RECOGNIZE SAFETY INFORMATION

- This is the **SAFETY ALERT SYMBOL.**
  - When you see this symbol on your machine or in this manual, be alert to the potential for personal injury.
  - Follow recommended precautions and safe operating practices.

001-E01A-0001-2 SA-001

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.**
- **CAUTION** also calls attention to safety messages in this manual.
- 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.

⚠ DANGER

⚠ WARNING

⚠ CAUTION

IMPORTANT

NOTE

SA-461

002-E01A-0461-6

PARK MACHINE SAFELY

To avoid accidents:
- Park machine on a firm, level surface.
- Lower bucket and/or other work tools to the ground.
- Turn auto-idle switch off (if equipped).
- 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-545

033-E10A-0545-3

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.

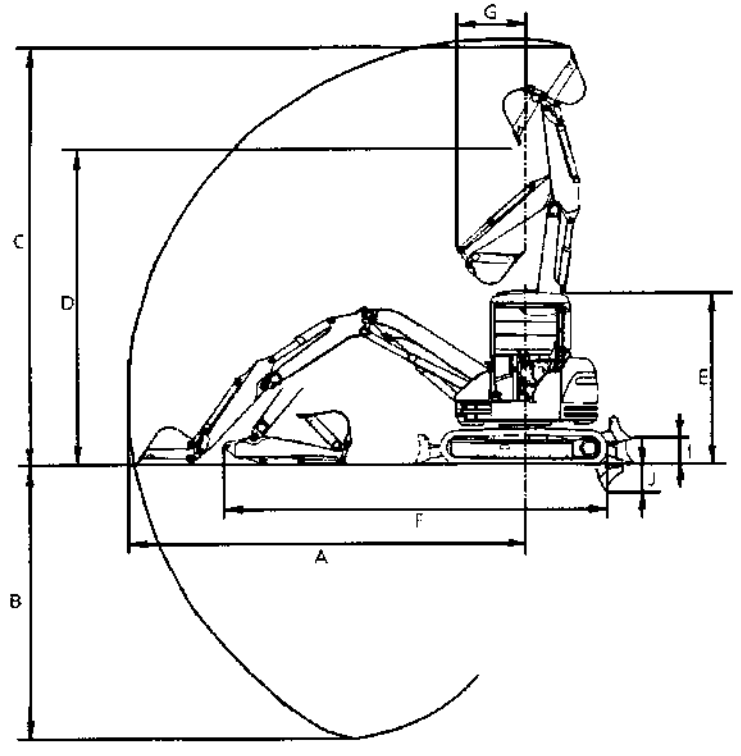
SA-018

- 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.

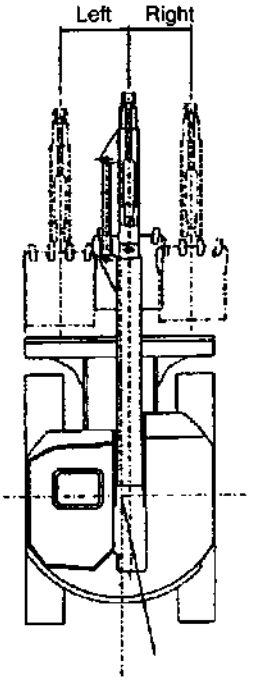
034-E01A-0496-4

SA-019

WORKING RANGES AND MACHINE DIMENSIONS FOR TRANSPORTATION



M568-11-002

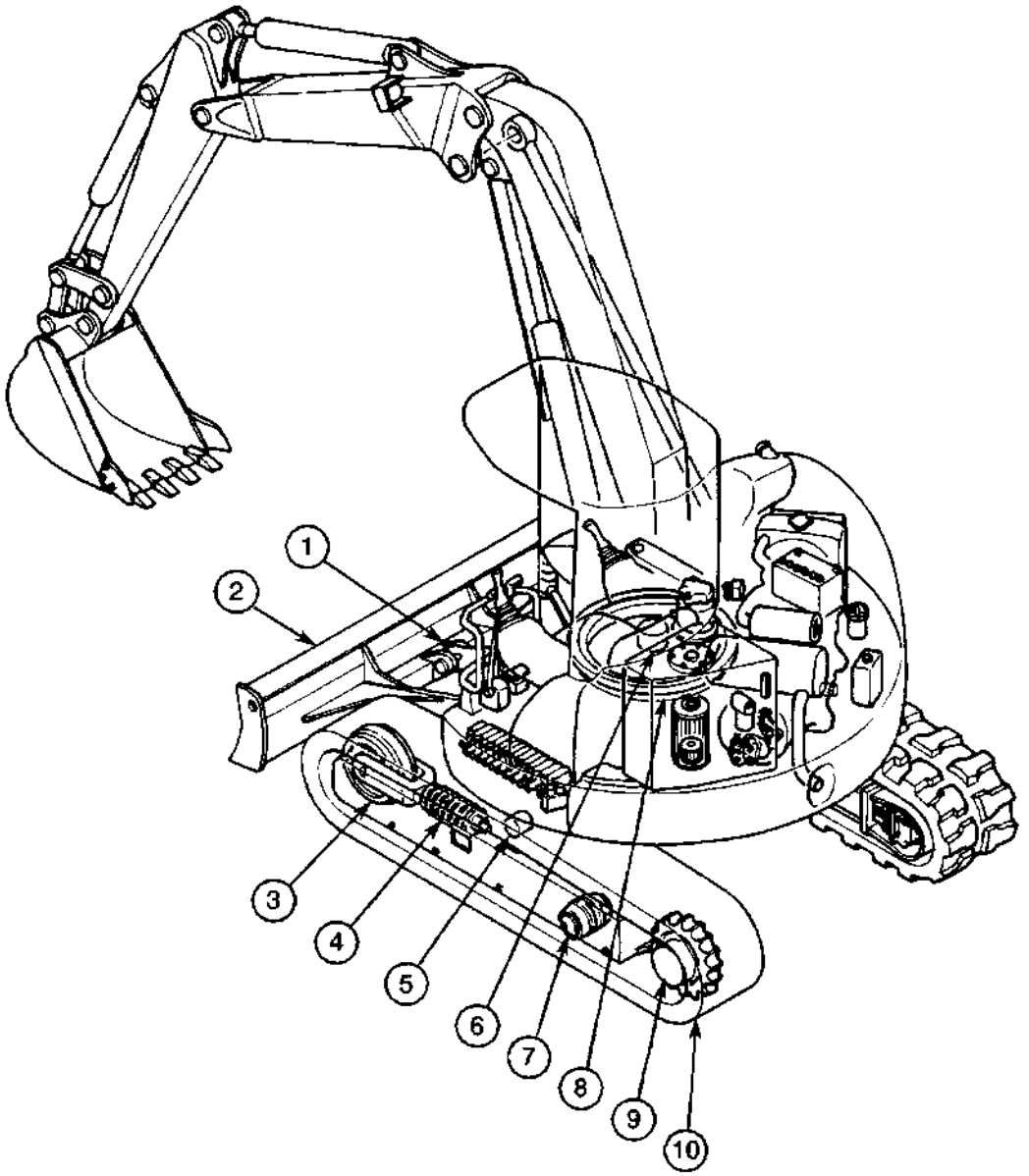


M552-11-003

Description \ Model		33Mu		58Mu	
		Canopy	Cab	Canopy	Cab
A: Maximum Digging Reach	mm (ft in)	4 820 (15′ 10″)	←	5 950 (19′ 6″)	←
B: Maximum Digging Depth	mm (ft in)	2 870 (9′ 5″)	←	4 000 (13′ 2″)	←
C: Maximum Cutting Height	mm (ft in)	5 920 (19′ 5″)	←	7 340 (24′ 1″)	←
D: Maximum Dumping Height	mm (ft in)	4 560 (15′ 0″)	←	5 610 (18′ 5″)	←
E: Transport Height	mm (ft in)	2 505 (8′ 3″)	←	2 570 (8′ 5″)	←
F: Overall Transport Length	mm (ft in)	4 320 (14′ 2″)	←	5 240 (17′ 2″)	←
G: Minimum Swing Radius	mm (ft in)	835 (2′ 9″)	←	1 045 (3′ 5″)	←
I: Blade Bottom Highest Position (above ground level)	mm (ft in)	330 (1′ 1″)	←	440 (1′ 5″)	←
J: Blade Bottom Lowest Position (below ground level)	mm (ft in)	360 (1′ 2″)	←	345 (1′ 2″)	←
K: Maximum Boom-Swing Angle	(°)	Left 50.5 Right 65.5	–	Left 66 Right 62	–
L: Offset Distance	mm (ft in)	Left 410 (1′ 4″) Right 630 (2′ 1″)	Left 410 (1′ 4″) Right 630 (2′ 1″)	Left 490 (1′ 7″) Right 810 (2′ 8″)	Left 490 (1′ 7″) Right 810 (2′ 8″)

NOTE: Transport height E does not include the shoe lug height.

58Mu



T533-01-01-001

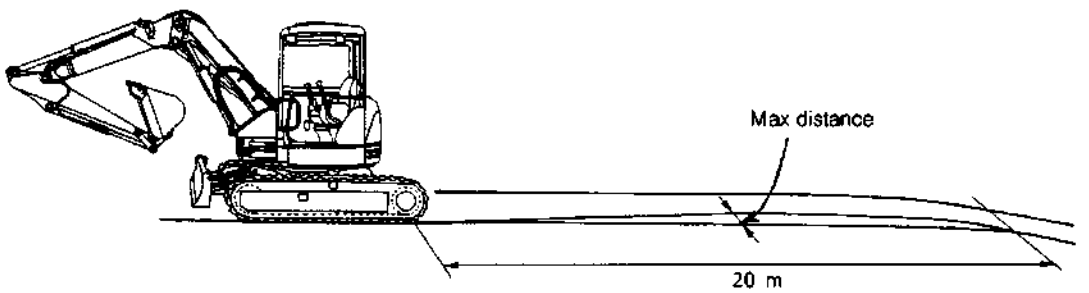
1— Blade Cylinder
2— Blade
3— Front Idler
4— Track Adjuster
5— Upper Roller
6— Center Joint
7— Lower Roller
8— Swing Bearing
9— Travel Device
10— Track

3.3 MISTRACK CHECK

Measure the amount of mistrack from a 20 m (65 ft 7 in) straight line to check deviation between the right and left track drive system performance.

Preparation:

1. Adjust the track sag of both tracks equally.
2. Provide a level, solid test yard 20 m (65 ft 7 in) in length, with an extra length of 3 to 5 m (9.8 to 16 ft) on both ends for machine acceleration and deceleration.
3. Hold the bucket 0.3 to 0.5 m (1.0 to 1.6 ft) above the ground with the arm and bucket rolled in.
4. Maintain the hydraulic oil temperature at 50° ± 5°C (122 ± 9°F).



T532-06-03-003

Measurement:

1. Measure the amount of mistracking in 1st and 2nd travel speeds.
2. Start traveling the machine in the acceleration zone with the travel levers pushed fully forward.
3. Measure the distance between a straight 20 m (65 ft 7 in) line and the track made by the machine.
4. After measuring the tracking deviation in forward travel, swing the upperstructure 180° and measure that in reverse travel.
5. Repeat steps (3) and (4) three times in each direction and calculate the mean values.

Evaluation:

Refer to T06-05 Standard.

Corrective Action:

Refer to T07-05 Troubleshooting.

PRACTICE SAFE MAINTENANCE

To avoid accidents:

- Understand service procedures before doing work.
- Keep 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 firm, level surface.
  2) Lower the bucket and/or other work tools to the ground.
  3) Turn the auto-idle switch off (if equipped).
  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 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.

- If a maintenance procedure must be performed with the engine running, do not leave 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.
- Never work under a machine raised by the boom.
- 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.
- Disconnect battery ground cable (−) before making adjustments to electrical systems or before welding on the machine.
- Illuminate your work area adequately but safely.
- Use a portable safety light for working inside or under the machine.
- Make sure that the bulb is enclosed by a wire cage. The hot filament of an accidentally broken bulb can ignite spilled fuel or oil.

SA-028

SA-527

SA-037

S500-E09A-0497-8

Assemble Control Valve

Before reassembling, clean components and parts with cleaning oil and dry them completely. Apply a film of clean hydraulic oil to inner parts, sliding parts in particular, before assembling in order to prevent seizures.
After disassembling, always replace used O-rings and oil seals with new ones.

Assemble Housing

1. Install check valve (29) and spring (28) into housing (1) of each section. Install O-ring (2) onto housing (1).

NOTE: In the 58Mu, poppet (29) is used in place of check valve (29).

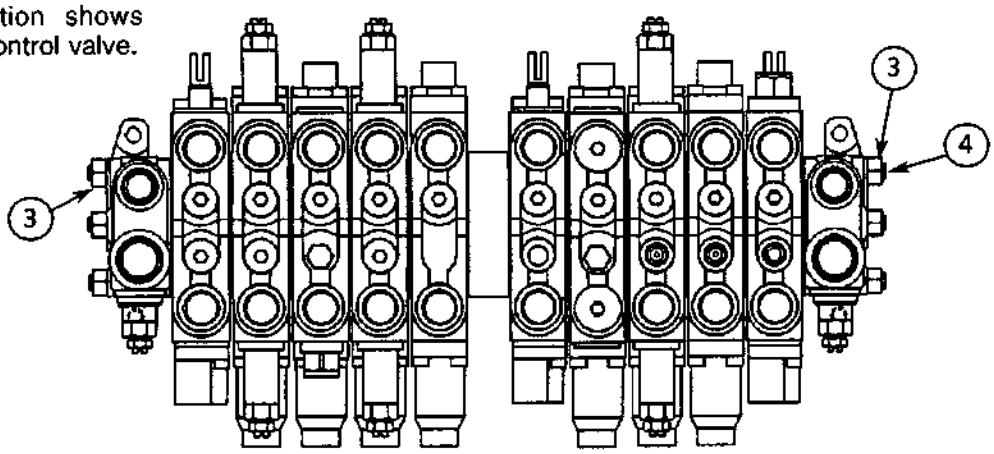
2. Align housing (1) of each section in the same order as they were before disassembling. Insert rods (4) and tighten nuts (3).

IMPORTANT: Apply Loctite #271 to the threads of rods (4).

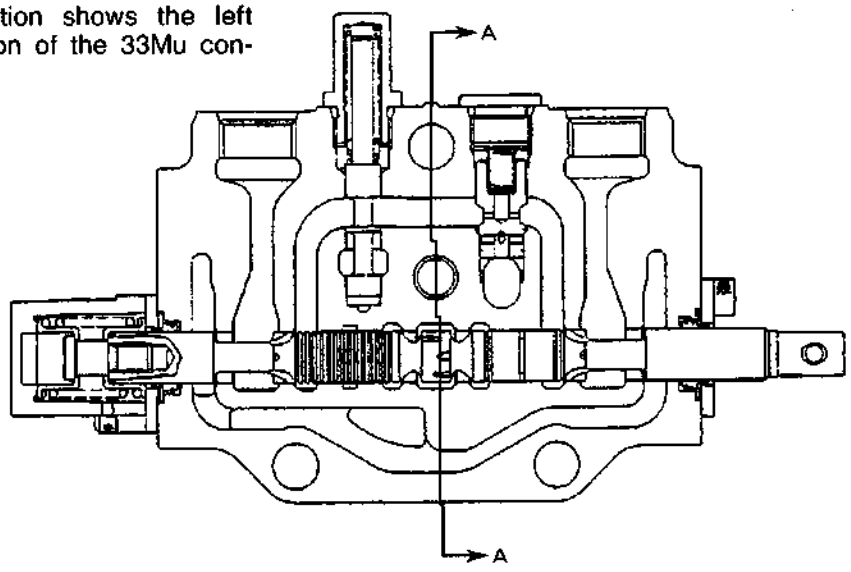
: 17 mm (33Mu)
14 mm (58Mu)

: 59^{+5} N·m ($6^{+0.5}$ kgf·m)
46 ± 2 N·m (4.7 ± 0.2 kgf·m)

The illustration shows the 33Mu control valve.



The illustration shows the left travel section of the 33Mu control valve.



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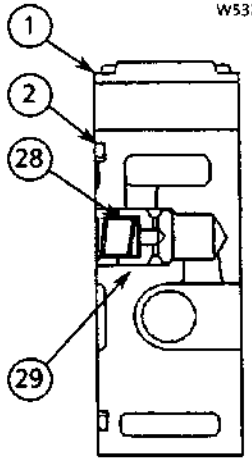


Section A-A

W532-02-04-003 W527-02-04-017

1— Housing
2— O-Ring
3— Nut
4— Rod
28— Spring
29— Check Valve

Assemble Travel Device (33Mu)

Before assembling, clean components and parts with cleaning oil and dry completely. Apply a film of clean hydraulic oil to inner parts, sliding parts in particular, before assembling in order to prevent seizures. Always replace used O-rings, oil seals and seals with new ones when re-assembling.

1. Install oil seal (8) into housing (13).

2. Install floating seal (12) on housing (13).

3. Tap bearing (30) onto housing (13) and tighten bearing nut (32).

Tightening Tool: ST 3146

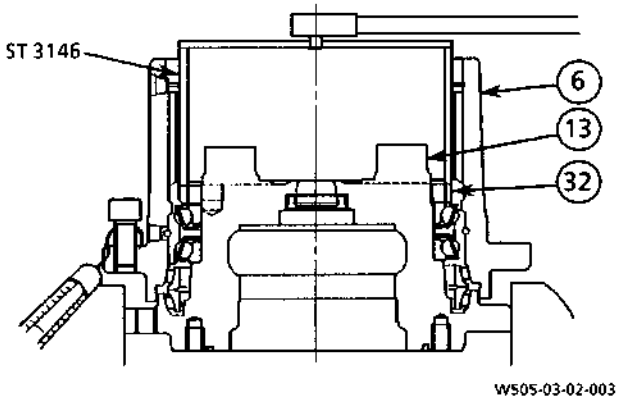
4. Tap ring gear (6) on housing (13) with a plastic hammer.

5. Adjust bearing (30) pre-load as follows:

   - Install tightening tool (ST 3146), torque wrench and a spring balance as illustrated to the right.
   - Rotate ring gear (6) 2 to 3 times for break-in test running.
   - Measure starting torque (F).
   - Tighten bearing nut (32) until the correct starting torque of F + (1.7 to 2.5) kgf·m is obtained.

NOTE: If the measured starting torque exceeds the upper limit of the specified torque, reset the pre-load as follows:
(1) Loosen bearing nut (32).
(2) Remove housing (13) from the vise.
(3) Tap housing (13) end facing the ring gear to release load.
(4) Readjust pre-load following step 5.

Spring Balance
Tightening Tool: ST 3146



W505-03-02-003

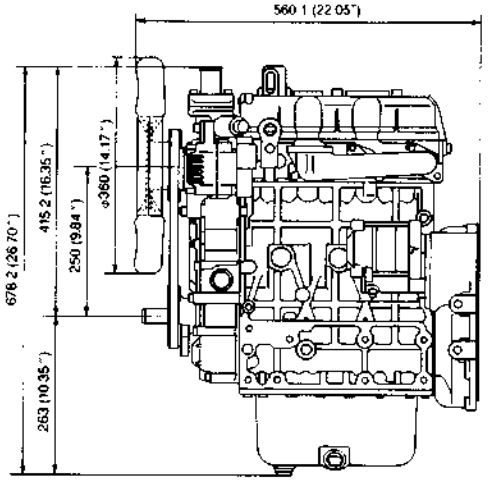
Unit: mm

	Part Name	Standard Dimensions	Allowable Limit	Corrective Measure
H	Pin	40	39.0	Replace
	Bushing (Arm Cylinder)	40	41.5	
I	Pin	40	39.0	
	Bushing (Arm Cylinder)	40	41.5	
J	Pin	40	39.0	
	Bushing (Bucket Cylinder)	40	41.5	
K	Pin	40	39.0	
	Bushing (Bucket Cylinder)	40	41.5	
	Bushing (Link A)	40	41.5	
	Link B	40	41.5	
L	Pin	40	39.0	
	Bushing (Arm)	40	41.5	
	Link B	40	41.5	
M	Pin	40	39.0	
	Bushing (Link A)	40	41.5	
N	Pin	40	39.0	
	Bushing (Arm)	40	41.5	
O	Pin	90	89.0	
	Bushing (Main Frame)	90	91.5	
P	Pin	45	44.0	
	Bushing (Boom Swing Cylinder)	45	46.5	
Q	Pin	45	44.0	
	Bushing (Boom Swing Cylinder)	45	46.5	
R	Pin	45	44.0	
	Bushing (Blade)	45	46.5	
S	Pin	45	44.0	
	Bushing (Blade Cylinder)	45	46.5	
T	Pin	45	44.0	
	Bushing (Blade Cylinder)	45	46.5	

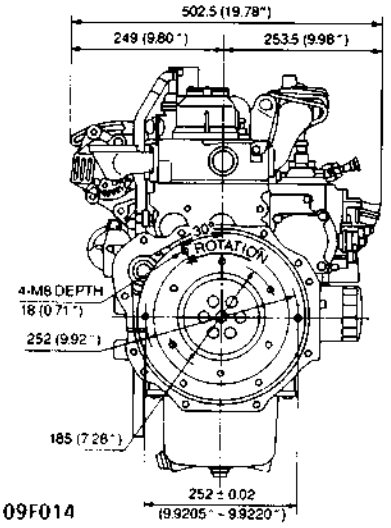
DIMENSIONS DIMENSIONS ABMESSUNGEN

D1403-B (E), D1703-B (E)

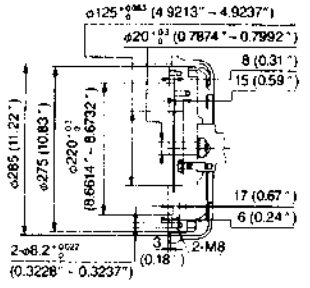
Unit, Unité, Einheit: mm (in)



A109F013

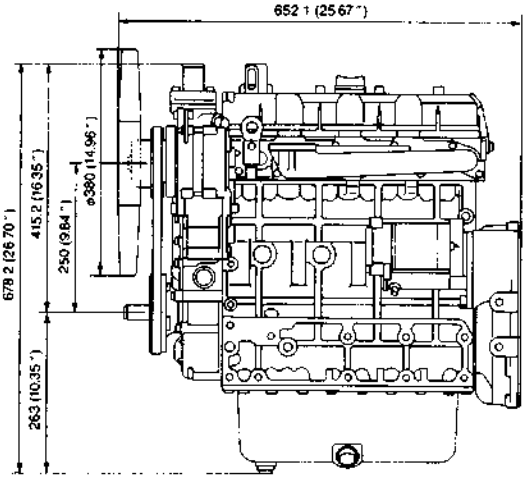


A109F014

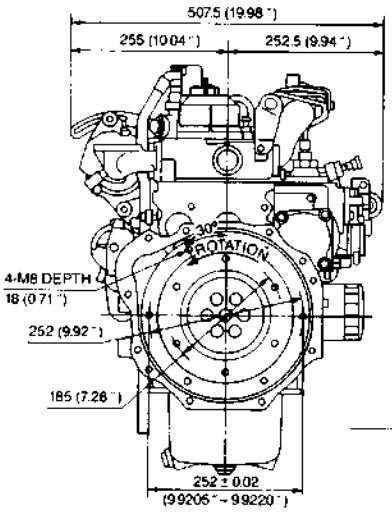


A109F015

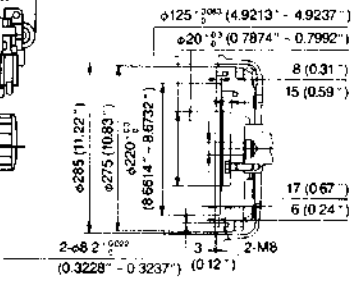
V1903-B (E), V2203-B (E)



A109F016

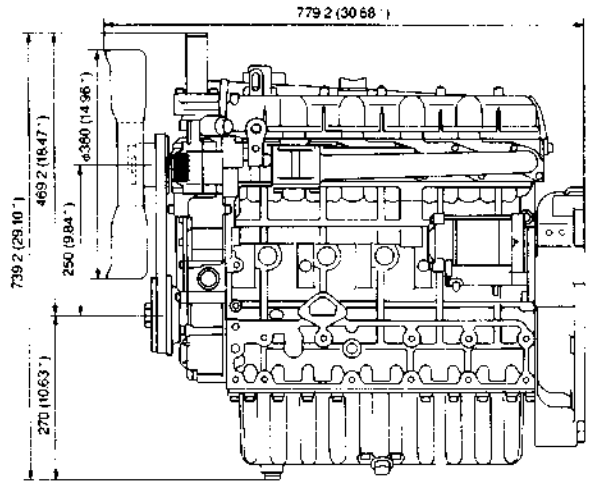


A109F017



A109F018

F2803-B (E)



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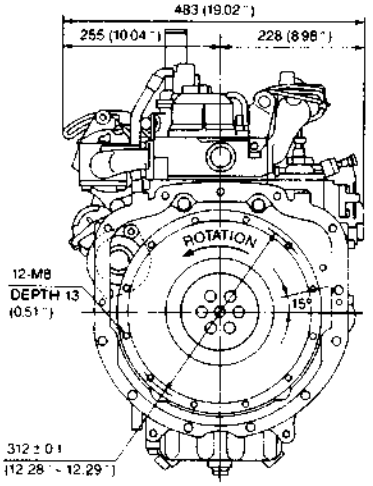
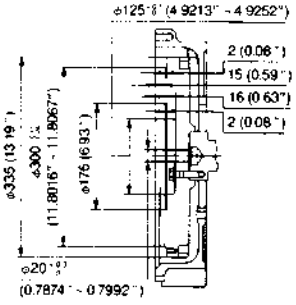


A109F022



A109F020

(1) Elément de pompe

L'élément de pompe (1) comporte un piston (3) et un cylindre (2).

Les surfaces de glissement sont usinées avec précision pour maintenir la pression d'injection au régime lent du moteur. Etant donné que le doigh de comande (7) s'emboîte dans le macnchon de contrôle, le piston (3) est tourné par le mouvement de la tige crémaillère pour augmenter ou diminuer le débit de refoulement de carburant.

Comme décrit ci-dessus, le piston (3) est usiné pour avoir la rainure verticale (5) et la rainure de contrôle (6).

(1) Elément de pompe
(2) Cylindre
(3) Piston
(4) Orifice d'admission
(5) Rainure verticale
(6) Rainure de contrôle
(7) Doigh de commande

(2) Clapet de refoulement

La clapet de refoulement comporte un clapet (1) et un siège de clapet (2).

La clapet de refoulement remplit les fonctions suivantes.

1. Fonction anti-retour

Si le carburant retourne de l'injecteur lorsque le piston descend, le temps depuis le commencement du refoulement suivant jusqu'au début d'injection est prolongé. Afin d'éviter un tel phénomène, l'écoulement de la chambre de refoulement au tuyau d'injection est interrompu par la clapet de refoulement, permettant ainsi de maintenir le carburant dans l'injecteur et le tuyau.

2. Fonction aspiration

Après le refoulement de carburant, le clapet descend, et la collerette cylindrique (4) entre en contact avec le siège de clapet (2). Le clapet descend davantage jusqu'à ce que sa surface de siège (3) se colle contre le siège de clapet. Pendant ce temps, le volume de carburant correspondant à (A) est aspiré depuis l'intérieur du tuyau d'injection et la pression interne du tuyau est réduite, permettant ainsi d'améliorer l'arrêt d'injection et de prèvenir le dégouttement de carburant après fuite.

(1) Clapet de refoulement
(2) Siège de clapet
(3) Surface de siège
(4) Collerette cylindrique

(1) Pumpenelement

Das Pumpenelement (1) besteht aus einem Kolben (3) und einem Zylinder (2).

Die Gleitflächen sind besonder feinbearbeitet, um den Einspritzdruck bei niedriger Motordrehzahl aufrechtzuerhalten. Da der Antriebsflansch (7) in die Regelhülse einpaßt, wird der Kolben (3) durch die Bewegung der Regelstange gedreht, und dadurch wird die Kraftstofförderung erhöht bzw. vermindert.

Wie vorstehend beschrieben, ist der Kolben (3) derart ausgeführt, daß er eine Längsnut (5) und eine Regelnut (6) besitzt.

(1) Pumpenelement
(2) Zylinder
(3) Kolben
(4) Zufuhröffnung
(5) Längsnut
(6) Regelnut
(7) Antriebsflansch

(2) Druckventill

Das Druckventil besteht aus dem Druckventil (1) und dem Druckventilsitz (2).

Das Druckventil funktiolniert wie folgt.

1. Verhinderung eines Gegenstroms

Wird der Kraftstoffluß aus der Einspritzdüsenseite bei Senken des Kolbens umgekehrt, erhöht sich der Zeitabstand zwischen dem Beginn der nächsten Zuführung und dem Beginn der Düseneinspritzung. Um dies zu vermeiden, unterbricht das Druckventil den Durchfluß zwischen dem Druckraum und Einspritzrohr und verhindert dadurch einen Gegenstrom, so daß die Düse und das Rohr stets mit Kraftstoff gefüllt ist.

2. Rücksaugfunktion

Nach erfolgter Kraftstofförderung senkt sich das Druckventil und der Kopf des Entlastungskolbens (4) kommt mit dem Druckventilsitz (2) in Berührung. Das Ventil sinkt weiter, bis seine Sitzfläche (3) fest am Druckventilsitz aufsitzt. Während dieser Zeit wird die Kraftstoffmenge (A) aus dem Inneren des Einzspritzrohrs zurückgesaugt, der Druck im Rohr fällt ab, eine verbesserte Einspritzabsperrung erfolgt und ein Leckagetröpfeln wird verhindert.

(1) Druckventil
(2) Druckventilsitz
(3) Sitzfläche
(4) Entlastungskolben

Anomalie	Cause possible	Solution	Page de ref.
Eau mélangée à l'huile de graissage	• Joint de culasse défectueux • Carter ou culasse pailleux	Remplacer Remplacer	
Faible pression d'huile	• Manque d'huile moteur • Crépine colmatée • Clapet de d'écharge collée par la saleté • Ressort de clapet de d'écharge fatigué ou cassé • Trop de jeu de marche d'un palier de villebrequin • Trop de jeu de marche d'un palier de tête de bielle • Trop de jeu de marche d'une coussinet de culbuteur • Passage d'huile colmaté • Type d'huile ne convenant pas • Pompe à huile défectueuse	Faire l'appoint Nettoyer Nettoyer Remplacer Remplacer Remplacer Remplacer Nettoyer Utiliser le type d'huile spécifié Réparer ou remplacer	S-68 S-40
Pression d'huile élevée	• Type d'huile ne convenant pas • Clapet de décharge défectueux	Utiliser le type d'huile spécifié Remplacer	S-40
Moteur surchauffé	• Manque d'huile moteur • Courroie de ventilateur cassée ou détendue • Manque de liquide de refroidissement • Nids d'abeilles ou ailettes de radiateur colmatés par la saleté • Intérieur du radiateur corrodé • Circuit de liquide de refoidissement corroddé • Bouchon de radiateur défectueux • Marche avec surcharge • Joint de culasse défectueux • Mauvais calage de l'injection • Type de carburant ne convenant pas	Faire l'appoint Changer ou régler Faire l'appoint Nettoyer Nettoyer ou remplacer Nettoyer ou remplacer Remplacer Diminuer la charge Remplacer Régler Utiliser le carburant spécifié	S-40
La batterie se décharge trop rapidement	• Manque d'électrolyte • Patinage de la courroie de ventilateur • Câblage débranché • Redresseur défectueux • Dynamo de ventilateur défectueux • Batterie défectueuse	Remettre de l'eau distillée et charger la batterie Régler la tension de la courroie ou la changer Rebrancher Remplacer Remplacer Changer	

(3) Points de verification de toutes les 75, 100, 150, 200 heures (Pour les détails, se référer à la page S-33)

Change d'huile moteur

1. Après avoir fait porté le moteur à température, le mettre à l'arrêt.
2. Pour vidanger l'huile usagée, enlever le bouchon de vidange se trouvant au bas du moteur et laisser l'huile s'écouler complètement.
3. Remettre le bouchon de vidange.
4. Remplir de l'huile neuve jusqu'à ce qu'elle atteint le trait supérieur de la jauge.

■ **IMPORTANT**

- **L'huile moteur doit être MIL-L-2104C ou a des propriétés conformes aux degrés CD/CE API.**
- **Changer le type d'huile moteur en fonction de la température ambiante.**
  Plus de 25°C ---------- SAE 30 ou 10W-30
  0°C à 25°C ---------- SAE 20 ou 10W-30
  Moins de 0°C ---------- SAE 10W ou 10W-30

Modeles	Profondeur de carter d'huile	
	124 mm	* 90 mm
D1403-B(E), D1703-B(E)	7,0 ℓ	5,6 ℓ
V1903-B(E), V2203-B(E)	9,5 ℓ	7,6 ℓ
F2803-B(E)	12,0 ℓ	—

* La profondeur du carter d'huile de 90 mm est optionnelle.

(4) Points de verification de toutes les 100 heures

Verification la tension de courroie de ventilateur

1. Appuyer sur la courroie de ventilateur entre la poulie de ventilateur et la poulie avec une force de 98 N (10 kgf).
   Vérifier si la tension de la courroie de ventilateur est de 10 à 12 mm.
2. Si la flexion n'est pas comprises dans la valeur de référence, desserrer les boulons et ecrous et ammener l'alternateur en place.

[A] Correct **[B] Incorrect**

Verification l'état de la courroie de ventilateur

1. Vérifier si la courroie de ventilateur est endommagée.
2. Vérifier si la courroie de ventilateur est usée et enfoncée dans la gorge de la poulie.
3. Remplacer la courroie de ventilateur si elle est endommagée, ou sérieusement usée et enfoncée profondément dans la gorge de la poulie.

(3) Überprüfungspunkte nach allen 75, 100, 150, 200 Stunden (Für die Einzelheiten siehe Seite S-34)

Austaush des Motoröls

1. Motor warm laufen lassen und dann ausschalten.
2. Um das alte Öl zu wechseln, die Ablaßschraube am Motorboden entfernen und das Öl vollständig ablassen.
3. Die Ablaßschraube wieder einsetzen.
4. Neues Öl bis zur oberen Einkerbung des Ölmeßstabes einfüllen.

■ **WICHTIG**

- **MIL-L-2104C oder ein Motoröl die der API-Klasse CD/CE Güte entspricht ist zu ver-wenden.**
  Die Motorölsorte gemäß der Umgebungstemperatur wechseln.
  Über 25°C ---------- SAE 30 oder 10W-30
  0°C bis 25°C ---------- SAE 20 oder 10W-30
  Unterhalb von 0°C ---------- SAE 10W oder 10W-30

Modelle	Tiefe der Ölwanne	
	124 mm	* 90 mm
D1403-B(E), D1703-B(E)	7,0 ℓ	5,6 ℓ
V1903-B(E), V2203-B(E)	9,5 ℓ	7,6 ℓ
F2803-B(E)	12,0 ℓ	—

* Die Ölwanne (T = 90 mm) ist optional.

(4) Überprüfungspunkte nach allen 100 Stunden

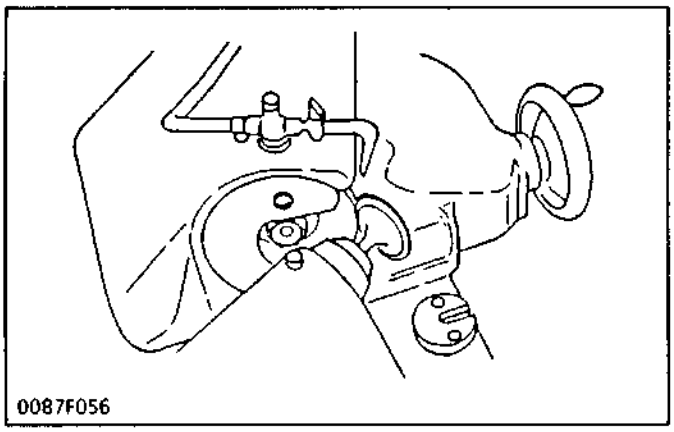
Überprüfung der Lüfterriemenspannung

1. Auf den Lüfterriemen zwischen der Lüfterriemenscheibe und Spannrolle mit dem einer Kraft von 98 N (10 kp) drücken.
   Überprüfen, ob die Durchsenkung des Lüfterriemens zwischen 10 bis 12 mm beträgt.
2. Wenn sich die Biegung nicht innerhalb der Sollwerte befindet, die Bolzen und Muttern lösen und den Alternator in Stellung bringen.

[A] Gut **[B] Schlecht**

Überprüfung auf Beschädigung des Lüfterriemens

1. Den Lüfterriemen auf Beschädigung überprüfen.
2. Überprüfen, ob der Lüfterriemen abgenutzt und in die Scheibenrille versenkt ist.
3. Den Lüfterriemen auswechseln wenn der Riemen beschädigt, bzw. stark abgetragen und in die Scheibenrille tief versenkt ist.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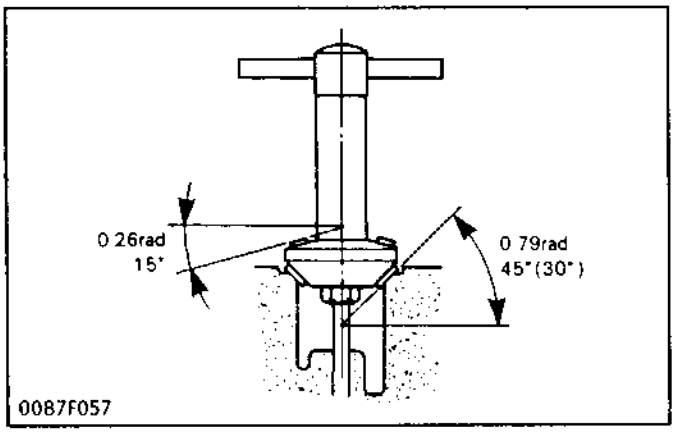
Correcting Valve and Valve Seat

■ **NOTE**
- **Before correcting the valve and seat, check the valve stem and the I.D. of the valve guide section, and repair them if necessary.**
- **After correcting the valve seat, be sure to check the valve recessing.**

1) Correcting Valve
1. Correct the valve with a valve refacer.



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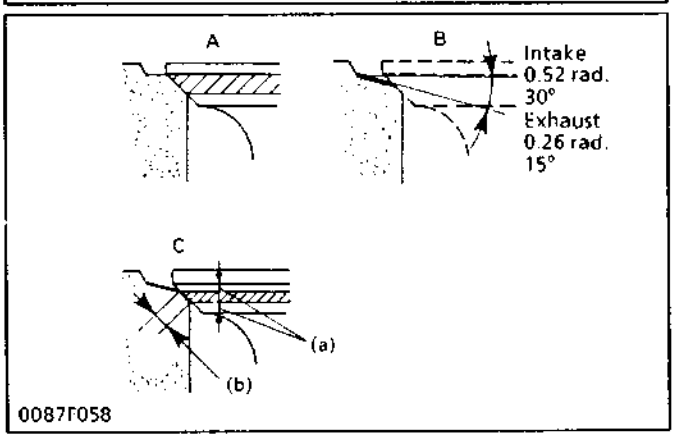
2) Correcting Valve Seat
1. Slightly correct the seat surface with a 60° (Intake valve) or 45° (Exhaust valve) seat cutter (1) (Code No: 07909-33102).
2. Resurface the seat surface with 30° valve seat cutter to intake valve seat and with 15° valve seat cutter to exhaust valve seat so that the width is close to specified valve seat width. (2.12 mm 0.0835 in.)
3. After resurfacing the seat, inspect for even valve seating, apply a thin film of compund between the valve face and the valve seat, and fit them with valve lapping tool.
4. Check valve sealing with prussian blue, the valve seating surface should show good contact all the way around.



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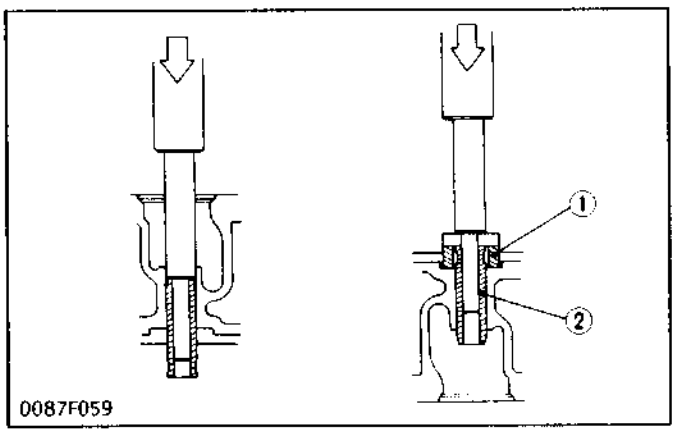
[A] Check Contact
[B] Correct Seat Width
[C] Check Contact

(a) Identical Dimensions
(b) Valve Seat Width



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(When removing)
1. Using a valve guide replacing tool, press out the used valve guide.

(When installing)
1. Clean a new valve guide, and apply engine oil to it.
2. Using a valve guide replacing tool, press in a new valve guide until it is flush with the cylinder head as shown in the figure.
3. Ream precisely the I.D. of the valve guide to the specified dimension. (See page S-16)

■ **NOTE**
- **Be careful not to strike valve guide with a hammer, etc. during replacement.**

(1) Spacer
(2) Valve Guide

9. The following symbols appear throughout this Worshop Manual. They tell you the type of service operation or step to perform.

 ... Remove

 ... Adjustment

 ... Installation

 ... Cleaning

 ... Disassembly

 ... Important Operation Requiring Extra Care

 ... Reassembly

 ... Specified Torque (Tighten)

 ... Alignment (Marks)

 ... Special Tool Use Required for Recommended (Isuzu Tool or Tools)

 ... Directional Indication

 ... Commercially Available Tool Use Required or Recommended

 ... Inspection

 ... Lubrication (Oil)

 ... Measurement

 ... Lubrication (Grease)

 ... Liquid Gasket Application

10. Direction 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.

The engine's direction of rotation is counterclockwise viewed from the flywheel.