CEBM027502

Shop Manual

PC390LL-10

LOG LOADER
ROAD BUILDER

SERIAL NUMBERS **PC390LL-10 A50601 and up**

ENGINE **6D114E-5**

August 2015

CONTENTS

SAFETY

Safety Notice

Important Safety Notice

Proper service and repair is extremely important for the safe operation of your machine. The service and repair techniques recommended and described in this manual are both effective and safe methods of operation. Some of these operations require the use of tools specially designed for the purpose.

To prevent injury to workers, the symbol ⚠ is used to mark safety precautions in this manual. The cautions accompanying this symbol should always be followed carefully. If any dangerous situation arises or may possibly arise, first consider safety, and take the necessary actions to deal with the situation.

General Precautions

Mistakes in operation are extremely dangerous. Read the OPERATION & MAINTENANCE MANUAL carefully BEFORE operating the machine.

1. Before performing any greasing or repairs, read all the precautions given on the decals which are fixed to the machine.

2. When performing any operation, always wear safety shoes and helmet. Do not wear loose work clothes, or clothes with buttons missing.
   - Always wear safety glasses when hitting parts with a hammer.
   - Always wear safety glasses when grinding parts with a grinder, etc.

3. If welding repairs are needed, always have a trained, experienced welder perform the work. When performing welding work, always wear welding gloves, apron, glasses, cap and other clothes suited for welding work.

WARNING! Never modify, weld, cut, or drill on any part of a ROPS structure. Doing so may weaken the structure which could lead to possible failure in a rollover situation.

4. When performing any operation with two or more workers, always agree on the operating procedure before starting. Always inform your fellow workers before starting any step of the operation. Before starting work, hang UNDER REPAIR signs on the controls in the operator's compartment.

5. Only qualified workers must perform the work and operation which require license or qualification.

6. Keep all tools in good condition and learn the correct way to use them. Before starting work, thoroughly check the tools, machine, forklift truck, service car, etc.

7. Decide a place in the repair workshop to keep tools and removed parts. Always keep the tools and parts in their correct places. Always keep the work area clean and make sure that there is no dirt or oil on the floor. Smoke only in the areas provided for smoking. Never smoke while working.

8. Before starting work, warm up your body thoroughly to start work under good conditions. Avoid continuous work for long hours and take rests at proper intervals to keep your body in good condition. Take rests in specified safe places.

Safety Points

1	Good arrangement
2	Correct work clothes
3	Following work standard
4	Making and checking signs
5	Prohibition of operation and handling by unlicensed workers
6	Safety check before starting work
7	Wearing protective goggles (for cleaning or grinding work)
8	Wearing shielding goggles and protectors (for welding work)
9	Good physical condition and preparation
10	Precautions against work which you are not used to or work with which you are too familiar

Preparations For Work

1. Before adding oil or making repairs, park the machine on hard, level ground, and block the wheels or tracks to prevent the machine from moving.

2. Before starting work, lower blade, ripper, bucket or any other work equipment to the ground. If this is not possible, insert the safety pin or use blocks to prevent the work equipment from falling. In addition, be sure to lock all the control levers and hang warning signs on them.

3. When disassembling or assembling, support the machine with blocks, jacks or stands before starting work.

4. Remove all mud and oil from the steps or other places used to get on and off the machine. Always use the handrails, ladders or steps when getting on or off the machine. Never jump on or off the machine. If it is impossible to use the handrails, ladders or steps, use a stand to provide safe footing.

Precautions During Work

1. When removing oil filler cap, drain plug or hydraulic pressure measuring plugs, loosen them slowly to prevent the oil from spurting out. Before disconnecting or removing components of the oil, coolant or air circuits, first remove the pressure completely from the circuit.

2. The coolant and oil in the circuits are hot when the engine is stopped, so be careful not to get burned. Wait for the oil and coolant to cool before performing any work on the oil or coolant circuits.

3. Before starting work, shut down the engine. When working on or around a rotating part, in particular, shut down the engine. When checking the machine without stopping the engine (measuring oil pressure, revolving speed, temperature, etc.) take extreme care not to get caught in rotating or moving parts.

4. For the machine equipped with a battery disconnect switch, before starting the work, check that the system operating lamp is turned OFF, and then turn the battery disconnect switch to the OFF (o) position and pull the switch key out. For machines with a battery disconnect switch, before starting the work, remove the leads from the battery. ALWAYS remove the lead from the negative (-) terminal first.

5. When raising heavy components, use a hoist or crane. Check that the wire rope, chains and hooks are free from damage. Always use lifting equipment which has ample capacity. Install the lifting equipment at the correct places. Use a hoist or crane and operate slowly to prevent the component from hitting any other part. Do not work with any part still raised by the hoist or crane.

6. When removing covers which are under internal pressure or under pressure from a spring, always leave two bolts in position on opposite sides. Slowly release the pressure, then slowly loosen the bolts to remove.

7. When removing components, be careful not to break or damage the wiring. Damaged wiring may cause electrical fires.

8. When removing piping, stop the fuel or oil from spilling out. If any fuel or oil drips on to the floor, wipe it up immediately. Fuel or oil on the floor can cause you to slip, or can even start fires.

9. Never use flammable liquids to clean parts, use only non-flammable approved cleaning solutions to clean parts.

10. Be sure to assemble all parts again in their original places. Replace any damaged part with new parts.
    - When installing hoses and wires, be sure that they will not be damaged by contact with other parts when the machine is being operated.

11. When installing high pressure hoses, make sure that they are not twisted. Damaged tubes are dangerous, so be extremely careful when installing tubes for high pressure circuits. Also check that connecting parts are correctly installed.

12. When assembling or installing parts, always use the specified tightening torques. When installing protective parts such as guards, or parts which vibrate violently or rotate at high speed, be particularly careful to check that they are installed correctly.

13. When aligning two holes, never insert your fingers or hand. Be careful not to get your fingers caught in a hole.

14. When measuring hydraulic pressure, check that the measuring tool is correctly assembled before taking any measurements.

15. Take care when removing or installing the tracks of track-type machines. When removing the track, the track separates suddenly, so never let anyone stand at either end of the track.

16. If the engine is operated for a long time in a place which is not ventilated well, you may suffer from gas poisoning. Accordingly, open the windows and doors to ventilate well.

17. Precautions for disconnecting and connecting hoses and tubes in air conditioner circuit.
    A. Disconnection

        i. Ask a qualified person for collection, and charge of the refrigerant

        ii. Never release the refrigerant (R134a) to the atmosphere.

        iii. When loosening the nuts fixing air conductance hoses and tubes, be sure to use two wrenches; one to fix and the other to loosen the nut.

WARNING! Collect the air conditioner refrigerant gas (R134a).
If the refrigerant gas (R134a) gets in your eyes, you may lose your sight, and if it touches your skin, you may suffer from frostbite. Accordingly, when collecting or adding it, you must be qualified for handling the refrigerant and wear protective goggles, gloves and clothing with long sleeves.

    B. Connection
        i. When installing the air conditioner circuit hoses and tubes, take care that dirt, dust, water, etc. will not enter them.

        ii. When connecting the air conditioner hoses and tubes, check that O-rings (1) are fitted to their joints.

        iii. Once an O-ring is used, it is deformed and deteriorated. Accordingly, do not reuse it.

        iv. When removing O-rings, use a soft tool so that the piping will not be damaged.

        v. Check that each O-ring is not damaged or deteriorated.

        vi. Apply compressor oil for refrigerant (R134a)

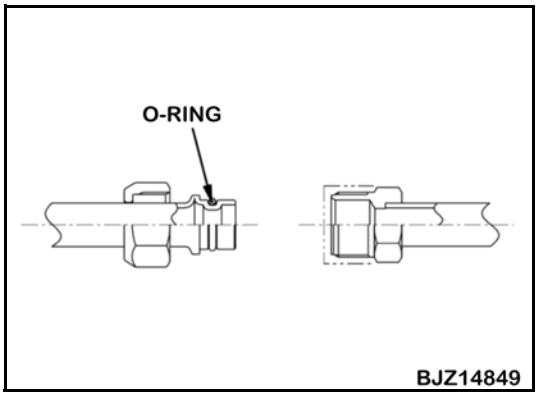
★ However, do not apply oil to the threads portion of a bolt, nut or union.

Manufacturer	Part Name
DENSO	ND-OIL8
VALEO THERMAL SYSTEMS	ZXL100PG (equivalent to PAG46)
SANDEN	SP-10

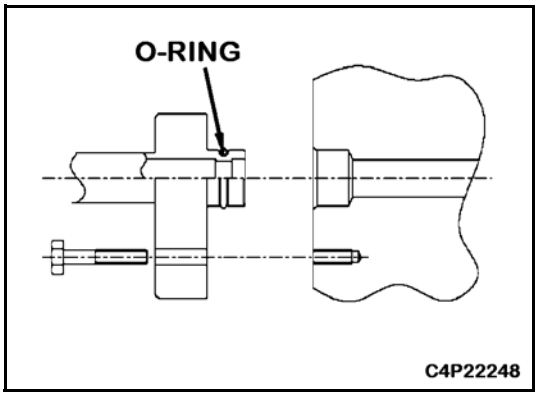
vii. When tightening nuts of the air conditioner hoses and tubes, be sure to use two wrenches; one to fix the nut and the other to tighten the nut to the specified torque (use a torque wrench for tightening).

★ Example of O-ring (fitted to every joint of hoses and tubes)

★ For tightening torque, see the precautions for installation in each section of “Disassembly and Assembly.”



18. When jump starting the machine, only use a machine of similar size and voltage. Never use a arc welder or other electrical generating equipment to jump start the machine. Carefully review the safety and procedures for jump starting the machine.



GENERAL

This shop manual has been prepared as an aid to improve the quality of repairs by giving the serviceman an accurate understanding of the product and by showing him the correct way to perform repairs and make judgements. Make sure you understand the contents of this manual and use it to full effect at every opportunity.

This shop manual mainly contains the necessary technical information for operations performed in a service workshop. For ease of understanding, the manual is divided into the following sections. These sections are further divided into each main group of components.

01 GENERAL

This section lists the general machine dimensions, performance specifications, component weights, and fuel, coolant and lubricant specification charts.

10 STRUCTURE AND FUNCTION

This section explains the structure and function of each component. It serves not only to give an understanding of the structure, but also serves as reference material for troubleshooting.

20 STANDARD VALUE TABLE

This section explains the standard values for new machine and judgement criteria for testing, adjusting and troubleshooting. This standard value table is used to check the standard values in testing and adjusting and to judge parts in troubleshooting.

30 TESTING AND ADJUSTING

This section explains checks to be made before and after performing repairs, as well as adjustments to be made at completion of the checks and repairs.

40 TROUBLESHOOTING

Troubleshooting charts correlating “Problems” to “Causes” are also included in this section.

50 DISASSEMBLY AND ASSEMBLY

This section explains the order to be followed when removing, installing, disassembling or assembling each component, as well as precautions to be taken for these operations.

60 MAINTENANCE STANDARD

This section gives the judgement standards when inspecting disassembled parts.

80 AIR CONDITIONING

This section explains the air conditioning system, structure and function, troubleshooting, disassembly, and assembly.

90 DIAGRAMS AND SCHEMATICS

This section has the foldout drawings for the machine.

NOTICE

The specifications contained in this shop manual are subject to change at any time and without any advance notice. Contact your distributor for the latest information.

HOW TO READ THE SHOP MANUAL

Volumes

Shop manuals are issued as a guide to performing repairs. They are divided as follows:

Chassis volume: Issued for every machine model
Engine volume: Issued for each engine series

Electrical volume: Each issued as one to cover all models
Attachment volume: Each issued as one to cover all models

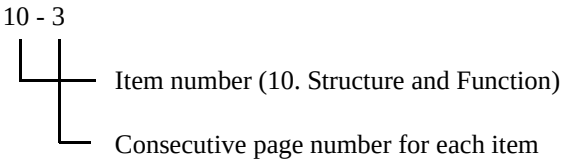
These various volumes are designed to avoid duplication of information. Therefore to deal with all repairs for any model, it is necessary that chassis, engine, electrical and attachment be available.

Distribution and Updating

Any additions, amendments or other changes will be sent to your distributors. Get the most up-to-date information before you start any work.

Filing Method

1. See the page number on the bottom of the page. File the pages in correct order.
2. Following examples show how to read the page number:
   Example:



3. Additional pages: Additional pages are indicated by a hyphen (-) and numbered after the page number. File as in the example.
   Example:

10-4
10-4-1
10-4-2
Added pages
10-5

Symbols

So that the shop manual can be of ample practical use, important places for safety and quality are marked with the following symbols.

Symbol	Item	Remarks
	Safety	Special safety precautions are necessary when performing the work.
★	Caution	Special technical precautions or other precautions for preserving standards are necessary when performing the work.
	Weight	Weight of parts or systems. Caution necessary when selecting hoisting wire or when working posture is important, etc.
	Tightening torque	Places that require special attention for tightening torque during assembly.
	Coat	Places to be coated with adhesives and lubricants etc.
	Fill	Places where oil, coolant or fuel must be added, and the capacity.
	Drain	Places where oil or coolant must be drained, and quantity to be drained.

HOISTING INSTRUCTIONS

Hoisting

★ If a part cannot be smoothly removed from the machine by hoisting, the following checks should be made.

1. Check for removal of all bolts fastening the part to the relative parts.
2. Check for existence of another part causing interface with the part to be removed.

Making Signs

1. Only one appointed worker must make signs and coworkers must communicate with each other frequently.
2. The appointed signaler must make specified signs clearly at a place where he is well seen from the operator's seat and where he can see the working condition easily.
3. The signaler must always stand in front of the load and guide the operator safely.
   - Do not stand under the load.
   - Do not step on the load.

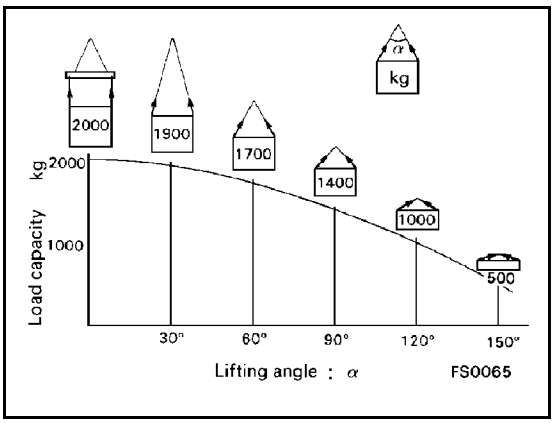
Precautions

Precautions for Sling Work

1. Check the slings before starting sling work.
2. Wear gloves during sling work. Use leather gloves, if available.
3. Measure the weight of the load visually and check its center of gravity.
4. Use a proper sling according to the weight of the load and method of slinging. If the wire ropes you use are too thick when slinging a light load, the load may slip and fall.
5. Do not sling a heavy load with one rope alone, but sling with two or more ropes symmetrically wound on to the load.

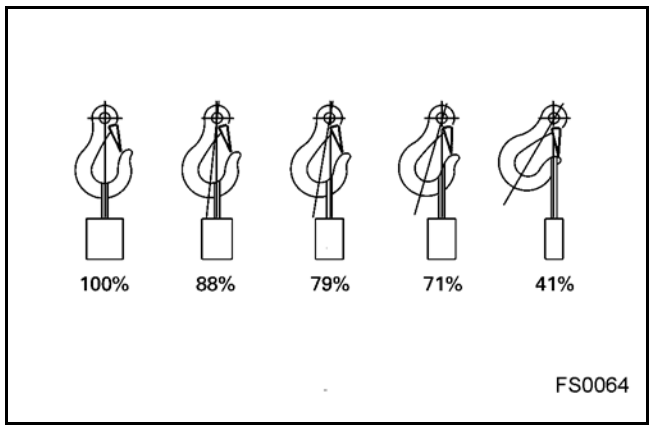
WARNING! Slinging with one rope may cause the load to turn during hoisting, the rope to untwist, or the rope to slip from its original winding position on the load, which can result in a dangerous accident.

6. Limit the hanging angle to 60°, as a rule.
   - Do not sling a heavy load with ropes forming a wide hanging angle from the hook. When hoisting a load with two or more ropes, the force subjected to each rope will increase with the hanging angles.
   - The following table shows the variation of allowable load in kg (lbs) when hoisting is made with two ropes, each of which is allowed to sling up to 1,000 kg (2,205 lbs) vertically, at various hanging angles.
   - When two ropes sling a load vertically, up to 2,000 kg (4,409 lbs) of total weight can be suspended. This weight is reduced to 1,000 kg (2,205 lbs) when two ropes make a 120° hanging angle. On the other hand, two ropes are subject to an excessive force as large as 4,000 kg (8,819 lbs) if they sling a 2,000 kg (4,409 lbs) load at a lifting angle of 150°.



7. When installing wire ropes to an angular load, apply pads to protect the wire ropes. If the load is slippery, apply proper material to prevent the wire rope from slipping.
8. Use the specified eyebolts and fix wire ropes, chains, etc. to them with shackles, etc.

9. Apply wire ropes from the middle portion of the hook.
    - Slinging near the edge of the hook may cause the rope to slip off the hook during hoisting, and a serious accident can result. Hooks have maximum strength at the middle portion.



10. Do not use twisted or kinked wire ropes.

11. When lifting up a load, observe the following.
    - Wind in the crane slowly until wire ropes are stretched. When settling the wire ropes by hand, do not grasp them but press them from above. If you grasp them, your fingers may be caught.
    - After the wire ropes are stretched, stop the crane and check the condition of the slung load, wire ropes, and pads.
    - If the load is unstable or the wire rope or chains are twisted, lower the load and lift it up again.
    - Do not lift the load at a slanted angle.

12. When lowering a load, observe the following.
    - When lowering a load, stop it temporarily at 30 cm (12 in) above the floor, and then lower it slowly.
    - Check that the load is stable, and then remove the sling.
    - Remove kinks and dirt from the wire ropes and chains used for the sling work, and put them in the specified place.

Precautions for Using Mobile Crane

Read the *Operation & Maintenance Manual* provided with the crane in advance and operate the crane safely.

Precautions for Using Overhead Hoist Crane

WARNING! Heavy parts (25 kg (55 lb) or more) must be lifted with a hoist, etc. In the *Disassembly and Assembly* section, every part weighing 25 kg or more is indicated clearly with the symbol.

1. Before starting work, inspect the wire ropes, brake, clutch, controller, rails, overwind stop device, ground fault protection circuit breaker, crane collision prevention device, and power application warning lamp, and check safety.

2. Observe the signs for sling work.

3. Operate the hoist at a safe place.

4. Check the direction indicator plates (east, west, south, and north) and the directions of the control buttons without fail.

5. Do not sling a load at an angle. Do not move the crane while the slung load is swinging.

6. Do not raise or lower a load while the crane is moving longitudinally or laterally.

7. Do not drag a sling.

8. When lifting up a load, stop it just after it leaves the ground and check safety, and then lift it up.

9. Consider the travel route in advance and lift up a load to a safe height.

10. Place the control switch at a position where it will not be an obstacle to work and passage.

11. After operating the hoist, do not swing the control switch.

Remember the position of the main switch so that you can turn off the power immediately in an emergency.

12. If the hoist stops because of a power failure, turn the power switch OFF. When turning on a switch which was turned OFF by the ground fault protection circuit breaker, check that the devices related to that switch are not in operational state.
13. If there is an obstacle around the hoist, stop the operation.

After finishing the work, stop the hoist at the specified position and raise the hook to at least 2 m (6.6 ft) above the floor. Do not leave the sling installed to the hook.

Selecting Wire Ropes

1. Use adequate ropes depending on the weight of parts to be hoisted. Refer to the following table.

Wire ropes (Standard “Z” or “S” twist ropes without galvanizing)		
Rope diameter	Allowable load	
mm	kN	tons
10	9.8	1.0
11.2	13.7	1.4
12.5	15.7	1.6
14	21.6	2.2
16	27.5	2.8
18	35.3	3.6
20	43.1	4.4
22.4	54.9	5.6
30	98.1	10.0
40	176.5	18.0
50	274.6	28.0
60	392.2	40.0

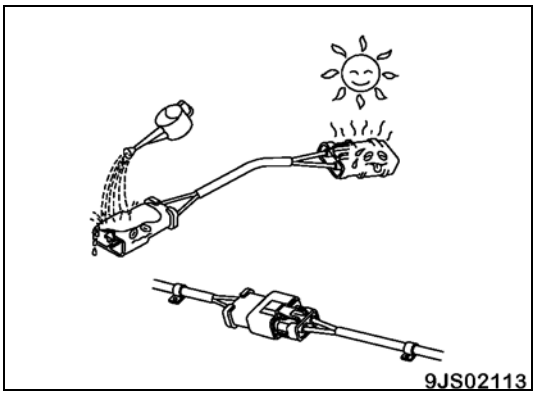
The allowable load value is 1/6 of the breaking strength of the rope used. Safety coefficient: 6

HANDLING ELECTRIC EQUIPMENT AND HYDRAULIC COMPONENTS

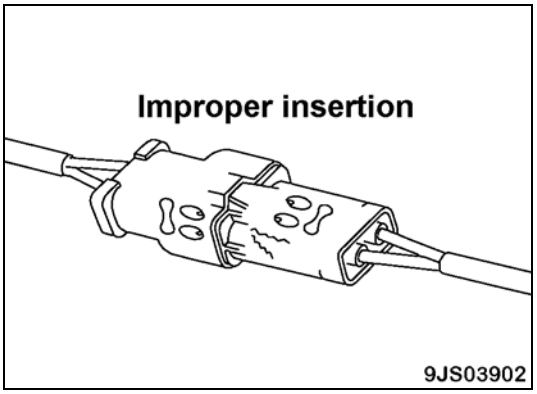
To maintain the performance of the machine over a long period, and to prevent failures or other troubles before they occur, correct operation, maintenance and inspection, troubleshooting, and repairs must be performed. This section deals particularly with correct repair procedures for mechatronics and is aimed at improving the quality of repairs. For this purpose, it gives sections on "Handling electric equipment" and "Handling hydraulic equipment" (particularly gear oil and hydraulic oil).

Points to Remember When Handling Electric Equipment

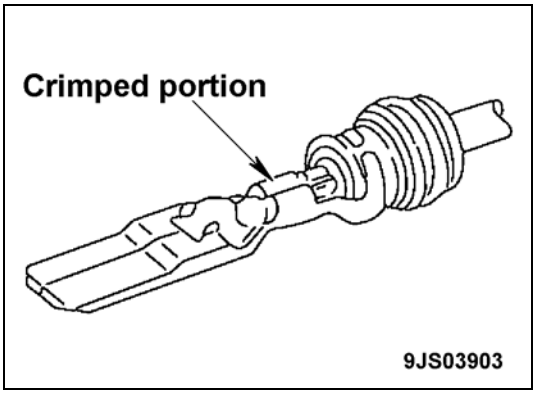
1. Handling wiring harnesses and connectors.
   - Wiring harnesses consist of wiring connecting one component to another component, connectors used for connecting and disconnecting one wire from another wire, and protectors or tubes used for protecting the wiring.
   - Compared with other electrical components fitted in boxes or cases, wiring harnesses are more likely to be affected by the direct effects of rain, water, heat, or vibration. Furthermore, during inspection and repair operations, they are frequently removed and installed again, so they are likely to suffer deformation or damage.
   - For this reason, it is necessary to be extremely careful when handling wiring harnesses.



2. Main failures occurring in wiring harness.
   A. Defective contact of connectors (defective contact between male and female).
      - Problems with defective contact are likely to occur because the male connector is not properly inserted into the female connector, or because one or both connectors are deformed or the position is not correctly aligned, or there is corrosion or oxidation of the contact surfaces.

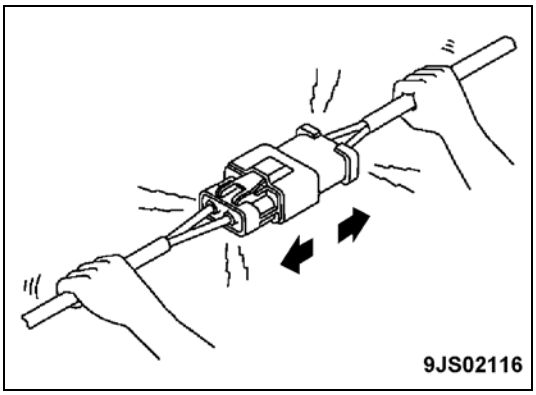


   B. Defective crimping or soldering of connectors.
      - The pins of the male and female connectors are in contact at the crimped terminal or soldered portion, but if there is excessive force brought to bear on the wiring, the plating at the joint will peel and cause improper connection or breakage.



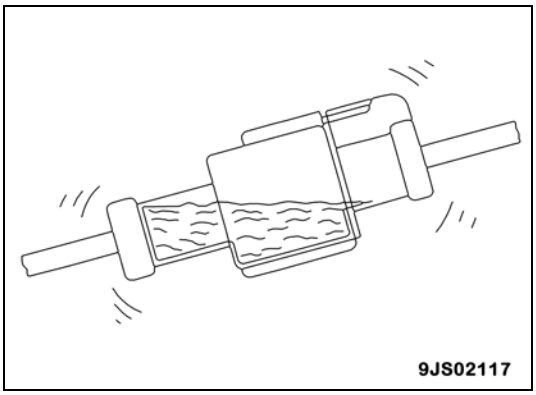
C. Disconnections in wiring.

- If the wiring is held and the connectors are pulled apart, or components are lifted with a crane with the wiring still connected, or a heavy object hits the wiring, the crimping of the connector may separate, or the soldering may be damaged, or the wiring may be broken.



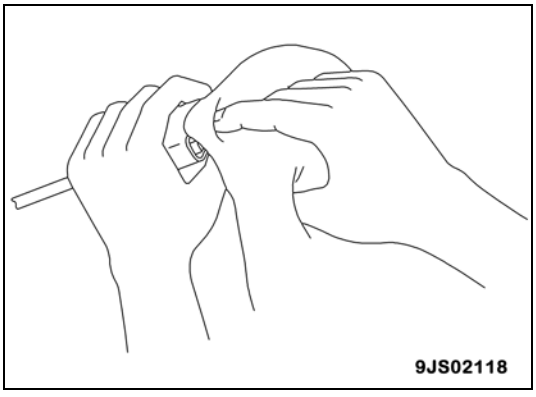
D. High-pressure water entering connector.

- The connector is designed to make it difficult for water to enter (drip-proof structure), but if high-pressure water is sprayed directly on the connector, water may enter the connector, depending on the direction of the water jet.
- Accordingly, take care not splash water over the connector. The connector is designed to prevent water from entering, but at the same time, if water does enter, it is difficult for it to be drained.
- Therefore, if water should get into the connector, the pins will be short-circuited by the water, so if any water gets in, immediately dry the connector or take other appropriate action before passing electricity through it.



E. Oil or dirt stuck to connector.

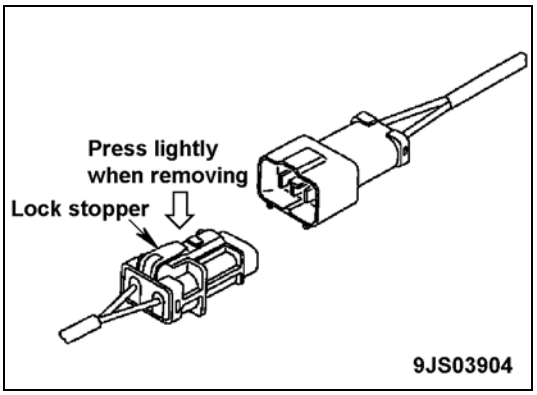
- If oil or grease are stuck to the connector and an oil film is formed on the mating surface between the male and female pins, the oil will not let the electricity pass, so there will be defective contact. If there is oil or grease stuck to the connector, wipe it off with a dry cloth or blow it dry with compressed air and spray it with a contact restorer.
  - ★ When wiping the mating portion of the connector, be careful not to use excessive force or deform the pins.
  - ★ If there is oil or water in the compressed air, the contacts will become even dirtier, so completely remove the oil and water from the compressed air before cleaning with compressed air.



3. Removing, installing, and drying connectors and wiring harnesses

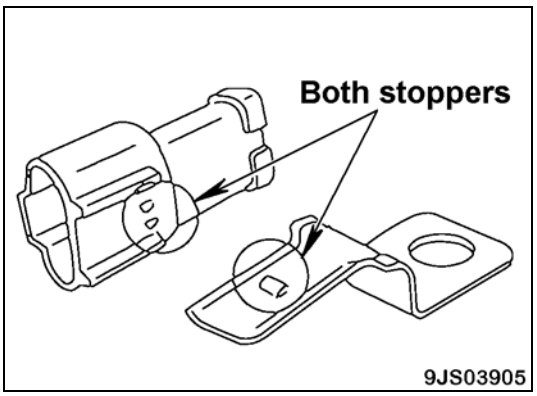
A. Disconnecting connectors.

- Hold the connectors when disconnecting.
  When disconnecting the connectors, hold the connectors. For connectors held by a screw, completely loosen the screw, then hold the male and female connectors in each hand and pull apart. For connectors which have a lock stopper, press the stopper down with your thumb and pull the connectors apart.
  ★ Never pull with one hand.

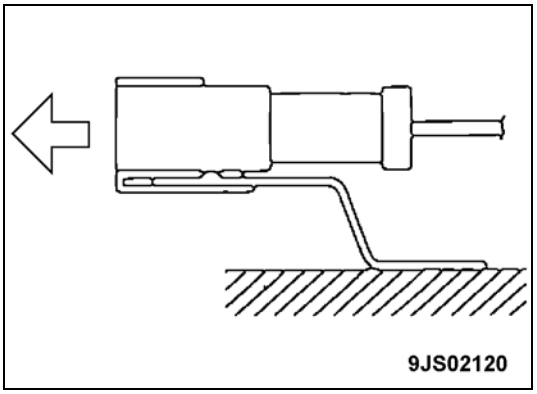


B. When removing from clips

- Both of the connector and clip have stoppers, which are engaged with each other when the connector is installed.

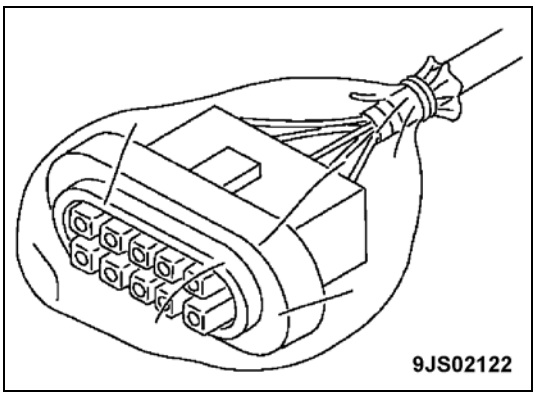


- When removing a connector from a clip, pull connector in a parallel direction to the clip for removing stoppers.
  ★ If the connector is twisted up and down or to the left or right, the housing may break.



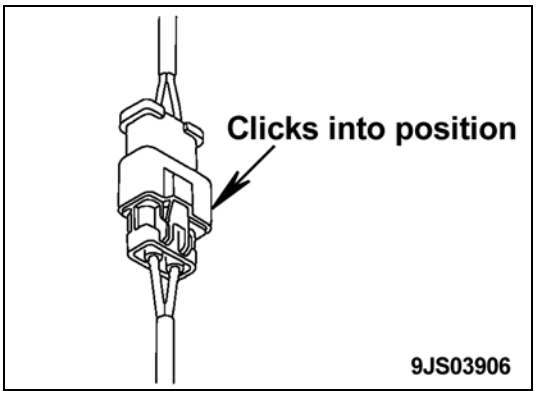
C. Action to take after removing connectors.
After removing any connector, cover it with a vinyl bag to prevent any dust, dirt, oil, or water from entering into the connector portion.

★ If the machine is left disassembled for a long time, it is particularly easy for improper contact to occur, so always cover the connector.

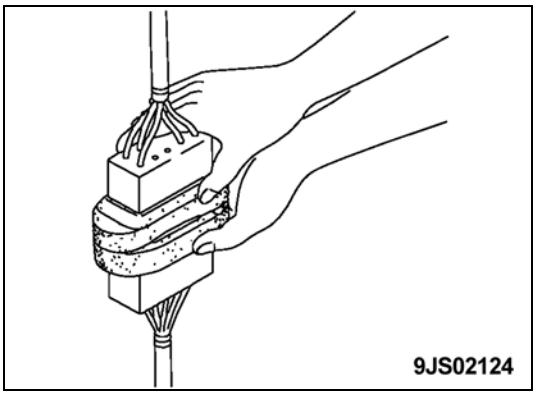


4. Connecting connectors
   A. Check the connector visually.

      • Check that there is no oil, dirt, or water stuck to the connector pins (mating portion). Check that there is no deformation, defective contact, corrosion, or damage to the connector pins. Check that there is no damage or breakage to the outside of the connector.



      • If there is any oil, water, or dirt stuck to the connector, wipe it off with a dry cloth. If any water has got inside the connector, warm the inside of the wiring with a dryer, but be careful not to make it too hot as this will cause short circuits.
      • If there is any damage or breakage, replace the connector.



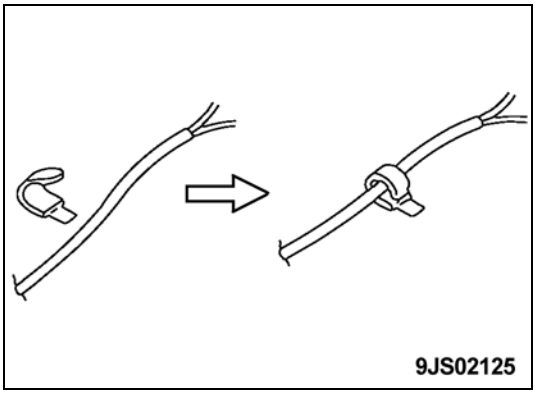
   B. Fix the connector securely.

      • Align the position of the connector correctly, and then insert it securely. For connectors with lock stopper, push in the connector until the stopper clicks into position.

   C. Correct any protrusion of the boot and any misalignment of the wiring harness.

      • For connectors fitted with boots, correct any protrusion of the boot. In addition, if the wiring harness is misaligned, or the clamp is out of position, adjust it to its correct position.

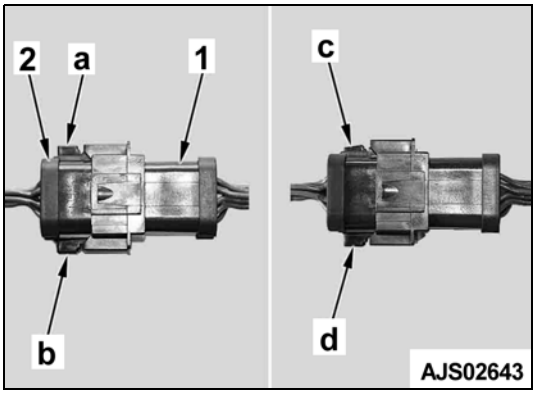
        ★ If the connector cannot be corrected easily, remove the clamp and adjust the position.
        ★ If the connector clamp has been removed, be sure to return it to its original position. Check also that there are no loose clamps.



   D. Connecting DT connectors

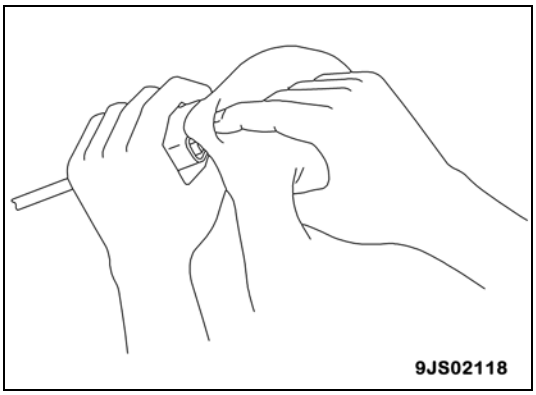
      • Since the DT 8-pin and 12-pin heavy duty wire connectors have two latches respectively, push them in until they click two times.

        1. Male connector
        2. Female connector
           ★ Normal locking state (Horizontal):a, b, d
           ★ Incomplete locking state (Diagonal):c

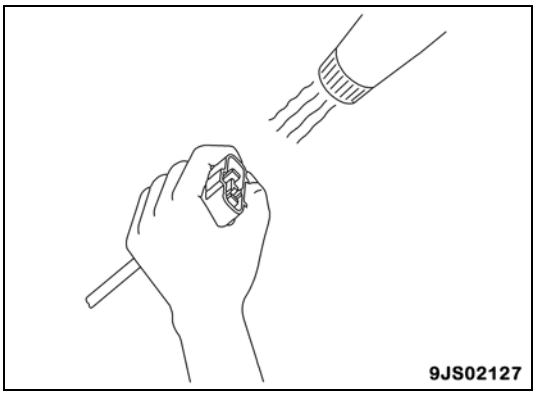


E. Drying wiring harness

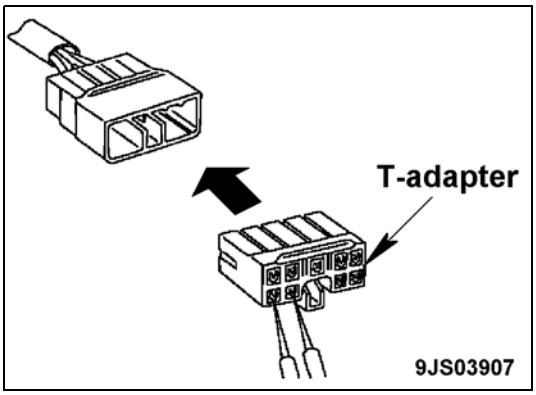
- If there is any oil or dirt on the wiring harness, wipe it off with a dry cloth. Avoid washing it in water or using steam. If the connector must be washed in water, do not use high-pressure water or steam directly on the wiring harness. If water gets directly on the connector, do as follows.
- Disconnect the connector and wipe off the water with a dry cloth.
  - ★ If the connector is blown dry with compressed air, there is the risk that oil in the air may cause defective contact, so remove all oil and water from the compressed air before blowing with air.



- Dry the inside of the connector with a dryer.
- If water gets inside the connector, use a dryer to dry the connector.
  - ★ Hot air from the dryer can be used, but regulate the time that the hot air is used in order not to make the connector or related parts too hot, as this will cause deformation or damage to the connector.



- Perform a continuity test on the connector.
- After drying, leave the wiring harness disconnected and perform a continuity test to check for any short circuits between pins caused by water.
  - ★ After completely drying the connector, blow it with contact restorer and reassemble.



5. Handling of connectors used on engine

★ Mainly, following engines are object for following connectors.

- 95E-5
- 107E-1, 107E-2
- 114E-3, 114E-5
- 125E-5, 125E-6
- 140E-5, 140E-6
- 170E-5
- 12V140E-3

6. Slide, lock type (Type 1) (FRAMATOME-3, FRAMATOME-2)
   - 95/107/114/125/140/170/12V140 Series

   - Various pressure sensors and Ne speed sensor. Examples:

     i. Charge (boost) pressure sensor in the air intake manifold: PIM (125/170/12V140 series)

     ii. Oil pressure sensor: POIL (125/170/12v140 series)

     iii. Oil pressure switch (95/107/114 series)

     iv. Ne speed sensor on flywheel housing: Ne (95/107/114/125/140/170/12v140 series)

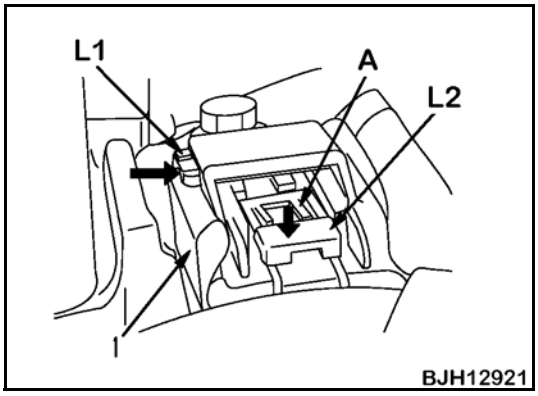
     v. Ambient pressure sensor: PAMB (125/170/12V140 series)

   A. Disconnection

      i. Slide lock (L1) to the right.

      ii. While pressing lock (L2), pull out connector (1) toward you.

   ★ Even if lock (L2) is pressed, connector (1) cannot be pulled out toward you, if part A does not float. In this case, float part A with a small flat-head screwdriver while press lock (L2), and then pull out connector (1) toward you.



   B. Connection

      i. Insert the connector straight until it “clicks.”

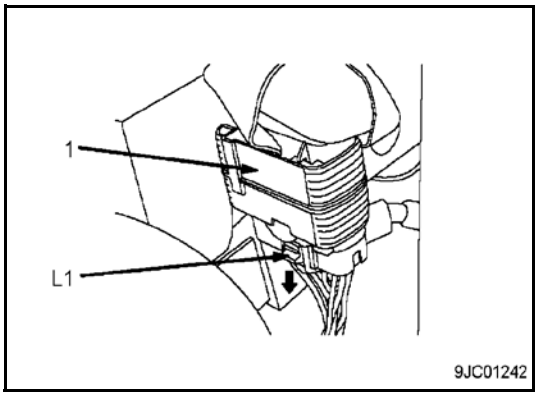
7. Slide, lock type (Type 2) (FRAMATOME-24)
   - 107/114/125 Series

   - Intermediate connector between machine wiring harness and engine wiring harness. Examples:

     i. Intermediate connector (engine wiring harness): OEM CONNECTION (107/114/125 series)

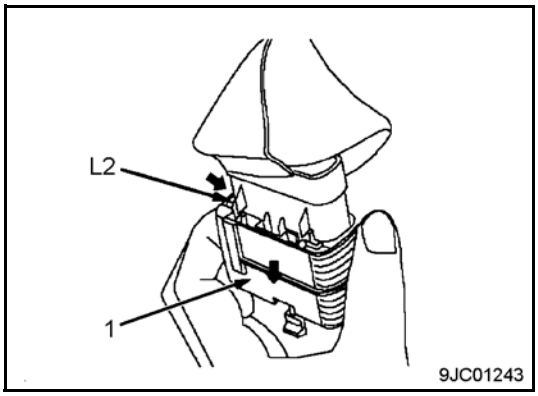
   A. Disconnection

i. Slide down lock (red) (L1).



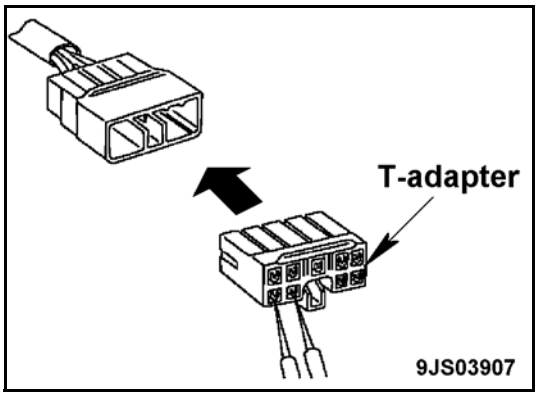
ii. While pressing lock (L2), pull out connector (1).

★ Lock (L2) is located in the back of connector (1).



B. Connection

i. Insert the connector straight until it “clicks.”



8. Pull lock type (PACKARD-2)
   - 95/107/114/125/140/170/12V140 Series

   - Various temperature sensors. Examples:
     i. Charge (boost) temperature sensor in the air intake manifold: TIM

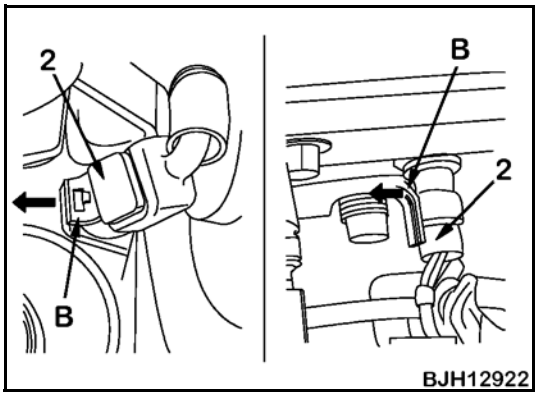
     ii. Fuel temperature sensor: TFUEL

     iii. Oil temperature sensor: TOIL

     iv. Coolant temperature sensor: TWTR and other.

   A. Disconnection

i. Disconnect the connector by pulling lock (B) (on the wiring harness side) of connector (2) outward.



B. Connection

i. Insert the connector straight in until it “clicks.”

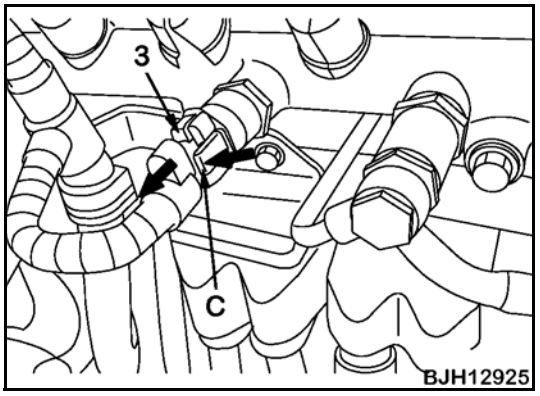
9. Push lock type (1)
   - 95/107/114 series.

   - Examples: Fuel pressure sensor in common rail (BOSCH-3)

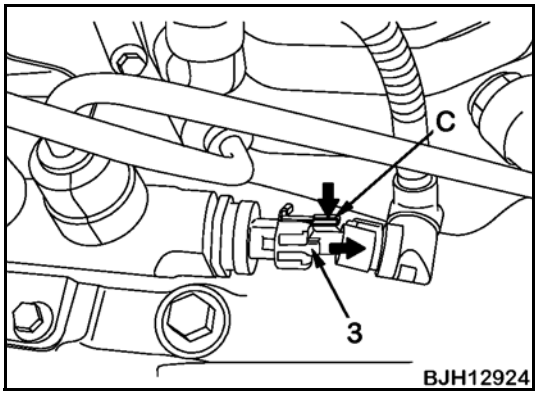
   A. Disconnection

      i. While pressing lock (C), pull out connector (3) in the direction of the arrow.

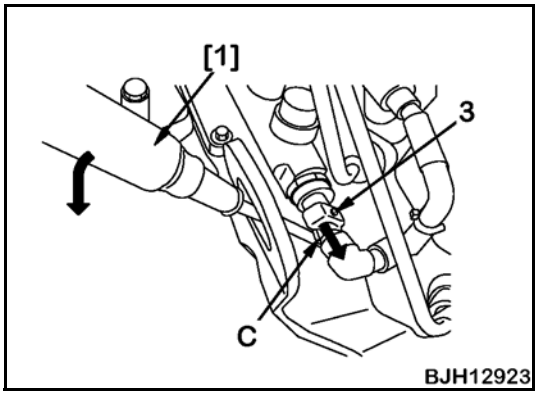
      - 114 series



      - 107 series



      ★ If the lock is located on the underside, use a flat-head screwdriver [1] since you cannot insert your fingers. While pressing up lock (C) of the connector with the flat-head screwdriver [1], pull out connector (3) in the direction of the arrow.



   B. Connection

      i. Insert the connector straight until it “clicks.”

10. Push lock type (2)
    - 107/114 series

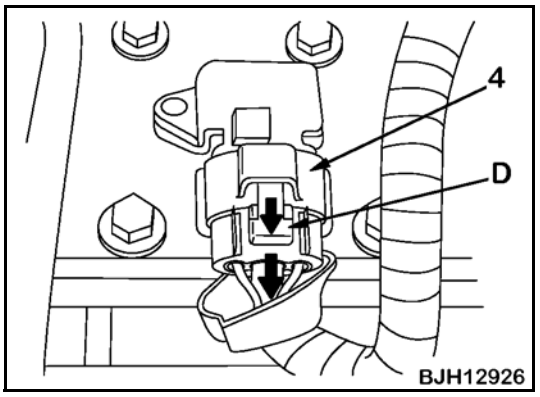
    - Examples: Charge (boost) pressure sensor in the air intake manifold (SUMITOMO-4)

    A. Disconnection

        i. While pressing lock (D), pull out connector (4) in the direction of the arrow.

    B. Connection

        i. Insert the connector straight in until it “clicks.”

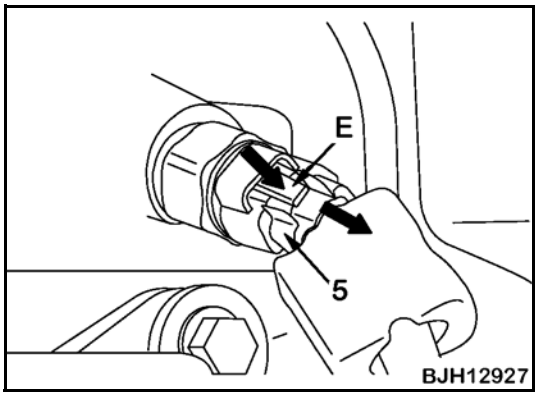


11. Push lock type (3)
    - 95/125/140/170/12v140 series

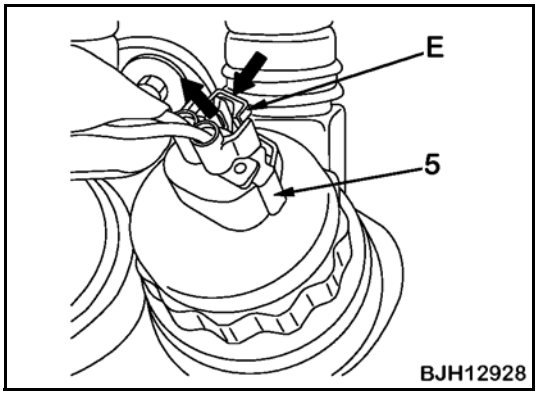
    A. Disconnection

        i. While pressing lock (E) of the connector, pull out connector (5) in the direction of the arrow.

    - Example: Fuel pressure sensor in common rail PFUEL etc. (AMP-3)



    - Example: Injection pressure control valve of supply pump: PCV (SUMITOMO-2)

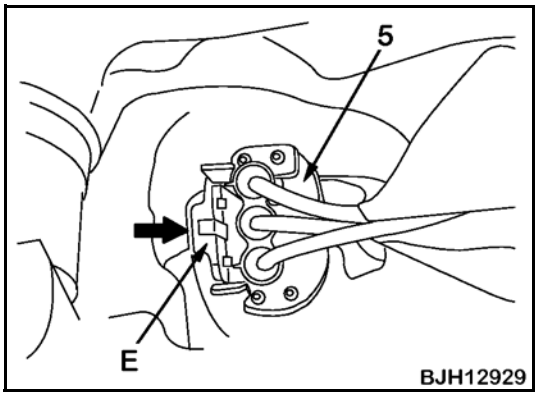


- Example: Speed sensor of supply pump: G (SUMITOMO -3)

★ Pull the connector straight up.

B. Connection

i. Insert the connector straight in until it “clicks.”



12. Turn-housing type (Round green connector)
- 140 series

- Example: Charge (boost) pressure sensor in the air intake manifold: PIM (CANNON-4), etc.

A. Disconnection

i. Turn housing (H1) in the direction of the arrow.

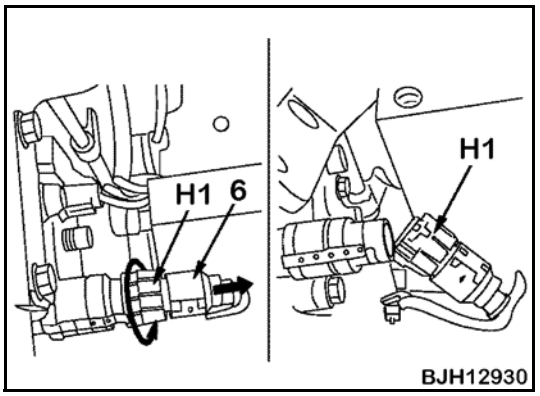
★ When the connector is unlocked, housing (H1) becomes heavy to turn.

ii. Pull out housing (H1) in the direction of the arrow.

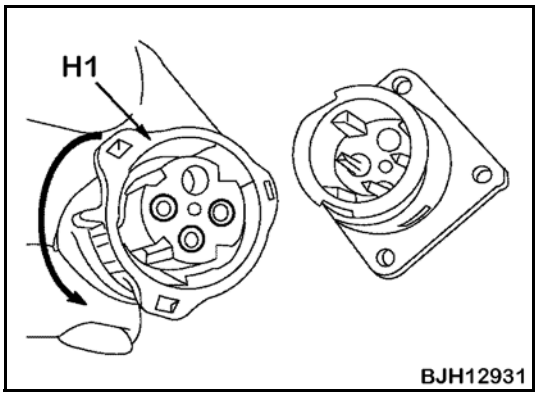
★ Housing (H1) is left on the wiring harness.

B. Connection

i. Insert the connector to the end, while aligning its groove to the other.



ii. Turn housing (H1) in the direction of the arrow until it “clicks.”

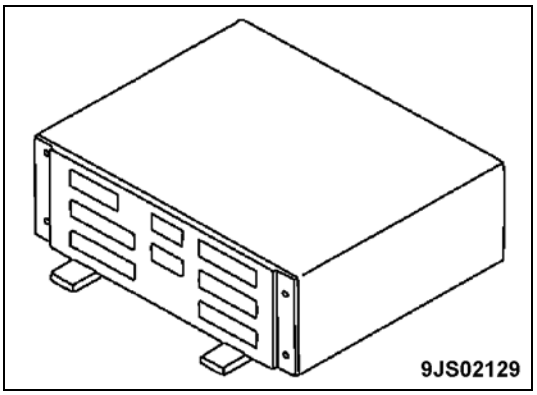


13. Handling controller
    A. The controller contains a microcomputer and electronic control circuits. These control all of the electronic circuits on the machine, so be extremely careful when handling the controller.

    B. Do not place objects on top of the controller.

    C. Cover the control connectors with tape or a vinyl bag. Never touch the connector contacts with your hand.

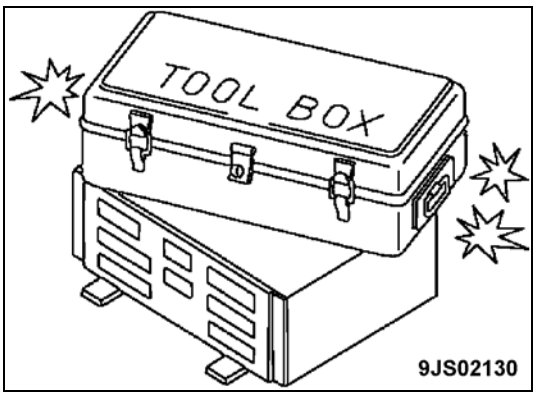
    D. During rainy weather, do not leave the controller in a place where it is exposed to rain.



    E. Do not place the controller on oil, water, or soil, or in any hot place, even for a short time. (Place it on a suitable dry stand.)

    F. Precautions when performing arc welding.

        • When performing arc welding on the body, disconnect all wiring harness connectors connected to the controller. Fit an arc welding ground close to the welding point.



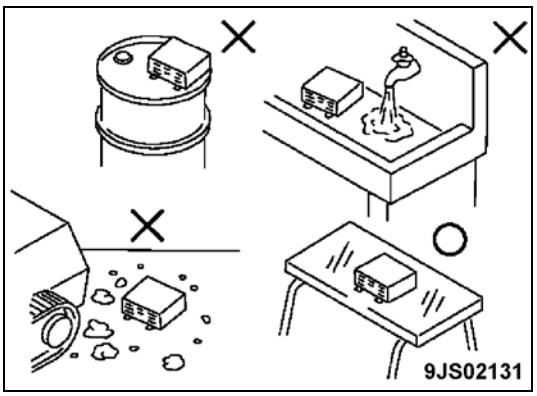
14. Points to remember when troubleshooting electric circuits.
    A. Always turn the power OFF before disconnecting or connecting connectors.

    B. Before performing troubleshooting, check that all the related connectors are properly inserted.

        • Disconnect and connect the related connectors several times to check.

    C. Always connect any disconnected connectors before going on to the next step.

        • If the power is turned ON with the connectors still disconnected, unnecessary abnormality displays will be generated.



    D. When performing troubleshooting of circuits (measuring the voltage, resistance, continuity, or current), move the related wiring and connectors several times and check that there is no change in the reading of the tester.

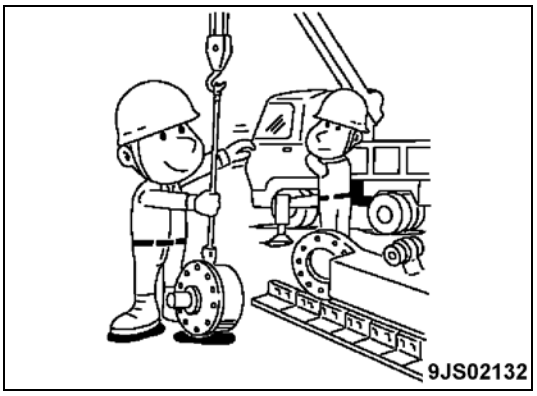
        • If there is any change, there is probably a defective contact in that circuit.

Points to Remember When Handling Hydraulic Equipment

With the increase in pressure and precision of hydraulic equipment, the most common cause of failure is dirt (foreign material) in the hydraulic circuit. When adding hydraulic oil, or when disassembling or assembling hydraulic equipment, it is necessary to be particularly careful.

1. Be careful of the operating environment.

- Avoid adding hydraulic oil, replacing filters, or repairing the machine in rain or high winds, or places where there is a lot of dust.

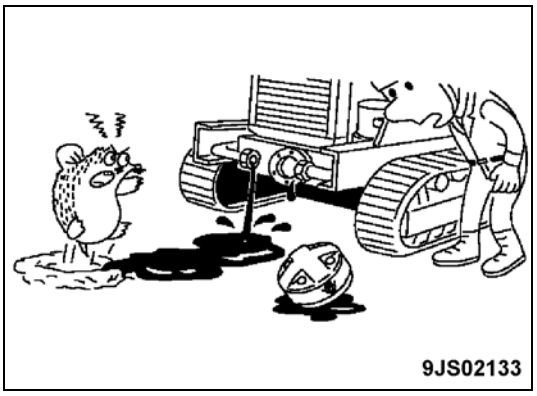


2. Disassembly and maintenance work in the field

- If disassembly or maintenance work is performed on hydraulic equipment in the field, there is danger of dust entering the equipment. It is also difficult to check the performance after repairs, so it is desirable to use unit exchange. Disassembly and maintenance of hydraulic equipment should be performed in a specially prepared dust proof workshop, and the performance should be checked with special test equipment.

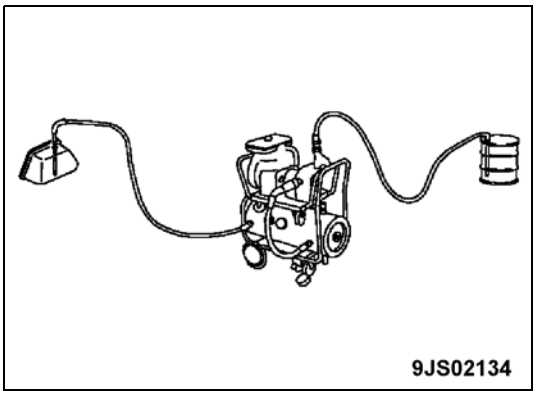
3. Sealing openings

- After any piping or equipment is removed, the openings should be sealed with caps, tapes, or vinyl bags to prevent any dirt or dust from entering. If the opening is left open or is blocked with a rag, there is danger of dirt entering or of the surrounding area being made dirty by leaking oil so never do this. Do not simply drain oil out onto the ground, but collect it and ask the customer to dispose of it, or take it back with you for disposal.



4. Do not let any dirt or dust get in during refilling operations

- Be careful not to let any dirt or dust get in when refilling with hydraulic oil. Always keep the oil filler and the area around it clean, and also use clean pumps and oil containers. If an oil cleaning device is used, it is possible to filter out the dirt that has collected during storage, so this is an even more effective method.

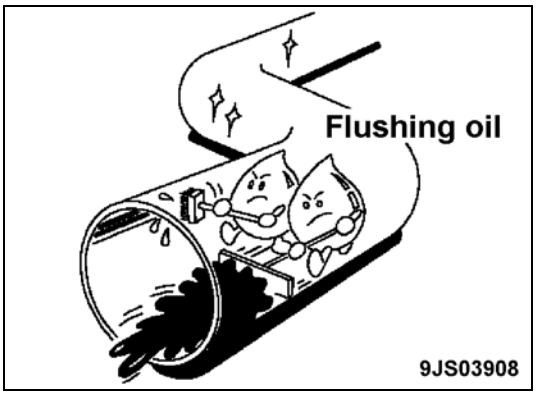


5. Change hydraulic oil when the temperature is high

- When hydraulic oil or other oil is warm, it flows easily. In addition, sludge can also easily be drained out from the circuit together with the oil, so it is best to change oil when it is still warm. When changing the oil, as much as possible of the old hydraulic oil must be drained out. (Drain the oil from the hydraulic tank, also drain the oil from the filter and from the drain plug in the circuit.) If any old oil is left, contaminants and sludge in it will mix with the new oil and will shorten the life of the hydraulic oil.

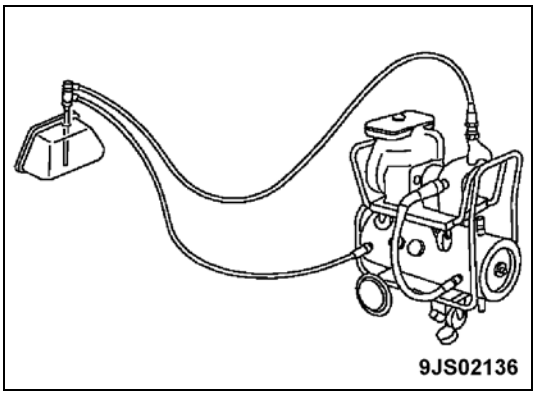
6. Flushing operations

- After disassembling and assembling the equipment, or changing the oil, use flushing oil to remove the contaminants, sludge, and old oil from the hydraulic circuit. Normally, flushing is performed twice: primary flushing is performed with flushing oil, and secondary flushing is performed with the specified hydraulic oil.

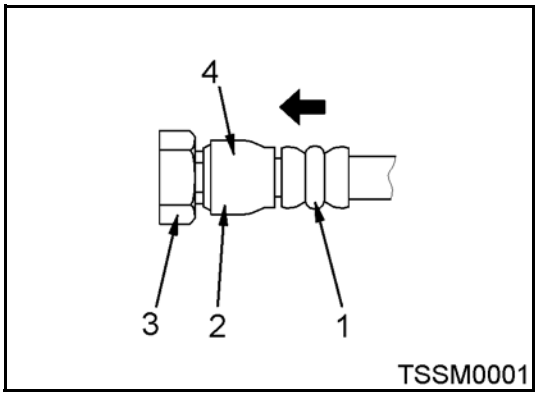


7. Cleaning operations

- After repairing the hydraulic equipment (pump, control valve, etc.), or when running the machine, perform oil cleaning to remove the sludge or contaminants in the hydraulic oil circuit. The oil cleaning equipment is used to remove the ultra fine {about 3 m (10 ft)} particles that the filter built in the hydraulic equipment cannot remove, so it is an extremely effective device.



PUSH PULL COUPLER



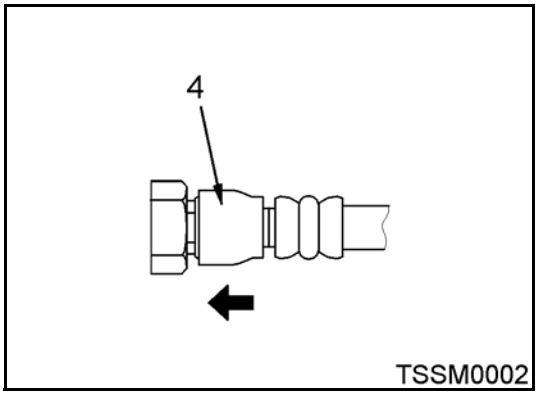
WARNING! Before performing the following work, release the residual pressure from the hydraulic tank. For details, see TESTING AND ADJUSTING, Releasing residual pressure from hydraulic tank.

WARNING! Even if the residual pressure is released from the hydraulic tank, some hydraulic oil flows out when the hose is disconnected. Accordingly, prepare a container for the drained oil.

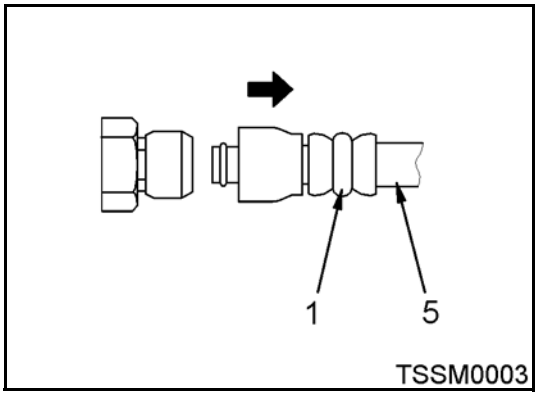
Type 1

Disconnection

1. Release the residual pressure from the hydraulic tank. For details, see TESTING AND ADJUSTING, Releasing residual pressure from hydraulic tank.
2. Hold the adapter (1) and push the hose joint (2) into the mating adapter (3). The adapter can be pushed in about 3.5 mm. Do not hold the rubber cap portion (4).
3. After the hose joint (2) is pushed into the adapter (3), press the rubber cap portion (4) against the adapter until it clicks.

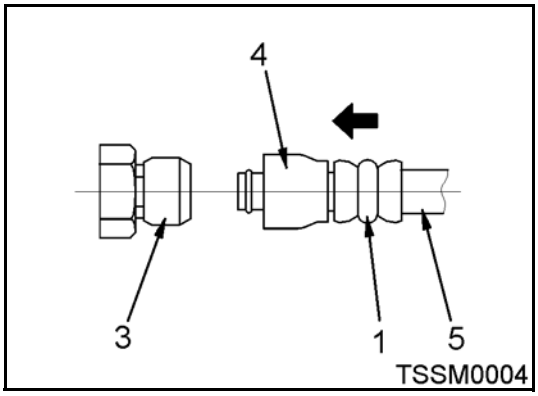


4. Hold the hose adapter (1) or hose (5) and pull it out. Since some hydraulic oil flows out, prepare a container for the drained oil.



Connection

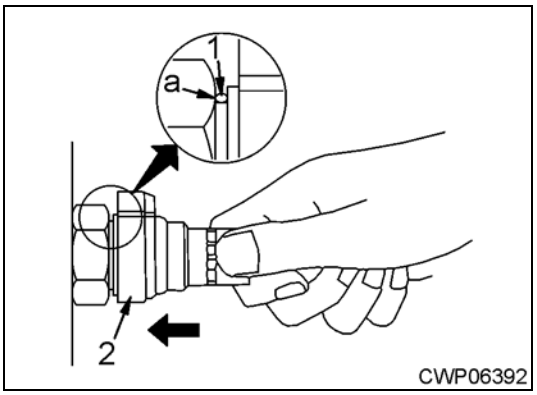
1. Hold the hose adapter (1) or hose (5) and insert it in the mating adapter (3), aligning them with each other. Do not hold the rubber cap portion (4).
2. After inserting the hose in the mating adapter, pull it back to check its connecting condition. When the hose is pulled back, the rubber cap portion moves toward the hose about 3.5 mm. This does not indicate an abnormality.



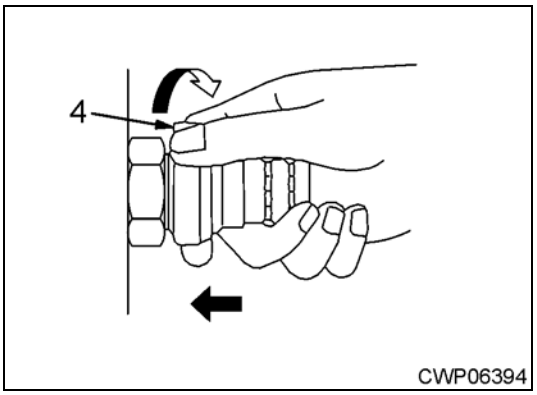
Type 2

Disconnection

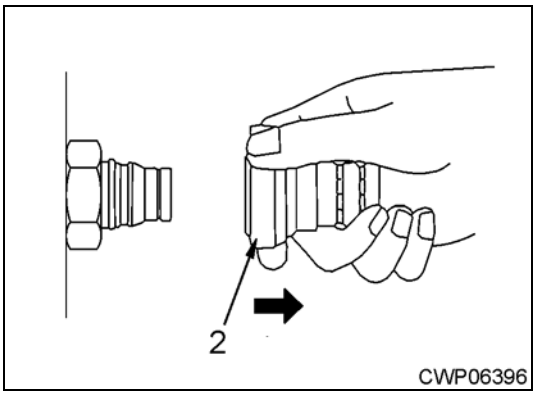
1. Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface **a** of the hexagonal portion at the male end.



2. Hold in the condition in Step 1, and turn the lever (4) to the right - clockwise.

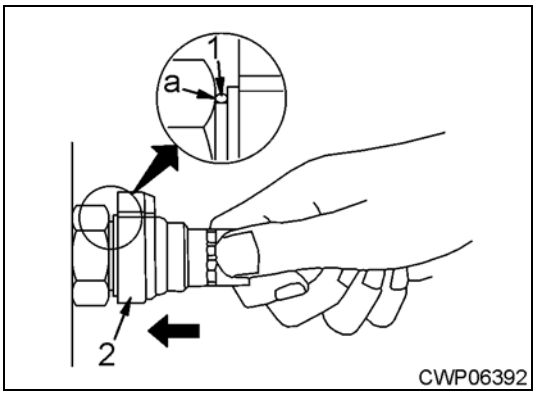


3. Hold in the condition in Steps 1 and 2, and pull out the whole body (2) to disconnect it.



Connection

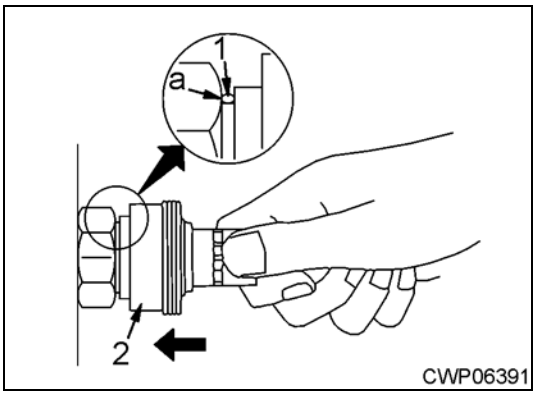
1. Hold the connector of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts surface **a** of the hexagonal portion at the male end to connect it.



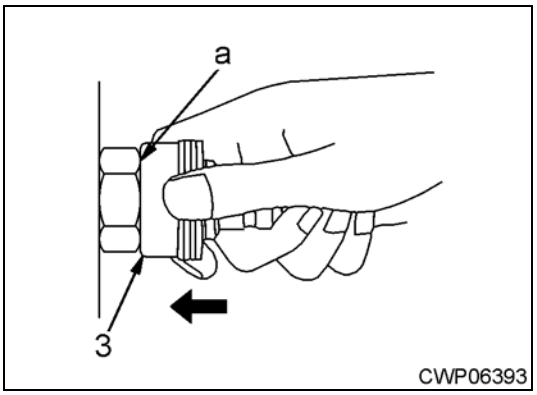
Type 3

Disconnection

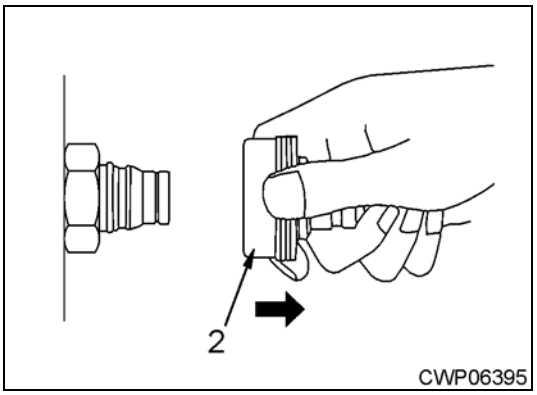
1. Hold the connector of the tightening portion and push the body (2) in straight until sliding prevention ring (1) contacts surface **a** of the hexagonal portion at the male end.



2. Hold in the condition in Step 1, and push until the cover (3) contacts surface **a** of the hexagonal portion at the male end.

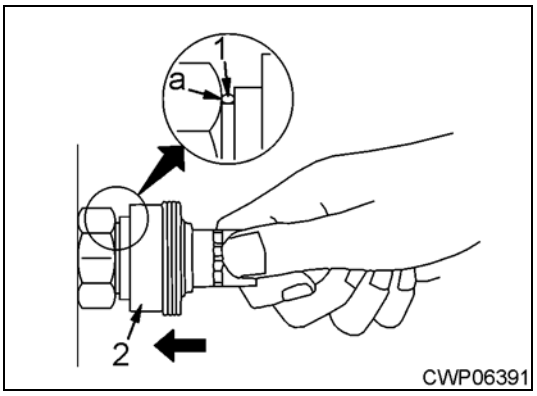


3. Hold in the condition in Steps 1 and 2, and pull out the whole body (2) to disconnect it.



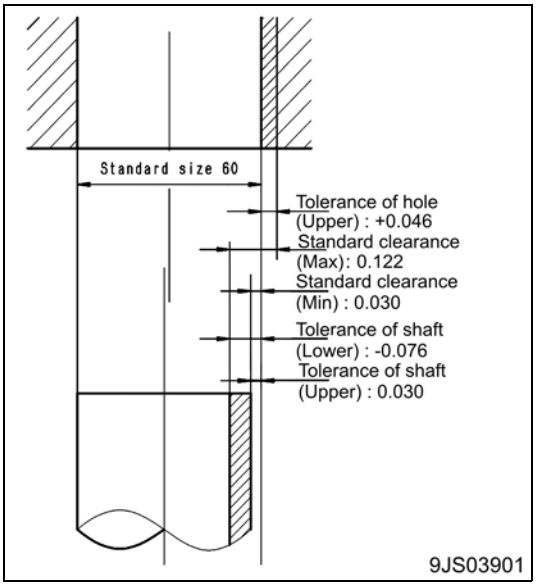
Connection

1. Hold the connector of the tightening portion and push the body (2) in straight until the slide prevention ring (1) contacts surface **a** of the hexagonal portion at the male end to connect it.



EXPLANATION OF MAINTENANCE STANDARD TERMS

● The maintenance standard values necessary for judgment of products and parts are described by the following terms.



1. Standard Size And Tolerance

- To be accurate, the finishing size of parts is a little different from one to another.
- To specify a finishing size of a part, a temporary standard size is set and an allowable difference from that size is indicated.
- The above size set temporarily is called the “standard size” and the range of difference from the standard size is called the “tolerance.”
- The tolerance with the symbols of + or – is indicated on the right side of the standard size.

Example:

Standard size	Tolerance
120	–0.022 –0.126

★ The tolerance may be indicated in the text and a table as [standard size (upper limit of tolerance/lower limit of tolerance)]. Example) 120 (–0.022/–0.126)

- Usually, the size of a hole and the size of the shaft to be fitted to that hole are indicated by the same standard size and different tolerances of the hole and shaft. The tightness of fit is decided by the tolerance.
- Indication of size of rotating shaft and hole and relationship drawing of them

Example:

Standard size	Tolerance	
	Shaft	Hole
60	–0.030 –0.076	+0.046 0

2. Standard Clearance And Standard Value

- The clearance made when new parts are assembled is called the "standard clearance," which is indicated by the range from the minimum clearance to the maximum clearance.
- When some parts are repaired, the clearance is generally adjusted to the standard clearance.
- A value of performance and function of new products or equivalent is called the "standard value." which is indicated by a range or a target value.
- When some parts are repaired, the value of performance/function is set to the standard value.

3. Standard Interference

- When the size of a hole is smaller than the size of a shaft because of the standard size and tolerance, the difference between these sizes is called the "interference."
- The range (A – B) from the difference (A) between the minimum size of the shaft and the maximum size of the shaft to the difference (B) between the maximum size of the shaft and the minimum size of the hole is the "standard interference."
- After repairing or replacing some parts, measure the size of their hole and shaft and check that the interference is in the standard range.

4. **Repair Limit and Allowable Value**
   - The size of a part changes because of wear and deformation while it is used. The limit of changed size is called the "repair limit."
   - If a part is worn to the repair limit must be replaced or repaired.
   - The performance and function of a product lowers while it is used. A value below which the product can be used without causing a problem is called the "allowable value."
   - If a product is worn to the allowable value, it must be checked or repaired. Since the permissible value is estimated from various tests or experiences in most cases, however, it must be judged after considering the operating condition and customer's requirement.
5. **Clearance Limit**
   - Parts can be used until the clearance between them is increased to a certain limit. The limit at which those parts cannot be used is called the "clearance limit."
   - If the clearance between the parts exceeds the clearance limit, they must be replaced or repaired.
6. **Interference Limit**
   - The allowable maximum interference between the hole of a part and the shaft of another part to be assembled is called the "interference limit."
   - The interference limit shows the repair limit of the part of smaller tolerance.
   - If the interference between the parts exceeds the interference limit, they must be replaced or repaired.

HANDLING OF FUEL SYSTEM DEVICES

- The common rail fuel injection system (CRI) consists of more precise parts than the conventional fuel injection pump and nozzles. If foreign matter enters this system, it can cause a problem. Use special care to prevent entry of foreign matter when performing inspection and maintenance of the fuel system.

Be careful of the work environment

- Avoid replacing filters or repairing the machine in rain, high winds, or at places where there is a lot of dust.

Sealing openings

- After any piping or equipment is removed, the openings should be sealed with caps, tapes, or vinyl bags to prevent any dirt or dust from entering. If the opening is left open or is blocked with a rag, there is danger of dirt entering or of the surrounding area being made dirty by leaking oil so never do this. Do not simply drain oil out onto the ground, but collect it and ask the customer to dispose of it, or take it back with you for disposal.

Cleaning off dust

- Wash the system carefully with clean fuel if dust enter the system.

Precautions for replacing fuel filter cartridge

- Be sure to use the Komatsu genuine fuel filter cartridge.
- Since the common rail fuel injection system (CRI) consists of more precise parts than the conventional fuel injection pump and nozzles, it employs a high-efficiency special filter to prevent foreign matter from entering it. If a filter other than the genuine one is used, the fuel system may have trouble. Accordingly, never use a substitute for the Komatsu genuine filter.

HANDLING OF INTAKE SYSTEM PARTS

- The Komatsu Variable Geometry Turbocharger (KVGT) consists of more precise parts (variable mechanism) than the conventional turbocharger. If foreign matter enters this system, it can cause a problem. Use special care to prevent entry of foreign matter when servicing the air intake system.

Be careful of the work environment

- Avoid repairing the machine in rain, high winds, or at places where there is a lot of dust.

Sealing openings

- Install a cap, tape, plastic bag, etc. to the open ends of disconnected piping to prevent entry of foreign matter. Never leave the openings uncovered nor plug the openings with rags. Foreign matter will enter the system.

STANDARD TIGHTENING TORQUE

Bolts And Nuts

- Unless there are special instructions, tighten metric nuts and bolts to the torque below (when using torque wrench).

★ The following table corresponds to the bolts in Figure A.

Thread diameter of bolt	Width across flats	Tightening torque	
mm	mm	N•m	lbf ft
6	10 (10)	11.8 - 14.7	8.70 - 10.84
8	13 (12)	27 - 34	19.91 - 25.07
10	17 (14)	59 - 74	43.51 - 54.57
12	19 (17)	98 - 123	72.28 - 90.72
14	22	157 - 196	115.79 - 144.56
16	24	245 - 309	180.70 - 227.91
18	27	343 - 427	252.98 - 314.94
20	30	490 - 608	361.40 - 448.44
22	32	662 - 829	488.27 - 611.44
24	36	824 - 1,030	607.75 - 759.68
27	41	1,180 - 1,470	870.32 - 1,084.22
30	46	1,520 - 1,910	1,121.09 - 1,408.74
33	50	1,960 - 2,450	1,445.62 - 1,807.02
36	55	2,450 - 3,040	1,807.02 - 2,242.19
39	60	2,890 - 3,630	2,131.55 - 2,677.35

★ Values with ( ) in the "Width across flats" column are for (*) marked bolt (flange bolt) shown in Fig. A.

★ The following table corresponds to the bolts in Figure B.

Thread diameter of bolt	Width across flats	Tightning torque	
mm	mm	N•m	lbf ft
6	10	5.9 - 9.8	4.35 - 7.22
8	13	13.7 - 23.5	10.10 - 17.33
10	14	34.3 - 46.1	25.29 - 34.00
12	27	74.5 - 90.2	54.94 - 66.52

Figure A

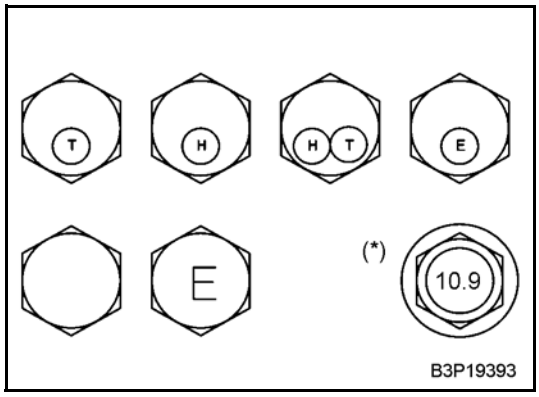
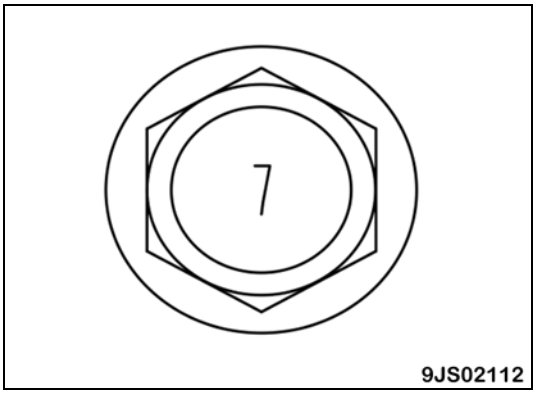


Figure B



Tightening Torque Of Hose Nuts

Use these torques for hose nuts.

Nominal No.	Thread diameter	Width across flat	Tightening torque	
	mm	mm	N•m	lbf ft
02	14	19	19.6 - 29.4	14.5 - 21.7
03	18	24	29.4 - 68.6	21.7 - 50.6
04	22	27	58.9 - 98.1	44.4 - 72.4
05	24	32	107.9 - 166.7	79.6 - 123.0
06	30	36	147.1 - 205.9	108.5 - 151.9
10	33	41	147.1 - 245.1	108.5 - 180.8
12	36	46	196.2 - 294.2	144.7 - 217.0
14	42	55	245.2 - 343.2	180.9 - 253.1

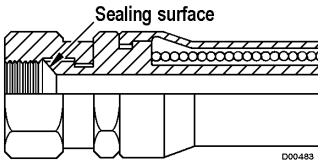
Tightening Torque Of Split Flange Bolts

Use these torques for split flange bolts.

Thread diameter	Width across flat	Tightening torque	
mm	mm	N•m	lbf ft
10	14	59 - 74	43.51 - 54.57
12	17	98 - 123	72.28 - 90.72
16	22	235 - 285	173.32 - 210.20

Tightening Torque For Flared Nuts

Use these torques for flared part of nut.



Thread diameter	Width across flat	Tightening torque	
mm	mm	N•m	lbf ft
14	19	24.5 ± 4.9	18.0 ± 3.6
18	24	49 ± 19.6	36.1 ± 14.4
22	27	78.5 ± 19.6	57.8 ± 14.4
24	32	137.3 ± 29.4	101.2 ± 21.6
30	36	176.5 ± 29.4	130.1 ± 21.6
33	41	196.1 ± 49	144.6 ± 36.1
36	46	245.2 ± 49	180.8 ± 36.1
42	55	294.2 ± 49	216.9 ± 36.1

Tightening Torques for Split Flanged Bolts

★ Unless otherwise specified, tighten split flanged bolt to the torque shown in the following table.

Thread Diameter	Width across Flats	Tightening Torque		
mm	mm	N•m	kgm	lbf ft
10	14	59 – 74	59 – 74	43.51 – 54.57
12	17	98 – 123	98 – 123	72.28 – 90.72
16	22	235 – 285	235 – 285	173.32 – 210.20

Tightening Torques For O-ring Boss Piping Joints

★ Unless there are special instructions, tighten the O-ring boss piping joints to the torque below.

Norminal No.	Thread diameter	Width across flat	Tightening torque N•m (lbf ft)	
	mm	mm	Range	Target
02	14	Varies depending on type of connector.	35 - 63 (25.81 - 46.46)	44 (32.45)
-	18		59 to 98 (43.5 - 72.3)	78 (57.5)
03, 04	20		84 - 132 (61.95 - 97.35)	103 (75.96)
05, 06	24		128 - 186 (94.40 - 137.18)	157 (115.79)
10, 12	33		363 - 480 (267.73 - 354.02)	422 (311.25)
14	42		746 - 1,010 (550.22 - 744.93)	883 (651.26)

Table Of Tightening Torques For O-ring Boss Plugs

★ Unless there are special instructions, tighten the O-ring boss plugs to the torque below.

Norminal No.	Thread diameter	Width across flat	Tightening torque N•m (lbf lb)	
	mm	mm	Range	Target
08	08	14	5.88 - 8.82 (4.33 - 6.50)	7.35 (5.42)
10	10	17	9.8 - 12.74 (7.22 - 9.39)	11.27 (8.31)
12	12	19	14.7 - 19.6 (10.84 - 14.45)	17.64 (13.01)
14	14	22	19.6 - 24.5 (14.45 - 18.07)	22.54 (16.62)
16	16	24	24.5 - 34.3 (18.07 - 25.29)	29.4 (21.68)
18	18	27	34.3 - 44.1 (25.29 - 32.52)	39.2 (28.91)
20	20	30	44.1 - 53.9 (32.52 - 39.75)	49.0 (36.14)
24	24	32	58.8 - 78.4 (43.36 - 57.82)	68.6 (50.59)
30	30	32	93.1 - 122.5 (68.66 - 90.35)	107.8 (79.50)
33	33	–	107.8 - 147.0 (79.50 - 108.42)	124.4 (91.75)
36	36	36	127.4 - 176.4 (93.96 - 130.10)	151.9 (112.03)
42	42	–	181.3 - 240.1 (133.72 - 177.08)	210.7 (155.40)
52	52	–	274.4 - 367.5 (202.38 - 271.05)	323.4 (238.52)

Tightening Torque For Hoses (Taper Seal Type And Face Seal Type)

★ Tighten the hoses (taper seal type and face seal type) to the following torque, unless otherwise specified.
★ Apply the following torque when the threads are coated (wet) with engine oil.

Nominal size of hose	Width across flats	Tightening torque (N•m (lbf ft))		Taper seal type	Face seal type	
		Range	Target	Thread size (mm)	Nominal thread size - Threads per inch, Thread series	Root diameter (mm) (Reference)
02	19	34 - 54 (25.0 - 39.8)	44 (32.4)	-	9/16 - 18UN	14.3
		34 - 63 (25.0 - 46.4)	44 (32.4)	14	-	-
03	22	54 - 93 (39.8 - 68.5)	74 (54.5)	-	11/16 -16UN	17.5
	24	59 - 98 (43.5 - 72.2)	78 57.5)	18	-	-
04	27	84 - 132 (61.9 - 97.3)	103 (75.9)	22	13/16 - 16UN	20.6
05	32	128 - 186 (94.4 - 137.1)	157 (115.7)	24	1 - 14UNS	25.4
06	36	177 - 245 (130.5 - 180.7)	216 (159.3)	30	1-3/16 - 12UN	30.2
(10)	41	177 - 245 (130.5 - 180.7)	216 (159.3)	33	-	-
(12)	46	197 - 294 (145.3 - 216.8)	245 (180.7)	36	-	-
(14)	55	246 - 343 (181.4 - 252.9)	294 (216.8)	42	-	-

Tightening Torque For Face Seal Joints

★ Tighten the face seal joints (sleeve nut type) made of plated steel pipes for low pressure service to be used for engines, etc. to the torque shown in this table.
★ Apply the following torque to the face seal joint while their threaded parts are coated with engine oil (wetted).

Outer Diameter of Pipe (mm)	Width across Flats (mm)	Tightening Torque N•m [kgm] {lbf ft}		Face seal	
		Range	Target	Nominal No. – Number of threads, Type of Thread	Thread Diameter (mm) (Reference)
8	19	14 – 16 [1.4 – 1.6] {10.33 – 11.80}	15 [1.5] {11.06}	9/16-18UN	14.3
10	22	24 – 27 [2.4 – 2.7] {17.70 – 19.91}	25.5 [2.6] {18.81}	11/16-16UN	17.5
12	24 (27)	43 – 47 [4.4 – 4.8] {31.72 – 34.67}	45 [4.6] {33.19}	13/16-16UN	20.6
15 (16)	30 (32)	60 – 68 [6.1 – 6.8] {44.25 – 50.15}	64 [6.5] {47.20}	1-14UN	25.4
22 (20)	36	90 – 95 [9.2 – 9.7] {66.38 – 70.07}	92.5 [9.4] {68.22}	1-3/16-12UN	30.2

For 102, 107, and 114 Engine Series (Bolts and Nuts)

★ Tighten the metric bolts and nuts of the 102, 107 and 114 engine series to the torque in this table, unless there are special instructions.

Thread Size	Tightening Torque		
	Bolts and Nuts		
mm	N•m	kgm	lbf in
6	10 ±2	1.02 ±0.20	88.51 ±17.70
8	24 ±4	2.45 ±0.41	17.70 ±2.95
10	43 ±6	4.38 ±0.61	31.72 ±4.43
12	77 ±12	7.85 ±1.22	56.79 ±8.85
14	—	—	—

For 102, 107, and 114 Engine Series (Eye Joints)

★ Tighten the metric eye joints of the 102, 107, and 114 engine series to the torque in this table, unless there are special instructions.

Thread size Tightening Torque			
mm	**N•m**	**kgm**	**lbf in**
6	8 ±2	0.81 ±0.20	70.81 ±17.70
8	10 ±2	1.02 ±0.20	88.51 ±17.70
10	12 ±2	1.22 ±0.20	106.21 ±17.70
12	24 ±4	2.45 ±0.41	212.42 ±35.40
14	36 ±5	3.67 ±0.51	26.55 ±3.69

For 102, 107, and 114 Engine Series (Taper Screws)

★ Tighten the taper screws (unit: inch) of the 102, 107, and 114 engine series to the torque in this table, unless there are special instructions.

	Tightening Torque					
Material	**In Cast Iron or Steel**			**In Aluminum**		
Thread Size (inch)	**N•m**	**kgm**	**lbf ft**	**N•m**	**kgm**	**lbf ft**
1/16	15 ±2	1.53 ±0.20	11.06 ±1.48	5 ±1	0.51 ±0.10	3.69 ±0.74
1/8	20 ±2	2.04 ±0.20	14.75 ±1.48	15 ±2	1.53 ±0.20	11.06 ±1.48
1/4	25 ±3	2.55 ±0.31	18.44 ±2.21	20 ±2	2.04 ±0.20	14.75 ±1.48
3/8	35 ±4	3.57 ±0.41	25.81 ±2.95	25 ±3	2.55 ±0.31	18.44 ±2.21
1/2	55 ±6	5.61 ±0.61	40.57 ±4.43	35 ±4	3.57 ±0.41	25.81 ±2.95
3/4	75 ±8	7.65 ±0.82	55.32 ±5.90	45 ±5	4.59 ±0.51	33.19 ±3.69

ELECTRIC WIRE CODE

In the wiring diagrams, various colors and symbols are employed to indicate the thickness of wires. This wire code table will help you understand WIRING DIAGRAMS.
Example: 05WB indicates a cable having a nominal number 05 and white coating with black stripe.

Classification By Thickness

Nominal number	Copper wire			Cable O.D. (mm)	Current rating (A)	Applicable circuit
	Number of strands	Dia. Of strand (mm)	Cross section (mm)			
0.85	11	0.32	0.88	2.4	12	Starting, lighting, signal etc.
2	26	0.32	2.09	3.1	20	Lighting, signal etc.
5	65	0.32	5.23	4.6	37	Charging and signal
15	84	0.45	13.36	7.0	59	Starting (Glow plug)
40	85	0.80	42.73	11.4	135	Starting
60	127	0.80	63.84	13.6	178	Starting
100	217	0.80	109.1	17.6	230	Starting

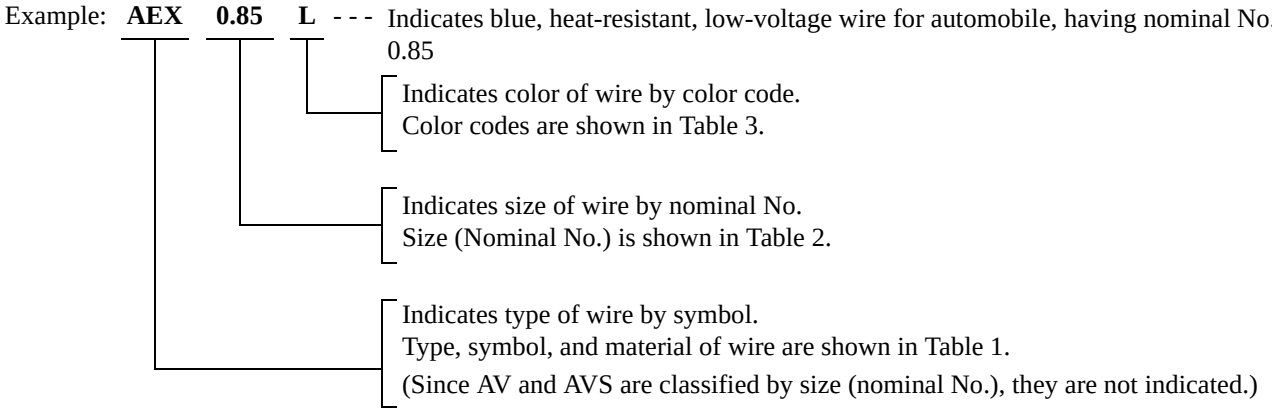
Classification By Color And Code

Priority	Circuits Classification		Charging	Ground	Starting	Lighting	Instrument	Signal	Other
1	Primary	Code	W	B	B	R	Y	G	L
		Color	White	Black	Black	Red	Yellow	Green	Blue
2	Auxiliary	Code	WR	—	BW	RW	YR	GW	LW
		Color	White & Red	—	Black & White	Red & White	Yellow & Red	Green & White	Blue & White
3		Code	WB	—	BY	RB	YB	GR	LR
		Color	White & Black	—	Black & Yellow	Red & Black	Yellow & Black	Green & Red	Blue & Red
4		Code	WL	—	BR	RY	YG	GY	LY
		Color	White & Blue	—	Black & Red	Red & Yellow	Yellow & Green	Green & Yellow	Blue & Yellow
5		Code	WG	—	—	RG	YL	GB	LB
		Color	White & Green	—	—	Red & Green	Yellow & Blue	Green & Black	Blue & Black
6		Code	—	—	—	RL	YW	GL	—
		Color	—	—	—	Red & Blue	Yellow & White	Green & Blue	—

How To Read Electric Wire Code

★ The information about the wires unique to each machine model is described in Troubleshooting section, Relational information of troubleshooting.

In the electric circuit diagram, the material, thickness, and color of each electric wire are indicated by symbols. The electric wire code is helpful in understanding the electric circuit diagram.



1. Type, Symbol, And Material
   AV and AVS are different in only thickness and outside diameter of the cover. CAVS has a circular compressed conductor. It differs from AV and AVS in the outside diameter of the conductor and the thickness of the cover. AEX is similar to AV in thickness and outside diameter of AEX, but different from AV and AVS in material of the cover.

(Table 1)

Type	Symbol	Material		Using temperature range °C (°F)	Example of use
Low-voltage wire for automobile	AV	Conductor	Annealed copper for electric appliance	–30 to +60 (-22 to +140)	General wiring (Nominal No. 5 and above)
		Insulator	Soft polyvinyl chloride		
Thin-cover low-voltage wire for automobile (type 1)	AVS	Conductor	Annealed copper for electric appliance		General wiring (Nominal No. 3 and below)
		Insulator	Soft polyvinyl chloride		
Thin low-voltage wire for automobile (type 2)	CAVS	Conductor	Annealed copper wire for electric appliance		For mid- to small-size excavators (nominal No. 125 and below)
		Insulator	Soft polyvinyl chloride		
Heat-resistant low-voltage wire for automobile	AEX	Conductor	Annealed copper for electric appliance	–50 to +110 (-58 to +230)	General wiring in extremely cold district, wiring at high-temperature place
		Insulator	Heat-resistant crosslinked polyethylene		

2. Dimensions

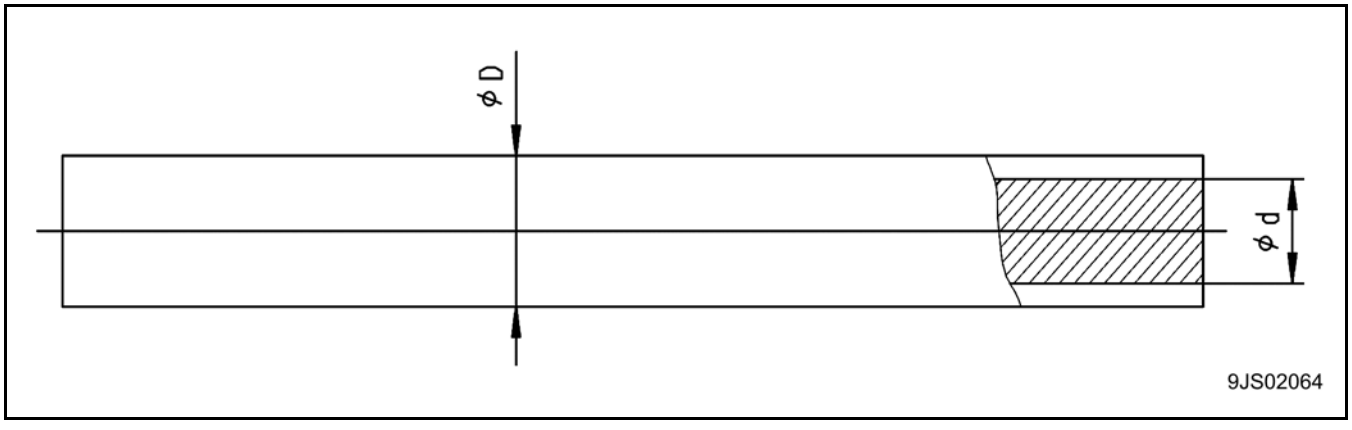
(Table 2)

Nominal No.			0.5f	(0.5)	0.75f	(0.85)	1.25f	(1.25)	2f	2	3f	3	5
Conductor		Number of strands/ Diameter of strand	20/0.18	7/0.32	30/0.18	11/0.32	50/0.18	16/0.32	37/0.26	26/0.32	58/0.26	41/0.32	65/0.32
		Sectional area (mm2)	0.51	0.56	0.76	0.88	1.27	1.29	1.96	2.09	3.08	3.30	5.23
		d (approx.)	1.0		1.2		1.5		1.9	1.9	2.3	2.4	3.0
Cover D	AVS	Standard	2.0		2.2		2.5		2.9	2.9	3.5	3.6	–
	AV	Standard	–		–		–		–	–	–	–	4.6
	AEX	Standard	2.0		2.2		2.7		3.0	3.1	–	3.8	4.6

Nominal No.			8	15	20	30	40	50	60	85	100
Conductor		Number of strands/ Diameter of strand	50/0.45	84/0.45	41/0.80	70/0.80	85/0.80	108/0.80	127/0.80	169/0.80	217/0.80
		Sectional area (mm2)	7.95	13.36	20.61	35.19	42.73	54.29	63.84	84.96	109.1
		d (approx.)	3.7	4.8	6.0	8.0	8.6	9.8	10.4	12.0	13.6
Cover D	AVS	Standard	–	–	–	–	–	–	–	–	–
	AV	Standard	5.5	7.0	8.2	10.8	11.4	13.0	13.6	16.0	17.6
	AEX	Standard	5.3	7.0	8.2	10.8	11.4	13.0	13.6	16.0	17.6

Nominal No.			0.5f	0.5	0.75f	0.85	1.25f	1.25
Conductor		Number of strands/ Diameter of strand	–	7/Circular compressed	–	11/Circular compressed	–	16/Circular Compressed
		Cross-section area ($mm^{2)}$	–	0.56	–	0.88	–	1.29
		d (approx.)	–	0.9	–	1.1	–	1.4
Cover D	CAVS	Standard	–	1.6	–	1.8	–	2.1

★ “f” of nominal No. denotes flexible”.



3. Color Codes Table

(Table 3)

Color Code	Color of wire
B	Black
Br	Brown
BrB	Brown & Black
BrR	Brown & Red
BrW	Brown & White
BrY	Brown & Yellow
Ch	Charcoal
Dg	Dark green
G	Green
GB	Green & Black
GL	Green & Blue
Gr	Gray
GR	Green & Red
GW	Green & White
GY	Green & Yellow
L	Blue
LB	Blue & Black
Lg	Light green
LgB	Light green & Black
LgR	Light green & Red

Color Code	Color of wire
LgW	Light green & White
LgY	Light green & Yellow
LR	Blue & Red
LW	Blue & White
LY	Blue & Yellow
O	Orange
P	Pink
R	Red
RB	Red & Black
RG	Red & Green
RL	Red & Blue
RW	Red & White
RY	Red & Yellow
Sb	Sky Blue
Y	Yellow
YB	Yellow & Black
YG	Yellow &Green
YL	Yellow & Blue
YR	Yellow & Red
YW	Yellow & White

- In a color code consisting of 2 colors, the first color is the color of the background and the second color is the color of the marking.
  Example: “GW” means that the background is Green and marking is White.

★ Types of circuits and color codes

(Table 4)

Type of wire		AVS, AV, CAVS						AEX	
Type of circuit	Charge	R	WG	–	–	–	–	R	–
	Ground	B	–	–	–	–	–	B	–
	Start	R	–	–	–	–	–	R	–
	Light	RW	RB	RY	RG	RL	–	D	–
	Instrument	Y	YR	YB	YG	YL	YW	Y	Gr
	Signal	G	GW	GR	GY	GB	GL	G	Br
	Others	L	LW	LR	LY	LB	–	L	–
		Br	BrW	BrR	BrY	BrB	–	–	–
		Lg	LgR	LgY	LgB	LgW	–	–	–
		O	–	–	–	–	–	–	–
		Gr	–	–	–	–	–	–	–
		P	–	–	–	–	–	–	–
		Sb	–	–	–	–	–	–	–
		Dg	–	–	–	–	–	–	–
		Ch	–	–	–	–	–	–	–

PRECAUTIONS FOR OPERATIONS

★ When carrying out removal or installation (disassembly or assembly) of units, be sure to follow the general precautions given in this section when carrying out the operation.

Precautions When Carrying Out Removal Work

- If the coolant contains antifreeze, dispose of it correctly.
- After disconnecting hoses or tubes, cover them or fit plugs to prevent dirt or dust from entering.
- When draining oil, prepare a container of adequate size to catch the oil.
- Confirm the match marks showing the installation position, and make match marks in the necessary places before removal to prevent any mistake when assembling.
- To prevent any excessive force from being applied to the wiring, always hold the connectors when disconnecting the connectors. Do not pull the wires.
- Fit wires and hoses with tags to show their installation position to prevent any mistake when installing.
- Check the number and thickness of the shims, and keep in a safe place.
- When raising components, be sure to use lifting equipment of ample strength.
- When using forcing screws to remove any components, tighten the forcing screws uniformly in turn.
- Before removing any unit, clean the surrounding area and fit a cover to prevent any dust or dirt from entering after removal.

★ Precautions when handling piping during disassembly

Fit the following plugs into the piping after disconnecting it during disassembly operations.

- Face seal type hoses and tubes

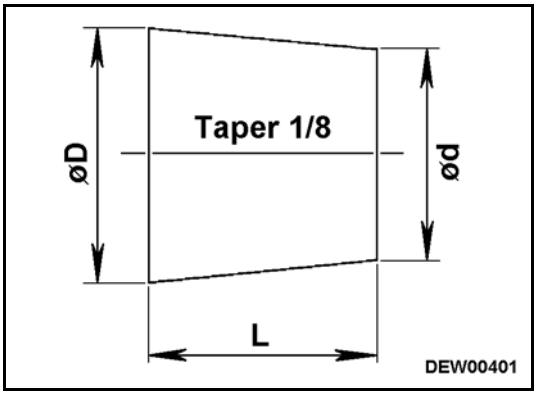
Nominal Number	Plug (nut end)	Sleeve Nut (elbow end)
02	07376-70210	02789-20210
03	07376-70315	02789-00315
04	07376-70422	02789-00422
05	07376-70522	02789-00522
06	07376-70628	02789-00628

- Split flange type hoses and tubes

Nominal Number	Flange (hose end)	Sleeve Head (tube end)	Split Flange
04	07379-00400	07378-10400	07371-30400
05	07379-00500	07378-10500	07371-30500

- If the part is not under hydraulic pressure, the following corks can be used.

Nominal Number	Part Number	Dimensions		
		D	d	L
06	07049-00608	6	5	8
08	07049-00811	8	6.5	11
10	07049-01012	10	8.5	12
12	07049-01215	12	10	15
14	07049-01418	14	11.5	18
16	07049-01620	16	13.5	20
18	07049-01822	18	15	22
20	07049-02025	20	17	25
22	07049-02228	22	18.5	28
24	07049-02430	24	20	30
27	07049-02734	27	22.5	34



Precautions When Carrying Out Installation Work

- Tighten all bolts and nuts (sleeve nuts) to the specified (KES) torque.
- Install the hoses without twisting or interference and fix them with intermediate clamps, if there are any.
- Replace all gaskets, O-rings, cotter pins, and lock plates with new parts.
- Bend the cotter pins and lock plates securely.
- When coating with adhesive, clean the part and remove all oil and grease, then coat the threaded portion with two to three drops of adhesive.
- When coating with gasket sealant, clean the surface and remove all oil and grease; check that there is no dirt or damage; then coat uniformly with gasket sealant.
- Clean all parts, and correct any damage, dents, burrs, or rust.
- Coat rotating parts and sliding parts with engine oil.
- When press-fitting parts, coat the surface with anti-friction compound (LM-P).
- After fitting snap rings, check that the snap ring is fitted securely in the ring groove.
- When connecting wiring connectors, clean the connector to remove all oil, dirt, or water; then connect securely.
- When using eyebolts, check that there is no deformation or deterioration; screw them in completely; and align the direction of the hook.
- When tightening split flanges, tighten uniformly in turn to prevent excessive tightening on one side.

★ When operating the hydraulic cylinders for the first time after reassembling cylinders, pumps, and other hydraulic equipment removed for repair, always bleed the air in the following manner:

1. Start the engine and run at low idle.
2. Operate the work equipment control lever to operate the hydraulic cylinder four to five times, stopping the cylinder 100 mm from the end of its stroke.
3. Next, operate the hydraulic cylinder three to four times to the end of its stroke.
4. After doing this, run the engine at normal speed.

★ When using the machine for the first time after repair or long storage, do the same procedure.

Precautions When Completing the Operation

1. Refilling with coolant, oil, and grease

   - If the coolant has been drained:
     - Close the drain valve securely and add coolant to the specified level.
     - Run the engine to circulate the coolant through the system.
     - Check the coolant level again. Add coolant to specified level again if necessary.
   - If the hydraulic equipment has been removed and installed again:
     - Add oil to the specified level.
     - Run the engine to circulate the oil through the system.
     - Check the oil level again. Add oil to specified level again if necessary.
   - If the piping or hydraulic equipment has been removed, always bleed the air from the system after reassembling the parts.
     - ★ For details, see *WORK EQUIPMENT: Bleeding Air from Hydraulic Circuit* in the *Testing and Adjusting* section.
   - Add the specified amount of grease (molybdenum disulphide grease) to the work equipment parts.

2. Checking cylinder head and manifolds for looseness

   - Check the cylinder head and intake and exhaust manifold for looseness.
   - If any part is loosened, retighten it.
     - ★ For the tightening torque, see *ENGINE AND COOLING SYSTEM: Cylinder Head Assembly* in the *Disassembly and Assembly* section.

3. Checking engine piping for damage and looseness

   - Intake and exhaust system
     - Check the piping for damage; the mounting bolts and nuts for looseness; and the joints for air suction and exhaust gas leakage.
     - If any part is loosened or damaged, retighten or repair it.
   - Cooling system
     - Check the piping for damage; the mounting bolts and nuts for looseness; and the joints for coolant leakage.
     - If any part is loosened or damaged, retighten or repair it.
   - Fuel system
     - Check the piping for damage; the mounting bolts and nuts for looseness; and the joints for fuel leakage.
     - If any part is loosened or damaged, retighten or repair it.

4. Checking KDPF and exhaust pipe for damage and looseness

   - Visually check the KDPF or muffler, exhaust pipe, shields and their mounting parts for cracks or damage.
     - If any part is damaged, replace it.
   - Check the mounting bolts and nuts of the KDPF or muffler, exhaust pipe, shields and their mounting parts for looseness.
     - If any bolt or nut is loosened, retighten it.

5. Checking of KDPF or muffler function

   - Check the KDPF or muffler for abnormal sound and sound different from that of a new one.
   - If any abnormal sound is heard, repair the KDPF or muffler. Refer to both the *Troubleshooting* and the *Disassembly and Assembly* sections.

CONVERSION TABLES

Method Of Using The Conversion Table

The Conversion Table in this section is provided to enable simple conversion of figures. For details of the method of using the Conversion Table, see the example given below.

EXAMPLE

- Method of using the Conversion Table to convert from millimeters to inches.

1. Convert 55 mm into inches.
   A. Locate the number 50 in the vertical column at the left side, take this as ①, then draw a horizontal line from ①.

   B. Locate the number 5 in the row across the top, take this as ②, then draw a perpendicular line down from ②.

   C. Take the point where the two lines cross as ③. This point ③ gives the value when converting from millimeters to inches. Therefore, 55 millimeters = 2.165 inches.

2. Convert 550 mm into inches.
   A. The number 550 does not appear in the table, so divide by 10 (move the decimal one place to the left) to convert it to 55 mm.

   B. Carry out the same procedure as above to convert 55 mm to 2.165 inches.

   C. The original value (550 mm) was divided by 10, so multiply 2.165 inches by 10 (move the decimal one place to the right) to return to the original value. This gives 550 mm = 21.65 inches.

Millimeters to inches 1 mm = 0.03937 in

	0	1	2	3	4	5 ②	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
						③				
50 ①	1.969	2.008	2.017	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Millimeters to Inches **1 mm = 0.03937 in**

	0	1	2	3	4	5	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Kilogram to Pound **1 kg = 2.2046 lb**

	0	1	2	3	4	5	6	7	8	9
0	0	2.20	4.41	6.61	8.82	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.66	30.86	33.07	35.27	37.48	39.68	41.89
20	44.09	46.30	48.50	50.71	51.91	55.12	57.32	59.53	61.73	63.93
30	66.14	68.34	70.55	72.75	74.96	77.16	79.37	81.57	83.78	85.98
40	88.18	90.39	92.59	94.80	97.00	99.21	101.41	103.62	105.82	108.03
50	110.23	112.44	114.64	116.85	119.05	121.25	123.46	125.66	127.87	130.07
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21
90	198.42	200.62	202.83	205.03	207.24	209.44	211.64	213.85	216.05	218.26

Liter to U.S. Gallon **1 L = 0.2642 U.S. Gal**

	0	1	2	3	4	5	6	7	8	9
0	0	0.264	0.528	0.793	1.057	1.321	1.585	1.849	2.113	2.378
10	2.642	2.906	3.170	3.434	3.698	3.963	4.227	4.491	4.755	5.019
20	5.283	5.548	5.812	6.076	6.340	6.604	6.869	7.133	7.397	7.661
30	7.925	8.189	8.454	8.718	8.982	9.246	9.510	9.774	10.039	10.303
40	10.567	10.831	11.095	11.359	11.624	11.888	12.152	12.416	12.680	12.944
50	13.209	13.473	13.737	14.001	14.265	14.529	14.795	15.058	15.322	15.586
60	15.850	16.115	16.379	16.643	16.907	17.171	17.435	17.700	17.964	18.228
70	18.492	18.756	19.020	19.285	19.549	19.813	20.077	20.341	20.605	20.870
80	21.134	21.398	21.662	21.926	22.190	22.455	22.719	22.983	23.247	23.511
90	23.775	24.040	24.304	24.568	24.832	25.096	25.361	25.625	25.889	26.153

Liter to U.K. Gallon **1 L = 0.21997 U.K. Gal**

	0	1	2	3	4	5	6	7	8	9
0	0	0.220	0.440	0.660	0.880	1.100	1.320	1.540	1.760	1.980
10	2.200	2.420	2.640	2.860	3.080	3.300	3.520	3.740	3.950	4.179
20	4.399	4.619	4.839	5.059	5.279	5.499	5.719	5.939	6.159	6.379
30	6.599	6.819	7.039	7.259	7.479	7.699	7.919	8.139	8.359	8.579
40	8.799	9.019	9.239	9.459	9.679	9.899	10.119	10.339	10.559	10.778
50	10.998	11.281	11.438	11.658	11.878	12.098	12.318	12.528	12.758	12.978
60	13.198	13.418	13.638	13.858	14.078	14.298	14.518	14.738	14.958	15.178
70	15.398	15.618	15.838	16.058	16.278	16.498	16.718	16.938	17.158	17.378
80	17.598	17.818	18.037	18.257	18.477	18.697	18.917	19.137	19.357	19.577
90	19.797	20.017	20.237	20.457	20.677	20.897	21.117	21.337	21.557	21.777

kgm to ft. lb. **1 kgm = 7.233 ft. lb.**

	0	1	2	3	4	5	6	7	8	9
0	0	7.2	14.5	21.7	28.9	36.2	43.4	50.6	57.9	65.1
10	72.3	79.6	86.8	94.0	101.3	108.5	115.7	123.0	130.2	137.4
20	144.7	151.9	159.1	166.4	173.6	180.8	188.1	195.3	202.5	209.8
30	217.0	224.2	231.5	238.7	245.9	253.2	260.4	267.6	274.9	282.1
40	289.3	296.6	303.8	311.0	318.3	325.5	332.7	340.0	347.2	354.4
50	361.7	368.9	376.1	383.4	390.6	397.8	405.1	412.3	419.5	426.8
60	434.0	441.2	448.5	455.7	462.9	470.2	477.4	484.6	491.8	499.1
70	506.3	513.5	520.8	528.0	535.2	542.5	549.7	556.9	564.2	571.4
80	578.6	585.9	593.1	600.3	607.6	614.8	622.0	629.3	636.5	643.7
90	651.0	658.2	665.4	672.7	679.9	687.1	694.4	701.6	708.8	716.1
100	723.3	730.5	737.8	745.0	752.2	759.5	766.7	773.9	781.2	788.4
110	795.6	802.9	810.1	817.3	824.6	831.8	839.0	846.3	853.5	860.7
120	868.0	875.2	882.4	889.7	896.9	904.1	911.4	918.6	925.8	933.1
130	940.3	947.5	954.8	962.0	969.2	976.5	983.7	990.9	998.2	1005.4
140	1012.6	1019.9	1027.1	1034.3	1041.5	1048.8	1056.0	1063.2	1070.5	1077.7
150	1084.9	1092.2	1099.4	1106.6	1113.9	1121.1	1128.3	1135.6	1142.8	1150.0
160	1157.3	1164.5	1171.7	1179.0	1186.2	1193.4	1200.7	1207.9	1215.1	1222.4
170	1129.6	1236.8	1244.1	1251.3	1258.5	1265.8	1273.0	1280.1	1287.5	1294.7
180	1301.9	1309.2	1316.4	1323.6	1330.9	1338.1	1345.3	1352.63	1359.8	1367.0
190	1374.3	1381.5	1388.7	1396.0	1403.2	1410.4	1417.7	1424.9	1432.1	1439.4

kg/cm^2 to lb/in^2 **1 kg/cm^2 = 14.2233lb/in^2**

	0	1	2	3	4	5	6	7	8	9
0	0	14.2	28.4	42.7	56.9	71.1	85.3	99.6	113.8	128.0
10	142.2	156.5	170.7	184.9	199.1	213.4	227.6	241.8	256.0	270.2
20	284.5	298.7	312.9	327.1	341.4	355.6	369.8	384.0	398.3	412.5
30	426.7	440.9	455.1	469.4	483.6	497.8	512.0	526.3	540.5	554.7
40	568.9	583.2	597.4	611.6	625.8	640.1	654.3	668.5	682.7	696.9
50	711.2	725.4	739.6	753.8	768.1	782.3	796.5	810.7	825.0	839.2
60	853.4	867.6	881.8	896.1	910.3	924.5	938.7	953.0	967.2	981.4
70	995.6	1010	1024	1038	1053	1067	1081	1095	1109	1124
80	1138	1152	1166	1181	1195	1209	1223	1237	1252	1266
90	1280	1294	1309	1323	1337	1351	1365	1380	1394	1408
100	1422	1437	1451	1465	1479	1493	1508	1522	1536	1550
110	1565	1579	1593	1607	1621	1636	1650	1664	1678	1693
120	1707	1721	1735	1749	1764	1778	1792	1806	1821	1835
130	1849	1863	1877	1892	1906	1920	19324	1949	1963	1977
140	1991	2005	2034	2048	2062	2077	2091	2105	2119	
150	2134	2148	2162	2176	2190	2205	2219	2233	2247	2262
160	2276	2290	2304	2318	2333	2347	2361	2375	2389	2404
170	2418	2432	2446	2460	2475	2489	2503	2518	2532	2546
180	2560	2574	2589	2603	2617	2631	2646	2660	2674	2688
190	2702	2717	2731	2745	2759	2773	2788	2802	2816	2830
200	2845	2859	2873	2887	2901	2916	2930	2944	2958	2973
210	2987	3001	3015	3030	3044	3058	3072	3086	3101	3115
220	3129	3143	3158	3172	3186	3200	3214	3229	3243	3257
230	3271	3286	3300	3314	3328	3343	3357	3371	3385	3399
240	3414	3428	3442	3456	3470	3485	3499	3513	3527	3542

Temperature

Fahrenheit Centigrade Conversion; a simple way to convert a Fahrenheit temperature reading into a Centigrade temperature reading or vise versa is to enter the accompanying table in the center or boldface column of figures. These figures refer to the temperature in either Fahrenheit or Centigrade degrees. If it is desired to convert from Fahrenheit to Centigrade degrees, consider the center column as a table of Fahrenheit temperatures and read the corresponding Centigrade temperature in the column at the left. If it is desired to convert from Centigrade to Fahrenheit degrees, consider the center column as a table of Centigrade values, and read the corresponding Fahrenheit temperature on the right.

°C		°F	°C		°F	°C		°F	°C		°F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	.35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4	85	185.0
-28.3	-19	-2.2	-8.9	16	60.8	10.6	51	123.8	30.0	86	186.8
-27.8	-18	-0.4	-8.3	17	62.6	11.1	52	125.6	30.6	87	188.6
-27.2	-17	1.4	-7.8	18	64.4	11.7	53	127.4	31.1	88	190.4
-26.7	-16	3.2	-7.2	19	66.2	12.2	54	129.2	31.7	89	192.2
-26.1	-15	5.0	-6.7	20	68.0	12.8	55	131.0	32.2	90	194.0
-25.6	-14	6.8	-6.1	21	69.8	13.3	56	132.8	32.8	91	195.8
-25.0	-13	8.6	-5.6	22	71.6	13.9	57	134.6	33.3	92	197.6
-24.4	-12	10.4	-5.0	23	73.4	14.4	58	136.4	33.9	93	199.4
-23.9	-11	12.2	-4.4	24	75.2	15.0	59	138.2	34.4	94	201.2
-23.3	-10	14.0	-3.9	25	77.0	15.6	60	140.0	35.0	95	203.0
-22.8	-9	15.8	-3.3	26	78.8	16.1	61	141.8	35.6	96	204.8
-22.2	-8	17.6	-2.8	27	80.6	16.7	62	143.6	36.1	97	206.6
-21.7	-7	19.4	-2.2	28	82.4	17.2	63	145.4	36.7	98	208.4
-21.1	-6	21.2	-1.7	29	84.2	17.8	64	147.2	37.2	99	210.2
-20.6	-5	23.0	-1.1	30	86.0	18.3	65	149.0	37.8	100	212.0
-20.0	-4	24.8	-0.6	31	87.8	18.9	66	150.8	40.6	105	221.0
-19.4	-3	26.6	0	32	89.6	19.4	67	152.6	43.3	110	230.0
-18.9	-2	28.4	0.6	33	91.4	20.0	68	154.4	46.1	115	239.0
-18.3	-1	30.2	1.1	34	93.2	20.6	69	156.2	48.9	120	248.0
-17.8	0	32.0	1.7	35	95.0	21.1	70	158.0	51.7	125	257.0
-17.2	1	33.8	2.2	36	96.8	21.7	71	159.8	54.4	130	266.0
-16.7	2	35.6	2.8	37	98.6	22.2	72	161.6	57.2	135	275.0
-16.1	3	37.4	3.3	38	100.4	22.8	73	163.4	60.0	140	284.0
-15.6	4	39.2	3.9	39	102.2	23.3	74	165.2	62.7	145	293.0
-15.0	5	41.0	4.4	40	104.0	23.9	75	167.0	65.6	150	302.0
-14.4	6	42.8	5.0	41	105.8	24.4	76	168.8	68.3	155	311.0
-13.9	7	44.6	5.6	42	107.6	25.0	77	170.6	71.1	160	320.0
-13.3	8	46.4	6.1	43	109.4	25.6	78	172.4	73.9	165	329.0
-12.8	9	48.2	6.7	44	111.2	26.1	79	174.2	76.7	170	338.0
-12.2	10	50.0	7.2	45	113.0	26.7	80	176.0	79.4	175	347.0