	MPa	-
Auxil Flw Cont P/S Output	MPa	Control signal to auxiliary flow rate control solenoid valve
Pumps 1&2 Torque P/S O/P FB	mA	Feedback from pump 1 and 2 torque control solenoid valve output
Pump 2 Flw Limit P/S O/P FB	mA	Feedback from maximum pump 2 flow rate limit control solenoid valve output

*NOTE: *: Optional*

Item	Unit	Data
Arm Regen P/S Output FB	mA	Feedback from solenoid valve unit (SC) output
Pressure Boost P/S Output FB	mA	Feedback from solenoid valve unit (SG) output
Digging Regen P/S O/P FB	mA	Feedback from solenoid valve unit (SF) output
Pump 1 Flw Limit P/S O/P FB*	mA	Feedback from maximum pump 1 flow rate limit control solenoid valve output
Analog Output FB 14	mA	-
Analog Output FB 15	mA	-
Analog Output FB 16	mA	-
Auxil Flw Cont P/S O/P FB	mA	Feedback from auxiliary flow rate control solenoid valve output
Digital Input 7	OFF/ON	-
PCSL Lever Switch	OFF/ON	Pilot shut-off switch ON/OFF status
Breaker Control Switch	OFF/ON	-
Power Boost Switch	OFF/ON	Power digging switch ON/OFF status
Power Mode Switch	OFF/ON	Power mode switch operating status
Travel Mode SW	LO/HI	Travel mode switch selection status
Auto-Idle Switch	OFF/ON	Auto-idle switch ON/OFF status
Digital Input 15	OFF/ON	-
Digital Input 14	OFF/ON	-
Digital Input 13	OFF/ON	-
Digital Input 12	OFF/ON	-

*NOTE: *: Optional*

Item	Unit	Data
Digital Input 8	OFF/ON	-
Digital Input 23	OFF/ON	-
Digital Input 22	OFF/ON	-
Digital Input 21	OFF/ON	-
Digital Input 20	OFF/ON	-
Digital Input 19	OFF/ON	-
Digital Input 18	OFF/ON	-
Digital Input 17	OFF/ON	-
Line Filter Restriction SW*	OFF/ON	Clogged line filter status
Digital Input 29	OFF/ON	-
Digital Input 28	OFF/ON	-
Digital Input 27	OFF/ON	-
Digital Input 26	OFF/ON	-
Digital Input 25	OFF/ON	-
Digital Input 24	OFF/ON	-
Warning Alarm	OFF/ON	Overload alarm ON/OFF status
Swing Alarm	OFF/ON	Swing alarm ON/OFF status
Travel Alarm	OFF/ON	Travel alarm ON/OFF status
Selector Valve*	OFF/ON	Selector valve ON/OFF status
Auxiliary Flow Combiner Valve*	OFF/ON	Auxiliary flow combiner control solenoid valve ON/OFF status
ON/OFF Valve Output 11	OFF/ON	-
ON/OFF Valve Output10	OFF/ON	-
ON/OFF Valve Output 9	OFF/ON	-

*NOTE: *: Optional*

Wiper/Light Controller

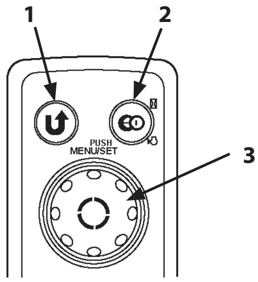
Item	Unit	Data
Wiper 1 Input	V	Input signal from wiper switch
Wiper 2 Input	V	Input signal from overhead window wiper switch
Washer 1 Switch	OFF/ON	Washer switch ON/OFF status
Washer 2 Switch	OFF/ON	Overhead window washer switch ON/OFF status
Work Light 1 Switch	OFF/ON	Work light switch 1 ON/OFF status
Work Light 2 Switch	OFF/ON	Work light switch 2 ON/OFF status
Cab Light Switch	OFF/ON	Cab light switch ON/OFF status
Wiper 1 Output	OFF/ON	Wiper relay ON/OFF status
Wiper 2 Output	OFF/ON	Overhead window wiper relay ON/OFF status
Washer 1 Output	OFF/ON	Washer relay ON/OFF status
Washer 2 Output	OFF/ON	Overhead window washer relay ON/OFF status
Work Light 1 Output	OFF/ON	Work light relay 1 ON/OFF status
Work Light 2 Output	OFF/ON	Work light relay 2 ON/OFF status
Cab Light 1 Output	OFF/ON	Cab light (door interlocking position) ON/OFF status
Cab Light 2 Output	OFF/ON	Cab light (ON position) ON/OFF status

Air Conditioner Unit

Item	Unit	Data
Compressor Operation	OFF/ON	Compressor operating status
Outdoor Air Temperature	°C	Input signal from ambient temperature sensor
Indoor Air Temperature	°C	Input signal from air circulation sensor
Amount of Insolation	W/m^2	Input signal from solar radiation sensor

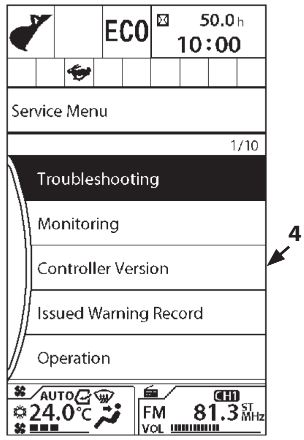
Controller Version

1. Turn select / set switch (3) and select Controller Version (4) on Service Menu.
2. When pushing select / set switch (3), the version of each controller appears. (Figure A)
3. When pushing back switch (1), the previous screen appears.
4. When pushing return to basic screen switch (2), the basic screen appears.



TDAA-05-02-030

A



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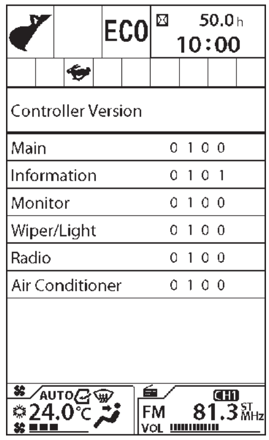


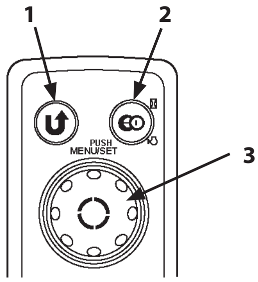
TDAA-05-02-009EN

Issued Warning Record

1. Turn select / set switch (3) and select Issued Warning Record (4) on Service Menu. When pushing select / set switch (3), the Issued Warning Record screen appears. (Figure A)
2. The logo and trouble of maximum ten alarms which were issued recently are displayed. (Refer To List of Alarm.)
3. Turn select / set switch (3) and select the displayed alarm. When pushing select / set switch (3), the time (ON / OFF) when the selected alarm has occurred / solved are displayed. (Figure B)
4. In case of current alarms, the time (---) when the selected alarm has solved is displayed. (Figure C)

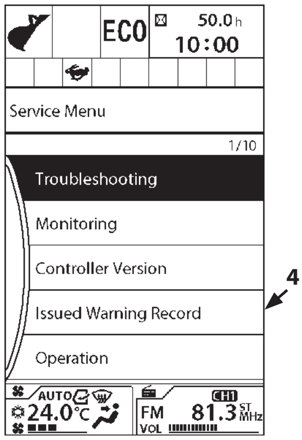
NOTE: The display of date and time depends on the setting. (Refer to the operator's manual.)

5. When pushing back switch (1), the previous screen appears.
6. When pushing return to basic screen switch (2), the basic screen appears.



TDAA-05-02-030

A



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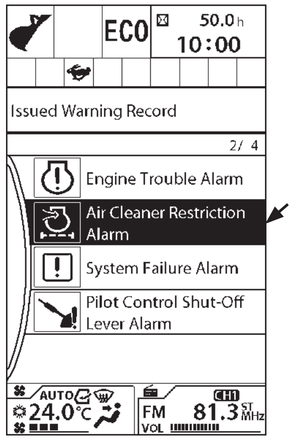
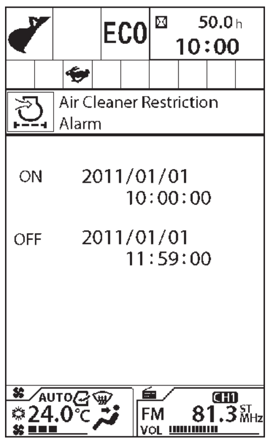


TDAA-05-02-021EN

B



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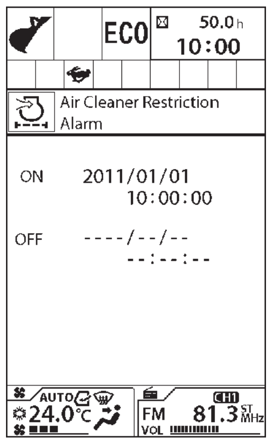
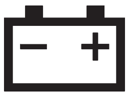
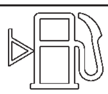
C



TDAA-05-02-023EN

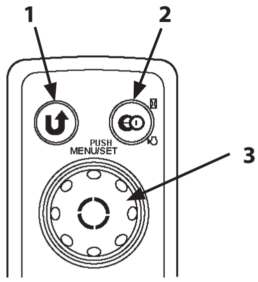
List of Alarm

Logo	Alarm	Trouble Screen	Remedy
 MDAA-01-067	Overheat Alarm	Coolant Temperature Is Abnormally High. Stop Operation. Run The Engine At Slow Idle To Cool Coolant Temperature.	Refer to Troubleshooting A.
 MDAA-01-068	Hydraulic Oil Overheat Alarm	Hydraulic Oil Temperature Is Abnormally High. Stop Operation, Check Hydraulic Oil Level And Any Oil Leaks From Hydraulic Circuit.	Refer to Troubleshooting A.
 MDAA-01-069	Engine Trouble Alarm	Engine Or Accessory Are Abnormal. Contact Your Nearest Authorized Dealer.	Refer to Engine Troubleshooting Manual.
 M178-01-037	Engine Oil Pressure Alarm	Engine Oil Pressure Is Low. Immediately Stop Engine. Check Engine Oil System And Oil Level.	Refer to Troubleshooting A.
 MDAA-01-028	Engine Start Disabled	Engine Cannot Start If Pilot Shut-Off Lever Is UNLOCK Position.	Set the pilot shut-off lever to the LOCK position.
 MDAA-01-028	Engine Start Disabled	Engine Cannot Start If Engine Shut-Off Switch Is ON Position.	Set the engine stop switch to the OFF position.
 M183-01-071	Alternator Alarm	Electrical System Is Abnormal. Check Alternator And Battery Systems.	Refer to Troubleshooting A.
 M178-01-034	Fuel Level Alarm	Fuel Level Is Low.	Refer to Troubleshooting A.

Logo	Alarm	Trouble Screen	Remedy
 M1CC-01-039	Hydraulic Oil Filter Restriction Alarm	Hydraulic Oil Filter Is Clogged. Replace Hydraulic Oil Filter Element.	Refer to Troubleshooting A.
 M1CC-01-039	Line Filter Restriction Alarm	Line Filter (Breaker Circuit Return Oil Filter) Is Clogged. Replace Line Filter Element.	Refer to Troubleshooting A.
 M183-01-067	Air Cleaner Restriction Alarm	Air Cleaner Is Clogged. Clean Or Replace Air Cleaner Element.	Refer to Troubleshooting A.
 MDAA-01-034	System Failure Alarm	Machine Network System Is Abnormal. Contact Your Nearest Authorized Dealer.	Refer to Troubleshooting A.
 MDAA-01-036	Pilot Control Shut-Off Lever Alarm	Pilot Control Shut-Off Lever System Is Abnormal. Contact Your Nearest Authorized Dealer.	Refer to Troubleshooting A.

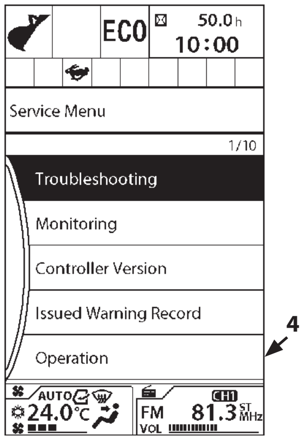
Operation

1. Turn select / set switch (3) and select Operation (4) on Service Menu. When pushing select / set switch (3), the Operation screen appears. (Figure A)
2. The hour meters are displayed.
3. When pushing back switch (1), the previous screen appears.
4. When pushing return to basic screen switch (2), the basic screen appears.

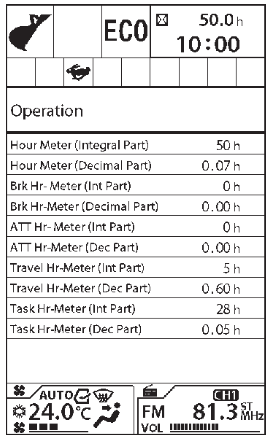


TDAA-05-02-030

A



TDAA-05-02-010EN



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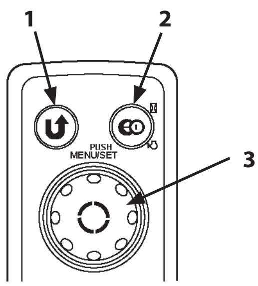
Communication Terminal Status

1. Turn select / set switch (3) and select Communication Terminal Status (4) on Service Menu. When pushing select / set switch (3), the Communication Terminal Status screen appears. (Figure A)
2. Each data of the communication terminals is displayed. (Refer To List of Communication Terminal Status.)
3. When pushing back switch (1), the previous screen appears.
4. When pushing return to basic screen switch (2), the basic screen appears.



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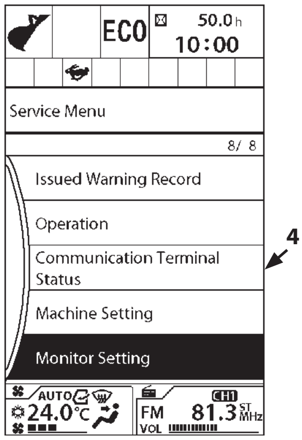

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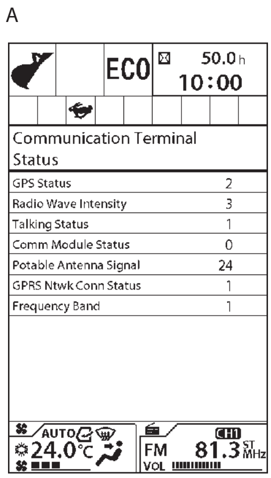


TDAA-05-02-034EN

List of Communication Terminal Status

Item	Unit	Data	
		Portable Terminal	Satellite Terminal (Optional)
GPS Status	0 to 2	0: Uncoupled Connection 1: Incomplete Positioning 2: Positioning State	0: Uncoupled Connection/ Incomplete Positioning 1: Positioning State
Radio Wave Intensity	0 to 3, 250, 254	0: Reception Level: 0 1: Reception Level: 1 2: Reception Level: 2 3: Reception Level: 3 250: Out of range 254: Not detected	0: Communication not available 1: Communication available
Talking Status	0, 1	0: Uncoupled Connection 1: Connection	-
Comm Module Status	0, 1	0: Correct 1: Incorrect	-
Potable Antenna Signal	0 to 31, 99	0 to 1: Out of range 2 to 8: Reception Level: 0 9 to 12: Reception Level: 1 13 to 17: Reception Level: 2 18 to 31: Reception Level: 3 99: Not detected	-
GPRS Ntwk Conn Status	0, 1	0: Failure 1: Success	-
Frequency Band	0 to 3	0 to 3	-

NOTE: The detail data of radio wave intensity are displayed for Antenna Signal.

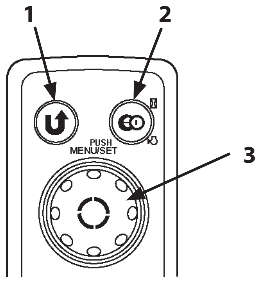
Machine Setting

NOTE: Machine Setting is not displayed in initialization.

- Constant Change
  1. Turn select / set switch (3) and select Machine Setting (4) on Service Menu. When pushing select / set switch (3), the Machine Setting screen appears. (Figure A)
  2. Turn select / set switch (3) and select the item to be adjusted. When pushing select / set switch (3), the adjustment screen for selected item appears. (Figure B) (Refer to List of Setting Item.)

NOTE: Li Speed (5) is selected as an example here.

  3. When pushing select / set switch (3), the color of selected adjustment item data is changed. Turn select / set switch (3), change the data, and push select / set switch (3). (Figure C)
  4. Turn select / set switch (3) and select a check mark. When pushing select / set switch (3), the setting has been completed.
  5. When pushing back switch (1), the previous screen appears.
  6. When pushing return to basic screen switch (2), the basic screen appears.



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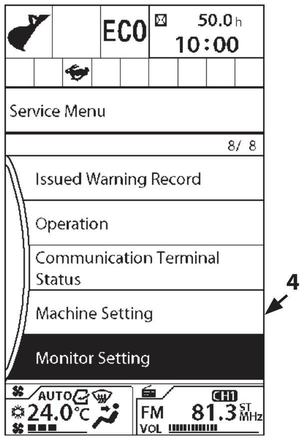

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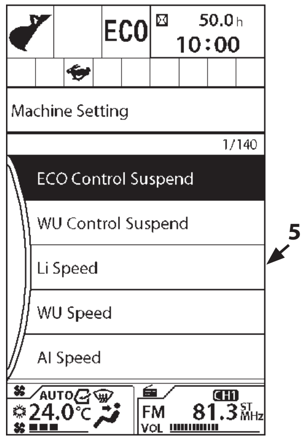

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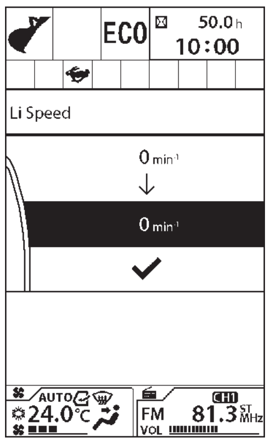

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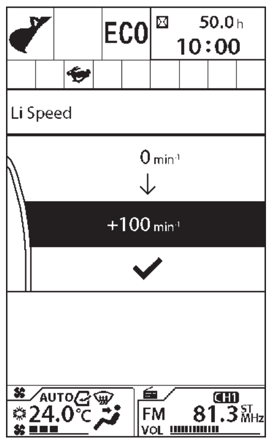


TDAA-05-02-072EN

List of Machine Setting Item (Constant Change)

Item	Unit	Data
ECO Control Suspend	0, 1	Setting of ECO control (casual deactivation) 0: Enable 1: Casual Deactivation
WU Control Suspend	0, 1	Setting of auto warming-up control (casual deactivation) 0: Hydraulic oil / coolant temperature auto warming-up control enable 1: Hydraulic oil / coolant temperature auto warming-up control casual deactivation
Li Speed	min^{-1}	Adjustment of slow idle engine speed
WU Speed	min^{-1}	Adjustment of auto warming-up engine speed
AI Speed	min^{-1}	Adjustment of auto-idle engine speed
PWR Mode Speed	min^{-1}	Adjustment of PWR mode fast idle engine speed
ECO Mode Selection	0, 1	ON/OFF of ECO control 0: OFF 1: ON
Power Mode Memory Selection	0, 1	Setting of power mode with the key switch ON 0: OFF (Power mode is ECO mode when turning the key switch ON.) 1: ON (The power mode when turning the key switch OFF is kept.)
Heater Control Selection	0, 1	ON/OFF of heater control 0: OFF 1: ON
Work Mode Memory Selection	0, 1	Setting of attachment mode with the key switch ON 0: OFF (Attachment mode is bucket (digging) mode when turning the key switch ON.) 1: ON (The attachment mode when turning the key switch OFF is kept.)
Power Mode Selection	0 to 4	Setting of power mode selection 0: ECO, PWR mode: Selected 1: ECO mode: Fixed 2: PWR mode: Fixed 3: ECO, PWR, HP mode: Selected 4: HP mode: Fixed

Item	Unit	Data
Air Conditioner Control Mode	0 to10	Selection of air conditioner specification 0: Unused (without an air conditioner) 1: STD cab (middle) (with an air conditioner) 2: STD cab (middle) (without an air conditioner) 3: STD cab (large) (with an air conditioner) 4: STD cab (large) (without an air conditioner) 5: US cab (75US class) (with an air conditioner) 6: US cab (75US class) (without an air conditioner) 7: US cab (135US class) (with an air conditioner) 8: US cab (135US class) (without an air conditioner) 9: US cab (225US class) (with an air conditioner) 10: US cab (225US class) (without an air conditioner)
ATT Speed Deceleration Waiting Time	ms	The time when the increased engine speed is held at attachment operation speed increase control

- List of Adjustment (Constant Change)

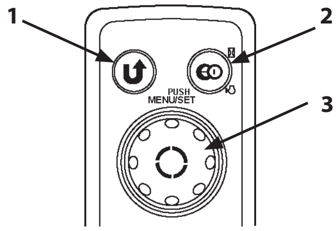
Item	Unit	Minimum Adjustment	Adjustable Range	Initial Value
ECO Control Suspend	0, 1	-	0, 1	0
WU Control Suspend	0, 1	-	0, 1	0
Li Speed	min^{-1}	10	0 to 400	0
WU Speed	min^{-1}	10	-600 to 200	0
AI Speed	min^{-1}	10	-400 to 400	0
PWR Mode Speed	min^{-1}	10	-200 to 100	0
ECO Control Selection	0, 1	-	0, 1	1
Power Mode Memory Selection	0, 1	-	0, 1	0
Heater Control Selection	0, 1	-	0, 1	1
Work Mode Memory Selection	0, 1	-	0, 1	1
Power Mode Selection	0 to 4	-	0 to 4	0
Air Conditioner Control Mode	0 to 10	-	0 to 10	1
ATT Speed Deceleration Waiting Time	ms	40	0 to 3000	1000

- Attachment Constant Change

1. Turn select / set switch (3) and select Machine Setting (4) on Service Menu. When pushing select / set switch (3), the Machine Setting screen appears. (Figure A)
2. Turn select / set switch (3) and select the item to be adjusted. When pushing select / set switch (3), the adjustment screen for selected item appears. (Figure B) (Refer to List of Setting Item.)

NOTE: ATT1 Type (5) is changed as an example here. (Initial setting: Breaker 1)

3. When pushing select / set switch (3), the color of selected adjustment item data is changed. Turn select / set switch (3), change the data, and push select / set switch (3). (Figure C)
4. Turn select / set switch (3) and select a check mark. When pushing select / set switch (3), the setting has been completed.
5. When pushing back switch (1), the previous screen appears.
6. When pushing return to basic screen switch (2), the basic screen appears.



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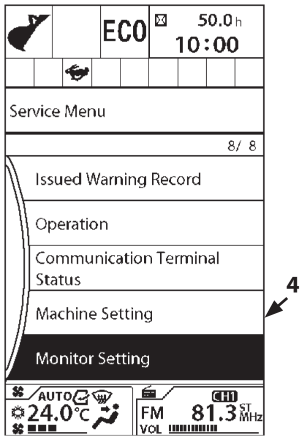

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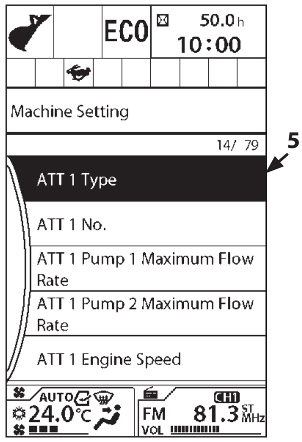

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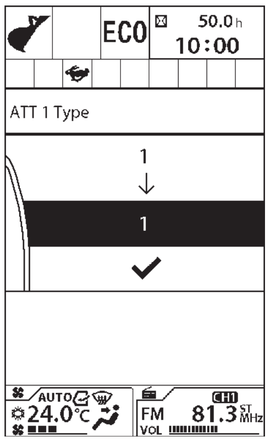

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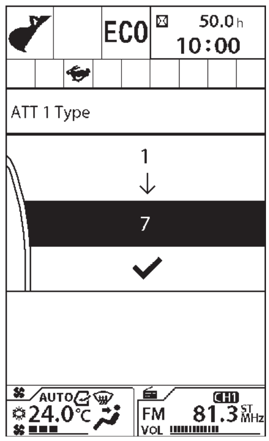

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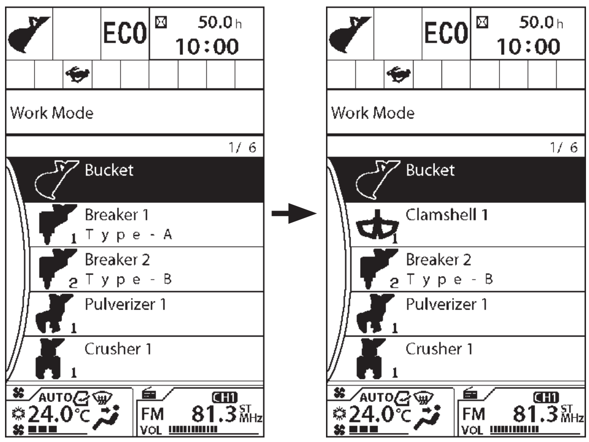


TDAA-05-02-026EN TDAA-05-02-076EN

List of Setting Item (Attachment Constant Change)

Item	Unit	Data
ATT1 Type	0 to 7	Kinds of attachment 0: Unset 1: Breaker 2: Pulverizer 3: Crusher 4: Vibrating Hammer 5: Others 6: Grapple 7: Clamshell
ATT1 No.	1 to 5	Selection of attachment setting No. 1: 1 2: 2 3: 3 4: 4 5: 5
ATT1 Pump 1 Maximum Flow Rate	L/min	Adjustment of maximum pump 1 flow rate when using attachment
ATT1 Pump 2 Maximum Flow Rate	L/min	Adjustment of maximum pump 2 flow rate when using attachment
ATT1 Engine Speed	min^{-1}	Adjustment of engine speed when using attachment
ATT1 Auxiliary Flow Combiner Valve*	0, 1	Setting of auxiliary flow combiner valve selection 0: OFF 1: ON

*NOTE: *: Optional*

- List of Adjustment (Attachment Constant Change)

ATT1

Item	Unit	Minimum Adjustment	Adjustable Range	Initial Value
ATT1 Type	0 to 7	-	0 to 7	1
ATT1 No.	1 to 5	-	1 to 5	1
ATT1 Pump 1 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT1 Pump 2 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT1 Engine Speed	min^{-1}	10	-500 to 100	0
ATT1 Auxiliary Flow Combiner Valve*	0, 1	-	0, 1	0

ATT2

Item	Unit	Minimum Adjustment	Adjustable Range	Initial Value
ATT2 Type	0 to 7	-	0 to 7	2
ATT2 No.	1 to 5	-	1 to 5	1
ATT2 Pump 1 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT2 Pump 2 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT2 Engine Speed	min^{-1}	10	-500 to 100	0
ATT2 Auxiliary Flow Combiner Valve*	0, 1	-	0, 1	1

*NOTE: *: Optional*

ATT3

Item	Unit	Minimum Adjustment	Adjustable Range	Initial Value
ATT3 Type	0 to 7	-	0 to 7	3
ATT3 No.	1 to 5	-	1 to 5	1
ATT3 Pump 1 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT3 Pump 2 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT3 Engine Speed	min^{-1}	10	-500 to 100	0
ATT3 Auxiliary Flow Combiner Valve*	0, 1	-	0, 1	1

ATT4

Item	Unit	Minimum Adjustment	Adjustable Range	Initial Value
ATT4 Type	0 to 7	-	0 to 7	6
ATT4 No.	1 to 5	-	1 to 5	1
ATT4 Pump 1 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT4 Pump 2 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT4 Engine Speed	min^{-1}	10	-500 to 100	0
ATT4 Auxiliary Flow Combiner Valve*	0, 1	-	0, 1	0

ATT5 to 11

Item	Unit	Minimum Adjustment	Adjustable Range	Initial Value
ATT5 to 11 Type	0 to 7	-	0 to 7	0
ATT5 to 11 No.	1 to 5	-	1 to 5	0
ATT5 to 11 Pump 1 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT5 to 11 Pump 2 Maximum Flow Rate	L/min	0.5	106 to 212	212
ATT5 to 11 Engine Speed	min^{-1}	10	-500 to 100	0
ATT5 to 11 Auxiliary Flow Combiner Valve*	0, 1	-	0, 1	0

*NOTE: *: Optional*

Monitor Setting

NOTE: Monitor Setting is not displayed in initialization.

- Operation Permission
  1. Turn select / set switch (3) and select Monitor Setting (4) on Service Menu. When pushing select / set switch (3), the Monitor Setting screen appears. (Figure A)
  2. Turn select / set switch (3) and select the item to change the setting. When pushing select / set switch (3), the setting screen for selected item appears. (Figure B) (Refer to List of Monitor Setting Item.)

NOTE: Engine Oil is selected as an example here.

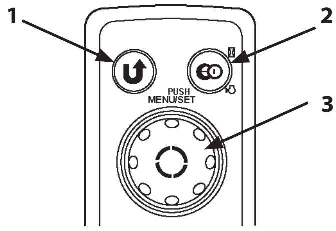
3. When pushing select / set switch (3), the color of selected item data is changed. Turn select / set switch (3), change the data, and push select / set switch (3). (Figure C)

NOTE: Setting Value:

1: Operation / Change: Possible

0: Operation / Change: Impossible

4. When Operation Permission is set to "0", it becomes impossible to operate RESET of Remains and Maintenance Interval of the maintenance items.
5. Turn select / set switch (3) and select a check mark. When pushing select / set switch (3), the setting has been completed.
6. When pushing back switch (1), the previous screen appears.
7. When pushing return to basic screen switch (2), the basic screen appears.



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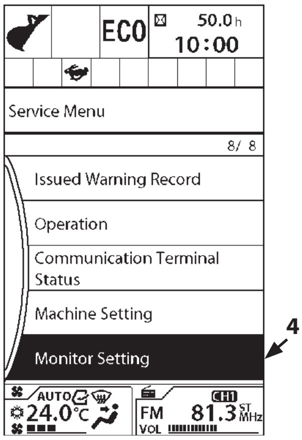

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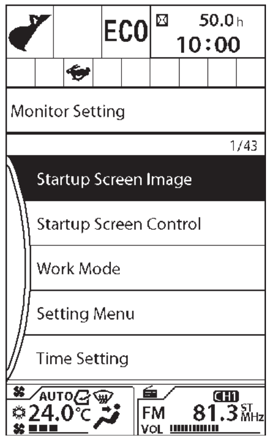

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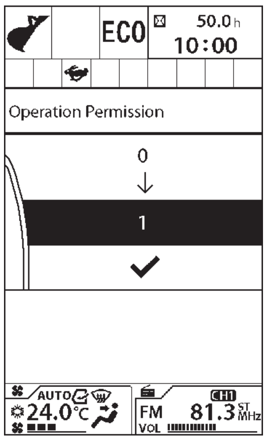
B



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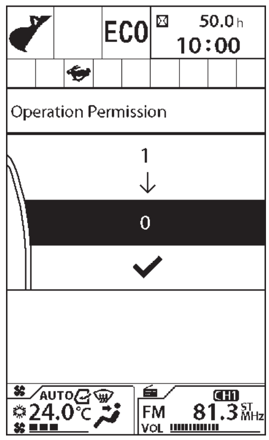

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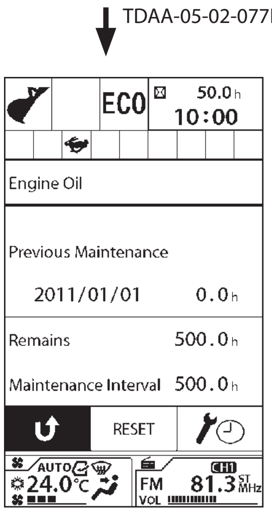

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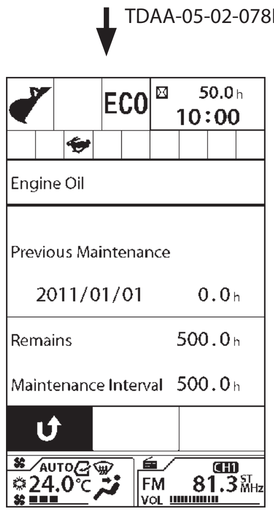


TDAA-05-02-051EN

- Maintenance Items
  1. Turn select / set switch (3) and select Monitor Setting (4) on Service Menu. When pushing select / set switch (3), the Monitor Setting screen appears. (Figure A)
  2. Turn select / set switch (3) and select the item to change the setting. When pushing select / set switch (3), the setting screen for selected item appears. (Figure B) (Refer to List of Monitor Setting Item.)

NOTE: Engine Oil is selected as an example here.

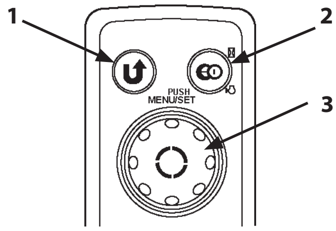
  3. When pushing select / set switch (3), the color of selected item data is changed. Turn select / set switch (3), change the data, and push select / set switch (3). (Figure C)

NOTE: Setting Value:

1: Operation / Change: Possible

0: Operation / Change: Impossible

  4. When Engine Oil is set to "0", the item of Engine Oil is deleted from setting menu.
  5. Turn select / set switch (3) and select a check mark. When pushing select / set switch (3), the setting has been completed.
  6. When pushing back switch (1), the previous screen appears.
  7. When pushing return to basic screen switch (2), the basic screen appears.



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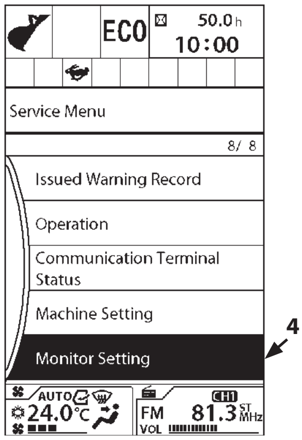

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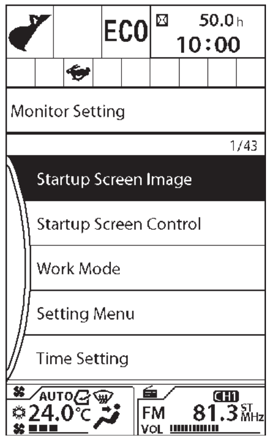

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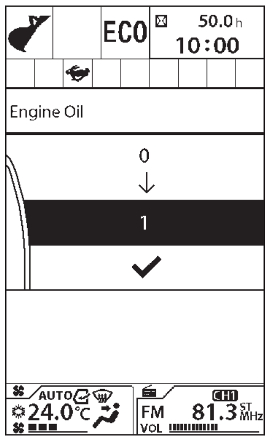

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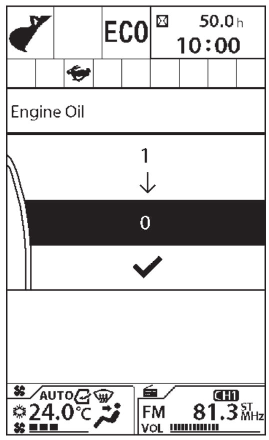

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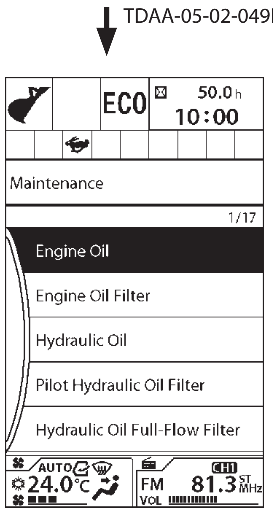

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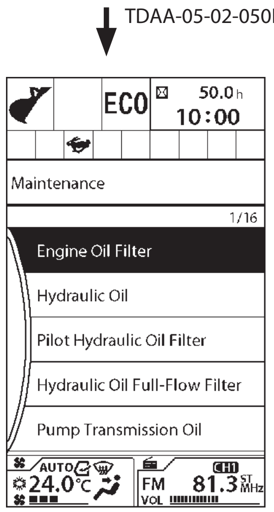


TDAA-05-02-080EN

List of Monitor Setting Item

Item	Unit	Details	Initial Value
Startup Screen Image	0: System Starting 1: HITACHI 2: John Deere 3: System Starting (Fixed) 4: REC	-	1
Startup Screen Control	0: Auto-Control: OFF 1: Auto-Control: ON	-	1
Work Mode	0: Void 1: Exist	with or without function	1
Crane Switch Memory	0: Non-storable 1: Store	-	1
Mail	0: Void 1: Exist	with or without function	0
Setting Menu	0: Void 1: Exist	with or without function	1
Time Setting	0: Void 1: Exist	with or without function	1
Attachment Adjust	0: Void 1: Exist	with or without function	1
Attachment Name Input	0: Void 1: Exist	with or without function	1
Breaker Alarm	0: Void 1: Exist	with or without function	1
Sub Meter Selection	0: Void 1: Exist	with or without function	1
Rear View Camera Monitor	0: Void 1: Exist	with or without function	0
Display Item Selection	0: Void 1: Exist	with or without function	1

Item	Unit	Details	Initial Value
Brightness Adjustment	0: Void 1: Exist	with or without function	1
Language	0: Void 1: Exist	with or without function	1
Unit Selection	0: Void 1: Exist	with or without function	1
Main Menu Sequence Change	0: Void 1: Exist	with or without function	1
Information Menu	0: Void 1: Exist	with or without function	1
Operation	0: Void 1: Exist	with or without function	1
Maintenance	0: Void 1: Exist	with or without function	1
Operation Permission	0: Inhibited 1: Permission	-	1
Engine Oil Filter	0: Un-displayed 1: Display	Display	1
Hydraulic Oil	0: Un-displayed 1: Display	Display	1
Pilot Hydraulic Oil Filter	0: Un-displayed 1: Display	Display	1
Hydraulic Oil Full-Flow Filter	0: Un-displayed 1: Display	Display	1
Pump Transmission Oil	0: Un-displayed 1: Display	Display	1
Travel Reduction Gear Oil	0: Un-displayed 1: Display	Display	1
Swing Reduction Gear Oil	0: Un-displayed 1: Display	Display	1
Swing Motor Drain Filter	0: Un-displayed 1: Display	Display	0

Item	Unit	Details	Initial Value
Swing Bearing Grease	0: Un-displayed 1: Display	Display	1
Air Cleaner Element	0: Un-displayed 1: Display	Display	1
Fuel Filter	0: Un-displayed 1: Display	Display	1
Air Conditioner Filter	0: Un-displayed 1: Display	Display	1
Line Filter	0: Un-displayed 1: Display	Display	1
User Setting 1	0: Un-displayed 1: Display	Display	1
User Setting 2	0: Un-displayed 1: Display	Display	1
Troubleshooting (Information Menu)	0: Void 1: Exist	with or without function	1
Monitoring (Information Menu)	0: Void 1: Exist	with or without function	1

Setting Menu

When logging on the service menu, The following items are added to the setting menu.

Setting Menu Item	During Normal Operation	When logging on service menu	Data
Breaker Alarm	Un-displayed	Display	Setting of breaker alarm ON/ OFF and the time until the alarm is operated
Attachment Adjust	Pump Flow Rate	←	Adjustment of pump flow rate
	Priority (Arm Roll-Out)	←	Adjustment of the priority on combined operation of attachment and arm roll-out

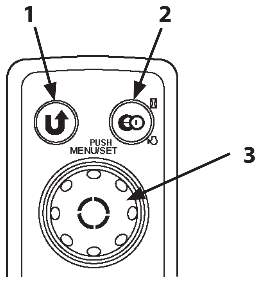
NOTE: Attachment Adjustment is displayed only when the work mode is attachment mode. (Attachment Adjustment is not displayed when the work mode is digging mode.)

Breaker Alarm

1. Turn select / set switch (3) and select Breaker Alarm (4) on the setting menu. When pushing select / set switch (3), the Breaker Alarm screen appears. (Figure A)
2. Push select / set switch (3) and turn Breaker Alarm ON.
3. Turn select / set switch (3) and set the setting time until Breaker Alarm is operated. When pushing select / set switch (3), the setting is completed.

NOTE: When ON is selected on the setting screen of Breaker Alarm and the breaker is operated for the setting time continuously, the buzzer sounds. (Refer to SYSTEM / Control System.)

4. When pushing back switch (1), the previous screen appears.
5. When pushing return to basic screen switch (2), the basic screen appears.



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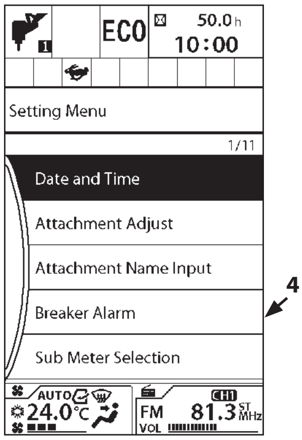

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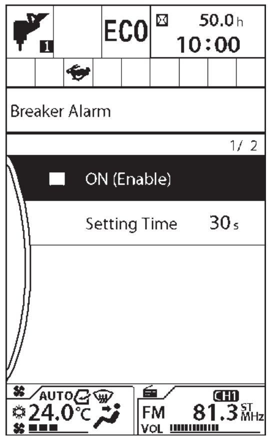
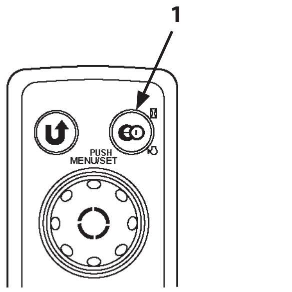


TDAA-05-02-013EN

Inspection of Hour Meter and Fuel Gauge

Inspection of Hour Meter and Fuel Gauge

1. In case pushing return to basic screen switch (1) for a while with the key switch set in the OFF position, hour meter (2) and fuel gauge (3) can be checked.



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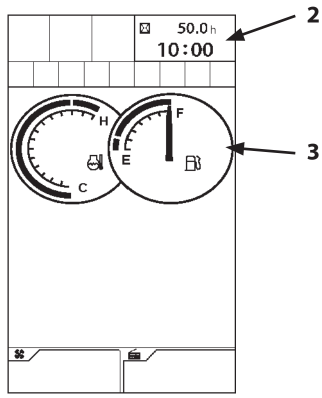

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Outline

Controller saves the input signals from various sensors and switches of the machine as data. Various input signals are recorded as Operation Data and Snapshot Data in monitor controller.

The recorded data is downloaded to the personal computer and is uploaded to the center server via LAN, so that the data can be used as "e-Service". The machine equipped with the communication terminal (optional) sends the data to the center server by using the communication terminal. (As for the communication system, refer to T5-3-7.)

List of Operation Data

List of Daily Report Data

Item		Details
Date		Date of daily report data.
Start: Time		Time when key switch is first turned ON during a day.
Stop: Time		Time when key switch is last turned OFF during a day.
Fuel Level		The value of the final remained fuel during a day. (Value is recorded by fuel sensor data from monitor controller.)
Fuel Usage Amount		The value of fuel used during a day. (Value is calculated and recorded by accumulated fuel usage amount from ECF.)
Machine Hour Meter		Hour meter cumulative hours. (Hours are recorded by hour meter from monitor controller.)
Engine Operating Hours	PWR Mode Hours	Total engine operating hours selecting PWR mode during a day. (Hours are recorded by power mode switch information from MC.)
	ECO Mode Hours	Total engine operating hours selecting ECO mode during a day. (Hours are recorded by power mode switch information from MC.)
Auto-Idle Switch ON Time		Hours when auto-idle switch is turned ON during a day. (Hours are recorded by switch from MC.)
Travel Operating Hours	Fast Idle (Hi) Traveling Hours	Total operating hours of travel mode (Hi) during a day. (Hours are recorded by travel mode switch information from MC.)
	Slow Idle (Lo) Traveling Hours	Total operating hours of travel mode (Lo) during a day. (Hours are recorded by travel mode switch information from MC.)
Swing Operating Hours		Total swing operating hours during a day. (Hours are recorded by swing pressure sensor information from MC.)
Digging Operating Hours		Total operating hours selecting front attachment during a day. (Hours are recorded by front attachment pressure sensor information from MC.)
Attachment Operating Hours	Breaker Operating Hours	Total operating hours selecting breaker during a day. (Hours are recorded by attachment information from MC.)
	Pulverizer Operating Hours	Total operating hours selecting secondary crusher during a day. (Hours are recorded by attachment information from MC.)
	Crusher Operating Hours	Total operating hours selecting hydraulic crusher during a day. (Hours are recorded by attachment information from MC.)
	Vibrating Hammer Operating Hours	Total operating hours selecting vibrating hammer during a day. (Hours are recorded by attachment information from MC.)
	Bucket Operating Hours or Others	Total operating hours selecting bucket during a day. (Hours are recorded by attachment information from MC.)

Item	Details
No Load Time	Total machine's waiting hours during a day. (Hours are recorded by each pressure sensor information from MC.)
Hydraulic Oil Temperature (Highest Temperature)	The highest hydraulic oil temperature during a day. (Value is recorded from MC.)
Engine Operating Hour Distribution Data	Engine operating hour distribution during a day. (Operating hours are recorded only when alternator output signal is continuously delivered for more than 10 minutes.)
Loaded Time Distribution Data	Machine operating hour distribution during a day. (Operating hours are recorded only when operating pressure is continuously detected for more than 5 minutes while the engine runs.)
Latitude	Signal from GPS antenna.
Longitude	Signal from GPS antenna.
Hydraulic Oil Temperature (Lowest Temperature)	The lowest hydraulic oil temperature during a day. (Value is recorded from MC.)

NOTE: The daily operation in this table is equivalent to the hours between 0:00 and 23:59:59 counted by the monitor controller built-in clock. In case the engine is kept operated beyond 0:00, such data are recorded as those for the following day.

List of Frequency Distribution Data

Item	Details
Pump Load	Frequency distribution of average pump delivery pressure of pumps 1 and 2
Average Pump Delivery Pressure in Digging Operation	Frequency distribution of average delivery pressure from pumps during digging operation
Average Pump Delivery Pressure in Travel Operation	Frequency distribution of average delivery pressure from pumps during travel operation
Hydraulic Oil Temperature	Frequency information of hydraulic oil temperature
Pump Load Rate	Frequency information of engine speed and average load rate (average of pump 1 load rate and pump 2 load rate)
Engine Load Rate	Frequency information of engine speed and engine torque

List of Total Operating Hours

Item		Details
Inner Hour Meter		Hour meter's value accumulated inside monitor controller
Machine Hour Meter		Hour meter's value accumulated in machine's monitor
Engine Operating Hour	PWR Mode Hours	Total engine operating hours selecting PWR mode
	ECO Mode Hours	Total engine operating hours selecting ECO mode
Auto-Idle Switch ON Time		Total hours when auto-idle switch is turned ON
Travel Operating Hour	Fast (High) Traveling Hours	Total operating hours of travel mode (High)
	Slow (Low) Traveling Hours	Total operating hours of travel mode (Low)
Swing Operating Hour		Total swing operating hours
Front Attachment Operating Hour		Total front attachment operating hours
Attachment Operating Hour	Breaker Operating Hours	Total operating hours selecting breaker during daily operation
	Secondary Crusher Operating Hours	Total operating hours selecting secondary crusher during daily operation
	Hydraulic Crusher Operating Hours	Total operating hours selecting hydraulic crusher during daily operation
	Vibrating Hammer Operating Hours	Total operating hours selecting vibrating hammer during daily operation
	Bucket Operating Hours or Others	Total operating hours selecting bucket during daily operation
No Load Time		Total machine's waiting hours
MC Communication Error Time		Total hours of MC communication error
ECF Communication Time Out Time		Total hours of ECF communication time out
Pressure Increasing Time		Total hours increasing pressure
Use Frequency of Power Digging Switch		Total frequency operating power digging switch
Frequency of Engine Start		Total frequency starting engine

Snapshot Data

Item		Details
Serial No.	-	Machine serial no.
Snapshot	Model 1	Difference of large-sized crawler, middle-sized crawler, wheeled excavator, and wheel loader
	Model 2	Detail difference on model 1
	DTC Code	Fault code and frequency of occurrence are displayed.
	Priority	-
	Hour Meter	Hour meter at a time when trouble occurred
	Occurrence: Year	Year at a time when trouble occurred
	Occurrence: Date	Date at a time when trouble occurred
	Occurrence: Time	Time at a time when trouble occurred
	SA	-
	SPN Version	001: Version 1 010: Version 2 011: Version 3 100: Version 4 111: Missing version

NOTE: The data on machine body system including MC are downloaded as for Snapshot Data Download (Hitachi). The data on engine system including ECF are downloaded as for Snapshot Data Download (Isuzu).

Communication System

The communication system is used for maintenance of the machine, "e-Service" by transmitting various data of the machine regularly via the communication terminal.

NOTE: Depending on the circumstances of the machine (ex. in the constructions, in the tunnel, affected by the surrounding building and affected of noise), the data transfer rate may become slower, or the communication might not be established. The communication system transmits digital data through the radio wave. If there is excessively noise or use of electrical equipment which causes noise near the machine, they cause reduces data transfer rate or communication might not be established at worst.

The communication system consists of communication terminal, GPS antenna and communication antenna.
The functions of each equipment are:

- Communication Terminal:
  Receives the data from monitor controller and GPS antenna, and sends the data to the communication antenna.
- GPS Antenna:
  Receives location information of the machine.
- Communication Antenna:
  Communicates the data.

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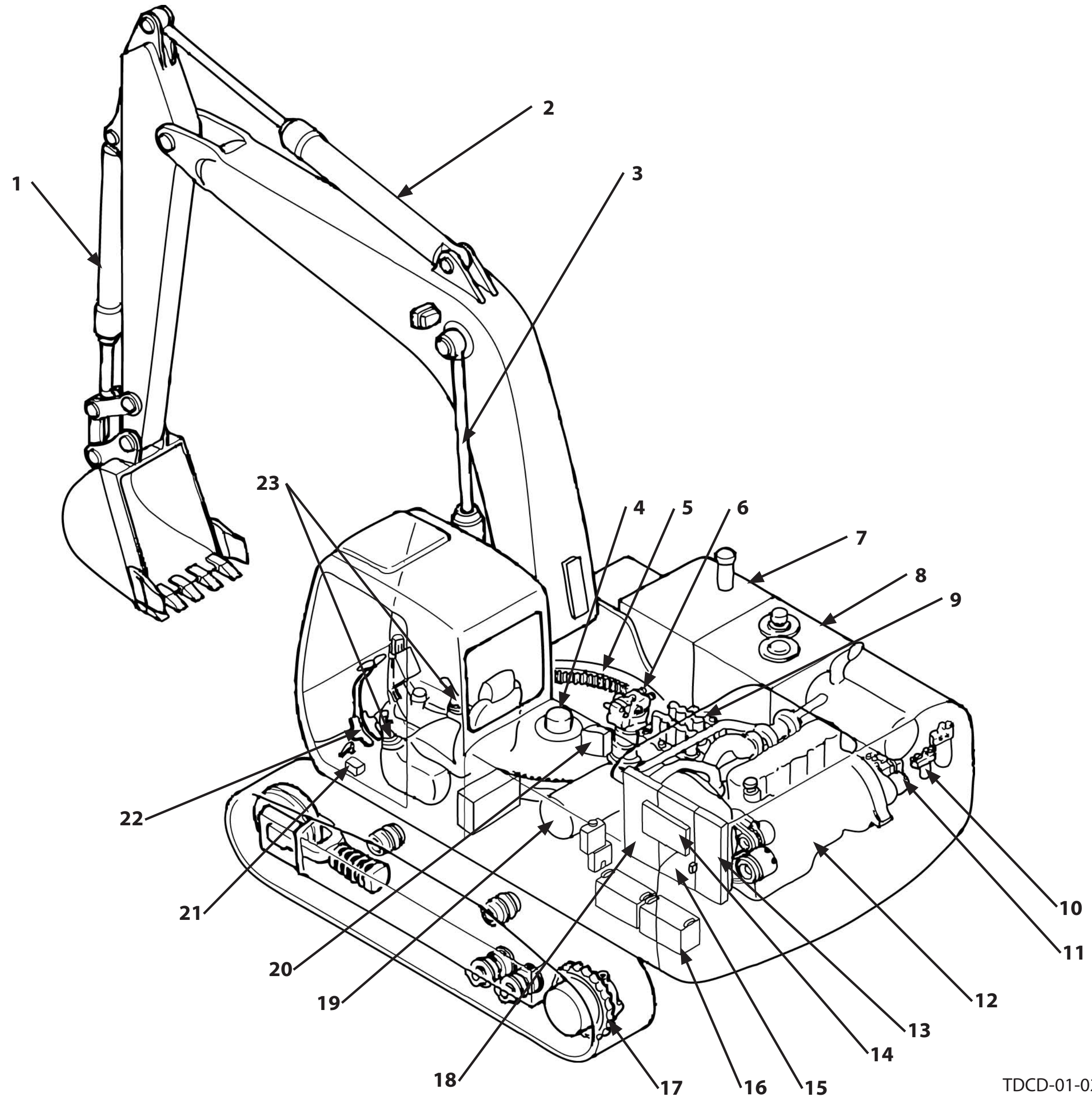
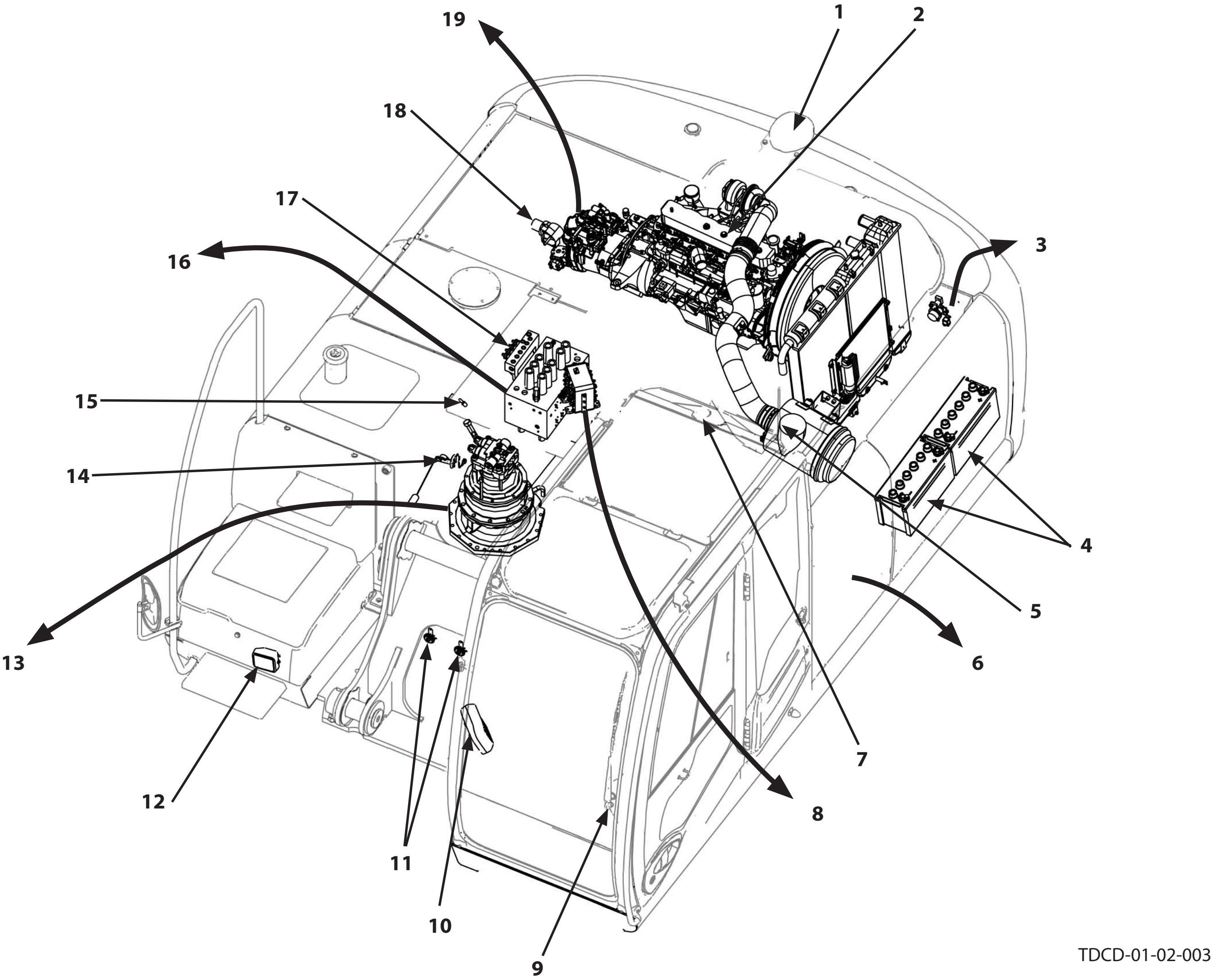
Main Component



TDCD-01-02-001

1- Bucket Cylinder
2- Boom Cylinder
3- Arm Cylinder
4- Center Joint
5- Swing Bearing
6- Swing Device
7- Fuel Tank
8- Hydraulic Oil Tank
9- Control Valve
10- Pilot Filter/ Pilot Relief Valve
11- Pump Device
12- Engine
13- Intercooler
14- Air Conditioner Condenser
15- Radiator
16- Battery
17- Travel Device
18- Oil Cooler
19- Air Cleaner
20- Signal Control Valve
21- Pilot Shut-Off Solenoid Valve
22- Travel Pilot Valve
23- Front Attachment / Swing Pilot Valve

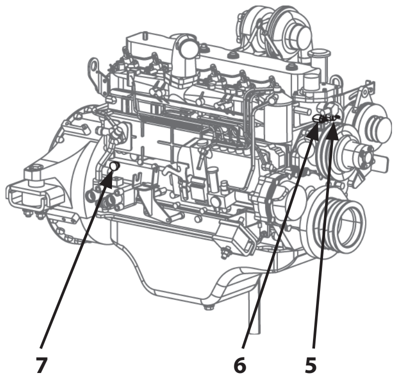
Electrical System (Overview)



1- Rear View Camera
2- Components Related with Engine (Refer to T5-4-3.)
3- Electrical System (Relays) (Refer to T5-4-7.)
4- Battery
5- *Communication Aerial (for Satellite Communication)
6- Electrical System (Around Air Cleaner) (Refer to T5-4-6.)
7- GPS Aerial
8- Components Related with Signal Control Valve (Refer to T5-4-9.)
9- Wiper Motor
10- Monitor
11- Horn
12- Work Light
13- Components Related with Swing Device (Refer to T5-4-11.)
14- Fuel Sensor
15- Hydraulic Oil Temperature Sensor
16- Components Related with Control Valve (Refer to T5-4-9.)
17- 3-Spool Solenoid Valve Unit
18- EC Motor/EC Sensor
19- Components Related with Pump Device (Refer to T5-4-8.)

*NOTE: *: This component is different by an area.*

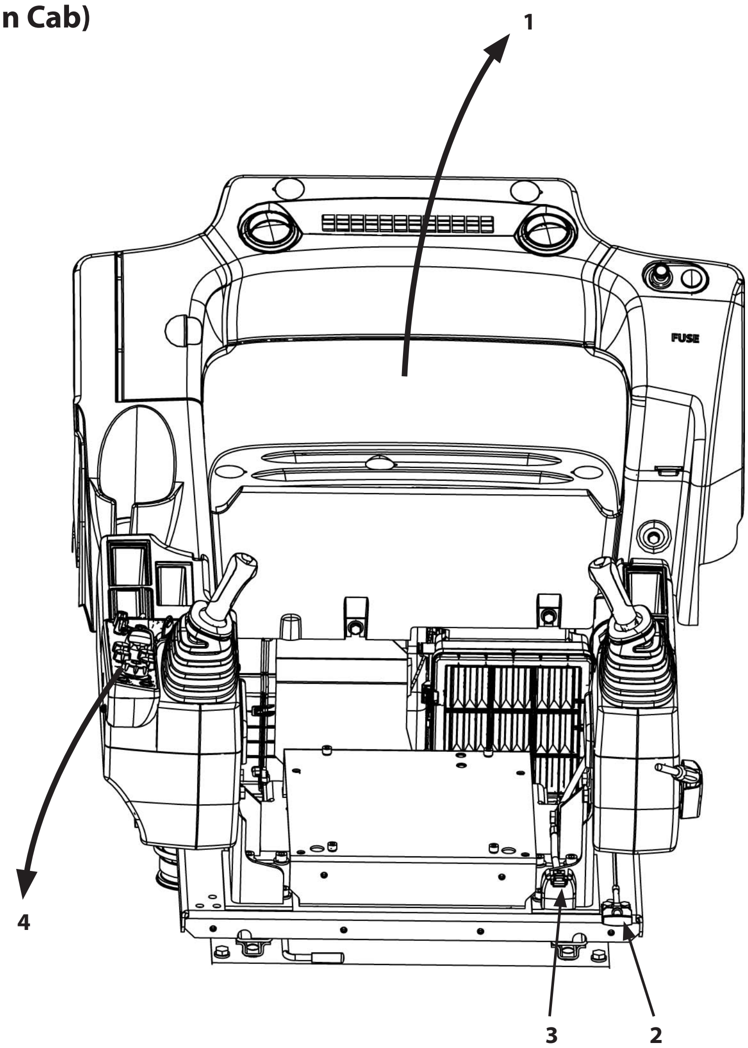
Engine



TDCD-01-02-008

5- Overheat Switch
6- Coolant Temperature Sensor
7- Engine Oil Pressure Switch

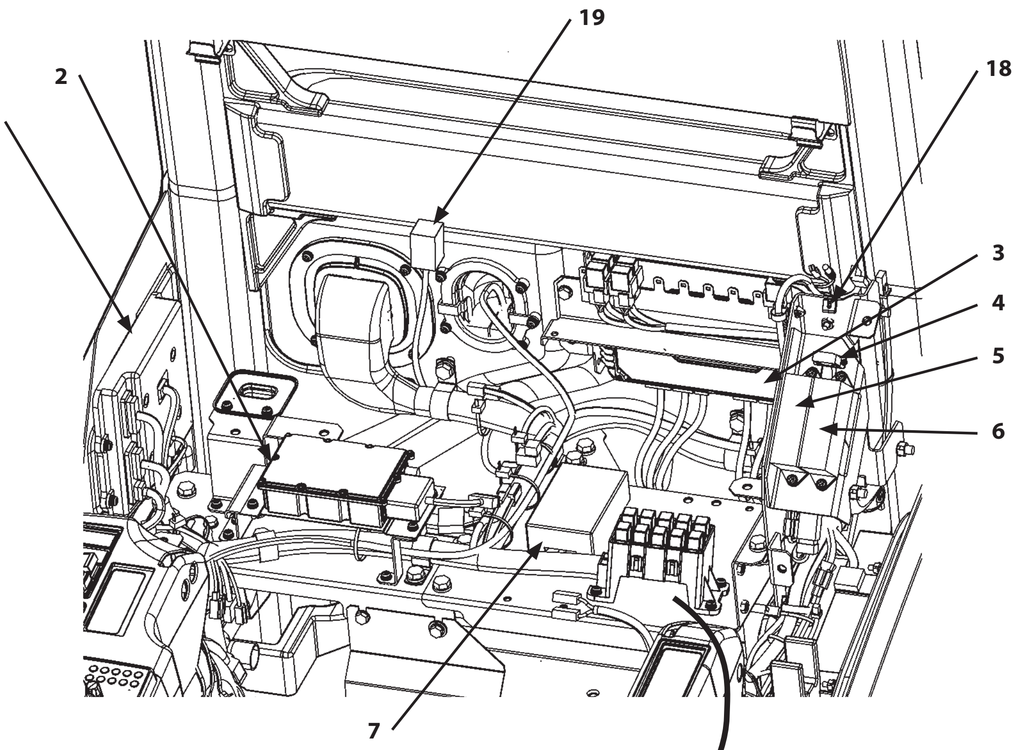
Electrical System (In Cab)



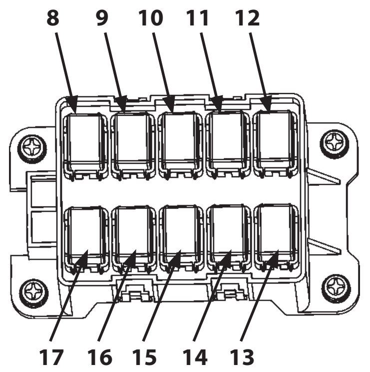
TDCD-01-02-004

1- Components Related with Rear Tray (Refer to T5-4-4.)
2- Engine Stop Knob
3- Engine Stop Switch
4- Components Related with Switch Panel (Refer to T5-4-5.)

Electrical System (Rear Tray)



TDCD-05-04-001

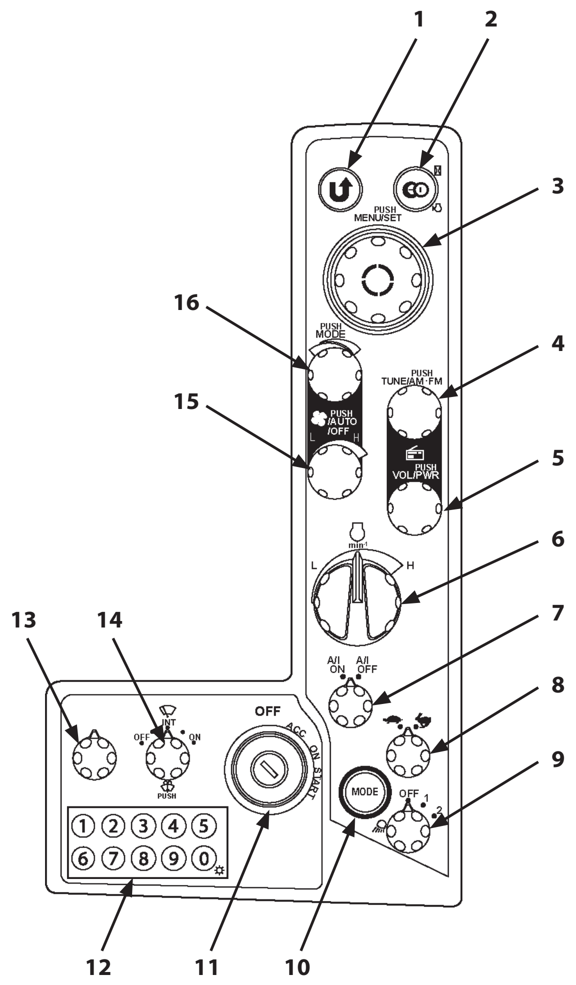


TDCD-01-02-009

1- Monitor Controller
2- *GSM (Mobile Communication Controller)
3- MC (Main Controller)
4- MPDr. Connector (Download Connector Using Combinedly)
5- Fuse Box
6- Fuse Box (for Attachment)
7- Wiper/Light Controller
8- Wiper Relay (R6)
9- Work Light Relay 1 (R7)
10- Work Light Relay 2 (R8)
11- Washer Relay (R9)
12- Horn Relay (R10)
13- Security Relay (R5)
14- Starter Cut Relay (R4)
15- Security Horn Relay (R3)
16- Pilot Shut-Off Relay (R2)
17- Load Damp Relay (R1)
18- Engine Learning Switch
19- QOS Controller

*NOTE: *: This component is different by an area.*

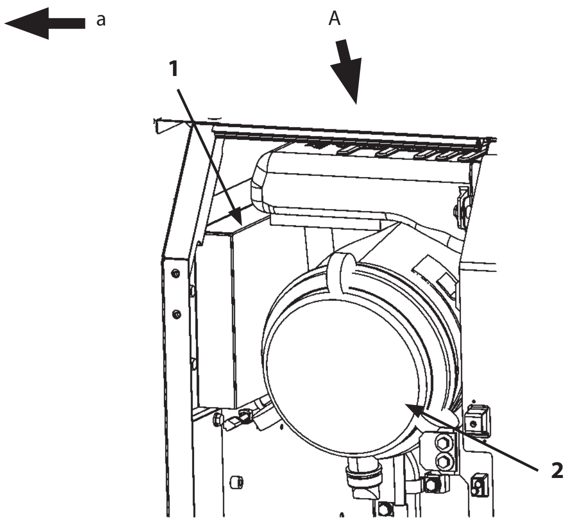
Electrical System (Switch Panel)



TDAA-05-02-059

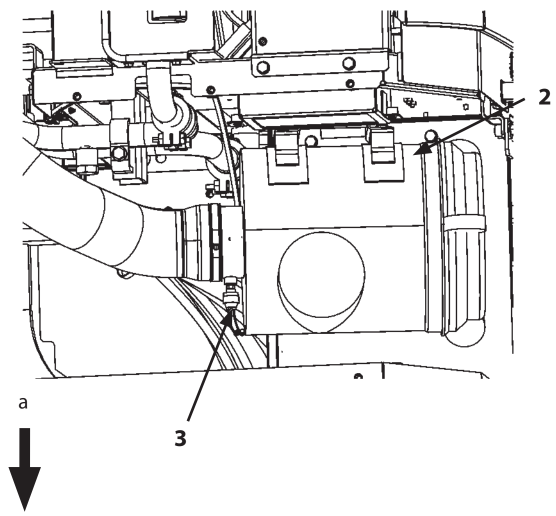
1- Return to Previous Screen Switch
2- Return to Basic Screen Switch
3- Selector/Set Switch
4- AM·FM Switch/Tuning Switch
5- Power Switch/Volume Control Switch
6- Engine Control Dial
7- Auto-Idle Switch
8- Travel Mode Switch
9- Work Light Switch
10- Power Mode Switch
11- Key Switch
12- TEN-key Switch
13- Overhead Window Wiper/ Overhead Window Washer Switch (Optional)
14- Wiper/Washer Switch
15- AUTO/OFF Switch/Blower Switch
16- Temperature Control Switch/ MODE Switch

Electrical System (Around Air Cleaner)



TDCD-01-02-006

View A



TDCD-01-02-007

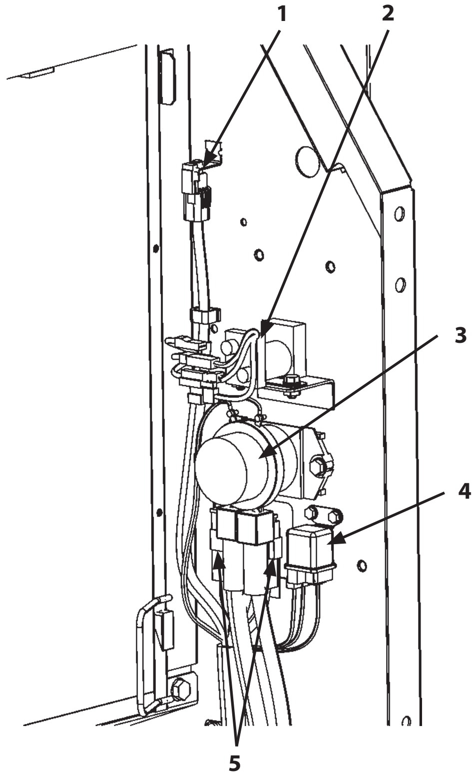
a- Machine Front

1- ECF (Engine Controller)

2- Air Cleaner

3- Air Cleaner Restriction Switch

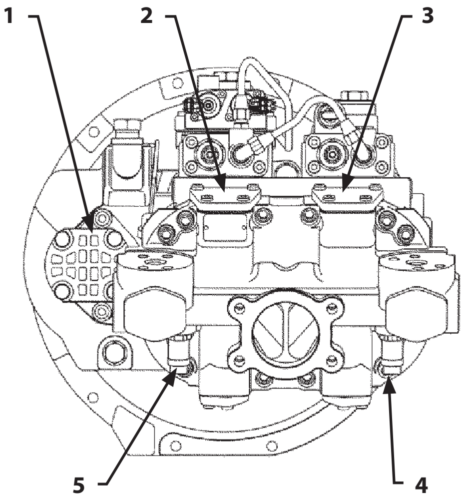
Electrical System (Relays)



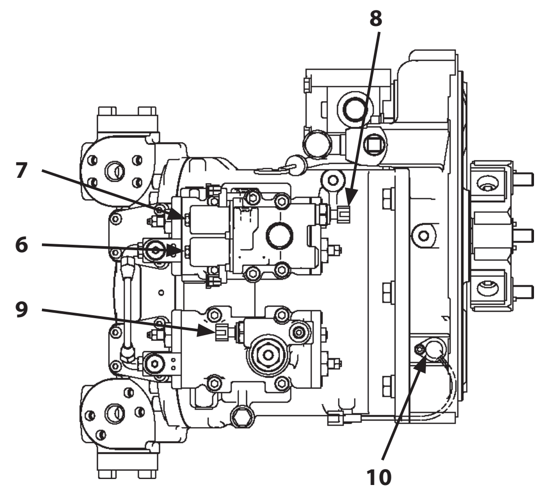
TDCD-01-02-002

1- Ambient Temperature Sensor
2- Starter Relay 2
3- Battery Relay
4- Glow Plug Relay
5- Fusible Link (Red: 45A, Black: 65A)

Pump Device



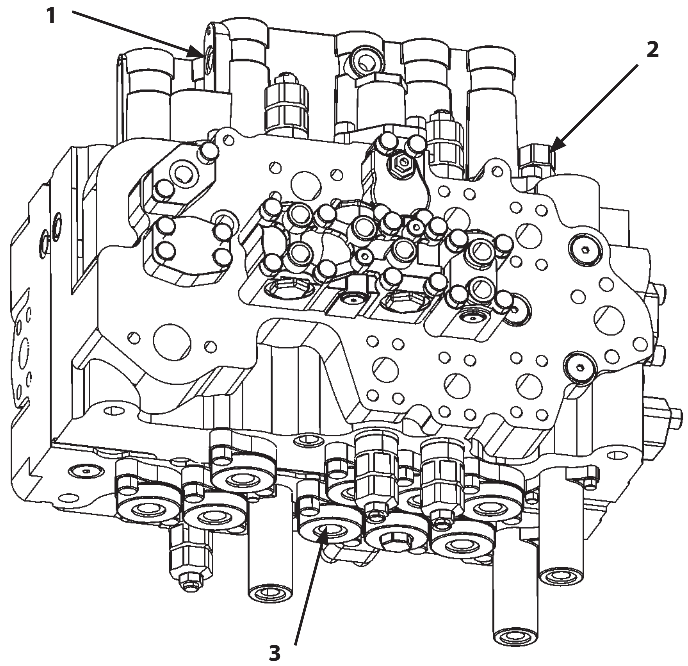
T1V1-01-02-032



TDCD-03-01-004

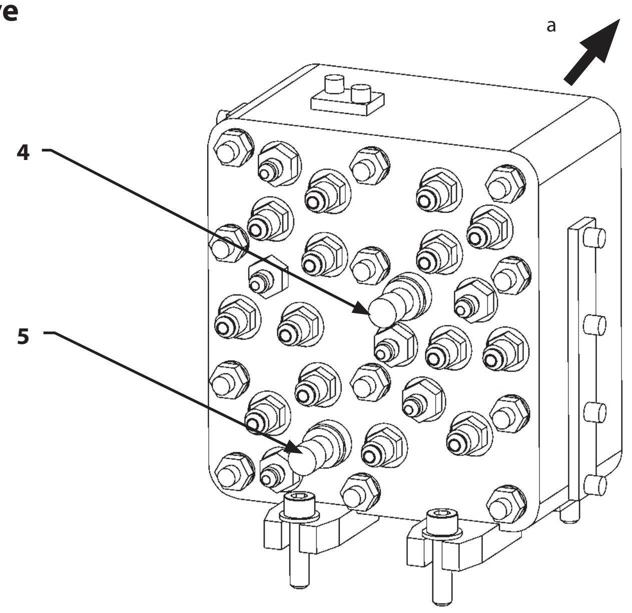
1- Pilot Pump
2- Pump 2
3- Pump 1
4- Pump 1 Delivery Pressure Sensor
5- Pump 2 Delivery Pressure Sensor
6- Torque Control Solenoid Valve
7- Maximum Pump 2 Flow Rate Limit Control Solenoid Valve
8- Pump 2 Control Pressure Sensor
9- Pump 1 Control Pressure Sensor
10- N Sensor

Control Valve



T1V1-03-03-073

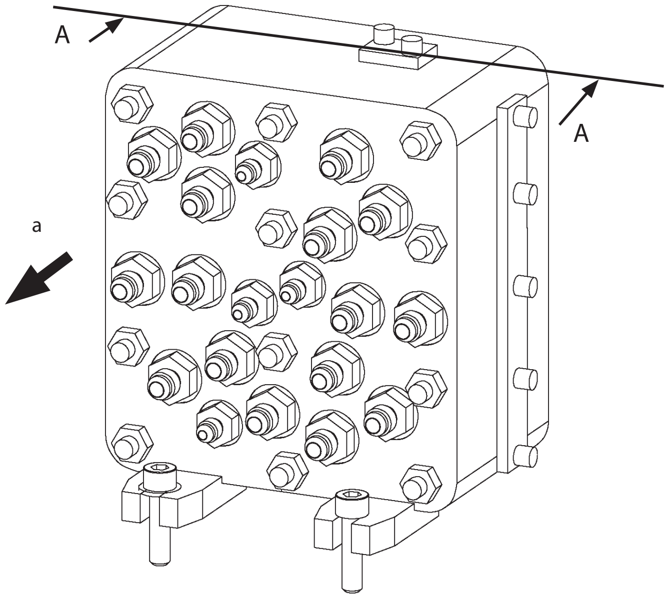
Signal Control Valve



T1V1-01-02-014

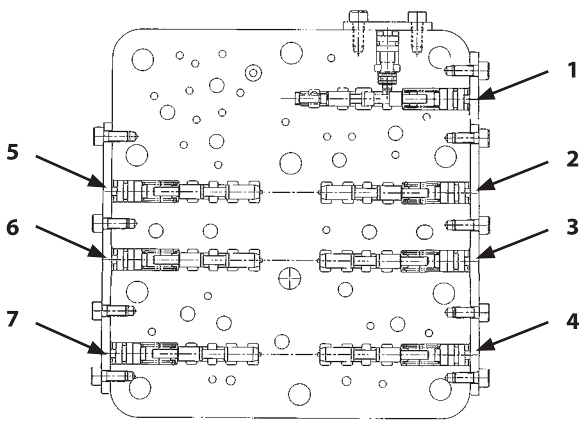
a- Pilot Valve Side

1- Pressure Sensor (Arm Roll-In)
2- Main Relief Valve
3- Pressure Sensor (Boom Raise)
4- Pressure Sensor (Swing)
5- Pressure Sensor (Travel)



T178-03-06-016

Cross Section A-A

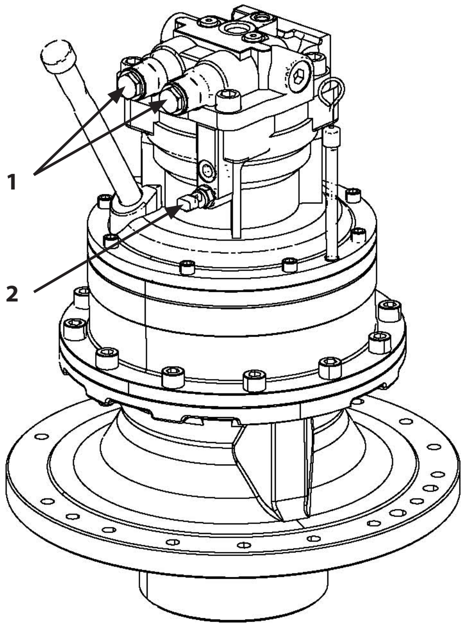


T178-03-06-002

a- Pilot Valve Side

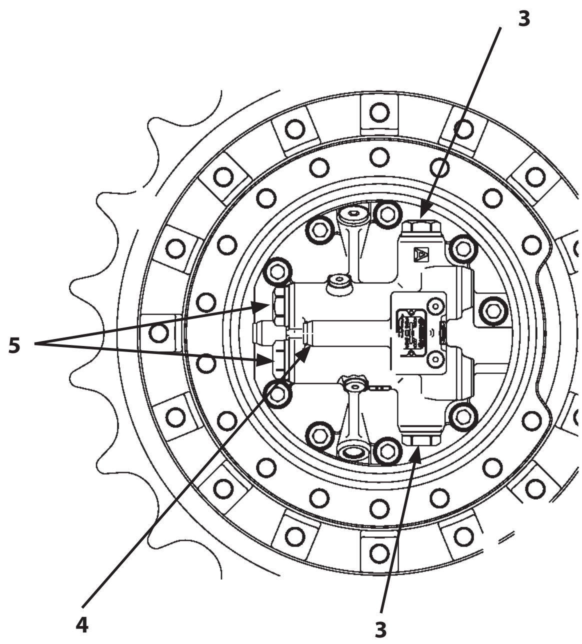
1- Shockless Valve
2- Bucket Flow Rate Control Valve Control Spool
3- Pump 2 Flow Rate Control Valve
4- Flow Combiner Valve Control Spool
5- Arm 1 Flow Rate Control Valve Control Spool
6- Pump 1 Flow Rate Control Valve
7- Swing Parking Brake Release Spool

Swing Device



T1V1-01-02-005

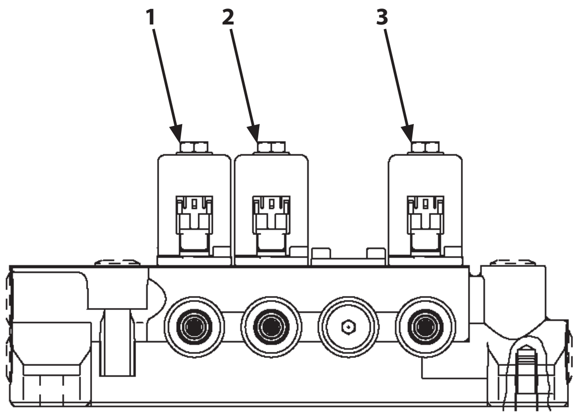
Travel Device



T1HD-01-02-001

1- Swing Relief Valve
2- Pressure Sensor (Front Attachment)
3- Counterbalance Valve
4- Travel Motor Swash Angle Control Valve
5- Travel Relief Valve

3-Spool Solenoid Valve Unit



TDCD-03-07-001

1- 3-Spool Solenoid Valve Unit (SC)

2- 3-Spool Solenoid Valve Unit (SF)

3- 3-Spool Solenoid Valve Unit (SG)

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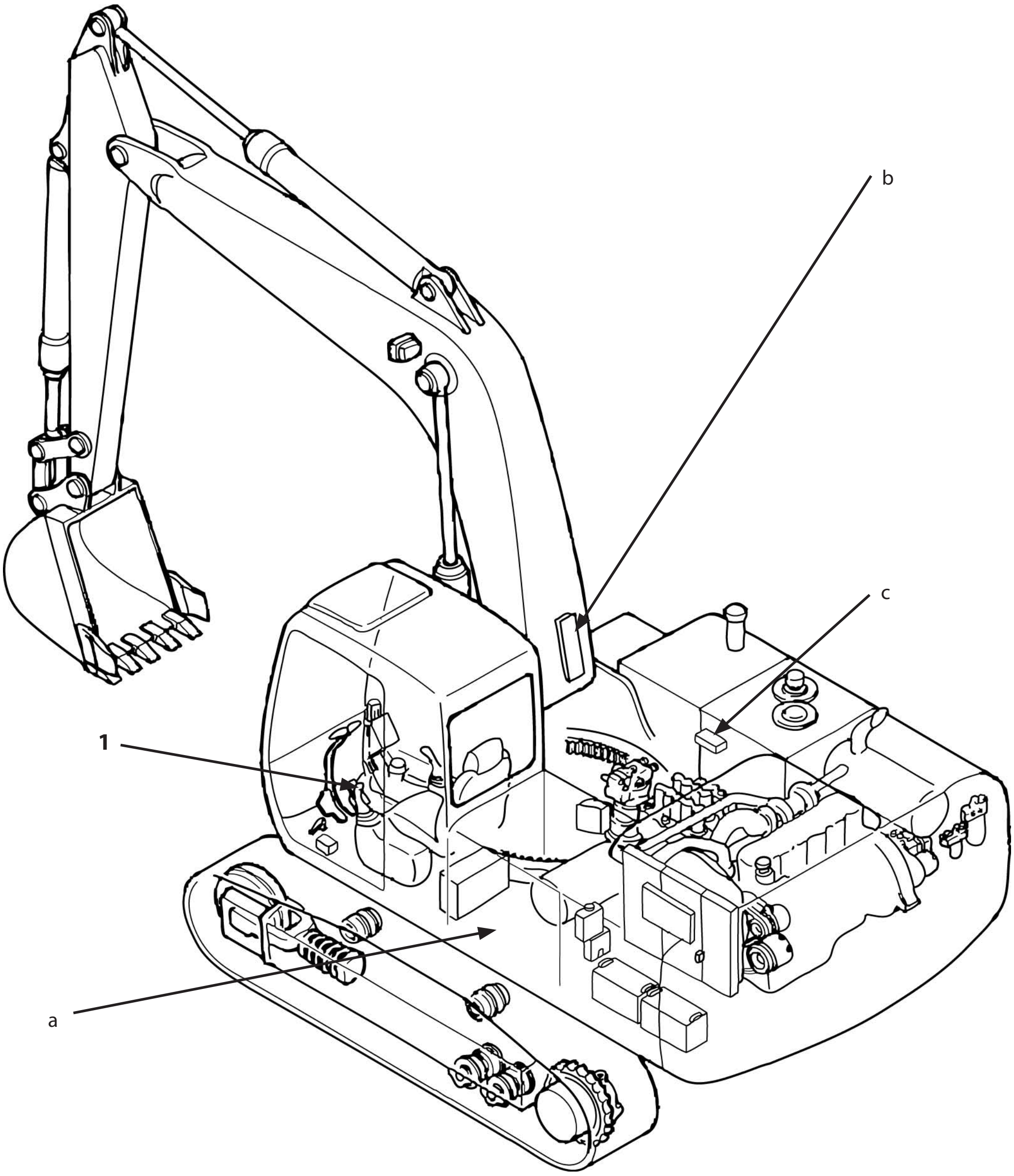
Layout of Attachment Spec. Parts



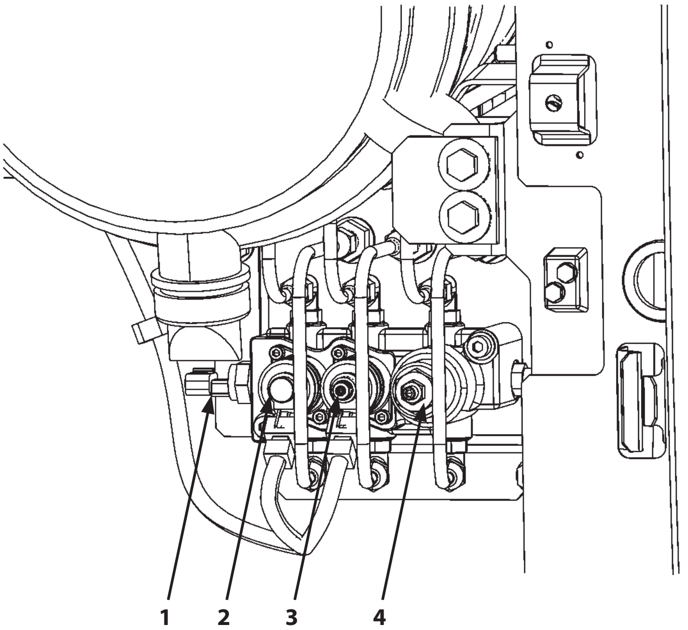
TDCD-01-02-005

a- Utility Space (Refer to T5-4-15.)
b- Boom Upper Side (Refer to T5-4-15.)
c- Selector Valve (Refer to T5-4-15.)

1- Pilot Valve (Auxiliary)

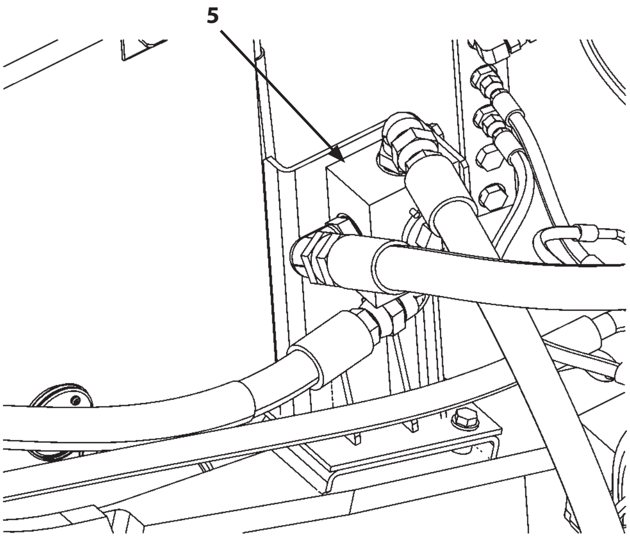
a	Utility Space	Pressure Sensor (Auxiliary)	Refer to T5-4-16.
		Auxiliary Flow Combiner Control Solenoid Valve	
		Auxiliary Flow Rate Control Solenoid Valve	
		Pressure Reducing Valve	
b	Boom Upper Side	Accumulator Control Valve	Refer to T5-4-17.
		Accumulator (High Pressure)	
		Accumulator (Low Pressure)	
		Secondary Pilot Relief Pressure Valve	
		Secondary Pilot Relief Pressure Control Valve	
c	Selector Valve	–	Refer to T5-4-16.

Utility Space



TDCD-01-02-011

Selector Valve



TDCD-01-02-012

1- Pressure Sensor (Auxiliary)

2- Auxiliary Flow Combiner Control Solenoid Valve

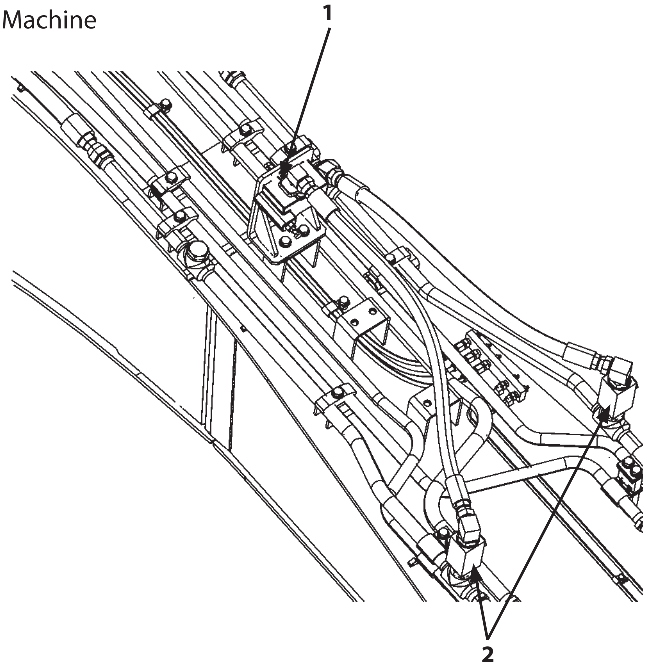
3- Auxiliary Flow Rate Control Solenoid Valve

4- Pressure Reducing Valve

5- Selector Valve

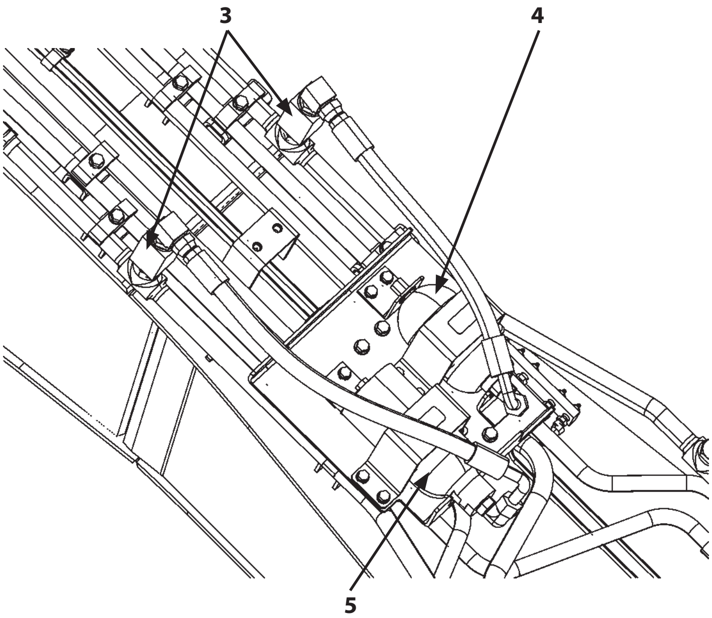
Boom Upper Side

Breaker 1 (HSB Breaker) Shared Machine



TDCD-01-02-013

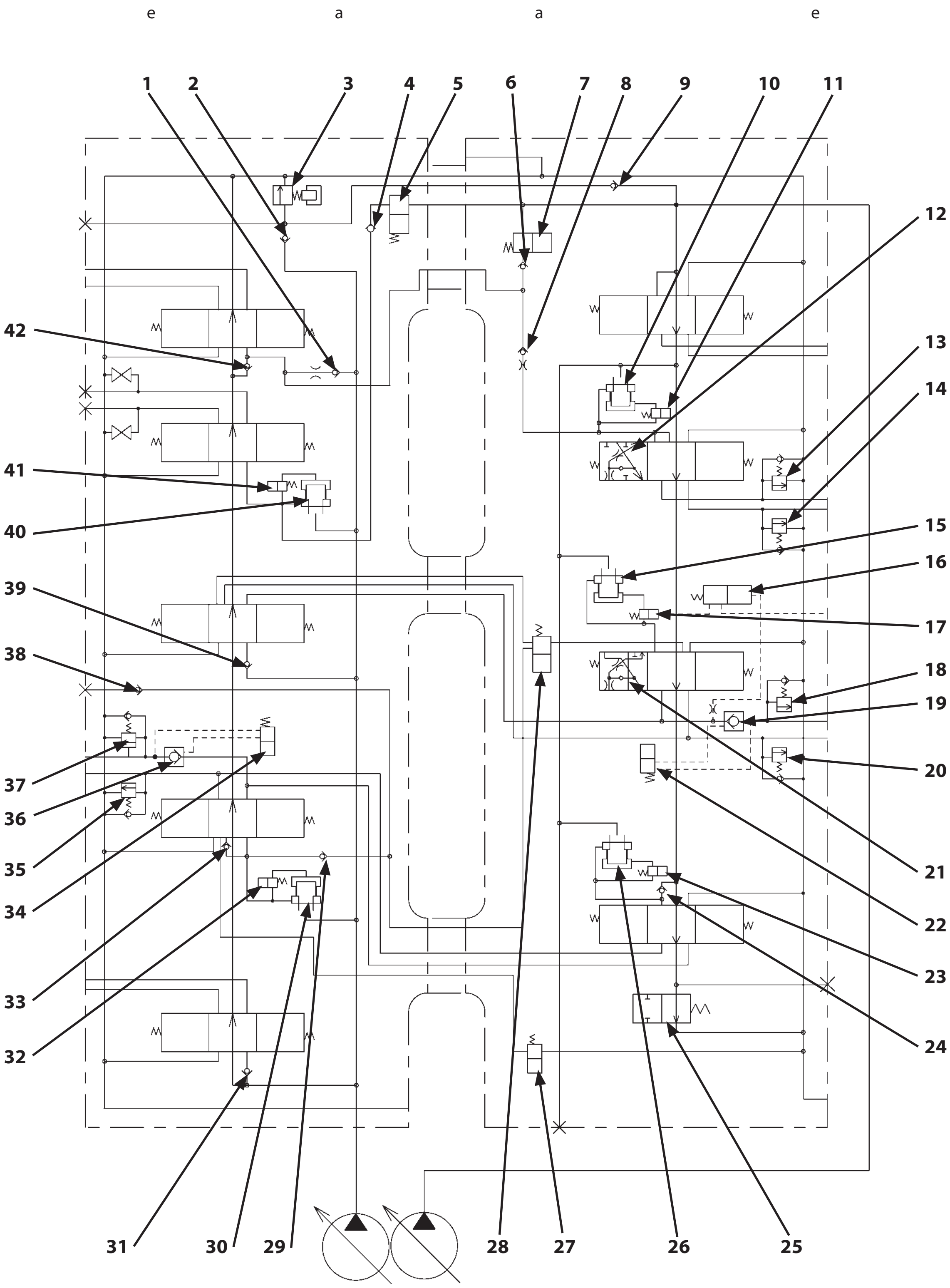
Breaker 2 (NPK Breaker) Shared Machine



TDCD-01-02-014

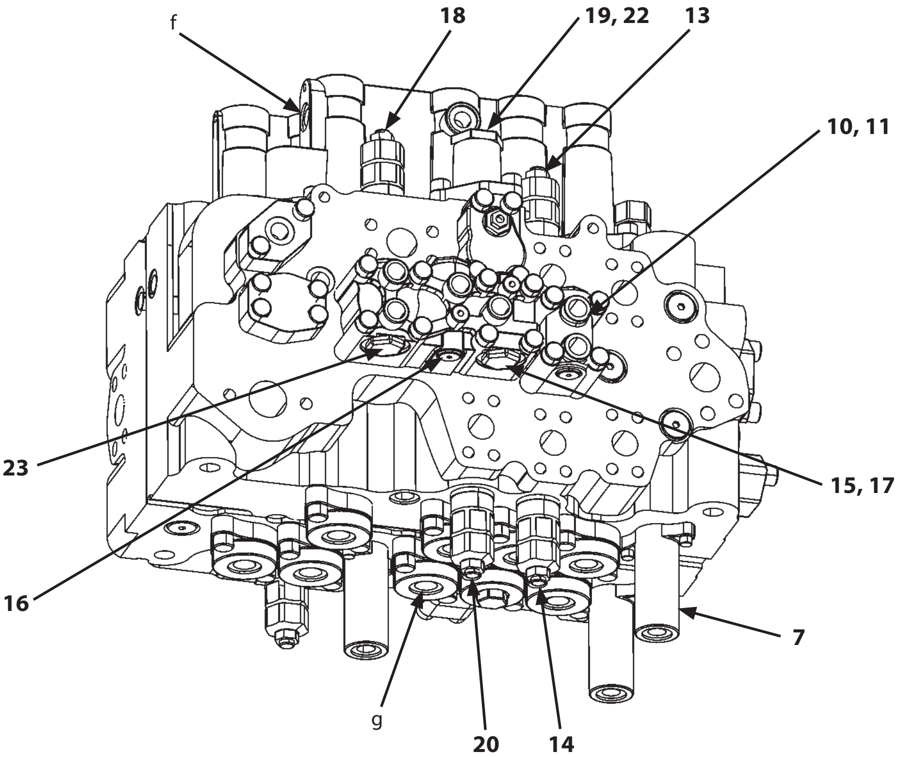
1- Secondary Pilot Relief Pressure Valve
2- Secondary Pilot Relief Pressure Control Valve
3- Accumulator Control Valve
4- Accumulator (Low Pressure)
5- Accumulator (High Pressure)

Components in Control Valve



T1V1-03-03-021

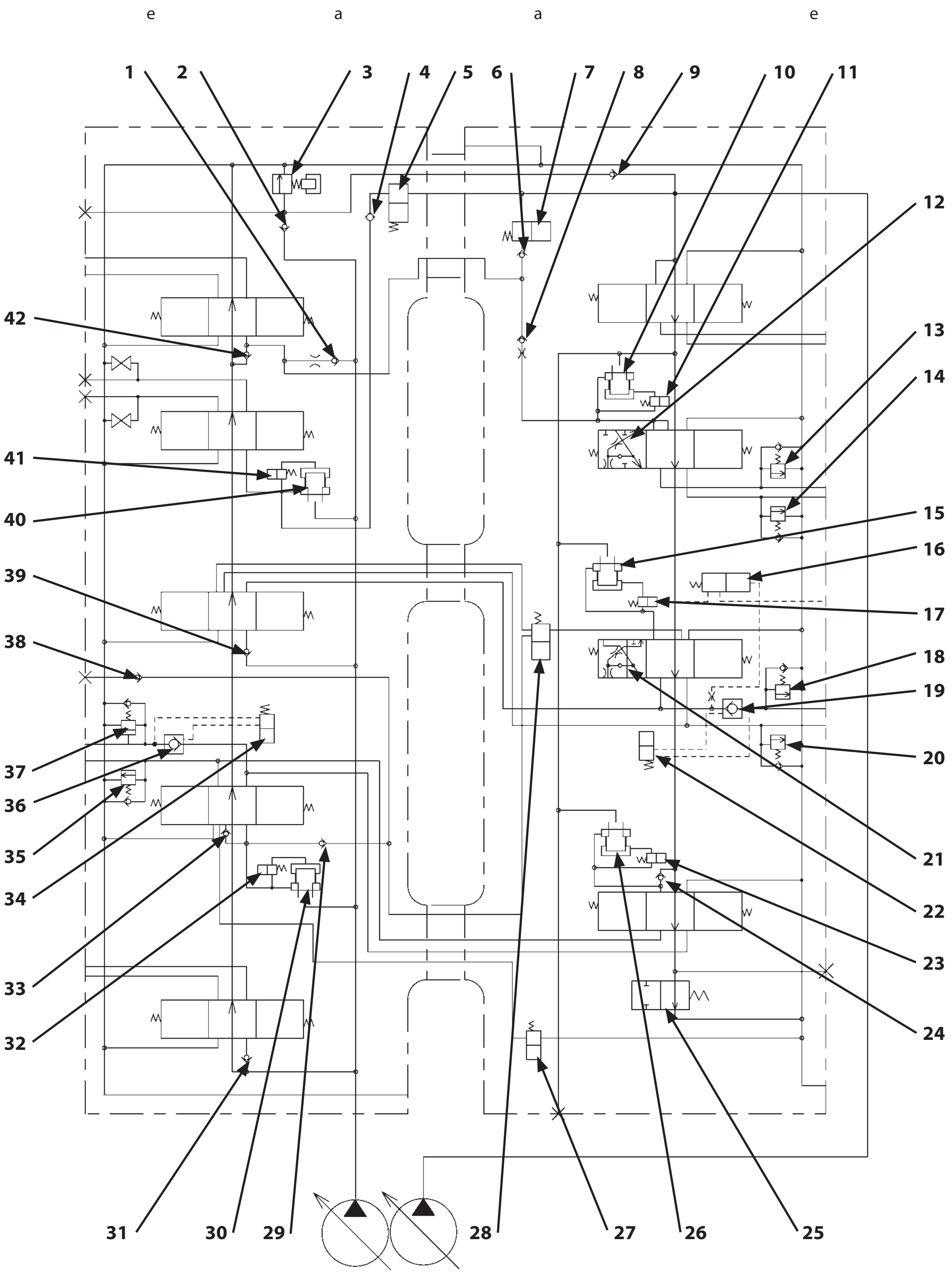
4-Spool Section



T1V1-03-03-073

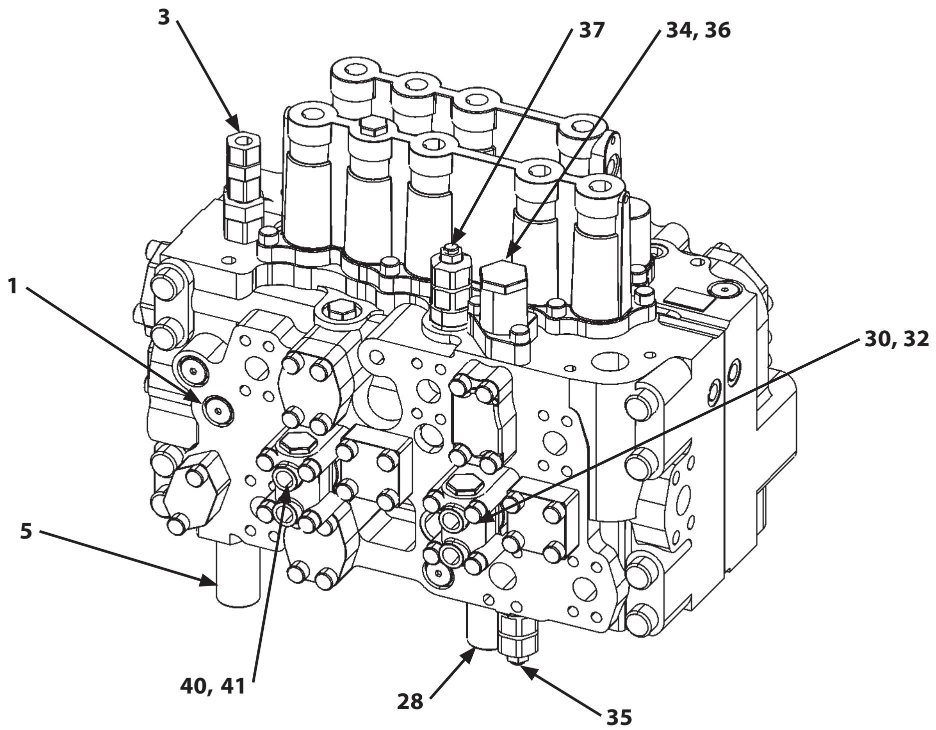
a- Machine Upper Side
e- Machine Lower Side
f- Arm Roll-In Pressure Sensor
g- Boom Raise Pressure Sensor

1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)



T1V1-03-03-021

5-Spool Section

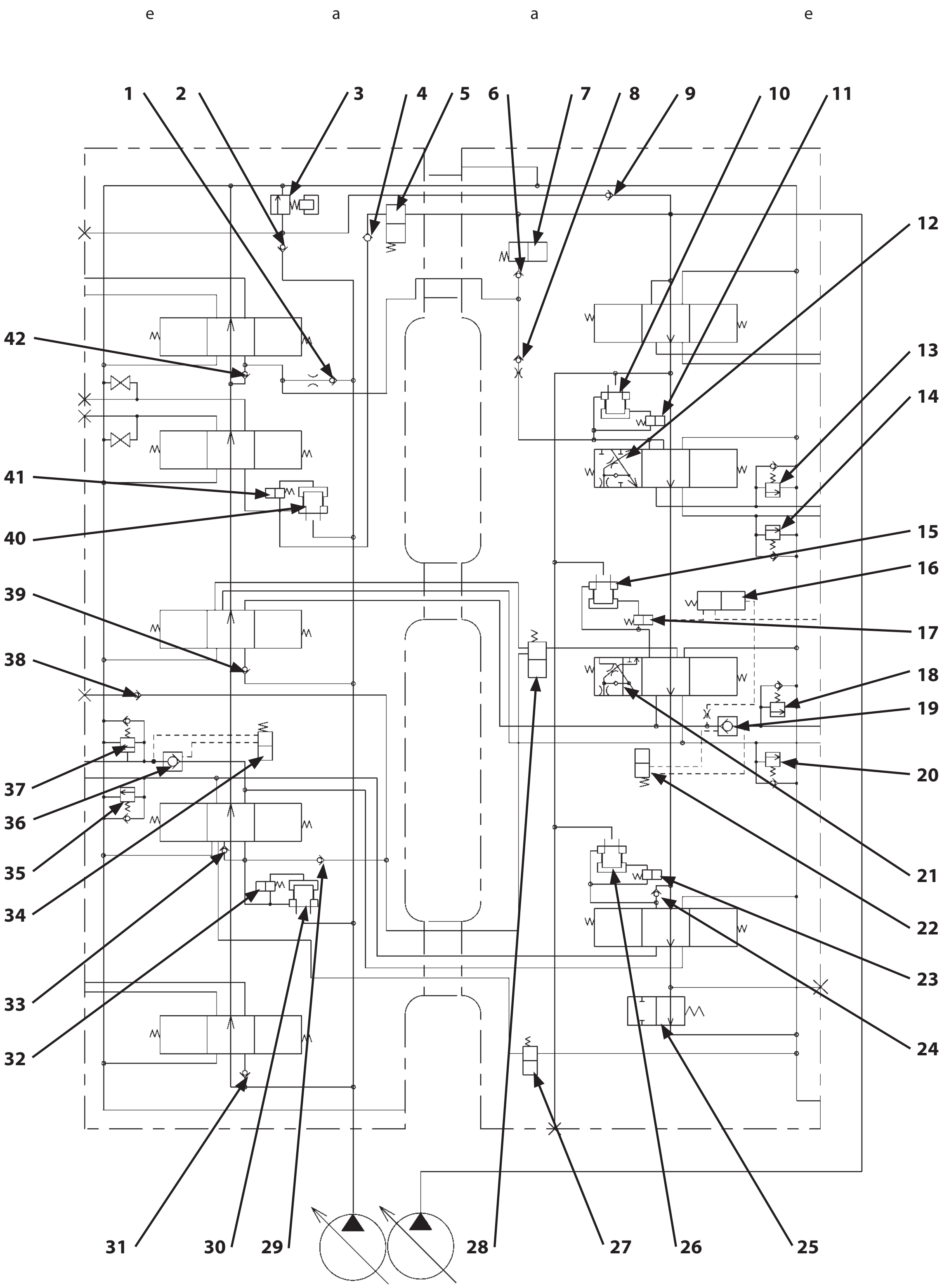


T1V1-03-03-072

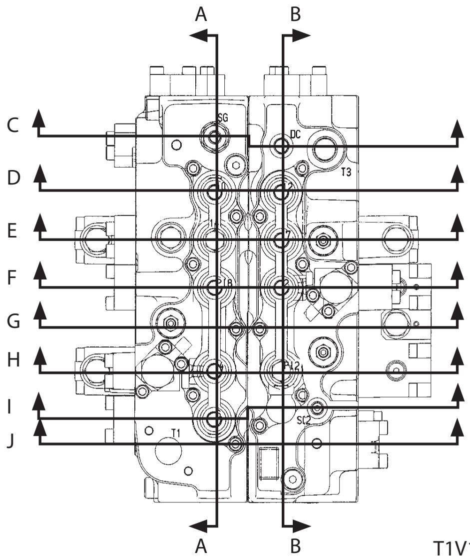
a- Machine Upper Side

e- Machine Lower Side

1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)

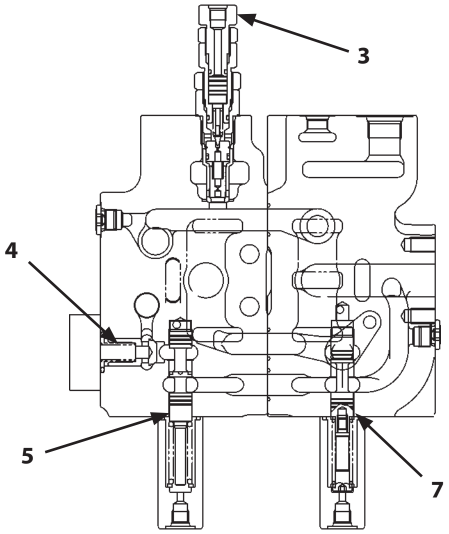


T1V1-03-03-021



T1V1-03-03-026

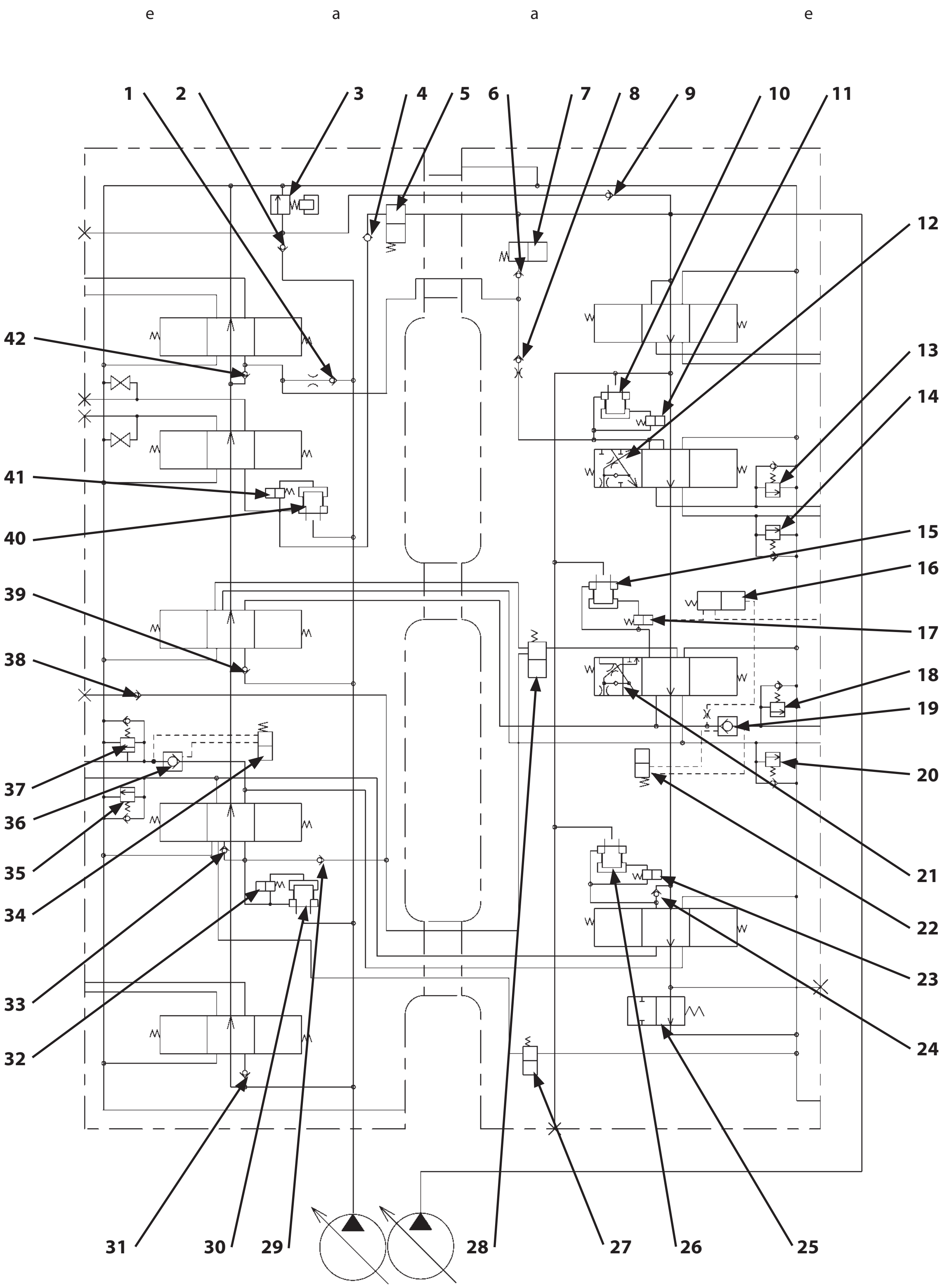
Section C-C



T1V1-03-03-003

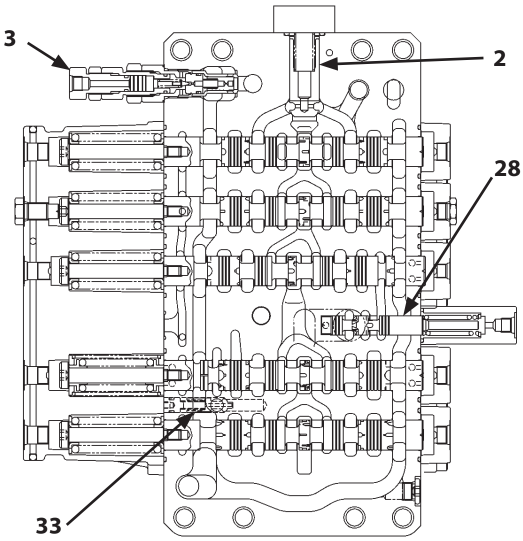
a- Machine Upper Side
c- Machine Lower Side

1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)



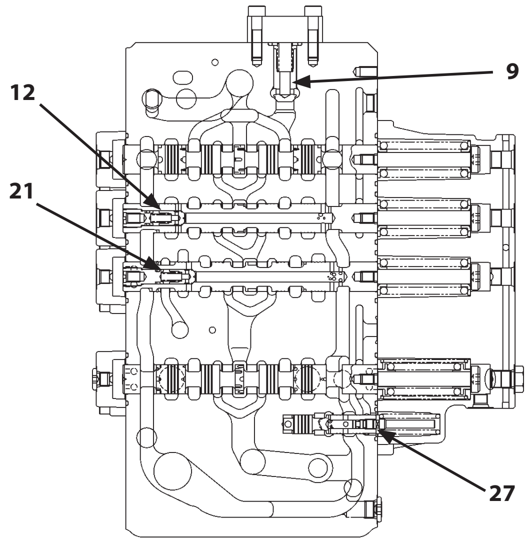
T1V1-03-03-021

Section A-A



T1V1-03-03-001

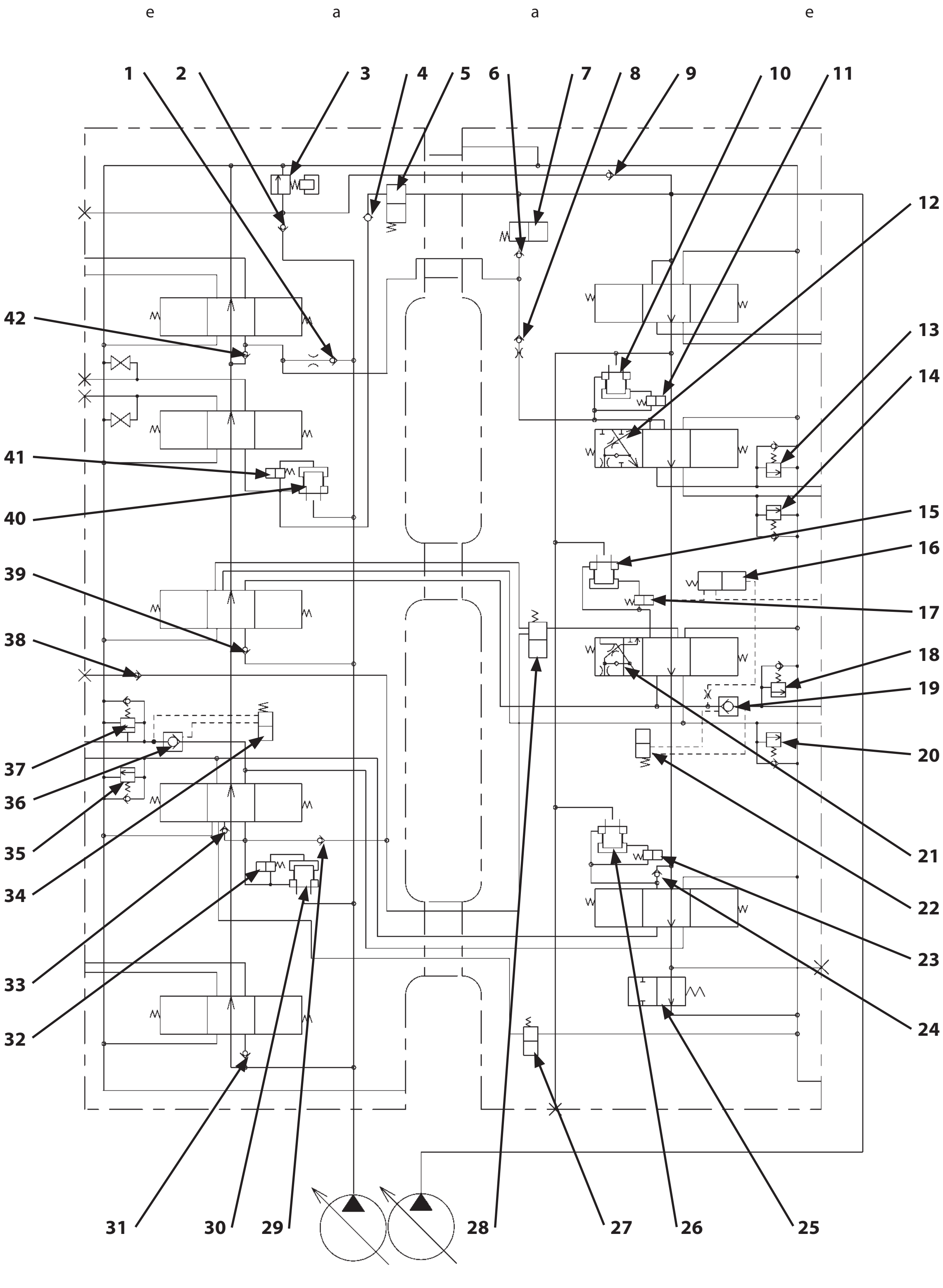
Section B-B



T1V1-03-03-002

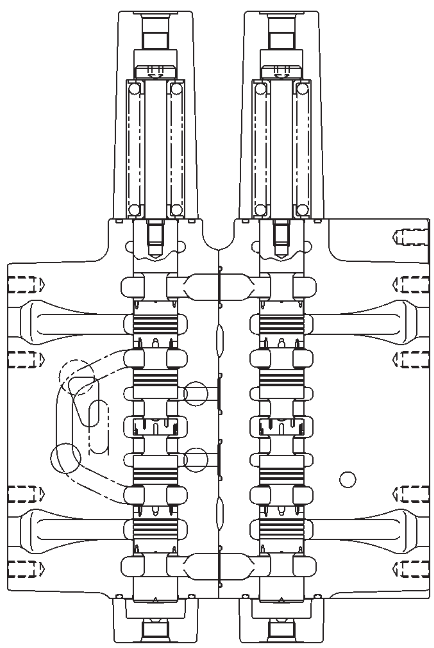
a- Machine Upper Side
c- Machine Lower Side

1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)



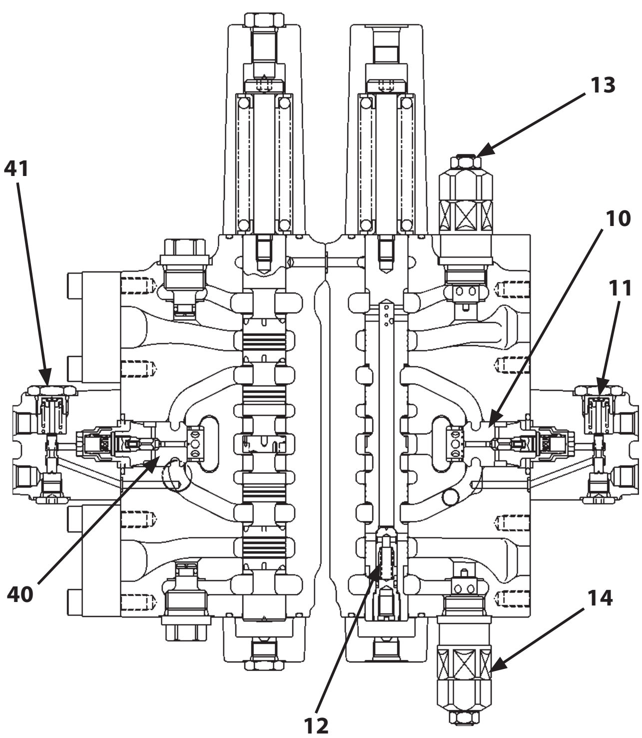
T1V1-03-03-021

Section D-D



T1V1-03-03-004

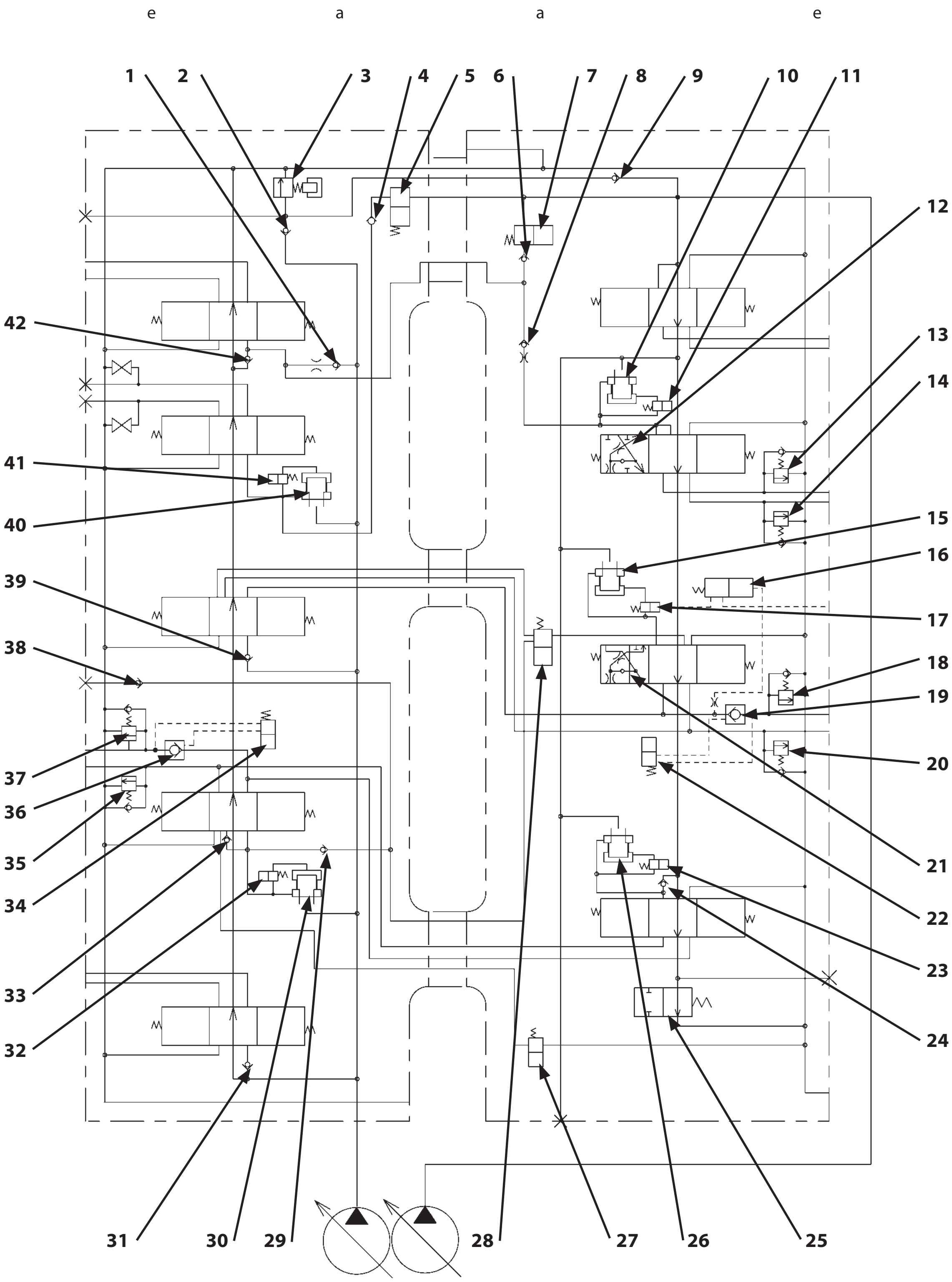
Section E-E



T1V1-03-03-005

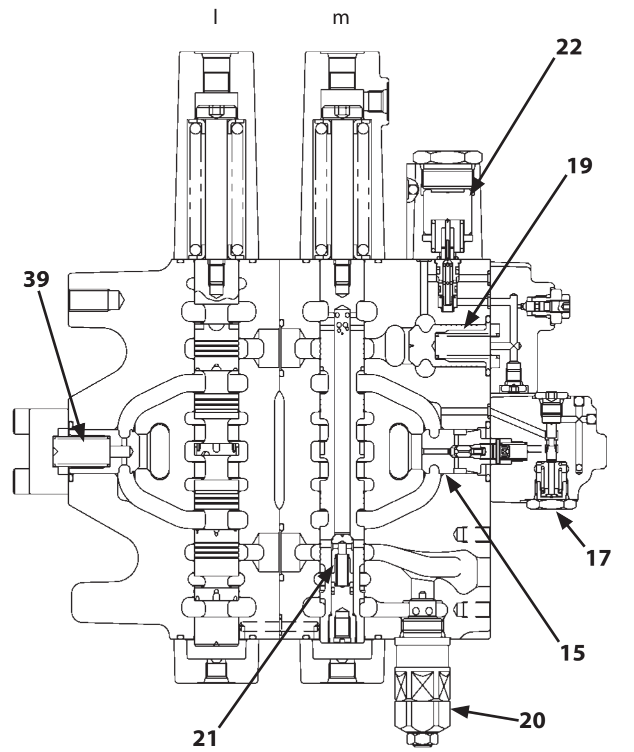
a- Machine Upper Side
e- Machine Lower Side
h- Travel (Left)
i- Travel (Right)
J- Auxiliary
k- Bucket

1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)



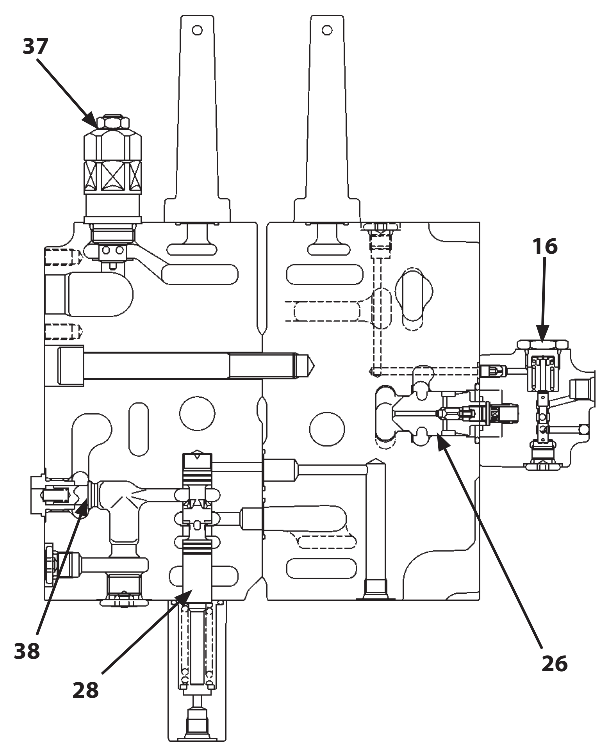
T1V1-03-03-021

Section F-F



T1V1-03-03-006

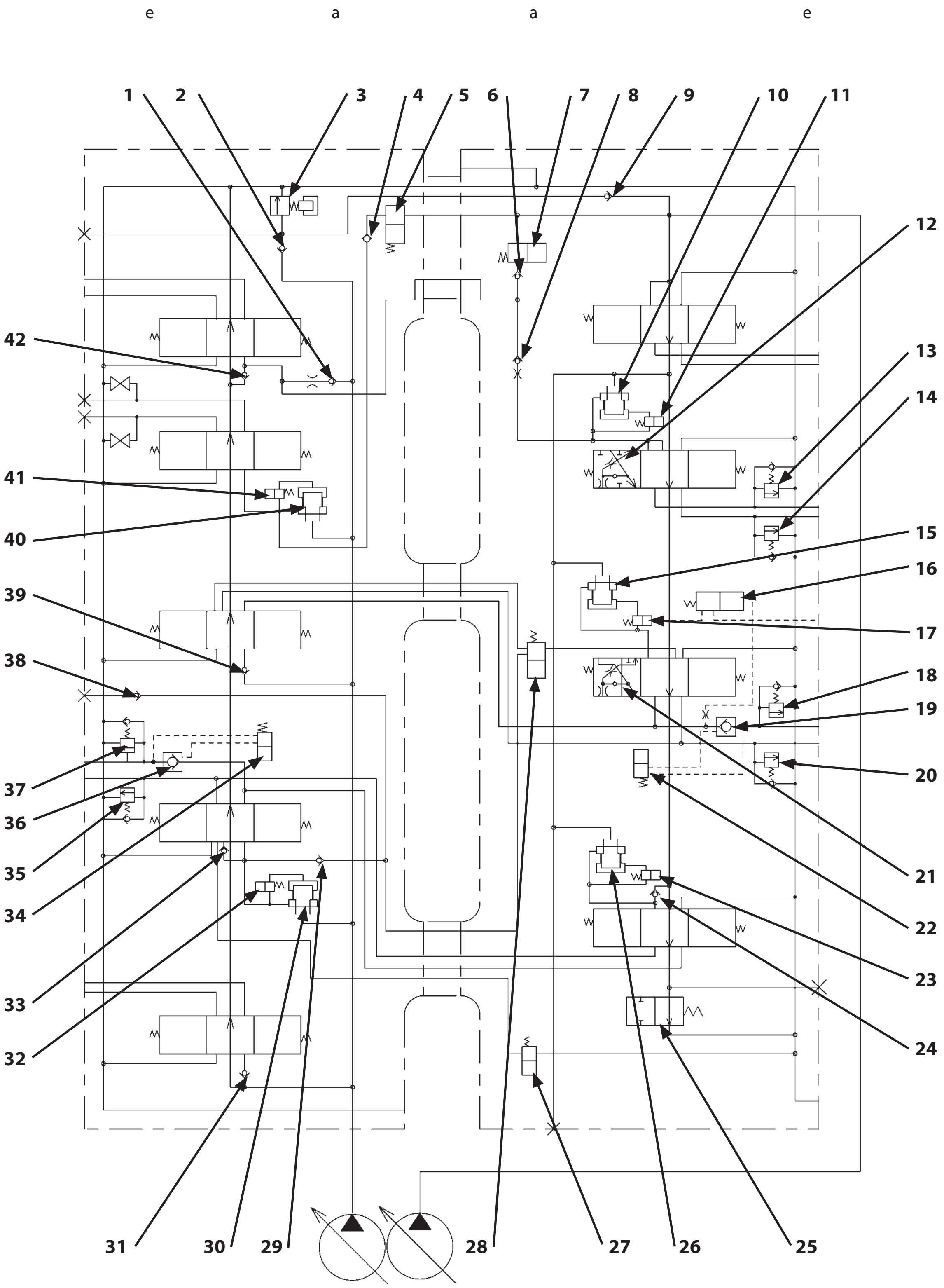
Section G-G



T1V1-03-03-007

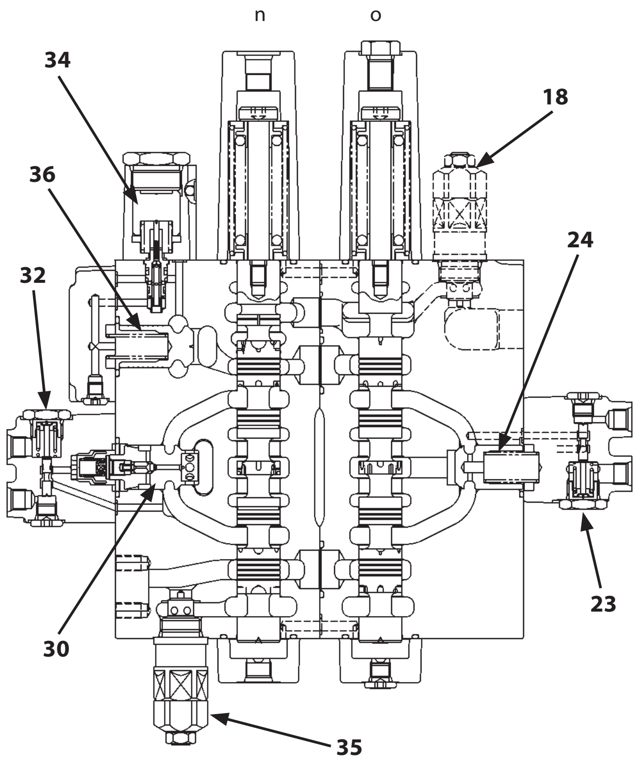
a- Machine Upper Side
e- Machine Lower Side
l- Boom 2
m- Boom 1

1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)



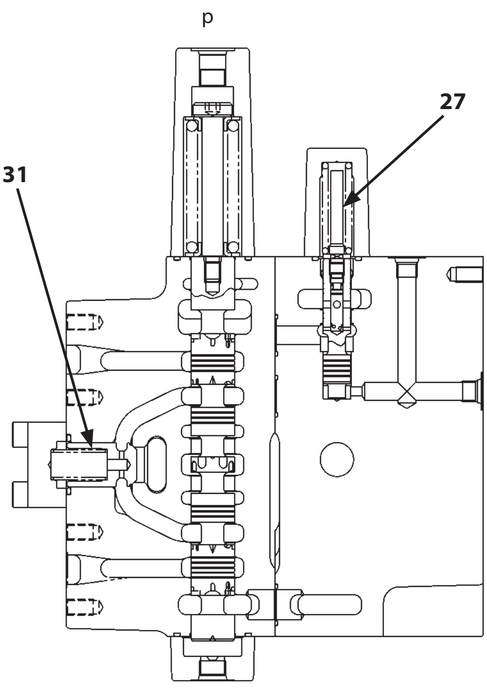
T1V1-03-03-021

Section H-H



T1V1-03-03-008

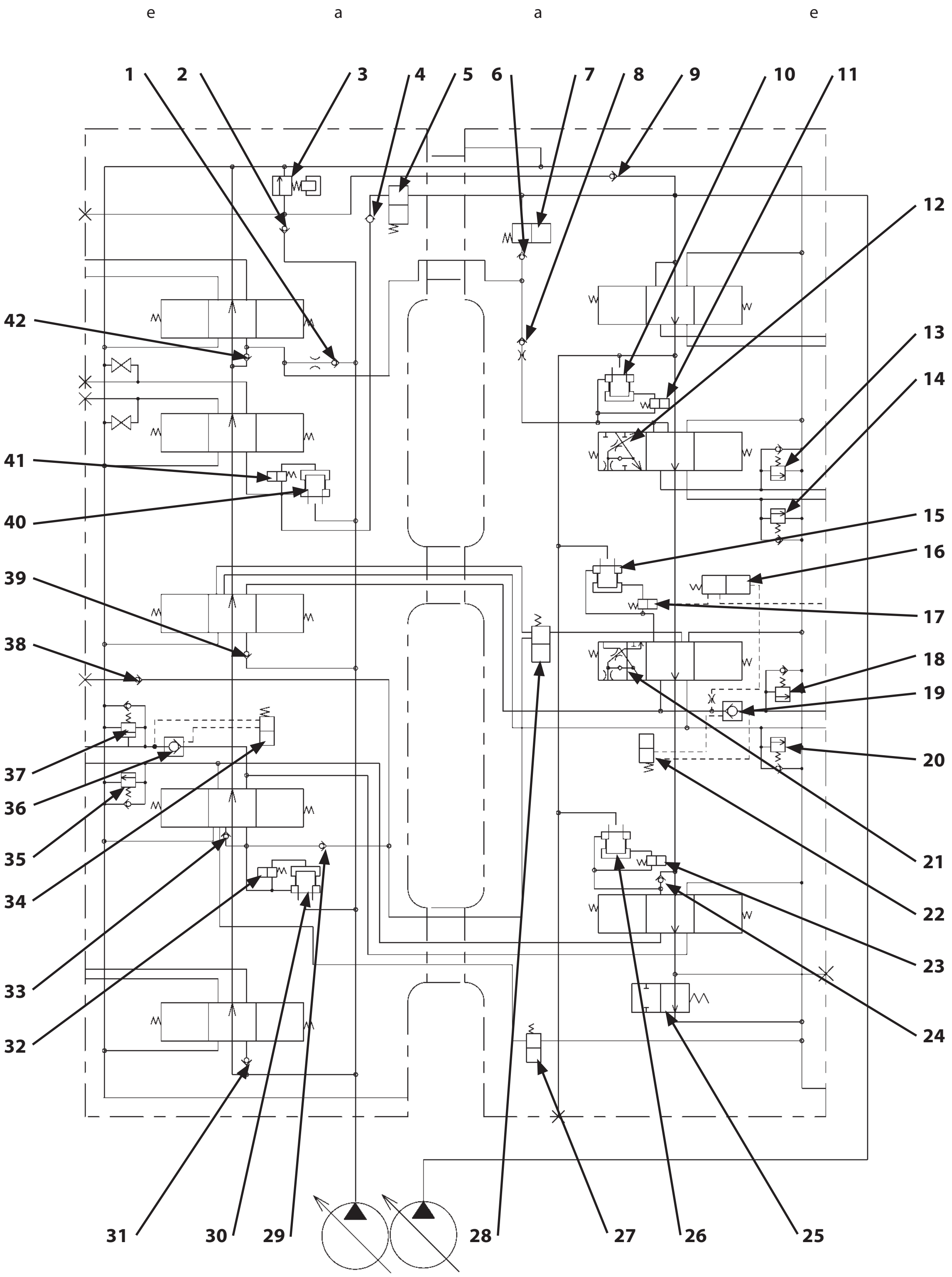
Section I-I



T1V1-03-03-009

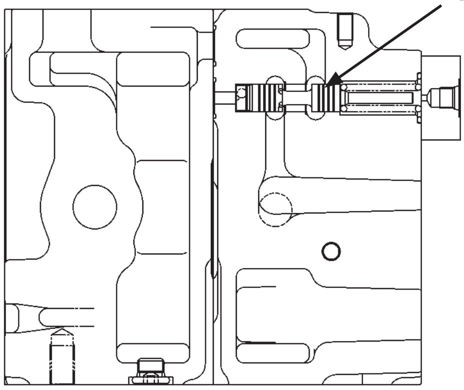
a- Machine Upper Side
e- Machine Lower Side
n- Arm 1
o- Arm 2
P- Swing

1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)



T1V1-03-03-021

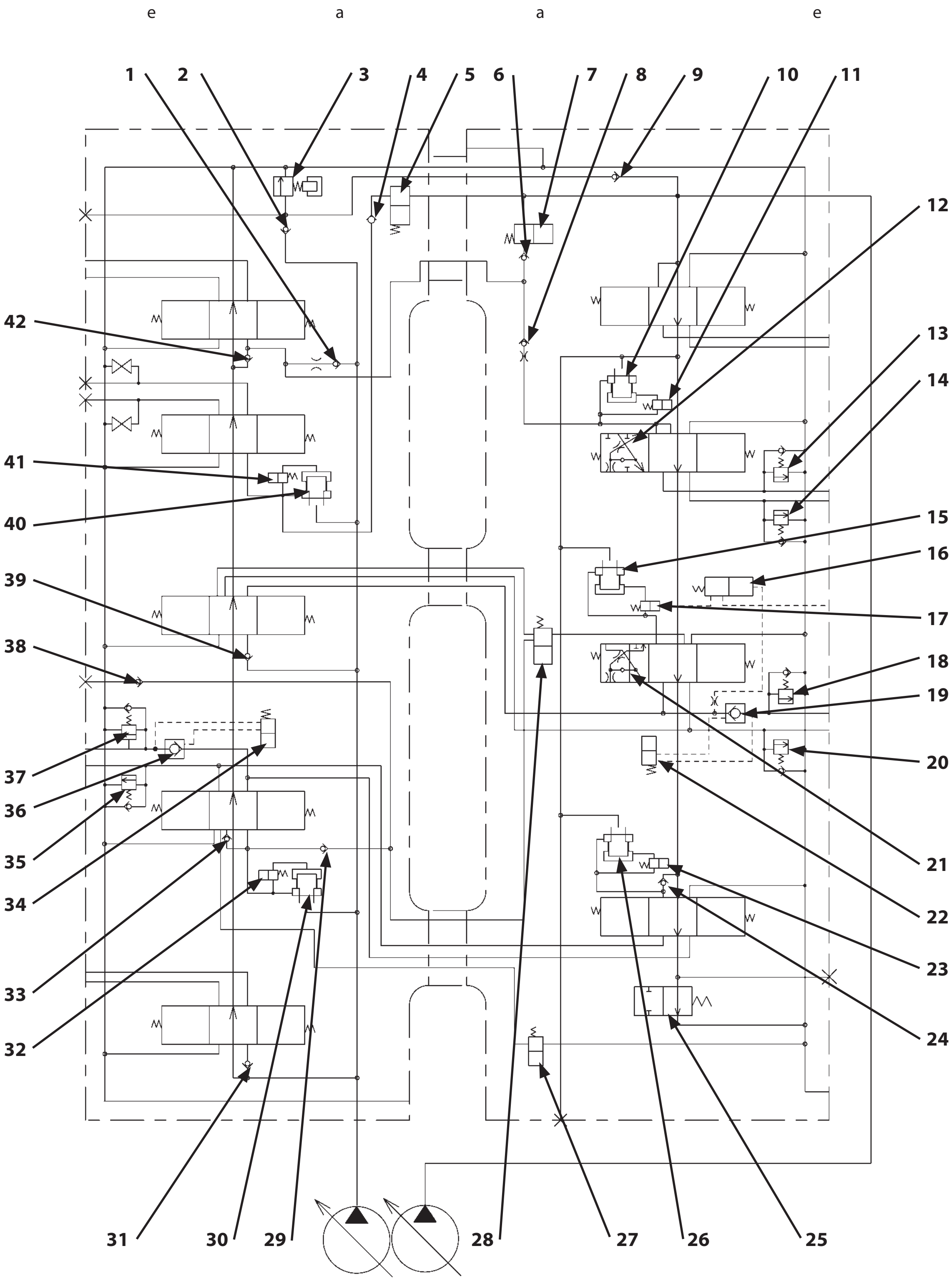
Section J-J



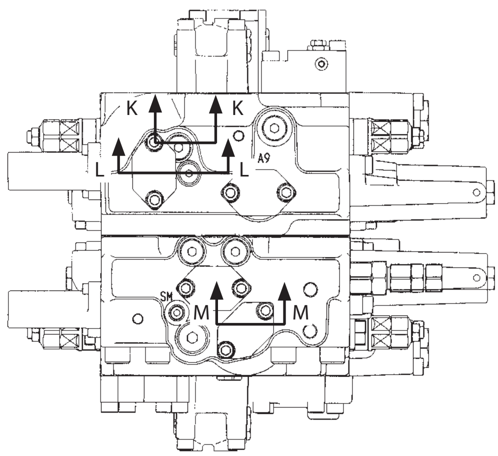
T1V1-03-03-010

a- Machine Upper Side
e- Machine Lower Side

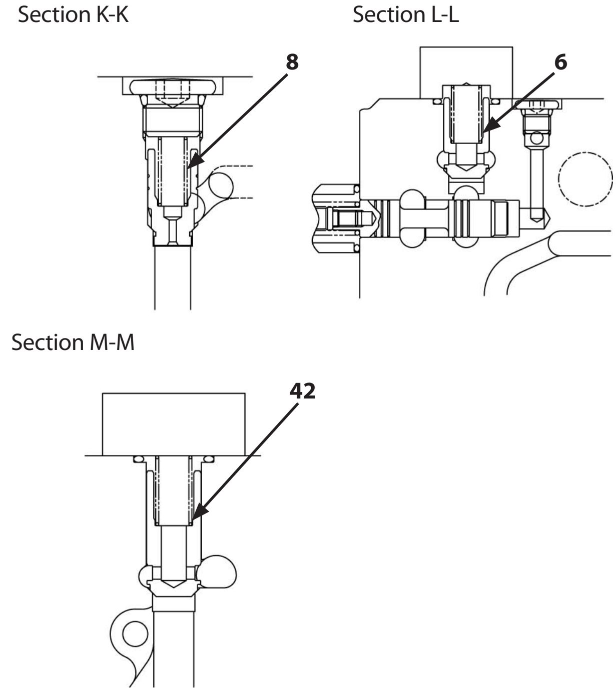
1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)



T1V1-03-03-021



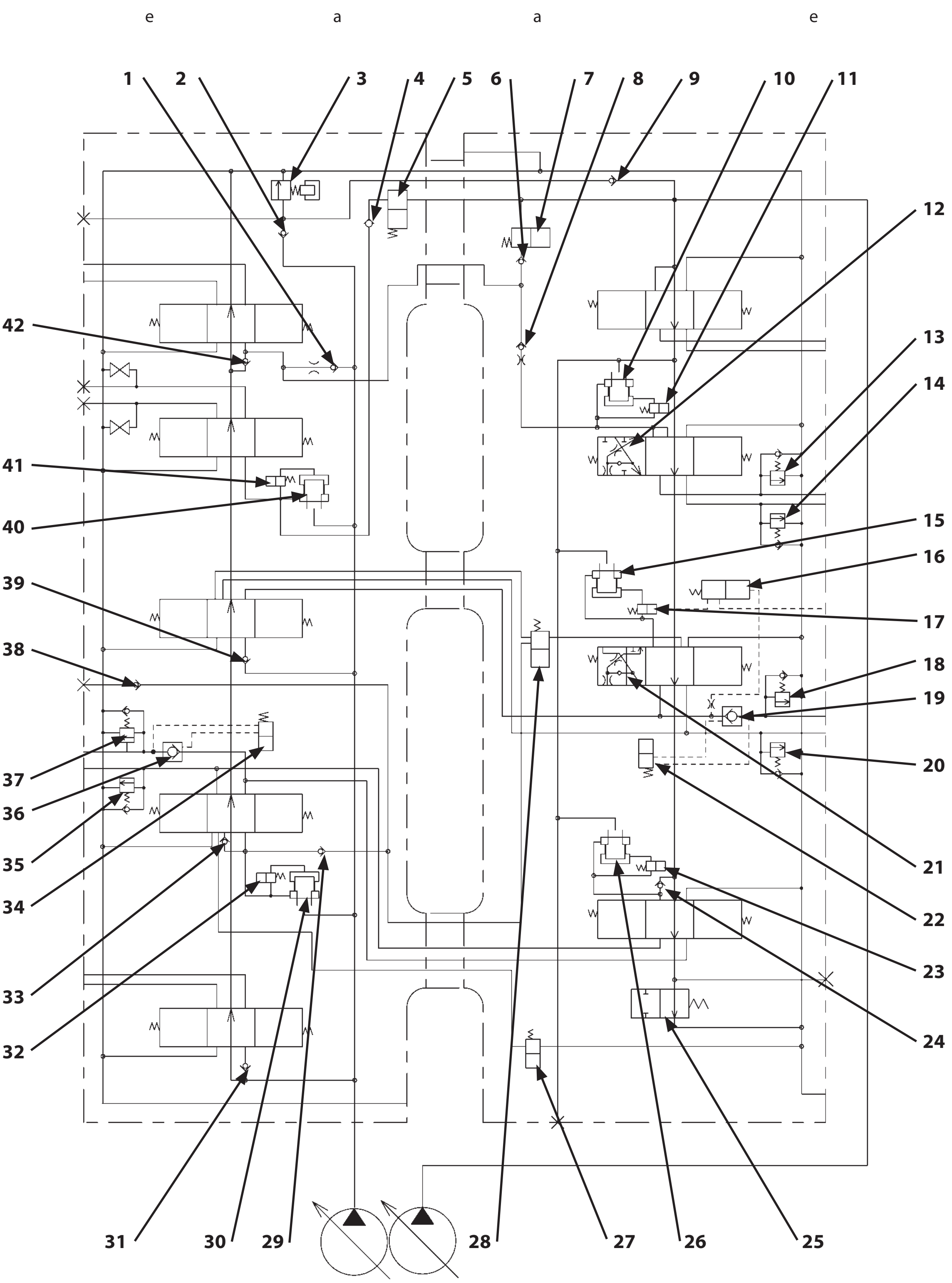
T1V1-03-03-027



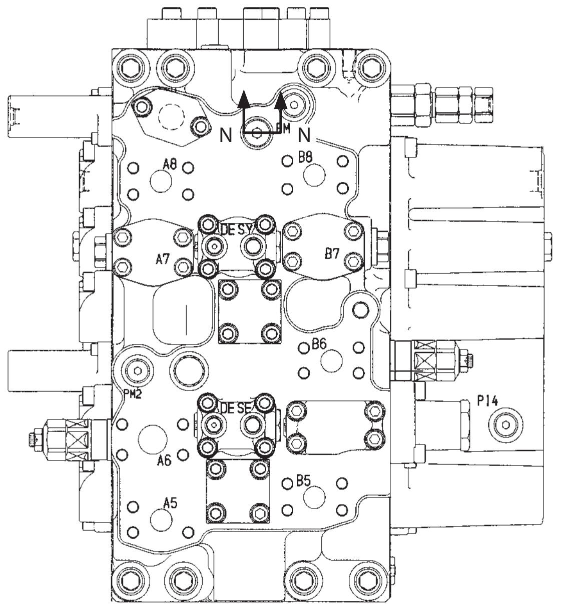
TDCD-03-03-030

a- Machine Upper Side
e- Machine Lower Side

1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)

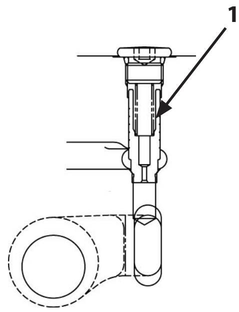


T1V1-03-03-021



T1V1-03-03-028

Section N-N



TDCD-03-03-031

a- Machine Upper Side
e- Machine Lower Side

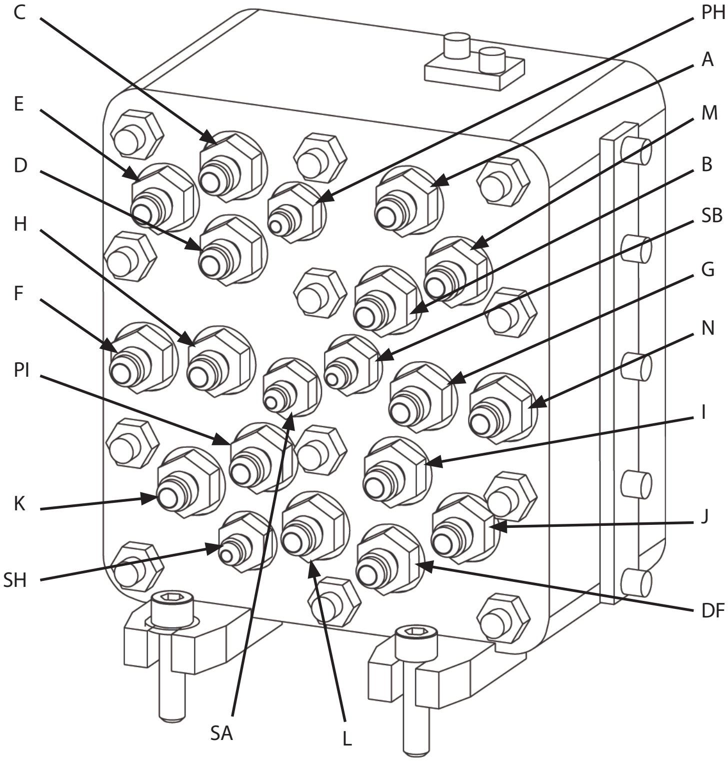
1- Load Check Valve (Travel (Left) Parallel Circuit)
2- Check Valve (Main Relief Circuit)
3- Main Relief Valves
4- Check Valve (Auxiliary Flow Combiner Circuit)
5- Auxiliary Flow Combiner Valve
6- Check Valve (Flow Combiner Circuit)
7- Flow Combiner Valve
8- Load Check Valve (Orifice) (Bucket)
9- Check Valve (Main Relief Circuit)
10- Bucket Flow Rate Control Valve (Poppet Valve)
11- Bucket Flow Rate Control Valve (Selector Valve)
12- Bucket Regenerative Valve
13- Overload Relief Valve (Bucket: Rod Side)
14- Overload Relief Valve (Bucket: Bottom Side)
15- Boom Flow Rate Control Valve (Poppet Valve)
16- Boom Lower Meter-In Cut Valve
17- Boom Flow Rate Control Valve (Selector Valve)
18- Overload Relief Valve (Boom: Bottom Side)
19- Boom Anti-Drift Valve (Check Valve)
20- Overload Relief Valve (Boom: Rod Side)
21- Boom Regenerative Valve
22- Boom Anti-Drift Valve (Selector Valve)
23- Arm 2 Flow Rate Control Valve (Selector Valve)
24- Load Check Valve (Arm 2 Tandem Circuit)
25- Bypass Shut-Out Valve
26- Arm 2 Flow Rate Control Valve (Poppet Valve)
27- Arm Regenerative Valve
28- Digging Regenerative Valve
29- Load Check Valve (Digging Regenerative Circuit)
30- Arm 1 Flow Rate Control Valve (Poppet Valve)
31- Load Check Valve (Swing Circuit)
32- Arm 1 Flow Rate Control Valve (Selector Valve)
33- Load Check Valve (Arm Regenerative Circuit)
34- Arm Anti-Drift Valve (Selector Valve)
35- Overload Relief Valve (Arm: Bottom Side)
36- Arm Anti-Drift Valve (Check Valve)
37- Overload Relief Valve (Arm: Rod Side)
38- Check Valve (Digging Regenerative Circuit)
39- Load Check Valve (Boom 2 Parallel Circuit)
40- Auxiliary Flow Rate Control Valve (Poppet Valve)
41- Auxiliary Flow Rate Control Valve (Selector Valve)
42- Load Check Valve (Travel (Left) Tandem Circuit)

Pilot Port

Pilot Valve Side

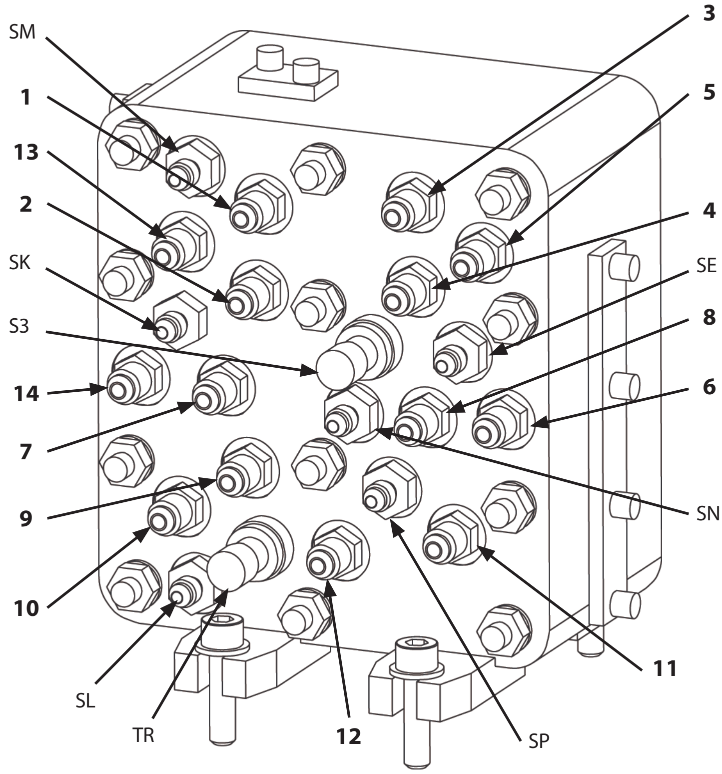
Port Name	Connected to	Remarks
Port A	Right Pilot Valve	Boom Raise Pilot Pressure
Port B	Right Pilot Valve	Boom Lower Pilot Pressure
Port C	Left Pilot Valve	Arm Roll-Out Pilot Pressure
Port D	Left Pilot Valve	Arm Roll-In Pilot Pressure
Port E	Left Pilot Valve	Swing (Left) Pilot Pressure
Port F	Left Pilot Valve	Swing (Right) Pilot Pressure
Port G	Right Pilot Valve	Bucket Roll-In Pilot Pressure
Port H	Right Pilot Valve	Bucket Roll-Out Pilot Pressure
Port I	Travel Pilot Valve	Travel (Left Forward) Pilot Pressure
Port J	Travel Pilot Valve	Travel (Left Reverse) Pilot Pressure
Port K	Travel Pilot Valve	Travel (Right Forward) Pilot Pressure
Port L	Travel Pilot Valve	Travel (Right Reverse) Pilot Pressure
Port M	Auxiliary Pilot Valve	Auxiliary Open Pilot Pressure
Port N	Auxiliary Pilot Valve	Auxiliary Close Pilot Pressure
Port SA	Pump 1 Regulator	Pump 1 Control Pressure
Port SB	Pump 2 Regulator	Pump 2 Control Pressure
Port PI	Pilot Shut-Off Solenoid Valve	Primary Pilot Pressure
Port PH	-	Plug
Port SH	Swing Parking Brake	Brake Release Pressure
Port DF	Hydraulic Oil Tank	Returning to Hydraulic Oil Tank

Pilot Valve Side



TDCD-03-06-002

Control Valve Side



TDCD-03-06-003

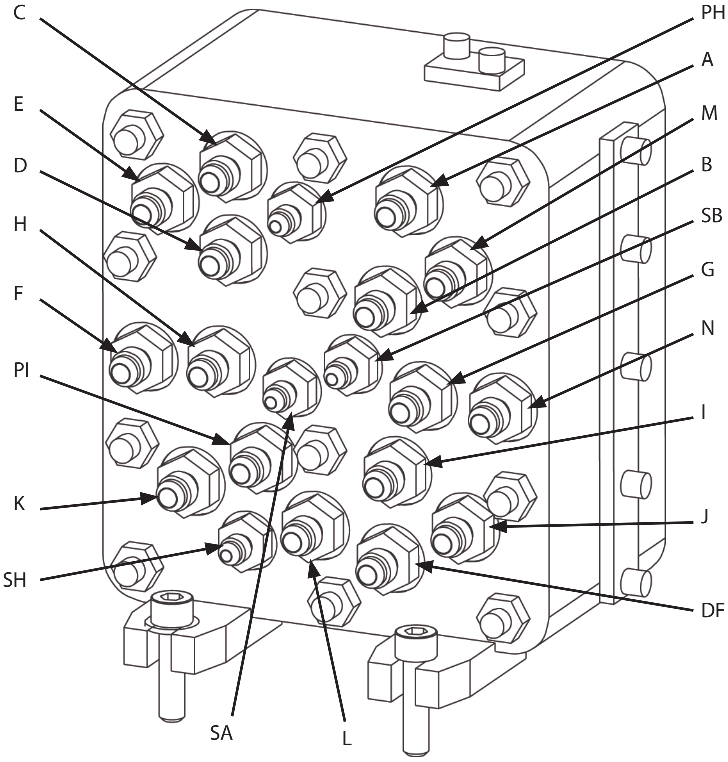
Control Valve Side

Port Name	Connected to	Remarks
Port 1	Control Valve	Boom Raise Pilot Pressure
Port 2	Control Valve	Boom Lower Pilot Pressure
Port 3	Control Valve	Arm Roll-Out Pilot Pressure
Port 4	Control Valve	Arm Roll-In Pilot Pressure
Port 5	Control Valve	Swing (Left) Pilot Pressure
Port 6	Control Valve	Swing (Right) Pilot Pressure
Port 7	Control Valve	Bucket Roll-In Pilot Pressure
Port 8	Control Valve	Bucket Roll-Out Pilot Pressure
Port 9	Control Valve	Travel (Left Forward) Pilot Pressure
Port 10	Control Valve	Travel (Left Reverse) Pilot Pressure
Port 11	Control Valve	Travel (Right Forward) Pilot Pressure
Port 12	Control Valve	Travel (Right Reverse) Pilot Pressure
Port 13	Control Valve	Auxiliary Open Pilot Pressure
Port 14	Control Valve	Auxiliary Close Pilot Pressure
Port SE	Hydraulic Oil Tank	Returning to Hydraulic Oil Tank
Port SM	Hydraulic Oil Tank	Returning to Hydraulic Oil Tank
Port SN	-	Plug
Port SP	Hydraulic Oil Tank	Returning to Hydraulic Oil Tank
Port SL	Control Valve	Flow Combiner Valve Control Pressure
Port SK	Control Valve	Bucket Flow Rate Control Valve Control Pressure
Port S3	Pressure Sensor (Swing)	-
Port TR	Pressure Sensor (Travel)	-

Machine with Attachment (Pulverizers 1 to 5 and Crushers 1 to 5) Equipped

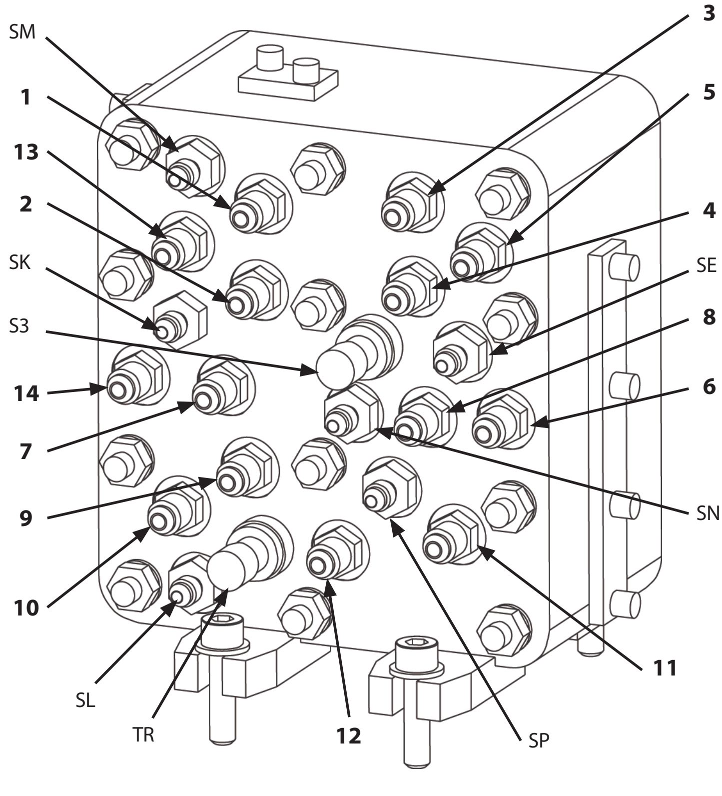
Port SM	Auxiliary Flow Combiner Solenoid Valve	Auxiliary Flow Combiner Valve Control Pressure
Port SN	Auxiliary Flow Rate Combiner Control Valve	Auxiliary Flow Combiner Valve Control Pressure
Port SP	Auxiliary Flow Combiner Solenoid Valve	Pump 1 Control Pressure

Pilot Valve Side



TDCD-03-06-002

Control Valve Side



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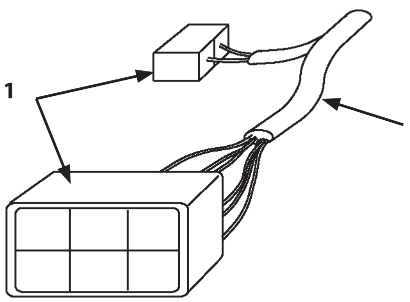
Troubleshooting A (Base Machine Diagnosis By Using Fault Codes) Procedure

Refer to troubleshooting A procedure in case any fault codes are displayed after diagnosing by using MPDr. or the service menu of the monitor.

- Diagnosis Procedure
  - The diagnosis procedures for the displayed fault codes are explained in this group.
  - In case more than one fault code are displayed at the same time, MC may be faulty or the power/ground of the sensor system may be faulty.
  - When the MC fault code is displayed with other fault code, replace MC.
  - When fault code 11003-3 (Abnormal Sensor Voltage) is displayed with other fault code, diagnose for fault code 11003-3 first.
  - In case more than one fault code other than those described above are displayed at the same time, diagnose for each fault code.
  - It may be required that the machine is operated or the test harness is connected at inspection.
    Check the items of preparation and perform inspection according to the procedures when diagnosing.

NOTE: Harness end connector viewed from the open end side by the all connectors image shown in this section.



T6L4-05-03-001

1- Harness End Connector 2- Harness

Contents Of Diagnosis

Fault Code

Preparation

Tools for a diagnosis and contents needing inspection beforehand are explained.

How to Read Table

Fault Code	Trouble	Inspection Method	Evaluation	Cause
(A)	(B)	(C)	(D)	(E)
		(F)	(G)	(H)

- A: Fault code
- B: Trouble details
- C, F: Inspection method for trouble cause
- D, G: Evaluation specification of check results
- E, H: Trouble cause for the fault code

Procedure:

1. Check an applicable line depending on displayed fault cord (A).
2. After checking or measuring on Inspection Method (C), refer to Evaluation (D) and judge the results.
3. In case the results are satisfied with Evaluation (D), the trouble cause becomes Cause (E).
   In case the results are not satisfied with Evaluation (D), go to the next procedure, Inspection Method (F).

Circuit Diagram of Test Harness

A connection point of the test harness and a point to check are explained.
(Only Pressure Sensor System Troubleshooting)

MC Fault Code List

Controller Hardware Failure

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11000-2	Abnormal EEPROM	Faulty MC	-	Replace MC.
11001-2	Abnormal RAM	Faulty MC	-	Replace MC.
11002-2	Abnormal A/D Converter	Faulty MC	-	Replace MC.
11003-3	Abnormal Sensor Voltage	Faulty MC Faulty sensor Faulty harness	Although the engine control dial is operated, the engine speed does not change.	Check the sensor connected to MC. Check the harness. Replace MC.

CAN Data Reception Failure

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11006-2	Engine Controller Communication Error	Faulty harness	The machine movement is slow. (During speed sensing, the torque is reduced.)	Check the harness.
11007-2	(CAN0) Information Controller Communication Error 1	Faulty MC Faulty CAN0 harness	The machine movement is slow.	Check the CAN0 harness. Replace MC.
11008-2	(CAN1) Information Controller Communication Error 2	Faulty MC Faulty CAN1 harness	The machine movement is slow.	Check the CAN1 harness. Replace MC.
11009-2	(CAN0) Monitor Controller Communication Error 1	Faulty MC Faulty CAN0 harness	The machine movement is slow.	Check the CAN0 harness. Replace MC.
11010-2	(CAN1) Monitor Controller Communication Error 2	Faulty MC Faulty CAN1 harness	The machine movement is slow.	Check the CAN1 harness. Replace MC.

Engine Failure

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11100-2	Abnormal Engine Speed	Engine speed: 4000 min^{-1} or more	The machine operation speed is slow. (During speed sensing, the torque is decreased.)	Check the crank speed sensor. Check the cam angle sensor.
11101-3	Engine Control Dial Sensor Circuit High Input	Voltage: more than 4.78 V	Trouble condition with the key switch ON: The engine speed is kept at slow idle speed. Trouble condition during operation: The engine speed is kept at the speed just before trouble.	Check the harness. Replace the engine control dial.
11101-4	Engine Control Dial Sensor Circuit Low Input	Voltage: less than 0.22 V	Trouble condition with the key switch ON: The engine speed is kept at slow idle speed. Trouble condition during operation: The engine speed is kept at the speed just before trouble.	Check the harness. Replace the engine control dial.

Pump Failure

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11200-3	Pump 1 Delivery Pressure Sensor Circuit High Input	Voltage: more than 4.8 V	Combined operation of arm roll-in and boom raise or combined operation of arm roll-in and swing: Arm speed is slow. Single operation of boom raise: Lifting force is weak. Travel: Slow speed	Check the harness. Replace the pump 1 delivery pressure sensor.
11200-4	Pump 1 Delivery Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	Combined operation of arm roll-in and boom raise or combined operation of arm roll-in and swing: Arm speed is slow. Single operation of boom raise: Lifting force is weak. Travel: Slow speed	Check the harness. Replace the pump 1 delivery pressure sensor.
11202-3	Pump 2 Delivery Pressure Sensor Circuit High Input	Voltage: more than 4.8 V	Combined operation of arm roll-in and boom raise or combined operation of arm roll-in and swing: Arm speed is slow. Travel: Slow speed	Check the harness. Replace the pump 2 delivery pressure sensor.
11202-4	Pump 2 Delivery Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	Combined operation of arm roll-in and boom raise or combined operation of arm roll-in and swing: Arm speed is slow. Travel: Slow speed	Check the harness. Replace the pump 2 delivery pressure sensor.

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11206-3	Pump 1 Flow Control Pressure Sensor Circuit High Input	Voltage: more than 4.8 V	Although speed normally returns to fast idle speed when a control lever is operated in ECO mode, engine speed is not increased in abnormal condition. Fast travel cannot be selected easily.	Check the harness. Replace the pump 1 control pressure sensor.
11206-4	Pump 1 Flow Control Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	Although speed normally returns to fast idle speed when a control lever is operated in ECO mode, engine speed is not increased in abnormal condition. Fast travel cannot be selected easily.	Check the harness. Replace the pump 1 control pressure sensor.
11208-3	Pump 2 Flow Control Pressure Sensor Circuit High Input	Voltage: more than 4.8 V	Although speed normally returns to fast idle speed when a control lever is operated in ECO mode, engine speed is not increased in abnormal condition. Fast travel cannot be selected easily.	Check the harness. Replace the pump 2 control pressure sensor.
11208-4	Pump 2 Flow Control Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	Although speed normally returns to fast idle speed when a control lever is operated in ECO mode, engine speed is not increased in abnormal condition. Fast travel cannot be selected easily.	Check the harness. Replace the pump 2 control pressure sensor.

Pilot Failure

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11301-3	Swing Pilot Pressure Sensor Circuit High Input	Voltage: more than 4.8V	Swing speed becomes slow. Combined operation of swing, arm roll-in, and boom raise: Boom raise speed becomes slow and arm speed becomes fast. Swing alarm (optional) continues to sound.	Check the harness. Replace the swing pilot pressure sensor.
11301-4	Swing Pilot Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	Swing speed becomes slow. Combined operation of swing, arm roll-in, and boom raise: Boom raise speed becomes slow and arm speed becomes fast. Swing alarm (optional) continues to sound.	Check the harness. Replace the swing pilot pressure sensor.
11302-3	Boom Raise Pilot Pressure Sensor Circuit High Input	Voltage: more than 4.8 V	During boom raise operation, engine speed does not increase. Combined operation of swing, arm roll-in, and boom raise: Boom does not raise easily. Single operation of boom raise: Lifting force is weak.	Check the harness. Replace the boom raise pilot pressure sensor.
11302-4	Boom Raise Pilot Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	During boom raise operation, engine speed does not increase. Combined operation of swing, arm roll-in, and boom raise: Boom does not raise easily. Single operation of boom raise: Lifting force is weak.	Check the harness. Replace the boom raise pilot pressure sensor.
11303-3	Arm Roll-In Pilot Pressure Sensor Circuit High Input	Voltage: more than 4.8 V	During arm roll-in operation, engine speed does not increase. Arm speed becomes fast.	Check the harness. Replace the arm roll-in pilot pressure sensor.
11303-4	Arm Roll-In Pilot Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	During arm roll-in operation, engine speed does not increase. Arm speed becomes fast.	Check the harness. Replace the arm roll-in pilot pressure sensor.

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11304-3	Travel Pilot Pressure Sensor Circuit High Input	Voltage: more than 4.8 V	Machine travels slowly. When traveling, engine speed does not increase to the specification. When traveling, engine speed does not return from auto-idle speed. When traveling, engine speed does not return from ECO speed. Travel alarm (optional) continues to sound.	Check the harness. Replace the travel pilot pressure sensor.
11304-4	Travel Pilot Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	Machine travels slowly. When traveling, engine speed does not increase to the specification. When traveling, engine speed does not return from auto-idle speed. When traveling, engine speed does not return from ECO speed. Travel alarm (optional) continues to sound.	Check the harness. Replace the travel pilot pressure sensor.
11307-3	Front Pilot Pressure Sensor Circuit High Input	Voltage: more than 4.8 V	Front attachment operating speed is slow. When operating the front attachment, engine speed does not increase to the specification. When operating the front attachment, engine speed does not return from auto-idle speed. When operating the front attachment, engine speed does not return from ECO speed.	Check the harness. Replace the front pilot pressure sensor.
11307-4	Front Pilot Pressure Sensor Circuit Low Input	Voltage: less than 0.1 V	Front attachment operating speed is slow. When operating the front attachment, engine speed does not increase to the specification. When operating the front attachment, engine speed does not return from auto-idle speed. When operating the front attachment, engine speed does not return from ECO speed.	Check the harness. Replace the front pilot pressure sensor.

Proportional Solenoid Valve Failure

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11400-2	Pump 2 Flow Rate Limit P/S Valve Abnormal FB	Solenoid valve output: 140 mA or more, feedback current: More than 920 mA or less than 70 mA; both are detected.	Pump 2 flow rate cannot be controlled.	Check the harness.
11400-3	Pump 2 Flow Rate Limit P/S Valve FB High Current	Current: more than 920 mA	Pump 2 flow rate can be always controlled. Machine mistracks. Boom raise operation speed is slow. Arm operation speed is slow. Attachment operation speed is slow.	Check the harness.
11400-4	Pump 2 Flow Rate Limit P/S Valve FB Low Current	Current: less than 70 mA	Pump 2 flow rate cannot be controlled.	Check the harness.
11401-2	Torque P/S Valve Abnormal FB	Solenoid valve output: 140 mA or more, feedback current: More than 920 mA or less than 70 mA; both are detected.	Machine overall operation is slow.	Check the harness.
11401-3	Torque P/S Valve FB High Current	Current: more than 920 mA	The engine stalls is remarkable at high loaded. In addition, the engine lug-down is remarkable.	Check the harness.
11401-4	Torque P/S Valve FB Low Current	Current: less than 70 mA	Machine overall operation is slow.	Check the harness.
11402-2	Solenoid Valve Unit (SF) Abnormal FB	Solenoid valve output: 140 mA or more, feedback current: More than 920 mA or less than 70 mA; both are detected.	During digging operation: Arm operation speed is slow. (As deceleration rate is low, this state is not easy to find.)	Check the harness.
11402-3	Solenoid Valve Unit (SF) FB High Input	Current: more than 920 mA	Combined operation of arm roll-in and boom raise during precision operation: The boom raise operation is not smooth.	Check the harness.
11402-4	Solenoid Valve Unit (SF) FB Low Input	Current: less than 70 mA	During digging operation: Arm operation speed is slow. (As deceleration rate is low, this state is not easy to find.)	Check the harness.

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11403-2	Solenoid Valve Unit (SC) Abnormal FB	Solenoid valve output: 140 mA or more, feedback current: More than 920 mA or less than 70 mA; both are detected.	Arm operation speed becomes fast.	Check the harness.
11403-3	Solenoid Valve Unit (SC) FB High Input	Current: more than 920 mA	Arm operation speed becomes slow. Cylinder hesitation easily occurs during combined operation.	Check the harness.
11403-4	Solenoid Valve Unit (SC) FB Low Input	Current: less than 70 mA	Arm operation speed becomes fast.	Check the harness.
11407-2	Solenoid Valve Unit (SG) Abnormal FB	Solenoid valve output: 140 mA or more, feedback current: More than 920 mA or less than 70 mA; both are detected.	Pressure increasing is impossible. Travel: Slow speed	Check the harness.
11407-3	Solenoid Valve Unit (SG) FB High Input	Current: more than 920 mA	Pressure always increases. Travel: Fast speed	Check the harness.
11407-4	Solenoid Valve Unit (SG) FB Low Input	Current: less than 70 mA	Pressure increasing is impossible. Travel: Slow speed	Check the harness.

Other Failures

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11901-3	Hydraulic Oil Temperature Sensor Circuit High Input	Voltage: more than 4.35 V	When hydraulic oil temperature is less than 0 °C, the auto-warming up control is impossible.	Check the harness.
11901-4	Hydraulic Oil Temperature Sensor Circuit Low Input	Voltage: less than 0.1 V	When hydraulic oil temperature is less than 0 °C, the auto-warming up control is impossible.	Check the harness.

ECF Fault Code List

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11600-2	Abnormal EEPROM	Faulty ECF	-	Replace ECF.
11601-2	Abnormal RAM	Faulty ECF	-	Replace ECF.
11602-2	Abnormal A/D conversion	Faulty ECF	-	Replace ECF.
11603-3	Abnormal sensor voltage	Faulty ECF Faulty sensor Faulty harness	Although the engine control dial is operated, the engine speed does not change.	Check the sensor connected to ECF. Check the harness. Replace ECF.
11604-2	Abnormal CAN communication	Faulty ECF Faulty CAN harness	The machine movement is slow.	Check the CAN harness. Replace ECF.
16605-2	Abnormal engine speed (overrunning)	Engine speed: more than 4000 min^{-1}	The machine movement is slow. (During speed sensing, the torque is reduced.)	Check the harness. Replace the N sensor.
16606-3	Abnormal EC angle sensor high voltage	Voltage: more than 4.78 V	Engine learning fails. Engine learning is impossible.	Check the harness. Replace the EC sensor.
16606-4	Abnormal EC angle sensor low voltage	Voltage: less than 0.22 V	Engine learning fails. Engine learning is impossible.	Check the harness. Replace the EC sensor.
16607-2	Target engine speed sent from MC	Faulty harness	The engine speed is kept at the speed just before trouble. (Can communication is impossible.)	Check the harness.

Monitor Controller (Monitor) Fault Code List

Fault Code	Trouble	Cause	Remedy
13002-2	ECF Communication Error	Faulty monitor controller Faulty CAN0 harness	Check the CAN0 harness. Replace monitor controller.
13003-2	MC Communication Error 1	Faulty monitor controller Faulty CAN0 harness	Check the CAN0 harness. Replace monitor controller.
13004-2	MC Communication Error 2	Faulty monitor controller Faulty CAN1 harness	Check the CAN1 harness. Replace monitor controller.
13005-2	Monitor Controller (Information) Communication Error 1	Faulty monitor controller Faulty CAN0 harness	Check the CAN0 harness. Replace monitor controller.
13006-2	Monitor Controller (Information) Communication Error 2	Faulty monitor controller Faulty CAN1 harness	Check the CAN1 harness. Replace monitor controller.
13007-2	Wiper / Light Controller Communication Error	Faulty monitor controller Faulty CAN1 harness	Check the CAN1 harness. Replace monitor controller.

Fault Code	Trouble	Cause	Remedy
20100-2	Overheat Alarm	Coolant temperature is high while the engine runs.	Check the harness. Replace the coolant temperature sensor.
20101-2	Engine Warning Alarm	Faulty engine system	Refer to ECF fault code list.
20102-2	Engine Oil Pressure Alarm	Engine oil pressure is reduced.	Check the harness. Replace the engine oil pressure switch.
20103-2	Alternator Alarm	Voltage at the regulator is high. Voltage at the regulator is low with the engine stopped.	Check the harness. Check the battery. Check the alternator.
20104-2	Fuel Level Alarm	Fuel level is lowered.	Check the harness. Replace the fuel sensor.
20105-2	Hydraulic Oil Filter Restriction Alarm	Clogged hydraulic oil filter. Open circuit in harness.	Check the harness. Replace the hydraulic oil filter restriction switch.
20106-2	Air Cleaner Restriction Alarm	Clogged air cleaner.	Check the harness. Replace the air cleaner restriction switch.
20109-2	Pilot Control Shut-Off Lever Alarm	Faulty pilot shut-off switch.	Check the harness. Replace the pilot shut-off switch.
20113-2	System Error Alarm	Faulty CAN communication bus line.	Check the CAN harness.
20114-2	Overheat Alarm	Coolant temperature is high within ten seconds after the engine starts.	Check the harness. Replace the overheat switch.

Monitor Controller (Information) Fault Code List

Fault Code	Trouble	Cause	Remedy
14001-2	Flash Memory Read/ Write Error	The internal memory of monitor controller is abnormal.	After initializing the monitor controller (information) by using MPDr., retry the troubleshooting. If the fault code is displayed after retry, the monitor controller may be broken. Replace the monitor controller. When initializing the monitor controller (information), all stored data is deleted.
14002-2	External RAM Read/ Write Error	The internal memory of monitor controller is abnormal.	After initializing the monitor controller (information) by using MPDr., retry the troubleshooting. If the fault code is displayed after retry, the monitor controller may be broken. Replace the monitor controller. When initializing the monitor controller (information), all stored data is deleted.
14003-2	Abnormal EEPROM	The internal memory of monitor controller is abnormal.	Retry the troubleshooting by using MPDr. If the fault code is displayed after retry, the monitor controller may be broken. Replace the monitor controller.
14006-2	Communication Terminal : Communication Error	Communication error with communication equipment	Check the communication line, power line for communication terminal, and fuses. Then, retry the troubleshooting by using MPDr. If the fault code is displayed after retry, the communication equipment may be broken. Replace the communication equipment.
14008-2	Abnormal Internal RAM	The internal memory of monitor controller is abnormal.	Retry the troubleshooting by using MPDr. If the fault code is displayed after retry, the monitor controller may be broken. Replace the monitor controller.
14021-2	Communication Terminal Security Error	Security failure of mobile communication equipment	Check the communication line. Check the GPS antenna. In case the communication equipment has been replaced, it may be considered faulty. After disable the checking function for mobile phone number by security setting of MPDr., enable it again. Retry the troubleshooting by using MPDr. If the fault code is displayed after retry, the communication equipment may be broken. Replace the communication equipment.
14022-2	SIM Card Error	Abnormal SIM card in mobile communication equipment	Retry the troubleshooting by using MPDr. If the fault code is displayed after retry, the communication equipment may be broken. Replace the communication equipment.
14023-2	Security Error	Communication error with MC	Check the CAN1 harness. Retry the troubleshooting by using MPDr. If the fault code is displayed after retry, MC may be broken. Replace MC.

NOTE: Fault codes 14021-2 and 14022-2 are displayed if mobile communication terminal is equipped.

Air Conditioner Controller Fault Code List

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11	Open circuit in air circulation sensor	Voltage: more than 4.95 V	Y value (air flow-in temperature) cannot be adjusted in response to the set-temperature.	Check the harness. Replace the air circulation sensor.
12	Shorted circuit in air circulation sensor	Voltage: less than 0.3 V	Y value (air flow-in temperature) cannot be adjusted in response to the set-temperature.	Check the harness. Replace the air circulation sensor.
13	Open circuit in fresh air sensor	Voltage: more than 4.88 V	Operation is controlled under such circumstance as no fresh air sensor is provided.	Check the harness. Replace the fresh air sensor.
14	Shorted circuit in fresh air sensor	Voltage: less than 0.096 V	Operation is controlled under such circumstance as no fresh air sensor is provided.	Check the harness. Replace the fresh air sensor.
18	Shorted circuit in solar radiation sensor	Voltage: more than 5.04 V	Operation is controlled under such circumstance as no solar radiation sensor is provided.	Check the harness. Replace the solar radiation sensor.
21	Open circuit in evaporator sensor	Voltage: more than 4.79 V	Operation is controlled under such circumstance as the evaporator temperature is set to 10 °C (50 °F).	Check the harness. Replace the evaporator sensor.
22	Shorted circuit in evaporator sensor	Voltage: less than 0.096 V	Operation is controlled under such circumstance as the evaporator temperature is set to 10 °C (50 °F).	Check the harness. Replace the evaporator sensor.
43	Abnormal air vent damper	Shorted circuit: Voltage: 0 V Open circuit: Voltage: more than 5 V	Air vent damper servo motor becomes inoperable.	Check the harness. Replace the air vent damper servo motor.
44	Abnormal air mix damper	Shorted circuit: Voltage: less than 0.2 V Open circuit: Voltage: more than 4.8 V	Air mix damper servo motor becomes inoperable.	Check the harness. Replace the air vent damper servo motor.
51	Abnormal high/low refrigerant pressure	Voltage: 0 V	The compressor clutch is disengaged. (The compressor stops.)	Check the harness. Replace the high/low pressure switch.
91	CAN communication error	Faulty CAN1 harness between monitor controller and air conditioner controller	Air conditioner stops.	Check the CAN1 harness. Replace air conditioner controller.
92	CAN bus off error	Faulty air conditioner controller Faulty CAN1 harness	Air conditioner stops.	Check the CAN1 harness. Replace air conditioner controller.

Communication Terminal Fault Code List

Fault Code	Trouble	Cause	Remedy
14100-2	Communication Terminal: Abnormal EEPROM	The internal memory of satellite communication terminal (optional) is abnormal.	Replace the controller (satellite communication terminal).
14101-2	Communication Terminal: Abnormal IB/OB Queue	The internal memory of satellite communication terminal (optional) is abnormal.	Replace the controller (satellite communication terminal).
14102-2	Communication Terminal: Abnormal Local Loop Back	Abnormality is detected on communication test with the satellite.	Check the communication antenna for satellite.
14103-2	Communication Terminal: No Satellite Found	Satellite can not be caught.	Check the communication antenna for satellite.
14104-2	Communication Terminal: Remote Loop Back Error 1	Abnormality is detected on communication test with the satellite and base station.	Replace the controller (satellite communication terminal).
14105-2	Communication Terminal: Remote Loop Back Error 2	Abnormality is detected on communication test with the satellite and base station.	Replace the controller (satellite communication terminal).
14106-2	Communication Terminal: Transmission/Receiving Data Unmatched	Transmission/receiving data with the satellite is unmatched.	Replace the controller (satellite communication terminal).
14107-2	Communication Terminal: Abnormal GSM Module	Abnormal mobile communication equipment	Replace the controller (mobile communication terminal).

NOTE: Fault codes 14100-2 to 14106-2 are satellite communication terminal. Fault code 14107-2 is mobile communication terminal.

MC Fault Codes 11000 to 11002

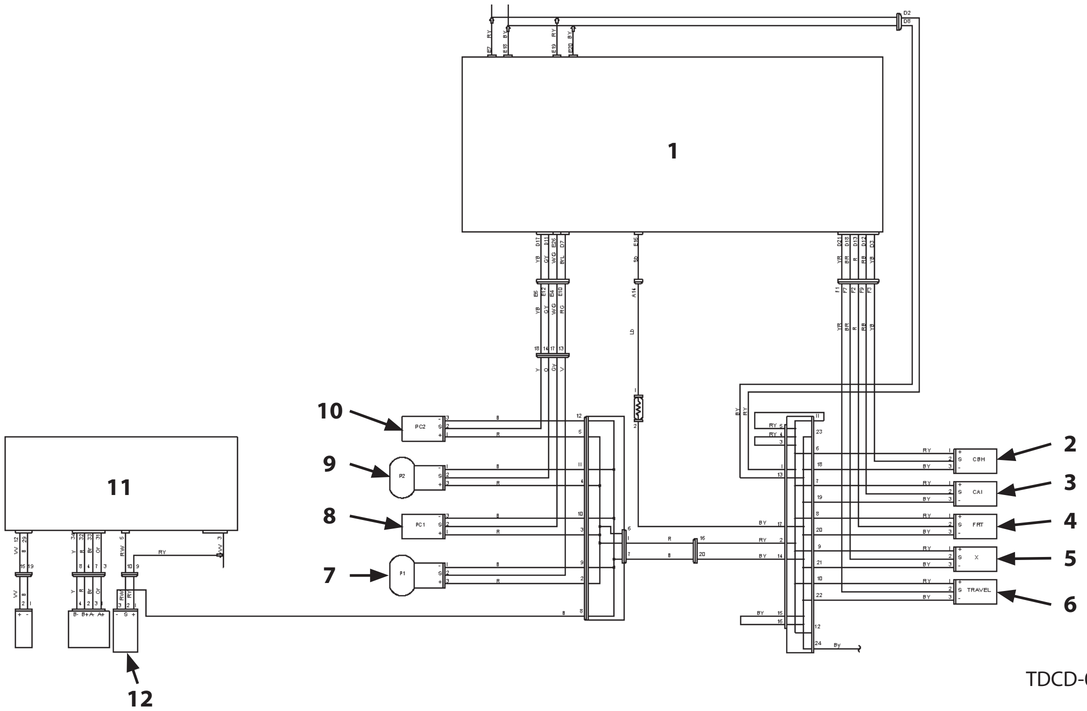
Fault Code	Trouble	Cause
11000-2	Abnormal EEPROM	Faulty MC
11001-2	Abnormal RAM	Faulty MC
11002-2	Abnormal A/D Converter	Faulty MC

NOTE: Even if the engine and the machine is operated normally with the fault code displayed after retrial, the machine can be operated as it is.

MC Fault Code 11003
ECF Fault Code 16603

IMPORTANT: When fault codes 11003-3 and 16603-3 (Abnormal Sensor Voltage) are displayed with other fault code, diagnose on fault codes 11003-3 and 16603-3 first.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11003-3 16603-3	Abnormal Sensor Voltage	Disconnect connectors from all sensors and switch panel. Retry the troubleshooting by using MPDr.	Fault codes 11003-3 and 16603-3 are not displayed.	Faulty sensor
		Measure voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		Check shorted circuit in harness between sensor harness end #1 and #3.	0 Ω	Shorted circuit in harness #1 and #3.
		-	Normal in above check.	Faulty controller

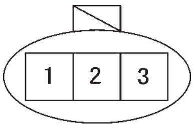


TDCD-05-06-001

1- MC
2- Pressure Sensor (Boom Raise)
3- Pressure Sensor (Arm Roll-In)
4- Pressure Sensor (Front Attachment)
5- Pressure Sensor (Swing)
6- Pressure Sensor (Travel)
7- Pump 1 Delivery Pressure Sensor
8- Pump 1 Control Pressure Sensor
9- Pump 2 Delivery Pressure Sensor
10- Pump 2 Control Pressure Sensor
11- ECF
12- EC Sensor

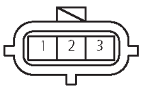
Connector (Harness end of connector viewed from the open end side)

- Pressure Sensor (Boom Raise)
- Pressure Sensor (Arm Roll-In)
- Pressure Sensor (Swing)
- Pressure Sensor (Travel)
- Pressure Sensor (Front Attachment)
- Pressure Sensor (Auxiliary) (Optional)
- Pump 1 Control Pressure Sensor
- Pump 2 Control Pressure Sensor



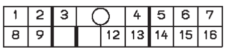
T6LE-05-05-011

- Pump 1 Delivery Pressure Sensor
- Pump 2 Delivery Pressure Sensor



TDCD-05-06-008

- Switch Panel
  (Engine Control Dial)



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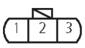
- EC Sensor



TDCD-05-06-009

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MC Fault Codes 11006, 11007,11009
ECF Fault Code 16604
Monitor Controller (Monitor) Fault Codes 13002, 13003, 13005

Preparation

- Check the wiring connections first.
- Check the CAN0 harness between the controllers.
  (Refer to CAN0 Harness Check on T5-6-24 to 26.)

Fault Code	Trouble	Inspection Method	Cause
11006-2	Engine Controller Communication Error	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
11007-2	Monitor Controller (Information) Communication Error 1 (CAN0)	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
11009-2	Monitor Controller (Monitor) Communication Error 1 (CAN0)	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
16604-2	CAN Communication Error	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
13002-2	ECF Communication Error	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
13003-2	MC Communication Error	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
13005-2	Monitor Controller (Information) Communication Error 1	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.

CAN0 Harness Check

Preparation

- Check the terminal of each controller in the table below according to the inspection.
- Before continuity check, set the key switch to the OFF position.

Evaluation

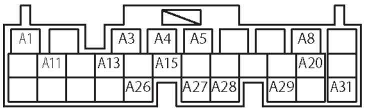
	Continuity (0 Ω)	Discontinuity (∞ Ω)
Continuity check (open circuit)	Correct	Discontinuity
Discontinuity check (shorted circuit)	Shorted circuit	Correct

Inspection	CAN Harness	MC	ECF	Monitor Controller
Continuity check between MC and each controller	High side	#A28	#10	#A24
	Low side	#A29	#27	#A23
Discontinuity check between CAN circuit and ground circuit in each controller	High side	#A28-#E1	#10-#2	#A24-#A22
		#A28-#E2	#10-#15	#A24-#B35
		#A28-#D1	-	#A24-#B36
		#A28-#E5	-	-
		#A28-#E6	-	-
	Low side	#A29-#E1	#27-#2	#A23-#A22
		#A29-#E2	#27-#15	#A23-#B35
		#A29-#D1	-	#A23-#B36
		#A29-#E5	-	-
		#A29-#E6	-	-

Inspection	CAN Harness	MC	ECF	Monitor Controller
Discontinuity check between CAN circuit and power circuit in each controller	High side	#A28-#E3	#10-#1	#A24-#B17
		#A28-#E4	#10-#17	#A24-#B18
		#A28-#D2	-	-
		#A28-#D5	-	-
		#A28-#D6	-	-
	Low side	#A29-#E3	#27-#1	#A23-#B17
		#A29-#E4	#27-#17	#A23-#B18
		#A29-#D2	-	-
		#A29-#D5	-	-
		#A29-#D6	-	-
Discontinuity check between CAN circuit and key signal circuit in each controller	High side	#A28-#E10	#10-#18	#A24-#A16
	Low side	#A29-#E10	#27-#18	#A23-#A16
Discontinuity check between CAN (High side) circuit and CAN (Low side) circuit in each controller	-	#A28-#A29	#10-#27	#A24-#A23

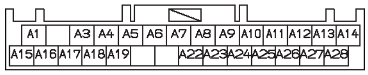
Connector (Harness end)

・ MC-A Connector



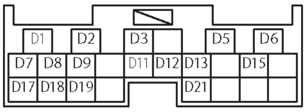
TDCD-05-06-006

・ Monitor Controller-A Connector



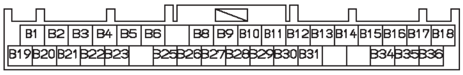
TDAB-05-06-011

・ MC-D Connector



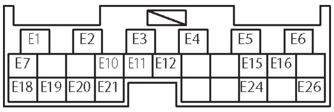
TDCD-05-06-002

・ Monitor Controller-B Connector



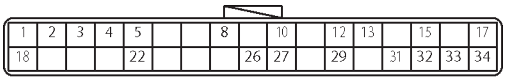
TDAB-05-06-012

・ MC-E Connector



TDCD-05-06-003

・ ECF Connector



TDCD-05-06-007

MC Fault Codes 11008, 11010

Monitor Controller (Monitor) Fault Codes 13004, 13006, 13007

Preparation

- Check the wiring connections first.
- Check the CAN1 harness between the controllers.
  (Refer to CAN1 Harness Check on T5-6-28 to 30.)

Fault Code	Trouble	Inspection Method	Cause
11008-2	Monitor Controller (Information) Communication Error 2 (CAN1)	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
11010-2	Monitor Controller (Monitor) Communication Error 2 (CAN1)	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
13004-2	MC Communication Error 2	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
13006-2	Monitor Controller (Information) Communication Error 2	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.
13007-2	Wiper/Light Controller Communication Error 2	Continuity check (open circuit)	Open circuit in harness.
		Discontinuity check (shorted circuit)	Shorted circuit in harness.

CAN1 Harness Check

Preparation

- Check the terminal of each controller in the table below according to the inspection.
- Before continuity check, set the key switch to the OFF position.

Evaluation

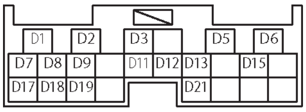
	Continuity (0 Ω)	Discontinuity (∞ Ω)
Continuity check (open circuit)	Correct	Open circuit
Discontinuity check (shorted circuit)	Shorted circuit	Correct

Inspection	CAN Harness	MC	Monitor Controller	Wiper/ Light Controller	Radio	A/C
Continuity check between MC and each controller	High side	#E15	#A26	#B1	#4	#9(A/C2)
	Low side	#E24	#A25	#B11	#12	#10(A/C2)
Discontinuity check between CAN circuit and ground circuit in each controller	High side	#E15-#E1	#A26-#A22	#B1-#A8	#4-#15	#9(A/C2)-#1(A/C1)
		#E15-#E2	#A26-#B35	-	-	-
		#E15-#D1	#A26-#B36	-	-	-
		#E15-#E5	-	-	-	-
		#E15-#E6	-	-	-	-
	Low side	#E24-#E1	#A25-#A22	#B11-#A8	#12-#15	#10(A/C2)-#1(A/C1)
		#E24-#E2	#A25-#B35	-	-	-
		#E24-#D1	#A25-#B36	-	-	-
		#E24-#E5	-	-	-	-
		#E24-#E6	-	-	-	-

Inspection	CAN Harness	MC	Monitor Controller	Wiper/ Light Controller	Radio	A/C
Discontinuity check between CAN circuit and power circuit in each controller	High side	#E15-#E3	#A26-#B17	#B1-#A4	#4-#8	#9(A/C2)-#2(A/C1)
		#E15-#E4	#A26-#B18	-	-	#9(A/C2)-#3(A/C1)
		#E15-#D2	-	-	-	-
		#E15-#D5	-	-	-	-
		#E15-#D6	-	-	-	-
	Low side	#E24-#E3	#A25-#B17	#B11-#A4	#12-#8	#10(A/C2)-#2(A/C1)
		#E24-#E4	#A25-#B18	-	-	#10(A/C2)-#3(A/C1)
		#E24-#D2	-	-	-	-
		#E24-#D5	-	-	-	-
		#E24-#D6	-	-	-	-
Discontinuity check between CAN circuit and key signal circuit in each controller	High side	#E15-#E10	#A26-#A16	#B1-#B19	#4-#16	#9(A/C2)-#4(A/C1)
	Low side	#E24-#E10	#A25-#A16	#B11-#B19	#12-#16	#10(A/C2)-#4(A/C1)
Discontinuity check between CAN (High side) circuit and CAN (Low side) circuit in each controller	-	#E15-#E24	#A26-#A25	#B1-#B11	#4-#12	#9(A/C2)-#10(A/C2)

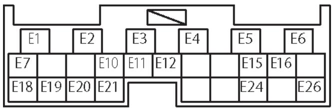
Connector (Harness end)

- MC-D Connector



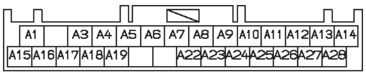
TDCD-05-06-002

- MC-E Connector



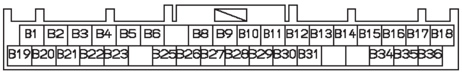
TDCD-05-06-003

- Monitor Controller-A Connector



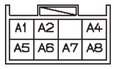
TDAB-05-06-011

- Monitor Controller-B Connector



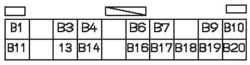
TDAB-05-06-012

- Wiper/ Light Controller-A Connector



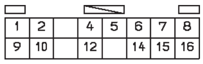
TDAB-05-06-018

- Wiper/ Light Controller-B Connector



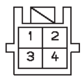
TDAB-05-06-019

- Radio Connector



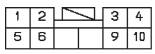
TDAB-05-06-010

- A/C1 Connector



TDAB-05-06-008

- A/C2 Connector



TDAB-05-06-009

MC Fault Code 11100

Preparation

・ Check the wiring connections first.
・ The actual engine speed which ECF sends by using the CAN bus line is abnormal. Diagnose ECF.

Fault Code	Trouble	Cause
11100-2	Abnormal Engine Speed	Engine speed: 4000 min^{-1} or more

MC Fault Code 11101

Preparation

- Check the wiring connections first.

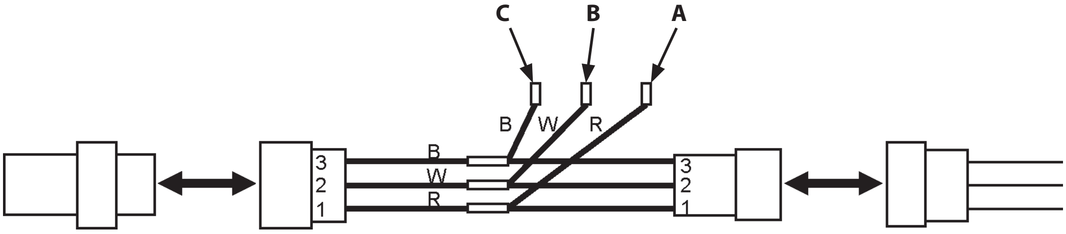
Fault Code	Trouble	Inspection Method	Evaluation	Cause
11101-3	Engine Control Dial Sensor Circuit High Input	Measurement of resistance between switch panel end #1 and #2	0 Ω	Faulty engine control dial.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11101-4	Engine Control Dial Sensor Circuit Low Input	Measurement of resistance between switch panel end #1 and #2	∞ Ω	Faulty engine control dial.
		Measurement of voltage between switch panel harness end #1 and body	0 V	Open circuit in harness #1.
		Measurement of voltage between switch panel harness end #1 and #3	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.

MC Fault Codes 11200, 11202

Preparation

- Check the wiring connections first.
- Connect the test harness (ST 6701) and dummy sensor equivalent to #4436271.
- Before inspection, set the key switch to the ON position.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11200-3	Pump 1 Delivery Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11200-4	Pump 1 Delivery Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.
11202-3	Pump 2 Delivery Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11202-4	Pump 2 Delivery Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.



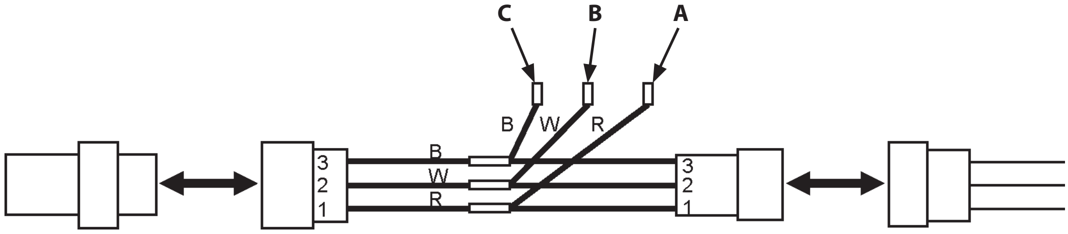
TDAA-05-06-003

MC Fault Codes 11206, 11208

Preparation

- Check the wiring connections first.
- Connect the test harness (ST 6703) and dummy sensor equivalent to #4436536.
- Before inspection, set the key switch to the ON position.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11206-3	Pump 1 Flow Control Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11206-4	Pump 1 Flow Control Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.
11208-3	Pump 2 Flow Control Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11208-4	Pump 2 Flow Control Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.



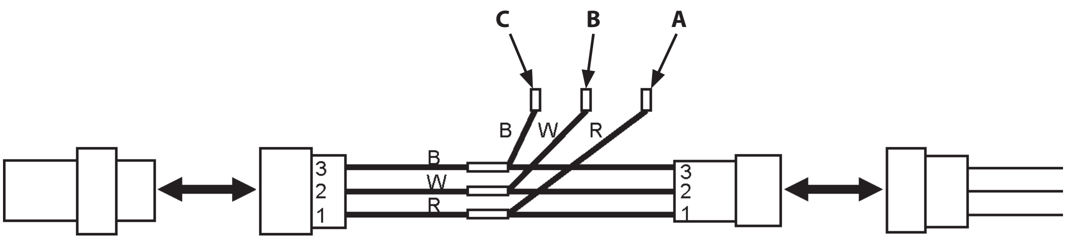
TDAA-05-06-003

MC Fault Codes 11301 to 11303

Preparation

- Check the wiring connections first.
- Connect the test harness (ST 6703) and dummy sensor equivalent to #4436535.
- Before inspection, set the key switch to the ON position.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11301-3	Swing Pilot Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11301-4	Swing Pilot Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.
11302-3	Boom Raise Pilot Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11302-4	Boom Raise Pilot Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.
11303-3	Arm Roll-In Pilot Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11303-4	Arm Roll-In Pilot Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
			Normal in above check.	Open circuit in harness #2.



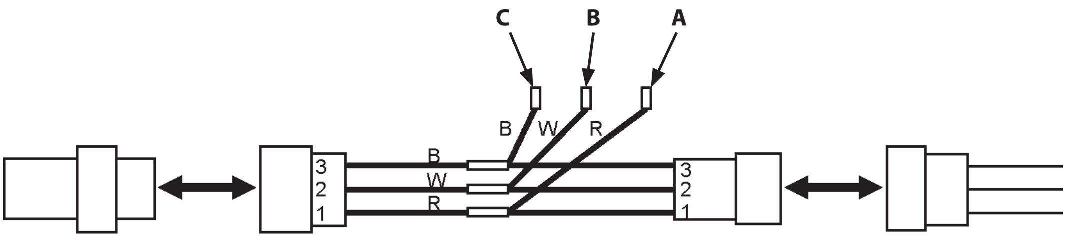
TDAA-05-06-003

MC Fault Codes 11304, 11307

Preparation

- Check the wiring connections first.
- Connect the test harness (ST 6703) and dummy sensor equivalent to #4436535.
- Before inspection, set the key switch to the ON position.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11304-3	Travel Pilot Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11304-4	Travel Pilot Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.
11307-3	Front Pilot Pressure Sensor Circuit High Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between B and body	Voltage: more than 4.5 V	Shorted circuit in harness #1 and #2.
11307-4	Front Pilot Pressure Sensor Circuit Low Input	Retry by using MPDr.	Un-displayed fault code	Faulty sensor.
		Measurement of voltage between A and body	0 V	Open circuit in harness #1.
		Measurement of voltage between A and C (GND)	0 V	Open circuit in harness #3.
			Normal in above check.	Open circuit in harness #2.



TDAA-05-06-003

MC Fault Code 11400

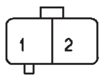
Preparation

- Check the wiring connections first.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11400-2	Pump 2 Flow Rate Limit P/S Valve Abnormal FB	Measurement of resistance between solenoid valve #1 and #2	0 / ∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Pump 2 Flow Rate Limit P/S Valve Output FB.	0 mA	Open circuit in harness #2.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11400-3	Pump 2 Flow Rate Limit P/S Valve FB High Current	Measurement of resistance between solenoid valve #1 and #2	0 Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11400-4	Pump 2 Flow Rate Limit P/S Valve FB Low Current	Measurement of resistance between solenoid valve #1 and #2	∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Pump 2 Flow Rate Limit P/S Valve Output FB.	0 mA	Open circuit in harness #2.

Connector (Harness end)

- Solenoid Valve Connector



T1V1-05-04-003

MC Fault Code 11401

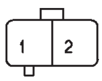
Preparation

- Check the wiring connections first.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11401-2	Torque P/S Valve Abnormal FB	Measurement of resistance between solenoid valve #1 and #2	0 / ∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Pumps 1 and 2 Torque Control P/S Valve Output FB.	0 mA	Open circuit in harness #2.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11401-3	Torque P/S Valve FB High Current	Measurement of resistance between solenoid valve #1 and #2	0 Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11401-4	Torque P/S Valve FB Low Current	Measurement of resistance between solenoid valve #1 and #2	∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Pumps 1 and 2 Torque Control P/S Valve Output FB.	0 mA	Open circuit in harness #2.

Connector (Harness end)

- Solenoid Valve Connector



T1V1-05-04-003

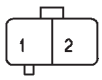
MC Fault Code 11402

Preparation

- Check the wiring connections first.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11402-2	Solenoid Valve Unit (SF) Abnormal FB	Measurement of resistance between solenoid valve #1 and #2	0 / ∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Digging Regeneration P/S Valve Output FB.	0 mA	Open circuit in harness #2.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11402-3	Solenoid Valve Unit (SF) FB High Input	Measurement of resistance between solenoid valve #1 and #2	0 Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11402-4	Solenoid Valve Unit (SF) FB Low Input	Measurement of resistance between solenoid valve #1 and #2	∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Digging Regeneration P/S Valve Output FB.	0 mA	Open circuit in harness #2.

Connector (Harness end)
- Solenoid Valve Connector



T1V1-05-04-003

MC Fault Code 11403

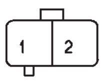
Preparation

- Check the wiring connections first.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11403-2	Solenoid Valve Unit (SC) Abnormal FB	Measurement of resistance between solenoid valve #1 and #2	0 / ∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Arm Regeneration P/S Valve Output FB.	0 mA	Open circuit in harness #2.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11403-3	Solenoid Valve Unit (SC) FB High Input	Measurement of resistance between solenoid valve #1 and #2	0 Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11403-4	Solenoid Valve Unit (SC) FB Low Input	Measurement of resistance between solenoid valve #1 and #2	∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Arm Regeneration P/S Valve Output FB.	0 mA	Open circuit in harness #2.

Connector (Harness end)

- Solenoid Valve Connector



T1V1-05-04-003

MC Fault Code 11407

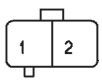
Preparation

- Check the wiring connections first.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11407-2	Solenoid Valve Unit (SG) Abnormal FB	Measurement of resistance between solenoid valve #1 and #2	0 / ∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Pressure Increase (Power Digging & Fast Travel Mode) P/S Valve Output FB.	0 mA	Open circuit in harness #2.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11407-3	Solenoid Valve Unit (SG) FB High Input	Measurement of resistance between solenoid valve #1 and #2	0 Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
11407-4	Solenoid Valve Unit (SG) FB Low Input	Measurement of resistance between solenoid valve #1 and #2	∞ Ω (Normal value: 22 Ω)	Faulty solenoid valve.
		Measurement of voltage between solenoid valve harness end #1 and body	0 V	Open circuit in harness #1.
		Monitor Pressure Increase (Power Digging & Fast Travel Mode) P/S Valve Output FB.	0 mA	Open circuit in harness #2.

Connector (Harness end)

- Solenoid Valve Connector



T1V1-05-04-003

MC Fault Code 11901

Preparation

- Check the wiring connections first.

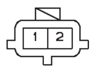
Fault Code	Trouble	Inspection Method	Evaluation	Cause
11901-3	Hydraulic Oil Temperature Sensor Circuit High Input	Measurement of resistance between sensor #1 and #2	Refer to the table.	Faulty sensor.
		-	Normal in above check.	Shorted circuit in harness #1.
11901-4	Hydraulic Oil Temperature Sensor Circuit Low Input	Measurement of resistance between sensor #1 and #2	Refer to the table.	Faulty sensor.
		Measure voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		-	Normal in above check.	Open circuit in harness #2.

Specification of Hydraulic Oil Temperature Sensor

Hydraulic Oil Temperature (°C)	Resistance (kΩ)
-30	(24.5)
-20	$15.04^{+1.29}_{-1.20}$
-10	(9.16)
0	(5.74)
10	(3.70)
20	$2.45^{+0.14}_{-0.13}$
30	(1.66)
40	(1.15)
50	(0.811)
60	(0.584)
70	(0.428)
80	0.318±0.008
90	(0.240)
100	(0.1836)
110	0.1417±0.0018
120	(0.1108)

Connector (Harness end)

- Hydraulic Oil Temperature Sensor



TDAB-05-06-023

ECF Fault Codes 16600 to 16602

Fault Code	Trouble	Cause
16600-2	Abnormal EEPROM	Faulty ECF
16601-2	Abnormal RAM	Faulty ECF
16602-2	Abnormal A/D Converter	Faulty ECF

NOTE: Even if the engine and the machine is operated normally with the fault code displayed after retrial, the machine can be operated as it is.

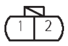
ECF Fault Code 16605

Preparation

・ Check the wiring connections first.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
16605-2	Abnormal engine speed (overrunning)	Measurement of resistance between sensor #1 and #2.	0 / ∞ Ω (Normal value: 810±240 Ω)	Faulty N sensor.
		-	Normal in above check.	Open or shorted circuit in harness #1 and #2.

Connector (Harness end)



TDCD-05-06-010

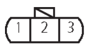
ECF Fault Code 16606

Preparation

・ Check the wiring connections first.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
16606-3	Abnormal EC angle sensor high voltage	Measurement of resistance between sensor #1 and #2.	0 / ∞ Ω (Normal value: 2.0±0.4 kΩ)	Faulty EC sensor.
			Normal in above check.	Shorted circuit in harness #1 and #2.
16606-4	Abnormal EC angle sensor low voltage	Measurement of resistance between sensor #1 and #2.	0 / ∞ Ω (Normal value: 2.0±0.4 kΩ)	Faulty EC sensor.
		Measurement of voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		Measurement of voltage between sensor harness end #1 and #3.	0 V	Open circuit in harness #3.
		-	Normal in above check.	Open circuit in harness #2.

Connector (Harness end)



TDCD-05-06-009

Air Conditioner Controller Fault Codes 11 to 22

Preparation

- Check the wiring connections first.
- Before inspection, set the key switch to the ON position.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11	Open circuit in air circulation sensor	Measurement of resistance between sensor #1 and #2.	∞ Ω (Normal value: 300 to 430 kΩ)	Faulty sensor.
		Measurement of voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		-	Normal in above check.	Open circuit in harness #2.
12	Shorted circuit in air circulation sensor	Measurement of resistance between sensor #1 and #2.	0 Ω (Normal value: 300 to 430 kΩ)	Faulty sensor.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
13	Open circuit in fresh air sensor	Measurement of resistance between sensor #1 and #2.	∞ Ω (Normal value: 100 to 210 kΩ)	Faulty sensor.
		Measurement of voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		-	Normal in above check.	Open circuit in harness #2.
14	Shorted circuit in fresh air sensor	Measurement of resistance between sensor #1 and #2.	0 Ω (Normal value: 100 to 210 kΩ)	Faulty sensor.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
18	Shorted circuit in solar radiation sensor	Continuity check between sensor harness end #1 and #2.	0 Ω	Shorted circuit in harness #1 and #2.
		-	Normal in above check.	Faulty sensor.
21	Open circuit in evaporator sensor	Measurement of resistance between sensor #1 and #2.	∞ Ω (Normal value: 100 to 115 kΩ)	Faulty sensor.
		Measurement of voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		-	Normal in above check.	Open circuit in harness #2.
22	Shorted circuit in evaporator sensor	Measurement of resistance between sensor #1 and #2.	0 Ω (Normal value: 100 to 115 kΩ)	Faulty sensor.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.

Air Conditioner Controller Fault Codes 43 to 92

Preparation

- Check the wiring connections first.
- Before inspection, set the key switch to the ON position.

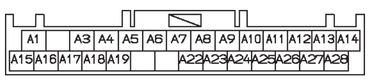
Fault Code	Trouble	Inspection Method	Evaluation	Cause
43	Abnormal air vent damper servo motor	Measurement of voltage between air vent damper harness end 7C and body. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and air vent damper servo motor.
		Measurement of voltage between air vent damper harness end 7C and 25D. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and air vent damper.
		-	Normal in above check.	Faulty air vent damper.
44	Abnormal air mix damper servo motor	Measurement of voltage between air mix damper harness end 7D and body. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and air mix damper servo motor.
		Measurement of voltage between air mix damper harness end 7D and 25E. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and air mix damper.
		-	Normal in above check.	Faulty air mix damper servo motor.
51	Abnormal high/ low refrigerant pressure	Measurement of voltage between high/low pressure switch harness end A21 and A05. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and high/low pressure switch.
		-	Normal in above check.	Faulty high/low pressure switch.
91	CAN communication error	Continuity check in CAN1 harness.	Normal	Faulty controller.
			Abnormal	Faulty CAN1 harness.
92	CAN bus off error	Continuity check in CAN1 harness.	Normal	Faulty controller.
			Abnormal	Faulty CAN1 harness.

Monitor Controller (Monitor) Fault Codes 20100 to 20106

Fault Code	Trouble	Inspection Method	Evaluation	Cause
20100-2	Overheat Alarm	Disconnect a connector from the coolant temperature sensor. Retry by using MPDr.	Displayed fault code	Faulty monitor controller or shorted circuit in harness.
			Un-displayed fault code	Faulty coolant temperature sensor.
20101-2	Engine Trouble Alarm	Diagnose on fault codes of ECF.	-	-
20102-2	Engine Oil Pressure Alarm	Disconnect a connector from the engine oil pressure switch. Retry by using MPDr.	Displayed fault code	Faulty monitor controller or shorted circuit in harness.
			Un-displayed fault code	Faulty engine oil pressure switch.
20103-2	Alternator Alarm	Measurement of voltage between monitor controller harness end #A15 and body	13 V to 33.5 V	Faulty monitor controller.
		Measurement of voltage at alternator terminal L	13 V to 33.5 V	Open circuit in harness.
		-	Normal in above check.	Faulty alternator.
20104-2	Fuel Level Alarm	Disconnect a connector from the fuel sensor. Retry by using MPDr.	Displayed fault code	Faulty monitor controller or shorted circuit in harness.
			Un-displayed fault code	Faulty fuel sensor.
20105-2	Hydraulic Oil Filter Restriction Alarm	Disconnect a connector from hydraulic oil filter restriction switch. Retry by using MPDr.	Displayed fault code	Faulty monitor controller or shorted circuit in harness.
			Un-displayed fault code	Faulty hydraulic oil filter restriction switch.
20106-2	Air Cleaner Restriction Alarm	Disconnect a connector from air cleaner restriction switch. Retry by using MPDr.	Displayed fault code	Faulty monitor controller or shorted circuit in harness.
			Un-displayed fault code	Faulty air cleaner restriction switch.

Connector (Harness end)

- Monitor Controller-A Connector



TDAB-05-06-011

Monitor Controller (Monitor) Fault Codes 20109, 20113, 20114

Fault Code	Trouble	Inspection Method	Evaluation	Cause
20109-2	Pilot Control Shut-Off Lever Alarm	Check of the pilot shut-off switch	Correct	Faulty harness.
			Incorrect	Faulty pilot shut-off switch.
20113-2	System Failure Alarm	Check of CAN Harness	-	Faulty CAN harness.
20114-2	Overheat Alarm	Disconnect a connector from the coolant temperature sensor. Retry by using MPDr.	Displayed fault code	Faulty monitor controller or shorted circuit in harness.
			Un-displayed fault code	Faulty coolant temperature sensor.

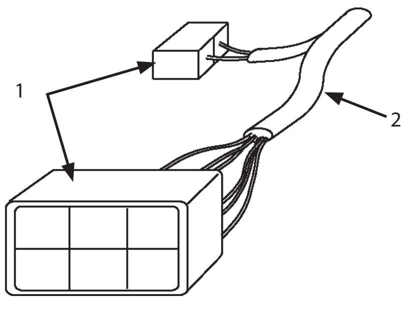
(Blank)

Troubleshooting B (Machine Diagnosis by Using Troubleshooting Symptom) Procedure

Refer to troubleshooting B procedures for diagnosis by using trouble symptom when no fault codes are displayed.

- Diagnosis Procedure
  - The diagnosis procedures for the displayed fault codes are explained in this group.
  - Perform diagnosis by using MPDr. or the service menu of monitor first.
  - In case any fault code has not been displayed by diagnosis, perform inspection according to the procedures when diagnosing.
  - When the fault code is displayed, refer to the troubleshooting A group and diagnose.
  - On the front section pages of this group, there are the tables indicating the relationship between machine trouble symptoms and related parts which may cause such trouble if failed. Start the troubleshooting with more probable causes selected by referring to these tables.

NOTE: Harness end connector viewed from the open end side by the all connectors image shown in this section.



T6L4-05-03-001

1- Harness End Connector 2- Harness

Contents of Diagnosis

Trouble Symptom

Preparation

Viewpoints for a diagnosis and contents needing inspection beforehand are explained.

How to Read Table

Procedure	Inspection Method	Condition	Evaluation	Cause
(A)	(B)	(C)	(D)	(E)
(F)	(G)	(H)	(I)	(J)

- A, F: Inspection order
- B, G: Inspection method for trouble cause
- C, H: Conditions for inspection
- D, I: Evaluation specification of check results
- E, J: Trouble cause for trouble symptom

Procedure:

1. Perform inspection according to Inspection Method (B) and Condition (C) of Procedure (A).
2. In case the results are applied to Evaluation (D), the trouble cause becomes Cause (E).

   In case the results are not applied to Evaluation (D), go to the next procedure, Procedure (F).

Relationship between Machine Trouble Symptoms and Related Parts

This table indicates the relationship between machine trouble symptoms and the potential problem parts, which may cause trouble if failed, and the evaluation methods of these components.

Parts / Item	MC (Main Controller)	Engine Control Dial	Auto-Idle Switch
Function	Controls engine, pump, and valve operation.	Instructs engine target speed.	Activates auto-idle control. ON: 0 V→Auto-idle control is operated. OFF: 5 V→Auto-idle control is not operated.
Symptoms in control system when trouble occurs	Depending on trouble situations, control system malfunction may differ. (The following symptoms in machine operation indicates that MC logic circuit has failed.)	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	Even if engine starts, engine speed remains in idle speed. As pump displacement is held at minimum, all actuator speeds are slow.	Trouble condition with the key switch ON: The engine speed is kept at slow idle speed. Trouble condition during operation: The engine speed is kept at the speed immediately before trouble.	Open circuit: Auto-idle is not operated. Shorted circuit: Even if auto-idle switch is in OFF position, auto-idle control is always operated.
Evaluation by Fault Code	11000, 11001, 11002, 11003	11101	-
Evaluation by Monitoring	-	MC: Demand Engine Speed ECF: Directed Engine Speed	MC: Auto-Idle Switch
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Item \ Parts	Power Mode Switch (ECO Mode)	Travel Mode Switch	Power Digging Switch
Function	Shifts power mode switch to ECO mode. ON: 0 V OFF: 5 V	Shifts solenoid valve unit (SG) and changes travel speed.	Shifts solenoid valve unit (SG) and activates power digging. ON: 0 V→Increasing pressure OFF: 5 V→Not increasing pressure
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	Open circuit: Even if ECO mode is selected, engine speed does not decrease with the control lever in neutral. Shorted circuit: Even if power mode switch is set to PWR from ECO with the control lever in neutral and the engine control dial in fast idle position, engine speed does not increase.	Open circuit: Travel speed remains unchanged in slow speed. Shorted circuit: Even if travel mode switch is in slow speed position, machine travels at fast speed.	Open circuit: Pressure does not increase. Shorted circuit: Pressure increase only for 8 seconds after the key switch is turned ON.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	MC: Power Mode Switch	MC: Travel Mode SW	MC: Power Boost Switch
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Item \ Parts	Pilot Shut-Off Switch (Pilot Shut-Off Lever)	Learning Switch	Pilot Shut-Off Solenoid Valve
Function	Shifts pilot shut-off solenoid valve.	Starts engine learning. ON: 0 V→Learning OFF: 5 V→Normal control	Opens and closes pilot circuit.
Symptoms in control system when trouble occurs	Same as shown below	Engine learning cannot be performed.	Same as shown below
Symptoms in machine operation when trouble occurs	Open circuit: Pilot shout-off switch is always OFF. Pilot shut-off solenoid valve is not shifted. Even if lever is operated with pilot shut-off lever in UNLOCK position, all actuator are not operated. Shorted circuit: Pilot shout-off switch is always ON. Engine does not start. If shorted circuit occurs while running engine, operate lever with pilot shut-off lever in LOCK position so that actuator is operated.	Machine will operate normally if problem is caused by open circuit or discontinuity of switch. (Only learning cannot be performed.) If shorted circuit occurs, learning mode operation starts. Therefore, engine will stall at 2 or 20 seconds after engine starts.	When closed: All actuators are not operated. (Pilot pressure oil is not supplied to pilot valve.) When open: Pilot pressure oil is always supplied to pilot valve.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	MC: PCSL Lever Switch	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T2-5	T2-2	T2-5

Item \ Parts	Hydraulic Oil Temperature Sensor	EC Motor	EC Sensor
Function	Monitors hydraulic oil temperature.	Moves governor lever.	Detects governor lever position. Detects minimum governor speed position (2.5 V) only when key switch is turned ON. Detects minimum and maximum speed position during engine learning control.
Symptoms in control system when trouble occurs	MC recognizes that hydraulic oil temperature is 120 °C when open circuit occurs. (Hydraulic oil temperature: 120 °C is not displayed on monitoring.)	Governor lever is not operated.	Engine speed is controlled based on idle position set when key switch is turned ON. Therefore, engine speed is always controlled with error in idle position setting if set incorrectly.
Symptoms in machine operation when trouble occurs	When hydraulic oil temperature is 0 °C or less when starting engine, auto-warming up control is not operated and engine runs at slow idle speed.	Even if engine control dial is rotated, engine speed does not change from slow speed. Even if starter rotates, starting engine is occasionally difficult. If engine runs faster than a certain speed and harness is disconnected, engine stalls. If engine runs slower than a certain speed and harness is disconnected, engine cannot be controlled. Engine cannot stop by using the key switch.	Error in setting will seldom occur so that change in machine operation will not be noticed. In case EC motor is set on lower side: Engine speed changes and engine runs slower than normal through the full range when engine control dial is rotated. In case EC motor is set on upper side: EC motor is driven so that it runs faster than the control range when engine control dial is set to Full. However, EC motor, a worm gear type, holds governor lever at maximum constant position and prevents engine stall. When engine control dial is set to minimum speed position, governor lever is returned to idle position. Engine speed fluctuates when it starts. Starting engine is occasionally difficult.
Evaluation by Fault Code	11901	-	ECF: 16606
Evaluation by Monitoring	MC: Hydraulic Oil Temperature	-	ECF: EC Sensor Voltage
Evaluation by using Test Harness	-	Install light harness (ST 7125). Check output signals from EC and harness condition.	-
Note	-	Engine is stopped by EC motor. (Engine stop motor is not provided.) Fuel cut-off cable is provided.	If EC sensor is faulty, engine learning is not performed.
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Item \ Parts	N Sensor	Pump 1 Delivery Pressure Sensor	Pump 2 Delivery Pressure Sensor
Function	Monitors engine speed in order to operate engine speed sensing control.	Detects pump 1 delivery pressure.	Detects pump 2 delivery pressure.
Symptoms in control system when trouble occurs	Speed sensing control is inoperable.	When output is 0 V or 5 V, the following symptoms occur.	When output is 0 V or 5 V, the following symptoms occur.
Symptoms in machine operation when trouble occurs	Engine stalls under adverse operating conditions such as at high altitude.	Engine speed does not increase during digging operation. Arm roll-in speed is fast during arm level crowding operation. During boom raise single operation, power is weak. As the machine is kept to travel at slow speed, speed does not change into fast.	Engine speed does not increase during digging operation. Arm roll-in speed is fast during arm level crowding operation. As the machine is kept to travel at slow speed, speed does not change into fast.
Evaluation by Fault Code	ECF: 16605	11200	11202
Evaluation by Monitoring	ECF: Actual Engine Speed (Abnormal data is detected.) MC: Actual Engine Speed (Abnormal data is detected.)	MC: Pump 1 Delivery Pressure	MC: Pump 2 Delivery Pressure
Evaluation by using Test Harness	-	-	-
Note	Even if signals from N sensor are not delivered due to faulty sensor or poor sensor installation, few changes in operational performance occur. Then, it makes troubleshooting difficult. Use monitor function.	Possible to judge if sensor or harness is faulty by switching pressure sensor with other delivery pressure sensor.	Possible to judge if sensor or harness is faulty by switching pressure sensor with other delivery pressure sensor.
Descriptions of Control (Operational Principle Section in T/M)	T2-1	T2-2	T2-2

Item \ Parts	Pump 1 Control Pressure Sensor	Pump 2 Control Pressure Sensor	Pressure Sensor (Boom Raise)
Function	Detects pump 1 pump control pressure.	Detects pump 2 pump control pressure.	Monitors boom raise pilot pressure.
Symptoms in control system when trouble occurs	When output is 0 V or 5 V, the following symptoms occur.	When output is 0 V or 5 V, the following symptoms occur.	When output is 0 V or 5 V, the following symptoms occur.
Symptoms in machine operation when trouble occurs	Engine speed does not decrease when operating bucket and travel (right) at ECO mode. Fast travel cannot be selected easily.	Engine speed does not decrease when operating travel (left) at ECO mode. Fast travel cannot be selected easily.	Engine speed is difficult to increase during digging operation. Arm roll-in speed is slow during combined operation of arm roll-in and boom raise. During boom raise single operation, power is weak. Boom raise speed is slow during combined operation of swing, arm roll-in, and boom raise.
Evaluation by Fault Code	11206	11208	11302
Evaluation by Monitoring	MC: Pump 1 Control Pressure	MC: Pump 2 Control Pressure	MC: Boom Raise Pilot Pressure
Evaluation by using Test Harness	-	-	-
Note	Possible to judge if sensor or harness is faulty by switching pressure sensor with other pump control pressure sensor.	Possible to judge if sensor or harness is faulty by switching pressure sensor with other pump control pressure sensor.	Possible to judge if pressure sensor is faulty or port is clogged by switching pressure sensor with other pressure sensor.
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Parts / Item	Pressure Sensor (Arm Roll-In)	Pressure Sensor (Front Attachment)	Pressure Sensor (Travel)
Function	Monitors arm roll-in pilot pressure.	Monitors front attachment pilot pressure.	Monitors travel pilot pressure.
Symptoms in control system when trouble occurs	When output is 0 V or 5 V, the following symptoms occur.	When output is 0 V or 5 V, the following symptoms occur.	When output is 0 V or 5 V, the following symptoms occur.
Symptoms in machine operation when trouble occurs	Engine speed is difficult to increase during digging operation. Arm roll-in speed is slow during combined operation of arm roll-in and boom raise. Arm roll-in speed is fast during arm level crowding operation. Attachment and boom raise speed are slow during combined operation of arm roll-in, boom raise, and attachment.	Even if the front attachment is operated, engine speed is kept at auto-idle speed. Even if the front attachment is operated with the engine running at slow idle speed, engine speed does not increase.	Even if the machine travels, engine speed is kept at auto-idle speed. Even if the machine travels with the engine running at slow idle speed, engine speed does not increase. As the machine is kept to travel at slow speed, speed does not change into fast. During combined operation of attachment and travel, the machine mistracks. Travel alarm (optional) continues to sound.
Evaluation by Fault Code	11303	11307	11304
Evaluation by Monitoring	MC: Arm Roll-In Pilot Pressure	MC: Front ATT Pilot Pressure	MC: Travel Pilot Pressure
Evaluation by using Test Harness	-	-	-
Note	Possible to judge if pressure sensor is faulty or port is clogged by switching pressure sensor with other pressure sensor.	Possible to judge if pressure sensor is faulty or port is clogged by switching pressure sensor with other pressure sensor.	Possible to judge if pressure sensor is faulty or port is clogged by switching pressure sensor with other pressure sensor.
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Item \ Parts	Pressure Sensor (Swing)	Pressure Sensor (Arm Roll-Out) (OP)	Pressure Sensor (Auxiliary) (OP)
Function	Monitors swing pilot pressure.	Monitors arm roll-out pilot pressure.	Monitors auxiliary pilot pressure.
Symptoms in control system when trouble occurs	When output is 0 V or 5 V, the following symptoms occur.	When output is 0 V or 5 V, the following symptoms occur.	When output is 0 V or 5 V, the following symptoms occur.
Symptoms in machine operation when trouble occurs	During combined operation of swing and boom raise, engine speed does not increase. Boom raise speed is slow and arm roll-in speed is fast during combined operation of swing, arm roll-in, and boom raise. Swing speed acceleration becomes poor and swing operation at constant speed is slow. Swing alarm (optional) continues to sound.	Arm roll-out speed is slow during combined operation of arm roll-out and attachment.	Even if the attachment is operated with the engine speed increasing, engine speed does not increase. Cylinder hesitates when operating the attachment. Attachment speed is slow during combined operation of attachment and arm roll-in.
Evaluation by Fault Code	11301	-	-
Evaluation by Monitoring	MC: Swing Pilot Pressure	MC: Arm Roll-Out Pilot Pressure (OP)	MC: ATT 1 Pilot Pressure
Evaluation by using Test Harness	-	-	-
Note	Possible to judge if pressure sensor is faulty or port is clogged by switching pressure sensor with other pressure sensor.	Possible to judge if pressure sensor is faulty or port is clogged by switching pressure sensor with other pressure sensor.	Possible to judge if pressure sensor is faulty or port is clogged by switching pressure sensor with other pressure sensor.
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Item \ Parts	Torque Control Solenoid Valve	Maximum Pump 1 Flow Rate Limit Control Solenoid Valve (OP)	Maximum Pump 2 Flow Rate Limit Control Solenoid Valve
Function	Supplies control pressure to pump.	Limits maximum pump 1 flow rate when operating attachment.	Limits maximum pump 2 flow rate when operating attachment.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	High current: Pump torque of pumps 1 and 2 are kept maximum. The engine stalls or engine lug-down is remarkable at high loaded. Low current: Pump torque of pumps 1 and 2 are kept minimum. Actuator speed are slow.	High current: Pump 1 flow rate is always limited. Machine mistracks. Boom, arm, and bucket operation speed are slow. Low current: Pump 1 flow rate is not always limited.	High current: Pump 2 flow rate is always limited. Machine mistracks. Boom, arm, and attachment operation speed are slow. Low current: Pump 2 flow rate is not always limited.
Evaluation by Fault Code	11401	-	11400
Evaluation by Monitoring	MC: Pumps 1&2 Torque P/S O/P, Pumps 1&2 Torque P/S O/P FB	MC: Tgt Pump 1 Flow Rate, Pump 1 Flw Limit P/S Output, Pump 1 Flw Limit P/S O/P FB	MC: Tgt Pump 2 Flow Rate, Pump 2 Flw Limit P/S Output, Pump 2 Flw Limit P/S O/P FB
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Parts / Item	Solenoid Valve Unit (SG)	5-Spool Solenoid Valve Unit (SF)	5-Spool Solenoid Valve Unit (SC)
Function	Increases relief pressure of main relief valve temporarily. Decreases displacement angle of travel motor to the minimum and increases travel speed.	Shifts digging regenerative valve.	Shifts arm regenerative valve and arm 2 flow rate control valve (selector valve).
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	High current: Pressure always increases. Machine is kept to travel at fast speed. Low current: Pressure always does not increase. Machine is kept to travel at slow speed.	High current: Always shifts digging regenerative valve. Low current: As digging regenerative valve is not shifted, arm roll-in speed is slow during combined operation of arm roll-in and boom raise.	High current: Always restricts arm regenerative valve. Arm speed becomes fast. Low current: Always shifts arm regenerative valve. (Regeneration is not performed.) Arm speed becomes slow. Cylinder hesitation easily occurs during combined operation.
Evaluation by Fault Code	11407	11402	11403
Evaluation by Monitoring	MC: Pressure Boost P/S Output, Pressure Boost P/S Output FB	MC: Digging Regen P/S O/P, Digging Regen P/S O/P FB	MC: Arm Regen P/S Output, Arm Regen P/S Output FB
Evaluation by using Test Harness	Install light harness (ST 7226). Check output signals from MC and harness condition.	Install light harness (ST 7226). Check output signals from MC and harness condition.	Install light harness (ST 7226). Check output signals from MC and harness condition.
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Item \ Parts	Main Relief Valve	Overload Relief Valve	Boom Anti-Drift Valve
Function	Prevents pressure in pump 1 and 2 circuits from exceeding the set pressure when control lever is operated.	Prevents actuator circuit pressure generated by external force from exceeding the set pressure with control lever set in neutral.	Forcibly opens check valve in boom lower return circuit and lowers boom only when boom is lowered. Prevents boom from drifting due to oil leaks in control valve.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	If stuck in fully closed position, hose of front attachment may be damaged. If stuck in fully open position, power is weak during digging and climbing operation.	If stuck in fully closed position, hose of front attachment may be damaged by external force. If stuck in fully open position, power is weak during digging operation.	If check valve is kept closed, boom does not lower smoothly. If check valve is kept open, machine cannot be raised off ground.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T3-3	T3-3	T3-3

Parts / Item	Arm Anti-Drift Valve	Flow Combiner Valve	Boom Regenerative Valve
Function	Forcibly opens check valve in arm roll-in return circuit and rolls arm in only when arm is rolled in. Prevents arm from drifting due to oil leaks in control valve.	Supplies pressure oil to both right and left travel spools from pump 1 during combined operation of travel and front attachment/ swing.	Supplies returning oil from boom cylinder bottom side to rod side and prevents cylinder hesitation.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	If check valve is kept closed, arm roll-in speed becomes slow. If check valve is kept open, front attachment drift increases due to oil leaks in control valve.	If stuck in fully closed position, machine mistracks to the left during combined operation of travel and front attachment/ swing. If stuck in fully open position, machine mistracks to the right during travel single operation.	If check valve is kept closed, boom does not lower smoothly. If check valve is kept open, machine cannot be raised off ground.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T3-3	T3-3	T3-3

Item \ Parts	Arm Regenerative Valve	Bucket Regenerative Valve	Arm 1 Flow Rate Control Valve
Function	Is shifted by pilot pressure from solenoid valve unit (SC). Supplies returning oil from arm cylinder rod side to arm cylinder bottom side and increases arm speed.	Supplies returning oil from bucket cylinder rod side to bottom side and prevents cylinder hesitation.	Is shifted by pilot pressure from arm 1 flow rate control valve control spool in signal control valve. Keeps swing power.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	If valve is kept closed, arm speed becomes extremely slow during arm level crowding operation. If valve is kept open, the lever operated first is given priority during combined operation of arm roll-in and swing.	If check valve is kept closed, bucket digging operation is not smooth. If check valve is kept open, power is weak.	If poppet valve or selector valve is stuck in fully closed position, swing power is lack. If poppet valve or selector valve is stuck in fully open position, arm roll-in speed becomes slow during arm level crowding operation.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T3-3	T3-3	T3-3

Item \ Parts	Arm 2 Flow Rate Control Valve	Boom Flow Rate Control Valve	Bucket Flow Rate Control Valve
Function	Is shifted by pilot pressure from solenoid valve unit (SC). Restricts arm 2 circuit and keeps boom raise speed during combined operation of arm roll-in and bucket.	Is shifted by pilot pressure from boom lower meter-in cut valve. Limits flow rate to boom 1 spool and improves combined operation.	Restricts bucket circuit and makes boom raise during combined operation of bucket, arm roll-in, and boom raise.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	If stuck in position with selector valve operated, bucket circuit is always restricted.
Symptoms in machine operation when trouble occurs	If poppet valve or selector valve is stuck in fully closed position, boom raise speed becomes slow. If poppet valve or selector valve is stuck in fully open position, arm roll-in speed becomes slow during arm level crowding operation.	If poppet valve or selector valve is stuck in fully open position, boom lower speed is fast during combined operation. If poppet valve or selector valve is stuck in fully closed position, machine cannot be raised off ground.	If poppet valve is stuck in fully closed position or if poppet valve is stuck in fully closed position by selector valve, bucket speed decreases. If poppet valve is stuck in fully open position or if poppet valve is stuck in fully open position by selector valve, boom cannot be raised during combined operation of bucket, arm roll-in, and boom raise.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T3-3	T3-3	T3-3

Item \ Parts	Auxiliary Flow Rate Control Valve	Auxiliary Flow Combiner Valve	Bypass Shut-Out Valve
Function	Is shifted by pilot pressure from auxiliary flow rate control solenoid valve.	Is shifted by pilot pressure from auxiliary flow combiner solenoid valve. Supplies pressure oil from pump 1 to auxiliary 1 spool.	Is shifted by pilot pressure from auxiliary flow combiner solenoid valve. Supplies pressure oil from pump 1 to auxiliary spool. Increases pressure of pump 1 with the track raised.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	If poppet valve or selector valve is stuck in fully closed position, attachment speed becomes slow. If poppet valve or selector valve is stuck in fully open position, travel speed becomes slow during combined operation of attachment and travel.	If stuck in fully closed position, attachment speed does not increase during combined operation of attachment. If stuck in fully open position, travel speed becomes slow during combined operation of attachment and travel.	If stuck in fully closed position, main relief valve continues to be relieved with all control levers set in neutral. If stuck in fully open position, attachment single operation speed becomes slow. Machine cannot be raised off ground.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T3-3	T3-3	T3-3

Parts / Item	Digging Regenerative Valve	Boom Lower Meter-In Cut Valve	Travel Motor Displacement Angle Control Valve
Function	Is shifted by pilot pressure from solenoid valve unit (SF). Supplies returning oil from boom cylinder rod side to arm cylinder bottom side and make arm roll-in speed fast.	Is shifted by returning oil from boom cylinder bottom side. Lowers boom due to own weight by the boom regenerative circuit during boom lower operation above ground and gives priority to operate other actuators. Gives priority to operate boom with the track raised and increases jack-up force.	Is shifted by pilot pressure from solenoid valve unit (SG). Shifts travel speed.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	If stuck in fully closed position, arm roll-in speed becomes slow during digging operation. If stuck in fully open position, boom raise speed becomes slow.	If stuck in fully closed position, boom lower speed becomes fast during combined operation. If stuck in fully open position, machine cannot be raised off ground.	If stuck in fully closed position, machine is kept to travel at slow speed. If stuck in fully open position, machine travels at fast speed with travel mode switch set in slow speed position.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T3-3	T3-3	T3-5

Item \ Parts	Pump 1 Flow Rate Control Valve	Pump 2 Flow Rate Control Valve	Swing Parking Brake Release Spool
Function	Supplies flow rate control pressure Pi according to lever stroke to pump 1 regulator when operating boom, arm, bucket, and travel (right).	Supplies flow rate control pressure Pi according to lever stroke to pump 2 regulator when operating boom raise, arm, swing, travel (left), and auxiliary.	Is shifted by pilot pressure of boom, arm, bucket, swing, and auxiliary. Supplies release pressure to swing parking brake.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	If stuck in fully closed position, pump 1 displacement angle is held at minimum while operating control lever. Travel (right) is not operated during travel single operation. Bucket speed extremely becomes slow. If stuck in fully open position, pump 1 displacement angle is held at maximum with control lever in neutral. Machine mistracks to the left when travel control lever is operated at half stroke. Pump 1 control pressure sensor monitors maximum pressure.	If stuck in fully closed position, pump 2 displacement angle is held at minimum while operating control lever. Travel (left) is not operated during travel single operation. If stuck in fully open position, pump 2 displacement angle is held at maximum with control lever in neutral. Machine mistracks to the right when travel control lever is operated at half stroke. Pump 2 control pressure sensor monitors maximum pressure.	If stuck in fully closed position, swing parking brake is kept applied. (Dragging is felt.) Even if control lever is operated at auto-idle control, engine speed does not increase as pressure sensor (front attachment) is always OFF. If stuck in fully open position, swing parking brake is kept released. (Machine vibrates while traveling.) Even if control lever is set to neutral with auto-idle switch ON, engine speed does not decrease as pressure sensor (front attachment) is always ON.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T3-6	T3-6	T3-6

Item \ Parts	Arm 1 Flow Rate Control Valve Control Spool	Bucket Flow Rate Control Valve Control Spool	Flow Combiner Valve Control Spool
Function	Is shifted by arm roll-in pilot pressure and supplies selection pressure to arm flow rate control valve 1 of 5-spool side of control valve.	Is shifted by arm roll-in pilot pressure and supplies boom raise pilot pressure to bucket flow rate control valve.	Is shifted by travel (right) pilot pressure. Supplies selection pressure to flow combiner valve in control valve.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	Same as shown below
Symptoms in machine operation when trouble occurs	If stuck in fully open position, arm speed becomes slow during arm single operation. (Arm flow rate control is activated constantly.) If stuck in fully closed position, swing power is lack during combined operation of swing and arm roll-in. (Arm flow rate control is deactivated.)	If stuck in fully open position, bucket speed becomes slow during combined operation of boom raise and bucket. (Bucket flow rate control is inoperable.) If stuck in fully closed position, boom cannot be raised during combined operation of bucket, arm roll-in, and boom raise.	If stuck in fully closed position, machine mistracks to the left during combined operation of travel and front attachment/swing. Travel (left) speed becomes slow. If stuck in fully open position, machine mistracks to the right when traveling. Travel (right) speed becomes slightly slow.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T3-6	T3-6	T3-6

Item \ Parts	Auxiliary Flow Combiner Control Solenoid Valve (OP)	Auxiliary Flow Rate Control Solenoid Valve (OP)	Selector Valve Control Solenoid Valve (OP)
Function	Shifts auxiliary flow combiner valve.	Shifts selector valve of auxiliary flow rate control valve.	Shifts selector valve.
Symptoms in control system when trouble occurs	Solenoid valve is not shifted. Pressure at output port becomes 0 MPa.	Same as shown below	Solenoid valve is not shifted. Pressure at output port becomes 0 MPa.
Symptoms in machine operation when trouble occurs	Attachment speed does not increase during attachment single operation.	High current: Attachment speed is slow during attachment single operation. Low current: Boom raise speed is slow during combined operation of boom raise, arm roll-out, and attachment.	Selector valve is not shifted. Connection of returning circuit is not shifted O/T (hydraulic oil tank) when breaker is selected. Breaker stroke becomes few.
Evaluation by Fault Code	11457	-	11458
Evaluation by Monitoring	MC: Auxiliary Flow Combiner Valve (OP)	MC: Auxil Flw Cont P/S Output, Auxil Flw Cont P/S O/P FB	MC: Selector Valve (OPT)
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Item \ Parts	Selector Valve (OP)	Accumulator Control Valve (OP)	Secondary Pilot Relief Pressure Control Solenoid Valve (OP)
Function	Shifts connection of returning circuit in attachment to hydraulic oil tank or control valve.	Is shifted by pilot pressure from selector valve control solenoid valve.	Is activated when selecting attachment, Secondary Pilot Relief Pressure ON and shifts secondary pilot relief pressure control valve spool.
Symptoms in control system when trouble occurs	Same as shown below	Same as shown below	If secondary pilot relief pressure control solenoid valve is not activated, pressure at output port becomes 0 MPa when selecting attachment, Secondary Pilot Relief Pressure ON.
Symptoms in machine operation when trouble occurs	If spool is stuck, connection of returning circuit is not shifted O/T (hydraulic oil tank) when breaker is selected. Breaker stroke becomes fewer.	If spool is stuck, selection to accumulator is turned OFF. Hydraulic pulsation (hose vibration) becomes big when breaker 2 is used.	Relief set pressure of auxiliary circuit does not decrease.
Evaluation by Fault Code	-	-	-
Evaluation by Monitoring	-	-	-
Evaluation by using Test Harness	-	-	-
Note	-	-	-
Descriptions of Control (Operational Principle Section in T/M)	T2-2	T2-2	T2-2

Item \ Parts	Secondary Pilot Relief Pressure Control Valve (OP)
Function	Is shifted by pilot pressure from secondary pilot relief control solenoid valve.
Symptoms in control system when trouble occurs	If spool is stuck or spring is damaged, relief circuit of breaker is disconnected.
Symptoms in machine operation when trouble occurs	Relief set pressure of auxiliary circuit does not decrease.
Evaluation by Fault Code	-
Evaluation by Monitoring	-
Evaluation by using Test Harness	-
Note	-
Descriptions of Control (Operational Principle Section in T/M)	T2-2

Correlation between Trouble Symptoms and Part Failures

This table indicates the relationship between machine troubles and parts contributing to the cause of the trouble if failed.
The trouble symptoms in this table are described provided that each trouble occurs independently. In case more than one trouble occurs at the same time, find out all faulty components while checking all suspected components in each trouble symptom.

The marks ●/○ in this table indicate the influence to trouble symptom.
●: Related, required to check
○: Related. However, in case this component fails, other trouble symptom will be more noticeable so that this component will not be the direct cause of the trouble concerned.

Engine System Troubleshooting

Parts \ Trouble Symptom	E-1 Starter does not rotate.	E-2 Even if starter rotates, engine does not start.	E-3 When engine control dial is fully rotated, engine stalls. Occasionally engine stalls during operation with engine control dial fully rotated and auto-idle ON. Engine speed is slower than specification in all operating range. Idle speed is faster or slower than specification.
MC		●	●
ECF			○
Monitor Controller			
EC Motor		●	○
EC Sensor		○	●
N Sensor			
Pump 1 Delivery Pressure Sensor			
Pump 2 Delivery Pressure Sensor			
Pump 1 Control Pressure Sensor			
Pump 2 Control Pressure Sensor			
Torque Control Solenoid Valve			
Pressure Sensor (Boom Raise)			
Pressure Sensor (Arm Roll-In)			
Pressure Sensor (Front Attachment)			
Pressure Sensor (Travel)			
Pressure Sensor (Swing)			
Hydraulic Oil Temperature Sensor			
Coolant Temperature Switch			
Key Switch	●		
Engine Control Dial			
Auto-Idle Switch			
Power Mode Switch			
Travel Mode Switch			
Learning Switch			●
QOS Controller			
Glow Plug Relay			
Battery Relay	●		
Starter Cut Relay	●		
Engine Electrical Equipment	●		
Engine Unit		●	●
Governor		●	●
Engine Stop Switch		○	
Remark	Check batteries.	Check fuel system. (filters and pipings)	Check fuel cut-off handle and engine control cable. Perform engine learning after replacing engine.

Trouble Symptom / Parts	E-4 Even if engine control dial is operated, engine speed does not change.	E-5 Engine speed does not increase after engine starts.	E-6 Even if key switch is turned OFF, engine does not stop.
MC	●	●	○
ECF	○	○	○
Monitor Controller			
EC Motor	●	○	○
EC Sensor			○
N Sensor			
Pump 1 Delivery Pressure Sensor			
Pump 2 Delivery Pressure Sensor			
Pump 1 Control Pressure Sensor			
Pump 2 Control Pressure Sensor			
Torque Control Solenoid Valve			
Pressure Sensor (Boom Raise)			
Pressure Sensor (Arm Roll-In)			
Pressure Sensor (Front Attachment)			
Pressure Sensor (Travel)			
Pressure Sensor (Swing)			
Hydraulic Oil Temperature Sensor		●	
Coolant Temperature Switch			
Key Switch		●	○
Engine Control Dial	●		
Auto-Idle Switch			
Power Mode Switch			
Travel Mode Switch			
Learning Switch			○
QOS Controller			
Glow Plug Relay			
Battery Relay			
Starter Cut Relay			
Engine Electrical Equipment			
Engine Unit	●		
Governor	●		
Remark			

Parts \ Trouble Symptom	E-7 ECO mode is faulty.	E-8 Travel HP mode is faulty.	E-9 Auto-idle system is faulty.
MC	●	●	●
ECF	○	○	○
Monitor Controller			
EC Motor	○	○	○
EC Sensor			
N Sensor			
Pump 1 Delivery Pressure Sensor	●	●	
Pump 2 Delivery Pressure Sensor	●	●	
Pump 1 Control Pressure Sensor	●		
Pump 2 Control Pressure Sensor	●		
Torque Control Solenoid Valve			
Pressure Sensor (Boom Raise)			
Pressure Sensor (Arm Roll-In)			
Pressure Sensor (Front Attachment)			○
Pressure Sensor (Travel)	○	○	○
Pressure Sensor (Swing)			
Hydraulic Oil Temperature Sensor			
Coolant Temperature Switch			
Key Switch			
Engine Control Dial	○	○	
Auto-Idle Switch			●
Power Mode Switch	●		○
Travel Mode Switch		●	
Learning Switch			
QOS Controller			
Glow Plug Relay			
Battery Relay			
Starter Cut Relay			
Engine Electrical Equipment			
Engine Unit			
Governor			
Swing Parking Brake Release Spool (Signal Control Valve)			●
Remark			

Trouble Symptom / Parts	E-10	E-11	E-12
	When traveling or operating front attachment with engine running at slow idle, engine hunts.	When attachment mode is selected, engine speed does not decrease.	Engine stalls within several seconds after engine has started.
MC	●	●	
ECF	○	○	
Monitor Controller		○	
EC Motor			
EC Sensor			
N Sensor			
Pump 1 Delivery Pressure Sensor			
Pump 2 Delivery Pressure Sensor			
Pump 1 Control Pressure Sensor			
Pump 2 Control Pressure Sensor			
Torque Control Solenoid Valve			
Pressure Sensor (Boom Raise)			
Pressure Sensor (Arm Roll-In)			
Pressure Sensor (Front Attachment)			
Pressure Sensor (Travel)			
Pressure Sensor (Swing)			
Hydraulic Oil Temperature Sensor			
Coolant Temperature Switch			
Key Switch			
Engine Control Dial			
Auto-Idle Switch			
Power Mode Switch			
Travel Mode Switch			
Learning Switch			●
QOS Controller			
Glow Plug Relay			
Battery Relay			
Starter Cut Relay			
Engine Electrical Equipment			
Engine Unit	●		
Governor			
Remark			Check fuel system for clogging.

Trouble Symptom / Parts	E-13 Engine stalls under adverse operating conditions such as at high altitude.	E-14 Engine is difficult to start at low temperature.
MC	●	
ECF	○	
Monitor Controller		
EC Motor		
EC Sensor		
N Sensor	●	
Pump 1 Delivery Pressure Sensor		
Pump 2 Delivery Pressure Sensor		
Pump 1 Control Pressure Sensor		
Pump 2 Control Pressure Sensor		
Pump Regulator	○	
Torque Control Solenoid Valve	●	
Pressure Sensor (Boom Raise)		
Pressure Sensor (Arm Roll-In)		
Pressure Sensor (Front Attachment)		
Pressure Sensor (Travel)		
Pressure Sensor (Swing)		
Hydraulic Oil Temperature Sensor		
Coolant Temperature Switch		●
Key Switch		
Engine Control Dial		
Auto-Idle Switch		
Power Mode Switch		
Travel Mode Switch		
Learning Switch		
QOS Controller		●
Glow Plug Relay		○
Battery Relay		
Starter Cut Relay		
Engine Electrical Equipment		
Engine Unit		●
Governor		
Remark		Check batteries.

All Actuator System Troubleshooting

Trouble Symptom / Parts	A-1	A-2	A-3
	All actuator speeds are slow.	All actuators are not operated.	Travel (left) is not operated during travel single operation. Swing single operation speed becomes slow. Arm speed is slightly slow during arm level crowding operation.
MC	●		
ECF	○		
Monitor Controller		○	
Torque Control Solenoid Valve	●		
Pilot Shut-Off Solenoid Valve		●	
Pump 2 Delivery Pressure Sensor			
Pressure Sensor (Swing)			
Pressure Sensor (Arm Roll-In)			
Pilot Shut-Off Switch		●	
Pilot Shut-Off Relay		●	
Security Relay		●	
Spool			
Main Relief Valve	○		
Arm 1 Flow Rate Control Valve			
Main Pump	●		●
Regulator	○		●
Pilot Pump	●		
Pilot Valve			
Pilot Relief Valve	●		
Pump 1 Flow Rate Control Valve (Signal Control Valve)			
Pump 2 Flow Rate Control Valve (Signal Control Valve)			●
Arm 1 Flow Rate Control Valve Control Spool (Signal Control Valve)			
Remark			

Trouble Symptom / Parts	A-4	A-5	A-6	A-7
	Travel (right) is not operated during travel single operation. Bucket single operation speed becomes slow. Boom cannot be raised properly during arm level crowding.	Actuator does not stop even if control lever is set to neutral.	Occasionally, swing or arm roll-in speed becomes slow during combined operation of swing and arm roll-in .	Actuator speed is faster than normal. Machine mistracks when travel control lever is operated at half stroke. Precise control cannot be performed.
MC				
ECF				
Monitor Controller				
Torque Control Solenoid Valve				
Pilot Shut-Off Solenoid Valve				
Pump 2 Delivery Pressure Sensor				
Pressure Sensor (Swing)				
Pressure Sensor (Arm Roll-In)				
Pilot Shut-Off Switch				
Pilot Shut-Off Relay				
Security Relay				
Spool		●		
Main Relief Valve				
Arm 1 Flow Rate Control Valve			●	
Main Pump	●			
Regulator	●			●
Pilot Pump				
Pilot Valve		●		
Pilot Relief Valve				
Pump 1 Flow Rate Control Valve (Signal Control Valve)	●			●
Pump 2 Flow Rate Control Valve (Signal Control Valve)				●
Arm 1 Flow Rate Control Valve Control Spool (Signal Control Valve)			●	
Remark				

Front Attachment System Troubleshooting

Trouble Symptom / Parts	F-1	F-2	F-3	F-4
	All front attachment actuator power are weak.	Even if power digging switch is pushed, power does not increase.	Some cylinders are not operated or speeds are slow.	Arm operation speed is slow during combined operation. Boom raise speed is slow during combined operation of boom raise and arm roll-in. Arm speed is slow during arm level crowding operation.
MC		●		●
Solenoid Valve Unit (SG)		●		
Solenoid Valve Unit (SF)				
Solenoid Valve Unit (SC)				●
Pump 1 Delivery Pressure Sensor				○
Pump 2 Delivery Pressure Sensor				○
Pressure Sensor (Swing)				○
Pressure Sensor (Boom Raise)				○
Pressure Sensor (Arm Roll-In)				○
Power Digging Switch		●		
Spool			●	
Main Relief Valve	●	●		
Overload Relief Valve		●	●	
Load Check Valve				
Digging Regenerative Valve				
Boom Regenerative Valve				
Arm Regenerative Valve				●
Bucket Regenerative Valve				
Boom Flow Rate Control Valve				
Arm 1 Flow Rate Control Valve				●
Arm 2 Flow Rate Control Valve				●
Bucket Flow Rate Control Valve				
Boom Lower Meter-In Cut Valve				
Boom Anti-Drift Valve				
Arm Anti-Drift Valve				
Emergency Valve				
Shockless Valve (Signal Control Valve)			●	
Shuttle Valve (Signal Control Valve)			●	
Bucket Flow Rate Control Valve Control Spool (Signal Control Valve)				
Arm 1 Flow Rate Control Valve Control Spool (Signal Control Valve)				●
Pilot Valve			●	
Cylinder			○	
Remark				

Trouble Symptom / Parts	F-5 Arm roll-in speed is slow during digging operation.	F-6 Bucket roll-in single operation speed is slightly slow. Bucket does not move smoothly during bucket roll-in single operation.	F-7 When starting to move arm during combined operation, arm does not smoothly move. Arm starts to move slightly slow during arm roll-in single operation. These troubles often occur when temperature is low.	F-8 When starting to move boom during combined operation, boom does not smoothly move. Boom starts to move slightly slow during boom lower single operation.
MC	●			
Solenoid Valve Unit (SG)				
Solenoid Valve Unit (SF)	●			
Solenoid Valve Unit (SC)				
Pump 1 Delivery Pressure Sensor	○			
Pump 2 Delivery Pressure Sensor	○			
Pressure Sensor (Swing)				
Pressure Sensor (Boom Raise)	○			
Pressure Sensor (Arm Roll-In)	○			
Power Digging Switch				
Spool				
Main Relief Valve				
Overload Relief Valve				
Load Check Valve				
Digging Regenerative Valve	●			
Boom Regenerative Valve				●
Arm Regenerative Valve			●	
Bucket Regenerative Valve		●		
Boom Flow Rate Control Valve				
Arm 1 Flow Rate Control Valve				
Arm 2 Flow Rate Control Valve				
Bucket Flow Rate Control Valve		●		
Boom Lower Meter-In Cut Valve				●
Boom Anti-Drift Valve				●
Arm Anti-Drift Valve			●	
Emergency Valve				
Shockless Valve (Signal Control Valve)		○		
Shuttle Valve (Signal Control Valve)		●		
Bucket Flow Rate Control Valve Control Spool (Signal Control Valve)				
Arm 1 Flow Rate Control Valve Control Spool (Signal Control Valve)				
Pilot Valve				
Cylinder				
Remark				

Trouble Symptom / Parts	F-9 When boom lower or arm roll-out is operated, boom or arm starts to move after moving slightly down.	F-10 Front attachment drifts remarkably.	F-11 Boom lower speed above ground is faster than other actuators during combined operation.	F-12 Machine cannot be raised off ground.
MC				
Solenoid Valve Unit (SG)				
Solenoid Valve Unit (SF)				
Solenoid Valve Unit (SC)				
Pump 1 Delivery Pressure Sensor				
Pump 2 Delivery Pressure Sensor				
Pressure Sensor (Swing)				
Pressure Sensor (Boom Raise)				
Pressure Sensor (Arm Roll-In)				
Power Digging Switch				
Spool		●		
Main Relief Valve				
Overload Relief Valve		●		
Load Check Valve	●			
Digging Regenerative Valve				
Boom Regenerative Valve				
Arm Regenerative Valve				
Bucket Regenerative Valve				
Boom Flow Rate Control Valve			●	●
Arm 1 Flow Rate Control Valve				
Arm 2 Flow Rate Control Valve				
Bucket Flow Rate Control Valve				
Boom Lower Meter-In Cut Valve			●	●
Boom Anti-Drift Valve	●	●		
Arm Anti-Drift Valve	●	●		
Emergency Valve		○		
Shockless Valve (Signal Control Valve)				
Shuttle Valve (Signal Control Valve)				
Bucket Flow Rate Control Valve Control Spool (Signal Control Valve)				
Arm 1 Flow Rate Control Valve Control Spool (Signal Control Valve)		●		
Pilot Valve				
Cylinder	●	●		
Remark				

Swing System Troubleshooting

Trouble Symptom / Parts	S-1	S-2
	Swing is slow or unmoving.	Swing is slow (power is weak) during combined operation of swing and arm roll-in. Swing does not start smoothly. Swing power is weak.
MC (Main Controller)		○
Torque Control Solenoid Valve		
Solenoid Valve Unit (SC)		
Pump 1 Delivery Pressure Sensor		
Pump 2 Delivery Pressure Sensor		○
Pump 1 Control Pressure Sensor		
Pump 2 Control Pressure Sensor		
Pressure Sensor (Travel)		
Pressure Sensor (Swing)		○
Pressure Sensor (Arm Roll-In)		○
Pump Device		
Spool		
Load Check Valve		
Arm 1 Flow Rate Control Valve		●
Swing Parking Brake Release Spool (Signal Control Valve)	●	
Pump 1 Flow Rate Control Valve (Signal Control Valve)		
Pump 2 Flow Rate Control Valve (Signal Control Valve)	●	
Arm 1 Flow Rate Control Valve Control Spool (Signal Control Valve)		●
Shuttle Valve (Signal Control Valve)	○	
Swing Device	●	
Pilot Valve	●	
Remark		

Travel/Other System Troubleshooting

Trouble Symptom / Parts	T-1	T-2	T-3
	Both right and left tracks do not rotate or rotate slowly.	One side track does not rotate or rotates slowly. Machine mistracks.	Machine mistracks during combined operation of travel and front attachment.
MC (Main Controller)			
Torque Control Solenoid Valve			
Solenoid Valve Unit (SG)			
Pump 1 Delivery Pressure Sensor			
Pump 2 Delivery Pressure Sensor			
Pump 1 Control Pressure Sensor			
Pump 2 Control Pressure Sensor			
Pressure Sensor (Travel)			
Pressure Sensor (Swing)			
Pressure Sensor (Arm Roll-In)			
Travel Mode Switch			
Pump Device			
Spool		●	
Load Check Valve			●
Arm 1 Flow Rate Control Valve			
Flow Combiner Valve			●
Pump 1 Flow Rate Control Valve (Signal Control Valve)		○	
Pump 2 Flow Rate Control Valve (Signal Control Valve)		○	
Flow Combiner Valve Control Spool (Signal Control Valve)			●
Arm 1 Flow Rate Control Valve Control Spool (Signal Control Valve)			
Shuttle Valve (Signal Control Valve)		○	
Travel Device		●	
Center Joint		●	
Pilot Valve		●	
Remark	Also, refer to T-5.	In case either bucket or swing is also slow, refer to A-3 or A-4.	

Trouble Symptom / Parts	T-4	T-5	O-1
	Occasionally, machine may mistrack when traveling with engine running at slow speed.	Fast travel is not selected. Travel mode does not change from slow mode to fast mode.	Wiper is not operated.
MC (Main Controller)	●		
Torque Control Solenoid Valve	●		
Solenoid Valve Unit (SG)		●	
Pump 1 Delivery Pressure Sensor	○	○	
Pump 2 Delivery Pressure Sensor	○	○	
Pump 1 Control Pressure Sensor		○	
Pump 2 Control Pressure Sensor		○	
Pressure Sensor (Travel)	○	○	
Pressure Sensor (Swing)	○	○	
Pressure Sensor (Arm Roll-In)			
Travel Mode Switch		●	
Pump Device	●		
Spool			
Load Check Valve			
Arm 1 Flow Rate Control Valve			
Flow Combiner Valve			
Pump 1 Flow Rate Control Valve (Signal Control Valve)			
Pump 2 Flow Rate Control Valve (Signal Control Valve)			
Flow Combiner Valve Control Spool (Signal Control Valve)			
Arm 1 Flow Rate Control Valve Control Spool (Signal Control Valve)			
Shuttle Valve (Signal Control Valve)			
Travel Device		●	
Center Joint			
Pilot Valve			
Remark			Operate the wiper switch.

Engine System Troubleshooting

E-1 Starter does not rotate.

Preparation

- Check that the pilot shut-off lever is in the LOCK position.
- This trouble has nothing to do with the electronic control system such as MC.
- Check the wiring connections first.
- In case the radio with the key switch set in the ACC position and the horn with the key switch set in the OFF position are operated normally, the harness between battery and key switch terminal B is considered normal.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Measure battery voltage and electrolyte density	-	The measured values are not within the normal values (Normal Value: Voltage: 24 V or more, Electrolyte density: 1.26 or more)	Faulty battery
2	Switch the starter cut relay with other general relay	Set the key switch to START after switching relays	Starter: Rotating	Faulty starter cut relay
3	Measure voltage between starter cut relay harness end #1 and #3	Key Switch: START	0 V	Open circuit in harness between key switch and starter cut relay
4	Measure voltage at starter relay 2 harness end terminal S	Key Switch: START	0 V	Open circuit in harness between starter cut relay and starter relay 2
5	Measure voltage at starter cut relay harness end #2	Key Switch: ON	0 V	Shorted circuit in harness between starter cut relay and engine stop switch
6	Measure voltage at battery relay terminal A	Key Switch: ON	0 V	Faulty battery relay
7	Measure voltage at starter terminal C	Key Switch: START	0 V	Faulty starter relay 2
8	Check continuity between key switch #1 and #6	Key Switch: START	∞ Ω	Faulty key switch
9	-	-	The check mentioned above is normal	Faulty starter

E-2 Even if starter rotates, engine does not start.

Preparation

- Check that the engine stop switch is in the OFF position.
- Check that fuses #8 and #17 are normal.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Visually inspect the governor lever	Key Switch: ON	The governor lever moves to the START position (normal)	Faulty engine unit
2	Connect the test harness (ST 7125) and operate the engine control dial	Key Switch: ON	Both lights: ON	Faulty EC motor
3	-	-	The check mentioned above is normal	Faulty MC

E-3 When engine control dial is fully rotated, engine stalls. Occasionally engine stalls during operation with engine control dial fully rotated and auto-idle ON. Engine speed is slower than specification in all operating range. Idle speed is faster or slower than specification.

Preparation

- In case engine learning has not been performed or engine learning has been incorrectly performed, engine speed becomes slower than specification across the operating range.
- In case the EC sensor is faulty, engine speed is controlled based on the governor lever position, which is judged as the idle position when the key switch is turned ON. Therefore, discrepancies in engine speed from specification will result. Depending on where the governor lever is positioned when the key switch is turned ON, discrepancy will differ, causing this trouble to be not reproducible.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Eng Learning Status	Key Switch: ON	Failure	Faulty MC or learning switch
2	Visually inspect the governor lever when performing engine learning	Key Switch: ON	The governor lever comes in contact with the stopper	Faulty engine and fuel system
3	-	-	The check mentioned above is normal	Faulty control cable or incorrectly adjusted engine governor lever

E-4 Even if engine control dial is operated, engine speed does not change.

Engine Speed (min^{-1})	Specification	Remark
Slow Idle	950±100	Control lever in neutral
Fast Idle (with ECO deactivated)	2050±50	Control lever in neutral, Heater control: OFF

Preparation

・Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor EC Dial and set the engine control dial to slow idle and fast idle	Key Switch: ON	The measured values are not within the normal values (Normal Value: Min.: 0.3 to 1.0 V, Max.: 4.0 to 4.7 V)	Faulty engine control dial
2	Connect the test harness (ST 7125) and operate the engine control dial	Key Switch: ON	Both lights: ON	Faulty EC motor
3	-	-	The check mentioned above is normal	Faulty MC

E-5 Engine speed does not increase after engine starts.

	Specification	Remark
Warming-Up Speed (min^{-1})	1400±100	

Preparation

- Refer to SYSTEM / Control System / Auto-Warming Up Control.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Hydraulic Oil Temperature	-	0 °C or more	Faulty hydraulic oil temperature sensor
2	-	-	The check mentioned above is normal	Faulty MC

E-6 Even if key switch is turned OFF, engine does not stop. (In case the engine does not stop, stop the engine by pulling the engine stop handle located under the seat stand. Then, begin inspection.)

Preparation

- Probably symptoms such as Engine speed is slower than specification in all operating range or Even if engine control dial is operated, engine speed does not change will come up. Perform troubleshooting for these symptoms.

E-7 ECO mode is faulty.

	Specification	Remark
Fast Idle Speed (ECO mode) (min^{-1})	2000±70	Control lever in neutral

Preparation

- In case other trouble symptoms occur, perform troubleshooting of these troubles first.
- The sensors detect the conditions necessary to operate ECO mode. Therefore, if these sensors fails, ECO mode becomes ineffective.
- Pump 1, 2 control pressure sensors, pump 1, 2 delivery pressure sensors, pressure sensor (travel) are also engaged in the ECO mode control. However, if these sensors fail, other operating functions will be also affected.
- Refer to SYSTEM / Control System / ECO Mode Control.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Check continuity between MC harness end #C16 and body	Power Mode Switch: ON	∞ Ω	Open circuit in harness between power mode switch and MC
2	Monitor Power Mode Switch and operate the power mode switch	Key Switch: ON	OFF is displayed	Faulty power mode switch
3	-	-	The check mentioned above is normal	Faulty MC

E-8 Travel HP mode is faulty.

	Specification	Remark
Fast Idle (Travel HP Mode) (min^{-1})	2050 to 2300	When relieving travel

- Even if the travel mode switch is set to FAST during travel single operation, travel HP mode is inoperable.

Preparation

- The sensors detect the conditions necessary to operate travel HP mode. Therefore, if these sensors fails, travel HP mode becomes ineffective.
- Pressure sensor (travel) and pumps 1, 2 delivery pressure sensors are also engaged in the travel HP mode control. However, if these sensors fail, other operating functions will be also affected.
- Refer to SYSTEM / Control System / Travel HP Mode Control.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Travel Mode SW	Travel Mode Switch: Fast	LO is displayed	Faulty travel mode switch
2	-	-	The check mentioned above is normal	Faulty MC

- Even if the travel mode switch is not set to FAST, travel mode becomes fast speed.

Preparation

- Travel must be operated when the average delivery pressures of pumps 1 and 2 are high, if travel HP mode control is performed. The sensors related to this condition may not be faulty at the same time.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Travel Mode SW	Travel Mode Switch: Slow	HI is displayed	Shorted circuit in harness between MC and travel mode switch
2	-	-	The check mentioned above is normal	Faulty MC

E-9 Auto-idle system is faulty.

	Specification	Remark
Auto-Idle Speed (min^{-1})	1300±100	

- Even if the control lever is set to neutral, auto-idle system is not operated.

Preparation

- In case other trouble symptoms occur, perform troubleshooting of these troubles first.
- Even if failure in pressure sensors (travel and front attachment) may have relevance to malfunction of the auto-idle control. However, if these sensors fail, other operating functions will also be affected.
- Refer to SYSTEM / Control System / Auto-Idle Control.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Check continuity between MC harness end #C14 and body	Auto-Idle Switch: ON	∞ Ω	Open circuit in harness between auto-idle switch and MC
2	Monitor Auto-Idle Switch and turn the auto-idle switch ON	Key Switch: ON	OFF is displayed	Faulty auto-idle switch
3	-	-	The check mentioned above is normal	Faulty MC

- Even if the auto-idle switch is in the OFF position, auto-idle system is operated.

Preparation

- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Check continuity between MC harness end #C14 and body	Auto-Idle Switch: OFF	0 Ω	Shorted circuit in harness between auto-idle switch and MC
2	Monitor Auto-Idle Switch and turn the auto-idle switch OFF	Key Switch: ON	ON is displayed	Faulty auto-idle switch
3	-	-	The check mentioned above is normal	Faulty MC

E-10 When traveling or operating front attachment with engine running at slow idle, engine hunts.

	Specification	Remark
Idle Speed-Up Speed (min^{-1})	900	

Preparation

- Even if failure in pressure sensors (travel and front attachment) may have relevance to malfunction of the idle speed-up control. However, if these sensors fail, other operating functions will also be affected. (Refer to Relationship Between Machine Trouble Symptoms And Related Parts)
- Refer to SYSTEM / Control System / Idle Speed-Up Control.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Demand Engine Speed and operate the front attachment	Engine Control Dial : Slow Idle	Engine speed is set to idle speed-up speed.	Faulty engine unit
2	-	-	The check mentioned above is normal	Faulty MC

E-11 When attachment mode is selected, engine speed does not decrease.

Preparation

- In case other trouble symptoms occur, perform troubleshooting of these troubles first.
- Refer to SYSTEM / Control System / Attachment Operation Speed Limit Control.
- Check if attachment speed adjustment has been set to Decrease (-).
- If the fault code is not displayed, MC may be faulty.

E-12 Engine stalls within several seconds after engine has started.

Preparation

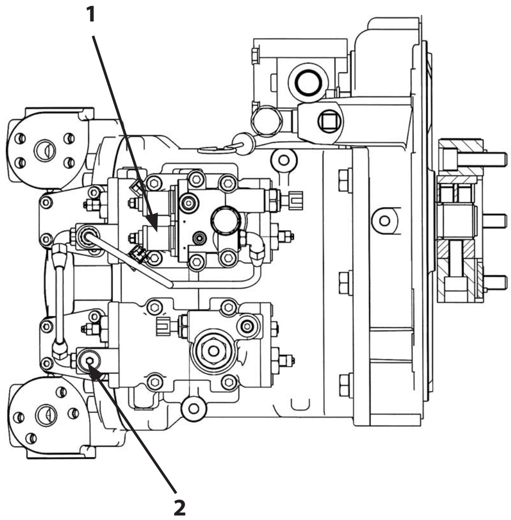
- If the learning switch is set to the learning position, the engine will stall in 5 seconds after the engine starts.
- If the engine stops with the learning switch set in the neutral position, the learning switch is faulty or the harness between learning switch and MC may be shorted.
- Check the wiring connections first.

E-13 Engine stalls under adverse operating conditions such as at high altitude.

Preparation

- If speed-sensing control is inoperable, the engine will stall under adverse operating conditions.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Install a pressure gauge to the output port and check change in pressure when a control lever is operated	-	Pressure does not change according to control lever stroke	Faulty torque control solenoid valve
2	-	-	The check mentioned above is normal	Faulty regulator



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1- Torque Control Solenoid Valve
2- Output Port

E-14 Engine is difficult to start at low temperature. (During cold weather or in cold districts, the engine is difficult to start or does not start although pre-heated.)

Preparation

- Check if electricity is routed to the glow plugs. Check the glow plugs for any abnormality.
- The pre-heat system is operated when coolant temperature is 10 °C or less.
- Check batteries.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Disconnect a connector from the coolant temperature sensor and measure voltage of the glow plug	Key Switch: ON	20 to 24 V	Faulty coolant temperature switch
2	Connect QOS controller terminal #4 to body by using a clip	-	The symptom disappears	Faulty QOS controller
3	Remove copper plates connecting each glow plug and measure each glow plug resistance	-	∞ Ω	Faulty glow plug
4	Measure voltage between glow plug relay harness end #1 and body	Key Switch: ON	0 V	Open circuit in harness between glow plug relay and battery
5	Measure voltage between glow plug relay harness end #3 and body	Key Switch: ON	0 V	Open circuit in harness between glow plug relay and key switch terminal M
6	-	-	The check mentioned above is normal	Faulty glow plug relay

All Actuator System Troubleshooting

A-1 All actuator speeds are slow.

	Specification	Remark
Primary Pilot Pressure (MPa)	$4.0^{+1.0}_{-0.5}$	Engine Control Dial : Fast Idle

Preparation

- Reduction in pump 1, and 2 flow rate due to some reasons or faulty pilot system (A-2) may cause this trouble.
- Check fuse of the torque control solenoid valve.
- Even if speed is satisfactory, in case power is weak, refer to the troubleshooting for faulty main relief valve (F-1).
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Boom Raise Pilot Pressure and relieve the boom raise circuit	-	The measured values are not within the normal values (Normal Value: 3.4-4.0 MPa)	Faulty pilot relief valve or clogged pilot filter
2	-	-	The check mentioned above is normal	Faulty pump device

A-2 All actuators are not operated.

Preparation

- The pilot shut-off circuit may be faulty.
- Even if the key switch is set to the START position with the pilot shut-off lever in the UNLOCK position, the starter does not rotate.
- Even if the key switch is set to the START position with the engine stop switch is in the ON position and the pilot shut-off lever is in the UNLOCK position, the starter rotates.
- Refer to SYSTEM / Electrical System.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor PCSL Lever Switch	Pilot Shut-Off Lever: UNLOCK Position	OFF is displayed	Faulty pilot shut-off switch.
2	Switch the pilot shut-off relay with other general relay	Pilot Shut-Off Lever: UNLOCK Position	The symptom disappears	Faulty pilot shut-off relay
3	Switch the security relay with other general relay	Pilot Shut-Off Lever: UNLOCK Position	The symptom disappears	Faulty security relay
4	Measure resistance between solenoid valve #1 and #2	-	0/∞ Ω (Normal Value: 49 Ω)	Faulty pilot shut-off solenoid valve
5	Measure voltage between pilot shut-off solenoid valve harness end #1 and body	Key Switch: ON	0 V	Open circuit in harness between pilot shut-off solenoid valve and battery relay
6	Measure voltage between pilot shut-off relay harness end #1 and body	Key Switch: ON	0 V	Open circuit in harness between pilot shut-off relay and battery relay
7	Check continuity between pilot shut-off relay harness end #1 and body	Connect pilot shut-off solenoid valve harness end terminal #2 to body	∞ Ω	Open circuit in harness between pilot shut-off solenoid valve and pilot shut-off relay
8	Check continuity between security relay harness end #4 and body	Connect pilot shut-off relay harness end terminal #5 to body	∞ Ω	Open circuit in harness between pilot shut-off relay and security relay
9	Check continuity between security relay harness end #3 and body	-	∞ Ω	Faulty ground in security relay
10	Check continuity between security relay harness end #2 and body	-	0 Ω	Shorted circuit in harness between monitor controller and security relay
11	-	-	The check mentioned above is normal	Faulty monitor controller

A-3 Travel (left) is not operated during travel single operation. Swing single operation speed becomes slow. Arm speed is slightly slow during arm level crowding operation. (All problems occur at the same time.)

Preparation

- The pump 2 flow rate is minimized (approx. 20 L/min) due to some reasons. Therefore, travel (left) and swing, which are driven by pressure oil from pump 2, move very slow.
- Pressure oil from pump 1 is also routed to the arm and boom cylinders so that the arm and boom can move at a slightly slow speed during single operation. However, during arm level crowding operation, pressure oil is routed to the boom prior to the arm so that arm speed becomes very slow.
- Refer to SYSTEM / Hydraulic System.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Pump 2 Control Pressure	Operate travel (left) control lever	Pressure does not increase according to control lever stroke	Stuck pump 2 flow rate control valve in signal control valve
2	-	-	The check mentioned above is normal	Faulty pump 2 regulator

A-4 Travel (right) is not operated during travel single operation. Bucket single operation speed becomes slow. Boom cannot be raised properly during arm level crowding. (All problems occur at the same time.)

Preparation

- The pump 1 flow rate is minimized (approx. 20 L/min) due to some reasons. Therefore, travel (right) and bucket, which are driven by pressure oil from pump 1, move very slow.
- Pressure oil from pump 2 is also routed to the arm and boom cylinders so that the arm and boom can move at a slightly slow speed during single operation. However, during arm level crowding operation, pressure oil is routed to the arm prior to the boom so that the boom cannot be raised properly.
- Refer to SYSTEM / Hydraulic System.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Pump 1 Control Pressure	Operate travel (right) control lever	Pressure does not increase according to control lever stroke	Stuck pump 1 flow rate control valve in signal control valve
2	-	-	The check mentioned above is normal	Faulty pump 1 regulator

A-5 Actuator does not stop even if control lever is set to neutral.

Preparation

- Stuck spool in the pilot valve or stuck main spool in the control valve is suspected.

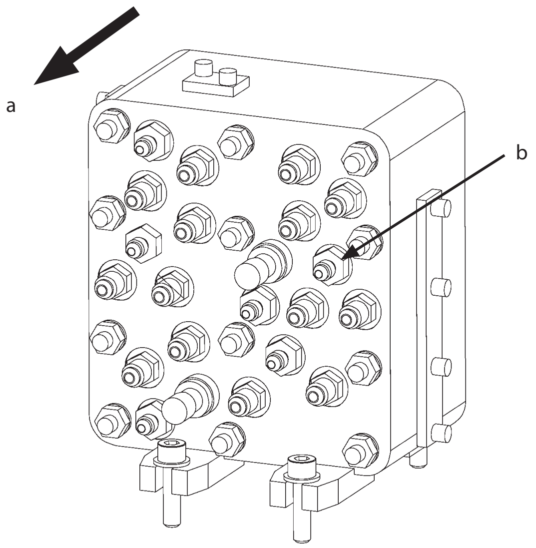
Procedure	Inspection Method	Condition	Evaluation	Cause
1	Set the pilot shut-off lever to the LOCK position	-	Actuator stops	Faulty pilot valve (stuck spool)
2	-	-	The check mentioned above is normal	Faulty control valve (stuck spool)

A-6 Occasionally, swing or arm roll-in speed becomes slow during combined operation of swing and arm roll-in.

Preparation

・ The arm 1 flow rate control valve may be faulty.
・ Refer to COMPONENT OPERATION / Control Valve.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Measure pressure at port SE of signal control valve	When relieving combined operation of swing and arm roll-in	The measured values are not within the normal values (Normal Value: approx. 3.9 MPa)	Stuck arm 1 flow rate control valve control spool in signal control valve
2	-	-	The check mentioned above is normal	Faulty arm 1 flow rate control valve in control valve



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a- Control Valve Side
b- Port SE

A-7 Actuator speed is faster than normal. Machine mistracks when travel control lever is operated at half stroke. Precise control cannot be performed.

Preparation

- The pump 1 or 2 flow rate is maximized due to some reasons. Therefore, the maximum flow rate is supplied and actuator speed is faster though the control lever does not reach the full stroke.
- The pressure oil from pump 1 makes travel (right) perform, and the pressure oil from pump 2 makes travel (left). Differential flow rate between pump 1 and pump 2 occurs and the machine mistracks when the travel control lever is operated at half stroke.
- Refer to SYSTEM / Hydraulic System.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Pump 1 Control Pressure	Operate bucket	Pressure does not increase according to control lever stroke	Stuck pump 1 flow rate control valve in signal control valve
2	Monitor Pump 2 Control Pressure	Operate swing	Pressure does not increase according to control lever stroke	Stuck pump 2 flow rate control valve in signal control valve
3	-	-	The check mentioned above is normal	Faulty pump regulator

Front Attachment System Troubleshooting

F-1 All front attachment actuator power are weak.

Main Relief Valve Set Pressure (MPa)	Specification	Remark
Arm, Bucket (Relief operation for each)	$34.3^{+2.0}_{-0.5}$	
Boom Raise Relief or Power Digging	$38.0^{+2.0}_{-1.0}$	

Preparation

- If operating speeds are extremely slow, pump control may be faulty (A-3, A-4). Faulty pilot system may also cause this trouble.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Pump 1 Delivery Pressure and Pump 2 Delivery Pressure	Arm relief operation	The measured values are not within the normal values (Normal Value: 34.3-36.3 MPa)	Faulty main relief valve (readjust)
2	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms

F-2 Even if power digging switch is pushed, power does not increase.

Preparation

- Refer to SYSTEM / Control System / Power Digging Control and Auto-Power Lift Control.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Power Boost Switch	Power Digging Switch: ON	OFF is displayed	Faulty power digging switch or open circuit in harness between power digging switch and MC
2	Monitor Pump 1 Delivery Pressure and Pump 2 Delivery Pressure	Relieve boom raise circuit	The measured values are not within the normal values (Normal Value: 38 to 40 MPa)	Faulty main relief valve
3	-	-	The check mentioned above is normal	Faulty MC

F-3 Some cylinders are not operated or speeds are slow.

Overload Relief Valve Set Pressure (MPa)	Specification	Remark
Boom, Arm Roll-Out, Bucket	$39.2^{+1.0}_{-0}$	

Preparation

- When other actuators (travel and swing motors) are operated normally, the pilot pump (primary pilot pressure) is considered to be normal.
- In case bucket single operation speed is slow, also refer to F-6.
- In case arm roll-in single operation speed is slow, also refer to F-7.
- In case boom lower single operation speed is slow, also refer to F-8.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Boom Raise Pilot Pressure and Arm Roll-In Pilot Pressure	Fully operate boom raise and arm roll-in	The measured values are not within the normal values (Normal Value: 3.4-4.0 MPa)	Faulty pilot valve or stuck spool of shockless valve in signal control valve (only boom raise)
2	Monitor Pump 1 Control Pressure and Pump 2 Control Pressure	Slowly operate the control lever	The measured values are not within the normal values (Normal Value: 2.9-3.9 MPa)	Faulty shuttle valve in signal control valve
3	Switch overload relief valves, of which the set pressure are same	-	Symptom is reversed	Faulty overload relief valve
4	-	-	The check mentioned above is normal	Stuck control valve spool, or faulty cylinder (faulty seal kit)

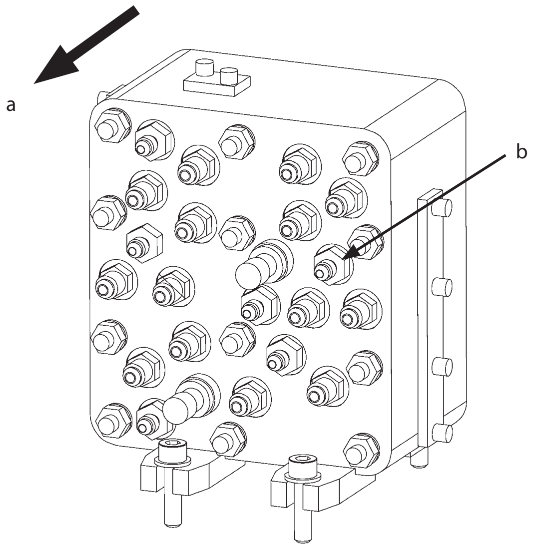
F-4 Arm operation speed is slow during combined operation. Boom raise speed is slow during combined operation of boom raise and arm roll-in. Arm speed is slow during arm level crowding operation.

	Specification	Remark
Boom Raise, Arm Roll-In (sec)	(4.3±0.5)	2.91 m arm 0.8 m^3 bucket

Preparation

・ Refer to SYSTEM / Control System / Arm Regenerative Control.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Measure pressure at port SE of signal control valve	When relieving combined operation of swing and arm roll-in	The measured values are not within the normal values (Normal Value: approx. 3.9 MPa)	Faulty arm 1 flow rate control valve control spool in signal control valve
2	Disassemble and inspect the arm 1 flow rate control valve	-	There is abnormality	Faulty arm 1 flow rate control valve
3	Disassemble and inspect the arm regenerative valve	-	There is abnormality	Faulty arm regenerative valve
4	Disassemble and inspect the arm 2 flow rate control valve	-	There is abnormality	Faulty arm 2 flow rate control valve
5	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms



T178-03-06-015

a- Control Valve Side b- Port SE

F-5 Arm roll-in speed is slow during digging operation.

Preparation

- Refer to SYSTEM / Control System / Digging Regenerative Control.

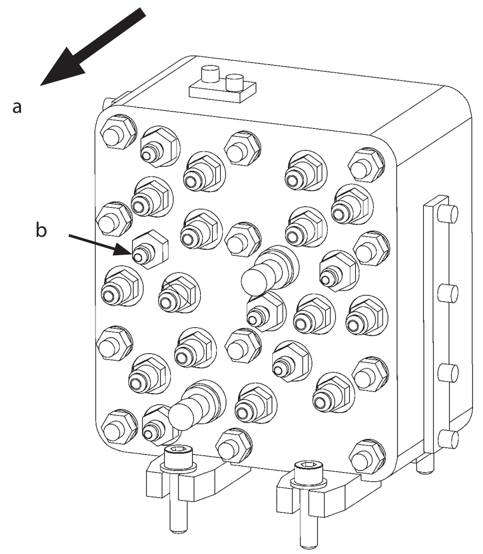
Procedure	Inspection Method	Condition	Evaluation	Cause
1	Disassemble and inspect the digging regenerative valve	-	There is abnormality	Faulty digging regenerative valve
2	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms

F-6 Bucket roll-in single operation speed is slightly slow. Bucket does not move smoothly during bucket roll-in single operation.

Preparation

- The bucket flow rate control valve or bucket regenerative valve may be faulty.
- Refer to COMPONENT OPERATION / Control Valve.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Measure pressure at port SK of signal control valve	When relieving combined operation of boom raise, arm roll-in, and bucket roll-in	approx. 3.9 MPa	Stuck bucket flow rate control valve control spool in signal control valve
2	Disassemble and inspect the bucket flow rate control valve	-	There is abnormality	Faulty bucket flow rate control valve
3	Disassemble and inspect the bucket regenerative valve	-	There is abnormality	Faulty bucket regenerative valve
4	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms



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a- Control Valve Side
b- Port SK

F-7 When starting to move arm during combined operation, arm does not smoothly move. Arm starts to move slightly slow during arm roll-in single operation. These troubles often occur when temperature is low.

Preparation

- Refer to COMPONENT OPERATION / Control Valve.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Disassemble and inspect the arm anti-drift valve	-	There is abnormality	Faulty arm anti-drift valve
2	Disassemble and inspect the arm regenerative valve	-	There is abnormality	Faulty arm regenerative valve
3	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms

F-8 When starting to move boom during combined operation, boom does not smoothly move. Boom starts to move slightly slow during boom lower single operation.

Preparation

- Refer to COMPONENT OPERATION / Control Valve.

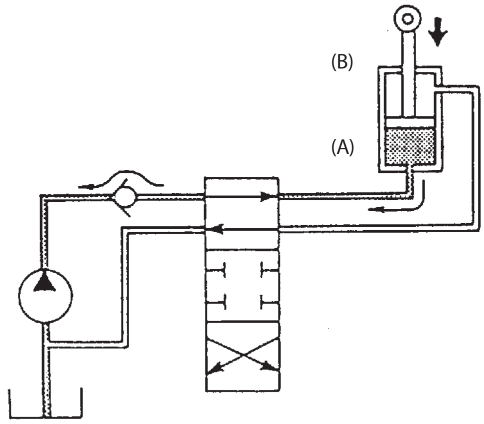
Procedure	Inspection Method	Condition	Evaluation	Cause
1	Disassemble and inspect the boom anti-drift valve	-	There is abnormality	Faulty boom anti-drift valve
2	Disassemble and inspect the boom lower meter-in cut valve	-	There is abnormality	Faulty boom lower meter-in cut valve
3	Disassemble and inspect the boom regenerative valve	-	There is abnormality	Faulty boom regenerative valve
4	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms

F-9 When boom raise or arm roll-out is operated, boom or arm starts to move after moving slightly down.

Preparation

- During the initial stage of operation, oil pressure and flow rate from the pump is low. Therefore, if the load check valve is faulty, the oil in the bottom side of the boom cylinder flows back into the circuit through the load check valve. Therefore, the boom cylinder is temporarily retracted.
- As oil pressure and flow rate from the pump is low, if oil leaks from bottom side (A) to rod side (B) due to faulty boom cylinder piston or cylinder barrel, the boom cylinder is temporarily retracted during the initial stage of operation. In addition, cylinder force is reduced. The boom cylinder drift increases in this case.

When the load check valve is faulty:

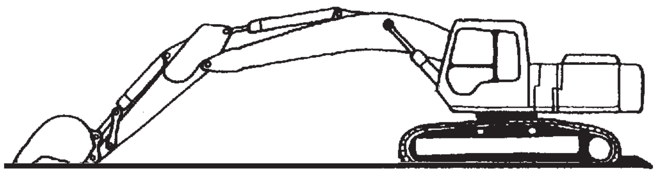


T105-07-04-012

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Disassemble and inspect the load check valve	-	There is abnormality	Faulty load check valve
2	Disassemble and inspect the anti-drift valves (boom, arm)	-	There is abnormality	Faulty anti-drift valve
3	-	-	The check mentioned above is normal	Faulty cylinder (seal kit)

F-10 Front attachment drifts remarkably.

- Boom Cylinder Internal Leakage Check
  1. With the bucket cylinder fully retracted and the arm cylinder slightly extended from the fully retracted position, lower the bucket tooth tips onto the ground.
  2. Disconnect the hoses from the boom cylinder rod side. Drain oil from the hoses and cylinders. (Plug the disconnected hose ends.)
  3. Retract the arm cylinder and lift the bucket off the ground. If oil flows out of the hose disconnected piping ends and the boom cylinders are retracted at this time, oil leaks in the boom cylinders. If no oil flows out of the hose disconnected piping ends but the boom cylinders are retracted, oil leaks in the control valve.



T105-07-04-009

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Set the pilot shut-off lever to the LOCK position	-	The symptom disappears	Faulty pilot valve
2	Switch overload relief valve	-	The symptom disappears	Faulty overload relief valve
3	Disassemble and inspect the anti-drift valves (boom, arm)	-	There is abnormality	Faulty anti-drift valve
4	Disassemble and inspect the emergency valve	-	There is abnormality	Faulty emergency valve
5	Disassemble and inspect the cylinder	-	There is abnormality	Faulty cylinder (seal kit)
6	-	-	The check mentioned above is normal	Scored control valve spool, broken spring, or loose spool end

F-11 Boom lower speed above ground is faster than other actuators during combined operation.

Preparation

- The boom lower meter-in cut valve or boom flow rate control valve may be faulty.
- Refer to SYSTEM / Hydraulic System and COMPONENT OPERATION / Control Valve.
- In case boom lower single operation speed is slow, also refer to F-8.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Disassemble and inspect the boom lower meter-in cut valve	-	There is abnormality	Faulty boom lower meter-in cut valve
2	Disassemble and inspect the boom flow rate control valve	-	There is abnormality	Faulty boom flow rate control valve
3	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms

F-12 Machine cannot be raised off ground.

Preparation

- The boom lower meter-in cut valve or boom flow rate control valve may be faulty.
- Refer to SYSTEM / Hydraulic System and COMPONENT OPERATION / Control Valve.
- In case boom lower single operation speed is slow, also refer to F-8.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Disassemble and inspect the boom lower meter-in cut valve	-	There is abnormality	Faulty boom lower meter-in cut valve
2	Disassemble and inspect the bypass shut-out valve	-	There is abnormality	Faulty bypass shut-out valve
3	Disassemble and inspect the boom flow rate control valve	-	There is abnormality	Faulty boom flow rate control valve
4	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms

Swing System Troubleshooting

S-1 Swing is slow or unmoving.

	Specification	Remark
Swing Speed (sec/3 rev)	13.5±1.0	The bucket should be empty

Preparation

- Check whether the pilot system is faulty or the main circuit is faulty.
- If other functions (front attachment and travel) are operated normally, the pilot pump (primary pilot pressure) is considered to be normal. If the pilot system is faulty, the cause of trouble may exist in the circuit after the pilot valve.
- In case travel (left) is also slow, also refer to A-3.

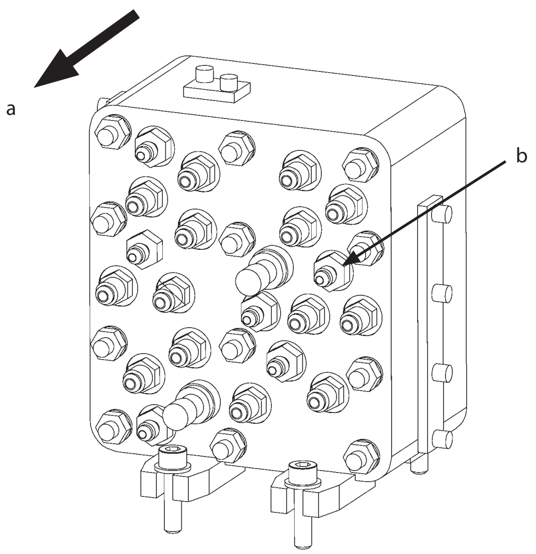
Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Swing Pilot Pressure	Fully swing	The measured values are not within the normal values (Normal Value: 3.4-4.0 MPa)	Faulty pilot valve
2	Monitor Pump 2 Control Pressure	Fully swing	The measured values are not within the normal values (Normal Value: 2.9-3.9 MPa)	Stuck pump 2 flow rate control valve in signal control valve
3	Monitor Front ATT Pilot Pressure	When relieving arm	The measured values are not within the normal values (Normal Value: approx. 3.9 MPa)	Faulty swing parking brake release spool in signal control valve
4	Disassemble and inspect the parking brake release valve in the swing motor	-	There is abnormality	Faulty swing parking brake release valve
5	Monitor Pump 2 Delivery Pressure	When relieving swing	The measured values are not within the normal values (Normal Value: approx. 33.3 MPa)	Faulty swing relief valve
6	Measure the swing motor drainage	With constant speed	The measured values are not within the normal values (Normal Value: 0.2-0.3 L/min)	Faulty swing motor
7	-	-	The check mentioned above is normal	Faulty swing reduction gear

S-2 Swing is slow (power is weak) during combined operation of swing and arm roll-in. Swing does not start smoothly. Swing power is weak.

Preparation

- Refer to SYSTEM / Hydraulic System / Valve Control Circuit and COMPONENT OPERATION / Control Valve.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Measure pressure at port SE of signal control valve	When relieving combined operation of swing and arm roll-in	The measured values are not within the normal values (Normal Value: approx. 3.9 MPa)	Faulty arm 1 flow rate control valve control spool in signal control valve
2	-	-	The check mentioned above is normal	Faulty arm 1 flow rate control valve



T178-03-06-015

a- Control Valve Side b- Port SE

Travel System Troubleshooting

T-1 Both right and left tracks do not rotate or rotate slowly.

Travel Speed (sec/10 m)	Specification	Remark
Fast Speed	6.6±0.6	
Slow Speed	(10.2±1.0)	

Preparation

- Both right and left pilot valves, travel motors, and/or control valve spools are unlikely to be faulty at the same time.
- If both travel systems are not operated, the pilot system, which is applied to both side travel motors, may be faulty. If the primary pilot pressure is lower than specification, the front attachment operating speed becomes slow as well. Refer to A-1.
- If the fast travel mode cannot be selected, refer to T-5.

T-2 One side track does not rotate or rotates slowly. Machine mistracks.

Track Revolution Speed (sec/3 rev)	Specification	Remark
Fast Speed	17.2±1.0	
Slow Speed	26.7±2.0	

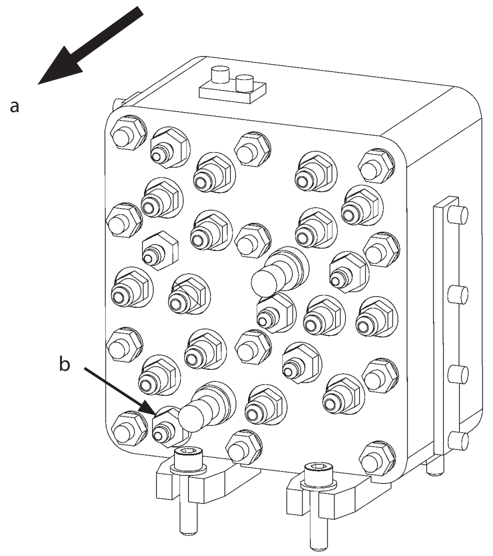
Preparation

- Check that both side track sags are equally adjusted.
- Faulty pump control will cause the machine to mistrack. In this case, other trouble symptoms such as slow bucket or swing single operation speed, or slow arm roll-in and boom raise speed during level crowding operation will occur at the same time.
- If both mistrack and other symptoms as described above occur at the same time, refer to A-3 and A-4.
- In only one side track does not rotate, the pilot valve, the control valve, the travel motor, or the center joint may be faulty.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Travel Pilot Pressure	Operate the control lever alternately	The measured values are not within the normal values (Normal Value: 3.4-4.0 MPa)	Faulty pilot valve
2	Switch right and left travel line hoses each other at the top of center joint	-	Symptom is reversed	Stuck control valve spool
3	Monitor Pump 1 Delivery Pressure and Pump 2 Delivery Pressure	When relieving travel	The measured values are not within the normal values (Normal Value: approx. 34.9 MPa)	Faulty travel relief valve
4	Switch forward travel relief valve with reverse travel one, or right travel relief valve with left one	-	Symptom is reversed	Faulty center joint
5	Measure the travel motor drainage	With the motor relieved	The measured values are not within the normal values (Normal Value: less than 15 L/min)	Faulty travel motor
6	Disassemble and inspect the counterbalance valve	-	There is abnormality	Faulty counterbalance valve
7	Disassemble and inspect the travel motor servo piston.	-	There is abnormality	Faulty travel motor servo piston
8	-	-	The check mentioned above is normal	Faulty travel reduction gear

T-3 Machine mistracks during combined operation of travel and front attachment.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Measure pressure at port SL of signal control valve	Combined operation of travel and front attachment	The measured values are not within the normal values (Normal Value: approx. 3.9 MPa)	Faulty flow combiner valve control spool in signal control valve
2	Disassemble and inspect the flow combiner valve	-	There is abnormality	Faulty flow combiner valve
3	Disassemble and inspect the load check valve	-	There is abnormality	Faulty load check valve
4	-	-	The check mentioned above is normal	Find out cause of trouble by tracing other trouble symptoms



T178-03-06-015

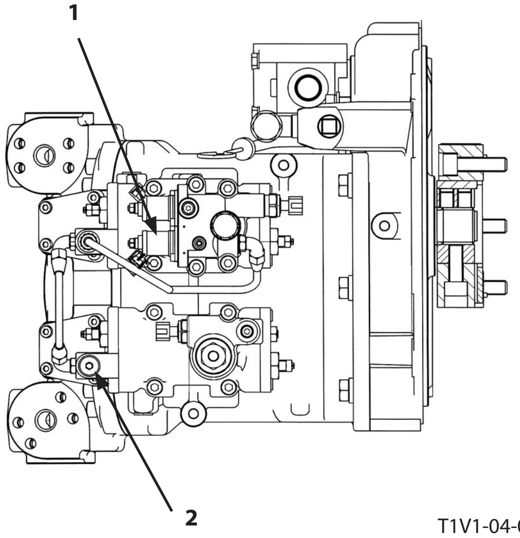
a- Control Valve Side   b- Port SL

T-4 Occasionally, machine may mistrack when traveling with engine running at slow speed.

Preparation

- Refer to SYSTEM / Control System / Travel Torque-Up Control.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Travel Pilot Pressure	Operate travel function	Pressure does not change according to control lever stroke	Faulty pressure sensor (travel)
2	Measure pressure at output port of torque control solenoid valve	Operate travel function	The measured values are not within the normal values (Normal Value: approx. 1.5 MPa)	Faulty torque control solenoid valve
3	-	-	The check mentioned above is normal	Faulty pump device



T1V1-04-05-002

1- Torque Control Solenoid Valve
2- Output Port

T-5 Fast travel is not selected. Travel mode does not change from slow mode to fast mode.

Preparation

- Refer to SYSTEM / Control System / Travel Motor Displacement Angle Control.
- Check the wiring connections first.
- If the maximum speed cannot reach at the fast mode, the travel HP mode control may be faulty. Refer to E-8.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Monitor Travel Mode SW	Shift the travel mode switch	HI/LO of travel mode are not shifted	Faulty travel mode switch or open circuit in harness between travel mode switch and MC
2	Monitor Travel Pilot Pressure	Operate travel function	Pressure does not change according to control lever stroke	Faulty pressure sensor (travel)
3	Disassemble and inspect	-	There is abnormality	Faulty travel motor displacement angle control valve
4	-	-	The check mentioned above is normal	Faulty travel motor or travel reduction gear

Other System Troubleshooting

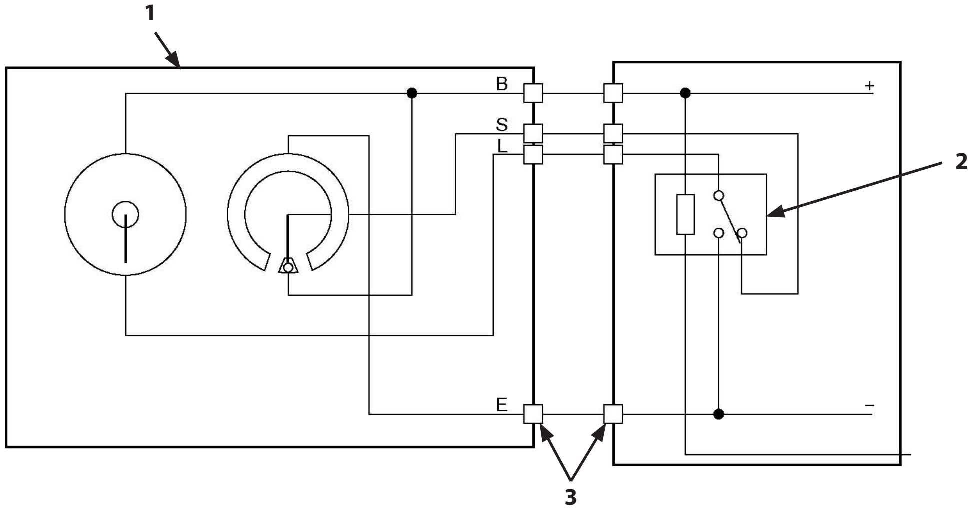
O-1 Wiper is not operated.

Preparation

- The wiper is driven by electric power routed via the relay circuit. The relay circuit is controlled by the wiper/light controller.
- In case the wiper is not operated, first check if the wiper relay is activated. Next, check if electric power is routed to the wiper motor.
- When the front window is open, the wiper is not operated. Check that the front window is closed securely.
- In case the washer is also not operated, check fuse #2.

Procedure	Inspection Method	Condition	Evaluation	Cause
1	Switch the wiper relay with other general relay	Key Switch: ON	The wiper is operated	Faulty wiper relay
2	Monitor Wiper 1 Input (or Wiper 2 Input)	Wiper Switch: ON Position (or Overhead Window Wiper Switch: ON Position)	OFF is displayed	Faulty wiper switch or open circuit in harness between wiper switch and wiper/light controller
3	Monitor Wiper 1 Output (or Wiper 2 Output)	Wiper Switch: ON Position (or Overhead Window Wiper Switch: ON Position)	OFF is displayed	Open circuit in harness between wiper relay and wiper/light controller
4	Measure voltage between window contact (cab side) terminals B and L	Key Switch: ON Wiper Switch: ON	0 V	Open circuit in harness between wiper relay and window contact
5	Measure voltage between window contact (wiper motor side) terminals B and L	Key Switch: ON Wiper Switch: ON	0 V	Open circuit in harness between window contact and wiper motor
6	-	-	The check mentioned above is normal	Faulty wiper motor

Wiper Driving Circuit



T1V1-05-07-004

1- Wiper Motor
2- Wiper Relay
3- Window Contact

Exchange Inspection

Exchange inspection method is a troubleshooting method to find the trouble location by exchanging the suspected part / component with another part / component having identical characteristics.

Many sensors and solenoid valves used on this machine are identical. Therefore, by using this switch-check method, faulty part /component, and/or harness can be easily found.

Ex.) Abnormal pump 1 delivery pressure high voltage (MC fault code: 11200-3)

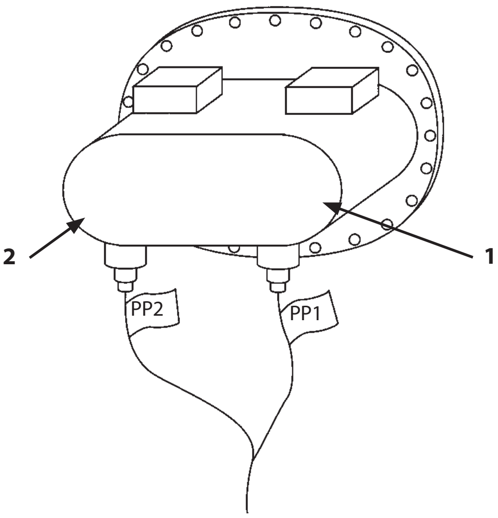
Check Method:

1. Switch two delivery pressure sensors located as shown in figure A to figure B.
2. Retry troubleshooting.

Result:
In case abnormal pump 2 delivery pressure high voltage (MC fault code 11202-3) is displayed, the pump 1 delivery pressure sensor is considered to be faulty.

In case abnormal pump 1 delivery pressure high voltage (MC fault code 11200-3) is displayed, the pump 1 delivery pressure sensor harness is considered to be faulty.

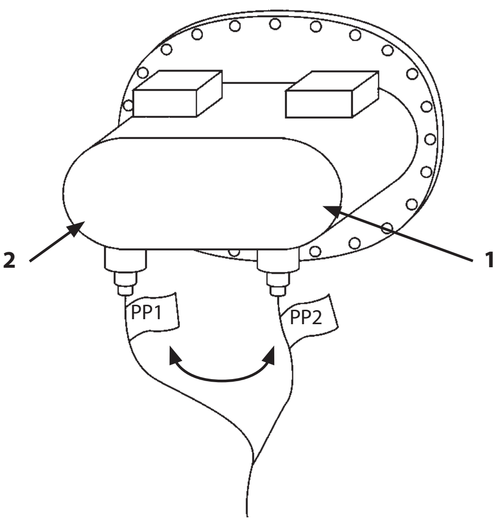
A



T157-07-04-006

1- Pump 1 (4-Spool Side) 2- Pump 2 (5-Spool Side)

B



T157-07-04-006

1- Pump 1 (4-Spool Side) 2- Pump 2 (5-Spool Side)

Applicability of Switch-Check Method

Fault Code	Trouble	Remedy
11200-3	Pump 1 Delivery Pressure Sensor Circuit High Input	Applicable (Harness / Sensor)
11200-4	Pump 1 Delivery Pressure Sensor Circuit Low Input	
11202-3	Pump 2 Delivery Pressure Sensor Circuit High Input	
11202-4	Pump 2 Delivery Pressure Sensor Circuit Low Input	
11206-3	Pump 1 Flow Control Pressure Sensor Circuit High Input	Applicable (Harness / Sensor)
11206-4	Pump 1 Flow Control Pressure Sensor Circuit Low Input	
11208-3	Pump 2 Flow Control Pressure Sensor Circuit High Input	
11208-4	Pump 2 Flow Control Pressure Sensor Circuit Low Input	
11301-3	Swing Pilot Pressure Sensor Circuit High Input	Applicable (Harness / Sensor)
11301-4	Swing Pilot Pressure Sensor Circuit Low Input	
11302-3	Boom Raise Pilot Pressure Sensor Circuit High Input	
11302-4	Boom Raise Pilot Pressure Sensor Circuit Low Input	
11303-3	Arm Roll-In Pilot Pressure Sensor Circuit High Input	
11303-4	Arm Roll-In Pilot Pressure Sensor Circuit Low Input	
11304-3	Travel Pilot Pressure Sensor Circuit High Input	
11304-4	Travel Pilot Pressure Sensor Circuit Low Input	
11307-3	Front Pilot Pressure Sensor Circuit High Input	
11307-4	Front Pilot Pressure Sensor Circuit Low Input	

Applicability of Switch-Check Method

Fault Code	Trouble	Remedy
11400-2	Pump 2 Flow Rate Limit P/S Valve Abnormal FB	Applicable (Harness)
11400-3	Pump 2 Flow Rate Limit P/S Valve FB High Current	
11400-4	Pump 2 Flow Rate Limit P/S Valve FB Low Current	
11401-2	Pump 1 and 2 Torque P/S Valve Abnormal FB	
11401-3	Pump 1 and 2 Torque P/S Valve FB High Current	
11401-4	Pump 1 and 2 Torque P/S Valve FB Low Current	
11402-2	Solenoid Valve Unit (SF) Abnormal FB	Applicable (Harness / Solenoid Valve)
11402-3	Solenoid Valve Unit (SF) FB High Input	
11402-4	Solenoid Valve Unit (SF) FB Low Input	
11403-2	Solenoid Valve Unit (SC) Abnormal FB	
11403-3	Solenoid Valve Unit (SC) FB High Input	
11403-4	Solenoid Valve Unit (SC) FB Low Input	
11407-2	Solenoid Valve Unit (SG) Abnormal FB	
11407-3	Solenoid Valve Unit (SG) FB High Input	
11407-4	Solenoid Valve Unit (SG) FB Low Input	

How to Lowering Boom in Case of Emergency and When Engine Stops

CAUTION: Prevent personal injury. Confirm that no one is under the front attachment before starting the procedure below.

If the engine stalls and cannot be restarted, lower the boom to the ground referring to the emergency boom lowering procedure stated below.

IMPORTANT: Lock nut (1) and screw (2) are located under the solenoid valve. Pay attention to the screw turns.

1. Loosen lock nut (1) of emergency valve (3). Loosen screw (2) one half of a turn. The boom lowering speed can be somewhat adjusted by loosening screw (2) more.
2. After the boom is lowered, tighten screw (2) and tighten lock nut (1) to the specifications below.

Lock Nut (1)

: 13 mm

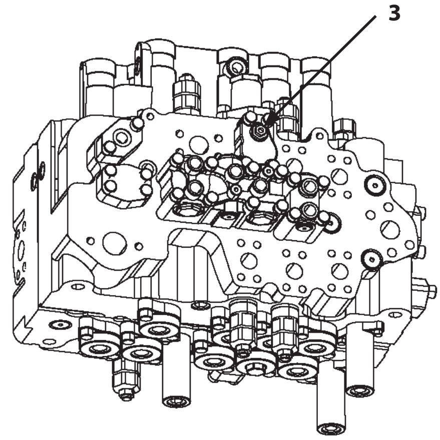
: 13 N·m (1.3 kgf·m)

Screw (2)

: 4 mm

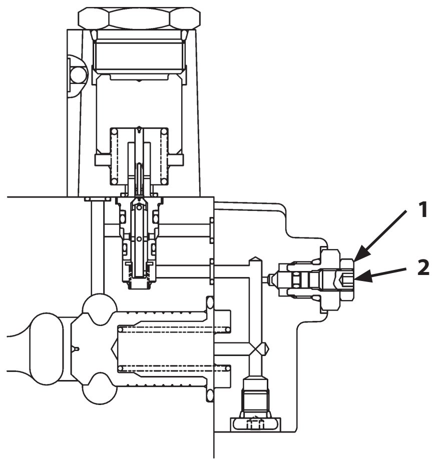
: 7.0 N·m (0.7 kgf·m)

NOTE: Excessive leakage may result if the screw and the lock nut are tightened insufficiently. Retighten the screw and the lock nut to specifications.



T1V1-05-04-005

3- Emergency Valve

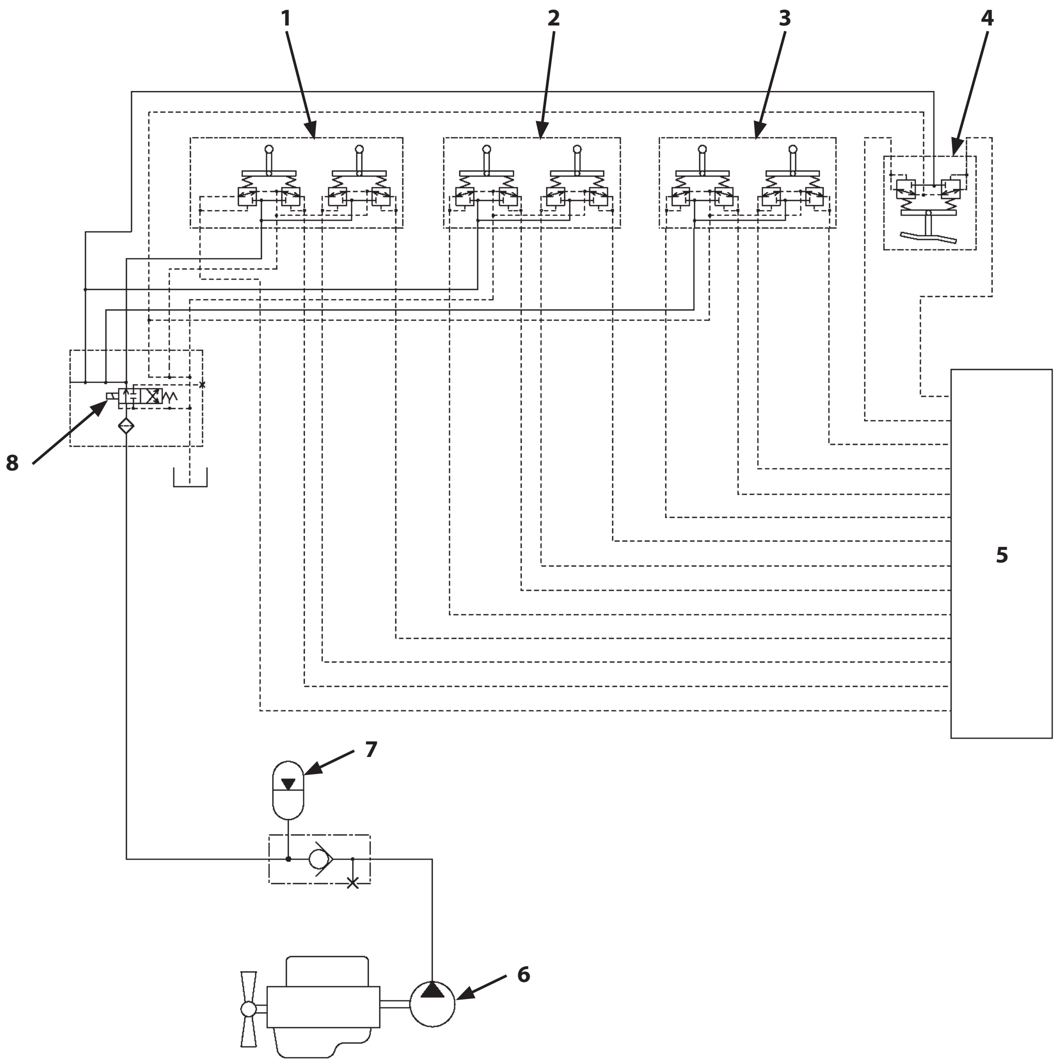


TCJB-05-07-001

1- Lock Nut 2- Screw

Attachment Circuit Pressure Release Procedure

As for the attachment specification machine, the accumulator is equipped between pilot pump and pilot valve.
When the control lever is operated after the engine is stopped by the engine stop knob with the pilot shut-off lever set in UNLOCK position, the accumulator releases pressure in the pilot circuit.



TDCD-05-07-001

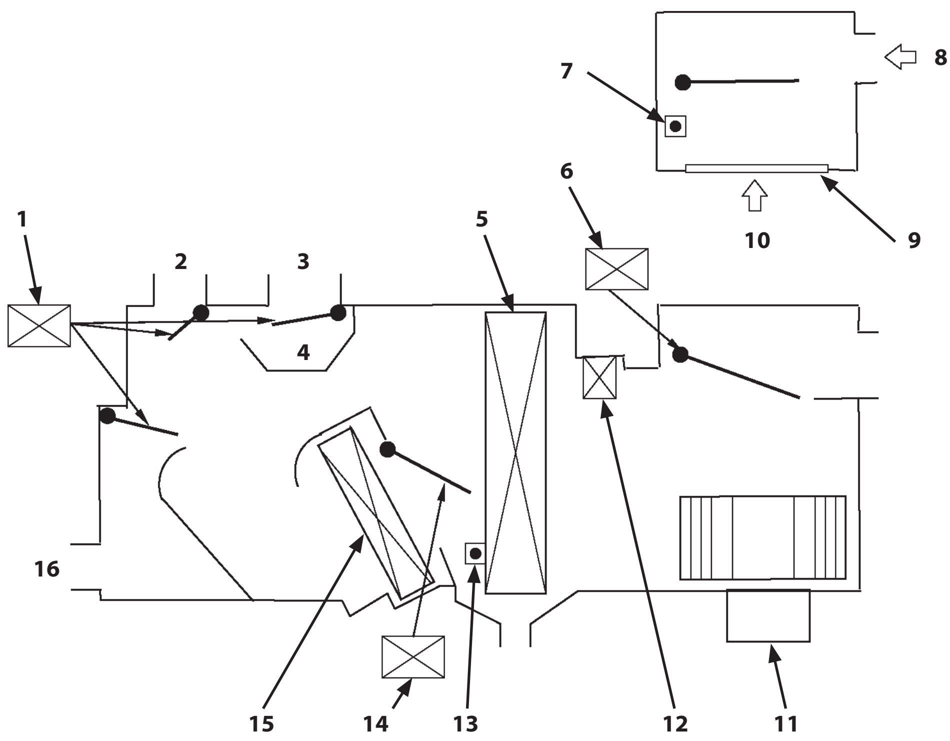
1- Travel Pilot Valve
2- Pilot Valve (Left)
3- Pilot Valve (Right)
4- Auxiliary Pilot Valve
5- Control Valve
6- Pilot Pump
7- Accumulator
8- Pilot Shut-Off Solenoid Valve

(Blank)

Outline

Operation layout of the air conditioning system is illustrated below.
Either fresh or re-circulated air is induced into the air conditioner unit by operating fresh / re-circulated air damper servo motor (6).
The induced air flows out of the vents through evaporator (5) or heater (15) by blower motor (11). Evaporator (5) is a device used to cool the air. Heater (15) is a device used to warm the air. In the air conditioning system, after the refrigerant is compressed by the compressor, it is sent to evaporator (5) in which the refrigerant expands to cool the air. Heater (15) warms air by first absorbing heat from warmed engine coolant. Evaporator (5) and heater (15) allow the introduced air to circulate in the system to maintain the temperature at the set temperature.

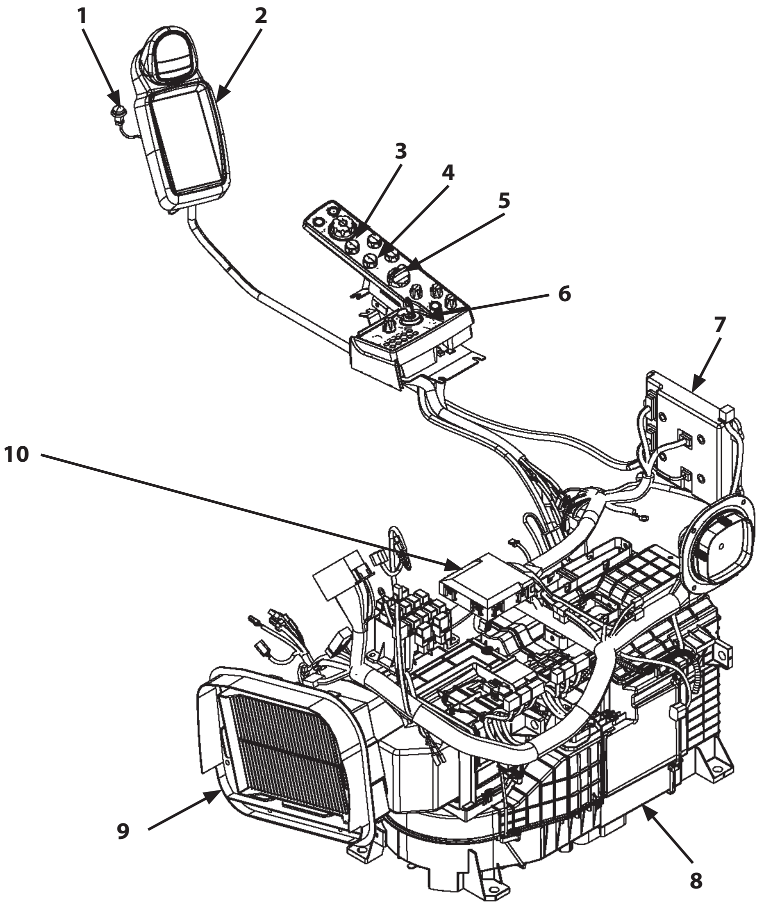
The vents (operator's front/rear vent, foot vent, and the front window) can be simultaneously or independently selected by air vent damper servo motor (1) in accordance with the set-ventilation mode.
The front widow and operator's front vents are manually selectable. The air conditioning controller controls the air conditioning system. The air conditioning controller controls the damper operation by corresponding to the job site conditions such as atmospheric and cab inside air temperatures, coolant temperature, operator's set-temperature, and the selected ventilation mode. In addition, the air conditioning controller displays the air conditioning system operation status on the monitor.



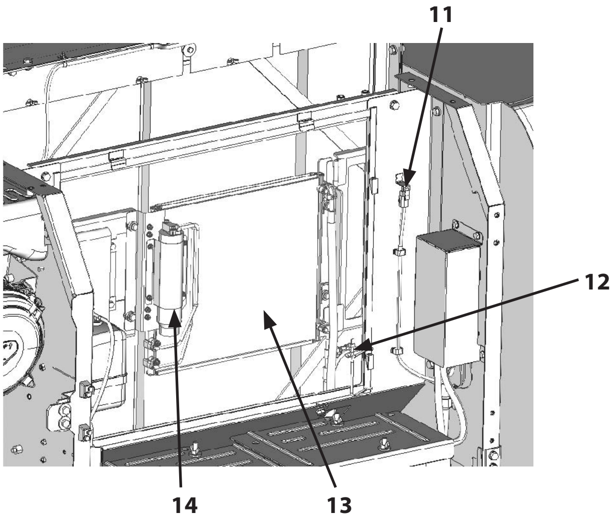
TDAA-05-07-001

1- Air Vent Damper Servo Motor
2- Defroster Vent
3- Rear Vent
4- Front Vent
5- Evaporator
6- Fresh / Re-circulated Air Damper Servo Motor
7- Re-circulated Air Sensor
8- Fresh Air Induction Port
9- Re-circulated Air Filter
10- Re-circulated Air Induction Port
11- Blower Motor
12- Power Transistor
13- Frost Sensor
14- Air Mix Damper Servo Motor
15- Heater Core
16- Foot Vent

Component Layout

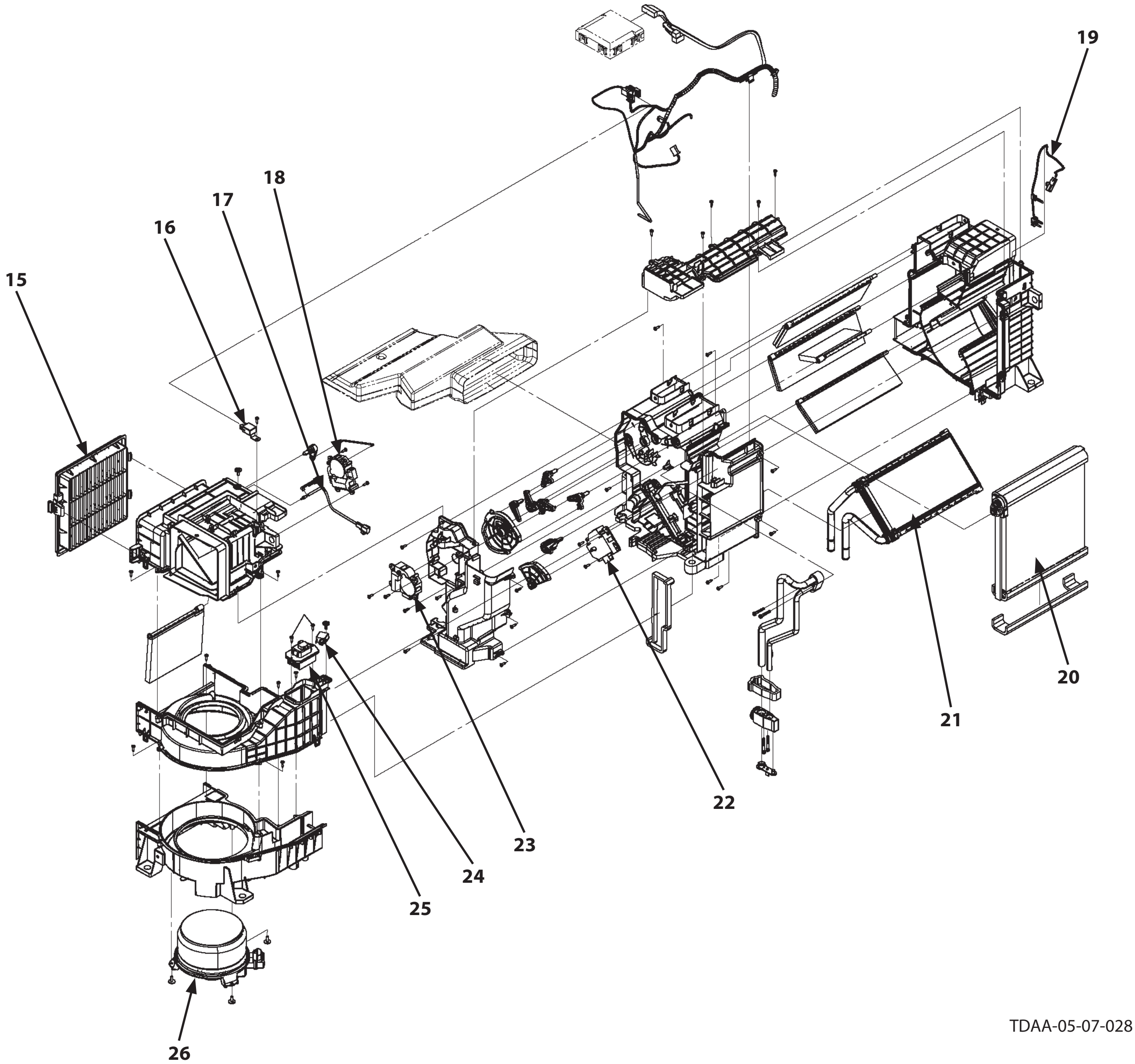


TDAA-05-07-027



TDAA-05-07-026

1- Solar Radiation Sensor
2- Monitor
3- Temperature Control Switch/ Mode Switch
4- AUTO/OFF Switch / Blower Switch
5- Engine Control Dial
6- Key Switch
7- Monitor Controller
8- Air Conditioner Unit
9- Fresh Air Filter
10- Air Conditioner Controller
11- Outdoor Ambient Temperature Sensor
12- High/Low Pressure Switch
13- Air Conditioner Condenser
14- Receiver Tank



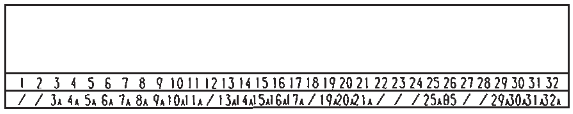
- 15- Re-circulated Air Filter
- 16- Compressor Relay
- 17- Re-circulated Air Sensor
- 18- Fresh / Re-circulated Air Damper Servo Motor
- 19- Frost Sensor
- 20- Evaporator
- 21- Heater Core
- 22- Air Mix Damper Servo Motor
- 23- Air Vent Damper Servo Motor
- 24- Blower Motor Relay
- 25- Power Transistor
- 26- Blower Motor

Functions of Main Parts

The functions of the main parts for the air conditioner are described below. The connector No. is shown in the parentheses after the part name.

- Controller

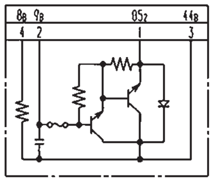
Controls the air conditioning system. According to the operator's requests sent via the switches, and the information regarding the air and refrigerant temperature sent from the sensors, the controller judges the air conditioner operating status and controls the blower motor and/or compressor operation as needed by operating the relays. In addition, the controller informs the operator of the air conditioner operating status by displaying the information on the monitor panel.



TDAA-05-07-002

- Power Transistor (CN7)

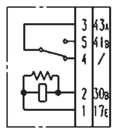
An electric switch to control blower motor voltage.



TDAA-05-07-003

- Blower Motor Relay (CN3)

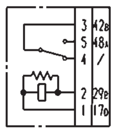
Supplies 24 volts of electricity to the blower motor when the air conditioner is operated. The blower motor relay is turned ON when excited by the current from terminal #30 in controller.



TDAA-05-07-004

- Compressor Relay (CN4)

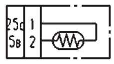
Supplies 24 volts of electricity to the compressor clutch when the air conditioner is operated. The compressor relay is turned ON when excited by the current from terminal #29 in controller.



TDAA-05-07-005

- Frost Sensor (CN12)

Monitors the fin temperature which is cooled by the evaporator. When the temperature is higher than 3°C (approx. 4.2 kΩ), the controller turns the compressor relay ON. When the temperature is lower than 2 °C (approx. 4.5 kΩ), the controller turns the compressor relay OFF. Therefore, the evaporator in the air conditioner unit is prevented from freezing. The electrical resistance in the frost sensor is 100 Ω to 115 kΩ.

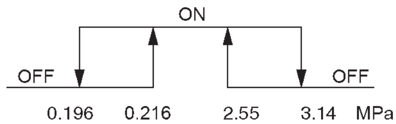


TDAA-05-07-006

- High/Low Pressure Switch (CN14)

Controls the compressor clutch solenoid while monitoring the compressor circuit pressure. The high/low pressure switch consists of a pressure gauge and a switch. The pressure gauge detects the lower pressure range (0.196 MPa to 0.216 MPa) and the surge pressure range (2.55 MPa to 3.14 MPa). When the circuit pressure is reduced to the lower pressure range or increases to the surge pressure range, the pressure gauge turns the switch OFF so that the compressor operation stops. If the pressure is reduced to the lower range, a lack of refrigerant is suspected. Therefore, damage to the compressor due to a lack of refrigerant is prevented. In case the pressure increases to the surge range, damage to the air conditioner circuit parts due to excessively high circuit pressure is prevented.

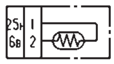
TDAA-05-07-007



TDAA-05-07-014

- Air Circulation Sensor (CN11)

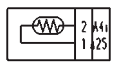
Monitors the temperatures (0 to 25 C) around the re-circulated air inlet as the interior air temperatures and converts them to the electrical resistance values. The temperatures 0 °C to 25 °C corresponds to a resistance of 1.645 kΩ (0 °C) to 5 kΩ (25 °C) respectively.
The electrical resistance in the air circulation sensor is 300 Ω to 430 kΩ.



TDAA-05-07-008

- Fresh Air Sensor (CN15)

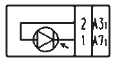
Monitors the temperature around the front side of the machine as the fresh air temperature, and converts the temperature to the electrical resistance value. The electrical resistance in the fresh air sensor is 100 Ω to 210 kΩ.



TDAA-05-07-009

- Solar Radiation Sensor (CN16)

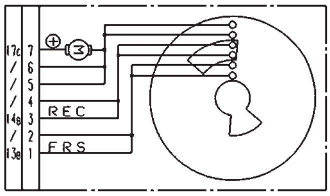
Converts the amount of solar radiation (illumination intensity) at the cab front to the current values.



TDAA-05-07-010

- Fresh / Re-circulated Air Damper Servo Motor (CN10)

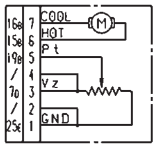
Opens or closes the fresh/re-circulated air selection louvers. The damper consists of a motor, link mechanism, and position sensing switch. The motor opens or closes the fresh/re-circulated air selection louvers via the link mechanism.



TDAA-05-07-011

- Air Mix Damper Servo Motor (CN9)

Controls opening/closing of the air mixing door in response to the set temperature. The damper consists of a motor, link mechanism, and potentiometer. The motor opens or closes the air mix door via the link mechanism. The potentiometer converts the link movements (the mix door strokes) to the voltage. Both ends of the potentiometer are energized by 5 V from terminals #7 (+) and #25 (-) in controller so that the potentiometer outputs voltage of 0.5 to 4.5 V from the center terminal to terminal #19 in controller corresponding to the link movement. When the set temperature is determined by temperature UP/DOWN signal from the controller, the controller calculates voltage (Vr) corresponding the link position. Further more, the controller checks the air mix door position by voltage (Vf) from the potentiometer. Then, after the controller decides the motor rotational direction (polarity of motor) based on the differential voltage between Vr and Vf, the controller sends out the current from terminals #15 and #16. The controller drives the motor until voltage (Vf) becomes equal to voltage (Vr).



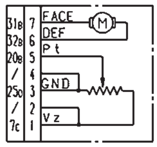
TDAA-05-07-012

- Air Vent Damper Servo Motor (CN8)

Opens or closes the front and rear air vent, foot vent, and defroster vent louvers. The damper consists of a motor, link mechanism, and potentiometer. The motor opens or closes vent louvers via the link mechanism. The potentiometer converts the link movements (vent louvers strokes) to the voltage. Both ends of the potentiometer are energized by 5 V from terminals #7 (+) and #25 (-) in controller so that the potentiometer outputs voltage of 0.5 to 4.5 V from the center terminal to terminal #20 in controller corresponding to the link movement. Depending on the MODE switch set position, vent louvers are operated as shown below:

- Front Air Vent: Open, Rear Air Vent: Close, Foot Air Vent: Close
- Front Air Vent: Open, Rear Air Vent: Open, Foot Air Vent: Close
- Front Air Vent: Open, Rear Air Vent: Open, Foot Air Vent: Open
- Front Air Vent: Close, Rear Air Vent: Close, Foot Air Vent: Open

When the front and rear air vent louvers positions are selected, the controller calculates potentiometer voltage (Vr). Furthermore, the controller checks the vent louvers positions by receiving voltage (Vf) from the potentiometer. Then, after the controller decides the motor rotational direction (polarity of motor) based on the differential voltage between Vr and Vf, the controller sends out the current from terminals #31 and #32. The controller drives the motor until voltage (Vf) becomes equal to voltage (Vr).



TDAA-05-07-013

Troubleshooting

IMPORTANT:

- **When replacing the compressor due to the breakage of compressor from internal lock, sufficiently clean the air conditioner circuit or replace all the parts.**
- **When cleaning is insufficient or all the parts are not replaced, the air conditioner may be broken due to contaminants remaining in the circuit.**
- **Using deteriorated LLC (coolant) or low-concentration LLC, the heater core will receive a bad influence and it may lead water leaks and shorten the service life of machine. Replace coolant and manage LLC concentration according to the Operator's Manual.**

Air Conditioner Controller Fault Code List

Fault Code	Trouble	Cause	Symptoms in Machine Operation When Trouble Occurs.	Remedy
11	Open circuit in re-circulated air sensor	Voltage: more than 4.95 V	Y value (air flow-in temperature) cannot be adjusted in response to the set-temperature.	Check the harness. Replace the re-circulated air sensor.
12	Shorted circuit in re-circulated air sensor	Voltage: less than 0.3 V	Y value (air flow-in temperature) cannot be adjusted in response to the set-temperature.	Check the harness. Replace the re-circulated air sensor.
13	Open circuit in outdoor ambient temperature sensor	Voltage: more than 4.88 V	Operation is controlled under such circumstance as no outdoor ambient temperature sensor is provided.	Check the harness. Replace the outdoor ambient temperature sensor.
14	Shorted circuit in outdoor ambient temperature sensor	Voltage: less than 0.096 V	Operation is controlled under such circumstance as no outdoor ambient temperature sensor is provided.	Check the harness. Replace the outdoor ambient temperature sensor.
18	Shorted circuit in solar radiation sensor	Voltage: more than 5.04 V	Operation is controlled under such circumstance as no solar radiation sensor is provided.	Check the harness. Replace the solar radiation sensor.
21	Open circuit in frost sensor	Voltage: more than 4.79 V	Operation is controlled under such circumstance as the frost temperature is set to 10 °C (50 °F).	Check the harness. Replace the frost sensor.
22	Shorted circuit in frost sensor	Voltage: less than 0.096 V	Operation is controlled under such circumstance as the frost temperature is set to 10 °C (50 °F).	Check the harness. Replace the frost sensor.
43	Abnormal air vent damper servo motor	Shorted circuit: Voltage: 0 V Open circuit: Voltage: more than 5 V	Air vent damper servo motor becomes inoperable.	Check the harness. Replace the air vent damper servo motor.
44	Abnormal air mix damper servo motor	Shorted circuit: Voltage: less than 0.2 V Open circuit: Voltage: more than 4.8 V	Air mix damper servo motor servo motor becomes inoperable.	Check the harness. Replace the air vent damper servo motor.
51	Abnormal high/low refrigerant pressure	Voltage: 0 V	The compressor clutch is disengaged. (The compressor stops.)	Check the harness. Replace the high/low pressure switch.
91	CAN communication error	Faulty CAN1 harness between monitor controller and air conditioner controller	Air conditioner stops.	Check the CAN1 harness. Replace air conditioner controller.
92	CAN bus off error	Faulty air conditioner controller Faulty CAN1 harness	Air conditioner stops.	Check the CAN1 harness. Replace air conditioner controller.

Air Conditioner Controller Fault Codes 11 to 22

Preparation

- Check the wiring connections first.
- Before inspection, set the key switch to the ON position.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
11	Open circuit in re-circulated air sensor	Measurement of resistance between sensor #1 and #2.	∞ Ω (Normal value: 300 to 430 kΩ)	Faulty sensor.
		Measurement of voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		-	Normal in above check.	Open circuit in harness #2.
12	Shorted circuit in re-circulated air sensor	Measurement of resistance between sensor #1 and #2.	0 Ω (Normal value: 300 to 430 kΩ)	Faulty sensor.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
13	Open circuit in outdoor ambient temperature sensor	Measurement of resistance between sensor #1 and #2.	∞ Ω (Normal value: 100 to 210 kΩ)	Faulty sensor.
		Measurement of voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		-	Normal in above check.	Open circuit in harness #2.
14	Shorted circuit in outdoor ambient temperature sensor	Measurement of resistance between sensor #1 and #2.	0 Ω (Normal value: 100 to 210 kΩ)	Faulty sensor.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.
18	Shorted circuit in solar radiation sensor	Continuity check between sensor harness end #1 and #2.	0 Ω	Shorted circuit in harness #1 and #2.
		-	Normal in above check.	Faulty sensor.
21	Open circuit in frost sensor	Measurement of resistance between sensor #1 and #2.	∞ Ω (Normal value: 100 to 115 kΩ)	Faulty sensor.
		Measurement of voltage between sensor harness end #1 and body.	0 V	Open circuit in harness #1.
		-	Normal in above check.	Open circuit in harness #2.
22	Shorted circuit in frost sensor	Measurement of resistance between sensor #1 and #2.	0 Ω (Normal value: 100 to 115 kΩ)	Faulty sensor.
		-	Normal in above check.	Shorted circuit in harness #1 and #2.

Air Conditioner Controller Fault Codes 43 to 92

Preparation

- Check the wiring connections first.
- Before inspection, set the key switch to the ON position.

Fault Code	Trouble	Inspection Method	Evaluation	Cause
43	Abnormal air vent damper servo motor	Measurement of voltage between air vent damper servo motor harness end 7C and body. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and air vent damper servo motor.
		Measurement of voltage between air vent damper servo motor harness end 7C and 25D. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and air vent damper servo motor.
		-	Normal in above check.	Faulty air vent damper servo motor.
44	Abnormal air mix damper servo motor	Measurement of voltage between air mix damper servo motor harness end 7D and body. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and air mix damper servo motor.
		Measurement of voltage between air mix damper servo motor harness end 7D and 25E. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and air mix damper servo motor.
		-	Normal in above check.	Faulty air mix damper servo motor.
51	Abnormal high/ low refrigerant pressure	Measurement of voltage between high/low pressure switch harness end A21 and A05. (AUTO/OFF switch / blower switch: ON)	0 V	Faulty controller or open circuit in harness between controller and high/low pressure switch.
		-	Normal in above check.	Faulty high/low pressure switch.
91	CAN communication error	Continuity check in CAN1 harness.	Normal	Faulty controller.
			Abnormal	Faulty CAN1 harness.
92	CAN bus off error	Continuity check in CAN1 harness.	Normal	Faulty controller.
			Abnormal	Faulty CAN1 harness.

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Faulty cooling (1)

Condition:
- Fault code: Un-displayed
- Airflow volume: faulty

Blower motor rotates	Normal speed	Clogged re-circulated air filter		Filter cleaning
		Clogged fresh air filter		Filter cleaning
		Obstacles are found in inlet area		Remove obstacles
		Deformation or breakage of blower		Replacement of blower
		Frosted evaporator		To A
		Adhered dirt on evaporator surface		Evaporator surface cleaning
	Slow speed	Power source decreases		Check battery charging system
		Poor battery terminal contact		Repair
		Faulty blower motor		Replace
		Faulty power transistor		Replace
Blower motor does not rotate	Faulty blower motor relay			Replace
	Faulty blower motor			Replace
	Faulty power transistor			Replace
	Blower interferes with case			Repair
	Faulty controller			Replace the controller
	Faulty ground in body			Make sure to ground
	Faulty wiring, disconnection of connector			Wirings inspection
	Blowout of power transistor thermal fuse due to locked motor			Replace motor
	Blowout of fuse	Replace with the same capacity fuse	Blower motor is locked	Replace blower motor
			Faulty wiring	Refer to wiring diagram and check
			Shorted circuit	Wirings inspection

A: Frosted evaporator

Frosted evaporator	Stop air conditioner and melt ice			
	With voltage applied to magnet clutch	Faulty magnet clutch circuit	Check of clutch circuit	Replace clutch relay
		Faulty wiring of frost sensor	Shorted circuit check	Repair
		Faulty frost sensor characteristics	Characteristic check	Replace evaporator sensor.
		Frost sensor is out of evaporator range (faulty sensitivity)	Reinsert (floating distance from evaporator is 3 mm or less)	
	No voltage applied to magnet clutch		Faulty magnet clutch	Replace magnet clutch

Faulty cooling (2)

Condition:
- Fault Code: Un-displayed
- Airflow volume: Normal
- Compressor: Compressor rotates normally
- Compressor pressure: Normal

Fresh air enters	Close window and door
	Readjust fresh / re-circulated air selection damper
Disconnection of A/M link	Setting link again

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Faulty cooling (3)

Condition:
- Fault Code: Un-displayed
- Airflow volume: Normal
- Compressor: Compressor rotates normally
- Compressor pressure: Abnormal

Pressure on low-pressure side is too high (approx. 0.29 MPa or more)	Overcharge air conditioner with refrigerant	Remove refrigerant thoroughly and recharge refrigerant to proper level after purging	
	Faulty compressor	Breakage of head gasket	Replace compressor
		Breakage of inlet valve	Replace compressor
		Clogged foreign matter into inlet valve	Replace compressor
	Excessive open of expansion valve	Faulty valve	Replace valve
Pressure on high-pressure side is too low (pressure is not approx. 0.98 MPa or more)	Abnormally low ambient temperature		
	Low refrigerant		To B
	Faulty compressor	Swash plate shoe is locked	Replace compressor
		Piston is locked	Replace compressor
		Faulty suction discharge valve	Replace compressor
	Faulty expansion valve	Clogged valve (foreign matter)	Replace valve
		Temporary clogged due to freezing valve (water intrusion)	Thoroughly perform purging after replacing valve and receiver
Pressure on low-pressure side is too low (pressure is approx. 0.05 MPa or less)	Abnormally low ambient temperature		
	Low refrigerant		To B
	Clogged during refrigeration cycle		To C
	Faulty expansion valve		To D
	Frosted evaporator		To A
Pressure is high on both sides of high-pressure and low-pressure	Lack of condenser cooling	Clogged fin with dirt or mud	Cleaning of fin (washing)
	Overcharge air conditioner with refrigerant	Remove refrigerant thoroughly and recharge refrigerant to proper level after purging	
Pressure is low on both sides of high-pressure and low-pressure	Lack of refrigerant		

A: Frosted evaporator

Frosted evaporator	Stop air conditioner and melt ice			
	With voltage applied to magnet clutch	Faulty magnet clutch circuit	Check of clutch circuit	Replace clutch relay
		Faulty wiring of frost sensor	Shorted circuit check	Repair
		Faulty frost sensor characteristics	Characteristic check	Replace frost sensor
		Frost sensor is out of evaporator range (faulty sensitivity)	Reinsert (floating distance from evaporator is 3 mm or less)	
	No voltage applied to magnet clutch		Faulty magnet clutch	Replace magnet clutch

B: Low refrigerant

Low refrigerant	Low refrigerant quantity	Charge refrigerant to proper level
	Gas leak	Check leak and charge with refrigerant after repairing faulty

C: Clogged during refrigeration cycle

Clogged during refrigeration cycle	Clogged receiver dryer	Replace
	Clogged foreign matter in piping	Replace

D: Faulty expansion valve

Faulty expansion valve	Clogged valve (foreign matter)	Replace valve
	Temporary clogged due to freezing valve (water intrusion)	Thoroughly perform purging after replacing valve and receiver

Faulty cooling (4)

Condition:
- Fault Code: Un-displayed
- Airflow volume: Normal
- Compressor: Compressor does not rotate normally

<table>
<tr><td colspan="6">Broken V belt or slipping</td><td>Replace V belt</td></tr>
<tr><td colspan="6">Faulty compressor (locked)</td><td>Replace</td></tr>
<tr><td rowspan="7">Faulty magnet clutch</td><td rowspan="7">Repair or replace.</td><td colspan="4">Open circuit in stator coil</td><td>Replace</td></tr>
<tr><td colspan="4">Air gap between rotor and stator is too large</td><td>Repair or Replacement</td></tr>
<tr><td rowspan="5">Clutch slipping</td><td colspan="3">Slip caused by key breakage or inserting no key</td><td>Replace key</td></tr>
<tr><td colspan="3">Greasy clutch surface</td><td>Remove oil</td></tr>
<tr><td colspan="3">Layer shorted coil</td><td>Replace</td></tr>
<tr><td colspan="3">Battery voltage drop</td><td>Charge</td></tr>
<tr><td colspan="3">Clogged foreign matter between rotor and stator</td><td>Overhaul</td></tr>
<tr><td rowspan="13">Clutch does not operate due to faulty electrical system</td><td rowspan="13">Check wiring</td><td colspan="4">Faulty controller</td><td>Replace the controller</td></tr>
<tr><td colspan="4">Faulty compressor clutch relay</td><td>Replace</td></tr>
<tr><td colspan="4">Faulty frost sensor</td><td>Replace</td></tr>
<tr><td colspan="4">Faulty high/low refrigerant pressure switch</td><td>Replace</td></tr>
<tr><td rowspan="9">Abnormal high pressure</td><td rowspan="4">Too high (2.54 MPa or more)</td><td colspan="3">Abnormally high ambient temperature</td></tr>
<tr><td>Lack of condenser cooling</td><td>Clogged fin with dirt or mud</td><td>Cleaning of fin (washing)</td></tr>
<tr><td>Overcharge air conditioner with refrigerant</td><td colspan="2">Remove refrigerant thoroughly and recharge refrigerant to proper level after purging</td></tr>
<tr><td>Air incorporation in refrigeration cycle</td><td colspan="2">Remove refrigerant thoroughly and recharge refrigerant to proper level after purging</td></tr>
<tr><td rowspan="5">Too low (0.98 MPa or less)</td><td colspan="3">Abnormally low ambient temperature</td></tr>
<tr><td colspan="2">Low refrigerant</td><td>To B</td></tr>
<tr><td colspan="2">Clogged during refrigeration cycle</td><td>To C</td></tr>
<tr><td colspan="2">Faulty expansion valve</td><td>To D</td></tr>
<tr><td colspan="2">Frosted evaporator</td><td>To A</td></tr>
</table>

A: Frosted evaporator

Frosted evaporator	Stop air conditioner and melt ice			
	With voltage applied to magnet clutch	Faulty magnet clutch circuit	Check of clutch circuit	Replace clutch relay
		Faulty wiring of frost sensor	Shorted circuit check	Repair
		Faulty frost sensor characteristics	Characteristic check	Replace evaporator sensor
		Frost sensor is out of evaporator range (faulty sensitivity)	Reinsert (floating distance from evaporator is 3 mm or less)	
	No voltage applied to magnet clutch		Faulty magnet clutch	Replace magnet clutch

B: Low refrigerant

Low refrigerant	Low refrigerant quantity	Charge refrigerant to proper level
	Gas leak	Check leak and charge with refrigerant after repairing faulty

C: Clogged during refrigeration cycle

Clogged during refrigeration cycle	Clogged receiver dryer	Replace
	Clogged foreign matter in piping	Replace

D: Faulty expansion valve

Faulty expansion valve	Clogged valve (foreign matter)	Replace valve
	Temporary clogged due to freezing valve (water intrusion)	Thoroughly perform purging after replacing valve and receiver

Faulty cooling (5)

Condition:

- Fault Code: 44 (Abnormal air mix damper servo motor)

Faulty wiring, open circuit, disconnection of connector	Wirings inspection
Faulty servo motor	Replace
Clogged foreign matter	Remove foreign matter

Condition:

- Fault Code: 51 (Abnormal high/low refrigerant pressure)

High pressure cut is operated	Abnormally high ambient temperature		
	Lack of condenser cooling	Clogged fin with dirt or mud	Cleaning of fin (washing)
	Overcharge air conditioner with refrigerant	Remove refrigerant thoroughly and recharge refrigerant to proper level after purging	
	Air incorporation in refrigeration cycle	Remove refrigerant thoroughly and recharge refrigerant to proper level after purging	
Low pressure cut is operated	Abnormally low ambient temperature		
	Low refrigerant	Low refrigerant quantity	Charge refrigerant to proper level
		Gas leak	Check leak and charge with refrigerant after repairing faulty
	Faulty compressor	Swash plate shoe is locked	Replace compressor
		Piston is locked	Replace compressor
		Faulty suction discharge valve	Replace compressor
	Faulty expansion valve	Clogged valve (foreign matter)	Replace valve
		Temporary clogged due to freezing valve (water intrusion)	Thoroughly perform purging after replacing valve and receiver

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Faulty heating (1)

Condition:

- Fault code: Un-displayed

Faulty air flow volume	Blower motor rotates	Normal speed	Clogged re-circulated air filter		Filter cleaning
			Clogged fresh air filter		Filter cleaning
			Obstacles are found in inlet area		Remove obstacles
			Deformation or breakage of blower		Replacement of blower
			Frosted evaporator		To A
			Adhered dirt on evaporator surface		Evaporator surface cleaning
		Slow speed	Power source decreases		Check battery charging system
			Poor battery terminal contact		Repair
			Faulty blower motor		Replace
			Faulty power transistor		Replace
	Blower motor does not rotate	Blowout of fuse	Replace with the same capacity fuse	Blower motor is locked	Replace blower motor
				Faulty wiring	Refer to wiring diagram and check
				Shorted circuit	Wirings inspection
		Faulty blower motor relay			Replace
		Faulty blower motor			Replace
		Faulty power transistor			Replace
		Blower interferes with case			Repair
		Faulty controller			Replace the controller
		Faulty ground in body			Make sure to ground
		Faulty wiring, disconnection of connector			Wirings inspection
		Blowout of power transistor thermal fuse due to locked motor			Replace motor
Air flow volume is normal	Coolant temperature is low				
	Coolant temperature is normal	Disconnection of air mix damper link			Setting link again
		Air incorporation in hot-water circuit			Air Bleeding Circuit
		Clogging, breakage and bending of piping			Repair or replace.
		Extremely low ambient temperature			
		Low engine coolant level			Charge engine coolant to proper level
		Broken heater core			Replace heater core

A: Frosted evaporator

Frosted evaporator	Stop air conditioner and melt ice			
	With voltage applied to magnet clutch	Faulty magnet clutch circuit	Check of clutch circuit	Replace clutch relay
		Faulty wiring of evaporator sensor	Shorted circuit check	Repair
		Faulty the evaporator sensor characteristics	Characteristic check	Replace frost sensor
		Evaporator sensor is out of evaporator range (faulty sensitivity)	Reinsert (floating distance from evaporator is 3 mm or less)	
	No voltage applied to magnet clutch		Faulty magnet clutch	Replace magnet clutch

Faulty heating (2)

Condition:
- Fault Code: 44 (Abnormal air mix damper servo motor)

Clogged foreign matter	Remove foreign matter
Faulty wiring, open circuit, disconnection of connector	Wirings inspection
Faulty damper	Replace

Others

- Faulty air vent switch

Fault code is un-displayed	Disconnection of link	Setting link again
Fault code 43 (Abnormal air vent damper servo motor)	Faulty wiring, open circuit, disconnection of connector	Wirings inspection
	Faulty servo motor	Replace
	Clogged foreign matter	Remove foreign matter

- Faulty fresh / re-circulated air selection

Fault code is un-displayed	Disconnection of link	Setting link again
	Faulty wiring, open circuit, disconnection of connector	Wirings inspection
	Faulty servo motor	Replace
	Clogged foreign matter	Remove foreign matter

- Ambient temperature is higher or lower than set-temperature

Fault code 11 (Open circuit in re-circulated air sensor)	Open circuit in harness, disconnection of connector	Wirings inspection
	Open circuit in air circulation sensor	Replace
Fault code 12 (Shorted circuit in re-circulated air sensor)	Shorted circuit in harness	Wirings inspection
	Shorted circuit in air circulation sensor	Replace
Fault code is un-displayed (Normal re-circulated air sensor)	Faulty cooling, faulty heating	Check by referring to the items of faulty cooling and faulty heating

- Noise

Case connection.	Louver resonance.	Repair or replace.
Blower fan motor connection.	Fan contacts case. Foreign matter enters case.	Remove foreign matter. Readjust fan motor location.
	Brush friction noise, metal and/or thrust washer contact.	Slight noise is unavoidable. Replace if loud.
Gas blowing sound (roaring).	Gas vibration noise (compressor discharge and/or suction gas noise).	No functional problem exists.
Expansion valve connection. Whistle sound. Gas blowing sound.	Abnormal noise from expansion valve. Expansion valve is normally functioning.	Replace expansion valve if whistle sound is heard. Gas flow noise can be slightly heard.
Clutch disengaging sound.	Faulty clutch bearing, and/or idle pulley bearing.	Replace.
	Contact of clutch amature due to resonance. Loose belt. Loose screws.	Repair or replace clutch. Re-tighten screws.
Compressor rotating sound.	Noisy compressor.	Repair or replace.
	Vibration due to V belt looseness. Loose screws.	Re-adjust belt. Re-tighten screws.

- Others

Water leak. Water splash.	Broken heater core. Broken hose.	Replace.
	Clogged case drain port and/or drain hose.	Clean.
Abnormal smell.	Absorbed cigarette and dust smell on evaporator fins.	Clean evaporator. When humidity is high, open door. While rotating fan at approx. 1500 min^{-1} in L mode for more than 10 minutes, flush smell out by condensed water.

(Blank)

Blower motor does not operate.

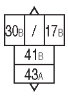
Preparation

・ Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause (check point)
1	Switch compressor relay with blower motor relay.	Key Switch: ON Blower Switch: ON	Blower motor does not operate.	Faulty blower motor relay.
2	Measurement of voltage between terminal #41B of blower motor relay harness end and body.	Key Switch: ON	0 V	Open circuit in harness between fuse #3 and blower motor relay.
3	Measurement of voltage between terminal #43B of blower motor harness end and body.	Key Switch: ON Blower Switch: ON	0 V	Open circuit in harness between blower motor relay and blower motor.
4	Continuity check between terminals #1 and #2 of blower motor harness end.	-	0 Ω	Faulty blower motor.
5	Measurement of voltage between terminal #44B of power transistor harness end and body.	Key Switch: ON Blower Switch: ON	0 V	Open circuit in harness between blower motor and power transistor.
6	Measurement of voltage between terminal #9B of power transistor harness end and body.	Key Switch: ON Blower Switch: ON	0 V	Faulty air conditioner controller.
7	-	-	Procedures as steps 1 to 6 above are normal.	Faulty power transistor.

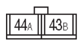
Connector (Harness end)

・ Blower Motor Relay



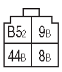
TDAB-05-07-020

・ Blower motor



TDAB-05-07-027

・ Power Transistor



TDAB-05-07-028

Compressor clutch does not operate.

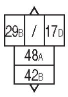
Preparation

- Check that fresh air temperature is 0 ˚C or more first. When fresh air temperature is less than 0 ˚C, the air conditioner controller turns the compressor clutch OFF in order to protect the compressor.
- Check that fault code 13 or 14 (abnormal fresh air sensor) is not displayed. When the fresh air sensor is abnormal, the compressor clutch does not operate.
- Check the wiring connections first.

Procedure	Inspection Method	Condition	Evaluation	Cause (check point)
1	Switch compressor relay with blower motor relay.	Key Switch: ON Blower Switch: ON	Compressor is not operable.	Faulty compressor relay.
2	Measurement of voltage between terminal #48A of compressor relay harness end and body.	Key Switch: ON	0 V	Open circuit in harness between fuse #3 and compressor relay.
3	Measurement of voltage between terminal #42A of compressor clutch relay harness end and body.	Key Switch: ON Blower Switch: ON	0 V	Open circuit in harness between compressor relay and compressor clutch.
4	-	-	Procedures as steps 1 to 3 above are normal.	Faulty compressor clutch.

Connector (Harness end)

- Compressor Relay



TDAB-05-07-019

- Compressor Clutch

TDAB-05-07-024

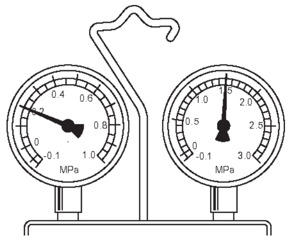
Cooling circuit check by using manifold gauge

Condition:
- Engine Speed: 1500 min^{-1}
- Cab Window: Fully Open
- Air Conditioner: ON
- Airflow volume: Maximum
- Temperature Control Switch: Maximum cool
- Fresh / re-circulated air selection: Re-circulated Air
- Air conditioner inlet temperature: 30 to 35 °C

1. In normal

- Low-pressure side pressure: 0.15 to 0.25 MPa
- High-pressure side pressure: 1.37 to 1.57 MPa

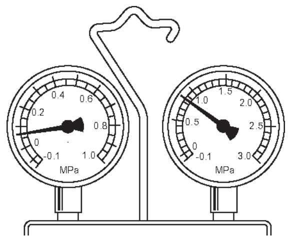
NOTE: The reading of manifold gauge may depend on conditions.



TDAA-05-07-018

2. Lack of refrigerant quantity

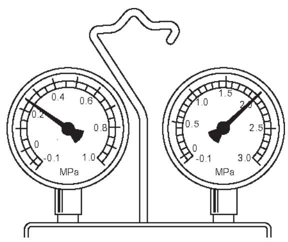
Trouble	Pressure is low on both sides of high-pressure and low-pressure. Cooling performance is low.
Cause	Refrigerant quantity is low. Gas leak.
Remedy	Check and repair of gas leak. Charge air conditioner with refrigerant.



TDAA-05-07-019

3. Excessive refrigerant, lack of condenser cooling

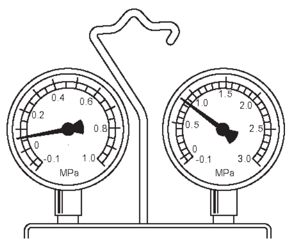
Trouble	Pressure is high on both sides of high-pressure and low-pressure. Cooling performance is low.
Cause	Overcharge air conditioner with refrigerant. Faulty condenser cooling.
Remedy	Adjust refrigerant quantity. Clean condenser. Check for machine cooling system.



TDAA-05-07-020

4. Water incorporation in circuit.

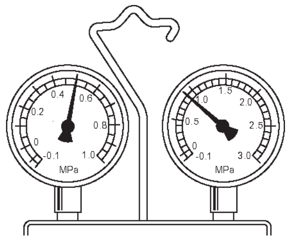
Trouble	After using a certain period of time, low-pressure side gradually indicates negative pressure.
Cause	Water is mixed in circuit.
Remedy	Replace receiver tank. Thoroughly perform purging before charging refrigerant to remove water.



TDAA-05-07-021

5. Faulty compression of compressor

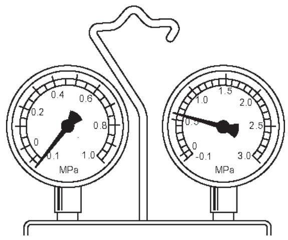
Trouble	Low-pressure side is high and high-pressure side is low. High-pressure becomes equal to low-pressure immediately after stopping the air conditioner.
Cause	Faulty compressor.
Remedy	Check and repair of compressor.



TDAA-05-07-022

6. Refrigerant does not circulate (clogged circuit)

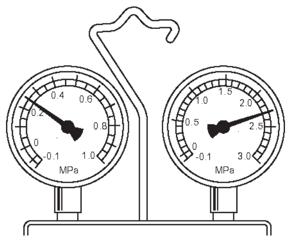
Trouble	When absolutely clogging, low-pressure side indicates negative pressure quickly. When slightly clogging, low-pressure side gradually indicates negative pressure.
Cause	Dirt or water adheres or freezes to expansion valves, refrigerant does not flow.
Remedy	Replace receiver tank. Perform purging.



TDAA-05-07-023

7. Air incorporation in circuit

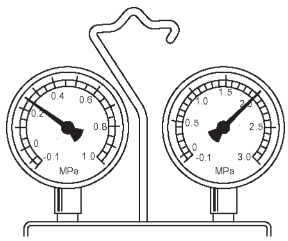
Trouble	Pressure is high on both sides of high-pressure and low-pressure. When touching low-pressure piping, it is not cold.
Cause	Air is mixed in system.
Remedy	Replace refrigerant. Perform purging.



TDAA-05-07-024

8. Excessive open of expansion valve

Trouble	Pressure is high on both sides of high-pressure and low-pressure. Frost (dew) adheres to low-pressure piping.
Cause	Faulty expansion valve.
Remedy	Check for installation of thermal cylinder.



TDAA-05-07-025

Work after Replacing Components

The following work is required after replacing compressor, high pressure hose, low pressure hose, condenser, receiver tank, liquid hose, and air conditioner unit. The same work is required when gas leakage is found.

1. Refill Compressor Oil

2. Charge Air Conditioner with Refrigerant

- Purging
- Charge air conditioner with refrigerant
- Warm-up operation
- Inspection

Refill Compressor Oil

When replacing the cooling circuit parts, refill compressor oil to the specified level.

Replacement parts	Compressor	Condenser	Evaporator	Receiver	D hose (between compressor and condenser)	L hose (between condenser and unit)	S hose (between unit and compressor)
Oil-replenishing quantity	Refer to the following.	40 cm^3 (2.4 in^3)	40 cm^3 (2.4 in^3)	20 cm^3 (1.2 in^3)	6 to 9 cm^3/m (0.4 to 0.5 in^3/m)	2 to 4 cm^3/m (0.1 to 0.2 in^3/m)	8 to 11 cm^3/m (0.5 to 0.7 in^3/m)

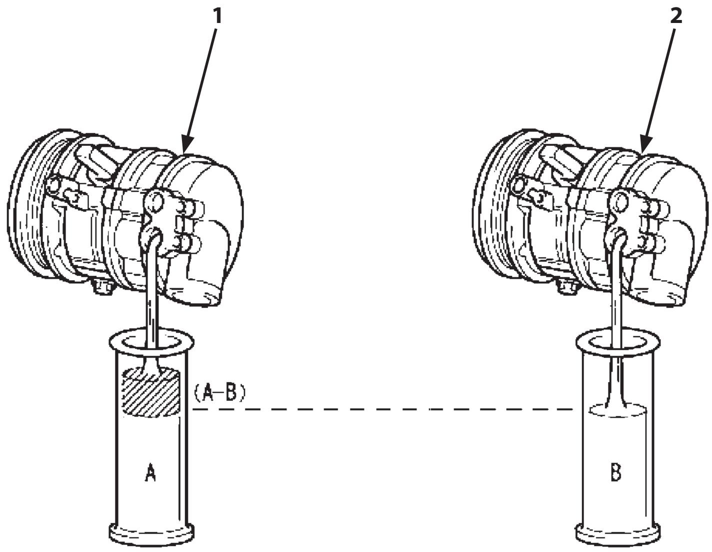
- In case of replacing compressor

New compressor (1) is charged with oil required for cooling circuit. When replacing new compressor (1), drain excess oil from new compressor (1). Adjust oil level so that it is the same level as oil (B) in compressor (2) to be replaced.

NOTE: Compressor oil quantity: 160 cm^3 (9.8 in^3)

- Compressor oil refill container

Oil type	Part No	Quantity
ND-OIL8	4422696	40 cm^3 (2.4 in^3)



TDAA-05-07-015

1- New Compressor
2- Replacing Compressor

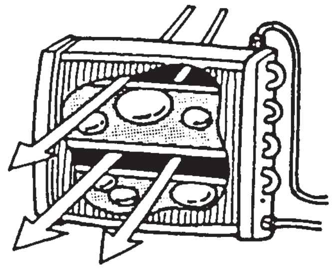
Charge Air Conditioner with Refrigerant

Necessity of Purging

Be sure to purge the air conditioner circuit with a vacuum before charging with refrigerant (R134a) because the following problems can arise if air or other gases remain in the A/C circuit.

1. Pressure rise in the high pressure side

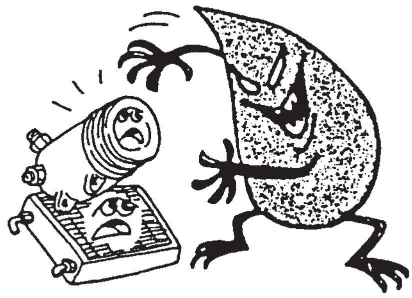
If air remains in the air conditioner circuit, this disturbs the heat exchange between refrigerant and air in the condenser, causing pressure to rise in the high pressure side (compressor side).
Usually, refrigerant gas is easily liquefied; however, air cannot be liquefied and remains as a gas in the condenser because the temperature at which air liquefies is extremely low. That is, liquidation of the refrigerant gas in the condenser decreases by the amount of air in the circuit, and the gas pressure in the high pressure side increases accordingly.



W115-02-10-001

2. Metal corrosion

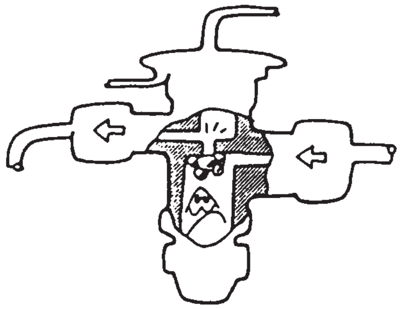
If air remains in the air conditioner circuit, a chemical reaction between refrigerant and moisture in the air takes place, and as a result, hydrochloric acid, that corrodes metals such as aluminum, copper and iron, is produced.



W115-02-10-002

3. Plugging of the expansion valve by moisture

When high pressure refrigerant gas passes through the expansion valve, gas pressure decreases and temperature drops. Moisture included in high pressure refrigerant gas in the air conditioner circuit freezes at the expansion valve orifice, plugging refrigerant flow. Operation of the air conditioner becomes unstable and cooling efficiency lowers.

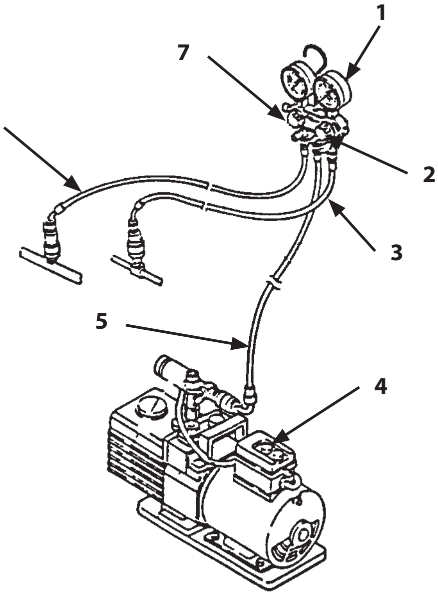


W115-02-10-003

Procedures for charging air conditioner with refrigerant

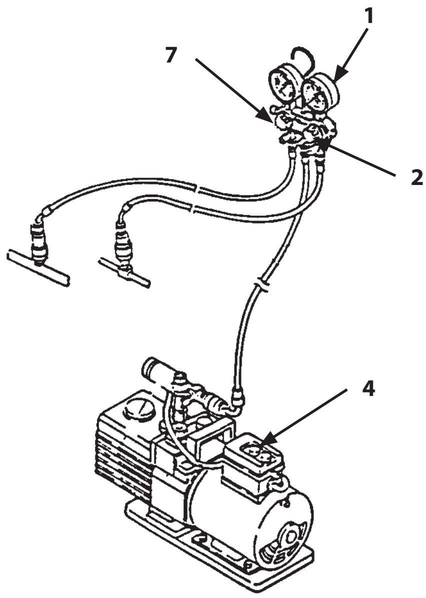
IMPORTANT: Do not mistake the charge hose connections.

1. Close high pressure valve (2) and low pressure valve (7) on manifold gauge (1). Connect high-pressure side charge hose (3) and low-pressure side charge hose (6) on manifold gauge (1) to the high-pressure side charge valve ("D" marked) and to the low-pressure side charge valve ("S" marked) located on the compressor, respectively. Connect charge hose (5) located on the center of manifold gauge (1) to vacuum pump (4).



W115-02-10-005

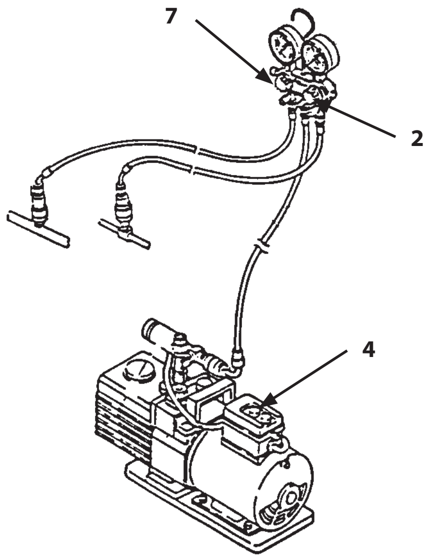
2. Open high pressure valve (2) and low pressure valve (7) on manifold gauge (1). Perform purging for 10 minutes or more by operating vacuum pump (4).



W115-02-10-005

IMPORTANT: If the pointer returns to 0, retighten the line connections and perform purging again.

3. When the low pressure gauge reading falls below -0.1 MPa (-750 mmHg), close high pressure valve (2) and low pressure valve (7) and stop vacuum pump (4). Wait for approximately five minutes and confirm that the pointer does not return to 0.

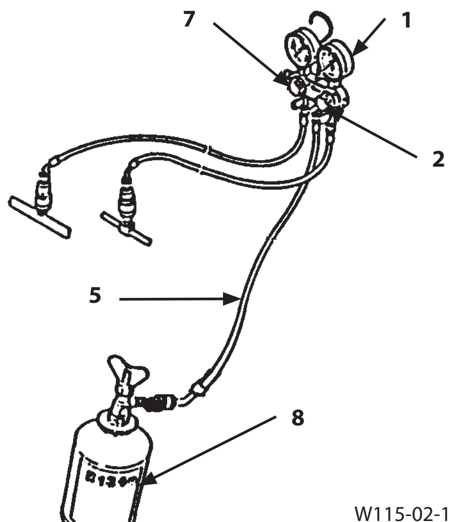


W115-02-10-005

4. With highpressure valve (2) and lowpressure valve (7) on manifold gauge (1) closed, connect charge hose (5) to refrigerant container (8).

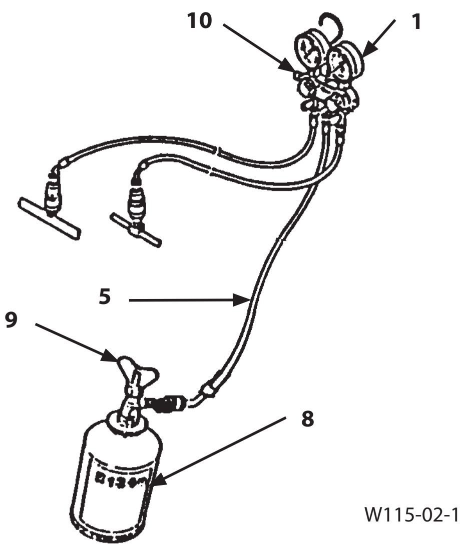
- Refrigerant

Specification	Part No.	Volume (g)
R134a	4333767	200
	4454005	250
	4351827	300



W115-02-10-007

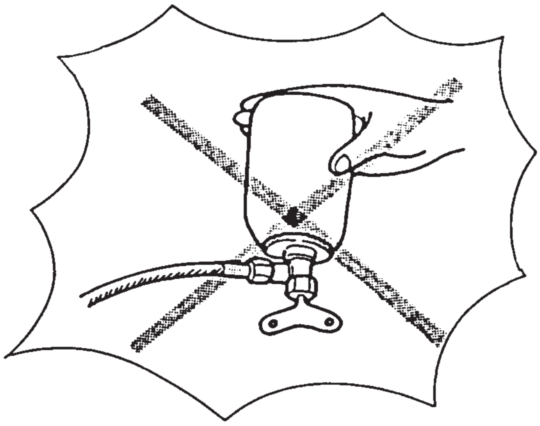
5. Open valve (9) of refrigerant container (8). Push air bleed valve (10) on manifold gauge (1) to purge air in charge hose (5) with the refrigerant pressure. When draining refrigerant, immediately release air bleed valve (10).



W115-02-10-007

IMPORTANT:

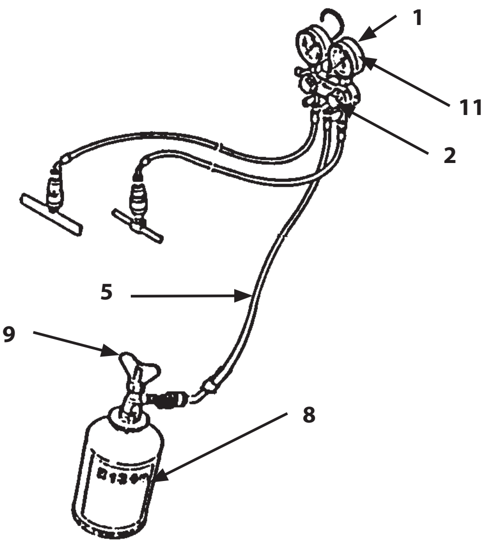
- **Always stop the engine when charging the air conditioner with refrigerant.**
- **Do not position the refrigerant container upside down during charging operation.**
- **When changing the refrigerant container during charging operation, be sure to purge air from the charge hose, as shown in step 10.**
- **Charge the low-pressure side hose first.**



W115-02-10-008

6. Fully tighten charge hose (5) connection to gauge manifold (1). Open high pressure valve (2) and valve (9) of refrigerant container (8). Charge with refrigerant (R134a). Close high pressure valve (2) and valve (9) of refrigerant container (8) when high pressure gauge (11) reading reaches 98 kPa (1 kgf/cm^2).

NOTE: Use warm water of 40 °C or less to warm refrigerant container (8) to aid in charging operation.



W115-02-10-007

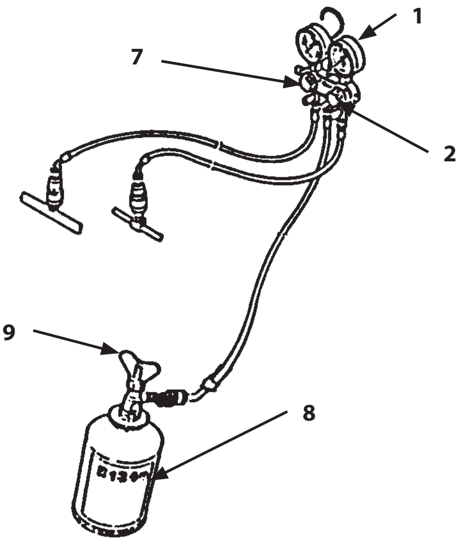
IMPORTANT: Use the leak tester for R134a.

7. After charging, check the line connections for gas leaks using leak tester.

8. Confirm that high pressure valve (2) and low pressure valve (7) on gauge manifold (1) and valve (9) of refrigerant container (8) are closed. Start the engine and operate the air conditioner.

Operating Conditions of the Air Conditioner

- Engine Speed: Slow Idle
- Cab Window: Fully Open
- Air Conditioner: ON
- Airflow volume: Maximum
- Temperature Control Switch: Maximum cool



W115-02-10-007

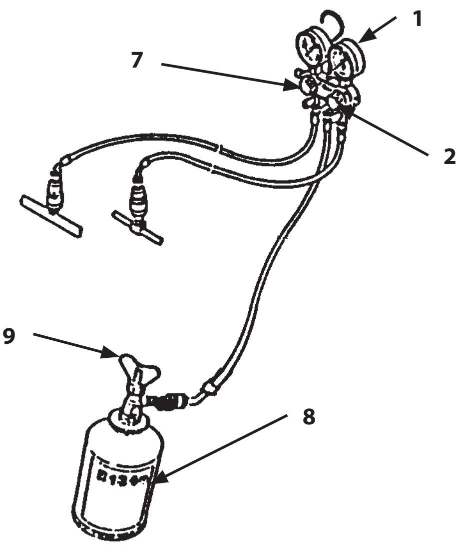
IMPORTANT: Do not open high pressure valve (2) on manifold gauge (1).

9. Open low pressure valve (7) on manifold gauge (1) and valve (9) of refrigerant container (8) to charge with refrigerant.

NOTE: Required refrigerant quantity: 850±50 g

10. If refrigerant container (8) becomes empty during the charging work, replace refrigerant container (8) with a new refrigerant container as follows:

- Close high pressure valve (2) and low pressure valve (7) on manifold gauge (1).
- Replace the empty container with new refrigerant container (8).
- Tighten, then slightly loosen refrigerant container (8) joint.
- Slightly open low pressure valve (7) on manifold gauge (1).
- When refrigerant container (8) joint starts to leak, immediately tighten refrigerant container (8) joint and close low-pressure valve (7) on manifold gauge (1).



W115-02-10-007

11. After charging, close low pressure valve (7) on manifold gauge (1) and valve (9) of refrigerant container (8), and stop the engine.

IMPORTANT: If the air conditioner is operated with very low refrigerant, a bad load will be exerted on the compressor. If the air conditioner is overcharged with refrigerant, cooling efficiency will lower and abnormal high pressure will arise in the air conditioner circuit, causing danger.

12. Start the engine and operate the air conditioner again. Check that cold air blow out from the vents.

Operating Conditions of the Air Conditioner

- Engine Speed: Slow Idle
- Cab Window: Fully Open
- Air Conditioner: ON
- Airflow volume: Maximum
- Temperature Control Switch: Maximum cool

CAUTION: When attempting to disconnect the high-pressure-side charge hose, refrigerant and compressor oil may spout. Disconnect the high-pressure side charge hose after the high-pressure side pressure drops to less than 980 kPa (10 kgf/ cm²).

13. After checking refrigerant quantity, disconnect the low-pressure-side charge hose first. Disconnect the low-pressure-side charge hose. Wait for the high-pressure-side pressure to drop to less than 980 kPa (10 kgf/cm², 142 psi). Disconnect the high-pressure-side charge hose.

Warm-up Operation

After charting the air conditioner, carry out warm-up operation five minute to lubricate system with compressor oil.

Operating Conditions of the Air Conditioner

- Engine Speed: Slow Idle
- Cab Window: Fully Open
- Air Conditioner: ON
- Airflow volume: Maximum
- Temperature Control Switch: Maximum cool

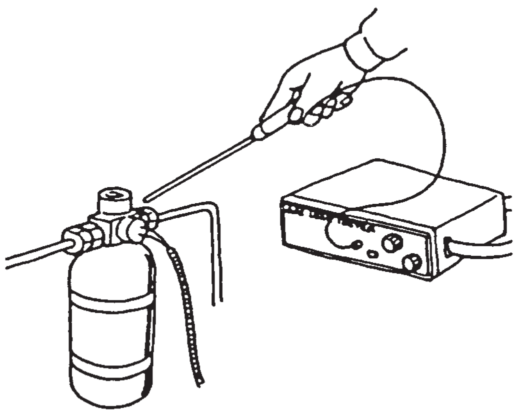
Inspection

After warm-up operation, carry out gas leak check and performance check.

CAUTION: Refrigerant will produce poisonous material if exposed to heat of 1000 °C or more. Never bring refrigerant close to a fire.

1. Check the air conditioner for gas leaks using a leak tester.

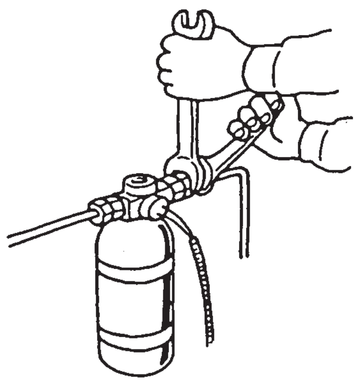
- Perform checking under well-ventilated conditions.
- Thoroughly wipe off dust from the charge hose connections of the compressor.
- Pay special attention to check the line connections.
- If any gas leaks are found, retighten the line connections.



W115-02-10-013

2. Performance Check. Carry out performance check of the air conditioner after checking each air conditioner component.

- Check each component for abnormalities.
- Carry out ON-OFF check of the compressor clutch.
- Check compressor fan belt tension.
- Check the coolant level in the radiator.
- Operate the air conditioner and check the performance.



W115-02-10-014

3. The checklist before the summer season is as follows:

- Check each air conditioner component for abnormalities.
- Check the line connections for oil leaks.
- Check refrigerant quantity.
- Check the engine cooling circuit.
- Check V belt for wear. Replace if necessary.
- Check for clogged condenser.

4. Off-Season Maintenance

- During off-season, operate the idler pulley and compressor at least once a month for a short time to check for any abnormal sounds.
- Do not remove the compressor belts during off-season. Operate the compressor occasionally at slow speed for 5 to 10 minutes with the belt slightly loosened in order to lubricate the machine parts.

NOTE: When the machine is in normal and the air conditioner is operated with the following conditions, air vent temperature decrease approx. 20°C or less. (it may be different under special environment.)

Operating Conditions of the Air Conditioner

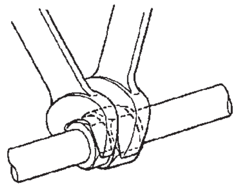
- Engine Speed: Fast Idle
- Cab Window: Fully closed
- Airflow volume: Maximum
- Temperature Control Switch: Maximum cool
- Fresh / re-circulated air selection: Re-circulated Air
- Season: Summer

Hose and Pipe Tightening Torque

Use the following tightening torque values when connecting the pipes.

Joint Location	Tube or Bolt Size	Tightening Torque N·m (kgf·m)
Nut type (Fig. A)	Pipe with dia. 8	12 to 15 (1.2 to 1.5)
	Pipe with D1/2	20 to 25 (2.0 to 2.5)
	Pipe with D5/8	30 to 35 (3.0 to 3.5)
Block joint (Fig. B)	Receiver M6 Bolt (4T)	4.0 to 7.0 (0.4 to 0.7)
	M6 Bolt (6T) for other than Receiver	8.0 to 12 (0.8 to 1.2)

A



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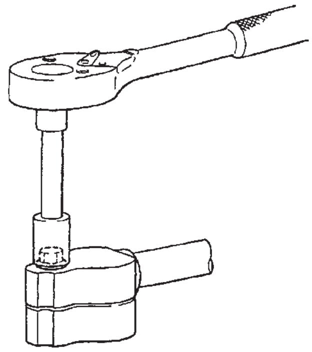
B



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The Attached Diagram List

The following diagrams are attached to this manual.

1. ZX200-5G/330-5G ELECTRICAL CIRCUIT DIAGRAM
   ZX200-5G/330-5G CONNECTORS

2. ZX200-5G/330-5G CAB HARNESS
   ZX200-5G ENGINE HARNESS

3. ZX200-5G/330-5G MONITOR HARNESS
   ZX200-5G/330-5G GSM (MOBILE COMMUNICATION TERMINAL) HARNESS

4. ZX200-5G/330-5G KEY SWITCH HARNESS
   ZX200-5G/330-5G PILOT SHUT-OFF SOLENOID VALVE HARNESS

5. ZX200-5G/330-5G REARVIEW CAMERA HARNESS

6. ZX200-5G HYDRAULIC CIRCUIT DIAGRAM (STANDARD)
   ZX200-5G HYDRAULIC CIRCUIT DIAGRAM (OPTIONAL)

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6BG1 TIER 2 ENGINE MANUAL

EDCD-EN-00

PART NO. EDCD-EN-00

HITACHI

Reliable solutions

Engine Manual

6BG1

Tier 2

Service Manual consists of the following separate Part No.

Technical Manual (Operational Principle)	: Vol. No.TODCD-EN
Technical Manual (Troubleshooting)	: Vol. No.TTDCD-EN
Workshop Manual	: Vol. No.WDCD-EN
Engine Manual	: Vol. No.EDCD-EN

SECTION 1

GENERAL INFORMATION

TABLE OF CONTENTS

GENERAL REPAIR INSTRUCTIONS

1. Before performing any service operation with the engine mounted, disconnect the grounding cable from the battery.

   This will reduce the chance of cable damage and burning due to short circuiting.
2. Always use the proper tool or tools for the job at hand.

   Where specified, use the specially designed tool or tools.
3. Use genuine ISUZU parts referring ISUZU PARTS CATALOG for the engines surely.
4. Never reuse cotter pins, gaskets, O-rings, lock washers, and self locking nuts. Discard them as you remove them. Replace them with new ones.
5. Always keep disassembled parts neatly in groups. This will ensure a smooth reassembly operation.

   It is especially important to keep fastening parts separate. These parts vary in hardness and design, depending on their installation position.
6. All parts should be carefully cleaned before inspection or reassembly.

   Oil ports and other openings should be cleaned with compressed air to make sure that they are completely free of obstructions.
7. Rotating and sliding part surfaces should be lubricated with oil or grease before reassembly.
8. If necessary, use a sealer on gaskets to prevent leakage.
9. Nut and bolt torque specifications should be carefully followed.
10. Always release the air pressure from any machine-mounted air tank(s) before dismounting the engine or disconnecting pipes and hoses. To not do so is extremely dangerous.
11. Always check and recheck you work. No service operation is complete until you have done this.
12. Information contained in the "Main Data and Specifications" of the Workshop Manual and the Instruction Book may differ. In this case, the information contained in the Instruction Book should be considered applicable.

NOTES ON THE FORMAT OF THIS MANUAL

This Workshop Manual is applicable to the 6BG1T of industrial diesel engines. Unless otherwise specified, these engines have common parts and components as well as data and specifications.

Illustrations used in this Workshop Manual are based on the 6BG1T engines.

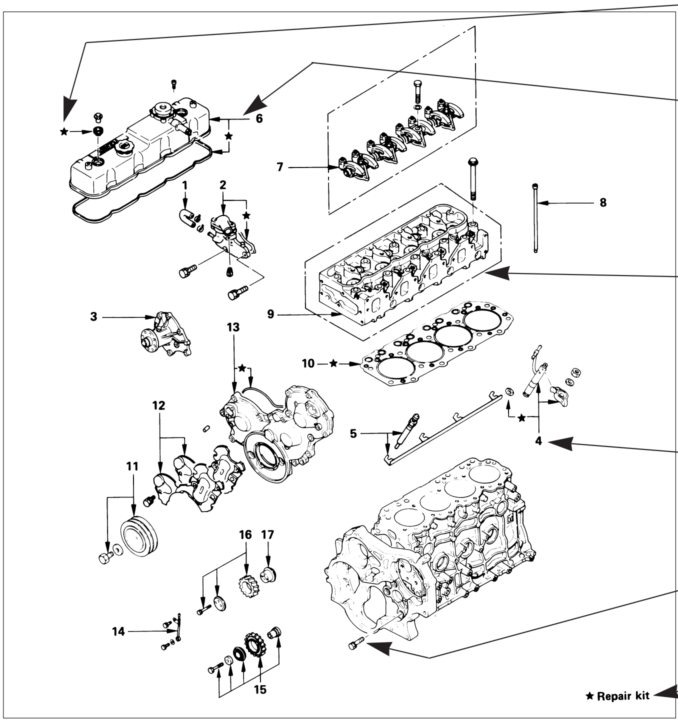
The 6BG1T engine are turbocharged.

1. Find the applicable section by referring to the Table of Contents at the beginning of the Manual.
2. Common technical data such as general maintenance items, service specifications, and tightening torques are included in the "General Information" section.
3. Each section is divided into sub-sections dealing with disassembly, inspection and repair, and reassembly.

   The section ENGINE ASSEMBLY is an exception. This part is divided into three sections to facilitates quick indexing.
4. When the same servicing operation is applicable to several different units, the manual will direct you to the appropriate page.
5. For the sake of brevity, self-explanatory removal and installation procedures are omitted.

   More complex procedures are covered in detail.

6. Each service operation section in this Workshop Manual begins with an exploded view of the applicable area. A brief explanation of the notation used follows.



Disassembly Steps - 2

1. Water by-pass hose
2. Thermostat housing
3. Water pump
▲ 4. Injection nozzle holder
5. Glow plug and glow plug connector
6. Cylinder head cover
▲ 7. Rocker arm shaft and rocker arm
8. Push rod
▲ 9. Cylinder head
10. Cylinder head gasket
▲ 11. Crankshaft damper pulley with dust seal
12. Timing gear case cover (Option)
13. Timing gear cover
14. Timing gear oil pipe
15. Idler gear “B” and shaft
▲ 16. Idler gear “A”
17. Idler gear shaft

Inverted Engine

Parts marked with an asterisk (*) are included in the repair kit.

Parts within a square frame are to be removed and installed as a single unit.

All parts within an irregularly shaped frame form a single assembly. They are considered a "major component". Individual parts within the irregularly shaped frame are considered "minor components".

The number tells you the service operation sequence.

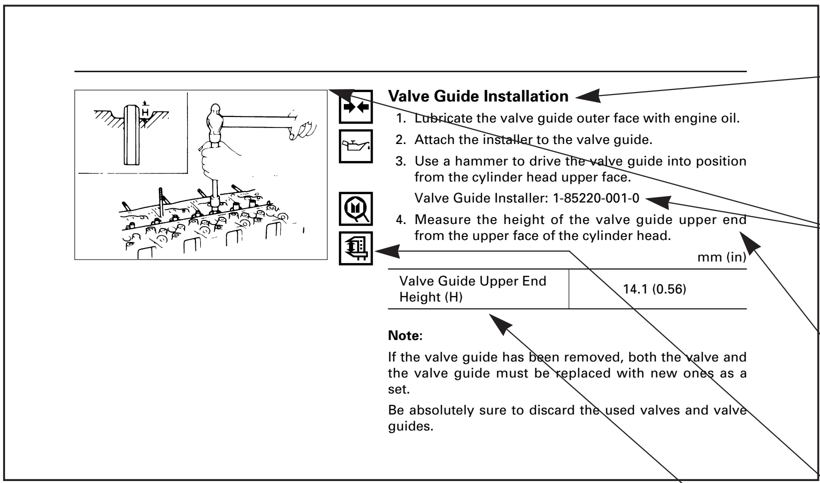
Removal of unnumbered parts is unnecessary unless replacement is required.

The "* Repair Kit" indicates that a repair kit is available.

The parts listed under "Reassembly Steps" or "Installation Steps" are in the service operation sequence.

The removal or installation of parts marked with a triangle (▲) is an important operation. Detailed information is given in the text.

7. Below is a sample of the text of the Workshop Manual.



Valve Guide Installation

1. Lubricate the valve guide outer face with engine oil.
2. Attach the installer to the valve guide.
3. Use a hammer to drive the valve guide into position from the cylinder head upper face.
   Valve Guide Installer: 1-85220-001-0
4. Measure the height of the valve guide upper end from the upper face of the cylinder head.

mm (in)

Valve Guide Upper End Height (H)	14.1 (0.56)

Note:

If the valve guide has been removed, both the valve and the valve guide must be replaced with new ones as a set.

Be absolutely sure to discard the used valves and valve guides.

This is the item shown in the illustration. It is marked with a triangle (▲) on the Major Components page.

Special tools are identified by the tool name and/or number.

The illustration shows how the special tool is to be used.

Letters and numbers contained in a circle refer to the illustration.

Symbols indicate the type of service operation or step to be performed. A detailed explanation of these symbols follows.

Service data and specifications are given in this table.

8. The following symbols appear throughout this Workshop Manual. They tell you the type of service operation or step to perform.

. . . Removal	. . . Adjustment
. . . Installation	. . . Cleaning
. . . Disassembly	. . . Important Operation Requiring Extra Care
. . . Reassembly	. . . Specified Torque (Tighten)
. . . Alignment (Marks)	. . . Special Tool Use Required or Recommended (Isuzu Tool or Tools)
. . . Directional Indication	. . . Commercially Available Tool Use Required or Recommended
. . . Inspection	. . . Lubrication (Oil)
. . . Measurement	. . . Lubrication (Grease)
. . . Sealant Application	

9. Measurement criteria are defined by the terms "standard" and "limit".

   A measurement falling within the "standard" range indicates that the applicable part or parts are serviceable.

   "Limit" should be thought of as an absolute value.

   A measurement which is outside the "limit" indicates that the applicable part or parts must be either repaired or replaced.

10. Components and parts are listed in the singular form throughout the Manual.

11. Directions used in this Manual are as follows:

    Front

    The cooling fan side of the engine viewed from the flywheel.

    Right

    The injection pump side of the engine.

    Left

    The exhaust manifold side of the engine.

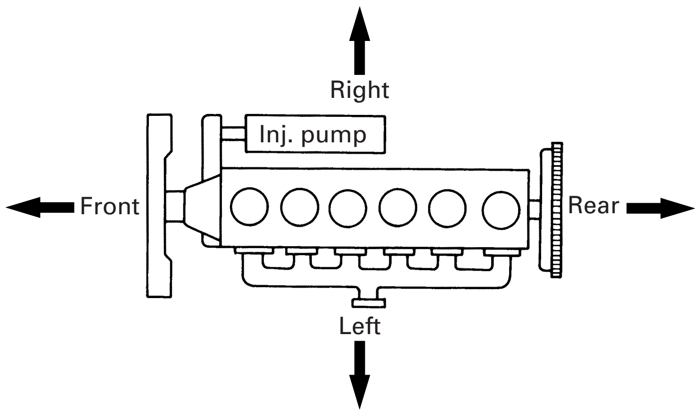
    Rear

    The flywheel side of the engine.

    Cylinder numbers are counted from the front of the engine.

    The front most cylinder is No. 1 and rear most cylinder is No. 6.

    The engine's direction of rotation is counterclockwise viewed from the flywheel.



MAIN DATA AND SPECIFICATIONS

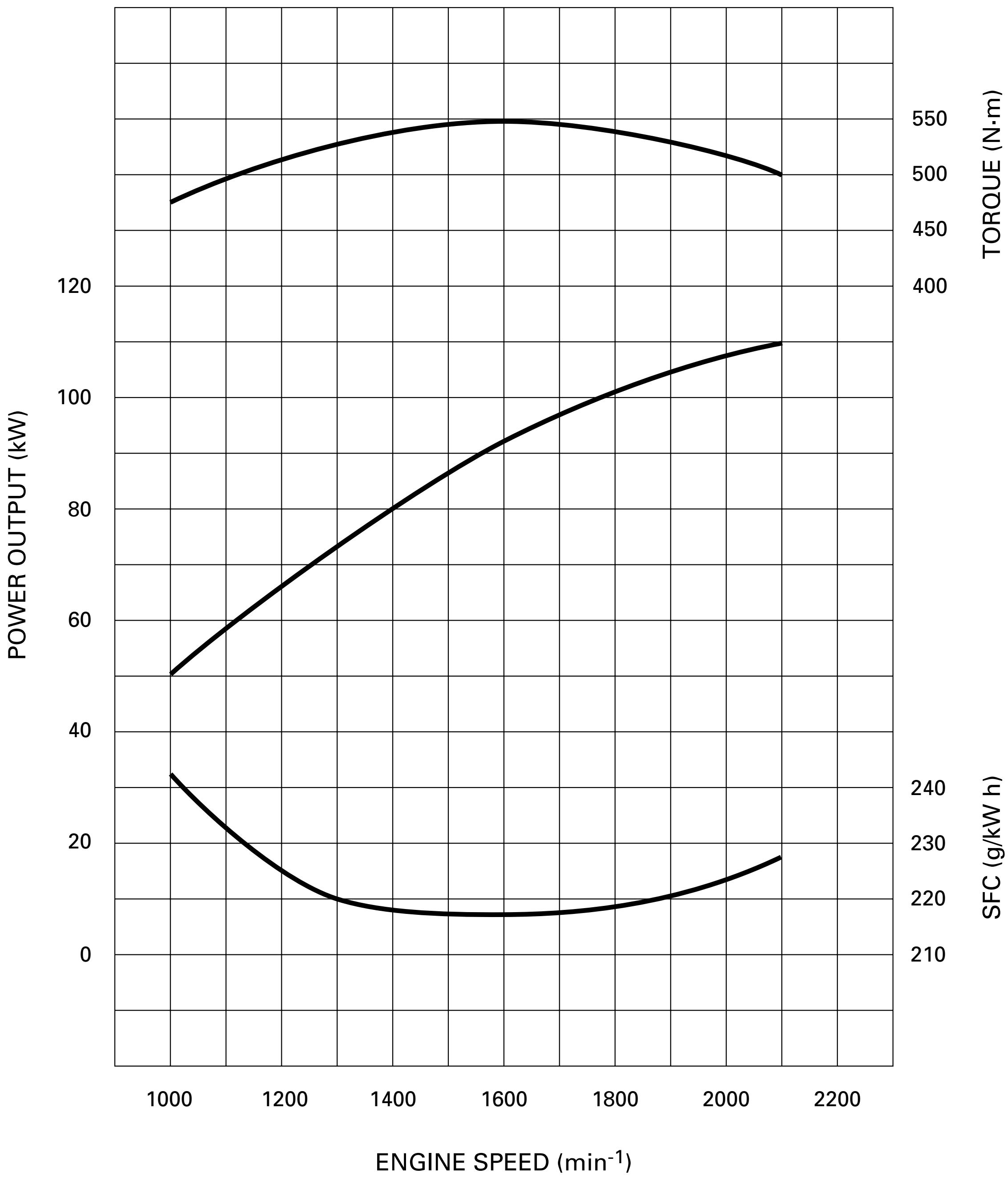
Item \ Engine Model		6BG1TRA	
Engine type		Water cooled, four cycle, vertical in-line overhead valve	
Combustion chamber type		Direct injection	
Cylinder liner type		Dry	
No. of cylinders – bore × stroke	mm (in)	6 – 105 × 125 (4.13 × 4.92)	
Total piston displacement	L (cid)	6.494 (396)	
Compression ratio		18 to 1	
Engine dimensions Length × width × height	mm (in)	1206 × 814.6 × 996 (47.5 × 32.1 × 39.2)	
Engine mass (Dry)	kg (lb)	490 (1080)	
Fuel injection order		1–5–3–6–2–4	
Fuel injection timing (BTDC)	degrees	AA-6BG1TRA	10
		CC-6BG1TRA-12/13	9
Specified fuel		Diesel fuel	
Injection pump		In-line plunger, Bosch A type	
Governor		Mechanical, RSV type	
Low idle speed	min^{-1}	880–920	
Injection nozzle		Hole type (with four orifices)	
Injection starting pressure	MPa (kgf/cm^2/psi)	18.1 (185/2,630)	
Fuel filter type		Cartridge (spin-on)	
Water sedimentor		Sediment/water level indicating type	
Compression pressure (At warm)	MPa (kgf/cm^2/psi)	3.0 (440) at 200 min^{-1} at sea level	
Valve clearances (At cold)	Intake mm (in)	0.40 (0.016)	
	Exhaust mm (in)	0.40 (0.016)	
Lubrication method		Pressurized circulation	
Oil pump		Gear type	
Main oil filter type		Cartridge (spin-on)	
Lubricating oil volume (Oil Pan)	L (US gal)	21.5 (5.68)	
Oil cooler		Water cooled integral type	
Cooling method		Pressurized forced circulation	
Coolant volume	L (US gal)	12.0 (3.2) Engine only	
Water pump		Belt driven impeller type	
Thermostat type		Wax pellet type	
Alternator	V-A	24–50	
Starter	V-KW	24–4.5	
Turbocharger manufacturer		IHI	
Turbocharger model		RHG6	

PERFORMANCE CURVE

MODEL AA-6BG1TRA

CONDITION:

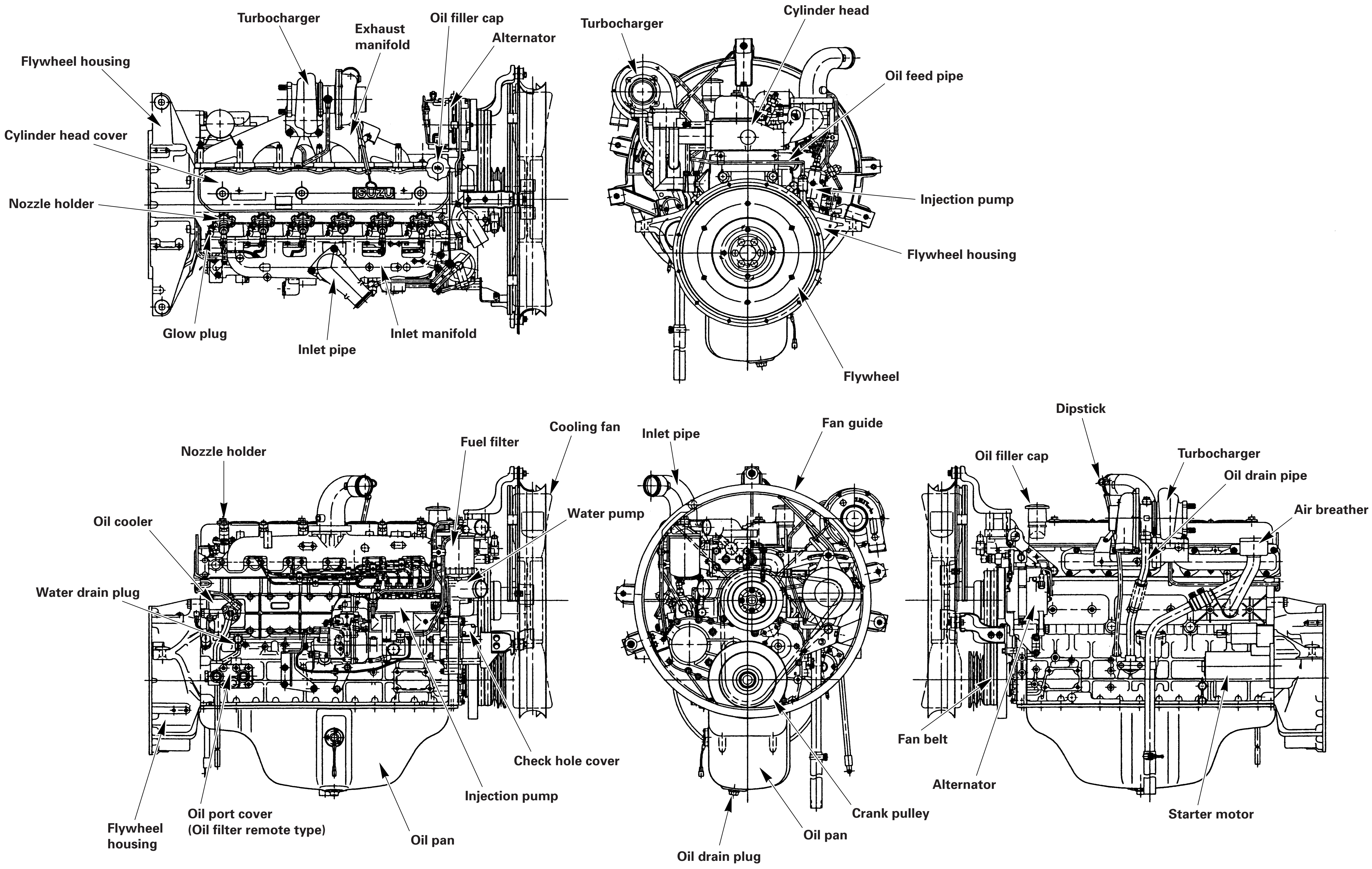
Ambient condition	: JIS standard	Air cleaner	: None
Break-in	: More than 30 hours	Alternator	: No Load
Cooling fan	: 650ϕ	Exhaust silencer	: None



Note: Some values are different due to the difference of the models and the specifications.

EXTERNAL VIEW

Note: Some components and shapes are different due to the difference of the models and the specifications.

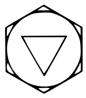
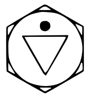
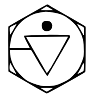


TIGHTENING TORQUE SPECIFICATIONS

The tightening torque values given in the table below are applicable to the bolts unless otherwise specified.

STANDARD BOLT

N·m (kgf·m/lb.ft)

Bolt Identification / Bolt Diameter × pitch (mm)	4	8 .8	9
		 	
M 6 × 1.0	3.9–7.8 (0.4–0.8/2.9–5.8)	4.9–9.8 (0.5–1.0/3.6–7.2)	――――――――
M 8 × 1.25	7.8–17.7 (0.8–1.8/5.8–13.0)	11.8–22.6 (1.2–2.3/8.7–16.6)	16.7–30.4 (1.7–3.1/12.3–22.4)
M10 × 1.25	20.6–34.3 (2.1–3.5/5.2–25.3)	27.5–46.1 (2.8–4.7/20.3–33.4)	37.3–62.8 (3.8–6.4/27.5–46.3)
* M10 × 1.5	19.6–33.4 (2.0–3.4/14.5–24.6)	27.5–45.1 (2.8–4.6/20.3–33.3)	36.3–59.8 (3.7–6.1/26.8–44.1)
M12 × 1.25	49.1–73.6 (5.0–7.5/36.2–54.2)	60.8–91.2 (6.2–9.3/44.8–67.3)	75.5–114.0 (7.7–11.6/55.7–83.9)
* M12 × 1.75	45.1–68.7 (4.6–7.0/33.3–50.6)	56.9–84.4 (5.8–8.6/42.0–62.2)	71.6–107.0 (7.3–10.9/52.8–78.8)
M14 × 1.5	76.5～115.0 (7.8～11.7/56.4～84.6)	93.2–139.0 (9.5–14.2/68.7–103.0)	114.0–.0 (11.6–17.4/83.9–126.0)
* M14 × 2.0	71.6–107.0 (7.3–10.9/52.8–78.8)	88.3–131.0 (9.0–13.4/65.1–96.9)	107.0–160.0 (10.9–16.3/78.8–118.0)
M16 × 1.5	104.0–157.0 (10.6–16.0/76.7–115.7)	135.0–204.0 (13.8–20.8/99.8–150.0)	160.0–240.0 (16.3–24.5/118.0–177.0)
* M16 × 2.0	100.0–149.0 (10.2–15.2/73.8–110.0)	129.0–194.0 (13.2–19.8/95.5–143.0)	153.0–230.0 (15.6–23.4/113.0–169.0)
M18 × 1.5	151.0–226.0 (15.4–23.0/111.0–166.0)	195.0–293.0 (19.9–29.9/144.0–216.0)	230.0–345.0 (23.4–35.2/169.0–255.0)
* M18 × 2.5	151.0–226.0 (15.4–23.0/111.0–166.0)	196.0–294.0 (20.0–30.0/145.0–217.0)	231.0–346.0 (23.6–35.3/171.0–255.0)
M20 × 1.5	206.0–310.0 (21.0–31.6/152.0–229.0)	270.0–405.0 (27.5–41.3/199.0–299.0)	317.0–476.0 (32.3–48.5/234.0–351.0)
* M20 × 2.5	190.0–286.0 (19.4–29.2/140.0–211.0)	249.0–375.0 (25.4–38.2/184.0–276.0)	293.0–440.0 (29.9–44.9/216.0–325.0)
M22 × 1.5	251.0–414.0 (25.6–42.2/185.0–305.0)	363.0–544.0 (37.0–55.5/268.0–401.0)	425.0–637.0 (43.3–64.9/313.0–469.0)
* M22 × 2.5	218.0–328.0 (22.2–33.4/161.0–242.0)	338.0–507.0 (34.5–51.7/250.0–374.0)	394.0–592.0 (40.2–60.4/291.0–437.0)
M24 × 2.0	359.0–540.0 (36.6–55.0/265.0–398.0)	431.0–711.0 (43.9–72.5/318.0–524.0)	554.0–831.0 (56.5–84.7/409.0–613.0)
* M24 × 3.0	338.0–507.0 (34.5–51.7/250.0–374.0)	406.0–608.0 (41.4–62.0/299.0–448.0)	521.0–782.0 (53.1–79.7/384.0–576.0)

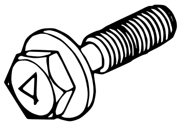
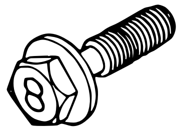
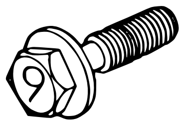
An asterisk (*) indicates that the bolts are used for female threaded parts that are made of soft materials such as casting.

TIGHTENING TORQUE SPECIFICATIONS

The tightening torque values given in the table below are applicable to the bolts unless otherwise specified.

FLANGED HEAD BOLT

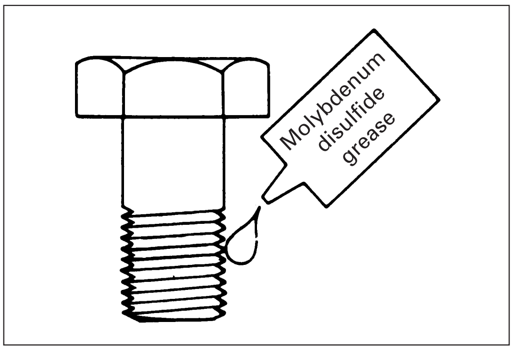
N·m (kgf·m/lb.ft)

Bolt Identification / Bolt Diameter × pitch (mm)			
M 6 × 1.0	4.6–8.5 (0.5–0.9/3.6–6.5)	6.6–12.2 (0.6–1.2/4.3–8.7)	——
M 8 × 1.25	10.5–196 (1.1–2.0/8.0–14.5)	15.3–28.4 (1.6–2.9/11.6–21.0)	18.1–33.6 (2.1–3.4/15.2–25.0)
M10 × 1.25	23.1–38.5 (2.4–3.9/17.4–28.2)	35.4–58.9 (3.6–6.1/26.0–44.1)	42.3–70.5 (4.3–7.2/31.1–52.1)
* M10 × 1.5	22.3–37.2 (2.3–3.8/16.6–27.5)	34.5–57.5 (3.5–5.8/25.3–42.0)	40.1–66.9 (4.1–6.8/29.7–49.2)
M12 × 1.25	54.9–82.3 (5.6–8.4/40.1–60.8)	77.7–117.0 (7.9–11.9/57.1–86.1)	85.0–128.0 (8.7–13.0/62.9–94.0)
* M12 × 1.75	51.0–76.5 (5.2–7.8/37.6–56.4)	71.4–107.0 (7.3–10.9/52.8–78.8)	79.5–119.0 (8.1–12.2/58.6–88.2)
M14 × 1.5	83.0–125.0 (8.5–12.7/61.5–91.9)	115.0–172.0 (11.7–17.6/84.6–127.0)	123.0–185.0 (12.6–18.9/91.1–137.0)
* M14 × 2.0	77.2–116.0 (7.9–11.8/57.1–85.3)	108.0–162.0 (11.1–16.6/80.3–120.0)	116.0–173.0 (11.8–17.7/85.3–128)
M16 × 1.5	116.0–173.0 (11.8–17.7/85.3–128)	171.0–257.0 (17.4–26.2/26.0–190)	177.0–265.0 (18.0–27.1/130.0–196.0)
* M16 × 2.0	109.0–164.0 (11.2–16.7/81.0–121.0)	163.0–244.0 (16.6–24.9/120.0–180.0)	169.0–253.0 (17.2–25.8/124.0–187.0)

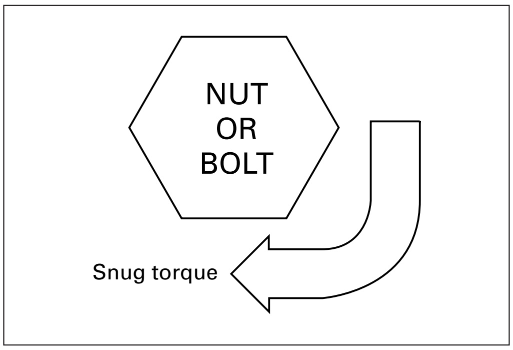
A bolt with an asterisk (*) is used for female screws of soft material such as cast iron.

ANGULAR NUT AND BOLT TIGHTENING METHOD

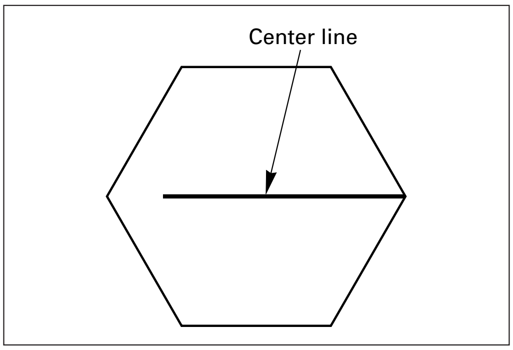
1. Carefully wash the nuts and bolts to remove all oil and grease.



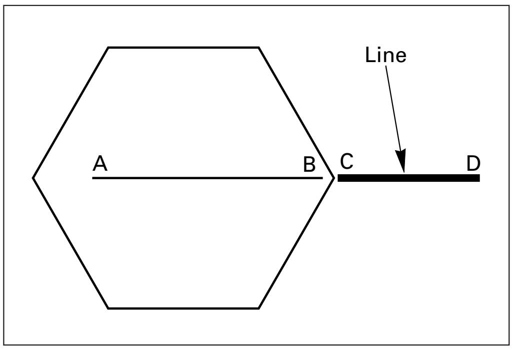
2. Apply a coat of molybdenum disulfide grease to the threads and setting faces of the nuts and bolts.



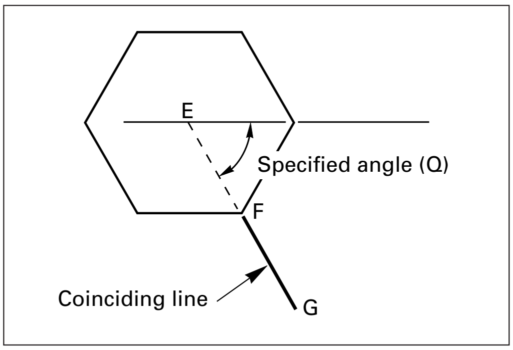
3. Tighten the nuts and bolts to the specified torque (snug torque) with a torque wrench.



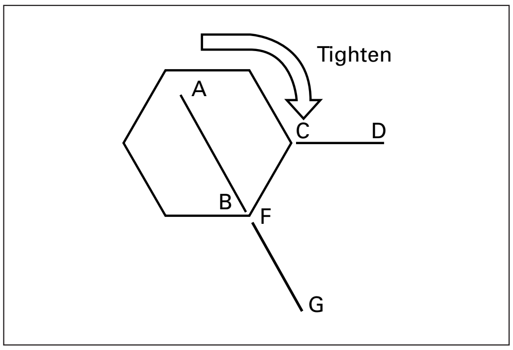
4. Draw a line [A-B] across the center of each bolt.



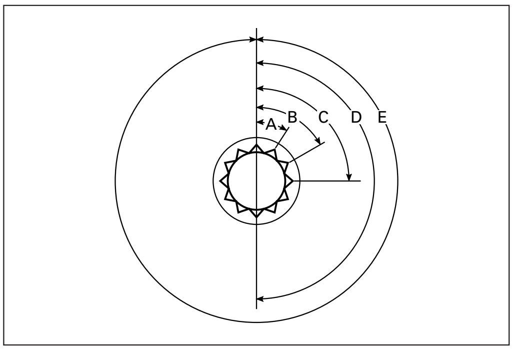
5. Draw another line (C-D) on the face of each of the parts to be clamped. This line should be an extension of the line [A-B].



6. Draw another line [F-G] on the face of each of the parts to be clamped. This line will be in the direction of the specified angle (Q) across the center [E] of the nut or bolt.



7. Use a socket wrench to tighten each nut or bolt to the point where the line [A-B] is aligned with the line [F-G].



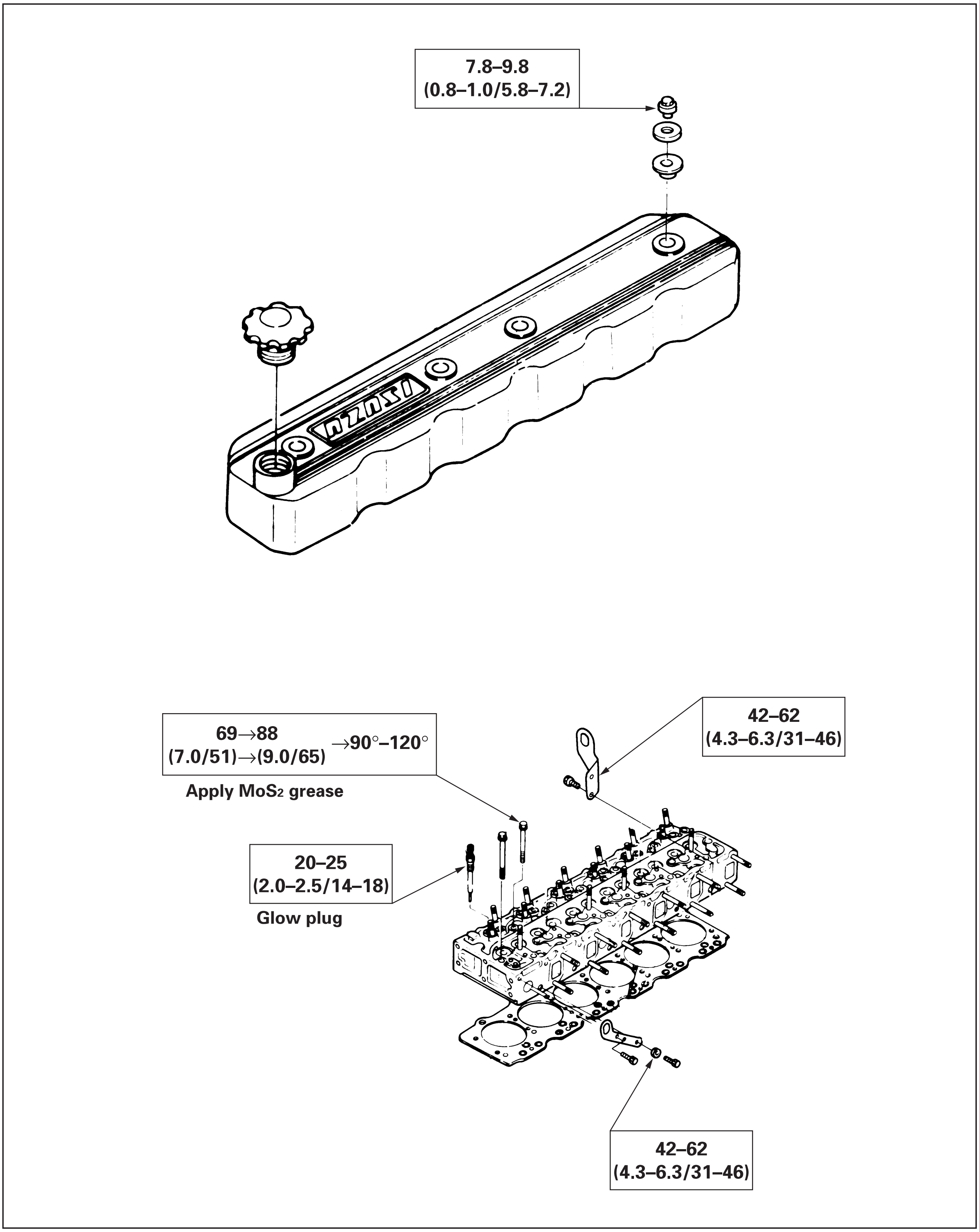
Example: Specified Angle and Tightening Rotation

A	30°	1/12 of a turn
B	60°	1/6 of a turn
C	90°	1/4 of a turn
D	180°	1/2 of a turn
E	360°	One full turn

MAJOR PART FIXING NUTS AND BOLTS

Cylinder Head and Cover

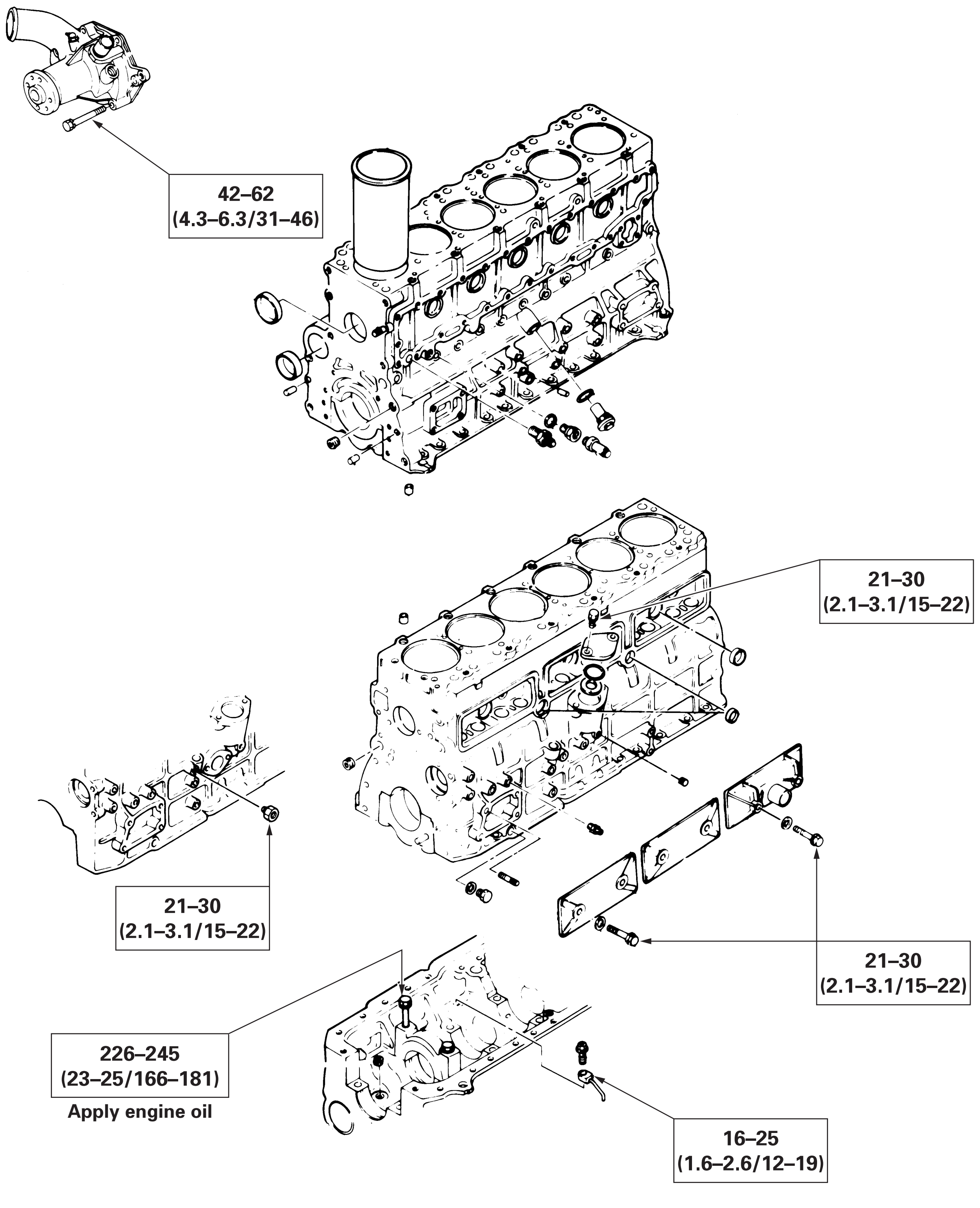
N·m (kgf·m/lb.ft)



MoS_2 . . . . . . Molybdenum disulfide paste.

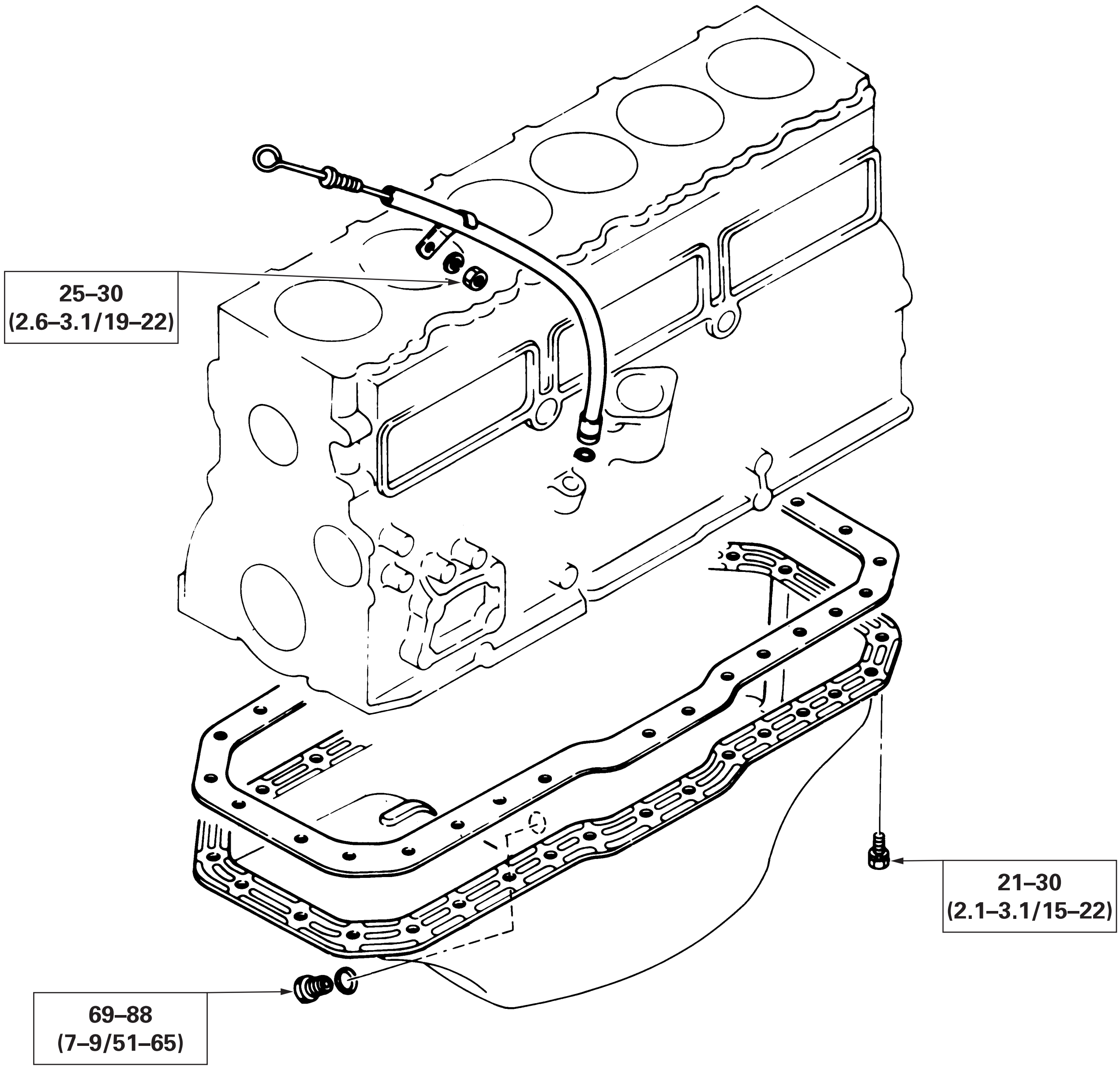
Cylinder Body

N·m (kgf·m/lb.ft)



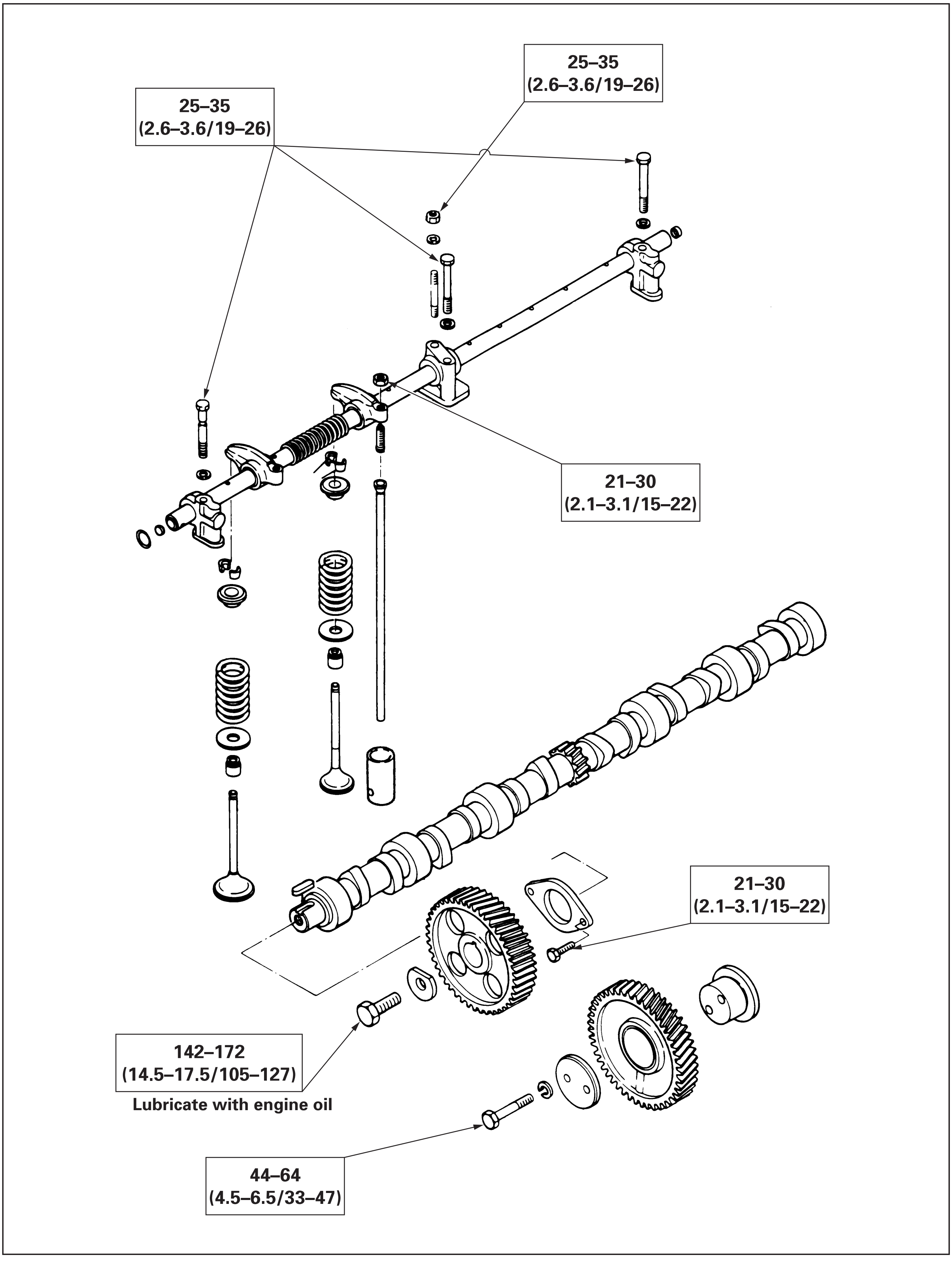
Oil Pan and Dipstick

N·m (kgf·m/lb.ft)



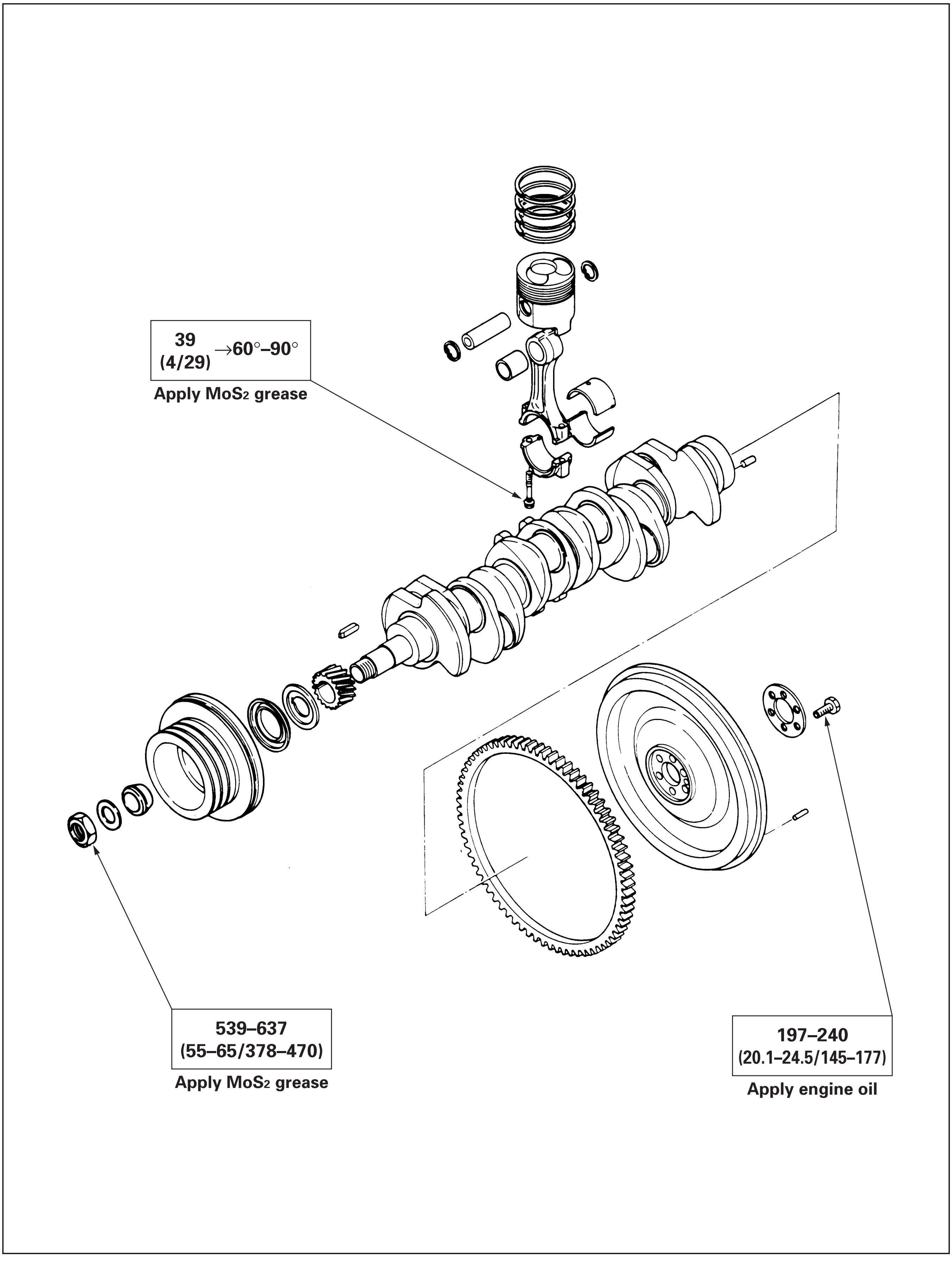
Camshaft and Rocker Arm

N·m (kgf·m/lb.ft)



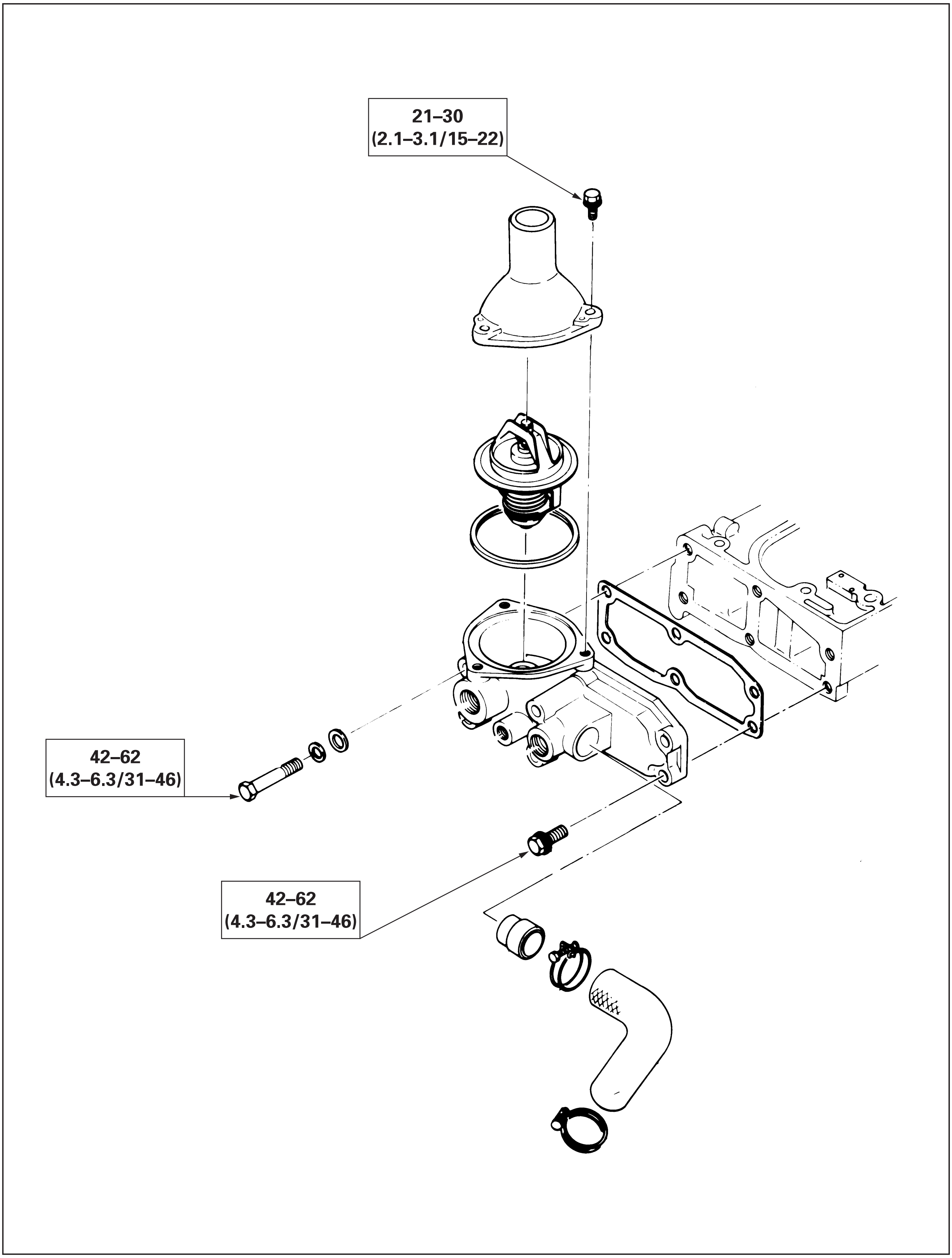
Crankshaft, Piston, and Flywheel

N·m (kgf·m/lb.ft)



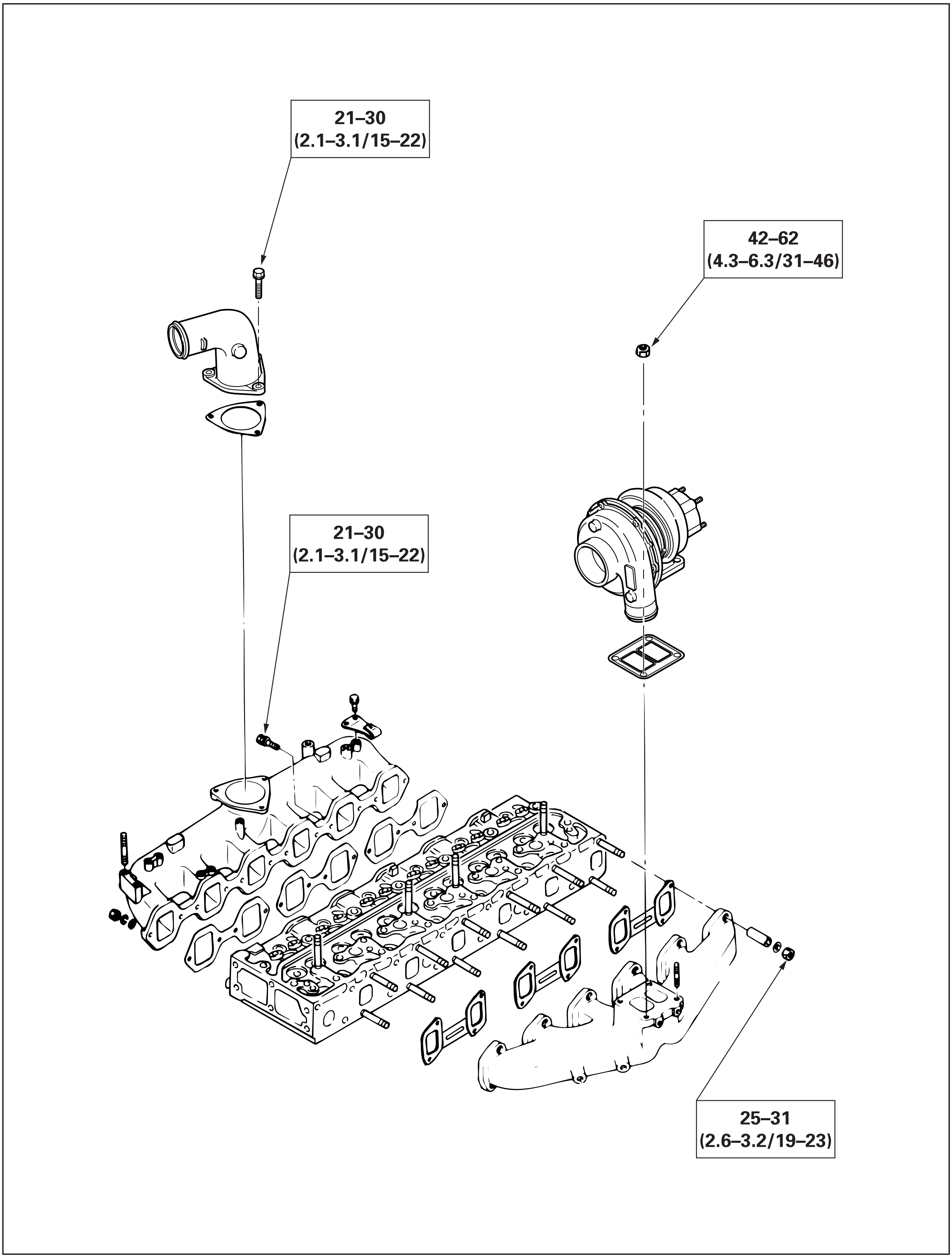
Thermostat and Thermostat Housing

N·m (kgf·m/lb.ft)



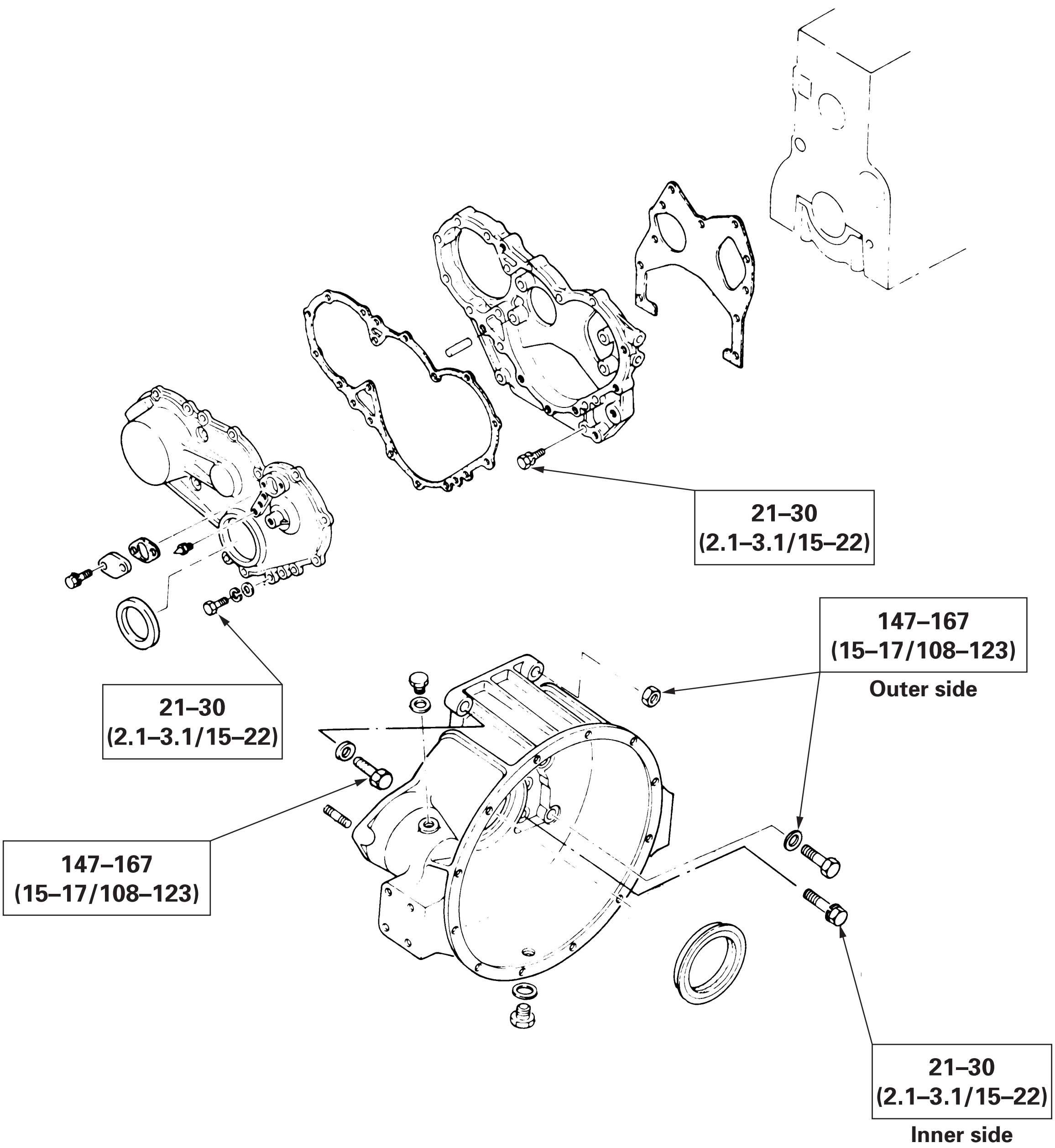
Intake and Exhaust Manifold

N·m (kgf·m/lb.ft)



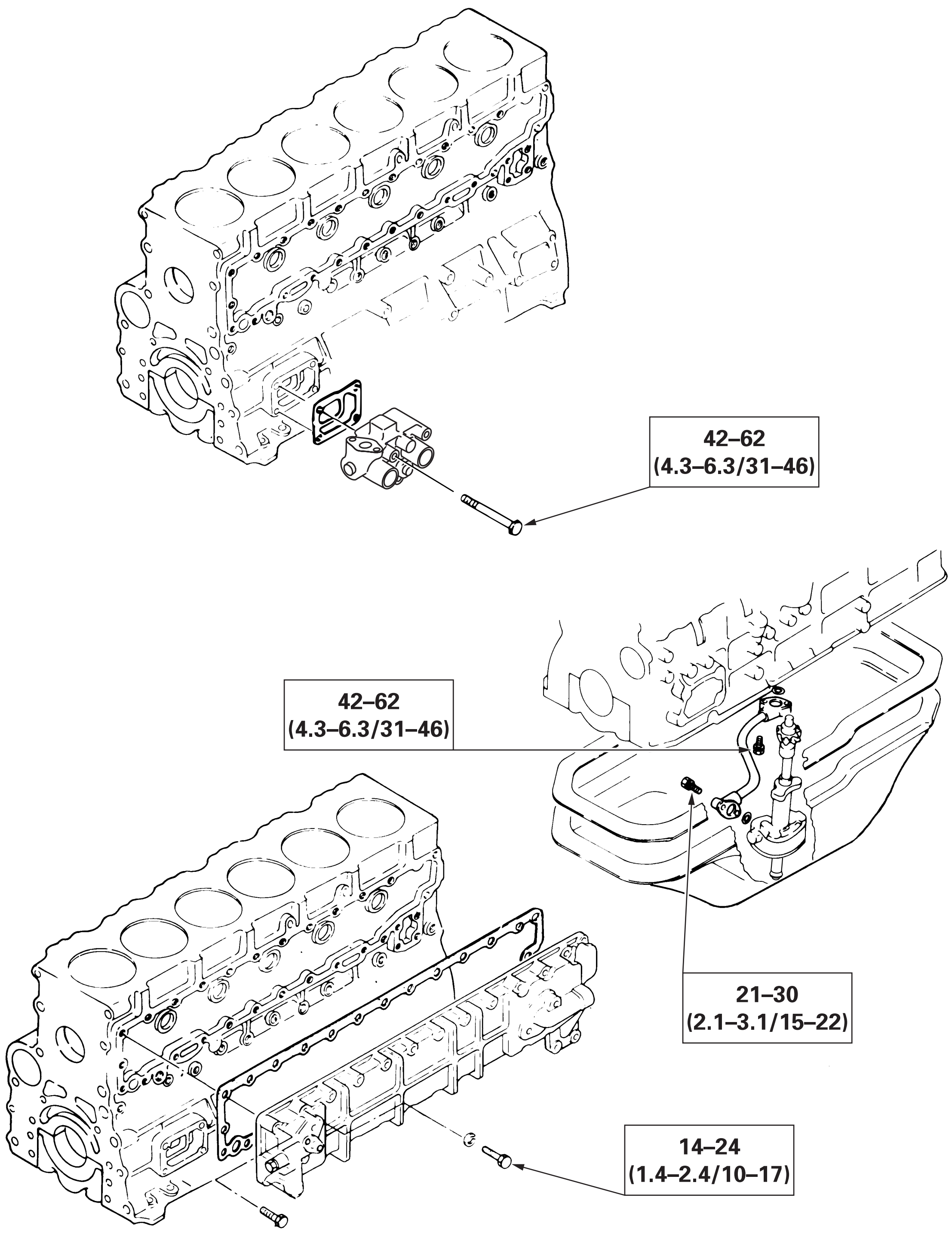
Timing Gear Case and Flywheel Housing

N·m (kgf·m/lb.ft)



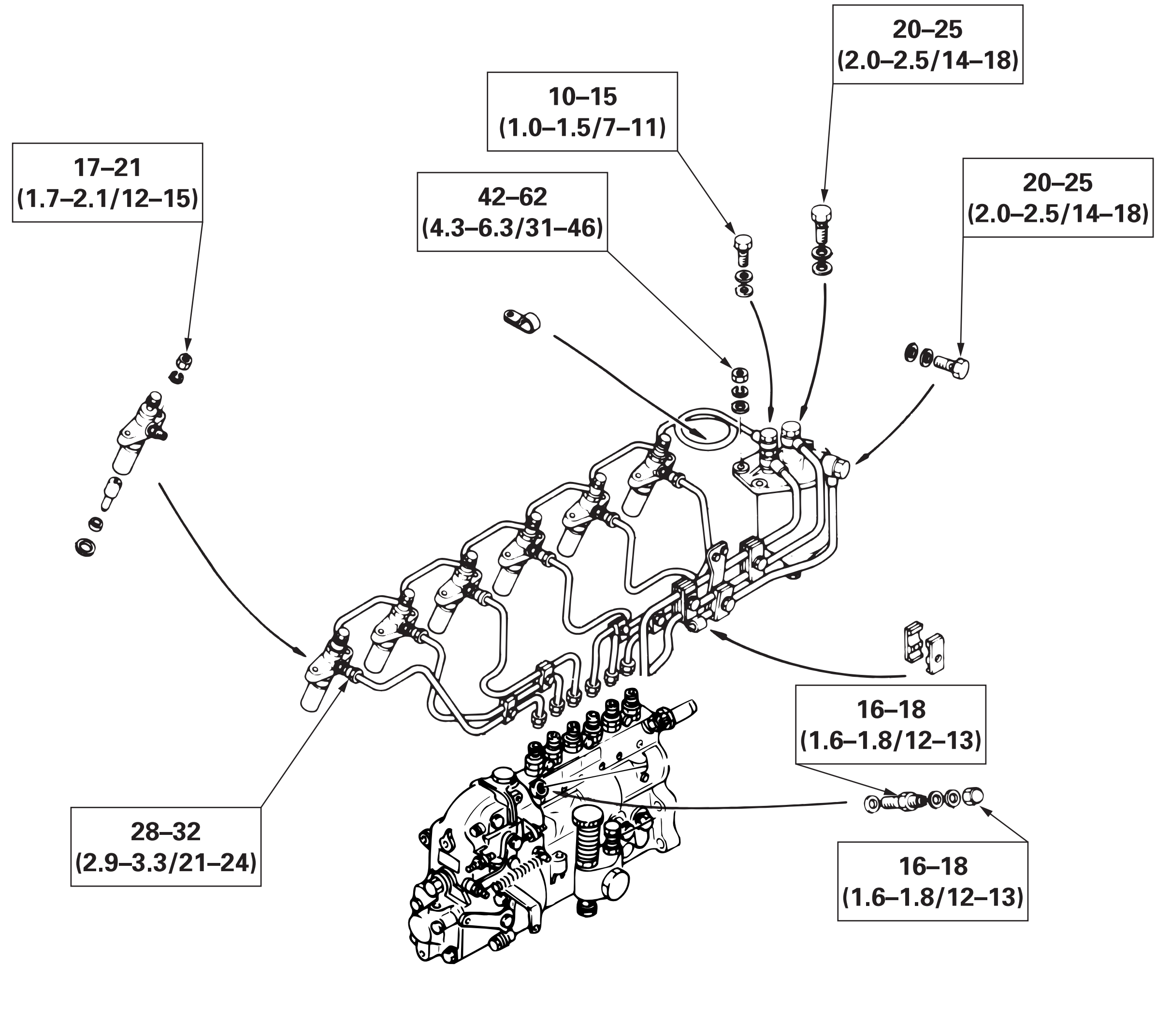
Oil Cooler, Oil Filter, and Oil Pump

N·m (kgf·m/lb.ft)



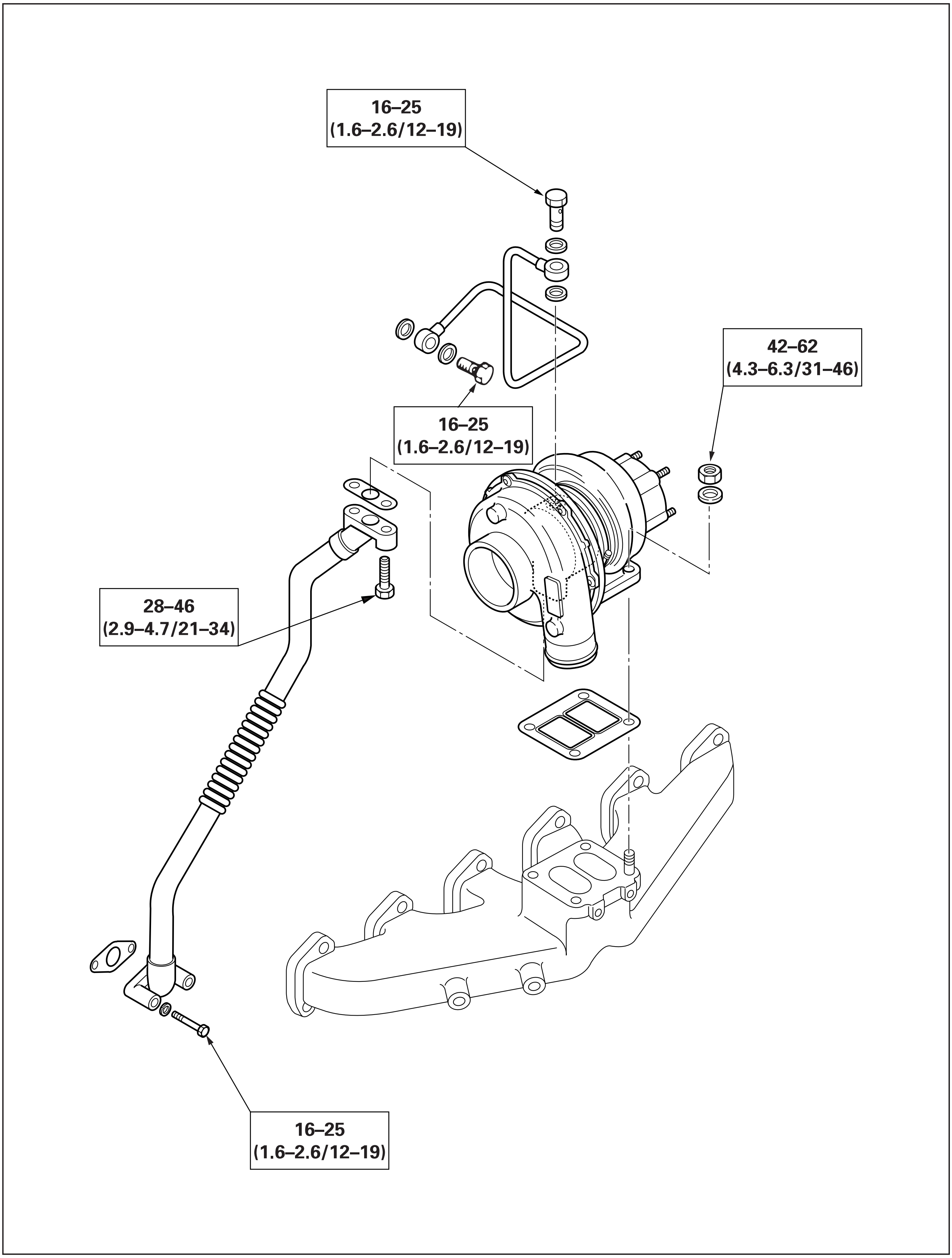
Fuel System

N·m (kgf·m/lb.ft)



Turbocharger

N·m (kgf·m/lb.ft)

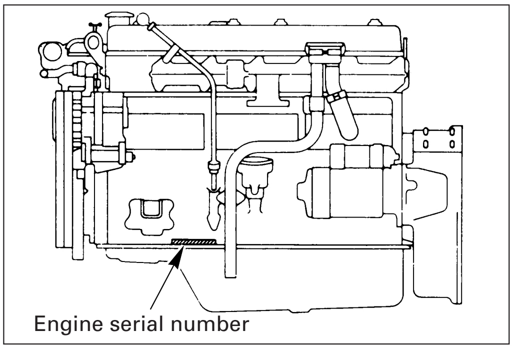


IDENTIFICATIONS

MODEL IDENTIFICATION

Engine Serial Number

The engine number is stamped on the front left hand side of the cylinder body.

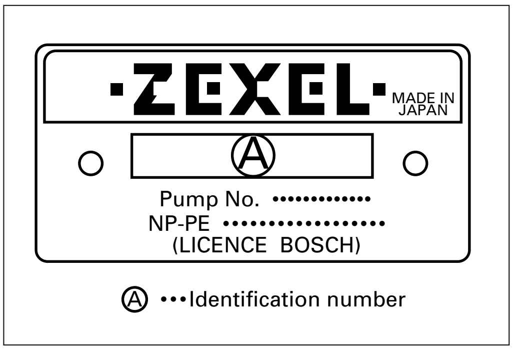


INJECTION PUMP IDENTIFICATION

Injection Pump Number

Injection volume should be adjusted after referring to the adjustment data applicable to the injection pump installed.

The injection pump identification number (A) is stamped on the injection pump identification plate.



Note:

Always check the identification number before beginning a service operation.

Applicable service data will vary according to the identification number. Use of the wrong service data will result in reduced engine performance and engine damage.

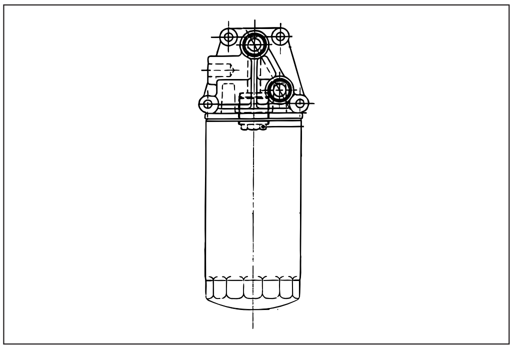
SECTION 2

MAINTENANCE

TABLE OF CONTENTS

ITEM **PAGE**

Note: Maintenance intervals such as fuel or oil filter changes should be referred to INSTRUCTION BOOK.



LUBRICATING SYSTEM

Main Oil Filter Replacement

Cartridge (Spin-On) Type
(Remote mount type)

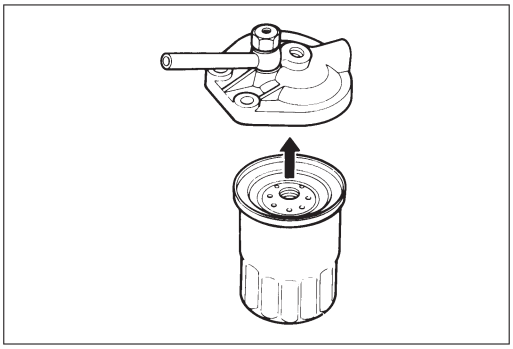
Removal

Removal and Installer: Filter Wrench

1. Loosen the used oil filter by turning it counterclockwise with the filter wrench.
2. Discard the used oil filter.

Installation

1. Wipe the oil filter mounting face with a clean rag.
   This will allow the new oil filter to seat properly.
2. Lightly oil the O-ring.
3. Turn in the new oil filter until the sealing face is fitted against the O-ring.
4. Use the filter wrench to turn in the oil filter an additional 3/4 of a turn or one turn.
5. Check the engine oil level and replenish to the specified level if required.
6. Start the engine and check for oil leakage from the oil filter.



FUEL SYSTEM

Fuel Filter Replacement

Cartridge (Spin-On) Type

Removal

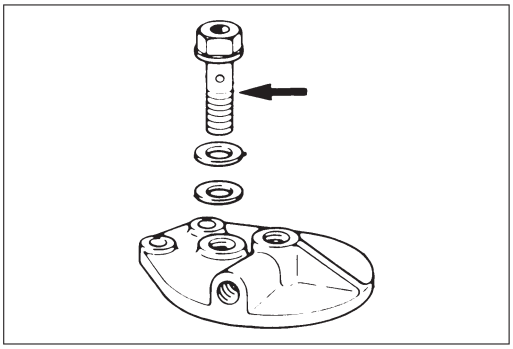
1. Loosen the fuel filter by turning it counterclockwise with the filter wrench or your hand. Discard the used filter.

   Filter Wrench
2. Wipe the fuel filter fitting face clean with a rag.

   This will allow the new fuel filter to seat properly.

Installation

1. Apply a light coat of engine oil to the O-ring.
2. Supply fuel to the new fuel filter.
   This will facilitate air bleeding.
3. Turn in the new fuel filter until the filter O-ring is fitted against the sealing face.
4. Use the filter wrench to turn in the fuel filter an additional 2/3 of a turn.



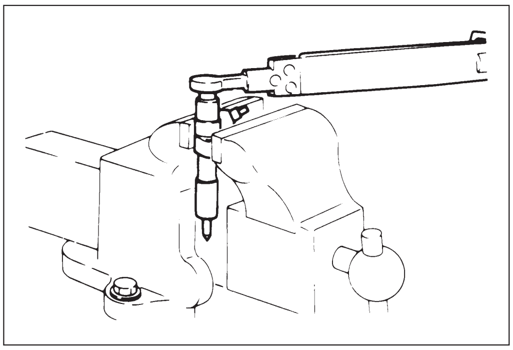
Overflow Valve

Check the overflow valve for clogging.

Check the ball side for suction leakage

kPa (kgf/cm^2/psi)

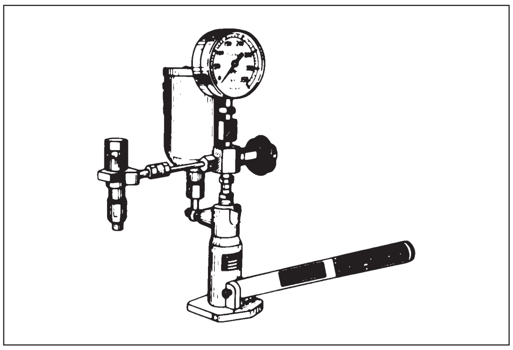
Overflow Valve Opening Pressure (Reference)	147 (1.5/21)



Injection Nozzle

Inspection procedure

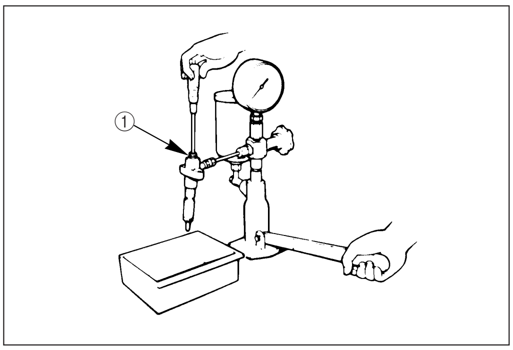
1. Clamp the injection nozzle holder in a vise.
2. Use a wrench to remove the injection nozzle holder cap.
3. Remove the injection nozzle holder from the vise.

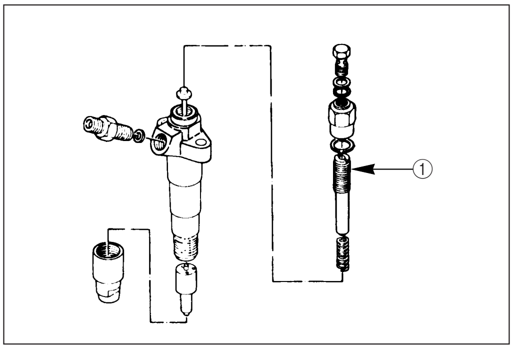


Adjusting Procedure

Injection Starting Pressure Check

1. Attach the injection nozzle holder to the injection nozzle tester.
2. Loosen the adjusting screw ①.
3. Check the injection nozzle starting pressure and the spray condition by operating the injection nozzle tester.
4. Adjust the injection nozzle starting pressure.
   Turn the adjusting screw clockwise while operating the injection nozzle tester handle.

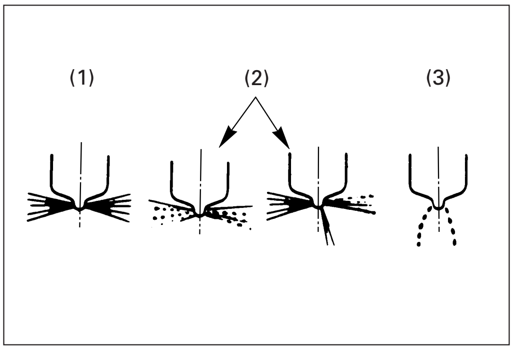




MPa (kgf/cm^2/psi)

Injection Starting Pressure	18.1 (185/2630)

WARNING
TEST FLUID FROM THE NOZZLE TESTER WILL SPRAY OUT UNDER GREAT PRESSURE. IT CAN EASILY PUNCTURE A PERSON'S SKIN. KEEP YOUR HANDS AWAY FROM THE NOZZLE TESTER AT ALL TIMES.

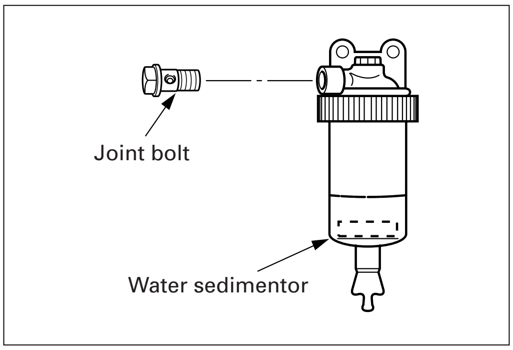


Spray Condition Check (During Injection Nozzle Tester Operation)

1. Tighten the cap nut.
2. Check the injection nozzle starting pressure.
3. Check the injection nozzle spray condition.

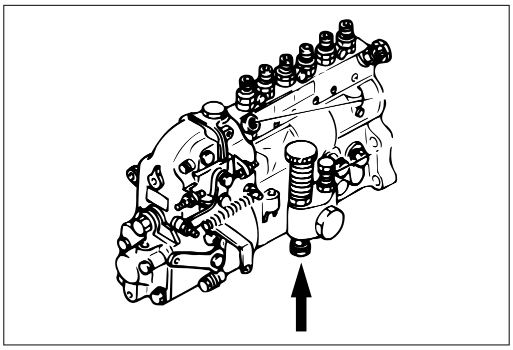
Operate the injection nozzle tester hand lever 4 to 6 times a second while looking for abnormal injection nozzle spray conditions.
Refer to the illustration for different spray conditions.

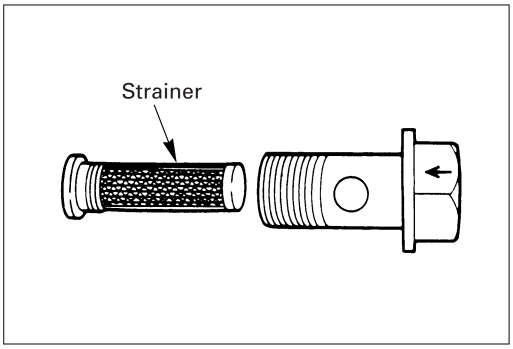
(1) Good
(2) Bad (Restrictions in orifice)
(3) Bad (Dripping)

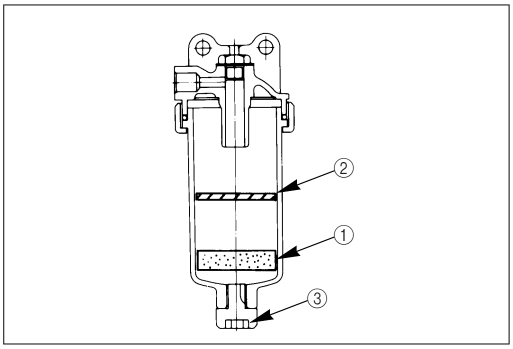


Water Sedimentor and Feed Pump Strainer

1. Remove the joint bolt.
2. Use a screwdriver to remove the strainer.
3. Wash the strainer in clean diesel fuel.







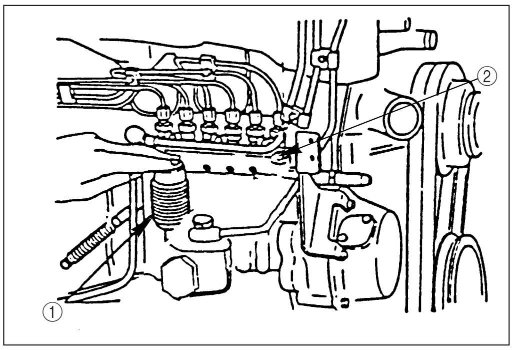
Water Separator (Water Sedimentor) (Optional Equipment)

Check the water separator float ① level.

If the float ① has reached level ②, loosen the drain plug ③ (at the bottom side of the water separator) to drain the water.

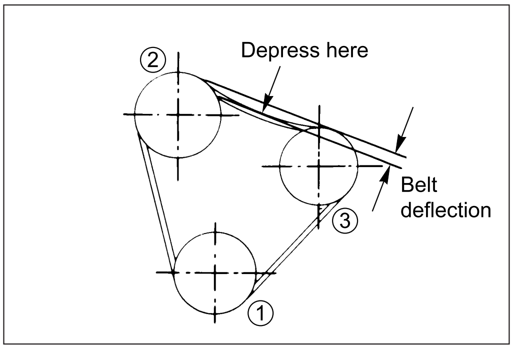
N·m (kgf·m/lb.ft)

Drain Plug Torque	9–15 (0.9–1.5/7–11)



Air Bleeding

1. Loosen the feed pump cap ① on the injection pump.
2. Loosen the bleeding screw ② on the injection pump.
3. Operate the feed pump until there are no more bubbles visible in the fuel being discharged from the loosened bleeding screw.
4. Retighten the bleeding screw.
5. Operate the feed pump several times and check for fuel leakage around the injection pump and the fuel filter.



COOLING SYSTEM

Cooling Fan Drive Belt

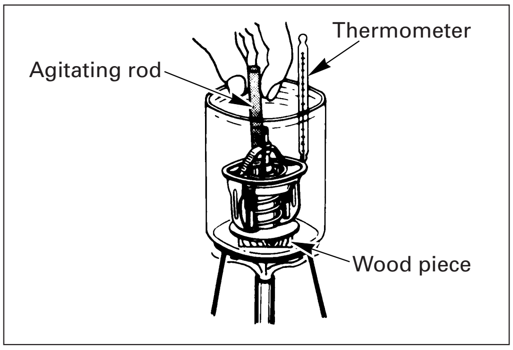
Adjustment

1. Check the cooling fan drive belt for cracking and other damage.
2. Check the drive belt tension by exerting a force of 10 kg (22lb) midway between the fan pulley ② and the generator ③.
3. Adjust the belt tension by loosening the alternator mounting bolt and the generator adjusting bolt and pivoting the generator.

   Be sure to retighten the bolts after adjusting the belt tension.

mm (in)

Cooling Fan Drive Belt Deflection	
Single belt	7–10 (0.28–0.39)
Scrum belt (2 belts are jointed)	3.5–6.0 (0.14–0.24)
Scrum belt (3 belts are jointed)	1.5–2.5 (0.06–0.10)



Thermostat

Inspection

Visually inspect the thermostat.

Replace the thermostat if excessive wear or damage is discovered during inspection.

Measure the valve lift.

mm (in)

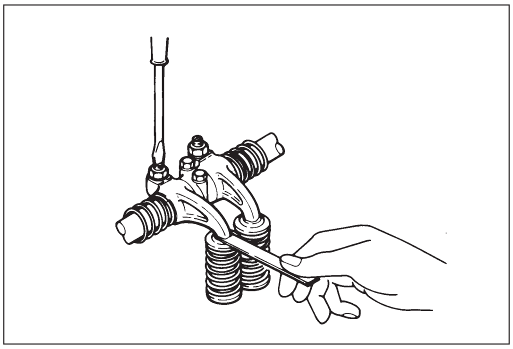
Amount of Valve Lift	10.0 (0.39)

°C(°F)

Valve Opening Temperature	
AA-6BG1TRA	80–84 (176–183)
CC-6BG1TRA-12/13	74.5–78.5 (166–173)

°C(°F)

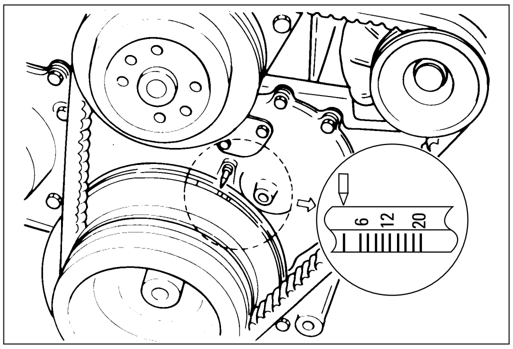
Valve Full Opening Temperature	90 (194)



VALVE CLEARANCE AND ADJUSTMENT

Note:

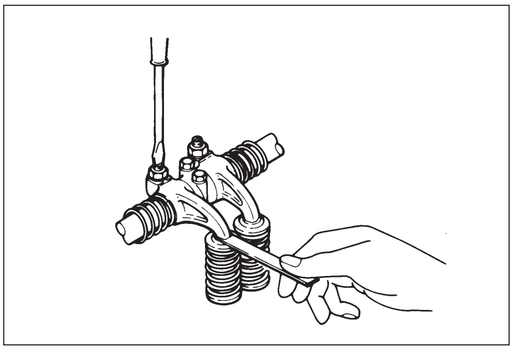
The cylinder head bolts were previously tightened with the "Angular Tightening Method". Therefore, it is not necessary to retighten the cylinder head bolts before adjusting the valve clearance.



1. Bring the piston in either the No. 1 cylinder or the No. 6 cylinder to Top Dead Center on the compression stroke by turning the crankshaft until the TDC notched line on the crankshaft pulley is aligned with the timing pointer.
2. Check to see if there is play in the No. 1 intake and exhaust valve rocker arms.

   If the No. 1 cylinder intake and exhaust valve rocker arms have play, the No. 1 piston is at TDC on the compression stroke.

   If the No. 1 cylinder intake and exhaust valve rocker arms are depressed, the No. 6 piston is at TDC on the compression stroke.

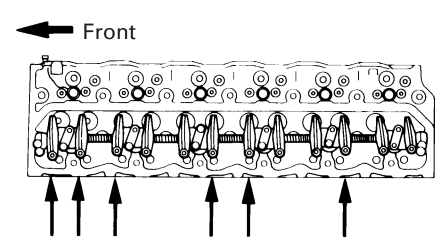


Adjust the No. 1 or the No. 6 cylinder valve clearances while their respective cylinders are at TDC on the compression stroke.

mm (in)

Intake and Exhaust Valve Clearance (cold)	0.40 (0.016)

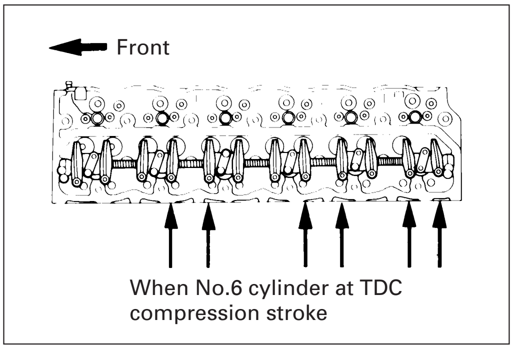
3. Loosen each valve clearance adjusting screw as shown in the illustration.
4. Insert a 0.40 mm (0.016 in) feeler gauge between the rocker arm and the valve stem end.
5. Turn the valve clearance adjusting screw until a slight drag can be felt on the feeler gauge.
6. Tighten the lock nut securely.



When No.1 cylinder at TDC in compression stroke

7. Rotate the crankshaft 360°.

   Realign the crankshaft pulley TDC notched line with the timing pointer.
8. Adjust the clearances for the remaining valves as shown in the illustration.



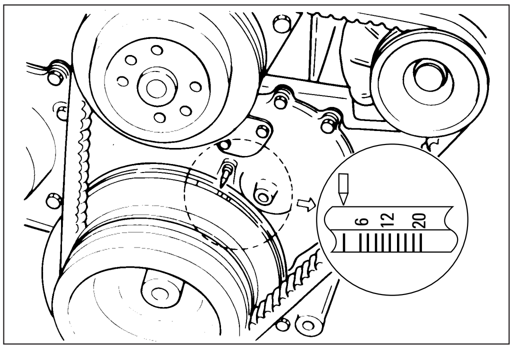
N·m (kgf·m/lb.ft)

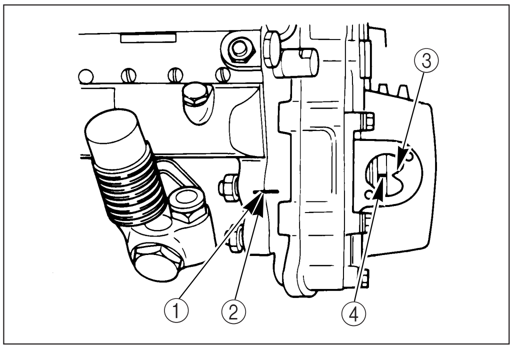
Rocker Arm Screw Lock Nut Torque	21–30 (2.1–3.1/15–22)

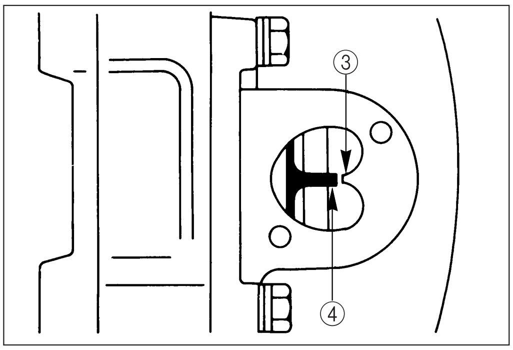
INJECTION TIMING

Note:

Take care to avoid entry of dust or foreign particles into the pump interior when the timing adjustment is made.







Checking Procedure

1. Align the crankshaft pulley TDC mark with the pointer.

   Remove the inspection hole cover at the front of the injection pump on the timing gear case cover.

   Check the alignment between the pointer ④ on the injection pump gear nut lock plate and the projection area mark ③ on the injection pump gear case.

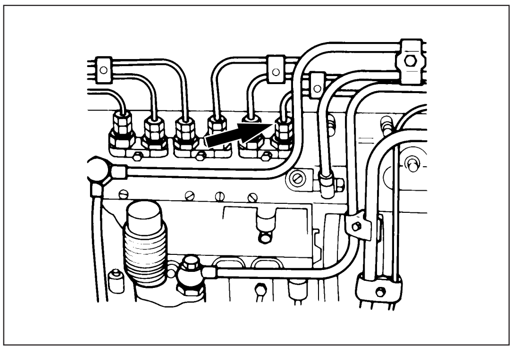
   If it is in misalignment, recheck with turning the crankshaft pulley one more turn to repeat the aforegoing procedure to mark sure that it is in alignment.

   Check the alignment of the notched lines ① and ②.

   (These notched lines were aligned at the factory to set the injection pump body and the mounting flange.)

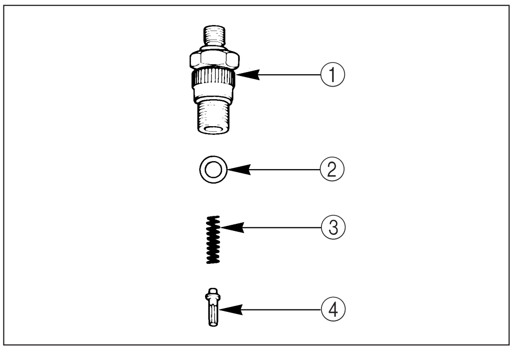
   Next, inspect the crankangle position of the injection starting.

2. Reversely turn the crankshaft pulley counterclockwise about 30° crankangle.



3. Disconnect the injection pipe from the No. 1 plunger.

   This will allow you to visually check the full injection starting flow at No. 1 plunger.

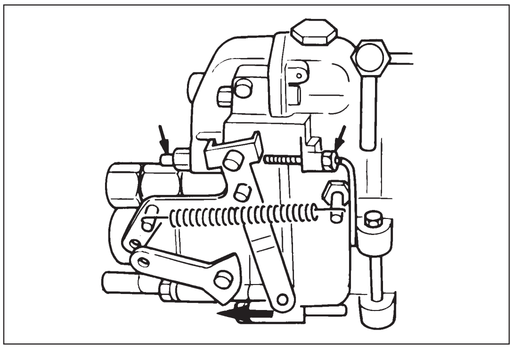


4. Remove the delivery valve holder ①, the valve seat ②, valve spring ③ the delivery valve ④ from the No. 1 plunger.

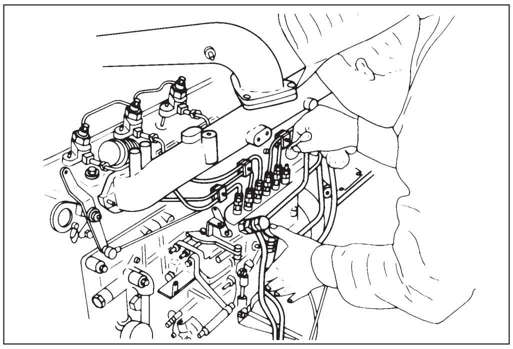
5. Reinstall the delivery holder ① and tighten it to the specified torque.

   Do not reinstall the delivery valve spring, the valve seat and the delivery valve.

   These parts will be reinstalled later.



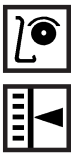
6. Hold the fuel control lever at the fully open position.



7. Slowly turn the crankshaft pulley clockwise, at the same time, continue to feed the fuel with pumping the priming pump.

   When the fuel stop to flow out from the No. 1 delivery valve holder, stop the pump instantaneously.

   This crankangle position is the injection starting of the engine.

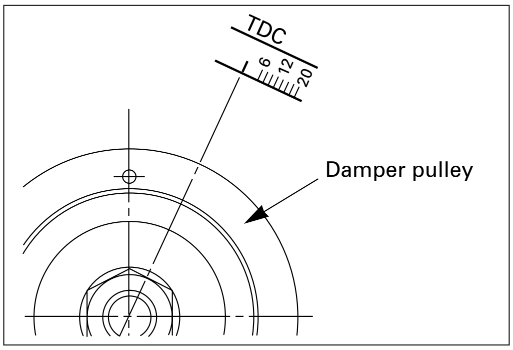


8. Observe and make sure that mark (injection starting angle line $\alpha°$) on the crankshaft pulley is aligning with the pointer.

   The timing line shows the injection starting angle of the engine.

   Blow out the remaining fuel from the delivery valve holder.

   Make sure that there is no fuel being delivered from the priming pump.



015ES002

Note

6BG1 engine has eight timing notch lines punched on the crankshaft damper pulley.

These notched lines must be aligned for correct engine timing.

Refer to the illustration.

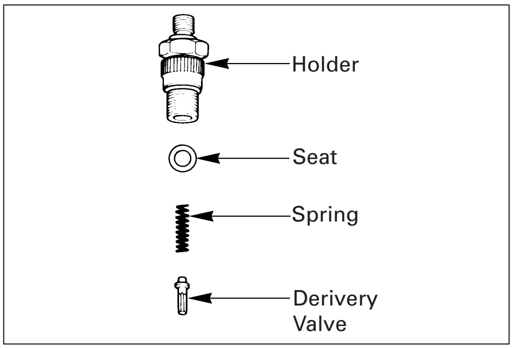
Degree

Injection Timing B.T.D.C	8-12

Note:

Injection pump injection timing will vary among identical engines contact your machine supplier or nearest ISUZU engine service outlet for the specifications applicable to your engine.

These specifications have been set by ISUZU and the OEM manufacturer.



9. Remove the delivery valve holder from the No. 1 plunger.
10. Reinstall the delivery valve internal parts (seat, spring, and valve) to the delivery valve holder.
11. Reinstall the delivery valve holder assembly to the No. 1 plunger and tighten it to the specified torque.

N·m (kgf·m/lb.ft)

Delivery Valve Holder Torque	39–44 (4–4.5/29–33)

12. Install the No. 1 cylinder injection pipe and tighten it to the specified torque.

N·m (kgf·m/lb.ft)

Injection Pipe Nut Torque	28–32 (2.9–3.3/21–24)

Note:

DO NOT OVERTIGHTEN THE INJECTION PUMP BODY.

THE INJECTION PUMP BODY IS MADE OF ALUMINUM. OVERTIGHTENING WILL DISTORT THE INJECTION PUMP BODY SHAPE AND ADVERSELY AFFECT CONTROL RACK OPERATION.

Adjusting Procedure

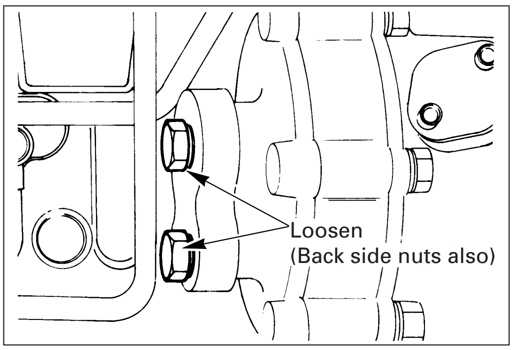
1. Align the pointer and the specified timing mark on the crank pulley.
2. Perform the operations described on page 2-10, 11, paragraphs 3, 4, 5, 6.
3. Loosen the four injection pump fixing nut.
4. To advance the timing

   Pivot the injection pump at the pump driveshaft toward out.

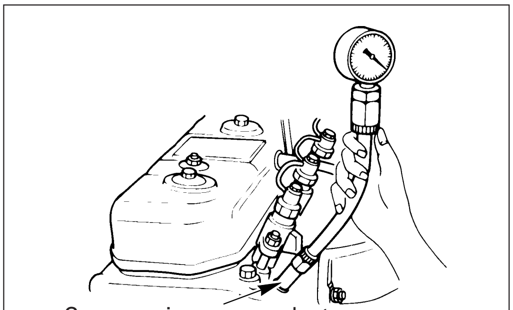
   To retard the timing.

   Pivot the injection pump at the pump driveshaft toward in. (toward the cylinder block)

   Reference; the 1 mm misalignment between the two setting mark lines corresponds to about 2° in crankangle.



5. Do a fine injection pump position adjustment, while continue the pumping operation to feed the fuel, and stop to pivot the injection pump when the fuel stop to flow out from the No. 1 delivery valve holder.
6. Tighten the four injection pump fixing nuts.
7. Once remove the No. 1 delivery valve holder, and reinstall the delivery valve, spring and the valve holder with the specified torque.
8. Install the No. 1 injection pipe and tighten it to the specified torque.



COMPRESSION PRESSURE MEASUREMENT

1. Operate the engine to warm-up until the coolant temperature reaches to 75°C (167°F).
2. Remove all of the glow plugs and the injection pipes.
3. Attach a compression gauge to the No. 1 cylinder glow plug installation threads.

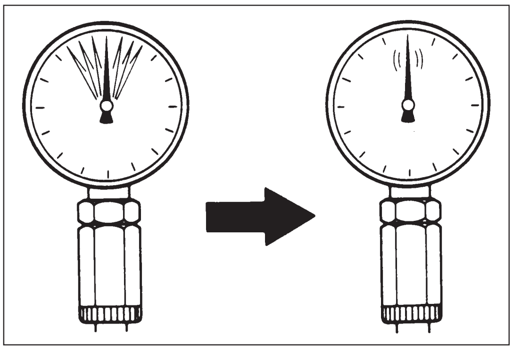
Note:

Compression pressure may be measured starting at any cylinder and in no particular cylinder order. However, it is very important that the compression pressure be measured in each cylinder.

Therefore, start at the No.1 cylinder and work back. In this way, you will be sure to measure the compression pressure in each cylinder.

Compression Gauge:

Compression Gauge Adapter: 5-85317-001-0



4. Crank the engine with the starter motor and take the compression gauge reading.

MPa (kgf/cm^2/psi) at 200 min^{-1} at sea level

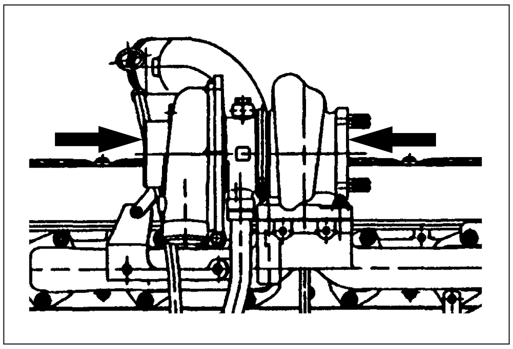
Standard	Limit
3.0 (31/440)	2.5 (26/370)

5. Repeat the procedure (Steps 2 and 3) for the remaining cylinders.

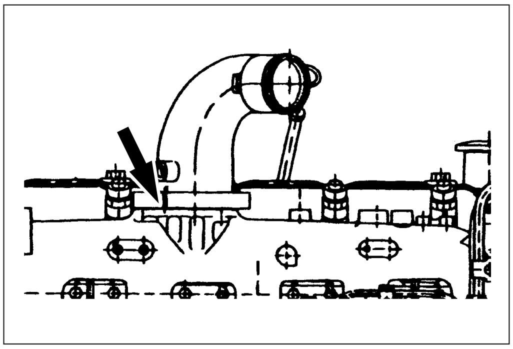
   Compression pressure should be approximately the same for each cylinder. A variation exceeding 200 kPa (2 kgf/cm^2/28 psi) is unacceptable.

   If the measured value exceeds the specified limit, the related parts must be checked.

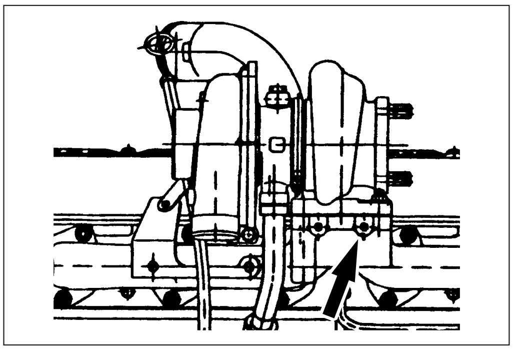
TURBOCHARGER INSPECTION



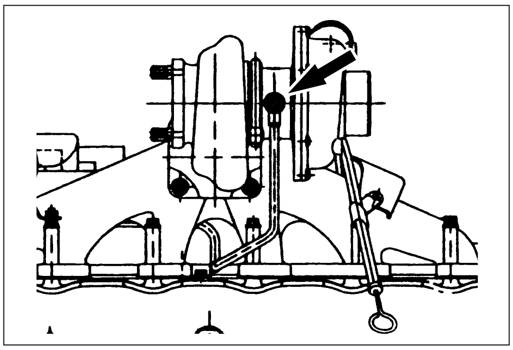
1. Check the air intake duct connections for air leakage. Check the turbine wheel for damage. Check the compressor blade for damage.



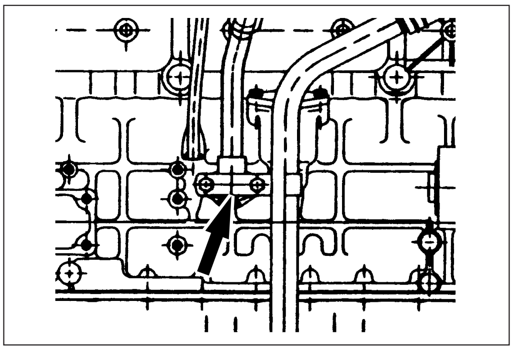
2. Check the intake manifold connections for air leakage.



3. Check the exhaust duct connections for smoke leakage.
4. Check the turbocharger mounting nuts for looseness.

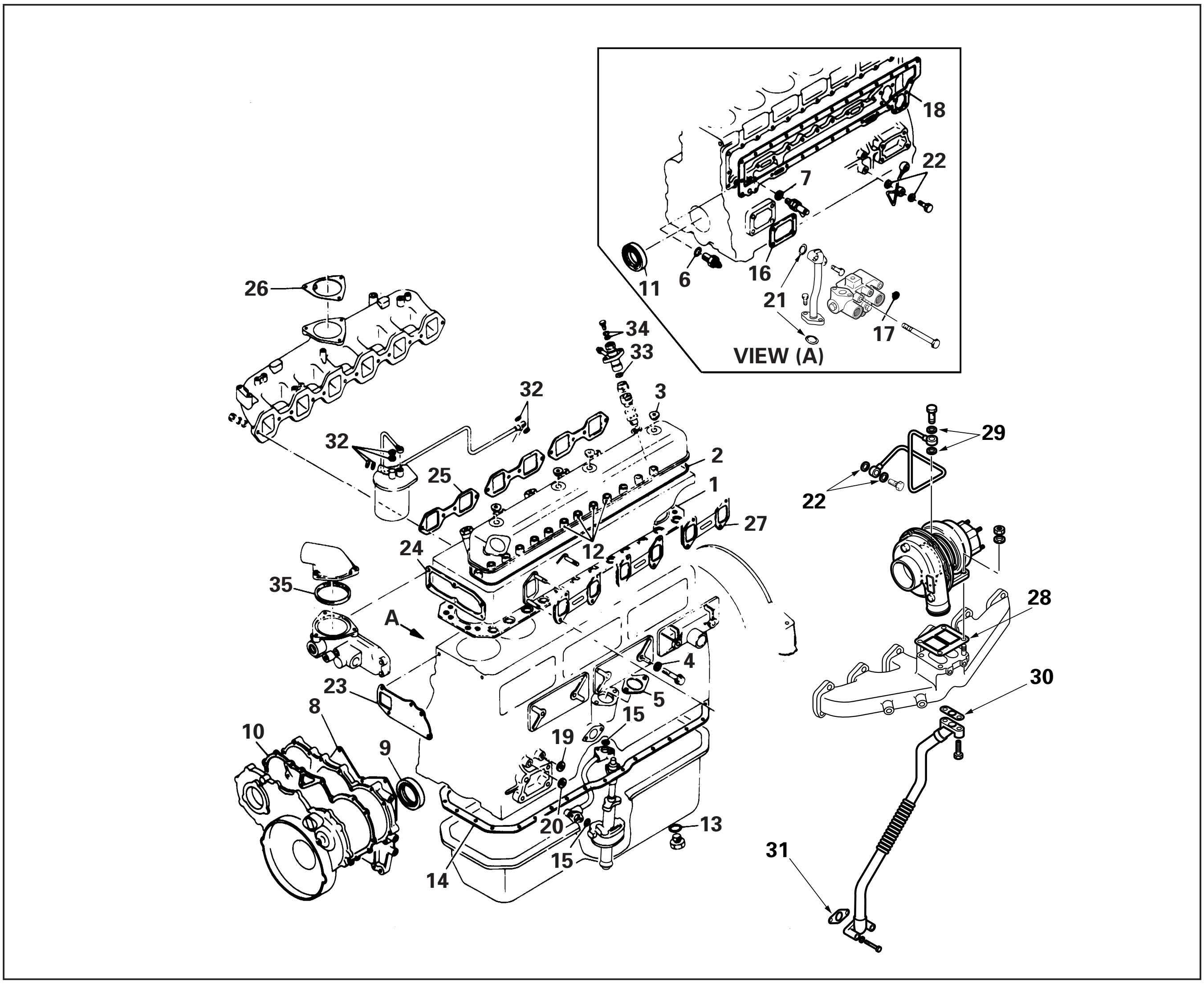


5. Check the oil feed pipe for oil leakage.



6. Check the oil return pipe joints for oil leakage.

ENGINE REPAIR KIT

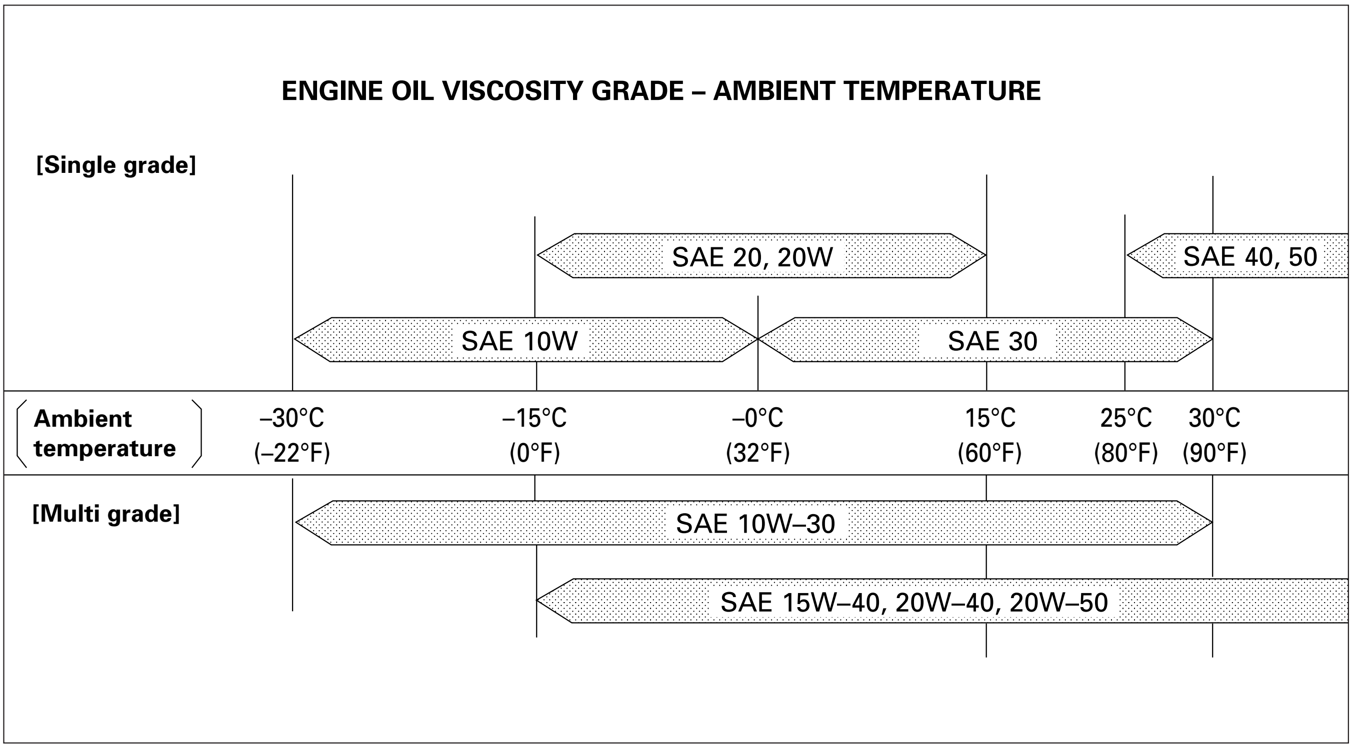


1. Cylinder head gasket
2. Cylinder head cover gasket
3. Cylinder head cover nut gasket
4. Chamber cover fixing bolt gasket
5. Oil pump hole cover gasket
6. Oil relief valve gasket
7. Water drain valve gasket
8. Gear case to cylinder block gasket
9. Crank pulley to gear case oil seal
10. Gear case cover gasket
11. Crankshaft rear end oil seal
12. Valve guide oil seal
13. Drain plug gasket
14. Oil pan gasket
15. Oil pipe gasket
16. Oil port cover gasket
17. Oil filter fixing bolt gasket
18. Oil cooler gasket
19. Oil pipe joint gasket
20. Joint bolt gasket
21. Oil pipe gasket
22. Injection pump oil pipe gasket
23. Water pump gasket
24. Thermostat housing gasket
25. Intake manifold gasket
26. Inlet pipe manifold gasket
27. Exhaust manifold gasket
28. Exhaust manifold to turbocharger gasket
29. Oil feed pipe gasket
30. Oil drain pipe gasket
31. Oil drain pipe gasket
32. Overflow fuel pipe gasket
33. Injection nozzle gasket
34. Injection nozzle leak off pipe gasket
35. Thermostat gasket

RECOMMENDED LUBRICANTS

ENGINE TYPE	TYPES OF LUBRICANTS (API)
With turbocharger	Diesel engine oil CD grade

ENGINE OIL VISCOSITY CHART



MEMO

SECTION 3

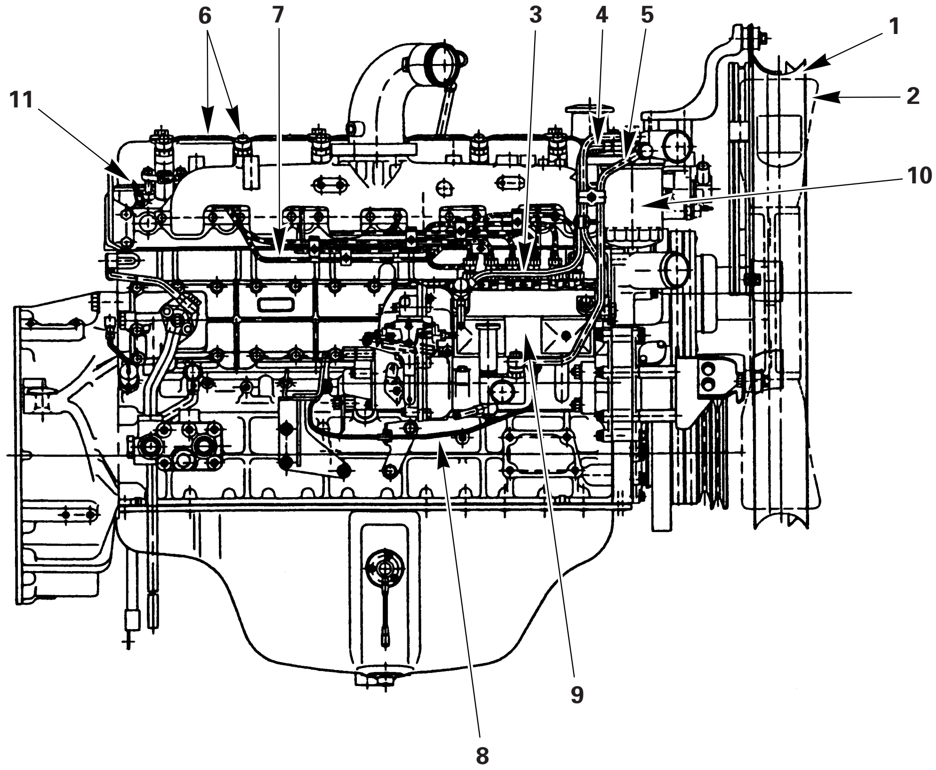
ENGINE ASSEMBLY I (DISASSEMBLY)

TABLE OF CONTENTS

EXTERNAL PARTS DISASSEMBLY STEPS

(Right-hand side)

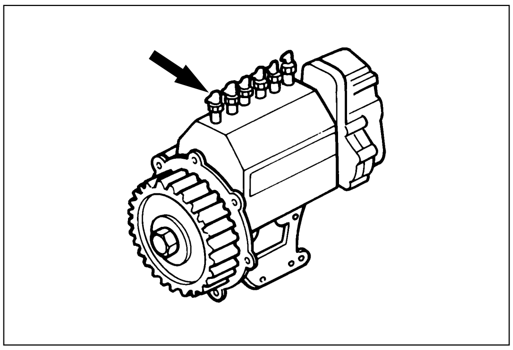
MODEL AA-6BG1T



Disassembly Steps

1. Fan guide and bracket
2. Cooling fan
3. Fuel pipe; return
4. Fuel pipe; filter to injection pump
5. Fuel pipe; feed pump to filter
6. Leak off pipe and injection nozzles
7. Injection pipe
8. Oil pipe; body to injection pump
9. Injetion pump
10. Fuel filter
11. Glow plug

Note: Some components and shapes are different due to the difference of the models and the specifications.



Important Operations

9. Injection Pump with Injection Pump Gear

Use the shipping plugs (or something similar) to seal the injection pump delivery valve ports. This will prevent the entry of foreign material.

Flange Mounted Injection Pump Removal

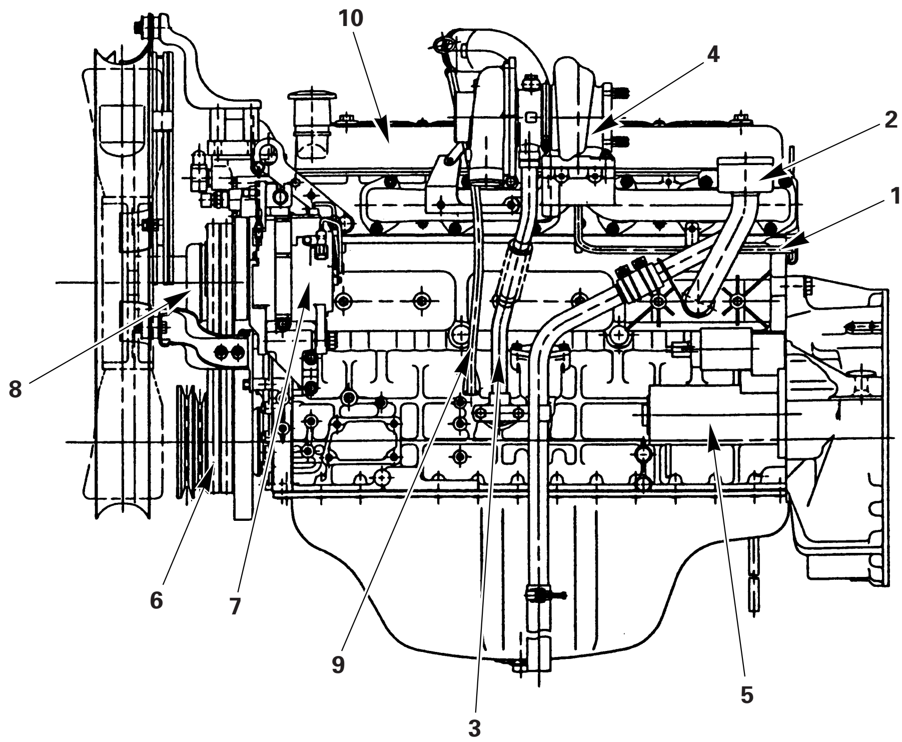
1) Remove the injection pump flange bolts.
2) Pull the injection pump with the injection pump drive gear free.

Refer to the illustration.

EXTERNAL PARTS DISASSEMBLY STEPS

(Left-hand side)

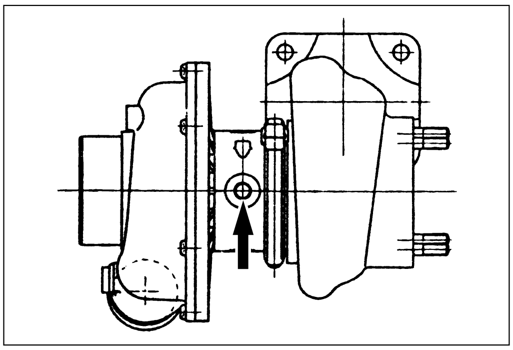
MODEL 6BG1T



Disassembly Steps

1. Oil feed pipe
2. Air breather
3. Oil drain pipe
4. Turbocharger
5. Starter motor
6. Fan belt
7. Alternator
8. Fan pulley
9. Oil dopstick and guide tube
10. Cylinder head cover

Note: Some components and shapes are different due to the difference of the models and the specifications.

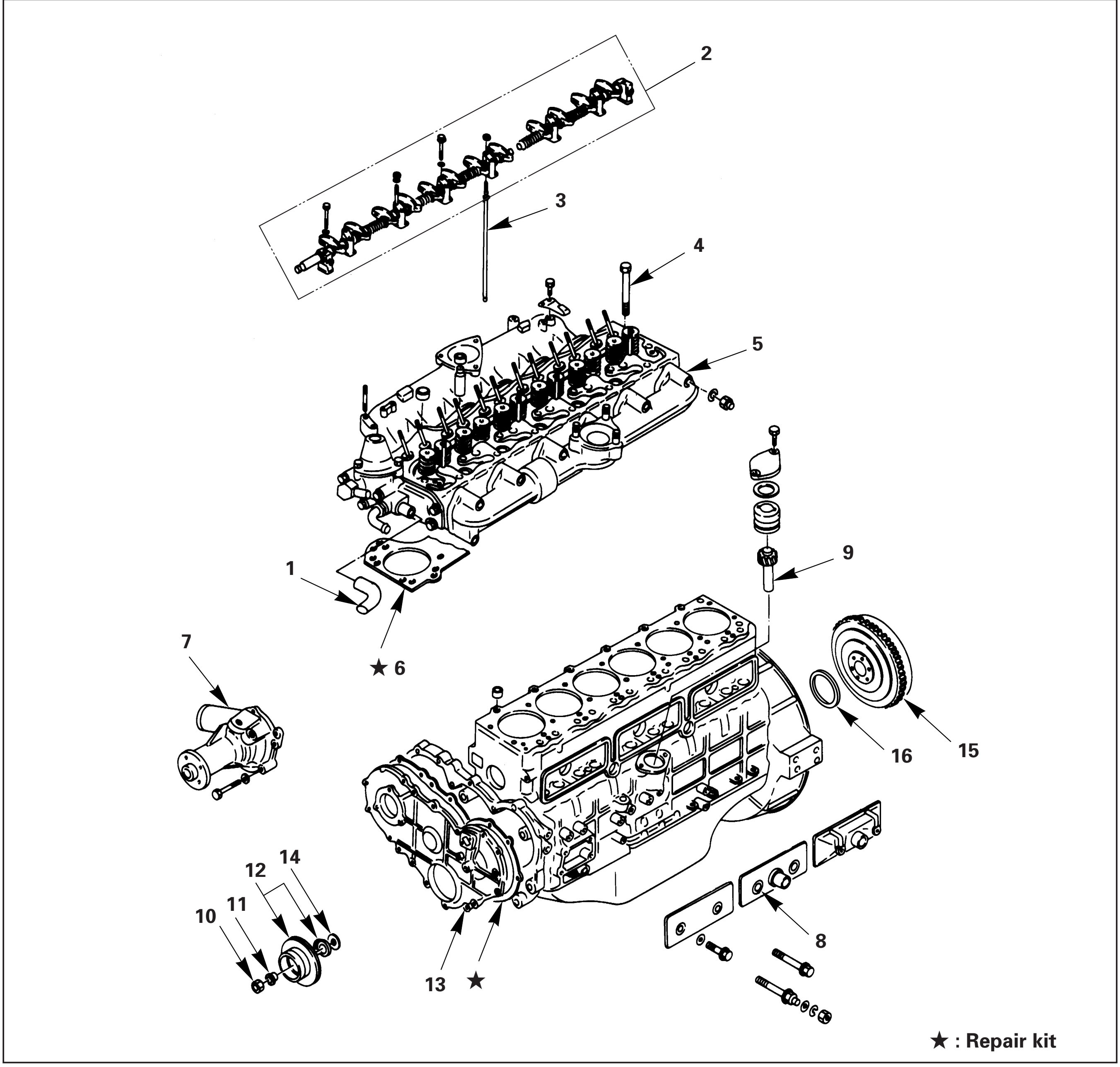


Important Operations

4. Turbocharger

Plug oil ports in turbocharger body immediately after removal of the turbocharger.

MAJOR COMPONENTS - I



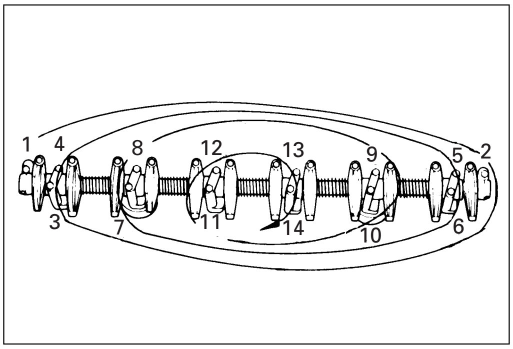
Disassembly Steps

1. Rubber hose ; water by-pass
▲ 2. Rocker arm shaft assembly
3. Push rod
▲ 4. Cylinder head bolt
5. Cylinder head assembly
6. Cylinder head gasket
7. Water pump assembly
8. Tappet chamber cover
9. Oil pump driving pinion
▲ 10. Crankshaft pulley nut
▲ 11. Taper bushing
12. Crankshaft pulley and dust thrower
13. Timing gear cover
14. Oil thrower
▲ 15. Flywheel
▲ 16. Rear oil seal

Important Operations

2. Rocker Arm Shaft

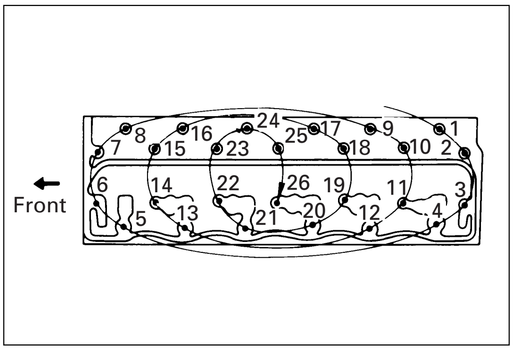
Loosen the rocker arm shaft fixing bolts a little at a time in numerical sequence as specified.



4. Cylinder Head Bolts

Loosen the cylinder head bolts a little at a time in the numerical order shown in the illustration.

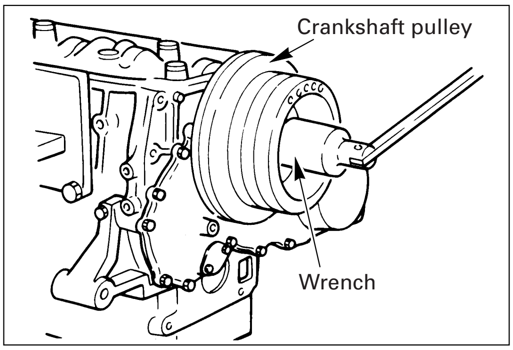
Cylinder head bolt wrench: 1-85111-003-0

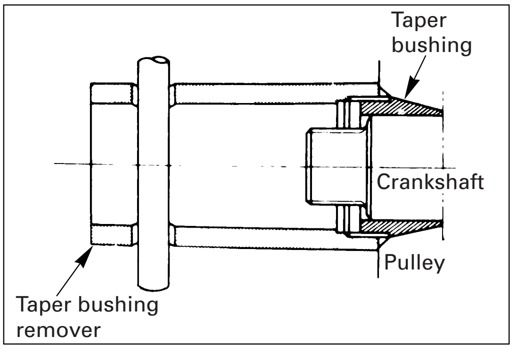


10. Crankshaft Pulley Nut

Wrench: 54 mm (2.13 in)

Use an appropriate wrench to remove the crankshaft pulley nut.

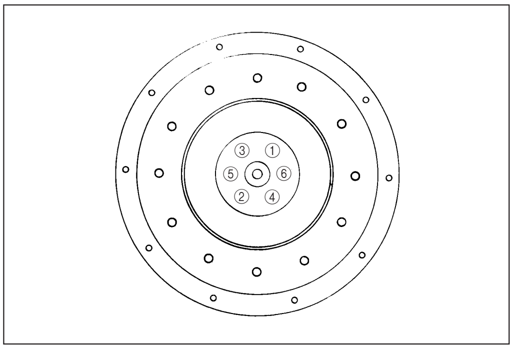




11. Taper Bushing

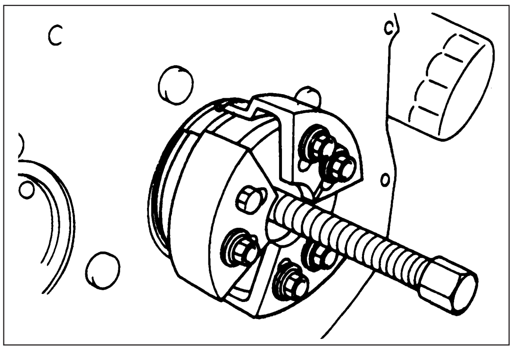
Remover: 9-8521-0122-0

Use the taper bushing remover to remove the crankshaft end taper bushing.



15. Flywheel

Loosen the flywheel bolt a little at a time in the numerical order as specified.

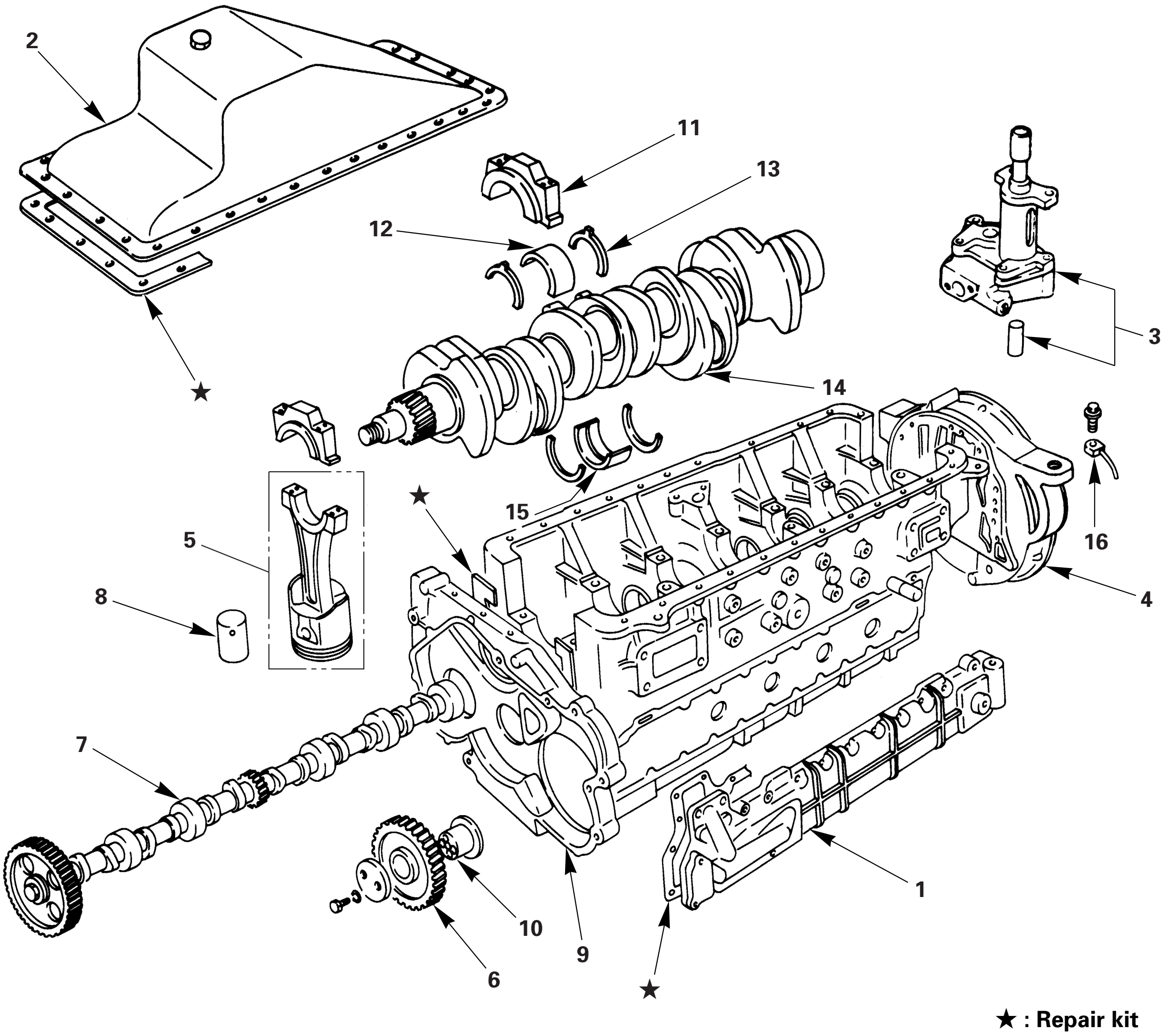


16. Crankshaft Rear Oil Seal (Axial Type)

With the oil seal pushed in deep, install the special tool as shown in the illustration and remove the oil seal.

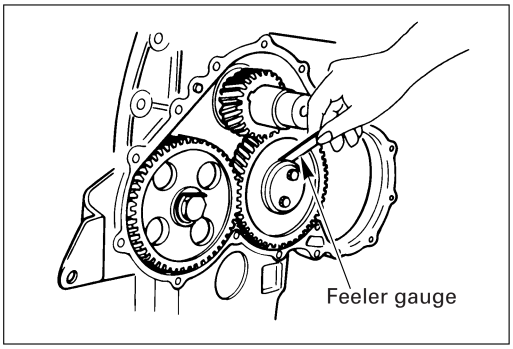
Oil Seal Remover: 5-8840-2360-0

MAJOR COMPONENTS - II



Disassembly Steps

1. Oil cooler
2. Oil pan
3. Oil pump and coupling
4. Flywheel housing
5. Piston and connecting rod
6. ▲ Idler gear
7. ▲ Camshaft
8. Tappet
9. Timing gear case
10. Idler gear shaft
11. ▲ Crankshaft bearing cap
12. Crankshaft bearing (lower half)
13. Thrust bearing
14. Crankshaft
15. Crankshaft bearing (upper half)
16. Oiling jet



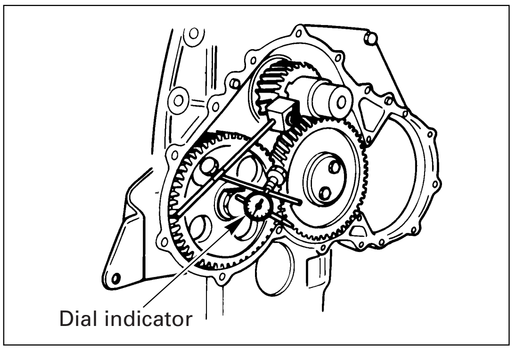
Important Operations

6. Idler Gear

Measure the following points before disassembly.

mm (in)

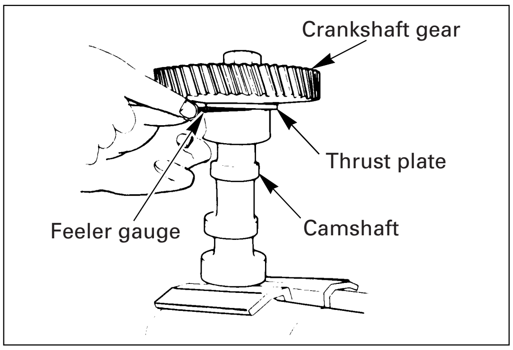
	Standard	Limit
Idler Gear End Play	0.128–0.185 (0.005–0.0070)	0.2 (0.008)



mm (in)

	Standard	Limit
Timing Gears Backlash	0.10–0.17 (0.004–0.007)	0.3 (0.012)

Includes the crankshaft gear, the camshaft gear, and the idler gear.

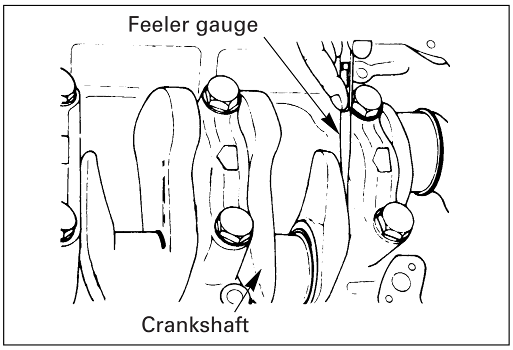


7 Camshaft

Measure the following points before disassembly.

mm (in)

	Standard	Limit
Cam Gear End Play	0.050–0.114 (0.002–0.005)	0.2 (0.008)



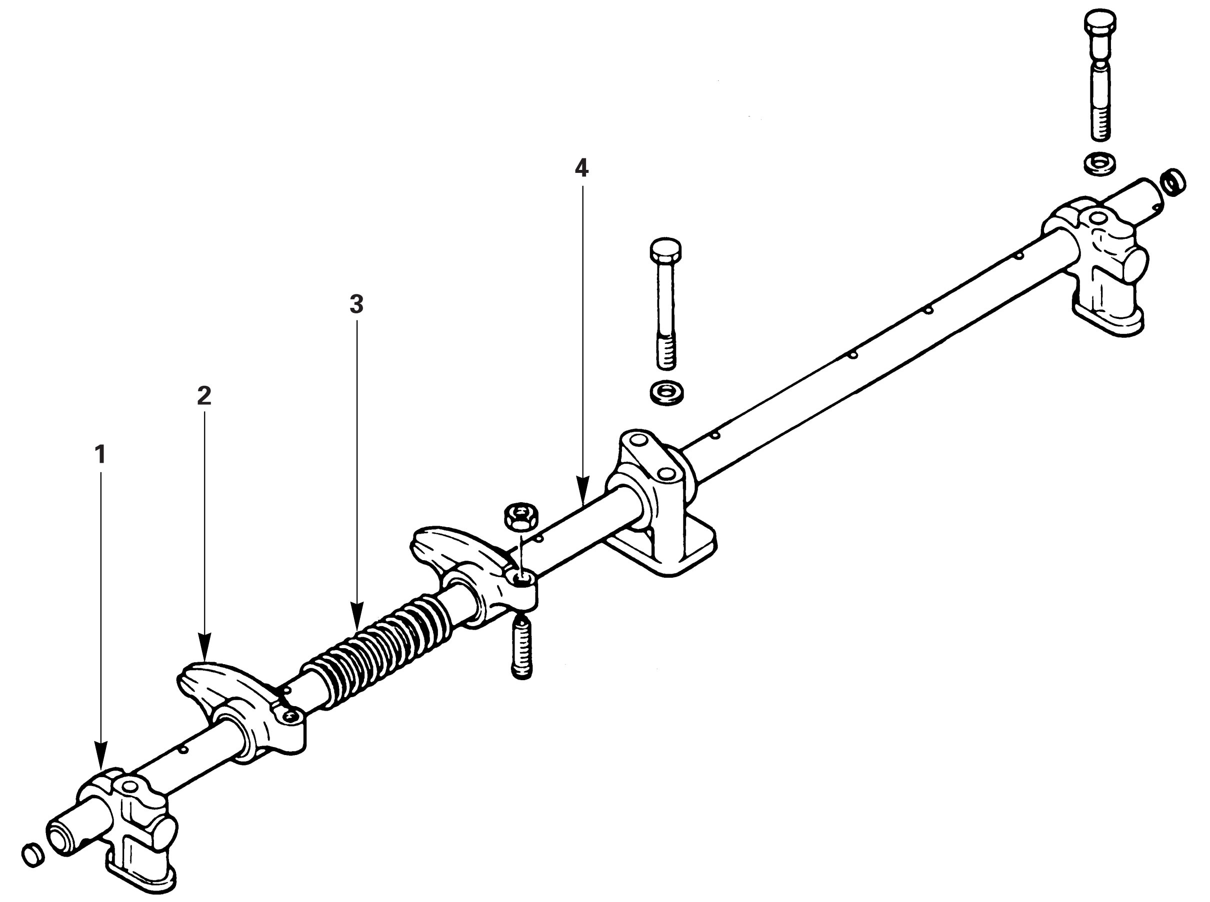
11. Crankshaft Bearing Cap

Measure the crankshaft end play at the thrust bearing (center main bearing) before disassembly.

mm (in)

	Standard	Limit
Crankshaft End Play	0.15–0.33 (0.006–0.013)	0.4 (0.016)

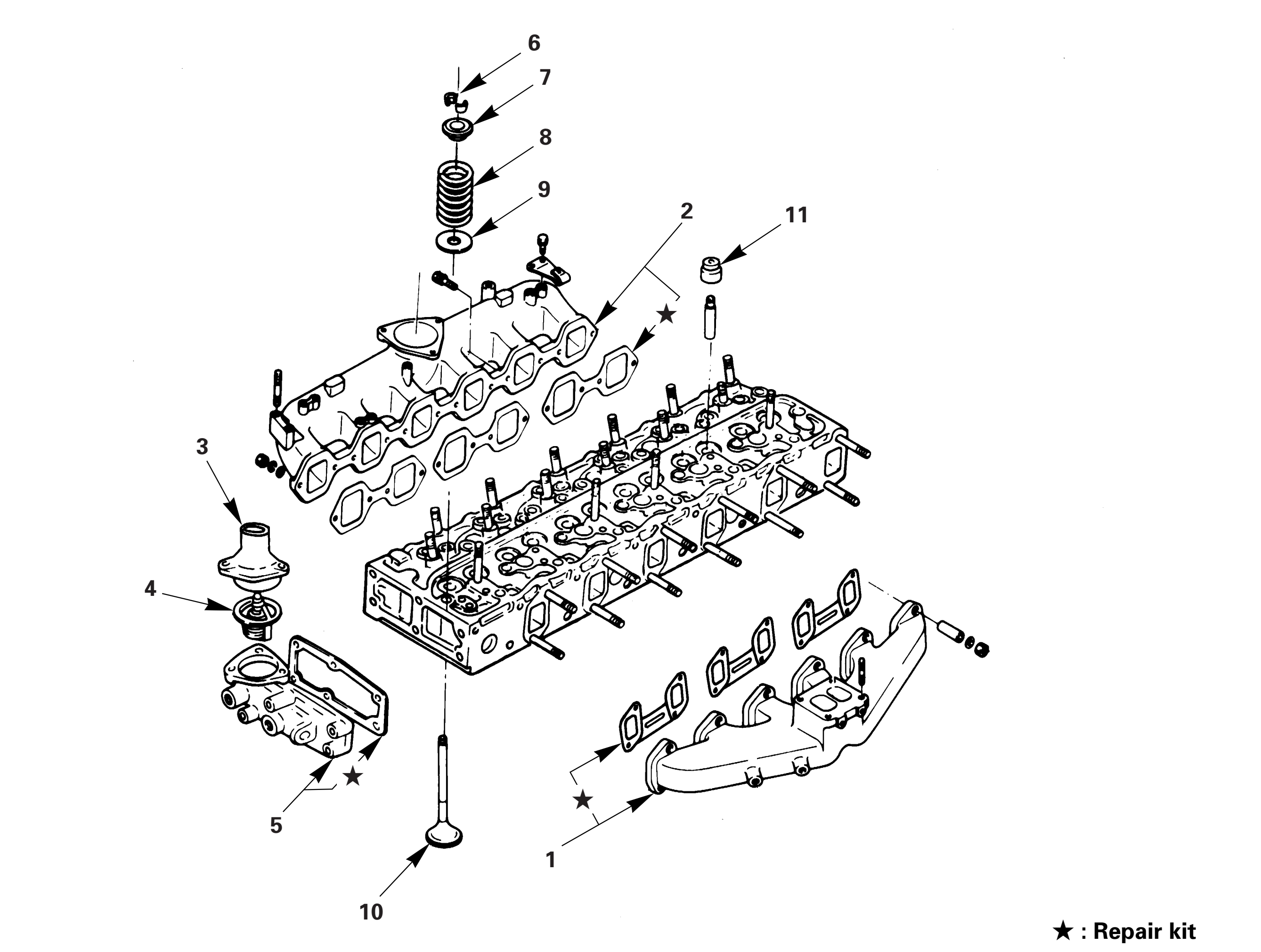
ROCKER ARM, AND ROCKER ARM SHAFT DISASSEMBLY STEPS



Disassembly Steps

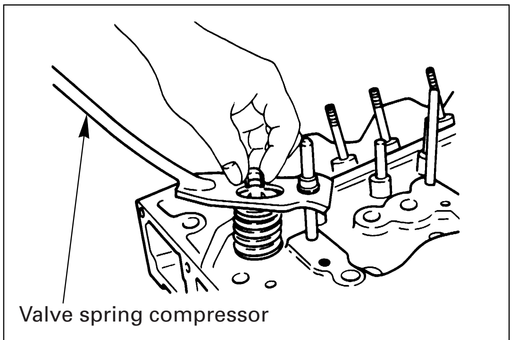
1. Bracket
2. Rocker arm
3. Spring
4. Rocker arm shaft

CYLINDER HEAD DISASSEMBLY STEPS



Disassembly Steps

1. Exhaust manifold and gasket
2. Intake manifold and gasket
3. Water outlet pipe
4. Thermostat
5. Thermostat housing and gasket
6. ▲ Split collar
7. Spring seat (upper)
8. Valve spring
9. Spring seat (lower)
10. Valve
11. Valve stem oil seal



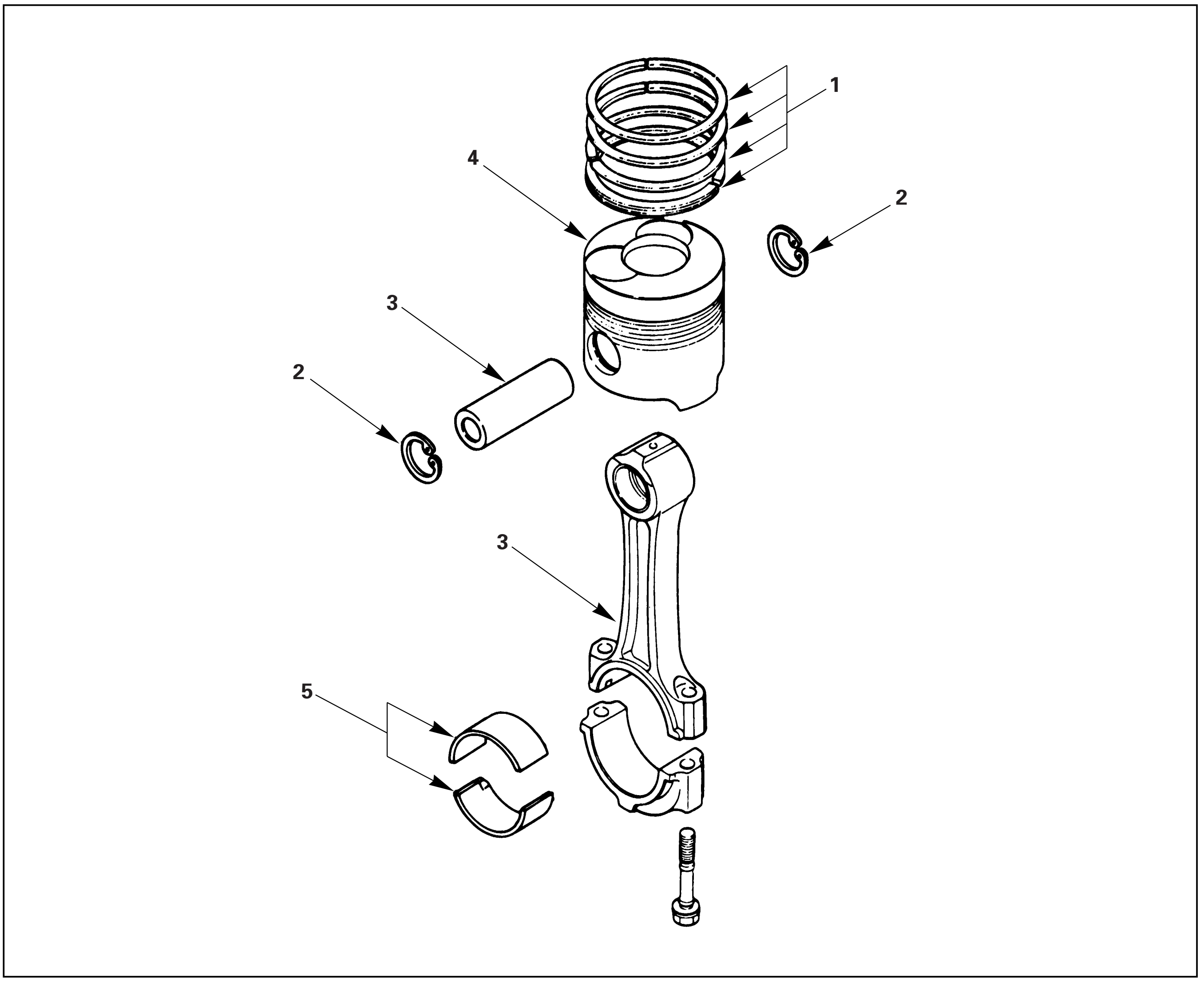
Important Operation

6. Split collar

Use the valve spring compressor to remove the split collar.

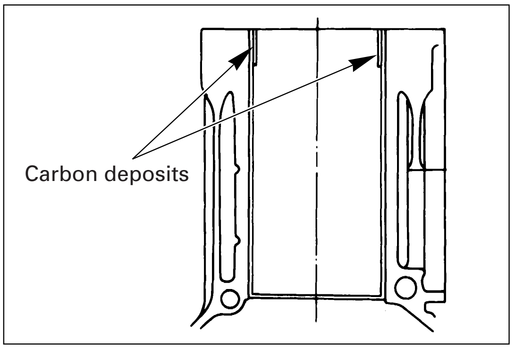
Valve Spring Compressor: 1-85235-006-0

PISTON AND CONNECTING ROD DISASSEMBLY STEPS



Disassembly Steps

▲ 1. Piston rings
▲ 2. Snap ring
▲ 3. Piston pin and connecting rod
4. Piston
5. Connecting rod bearing

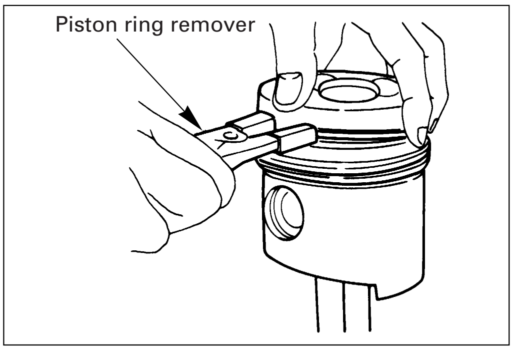


Important Operation

Note:

Remove any carbon deposits from the upper part of the cylinder bore.

This will prevent damage to the piston and the piston rings when they are removed from the cylinder bore.

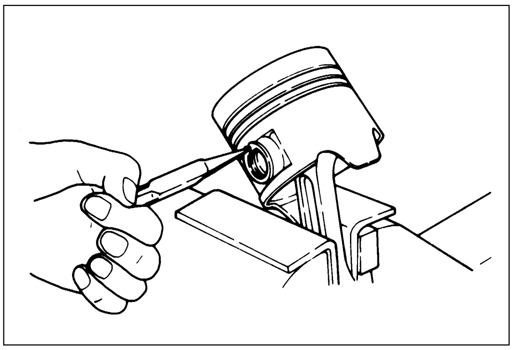


1. Piston Rings

Use a piston ring remover to remove the piston rings.

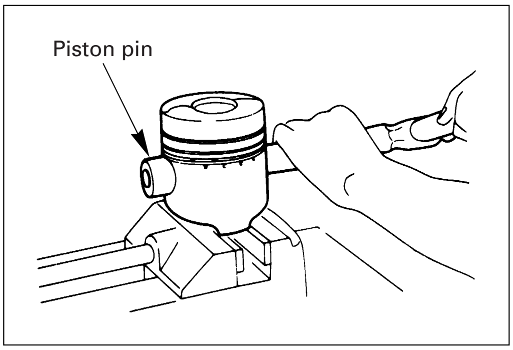
Do not attempt to use some other tool. Piston ring stretching will result in reduced piston ring tension.

Piston ring remover:



2, 3. Snap Ring and Piston Pin

(1) Use a pair of snap ring pliers to remove the snap ring.



(2) Tap the piston pin out with a hammer and brass bar.

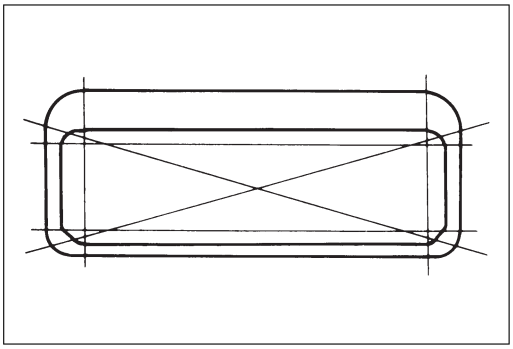
SECTION 4

ENGINE ASSEMBLY II (INSPECTION & REPAIR)

TABLE OF CONTENTS

INSPECTION AND REPAIR

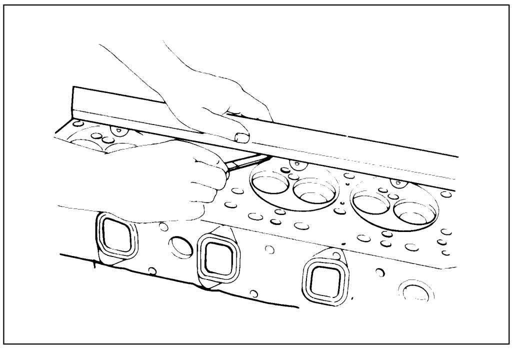
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



CYLINDER HEAD

Cylinder Head Lower Face Warpage

1. Use a straight edge and a feeler gauge to measure the four sides and the two diagonals of the cylinder head lower face.
2. Regrind the cylinder head lower face if the measured values are greater than the specified limit but less than the maximum grinding allowance.



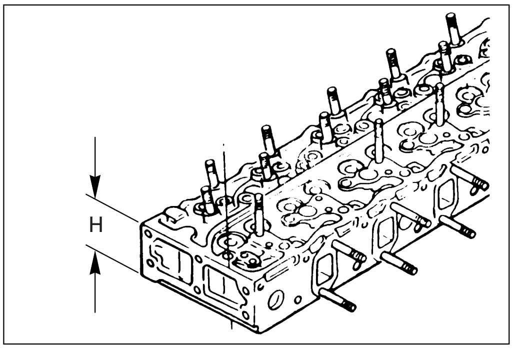
If the measured values exceed the maximum grinding allowance, the cylinder head must be replaced.

Cylinder Head Lower Face Warpage mm (in)

Standard	Limit	Maximum Grinding Allowance
0.075 (0.003) or less	0.2 (0.0079)	0.3 (0.012)

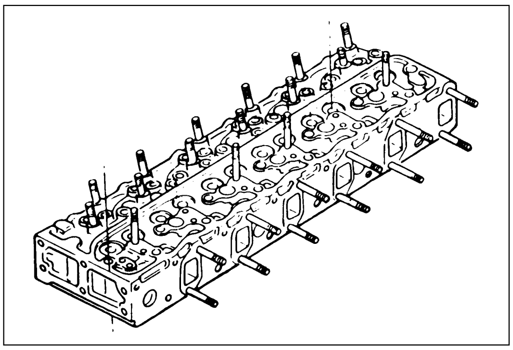
Cylinder Head Height (Reference) mm (in)

Standard	Limit
89.95 (3.541)–90.05 (3.545)	89.65 (3.530)



Note:

If the cylinder head lower face is reground, valve depression must be checked.

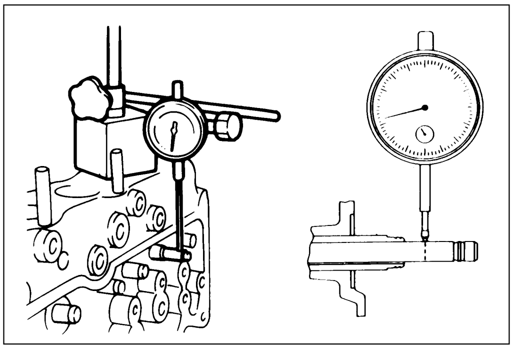


Water Jacket Water Pressure Test

Use the hydraulic gauge to check the water jacket water pressure.

Apply water pressure to the water jacket at 490 kPa (5 kgf/cm^2/71.1 psi) for three minutes.

Check the entire cylinder head for water leakage.



VALVE GUIDE

Valve Stem and Valve Guide Clearance

Measuring Method - 1

1. With the valve stem inserted in the valve guide, set the dial indicator needle to "0".
2. Move the valve head from side to side

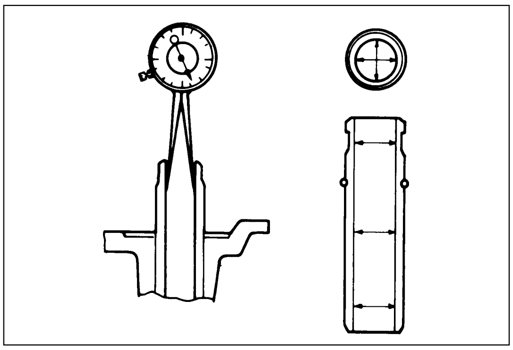
   Note the total dial indicator reading (TIR).

   This value is the clearance between the valve stem and the valve guide.

   If the measured values exceed the specified limit, the valve and the valve guide must be replaced as a set.

Valve Stem Clearance mm (in)

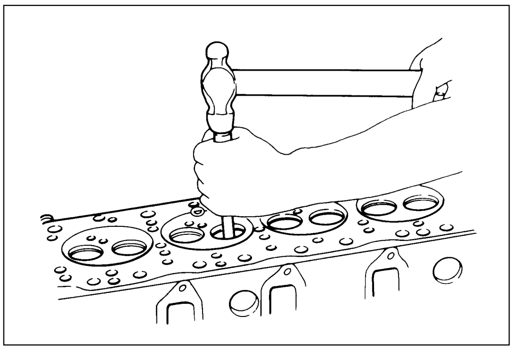
	Standard	Limit
Intake Side TIR	0.039-0.071 (0.0015-0.0028)	0.20 (0.008)
Exhaust Side TIR	0.064-0.096 (0.0025-0.0038)	0.25 (0.0098)



Measuring Method - II

1. Measure the valve stem outside diameter.
2. Use a caliper calibrator or a telescoping gauge to measure the valve guide inside diameter.

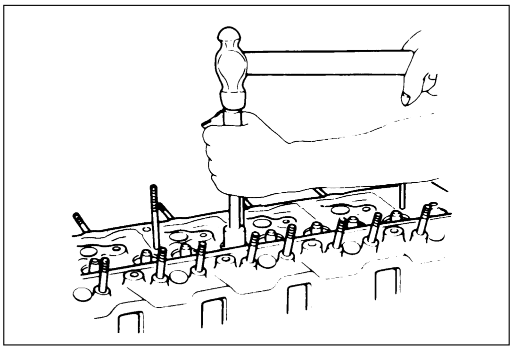
   The difference between the valve stem outside diameter and the valve guide inside diameter is equal to the valve stem clearance.



Valve Guide Replacement

Valve Guide Removal

Use a hammer and the valve guide remover to drive out the valve guide from the cylinder head lower face.
Valve Guide Remover: 9-85220-035-0



Installation

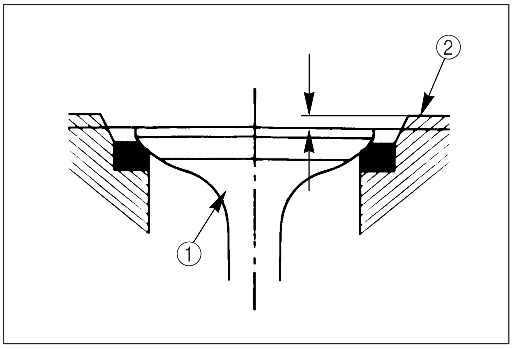
1. Apply clean engine oil the outer periphery of the valve guide.
2. Attach the installer to the valve guide.
3. Use a hammer to drive in the valve guide from the upper face of the head until the installer’s lower edge meets the head surface.

   Valve guide installer: 1-85232-001-0

4. After installation, measure the distance (height) from the cylinder head’s upper surface to the upper edge of the valve guide.

Height to valve guide upper edge mm (in)

14.1 (0.555)



Valve Depression

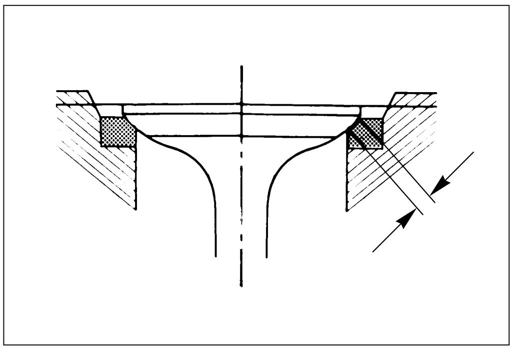
1. Install the valve ① to the cylinder head ②.
2. Use a depth gauge or a straight edge with steel rule to measure the valve depression from the cylinder head lower surface.

   If the measured value exceeds the specified limit, the valve seat insert and/or valve must be replaced.

   If the valve is replaced, the valve guide must be also replaced.

mm (in)

	Standard	Limit
Intake and Exhaust Valve Depression	1.0 (0.039)	2.5 (0.098)



Valve Contact Width

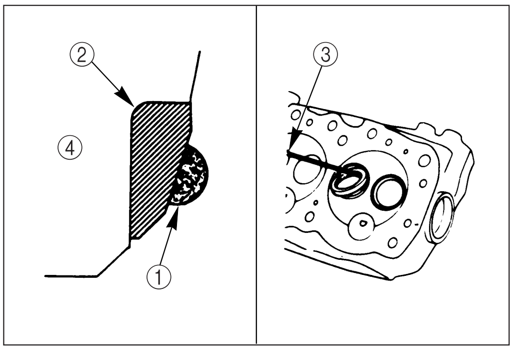
1. Inspect the valve contact faces for roughness and unevenness.

   Make smooth the valve contact surfaces.
2. Measure the valve contact width.

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

mm (in)

	Standard	Limit
Valve Contact Width	1.5 (0.059)	2.0 (0.079)



Valve Seat Insert Replacement

Valve Seat Insert Removal

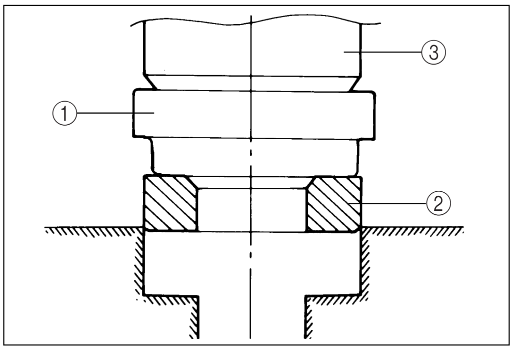
1. Arc weld the entire inside circumference ① of the valve seat insert ②.
2. Allow the valve seat insert to cool for a few minutes.

   This will invite contraction and make removal of the valve seat insert easier.

3. Use a screwdriver ③ to pry the valve seat insert free.

   Take care not to damage the cylinder head ④.

4. Carefully remove carbon and other foreign material from the cylinder head insert bore.



Valve Seat Installation

1. Carefully place the attachment ① (having the smaller outside diameter than the valve seat insert) on the valve seat insert ②.

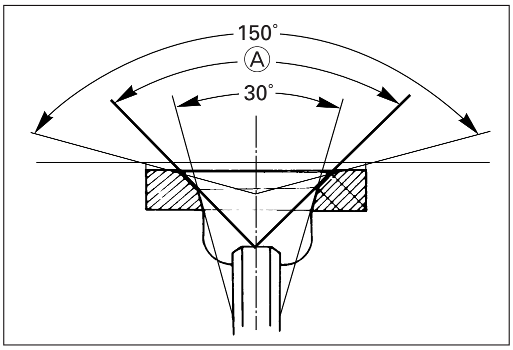
Note:

The smooth side of the attachment must contact the valve seat insert.

2. Use a bench press ③ to slowly apply pressure to the attachment and press the valve seat insert into place. (Amount of pressure needed is more than 25 kN (2,500 kgf/5,512 lb)

Note:

Do not apply an excessive amount of pressure with the bench press. Damage to the valve seat insert will result.



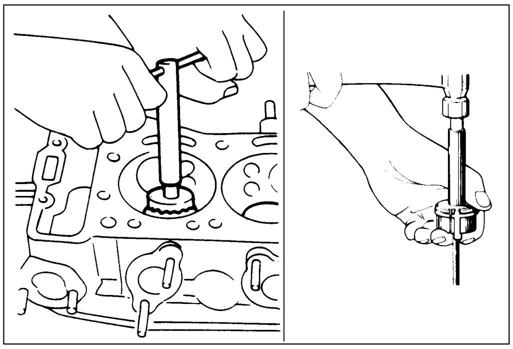
Valve Seat Insert Correction

1. Remove the carbon deposits from the valve seat insert surface.

2. Use valve cutters (15°, 30°, or 75° blades) to remove scratches and other rough areas.

   This will bring the contact width back to the standard value of 90° Ⓐ.

   Remove only the scratches and rough areas. Do not cut away too much. Take care not to cut away unblemished areas of the valve seat surfaces.

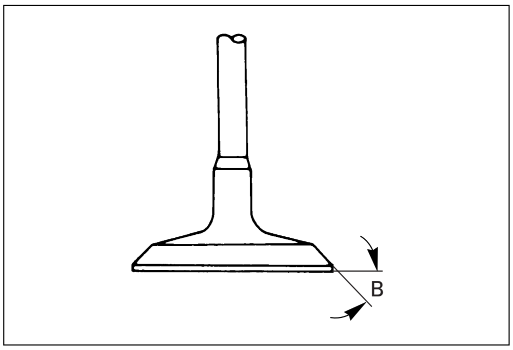


Angle Location	Standard
Intake Valve Seat Angle Ⓑ	45°
Exhaust Valve Seat Angle Ⓑ	45°

Note:

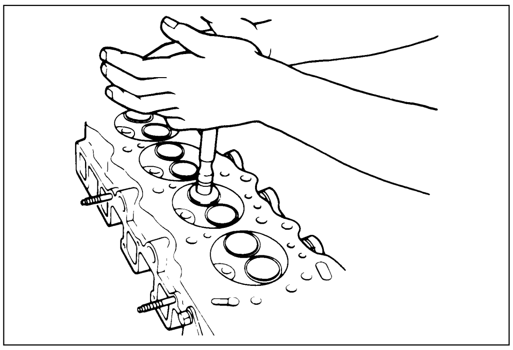
Use an adjustable valve cutter pilot.

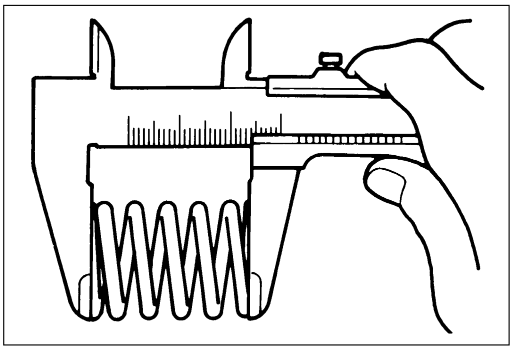
Do not allow the cutter pilot to wobble inside the valve guide.



3. Apply abrasive compound to the valve seat insert surface.
4. Insert the valve into the valve guide.
5. Hand lap the valve and the valve seat with a lapping cup.

   This will provide optimum valve and valve seat contact for effective gas sealing.
6. Check that the valve contact width is correct.
7. Check that the valve seat insert surface is in contact with the entire circumference of the valve.





VALVE SPRING

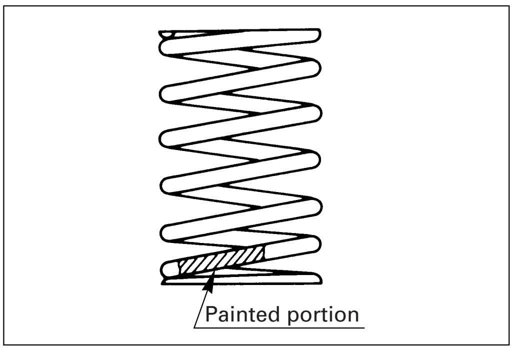
Valve Spring Free Length

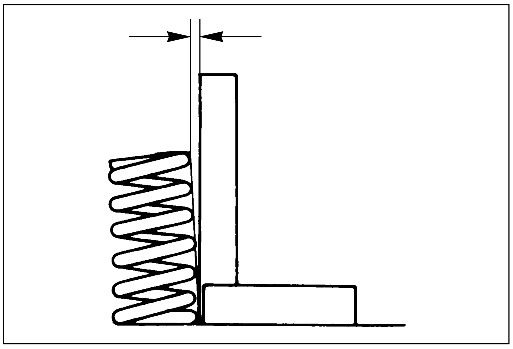
Use a vernier caliper to measure the valve spring free length.

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

mm (in)

	Color	Standard	Limit
Exhaust and Intake Valve Spring Free Length	blue	60.6 (2.39)	58.0 (2.28)





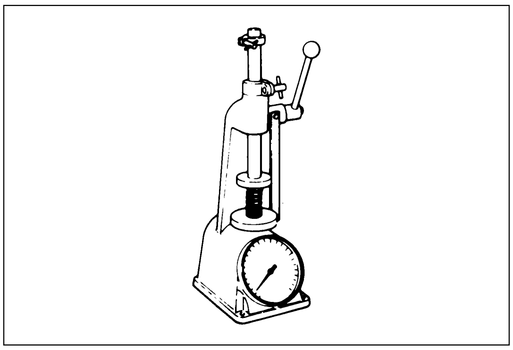
Valve Spring Inclination

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 (in)

	Standard	Limit
Valve Spring Inclination	less than 1.9 (0.075)	2.7 (0.106)



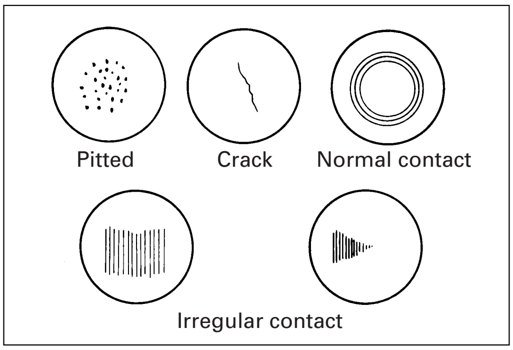
Valve Spring Tension

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.

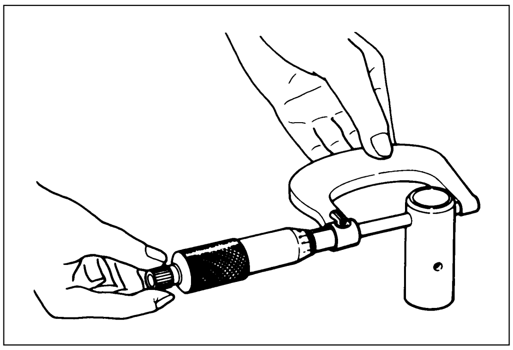
N (kg/lb)

Set Length	Standard	Limit
44.5 mm (1.752 in)	142 (14.5/30.9)	127 (13.0/28.7)



TAPPET (Cam Follower or Valve Lifter)

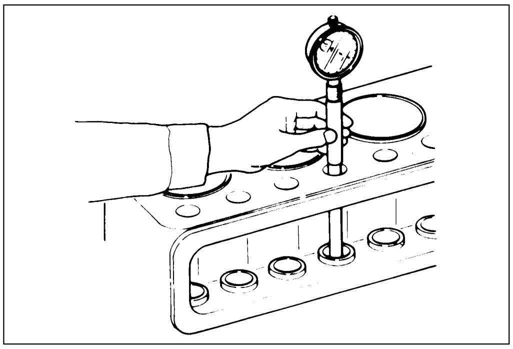
Inspect the tappets for excessive wear, damage and any abnormalities.



Use a micrometer to measure the tappet diameter.

mm (in)

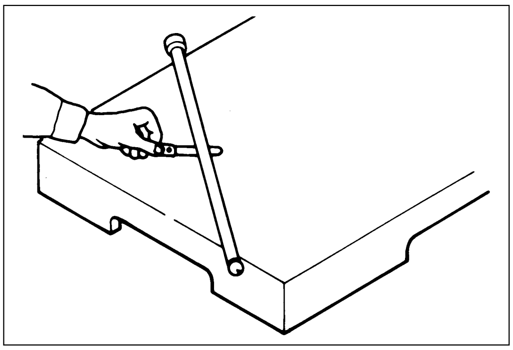
	Standard	Limit
Tappet Diameter	27.97–27.98 (1.1020–1.1024)	27.92 (1.1000)



Use a dial indicator to measure the clearance between the tappet and cylinder body tappet travelling bore.

mm (in)

	Standard	Limit
Tappet and Tappet Travelling Bore Clearance	0.020–0.054 (0.001–0.002)	0.1 (0.004)



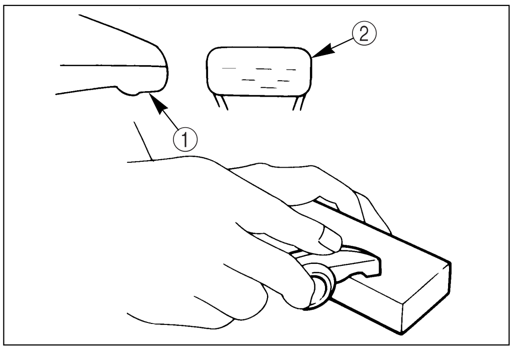
PUSH ROD

Use a filler gauge to measure the valve push rod run out.

Roll the push rod along a smooth flat surface (illustration).

mm (in)

	Limit
Push Rod Run-Out	0.3 (0.012)

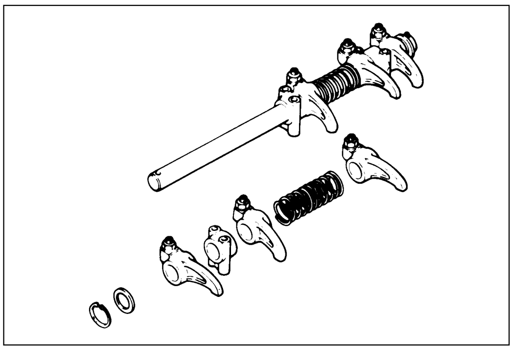


Rocker Arm Correction

Inspect the rocker arm valve stem contact surfaces for ridge ① and scoring ②.

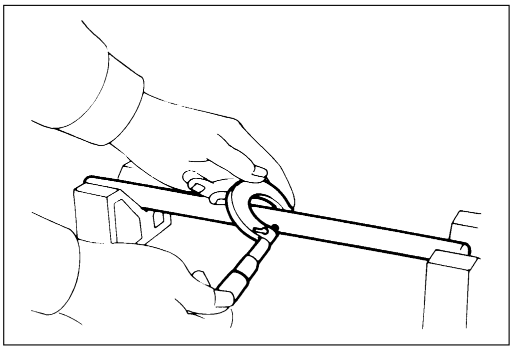
If the surfaces have light ridge or scoring, they may be honed with an oil stone.

If the ridge or scoring is severe, the rocker arm must be replaced.



ROCKER ARM SHAFT AND ROCKER ARM

Inspect all disassembled parts for wear, damage and any abnormalities.



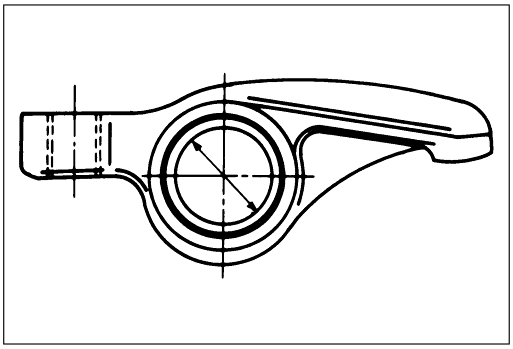
Rocker Arm Shaft Outside Diameter

Use a micrometer to measure the rocker arm outside diameter.

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

mm (in)

	Standard	Limit
Rocker Arm Shaft Diameter	18.98–19.00 (0.747–0.748)	18.85 (0.742)



Rocker Arm Shaft and Rocker Arm Clearance

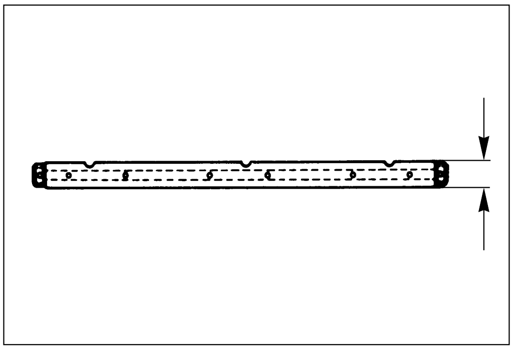
1. Use a vernier caliper to measure the rocker arm bushing inside diameter.

mm (in)

	Standard	Limit
Rocker Arm Bushing Inside Diameter	19.01–19.03 (0.749–0.750)	19.05 (0.751)

2. Measure the rocker arm shaft outside diameter.

   Replace either the rocker arm or the rocker arm shaft if the clearance exceeds the specified limit.

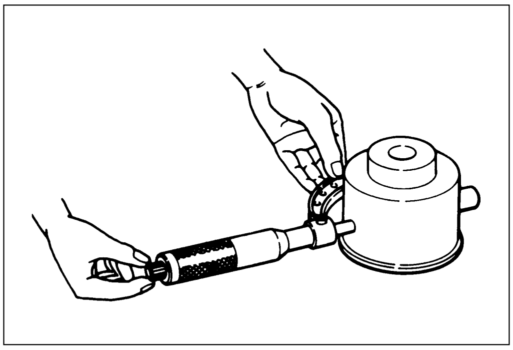


mm (in)

	Standard	Limit
Rocker Arm Bushing and Rocker Arm Shaft Clearance	0.01–0.05 (0.0004–0.0020)	0.2 (0.0079)

3. Check that the rocker arm oil port is free of obstructions.

   If necessary, use compressed air to clean the rocker arm oil port.



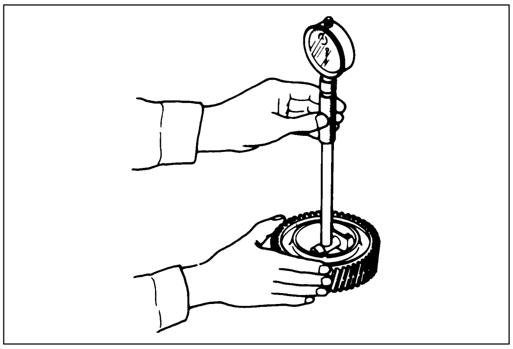
IDLER GEAR AND IDLER GEAR SHAFT

1. Use a micrometer to measure the idler gear shaft outside diameter.

   If measured diameter exceeds specified limit, replace the idler gear shaft.

mm (in)

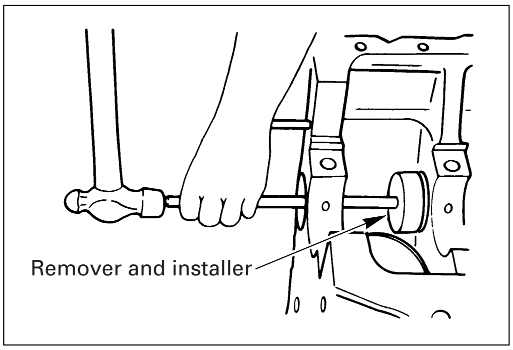
	Standard	Limit
Idler Gear Shaft Outside Diameter	44.945–44.975 (1.769–1.771)	44.9 (1.768)



2. Use a dial indicator to measure the idler gear inside diameter.

mm (in)

	Standard	Limit
Idler Gear and Idler Gear Shaft Clearance	0.025–0.085 (0.001–0.003)	0.2 (0.008)



CAMSHAFT

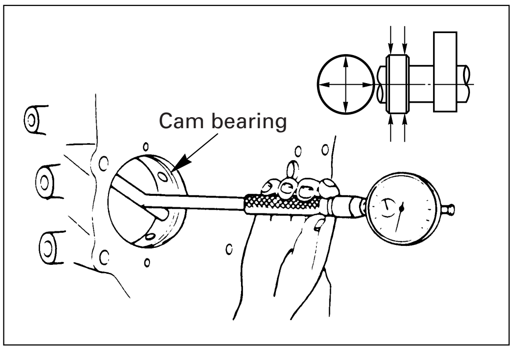
1. Use the camshaft bearing remover and installer to remove camshaft bearing from the cylinder body.

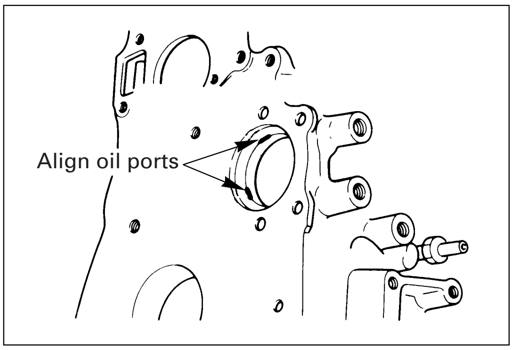
   Camshaft Bearing Remover and Installer: 9-8523-1818-0

2. Measure the clearance between the cam journal and the camshaft bearing.

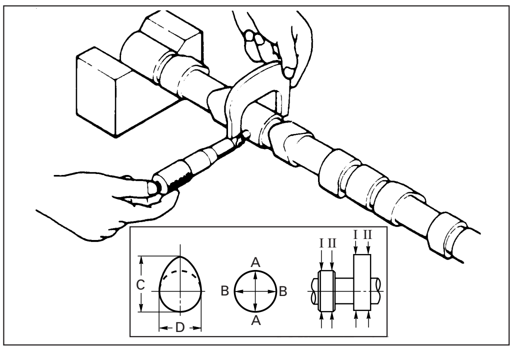
mm (in)

	Standard	Limit
Cam Journal and Cam Bearing Clearance	0.03–0.09 (0.001–0.004)	0.15 (0.006)





3. Align the camshaft bearing oil holes with the mating oil ports (machined on the cylinder body camshaft bearing fitting bore).

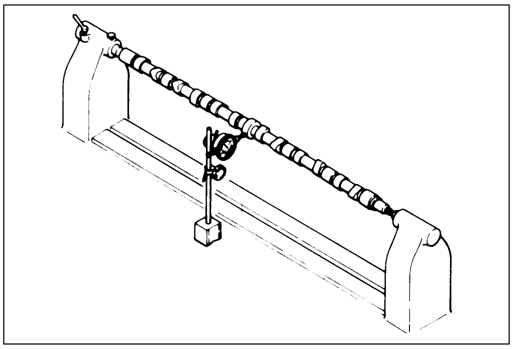


4. Use a micrometer to measure the cam lobe height.

   If the cam lobe height is less than the specified limit, the camshaft must be replaced.

mm (in)

	Standard	Limit
Cam Lobe Height (C-D)	7.71 (0.304)	7.21 (0.284)
Cam Journal Diameter	55.94–55.97 (2.202–2.204)	55.6 (2.189)



5. Place the camshaft on a measuring stand.

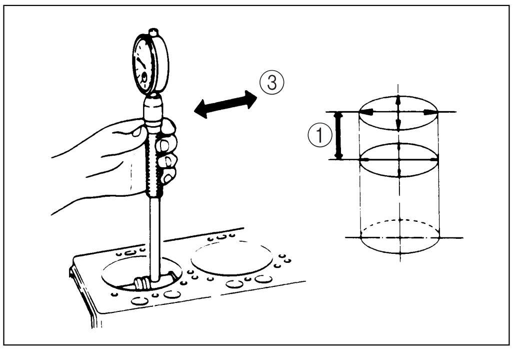
   Use a dial indicator to measure the camshaft runout.

   Note the total indicator reading (TIR).

   If the measured run-out exceeds the specified limit, the camshaft must be replaced.

mm (in)

	Limit
Camshaft Run-Out TIR	0.12 (0.005)



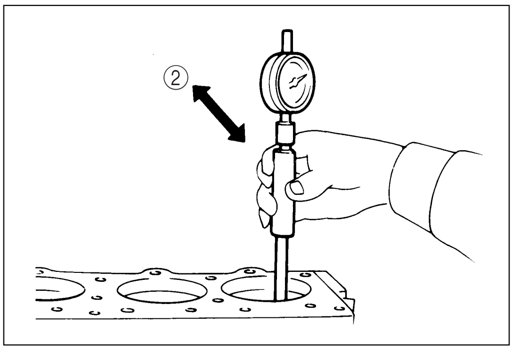
CYLINDER BODY AND LINER

Cylinder Liner Bore Measurement

Use a cylinder indicator to measure the cylinder liner bore at measuring position ① in line with the crankshaft ② and across the crankshaft ③.

Measuring Point ① mm (in): 20.0 (0.79) (Maximum Wear Portion)

If the measured value exceeds the specified limit, the cylinder liner must be replaced.



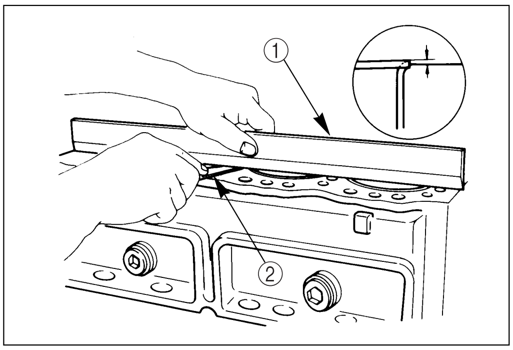
mm (in)

	Standard	Limit
Cylinder Liner Bore Total Indicator Reading	105.021–105.060 (4.1347–4.1362)	105.20 (4.1417)

Note:

The inside of the dry type cylinder liner is chrome plated. It cannot be rebored or honed.

If the inside of the cylinder liner is scored or scorched, the cylinder liner must be replaced.



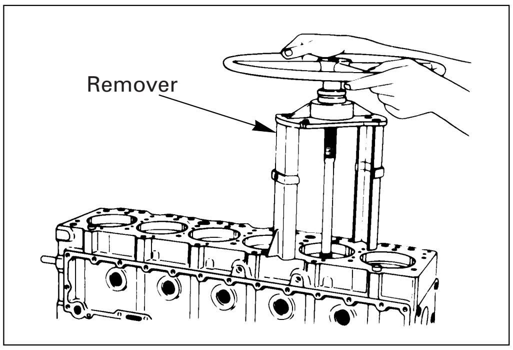
Cylinder Liner Projection Inspection

1. Hold a straight edge ① along the top edge of the cylinder liner to be measured.
2. Use a feeler gauge ② to measure each cylinder liner projection.

mm (in)

	Standard
Cylinder Liner Projection	0.03–0.10 (0.001–0.004)

The difference in the cylinder liner projection height between any two adjacent cylinders must not exceed 0.03 mm (0.001 in).



Cylinder Liner Replacement

Cylinder Liner Removal

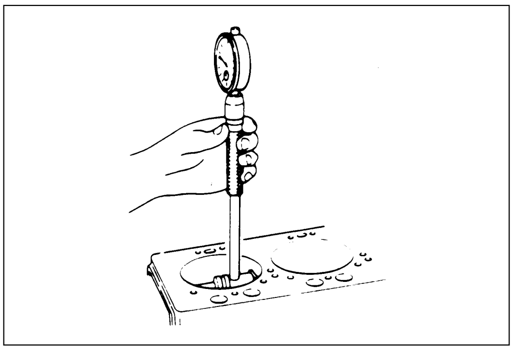
1. Set the cylinder liner remover to the cylinder liner.
2. Check that the remover shaft ankle is firmly gripping the cylinder liner bottom edge.
3. Slowly turn the remover shaft handle counterclockwise to pull the cylinder liner free.

   Cylinder Liner Remover: 9-8523-1169-0

   Cylinder Liner Remover Ankle: 5-8523-1004-0

Note:

Take care not to damage the cylinder body upper face during the cylinder liner removal procedure.



Cylinder Bore Measurement

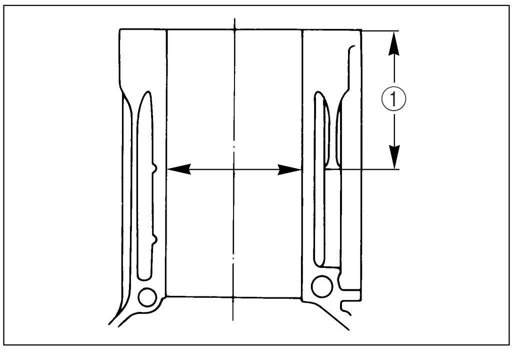
Cylinder Liner Grade Selection

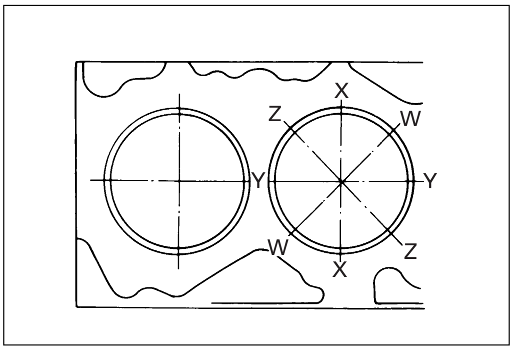
The term "grade" refers to the cylinder body inside diameter and the cylinder liner outside diameter combination.

Measure the cylinder body inside diameter and select the appropriate cylinder liner grade.

Loose fitting cylinder liners (the liner is too small for the cylinder bore) will adversely affect engine cooling efficiency and may lead to serious engine damage.

Cylinder liners which are too large for the cylinder bore will be difficult to install.



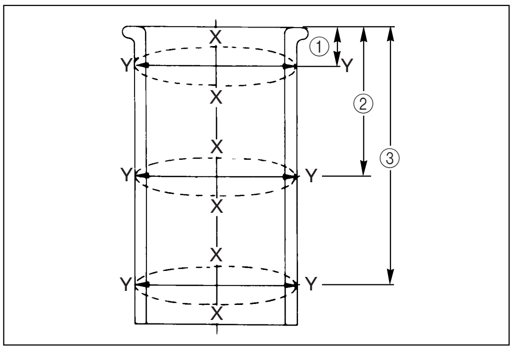


Cylinder Body Inside Diameter Measurement

1. Take measurements at measuring point ① across the positions W–W, X–X, Y–Y, and Z–Z.

   Measuring Point ① : 115 mm (4.531 in)

2. Calculate the average value of the four measurements to determine the correct cylinder liner grade.



Cylinder Liner Outside Diameter Measurement

1. Take measurements at measuring point ①, ②, and ③.

   Measuring Points mm (in):

   ① 20.0 (0.788)

   ② 105.0 (4.137)

   ③ 195.0 (7.683)

2. Calculate the average value of the 6 measurements to determine the correct cylinder liner grade.

mm (in)

Cylinder Liner Fitting Clearance Standard	0.001–0.019 (0.00004–0.0007)

Cylinder Bore and Cylinder Liner Outside Diameter Combinations

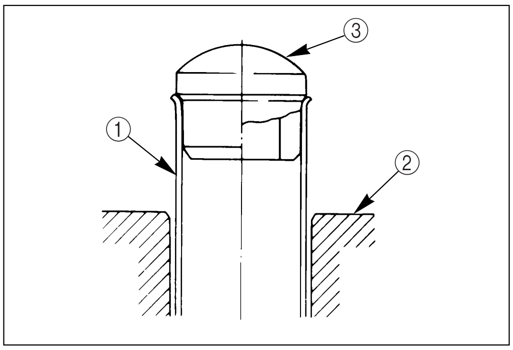
(Reference)

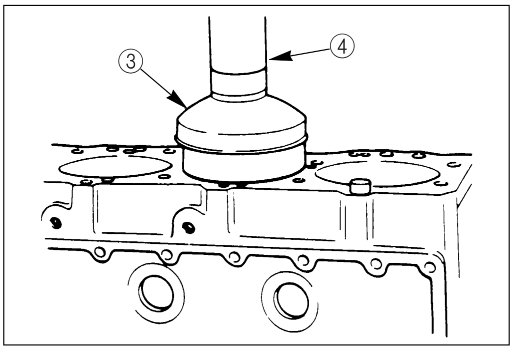
mm (in)

Grade	Cylinder Bore	Cylinder Liner Outside Diameter
1	107.001–107.010 (4.2126–4.2130)	107.011–107.020 (4.2130–4.2134)
2	107.011–107.020 (4.2130–4.2134)	107.021–107.030 (4.2134–4.2138)
3	107.021–107.030 (4.2134–4.2138)	107.031–107.040 (4.2138–4.2142)

Cylinder Liner Installation

1. Carefully wipe away any foreign material from the cylinder liner inside and outside surfaces and the cylinder bore.
2. Use new kerosene or diesel oil to thoroughly clean the cylinder liner and bore surfaces.
3. Use a clean rag to remove all traces of kerosene or diesel oil from the cylinder liner and bore surfaces.



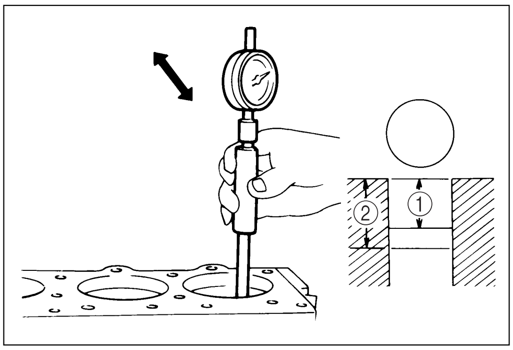


4. Insert the cylinder liner ① into the cylinder body ② from the top of the cylinder body.
5. Set the cylinder liner installer ③ to the top of the cylinder liner.

   Cylinder Liner Installer: 5-8522-1018-0
6. Position the cylinder body so that the installer center ③ is directly beneath the bench press shaft center ④.
7. Check that the cylinder liner is set perpendicular to the cylinder.

   Check that the cylinder liner does not wobble.
8. Use the bench press to apply an initial seating force of 5 kN (500 kgf/1,102 lb) to the cylinder liner.
9. Use the bench press to apply a final seating force of 25 kN (2,500 kgf/5,512 lb) to fully seat the cylinder liner.
10. After installing the cylinder liner, measure the cylinder liner projection.

    Refer to "Cylinder Liner Projection Inspection."



Piston Grade Selection

The term "piston grade" refers to the piston diameter and cylinder liner bore combination.

Selection of the proper piston grade will ensure efficient engine operation, free from cylinder liner and piston problems.

Cylinder Liner Bore Measurement

1. Locate the two measuring points.
   Cylinder Liner Measuring Point ①: 20 mm (0.788 in)
   Cylinder Liner Measuring Point ②: 105 mm (4.173 in)
2. Measure the cylinder liner bore at measuring point ① and ② in four different directions (W–W, X–X, Y–Y, and Z–Z).
3. Calculate the average value of the eight measurements.

mm (in)

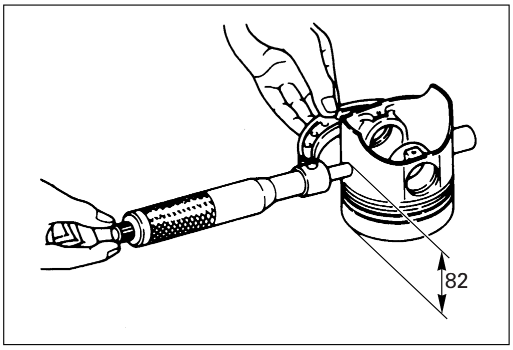
Cylinder Liner Bore Total Indicator Reading	105.021–105.060 (4.1347–4.1362)

Relation between liner bore and piston grade mm (in)

Liner Bore Diameter	Piston Grade
105.021–105.040 (4.1347–4.1354)	AX
105.041–105.060 (4.1355–4.1362)	CX

Note:

It is most important that the correct piston grade be used. Failure to select the correct piston grade will result in piston seizure.



Piston Outside Diameter

Measure the piston outside diameter at the measuring piston shown in the illustration.

Piston Grade (For service parts) mm (in)

Piston Outside Diameter	Piston Grade
104.959–104.974 (4.1322–4.1328)	AX
104.975–104.990 (4.1329–4.1335)	CX

Cylinder Liner Bore and Piston Clearance

mm (in)

Cylinder Liner Bore and Piston Clearance	0.051–0.085 (0.002–0.0033)

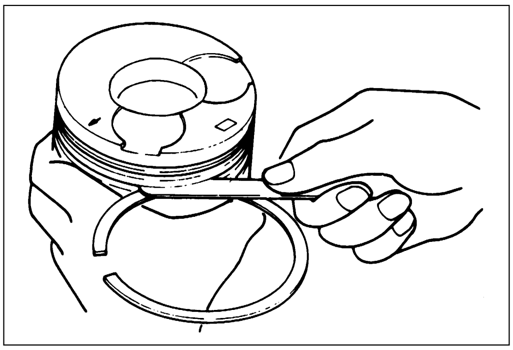
Note:

Cylinder liner piston kit clearances are preset. However, the cylinder liner installation procedure may result in slight decreases in cylinder liner bore clearances.

Piston Selection

Select the same grade number as the one for the cylinder liner inside diameter.

Grade of cylinder inside diameter	Grade of piston	Combination
AX	AX	OK
CX	CX	OK
AX	CX	NG
CX	AX	NG



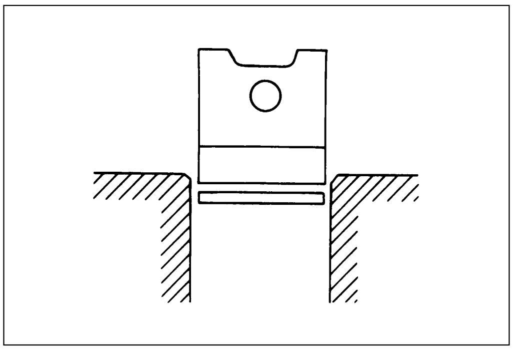
PISTON AND PISTON RING

Piston Ring and Piston Ring Groove Clearance

Use a feeler gauge to measure the clearance between the piston ring and the piston ring groove.

Do this at several points around the piston.

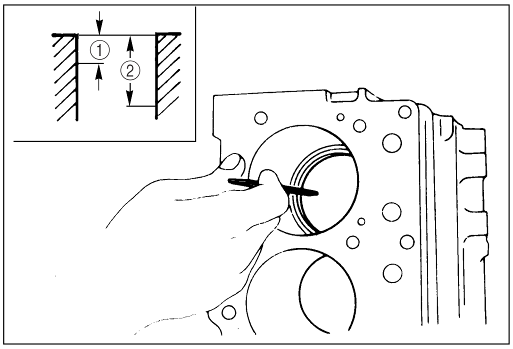
If the clearance between the piston ring and the piston ring groove exceeds the specified limit, the piston ring must be replaced.



Piston Ring and Piston Ring Groove Clearance

mm (in)

	Standard	Limit
1st Compression Ring	—	—
2nd Compression Ring	0.07–0.11 (0.0027–0.0043)	
3rd Compression Ring	0.05–0.09 (0.0020–0.0035)	0.15 (0.0059)
Oil Ring	0.03–0.07 (0.0012–0.0028)	



Piston Ring Gap

1. Insert the piston ring horizontally (in the position it would assume if it were installed to the piston) into the cylinder liner.
2. Use an inverted piston to push the piston ring into the cylinder liner until it reaches either measuring point ① or measuring point ②. Cylinder liner diameter is the smallest at these two points.

   Do not allow the piston ring to slant to one side or the other. It must be perfectly horizontal.

   Cylinder Liner Measuring Point ①: 10mm (0.39 in)

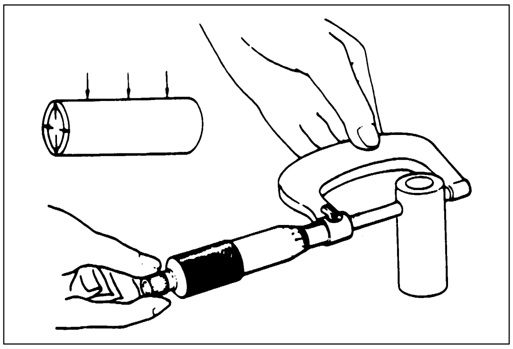
   Cylinder Liner Measuring Point ②: 130mm (5.12 in)
3. Use a feeler gauge to measure the piston ring gap.

   If the measured value exceeds the specified limit, the piston ring must be replaced.

Piston Ring Gap

mm (in)

	Standard	Limit
1st Compression Ring	0.35–0.50 (0.014–0.020)	1.5 (0.059)
2nd Compression Ring	0.60–0.75 (0.0236–0.0295)	
3rd Compression Ring	0.60–0.75 (0.0236–0.0295)	
Oil Ring	0.30–0.50 (0.012–0.020)	



PISTON PIN

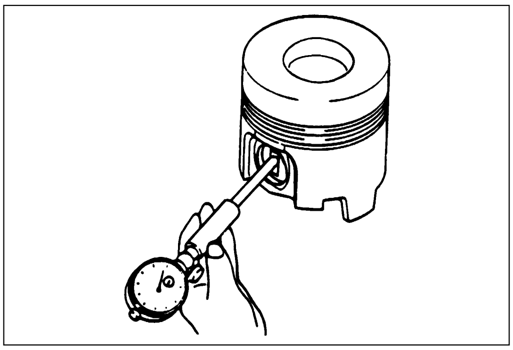
Piston Pin Outside Diameter

Use a micrometer to measure the piston pin outside diameter at several points.

If the measured piston pin outside diameter exceeds the specified limit, the piston pin must be replace.

mm (in)

	Standard	Limit
Piston Pin Outside Diameter	35.000–35.005 (1.3780–1.3781)	34.95 (1.3760)

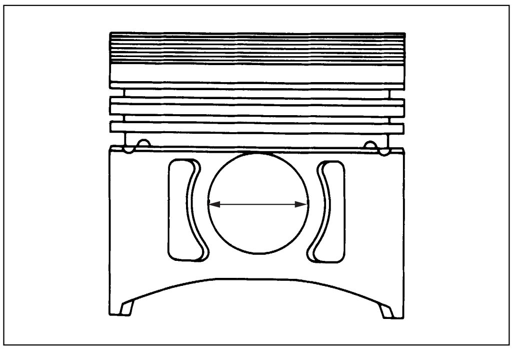


Piston Pin and Piston Clearance

Use an inside dial indicator to measure the piston pin hole.

mm (in)

	Standard
Piston Pin Hole Diameter	35.010–35.018 (1.3783–1.3787)

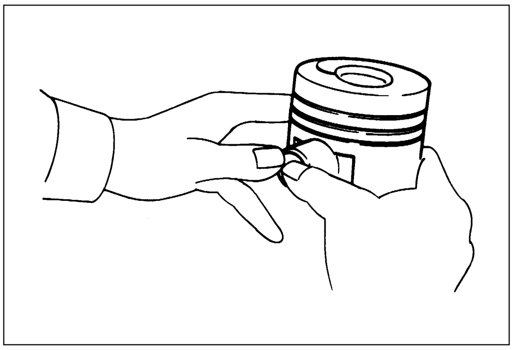


Piston Pin and Piston Pin Hole Clearance

Determine the clearance between the piston pin and the piston pin hole by calculating the difference between the piston pin hole diameter and the piston pin outside diameter.

mm (in)

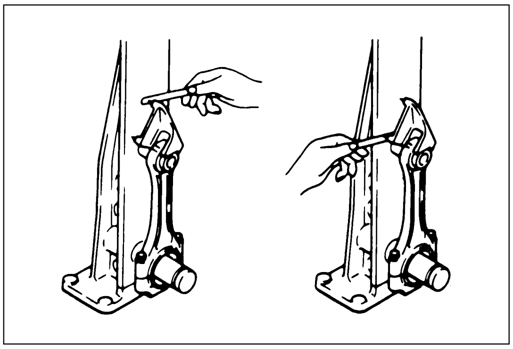
	Standard	Limit
Piston Pin and Piston Pin Hole Clearance	0.010–0.023 (0.00039–0.0009)	0.050 (0.00197)



If an inside dial indicator is not available, use the following procedure to check the piston pin fit.

1. Use a piston heater to heat the piston to approximately 60°C (140°F).
2. Push strongly against the piston pin with your thumbs.

   The piston pin fitting should feel tight.



CONNECTING ROD

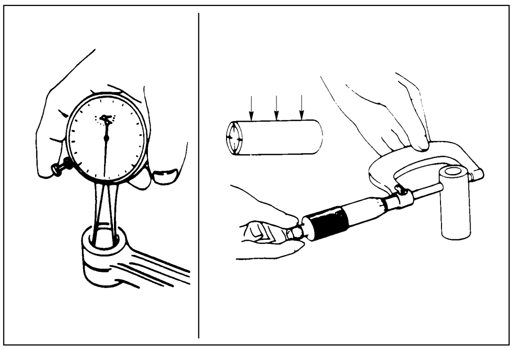
Connecting Rod Alignment

Use a connecting rod aligner to measure the connecting rod's twist distortion and parralelism between the rod's large and small ends.

If the measured value exceeds the limit, replace the connecting rod.

Connecting Rod Alignment
(Per Length of 100 mm (3.94 in) mm (in)

	Standard	Limit
Twist, Parallelism	0.05 (0.002) or less	0.20 (0.0079)



Piston Pin and Connecting Rod Small End Bushing Clearance

Use a caliper calibrator and a micrometer to measure the piston pin and connecting rod small end bushing clearance.

If the clearance between the piston pin and the connecting rod small end bushing exceeds the specified limit, replace either the piston pin or the connecting rod bushing.

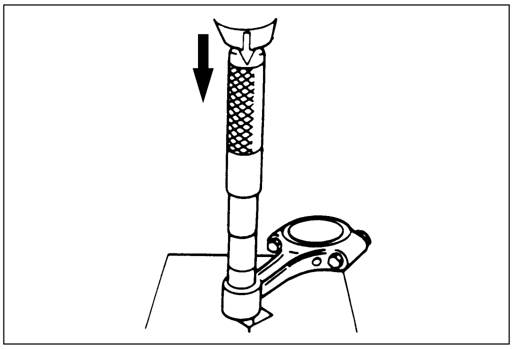
mm (in)

	Standard	Limit
Piston Pin and Connecting Rod Small End Bushing Clearance	0.012–0.025 (0.00047–0.00098)	0.05 (0.00197)

Connecting Rod Bushing Replacement

Connecting Rod Bushing Removal

1. Clamp the connecting rod in a vise.
2. Use a brass bar and a bench press or hammer to remove the connecting rod bushing.



Connecting Rod Bushing Installation

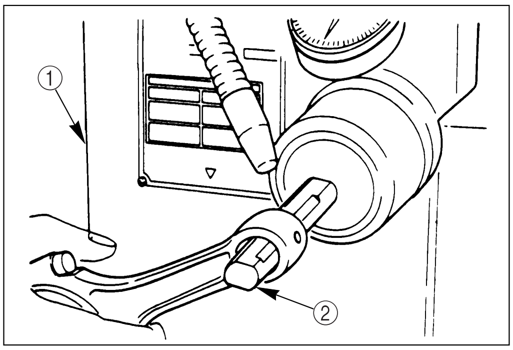
Use the connecting rod bushing installer to install the connecting rod bushing.

Connecting Rod Bushing Installer: 9-8523-1369-0

Note:

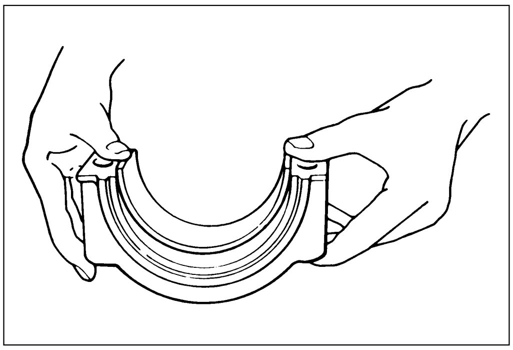
The connecting rod bushing oil port must be aligned with the connecting rod oil port.

3. Use a piston pin hole grinder ① fitted with a reamer ② or an adjustable pilot reamer to ream the piston pin hole.



mm (in)

	Standard
Connecting Rod Bushing Inside Diameter	35.017–35.025 (1.3786–1.3789)



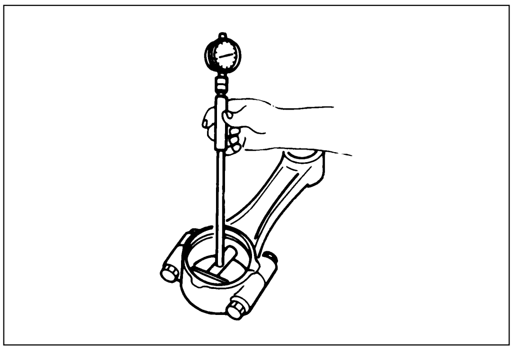
Connecting Rod Bearing Inspection

1. Fit the connecting rod bearing lower half into the connecting rod bearing cap.
2. Check the connecting rod bearing lower half tension.

   If the tension is insufficient, the bearing must be replaced.
3. Tighten the connecting rod and the bearing cap to the specified torque.

N·m (kgf·m/lb.ft)

	1st step	2nd step
Connecting Rod and Bearing Cap Bolt Tightening Torque	39 (4/29)	60°–90°



4. Use an inside dial indicator to measure the connecting rod inside diameter.

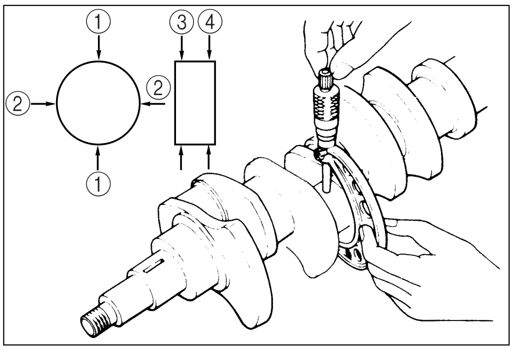
mm (in)

Connecting Rod Bearing Nominal Diameter	64 (2.520)

CRANKSHAFT

Crankshaft and Bearing Inspection

1. Inspect the crankshaft journal surfaces and the crank pin surfaces for excessive wear and damage.
2. Inspect the oil seal fitting surfaces of the crankshaft front and rear ends for excessive wear and damage.
3. Replace or repair the crankshaft if any excessive wear or damage is discovered.
4. Inspect the crankshaft oil ports for obstructions.
5. Use high pressure air to clean the oil ports if necessary.



Crankshaft Journal and Crankpin Outside Diameter

1. Use a micrometer to measure the crankshaft journal outside diameter across points ① – ① and ② – ②.
2. Use the micrometer to measure the crankshaft journal outside diameter at the two points (③ and ④).
3. Repeat steps 1 and 2 to measure the crankshaft outside diameter.

mm (in)

	Position at	Standard
Crankshaft Journal Diameter	Center Bearing Only	79.905–79.925 (3.1459–3.1467)
	Other Bearings	79.919–79.939 (3.1464–3.1472)

mm (in)

	Standard
Crankshaft Pin Diameter	63.924–63.944 (2.5167–2.5175)

4. Measure the crankshaft journal outside diameter (and/or the crankpin outside diameter) and the bearing inside diameters to determine the bearing clearance.

Crankshaft Journal and Bearing Clearances

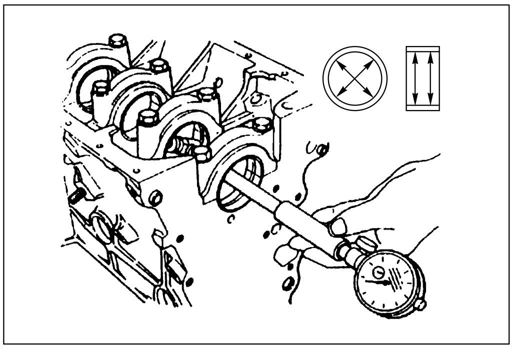
mm (in)

	Position at	Standard	Limit
Crankshaft Journal and Main Bearing Clearance	Center Bearing Only	0.039–0.098 (0.0015–0.0039)	0.11 (0.0043)
	Other Bearings	0.025–0.084 (0.0010–0.0033)	

Crankshaft Pin and Bearing Clearances

mm (in)

	Standard	Limit
Crankpin and Connecting Rod Bearing Clearance	0.03–0.073 (0.0012–0.0029)	0.10 (0.0039)



Crankshaft Journal Bearing Inside Diameter

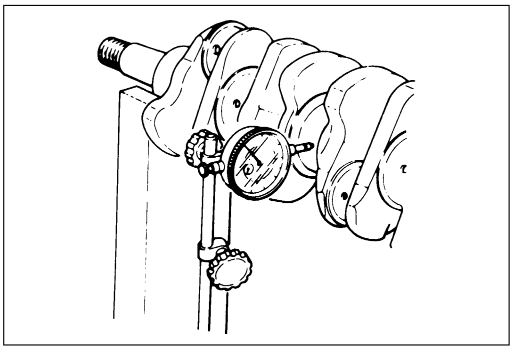
1. Install the main bearing cap with bearings to the cylinder body with the specified torque and facing the arrow mark on the bearing cap toward front. Place them in order of punched cylinder numbers.
2. Use an inside dial indicator to measure the main bearing diameters.

N·m (kgf·m/lb.ft)

Main Bearing Cap Torque	226 – 245 (23 – 25/166 – 181)

mm (in)

Main Bearing Nominal Diameter	80 (3.1496)



Crankshaft Run-Out

1. Mount the crankshaft on a set of V-blocks.
2. Set a dial indicator to the center of the crankshaft journal.
3. Gently turn the crankshaft in the normal direction of engine rotation.

   Read the dial indicator (TIR) as you turn the crankshaft.

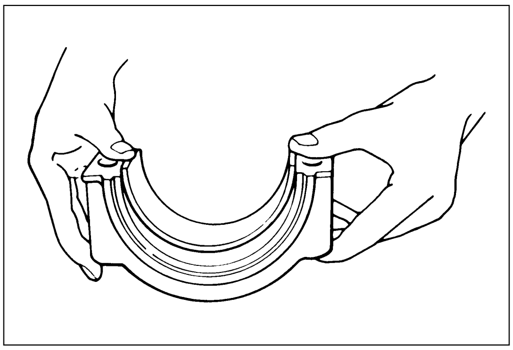
   If the measured value exceeds the specified limit, the crankshaft must be replaced.

mm (in)

	Standard	Limit
Crankshaft Run-Out	0.05 (0.002) or less	0.40 (0.016)

If the crankshaft generated a crack after repair, replace the crankshaft.

Crankshaft can not be bench pressed, because it is finished with tufftride method.



Main Bearing and Connecting Rod Bearing Tension

Check to see if the bearing has enough tension, so that good finger pressure is needed to fit the bearing into position.

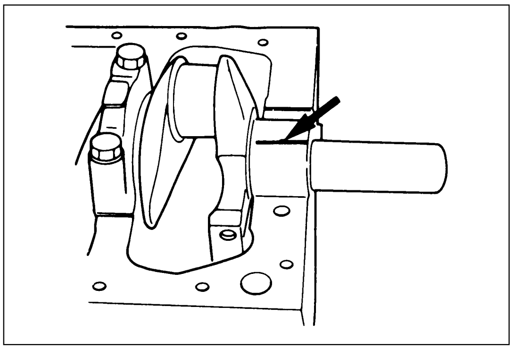
Crankshaft Regrinding

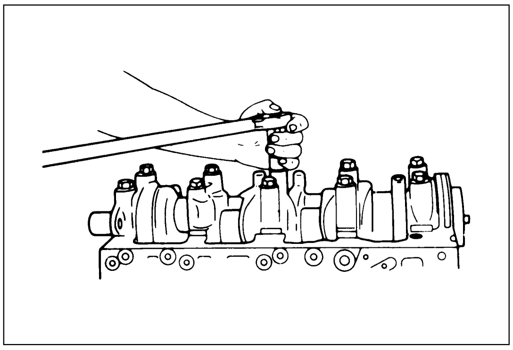
Note:

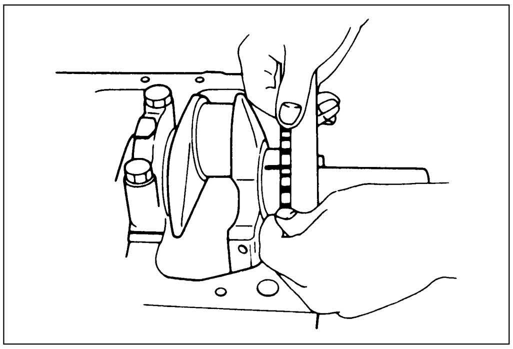
Crankshaft for 6BG1T can not be reground because it is finished with TUFFTRIDE method.

For the crankshaft on 6BG1T, no attempt should be made to grind finish the faces of the journals and crankpins as they are TUFFTRIDED (Special hardening treatment).

Therefore, the undersize bearings are not prepared:







Plastigage Clearance Measurements

This is another method to measure the crankjournal bearing clearance.

Crankshaft Journal Bearing Clearance

1. Clean the cylinder body, the journal bearing fitting portions, the bearing cap, and the inside the outside surfaces of the bearing.
2. Install the new journal bearing to the cylinder body.
3. Carefully place the crankshaft on the bearing.
4. Rotate the crankshaft approximately 30° to seat the bearing.
5. Place the Plastigage (arrow) over the crankshaft journal across the full width of the bearing.

   Apply engine oil to the Plastigage to keep it from falling.
6. Install the bearing cap with the bearing.
7. Tighten the bearing cap to the specified torque.

   Do not allow the crankshaft to turn during bearing cap installation and tightening.
8. Remove the bearing cap.
9. Compare the width of the plastigage attached to either the crankshaft or the bearing against the scale printed on the plastigage container.

   If the measured value exceeds the limit, perform the following additional steps.
   1) Use a micrometer to measure the crankshaft outside diameter.
   2) Use an inside dial indicator to measure the bearing inside diameter.
   3) Replace the crankshaft and/or the bearing if the measured value(s) exceed the limit.

Crankshaft Pin Bearing Clearance

1. Clean the crankshaft, the connecting rod, the bearing cap, and the bearings.
2. Install the bearing to the connecting rod.

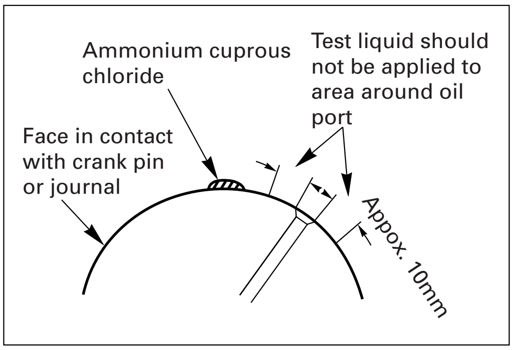
   Do not allow the crankshaft to move when installing the bearing cap.
3. Hold the connecting rod (with the bearing installed) against the crankshaft pin.
4. Attach the plastigage to the crankshaft pin.

   Apply engine oil to the plastigage to keep it from falling.
5. Install the connecting rod bearing cap and tighten it to the specified torque.

   Do not allow the connecting rod to move when installing and tightening the bearing cap.
6. Remove the bearing cap.
7. Compare the width of the plastigage attached to either the crankshaft or the bearing against the scale printed on the plastigage container.

   If the measured value exceeds the limit, perform the following additional steps.

   1) Use a micrometer to measure the crankshaft outside diameter.
   2) Use an inside dial indicator to measure the bearing inside diameter.
   3) Replace the crankshaft and/or the bearing if the measured value(s) exceed the limit.



Crankshaft Tufftriding Inspection

Inspection

1. Use an organic cleaner to thoroughly clean the crankshaft. There must be no traces of oil on the surfaces to be inspected.
2. Prepare a 10% solution of ammonium cuprous chloride (dissolved in distilled water).
3. Use a spot glass rod to apply the solution to the surface to be inspected.

   Hold the surface to be inspected perfectly horizontal to prevent the solution from running.

Note:

Do not allow the solution to come in contact with the oil ports and their surrounding area.

Judgement

1. Wait for thirty to forty seconds.

   If there is no discoloration after thirty or forty seconds, the crankshaft is usable.

   If discoloration appears (the surface being tested will become the color of copper), the crankshaft must be replaced.
2. Clean the surface being tested with clean water of steam immediately after completing the test.

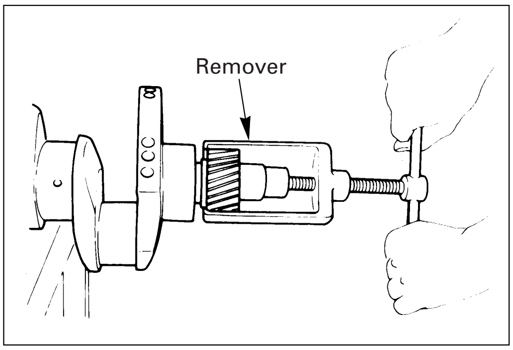
Note:

The ammonium cuprous chloride solution is highly corrosive. Because of this, it is imperative that the surfaces being tested be cleaned immediately after completing the test.

Crankshaft Gear Inspection

Visually inspect the crankshaft gear.

Replace the crankshaft gear if excessive wear or damage is discovered.

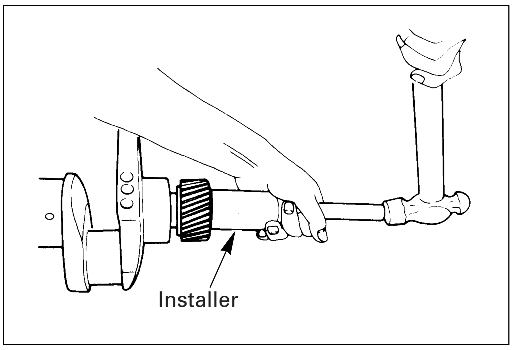


Crankshaft Gear Replacement

Removal

Use the crankshaft gear remover to remove the crankshaft gear.

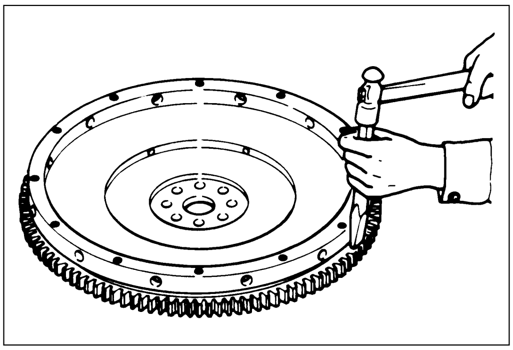
Crankshaft Gear Remover: 9-8521-0141-0



Installation

Use the crankshaft gear installer to install the crankshaft gear.

Crankshaft Gear Installer: 9-8522-0033-0



FLYWHEEL

Ring Gear Inspection

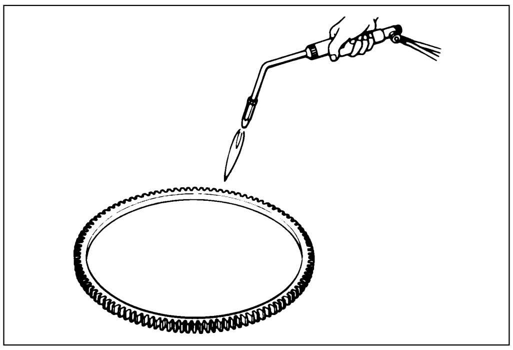
Inspect the ring gear.

If the ring gear teeth are broken or excessively worn, the ring gear must be replaced.

Ring Gear Replacement

Ring Gear Removal

Strike around the edges of the ring gear with a hammer and chisel to remove it.

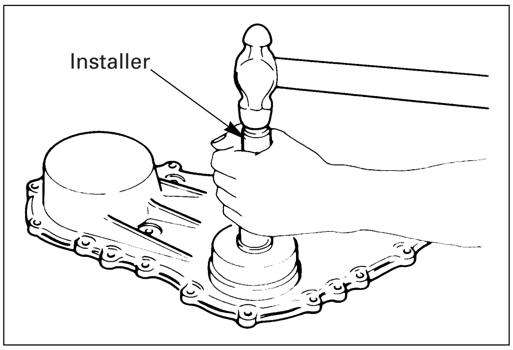


Ring Gear Installation

1. Heat the ring gear evenly with a gas-burner to invite thermal expansion.

   Do not allow the temperature of the ring gear to exceed 200°C (390°F).

2. Use a hammer to install the ring gear when it is sufficiently heated.



TIMING GEAR CASE COVER

Crankshaft Front Oil Seal Replacement

Removal

Use an adapter and a hammer to remove the crankshaft front end oil seal.

Installation

Use the crankshaft front oil seal installer to install the crankshaft front oil seal.

Crankshaft Front Oil Seal Installer: 9-8522-0034-0

MEMO

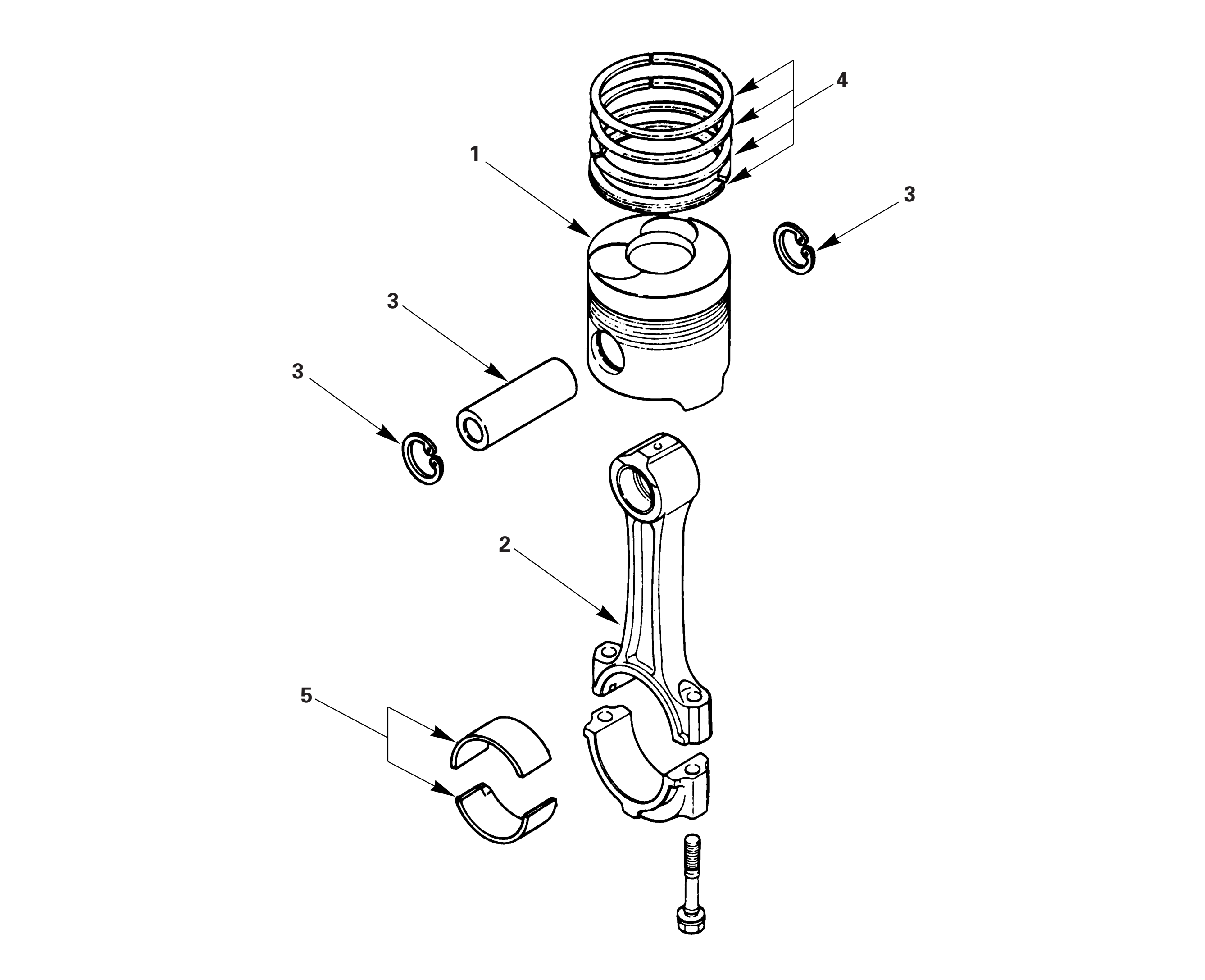
SECTION 5

ENGINE ASSEMBLY III (REASSEMBLY)

TABLE OF CONTENTS

PISTON AND CONNECTING ROD REASSEMBLY STEPS

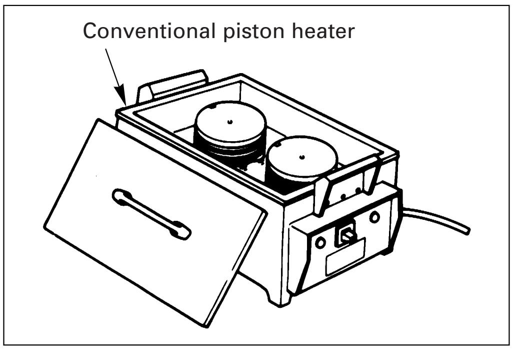
MIRROR COMPONENT



Reassembly Steps

▲ 1. Piston
▲ 2. Connecting-rod
▲ 3. Piston pin, Snap ring
▲ 4. Piston ring
▲ 5. Connecting rod bearing

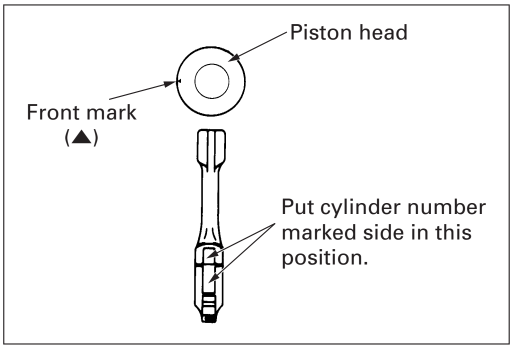
PISTON AND CONNECTING ROD



Important Operations

1. Piston

Use a piston heater to heat the pistons to approximately 60°C (140°F).



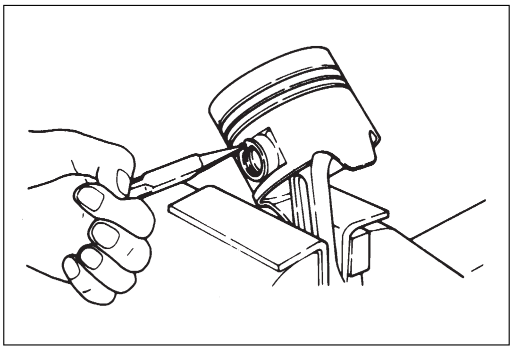
2. Connecting Rod

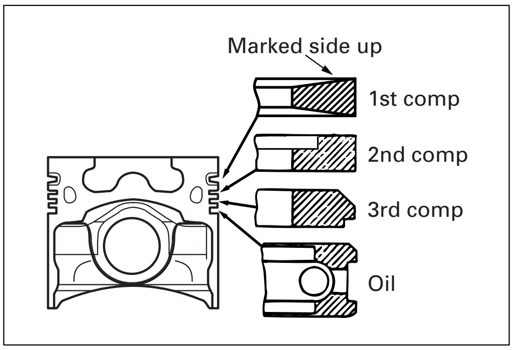
1) Install the connecting rod to the piston with setting the marks as illustrated.
2) Install the piston pin into the piston and the connecting rod bushing.

   Refer the description of piston pin in page 4-19.

3. Piston Pin, Snap Ring

1) Use a pair of snap ring pliers to install the piston pin snap ring.
2) Check that the piston moves smoothly on the piston pin.





4. Piston Ring

1) Use a piston ring installer to install the three piston rings.

   Piston Ring Installer

   Install the piston rings in the following order.

   (1) Oil ring
   (2) 3rd compression ring
   (3) 2nd compression ring
   (4) 1st compression ring

   The marked side of the three compression rings must be facing up.

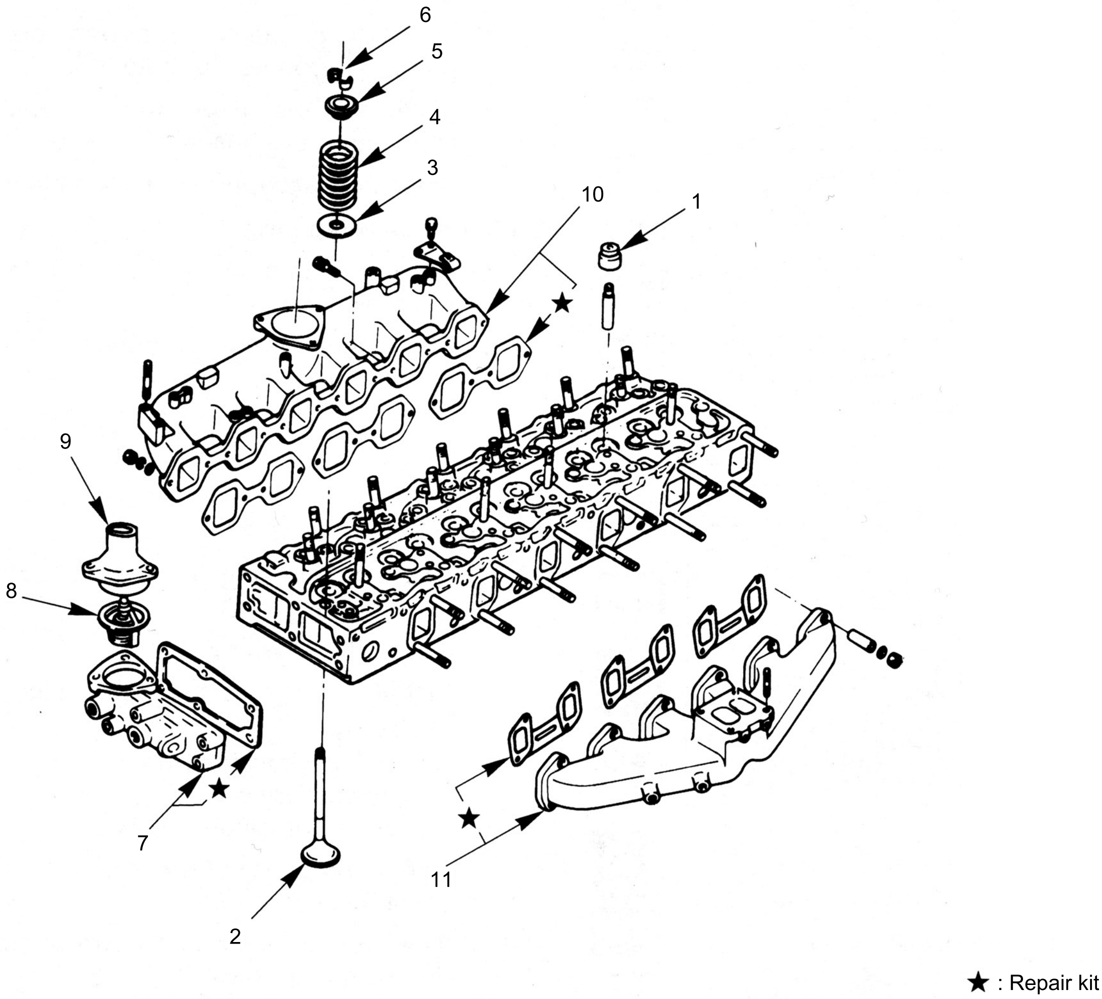
   The undercut side of the 3rd compression ring will be facing down.

   As the oil ring has no any facing mark, it may face in either direction.
2) Lubricate the piston ring surfaces with engine oil.
3) Check that the piston rings rotate smoothly in the piston ring grooves.

5. Connecting Rod Bearing

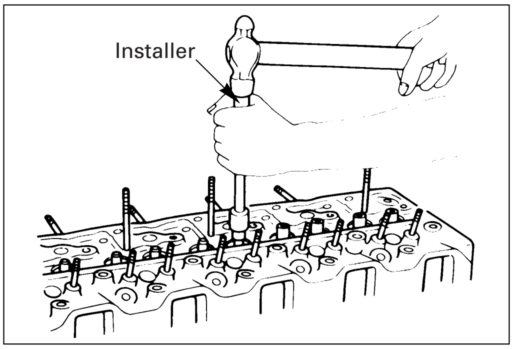
1) Install the connecting rod bearings to the connecting rod large-end and the connecting rod cap.
2) Install the bearing cap to the connecting rod with semi-tightening the cap bolts.
3) Lubricate the bearing with engine oil.

CYLINDER HEAD REASSEMBLY STEPS



Reassembly Steps

▲ 1. Valve stem oil seal
▲ 2. Intake and exhaust valves
3. Spring seat (Lower)
▲ 4. Intake and exhaust valve springs
5. Spring seat (Upper) or valve rotator
▲ 6. Spring seat split collar
7. Thermostat housing and gasket
8. Thermostat
9. Water outlet pipe
▲ 10. Intake manifold and gasket
▲ 11. Exhaust manifold and gasket

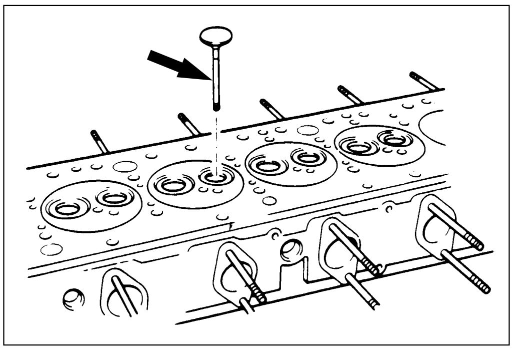


Important Operations

1. Valve Stem Oil Seal

1) Lubricate the oil seals and valve stem sealing areas with engine oil.
2) Use a valve stem oil seal installer to install the oil seal.

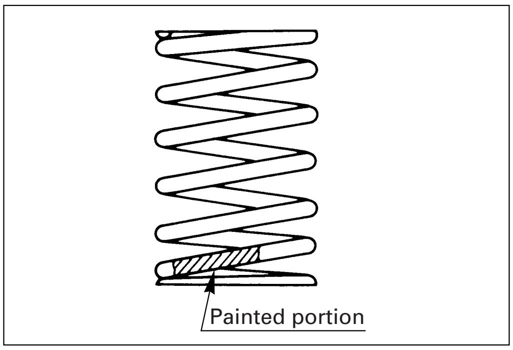
   Valve Stem Oil Seal Installer: 1-85221-005-0



2. Intake and Exhaust Valves

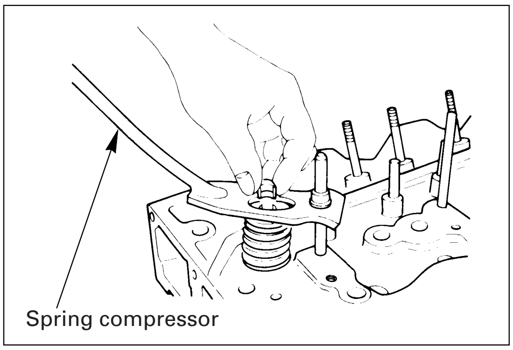
1) Place the cylinder head on a flat wooden surface.
2) Lubricate valve stems with engine oil.
3) Install the valves to the intake or exhaust guides.

   Install the valves to their original lapped valve seats.



4. Intake and Exhaust Valve Springs

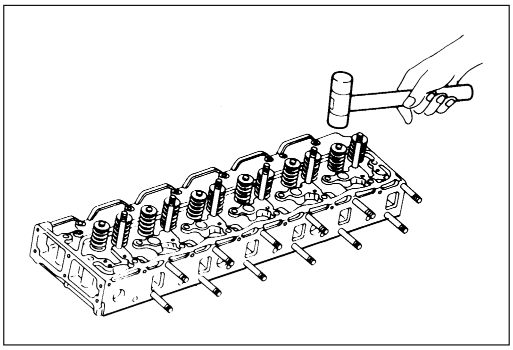
Install the valve springs with their painted end (the close pitched end) facing down.



6. Spring Seat Split Collar

1) Use a spring compressor to push the valve spring into position.
2) Install the spring seat split collar.
3) Set the spring seat split collar by tapping lightly around the head of the collar with a rubber hammer.

   Spring Compressor: 1-85235-006-0



10. Intake Manifold and Gasket

1) Install the intake manifold gasket.

   The intake manifold gasket must be installed with its unchamfered corner facing up and to the front of the engine.

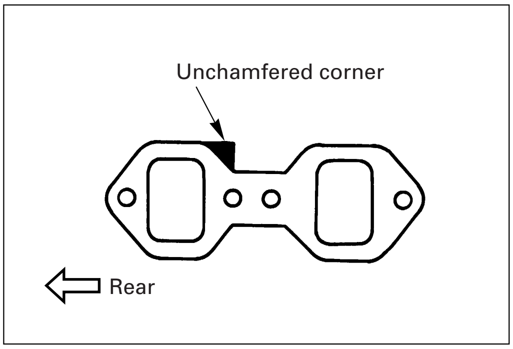
   Refer to the illustration.

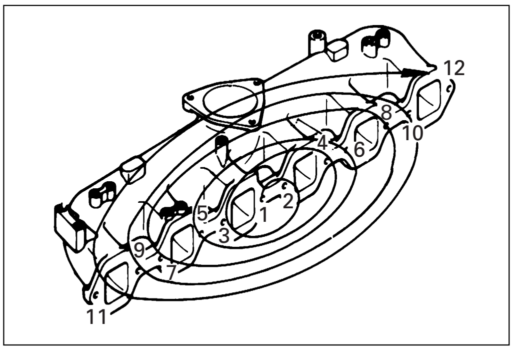
2) Install the intake manifold.

3) Tighten the intake manifold bolts to the specified torque a little at a time in the numerical order shown in the illustration.

N·m (kgf·m/lb.ft)

Intake Manifold Bolt Torque	21–30 (2.1–3.1/15–22)





11. Exhaust Manifold and Gasket

1) Install the exhaust manifold gasket.

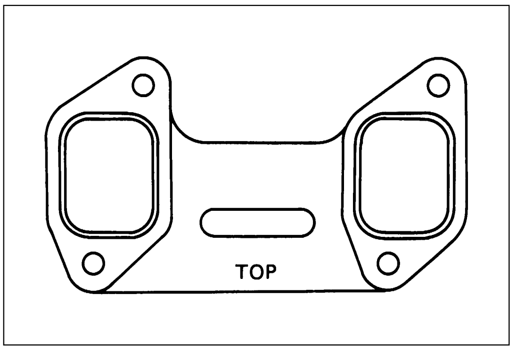
   The "TOP" mark must be facing up.

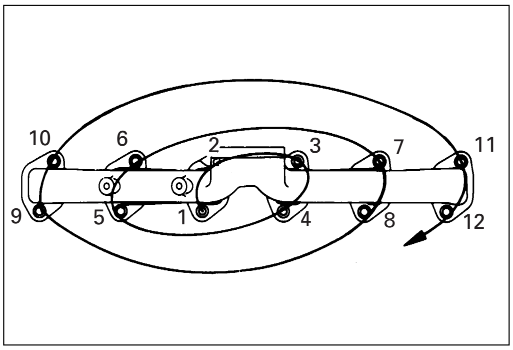
2) Install the exhaust manifold.

3) Tighten the exhaust manifold bolts to the specified torque a little at a time in the numerical order shown in the illustration.

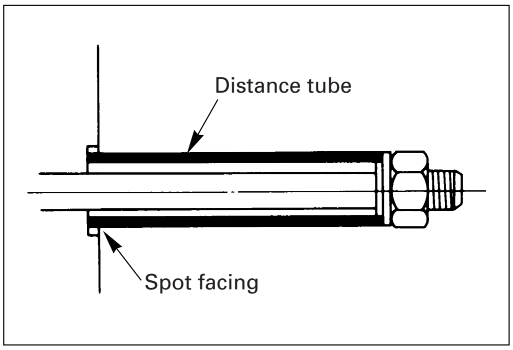
N·m (kgf·m/lb.ft)

Exhaust Manifold Bolt Torque	25–31 (2.6–3.2/19–23)

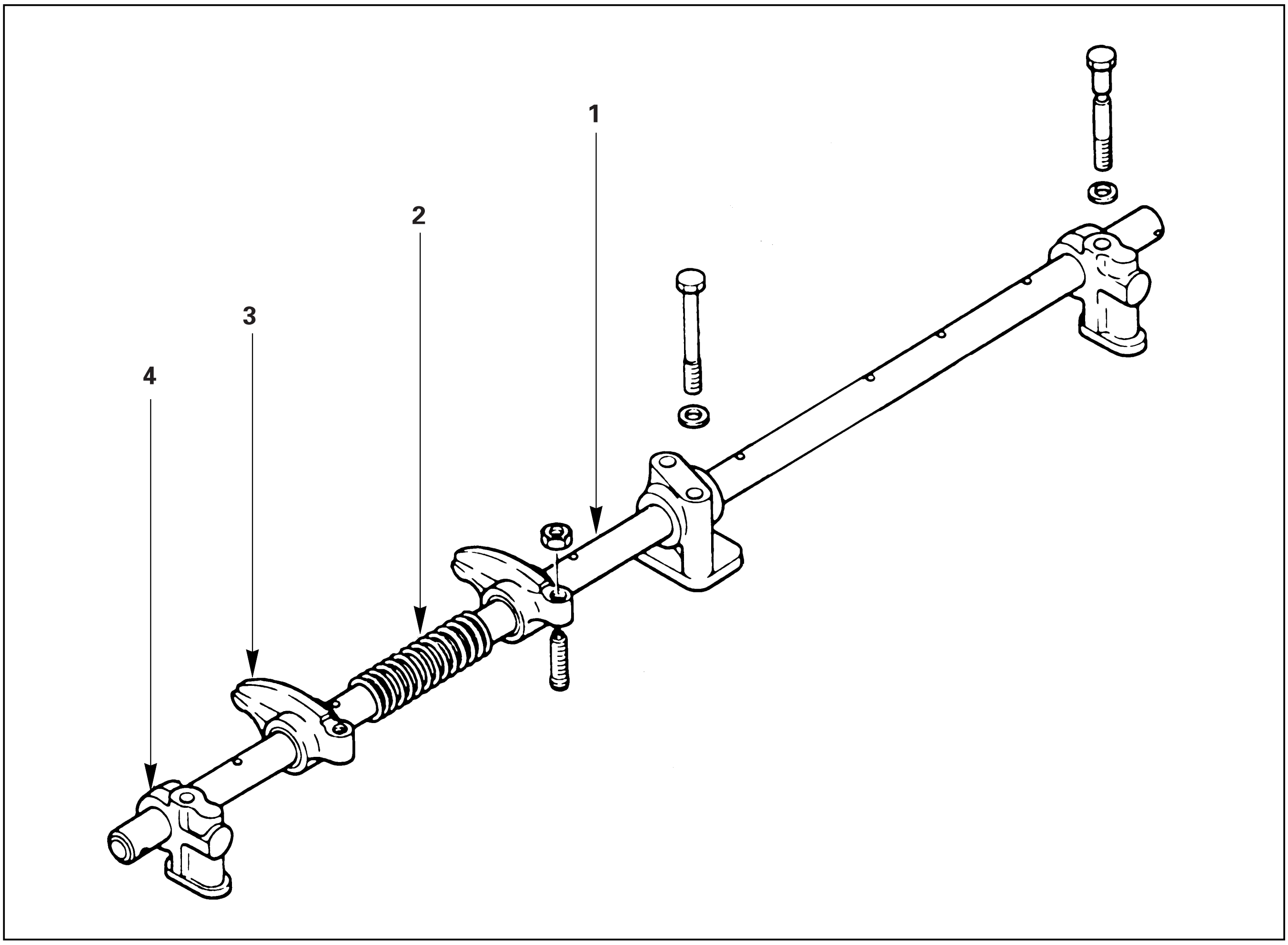




4) Install either end of the distance tube to the spot facing.



ROCKER ARM AND ROCKER ARM SHAFT REASSEMBLY STEPS



Reassembly Steps

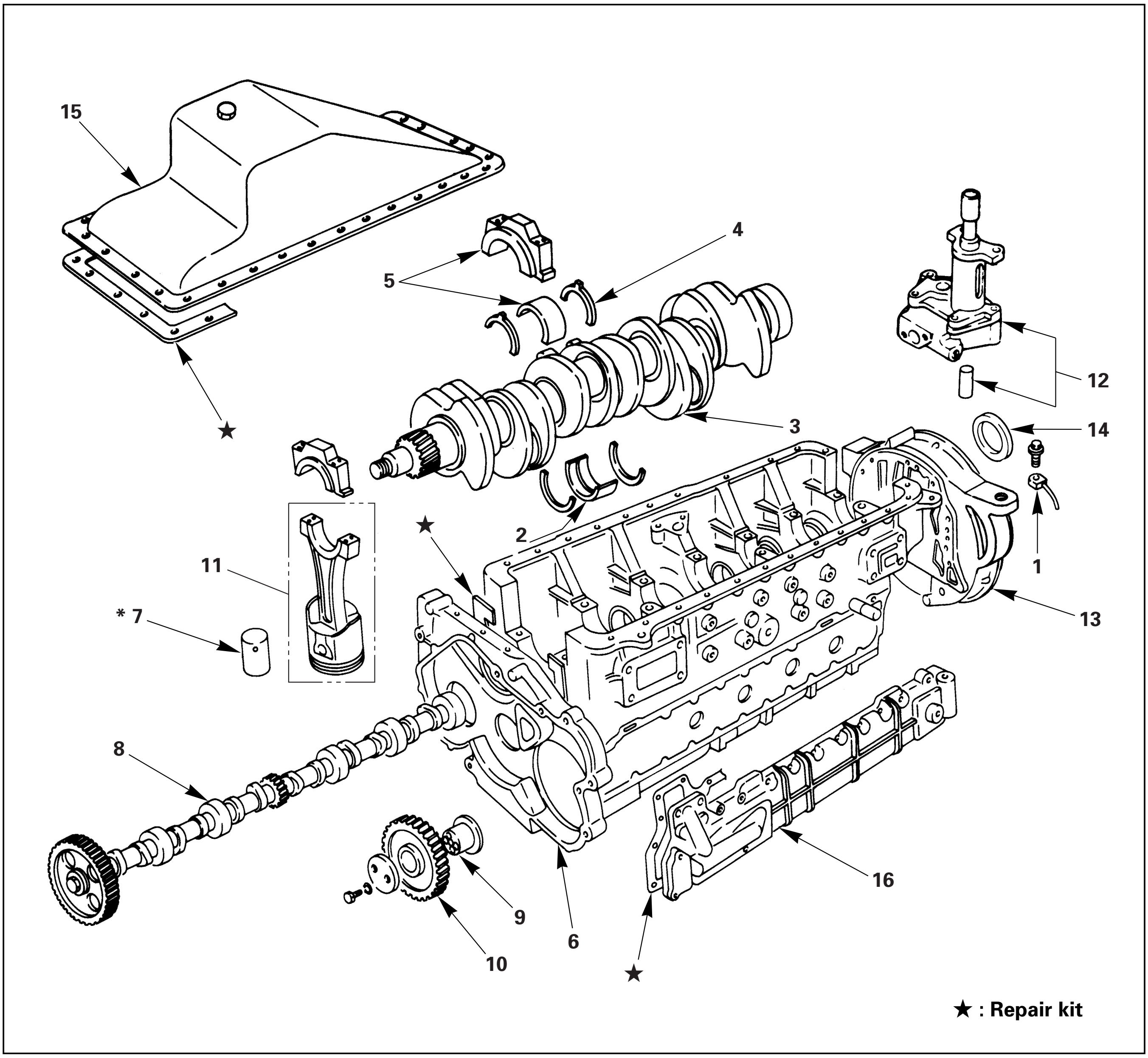
▲ 1. Rocker arm shaft
2. Spring
3. Rocker arm
4. Bracket

Important Operation

1. Rocker Arm Shaft

The rocker arm shaft must be installed with the oil ports facing up.

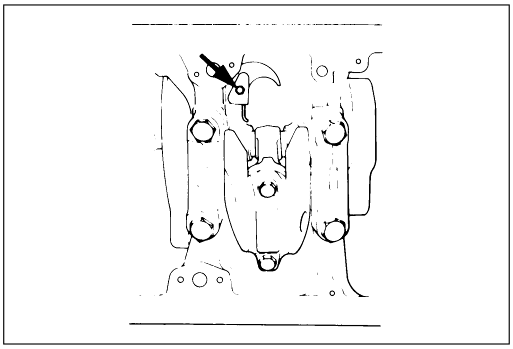
MAJOR COMPONENT REASSEMBLY STEPS I



Reassembly Steps

▲ 1. Oil jet
▲ 2. Crankshaft bearing (upper half)
3. Crankshaft
▲ 4. Thrust bearing
▲ 5. Crankshaft bearing (lower half) and crankshaft bearing cap
▲ 6. Timing gear case
* 7. Tappet
▲ 8. Camshaft
▲ 9. Idler gear shaft
▲ 10. Idler gear
▲ 11. Piston and connecting rod
▲ 12. Oil pump and coupling
▲ 13. Flywheel housing
▲ 14. Rear oil seal
▲ 15. Oil pan
▲ 16. Oil cooler

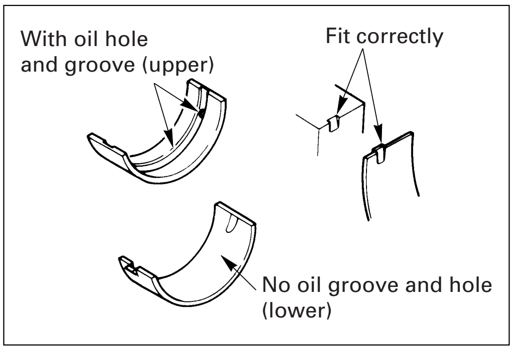
* The tappet must be installed before the camshaft installation.



Important Operations

1. Oil Jet

Install the oil jets taking care not to damage the oil jet nozzles.



N·m (kgf·m/lb.ft)

Oil Jet Torque	16–25 (1.6–2.6/12–19)

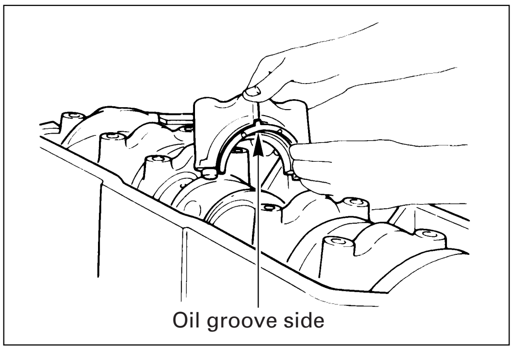
2. Crankshaft Bearing (Upper Half)

5. Crankshaft Bearing (Lower Half) and Crankshaft Bearing Cap

The Crankshaft Bearing Configuration

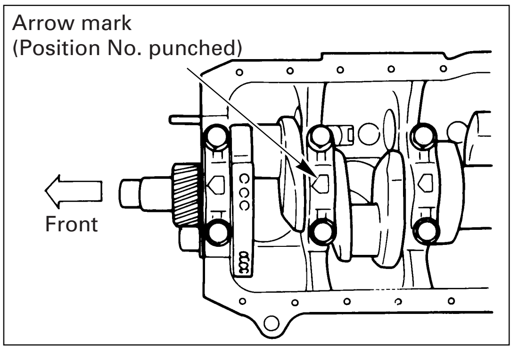
	With Oil Groove	Without Oil Groove
Bearing Upper Half	All Upper Halves	—
Bearing Lower Half	—	All Lower Halves

Take care not to misinstall the bearing halves.



4. Thrust Bearing

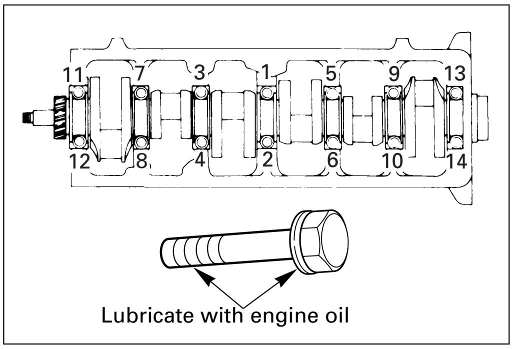
Install the thrust bearings with the oil groove side facing the crankshaft sliding face.



5. Crankshaft Bearing Cap

1) Lubricate the bearing cap bolts with engine oil.
2) Install the bearing caps to the crankshaft.

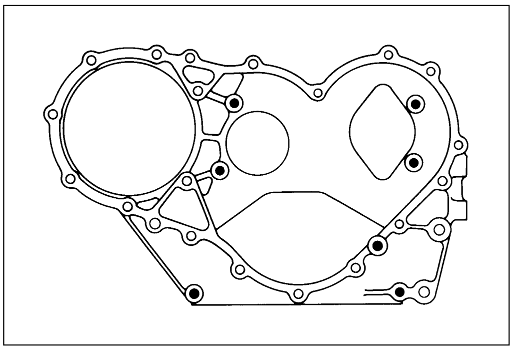
   The arrow mark must be pointing to the front of the engine.
3) Tighten the bearing cap bolts to the specified torque a little at a time in the numerical order shown in the illustration.



N·m (kgf·m/lb.ft)

Crankshaft Bearing Cap Bolt Torque	226–245 (23.0–25.0/166–181)

4) Check that the crankshaft turns smoothly by manually rotating it.

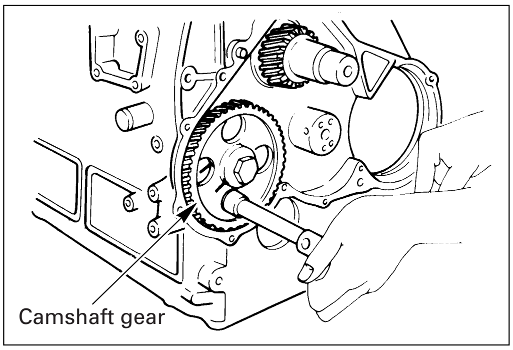


6. Timing Gear Case

1) Apply liquid gasket to the timing gear case surfaces contacting the cylinder body.
2) Tighten the timing gear case bolts to the specified torque.

N·m (kgf·m/lb.ft)

Timing Gear Case Bolt Torque	21–30 (2.1–3.1/15–22)



8. Camshaft

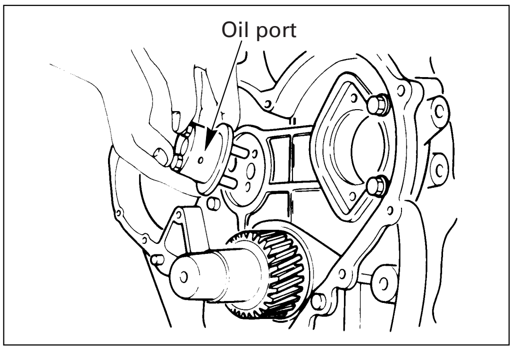
Tighten the thrust plate bolts through the camshaft gear hole.

N·m (kgf·m/lb.ft)

Thrust Plate Bolt Torque	21–30 (2.1–3.1/15–22)

N·m (kgf·m/lb.ft)

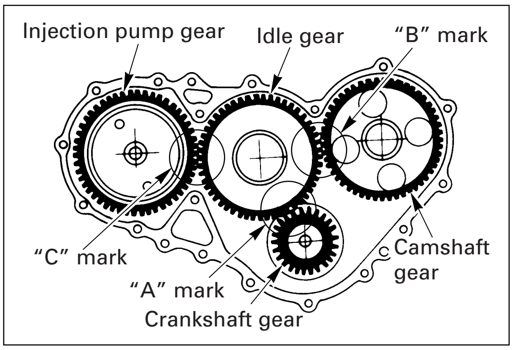
Camshaft Gear Bolt Torque	142–172 (14.5–17.5/105–127)



9. Idler Gear Shaft

Use the thrust collar fixing bolt as a guide to install the idler gear shaft.

The oil port must be facing the camshaft.



10. Idler Gear

1) Install the idler gear.

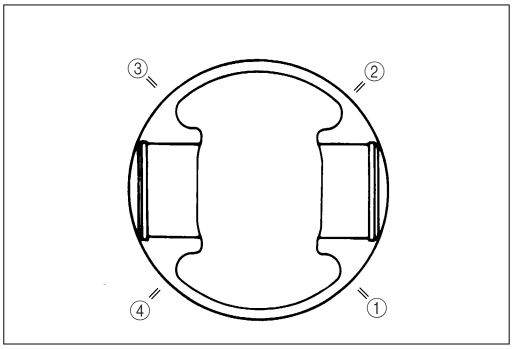
Set the timing marks [A] and [B] as shown in the illustration.

2) Tighten the idler gear bolts seating the thrust collar to the specified torque.

The thrust collar must be installed with the chamfered side facing the front of the engine.

N·m (kgf·m/lb.ft)

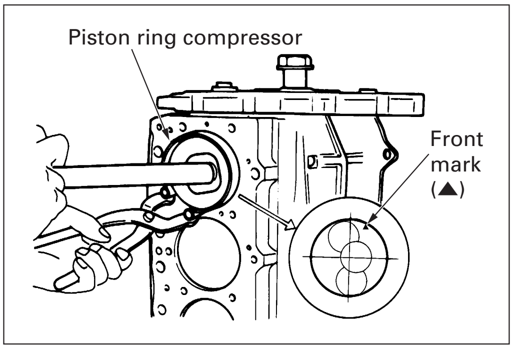
Idle Gear Bolt Torque	44–64 (4.5–6.5/33–47)



11. Piston and Connecting Rod

Position the piston ring gaps as shown in the illustration.

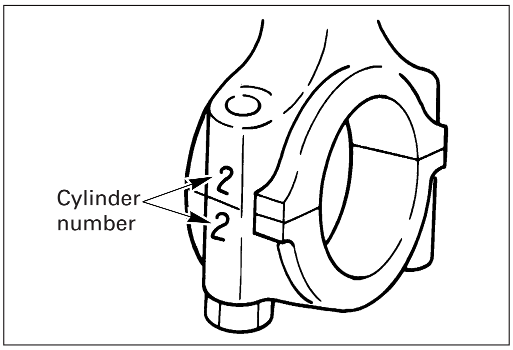
1) Set the piston ring gaps as shown in the illustration.
2) Lubricate the piston, the piston rings, and the connecting rod bearings with engine oil.
3) Position the piston front mark towards the front of the engine.



4) Use the piston ring compressor to compress the piston rings.

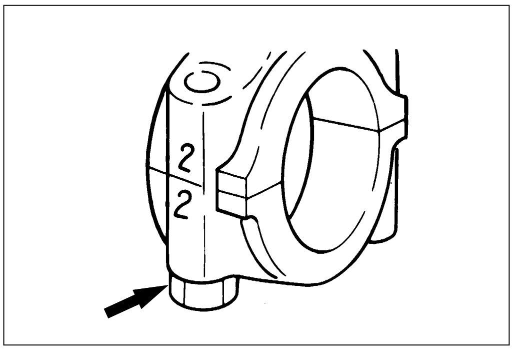
   Piston Ring Compressor: 9-8522-1251-0
5) Use a hammer grip to push the piston in until it makes contact with the crankpin.

   At the same time, rotate the crankshaft until the crankpin reaches its highest point.



6) Set the bearing cap cylinder number marks and the connecting rod cylinder number marks.

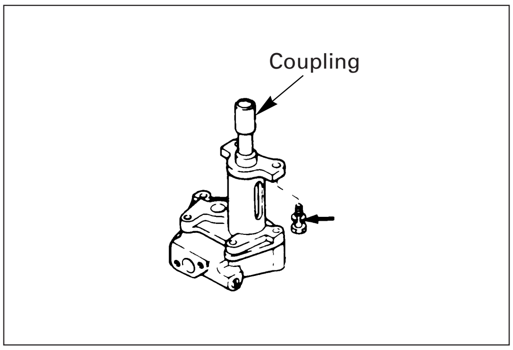
   The marks must be facing the exhaust manifold.



7) Lubricate the connecting rod cap bolt threads and setting fases with Mos grease.
8) Use the angular tightening method to tighten the connecting rod cap bolts to the specified torque.

N·m (kgf·m/lb.ft)

	1st step	2nd step
Connecting Rod Bolt Torque and Angle	39 (4/29)	60°–90°

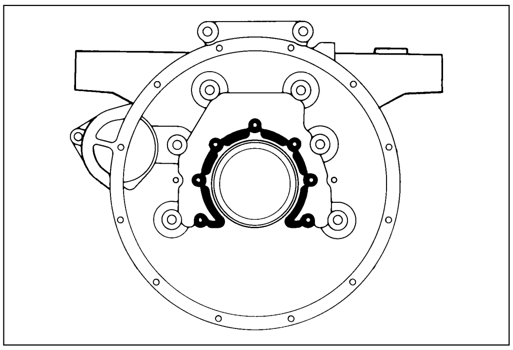


12. Oil Pump and Coupling

1) Lubricate the oil pump with the specified grade of engine oil.
2) Install the oil pump with the coupling.
3) Tighten the oil pump bolts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Pump Bolt Torque	42–62 (4.3–6.3/31–46)



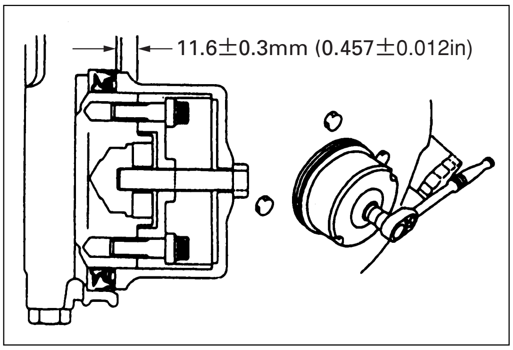
13. Flywheel Housing

1) Apply a sealant to the shaded area of the illustration.
2) Install the flywheel housing.

   Tighten the flywheel housing bolts to the specified torque.

N·m (kgf·m/lb.ft)

Flywheel Housing Bolt Torque	Outer Bolt	147–167(15.0–17.0/108–123)
	Inner Bolt	21–30 (2.1–3.1/15–22)

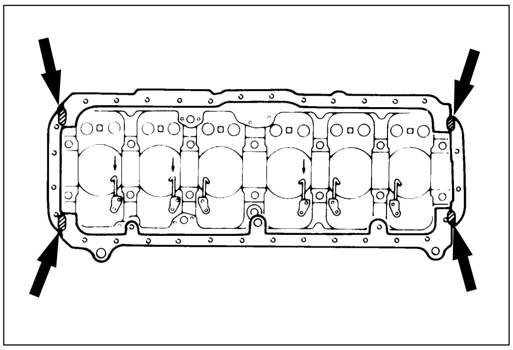


14. Rear Oil Seal (Axial Type)

1) Tighten the adapter to the crankshaft rear and section with 2 bolts.
2) Insert the oil seal into the peripheral section of adapter.
3) Insert the sleeve into the adapter section, and 1) tighten it with a bolt until the adapter section hits the sleeve.
4) Remove the adapter and the sleeve.
5) With the seal pressed in, check the dimension of the oil seal section.

   Standard Dimension = 11.6 ± 0.3 mm (0.457 ± 0.012 in)

   Rear oil Seal Installer: 5-8840-9037-0



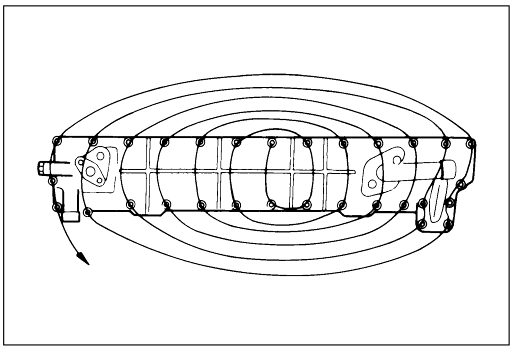
15. Oil Pan

1) Apply sealant to the area indicated by the arrows in the illustration.
2) Install the oil pan gasket
3) Install the oil pan.

   Tighten the oil pan bolts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Pan Bolt Torque	21–30 (2.1–3.1/15–22)



16. Oil Cooler

1) Apply sealant to the oil cooler gasket.
2) Install the oil cooler gasket to the oil cooler body case.
3) Install the oil cooler.

   Tighten the oil cooler bolts to the specified torque.

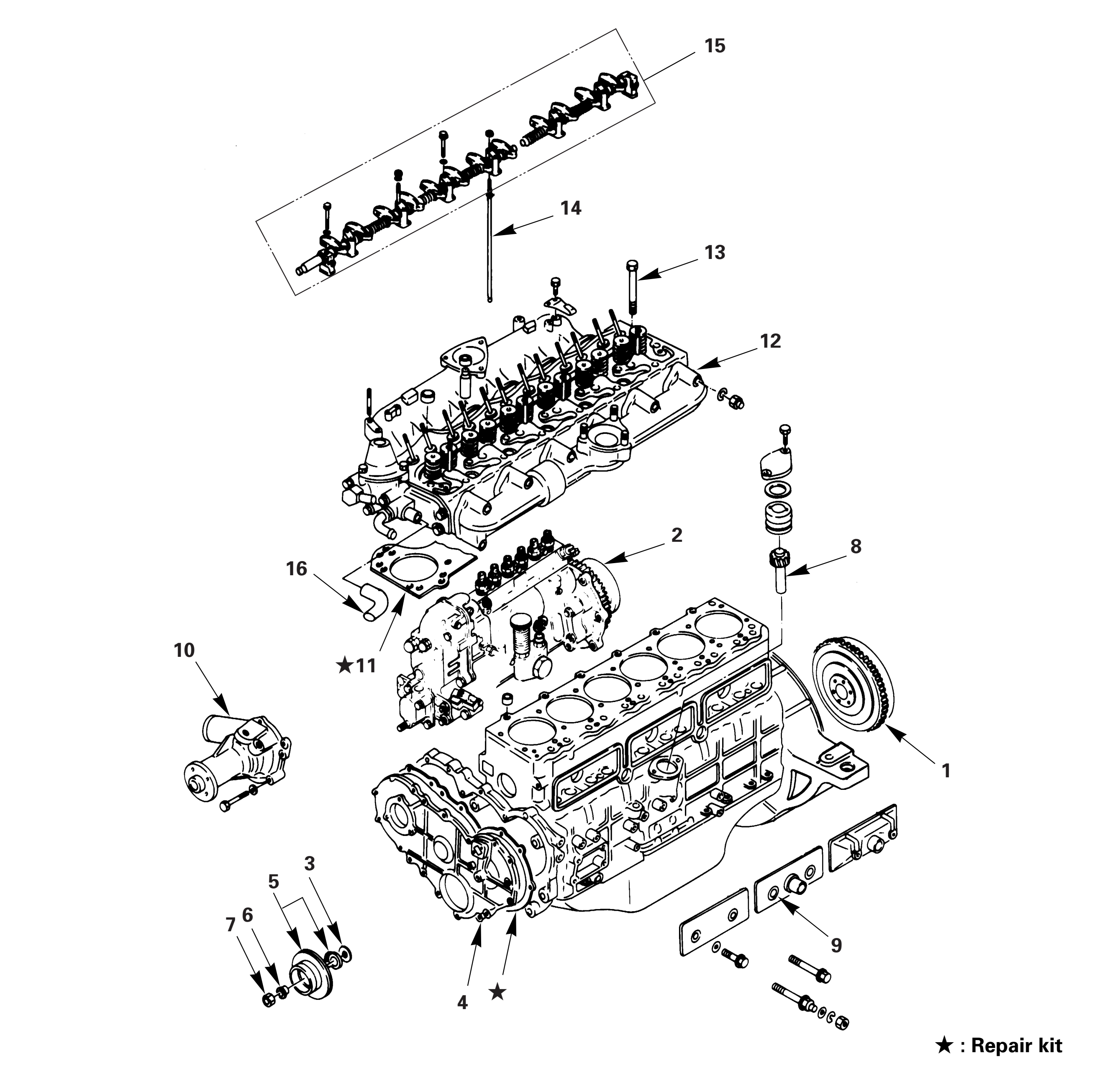
   Start from the middle and work out to either side.

   Refer to the illustration

N·m (kgf·m/lb.ft)

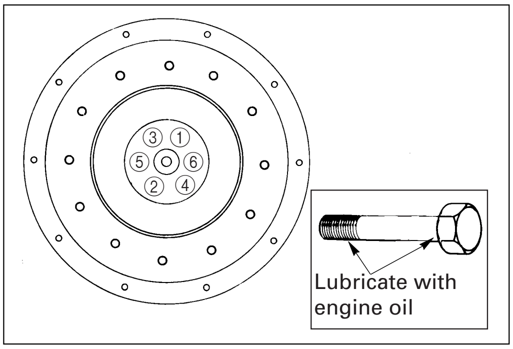
Oil Cooler Torque	14–24 (1.4–2.4/10–17)

MAJOR COMPONENT REASSEMBLY STEPS II



Reassembly Steps

- ▲ 1. Flywheel
- ▲ 2. Injection pump and injection pump gear
- 3. Oil thrower
- 4. Timing gear cover
- 5. Crankshaft pulley and dust thrower
- 6. Taper bushing
- ▲ 7. Crankshaft pulley nut
- 8. Oil pump driving pinion
- ▲ 9. Tappet chamber cover
- ▲ 10. Water pump
- ▲ 11. Cylinder head gasket
- ▲ 12. Cylinder head
- ▲ 13. Cylinder head bolt
- 14. Push rod
- ▲ 15. Rocker arm and rocker arm shaft
- 16. Rubber hose (Water by-pass)



Important Operations

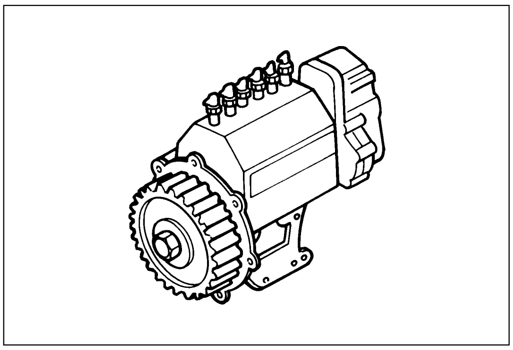
1. Flywheel

1) Lubricate the flywheel bolt threads.
2) Install the flywheel.

   The crankshaft rear end dowel pin and the flywheel dowel hole must be aligned.
3) Tighten the flywheel bolts to the specified torque in the numerical order shown in the illustration.

N·m (kgf·m/lb.ft)

Flywheel Bolt Torque	197–240(20.1–24.5/145–177)



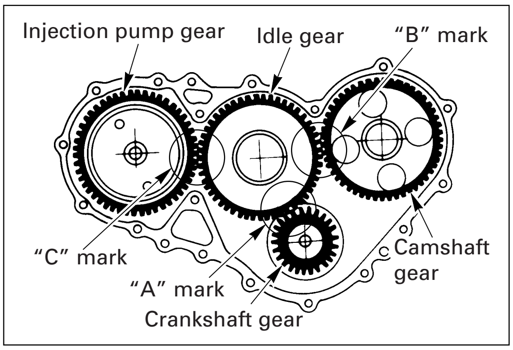
2. Injection Pump and Injection Pump Gear Assembly

1) Install the injection pump bracket with the injection pump to the timing gear case.

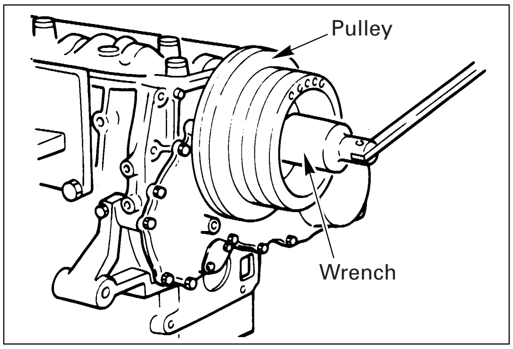
   Dowel the injection pump bracket with the timing gear case.
2) Tighten the injection pump bolts to the specified torque.

N·m (kgf·m/lb.ft)

Injection Pump Bolt Torque	21 – 30 (2.1 – 3.1/15 – 22)



3) Align the injection pump gear "C" timing mark with the idler gear "C" timing mark.

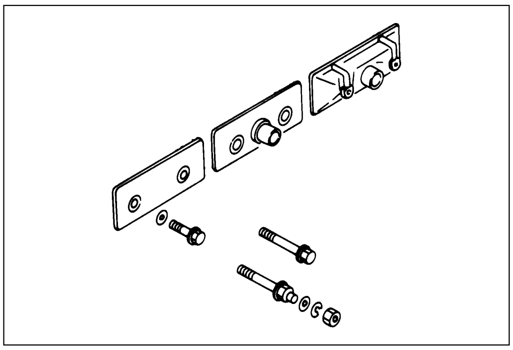


7. Crankshaft Pulley Nut

1) Apply MoS_2 to the crankshaft pulley nut threads and fitting face.
2) Use the appropriate wrench to tighten the crankshaft pulley nut to the specified torque.

N·m (kgf·m/lb.ft)

Crankshaft Pulley Nut Torque	539–637 (55–65/378–470)

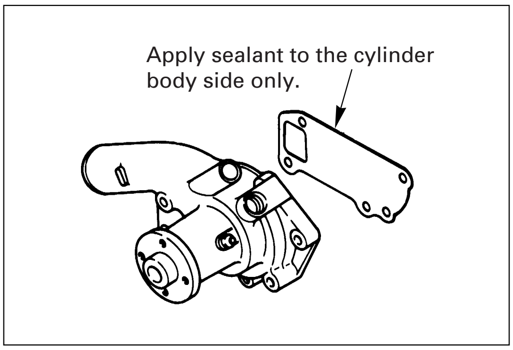


9. Tappet Chamber Cover

1) Apply sealant (TB 1207B) to the tappet chamber cover.
2) Install the tappet chamber cover and tighten the bolts to the specified torque.

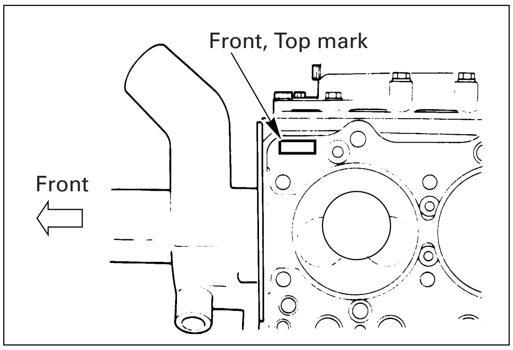
N·m (kgf·m/lb.ft)

Tappet Chamber Cover Bolt Torque	21–30 (2.1 – 3.1/15 – 22)



10. Water Pump

Apply sealant (Belco Bond No. 4) to the water pump gasket before installing the water pump.



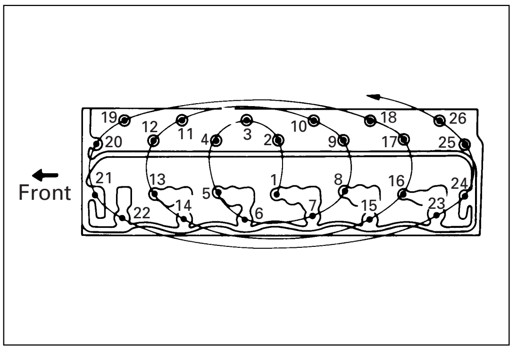
11. Cylinder Head Gasket

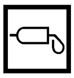
12. Cylinder Head

13. Cylinder Head Bolt

1) Carefully place the cylinder head gasket on the cylinder body upper surface.

   The gasket "TOP" mark must be facing up.
2) Align the cylinder body dowels and the cylinder head dowel holes.





3) Carefully place the cylinder head on the cylinder body.

4) Tighten the cylinder head bolt as follows.

   1) As cylinder head bolts have two kinds of length, install them at proper location.

      The shorter ones (6 bolts) must be used at the injection pump side.

   2) Follow the numerical sequence shown in the illustrations.

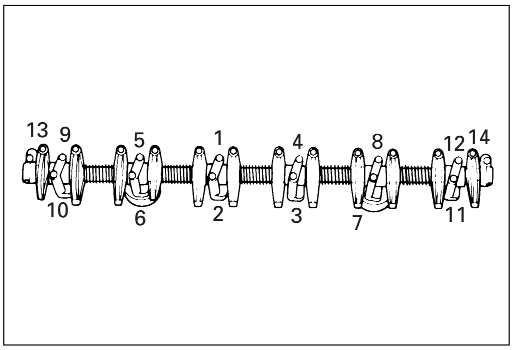
   3) The cylinder head bolt tightening method vary depending on the gasket type to be used.

Apply molybdenum disulfide grease to the cylinder head bolt threads and setting faces.

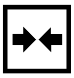
Use the Angular Tightening Method.

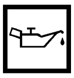
N·m (kgf·m/lb.ft)

	1st step	2nd step	3rd step
Bolt Torque	69 (7.0/51)	88 (9.0/65)	90°–120°



15. Rocker Arm and Rocker Arm Shaft

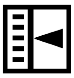




1) Check that the rocker arm shaft bracket lower surface oil port is free from obstruction.
2) Install the rocker arm shaft with the bracket to the cylinder head.
3) Tighten the rocker arm bracket bolts to the specified torque a little at a time in the numerical order shown in the illustration.
4) Lubricate the rocker arm and the rocker arm shaft with engine oil.

N·m (kgf·m/lb.ft)

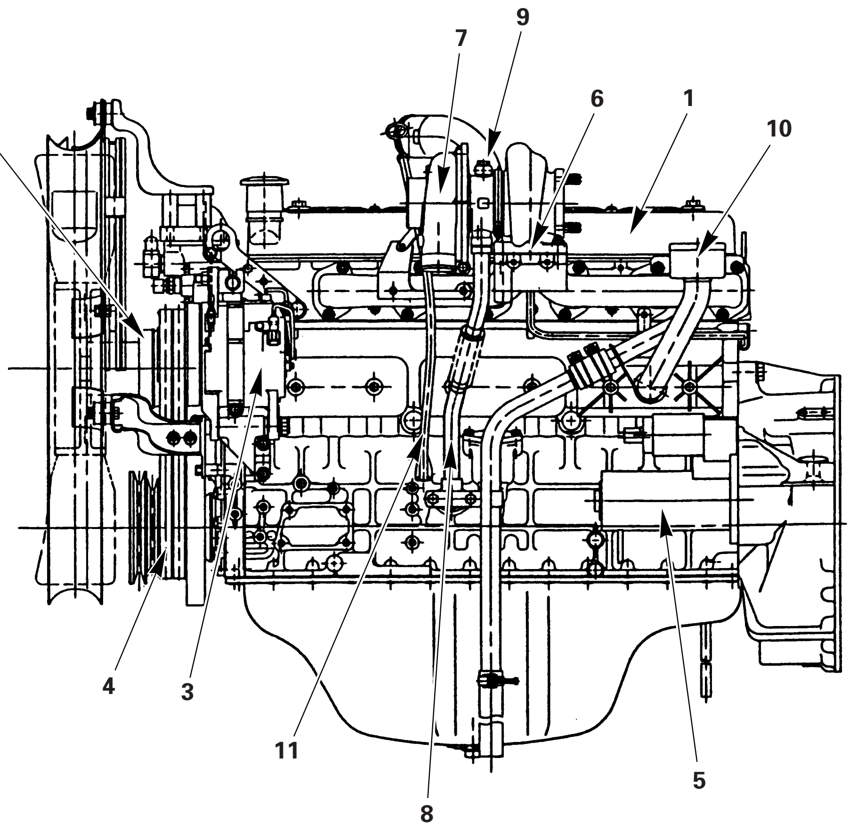
Rocker Arm Shaft Bracket Bolt and Nut Torque	25–35 (2.6–3.6/19–26)



5) Adjust the valve clearance.

Refer to MAINTENANCE for the valve clearance adjustment procedure.

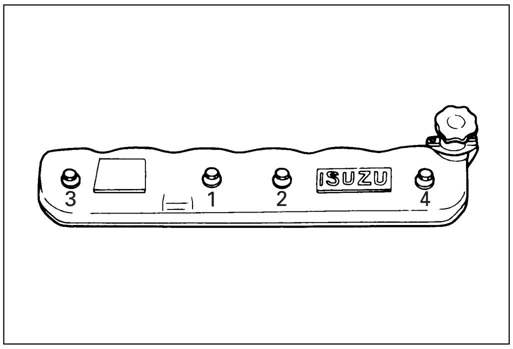
EXTERNAL PARTS REASSEMBLY STEPS (Left-hand side)



Reassembly Steps

- ▲ 1. Cylinder head cover
- 2. Fan pulley
- 3. Alternator
- ▲ 4. Fan belt
- ▲ 5. Starter
- ▲ 6. Turbocharger mounting flange gasket.
- ▲ 7. Turbocharger
- ▲ 8. Oil drain pipe
- ▲ 9. Oil feed pipe
- 10. Air breather
- 11. Dipstick and guide tube

Note: Some components and shapes are different due to the difference of the models and the specifications.



Important Operations

1. Cylinder Head Cover

1) Check that the rocker arms, the rocker arm shafts, and the valve springs are thoroughly lubricated with engine oil.

   If required, relubricate these parts.

2) Place the cylinder head cover gasket on the cylinder head cover.

   Check the head cover gasket for looseness.

3) Tighten the cylinder head cover bolts to the specified torque a little at a time in the sequence shown in the illustration.

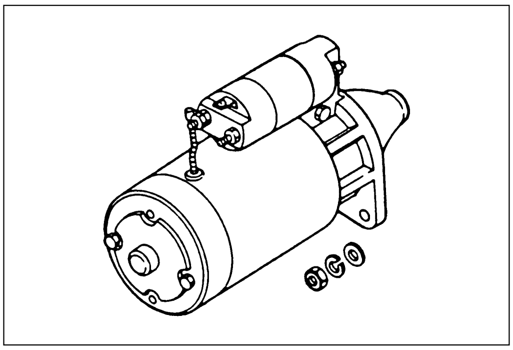
N·m (kgf·m/lb.ft)

Cylinder Head Cover Bolt Torque	7.8 – 9.8 (0.8 – 1.0/5.8 – 7.2)

4. Fan Belt

Adjust the fan belt tension.

Refer to MAINTENANCE for the fan belt tension adjustment.

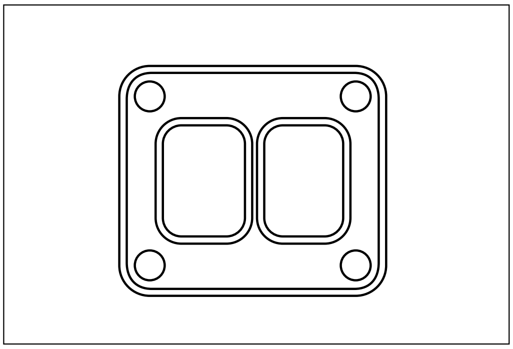


5. Starter

Install the starter to the flywheel housing and tighten the bolts to the specified torque.

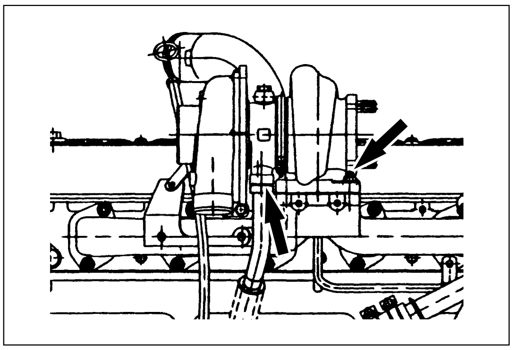
N·m (kgf·m/lb.ft)

Starter Fixing Bolts Torque	75 – 91 (7.6 – 9.3/55 – 67)



6. Turbocharger Mounting Flange Gasket

Carefully position the gasket with the edged side facing up.



7. Turbocharger

Semitighten the turbocharger mounting nuts.

The nuts will be fully tightened after installation of the oil pipes.

N·m (kgf·m/lb.ft)

Turbocharger Mounting Nut Torque	42 – 62 (4.3 – 6.3/31 – 46)

8. Oil Drain Pipe

1) Remove the exhaust manifold distance tube immediately beneath the turbocharger.

   This will make it easier to install the oil drain pipe.

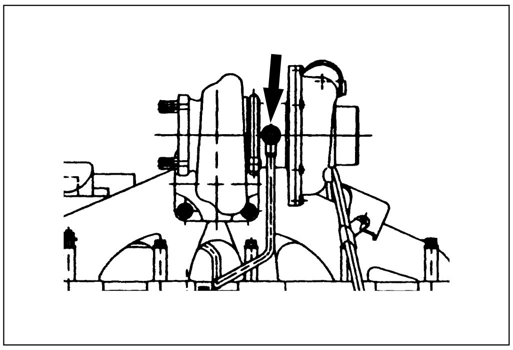
2) Install the oil drain pipe and tighten the oil drain pipe flange nuts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Drain Pipe Torque	28 – 46 (2.9 – 4.7/21 – 34)

3) Reinstall the exhaust manifold distance tube and tighten it to the specified torque.

   Exhaust manifold nut torque is shown in the page 5-6.



9. Oil Feed Pipe

1) Pre-lubricate the turbocharger with CD grade oil through the oil port shown by the arrow in the illustration.

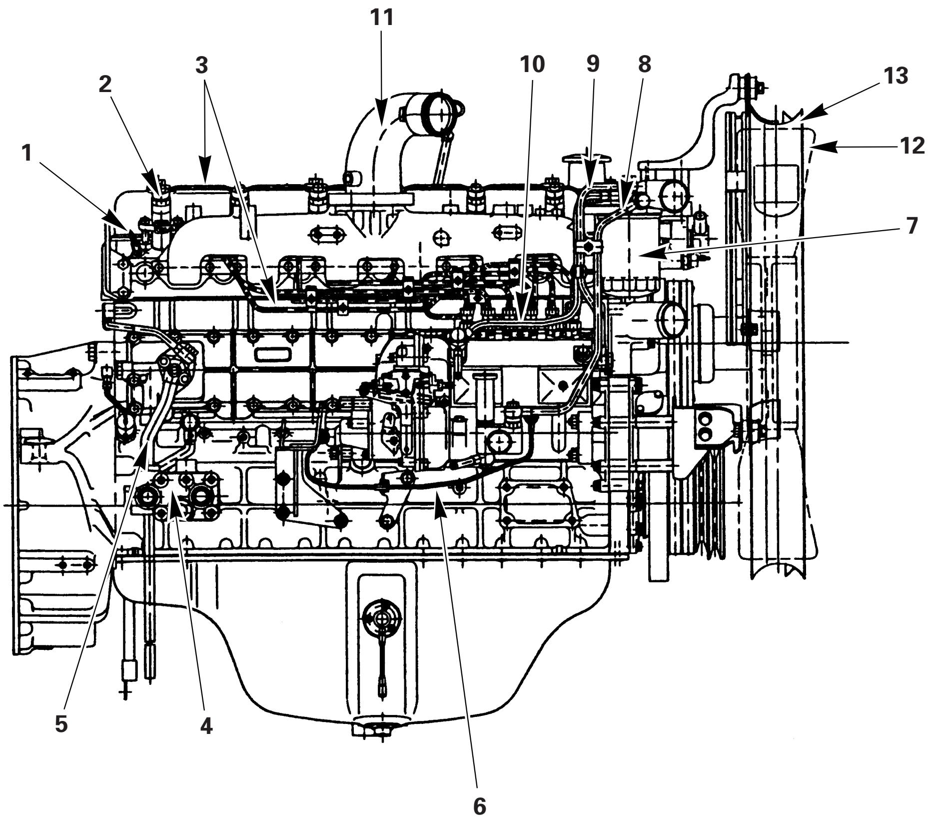
2) Install the oil feed pipe and tighten the pipe flange bolts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Feed Pipe Flange Bolt Torque	16 – 25 (1.6 – 2.6/12 – 19)

EXTERNAL PARTS REASSEMBLY STEPS (Right-hand Side)

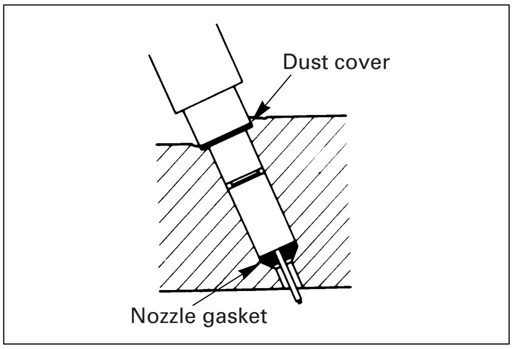
MODEL 6BG1T



Reassembly Steps

1. Glow plug
▲ 2. Injection nozzle
▲ 3. Injection pipe and fuel leak off pipe
▲ 4. Oil port cover
5. Oil pipe; filter to cooler
6. Oil pipe; injection pump to engine body
7. Fuel filter
▲ 8. Fuel pipe; feed pump to fuel filter
▲ 9. Fuel pipe; fuel filter to injection pump
▲ 10. Fuel return pipe
▲ 11. Inlet pipe
12. Cooling fan
▲ 13. Fan guide

Note: Some components and shapes are different due to the difference of the models and the specifications.



Important Operation

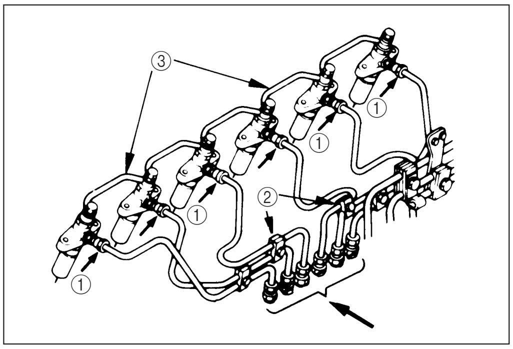
2. Injection Nozzle

Install the injection nozzles with the injection nozzle gaskets.

Be careful not to damage the nozzle tips.

N·m (kgf·m/lb.ft)

Injection Nozzle Bolt Torque	17 – 21 (1.7 – 2.1/12 – 15)



3. Injection Pipe and Fuel Leak Off Pipe

1) Install the fuel injection pipes ① and tighten the bolts to the specified torque.

N·m (kgf·m/lb.ft)

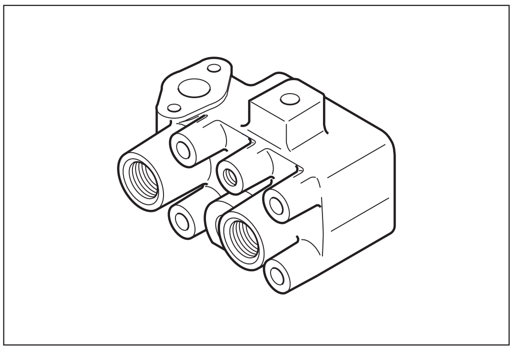
Injection Pipe Torque	28 – 32 (2.9 – 3.3/21 – 24)

2) Carefully position and set the clips ②.

   It is very important that each clip be positioned correctly.

   An improperly positioned clip will result in objectionable fuel pulsing noise and injection pipe breakage.

3) Install the fuel leak off pipes ③.

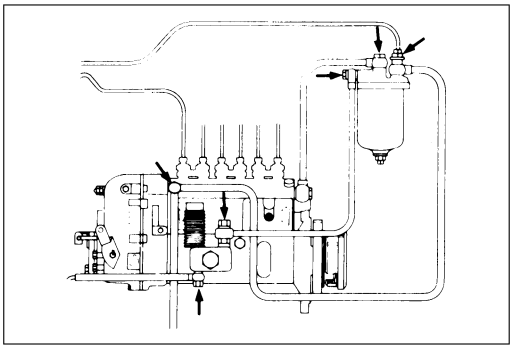


4. Oil port cover

Install the oil port cover with tightening the bolts securely.

N·m (kgf·m/lb.ft)

Oil Port Cover Bolt Torque	42 – 62 (4.3 – 6.3/31 – 46)



8. Fuel Pipe (Feed Pump to Fuel Filter)

9. Fuel Pipe (Fuel Filter to Injection Pump)

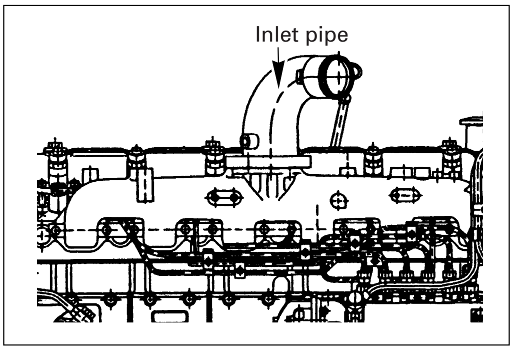
10. Fuel Return Pipe

Install the fuel pipes and tighten the fuel pipe joint bolts to the specified torque.

Take care not to interchange the check valves and joint bolts.

N·m (kgf·m/lb.ft)

Fuel Pipe Joint Bolt Torque	16 – 18 (1.6 – 1.8/12 – 13)

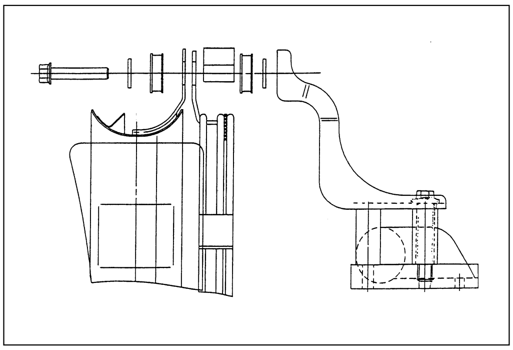


11. Inlet Pipe

Install the inlet pipe and tighten the inlet pipe flange bolts to the specified torque.

N·m (kgf·m/lb.ft)

Inlet Pipe Flange Bolt Torque	21 – 30 (2.1 – 3.1/15 – 22)



13. Fan guide

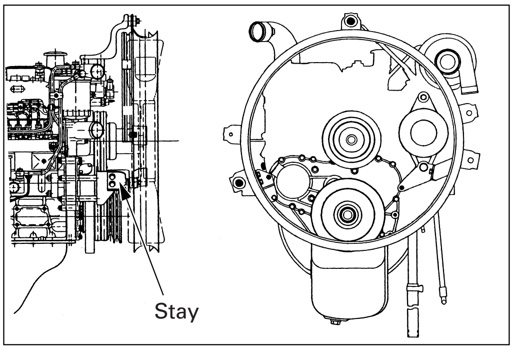
Install the upper bracket, mount rubber, fan guide and fan guard, and tighten the bolts to the specified torque.

N·m (kgf·m/lb.ft)

Mount Rubber Fixing Bolt Torque	30 (3.1/22)

N·m (kgf·m/lb.ft)

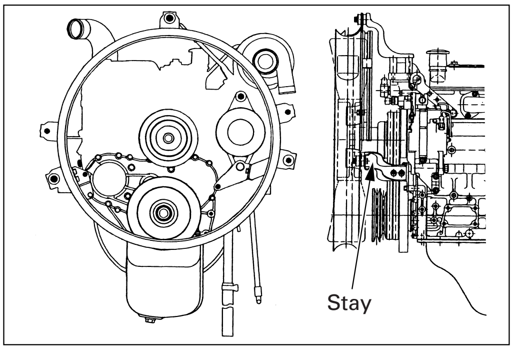
Bracket Fixing Bolt Torgue	40 (4.1/30)



Stay (Right side)

N·m (kgf·m/lb.ft)

Stay Fixing Bolt Torgue	40 (4.1/30)



Stay (Left side)

N·m (kgf·m/lb.ft)

Stay Fixing Bolt Torgue	40 (4.1/30)

Fan and Fan guide clearance

Adjust the clearance between the fan and fan guide.

mm (in)

Clearance between fan and fan guide	4 – 8 (0.157 – 0.315)

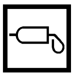
Injection Timing Adjustment

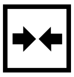
Check that the fuel injection timing is correct.

Refer to "MAINTENANCE" for the injection timing adjustment.

ENGINE TUNING OPERATION

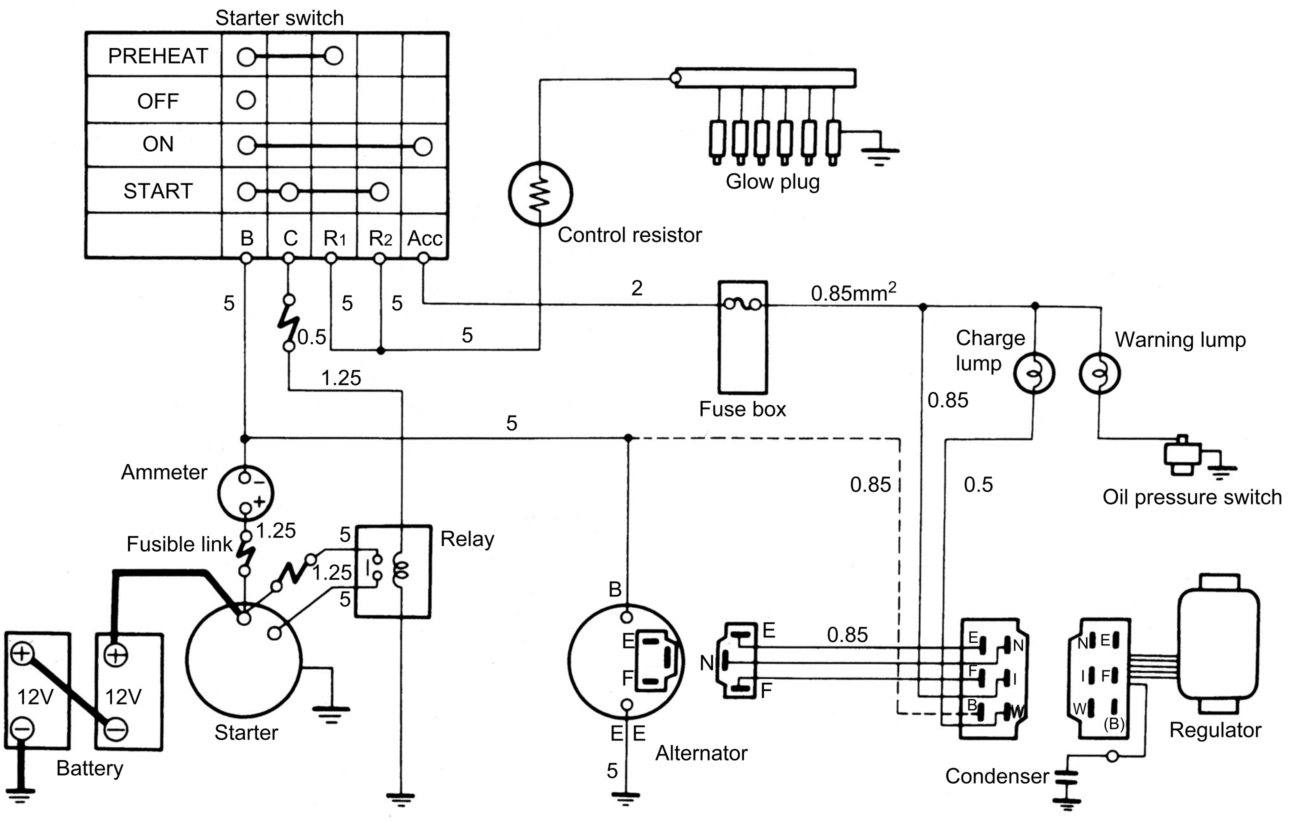
After reassembly, the engine must be tuned. This will ensure that the engine operates at its maximum efficiency.

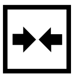


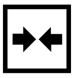


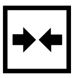
1. Mount the engine on a test bench.
2. Fill the engine with the specified oil.
3. Connect the cooling pipes and the fuel pipes.

Reference









4. Connect the electrical wiring.

   Refer to the wiring diagram.
5. Connect the air intake line to the air cleaner.
6. Connect the exhaust pipe.
7. Manually operate the fuel feed pump to feed fuel to the engine.
8. Bleed the fuel lines of air.

   Refer to Page 2-6 of Section 2 MAINTENANCE for the air bleeding procedure.

9. Crank the engine with the starter (non-ignition operation) for about twenty seconds.

   This will prelubricate the engine internal components.

10. Start the engine and allow it to run at 750 to 800 min^{-1} for five minutes.
11. Remove the cylinder head cover while the engine is running.
12. Check that the engine oil is continuously circulating from the oil pump to the valve rockers through the cylinder head.

    If there is no oil circulation or if the oil circulation is sluggish, stop the engine and make the appropriate repairs or adjustments.

    Reinstall the cylinder head cover.

13. Increase the engine speed to 1,500 min^{-1} to do the engine warming-up operation.
14. Check the engine for oil, fuel, coolant, and air intake leakage.
15. Check for abnormal noise and odor.
16. Check for abnormal electrical charging.
17. Check the engine fastening parts for looseness.
18. When the engine coolant temperature reached to 75°C (167°F) or more, increase the engine speed to 2,000 min^{-1} and allow it to run for twenty minutes.

    This will give the engine the essential run-in operating time.

19. Adjust the engine operation speed to the specified value.
20. Stop the engine to complete the tuning procedure.

SECTION 6

LUBRICATING SYSTEM

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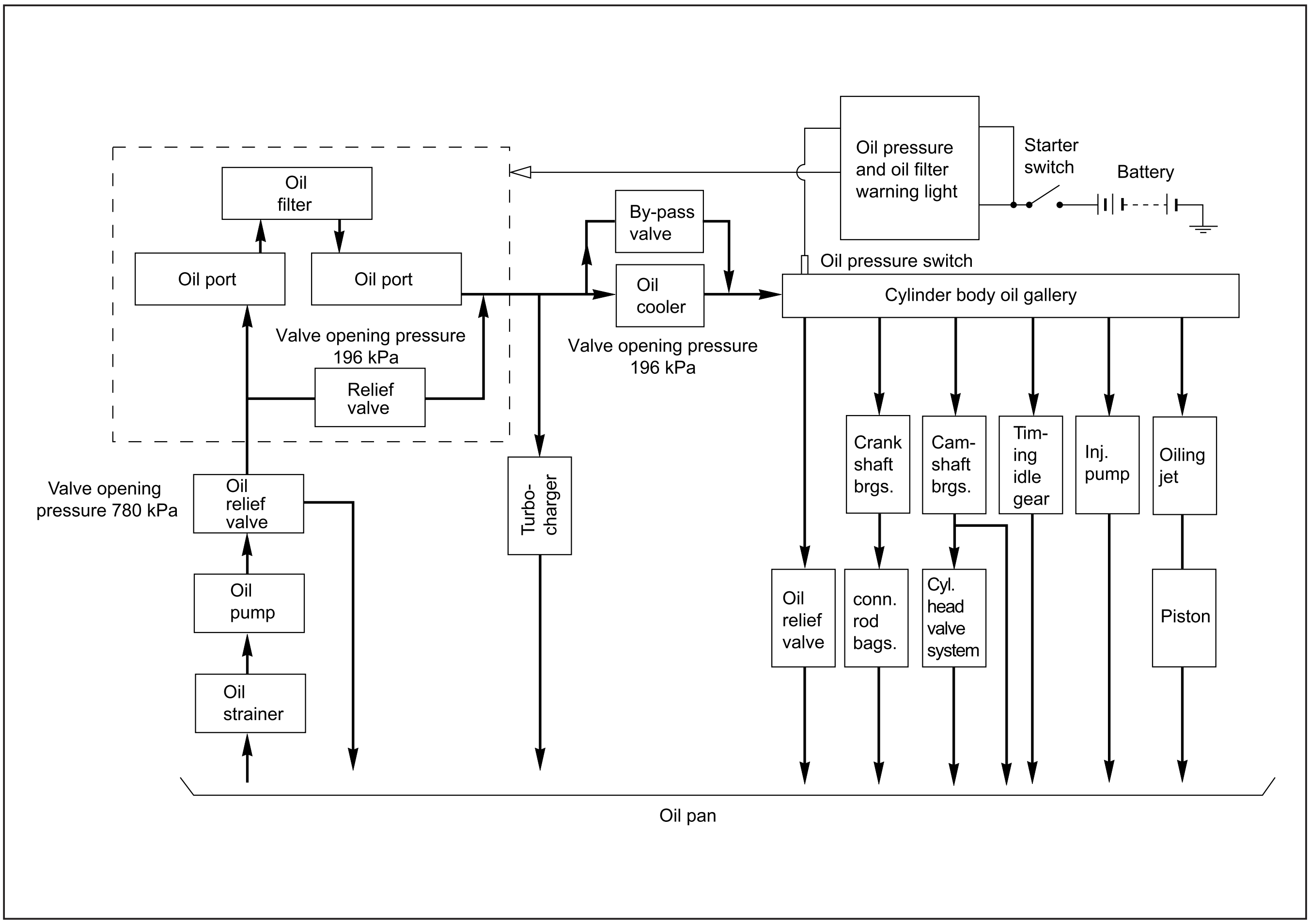
ITEM **PAGE**

GENERAL DESCRIPTION



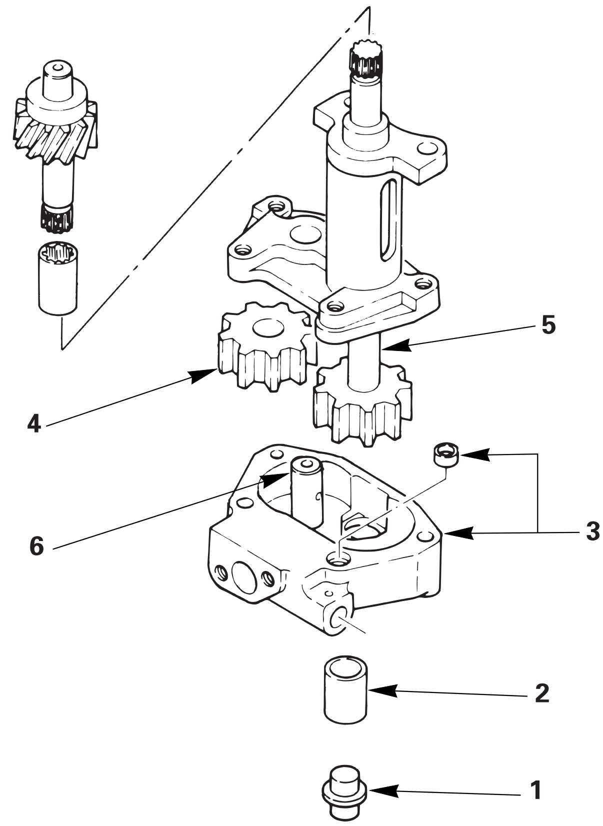
This family of engines uses a normal forced circulation lubricating system.

The gear type oil pump is driven by the camshaft oil pump drive.

The cartridge (spin-on) type oil filter is used.

OIL PUMP

DISASSEMBLY

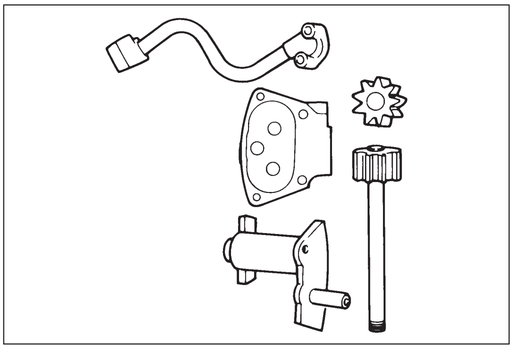


Disassembly Steps

1. Strainer
2. Suction pipe
3. Cover and dowel
4. Driven gear
5. Drive shaft and gear
6. Driven gear shaft

INSPECTION REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

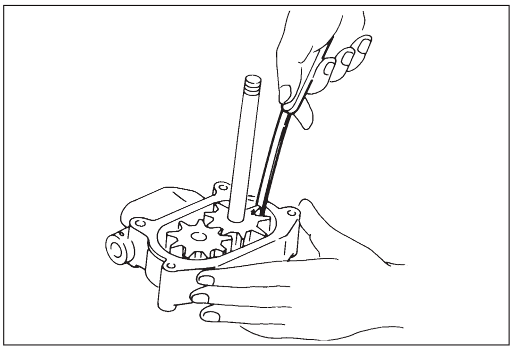


Visually inspect the disassembled parts for excessive wear and damage.

Oil Pump Drive Gear

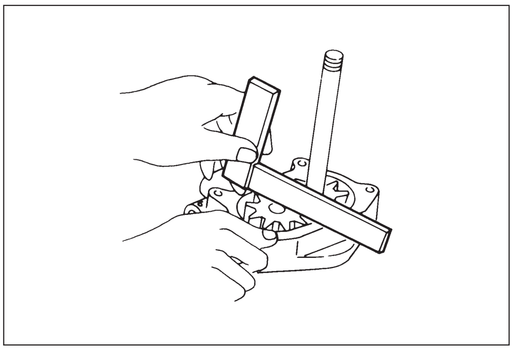
Use a feeler gauge to measure the clearance between the oil pump cover (oil pump case) inside surface and the drive gear.

If the clearance exceeds the specified limit, the drive gear and/or the oil pump cover must be replaced.



mm (in)

	Limit
Oil Pump Cover and Oil Pump Drive Gear Clearance	0.20 (0.0079)



Oil Pump Driven Gear

Use a feeler gauge to measure the clearance between the oil pump case cover inside surface and the driven gear.

If the clearance exceeds the specified limit, the driven gear or the oil pump cover must be replaced.

mm (in)

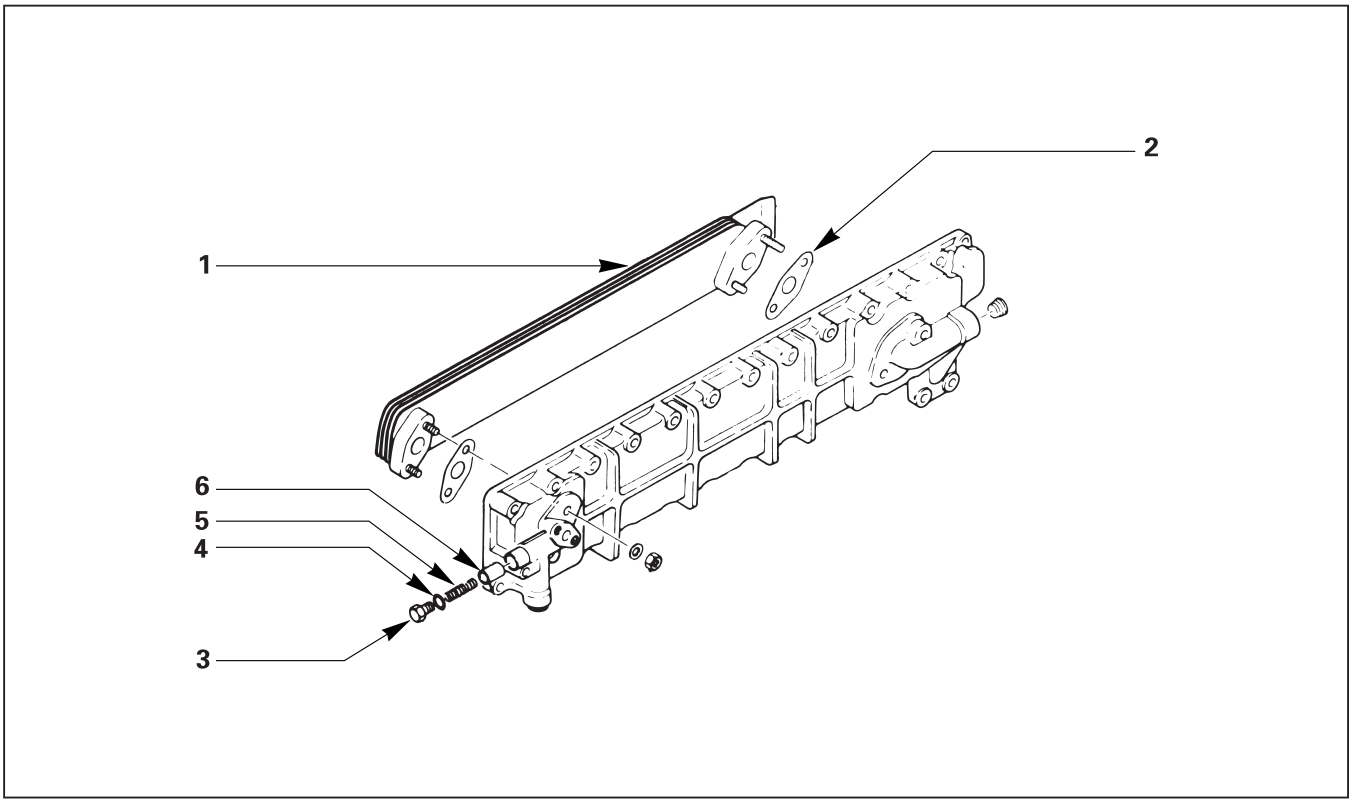
	Limit
Oil Pump Body and Driven Gear Clearance	0.15 (0.0059)

REASSEMBLY

To assemble, follow the disassembly procedures in reverse order.

OIL COOLER

DISASSEMBLY



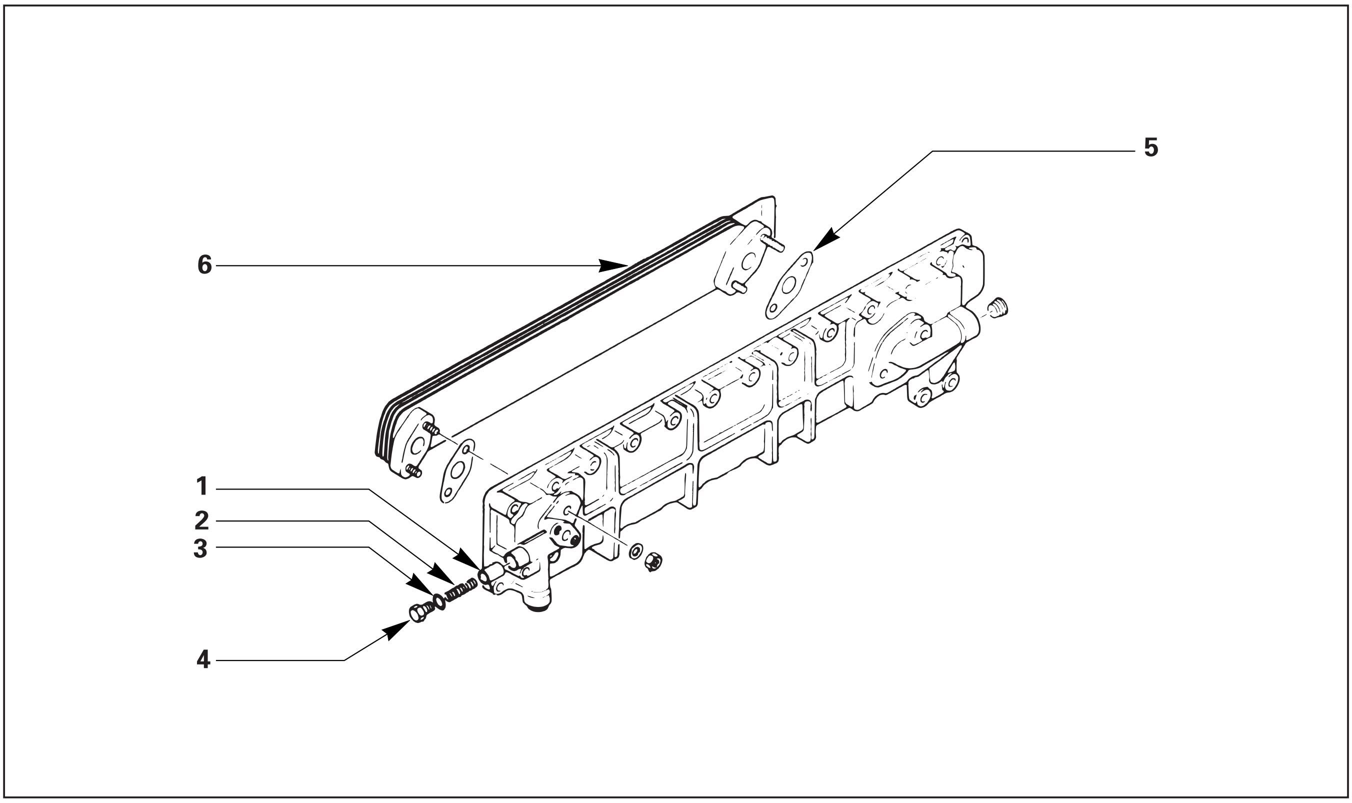
Disassembly Steps

1. Oil cooler element
2. Element gasket
3. By-pass valve plug
4. O-ring; plug
5. By-pass valve spring
6. By-pass valve

INSPECTION AND REPAIR

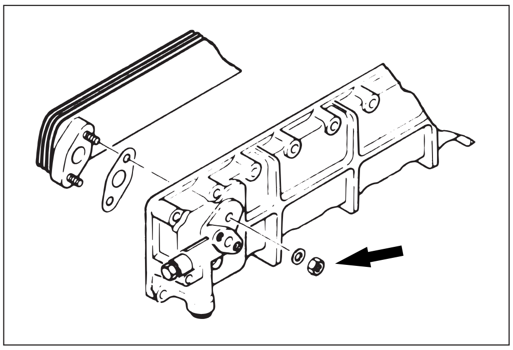
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

REASSEMBLY



Reassembly Steps

1. By-pass valve
2. By-pass valve spring
3. O-ring; plug
4. By-pass valve plug
5. Element gasket
6. ▲ Oil cooler element



Important Operation

6. Oil Cooler Element

Install the oil cooler element to the oil cooler, and tighten the cooler element fixing nuts to the specified torque.

N·m (kgf·m/lb.ft)

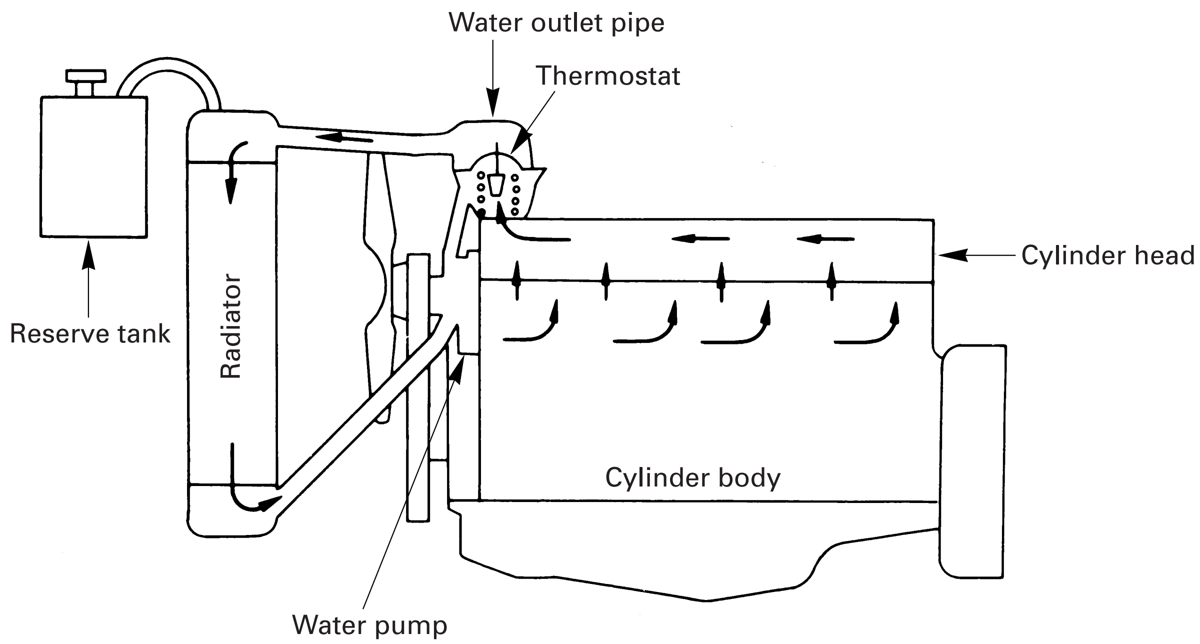
Oil Cooler Element Fixing Nut Torque	25–34 (2.5–3.5/18–25)

SECTION 7

COOLING SYSTEM

TABLE OF CONTENTS

GENERAL DESCRIPTION

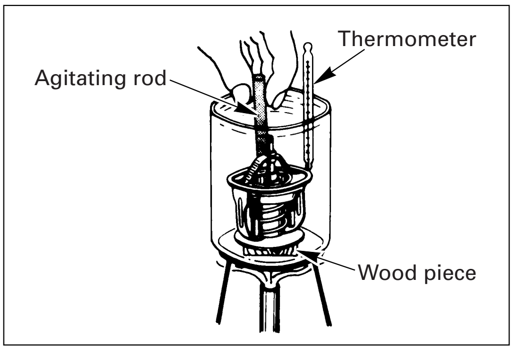


This family of engines uses a pressurized, forced circulation cooling system with a V-belt driven centrifugal water pump and a wax pellet thermostat with jiggle valve.

THERMOSTAT

INSPECTION AND REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



Visually inspect the thermostat function referring Section 2 MAINTENANCE in page 2-7.

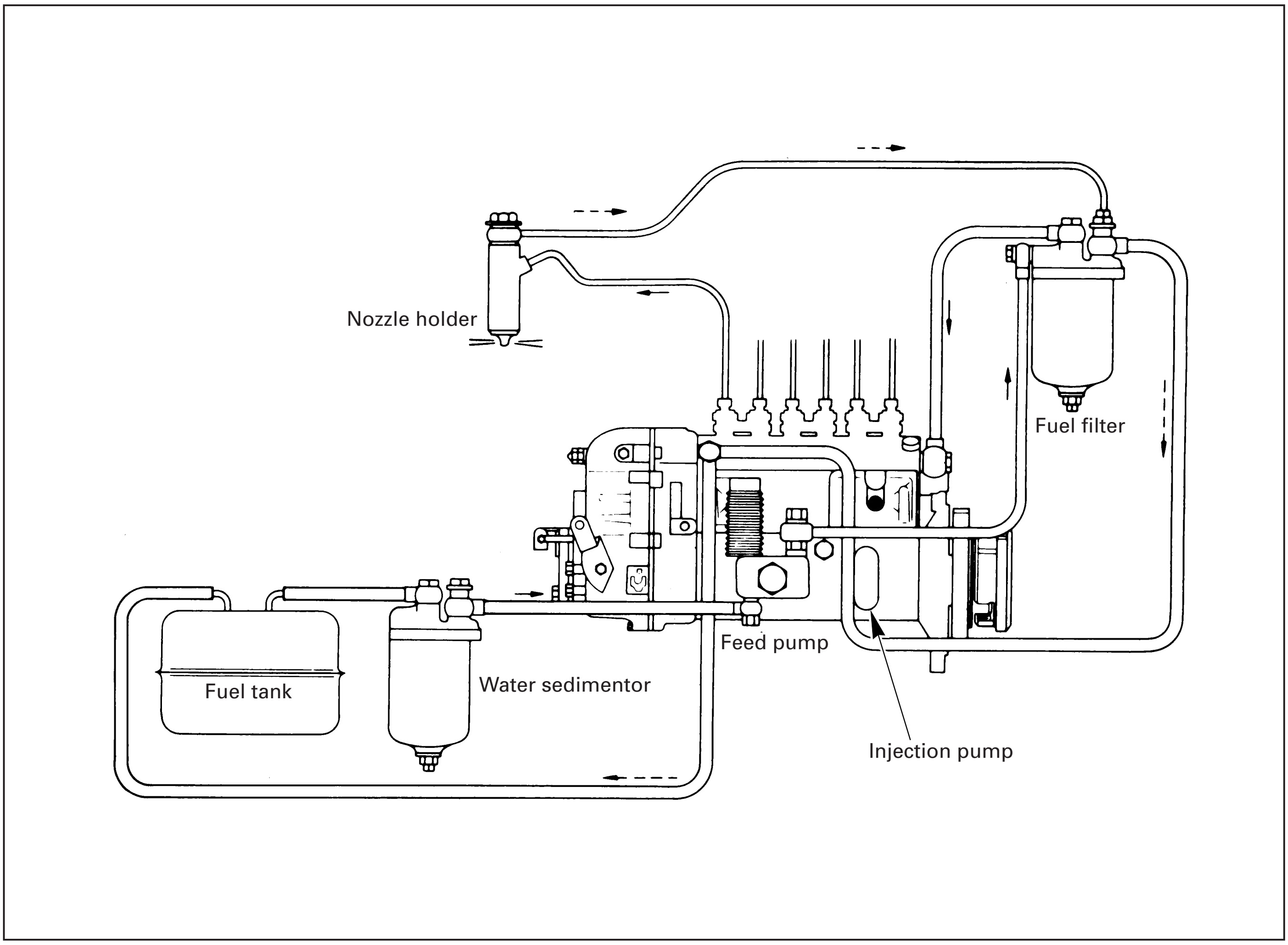
MEMO

SECTION 8

FUEL SYSTEM

TABLE OF CONTENTS

GENERAL DESCRIPTION



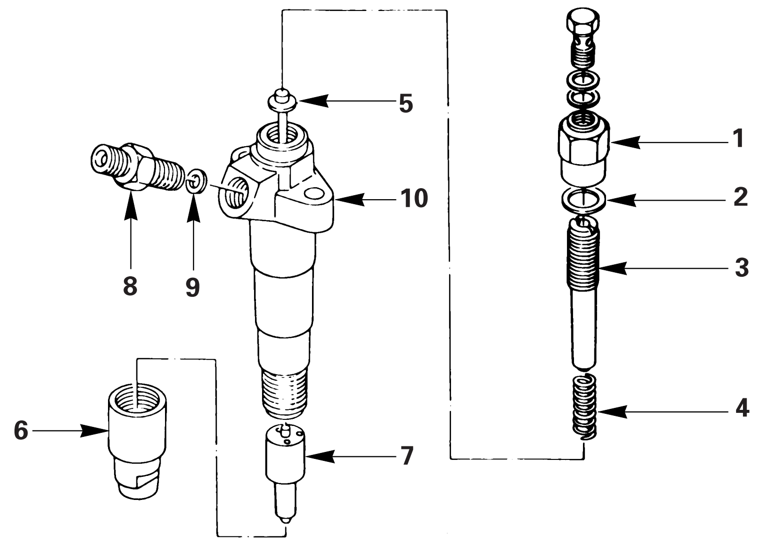
The fuel system consists of the fuel tank, the water sedimentor, the fuel filter, the injection pump, and the injection nozzle.

The fuel from the fuel tank passes through the water sedimentor and the fuel filter where water particles and other foreign material are removed from the fuel.

Fuel, fed by the injection pump plunger, is delivered to the injection nozzle in the measured volume at the optimum timing for efficient engine operation.

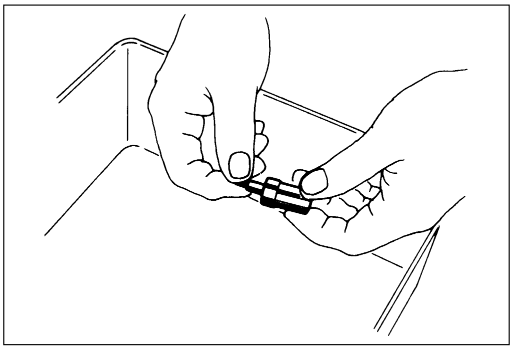
INJECTION NOZZLE

DISASSEMBLY



Disassembly Steps

1. Nozzle holder cap nut
2. Cap nut gasket
3. Nozzle adjusting screw
4. Push rod spring
5. Nozzle holder push rod
6. Retaining nut
7. ▲ Injection nozzle
8. Injection pipe connector
9. Connector gasket
10. Nozzle holder body



Important Operation

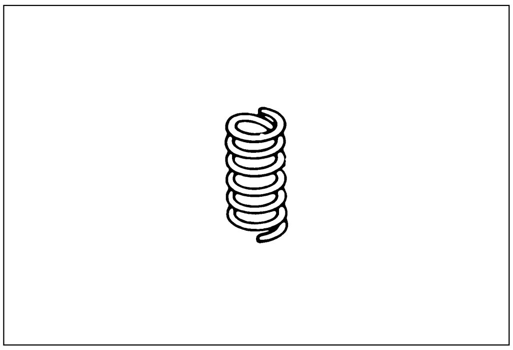
7. Nozzle

Remove the nozzle assembly from the nozzle body.

Keep the parts separately to maintain the proper needle valve to body combination.

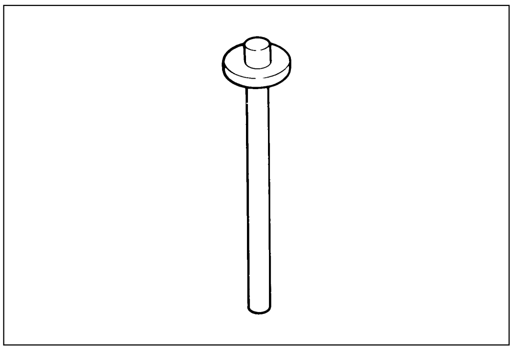
INSPECTION AND REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



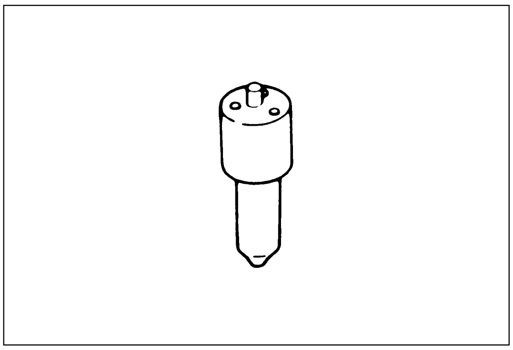
Push Rod Spring

Check the push rod spring for wear, weakness, and corrosion.



Nozzle Holder Push Rod

1. Check the nozzle holder push rod curvature.
2. Check the nozzle holder push rod and needle valve contact surfaces for excessive wear and poor contact.



Injection Nozzle

1. Check the injection nozzle needle valve, the valve seat, and the injection nozzle hole for carbon deposits.

   If carbon deposits are present, the injection nozzle and the needle valve must be replaced.
2. Hold the nozzle body vertically.

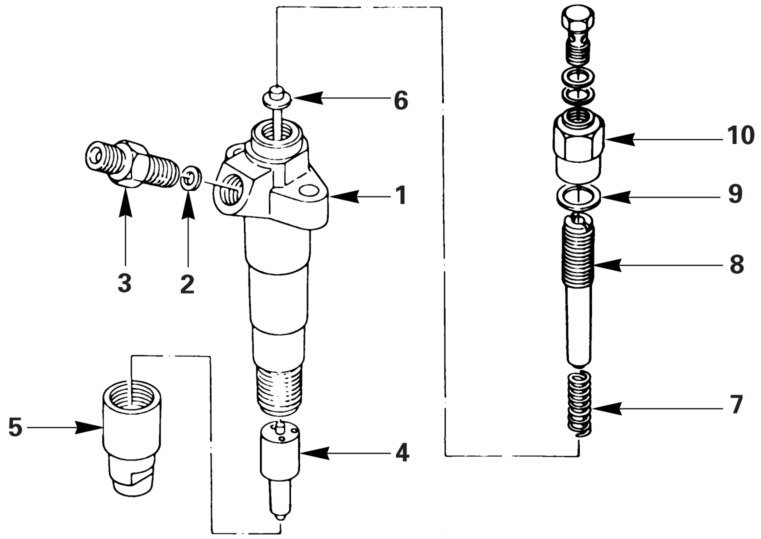
   Pull the needle valve about one-third of the way out of the nozzle body.

   Release the needle valve.

   Check that the needle valve falls back into the nozzle body as far as the valve seat.

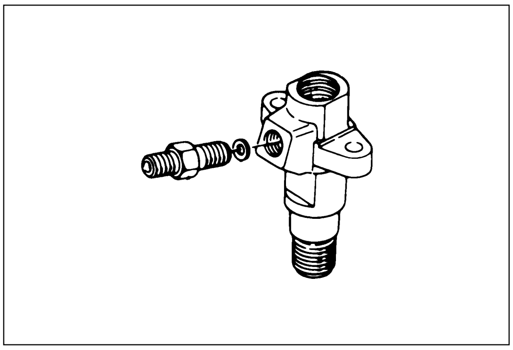
   If the needle valve does not fall back into the nozzle body as far as the valve seat, the injection nozzle and the needle valve must be replaced.

REASSEMBLY



Reassembly Steps

1. Nozzle holder body
2. Connector gasket
3. ▲ Injection pipe connector
4. ▲ Injection nozzle
5. ▲ Retaining nut
6. Nozzle holder push rod
7. Push rod spring
8. Nozzle adjusting screw
9. Cap nut gasket
10. ▲ Nozzle holder cap nut

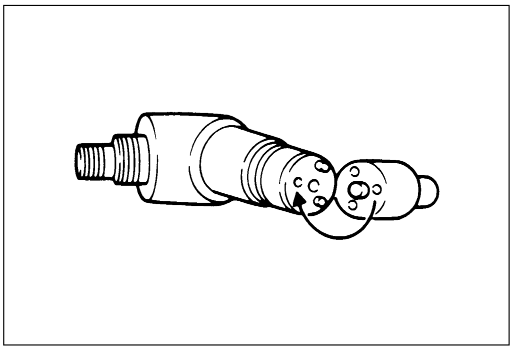


Important Operation

3. Injection Pipe Connector

N·m (kgf·m/lb.ft)

Nozzle Connector Torque	49 – 59 (5.0 – 6.0/36 – 43)

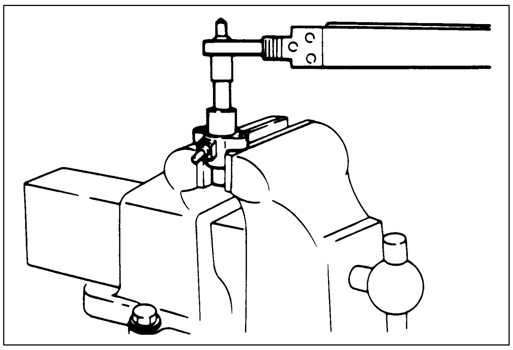


4. Injection Nozzle

There must be no oil on the contact surfaces of the injection nozzle and the injection nozzle holder.

Clean these contact surfaces with diesel fuel before installation.

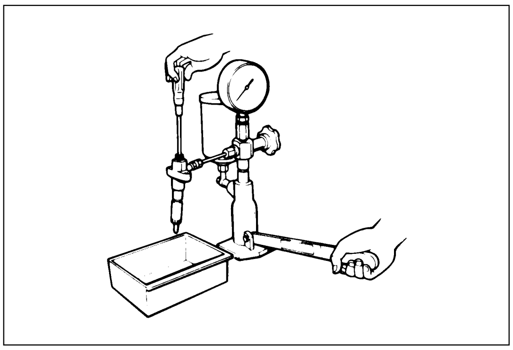
The nozzle dowel pin must be aligned with the dowel hole in the nozzle holder body.



5. Retaining Nut

N·m (kgf·m/lb.ft)

Nozzle Retaining Nut Torque	59 – 78 (6 .0 – 8.0/43 – 58)



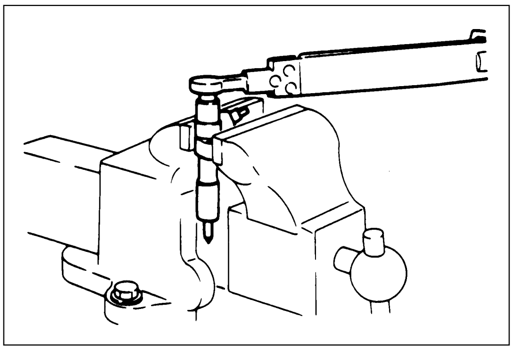
Injection Starting Pressure Adjustment

The injection nozzle injection starting pressure can be adjusted after the adjusting screw is installed.

Refer to "FUEL SYSTEM" on Page 2-4 of the "MAINTENANCE" Section of this Workshop Manual.

MPa (kgf/cm^2/psi)

Injection Starting Pressure	18.1 (185/2630)

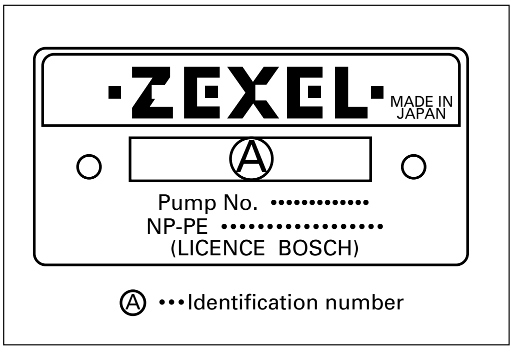


10. Nozzle Holder Cap Nut

N·m (kgf·m/lb.ft)

Cap Nut Torque	39 – 49 (4.0 – 5.0/29 – 36)

INJECTION PUMP CALIBRATION DATA



IDENTIFICATION PLATE AND PRODUCT SERIAL NUMBER

1 . Injection pump adjustment and repair should be made by the nearest ZEXEL CORPORATION or ROBERT BOSCH Authorized Service Outlet.

2. When you ask such authorized service outlet the adjustment or repair, the identification Plate and Product Serial Number will give them a necessary clue to get technical data distributed by the manufacturers previously.

   Without this data, the Service Outlet will be unable to effectively service your injection pump.

   If you are unable to locate the data applicable to your injection pump, please contact ISUZU MOTORS LTD through your machine supplier.

3. Do not remove the Identification Plate and Product Serial Number from the injection pump.

   Keep the Identification Plate and Product Serial Number clean at all times. Do not allow it to rust or become illegible.

Note: Examples of test conditions and calibration data are as follows.

TEST CONDITIONS REQUIRED FOR THE FUEL INJECTION AMOUNT ADJUSTMENT

Injection Nozzle		*ZEXEL No.: 105160-5130 Bosch Type No.: NP-DLLA149SM304
Injection Nozzle Holder		ZEXEL No.: 105030-4750
Injection Starting Pressure	MPa (kgf/cm²/psi)	18.1 (185/2630)
Injection Line Dimensions	mm (in.)	
Inside Diameter		1.8 (0.071)
Outside Diameter		6.0 (0.236)
Length		600.0 (23.6)
Transfer Pump Pressure	kPa (kgf/cm²/psi)	157 (1.6/23)
Testing Diesel Fuel		ISO4113 or SAE Standard Test Oil (SAEJ967D)
Operating Temperature	°C (°F)	40 – 45 (104 – 113)
Pump Rotation Direction		Clockwise (Viewed from the drive side)

INJ. PUMP CALIBRATION DATA

ENGINE MODEL 6BG1–TRA

Ass'y No. 101602–8950
Date : 29 Oct 1999 1
Company : ISUZU
No. 1–15603–328–0

Injection pump : PES6AD 101062–8390 Governor : EP/RSV 105419–4030 Timing device :

1. Test Conditions :

Pump rotation : clockwise (viewed from drive side)

Nozzle & Nozzle Holder Ass'y : 105780–8140 (BOSCH Type No. EF8511/9A)

Nozzle : 105780–0000 (BOSCH Type No. DN12SD12T)   Nozzle Holder : 105780–2080 (BOSCH Type No. EF8511/9)

Nozzle opening pressure : 17.2 MPa (175 kgf/cm^2)   Transfer pump pressure : 157 kPa (1.6 kgf/cm^2)

Injection pipe : Outer Dia. 6 mm × Inner Dia. 2 mm – Length 600 mm

Test Oil : ISO4113 or SAE Standard Test Oil (SAE J967d)   Oil Temp. : 40^{+5} °C

Overflow valve opening pressure : 127 kPa (1.3 kgf/cm^2)

2. Injection Timing :

Pre-stroke : No. 1 Plunger 4.0 ± 0.05 mm   Note : Adjust with rack position of mm

Injection order : 1 —(60°±30′)— 5 , 1 —(120°±30′)— 3 , 1 —(180°±30′)— 6 , 1 —(240°±30′)— 2 , 1 —(300°±30′)— 4

(interval : °± 30′)

Plungers are numbered from the Driver side.

Tappet clearance : Bolt adjustment type ; More than 0.3 mm for all cylinders.
Shim adjustment type ; Manually rotate the camshaft 2~3 times and confirm that it rotates smoothly.

4. Injection Quantity :

Adjusting point	Rack Position (mm)	Pump Speed (r/min)	Injection q'ty (cm^3/1000 strokes)	Max. var bet. cyl (%)	Fixed	Remarks
A	10.3	1,075	89 ± 1.5	± 2	Lever	Basic
C	Approx. 7.5	450	9 ± 1.3	± 14	Rack	
D	–	100	150 ± 5	–	Lever	Rack limit

5. Timing advance specification :

Pump speed (r/min)							
Advance angle (°)							

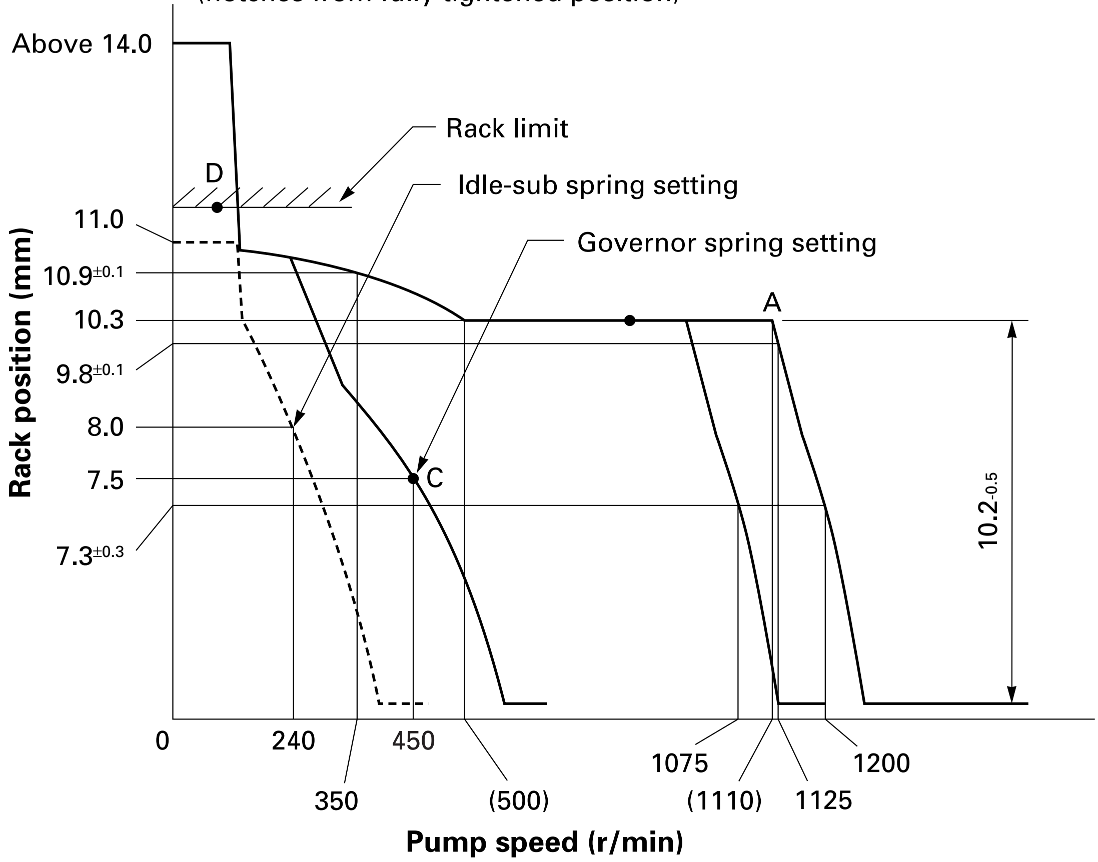
ZEXEL

ZEXEL CORPORATION
Service Department 1

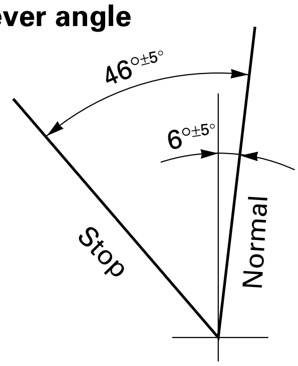
3. Governor adjustment

101602–8950

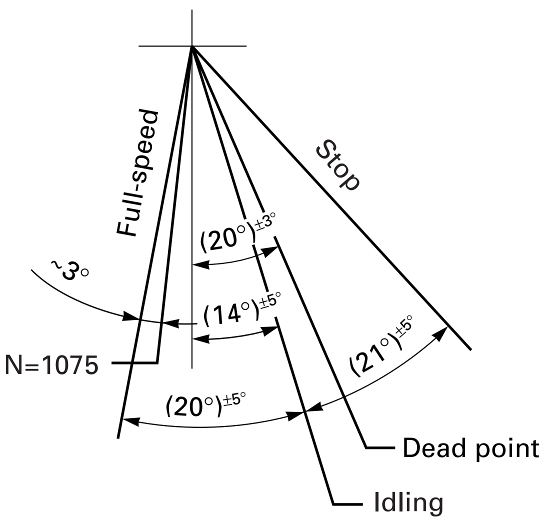
Recommended speed droop adjustment screw position: 9 (notches from fully tightened position)



Stop lever angle



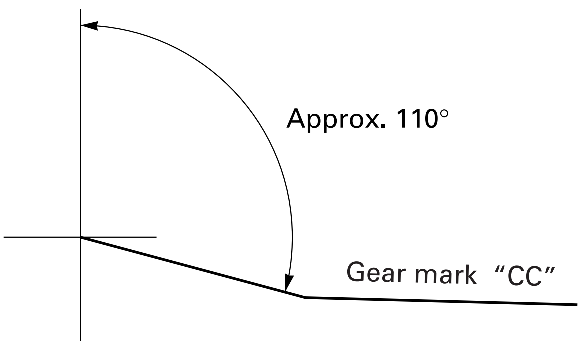
Speed control lever angle



Timing setting

At No.1 plunger's beginning of injection position

B. T. D. C. : 10°



SECTION 9

TURBOCHARGER

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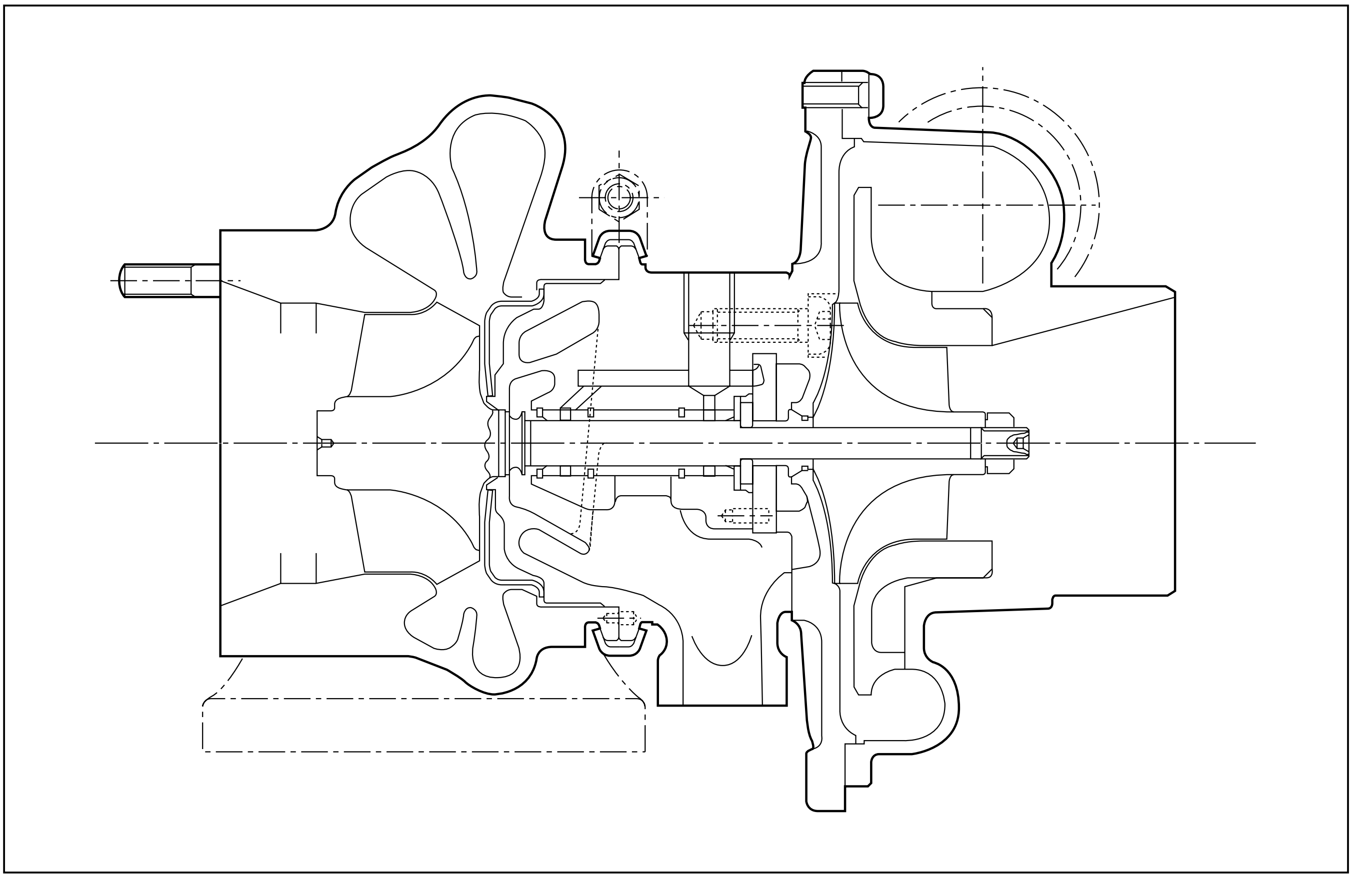
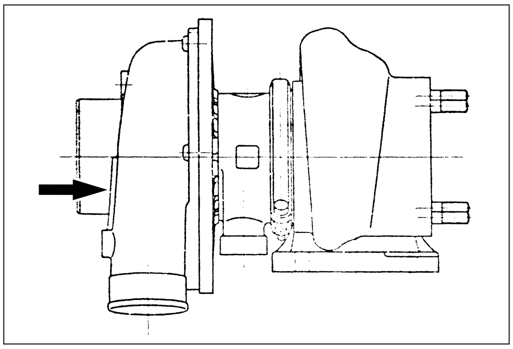
GENERAL DESCRIPTION



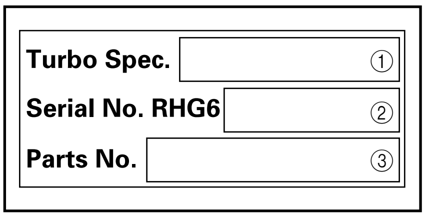
TURBOCHARGER IDENTIFICATION



IDENTIFICATION

The IHI Turbocharger nameplate gives the date of manufacture and other important information required to identify the unit when service inquiries or part orders are made.

The arrow in the illustration indicates the location of the Turbocharger nameplate.



IHI Turbocharger

The turbocharger nameplate has the following information stamped on it. Refer to the illustration at the left.

(1) Turbo Specification Number, Production Year and Month

(2) Production Date, Daily Serial Number

(3) ISUZU Parts Number

ITEM CONFIRMED ON TURBOCHARGER

Before removing the turbocharger, be sure to check the following items:

(1) Oil leak from turbocharger

(2) Abnormal noise from turbocharger

(3) Acceleration is not felt. The engine is out of order.

Caution:

The turbocharger is heated hot right after the engine stops.

Be sure to cool the engine sufficiently for safety before inspection.

TURBOCHARGER CHECKING PROCEDURES

(1) Idle the engine on the machine and visually check all parts around the turbocharger to find abnormal phenomena.

Record the phenomena and their locations if any.

(2) Pay special attention to the states of the air inlet and outlet hoses of the turbocharger, and check that the bands are not loose and no oil is leaking.

(3) Inspect the appearance of the turbocharger referring to the checkpoints for each problem (oil leak, abnormal noise, irregular acceleration and insufficient output).

TROUBLESHOOTING

OIL LEAK

Check the appearance of the turbocharger to find oil leak positions.

Checkpoint	Cause	Remedy
Turbine housing gas inlet and outlet tightening positions. Mating face between turbine housing and bearing housing.	Abrasion of turbo bearing due to trouble in the oil supply system.	Check the turbo air inlet side.
Turbo oil inlet side tightening position.	Loosening of bolt. Damage of O-ring.	Tighten the bolts additionally. Replace the O-ring with a new one.
Outer periphery of compressor housing.	Oil leak from tightening position due to oil leak from the air compressor.	The turbocharger is in order.

ABNORMAL NOISE

Check the situation when an abnormal noise occurs.

Abnormal noise can be divided into the following three types:

Phenomenon	Cause	Remedy
Noise like something passing through the air (Whistling noise).	This noise occurs when the turbocharger rotates at a high speed.	The rotor generally generates this sound. This is not a problem.
Metallic noise	Breakage of foreign matter entered from outside the turbocharger. Abrasion of turbo bearing due to trouble in the oil supply system.	Check the air inlet side of the turbocharger.
Air or gas leaking noise	Loosening or disconnection of air or gas pipe to the turbocharger.	Tighten bolts, screws, hose band, etc. additionally at the air or gas pipe connections.

IRREGULAR ACCELERATION, INSUFFICIENT OUTPUT

The life of the turbocharger has terminated except damage due to abrasion of the bearing.

Checkpoint	Cause	Remedy
Check looseness and disconnection of air and gas pipes to the turbocharger.	Malperformance due to leak of air or exhaust gas.	Tighten bolts, screws and hose bands additionally at the air and gas pipe tightening positions.
Check the air inlet side of the turbo.		
Check the engine body.		

Check of Air Inlet Side of Turbocharger

Disconnect the hose from the air inlet side for the inspection.

Checkpoint	Cause	Remedy
Check if oil adheres the inside and the outside of the air inlet of the turbo.	Oil leak from tightening position due to oil leak from the air compressor.	The turbo is in order.
Looseness or drop of shaft end nuts, bent of blade (Abrasion or damage).	Breakage of foreign matter entered from outside the turbo. Abrasion of the turbo bearing due to trouble in the oil supply system.	Replace the turbo with a new one due to malfunction. When replace the turbo, check if the feed oil pipe is clogged.
Check contact between the blade and the compressor housing.	Abrasion of turbo bearing due to trouble in the oil supply system.	Replace the turbo with a new one due to malfunction. When replacing the turbo, check if the feed oil pipe is clogged.

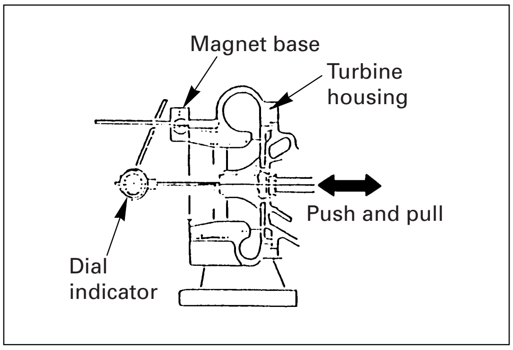
INSPECTION AND REPAIR

If excessive wear or damage is discovered during inspection, the appropriate parts must be adjusted, repaired, or replaced. Damage or improper adjustment of the turbocharger will inhibit sufficient air flow to the engine, preventing it from delivering full performance.

If the engine demonstrates a significant drop in performance, check for engine damage or wear. If no significant engine damage or wear can be found, it is likely that the turbocharger is at fault.

When reduced performance is the result of a faulty turbocharger, contact your nearest IHI or Mitsubishi Service Center for the proper repairs.

The following is primarily a description of the particularly important rotor shaft end play, and bearing clearance standard and limit values.



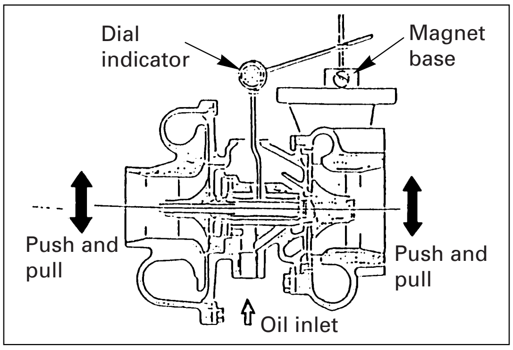
Rotor Shaft Axial Play Measurement

1) Install a dial indicator on the turbine housing as illustrated.
2) Use the dial indicator to measure the rotor shaft axial play with moving the shaft push and pull. Read the total indicator reading (TIR).

mm (in)

IHI RHG6	Limit
Rotor Shaft Axial Play TIR	0.11 (0.00433)

3) If the measured value exceeds the specified limit the shaft must be replaced.



Rotor Shaft Radial Play Measurement

1) Turn over the turbocharger with the turbine exhaust inlet flange facing up.
2) Install a dial indicator to measure the rotor shaft radial play.
3) Use the dial indicator to measure the play. Read the TIR.

mm (in)

IHI RHG6	Limit
Rotor Shaft Radial Play TIR	0.205 (0.00807)

4) If the measured value exceeds the specified limit replace the shaft.

MEMO

SECTION 10

ENGINE ELECTRICALS

TABLE OF CONTENTS

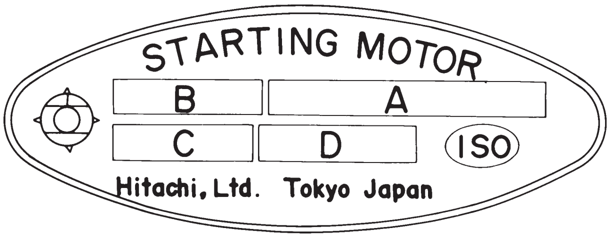
STARTER IDENTIFICATION

The starter identification plate is attached to the starter motor outside yoke. The ISUZU part number, the manufacturer's code number, and other important information are stamped on the plate.

Refer to the identification plate together with the "Main Data and Specifications" Tables and accompanying charts in this Manual when requesting service assistance from a qualified electrical repair shop.

If you are unable to locate the data applicable to your engine, please contact ISUZU MOTORS LIMITED through your machine supplier.

HITACHI IDENTIFICATION PLATE



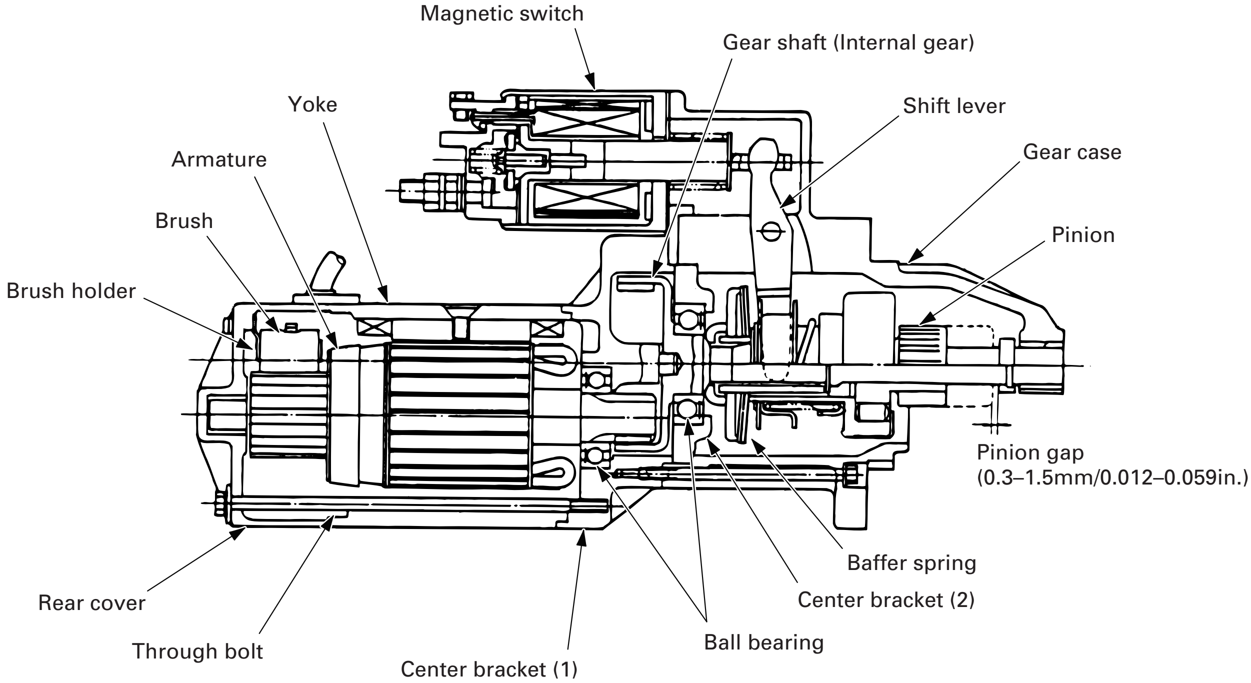
A: Isuzu part number
B: Manufacturer's code number
C: Rated output
D: Manufacturer's production mark

STARTER

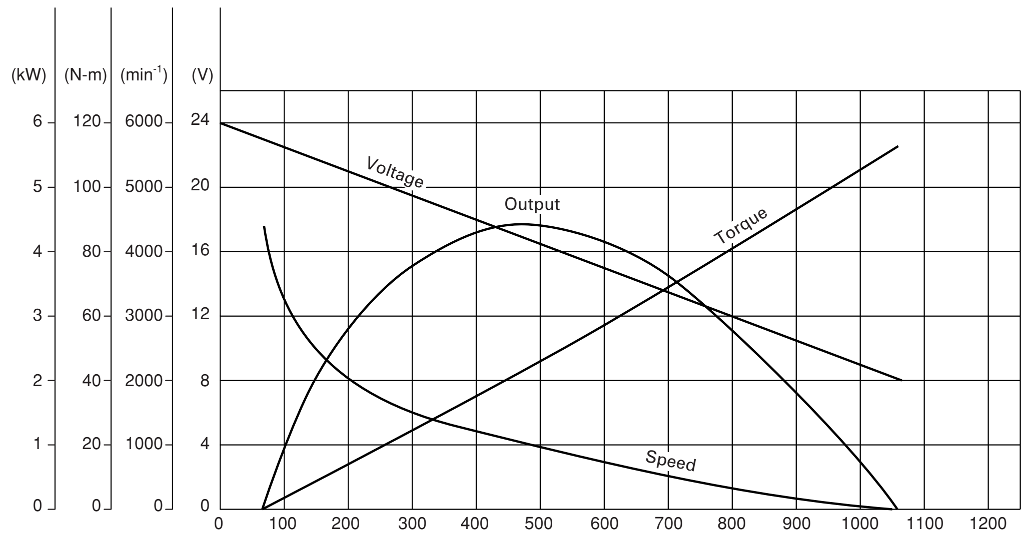
MAIN DATA AND SPECIFICATIONS

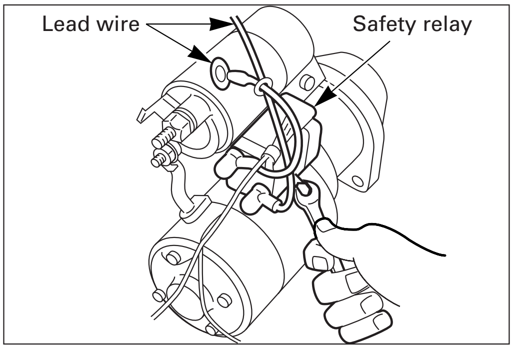
Isuzu Part No.		181100-338*
Manufacturer's code No. (HITACHI)		S25-172
Rated voltage	(V)	24
Rated output	(kW)	4.5
Rating	(Sec)	30
Direction of rotation (Viewed from the pinion side)		Clockwise
Clutch type		Roller
Terminal voltage (No load)	(V)	24
Minimum current (No load)	(A)	Less than 100
Starter motor minimum operating speed (No load)	(min^{-1})	More than 3500
Pinion gear		
Modules		3
Number of teeth		11
Outside diameter	mm (in.)	40.64 (1.60)
Travel distance	mm (in.)	1.5 (0.032)
Yoke outside diameter	mm (in.)	90 (3.54)
Number of poles		4
Magnetic switch (at 20°C [68°F])		
Series coil resistance	(Ω)	0.187
Shunt coil resistance	(Ω)	1.31
Brush length		
Standard	mm (in.)	22 (0.866)
Limit	mm (in.)	14 (0.551)
Brush spring standard fitting load	N (kg/lbs.)	38 (3.85/8.49)
Commutator		
Outside diameter		
Standard	mm (in.)	37.0 (1.457)
Limit	mm (in.)	36.5 (1.437)
Difference between the largest and smallest diameters (Run-out)		
Limit	mm (in.)	0.1 (0.004)
Depth of undercut mica		
Standard	mm (in.)	0.5–0.8 (0.020–0.031)
Limit	mm (in.)	0.2 (0.008)

STARTER MOTOR SECTIONAL VIEW



PERFORMANCE



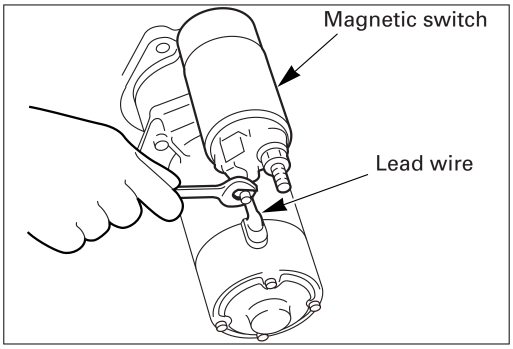


DISASSEMBLY

Removal of Safety Relay

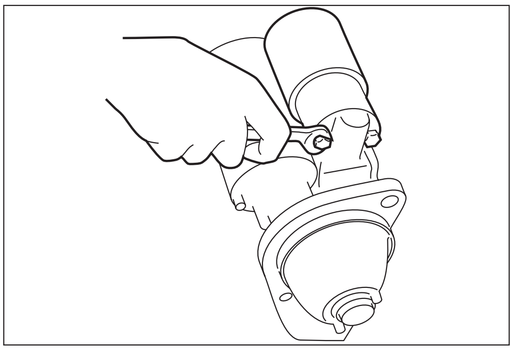
Remove the nut M10 (17 mm/0.669 in) and bolt M5 (8 mm/0.315 in) from the magnetic switch.

Then remove 2 pieces of the bolt M6 (10 mm/0.393 in).



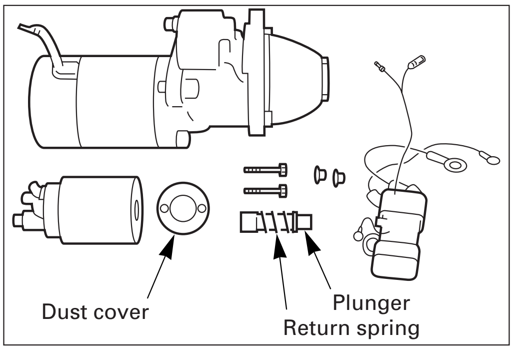
Disconnection of Lead Wire

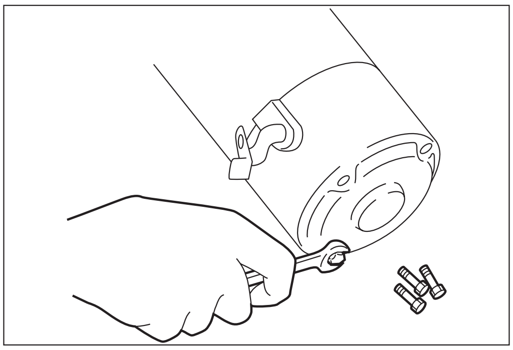
Remove the nut M10 (17 mm/0.669 in) from the magnetic switch and disconnect the lead wire.



Removal of Magnetic Switch

Remove 2 pieces of the bolts M6 (10 mm/0.393 in).

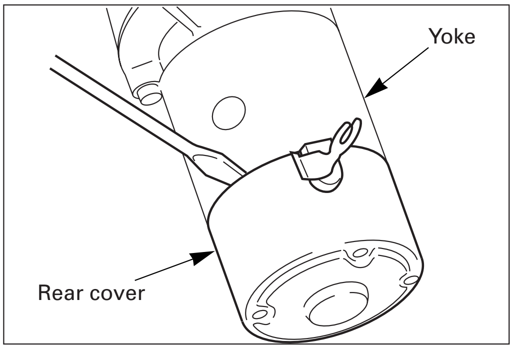


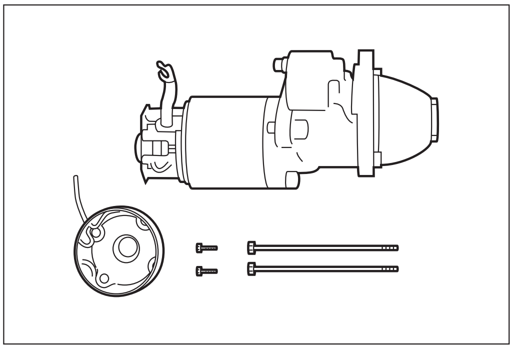


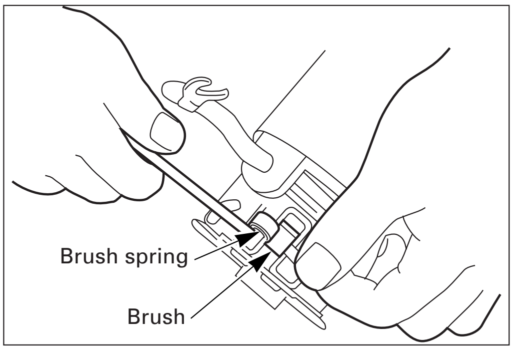
Removal of Rear Cover

Remove 2 pieces of the brush holder tightening screw M4 and then remove 2 pieces of the through bolt M6 (10 mm/0.393 in).

Then, remove the rear cover and the yoke using a straight screwdriver.





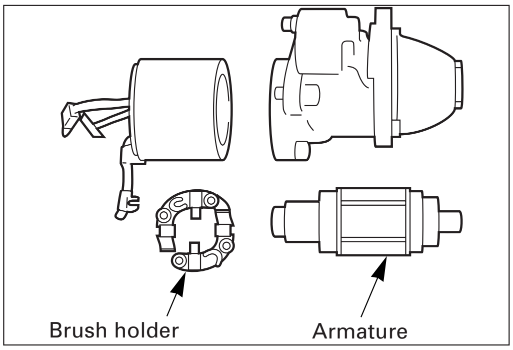


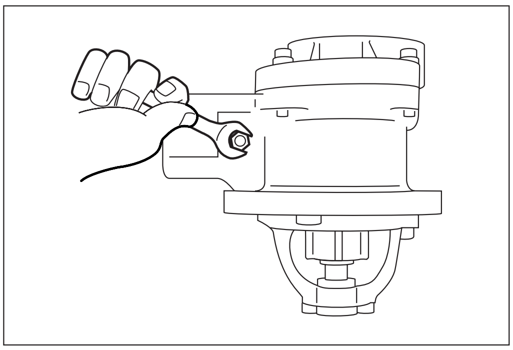
Removal of Brush Holder

For the brush on the (-) side, press the brush spring to the brush side to raise the brush from the commutator face of the armature.

For the brush on the (+) side, pull it out of the brush holder.

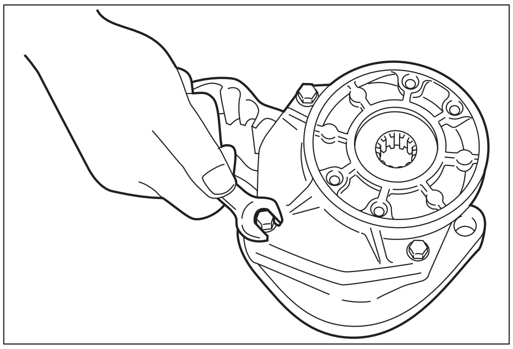
When the brush holder is removed, the yoke can be separated from the center bracket.





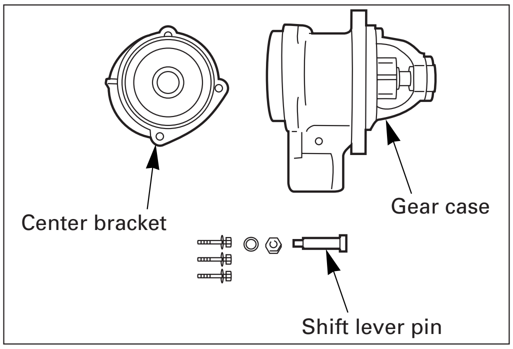
Removal of Shift Lever Pin

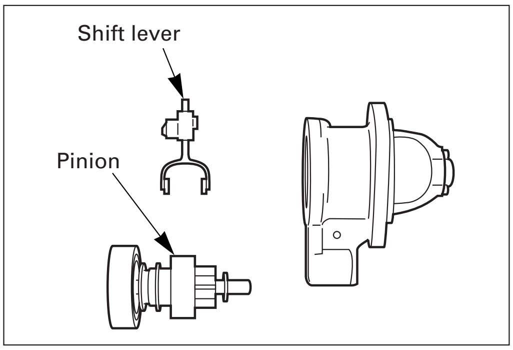
Remove the nut M10 (17 mm/0.669 in) and pull out the shift lever pin.

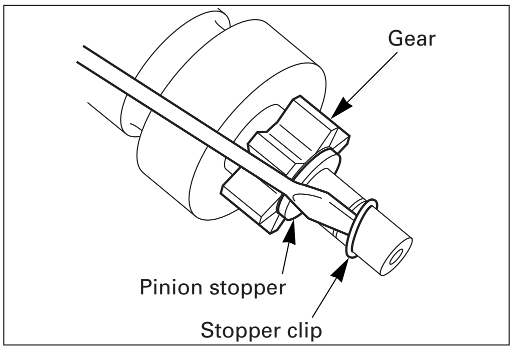


Disassembly of Gear Case and Center Bracket

Remove bolts and separate center bracket from gear case.

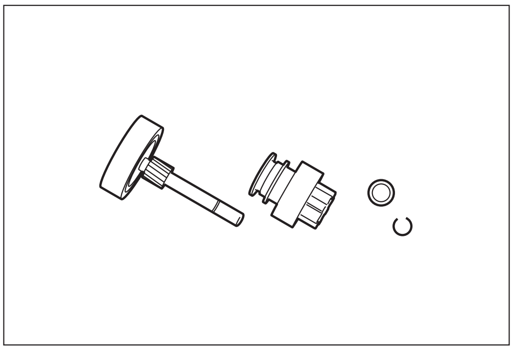






Removal of Pinion

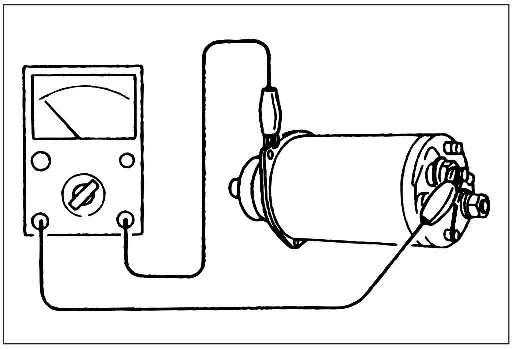
Slide the pinion stopper to the pinion side and remove the pinion stopper grip using a straight screwdriver.



INSPECTION AND REPAIR

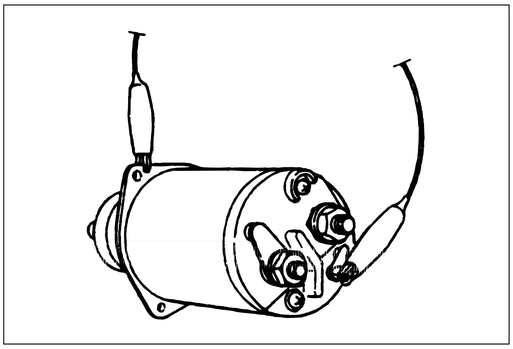
1. Magnetic Switch Assembly

Never perform an operation test of the magnetic switch alone.

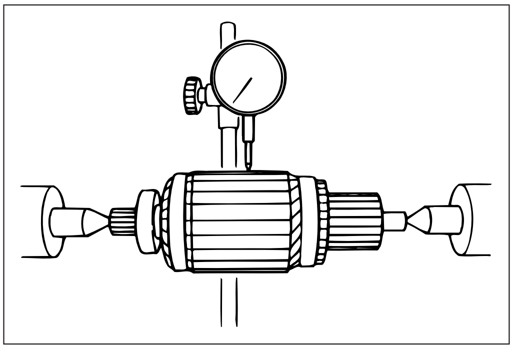


(1) Coil inspection

1) Use a tester to check for shorts in the shunt coil and the series coil.
Check for continuity between the magnetic switch's M terminal and the case; if continuity is not present, a short is likely (resistance value: about 1.0 Ω).



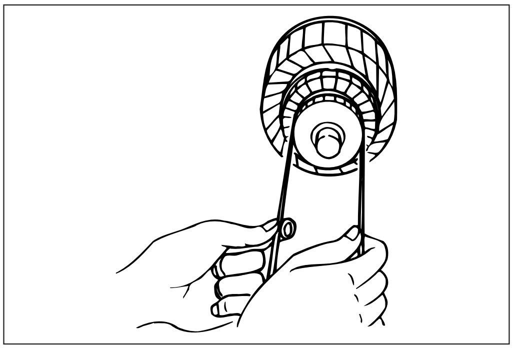
2) Apply 24 V between the case and the magnetic switch's M terminal; if the coil is good, the plunger should not retract; if the plunger attempts to retract, the coil is defective.



2. Armature assembly

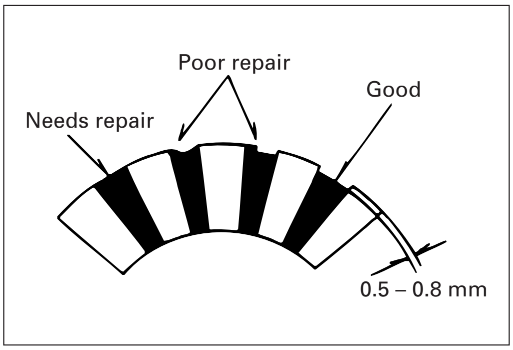
(1) Shaft runout measurement

Measure shaft runout using a dial gauge; if the runout is 0.05 mm (0.002 in) or more, repair or replacement is required.

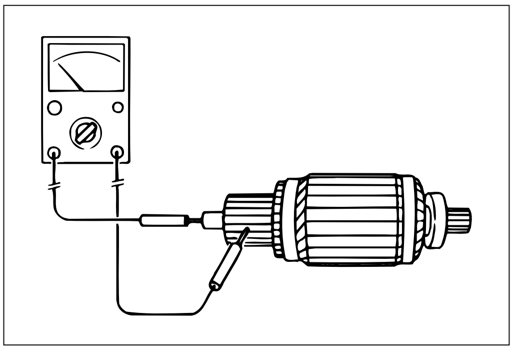


(2) Commutator Inspection

1) Inspect the surface of the commutator. If the surface is rough, sand with #400 – 600 sandpaper; if severely tarnished, or if the runout is 0.1 mm (0.004 in) or more, repair on a lathe.



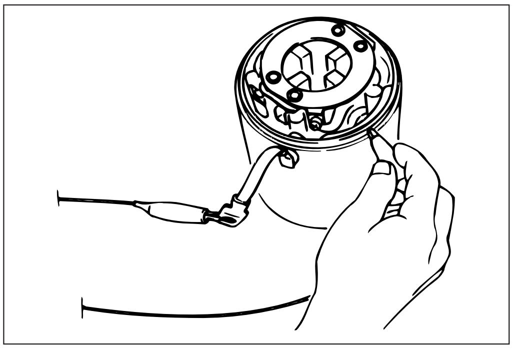
2) Inspect the depth of segment mica undercut, and repair if 0.2 mm (0.008 in) or less.

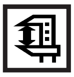


(3) Armature coil inspection

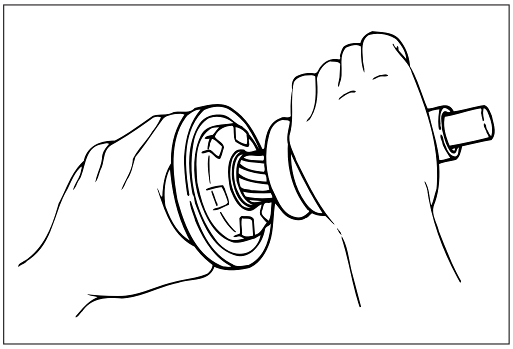
1) Place the armature on a growler tester and hold a piece of steel to the armature core. No vibration should be felt in the steel piece.

2) Check the armature with a tester; no continuity should be present between the commutator and shaft.





3. **Field coil Inspection**
   (1) Use a tester to check for any broken winding. A broken wire is indicated if no continuity is found between the field coil's M terminal and the brush lead wire (shunt coil resistance about 4.3 Ω).
   (2) Check for continuity between the field coil and the yoke; repair or replace if continuity is found. (Perform this measurement with the shunt coil's ⊖ terminal disconnected from the yoke.)



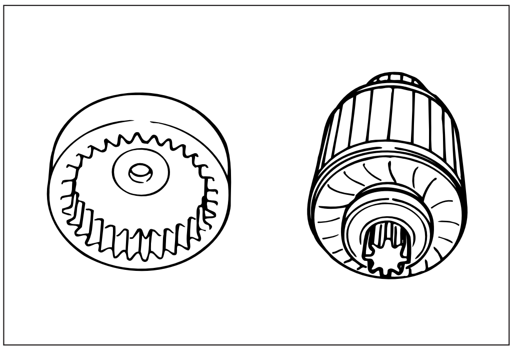
4. **Overrunning clutch**

   Rotate the pinion by hand and confirm that it turns in one direction only.

   Inspect the pinion's teeth and replace those demonstrating excessive wear or damage.

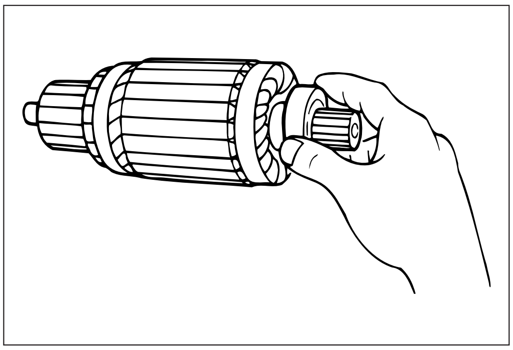
Note:

When cleaning the overrunning clutch, do not immerse the entire clutch in the cleaning solution, since the grease inside the clutch will be dissolved, leading to seizure.



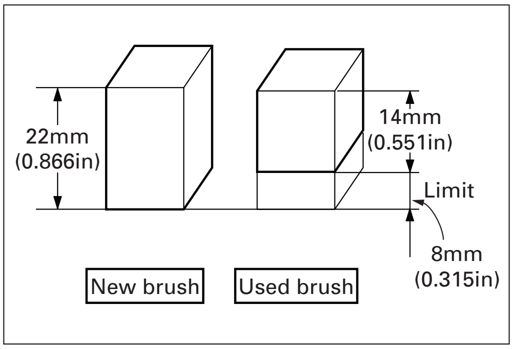
5. **Reduction gear**

   Inspect the reduction gear for excessive wear.



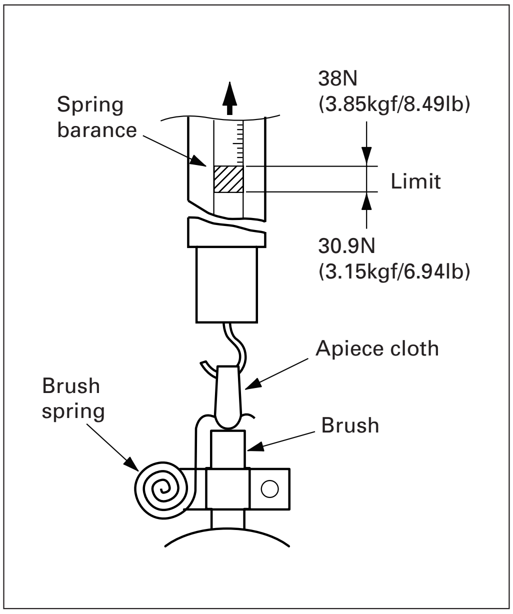
6. **Bearings**

   Rotate the armature bearings' outer race by hand, and confirm that it turns smoothly.



7. Brush

(1) Check the brush wear state and the brush spring pressure.



(2) Check the brush checking action.
When the brush does not move well, check if the brush holder is bent or if the brush holder sliding surface is soiled.
Repair it if necessary and clean the brush holder.

REASSEMBLY

Reassembly is made in reverse of disassembly, but pay attention to the following.

Grease at designated position.

Pinion sliding section, Magnetic switch plunger sliding section.	NPC FG-6A
Reduction gear	MUL TEMP SRL
Shift lever	NPC FG-6A

Gear shaft thrust

One 0.25 mm (0.01 in) thick thrust washer is set between the center bracket and the gear shaft.

One 0.25 mm (0.01in) thick thrust washer is set on top of gear shaft also.

At the time of reassembling, be sure to check that there are the washers.

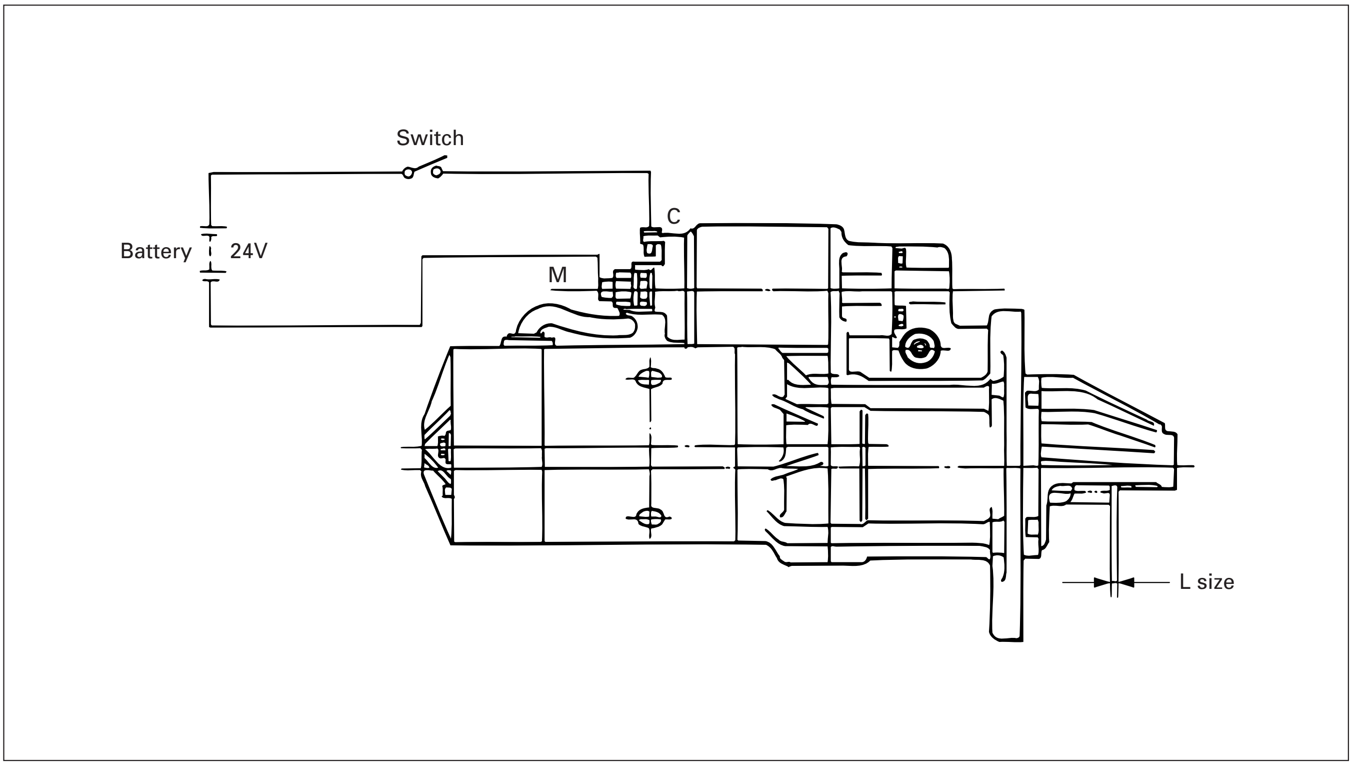
The appropriate thrust ranges from 0.1 – 0.4 mm (0.004 – 0.016 in), but if is it more than 0.7 mm (0.028 in), add a thrust washer but use care not to reduce it to zero.

Screw Tightening Torque

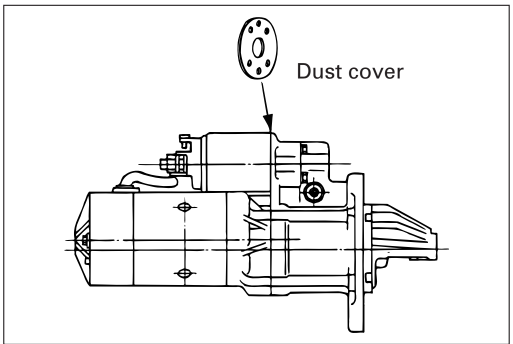
Tightening position	Tightning Torque N·m (kgf·cm/lb.ft)
Brush tightening screw, M4	1.7–2.4 (17–24/1.2–1.7)
C terminal tightening bolt, M5	2.5–3.4 (25–35/1.8–2.5)
Magnetic switch tightening bolt, M6	6.4–8.3 (65–85/4.7–6.1)
Motor tightening through bolt, M6	6.9–7.8 (70–80/5.1–5.8)
Shift lever pin tightening nut, M10	6.4–8.3 (65–85/4.7–6.1)
M terminal tightening nut, M10	7.4–9.8 (75–100/5.4–7.2)

ADJUSTMENT

Size, L, of Pinion Pop-up with Magnetic Switch.



Connection Diagram



Adjustment of L size

When the pinion is pushed out with the magnetic switch, the pinion move size, L, (0.3–1.5 mm/0.012–0.06 in) in the thrust direction is measured.

When the L size is out of the normal range, insert the dust cover as shown in left Fig. to adjust the size.

PERFORMANCE TEST

For the performance test of the starter, a no-load test is conducted according to the procedures mentioned below.

Before the performance test, fix the starter on the test bench.

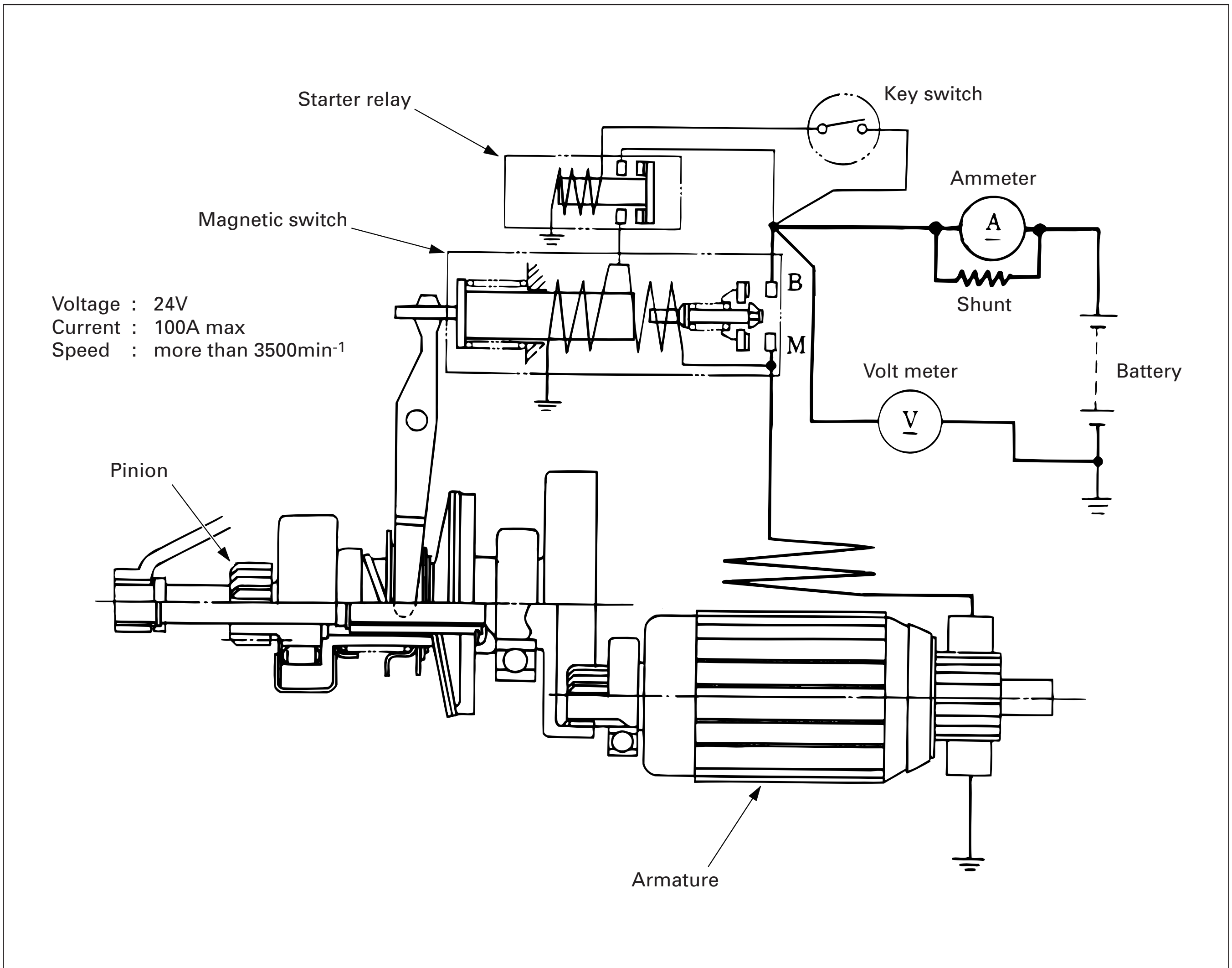
Note: Since the rated time is 30 sec., conduct the test promptly.

No-Load Test

See the following figure for connection.

Close the key switch, and the starter will be energized and will start rotating.

Then, measure the current and the number of revolutions.



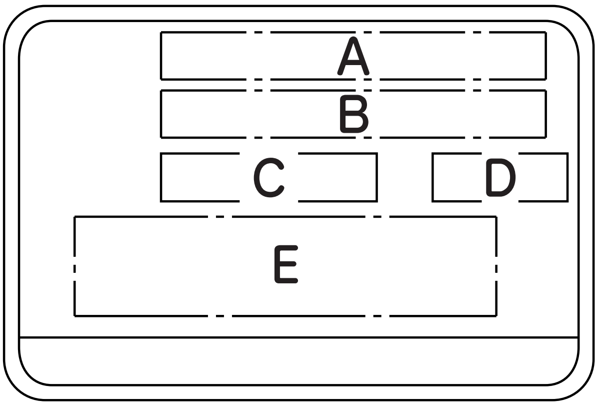
ALTERNATOR IDENTIFICATION

The alternator identification plate is attached to the alternator rear bracket. The ISUZU part number, the manufacturer's code number, and other important information are stamped on the plate.

Refer to the identification plate together with the "Main Data and Specifications" Tables and accompanying charts in this Manual when requesting service assistance from a qualified electrical repair shop.

If you are unable to locate the data applicable to your engine, please contact ISUZU MOTORS LIMITED through your machine supplier.

MITSUBISHI IDENTIFICATION PLATE



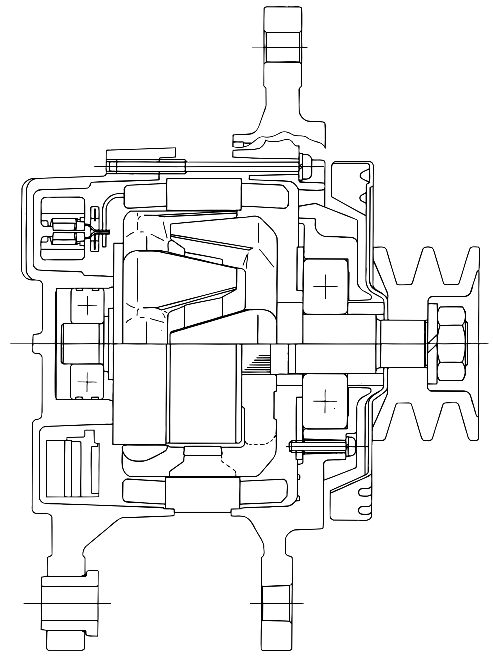
A: Isuzu part number
B: Manufacturer's short type name
C: System voltage output
D: Manufacturer's lot no.
E: Bar code

MAIN DATA AND SPECIFICATIONS

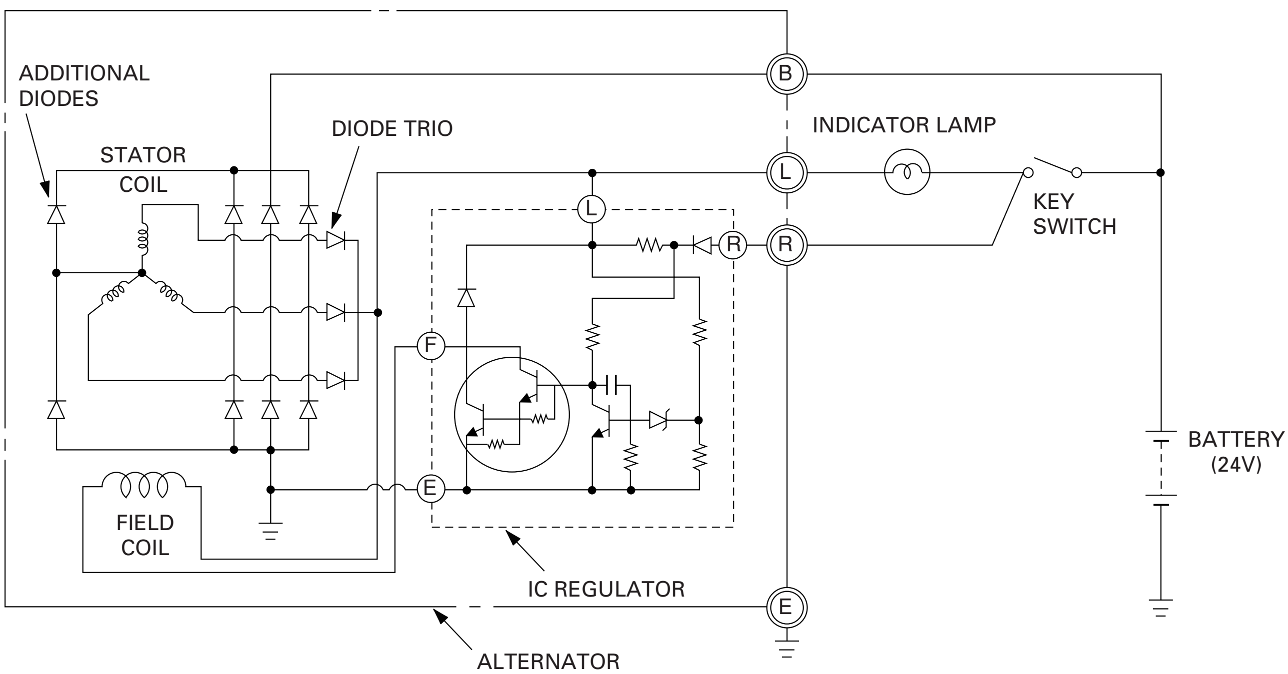
ALTERNATOR

Isuzu Part No.		AA-6BG1TRA	1-81200-530∗
		CC-6BG1TRA-12/13	1-81200-603∗
Manufacturer's code No. (MITSUBISHI)		A004T05486	
Rated voltage	(V)	24	
Rated output	(A)	50	
Rated speed	(min^{-1})	5000	
Rated output at r.p.m	(Amp./Volt/min^{-1})	50/27/5000	
No-load output at 0 Amp.	(Volt/min^{-1})	24/900	
Direction of rotation as viewed from pulley side		Clockwise	
Polarity grounded		(—)	
Pulley diameter	mm (in.)	80 (3.15)	
Coil resistance at 20°C			
Field coil	(Ω)	4.4–5.2	
Regulator's applicable			
Isuzu part No.		1-81260-0170	
Manufacturer's code No.		A866X38282	

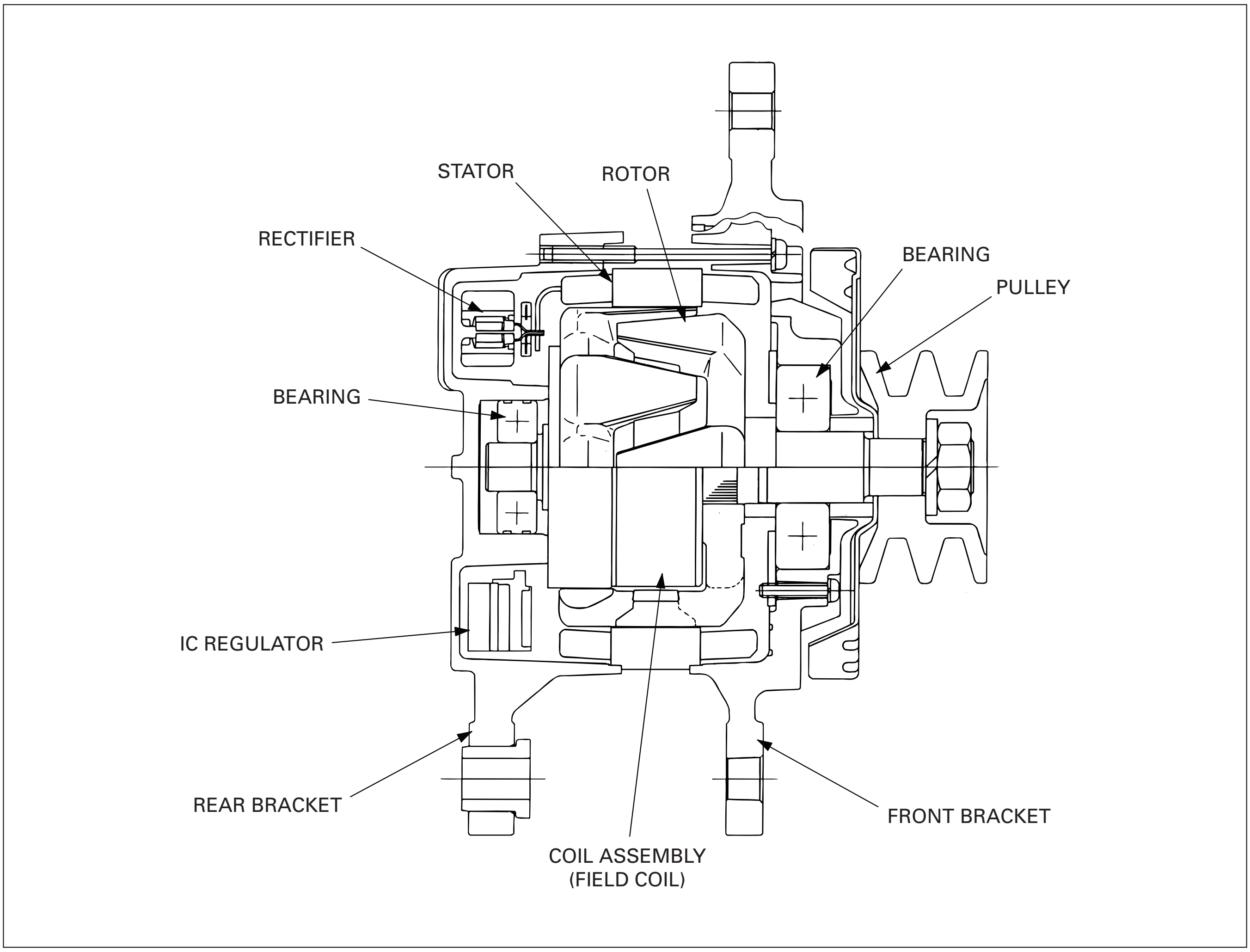
ALTERNATOR SECTIONAL VIEW



CHARGING CIRCUIT



STRUCTURE



This alternator is a brushless unit.

The main components are the rotor, stator, rectifier assembly, front bracket, rear bracket, IC regulator, bearings and pulley.

The movable parts in the assembly are the rotor and pulley.

The field coil is fixed to the rear bracket.

To rectify 3–phase Alternator in the stator coil to direct current, 6 main diodes and 2 additional diodes are used: 3 main diodes are called “positive diode”, while the others are called “negative” diode.

Also, 3 small diodes called “diode trio” are used and the field current is supplied from these diodes.

This alternator has three terminals; a terminal-B (DC power output terminal), terminal-L and terminal-R.

Since terminal-L is connected to the field coil, it is an input terminal of initial exciting current together with terminal-R until the alternator begins to generate.

Also, it has another function of a voltage output terminal (current output capacity is only one ampere).

When terminal-L voltage reaches to battery voltage it turns the indicator lamp off.

The bearings are sealed so no periodic lubrication is required.

The IC regulator is a solid state unit so that it can be serviced as an assembly.

DISASSEMBLY

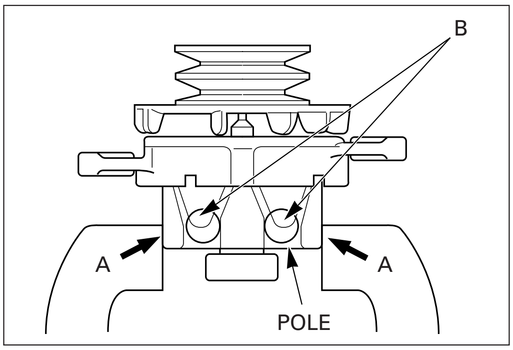
Note:

Before disassembling alternator, be sure to put match marks at two locations (front bracket and rear bracket) so that any possible mistake can be aboided.

(1) Remove four through bolts. Pry between stator and front bracket with the blade of a screwdriver. Carefully separate the front bracket, pulley and rotor assembly away from the stator and rear bracket assembly.

Note:

Do not inseart screwdriver too deep, or the starter coil will be damaged.



(2) Cramp the rotor in a vice, being careful not to distort the rotor poles, and remove the pulley securing nut, pulley, fan, spacer and front bracket.

Note:

When vice or tool is used to secure the rotor, be sure to hold the location “A”. Do not hold the location “B” as it does not have enough structural strength.

(3) If necessary remove the front bracket bearing, remove four retainer screws and press the bearing out of bracket with a suitable socket.

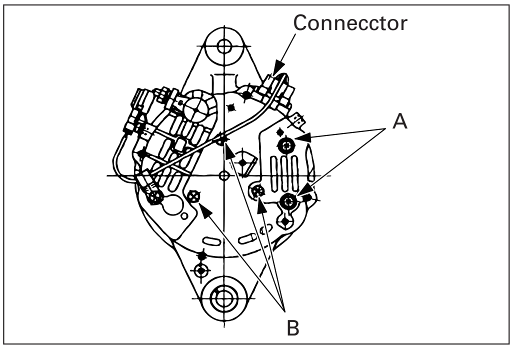
Note:

Do not remove bearing for normal service. If bearing is removed, the bearing must be replaced.

(4) If necessary to remove the rotor bearing, remove the bearing with a normal bearing puller.

Note:

Do not remove bearing for normal service. If bearing is removed, the bearing must be replaced.

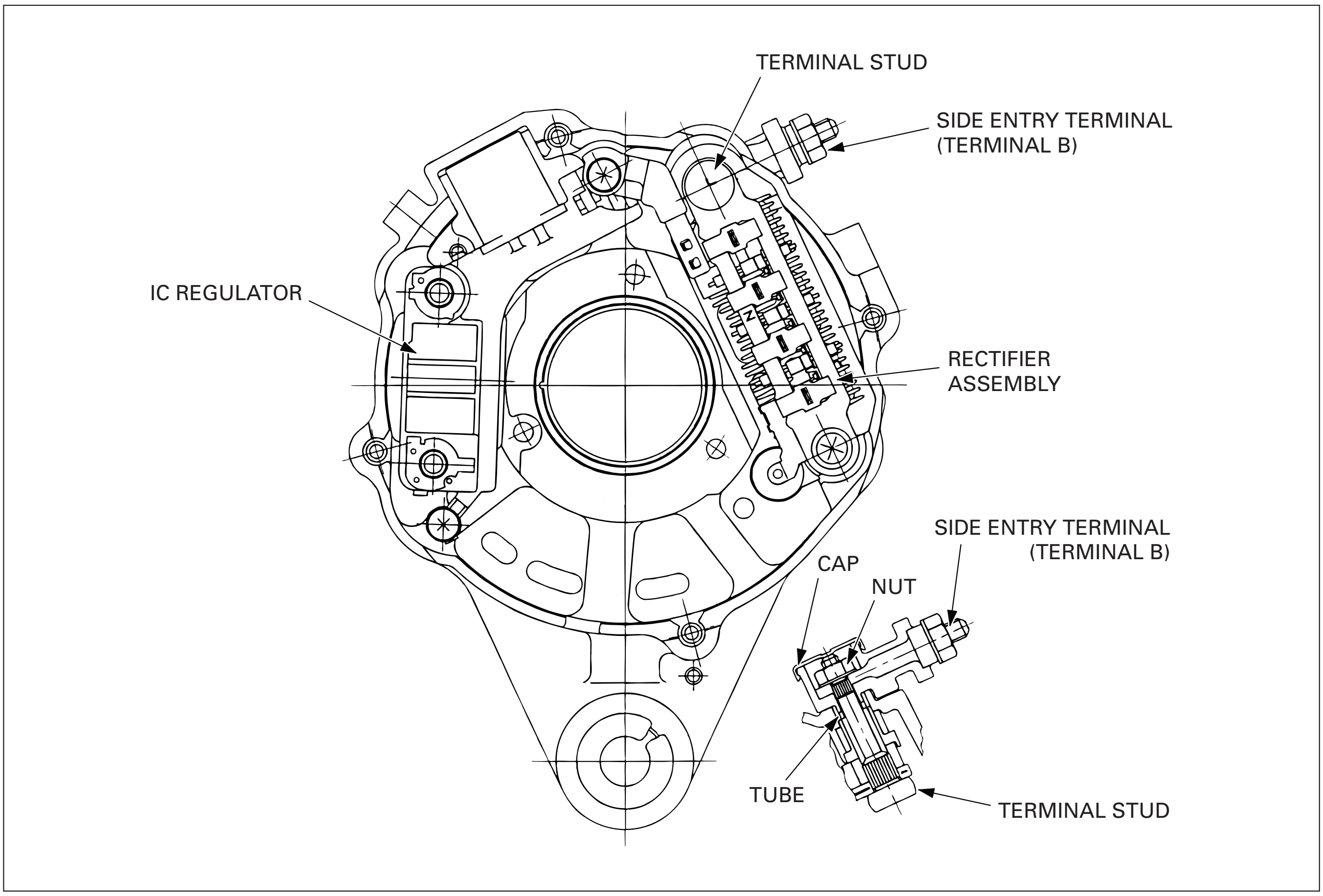


(5) To move the coil assembly from the rear bracket; first, remove two screws “A” that hold the terminal plate of coil to the IC regulator.
If the screws “A” are removed before removing screws B that hold the coil assembly to the rear bracket, the terminal plate may be broken.
While being careful not to damage the terminal plate, hold the coil assembly by hand.
Then, remove the coil assembly by removing the screw “B”.

(6) Disconect the connector
(7) Remove the cap and nut from the terminal stud on the rectifier.
Pry between the rear bracket and side entry terminal, and remove the side entry terminal.
The tube will remain in the bracket.

Note:

Do not loss the tube.



(8) Remove the rectifier retaining screw and two IC regulator retaining screws.
Separate the stator and rectifier assemblies, as a unit, from the rear bracket.
Then remove IC regulator.

(9) Unsolder four stator coil leads and remove the stator from the rectifier.

Note:

High temperature solder (Melting point of 446° F) is used to secure stator coil leads to rectifier terminals.

Disconnect quickly, use a 180–270 watts soldering iron more than about 5 seconds because the diode may be damaged if it is overheated.

INSPECTIONS

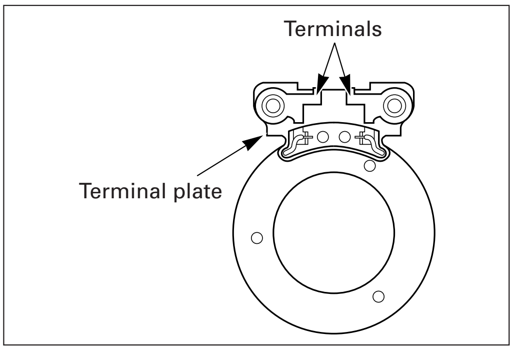
(1) Stator

Visually inspect the stator for damage, a loose connection, or discolored windings.

a. Check for continuity between each pair of the stator coil leads using a circuit tester.
   Replace the stator if there is no continuity.
b. Check for continuity between the stator coil leads and core using a circuit tester.
   Replace the stator if there is no continuity.

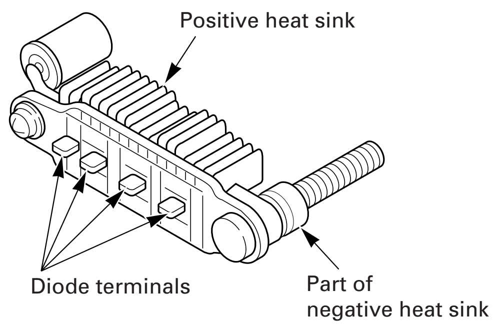
(2) Rotor

a. Check the bearing for any scraping noise, roughness, or grease leakage (If the amount of grease leakage is very small, wipe it away.), and replace it as necessary.
   It is more effective to check with the bearing fitted onto the rotor shaft than to check the bearing itself (with no parts mounted).



(3) Coil assembly

a. Measure the coil resistance between both terminals on the terminal plate using an ohmmeter.
   If it is not within specification, replace the coil assembly.



(4) Rectifier assembly

a. Positive diodes and positive side additional diode.
   Check for continuity between the positive heat sink and each of four diodes terminals with a circuit tester.
   If there is continuity in both directions, the diode is shorted.
   Replace the rectifier assembly.
   If there is no continuity in both directions, the diode is open-circuit.
   Replace the rectifier assembly.

b. Negative diodes and negative side additional diode.
   Check for continuity between the negative heat sink and each of four diodes terminals with a circuit tester. If there is continuity in both directions, the diode is shorted. Replace the rectifier assembly.
   If there is no continuity in both directions, the diode is open-circuit.
   Replace the rectifier assembly.

c. Diode trio (Three small diodes)
   Using a circuit tester, check the diode trio for continuity in both directions.
   If there is either continuity or open circuit in both directions, the diode trio is defective.
   Replace the rectifier assembly.

(5) Front bracket bearing

Check the bearing for any scraping noise, roughness, or grease leakage (If the amount of leakage is very small, wipe it away.) and replace it as necessary.

It is more effective to check with the bearing fitted into the front bracket than to check the bearing itself (with no parts mounted).

(6) Regulator

The regulator cannot be checked with a circuit tester.

After the alternator has been completely assembly, the unit should be tested to make certain it will control the alternator voltage properly.

REASSEMBLY

To reassemble the alternator, follow the reverse of disassembling procedure, and observe the following precautions:

(1) Lubrication is not required. Both bearing are prelubricated.

Note:

For the rotor bearing with resin bands, grease should not be applied. Remove oils completely to prevent creep of the bearing if found on the bearing box.

(2) High temperature solder (Melting point of 466° F) should be used.

Solder quickly, use a 180–270 watts soldering iron no more than about 5 seconds because the rectifier may be damaged if it is overheated.

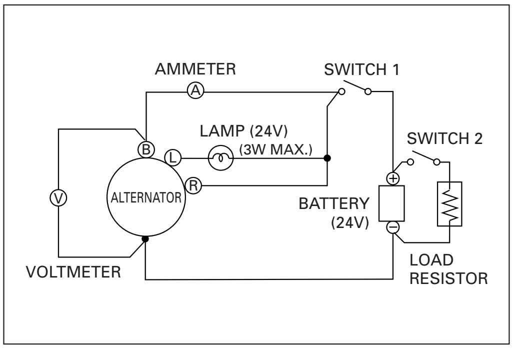
(3) Tightening torque.

- Pulley securing nut. : 147 N·m
- Through bolts. : 4.9 N·m
- Bearing retainer screws. : 3.4 N·m
- Coil assembly retaining screws. : 3.4 N·m
- Rectifier retaining screw. : 3.4 N·m
- Regulator retaining screws. : 3.4 N·m
- Nut for stud bolt. : 8.8 N·m

(4) To assemble the rear bracket / starter assembly and front bracket / rotor assembly.

a. Since the rotor bearing and rear bracket fitting is tight, before installing the rotor into the rear bracket assembly, heat the area around the bearing box of the rear bracket to 122 to 144° F.

b. After the alternator has been completely assembled, rotate the pulley slowly by hand to be sure that the rotor turns smooyhly.



BENCH TEST

To check the alternator on a test bench, proceed as follows:

Regulated Voltage Test

(1) Make connections as shown in Fig.

Use a 0–100 ampere scale ammeter and a 0–30 volt scale voltmeter.

Use a variable load resistor of capacity 0–50 ampere minimum.

(2) Close switch 1. Open switch 2.

Lamp should light. If the lamp does not light, check voltage at terminal-L.

When the voltage is nearly to battery voltage check the alternator.

When the voltage is low the lamp or relational wiring is open circuit.

(3) Slowly increase the alternator speed.

Be sure the lamp goes out until the alternator speed reaches to approx. 1300 min^{-1}.

Observe the voltage.

If the voltage is uncontrolled with speed and increases above 30V, a defective IC regulator is suspected.

If the voltage does not increase higher than battery voltage, this means alternator does not generate.

Recheck the alternator.

(4) Increase the alternator speed to approx. 500 min^{-1} and take the ammeter reading.

If the ammeter reading is 5A or less, take the voltmeter reading without changing the alternator speed (approx. 500 min^{-1}).

The reading is the regulated voltage.

If the ammeter reading is more than 5A, continue to charge battery until the reading falls to less than 5A or replace the battery with a fully charged one.

If the regulated voltage does not meet specifications limits, it will have to be replaced.

CURRENT OUTPUT TEST

The current output test determines whether or not alternator is capable of supplying its reted current output.

(1) After the regulated voltage test is completed reduce the alternator revolution.

(2) Close the switch 1. Be sure the lamp lights.

(3) Set the load resistor in maximum resistance value position (Minimum current draw) and close the switch 2.

(4) Increase and hold the alternator speed to 5000 min^{-1} and adjust the load resistor to obtain maximum current output.

Run the alternator for 15 minutes at this speed and output to rise in the alternator temperature.

After 15 minutes rotate the alternator to specified speed (2500 and 5000 min^{-1}) and adjust the load resistor to obtain maximum current output.

The output should be within specifications limits.

If the output is less than specifications limits, recheck the alternator as overed in [INSPECTIONS].

FAULT FINDING

SYMPTOM	PROBABLE CAUSE
No output	a. Defective IC regulator b. Open field coil
Low output	a. Defective diode b. Defective starter coil c. Defective rectifier d. Field coil rare short
Regulated voltage too high	a. Defective IC regulator
Abnormal noise	a. Bearing fault b. Rectifier fault c. Interference due to entry of foreign meterials

SPECIFICATIONS

Make		Mitsubishi electric co.	
Isuzu Part Number		181200-5300	
Maker Model code		A004TU5486	
Rated output		24V-50A	
Output characteristic (at hot condition)	Volts Current min^{-1}	27V 42A Min. 2500	27V 50A Min. 5000
Field coil resistance (at 20°C)		4.4-5.2 Ω	
Regulator regulated voltage		28-29V	
Rotational direction (viewed from pulley)		Clockwise	

MEMO

SECTION 11

TROUBLESHOOTING

TABLE OF CONTENTS

Note:

Use this section to quickly diagnose and repair engine failures.

Each troubleshooting chart has three headings arranged from left to right

(1) Check point (2) Trouble cause (3) Remedy

HARD STARTING

1) STARTER INOPERATIVE

Checkpoint		Trouble Cause		Remedy
Neutral switch (If so equipped)	NG	Defective neutral switch	NG	Replace the neutral switch
Battery	NG	Loose battery cable terminals Poor connections due to rusting	NG	Clean and/or retighten the battery cable terminals
	NG	Battery discharged or weak	NG	Recharge or replace the battery
	NG	Fan belt loose or broken	NG	Adjust or replace the fan belt
OK ↓ Fusible link	NG	Fusible link shorted	NG	Replace the fusible link
OK ↓ Starter switch	NG	Defective starter switch or starter relay	NG	Replace the starter switch or the starter relay
OK ↓ Starter	NG	Defective magnetic switch or starter relay	NG	Repair or replace the magnetic switch
OK ↓ Starter	NG	Defective starter motor	NG	Repair or replace the starter motor

HARD STARTING

2) STARTER OPERATES BUT ENGINE DOES NOT TURN OVER

Checkpoint		Trouble Cause		Remedy
Battery	NG	Loose battery cable terminals Poor connections due to rusting	NG	Clean and/or retighten the battery cable terminals
	NG	Battery discharged or weak	NG	Recharge or replace the battery
	NG	Fan belt loose or broken	NG	Adjust or replace the fan belt
OK				
Starter	NG	Defective pinion gear	NG	Replace the pinion gear
	NG	Defective magnetic switch	NG	Repair or replace the magnetic switch
	NG	Brush wear Weak brush spring	NG	Replace the brush and/or the brush spring
OK				
Engine	NG	Piston, crank bearing seizure, or other damage	NG	Repair or replace the related parts

HARD STARTING

3) ENGINE TURNS OVER BUT DOES NOT START

FUEL IS BEING DELIVERED TO THE INJECTION PUMP

Continued from the previous page

OK

Checkpoint		Trouble Cause		Remedy
Injection nozzle	NG	Injection nozzle injection starting pressure too low Improper spray condition	NG	Adjust or replace the injection nozzle
OK				
Injection pump	NG	Defective fuel injection nozzle resulting in fuel drippage after fuel injection	NG	Replace the delivery valve
	NG	Defective injection pump control rack operation	NG	Repair or replace the injection pump control rack
	NG	Injection pump plunger worn or stuck	NG	Replace the injection pump plunger assembly
OK	NG	Injection pump governor spring seizure	NG	Replace the injection pump governor spring

HARD STARTING

4) ENGINE TURNS OVER BUT DOES NOT START

Checkpoint		Trouble Cause		Remedy
Engine stop mechanism	NG	Defective engine stop mechanism control wire improperly adjusted	NG	Replace the engine stop mechanism Adjust the control wire

FUEL IS NOT BEING DELIVERED TO THE INJECTION PUMP

Checkpoint		Trouble Cause		Remedy
Fuel	NG	Fuel tank is empty	NG	Fill the fuel tank
OK ↓				
Fuel piping	NG	Clogged or damaged fuel lines Loose fuel line connections	NG	Repair or replace the fuel lines Retighten the fuel line connections
OK ↓				
Fuel filter	NG	Fuel filter overflow valve does not close	NG	Repair or replace the fuel filter overflow valve
	NG	Clogged fuel filter element	NG	Replace the fuel filter element or the fuel filter cartridge
OK ↓				
Fuel system	NG	Air in the fuel system	NG	Bleed the air from the fuel system

Continued on the next page

UNSTABLE LOW IDLING

Checkpoint	Trouble Cause	Remedy
Low idling system	NG → Low idling improperly adjusted	NG → Adjust the low idling
OK ↓ Low idling speed control device	NG → Defective low idling speed control device	NG → Repair or replace the low idling speed control device
OK ↓ Throttle control system	NG → Throttle control system improperly adjusted	NG → Adjust the throttle control system
OK ↓ Fuel system	NG → Fuel system leakage or blockage	NG → Repair or replace the fuel system
	NG → Air in the fuel system	NG → Bleed the air from the fuel system
	NG → Water particles in the fuel system	NG → Change the fuel
OK ↓ Fuel filter	NG → Clogged fuel filter element	NG → Replace the fuel filter element or the fuel filter cartridge

Continued on the next page

UNSTABLE LOW IDLING

Continued from the previous page

OK

Checkpoint	Trouble Cause	Remedy
Injection pump	NG → Defective governor lever operation	NG → Repair or replace the governor lever
	NG → Broken plunger spring	NG → Replace the plunger spring
	NG → Worn plunger	NG → Replace the plunger assembly
	NG → Worn camshaft	NG → Replace the camshaft
	NG → Worn roller tappet	NG → Replace the roller tappet
OK ↓ Valve clearance	NG → Valve clearance improperly adjusted	NG → Adjust the valve clearance
OK ↓ Compression pressure	NG → Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	NG → Replace the related parts

INSUFFICIENT POWER

Checkpoint	Trouble Cause	Remedy
Air cleaner	Clogged air cleaner element	Clean or replace the air cleaner element
Fuel	Water particles in the fuel	Replace the fuel
Fuel filter	Clogged fuel filter element	Replace the fuel filter element or the fuel filter cartridge
Fuel feed pump	Defective fuel feed pump	Repair or replace the fuel feed pump
Injection nozzle	Injection nozzle sticking	Replace the injection nozzle
	Injection nozzle injection starting pressure too low Improper spray condition	Adjust or replace the injection nozzle
Fuel injection pipes	Fuel injection pipes damaged or obstructed	Replace the fuel injection pipes

Continued on the next page

INSUFFICIENT POWER

Continued from the previous page

OK

Checkpoint		Trouble Cause		Remedy
Injection pump	NG	Defective delivery valve	NG	Replace the delivery valve
	NG	Defective timer	NG	Repair or replace the timer
	NG	Improper control lever operation	NG	Adjust or replace the control lever
	NG	Defective injection timing	NG	Adjust the injection timing Repair or replace the injection pump timer
	NG	Weak governor spring	NG	Replace the governor spring
	NG	Worn plunger	NG	Replace the plunger assembly
	NG	Worn camshaft	NG	Replace the camshaft

Continued on the next page

INSUFFICIENT POWER

Continued from the previous page

Checkpoint	Trouble Cause	Remedy
Injection pump	Worn roller tappet	Replace the roller tappet
Turbocharger	Exhaust gas leakage from the exhaust system Air leakage from the intake system	Repair or replace the related parts
	Defective turbocharger assembly	Replace the turbocharger assembly
Compression pressure	Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	Replace the related parts
Valve clearance	Valve clearance improperly adjusted	Adjust the valve clearance
Valve spring	Valve spring weak or broken	Replace the valve spring
Exhaust system	Exhaust pipe clogged	Clean the exhaust pipe
Full load adjusting screw seal	Open and improperly set adjusting screw seal	Adjust and reseal the adjusting screw

EXCESSIVE FUEL CONSUMPTION

Checkpoint		Trouble Cause		Remedy
Fuel system	NG	Fuel leakage	NG	Repair or replace the fuel system related parts
OK				
Air cleaner	NG	Clogged air cleaner element	NG	Clean or replace the air cleaner element
OK				
Low idling speed	NG	Poorly adjusted low idle speed	NG	Adjust the low idle speed
OK				
Injection nozzle	NG	Injection nozzle injection starting pressure too low Improper spray condition	NG	Adjust or replace the injection nozzle
OK				
Fuel injection timing	NG	Fuel injection timing improperly adjusted	NG	Adjust the fuel injection timing
OK				
Injection pump	NG	Defective delivery valve result-ing is fuel drippage after fuel injection	NG	Replace the delivery valve
OK				
Turbocharger	NG	Air leakage from the turbocharger intake side	NG	Repair the turbocharger intake side

Continued on the next page

EXCESSIVE FUEL CONSUMPTION

Continued from the previous page

OK

Checkpoint	Trouble Cause	Remedy
Turbocharger	NG → Defective turbocharger assembly	NG → Replace the turbocharger assembly
OK ↓ Valve clearance	NG → Valve clearance improperly adjusted	NG → Adjust the valve clearance
OK ↓ Compression pressure	NG → Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	NG → Replace the related parts
OK ↓ Valve spring	NG → Valve spring weak or broken	NG → Replace the valve spring

EXCESSIVE OIL CONSUMPTION

Checkpoint		Trouble Cause		Remedy
Engine oil	NG	Engine oil unsuitable Too much engine oil	NG	Replace the engine oil Correct the engine oil volume
OK				
Oil seal and gasket	NG	Oil leakage from the oil seal and/or the gasket	NG	Replace the oil seal and/or the gasket
OK				
Air breather	NG	Clogged air breather	NG	Clean the air breather
OK				
Inlet and exhaust valves Valve seals	NG	Defective valve seals Worn valve stems and valve guides	NG	Replace the valve seals, the valves, and the valve guides
OK				
Piston rings	NG	Piston rings worn, broken or improperly installed	NG	Replace the piston rings or properly install
OK				
Cylinder liners	NG	Cylinder lines scored or worn	NG	Replace the cylinder liners

OVERHEATING

Checkpoint	Trouble Cause	Remedy
Cooling water	NG → Insufficient cooling water	NG → Replenish the cooling water
OK ↓ Fan belt	NG → Fan belt loose or cracked causing slippage	NG → Replace the fan belt
OK ↓ Radiator	NG → Defective radiator cap or clogged radiator core	NG → Replace the radiator cap or clean the radiator core
OK ↓ Water pump	NG → Defective water pump	NG → Repair or replace the water pump
OK ↓ Cylinder head and cylinder body sealing cap	NG → Defective sealing cap resulting in water leakage	NG → Replace the sealing cap
OK ↓ Thermostat	NG → Defective thermostat	NG → Replace the thermostat
OK ↓ Cooling system	NG → Cooling system clogged by foreign material	NG → Clean the foreign material from the cooling system

Continued on the next page

OVERHEATING

Checkpoint		Trouble Cause		Remedy
Fuel injection timing	NG	Fuel injection timing improperly adjusted	NG	Adjust the fuel injection timing

Continued from the previous page

OK → Fuel injection timing

WHITE EXHAUST SMOKE

Checkpoint		Trouble Cause		Remedy
Fuel	NG	Water particles in the fuel	NG	Replace the fuel
OK				
Fuel injection timing	NG	Delayed fuel injection timing	NG	Adjust the fuel injection timing
OK				
Compression pressure	NG	Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	NG	Replace the related parts
OK				
Turbocharger	NG	Defective turbocharger	NG	Replace the turbocharger
OK				
Inlet and exhaust valves Valve seals	NG	Defective valve seals Worn valves stems and valve guides	NG	Replace the valve seals, the valves, and the valve guides
OK				
Piston rings	NG	Piston rings worn, broken or improperly installed	NG	Replace the piston rings or properly install
OK				
Cylinder liners	NG	Cylinder lines scored or worn	NG	Replace the cylinder liners

DARK EXHAUST SMOKE

Checkpoint		Trouble Cause		Remedy
Air cleaner	NG	Clogged air cleaner element	NG	Clean or replace the air cleaner element
OK				
Injection nozzle	NG	Injection nozzle injection starting pressure too low Improper spray condition	NG	Adjust or replace the injection nozzle
OK				
Fuel injection timing	NG	Fuel injection timing improperly adjusted	NG	Adjust the fuel injection timing
OK				
Injection pump	NG	Defective delivery valve resulting in fuel drippage after fuel injection	NG	Replace the delivery valve
	NG	Excessive injection volume	NG	Adjust the injection volume

OIL PRESSURE DOES NOT RISE

Checkpoint		Trouble Cause		Remedy
Engine oil	NG	Improper viscosity engine oil Too much engine oil	NG	Replace the engine oil Correct the engine oil volume
OK				
Oil pressure gauge or unit Oil pressure indicator light	NG	Defective oil pressure gauge or unit Defective indicator light	NG	Repair or replace the oil pressure gauge or unit Replace the indicator light
OK				
Oil filter	NG	Clogged oil filter element	NG	Replace the oil filter element or the oil filter cartridge
OK				
Relief valve and by-pass valve	NG	Relief valve sticking and/or weak by-pass valve spring	NG	Replace the relief valve and/or the by-pass valve spring
OK				
Oil pump	NG	Clogged oil pump strainer	NG	Clean the oil pump strainer
	NG	Worn oil pump related parts	NG	Replace the oil pump related parts
OK				
Rocker arm shaft	NG	Worn rocker arm bushing	NG	Replace the rocker arm bushing

Continued on the next page

OIL PRESSURE DOES NOT RISE

Continued from the previous page

Checkpoint		Trouble Cause		Remedy
OK ↓ Camshaft	NG	Worn camshaft and camshaft bearing	NG	Replace the camshaft and the camshaft bearings
OK ↓ Crankshaft and bearings	NG	Worn crankshaft and bearings	NG	Replace the crankshaft and/or the bearings

ABNORMAL ENGINE NOISE

1. Engine Knocking

Check to see that the engine has been thoroughly warmed up before beginning the troubleshooting procedure.

Checkpoint		Trouble Cause		Remedy
Fuel	NG	Fuel unsuitable	NG	Replace the fuel
OK				
Fuel injection timing	NG	Fuel injection timing improperly adjusted	NG	Adjust the fuel injection timing
OK				
Injection nozzle	NG	Improper injection nozzle starting pressure and spray condition	NG	Adjust or replace the injection nozzle
OK				
Compression pressure	NG	Blown out head gasket Broken piston ring	NG	Replace the head gasket or the piston ring

2. Gas Leakage Noise

Checkpoint		Trouble Cause		Remedy
Exhaust pipes	NG	Loosely connected exhaust pipes Broken exhaust pipes	NG	Tighten the exhaust pipe connections Replace the exhaust pipes
OK				
Injection nozzles and/or glow plugs	NG	Loose injection nozzles and/or glow plugs	NG	Replace the washers Tighten the injection nozzles and/or the glow plugs

Continued on the next page

ABNORMAL ENGINE NOISE

2. Gas Leakage Noise

Continued from the previous page

Checkpoint		Trouble Cause		Remedy
OK ↓				
Exhaust manifold	NG	Loosely connected exhaust manifold and/or glow plugs	NG	Tighten the exhaust manifold connections
OK ↓				
Cylinder head gasket	NG	Damaged cylinder head gasket	NG	Replace the cylinder head gasket

3. Continuous Noise

Checkpoint		Trouble Cause		Remedy
Fan belt	NG	Loose fan belt	NG	Readjust the fan belt tension
OK ↓				
Cooling fan	NG	Loose cooling fan	NG	Retighten the cooling fan
OK ↓				
Water pump bearing	NG	Worn or damaged water pump bearing	NG	Replace the water pump bearing
OK ↓				
Alternator or vacuum pump	NG	Defective alternator or vacuum pump	NG	Repair or replace the alternator or the vacuum pump
OK ↓				
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance

ABNORMAL ENGINE NOISE

4. Slapping Noise

Checkpoint		Trouble Cause		Remedy
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance
OK				
Rocker arm	NG	Damaged rocker arm	NG	Replace the rocker arm
OK				
Flywheel	NG	Loose flywheel bolts	NG	Retighten the flywheel bolts
OK				
Crankshaft and thrust bearings	NG	Worn or damaged crankshaft and/or thrust bearings	NG	Replace the crankshaft and/or the thrust bearings
OK				
Crankshaft and connecting rod bearings	NG	Worn or damaged crankshaft and/or connecting rod bearings	NG	Replace the crankshaft and/or the connecting rod bearings
OK				
Connecting rod bushing and piston pin	NG	Worn or damaged connecting rod bushing and piston pin	NG	Replace the connecting rod bushing and/or the piston pin
OK				
Piston and cylinder liner	NG	Worn or damaged piston and cylinder liner Foreign material in the cylinder	NG	Replace the piston and the cylinder liner

SECTION 12

SPECIAL TOOL LIST

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SPECIAL TOOL LIST

ITEM NO.	ILLUSTRATION	PART NO.	PARTS NAME	PAGE
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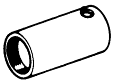
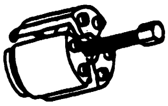
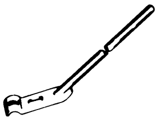
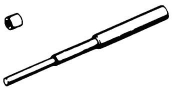
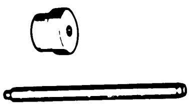
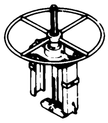
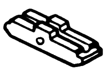
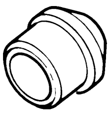
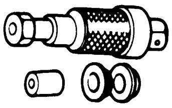
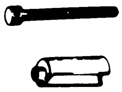
2.		1-85111-003-0	Cylinder head bolt wrench	3–7
3.		9-8521-0122-0	Crankshaft taper bushing remover	3–8
4.		5-8840-2360-0	Rear oil seal remover	3–8
5.		1-85235-006-0	Valve spring compressor	3–12 5–5
6.		1-85232-001-0 9-85220-035-0	Valve guide remover and installer	4–3
7.		9-8523-1818-0	Camshaft bearing remover and installer	4–10
8.		9-8523-1169-0	Cylinder liner remover	4–12
9.		5-8523-1004-0	Cylinder liner remover ankle	4–12
10.		5-8522-1018-0	Cylinder liner installer	4–15

ITEM NO.	ILLUSTRATION	PART NO.	PARTS NAME	PAGE
11.		9-8523-1369-0	Connecting rod bushing installer	4–21
12.		9-8521-0141-0	Crankshaft gear remover	4–28
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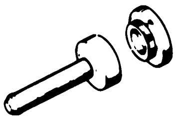
14.		9-8522-0034-0	Crankshaft front oil seal installer	4–29
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MEMO

SECTION 13

REPAIR STANDARDS

GENERAL RULES

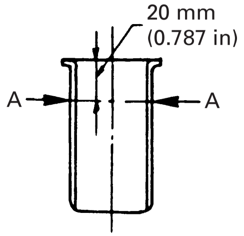
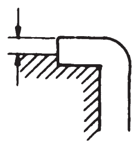
1. These tables provide standards relating the repair of the following diesel engine;

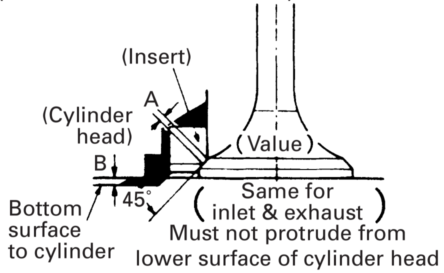
   Model 6BG1TRA

2. These Repair Standards are based on inspection items, together with dimensions, assembly standards, limit values, and repair procedures.
   (1) Nominal dimensions are the standard production values.
   (2) Assembly standards considered to be the values used as objectives during the assembly procedures which follow repairs; as a result, they may be somewhat at variance with the assembly dimensions of a new engine.
   (3) Limit values refer to the measured values resulting from wear, etc., beyond which a part must not be used. If a measured value falls beyond the limit value, the part involved must be repaired or replaced.
   (4) “Repair Procedures” indicates normal repair methods.
   (5) Unless otherwise stated, the unit of numerical values in tables should be taken to refer to millimeters. mm (in).

3. Explanation of Terms Used in Tables
   (1) The dimension of “wear” refers to the difference between the dimensions of a part which is not worn (or the “nominal dimension” of a part without wear) and the dimension of the part suffering from the most wear (the dimension of the worn part).
   (2) Uneven wear means the difference between the maximum and minimum wear values.

4. When repairs are requested on the overall engine, first perform bench tests to determine what parts require repairs, then perform the minimum disassembly and repairs required to correct the problems. When repairs on a specific engine part are requested, repairs to be made in reference to the relevant items in accordance with the repair standards listed in this manual.

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Time for engine disassembly and repair		Cylinder compression pressure MPa (kgf/cm²/psi)	3.0 (31/440)		2.5 (26/370)	Disassemble and repair engine	Water temperature 70 – 85°C, (158 – 185°F) engine speed 200 min^{-1} (varies depending on altitude)
		Fuel consumption L/h	100%		140%		New engine performance is assumed 100%
		Lubricating oil consumption L/h	100%		200%		
Engine Body	Cylinder Block	Wear on liner bore Measured at A–A 	Dia. 105 (4.1339)		Dia 105.2 (4.1417)	Upper step wear must be repaired, or replace with standard dimension liner	(Ref) Cylinder & liner interference 0.001 – 0.019 (0.00004 – 0.0007)
		Liner projection 		0.03 – 0.10 (0.001 – 0.004)		Some projection must be present	Difference in liner projection between neighboring cylinders not to exceed 0.03 (0.001)
		Cylinder block upper face warpage		0.05 or less (0.002)	0.2 (0.0079)	Must be repairable	0.3 (0.0118)
		Pressure test: 3 minutes kPa (kgf/cm²/psi)		490 (5/71.1)		Leaks require repair or replacement	

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Engine Body	Cylinder Head	Valve seat depression: B (both inlet and exhaust) 		1.0 (0.039)	2.5 (0.098)	Replace insert	Valve seat angle: α 45°
		Contact width with valve seat: A		1.5 (0.059)	2.0 (0.079)	Repair with valve seat cutter	After repair, be sure to lap contact surfaces
		Warpage and flatness of cylinder head lower face (mounting surface)		0.075 or less (0.003)	0.2 0.079	Cannot be repaired: must replace cylinder head	
		Warpage of manifold mounting surface		0.05 or less (0.002)	0.4 (0.016)	repair	
		Water-pressure test, 3 minutes kPa (kgf/cm^2/psi)		490 (5/71.1)		Leaks require repair or replacement	
		Cylinder head bolts tightening torque (angular tightening method) N·m (kgf-m/lb·ft)		69 (7.0/51) ↓ 88 (9.0/65) ↓ 90° – 120°		• Clean bolt mounting surfaces and threads, and apply molybdenum disulfide grease. • Never tighten again after using angular tightening method. • Reuse bolts max. 2 times	

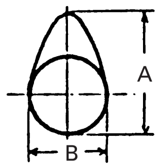
Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Pistons	Clearance with cylinder: grade position from upper face 82 mm (3.228 in)			Clearance with major axis 0.051 – 0.085 (0.002 – 0.0033)			
		Piston pin and piston pin hole clearance			0.010 – 0.023 (0.00039 – 0.0009)	0.05 (0.00197)	Replace piston or piston pin	
		Pin wear			35.000 – 35.005 (1.3780 – 1.3781)	34.95 (1.3760)	Replace piston pin	
	Piston Ring	Piston Ring Gap	No. 1 compression ring		0.35 – 0.50 (0.014 – 0.020)	1.5 (0.059)	Replace rings when performing engine disassembly and repair	Gauge inner standard diameter 105 (4.134)
			No. 2 compression ring		0.60 – 0.75 (0.0236 – 0.0295)			
			No. 3 compression ring		0.60 – 0.75 (0.0236 – 0.0295)			
			Oil ring		0.30 – 0.50 (0.014 – 0.020)			
		Tension N (kgf/lb)	No. 1 compression ring		20.4 – 30.6 (2.08 – 3.12/ 4.59 – 6.88)	9.8 (1.0/2.2)	Replace	Measure with ring compressed to standard ring gap.
			No. 2 compression ring		14.1 – 21.2 (1.44 – 2.16/ 3.17 – 4.76)	4.9 (0.5/1.1)		
			No. 3 compression ring		14.1 – 21.2 (1.44 – 2.16/ 3.17 – 4.76)	4.9 (0.5/1.1)		
			Oil ring		36.3 – 55.9 (3.7 – 5.7/ 8.16 – 12.6	31 (3.2/7.05)	Replace	Measure with expander attached

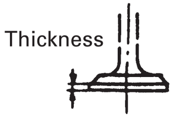
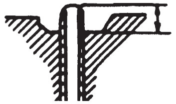
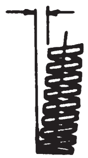
Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Piston Ring	Clearance between piston ring and ring groove	No. 1 compression ring		–	–	Replace rings or piston	When assembling compression rings on piston, be sure ring's marked surface is up. Backwards installation will result in excessive oil consumption. No top/bottom to oil ring.
			No. 2 compression ring		0.070 – 0.110 (0.0028 – 0.0043)	0.15 (0.0059)		
			No. 3 compression ring		0.050 – 0.090 (0.0020 – 0.0035)	0.15 (0.0059)		
			Oil ring		0.030 – 0.070 (0.0012 – 0.0028)	0.15 (0.0059)		
		Ring gap orientation					At 90° intervals	

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Crankshaft	Uneven wear on journal and pins	Dia. 80 (3.1496) Dia. 64 (2.5197)		0.05 (0.002)	Replace	Do not attempt to grind: always replace with new parts
		Journal Diameter	Center Bearing only	79.905 – 79.925 (3.1459 – 3.1467)		Replace	
			Other Bearing	79.919 – 79.939 (3.1464 – 3.1472)			
		Pin Diameter		63.924 – 63.944 (2.5167 – 2.5175)		Replace	
		Journal and pin finish precision (taper and ellipse)		Ellipse and taper 0.007 (0.0003)			
		Journal and bearing arc spread				Use those with projection and proper arc; take care with back side fit	
		Clearance between journal and bearing	Center Bearing only	0.039 – 0.098 (0.0015 – 0.0039)	0.11 (0.0043)	Replace bearing	
			Other Bearing	0.025 – 0.084 (0.0010 – 0.0033)			
		Journal bearing undersize				Undersize bearings cannot be used	
		Crankshaft end play		0.15 – 0.33 (0.006 – 0.013)	0.4 (0.016)	Replace thrust bearings	Measure at crankshaft's No. 4 bearing thrust surface
		Crankshaft runout		0.05 or less (0.002)	0.4 (0.016)	Replace	
		Ring gear				Perform lapping on gears with burrs; in cases of severe damage, replace.	
		Crankshaft balance (g-cm)		36 or less		Check dynamic balance	(Ref. value) At ends of journal

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Crankshaft	Crankshaft bearing cap bolt torque N·m (kgf-m/lb·ft)		226 – 245 (23 – 25/166 – 181)		Apply engine oil to threads and seating areas of bolts before tightening	Do not catch foreign matter in bolts
		Crankshaft rear oil seal wear				In case of oil leak, replace oil seal	Check for oil seal collapse

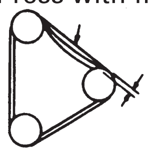
Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Connecting Rod	Connecting rod bearing arc spread				Use those with projection and proper arc; take care work back side fit	
		Clearance between connecting rod bearing and crankpin		0.030 – 0.073 (0.0012 – 0.0029)	0.10 (0.0039)	Replace bearing or crankshaft	Take special care with crankpin precision
		Contact between connecting rod bearing and crankpin				Replace parts with poor contact or abrasions	
		Clearance between smallend bushing and piston pin		0.012 – 0.025 (0.00047 – 0.00098)	0.05 (0.00197)	Replace bushing or pin	Sufficient gap to allow smooth rotation when holding big end
		Connecting rod bearing undersize					Crank must not be ground (no undersizes available)
		Connecting rod and crankpin end play		0.17 – 0.30 (0.0067 – 0.011)	0.35 (0.014)	Replace connecting rod	
		Center distance between big end and small end (mm)	192 (7.559)				Reference value
		Big end to small end hole twist (per 100 mm)		0.05 or less (0.002)	0.2 (0.0079)	Repair or replace	
		Big end to small end hole parallelism (per 100 mm)		0.05 or less (0.002)	0.2 (0.0079)	Repair or replace	
		Piston weight difference after assembly g		20 or less		Repair or replace	
		Bearing cap bolt tightening torque (angular tightening method) N·m (kgf-m/lb·ft)	39 (4.0/29) ↓ 60° – 90°			Apply molybdenum disulfide grease to bolts before tightening	

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Camshaft	Journal uneven wear	Dia. 56 (2.205)		0.05 (0.002)	Replace camshaft	
		Clearance between journal and bearing		0.03 – 0.09 (0.001 – 0.004)	0.15 (0.006)	Replace camshaft or bearing	
		Journal wear	Dia. 56 (2.205)	Dia. 55.94 – 55.97 (2.202 – 2.204)	Dia. 55.6 (2.189)	Replace camshaft	
		Cam height: A – B 	7.71 (0.304)		7.21 (0.284)	Replace camshaft	Minor step wear on cams can be repaired
		Camshaft runout			0.12 (0.005)	Replace camshaft	Measure with dial gauge at No. 3 or No. 4 journal, runout during one rotation.
		Camshaft play (front-back direction)		0.050 – 0.114 (0.002 – 0.005)	0.2 (0.008)		

Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Valve System	Valves	Inlet valve stem wear		Dia. 9 (0.3543)		Dia. 8.88 (0.3496)	Replace valve and valve guide together	Measure valve stem at three positions
		Exhaust valve stem wear						
		Clearance between inlet valve stem and valve guide			0.039 – 0.071 (0.0015 – 0.0028)	0.20 (0.008)	Replace valve and valve guide together	
		Clearance between exhaust valve stem and guide			0.064 – 0.096 (0.0025 – 0.0038)	0.25 (0.0098)		
		Interference between valve guide and cylinder head			0.024 (0.0009)			Apply oil to valve guide and press in
		Valve thickness 		1.5 (0.059)		1.00 (0.039)	Replace valve and valve guide together	
		Height of valve guide above cylinder head 		14.1 (0.555)				Reference value
		Valve stem oil seal lip		Dia. 8.5 (0.335)		Dia. 8.8 (0.346)	Replace oil seal	Don’t damage lip.
		Valve spring	Tension N (kgf/lb) (When compressed to installed length) 44.5mm(1.752in)		142 (14.5/30.9)	127 (13.0/28.7)	Replace valve spring	
			Free height mm (in)		60.6 (2.39)	58.0 (2.28)		
			Inclination  mm (in)		less than 1.9 (0.075)	2.7 (0.106)		

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Valve System	Valves	Valve clearance (inlet & exhaust) (cold)		0.4 (0.016)		Adjust	
		Clearance between rocker arm shaft and rocker arm		0.01 – 0.05 (0.0004 – 0.002)	0.2 (0.0079)	Replace bushing or shaft	
		Rocker arm shaft wear		18.98 – 19.00 (0.747 – 0.748)	Dia. 18.85 (0.742)	Replace	
Intake System	Air cleaner	Air cleaner element condition					Special order item from manufacturer

Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Lubricating System	Oil pressure	Lubricating oil pressure kPa (kgf/cm^2/psi)			290 – 390 (3.0 – 4.0/43 – 57)	196 (2.0/28)		
	Oil lpump and Relief valve	Clearance between pump body inner wall and gear teeth mm			0.075 – 0.150 (0.003 – 0.0059)	0.2 (0.0079)	Replace bushing, gear or body	
		Pumping rate L/min (1650 min^{-1}, SAE #30, pumping pressure 392 kPa (4 kgf/cm^2/57 psi) oil temp. 80°C (176°F))			53.3			
		End gap between pump cover and gear			0.040 – 0.094 (0.0016 – 0.0037)	0.15 (0.0059)	Replace gear or cover	
		Clearance between drive shaft and pump body			0.032 – 0.070 (0.0013 – 0.0028)	0.15 (0.0059)		
		Clearance between drive shaft and bushing			0.045 – 0.078 (0.0018 – 0.0031)	0.15 (0.0059)	Replace bushing	
		Diameter of drive shaft		Dia. 16 (0.6299)		Dia 15.9 (0.626)	Replace shaft	
		Initial operating pressure of relief valve kPa (kgf/cm^2/psi)	Oil gallery		441 (4.5/64)			Reference value
			Oil pump		785 (8/114)			
	Oil filter	Clogging and damage to oil filter					Replace	Replace cartridge every 500 hours of operation
		Initial operating pressure of main oil filter relief valve kPa (kgf/cm^2/psi)			196 (2.0/28)			

Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Cooling System	Water pump	Water pump ball bearing chatter (radial direction)			0.008 – 0.010 (0.0003 – 0.0004)	0.2 (0.0079)	Replae	#6305 (2) #6205 (1)
		Pumping rate L/min (pumping speed 3720 min^{-1}, water temp 30°C (86°F) Total head 13.5m(531.5in) or more)			300			
		Clearance between pump impeller and pump body mm (in)			0.3 – 1.0 (0.0118 – 0.039)		Repair or replace if impeller and pump body are touching	
		Fan belt deflection Press with finger  mm (in)	Single belt		About 7 – 10 (0.276 – 0.394)		Adjust	(Reference) 98N (10kgf/22lb)
			Scrum belt (2 belts are jointed)		About 3.5 – 6.0 (0.138 – 0.236)			
			Scrum belt (3 belts are jointed)		About 1.5 – 2.5 (0.059 – 0.098)			
		Initial thermostat operating temperature (at sea level)	AA-6BG1TRA		82 ± 2°C (179.6 ± 35.6°F)			Replace thermostat if operation is incorrect.
			CC-6BG1TRA-12/13		76.5 ± 2°C (169.7 ± 35.6°F)			
		Thermostat full-open temperature (at sea level)			90°C (194°F)		Temperature at which thermostat lift reaches 10mm(0.394in) or more.	
		Fan center and bearing shaft interference			0.07 – 0.11 (0.003 – 0.004)		Replace water pump ASM	
		Bearing shaft and impeller interference			0.020 – 0.060 (0.0008 – 0.0024)		Replace water pump ASM	
		Pulley and fan center clearance			0.14 or less (0.006)		Replace water pump ASM	

Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Piping, etc.	Clogged, cracked, loose fuel pipes, injection pipes, nozzle holders; defective seals.					Repair or replace	
		Fuel filter element clogging or damage					Replace	Cartridge type
	Injection pump	Delivery valve	Delivery valve wear				Inspect for damage to valve's piston and seat; replace in case of severe vertical cracks on piston or impact scars on seat with loss of finish gloss. Immerse delivery valve in clean diesel fuel, then lightly press lower part of valve seat with finger and release; replace assembly if valve does not return to original state when finger is released.	

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Injectipn pump	AA-6BG1TRA					

	Adjustment Item \ Pump Part No.	1-15603-328-0
Adjustment Conditions	Rotation Direction	Clockwise (viewed from drive side)
	Nozzle	105780-0000 (BOSCH Type No. DN12SD12T)
	Nozzle holder assembly	105780-2080 (BOSCH Type No. EF8511/9)
	Nozzle opening pressure MPa (kgf/cm^2/psi)	17.2 (175/2490)
	Fuel pumping pressure kPa (kgf/cm^2/psi)	157 (1.6/23)
	Pipe (o.d. x i.d. x lenght) mm (in)	Dia. 6(0.236) x Dia. 2(0.079) x 600(23.62)
	Test fuel	ISO4113 or SAE Standard Oil (SAE J967d)
	Fuel temperature °C (°F)	40 – 45 (104 – 113)

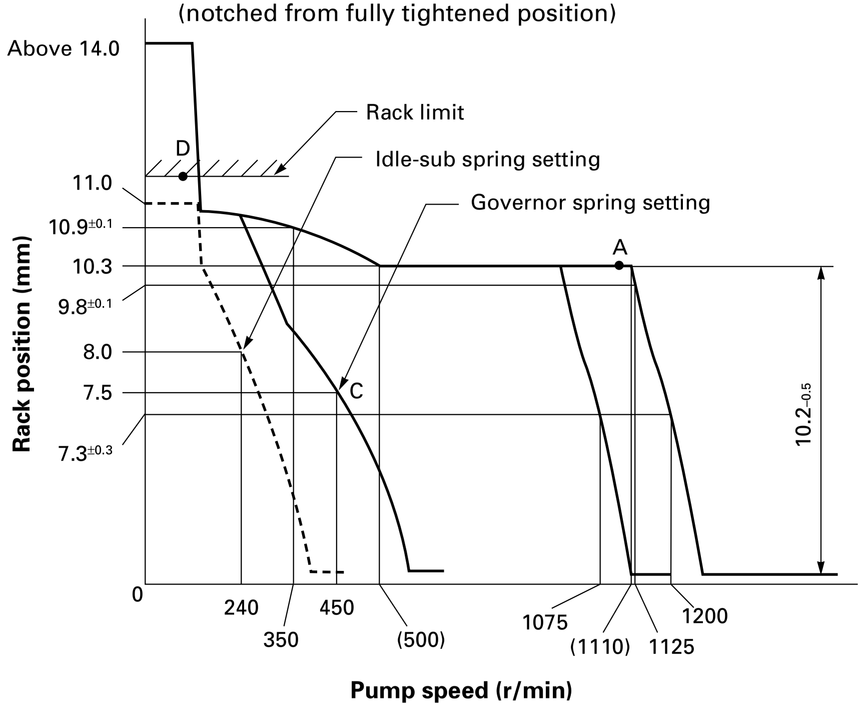
Injection adjustment

Adjustment point	Rack position mm (in)	Pump speed (min^{-1})	Injection q'ty (mm^3/1000 strokes)	Max. var bet. cyl (%)	Fixed	Remarks
A	10.3 (0.4449)	1075	89 ± 1.5	± 2	Lever	Basic
C	Approx 7.5 (0.295)	450	9 ± 1.3	± 14	Rack	
D	–	100	150 ± 5	–	Lever	Rack limit

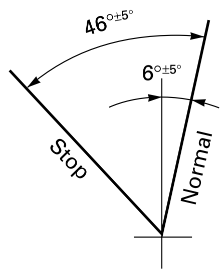
Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Injectipn pump	AA-6BG1TRA					

Governor perfomance curve

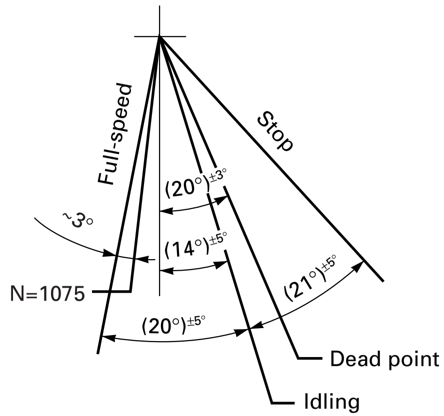
Recommended speed droop adjustment screw position:9
(notched from fully tightened position)



Stop lever angle



Speed lever angle



Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Injectipn pump	CC-6BG1TRA-12					

	Adjustment Item / Pump Part No.	8-98175-951-*
Adjustment Conditions	Rotation Direction	Clockwise (viewed from drive side)
	Nozzle	105780-0000 (BOSCH Type No. DN12SD12T)
	Nozzle holder assembly	105780-2080 (BOSCH Type No. EF8511/9)
	Nozzle opening pressure MPa (kgf/cm^2/psi)	17.2 (175/2490)
	Fuel pumping pressure kPa (kgf/cm^2/psi)	255 (2.6/37)
	Pipe (o.d. x i.d. x lenght) mm (in)	Dia. 6(0.236) x Dia. 2(0.079) x 600(23.62)
	Test fuel	ISO4113 or SAE Standard Oil (SAE J967d)
	Fuel temperature °C (°F)	40 – 45 (104 – 113)

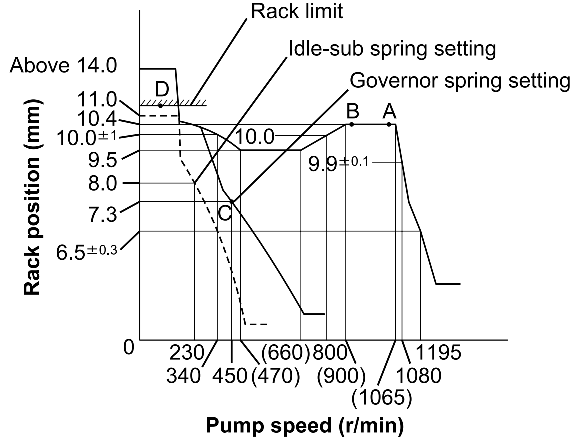
Injection adjustment

Adjustment point	Rack position mm (in)	Pump speed (min^{-1})	Injection q'ty (mm^3/1000 strokes)	Max. var bet. cyl (%)	Fixed	Remarks
A	10.4 (0.4094)	1050	95 ± 1.5	± 2	Lever	Basic
C	Approx 7.3 (0.2874)	450	12 ± 1.3	± 14	Rack	
D	–	100	105 ± 5	–	Lever	Rack limit

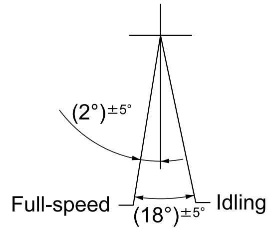
Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Injectipn pump	CC-6BG1TRA-12					

Governor perfomance curve

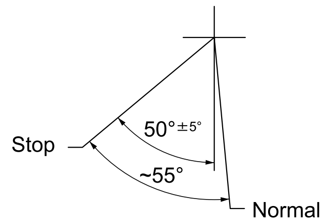
Recommended speed droop adjustment screw position:9
(notched from fully tightened position)



Stop lever angle



Speed lever angle



Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Injectipn pump	CC-6BG1TRA-13					

Adjustment Item \ Pump Part No.		1-15603-396-*
Adjustment Conditions	Rotation Direction	Clockwise (viewed from drive side)
	Nozzle	105780-0000 (BOSCH Type No. DN12SD12T)
	Nozzle holder assembly	105780-2080 (BOSCH Type No. EF8511/9)
	Nozzle opening pressure MPa (kgf/cm^2/psi)	17.2 (175/2490)
	Fuel pumping pressure kPa (kgf/cm^2/psi)	255 (2.6/37)
	Pipe (o.d. x i.d. x lenght) mm (in)	Dia. 6(0.236) x Dia. 2(0.079) x 600(23.62)
	Test fuel	ISO4113 or SAE Standard Oil (SAE J967d)
	Fuel temperature °C (°F)	40 – 45 (104 – 113)

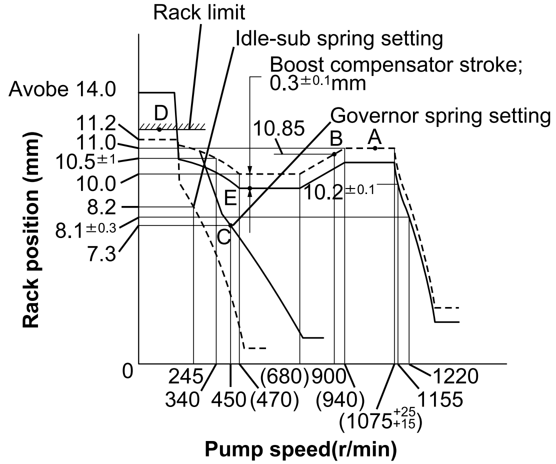
Injection adjustment

Adjustment point	Rack position mm (in)	Pump speed (min^{-1})	Injection q'ty (mm^3/1000 strokes)	Max. var bet. cyl (%)	Fixed	Remarks
A	11.0 (0.4331)	1075	110.5 ± 1.5	± 2	Lever	Basic
C	Approx 7.3 (0.2784)	450	12 ± 1.3	± 14	Rack	
D	–	100	150 ± 5	–	Lever	Rack limit

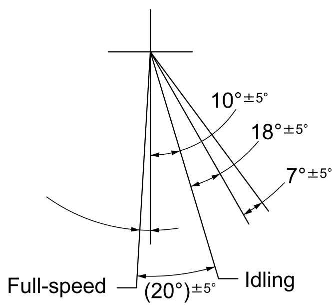
Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Injectipn pump	CC-6BG1TRA-13					

Governor perfomance curve

Recommended speed droop adjustment screw position:9
(notched from fully tightened position)



Stop lever angle



Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel system	Injection Nozzle	Technology Needle valve seat: 7.8MPa (80 kgf/cm^2/138psi)				Repair or replace parts with leaks from seat area	
		Needle valve shaft seat: seconds (Impress fuel pressure of 29.4MPa (300kgf/cm^2/4267psi) (nozzle starting pressure and measure time required for pressure to drop from 24.5MPa (250kgf/cm^2/3556psi) to19.6MPa (200kgf/cm^2/2845psi).)		5.0 or more		Replace	Fuel used: diesel fuel; clay (Redwood); 37 – 40 seconds 120°C (248°F)
		Fuel spray and injection (Impress fuel pressure of Adjust needls valve opening pressure to 19.1MPa (195kgf/cm^2/2770psi))	① Visually inspect, no relatively large drops scattered. ② No drops scattered to one side. ③ No unevenness of spray from jets.			Replace faulty parts	
Electrical	Charge/Discharge indication	Warning lamp indication				If warning indicator lights when engine is operating at normal speeds, check and repair electrical system.	
	Wiring	Check for looseness, cuts or damaged insulation to wiring.				Repair	
	Alternator 24V, 50A MITSUBISHI 1-81200-530-* (AA-6BG1TRA) 1-81200-603-* (CC-6BG1TRA-12/13)	Rotor: Shaft runout		0.06 or less (0.0024)	0.1 (0.0038)	Replace rotor	
		Rotor: Bearing chatter				Replace bearings	Rotate by hand and check for smooth rotation; no abnormal sound or resistance should be felt.
		Performance: Rated output current 27 V (5000 min^{-1})		50A			

Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Electrical	Starter 24V, 4.5 kW (HITACHI 1-81100-348-∗)	Loose mount					Repair	
		Brush height			22 (0.866)	14 (0.551)	Replace	
		Magnetic switch	Series coil resistance value (Ω)		0.187 20°C (68°F)			If coil resistance value is severely abnormal, replace switch.
			Shant coil resistance value (Ω)		1.31 20°C (68°F)			
		Commutator	O.D.	Dia. 37 (1.457)		Dia. 36.5 (1.437)	Replace armature	
			Undercut depth		0.5 – 0.8 (0.02 – 0.031)	0.2 (0.008)	Repair	
		Ball bearings	Rear side (armature)	Dia. 28 (1.102)			6001 D	Replace if rotation is not smooth or if abnormal sounds are heard.
			Front (armature)	Dia. 16 (0.630)			6905 D	
			Pinion shaft (shaft)	Dia. 16 (0.630)				
		Performance	Unloaded characteristics (24V, 100A or less)		3500 min^{-1}			Smooth pinion operation without noise
	Preheater	Control register, glow plug					Replace if cut wiring or shorts are found	
	Battery	Battery terminals						Special order from original manufac-turer; manufacturer's specs.
		Plates, separator plates, container, etc.						
		Electrolyte turbidity						

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Electrical	Battery	Electrolyte specific gravity (at recharging, 20°C)					Special order from original manufacturer
		Capacity (20 hours)					
		Electrode voltage					
		Electrolye surface height					
Final Inspection		Engine run-in operation				30 minutes or more	
		Cylinder compression pressure MPa (kgf/cm^2/psi) [water temp. 70 – 85°C, (158 – 185°F) about 200 min^{-1}]		3.0 (31/441)	2.5 (26/370)	Inspect	Warm engine
		Difference in compression between cylinders kPa (kgf/cm^2/psi) [water temp. 70 – 85°C, (158 – 185°F) about 200 min^{-1}]			290 (3.0/43)	Inspect	Warm engine
		Lubricating oil pressure kPa (kgf/cm^2/psi)		290 – 390 (3.0 – 4.0/43 – 57)	200 or less (2.0/28)	Adjust	
		Output check		85% or more			When new engine output is 100%
		Fuel consumption check		110% or less			

MEMO

SECTION 14

CONVERSION TABLE

TABLE OF CONTENTS

ITEM **PAGE**

LENGTH

MILLIMETERS TO INCHES

mm	in.	mm	in.	mm	in.	mm	in.
1	0.0394	26	1.0236	51	2.0079	76	2.9921
2	0.0787	27	1.0630	52	2.0472	77	3.0315
3	0.1181	28	1.1024	53	2.0866	78	3.0709
4	0.1575	29	1.1417	54	2.1260	79	3.1102
5	0.1969	30	1.1811	55	2.1654	80	3.1496
6	0.2362	31	1.2205	56	2.2047	81	3.1890
7	0.2756	32	1.2598	57	2.2441	82	3.2283
8	0.3150	33	1.2992	58	2.2835	83	3.2677
9	0.3543	34	1.3386	59	2.3228	84	3.3071
10	0.3937	35	1.3780	60	2.3622	85	3.3465
11	0.4331	36	1.4173	61	2.4016	86	3.3858
12	0.4724	37	1.4567	62	2.4409	87	3.4252
13	0.5118	38	1.4961	63	2.4803	88	3.4646
14	0.5512	39	1.5354	64	2.5197	89	3.5039
15	0.5906	40	1.5748	65	2.5591	90	3.5433
16	0.6299	41	1.6142	66	2.5984	91	3.5827
17	0.6693	42	1.6535	67	2.6378	92	3.6220
18	0.7087	43	1.6929	68	2.6772	93	3.6614
19	0.7480	44	1.7323	69	2.7165	94	3.7008
20	0.7874	45	1.7717	70	2.7559	95	3.7402
21	0.8268	46	1.8110	71	2.7953	96	3.7795
22	0.8661	47	1.8504	72	2.8346	97	3.8189
23	0.9055	48	1.8898	73	2.8740	98	3.8583
24	0.9449	49	1.9291	74	2.9134	99	3.8976
25	0.9843	50	1.9685	75	2.9528	100	3.9370
101	3.9764	111	4.3701	121	4.7638	131	5.1575
102	4.0157	112	4.4094	122	4.8031	132	5.1969
103	4.0551	113	4.4488	123	4.8425	133	5.2362
104	4.0945	114	4.4882	124	4.8819	134	5.2756
105	4.1339	115	4.5276	125	4.9213	135	5.3150
106	4.1732	116	4.5669	126	4.9606	136	5.3543
107	4.2126	117	4.6063	127	5.0000	137	5.3937
108	4.2520	118	4.6457	128	5.0394	138	5.4331
109	4.2913	119	4.6850	129	5.0787	139	5.4724

INCHES TO MILLIMETERS

in.	mm	in.	mm
1/64	0.3969	33/64	13.0969
1/32	0.7938	17/32	13.4938
3/64	1.1906	35/64	13.8906
1/16	1.5875	9/16	14.2875
5/64	1.9844	37/64	14.6844
3/32	2.3813	19/32	15.0813
7/64	2.7781	39/64	15.4781
1/8	3.1750	5/8	15.8750
9/64	3.5719	41/64	16.2719
5/32	3.9688	21/32	16.6688
11/64	4.3656	43/64	17.0656
3/16	4.7625	11/16	17.4625
13/64	5.1594	45/64	17.8594
7/32	5.5563	23/32	18.2563
15/64	5.9531	47/64	18.6531
1/4	6.3500	3/4	19.0500
17/64	6.7469	49/64	19.4469
9/32	7.1438	25/32	19.8438
19/64	7.5406	51/64	20.2406
5/16	7.9375	13/16	20.6375
21/64	8.3344	53/64	21.0344
11/32	8.7313	27/32	21.4313
23/64	9.1281	55/64	21.8281
3/8	9.5250	7/8	22.2250
25/64	9.9219	57/64	22.6219
13/32	10.3188	29/32	23.0188
27/64	10.7156	59/64	23.4156
7/16	11.1125	15/16	23.8125
29/64	11.5094	61/64	24.2094
15/32	11.9063	31/32	24.6063
31/64	12.3031	63/64	25.0031
1/2	12.7000	1	25.4000

14–2 CONVERSION TABLE

LENGTH

FEET TO METERS

ft.	0	1	2	3	4	5	6	7	8	9	ft.
	m	m	m	m	m	m	m	m	m	m	
—	—	0.305	0.610	0.914	1.219	1.524	1.829	2.134	2.438	2.743	—
10	3.048	3.353	3.658	3.962	4.267	4.572	4.877	5.182	5.486	5.791	10
20	6.096	6.401	6.706	7.010	7.315	7.620	7.925	8.230	8.534	8.839	20
30	9.144	9.449	9.754	10.058	10.363	10.668	10.973	11.278	11.582	11.887	30
40	12.192	12.497	12.802	13.106	13.411	13.716	14.021	14.326	14.630	14.935	40
50	15.240	15.545	15.850	16.154	16.459	16.764	17.069	17.374	17.678	17.983	50
60	18.288	18.593	18.898	19.202	19.507	19.812	20.117	20.422	20.726	21.031	60
70	21.336	21.641	21.946	22.250	22.555	22.860	23.165	23.470	23.774	24.079	70
80	24.384	24.689	24.994	25.298	25.603	25.908	26.213	26.518	26.822	27.127	80
90	27.432	27.737	28.042	28.346	28.651	28.956	29.261	29.566	29.870	30.175	90
100	30.480	30.785	31.090	31.394	31.699	32.004	32.309	32.614	32.918	33.223	100

METERS TO FEET

m	0	1	2	3	4	5	6	7	8	9	
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	
—	—	3.2808	6.5617	9.8425	13.1234	16.4042	19.6850	22.9659	26.2467	29.5276	—
10	32.8084	36.0892	39.3701	42.6509	45.9318	49.2126	52.4934	55.7743	59.0551	62.3360	10
20	65.6168	68.8976	72.1785	75.4593	78.7402	82.0210	85.3018	88.5827	91.8635	95.1444	20
30	98.4252	101.7060	104.9869	108.2677	111.5486	114.8294	118.1102	121.3911	124.6719	127.9528	30
40	131.2336	134.5144	137.7953	141.0761	144.3570	147.6378	150.9186	154.1995	157.4803	160.7612	40
50	164.0420	167.3228	170.6037	173.8845	177.1654	180.4462	183.7270	187.0079	190.2887	193.5696	50
60	196.8504	200.1312	203.4121	206.6929	209.9738	213.2546	216.5354	219.8163	223.0971	226.3780	60
70	229.6588	232.9396	236.2205	239.5013	242.7822	246.0630	249.3438	252.6247	255.9055	259.1864	70
80	262.4672	265.7480	269.0289	272.3097	275.5906	278.8714	282.1522	285.4331	288.7139	291.9948	80
90	295.2756	298.5564	301.8373	305.1181	308.3990	311.6798	314.9606	318.2415	321.5223	324.8032	90
100	328.0840	331.3648	334.6457	337.9265	341.2074	344.4882	347.7690	351.0499	354.3307	357.6116	100

MILES TO KILOMETERS

miles	0	1	2	3	4	5	6	7	8	9	
	km	km	km	km	km	km	km	km	km	km	
—	—	1.609	3.219	4.828	6.437	8.047	9.656	11.265	12.875	14.484	—
10	16.093	17.703	19.312	20.921	22.531	24.140	25.749	27.359	28.968	30.577	10
20	32.187	33.796	35.405	37.015	38.624	40.234	41.843	43.452	45.062	46.671	20
30	48.280	49.890	51.499	53.108	54.718	56.327	57.936	59.546	61.155	62.764	30
40	64.374	65.983	67.592	69.202	70.811	72.420	74.030	75.639	77.248	78.858	40
50	80.467	82.076	83.686	85.295	86.904	88.514	90.123	91.732	93.342	94.951	50
60	96.560	98.170	99.779	101.388	102.998	104.607	106.216	107.826	109.435	111.044	60
70	112.654	114.263	115.872	117.482	119.091	120.701	122.310	123.919	125.529	127.138	70
80	128.747	130.357	131.966	133.575	135.185	136.794	138.403	140.013	141.622	143.231	80
90	144.841	146.450	148.059	149.669	151.278	152.887	154.497	156.106	157.715	159.325	90
100	160.934	162.543	164.153	165.762	167.371	168.981	170.590	172.199	173.809	175.418	100

KILOMETERS TO MILES

km	0	1	2	3	4	5	6	7	8	9	
	miles	miles	miles	miles	miles	miles	miles	miles	miles	miles	
—	—	0.621	1.243	1.864	2.485	3.107	3.728	4.350	4.971	5.592	—
10	6.214	6.835	7.456	8.078	8.699	9.321	9.942	10.563	11.185	11.806	10
20	12.427	13.049	13.670	14.292	14.913	15.534	16.156	16.777	17.398	18.020	20
30	18.641	19.262	19.884	20.505	21.127	21.748	22.369	22.991	23.612	24.233	30
40	24.855	25.476	26.098	26.719	27.340	27.962	28.583	29.204	29.826	30.447	40
50	31.069	31.690	32.311	32.933	33.554	34.175	34.797	35.418	36.039	36.661	50
60	37.282	37.904	38.525	39.146	39.768	40.389	41.010	41.632	42.253	42.875	60
70	43.496	44.117	44.739	45.360	45.981	46.603	47.224	47.845	48.467	49.088	70
80	49.710	50.331	50.952	51.574	52.195	52.816	53.438	54.059	54.681	55.302	80
90	55.923	56.545	57.166	57.787	58.409	59.030	59.652	60.273	60.894	61.516	90
100	62.137	62.758	63.380	64.001	64.622	65.244	65.865	66.487	67.108	67.729	100

AREA

SQUARE INCHES TO SQUARE CENTIMETERS

in^2	0	1	2	3	4	5	6	7	8	9	in^2
	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	
—	—	6.452	12.903	19.355	25.806	32.258	38.710	45.161	51.613	58.064	—
10	64.516	70.968	77.419	83.871	90.322	96.774	103.226	109.677	116.129	122.580	10
20	129.032	135.484	141.935	148.387	154.838	161.290	167.742	174.193	180.645	187.096	20
30	193.548	200.000	206.451	212.903	219.354	225.806	232.258	238.709	245.161	251.612	30
40	258.064	264.516	270.967	277.419	283.870	290.322	296.774	303.225	309.677	316.128	40
50	322.580	329.032	335.483	341.935	348.386	354.838	361.290	367.741	374.193	380.644	50
60	387.096	393.548	399.999	406.451	412.902	419.354	425.806	432.257	438.709	445.160	60
70	451.612	458.064	464.515	470.967	477.418	483.870	490.322	496.773	503.225	509.676	70
80	516.128	522.580	529.031	535.483	541.934	548.386	554.838	561.289	567.741	574.192	80
90	580.644	587.096	593.547	599.999	606.450	612.902	619.354	625.805	632.257	638.708	90
100	645.160	651.612	658.063	664.515	670.966	677.418	683.870	690.321	696.773	703.224	100

SQUARE CENTIMETERS TO SQUARE INCHES

cm^2	0	1	2	3	4	5	6	7	8	9	cm^2
	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	
—	—	0.155	0.310	0.465	0.620	0.775	0.930	1.085	1.240	1.395	—
10	1.550	1.705	1.860	2.015	2.170	2.325	2.480	2.635	2.790	2.945	10
20	3.100	3.255	3.410	3.565	3.720	3.875	4.030	4.185	4.340	4.495	20
30	4.650	4.805	4.960	5.115	5.270	5.425	5.580	5.735	5.890	6.045	30
40	6.200	6.355	6.510	6.665	6.820	6.975	7.130	7.285	7.440	7.595	40
50	7.750	7.905	8.060	8.215	8.370	8.525	8.680	8.835	8.990	9.145	50
60	9.300	9.455	9.610	9.765	9.920	10.075	10.230	10.385	10.540	10.695	60
70	10.850	11.005	11.160	11.315	11.470	11.625	11.780	11.935	12.090	12.245	70
80	12.400	12.555	12.710	12.865	13.020	13.175	13.330	13.485	13.640	13.795	80
90	13.950	14.105	14.260	14.415	14.570	14.725	14.880	15.035	15.190	15.345	90
100	15.500	15.655	15.810	15.965	16.120	16.275	16.430	16.585	16.740	16.895	100

VOLUME

CUBIC INCHES TO CUBIC CENTIMETERS

in^3	0	1	2	3	4	5	6	7	8	9	in^3
	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	
—	—	16.387	32.774	49.161	65.548	81.935	98.322	114.709	131.097	147.484	—
10	163.871	180.258	196.645	213.032	229.419	245.806	262.193	278.580	294.967	311.354	10
20	327.741	344.128	360.515	376.902	393.290	409.677	426.064	442.451	458.838	475.225	20
30	491.612	507.999	524.386	540.773	557.160	573.547	589.934	606.321	622.708	639.095	30
40	655.483	671.870	688.257	704.644	721.031	737.418	753.805	770.192	786.579	802.966	40
50	819.353	835.740	852.127	868.514	884.901	901.289	917.676	934.063	950.450	966.837	50
60	983.224	999.611	1015.998	1032.385	1048.772	1065.159	1081.546	1097.933	1114.320	1130.707	60
70	1147.094	1163.482	1179.869	1196.256	1212.643	1229.030	1245.417	1261.804	1278.191	1294.578	70
80	1310.965	1327.352	1343.739	1360.126	1376.513	1392.900	1409.288	1425.675	1442.062	1458.449	80
90	1474.836	1491.223	1507.610	1523.997	1540.384	1556.771	1573.158	1589.545	1605.932	1622.319	90
100	1638.706	1655.093	1671.481	1687.868	1704.255	1720.642	1737.029	1753.416	1769.803	1786.190	100

CUBIC CENTIMETERS TO CUBIC INCHES

cm^3(cc)	0	1	2	3	4	5	6	7	8	9	cm^3(cc)
	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	
—	—	0.0610	0.1220	0.1831	0.2441	0.3051	0.3661	0.4272	0.4882	0.5492	—
10	0.6102	0.6713	0.7323	0.7933	0.8543	0.9153	0.9764	1.0374	1.0984	1.1594	10
20	1.2205	1.2815	1.3425	1.4035	1.4646	1.5256	1.5866	1.6476	1.7086	1.7697	20
30	1.8307	1.8917	1.9527	2.0138	2.0748	2.1358	2.1968	2.2579	2.3189	2.3799	30
40	2.4409	2.5019	2.5630	2.6240	2.6850	2.7460	2.8071	2.8681	2.9291	2.9901	40
50	3.0512	3.1122	3.1732	3.2342	3.2952	3.3563	3.4173	3.4783	3.5393	3.6004	50
60	3.6614	3.7224	3.7834	3.8444	3.9055	3.9665	4.0275	4.0885	4.1496	4.2106	60
70	4.2716	4.3326	4.3937	4.4547	4.5157	4.5767	4.6377	4.6988	4.7598	4.8208	70
80	4.8818	4.9429	5.0039	5.0649	5.1259	5.1870	5.2480	5.3090	5.3700	5.4310	80
90	5.4921	5.5531	5.6141	5.6751	5.7362	5.7972	5.8582	5.9192	5.9803	6.0413	90
100	6.1023	6.1633	6.2243	6.2854	6.3464	6.4074	6.4684	6.5295	6.5905	6.6515	100

14–4 CONVERSION TABLE

VOLUME

GALLONS (U.S.) TO LITERS

U.S. gal.	0	1	2	3	4	5	6	7	8	9	U.S.gal.
	liters	liters	liters	liters	liters	liters	liters	liters	liters	liters	
——	——	3.7854	7.5709	11.3563	15.1417	18.9271	22.7126	26.4980	30.2834	34.0688	——
10	37.8543	41.6397	45.4251	49.2106	52.9960	56.7814	60.5668	64.3523	68.1377	71.9231	10
20	75.7085	79.4940	83.2794	87.0648	90.8502	94.6357	98.4211	102.2065	105.9920	109.7774	20
30	113.5628	117.3482	121.1337	124.9191	128.7045	132.4899	136.2754	140.0608	143.8462	147.6317	30
40	151.4171	155.2025	158.9879	162.7734	166.5588	170.3442	174.1296	177.9151	181.7005	185.4859	40
50	189.2714	193.0568	196.8422	200.6276	204.4131	208.1985	211.9839	215.7693	219.5548	223.3402	50
60	227.1256	230.9110	234.6965	238.4819	242.2673	246.0528	249.8382	253.6236	257.4090	261.1945	60
70	264.9799	268.7653	272.5507	276.3362	280.1216	283.9070	287.6925	291.4779	295.2633	299.0487	70
80	302.8342	306.6196	310.4050	314.1904	317.9759	321.7613	325.5467	329.3321	333.1176	336.9030	80
90	340.6884	344.4739	348.2593	352.0447	355.8301	359.6156	363.4010	367.1864	370.9718	374.7573	90
100	378.5427	382.3281	386.1136	389.8990	393.6844	397.4698	401.2553	405.0407	408.8261	412.6115	100

LITERS TO GALLONS (U.S.)

liters	0	1	2	3	4	5	6	7	8	9	liters
	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	
——	——	0.2642	0.5283	0.7925	1.0567	1.3209	1.5850	1.8492	2.1134	2.3775	——
10	2.6417	2.9059	3.1701	3.4342	3.6984	3.9626	4.2268	4.4909	4.7551	5.0193	10
20	5.2834	5.5476	5.8118	6.0760	6.3401	6.6043	6.8685	7.1326	7.3968	7.6610	20
30	7.9252	8.1893	8.4535	8.7177	8.9818	9.2460	9.5102	9.7744	10.0385	10.3027	30
40	10.5669	10.8311	11.0952	11.3594	11.6236	11.8877	12.1519	12.4161	12.6803	12.9444	40
50	13.2086	13.4728	13.7369	14.0011	14.2653	14.5295	14.7936	15.0578	15.3220	15.5861	50
60	15.8503	16.1145	16.3787	16.6428	16.9070	17.1712	17.4354	17.6995	17.9637	18.2279	60
70	18.4920	18.7562	19.0204	19.2846	19.5487	19.8129	20.0771	20.3412	20.6054	20.8696	70
80	21.1338	21.3979	21.6621	21.9263	22.1904	22.4546	22.7188	22.9830	23.2471	23.5113	80
90	23.7755	24.0397	24.3038	24.5680	24.8322	25.0963	25.3605	25.6247	25.8889	26.1530	90
100	26.4172	26.6814	26.9455	27.2097	27.4739	27.7381	28.0022	28.2664	28.5306	28.7947	100

GALLONS (IMP.) TO LITERS

Imp gal.	0	1	2	3	4	5	6	7	8	9	Imp gal.
	liters	liters	liters	liters	liters	liters	liters	liters	liters	liters	
——	——	4.5459	9.0918	13.6377	18.1836	22.7295	27.2754	31.8213	36.3672	40.9131	——
10	45.4590	50.0049	54.5508	59.0967	63.6426	68.1885	72.7344	77.2803	81.8262	86.3721	10
20	90.9180	95.4639	100.0098	104.5557	109.1016	113.6475	118.1934	122.7393	127.2852	131.8311	20
30	136.3770	140.9229	145.4688	150.0147	154.5606	159.1065	163.6524	168.1983	172.7442	177.2901	30
40	181.8360	186.3819	190.9278	195.4737	200.0196	204.5655	209.1114	213.6573	218.2032	222.7491	40
50	227.2950	231.8409	236.3868	240.9327	245.4786	250.0245	254.5704	259.1163	263.6622	268.2081	50
60	272.7540	277.2999	281.8458	286.3917	290.9376	295.4835	300.0294	304.5753	309.1212	313.6671	60
70	318.2130	322.7589	327.3048	331.8507	336.3966	340.9425	345.4884	350.0343	354.5802	359.1261	70
80	363.6720	368.2179	372.7638	377.3097	381.8556	386.4015	390.9474	395.4933	400.0392	404.5851	80
90	409.1310	413.6769	418.2228	422.7687	427.3146	431.8605	436.4064	440.9523	445.4982	450.0441	90
100	454.5900	459.1359	463.6818	468.2277	472.7736	477.3195	481.8654	486.4113	490.9572	495.5031	100

LITERS TO GALLONS (IMP.)

liters	0	1	2	3	4	5	6	7	8	9	liters
	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	
——	——	0.2200	0.4400	0.6599	0.8799	1.0999	1.3199	1.5399	1.7598	1.9798	——
10	2.1998	2.4198	2.6398	2.8597	3.0797	3.2997	3.5197	3.7397	3.9596	4.1796	10
20	4.3996	4.6196	4.8396	5.0595	5.2795	5.4995	5.7195	5.9395	6.1594	6.3794	20
30	6.5994	6.8194	7.0394	7.2593	7.4793	7.6993	7.9193	8.1393	8.3592	8.5792	30
40	8.7992	9.0192	9.2392	9.4591	9.6791	9.8991	10.1191	10.3391	10.5590	10.7790	40
50	10.9990	11.2190	11.4390	11.6589	11.8789	12.0989	12.3189	12.5389	12.7588	12.9788	50
60	13.1988	13.4188	13.6388	13.8587	14.0787	14.2987	14.5187	14.7387	14.9586	15.1786	60
70	15.3986	15.6186	15.8386	16.0585	16.2785	16.4985	16.7185	16.9385	17.1584	17.3784	70
80	17.5984	17.8184	18.0384	18.2583	18.4783	18.6983	18.9183	19.1383	19.3582	19.5782	80
90	19.7982	20.0182	20.2382	20.4581	20.6781	20.8981	21.1181	21.3381	21.5580	21.7780	90
100	21.9980	22.2180	22.4380	22.6579	22.8779	23.0979	23.3179	23.5379	23.7578	23.9778	100

MASS

POUNDS TO KILOGRAMS

lbs.	0	1	2	3	4	5	6	7	8	9	lbs.
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—	—	0.454	0.907	1.361	1.814	2.268	2.722	3.175	3.629	4.082	—
10	4.536	4.989	5.443	5.897	6.350	6.804	7.257	7.711	8.165	8.618	10
20	9.072	9.525	9.979	10.433	10.886	11.340	11.793	12.247	12.701	13.154	20
30	13.608	14.061	14.515	14.968	15.422	15.876	16.329	16.783	17.236	17.690	30
40	18.144	18.597	19.051	19.504	19.958	20.412	20.865	21.319	21.772	22.226	40
50	22.680	23.133	23.587	24.040	24.494	24.947	25.401	25.855	26.308	26.762	50
60	27.215	27.669	28.123	28.576	29.030	29.483	29.937	30.391	30.844	31.298	60
70	31.751	32.205	32.658	33.112	33.566	34.019	34.473	34.926	35.380	35.834	70
80	36.287	36.741	37.194	37.648	38.102	38.555	39.009	39.462	39.916	40.370	80
90	40.823	41.277	41.730	42.184	42.637	43.091	43.545	43.998	44.452	44.905	90
100	45.359	45.813	46.266	46.720	47.173	47.627	48.081	48.534	48.988	49.441	100

KILOGRAMS TO POUNDS

kg	0	1	2	3	4	5	6	7	8	9	kg
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
—	—	2.205	4.409	6.614	8.818	11.023	13.228	15.432	17.637	19.842	—
10	22.046	24.251	26.455	28.660	30.865	33.069	35.274	37.479	39.683	41.888	10
20	44.092	46.297	48.502	50.706	52.911	55.116	57.320	59.525	61.729	63.934	20
30	66.139	68.343	70.548	72.752	74.957	77.162	79.366	81.571	83.776	85.980	30
40	88.185	90.389	92.594	94.799	97.003	99.208	101.413	103.617	105.822	108.026	40
50	110.231	112.436	114.640	116.845	119.049	121.254	123.459	125.663	127.868	130.073	50
60	132.277	134.482	136.686	138.891	141.096	143.300	145.505	147.710	149.914	152.119	60
70	154.323	156.528	158.733	160.937	163.142	165.347	167.551	169.756	171.960	174.165	70
80	176.370	178.574	180.779	182.983	185.188	187.393	189.597	191.802	194.007	196.211	80
90	198.416	200.620	202.825	205.030	207.234	209.439	211.644	213.848	216.053	218.257	90
100	220.462	222.667	224.871	227.076	229.280	231.485	233.690	235.894	238.099	240.304	100

KILOGRAMS TO NEWTON

kg	0	1	2	3	4	5	6	7	8	9	kg
	N	N	N	N	N	N	N	N	N	N	
—	—	9.81	19.61	29.42	39.23	49.03	58.84	68.65	78.45	88.26	—
10	98.07	107.87	117.68	127.49	137.29	147.10	156.91	166.71	176.52	186.33	10
20	196.13	205.94	215.75	225.55	235.36	245.17	254.97	264.78	274.59	284.39	20
30	294.20	304.01	313.81	323.62	333.43	343.23	353.04	362.85	372.65	382.46	30
40	392.27	402.07	411.88	421.69	431.49	441.30	451.11	460.91	470.72	480.53	40
50	490.34	500.14	509.95	519.76	529.56	539.37	549.18	558.98	568.79	578.60	50
60	588.40	598.21	608.02	617.82	627.63	637.44	647.24	657.05	666.86	676.66	60
70	686.47	696.28	706.08	715.89	725.70	735.50	745.31	755.12	764.92	774.73	70
80	784.54	794.34	804.15	813.96	823.76	833.57	843.38	853.18	862.99	872.80	80
90	882.60	892.41	902.22	912.02	921.83	931.64	941.44	951.25	961.06	970.86	90
100	980.67	990.48	1000.28	1010.09	1019.90	1029.70	1039.51	1049.32	1059.12	1068.93	100

NEWTON TO KILOGRAMS

N	0	10	20	30	40	50	60	70	80	90	N
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
100	10.197	11.217	12.237	13.256	14.276	15.296	16.316	17.335	18.355	19.375	100
200	20.394	21.414	22.434	23.454	24.473	25.493	26.513	27.532	28.552	29.572	200
300	30.592	31.611	32.631	33.651	34.670	35.690	36.710	37.730	38.749	39.769	300
400	40.789	41.809	42.828	43.848	44.868	45.887	46.907	47.927	48.947	49.966	400
500	50.986	52.006	53.025	54.045	55.065	56.085	57.104	58.124	59.144	60.163	500
600	61.183	62.203	63.223	64.242	65.262	66.282	67.302	68.321	69.341	70.361	600
700	71.380	72.400	73.420	74.440	75.459	76.479	77.499	78.518	79.538	80.558	700
800	81.578	82.597	83.617	84.637	85.656	86.676	87.696	88.716	89.735	90.755	800
900	91.775	92.795	93.814	94.834	95.854	96.873	97.893	98.913	99.933	100.952	900
1000	101.972	102.992	104.011	105.031	106.051	107.071	108.090	109.110	110.130	111.149	1000

14–6 CONVERSION TABLE

PRESSURE

POUNDS PER SQUARE INCHES TO KILOGRAMS PER SQUARE CENTIMETERS

lb/in²	0	1	2	3	4	5	6	7	8	9	lb/in²
(psi)	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	(psi)
—	—	0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5625	0.6328	—
10	0.7031	0.7734	0.8437	0.9140	0.9843	1.0546	1.1249	1.1952	1.2655	1.3358	10
20	1.4061	1.4764	1.5468	1.6171	1.6874	1.7577	1.8280	1.8983	1.9686	2.0389	20
30	2.1092	2.1795	2.2498	2.3201	2.3904	2.4607	2.5311	2.6014	2.6717	2.7420	30
40	2.8123	2.8826	2.9529	3.0232	3.0935	3.1638	3.2341	3.3044	3.3747	3.4450	40
50	3.5154	3.5857	3.6560	3.7263	3.7966	3.8669	3.9372	4.0075	4.0778	4.1481	50
60	4.2184	4.2887	4.3590	4.4293	4.4996	4.5700	4.6403	4.7106	4.7809	4.8512	60
70	4.9215	4.9918	5.0621	5.1324	5.2027	5.2730	5.3433	5.4136	5.4839	5.5543	70
80	5.6246	5.6949	5.7652	5.8355	5.9058	5.9761	6.0464	6.1167	6.1870	6.2573	80
90	6.3276	6.3979	6.4682	6.5386	6.6089	6.6792	6.7495	6.8198	6.8901	6.9604	90
100	7.0307	7.1010	7.1713	7.2416	7.3119	7.3822	7.4525	7.5228	7.5932	7.6635	100

KILOGRAMS PER SQUARE CENTIMETERS TO POUNDS PER SQUARE INCHES

kg/cm²	0	1	2	3	4	5	6	7	8	9	kg/cm²
	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	
—	—	14.22	28.45	42.67	56.89	71.12	85.34	99.56	113.78	128.01	—
10	142.23	156.45	170.68	184.90	199.12	213.35	227.57	241.79	256.01	270.24	10
20	284.46	298.68	312.91	327.13	341.35	355.58	369.80	384.02	398.24	412.47	20
30	426.69	440.91	455.14	469.36	483.58	497.81	512.03	526.25	540.47	554.70	30
40	568.92	583.14	597.37	611.59	625.81	640.04	654.26	668.48	682.70	696.93	40
50	711.15	725.37	739.60	753.82	768.04	782.27	796.49	810.71	824.93	839.16	50
60	853.38	867.60	881.83	896.05	910.27	924.50	938.72	952.94	967.16	981.39	60
70	995.61	1009.83	1024.06	1038.28	1052.50	1066.73	1080.95	1095.17	1109.39	1123.62	70
80	1137.84	1152.06	1166.29	1180.51	1194.73	1208.96	1223.18	1237.40	1251.62	1265.85	80
90	1280.07	1294.29	1308.52	1322.74	1336.96	1351.19	1365.41	1379.63	1393.85	1408.08	90
100	1422.30	1436.52	1450.75	1464.97	1479.19	1493.42	1507.64	1521.86	1536.08	1550.31	100

KILOGRAMS PER SQUARE CENTIMETERS TO KILO PASCAL

kg/cm²	0	1	2	3	4	5	6	7	8	9	kg/cm²
	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	
—	—	98.1	196.1	294.2	392.3	490.3	588.4	686.5	784.5	882.6	—
10	980.7	1078.7	1176.8	1274.9	1372.9	1471.0	1569.1	1667.1	1765.2	1863.3	10
20	1961.3	2059.4	2157.5	2255.5	2353.6	2451.7	2549.7	2647.8	2745.9	2843.9	20
30	2942.0	3040.1	3138.1	3236.2	3334.3	3432.3	3530.4	3628.5	3726.5	3824.6	30
40	3922.7	4020.7	4118.8	4216.9	4314.9	4413.0	4511.1	4609.1	4707.2	4805.3	40
50	4903.4	5001.4	5099.5	5197.6	5295.6	5393.7	5491.8	5589.8	5687.9	5786.0	50
60	5884.0	5982.1	6080.2	6178.2	6276.3	6374.4	6472.4	6570.5	6668.6	6766.6	60
70	6864.7	6962.8	7060.8	7158.9	7257.0	7355.0	7453.1	7551.2	7649.2	7747.3	70
80	7845.4	7943.4	8041.5	8139.6	8237.6	8335.7	8433.8	8531.8	8629.9	8728.0	80
90	8826.0	8924.1	9022.2	9120.2	9218.3	9316.4	9414.4	9512.5	9610.6	9708.6	90
100	9806.7	9904.8	10002.8	10100.9	10199.0	10297.0	10395.1	10493.2	10591.2	10689.3	100

KILO PASCAL TO KILOGRAMS PER SQUARE CENTIMETERS

KPa	0	100	200	300	400	500	600	700	800	900	KPa
	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
1000	10.197	11.217	12.237	13.256	14.276	15.296	16.316	17.335	18.355	19.375	1000
2000	20.394	21.414	22.434	23.454	24.473	25.493	26.513	27.532	28.552	29.572	2000
3000	30.592	31.611	32.631	33.651	34.670	35.690	36.710	37.730	38.749	39.769	3000
4000	40.789	41.809	42.828	43.848	44.868	45.887	46.907	47.927	48.947	49.966	4000
5000	50.986	52.006	53.025	54.045	55.065	56.085	57.104	58.124	59.144	60.163	5000
6000	61.183	62.203	63.223	64.242	65.262	66.282	67.302	68.321	69.341	70.361	6000
7000	71.380	72.400	73.420	74.440	75.459	76.479	77.499	78.518	79.538	80.558	7000
8000	81.578	82.597	83.617	84.637	85.656	86.676	87.696	88.716	89.735	90.755	8000
9000	91.775	92.795	93.814	94.834	95.854	96.873	97.893	98.913	99.933	100.952	9000
10000	101.972	102.992	104.011	105.031	106.051	107.071	108.090	109.110	110.130	111.149	10000

TORQUE

FOOT POUNDS TO KILOGRAMMETERS

ft. lbs.	0	1	2	3	4	5	6	7	8	9	ft lbs.
	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	
—	—	0.138	0.277	0.415	0.553	0.691	0.830	0.968	1.106	1.244	—
10	1.383	1.521	1.659	1.797	1.936	2.074	2.212	2.350	2.489	2.627	10
20	2.765	2.903	3.042	3.180	3.318	3.457	3.595	3.733	3.871	4.010	20
30	4.148	4.286	4.424	4.563	4.701	4.839	4.977	5.116	5.254	5.392	30
40	5.530	5.669	5.807	5.945	6.083	6.222	6.360	6.498	6.636	6.775	40
50	6.913	7.051	7.190	7.328	7.466	7.604	7.743	7.881	8.019	8.157	50
60	8.296	8.434	8.572	8.710	8.849	8.987	9.125	9.263	9.402	9.540	60
70	9.678	9.816	9.955	10.093	10.231	10.370	10.508	10.646	10.784	10.923	70
80	11.061	11.199	11.337	11.476	11.614	11.752	11.890	12.029	12.167	12.305	80
90	12.443	12.582	12.720	12.858	12.996	13.135	13.273	13.411	13.549	13.688	90
100	13.826	13.964	14.103	14.241	14.379	14.517	14.656	14.794	14.932	15.070	100

KILOGRAMMETERS TO FOOT POUNDS

kg-m	0	1	2	3	4	5	6	7	8	9	kg-m
	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	
—	—	7.23	14.47	21.70	28.93	36.17	43.40	50.63	57.86	65.10	—
10	72.33	79.56	86.80	94.03	101.26	108.50	115.73	122.96	130.19	137.43	10
20	144.66	151.89	159.13	166.36	173.59	180.83	188.06	195.29	202.52	209.76	20
30	216.99	224.22	231.46	238.69	245.92	253.16	260.39	267.62	274.85	282.09	30
40	289.32	296.55	303.79	311.02	318.25	325.49	332.72	339.95	347.18	354.42	40
50	361.65	368.88	376.12	383.35	390.58	397.82	405.05	412.28	419.51	426.75	50
60	433.98	441.21	448.45	455.68	462.91	470.15	477.38	484.61	491.84	499.08	60
70	506.31	513.54	520.78	528.01	535.24	542.48	549.71	556.94	564.17	571.41	70
80	578.64	585.87	593.11	600.34	607.57	614.81	622.04	629.27	636.50	643.74	80
90	650.97	658.20	665.44	672.67	679.90	687.14	694.37	701.60	708.83	716.07	90
100	723.30	730.53	737.77	745.00	752.23	759.47	766.70	773.93	781.16	788.40	100

KILOGRAMMETERS TO NEWTONMETERS

kg-m	0	1	2	3	4	5	6	7	8	9	kg-m
	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	
—	—	9.81	19.61	29.42	39.23	49.03	58.84	68.65	78.45	88.26	—
10	98.07	107.87	117.68	127.49	137.29	147.10	156.91	166.71	176.52	186.33	10
20	196.13	205.94	215.75	225.55	235.36	245.17	254.97	264.78	274.59	284.39	20
30	294.20	304.01	313.81	323.62	333.43	343.23	353.04	362.85	372.65	382.46	30
40	392.27	402.07	411.88	421.69	431.49	441.30	451.11	460.91	470.72	480.53	40
50	490.34	500.14	509.95	519.76	529.56	539.37	549.18	558.98	568.79	578.60	50
60	588.40	598.21	608.02	617.82	627.63	637.44	647.24	657.05	666.86	676.66	60
70	686.47	696.28	706.08	715.89	725.70	735.50	745.31	755.12	764.92	774.73	70
80	784.54	794.34	804.15	813.96	823.76	833.57	843.38	853.18	862.99	872.80	80
90	882.60	892.41	902.22	912.02	921.83	931.64	941.44	951.25	961.06	970.86	90
100	980.67	990.48	1000.28	1010.09	1019.90	1029.70	1039.51	1049.32	1059.12	1068.93	100

NEWTONMETERS TO KILOGRAMMETERS

N-m	0	10	20	30	40	50	60	70	80	90	N-m
	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
100	10.197	11.217	12.236	13.256	14.276	15.296	16.315	17.335	18.355	19.374	100
200	20.394	21.414	22.433	23.453	24.473	25.493	26.512	27.532	28.552	29.571	200
300	30.591	31.611	32.630	33.650	34.670	35.690	36.709	37.729	38.749	39.768	300
400	40.788	41.808	42.827	43.847	44.867	45.887	46.906	47.926	48.946	49.965	400
500	50.985	52.005	53.024	54.044	55.064	56.084	57.103	58.123	59.143	60.162	500
600	61.182	62.202	63.221	64.241	65.261	66.281	67.300	68.320	69.340	70.359	600
700	71.379	72.399	73.418	74.438	75.458	76.478	77.497	78.517	79.537	80.556	700
800	81.576	82.596	83.615	84.635	85.655	86.675	87.694	88.714	89.734	90.753	800
900	91.773	92.793	93.812	94.832	95.852	96.872	97.891	98.911	99.931	100.950	900
1000	101.970	102.990	104.009	105.029	106.049	107.069	108.088	109.108	110.128	111.147	1000

TEMPERATURE

FAHRENHEIT TO CENTIGRADE

°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
-60	-51.1	-2	-18.9	56	13.3	114	45.6	172	77.8	230	110.0	288	142.2	346	174.4
-58	-50.0	0	-17.8	58	14.4	116	46.7	174	78.9	232	111.1	290	143.3	348	175.6
-56	-48.9	2	-16.7	60	15.6	118	47.8	176	80.0	234	112.2	292	144.4	350	176.7
-54	-47.8	4	-15.6	62	16.7	120	48.9	178	81.1	236	113.3	294	145.6	352	177.8
-52	-46.7	6	-14.4	64	17.8	122	50.0	180	82.2	238	114.4	296	146.7	354	178.9
-50	-45.6	8	-13.3	66	18.9	124	51.1	182	83.3	240	115.6	298	147.8	356	180.0
-48	-44.4	10	-12.2	68	20.0	126	52.2	184	84.4	242	116.7	300	148.9	358	181.1
-46	-43.3	12	-11.1	70	21.1	128	53.3	186	85.6	244	117.8	302	150.0	360	182.2
-44	-42.2	14	-10.0	72	22.2	130	54.4	188	86.7	246	118.9	304	151.1	362	183.3
-42	-41.1	16	-8.9	74	23.3	132	55.6	190	87.8	248	120.0	306	152.2	364	184.4
-40	-40.0	18	-7.8	76	24.4	134	56.7	192	88.9	250	121.1	308	153.3	366	185.6
-38	-38.9	20	-6.7	78	25.6	136	57.8	194	90.0	252	122.2	310	154.4	368	186.7
-36	-37.8	22	-5.6	80	26.7	138	58.9	196	91.1	254	123.3	312	155.6	370	187.8
-34	-36.7	24	-4.4	82	27.8	140	60.0	198	92.2	256	124.4	314	156.7	372	188.9
-32	-35.6	26	-3.3	84	28.9	142	61.1	200	93.3	258	125.6	316	157.8	374	190.0
-30	-34.4	28	-2.2	86	30.0	144	62.2	202	94.4	260	126.7	318	158.9	376	191.1
-28	-33.3	30	-1.1	88	31.1	146	63.3	204	95.6	262	127.8	320	160.0	378	192.2
-26	-32.2	32	0.0	90	32.2	148	64.4	206	96.7	264	128.9	322	161.1	380	193.3
-24	-31.1	34	1.1	92	33.3	150	65.6	208	97.8	266	130.0	324	162.2	382	194.4
-22	-30.0	36	2.2	94	34.4	152	66.7	210	98.9	268	131.1	326	163.3	384	195.6
-20	-28.9	38	3.3	96	35.6	154	67.8	212	100.0	270	132.2	328	164.4	386	196.7
-18	-27.8	40	4.4	98	36.7	156	68.9	214	101.1	272	133.3	330	165.6	388	197.8
-16	-26.7	42	5.6	100	37.8	158	70.0	216	102.2	274	134.4	332	166.7	390	198.9
-14	-25.6	44	6.7	102	38.9	160	71.1	218	103.3	276	135.6	334	167.8	392	200.0
-12	-24.4	46	7.8	104	40.0	162	72.2	220	104.4	278	136.7	336	168.9	400	204.4
-10	-23.3	48	8.9	106	41.1	164	73.3	222	105.6	280	137.8	338	170.0	410	210.0
-8	-22.2	50	10.0	108	42.2	166	74.4	224	106.7	282	138.9	340	171.1	420	215.6
-6	-21.1	52	11.1	110	43.3	168	75.6	226	107.8	284	140.0	342	172.2	430	221.1
-4	-20.0	54	12.2	112	44.4	170	76.7	228	108.9	286	141.1	344	173.3	440	226.7

CENTIGRADE TO FAHRENHEIT

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-50	-58.0	-18	-0.4	14	57.2	46	114.8	78	172.4	110	230.0	142	287.6	174	345.2
-49	-56.2	-17	1.4	15	59.0	47	116.6	79	174.2	111	231.8	143	289.4	175	347.0
-48	-54.4	-16	3.2	16	60.8	48	118.4	80	176.0	112	233.6	144	291.2	176	348.8
-47	-52.6	-15	5.0	17	62.6	49	120.2	81	177.8	113	235.4	145	293.0	177	350.6
-46	-50.8	-14	6.8	18	64.4	50	122.0	82	179.6	114	237.2	146	294.8	178	352.4
-45	-49.0	-13	8.6	19	66.2	51	123.8	83	181.4	115	239.0	147	296.6	179	354.2
-44	-47.2	-12	10.4	20	68.0	52	125.6	84	183.2	116	240.8	148	298.4	180	356.0
-43	-45.4	-11	12.2	21	69.8	53	127.4	85	185.0	117	242.6	149	300.2	181	357.8
-42	-43.6	-10	14.0	22	71.6	54	129.2	86	186.8	118	244.4	150	302.0	182	359.6
-41	-41.8	-9	15.8	23	73.4	55	131.0	87	188.6	119	246.2	151	303.8	183	361.4
-40	-40.0	-8	17.6	24	75.2	56	132.8	88	190.4	120	248.0	152	305.6	184	363.2
-39	-38.2	-7	19.4	25	77.0	57	134.6	89	192.2	121	249.8	153	307.4	185	365.0
-38	-36.4	-6	21.2	26	78.8	58	136.4	90	194.0	122	251.6	154	309.2	186	366.8
-37	-34.6	-5	23.0	27	80.6	59	138.2	91	195.8	123	253.4	155	311.0	187	368.6
-36	-32.8	-4	24.8	28	82.4	60	140.0	92	197.6	124	255.2	156	312.8	188	370.4
-35	-31.0	-3	26.6	29	84.2	61	141.8	93	199.4	125	257.0	157	314.6	189	372.2
-34	-29.2	-2	28.4	30	86.0	62	143.6	94	201.2	126	258.8	158	316.4	190	374.0
-33	-27.4	-1	30.2	31	87.8	63	145.4	95	203.0	127	260.6	159	318.2	191	375.8
-32	-25.6	0	32.0	32	89.6	64	147.2	96	204.8	128	262.4	160	320.0	192	377.6
-31	-23.8	1	33.8	33	91.4	65	149.0	97	206.6	129	264.2	161	321.8	193	379.4
-30	-22.0	2	35.6	34	93.2	66	150.8	98	208.4	130	266.0	162	323.6	194	381.2
-29	-20.2	3	37.4	35	95.0	67	152.6	99	210.2	131	267.8	163	325.4	195	383.0
-28	-18.4	4	39.2	36	96.8	68	154.4	100	212.0	132	269.6	164	327.2	196	384.8
-27	-16.6	5	41.0	37	98.6	69	156.2	101	213.8	133	271.4	165	329.0	197	386.6
-26	-14.8	6	42.8	38	100.4	70	158.0	102	215.6	134	273.2	166	330.8	198	388.4
-25	-13.0	7	44.6	39	102.2	71	159.8	103	217.4	135	275.0	167	332.6	199	390.2
-24	-11.2	8	46.4	40	104.0	72	161.6	104	219.2	136	276.8	168	334.4	200	392.0
-23	-9.4	9	48.2	41	105.8	73	163.4	105	221.0	137	278.6	169	336.2	210	410.0
-22	-7.6	10	50.0	42	107.6	74	165.2	106	222.8	138	280.4	170	338.0	220	428.0
-21	-5.8	11	51.8	43	109.4	75	167.0	107	224.6	139	282.2	171	339.8	230	446.0
-20	-4.0	12	53.6	44	111.2	76	168.8	108	226.4	140	284.0	172	341.6	240	464.0
-19	-2.2	13	55.4	45	113.0	77	170.6	109	228.2	141	285.8	173	343.4	250	482.0

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