



# **OPERATION and MAINTENANCE MANUALS**

**For**

**BRISBANE CITY COUNCIL**

**At**

**BRISBANE WATER**

**SEWAGE PUMP STATION**

**SP181 SINNAMON ROAD**

Manuals Prepared by:

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**REVISION B: July 2003**



**OPERATION and MAINTENANCE MANUALS**

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**Revision Status**

| Revision | Date     | Initials | Comments            |
|----------|----------|----------|---------------------|
| A        | 26/05/03 | JP       | Issued for approval |
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Prepared by: Jim Pringle

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

Reviewed  
Project Manager: \_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_





## **TABLE OF CONTENTS**

**Section 1. Instructions for use**

**Section 2. Deutz Operation Manual**

**Section 3. Deutz Spare Parts Catalogue**

**Section 4. Stamford Installation, Service & Maintenance Manual**

**Section 5. PLC – GE Fanuc**

**Section 6. Functional Description**

**Section 7. Drawings**

**Section 8. Test Reports**



# SP181

## Section 1 - Instructions of Use





## OPERATION and MAINTENANCE MANUALS

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### INSTRUCTIONS FOR USE

1. Units placed on site using “Hook Truck” (Cleanaway Type) over cable pit.
2. Cable pit to be under switchboard section of unit (rear).
3. Attach hold down / anti-theft chains to location points at rear of unit (beside switchboard).
4. Check engine lube oil level.
5. Check engine coolant level.
6. Check the battery is connected and the electrolyte level is correct.
7. Connect cables to plugs via colour-coded sequence.
8. Connect power inlet socket (240V).
9. Connect communication socket.
10. Connect pump station control socket.
11. Check fuel level (mechanical gauge beside fill point).
12. Refer to section 6, Functional Description for start/run and connection procedure.
13. Remember **SAFETY** is important **ALWAYS** wear your Personal Protection Equipment (PPE)



# SP181

## Section 2 - Deutz Operation Manual



**Operation Manual**

**912**

**913**

**0297 9690 en**

**Engine  
Serial Number**

|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|

Please enter the engine serial number here. This number should be quoted when inquiring about Customer Service, Repairs or Spare Parts (see Section 2.1).

All rights reserved. Technical modifications required to improve our engines are reserved with regard to specification data and other technical information contained in this Operation Manual. No parts of this Manual may be reproduced in any form or by any means without our written approval.





# Foreword

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Dear Customer,

Air / liquid-cooled DEUTZ engines are designed for a large number of applications. Consequently, a wide range of variants are offered to meet the requirements of specific cases.

*Your engine is appropriately equipped for the installation concerned, which means that not all of the components described in this Operation Manual are necessarily mounted to your engine.*

We have endeavoured to highlight any differences so that you will be able to locate the operating and maintenance instructions relevant to your engine quickly and easily.

Please read this Manual before starting your engine, and always observe the operating and maintenance instructions.

We are available to help with any additional inquiries  
Sincerely,

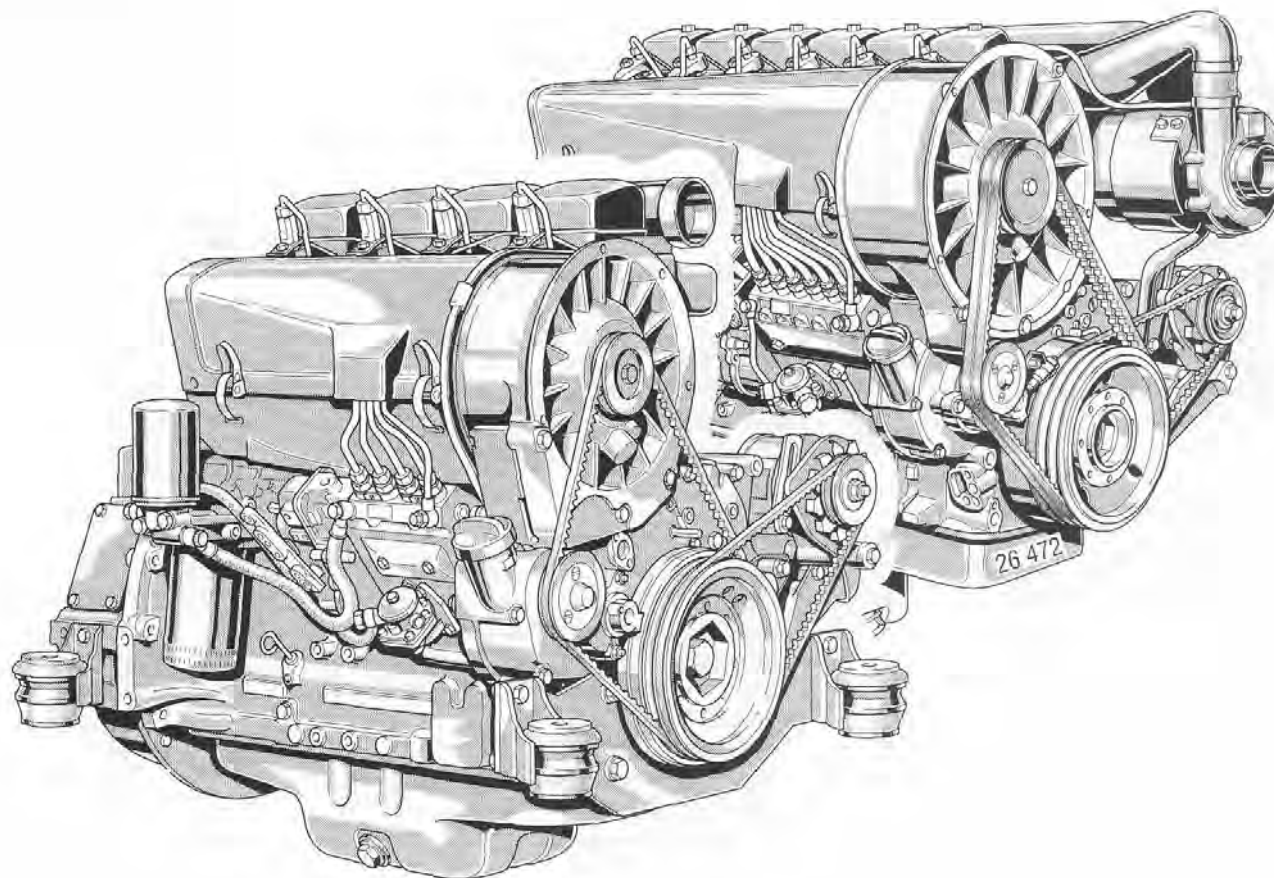
**DEUTZ AG**



# Index

|          |  |          |   |           |   |
|----------|--|----------|---|-----------|---|
| <b>1</b> | <b>General</b>   | 3.4      | Stopping                                    | 6.5       | Belt Drives                                       |
| <b>2</b> | <b>Engine Description</b>  | 3.4.1    | Mechanical Shutdown                         | 6.5.1     | Checking V-Belts                                  |
| 2.1      | Model  | 3.4.2    | Electrical Shutdown                         | 6.5.2     | Changing the Fan V-Belt                           |
| 2.1.1    | Rating Plate   | 3.5      | Operating Conditions                        | 6.5.3     | Tensioning Alternator Belts                       |
| 2.1.2    | Rating Plate Location  | 3.5.1    | Winter Operation                            | 6.5.4     | Changing Alternator Belts                         |
| 2.1.3    | Engine Serial Number   | 3.5.2    | High Ambient Temperatures, High Altitude    | 6.5.5     | Checking Warning System                           |
| 2.1.4    | Cylinder Numbering   | <b>4</b> | <b>Operating Media</b>                      | 6.5.6     | Tensioning and Changing Air Compressor V-Belts    |
| 2.1.5    | Direct Injection   | 4.1      | Lube Oil                                    | 6.5.7     | Air Compressor Design with Double V-Belt          |
| 2.1.6    | Two-stage Combustion   | 4.1.1    | Quality Grade                               | 6.6       | Adjustments                                       |
| 2.2      | Engine Illustrations   | 4.1.2    | Viscosity                                   | 6.6.1     | Checking / Adjusting Valve Clearance              |
| 2.2.1    | Service Side F4L 912   | 4.2      | Fuel  | 6.7       | Accessories                                       |
| 2.2.2    | Exhaust Side F4L 912   | 4.2.1    | Quality Grade                               | 6.7.1     | Battery   |
| 2.2.3    | Service Side BF4L 913  | 4.2.2    | Winter-Grade Fuel                           | 6.7.2     | Three-Phase Alternator                            |
| 2.2.4    | Exhaust Side BF4L 913  | <b>5</b> | <b>Routine Maintenance</b>                  | 6.7.3     | Lifting Tackle                                    |
| 2.3      | Lube Oil Circuit   | 5.1      | Maintenance Schedule                        | 6.8       | Cleaning the Engine                               |
| 2.3.1    | Lube Oil Circuit FL 912/913  | 5.2      | Maintenance Chart                           | 6.8.1     | Cleaning the Engine                               |
| 2.4      | Fuel System Schematic  | 5.3      | Maintenance Work Completed                  | 6.9       | Additional Maintenance                            |
| 2.4.1    | Fuel Circuit   | <b>6</b> | <b>Service and Maintenance</b>              | 6.9.1     | Checking the Mountings                            |
| 2.5      | Engine Cooling   | 6.1      | Lube Oil System                             | 6.9.2     | Checking the Function of the Heating Pipe         |
| 2.5.1    | Regulation of Coolant Flow using the Exhaust Thermostat              | 6.1.1    | Oil Change Intervals                        | 6.9.3     | Checking the Function of the Flame Glowing System |
| 2.5.2    | Regulation of Coolant Flow using the Exhaust Thermostat and Solenoid | 6.1.2    | Checking Oil Level / Changing Oil Level     | <b>7</b>  | <b>Faults, Causes and Remedies</b>                |
| <b>3</b> | <b>Engine Operation</b>  | 6.1.3    | Changing Oil Filter                         | 7.1       | Diagnosis Chart                                   |
| 3.1      | Commissioning  | 6.1.4    | Changing the Partial-Flow Oil Filter Insert | <b>8</b>  | <b>Engine Preservation</b>                        |
| 3.1.1    | Adding Engine Oil  | 6.2      | Fuel System                                 | 8.1       | Preservation                                      |
| 3.1.2    | Filling Oil Bath Air Cleaner   | 6.2.1    | Changing Fuel Filter                        | 8.1.1     | Preserving Engine                                 |
| 3.1.3    | Adding Fuel  | 6.2.2    | Fuel Precleaner Cleaning the Fuel Filter    | 8.1.2     | Removing Engine Preservatives                     |
| 3.1.4    | Ventilation  | 6.3      | Cooling System                              | <b>9</b>  | <b>Technical Specifications</b>                   |
| 3.1.5    | Other Preparations   | 6.3.1    | Cleaning Intervals                          | 9.1       | Engine Specifications and Settings                |
| 3.1.6    | Additional Maintenance Work  | 6.4      | Combustion Air Filter                       | 9.2       | Torque Wrench Settings                            |
| 3.1.7    | Selector Switch for Oil Heater                                       | 6.4.1    | Cleaning Intervals                          | 9.3       | Tools   |
| 3.2      | Starting   | 6.4.2    | Emptying Cyclone Type Precleaner            | <b>10</b> | <b>Service</b>                                    |
| 3.2.1    | Electric Starting  | 6.4.3    | Cleaning Oil Bath Air Cleaner               |           |   |
| 3.3      | Monitoring Systems   | 6.4.4    | Dry Type Air Cleaner                        |           |   |
| 3.3.1    | Engine Oil Pressure  |          |   |           |   |
| 3.3.2    | Engine Temperature   |          |   |           |   |
| 3.3.3    | Cooling Fan Drive  |          |   |           |   |







# General

1

## DEUTZ Diesel Engines

are the product of many years of research and development. The resulting know-how, coupled with stringent quality standards, guarantee their long service life, high reliability and low fuel consumption.

It goes without saying that DEUTZ Diesel Engines meet the highest standards for environmental protection.

## Beware of Running Engine

Shut the engine down before carrying out maintenance or repair work. Ensure that the engine cannot be accidentally started. Risk of accidents.

When the work is complete, be sure to refit any panels and guards that may have been removed. Never fill the fuel tank while the engine is running. Observe industrial safety regulations when running the engine in an enclosed space or underground.

## Care and Maintenance

Sound care and maintenance practices will ensure that the engine continues to meet the requirements placed on it. Recommended service intervals must be observed and service and maintenance work carried out conscientiously.

Special care should be taken under abnormally demanding operating conditions.

## Safety



This symbol is used for all safety warnings. Please follow them carefully. The attention of operating personnel should be drawn to these safety instructions. General safety and accident prevention regulations laid down by law must also be observed.

## Asbestos



DEUTZ original parts are asbestos-free.

## Service

Please contact one of our authorized service representatives in the event of breakdowns or for spare parts inquiries. Our trained specialists will carry out repairs quickly and professionally, using only genuine spare parts.

Original parts from DEUTZ AG are always produced in accordance with state-of-the-art technology. Please turn to the end of this manual for further service information.

### California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.



## Engine Description

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### 2

- 2.1 Model**
- 2.2 Engine Illustration**
- 2.3 Lube Oil Circuit**
- 2.4 Fuel System Schematic**
- 2.5 Engine Cooling**

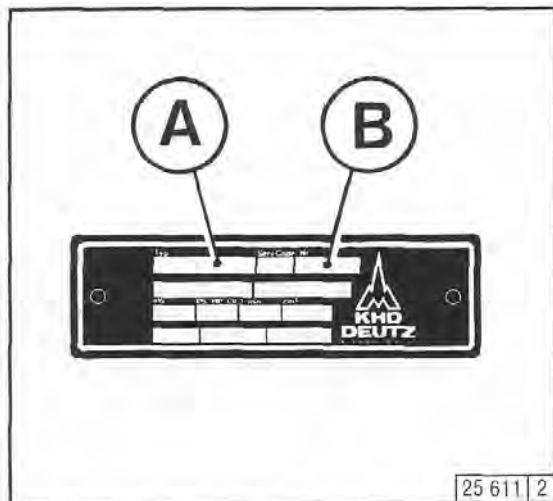


# Engine Description

## 2.1 Model

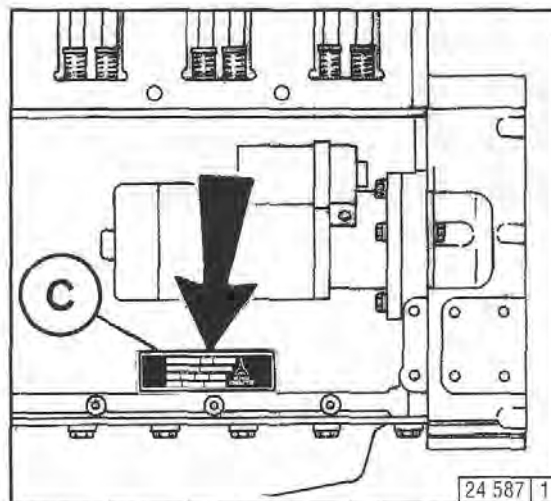
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### 2.1.1 Rating Plate



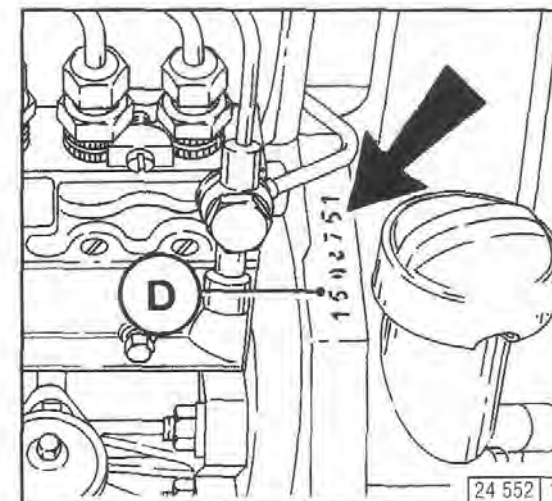
The model **A**, the engine serial number **B** and the performance data are stamped on the rating plate. The model and engine serial number must be given when ordering parts.

### 2.1.2 Rating Plate Location



The rating plate **C** is attached to the crankcase; depending on the design, a second rating plate may be attached to the air duct.

### 2.1.3 Engine Serial Number



The engine serial number **D** is stamped on the crankcase as well as the rating plate.

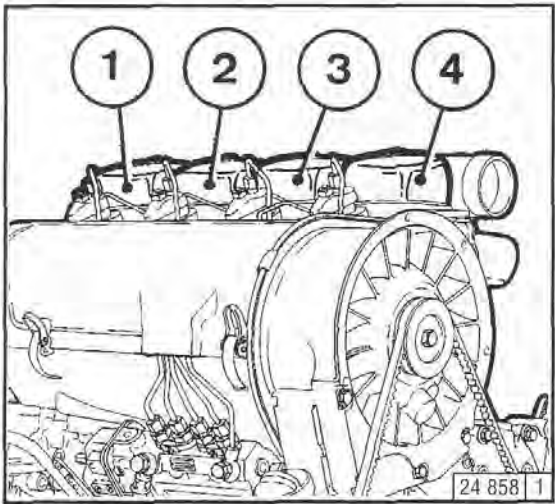


## 2.1 Model

## Engine Description

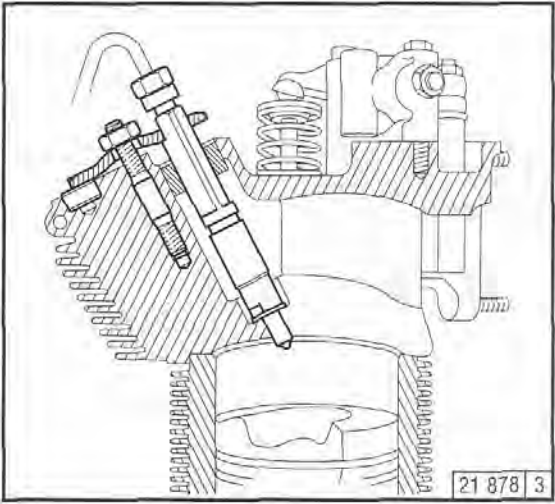
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### 2.1.4 Cylinder Numbering



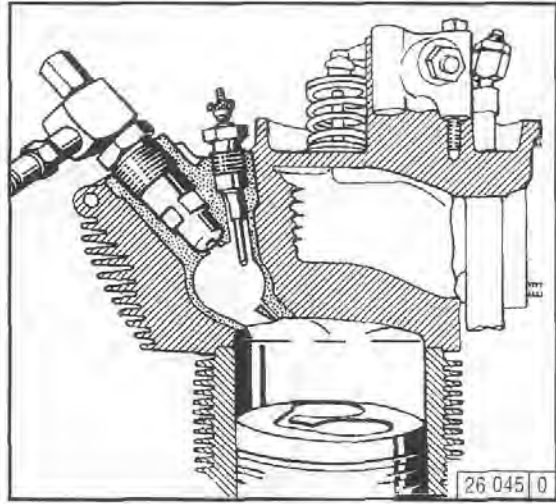
Cylinders are numbered consecutively, beginning at the flywheel end.

### 2.1.5 Direct Injection FL 912



Engines with direct injection are used where high performance is required.

### 2.1.6 Two-stage Combustion FL 912W



Engines with two-stage combustion are used where it is particularly important to keep exhaust emissions to an absolute minimum.

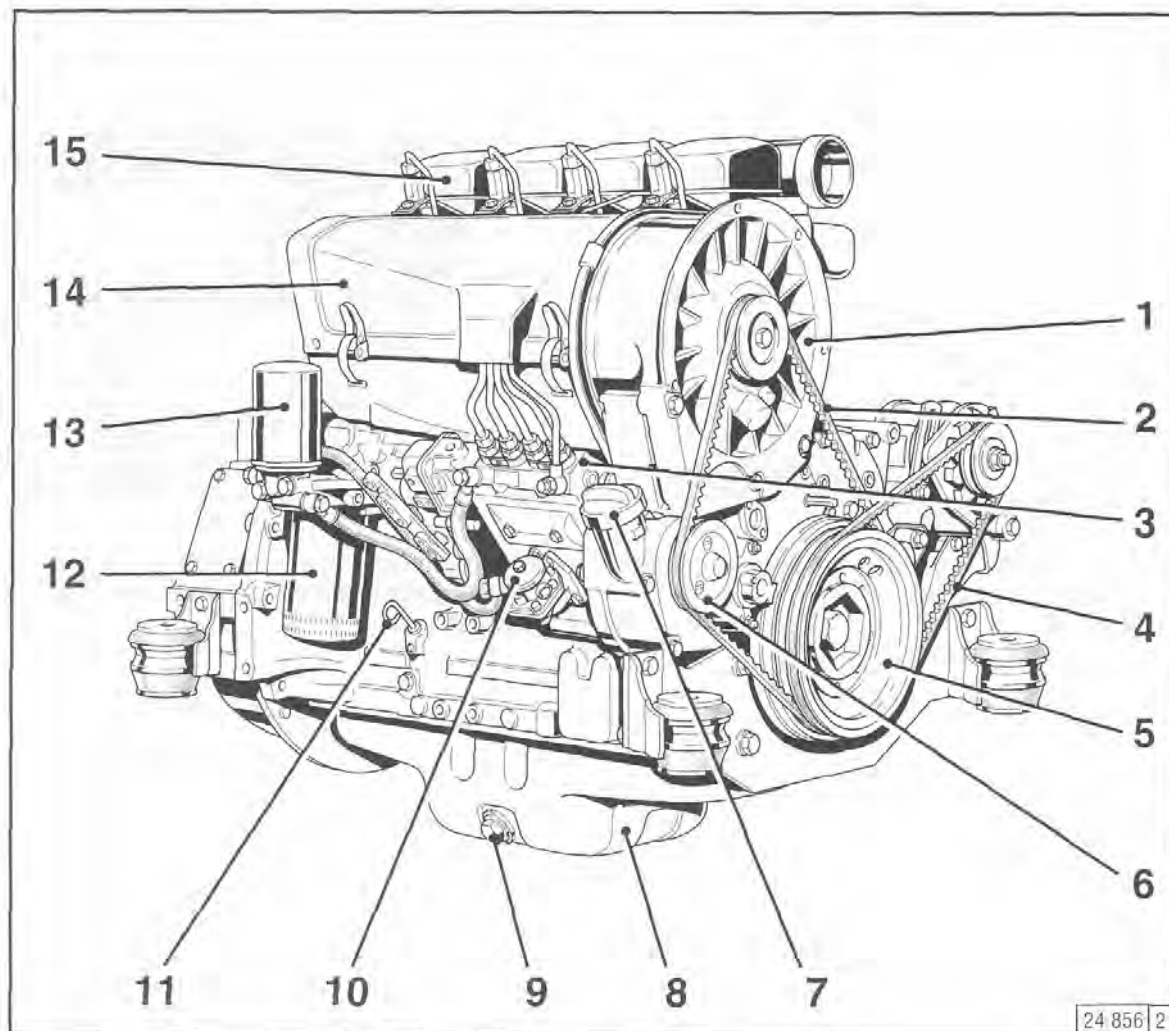


# Engine Description

## 2.2 Engine Illustrations

2

### 2.2.1 Service Side F4L 912



- 1 Fan
- 2 V-belt (fan)
- 3 Injection pump
- 4 V-belt (alternator)
- 5 V-belt pulley
- 6 Tension roller
- 7 Oil fill point
- 8 Oil pan
- 9 Oil drain plug
- 10 Fuel pump
- 11 Oil dipstick
- 12 Lube oil filter
- 13 Easy-change fuel filter
- 14 Air duct cover
- 15 Cylinder-head cover

24 856 2

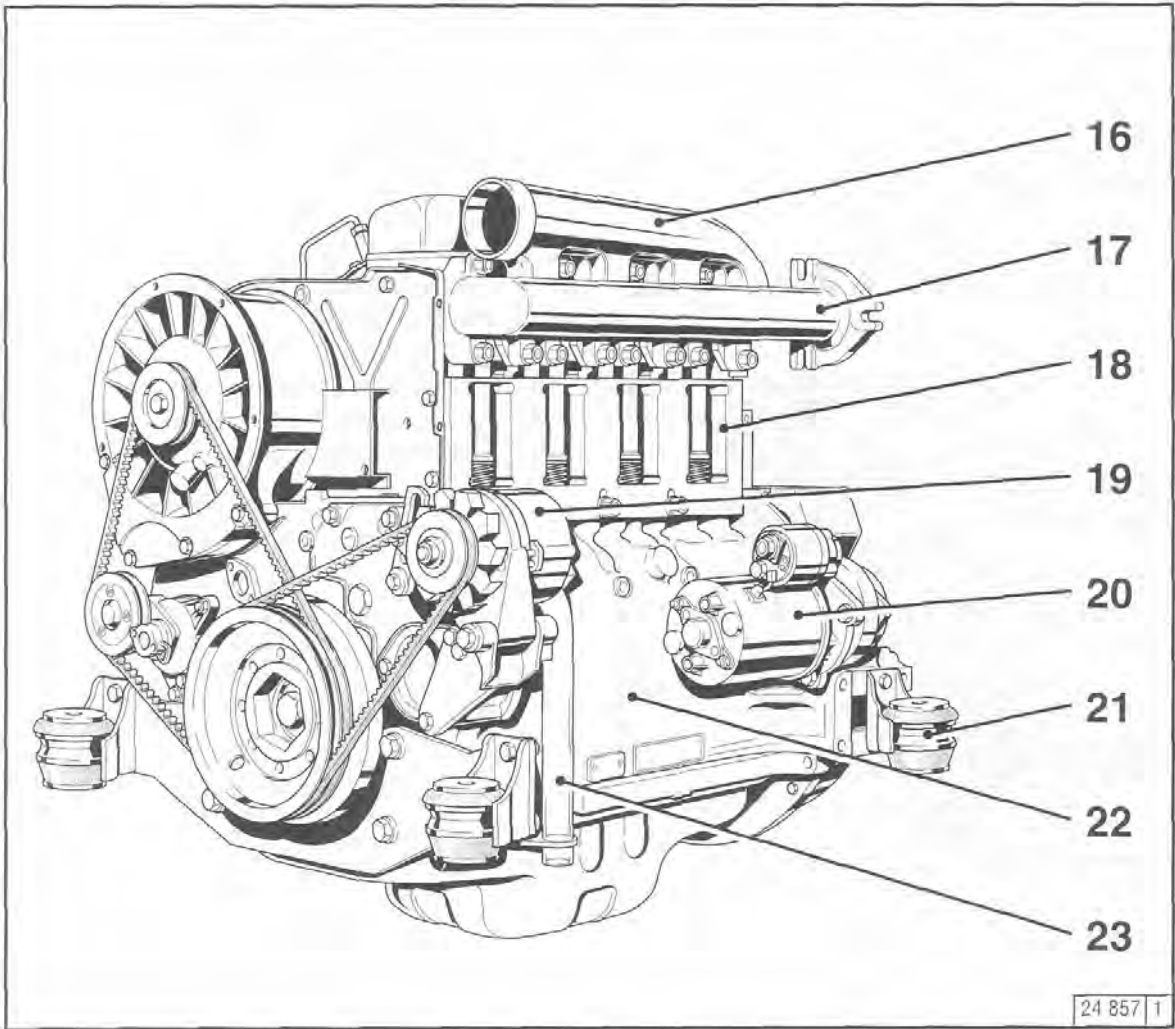


## 2.2 Engine Illustrations

## Engine Description

### 2.2.2 Exhaust Side F4L 912

2



- 16 Air-intake pipe
- 17 Exhaust manifold pipe
- 18 Screen
- 19 Alternator
- 20 Starter
- 21 Engine mounting
- 22 Crankcase
- 23 Crankcase ventilation

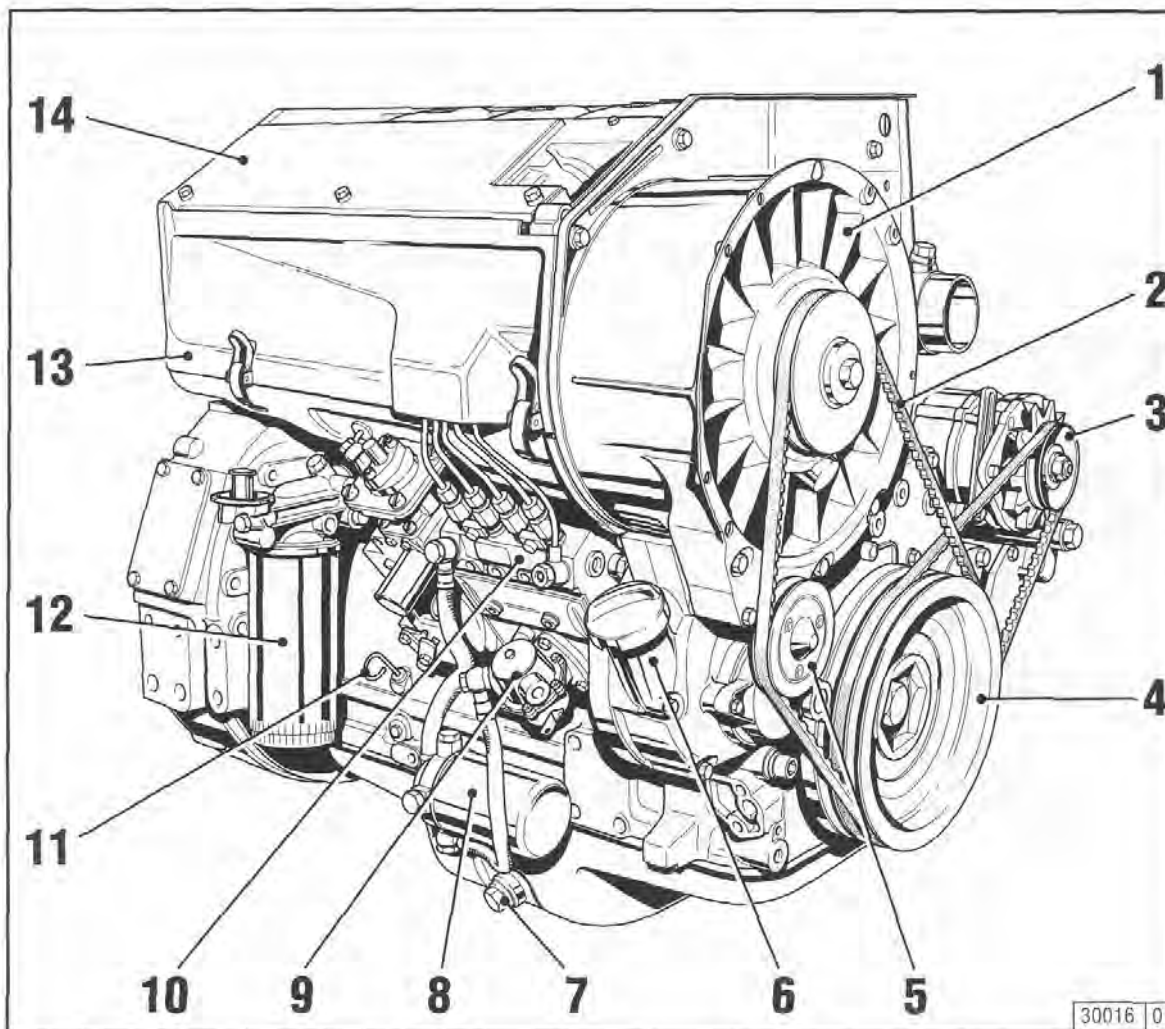


# Engine Description

## 2.2 Engine Illustrations

2

### 2.2.3 Service Side BF4L 913



- 1 Fan
- 2 V-belt (fan)
- 3 V-belt (alternator)
- 4 V-belt pulley on crankshaft
- 5 Tension roller
- 6 Oil fill point
- 7 Oil drain plug
- 8 Fuel filter cartridge
- 9 Fuel pump with fuel precleaner
- 10 Injection pump
- 11 Oil dipstick
- 12 Lube oil filter cartridge
- 13 Air duct cover
- 14 Engine oil radiator cover

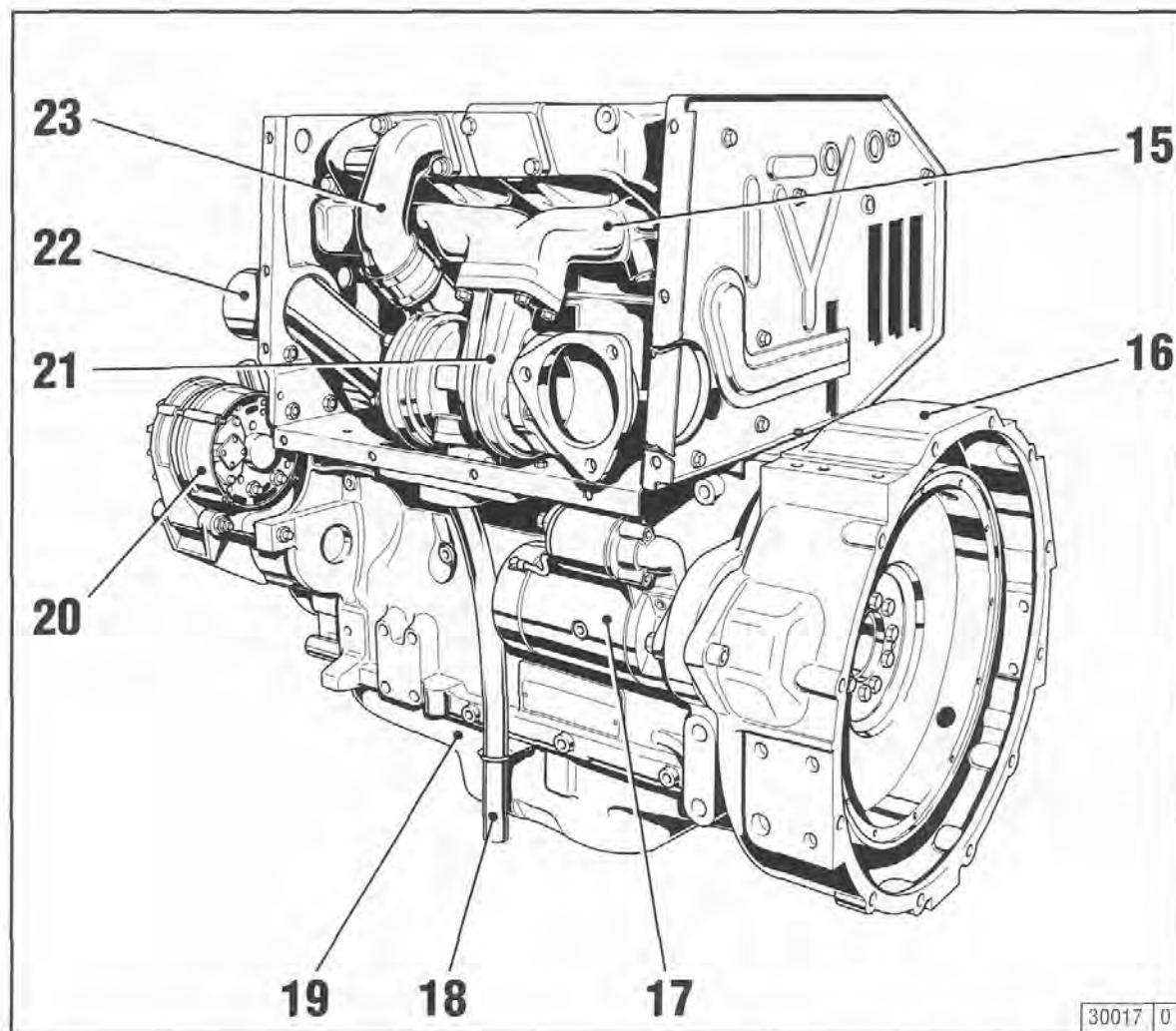
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## 2.2 Engine Illustrations

## Engine Description

### 2.2.4 Exhaust Side BF4L 913

**2**

- 15 Exhaust manifold line
- 16 Terminal housing
- 17 Starter
- 18 Crankcase ventilation
- 19 Oil pan
- 20 Alternator
- 21 Exhaust turbocharger
- 22 Air-intake pipe-exhaust turbocharger
- 23 Charge-air line

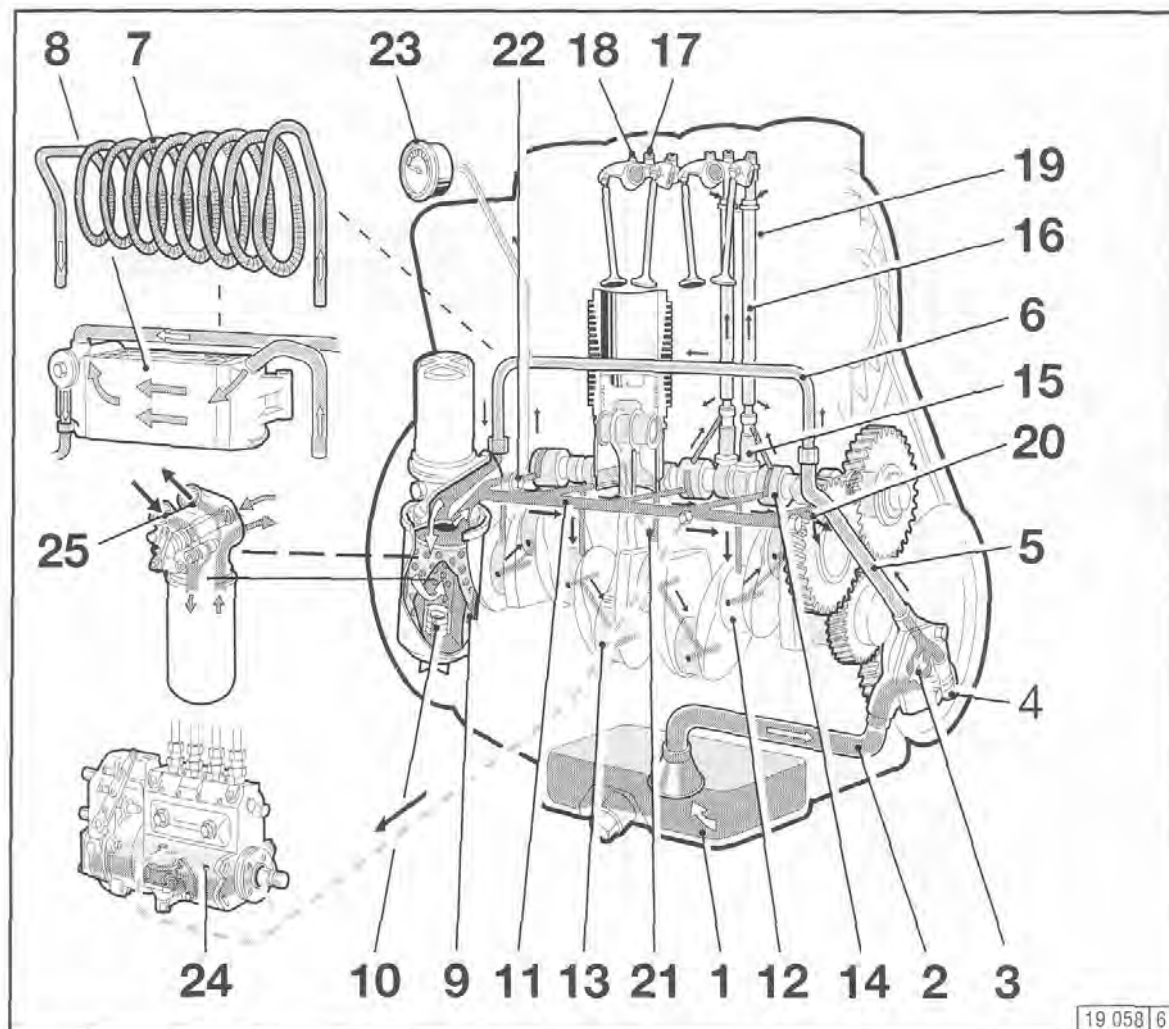


# Engine Description

## 2.3 Lube Oil Circuit

2

### 2.3.1 Lube Oil Circuit FL 912 / 913



- 1 Oil pan
- 2 Intake manifold
- 3 Oil pump
- 4 Oil pressure control valve
- 5 Pressure-oil line
- 6 Bypass line or selectively
- 7 Finned pipe spiral or selectively
- 8 Frame oil cooler
- 9 Lube oil filter
- 10 Safety valve
- 11 Main oil gallery
- 12 Crankshaft bearing
- 13 Con-rod bearing
- 14 Camshaft bearing
- 15 Tappets
- 16 Push rod (hollow, for oil feed to rocker arm lubrication)
- 17 Rocker arm bearing
- 18 Metering plug (r. arm lubrication)\*
- 19 Protective sleeve for push rod
- 20 Throttle bore (for lubrication of the gear wheels)
- 21 Injection jet for cooling the pistons
- 22 Connection for oil pressure gauge
- 23 Oil pressure gauge
- 24 Injection pump connected to lube oil circuit
- 25 Connection point for oil heating\*\*

\* only for inclined engines

\*\* in this instance the filter holder must be replaced. Please contact our service representative for this alteration.



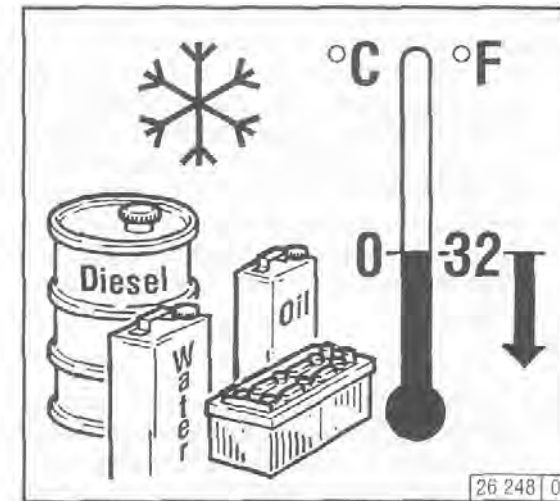
## 3.5 Operating Conditions

## Engine Operation

3

### 3.5.1 Winter Operation

- **Lube Oil Viscosity**
  - Select the oil viscosity (SAE grade) according to the ambient temperature when the engine is started, see 4.1.2
  - Increase oil change frequency when operating below  $-10^{\circ}\text{C}$ , see 6.1.1
- **Diesel Fuel**
  - Use winter-grade diesel fuel for operation below  $0^{\circ}\text{C}$ , see 4.2.2
- **Additional Maintenance Work**
  - Drain the sludge from the fuel tank once a week. (Unscrew the sludge drain plug.)
  - If necessary, allow the oil in the oil bath air cleaner and the engine oil to settle at the ambient temperature.
  - Below  $-20^{\circ}\text{C}$ , after removing the starter if necessary, smear the ring gear on the fly wheel via the pinion bore from time to time with cold-resistant grease (e.g. Bosch grease FT 1 V 31).
- **Battery**
  - Efficient cold starting requires a healthy battery, see 6.7.1
  - The starting limit temperatures can be lowered by  $4\text{--}5^{\circ}\text{C}$  by heating the battery up to about  $+20^{\circ}\text{C}$ . (To do so, remove the battery and store in a warm place.)
- **Cold-Start Aid**
  - At temperatures near or below freezing point, use glow plugs if necessary, see 3.2.1. This not only lowers the starting limit temperature, but provides easier starting at temperatures normally not requiring a starting aid.





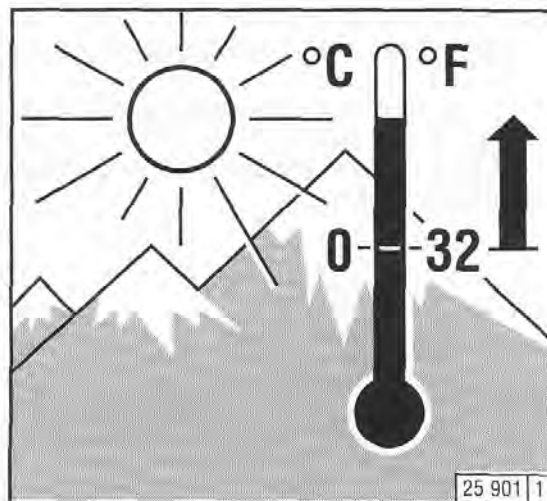
# Engine Operation

## 3.5 Operating Conditions

**3**

### 3.5.2 High Ambient Temperatures, High Altitude

- As the altitude and ambient temperature rise, the density of air tends to decrease, which affects the maximum power output of the engine, the exhaust gas quality and, in extreme cases, the starting behaviour. Under transient conditions, the engine can be used at altitudes up to 1000 m and temperatures up to 30 °C. If the engine is to operate under more severe conditions (at higher altitudes or temperatures), it will be necessary to reduce the injected fuel quantity and thus, engine power.
- If you have any doubts about engine operation under these or similar conditions, ask your engine or equipment supplier whether the engine has been derated in the interests of reliability, service life and exhaust gas quality (smoke). Otherwise contact DEUTZ SERVICE.



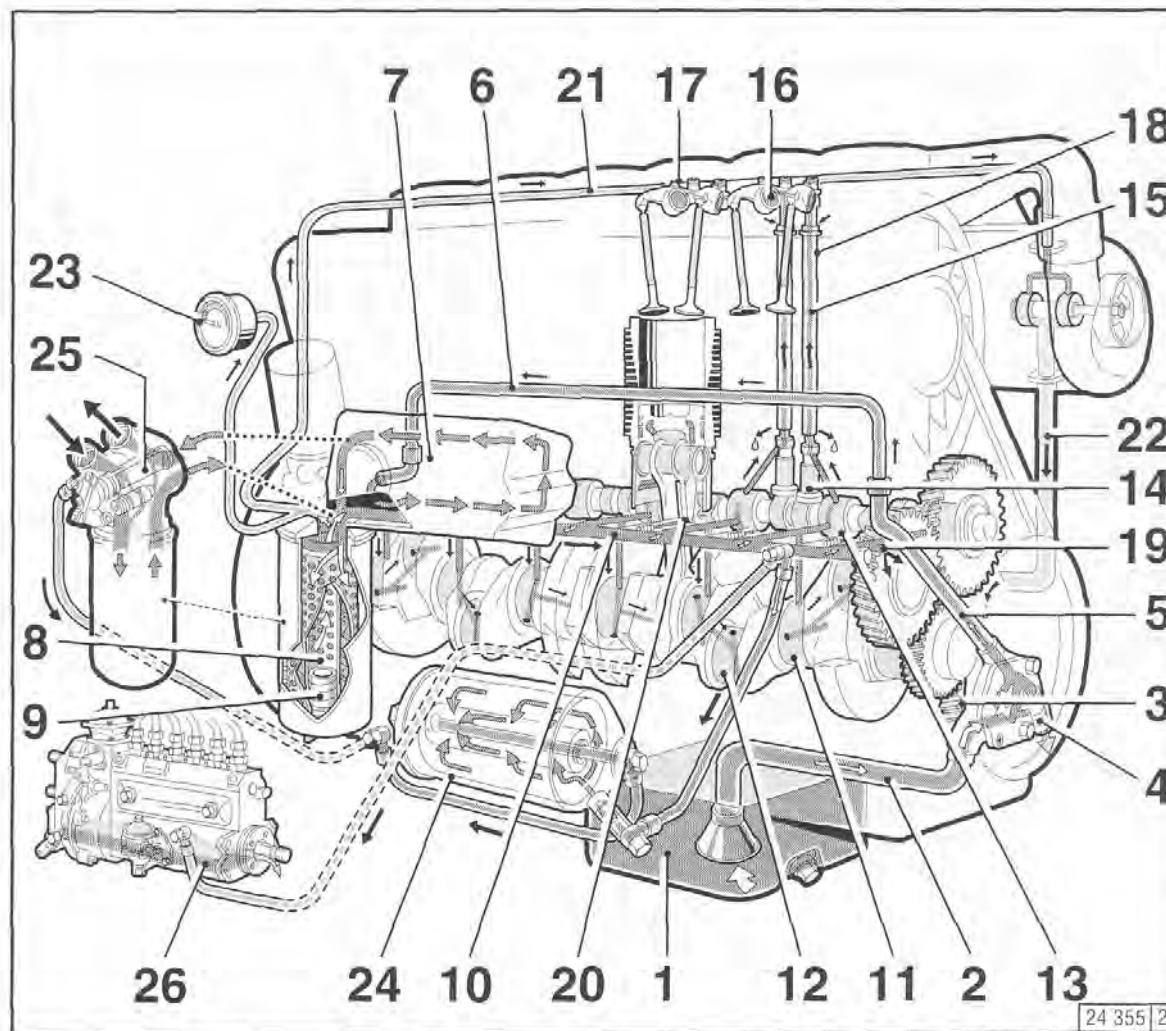


## 2.3 Lube Oil Circuit

## Engine Description

### 2.3.1 Lube Oil Circuit BF6L 913

2



- 1 Oil pan
- 2 Intake manifold
- 3 Oil pump
- 4 Oil pressure control valve
- 5 Pressure-oil line
- 6 Connecting line to oil cooler
- 7 Frame oil cooler
- 8 Lube oil filter
- 9 Safety valve
- 10 Main oil gallery
- 11 Crankshaft bearing
- 12 Con-rod bearing
- 13 Camshaft bearing
- 14 Tappets (with impulse lubrication of the rocker arm)
- 15 Push rod (hollow, for oil feed to r. arm lubrication)
- 16 Rocker arm bearing
- 17 Metering plug (r. arm lubrication)\*
- 18 Protective sleeve for push rod (oil return from cylinder head to crankcase)
- 19 Throttle bore (for lubrication of the gear wheels)
- 20 Injection jet for cooling the pistons
- 21 Oil line for lub. of the exhaust turbocharger
- 22 Oil ret. line from exhaust turboc. to the crankcase
- 23 Oil pressure gauge
- 24 Partial-flow lube oil filter
- 25 Connection point for oil heating\*\*
- 26 Injection pump connected to lube oil circuit

\* only for inclined engines

\*\* in this instance the filter holder must be replaced. Please contact our service representative for this alteration.

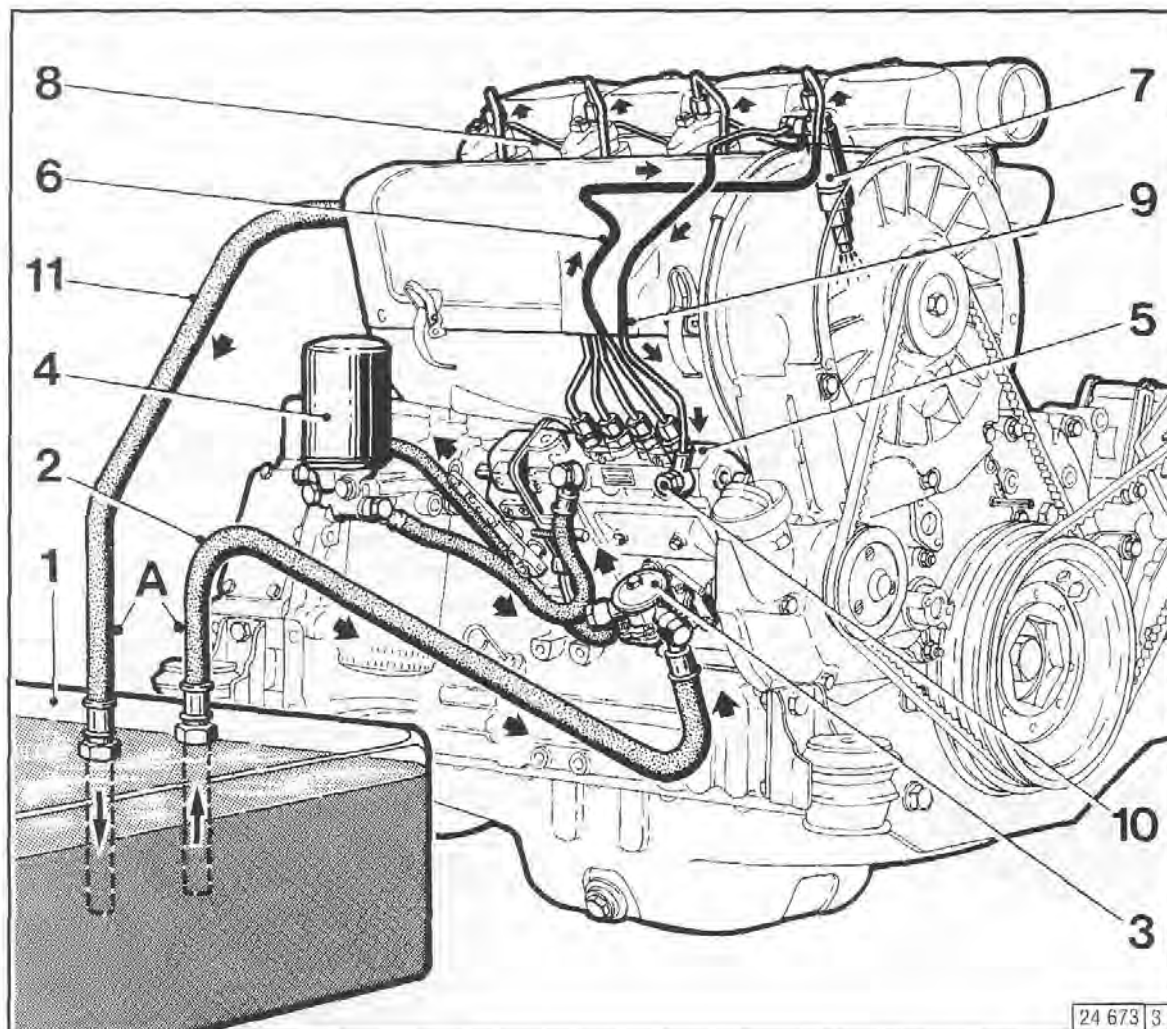


## Engine Description

## 2.4 Fuel System Schematic

2

### 2.4.1 Fuel Circuit



- 1 Fuel tank
- 2 Fuel line from tank to fuel pump
- 3 Fuel supply pump
- 4 Easy-change fuel filter
- 5 Injection pump
- 6 Injection lines
- 7 Injection valves
- 8 Oil leakage line
- 9 Fuel overflow pipe
- 10 Overflow valve
- 11 Fuel return line to tank
- A Clearance; keep as far apart as possible

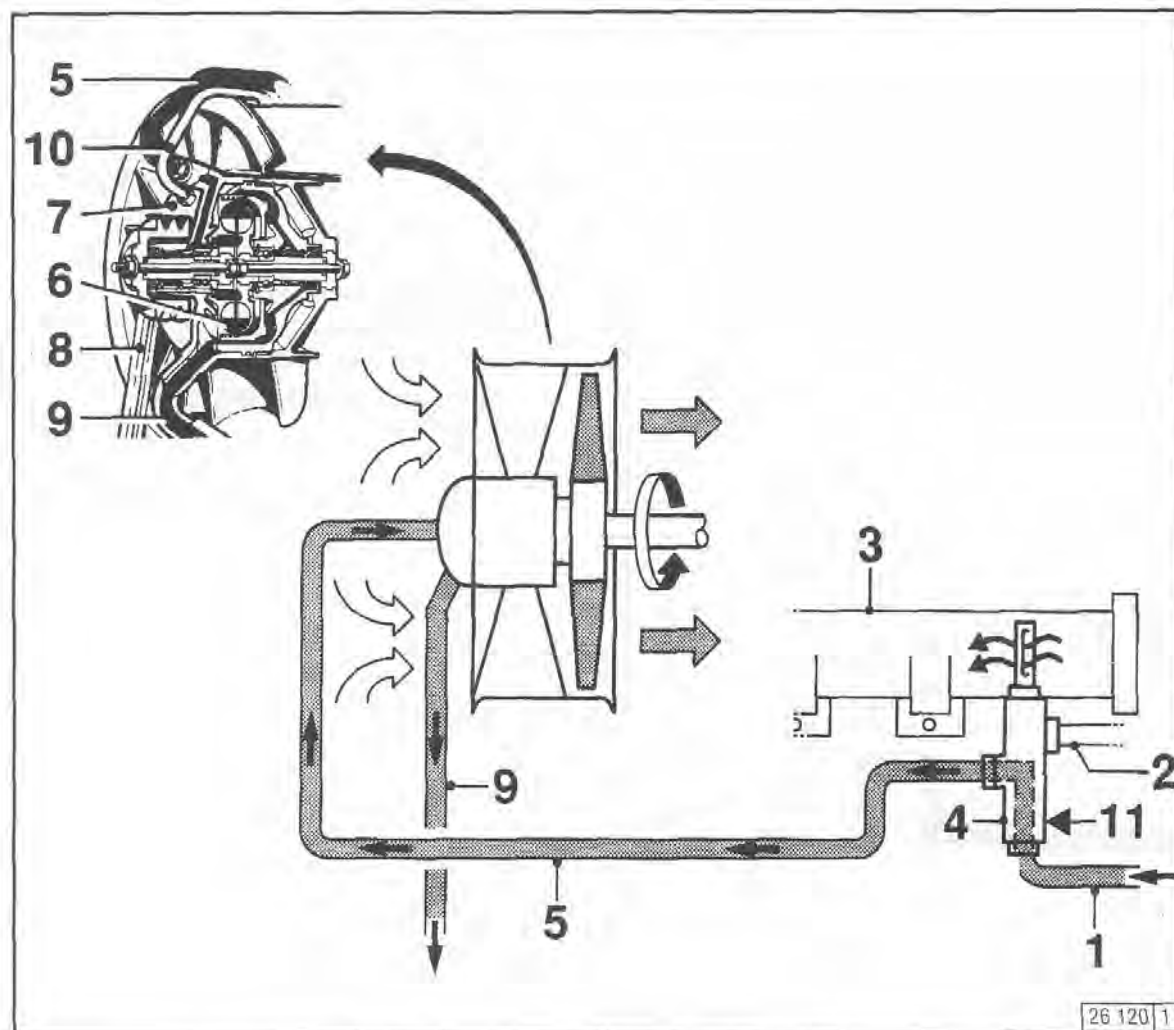
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## 2.5 Engine Cooling

## Engine Description

### 2.5.1 Regulation of Coolant Flow using the Exhaust Thermostat

**2**


- 1 Pressure-oil line from engine to exhaust thermostat
- 2 Air line to exhaust thermostat
- 3 Exhaust manifold pipe
- 4 Exhaust thermostat
- 5 Control line to hydraulic coupling
- 6 Hydraulic coupling
- 7 Cooling fan
- 8 Cooling fan drive
- 9 Oil return line to crankcase
- 10 Ventilation line
- 11 Adjusting pin with special seal

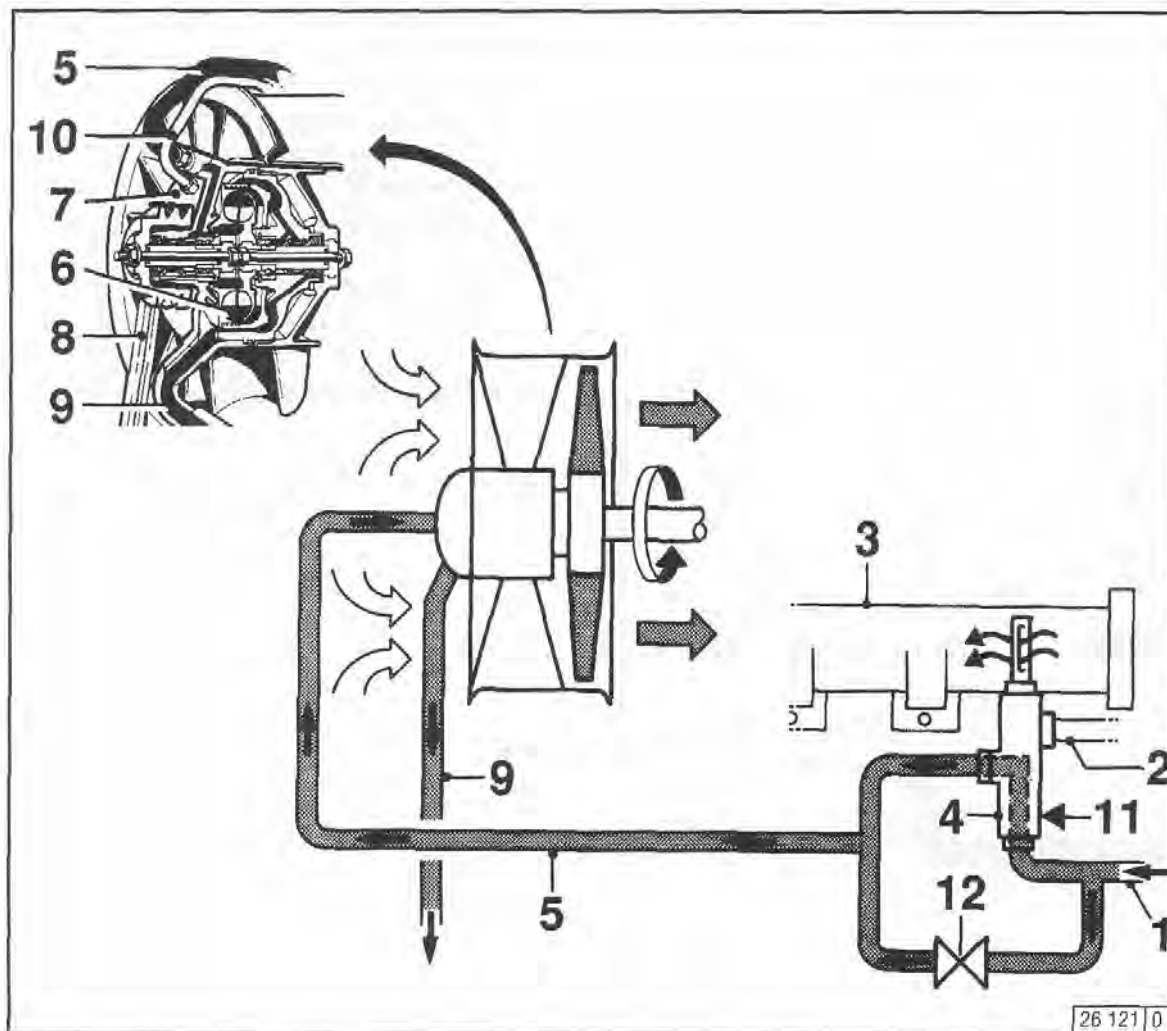


# Engine Description

## 2.5 Engine Cooling

2

### 2.5.2 Regulation of Coolant Flow using the Exhaust Thermostat and Solenoid



- 1 Pressure-oil line from engine to exhaust thermostat
- 2 Air line to exhaust thermostat
- 3 Exhaust manifold pipe
- 4 Exhaust thermostat
- 5 Control line to hydraulic coupling
- 6 Hydraulic coupling
- 7 Cooling fan
- 8 Cooling fan drive
- 9 Oil return line to crankcase
- 10 Ventilation line
- 11 Adjusting pin with special gasket
- 12 Solenoid



# Engine Operation

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**3**

- 3.1 Commissioning**
- 3.2 Starting**
- 3.3 Monitoring Systems**
- 3.4 Stopping**
- 3.5 Operating Conditions**

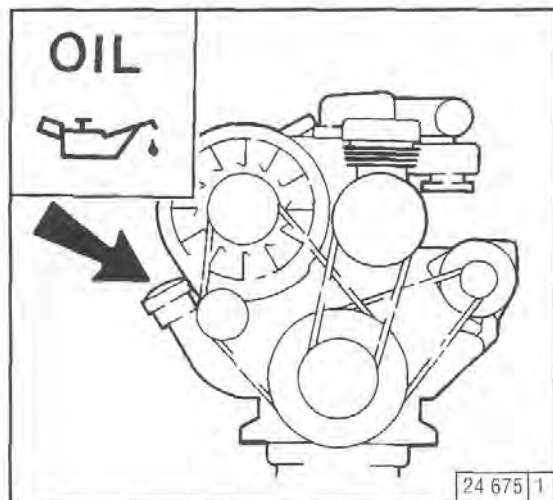


# Engine Operation

## 3.1 Commissioning

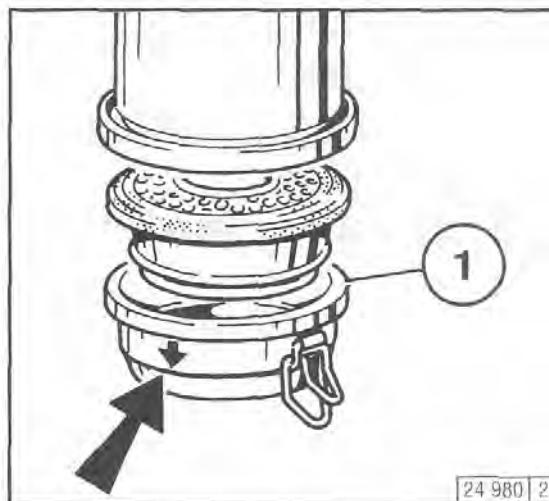
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### 3.1.1 Adding Engine Oil



As a rule, engines are delivered empty of oil. Pour lube oil into the oil filler neck (arrow). For oil grade and viscosity, see 4.1

### 3.1.2 Filling Oil Bath Air Cleaner



Fill oil cup 1 of the oil bath air cleaner with engine oil up to the arrow. For oil grade and viscosity, see 4.1

### 3.1.3 Adding Fuel



Use only commercial-grade diesel fuel. For fuel grade, see 4.2. Use summer or winter-grade fuel, depending on the ambient temperature.



Oil may not be filled into the dust collector of the precleaner, if this is fitted.



Never fill the tank while the engine is running. Keep the filler cap area clean and do not spill fuel.



# Engine Operation

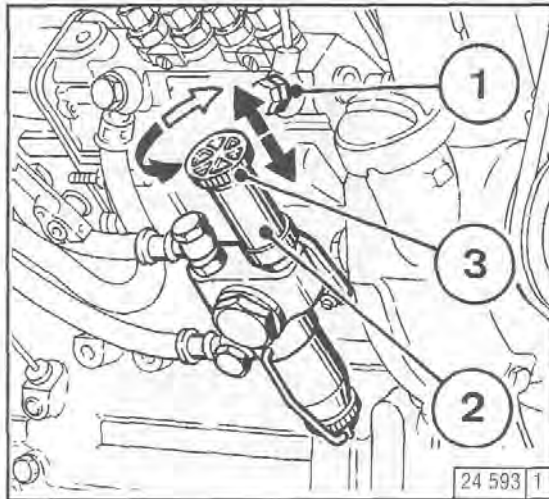
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## 3.1 Commissioning

### 3.1.4 Ventilation

Model:

“Bosch” fuel pump

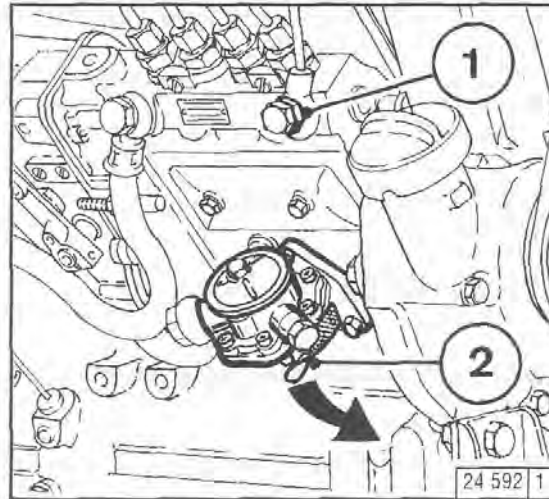


- Loosen overflow valve 1 at the lower (larger) hexagon.
- Loosen hand pump 2 at the notched grip 3 by unscrewing by several turns to the left.
- Actuate hand pump 2 until bubble-free fuel is emitted at the loosened overflow valve 1.
- Tighten overflow valve 1, continuing to pump at the same time.
- Tighten grip 3.

### Ventilation

Model:

“IMSA” fuel pump



- Loosen overflow valve 1 at the lower (larger) hexagon.
- Actuate preliminary pump lever 2 against the spring pressure until bubble-free fuel is emitted at the loosened overflow valve 1.
- Tighten overflow valve 1, continuing to pump at the same time.



# Engine Operation

## 3.1 Commissioning

3

### 3.1.5 Other Preparations

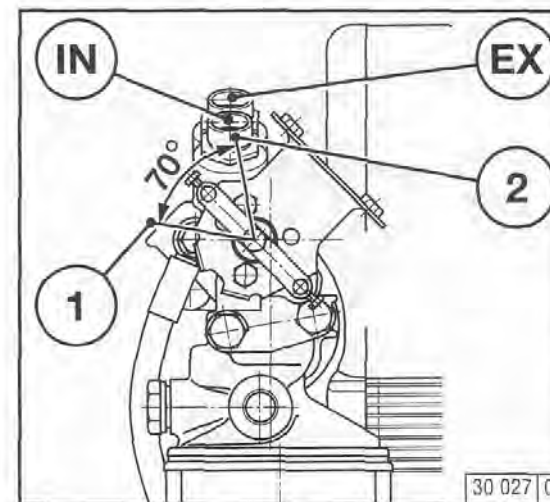
- Check battery and cable connections, see 6.7.1
- Transport hooks  
Remove if fitted (see 6.7.3).
- Trial run  
After the engine has been prepared, let it run for about 10 minutes without load.
- During and after trial run
  - Check the engine for leaks.
- After the engine has been turned off
  - Check the oil level, see 6.1.2
  - If necessary, top up oil, see 3.1.1
  - Retension V-belts, see 6.5
- Breaking in  
During the break-in phase – about 200 operating hours – check the oil level twice a day. After the engine is broken in, checking once a day will be sufficient.

### 3.1.6 Additional Maintenance Work

The following maintenance should be carried out after 50-150 operating hours:

- Change lube oil, see 6.1.2
- Change oil filter cartridge, see 6.1.3
- Change fuel filter cartridge, see 6.2.1
- Check V-belts and retension as necessary, see 6.5
- Check valve clearance and adjust as necessary, see 6.6.1
- Check the engine for leaks.
- Check the engine mount and adjust as necessary, see 9.2

### 3.1.7 Selector Switch for Oil Heater



Position of selector switch for oil filter console with oil heater connection:

Pos. 1: open  
Pos. 2: closed



For engines without oil heating, the selector switch is always open  
Pos. 2: to lock closed.



# Engine Operation

## 3.2 Starting

3

### 3.2.1 Electric Starting



Before starting, make sure that nobody is standing in the immediate vicinity of the engine or driven machine.

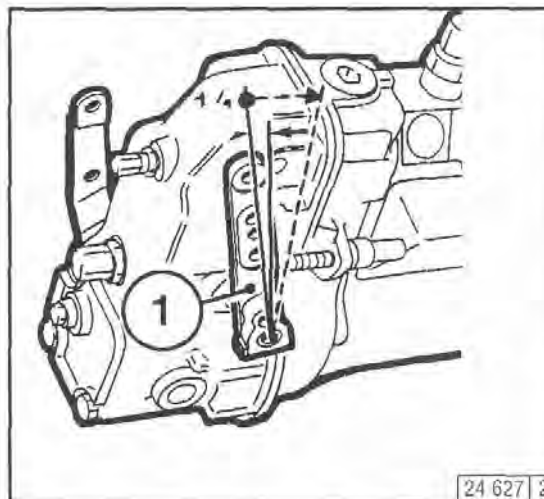
After repair work:

Check that all guards have been replaced and that all tools have been removed from the engine.

When starting with flame glow system, do not use any other starter substance (e.g. injection with start pilot).

**Caution:** If the speed regulator has been removed, the engine must not be tested under any circumstances:

**Disconnect the battery.**

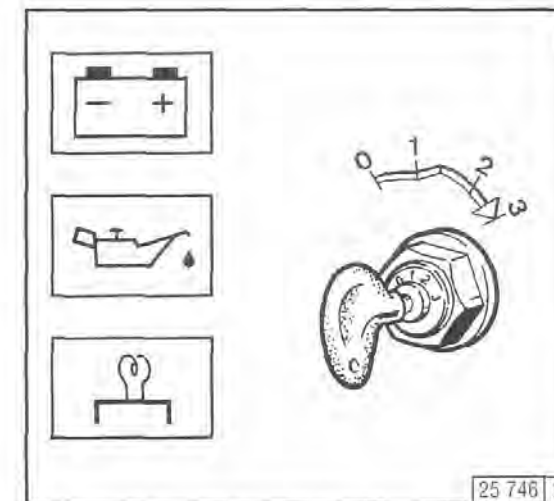


- Where possible, disengage the clutch to separate the engine from any driven parts.
- Move speed control lever 1 into idle position.

Do not actuate the starter for more than 20 seconds. If the engine does not catch, wait a minute then try again.

If the engine does not catch after two attempts, refer to the Diagnosis Chart (see 7.1).

### Starting without Cold-Start Aid



- Insert key.
  - Position 0 = no operating voltage
- Turn key clockwise
  - Position 1 = operating voltage
  - Pilot lights come on.
- Push the key in and turn it further clockwise against spring pressure
  - Position 2 = no function
  - Position 3 = start
- Release key as soon as engine fires
  - Pilot lights go out.

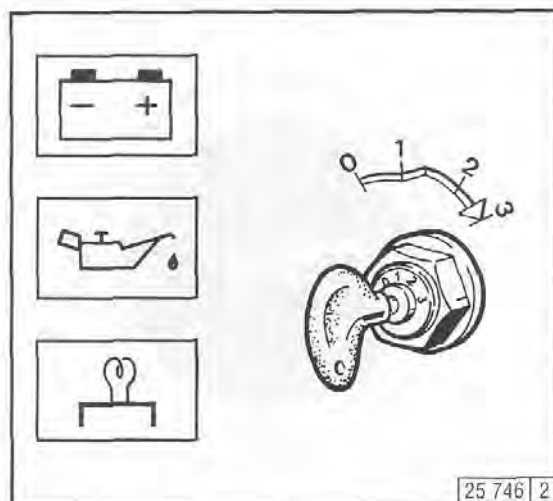


## 3.2 Starting

## Engine Operation

**3**

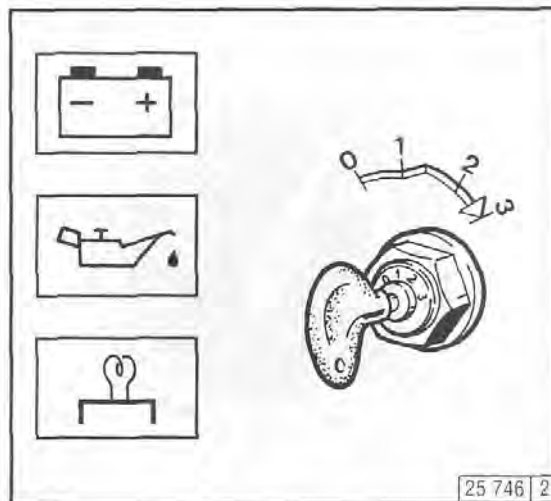
**with Cold-Start Aid/Flame Glow Plug**  
FR 60 = 9.5 and 19 volts



- Insert key.
  - Position 0 = no operating voltage.
- Turn key clockwise.
  - Position 1 = operating voltage
  - Pilot lights come on.
- Push key in and turn further clockwise against spring pressure.
  - Glow plug indicator comes on.
  - Position 2 = Preheat for approx. 60 seconds (hold key in position)\*.
  - Glow plug indicator goes out.
  - Position 3 = start
- Release key as soon as engine fires.
  - Pilot lights go out.

\* By afterignition in position 2 for up to approx. 3 mins, it is possible to lower further the exhaust gas opacity in the revving-up phase.

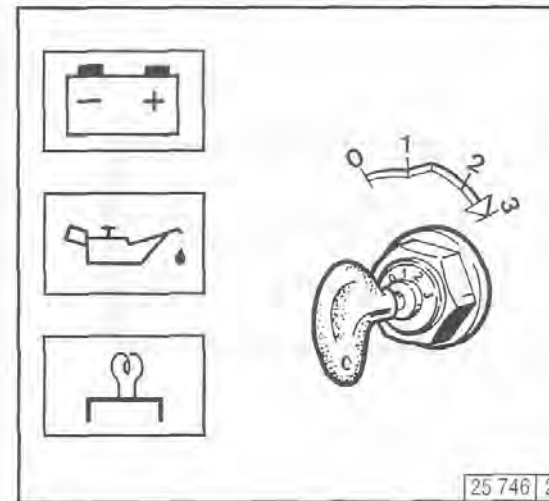
**with Cold-Start Aid/Flame Glow Plug**  
FR 20/30 = 11 and 23 volts



- Insert key.
  - Position 0 = no operating voltage
- Turn key clockwise.
  - Position 1 = operating voltage
  - Pilot lights come on.
- Push key in and turn further clockwise against spring pressure.
  - Glow plug indicator comes on.
  - Position 2 = Preheat for approx. 20-30 seconds (hold key in position)\*.
  - Glow plug indicator goes out
  - Position 3 = start
- Release key as soon as engine fires
  - Pilot lights go out.

\* By afterignition in position 2 for up to approx. 3 mins, it is possible to lower further the exhaust gas opacity in the revving-up phase.

**with heating pipe**



- Insert key.
  - Position 0 = no operating voltage.
- Turn key clockwise.
  - Position 1 = operating voltage
  - Pilot lights come on.
- Push key in and turn further clockwise against spring pressure.
  - Position 2 = Preheat for approx. 60 seconds (hold key in position)\*.
  - Position 3 = start
- Release key as soon as engine fires
  - Pilot lights go out.

\* By afterignition in position 2 for up to approx. 3 mins, it is possible to lower further the exhaust gas opacity in the revving-up phase.



# Engine Operation

## 3.3 Monitoring Systems

3

### 3.3.1 Engine Oil Pressure

#### Oil Pressure Pilot Light



- The oil pressure pilot light comes on with operating voltage on and engine off.
- The oil pressure pilot light should go out when the engine is running.

#### Oil Pressure Indicator



- The pointer must remain in the green sector over the entire range.

#### Oil Pressure Gauge



- The pointer must indicate the minimum oil pressure (see 9.1).



## 3.3 Monitoring Systems

## Engine Operation

3

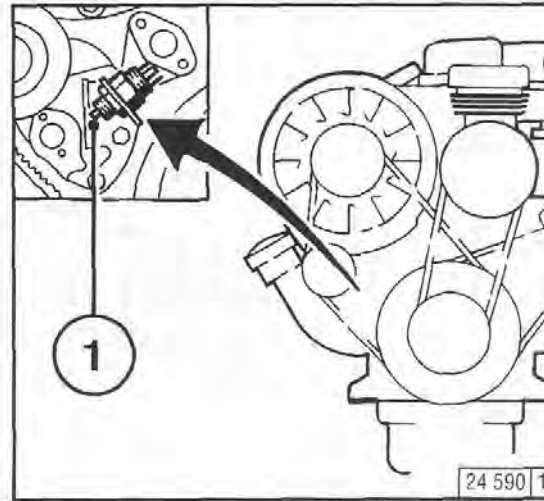
### 3.3.2 Engine Temperature

#### Temperature Gauge



- The engine temperature gauge pointer should remain in the green sector most of the time. It should rarely enter the yellow-green sector. If the pointer enters the orange sector, the engine is overheating. Turn off and establish the cause from the Diagnosis Chart (see 7.1).

### 3.3.3 Cooling Fan Drive



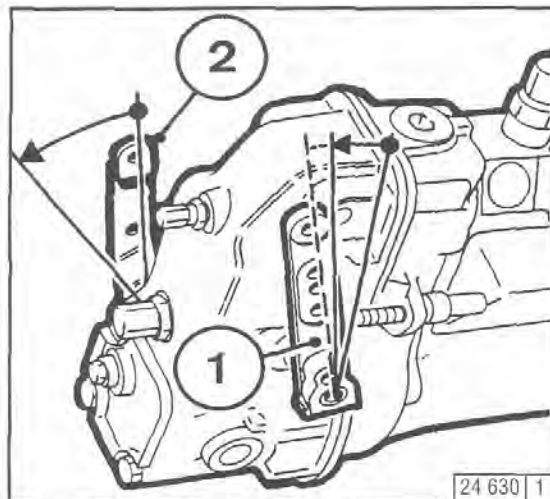
- If the V-belt rips, pressure pin 1 of the electrical switch is actuated by the tension roller and an acoustic or light signal is given.  
**Switch off the engine immediately to prevent overheating.**



# Engine Operation

## 3.4 Stopping

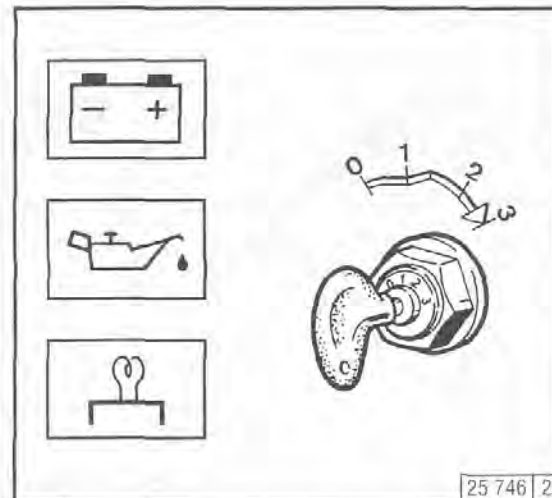
### 3.4.1 Mechanical Shutdown



- Move speed control lever 1 to low idle.
- Operate shutdown lever 2 until the engine comes to a stop. The charge pilot light and the oil pressure pilot light will come on when the engine stops.
- Turn key anticlockwise (to position 0) and remove. The pilot lights will go out.

### 3.4.2 Electrical Shutdown

#### Ignition Key



- Turn key anticlockwise (to position 0) and remove. The pilot lights will go out.

If possible, do not suddenly switch off the engine when under full load.



## Operating Media

---

### 4

#### 4.1 Lube Oil

#### 4.2 Fuel



# Operating Media

## 4.1 Lube Oil

4

### 4.1.1 Quality grade

Lube oils are differentiated according to their performance and quality class. In common use are specifications named after the **API** (American Petroleum Institute) and **ACEA** (European Engine Oil Sequences).

#### Approved API Oils:

At least: CF-4

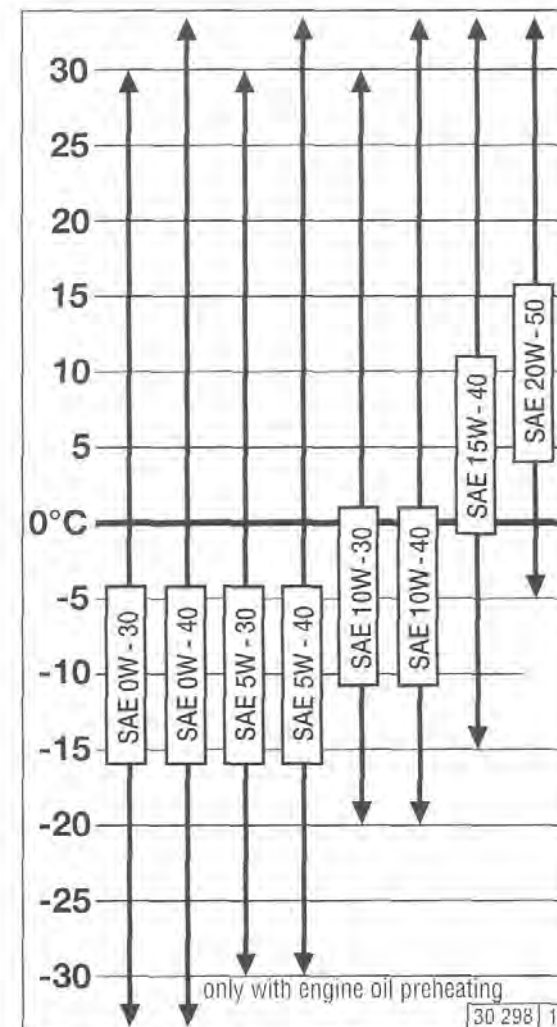
#### Approved ACEA Oils:

At least: E1-96

Oil change intervals, see 6.1.1  
Oil capacities, see 9.1

### 4.1.2 Viscosity

As the viscosity of the lube oil is dependent on temperature, the choice of SAE grade should be governed by the ambient temperature prevailing at the engine operating site. Optimum operating behaviour will be attained if you take the accompanying oil viscosity diagram as a guide. Should the temperature fall temporarily below the limits of SAE grade selected, cold starting may be affected but the engine will not be damaged. In order to keep wear to a minimum, do not exceed application limits for extended periods of time. Oil changes dictated by the seasons can be avoided by using multi-grade lube oils. Multi-grade oils – particularly light-flowing oils – also reduce fuel consumption.





4.2 Fuel

Operating Media

4

4.2.1 Quality Grade

Use commercially available diesel fuel with less than 0.5 % sulphur content. If the sulphur content is higher than 0.5 % oil change intervals should be reduced, see 6.1.1

The following fuel specifications / standards are approved:

- DIN EN 590
- BS 2869: A1 and A2 (with A2, take note of the sulphur content!)
- ASTM D 975-88; 1-D and 2-D
- NATO Code F-54 and F-75

Any exhaust emission levels which may have been determined during type approval tests always refer to the reference fuel prescribed by the authorities for the type approval test.

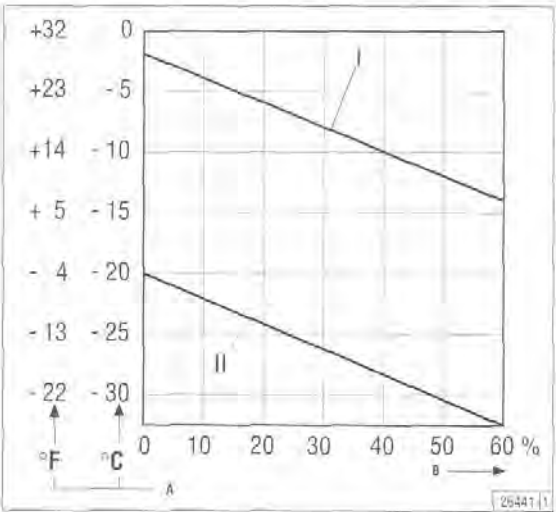
4.2.2 Winter-Grade Fuel

Waxing may occur at low temperatures, clogging the fuel system and reducing engine efficiency. If the ambient temperature is less than 0 °C, winter-grade fuel (suitable down to -15 °C) should be used. (This fuel is usually available from the filling stations well in advance of the cold months). Diesel fuel containing additives (Super diesel) is often on sale as well, for use down to -20 °C.

- Below -20 °C, petroleum must be added. For the required mixing ratios please refer to the adjacent diagram.
- For arctic climate zones down to -44 °C special diesel fuels can be used.

If summer-grade diesel fuel must be used at temperatures below 0 °C, up to 60% kerosene can be added (see diagram).

In most cases, adequate resistance to cold can be obtained by adding a flow improver (additive). Please inquire at DEUTZ-PARTNER.



| Legend: |                              |
|---------|------------------------------|
| I       | Summer diesel fuel           |
| II      | Winter diesel fuel           |
| A       | Ambient                      |
| B       | Proportion of Kerosene to be |



Mix in tank only. Fill with the appropriate amount of kerosene first, then add the diesel fuel.



## **Routine Maintenance**

---

### **5**

- 5.1 Maintenance Schedule**
- 5.2 Maintenance Charts**
- 5.3 Maintenance Work Completed**



# Routine Maintenance

## 5.1 Maintenance Schedule

5

| Once<br>after<br>2) | every<br>10 OH<br>or<br>daily | Operating hours (OP) <sup>1)</sup> |     |       |      |      |      |      | check |   |           | See<br>Section                                 |             |
|---------------------|-------------------------------|------------------------------------|-----|-------|------|------|------|------|-------|---|-----------|--|-------------|
|                     |                               | 125                                | 250 | every |      |      | 3000 | 5000 |       |   | clean     |  |             |
|                     |                               |                                    |     | 500   | 1000 | 2000 |      |      |       |   | change    |  |             |
|                     |                               |                                    |     |       |      |      |      |      |       |   | Operation |  |             |
| 50-150              |                               |                                    |     |       |      |      |      |      |       |   |           |  |             |
|                     | ●                             |                                    |     |       |      |      |      |      | ●     |   |           | Oil level in engine / separate container       | 6.1.2       |
| ●                   |                               |                                    |     |       |      |      |      |      | ●     |   |           | Engine leaks                                   |             |
|                     | ●                             |                                    |     |       |      |      |      |      | ●     |   |           | Oil bath- and dry type air cleaners 3) 4)      | 6.3/6.4     |
|                     |                               | ●                                  |     |       |      |      |      |      | ●     |   |           | Battery and cable connectors                   | 6.7.1       |
|                     |                               | ●                                  | ●   | ●     |      |      |      |      | ●     |   |           | Cooling system (depending on engine use) 3) 6) | 6.3.1/6.3.2 |
| ●                   |                               | ●                                  | ●   | ●     |      |      |      |      | ●     | ● |           | Engine oil (depending on engine use) 5)        | 6.1.1/6.1.2 |
| ●                   |                               |                                    |     | ●     |      |      |      |      |       | ● |           | Oil filter cartridge                           | 6.1.3       |
| ●                   |                               |                                    |     |       |      |      |      |      |       | ● |           | Fuel filter cartridge                          | 6.2.1       |
| ●                   |                               |                                    |     | ●     | ●    |      |      |      | ●     |   |           | Valve clearance (adjust if necessary)          | 6.6.1       |
| ●                   |                               |                                    |     |       | ●    |      |      |      | ●     |   |           | Engine mounts (retighten if necessary)         | 9.2         |
| ●                   |                               |                                    | ●   |       |      |      |      |      | ●     |   |           | V-belts (retension if necessary)               | 6.5         |
|                     |                               |                                    | ●   |       |      |      |      |      | ●     |   |           | Warning system                                 | 6.5.5       |
| ●                   |                               |                                    |     |       |      |      |      |      |       | ● |           | Fuel precleaner                                | 6.2.2       |
| ●                   |                               |                                    |     |       | ●    |      |      |      | ●     |   |           | Mountings                                      | 6.8.1       |
|                     |                               |                                    |     |       | ●    |      |      |      | ●     |   |           | Flame glow plugs 4)                            | 6.8.3       |
|                     |                               |                                    |     | ●     |      |      |      |      |       | ● |           | Partial-flow oil filter                        | 6.1.4       |
|                     |                               |                                    |     |       |      |      | ●    |      | ●     |   |           | Sheathed element heater plugs                  |             |

The specified engine maintenance times are maximum values. Depending on the operating environment, shorter maintenance intervals may be required. Please observe the operating instructions of the equipment manufacturer.

- 1) Recommended maximum
- 2) Commissioning new or reconditioned engines
- 3) Clean if needed, see Section 6.3
- 4) Change if necessary. If fitted, service after service indicator.
- 5) Oil change interval, see Section 6.1.1
- 6) Clean system / cooling fins.

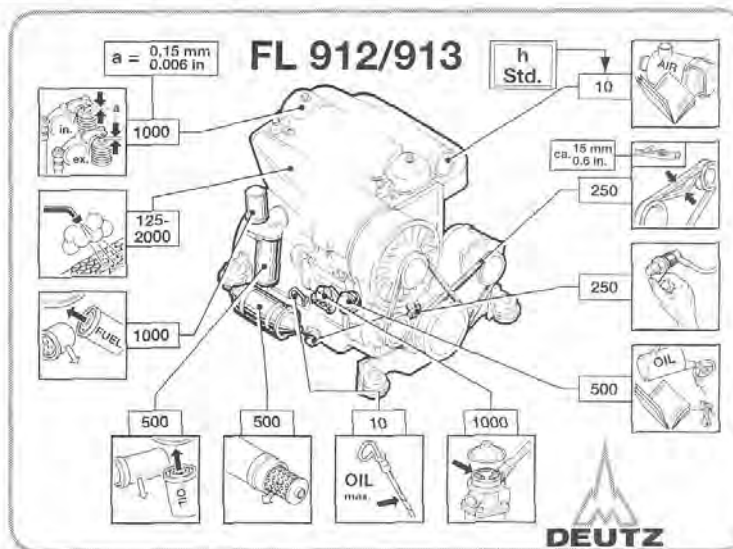


## 5.2 Maintenance Charts

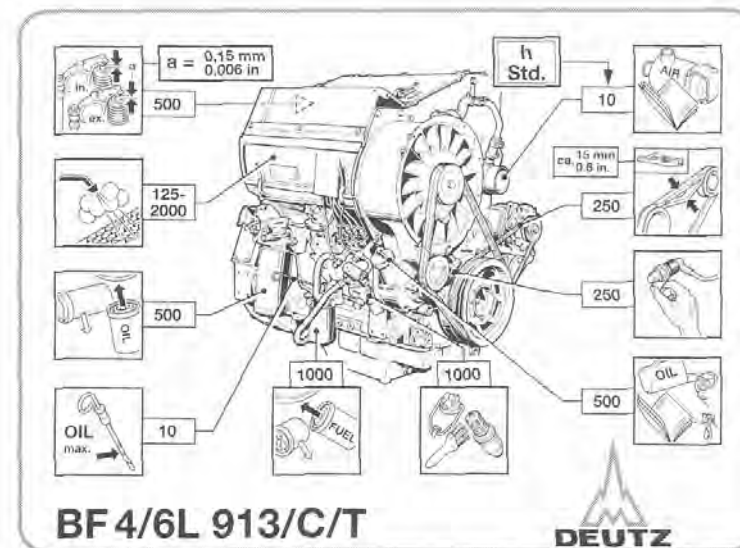
The maintenance charts shown here are supplied as self-adhesive labels with each engine. They should be affixed where they can be seen clearly on the engine or driven equipment.

Check that this is the case.

If necessary, ask your engine or equipment supplier for a fresh supply of labels.  
Routine work should be carried out according to the schedule in 5.1



0297 7224 1



0297 4070 1



Stop the engine before carrying out any maintenance work.



## Routine Maintenance

## 5.3 Completed Maintenance Jobs

**5**

| Hours  | Date | Signature / Stamp | Hours | Date | Signature / Stamp |
|--|------|-------------------|-------|------|-------------------|
| 50-150*  |      |                   | —     |      |                   |
| 125  |      |                   | 250   |      |                   |
| 375  |      |                   | 500   |      |                   |
| 625  |      |                   | 750   |      |                   |
| 875  |      |                   | 1000  |      |                   |
| 1125   |      |                   | 1250  |      |                   |
| 1375   |      |                   | 1500  |      |                   |
| 1625   |      |                   | 1750  |      |                   |
| 1875   |      |                   | 2000  |      |                   |
| 2115   |      |                   | 2250  |      |                   |
| 2375   |      |                   | 2500  |      |                   |
| 2625   |      |                   | 2750  |      |                   |
| * Commissioning new and overhauled engines.<br>The maintenance jobs duly completed can be recorded in the above table. |      |                   |       |      |                   |



## 5.3 Completed Maintenance Jobs

## Routine Maintenance

**5**

| Hours   | Date | Signature / Stamp | Hours | Date | Signature / Stamp |
|---|------|-------------------|-------|------|-------------------|
| 2875  |      |                   | 3000  |      |                   |
| 3125  |      |                   | 3250  |      |                   |
| 3375  |      |                   | 3500  |      |                   |
| 3625  |      |                   | 3750  |      |                   |
| 3875  |      |                   | 4000  |      |                   |
| 4125  |      |                   | 4250  |      |                   |
| 4375  |      |                   | 4500  |      |                   |
| 4625  |      |                   | 4750  |      |                   |
| 4875  |      |                   | 5000  |      |                   |
| 5125  |      |                   | 5250  |      |                   |
| 5375  |      |                   | 5500  |      |                   |
| 5625  |      |                   | 5750  |      |                   |
| The maintenance jobs duly completed can be recorded in the above table. |      |                   |       |      |                   |



## Routine Maintenance

### 5.3 Completed Maintenance Jobs

**5**

| Hours   | Date | Signature / Stamp | Hours | Date | Signature / Stamp |
|---|------|-------------------|-------|------|-------------------|
| 5875  |      |                   | 6000  |      |                   |
| 6125  |      |                   | 6250  |      |                   |
| 6375  |      |                   | 6500  |      |                   |
| 6625  |      |                   | 6750  |      |                   |
| 6875  |      |                   | 7000  |      |                   |
| 7125  |      |                   | 7250  |      |                   |
| 7375  |      |                   | 7500  |      |                   |
| 7625  |      |                   | 7750  |      |                   |
| 7875  |      |                   | 8000  |      |                   |
| 8125  |      |                   | 8250  |      |                   |
| 8375  |      |                   | 8500  |      |                   |
| 8625  |      |                   | 8750  |      |                   |
| The maintenance jobs duly completed can be recorded in the above table. |      |                   |       |      |                   |



## Service and Maintenance

---

### 6

- 6.1 Lubrication System**
- 6.2 Fuel System**
- 6.3 Cooling System**
- 6.4 Combustion Air System**
- 6.5 Belt Drives**
- 6.6 Adjustments**
- 6.7 Accessories**
- 6.8 Engine Cleaning**
- 6.9 Additional Maintenance**



# Service and Maintenance

## 6.1 Lubrication System

6

### 6.1.1 Oil Change Intervals

- The oil change intervals are dependent on the engine application and the quality of the lube oil.
- If the engine runs fewer hours during the year than stated in the table, the oil should be changed at least once a year.
- The table refers to the following conditions:
  - For diesel fuel: sulphur content max. 0.5% by weight.
  - Continuous ambient temperatures down to -10 °C (+14 °F).
- If the sulphur content is > 0.5 to 1% or the continuous ambient temperature below -10 °C (+14 °F), the intervals between oil changes should be halved.
- In the case of fuels containing more than 1% sulphur, contact your **service representative**.

Change the oil with the engine off but still warm (lube oil temperature approx. 80 °C).

| Installed engines   |                       |                           | Lube oil intervals in OH    |                      |              |
|---|-----------------------|---------------------------|-----------------------------|----------------------|--------------|
|   |                       |                           | Naturally aspirated engines | Turbocharged engines |              |
| Lube oil quality  | API classification    |                           | CF-4/CH-4/CG-4              | CF-4                 | CH-4/CG-4    |
|   | ACEA classification   |                           | E1-E3/96+ E4-98             | E1-E2/96             | E3-96+ E4-98 |
| Normal oil usage, e.g.:   |                       |                           | 500                         | 250                  | 500          |
| Road vehicles, cranes, construction machinery, ships, electrical units, pumps, rail-run vehicles  |                       |                           |                             |                      |              |
| Heavy-duty oil usage, e.g.:   |                       |                           | 250                         | 125                  | 250          |
| Combine harvesters, emergency pumps, underground equipment, sweeping machines, winter operation equipment, emergency power generating units |                       |                           |                             |                      |              |
| Vehicle engines   |                       |                           | Lube oil intervals in km    |                      |              |
|   |                       |                           | Naturally aspirated engine  | Turbocharged engine  |              |
| Lube oil quality  | API classification    |                           | CF-4/CH-4/CG-4              | CF-4                 | CH-4-/CG-4   |
|   | ACEA classification   |                           | E1-E3/96+ E4-98             | E1-E2/96             | E3-96+ E4-98 |
| Service group   | Annual kilometrage km | average speed approx km/h |                             |                      |              |
| I   | > 30 000              | 20                        | 10 000                      | 5 000                | 10 000       |
| II  | 30 000 – 100 000      | 40                        | 20 000                      | 10 000               | 20 000       |
| III   | < 100 000             | 60                        | 30 000                      | 15 000               | 30 000       |



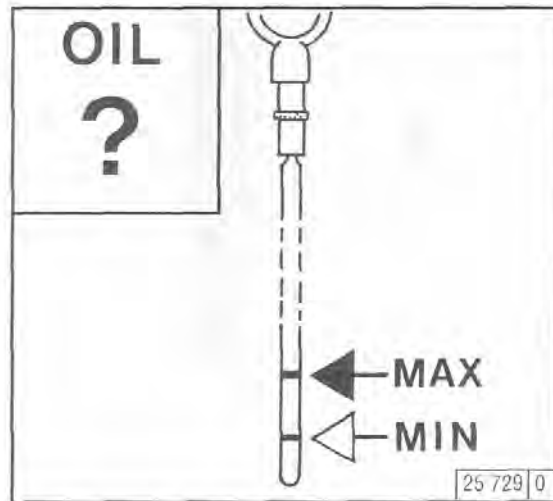
## 6.1 Lubrication System

## Service and Maintenance

6

### 6.1.2 Checking Oil Level / Changing Engine Oil

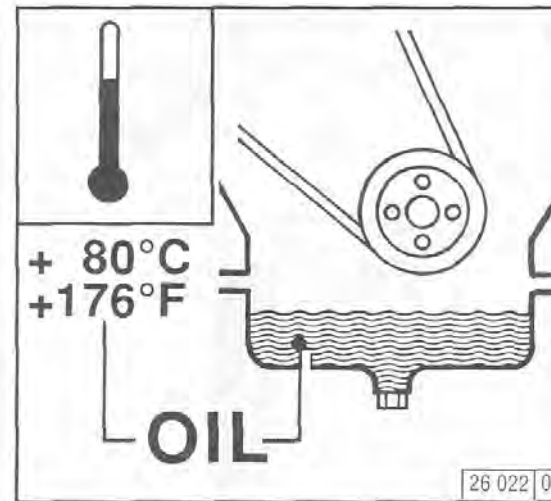
#### 6.1.2.1 Checking Oil Level



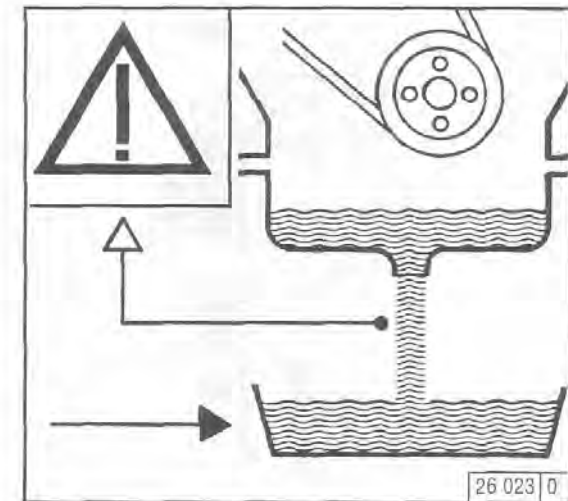
- Ensure that the engine or vehicle is in a horizontal position.
- – **Warm engine:**  
Switch off engine, wait 5 minutes and check the oil level.
- – **Cold engine:**  
Check oil level.  
To this end:
- Remove the oil dipstick.
- Wipe the dipstick with a non-fibrous, clean cloth.
- Insert it to the stop and remove again.
- Check the oil level, and if necessary, top up to the “MAX” mark.
  - If the oil level is only just above the “MIN” mark, more oil must be added.

The oil level must not fall below the “MIN” marking.

#### 6.1.2.2 Engine Oil Change



- Ensure that the engine or vehicle is on a level surface.
- Allow the engine to warm up
  - Lube oil temperature approx. 80°C.
- Switch off the engine.



- Place oil tray under the engine.
- Unscrew drain plug.
- Drain oil.
- Fit oil drain plug, with the new gasket and tighten firmly (for torque, see 9.2).
- Fill with lube oil.
  - For grade / viscosity, see 4.1
  - For quantity, see 9.1
- Check oil level, see 6.1.2.1



Be careful when draining hot oil – danger of scalds! Do not let used oil run into the soil but catch it in a container ready for proper disposal.

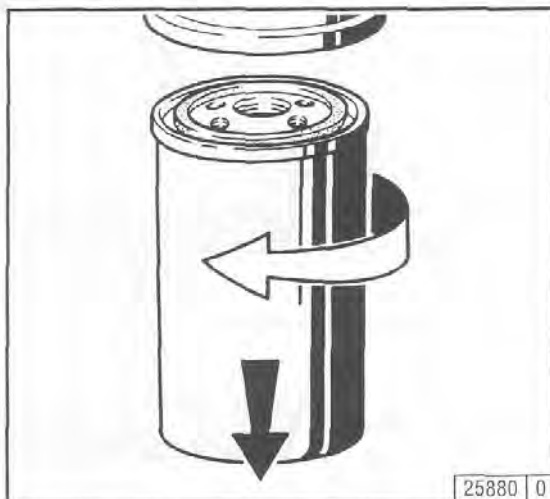


# Service and Maintenance

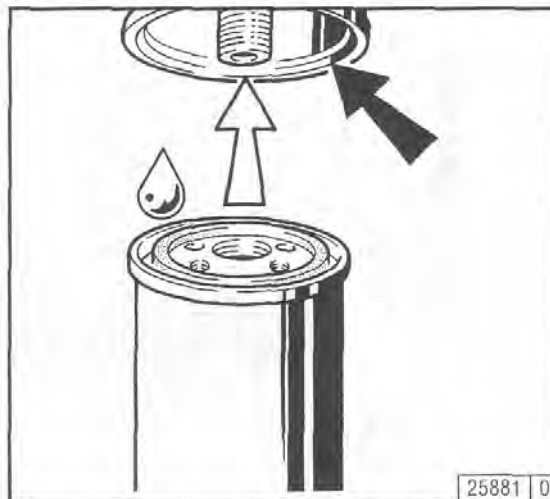
## 6.1 Lubrication System

6

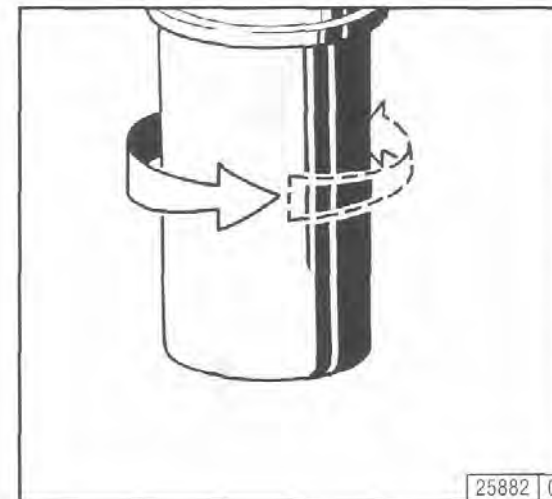
### 6.1.3 Changing Oil Filter



- Undo the filter cartridge using a commercial tool and spin off.
- Catch any dripping oil.



- Clean any dirt from the filter carrier rim.
- Lightly oil the rubber gasket of the new oil filter cartridge.
- Screw in the new cartridge finger tight against the gasket.



- Tighten the oil filter cartridge with another half-turn.
- Check oil level, see 6.1.2
- Check oil pressure, see 3.3.1
- Check cartridge seal for leaks.



Beware of burns from hot oil.

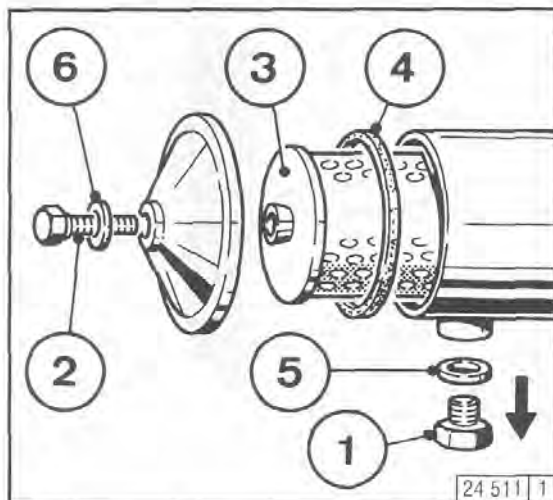


## 6.1 Lubrication System

## Service and Maintenance

### 6.1.4 Changing the Partial-Flow Oil Filter Insert

6



- Unscrew oil drain plug 1 and drain off oil.
- Unscrew tension screw 2. Remove the cover.
- Unscrew the dirtied filter insert 3. Clean the filter housing.
- Check and if necessary replace cover seal 4.
- Screw in oil drain plug 1 with new seal 5.
- Fit new filter insert.
- Screw on cover with sealing ring 6.
- Check for leaks and check the oil pressure during a test run.

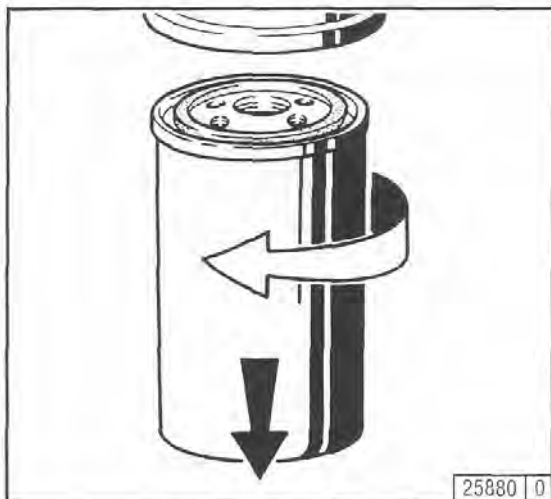


# Service and Maintenance

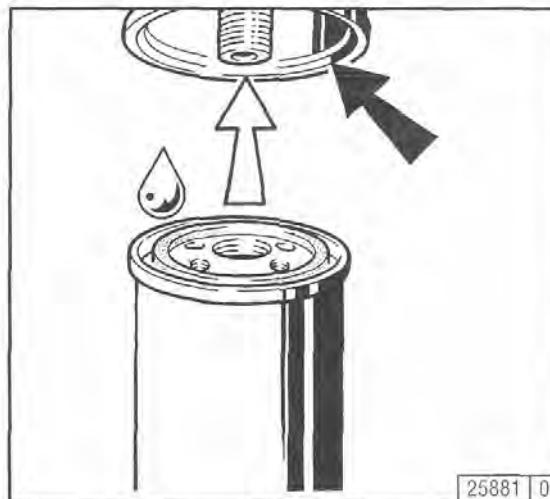
## 6.2 Fuel System

6

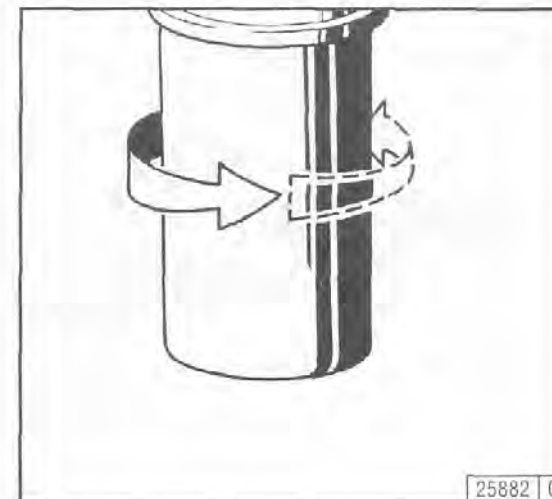
### 6.2.1 Changing Fuel Filter



- Close fuel stopcock.
- Undo fuel filter cartridge with commercial tool and spin off.
- Catch any fuel.



- Clean any dirt from the filter cartridge with a final half-turn.
- Apply light film of oil or diesel fuel to the rubber gasket of the new fuel filter cartridge.
- Screw in the new cartridge finger tight against the gasket.



- Tighten the fuel filter cartridge with a final half-turn.
- Open fuel stopcock.
- Check for leaks.



Keep naked flames away when working on the fuel system. Do not smoke.

The fuel system does not need to be bled.

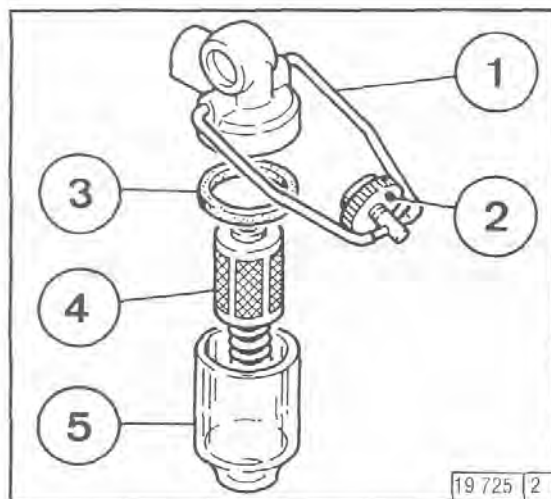


## 6.2 Fuel Filter

## Service and Maintenance

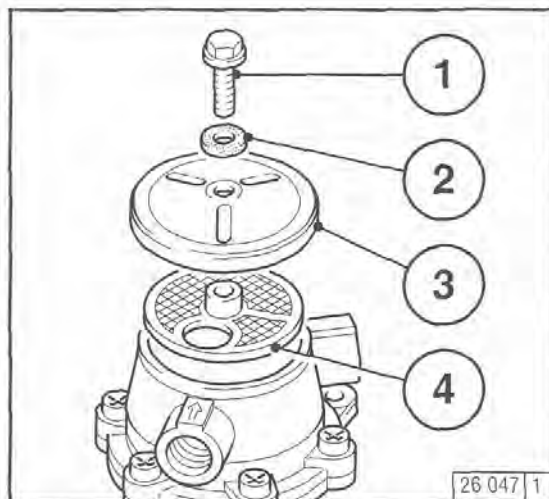
**6**

### 6.2.2 Fuel Precleaner Cleaning the Fuel Filter "Bosch" model



- Close the fuel shut-off valve.
- Loosen tensioning nut 2.
- Swing wire clip 1 to the side.
- Remove filter cone 5 with strainer 4 and clean in fuel.
- Use a new seal 3 for filter cone 5.
- Bleed the fuel system, see 3.1.4
- Check for leaks.

### Cleaning the Fuel Filter "IMSA" model



- Close the fuel shut-off valve.
- Loosen hexagonal nut 1 and unscrew with sealing ring 2.
- Remove cover 3.
- Remove fuel strainer 4.

- Clean the fuel strainer 4 in fuel. Replace if necessary.
- Refit in the reverse order.
- Bleed fuel system, see 3.1.4
- Check for leaks.



No naked flames when working on the fuel system.  
No smoking!



# Service and Maintenance

## 6.3 Cooling System

6

### 6.3.1 Cleaning Intervals

- The amount of contamination in the cooling system depends on the engine application.
- Spilled oil or fuel on the engine increases the risk of contamination. Be especially careful if the engine is used in dusty environments.
- Serious contamination can occur, for example:
  - on construction sites where there is a high level of air-borne dust.
  - in harvesting application where there are high concentrations of chaff and chopped straw in the vicinity of the machine.
- Because applications vary, cleaning intervals have to be determined from case to case. The cleaning intervals given in the table on the right can be used as a guide.

| Inspection and cleaning intervals<br><br>Recommended OH | Engine application   |
|---|--|
| 2000  | Ships, Electrical units in enclosed areas, pumps   |
| 1000  | Vehicles on reinforced highways  |
| 500   | Tractors, fork-lift trucks, mobile electrical units  |
| 250   | Vehicles on construction sites and on roads with loose surfaces, construction machinery, compressors, mining equipment |
| 125   | Agricultural machinery, tractors used for harvesting purposes  |



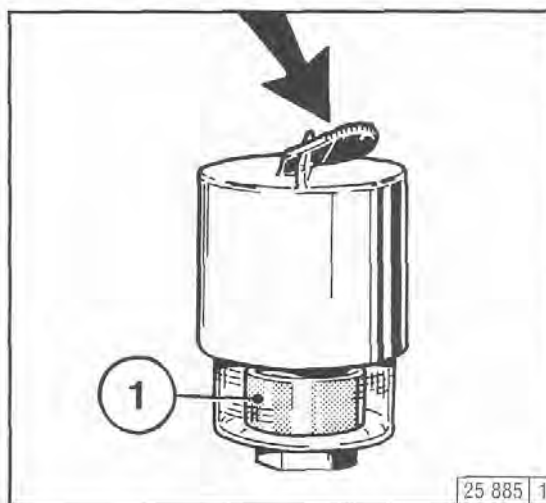
## 6.4 Combustion Air Filter

## Service and Maintenance

### 6.4.1 Cleaning Intervals

6

- The amount of dirt in the air cleaner depends on the amount of dust in the air and the size of the air cleaner used. If a high level of dust is anticipated, a cyclone-type precleaner can be fitted to the air cleaner.
- Cleaning intervals will have to be determined from case to case.
- If dry-type air cleaners are used, they should be cleaned only in accordance with the service indicator or the service switch.
- Air cleaner servicing is needed when:
  - **Service indicator**  
the red signal 1 is fully visible when the engine is off.
  - **Service switch**  
the yellow pilot light comes on when the engine is running.
- After carrying out service work, reset the signal by pressing the button on the service indicator.



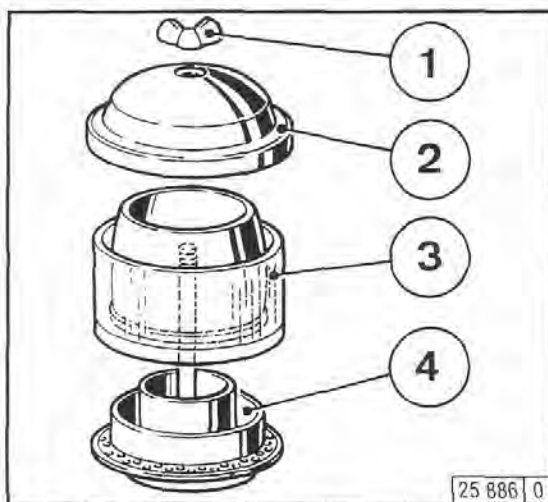


## Service and Maintenance

## 6.4 Combustion Air Filter

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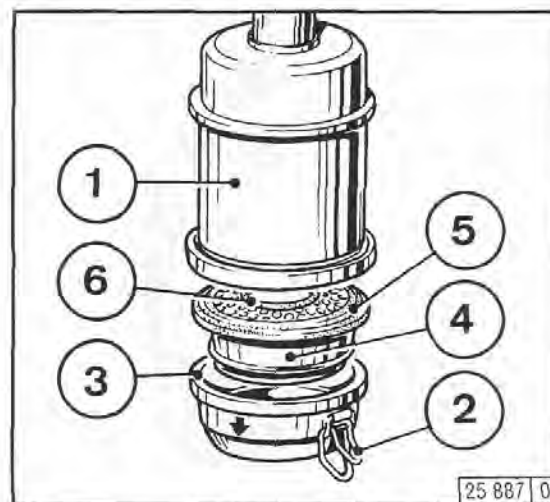
### 6.4.2 Emptying Cyclone Type Precleaner



- Undo wing nut 1 and remove cover 2.
- Remove collector bowl 3 from lower section 4 and empty. Clean leaves, straw and other foreign matter from lower section of pre-cleaner.
- Reposition collector bowl 3 onto lower section 4, fasten cover 2 in place by tightening wing nut 1.

Never fill collector bowl with oil. Replace collector bowl if damaged.

### 6.4.3 Cleaning Oil Bath Air Cleaner



- Turn engine off and wait about 10 minutes for the oil to drain from filter housing 1.
- Release snap clips 2 and remove oil cup 3 together with filter element 4. If necessary prise element out with a screwdriver, taking care not to damage the rubber gasket 5.
- Remove dirty oil and sludge. Clean oil cup.
- Clean filter element 4 in diesel fuel and allow to drip-dry.

- Clean filter housing 1 if very dirty.
- Inspect and replace rubber gasket 5 and 6 if necessary.
- Fill oil cup with engine oil up to the mark (arrow) (for viscosity, see 4.1.2).
- Refit oil cup and element to filter housing and secure with snap clips.



Never clean air cleaner with gasoline. Dispose of cold oil in accordance with environmental regulations!



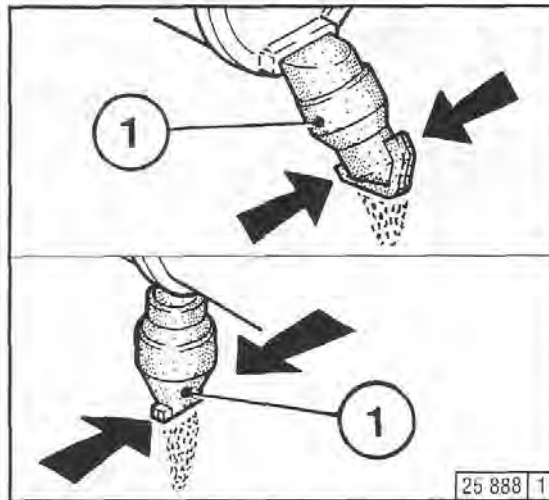
## 6.4 Combustion Air Filter

## Service and Maintenance

6

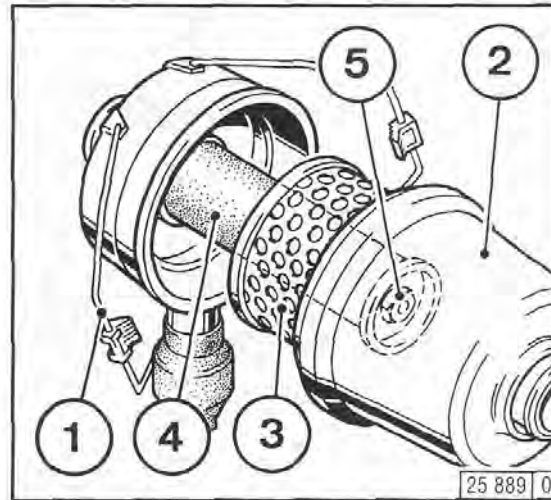
### 6.4.4 Dry Type Air Cleaner

#### Dust Discharge Valve



- Empty dust discharge valve 1 by pressing apart lips of discharge slot as indicated by arrows.
- Clean discharge slot from time to time.
- Remove any caked dirt by pressing together the upper section of the valve.

#### Filter Cartridges



- Undo clip fasteners 1.
- Take off hood 2 and remove cartridge 3.
- Clean cartridge (replace at least once a year).
- Clean cartridge 3.  
Blow out from inside out with dry compressed air (max. 5 bar), (or in difficult cases, tap out, taking care not to damage the cartridge, or wash according to manufacturer's instructions).
- Through regular removal and replacement, the gaskets on the filter cartridge can become damaged. Check paper filter (light showing through) and gaskets for damage. Replace if necessary.

- After five cleaner services or after two years at the latest, replace safety cartridge 4 (never clean).  
To do so:  
– Undo hex. nut 5 and remove cartridge 4.  
– Install new cartridge, insert and tighten hex. nut.
- Install cartridge 3, replace hood 2 and do up clip fasteners 1.



Never clean filter cartridge with gasoline or hot fluids.

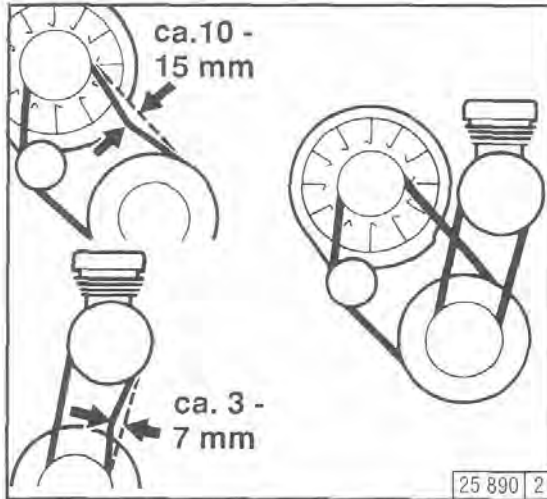


# Service and Maintenance

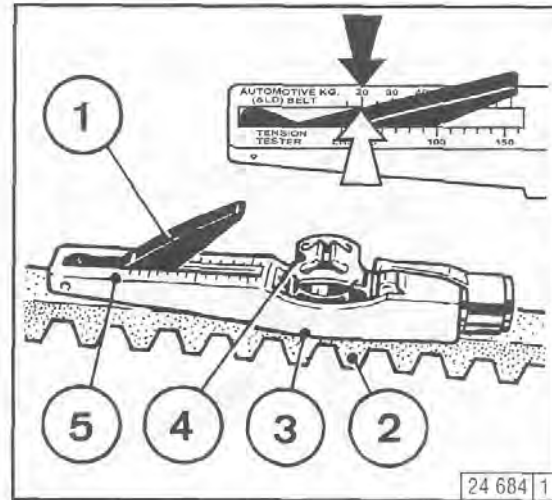
## 6.5 Belt Drives

6

### 6.5.1 Checking V-Belts



- Inspect entire V-belt for damage.
- Replace damaged V-belts.
- After installing new belts, run engine for 15 minutes, then check belt tension.
- To check the tension of the V-belt, use a tension gauge (see 9.3).
  - Place indicator arm 1 into gauge.
  - Position gauge on V-belt 2, midway between the pulleys, with flange 3 on bottom of gauge against the edge of belt.
  - Push slowly on the black pad 4 at right angles to belt 2 until the spring is heard or felt to trigger.

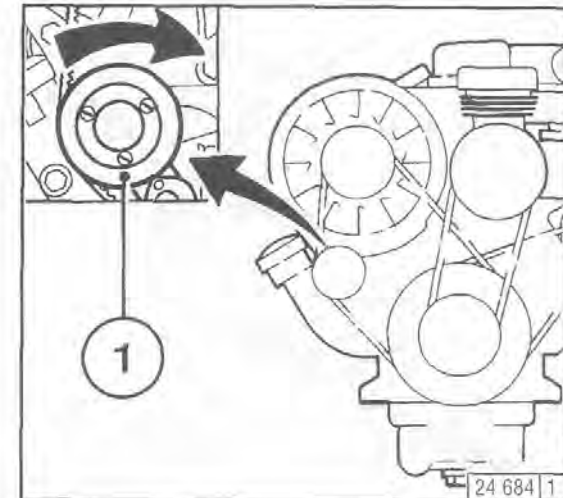


- Carefully remove the gauge without altering the position of the indicator arm 1. Read off the value where the black indicator arm 1 intersects scale 5 (arrow). For settings, see 9.1
- If necessary, retension belt and measure again.



Check tension and change belts only with the engine off. Refit belt guard, if provided.

### 6.5.2 Changing the Fan V-Belt



- To replace, press in tension roller 1 using a commercial tool and remove the V-belts.
- Fit new V-belts.

When new V-belts are fitted, check the belt tension after ca. 15 minutes running time.

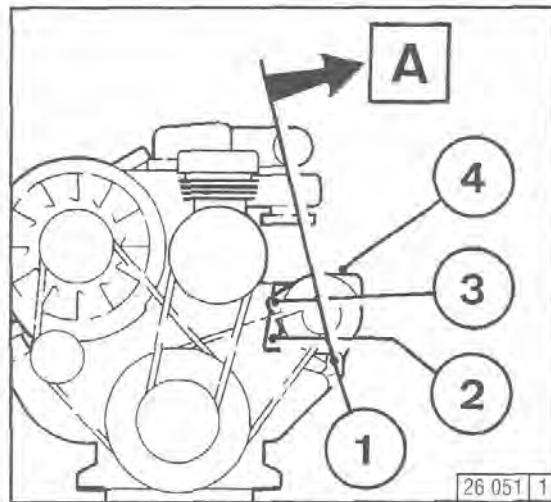


## 6.5 Belt Drives

## Service and Maintenance

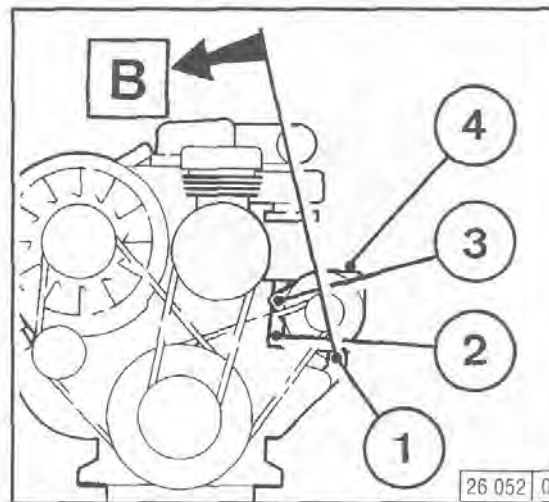
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### 6.5.3 Tensioning Alternator Belts



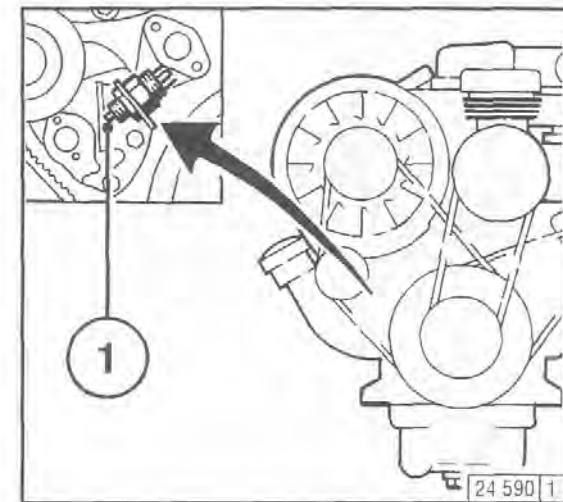
- Loosen bolts 1, 2 and 3.
- Press alternator 4 outwards in direction of arrow A until correct belt tension is achieved.
- Retighten bolts 1, 2 and 3.

### 6.5.4 Changing Alternator Belts



- Remove fan V-belts as described under 6.5.2
- Loosen bolts 1, 2 and 3.
- Swing alternator 4 inwards in direction of arrow B.
- Remove V-belts and place on new belt.
- Swing alternator 4 outwards in direction of arrow A until correct belt tension is achieved.
- Retighten bolts 1, 2 and 3.
- Fit fan V-belts.

### 6.5.5 Checking Warning System



- If the V-belt rips, pressure pin 1 of the electrical switch is actuated by the tension roller and an acoustic or light signal is given.
- Functional check by pressing in pin 1.



Only check/tension/replace V-belts when the engine is at a standstill. If necessary, replace V-belt cover.

Retighten new V-belts after 15 minutes running time.



Only carry out a check when the engine is at a standstill.

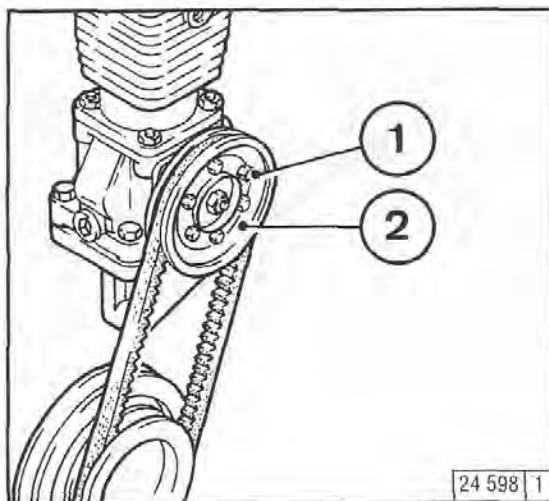


# Service and Maintenance

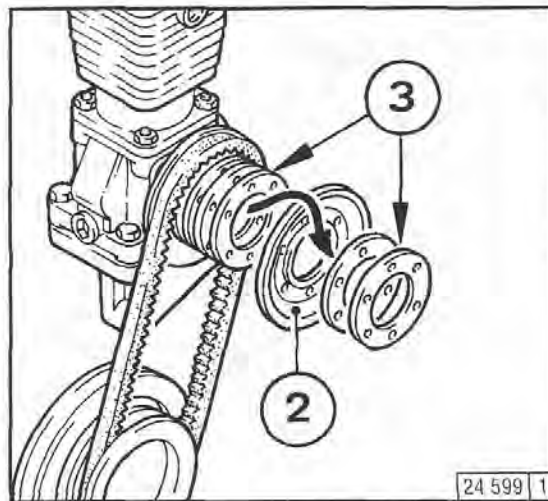
## 6.5 Belt Drives

### 6

#### 6.5.6 Tensioning and Changing Air Compressor V-Belts



- Unscrew hexagonal bolts 1.
- Remove outer half of belt pulley 2.
- If necessary replace the V-belts.



- To tighten, remove one or more of the inner intermediate discs 3. Place the removed discs on the removed half of the V-belt pulley 2.
- Retighten bolt 1. Whilst tightening, simultaneously rotate the engine to prevent the V-belt from being crushed.

When new V-belts are fitted, check the belt tension after ca. 15 minutes running time.

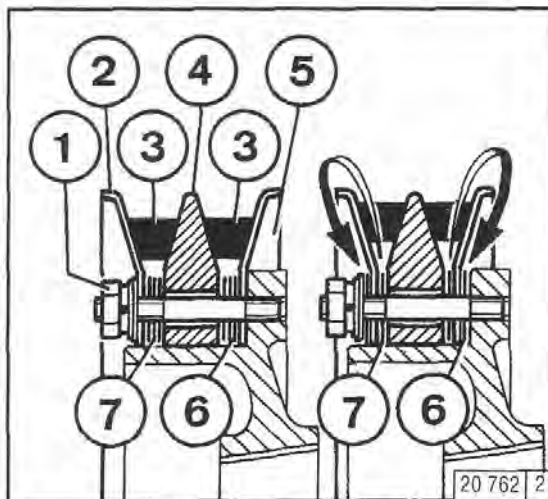


## 6.5 Belt Drives

## Service and Maintenance

### 6.5.7 Air Compressor Design with Double V-Belt

6



- Screw off hexagonal nut 1, remove V-belt pulley half 2, V-belt 3 and intermediate disc packet 7.
- Remove intermediate disc 4, rear V-belt 3, intermediate disc packet 6 and V-belt disc half 5.
- To tighten, remove one or more of the intermediate discs from packet 6 or 7. Place the removed discs in front of or behind V-belt pulley halves 2, so that the V-belt remains aligned. Always take the same number of discs from each packet.

- Fit in the reverse order. Whilst tightening nut 1, the engine must be rotated to prevent the V-belts from being crushed.

If a V-belt is worn or damaged, both belts in the set must be replaced. The difference in the length of the new V-belts may not exceed 0.15%.

Only check or replace the V-belts when the engine is at a standstill.  
If necessary, replace the V-belt cover. When new V-belts are fitted, check the belt tension after approx. 15 minutes running time.

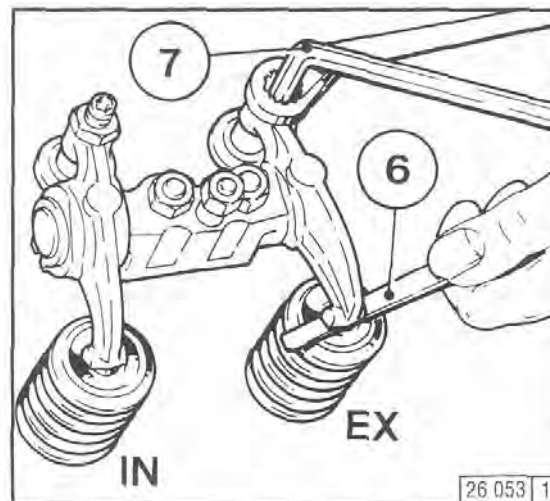
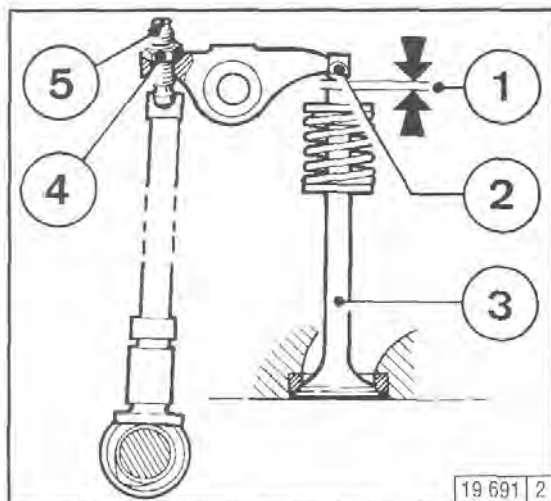


# Service and Maintenance

## 6.6 Adjustments

6

### 6.6.1 Checking / Adjusting Valve Clearances



- Remove the cylinder head cover.
- Position crankshaft as per schematic 6.6.1.1
- Before adjusting valve clearance, allow engine to cool down for at least 30 minutes. The oil temperature should be below 80 °C.
- Check valve clearance 1 between rocker arm / tappet contact face 2 and valve stem 3 with feeler gauge 6 (there should be only slight resistance when feeler blade is inserted).  
For permissible valve clearance, see 9.1

- Adjust valve clearance if necessary:
  - Release locknut 4.
  - Use screwdriver 7 to turn setscrew 5 so that the correct clearance is attained after locknut 4 has been tightened.
- Check and adjust valve clearance on all remaining cylinders.
- Replace cylinder head cover (use new gasket if needed).

Only inclined engines are fitted with an additional oil jet for lubrication of the bearing. Any adjustments must be carried out in an authorised specialist workshop.

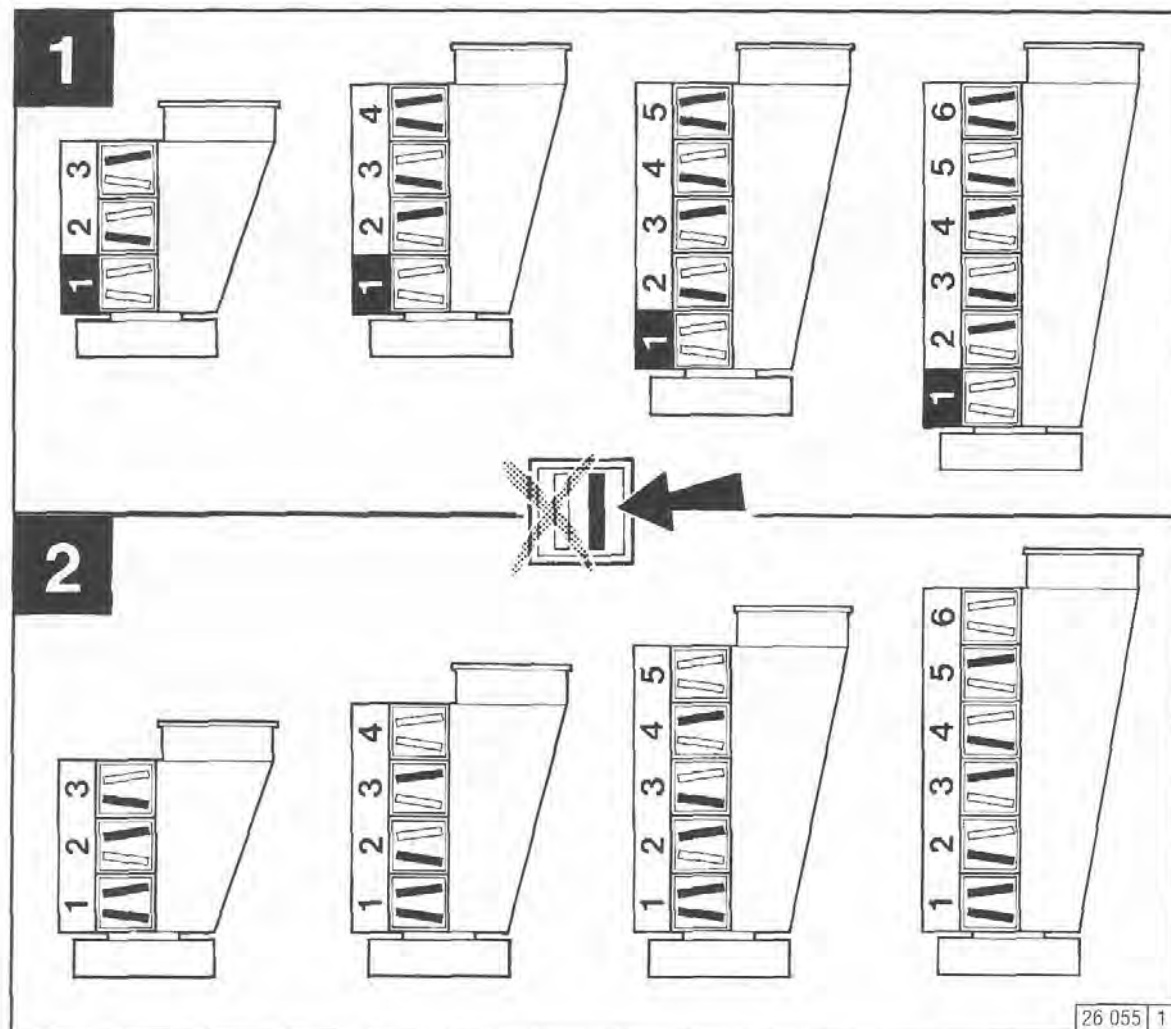


## 6.6 Adjustments

## Service and Maintenance

**6**

### 6.6.1.1 Valve Clearance Adjustments Schematic



#### ● Crankshaft Position 1:

Turn crankshaft until both valves in cylinder 1 overlap (exhaust valve about to close, inlet valve about to open). Adjust clearance of valves **marked in black** on schematic. Mark respective rocker arm with chalk to show that adjustment has been done.

#### ● Crankshaft Position 2:

Turn crankshaft one full revolution (360°). Adjust clearance of valves **marked in black** on schematic.

26 055 1



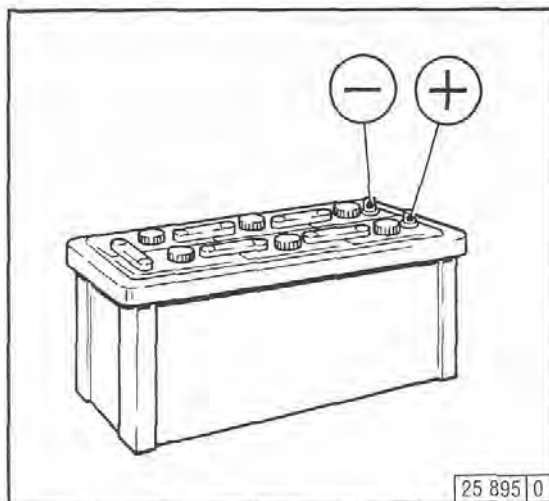
# Service and Maintenance

## 6.7 Accessories

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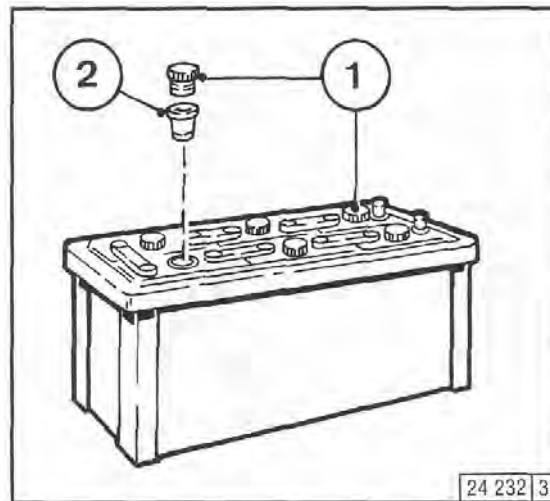
### 6.7.1 Battery

#### 6.7.1.1 Checking Battery and Cable Connectors



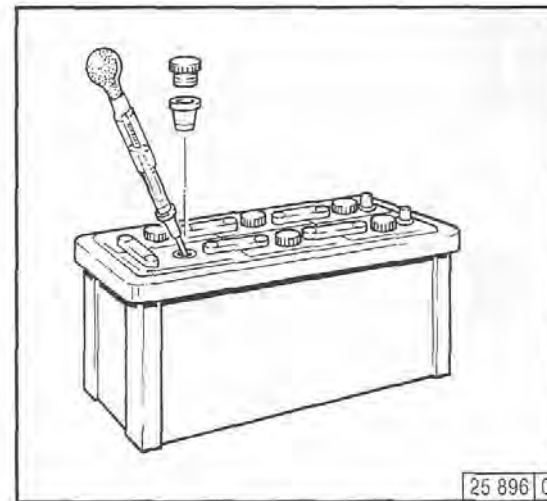
- Keep battery clean and dry.
- Undo dirty clamps.
- Clean terminal posts (+ and -) and clamps of the battery, and grease with acid-free and acid-resistant grease.
- When reassembling, ensure that clamps make good contact. Do up clamp bolts finger tight.

#### 6.7.1.2 Checking Electrolyte Level



- Remove caps 1.
- If testers 2 are used, the electrolyte should come up to their base.
- If testers are not used, the electrolyte level should be 10-15 mm above the top of the plates.
- If necessary, top up with distilled water.
- Replace caps.

#### 6.7.1.3 Checking Electrolyte Density



- Measure the electrolyte density of individual cells with a commercial hydrometer.

The hydrometer reading (see table on following page) indicates the state of charge. During measurement, the temperature of the electrolyte should preferably be +20 °C.



## 6.7 Accessories

## Service and Maintenance

**6**

| in [kg/ l] |         | in[°Bé (Baumégrad) *] |         | State of Charge                  |
|------------|---------|-----------------------|---------|----------------------------------|
| Normal     | Tropics | Normal                | Tropics |                                  |
| 1,28       | 1,23    | 32                    | 27      | Fully charged                    |
| 1,20       | 1,12    | 24                    | 16      | Half charged, recharge           |
| 1,12       | 1,08    | 16                    | 11      | Discharged, recharge immediately |

\* Measurement of electrolyte density in ° Bé (Baumégrad) is out of date and rarely used today.



The gases emitted by the battery are explosive! Keep sparks and naked flames away from the battery. Do not allow battery acid to come into contact with skin or clothing.

Wear protective goggles. Do not rest tools on the battery.



# Service and Maintenance

## 6.7 Accessories

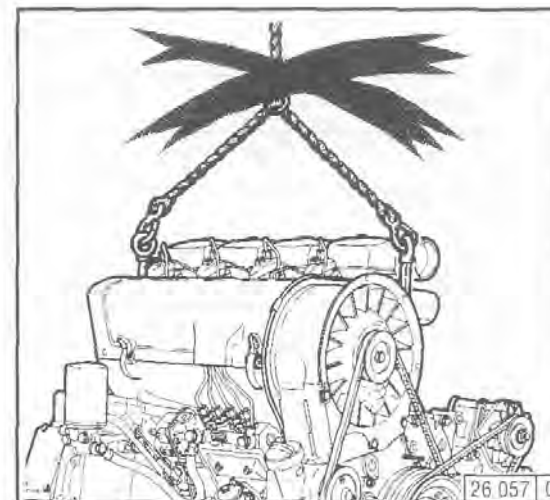
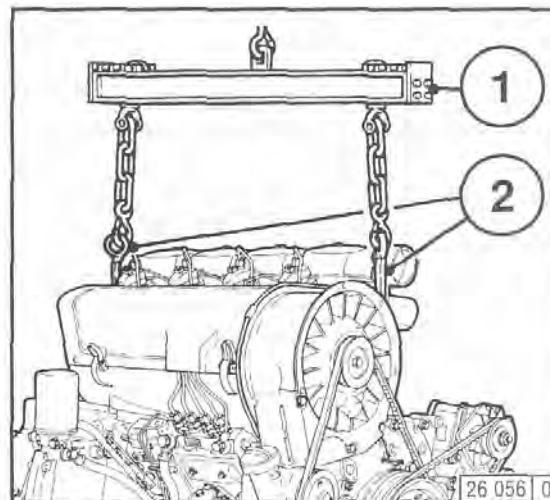
6

### 6.7.2 Three-Phase Alternator

### 6.7.3 Lifting Tackle

#### Notes on the three-phase system:

- Never disconnect the cables between battery, alternator and regulator while the engine is **running**.
- If, however, it is necessary to start and operate the engine without the battery, disconnect the regulator from the alternator before starting.
- Be sure not to confuse the battery terminals.
- Replace defective bulb of the charge pilot lamp immediately.
- When washing the engine, cover up the alternator and regulator.
- The habit of touching a lead against the frame to check whether it is live must under no circumstances be used with three-phase electrical systems.
- In case of electric welding, connect the ground terminal on the welder directly to the piece being welded.



- Always use proper lifting tackle 1 when transporting the engine.
- After transportation and before commissioning of the engine: Remove transport eyes 2.



Use only the correct lifting tackle.



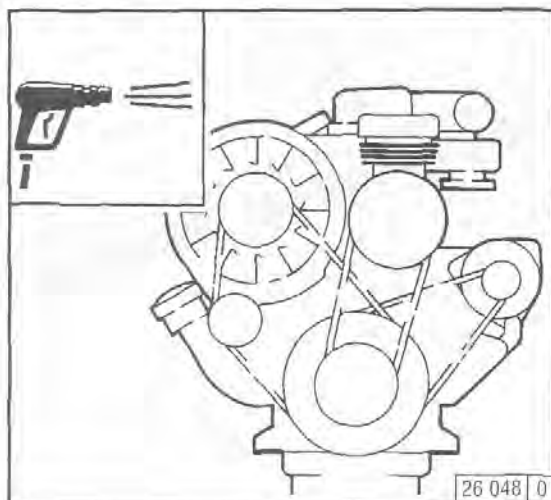
## 6.8 Engine Cleaning

## Service and Maintenance

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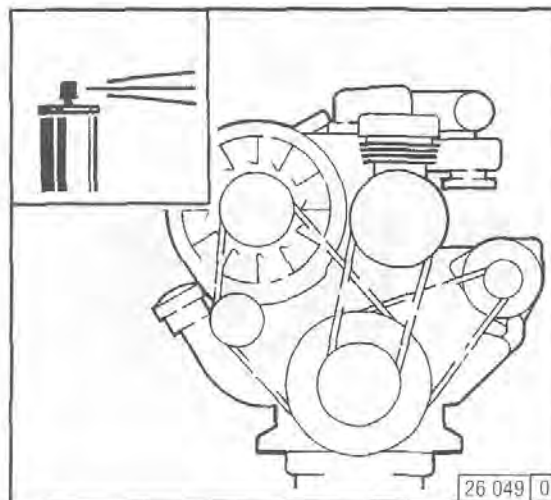
### 6.8.1 Cleaning the Engine

#### With Compressed Air



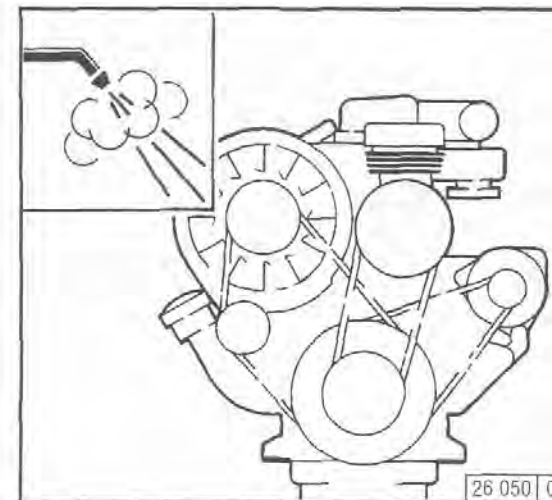
- Switch off the engine.
- Remove engine covers, cooling-air hoods. Replace following cleaning and before test run.
- Cover electrical / electronic components / connections (e.g. alternator, starter, regulator, solenoid).
- Pass compressed air through the engine, being careful with the cooler and cooling fins (start at the exhaust side). Remove dirt which has been blown into the inner compartment.

#### With Cold-Cleaning Compound



- Switch off the engine.
- Remove engine covers, cooling-air hoods. Replace following cleaning and before test run.
- Cover electrical / electronic components / connections (e.g. alternator, starter, regulator, solenoid).
- Spray engine with commercial cold-cleaning compound and leave to work for approx. 10 minutes.
- Spray engine clean with water jet and if necessary repeat procedure.
- Drive the engine warm so that remaining water evaporates.

#### With High-Pressure Equipment



- Switch off the engine.
- Remove engine covers, cooling-air hoods. Replace following cleaning and before test run.
- Cover electrical / electronic components / connections (e.g. alternator, starter, regulator, solenoid).
- Clean engine with steam jet (max. spray pressure 60 bar, max. steam temperature 90 °C)
- Drive the engine warm so that remaining water evaporates.



The engine may only be cleaned when it is at a standstill.

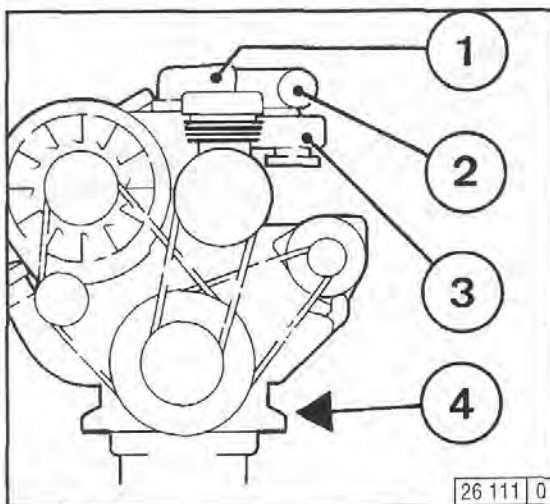


# Service and Maintenance

## 6.9 Additional Maintenance

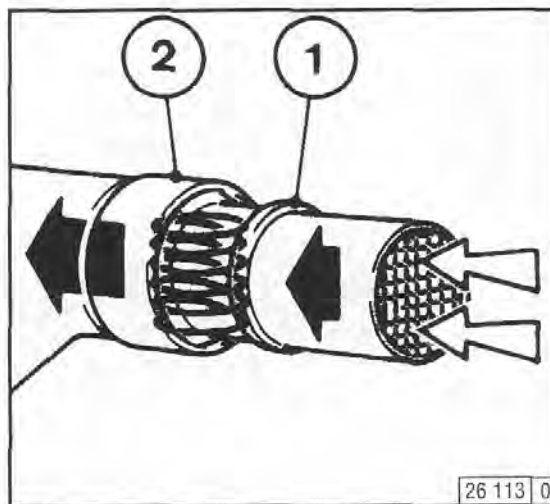
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### 6.9.1 Checking the Mountings



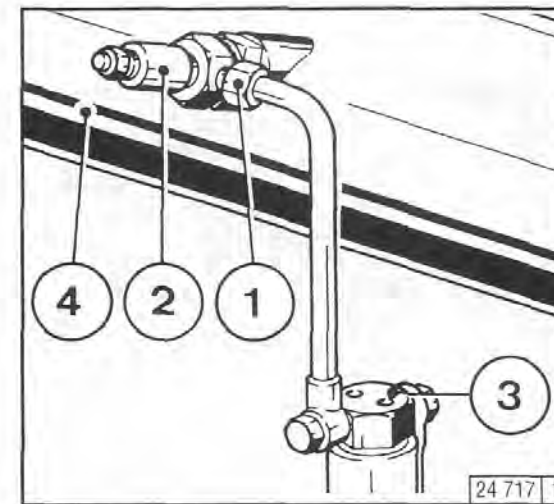
- Cylinder head cover 1
- Air-intake pipe 2
- Coupling sleeves 3
- Exhaust line 3
- Engine mounting 4

### 6.9.2 Checking the Function of the Heating Pipe



- When functioning correctly, the heating pipe heats up via the integrated heating coil when starting with preheating.
  - 1 heating pipe
  - 2 air intake pipe

### 6.9.3 Checking the Function of the Flame Glowing System



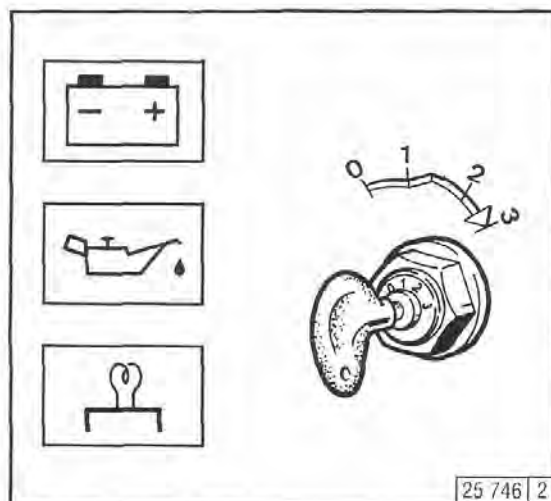
- When functioning correctly, intake pipe 4 heats up in the vicinity of flame glow plug 2 when starting with preheating.



## 6.9 Additional Maintenance

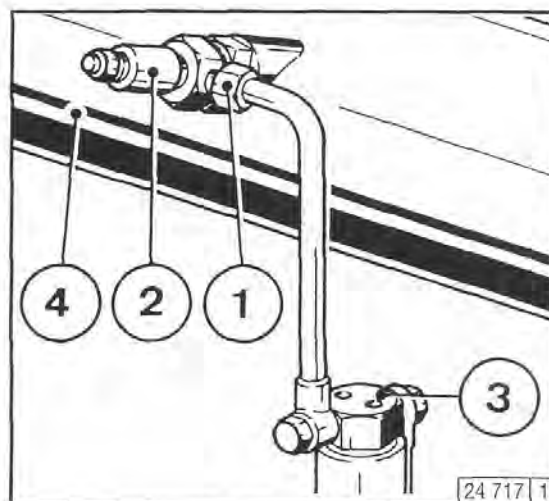
## Service and Maintenance

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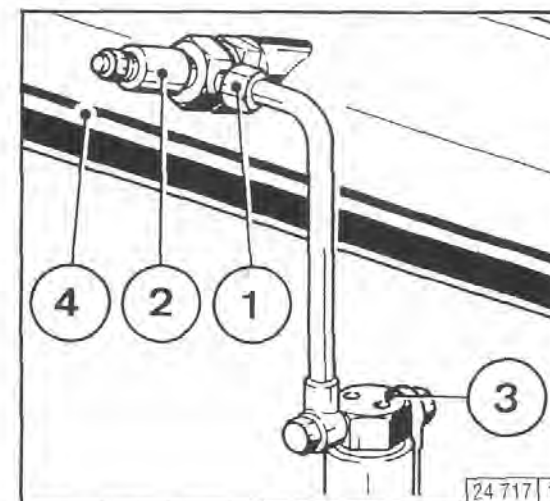
### Test stage 1:

- Move speed adjustment lever and shut-off lever to “stop” position.
- Insert key
  - Position 0 = no operating voltage
- Turn key clockwise.
  - Position 1 = operating voltage
  - Pilot lights come on.
- Press in key and turn further clockwise against the spring pressure.
  - Position 2 = preheat, hold for approx. 1 minute.
  - Preheat lamp lights up.
- Otherwise flame glow plug defective or power interrupted.



### Test stage 2:

- Loosen pipe connection 1.
- Rotate engine with starter, key on switch position 3.
- Fuel must be emitted at loosened pipe connection. Otherwise have the system, solenoid 3, checked by a specialist.



### Test stage 3:

- Loosen pipe connection 1.
  - Remove flame glow plug 2.
  - Rotate engine with starter, key in switch position 3.
  - Fuel must be emitted at flame glow plug 2, replace plug 2 as necessary.
  - Use sealant DEUTZ DW 47 when fitting flame glow plug 2.
  - Refit flame glow plug 2 on fuel line.
- Keep clear of rotating parts.



Collect any leaked fuel and dispose of in an environmentally friendly fashion.



# Faults, Causes and Remedies

---

7

## 7.1 Diagnosis Chart



# Faults, Causes and Remedies

## 7.1 Diagnosis Chart

7

| Fault   |  |   |   |  |   |   |   |   |  | Remedy         |     |
|---|--|---|---|--|---|---|---|---|--|----------------|-----|
| Engine fails or is difficult to start               |  |   |   |  |   |   |   |   |  | Inspect        | I   |
| Engine starts but runs unevenly or stalls           |  |   |   |  |   |   |   |   |  | Adjust         | A   |
| Engine overheats. Temperature monitor gives warning |  |   |   |  |   |   |   |   |  | Replace        | R   |
| Engine gives poor performance                       |  |   |   |  |   |   |   |   |  | Clean          | C   |
| Engine not firing on all cylinders                  |  |   |   |  |   |   |   |   |  | Top up         | T   |
| Engine has little or no oil pressure                |  |   |   |  |   |   |   |   |  | Lower level    | L   |
| Engine oil consumption excessive                    |  |   |   |  |   |   |   |   |  |                |     |
| Engine smokes – blue                                |  |   |   |  |   |   |   |   |  |                |     |
| – white   |  |   |   |  |   |   |   |   |  |                |     |
| – black   |  |   |   |  |   |   |   |   |  |                |     |
| Cause   |  |   |   |  |   |   |   |   |  | Section        |     |
| ●   |  |   |   |  |   |   |   |   | Not declutched (where possible)  | Operation      | I   |
| ●   |  |   |   |  |   |   | ● |   | Below starting limit temperature                                       |                | I   |
| ●   |  |   | ● |  |   |   |   |   | Engine shut-off lever not in stop position (shut-off magnet defective) |                | I   |
|   |  | ● |   |  | ● |   |   |   | Oil level too low  |                | T   |
|   |  | ● | ● |  |   | ● | ● |   | Oil level too high   |                | L   |
|   |  |   |   |  | ● | ● | ● |   | Excessive inclination of engine  |                | I/A |
|   |  |   |   |  |   | ● | ● |   | Engine predominantly operated at lower load                            |                | I   |
| ●   |  | ● | ● |  |   | ● | ● | ● | Air cleaner clogged / turbocharger defective                           | Combustion air | R   |
|   |  | ● | ● |  |   |   |   | ● | Air cleaner service switch / indicator defective                       |                | I/R |
|   |  |   | ● |  |   |   |   |   | LDA defective (leak in connecting line) only with charged engines      |                | I/R |
|   |  | ● | ● |  |   |   |   | ● | Exhaust counter pressure too high                                      |                | I   |
|   |  |   | ● |  |   |   |   | ● | Charge-air line leaking, only with charged engines                     |                | I/A |
|   |  | ● |   |  |   |   |   |   | Charge-air line leaking, only with charged engines                     | Cooling system | I/C |
|   |  | ● | ● |  |   |   |   | ● | Charge air cooler clogged  |                | I/C |
|   |  | ● |   |  | ● |   |   |   | Oil cooler air and/or oil side clogged                                 |                | I/C |
|   |  | ● |   |  |   |   |   |   | Cooling fan or exhaust thermostat defective, V-belts ripped or loose   |                | I/R |
|   |  | ● |   |  |   |   |   |   | Cooling air temperature rise / heating short circuit                   |                | I   |
|   |  | ● |   |  |   |   |   |   | Cooling air fins loose, cracked or missing                             | I              |     |



## 7.1 Diagnosis Chart

## Faults, Causes and Remedies

7

| Fault   |   |   |   |   |   |   |   |   |   | Remedy  |        |       |
|---|---|---|---|---|---|---|---|---|---|---|--------|-------|
| Engine fails or is difficult to start               |   |   |   |   |   |   |   |   |   | Inspect   | I      |       |
| Engine starts but runs unevenly or stalls           |   |   |   |   |   |   |   |   |   | Adjust  | A      |       |
| Engine overheats. Temperature monitor gives warning |   |   |   |   |   |   |   |   |   | Replace   | R      |       |
| Engine gives poor performance                       |   |   |   |   |   |   |   |   |   | Clean   | C      |       |
| Engine not firing on all cylinders                  |   |   |   |   |   |   |   |   |   | Top up  | T      |       |
| Engine has little or no oil pressure                |   |   |   |   |   |   |   |   |   | Lower level                                     | L      |       |
| Engine oil consumption excessive                    |   |   |   |   |   |   |   |   |   |   |        |       |
| Engine smokes – blue                                |   |   |   |   |   |   |   |   |   |   |        |       |
| – white   |   |   |   |   |   |   |   |   |   |   |        |       |
| – black   |   |   |   |   |   |   |   |   |   |   |        |       |
| Cause   |   |   |   |   |   |   |   |   |   | Section   |        |       |
| ●   |   |   |   |   |   |   |   |   | Battery defective or discharged   | Electrics                                       | I      |       |
| ●   |   |   |   |   |   |   |   |   | Electric cable connections to starter electrical system loose or oxidised |   | I      |       |
| ●   |   |   |   |   |   |   |   |   | Starter defective or pinion does not engage                               |   | I      |       |
|   |   |   |   |   | ● |   |   |   | Oil pressure switch/oil pressure gauge defective                          |   | I/R    |       |
| ●   | ● | ● | ● | ● |   |   |   | ● | ●   | Incorrect valve clearance                       | Engine | A     |
| ●   | ● |   | ● | ● |   |   |   |   |   | Leaking injection line                          |        | I/C   |
|   |   | ● |   |   |   |   |   |   |   | Vent line clogged                               |        | I/C   |
| ●   | ● |   |   |   |   |   |   | ● |   | Flame glow system/heating pipe defective        |        | I/R   |
| ●   | ● | ● | ● | ● |   |   |   | ● | ●   | Injection valve defective                       |        | I/R   |
| ●   | ● |   | ● | ● |   |   |   |   |   | Air in fuel system                              |        | P/R   |
| ●   | ● |   | ● | ● |   |   |   |   |   | Fuel filter/fuel precleaner clogged             |        | I/C/R |
|   |   | ● |   |   |   | ● |   |   |   | Oil filter defective                            |        | R     |
| ●   |   |   |   |   | ● | ● |   |   |   | Incorrect SAE class or grade of engine lube oil |        | R     |
| ●   | ● |   | ● | ● |   |   |   | ● | ●   | Compression pressure too low                    |        | I     |
|   |   |   |   |   |   |   | ● |   |   | Oil in combustion chamber                       | I/C    |       |
|   |   |   |   |   |   |   |   |   |   |   |        |       |



# Engine Preservation

---

8

## 8.1 Preservation



# Engine Preservation

## 8.1 Preservation

### 8

#### 8.1 Preservation

If the engine is to remain idle for an extended period of time, it is necessary to take protective measures to prevent rust formation. The preservative measures described here will protect the engine for up to 6 month. The procedure will have to be reversed before the engine is recommissioned.

- Anti-corrosion oils to specification:
  - MIL-L-21260B
  - TL 9150-037/2
  - Nato Code C 640 / 642
- Recommended cleansing agent to remove preservatives when recommissioning engine:
  - Petroleum benzine (hazardous materials class A3)

#### 8.1.1 Preserving Engine

- Clean engine (with cold cleansing agent if preferred) using high pressure equipment.
- Run engine until warm, then turn off.
- Drain engine oil, see 6.1.2, and fill with anti-corrosion oil.
- If necessary, clean oil bath cleaner, see 6.4.3, and fill with anti-corrosion oil.
- Drain fuel from tank.
- Make up a mixture of 90% diesel fuel and 10% anti-corrosion oil, and refill fuel tank.
- Run engine for about 10 minutes.
- Turn engine off.
- Turn engine over manually several times to preserve the cylinders and combustion chamber. When rotating with starter, place shut-off lever in stop position.
- Remove V-belts and store dry in wrapped condition.
- Spray grooves on V-belt pulleys with anti-corrosion spray.
- Close off intake ports and exhaust ports.

#### 8.1.2 Removing Engine Preservatives

- Remove anti-corrosion agent from grooves in V-belt pulleys.
- Install V-belts. Retension after brief operation if necessary, see 6.5
- Remove plugs from intake port and exhaust port.
- Set the engine in operation.



# Technical Specifications

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## 9

- 9.1 Engine Specifications and Settings**
- 9.2 Torque Wrench Settings**
- 9.3 Tools**



# Technical Specifications

## 9.1 Engine Specifications and Settings

9

| Model   | F3L 912                                 | F4L 912            | F5L 912            | F6L 912            |
|---|---|--------------------|--------------------|--------------------|
| Numbers of cylinders  | 3                                       | 4                  | 5                  | 6                  |
| Cylinder arrangement  |   |                    | vertical in line   |                    |
| Bore [mm]   |   |                    | 100                |                    |
| Stroke [mm]   |   |                    | 120                |                    |
| Total displacement [cm <sup>3</sup> ]   | 2827                                    | 3770               | 4712               | 5655               |
| Compression ratio [ε]   |   |                    | 19                 |                    |
| Working cycle   | 4-stroke diesel induction engine        |                    |                    |                    |
| Combustion system   | direct injection                        |                    |                    |                    |
| Direction of rotation   | counterclockwise                        |                    |                    |                    |
| Weight incl. integrated cooling system as per DIN 70020-A (without starter, with alternator) [ca. kg] | 270 <sup>5)</sup>                       | 300 <sup>5)</sup>  | 380 <sup>5)</sup>  | 410 <sup>5)</sup>  |
| Engine power [kW (PS)]  |   |                    | 1)                 |                    |
| Speed [1/min]   |   |                    | 1)                 |                    |
| Lubrication   | pressure lubrication                    |                    |                    |                    |
| SAE oil   | 15W 40                                  |                    |                    |                    |
| Oil temperature in oil pan [°C]   | 125                                     |                    |                    |                    |
| Min. oil pressure in warm condition (120 °C) at low idling speed / rated speed [bar]                  | 0,4 <sup>4)</sup>                       |                    |                    |                    |
| Oil change quantity without filter [ca. ltr.]   | 9,0 <sup>3)</sup>                       | 12,0 <sup>3)</sup> | 13,5 <sup>3)</sup> | 14,5 <sup>3)</sup> |
| Oil change quantity with filter [ca. ltr.]  | 9,5 <sup>3)</sup>                       | 12,5 <sup>3)</sup> | 14,0 <sup>3)</sup> | 15,5 <sup>3)</sup> |
| Valve clearance with cold engine [mm]   | inlet 0.15 + 0.05 / exhaust 0.15 + 0.05 |                    |                    |                    |
| Opening pressure of the injection valve [bar]   | 250 +8                                  |                    |                    |                    |
| Start of delivery [°crank angle b TDC]  | 1)                                      |                    |                    |                    |
| Firing order  | 1-2-3                                   | 1-3-4-2            | 1-2-4-5-3          | 1-5-3-6-2-4        |
| V-belt pressure: pretension / tighten   | preload / torquing load <sup>2)</sup>   |                    |                    |                    |
| Alternator fan [N]  | 450 / 300 ± 20                          |                    |                    |                    |
| Compressor [N]  | 550 / 400 ± 20                          |                    |                    |                    |

1) Engine power, speed, start of delivery are stamped on engine rating plate, see also 2.1

2) Tighten after 15 minutes, after the engine has been driven under load.

3) Ca. value can vary depending on model. **The upper oil dipstick marking should always be taken as authoritative.**

4) Values for engines without engine oil heating.

5) Ca. value can vary depending on oil pan design.



## 9.1 Engine Specifications and Settings

## Technical Specifications

9

| Model   | F3L 913                                 | F4L 913            | F6L 913            |
|---|---|--------------------|--------------------|
| Numbers of cylinders  | 3                                       | 4                  | 6                  |
| Cylinder arrangement  |   | vertical in line   |                    |
| Bore [mm]   |   | 102                |                    |
| Stroke [mm]   |   | 125                |                    |
| Total displacement [cm <sup>3</sup> ]   | 3064                                    | 4086               | 6128               |
| Compression ratio [ε]   |   | 19                 |                    |
| Working cycle   | 4-stroke diesel induction engine        |                    |                    |
| Combustion system   | direct injection                        |                    |                    |
| Direction of rotation   | counterclockwise                        |                    |                    |
| Weight incl. integrated cooling system as per DIN 70020-A (without starter, with alternator) [ca. kg] | 277 <sup>4)</sup>                       | 320 <sup>4)</sup>  | 420 <sup>4)</sup>  |
| Engine power [kW (PS)]  |   | 1)                 |                    |
| Speed [1/min]   |   | 1)                 |                    |
| Lubrication   | pressure lubrication                    |                    |                    |
| SAE oil   | 15W 40                                  |                    |                    |
| Oil temperature in oil pan [°C]   | 125                                     |                    |                    |
| Min. oil pressure in warm condition (120 °C) at low idling speed / rated speed [bar]                  | 0,4 <sup>4)</sup>                       |                    |                    |
| Oil change quantity without filter [ca. ltr.]   | 8,0 <sup>3)</sup>                       | 12 <sup>3)</sup>   | 16,5 <sup>3)</sup> |
| Oil change quantity with filter [ca. ltr.]  | 9,5 <sup>3)</sup>                       | 13,5 <sup>3)</sup> | 18,5 <sup>3)</sup> |
| Valve clearance with cold engine [mm]   | inlet 0.15 + 0.05 / exhaust 0.15 + 0.05 |                    |                    |
| Opening pressure of the injection valve [bar]   | 250 + 8                                 |                    |                    |
| Start of delivery [°crank angle b TDC]  | 1)                                      |                    |                    |
| Firing order  | 1-2-3                                   | 1-3-4-2            | 1-5-3-6-2-4        |
| V-belt pressure: pretension / tighten   | preload / torquing load <sup>2)</sup>   |                    |                    |
| Alternator fan [N]  | 450 / 300 ± 20                          |                    |                    |
| Compressor [N]  | 550 / 400 ± 20                          |                    |                    |

1) Engine power, speed, start of delivery are stamped on engine rating plate, see also 2.1

2) Tighten after 15 minutes, after the engine has been driven under load.

3) Ca. value can vary depending on model. **The upper oil dipstick marking should always be taken as authoritative.**

4) Ca. value can vary depending on oil pan design.



# Technical Specifications

## 9.1 Engine Specifications and Settings

| Model 913/C/CT  | F3L 913W          | F4L 912W                                | F6L 912W           |
|---|-------------------|---|--------------------|
| Numbers of cylinders  | 3                 | 4                                       | 6                  |
| Cylinder arrangement  |                   | vertical in line                        |                    |
| Bore [mm]   |                   | 102                                     |                    |
| Stroke [mm]   |                   | 125                                     |                    |
| Total displacement [cm <sup>3</sup> ]   | 3064              | 4086                                    | 6128               |
| Compression ratio [ε]   |                   | 22                                      |                    |
| Working cycle   |                   | 4-stroke diesel induction engine        |                    |
| Combustion syst   |                   | direct injection                        |                    |
| Direction of rotation   |                   | counterclockwise                        |                    |
| Weight incl. integrated cooling system as per DIN 70020-A (without starter, with alternator) [ca. kg] | 270 <sup>4)</sup> | 300 <sup>4)</sup>                       | 410 <sup>4)</sup>  |
| Engine power [kW (PS)]  |                   | 1)                                      |                    |
| Speed [1/min]   |                   | 1)                                      |                    |
| Lubrication   |                   | pressure lubrication                    |                    |
| SAE oil   |                   | 15W 40                                  |                    |
| Oil temperature in oil pan [°C]   |                   | 125                                     |                    |
| Min. oil pressure in warm condition (120 °C) at low idling speed / rated speed [bar]                  |                   | 0,4 <sup>4)</sup>                       |                    |
| Oil change quantity without filter [ca. ltr.]   | 8,0 <sup>3)</sup> | 12 <sup>3)</sup>                        | 16,5 <sup>3)</sup> |
| Oil change quantity with filter [ca. ltr.]  | 9,5 <sup>3)</sup> | 13,5 <sup>3)</sup>                      | 18,5 <sup>3)</sup> |
| Valve clearance with cold engine [mm]   |                   | inlet 0.15 + 0.05 / exhaust 0.15 + 0.05 |                    |
| Opening pressure of the injection valve [bar]   |                   | 120 + 10                                |                    |
| Start of delivery [°crank angle b TDC]  |                   | 1)                                      |                    |
| Firing order  | 1-2-3             | 1-3-4-2                                 | 1-5-3-6-2-4        |
| V-belt pressure: pretension / tighten   |                   | preload / torquing load <sup>2)</sup>   |                    |
| Alternator fan [N]  |                   | 450 / 300 ± 20                          |                    |
| Compressor [N]  |                   | 550 / 400 ± 20                          |                    |

1) Engine power, speed, start of delivery are stamped on engine rating plate, see also 2.1

2) Tighten after 15 minutes, after the engine has been driven under load.

3) Ca. value can vary depending on model. **The upper oil dipstick marking should always be taken as authoritative.**

4) Ca. value can vary depending on oil pan design.



## 9.1 Engine Specifications and Settings

## Technical Specifications

9

| Model 913/C/CT  | BF4L 913                                      | BF6L 913           | BF6L 913 C         |
|---|---|--------------------|--------------------|
| Numbers of cylinders  | 4   | 6                  | 6                  |
| Cylinder arrangement  |   | vertical in line   |                    |
| Bore [mm]   |   | 102                |                    |
| Stroke [mm]   |   | 125                |                    |
| Total displacement [cm <sup>3</sup> ]   | 4086  | 6128               | 6128               |
| Compression ratio [ε]   | 18  | 18                 | 17                 |
| Working cycle   | supercharged 4-stroke diesel induction engine |                    |                    |
| Combustion syst   | direct injection                              |                    |                    |
| Direction of rotation   | counterclockwise                              |                    |                    |
| Weight incl. integrated cooling system as per DIN 70020-A (without starter, with alternator) [ca. kg] | 360 <sup>3)</sup>                             | 485 <sup>5)</sup>  | 510 <sup>5)</sup>  |
| Engine power [kW (PS)]  |   | 1)                 |                    |
| Speed [1/min]   |   | 1)                 |                    |
| Lubrication   | pressure lubrication                          |                    |                    |
| SAE oil   | 15W 40  |                    |                    |
| Oil temperature in oil pan [°C]   | 125   |                    |                    |
| Min. oil pressure in warm condition (120 °C) at low idling speed / rated speed [bar]                  | 0,5 <sup>4)</sup>                             |                    |                    |
| Oil change quantity without filter [ca. ltr.]   | 9,5 <sup>3)</sup>                             | 16,0 <sup>3)</sup> | 16,0 <sup>3)</sup> |
| Oil change quantity with filter [ca. ltr.]  | 11,5 <sup>3)</sup>                            | 18,2 <sup>3)</sup> | 18,2 <sup>3)</sup> |
| Valve clearance with cold engine [mm]   | inlet 0.15 + 0.05 / exhaust 0.15 + 0.05       |                    |                    |
| Opening pressure of the injection valve [bar]   | 250 + 8                                       |                    |                    |
| Start of delivery [°crank angle b TDC]  | 1)  |                    |                    |
| Firing order  | 1-3-4-2                                       | 1-5-3-6-2-4        | 1-5-3-6-2-4        |
| V-belt pressure: pretension / tighten   | preload / torquing load <sup>2)</sup>         |                    |                    |
| Alternator fan [N]  | 450 / 300 ± 20                                |                    |                    |
| Compressor [N]  | 550 / 400 ± 20                                |                    |                    |

1) Engine power, speed, start of delivery are stamped on engine rating plate, see also 2.1

2) Tighten after 15 minutes, after the engine has been driven under load.

3) Ca. value can vary depending on model. **The upper oil dipstick marking should always be taken as authoritative.**

4) Values for engines without engine oil heating.

5) Ca. value can vary depending on oil pan design.



# Technical Specifications

## 9.1 Engine Specifications and Settings

9

| Location                             | Preload<br>[Nm] | Torquing load |           |           |           | Total       | Remarks   |
|--------------------------------------|-----------------|---------------|-----------|-----------|-----------|-------------|-----------|
|                                      |                 | 1st stage     | 2nd stage | 3rd stage | 4th stage |             |           |
| Alternator mounting                  | 20              | 180°          | —         | —         | —         | 180°        | M10 x 180 |
|                                      | 30              | 180°          | —         | —         | —         | 180°        | M14 x 230 |
| Cylinder head cover                  | —               | —             | —         | —         | —         | 12 ± 1,2 Nm | —         |
| Rocker arm set screw                 | —               | —             | —         | —         | —         | 22 ± 2 Nm   | —         |
| Support foot                         | 30              | 15°           | 60°       | —         | —         | 75°         | M14 x 100 |
|                                      | 30              | 45°           | 60°       | —         | —         | 105°        | M14 x 110 |
|                                      | 30              | 45°           | 60°       | —         | —         | 105°        | M14 x 125 |
| Air intake manifold                  | —               | —             | —         | —         | —         | 22 ± 2 Nm   | —         |
| Exhaust manifold                     | —               | —             | —         | —         | —         | 40 ± 4 Nm   | —         |
| Oil drain plug – cast iron oil pan   | —               | —             | —         | —         | —         | 150 ± 10 Nm | M22 x 1,5 |
| Oil drain plug – sheet metal oil pan | —               | —             | —         | —         | —         | 100 ± 10 Nm | M30 x 1,5 |
| Injection valve mounting             | —               | —             | —         | —         | —         | 25–30 Nm    | —         |

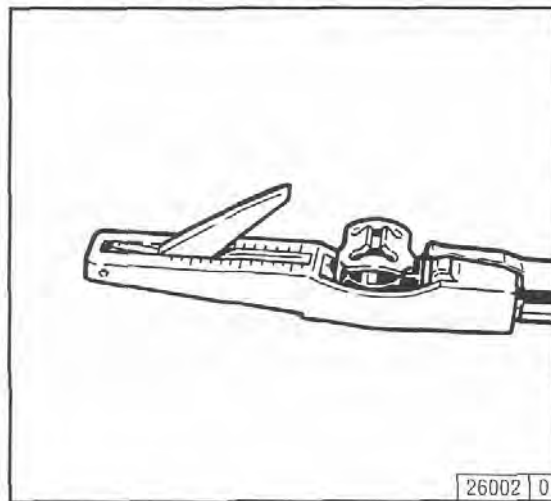


## 9.1 Engine Specifications and Settings

## Technical Specifications

**9**

### V-belt Tension Gauge



The V-belt tension gauge can be obtained under order number **8115** from:

**COMPANY WILBÄR**  
Postfach 14 05 80  
D-42826 Remscheid



# Notes

9

## CALIFORNIA PROPOSITION 65 INFORMATION

### TO CALIFORNIA CUSTOMERS AND TO CUSTOMERS SELLING DIESEL ENGINE EQUIPMENT INTO OR FOR USE IN CALIFORNIA.

Proposition 65, a California law, requires warnings on products which expose individuals in California to chemicals listed under that law, including certain chemicals in diesel engine exhaust.

**Obligations of Manufactures of Diesel-Powered Off-Road Equipment.** The California Superior Court has approved either of the following two methods of compliance with Proposition 65 requirements by manufactures of off-road equipment containing diesel engines. (The court order containing these provisions is attached.)

1. **On-Equipment Warning.** Place the warning pictured in attachment 1 on all equipment shipped by you into or for sale in California after January 1, 1996. The warning must be in a location where it is easily visible to the operator of the equipment when (s)he is operating the equipment. The warning must be secured to the equipment. If warnings or operating instructions are provided through a digital display, you may use that method of providing warning.
2. **Operator Manual Warning.** When the operator manual is next revised or by December 31, 1995 whichever is earlier, place the warning in attachment 2 in the operator manual. The warning may be either printed in the manual or on a sticker.

The warning must appear in one of the following locations:

- Inside The front cover
- Inside the back cover
- Outside the front cover
- Outside the back cover
- As the first page of text

Under either alternative, the warning must appear in the same size, print and format as the attachment selected or be of an equally conspicuous size and format. If the warning is provided in an on-screen display, the warning must contain the language in the attachment and must be provided at the time of or in connection with ignition in the same manner as other safety warnings electronically communicated on screen.

**Obligation of Resellers of Diesel Engines.** This letter must accompany any loose diesel engine sold in California. Should you have any questions, please call Deutz Corporation Product Support Department.



Warnings to Place on Equipment

Warning in the Manual

**CALIFORNIA**

**Proposition 65 Warning**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

**CALIFORNIA**

**Proposition 65 Warning**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

or

**CALIFORNIA**

**Proposition 65 Warning**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.



# Notes

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# SP181

## Section 3 - Deutz Spare Parts Manual



Spare Parts Catalogue

F3-6L 912/W  
+ E-Pac

Dealer's stamp

0297 7572

Engine  
Serial No:

|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|

Please enter here the serial No. of your engine. This will facilitate dealing with your questions concerning after-sales service, repair and spare parts.

This Spare Parts Catalogue is subject to engineering changes necessary for engine advancement. All rights reserved. No part of this publication may be reproduced or multiplied in any form, without our prior permission in writing.





# Preface

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Dear Customer,

aircooled DEUTZ diesel engines are developed to meet the requirements of a wide range of applications. An extensive program of variant options gives them their high flexibility.

Your engine is custom-made, i.e. specifically equipped for your requirement, which means that not all of the components and assemblies contained in this Catalogue are fitted to your engine.

The greater part of the illustrations does not depict all details, and yet you will find it easy to differentiate between versions and thus to identify the parts pertaining to your engine model. **Fig. Item No., Assembly Group No. Engine Serial No.** are the codes that infallibly lead to selection of the correct parts.

When placing your order, please observe our ordering hints. This will allow speedy and reliable delivery of the required parts that are based on latest engineering standards.

If there are any questions, please do not hesitate to contact us.

Sincerely,  
**DEUTZ AG**



# Preface

## DEUTZ Diesel Engines

are products based on long-standing research and development. The deep funds of acquired know-how in conjunction with high quality requirements guarantee that engines leaving our works achieve a long life, high reliability and excellent fuel economy. Naturally, they also attain best ratings as regards environmental protection.

## Genuine DEUTZ Parts

are subject to equally stringent quality requirements as the engines themselves. Improvements in engine design certainly also pass into the genuine DEUTZ parts. To ensure that your engine will retain its functions and high reliability, you should use genuine DEUTZ parts only.

## DEUTZ Exchange Components



components equal genuine DEUTZ parts.

are a cheap alternative. Of course, they are subject to the same high quality requirements as new parts. And as regards functions and reliability, DEUTZ exchange

## SERVICE

In case of operational trouble with your equipment or queries about spare parts please turn to your nearest service dealership. Our skilled staff of service experts will trace and remedy any defect quickly, using genuine DEUTZ parts.

## Beware of the Running Engine

Be sure to shut down the engine before performing maintenance or repair work. After repair, put back in place any removed panels and guards. When doing work on the running engine, working clothes should fit tightly so that loose ends cannot get caught. Do not run the engine in enclosed rooms – poison hazard.

## Asbestos

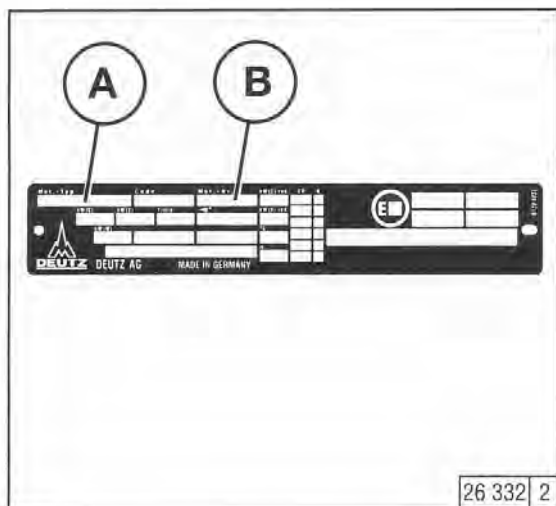


Gaskets used for this engine do not contain asbestos. Please use suitable spare parts when carrying out maintenance and repair work.



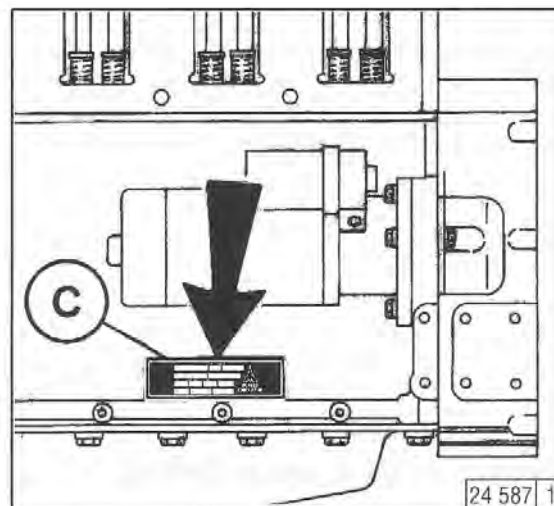
# Description of Engine

## 1. Maker's Nameplate



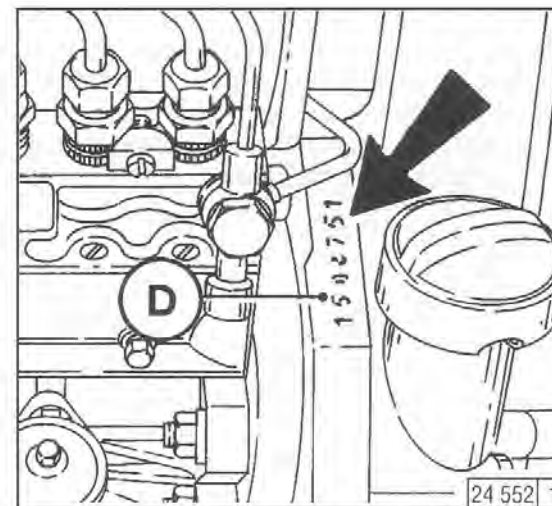
Engine model designation **A**, Engine Ser. No. **B** and the power rating are given on the maker's nameplate. Be sure to state engine model and engine serial number when writing out a parts order.

## 2. Position of Nameplate



The nameplate **C** is attached to the crankcase.

## 3. Engine Serial No.



The engine serial No. **D** is stamped on the crankcase and also on the nameplate.



# Ordering spare parts

## Order information

Please specify the following information when ordering original DEUTZ parts:

- Engine no.
- Ident. no.
- Quantity

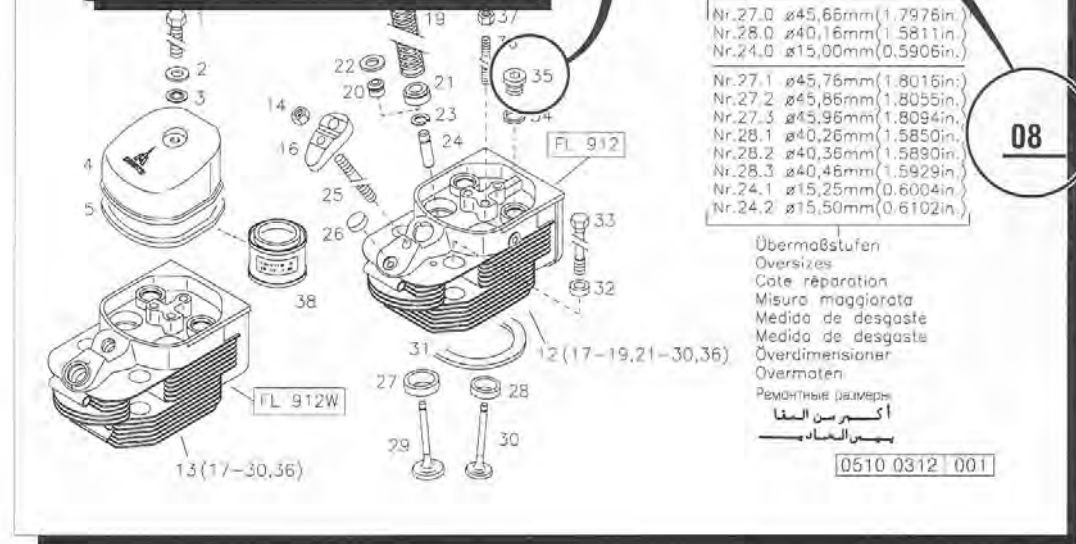
## Document structure

- The picture diagrams in this spare parts list are sorted according to engine assembly groups.
- Each section is preceded by an overview of the assembly groups.
- The ident. no. **08/35** is made up of the assembly group (e.g. **08**) and item number (e.g. **35**).

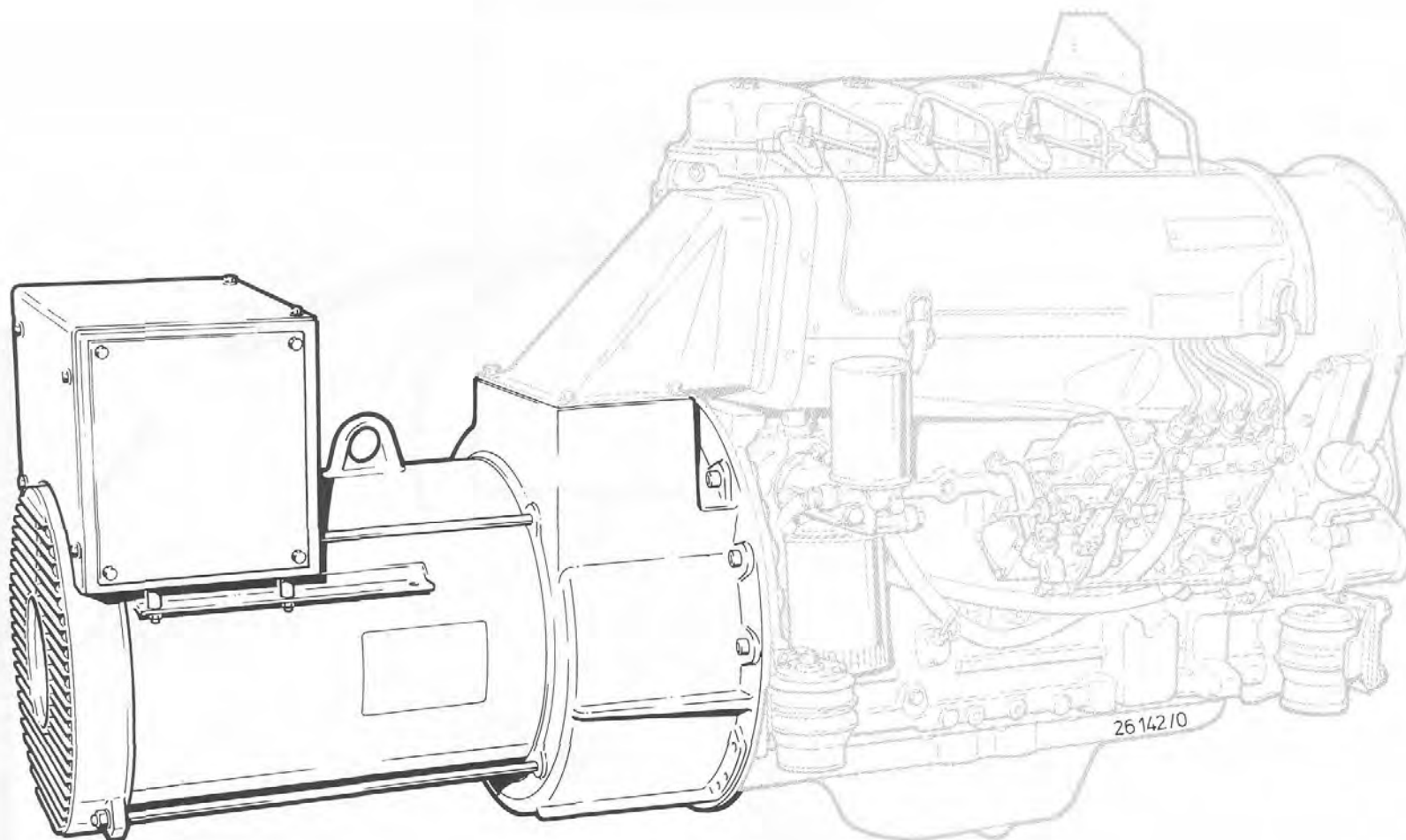
## Ordering spare parts

Engine no.: 6 766 956

| Item | Qty. | Ident. no. | Comments |
|------|------|------------|----------|
| 1.   | 1    | 01/ 2      |          |
| 2.   | 4    | 08/35      |          |
| 3.   | 1    | 15/ 6      |          |
|      |      |            |          |
|      |      |            |          |









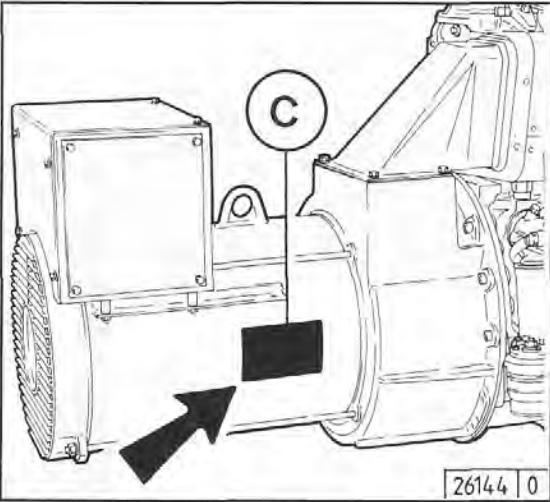
# Description of Generator

## 1. Maker's Nameplate



The model designation **A**, the generator serial number **B** and the performance data are stamped on the maker's nameplate. When ordering spare parts, it is essential to quote the model designation, the engine serial number and the generator serial number.

## 2. Position of Nameplate



The nameplate **C** is attached to the stator housing.



# Service

## Knowing it's DEUTZ

DEUTZ has always stood for excellence in motor construction, pioneering many developments in the industry. As an independent motor manufacturer, we offer — worldwide — a comprehensive range of diesel and gas motors spanning from 4kW to 7,400kW. Our products are perfectly tailored to meet our customers' individual requirements.

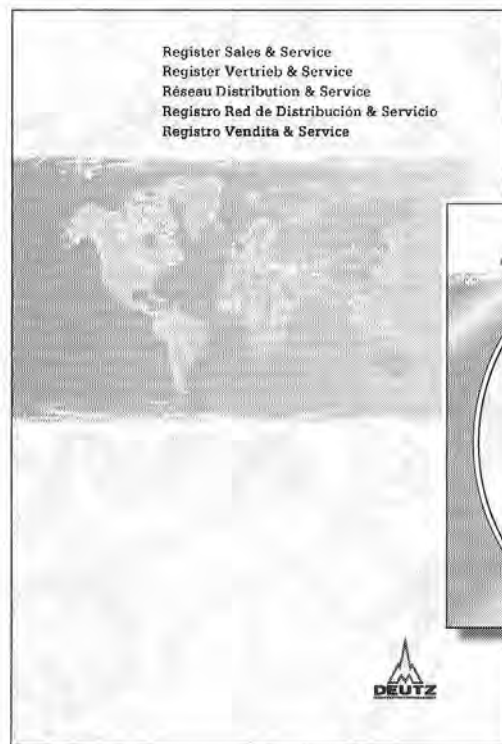
Over 1.4 million DEUTZ motors do their job reliably all over the world. We are determined to preserve the high standard of performance and dependability of our motors, thus keeping our customers satisfied at all times. Therefore we are represented worldwide through a network of highly competent service partners who will meet the needs of our customers, wherever they are.

This is why DEUTZ is not only the name for motors which pack a lot of inventive genius. DEUTZ also means reliable service and comprehensive support to enhance your motor's performance.

This index Sales & Service offers you an overview of the DEUTZ partners in your vicinity, including the products for which they are responsible and the range of services provided. But even when no direct product responsibility is mentioned, your DEUTZ partner will be happy to help you with expert advice.

The Index is constantly updated. Please ask your DEUTZ service partner for the latest edition.

DEUTZ AG — at your service.



Order-No.: 0297 7444



Order-No.: 0297 7445 (CD-ROM)

Obtainable from the local service Partner responsible for you or from:

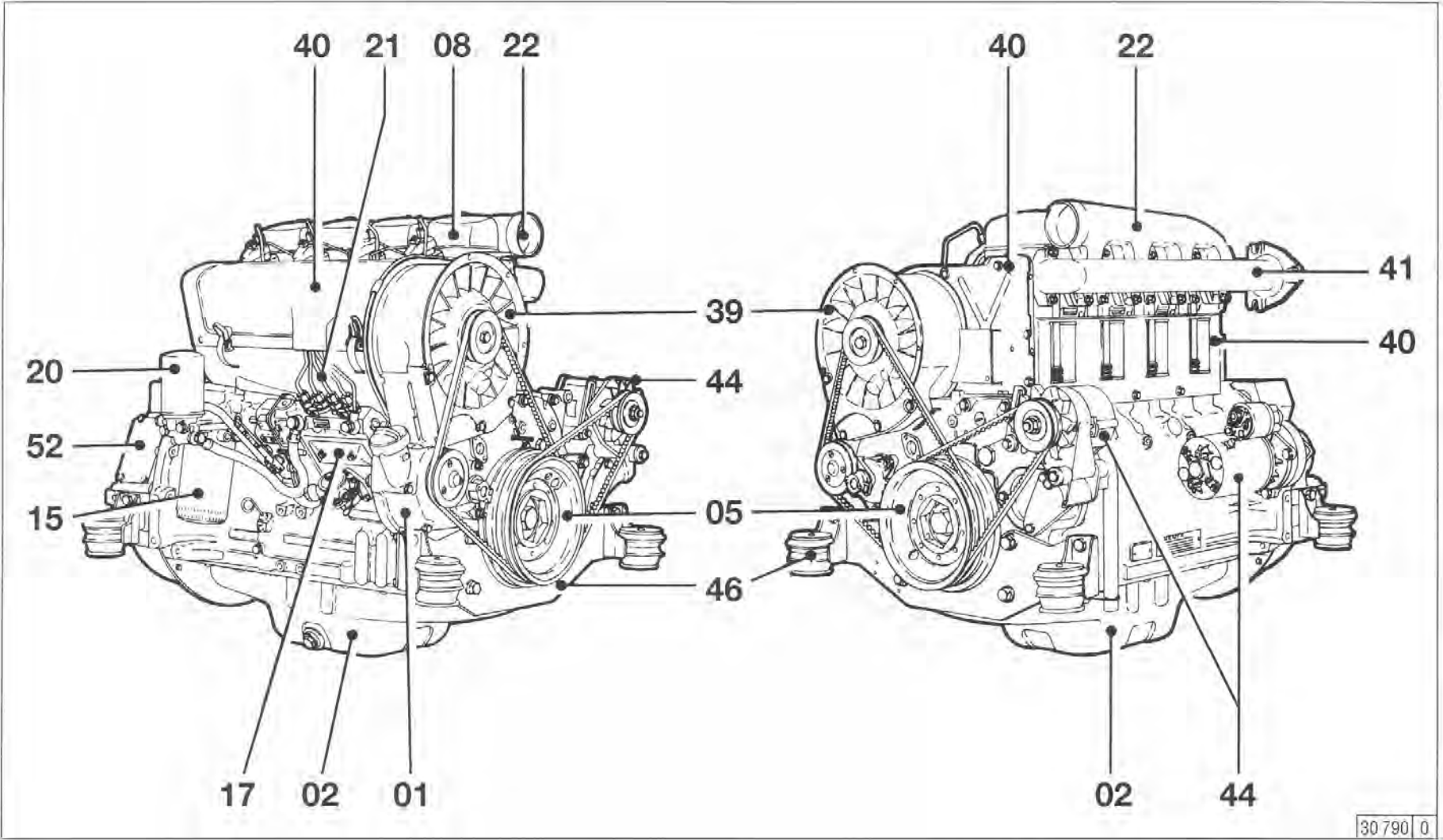
DEUTZ AG  
Deutz-Mülheimer Str. 147-149  
D-51057 Köln

Phone: 0049-221-822-0  
Telefax: 0049-221-822-5304  
Telex: 8812-0 khd d  
<http://www.deutz.de>



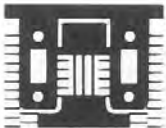


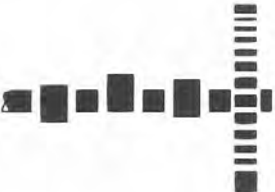




**Bildtafeln**  
**Illustrations**  
**Figures**  
**Grabados**  
**Quadros de figuras**  
**Tavole**  
**Afbeeldingen**  
**Planscher**  
**Illustrationer**  
**Kuvat**  
**Bilder**  
**Διαγράμματα**  
**Иллюстрации**  
**الرسوم والأشكال التوضيحية**







|    |   |    |   |    |   |
|----|---|----|---|----|---|
| 01 |    | 05 |     | 08 |  |
| 02 |    | 06 |    | 10 |  |
| 04 |  | 07 |  |    |   |



Exploded view diagram of a mechanical assembly, likely a pump or engine component. The diagram shows various parts numbered 1 through 81, along with a can of DW 49 grease and a bottle of DW 55 oil. The assembly is shown in a disassembled state, with parts arranged around a central base. The diagram includes labels for different part numbers and their corresponding positions. A note at the bottom right indicates "15 (10-13, 17, 19-22, 24, 43-47, 50, 51, 355)".

Key components and labels visible in the diagram include:

- Part numbers: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81.
- Grease can: DW 49 (1000 1204)
- Oil bottle: DW 55 (1000 1251)
- Assembly note: 15 (10-13, 17, 19-22, 24, 43-47, 50, 51, 355)

Page 94 of 393



**01**

|              |  |   |
|--------------|--|---|
| Nr.16        | <div> <div>Normal</div> <div>Номинальный размер</div> <div>عادي</div> </div> <div>70,00mm Ø (2.7559 in.)</div>   |   |
| Nr.16/1      | <div> <div>Untermaßstufen</div> <div>Undersizes</div> <div>Cote réparation</div> <div>Misura minorata</div> <div>Medida de desgaste</div> <div>Medida de desgaste</div> <div>Underdimensioner</div> <div>Ondermaten</div> <div>Ремонтные размеры</div> </div> <div> <div>69,75mm Ø (2.7459 in.)</div> <div>69,50mm Ø (2.7362 in.)</div> <div>69,25mm Ø (2.7263 in.)</div> <div>69,00mm Ø (2.7165 in.)</div> <div>68,75mm Ø (2.7066 in.)</div> <div>68,50mm Ø (2.6968 in.)</div> </div> | <div> <div>für Lagerzapfen</div> <div>for bearing journal</div> <div>pour tourillon</div> <div>perno del cuscinetto di banco</div> <div>para muñón de cigüeñal</div> <div>para munhão do virabrequim</div> <div>för ramlagertappar</div> <div>voor Lagertap</div> <div>для шеек коленчатого вала</div> <div>لتيلفة المحاور</div> </div> |
| Nr.16/2      |  |   |
| Nr.16/3      |  |   |
| Nr.16/4      |  |   |
| Nr.16/5      |  |   |
| Nr.16/6      | <div>أقل من المقاييس العادية</div>   |   |
| Nr.18,23     | <div> <div>Normal</div> <div>Номинальный размер</div> <div>عادي</div> </div> <div>3,00 mm (0.1181 in.)</div>   |   |
| Nr.18/1,23/1 | <div> <div>Übermaßstufen</div> <div>Oversizes</div> <div>Cote réparation</div> <div>Misura maggiorata</div> <div>Medida de desgaste</div> <div>Medida de desgaste</div> <div>Överdimensioner</div> <div>Overmaten</div> <div>Ремонтные размеры</div> </div> <div> <div>3,25 mm (0.1279 in.)</div> <div>3,50 mm (0.1378 in.)</div> <div>3,75 mm (0.1476 in.)</div> <div>4,00 mm (0.1575 in.)</div> </div>   | <div> <div>dick</div> <div>thick</div> <div>épais</div> <div>spessore</div> <div>espesor</div> <div>grossura</div> <div>tjock</div> <div>dik</div> <div>толщина</div> <div>سميك</div> </div>  |
| Nr.18/2,23/2 |  |   |
| Nr.18/3,23/3 |  |   |
| Nr.18/4,23/4 | <div>أكبر من المقاييس العادية</div>  |   |

Genaue Schleifmaße in mm und inch siehe Werkstattshandbuch.

The exact grinding dimensions in mm and inch can be taken from the Workshop Manual.

Pour les cotes de rectification exactes en mm et en pouce, voir Manuel d'Atelier.

Per le misure esatte di rettifica in mm vedasi manuale per il meccanico di officina.

Las medidas de rectificación, exactas, en mm y en inch, pueden verse en el Manual de Taller.

A medidas de retificação, exatas, em mm e em inch podem verse no Manual de Oficina.

Exakta slipmått i mm och tum-återfinns i verkstadshandboken.

Voor Zuivere slijpmaten in mm en inches zie werkplaats handboek.

Точные размеры для шлифования в мм и дюймах см. в руководстве по ремонту.

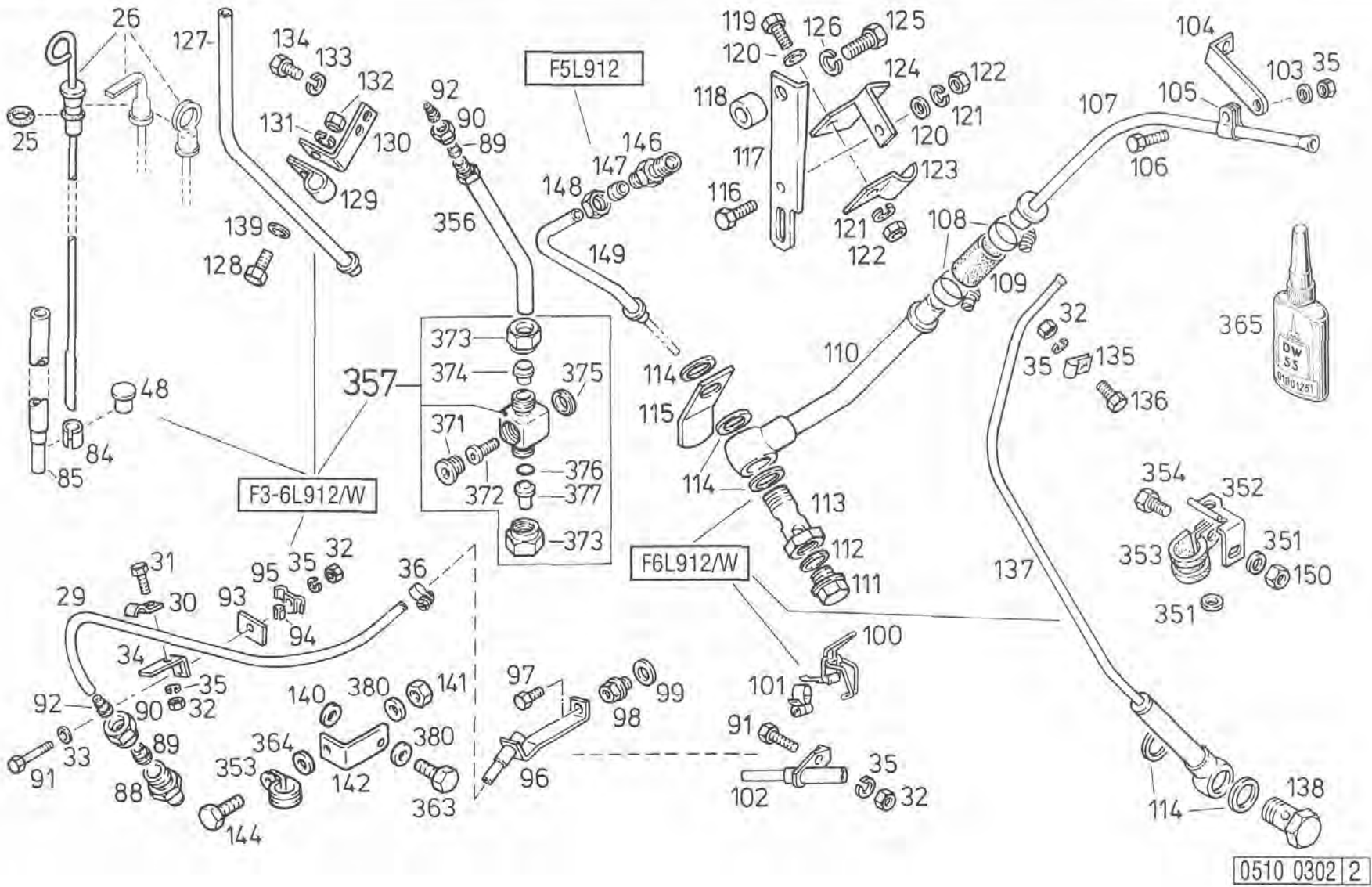
المقاييس النهائية للتجليخ بالم أو بالبوصة ، أنظر كتاب الورشة .

0510 0301





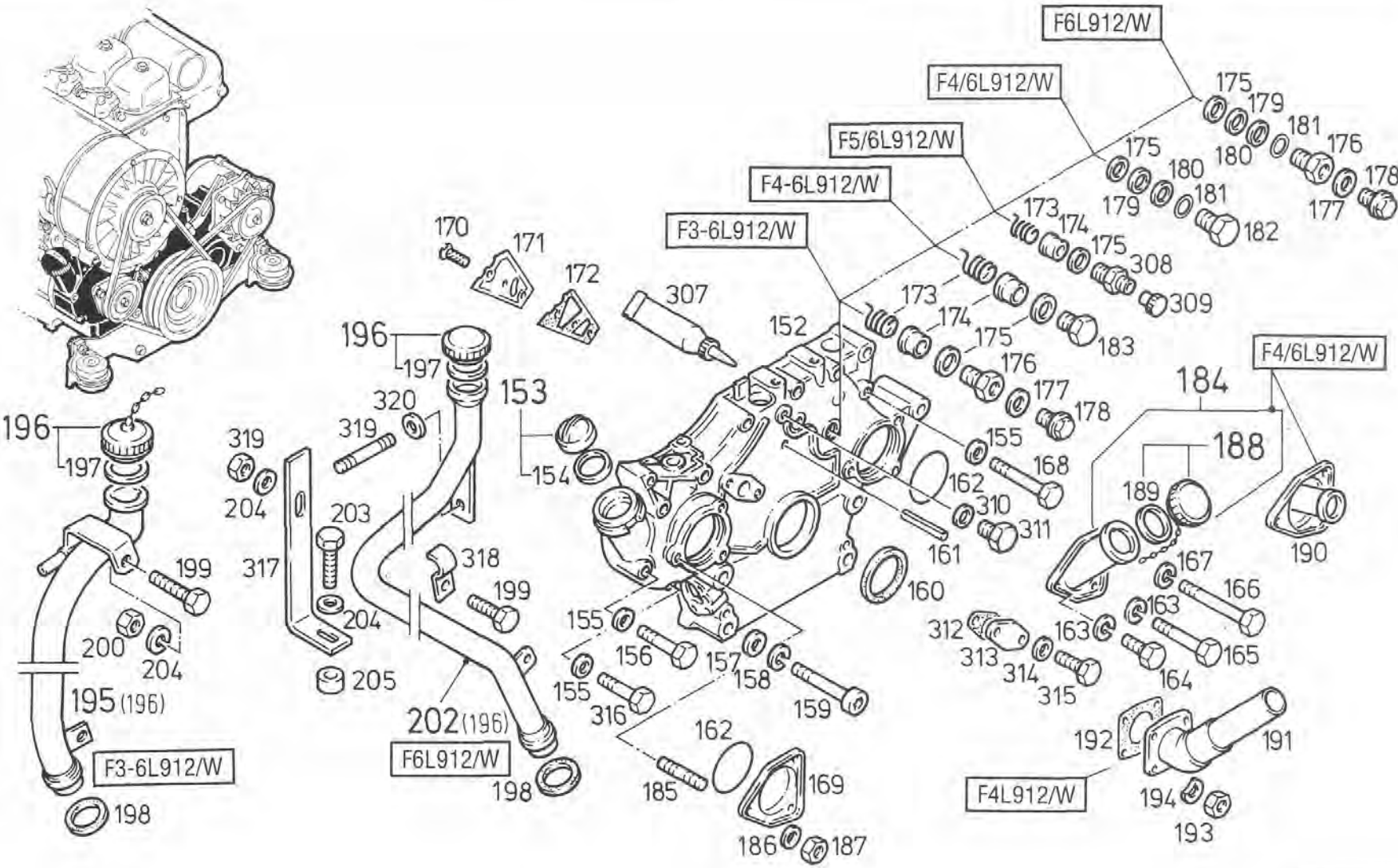
01







**01**

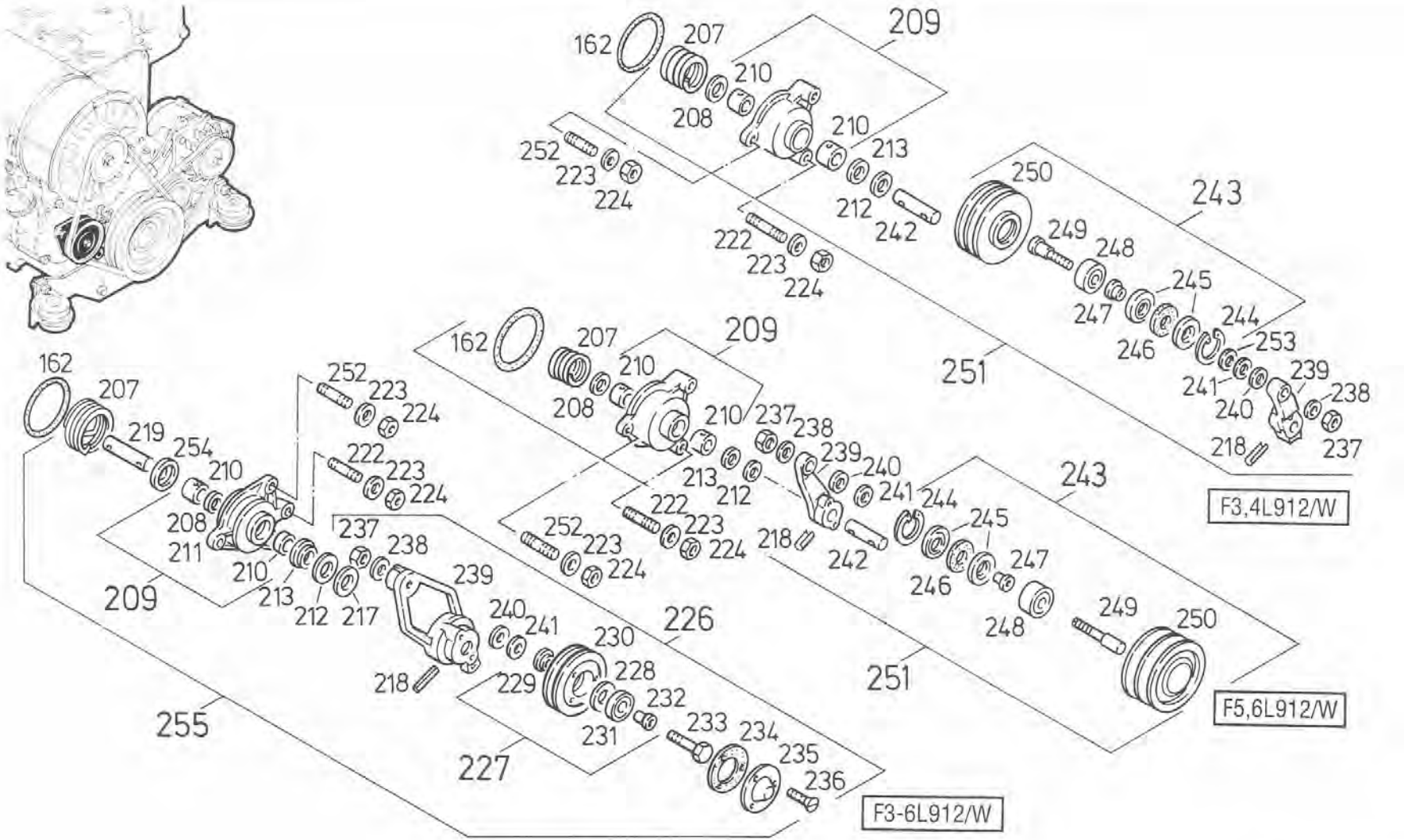


0510 0303 | 1



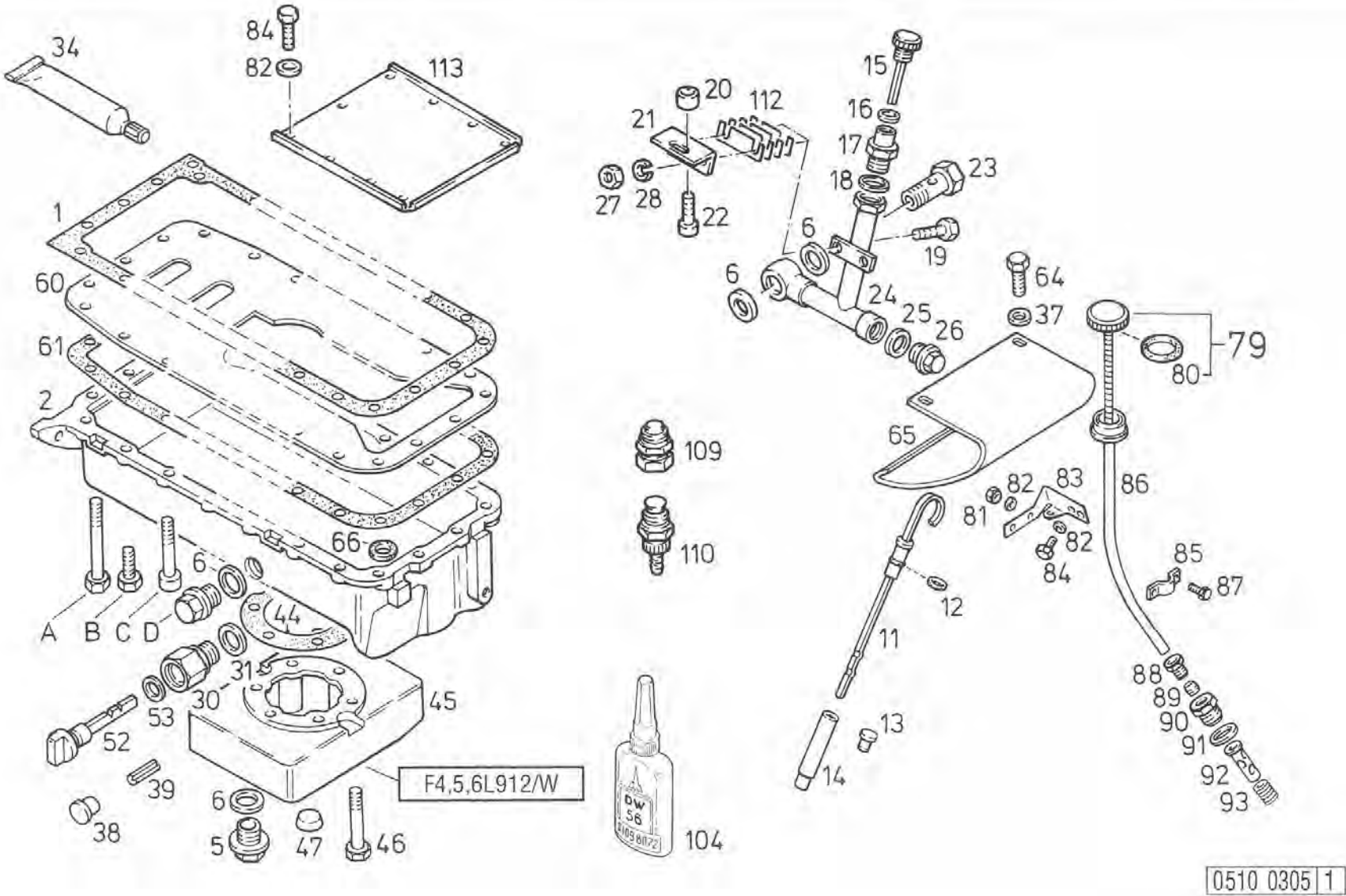


1



0510 0304 1



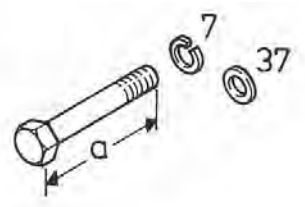




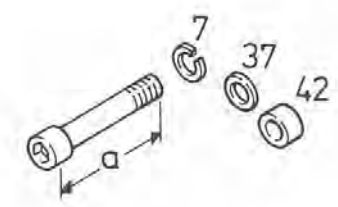


02

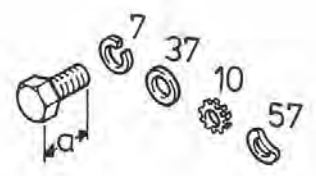
|   | $\phi \times a$ |
|---|-----------------|
| A | 36 = M8 × 40    |
|   | 29 = M8 × 45    |
|   | 78 = M8 × 50    |
|   | 74 = M8 × 70    |
|   | 43 = M8 × 90    |
|   | 58 = M8 × 100   |
|   | 3 = M8 × 110    |
|   | 35 = M8 × 130   |
|   | 77 = M8 × 140   |
|   | 72 = M8 × 180   |
|   | 67 = M8 × 200   |
|   | 111 = M8 × 80   |



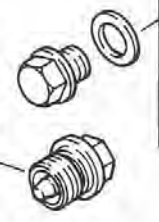
|   |              |
|---|--------------|
| C | 40 = M8 × 16 |
|   | 62 = M8 × 20 |
|   | 41 = M8 × 25 |
|   | 63 = M8 × 30 |
|   | 59 = M8 × 35 |
|   | 75 = M8 × 50 |



|   |              |
|---|--------------|
| B | 4 = M8 × 25  |
|   | 73 = M8 × 28 |
|   | 22 = M8 × 30 |
|   | 51 = M8 × 35 |
|   | 48 = M8 × 45 |

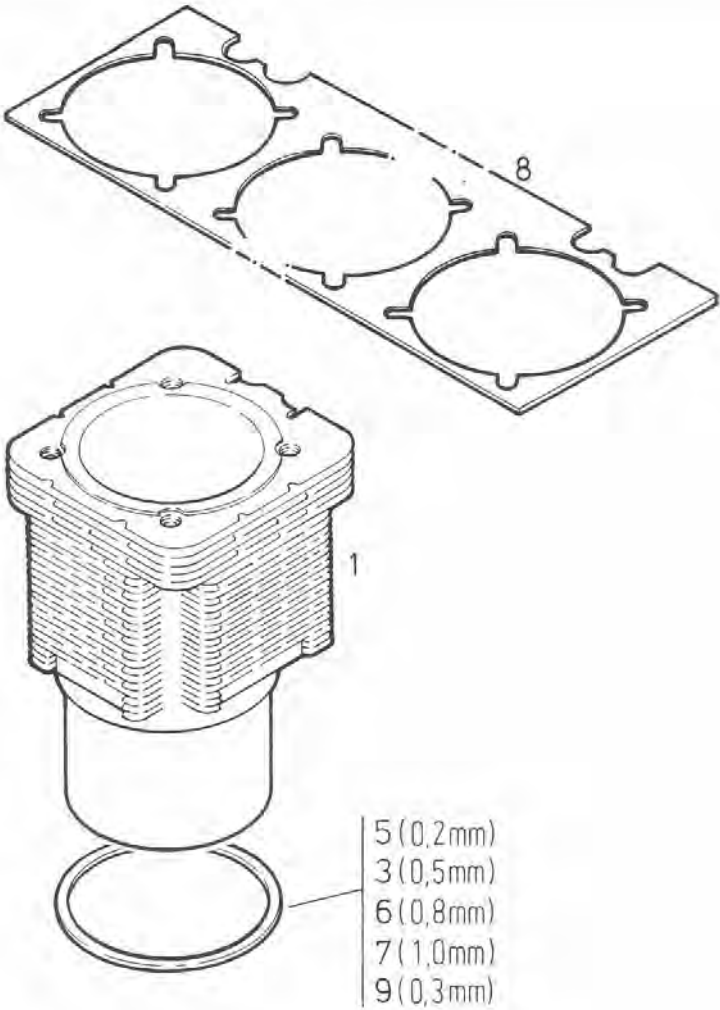


|   |                |
|---|----------------|
| D | 54 = M16 × 1,5 |
|   | 49 = M18 × 1,5 |
|   | 8 = M22 × 1,5  |
|   | 5 = M30 × 1,5  |
|   | 76 = M22 × 1,5 |
|   | 105 = M42 × 2  |
|   | 107 = M48 × 2  |
|   | 55 = A16 × 20  |
|   | 50 = A18 × 22  |
|   | 9 = A22 × 27   |
|   | 6 = A30 × 36   |
|   | 106 = A42 × 49 |
|   | 108 = A48 × 55 |



0510 1211 0



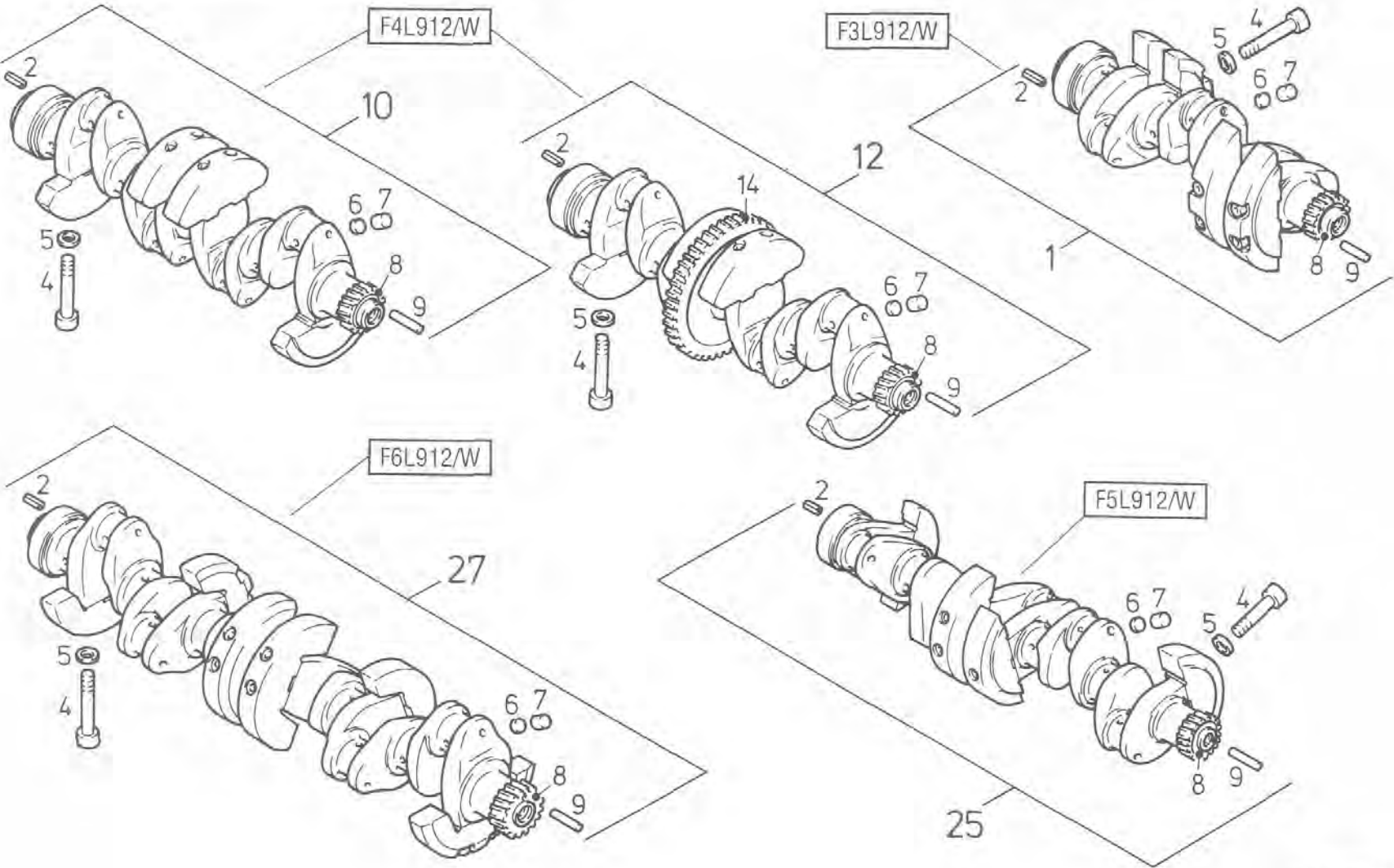


0510 0306 2



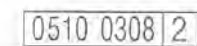


15



0510 0307 1

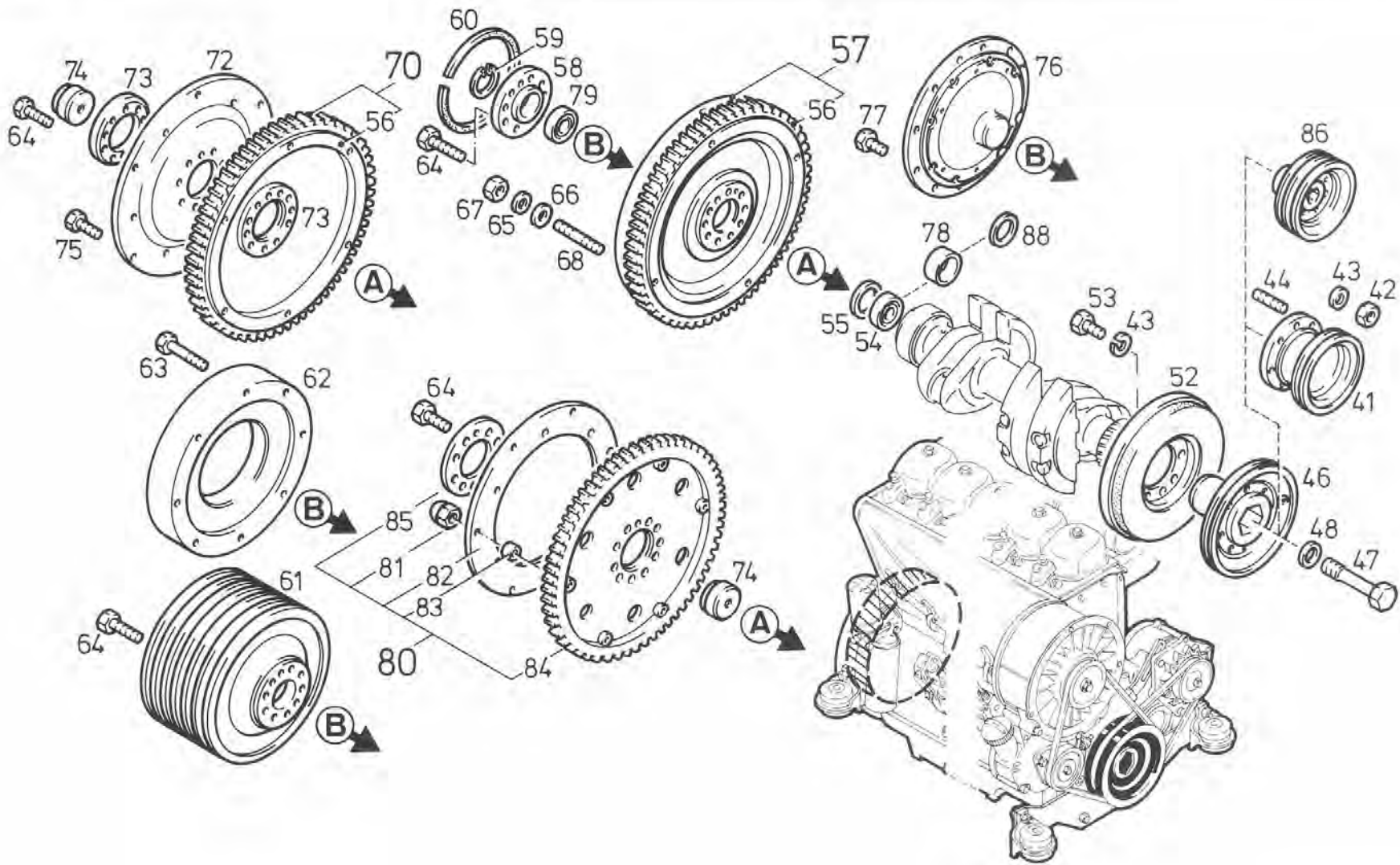






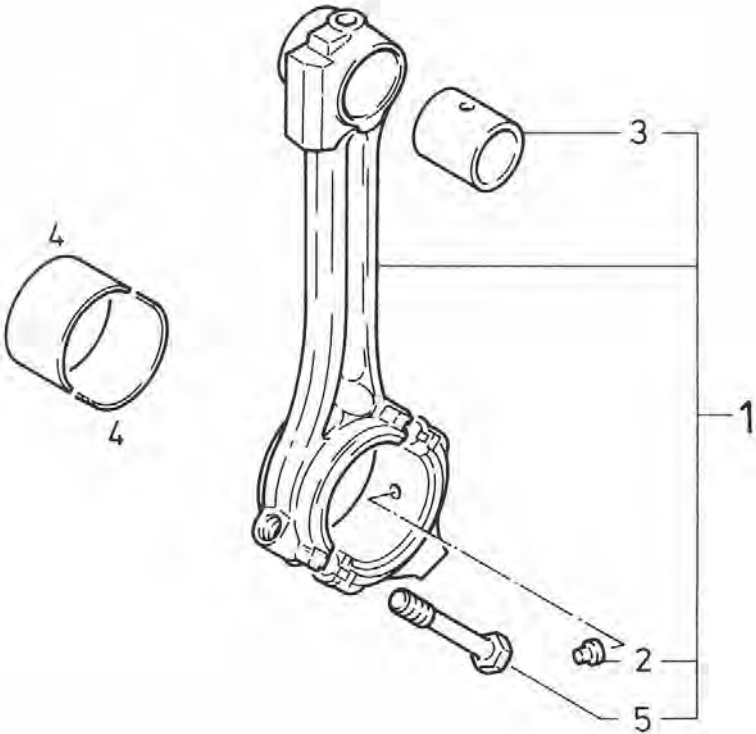


15



0510 0309 2





Normal  
Номинальный размер  
عادي  
Nr. 4       $\phi$  60,00 (2.3622 in.)

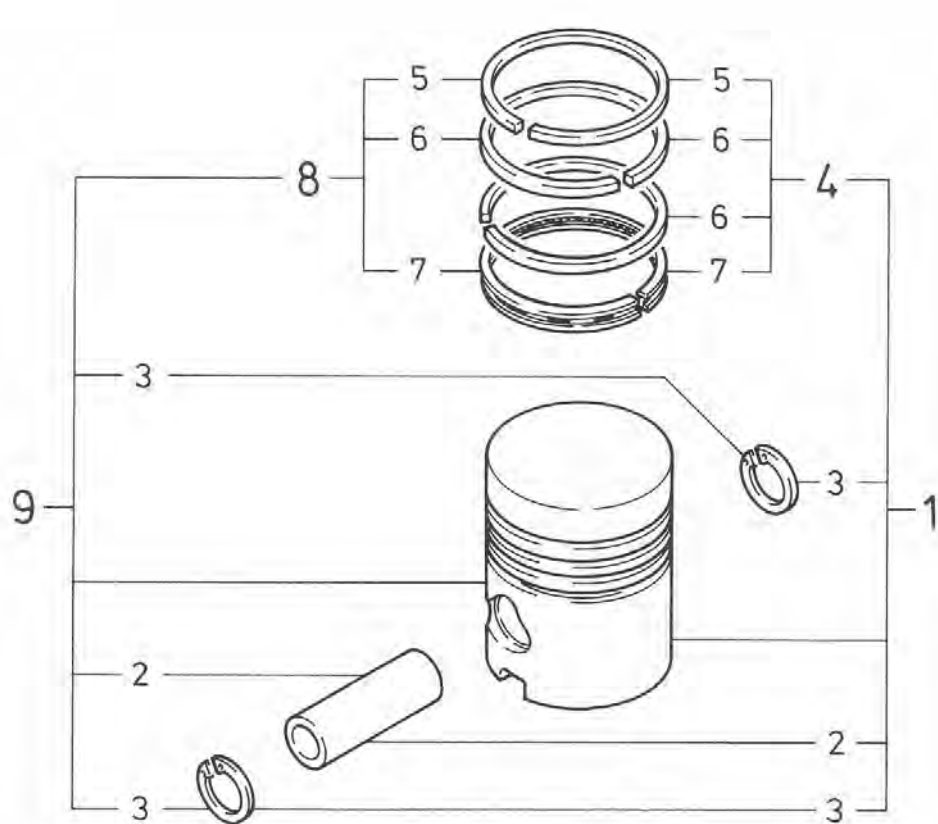
Untermaßstufen  
Undersizes  
Cote réparation  
Misura minorata  
Medida de desgaste  
Medida de desgaste  
Underdimensioner  
Ondermaten  
Ремонтные размеры  
أقل من المقياس  
مقياس العادية  
Nr. 4 / 1       $\phi$  59,75 (2.3523 in.)  
Nr. 4 / 2       $\phi$  59,50 (2.3425 in.)  
Nr. 4 / 3       $\phi$  59,25 (2.3327 in.)  
Nr. 4 / 4       $\phi$  59,00 (2.3228 in.)  
Nr. 4 / 5       $\phi$  58,75 (2.3130 in.)  
Nr. 4 / 6       $\phi$  58,50 (2.3031 in.)

0510 0310





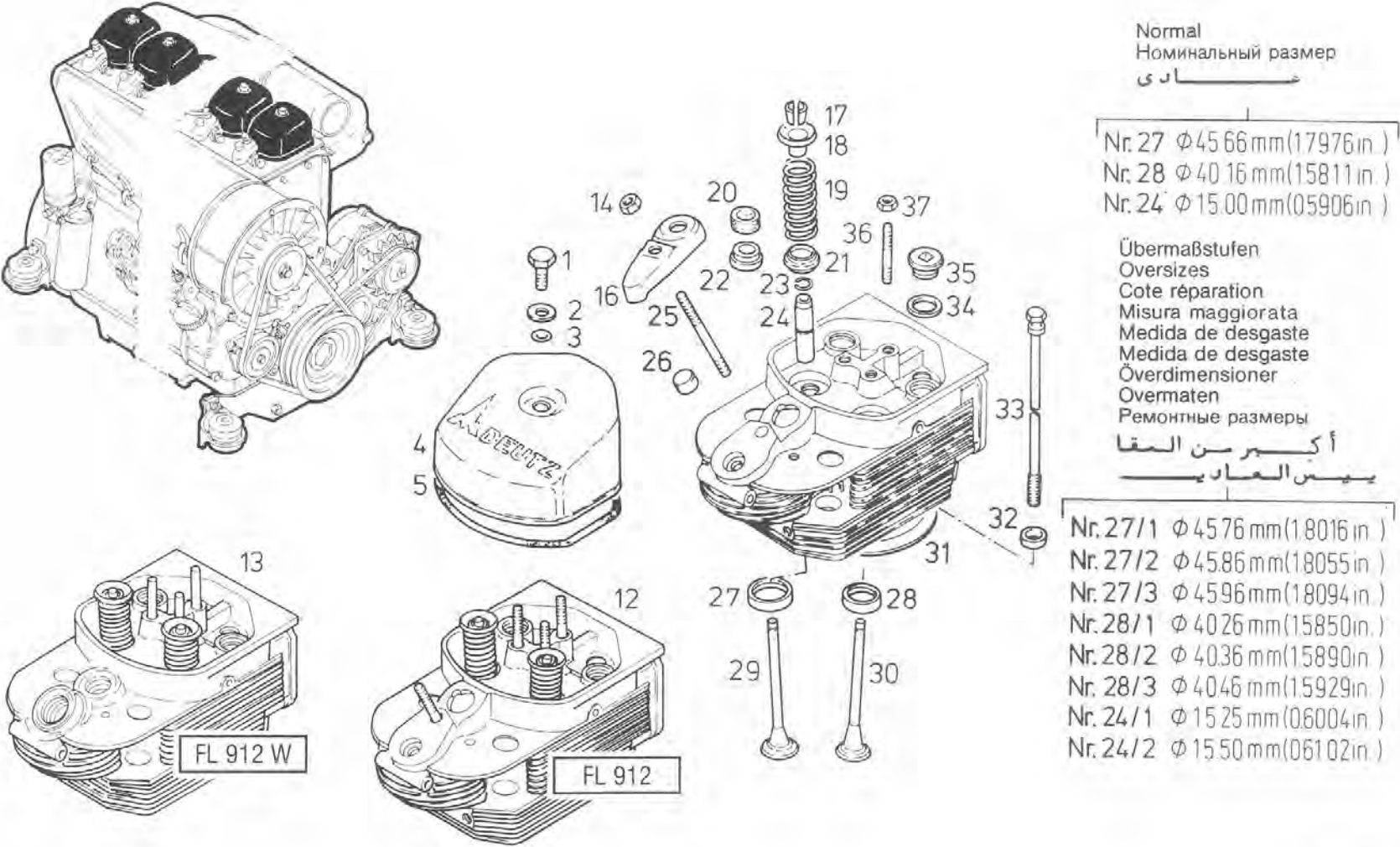
17



| Normal<br>Номинальный размер<br>عادي  |  |
|---|--|
| Nr. 1   | $\phi$ 100mm (3.9730in.)               |
| Nr. 9   | $\phi$ 100mm (3.9730in.)               |
| Nr. 5   | $\phi$ 100x91,4mm (3.9730x3.5984in.)   |
| Nr. 6   | $\phi$ 100x91,4mm (3.9730x3.5984in.)   |
| Nr. 7   | $\phi$ 100x90,9mm (3.9730x3.5784in.)   |
| <hr/>   |  |
| Nr. 1/1   | $\phi$ 100,5mm (3.9567in.)             |
| Nr. 9/1   | $\phi$ 100,5mm (3.9567in.)             |
| Nr. 5/1   | $\phi$ 100,5x91,9mm (3.9567x3.6181in.) |
| Nr. 6/1   | $\phi$ 100,5x91,9mm (3.9567x3.6181in.) |
| Nr. 7/1   | $\phi$ 100,5x91,4mm (3.9567x3.5984in.) |
| <hr/>   |  |
| Übermaßstufen<br>Oversizes<br>Cote réparation<br>Misura maggiorata<br>Medida de desgaste<br>Medida de desgaste<br>Överdimensioner<br>Overmaten<br>Ремонтные размеры<br>أكبر من المقاييس العادية |  |

0510 0311



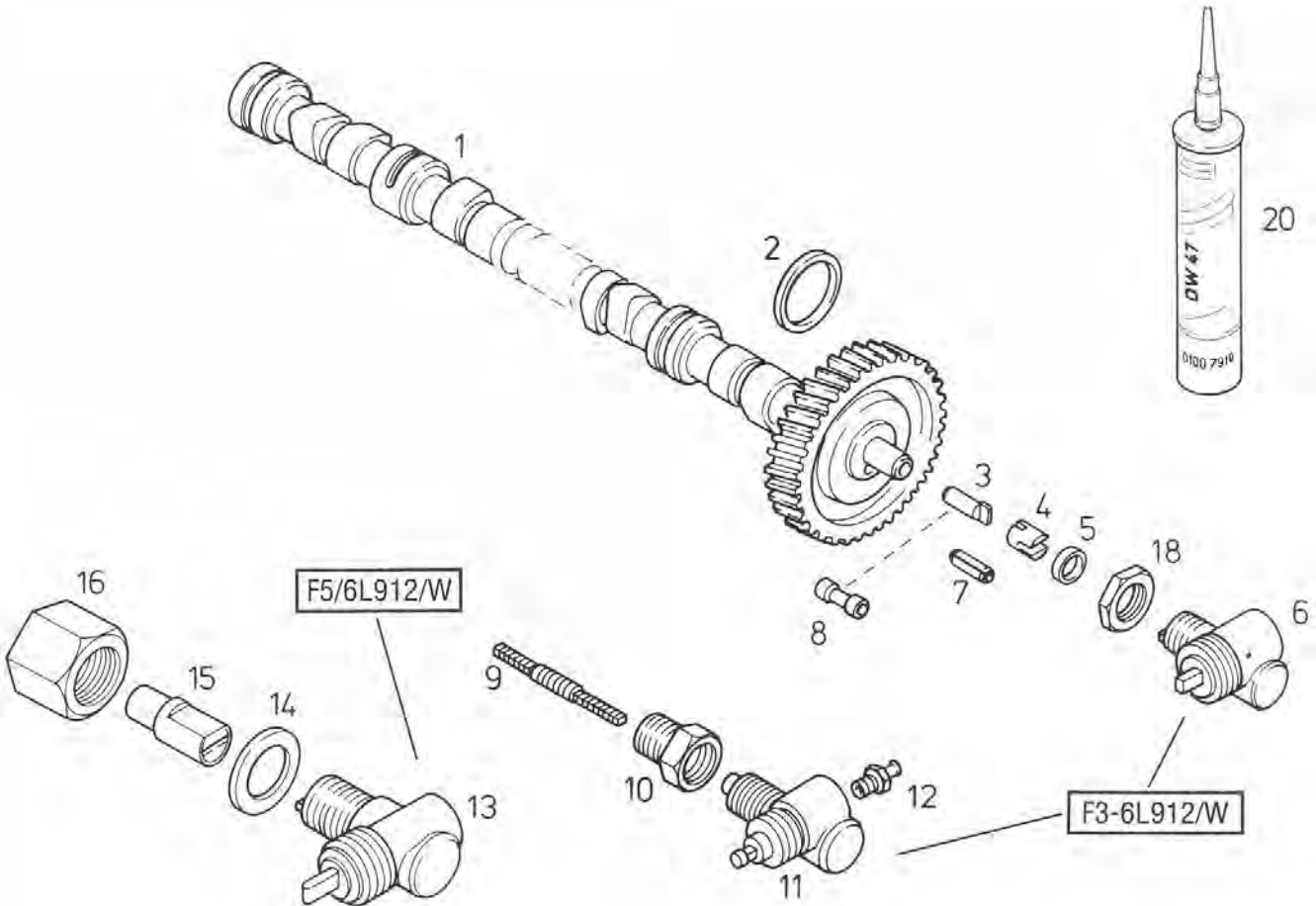


0510 0312



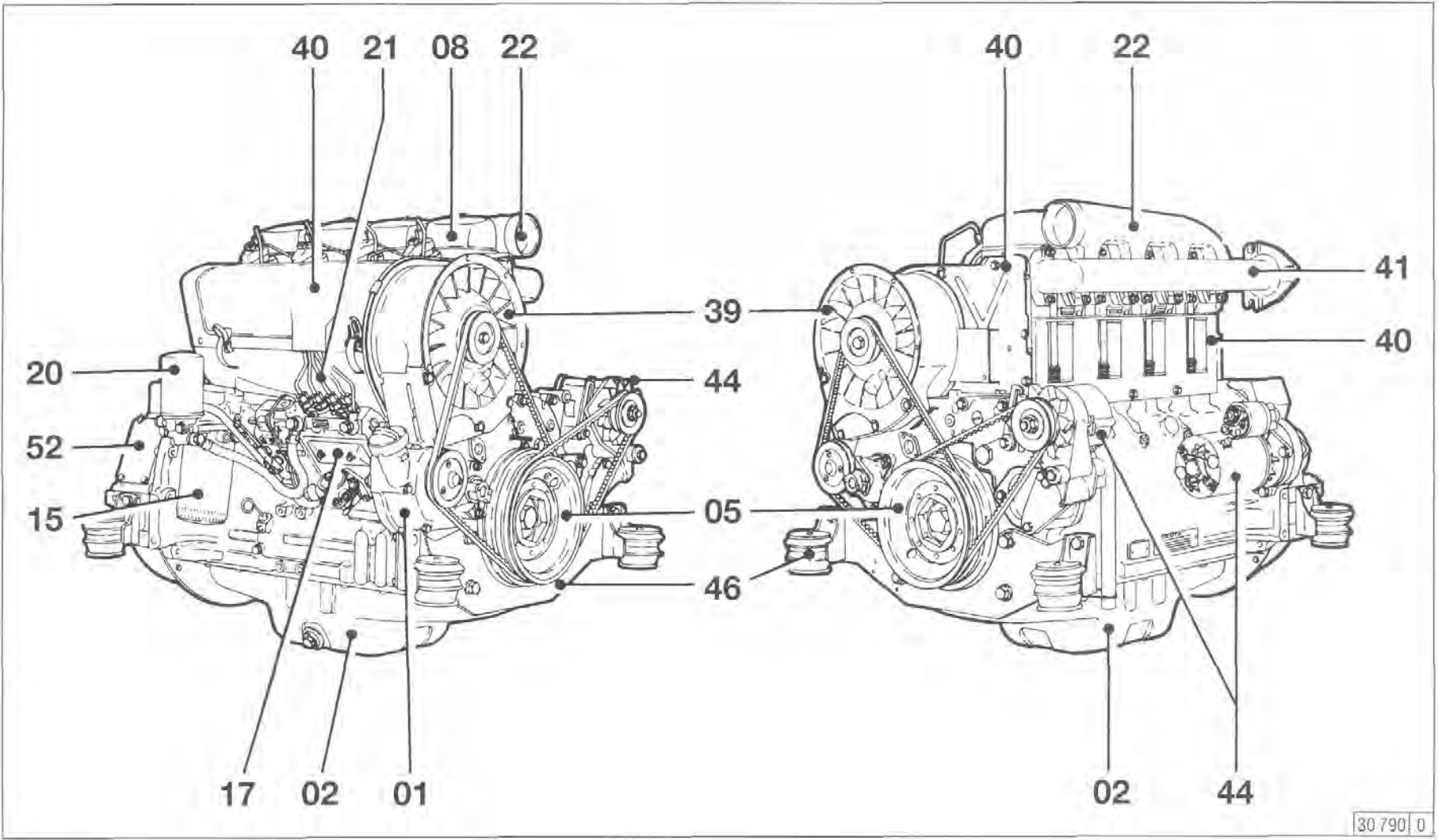


1

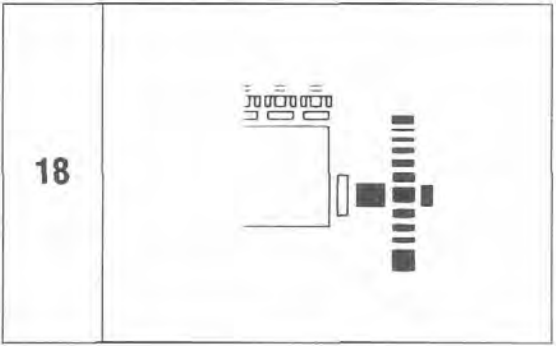
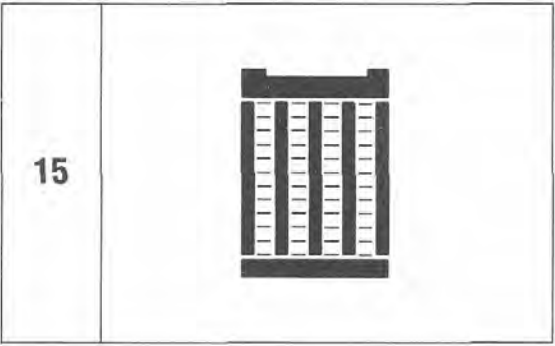
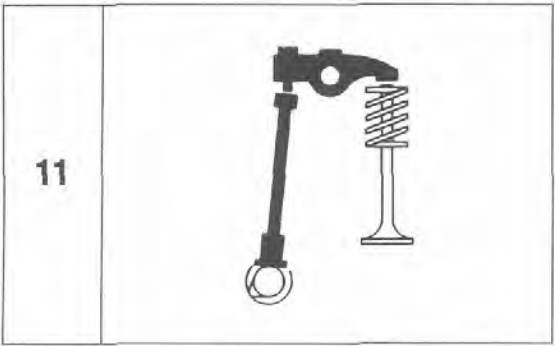


0510 0313 2

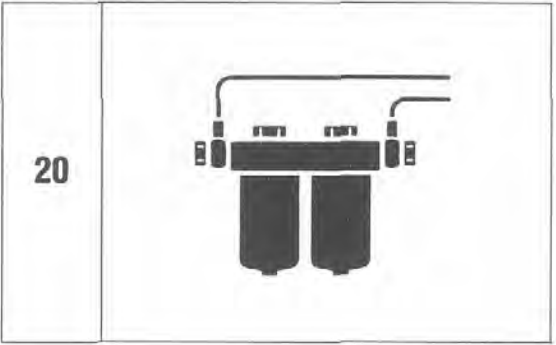
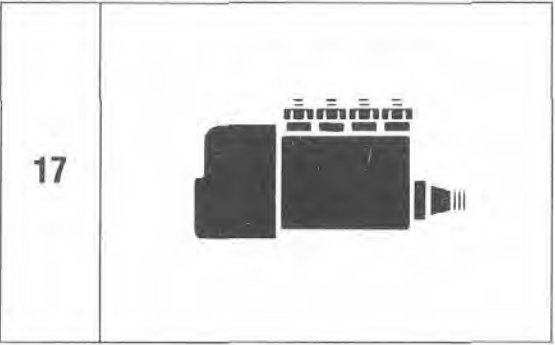
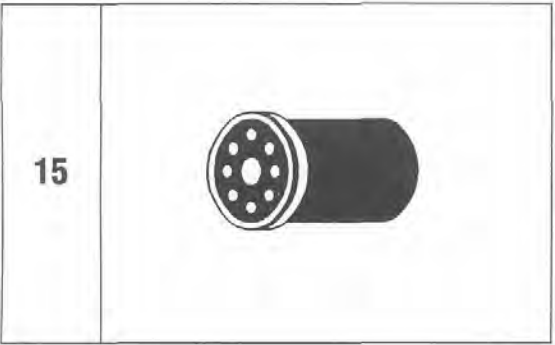
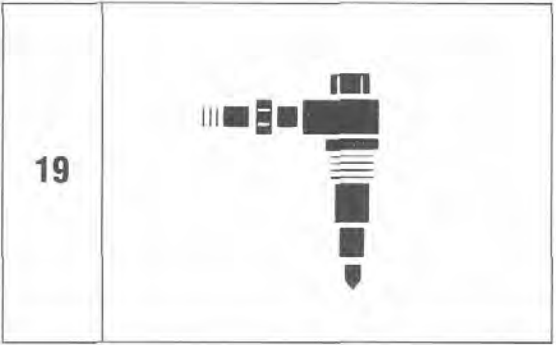
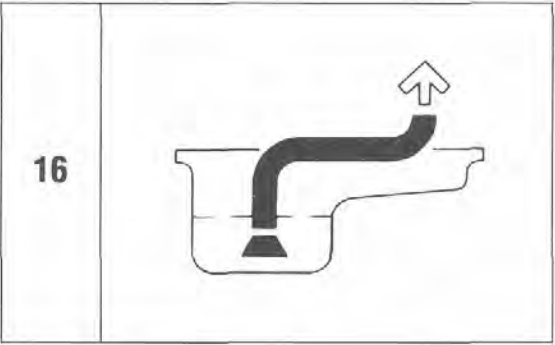
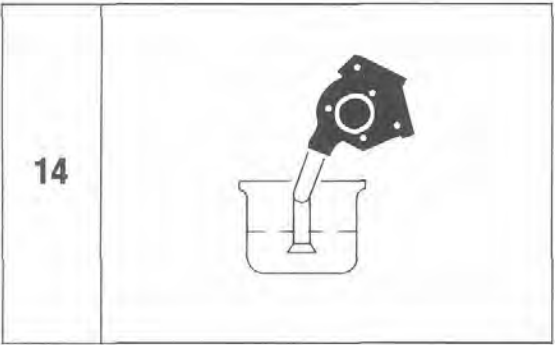








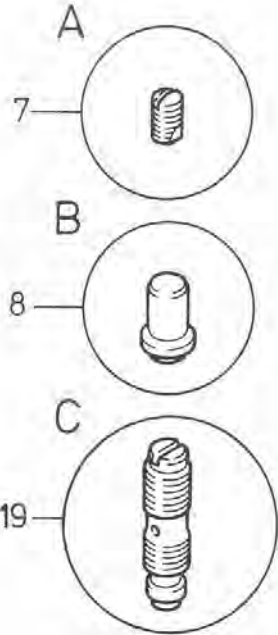
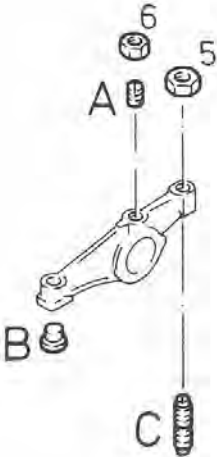
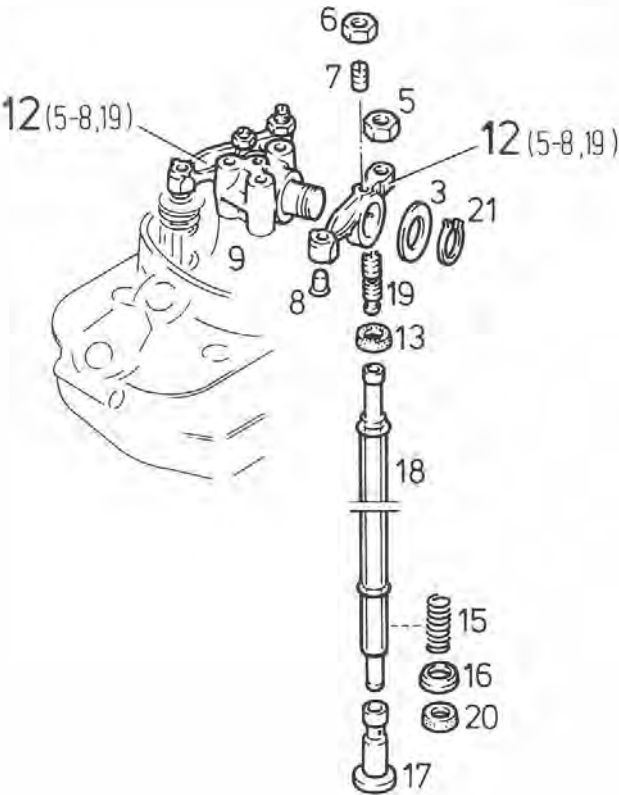
11  
20





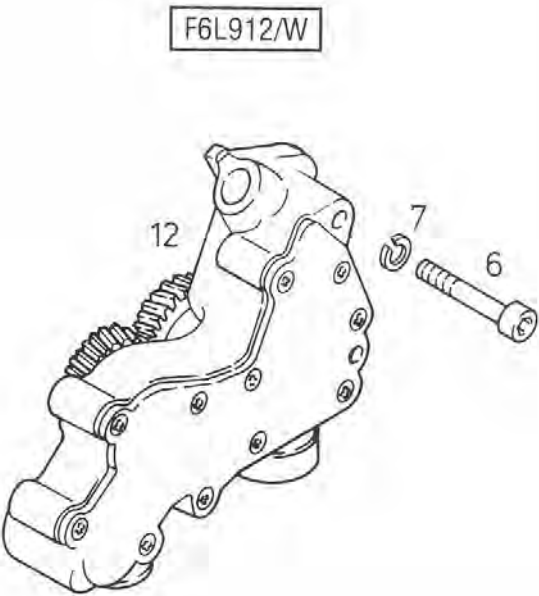
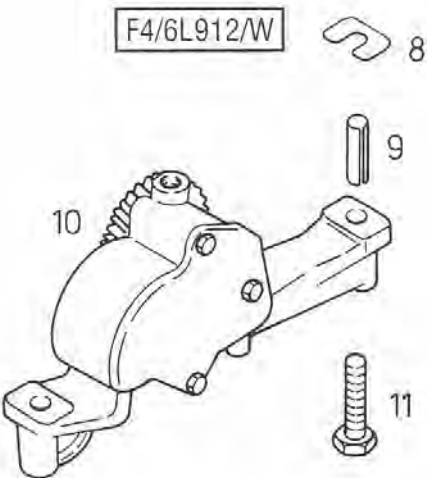


1



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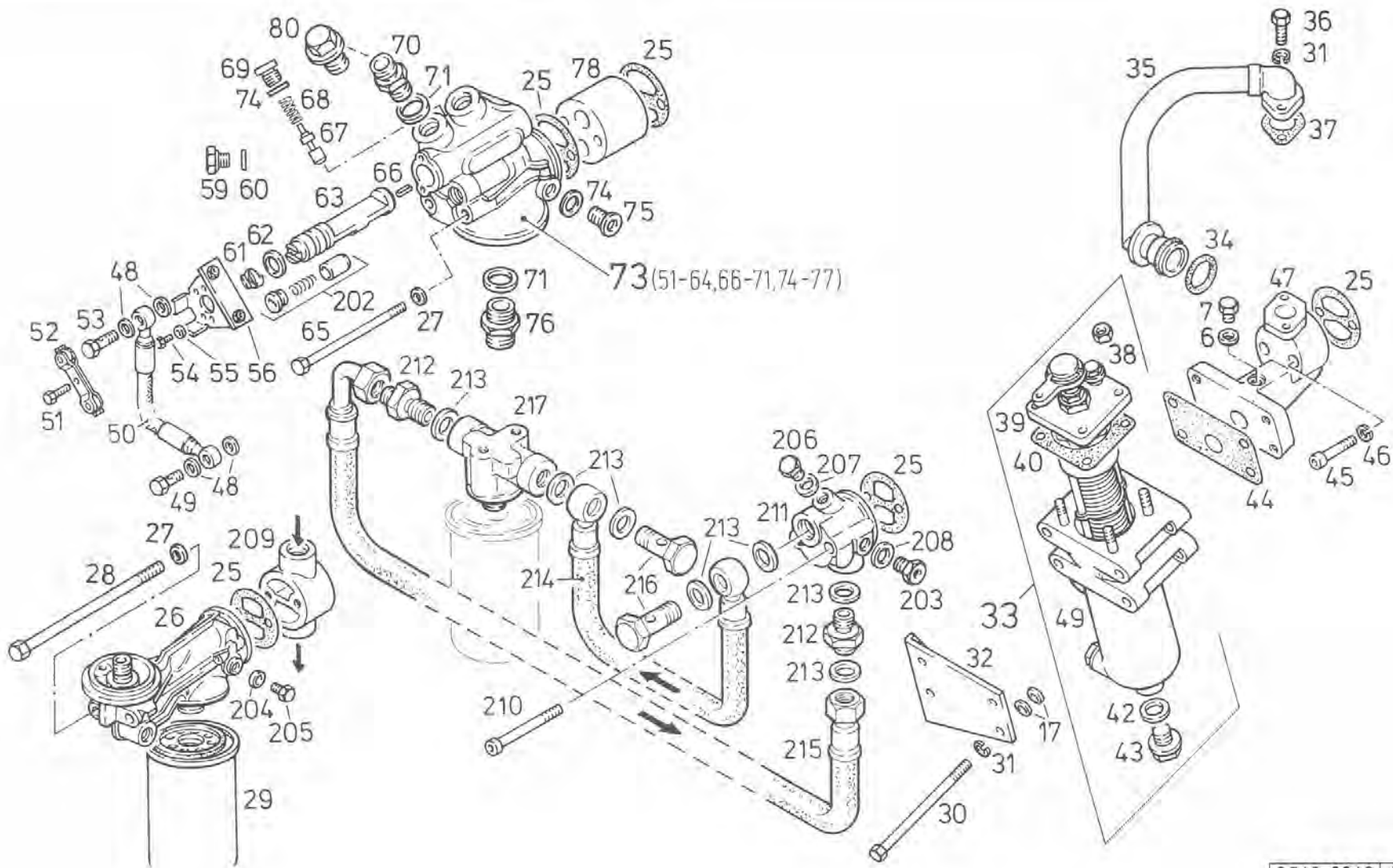








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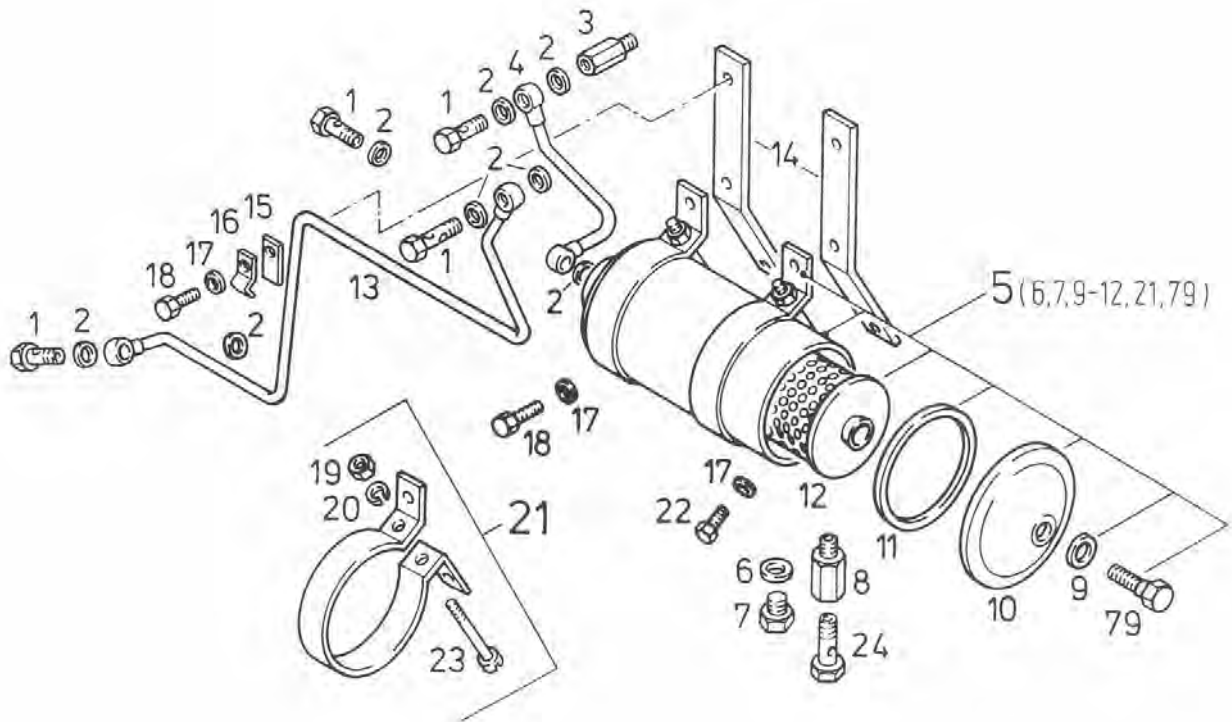


0510 0316 1





**15**

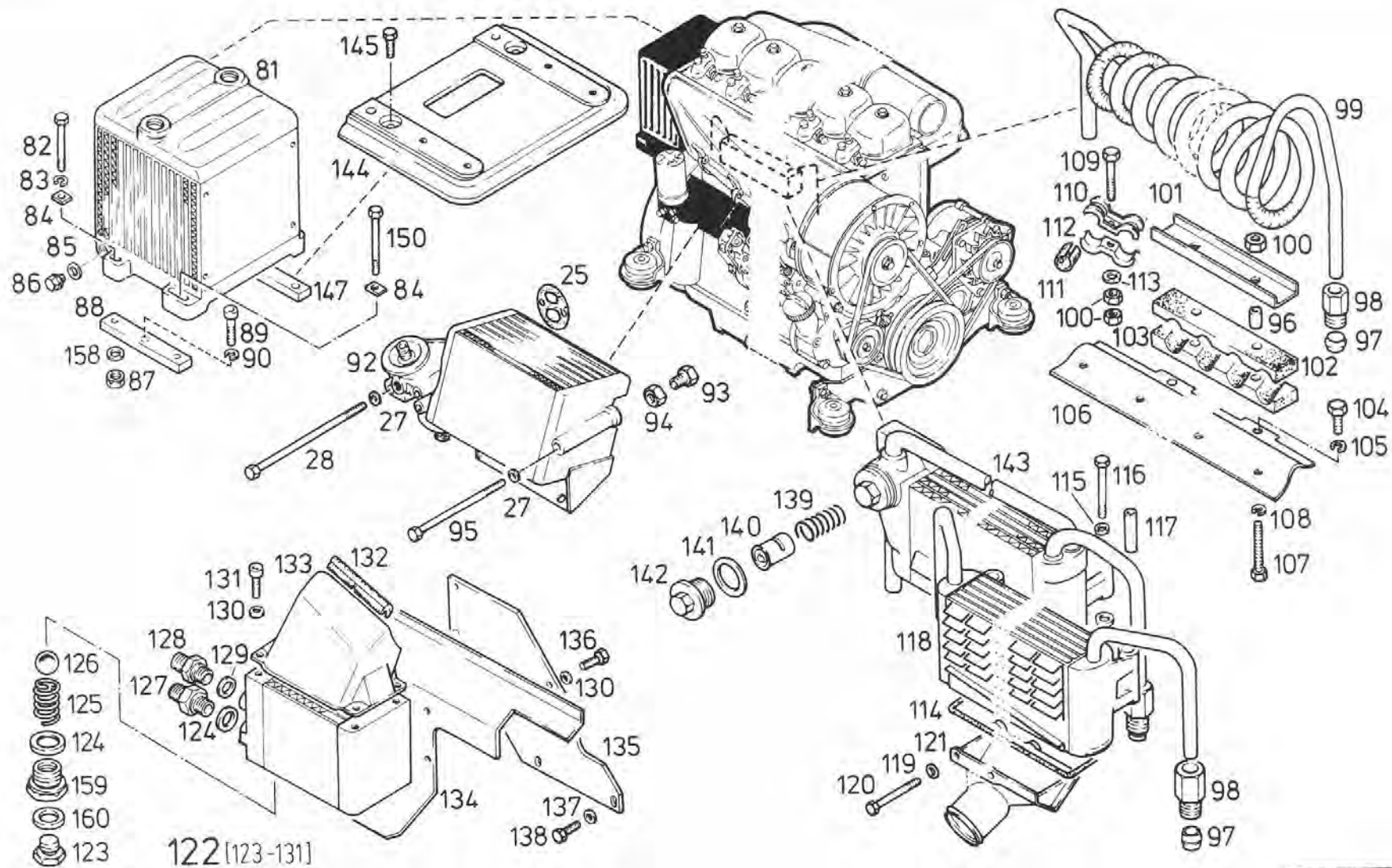


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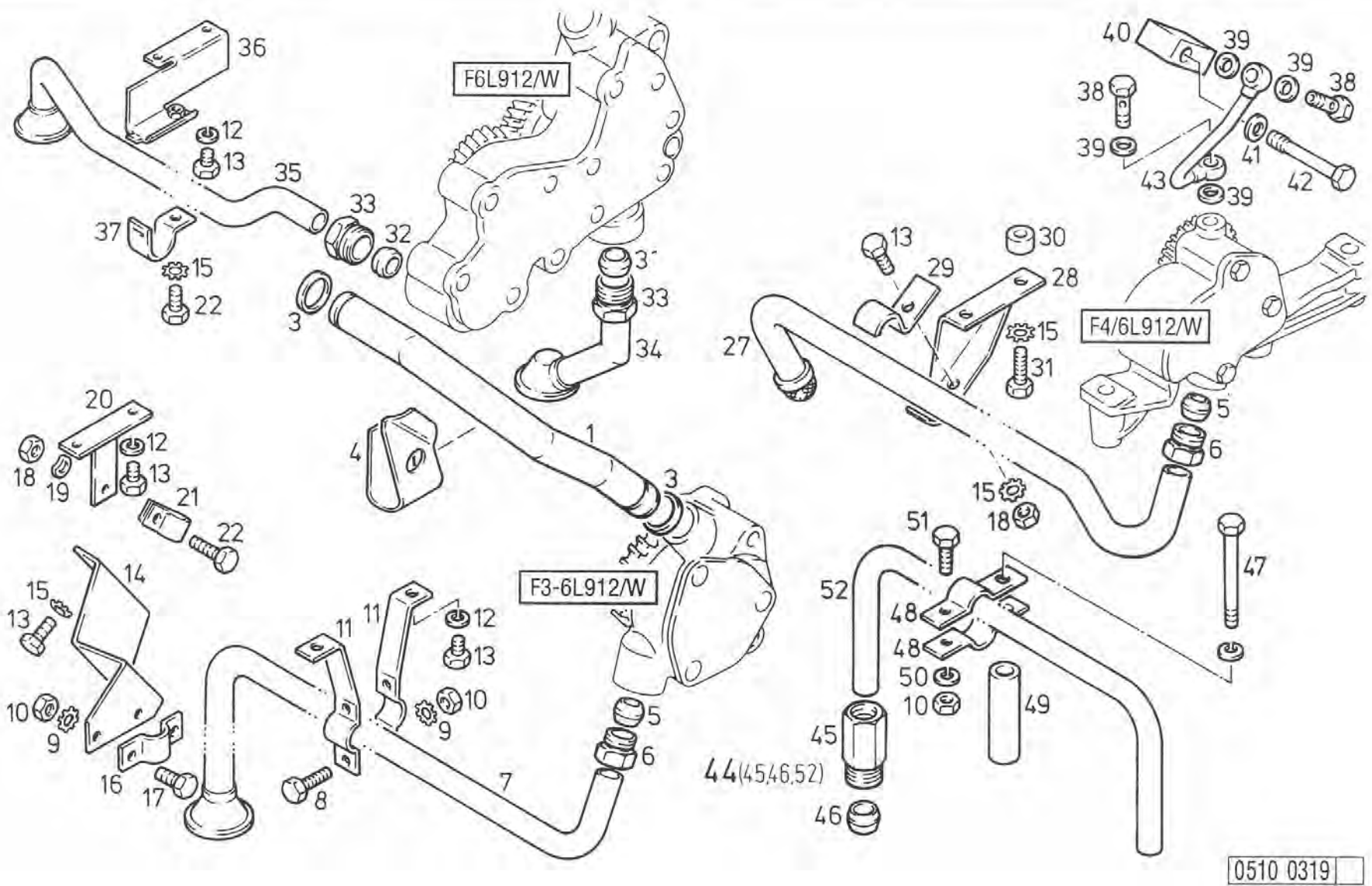


5



0510 0318 2



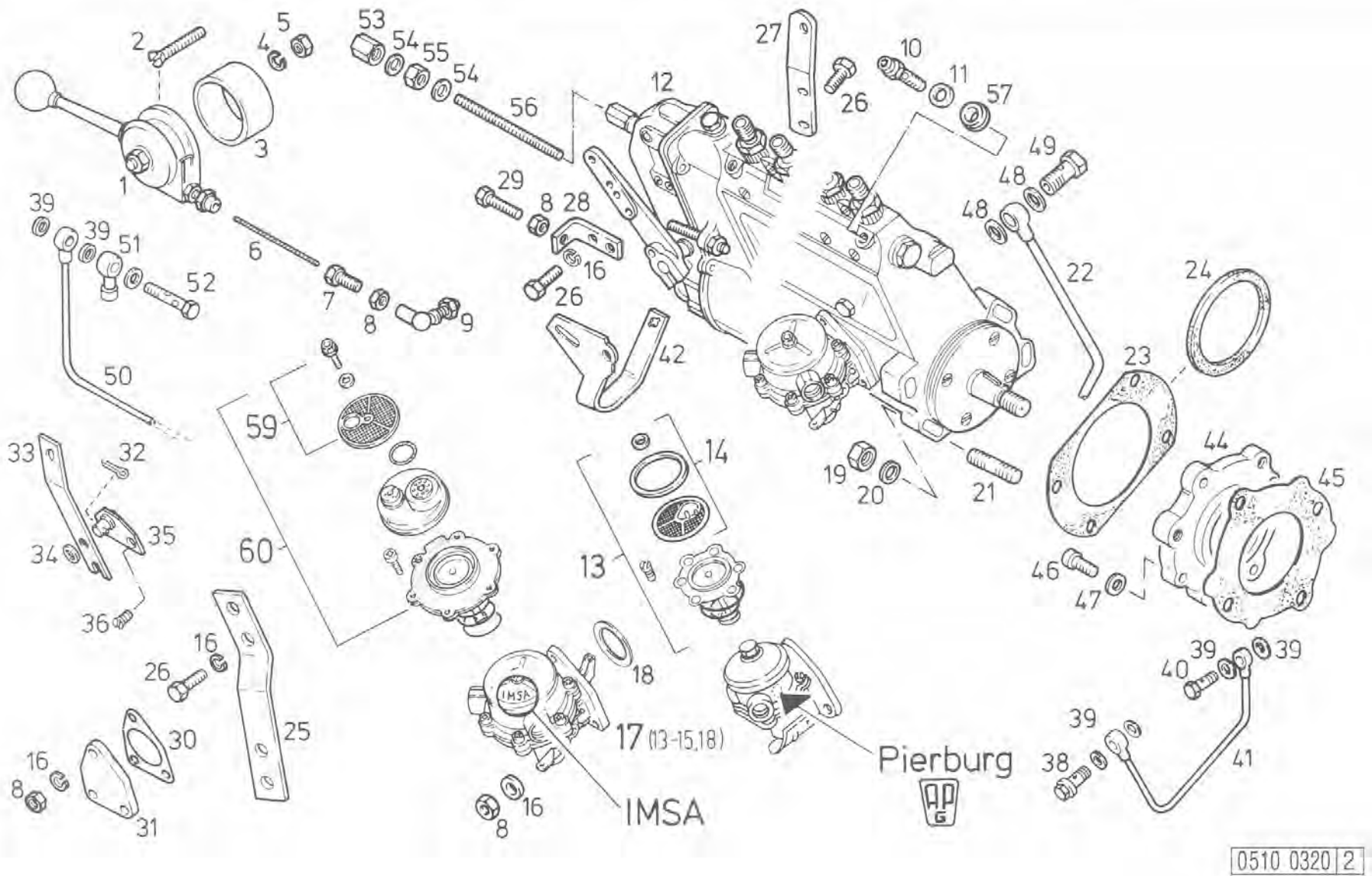


**16**

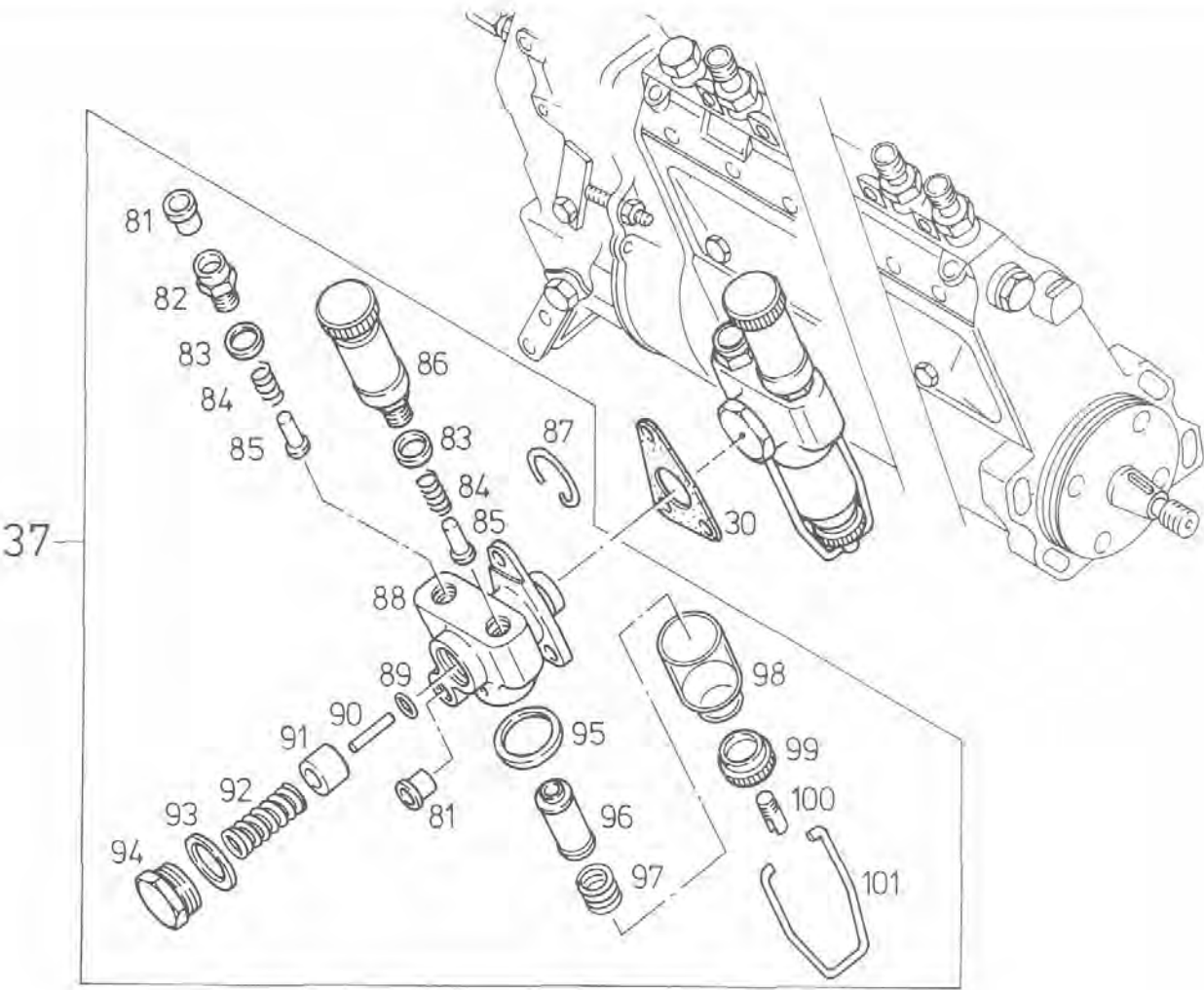




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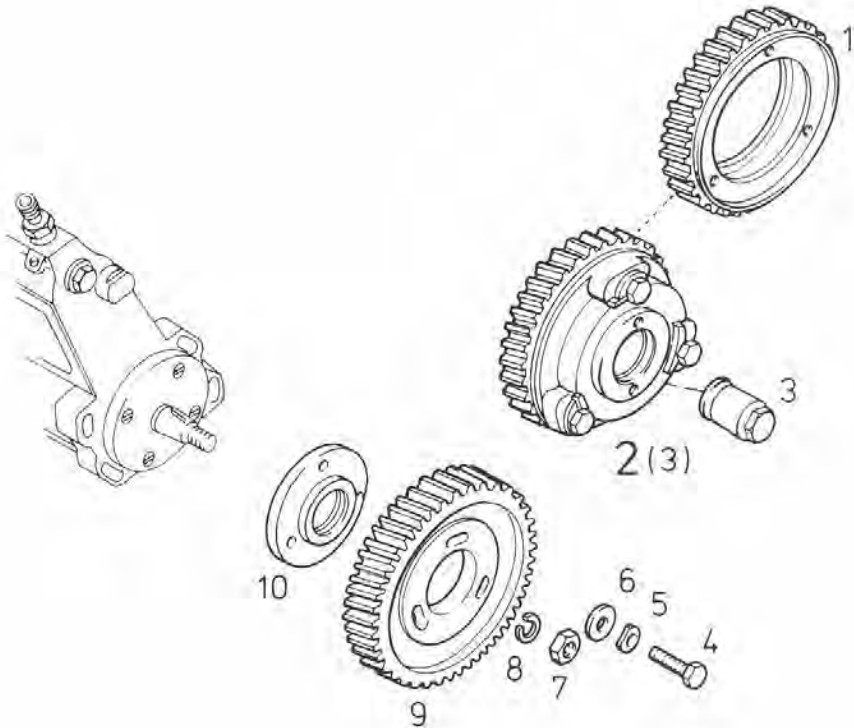








8

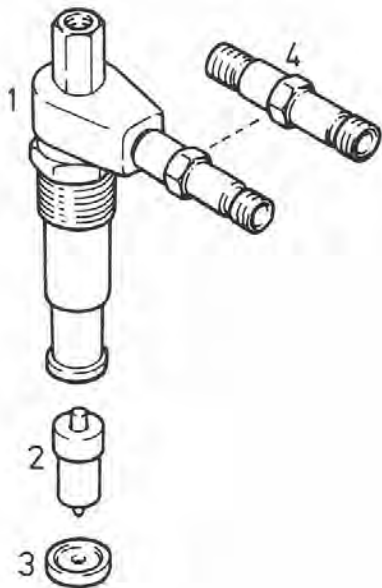


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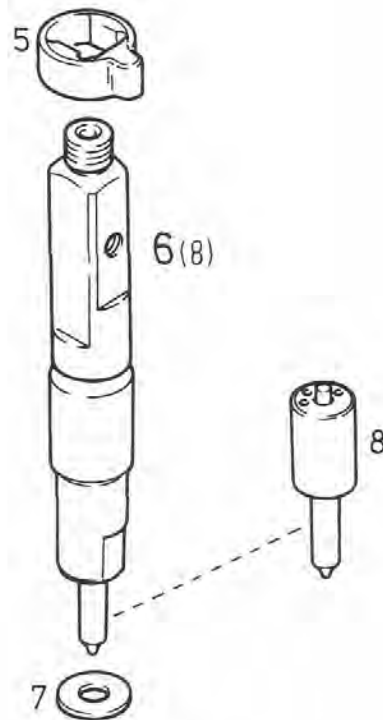




FL 912 W



FL 912



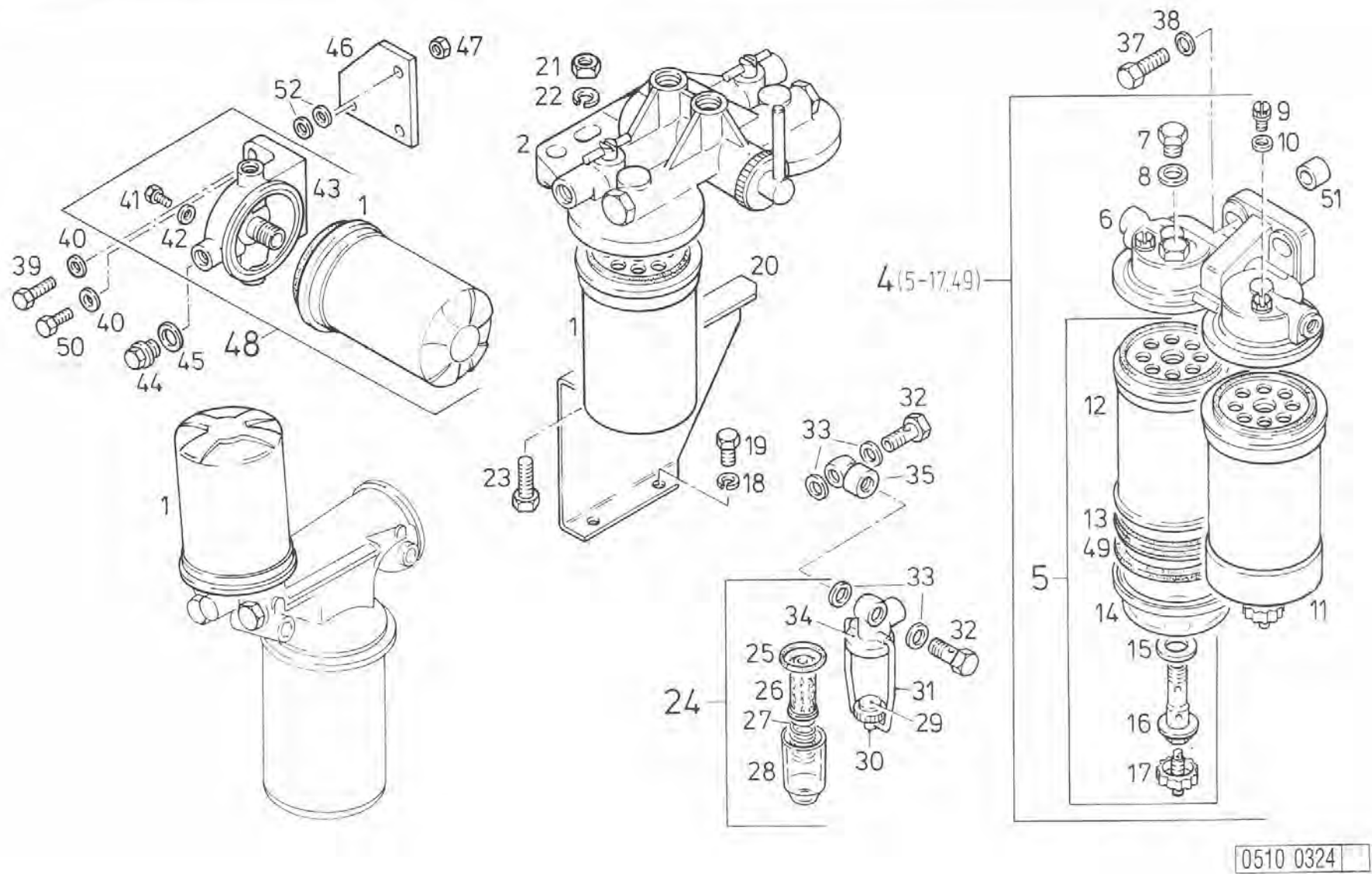
**19**

0510 0323

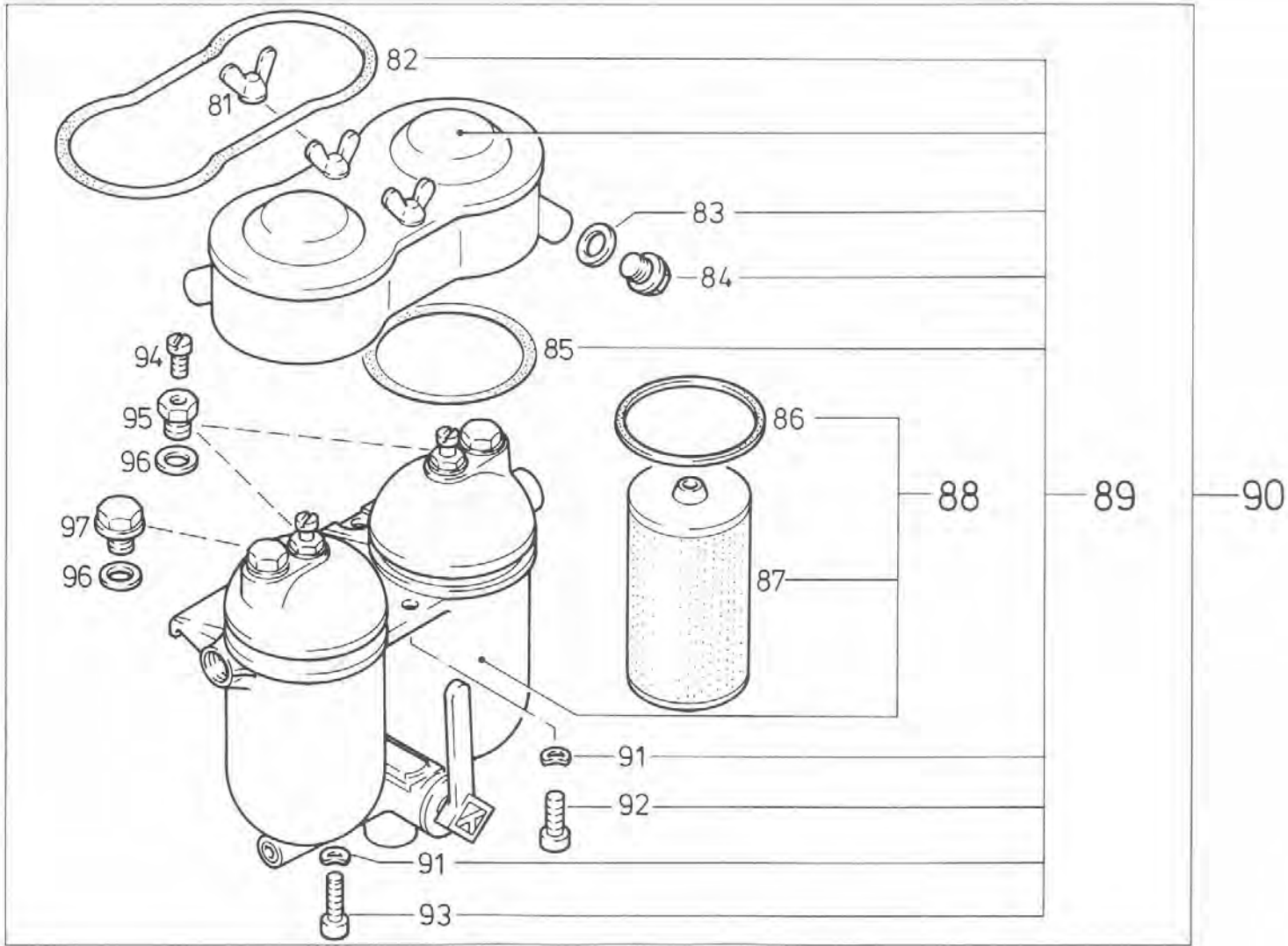




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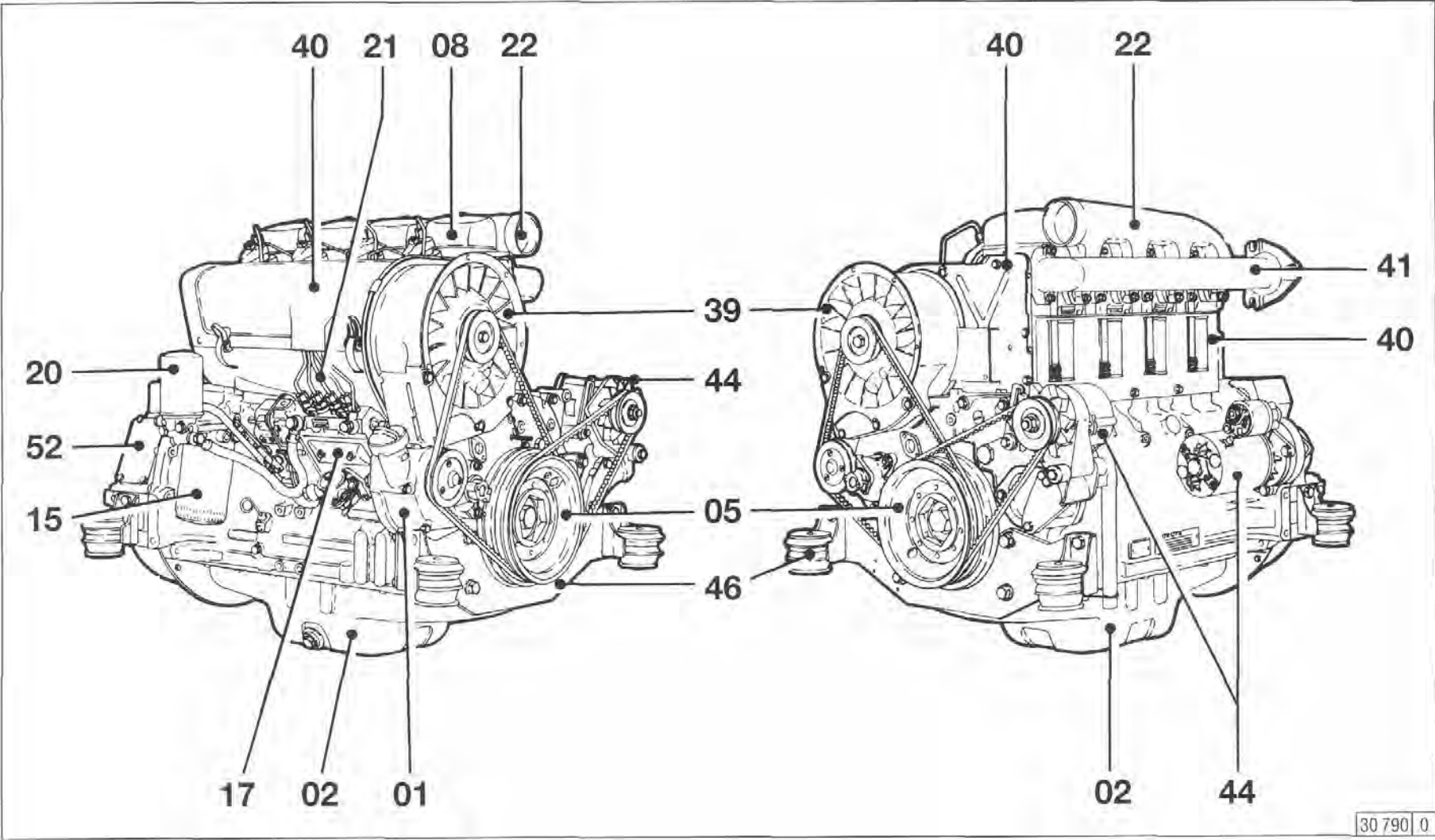




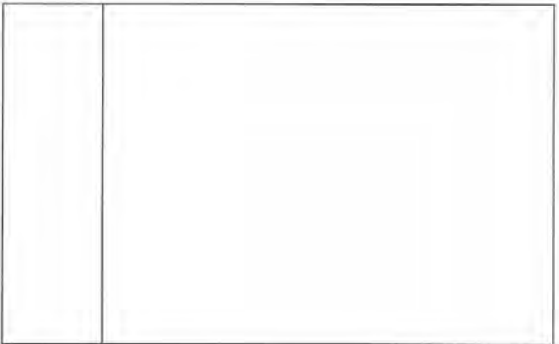
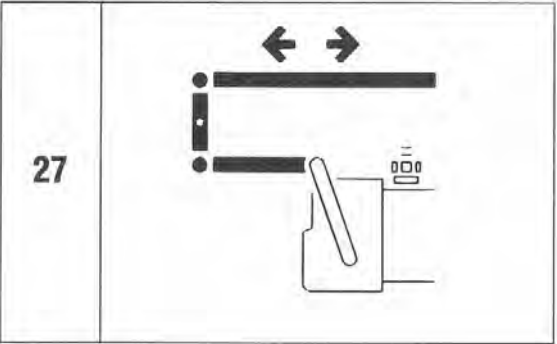
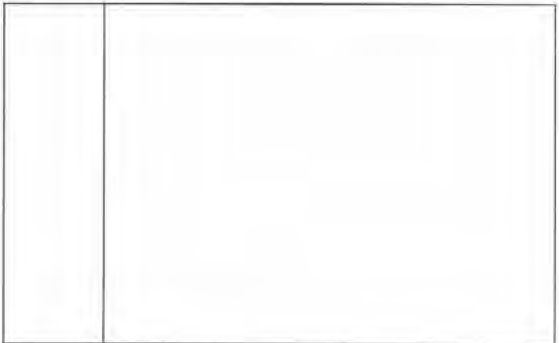
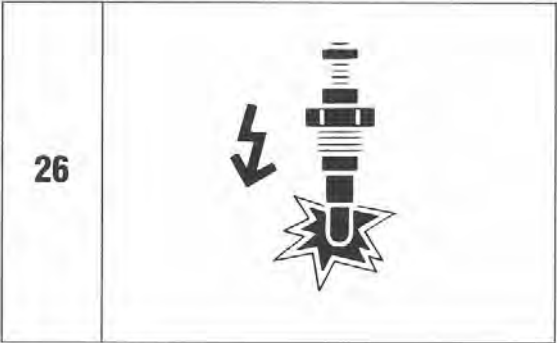
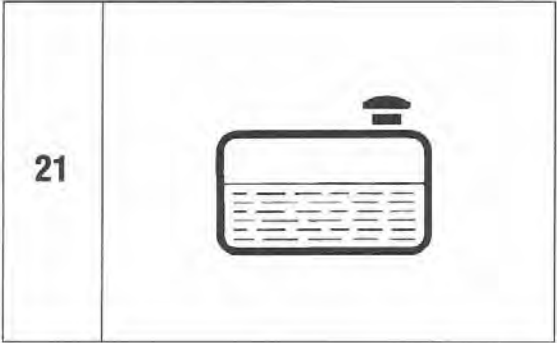
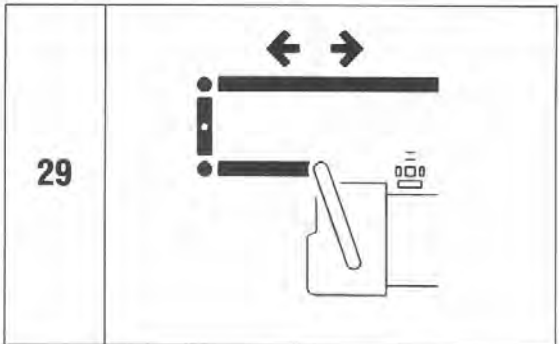
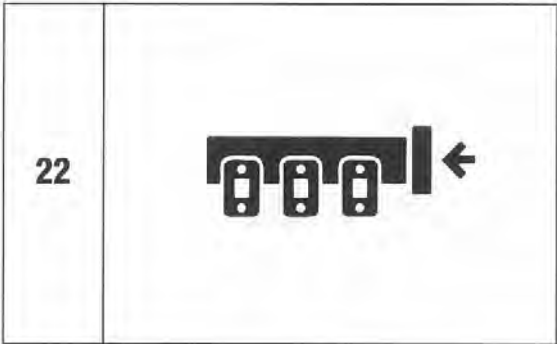


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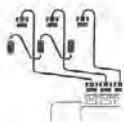




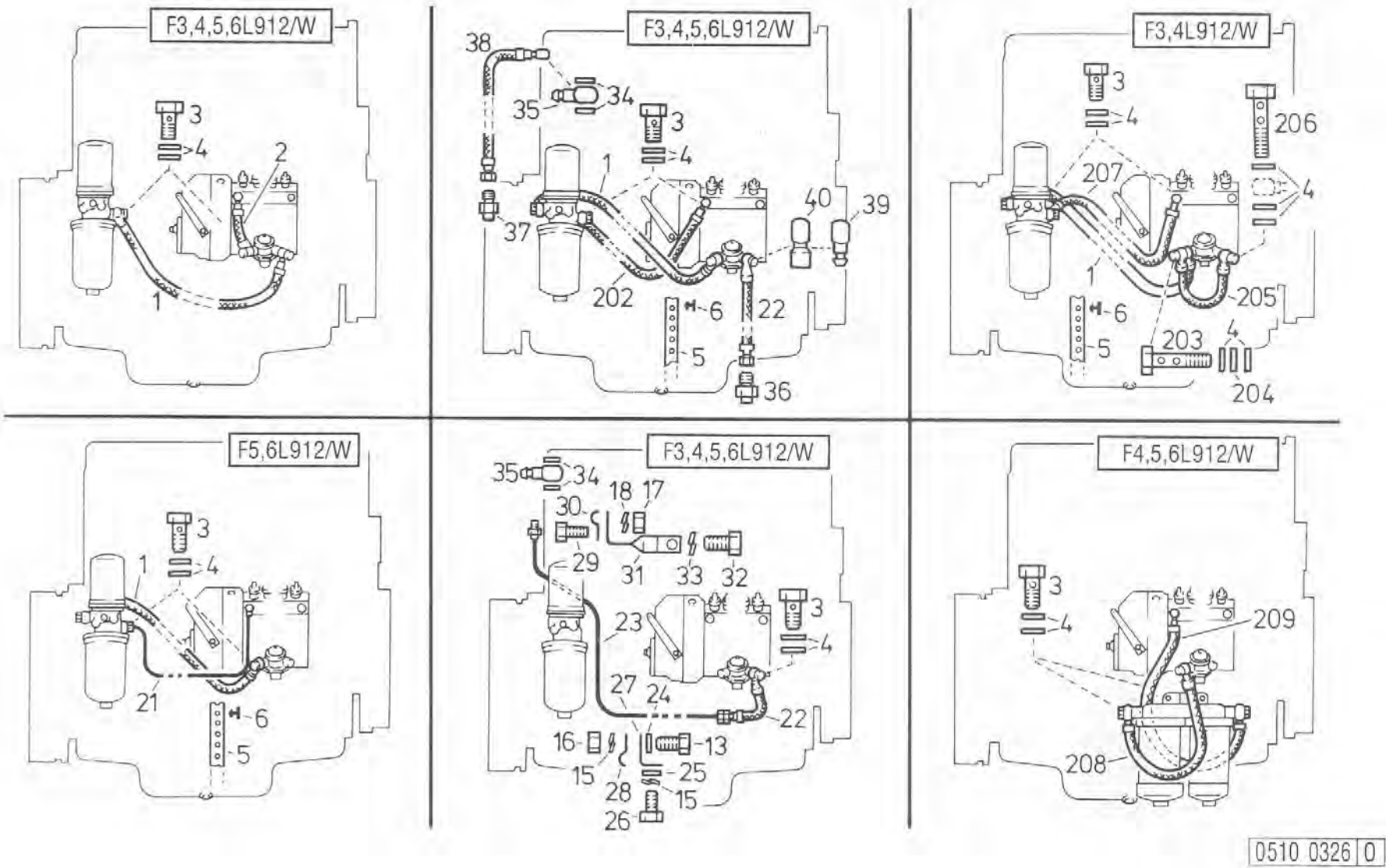




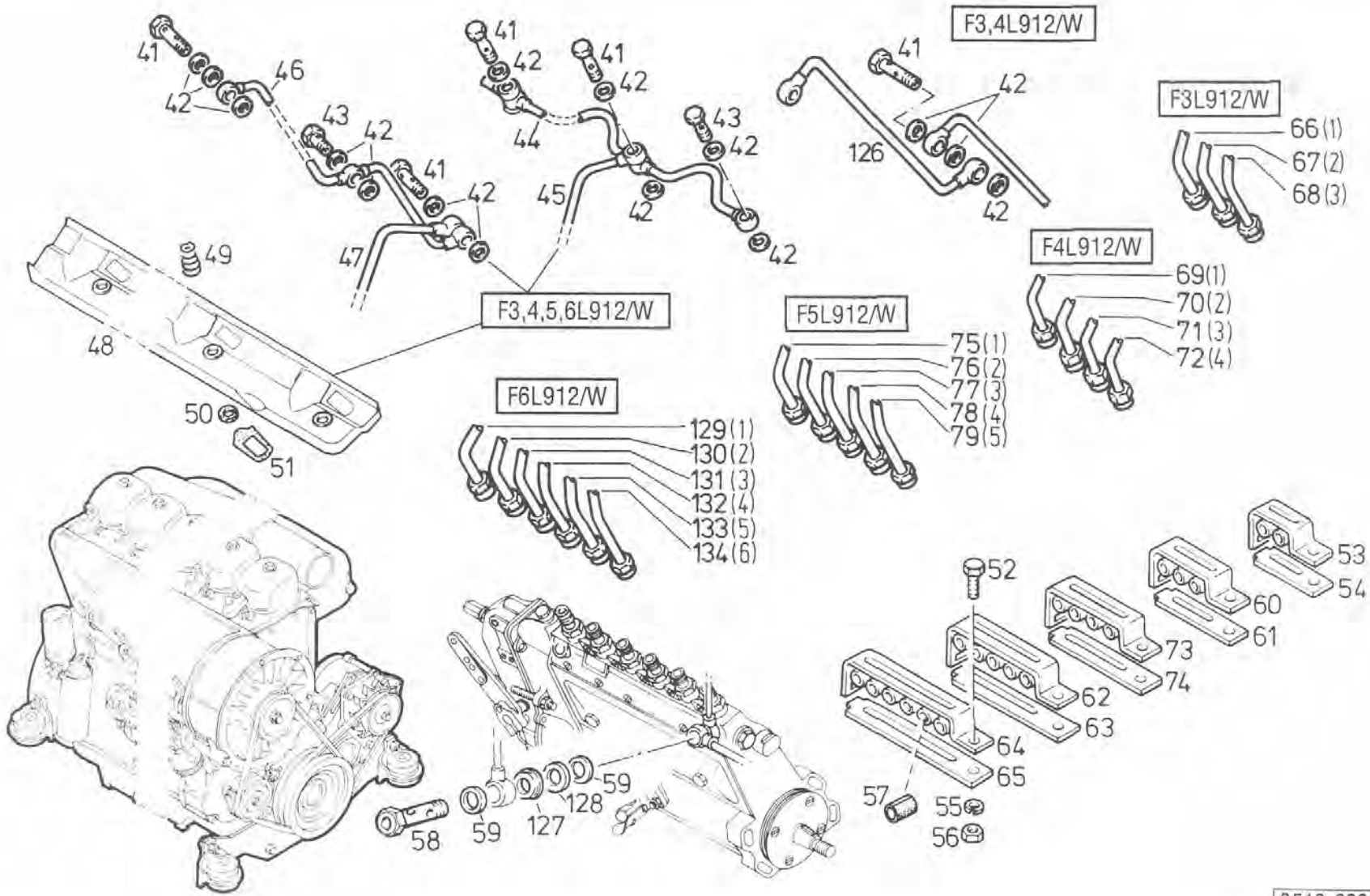




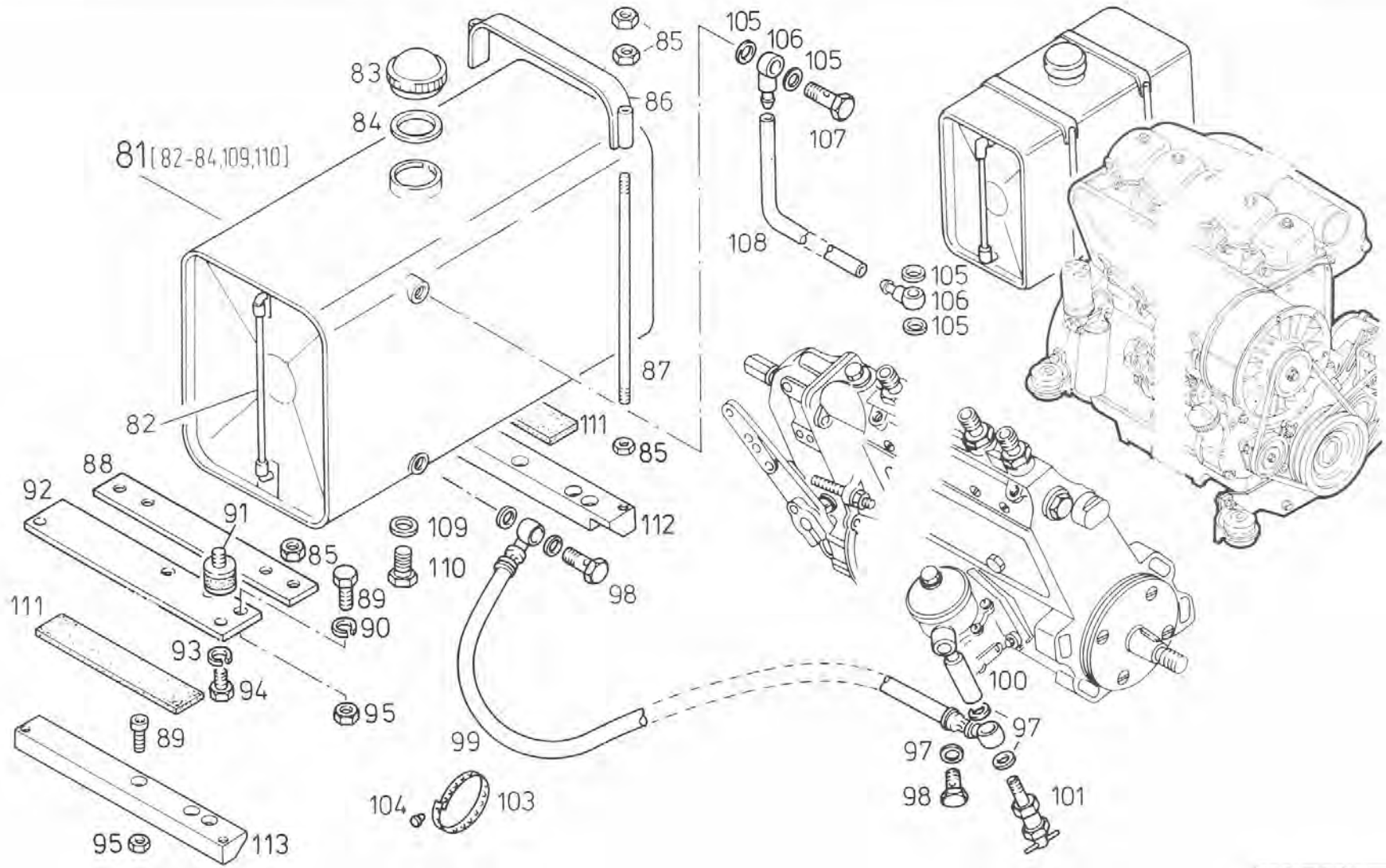
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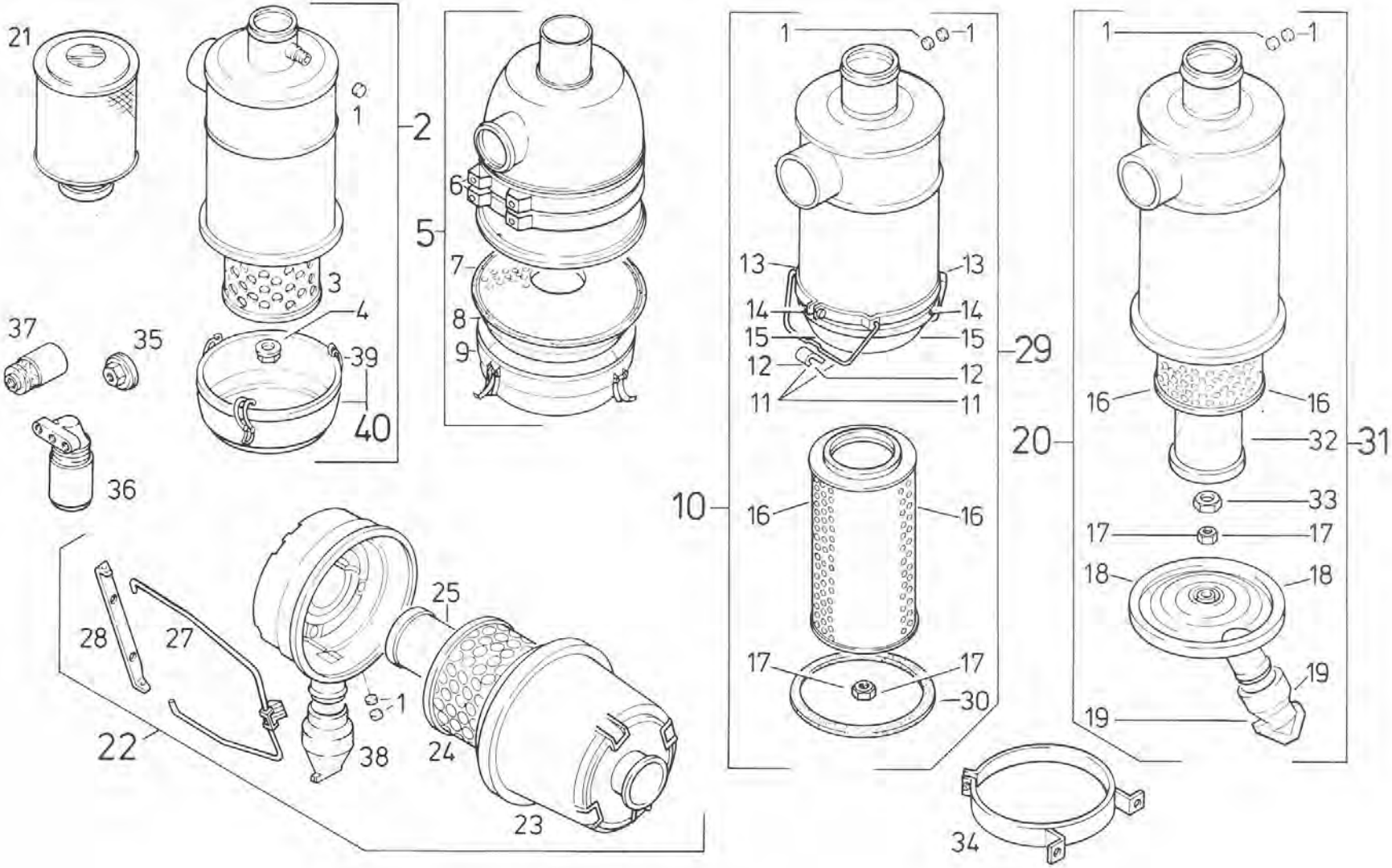






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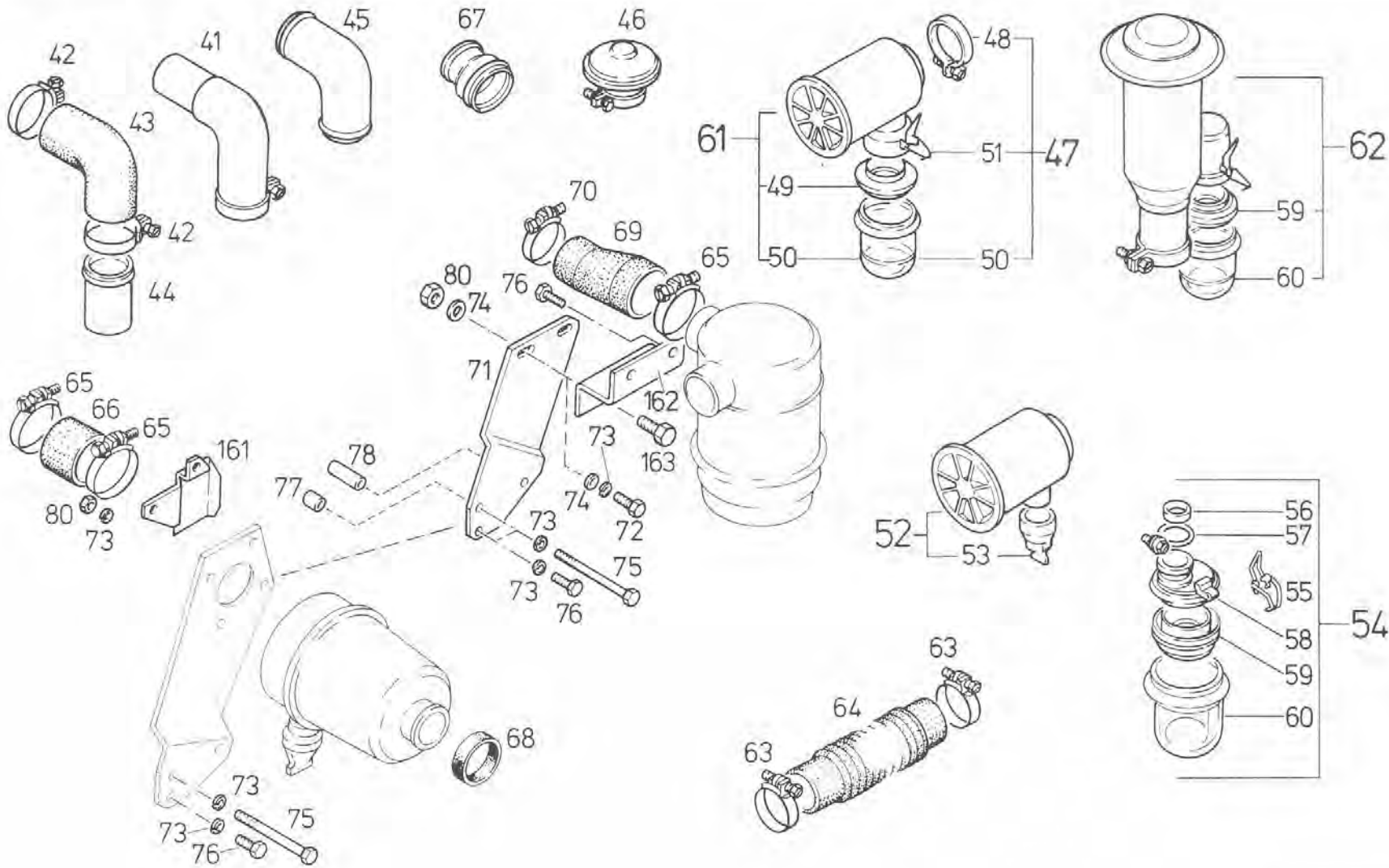
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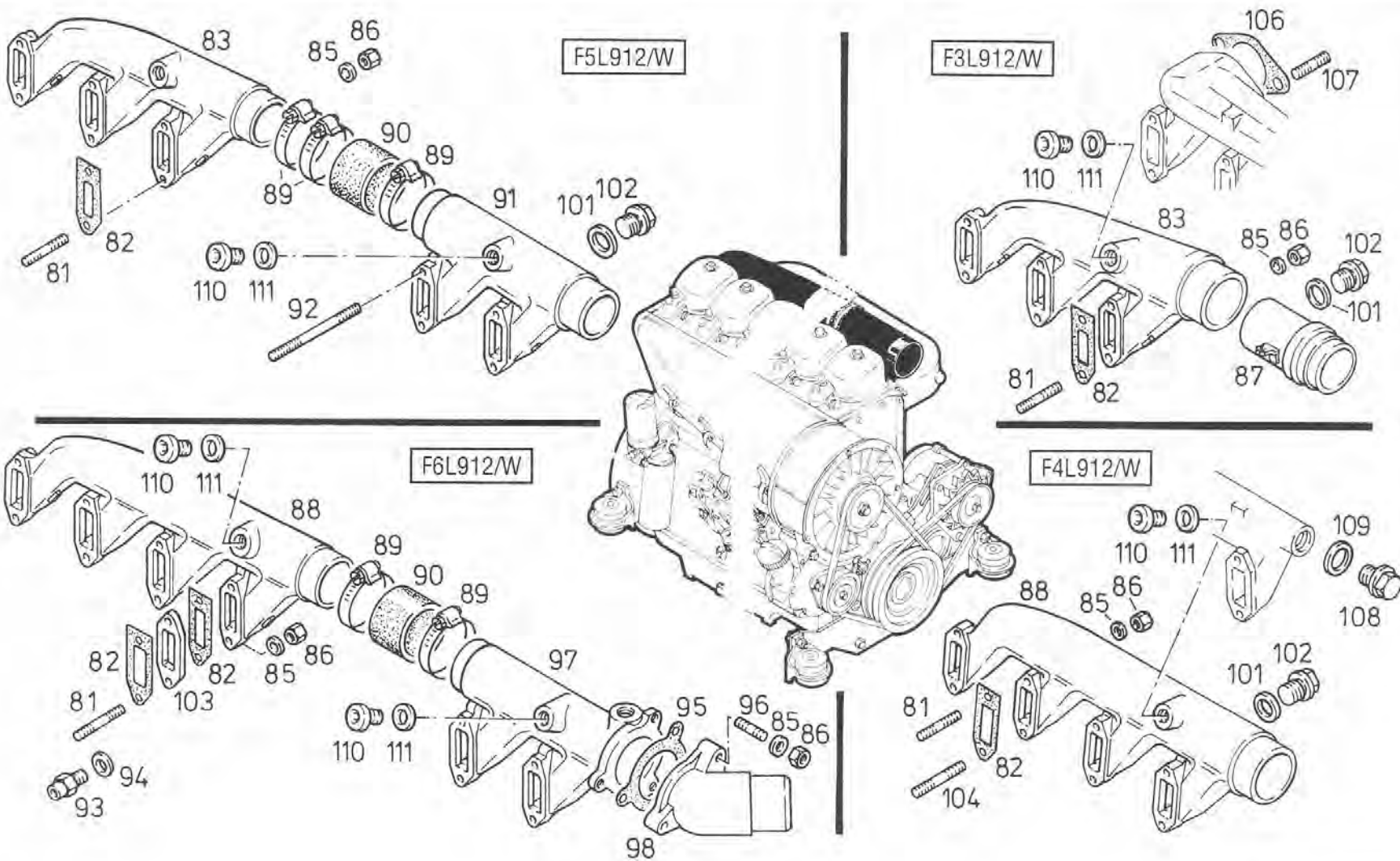


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0510 0331





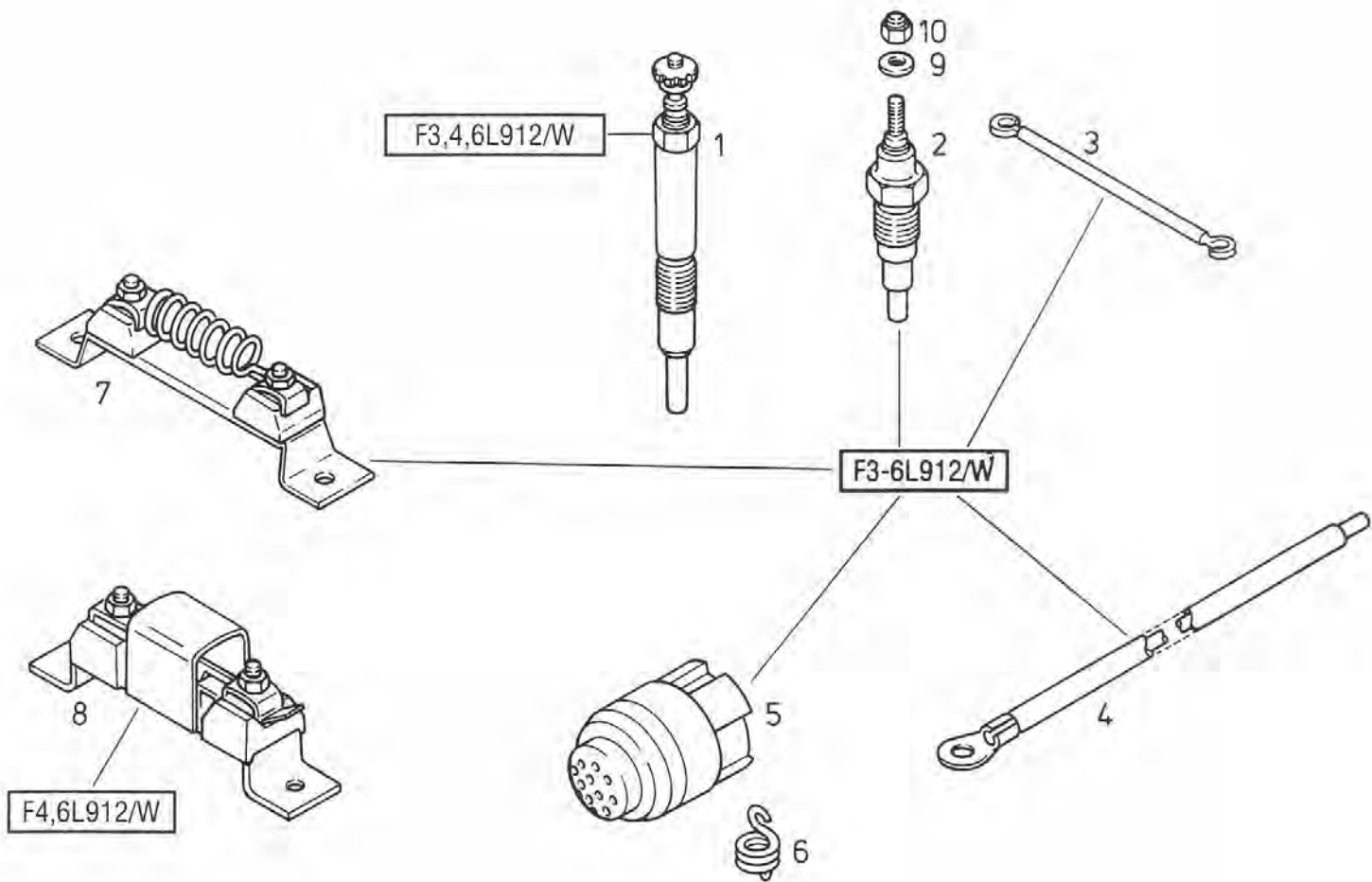
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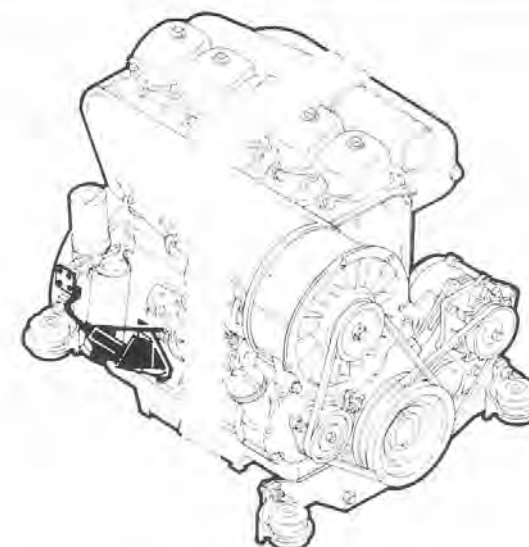


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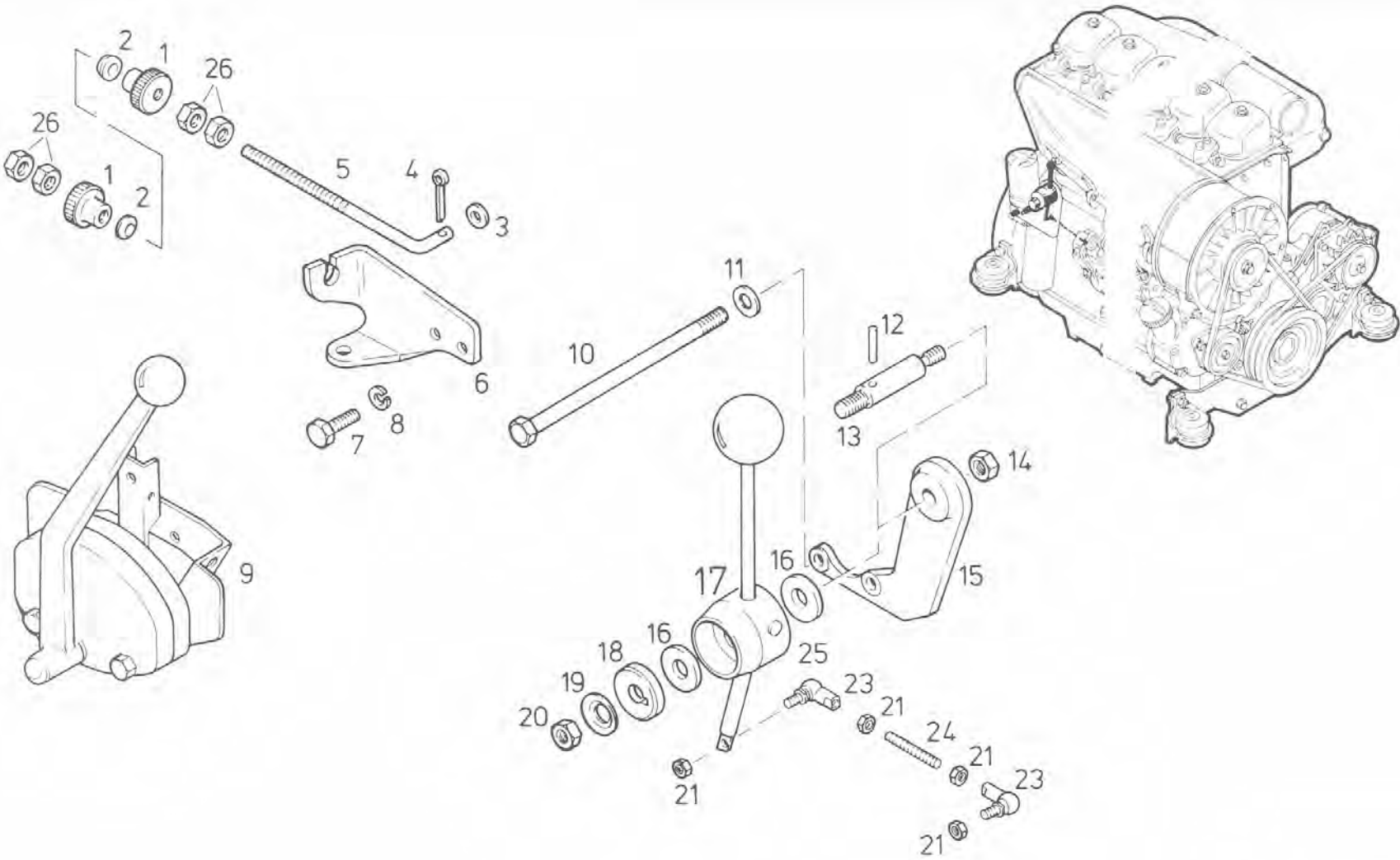


Page 132 of 393



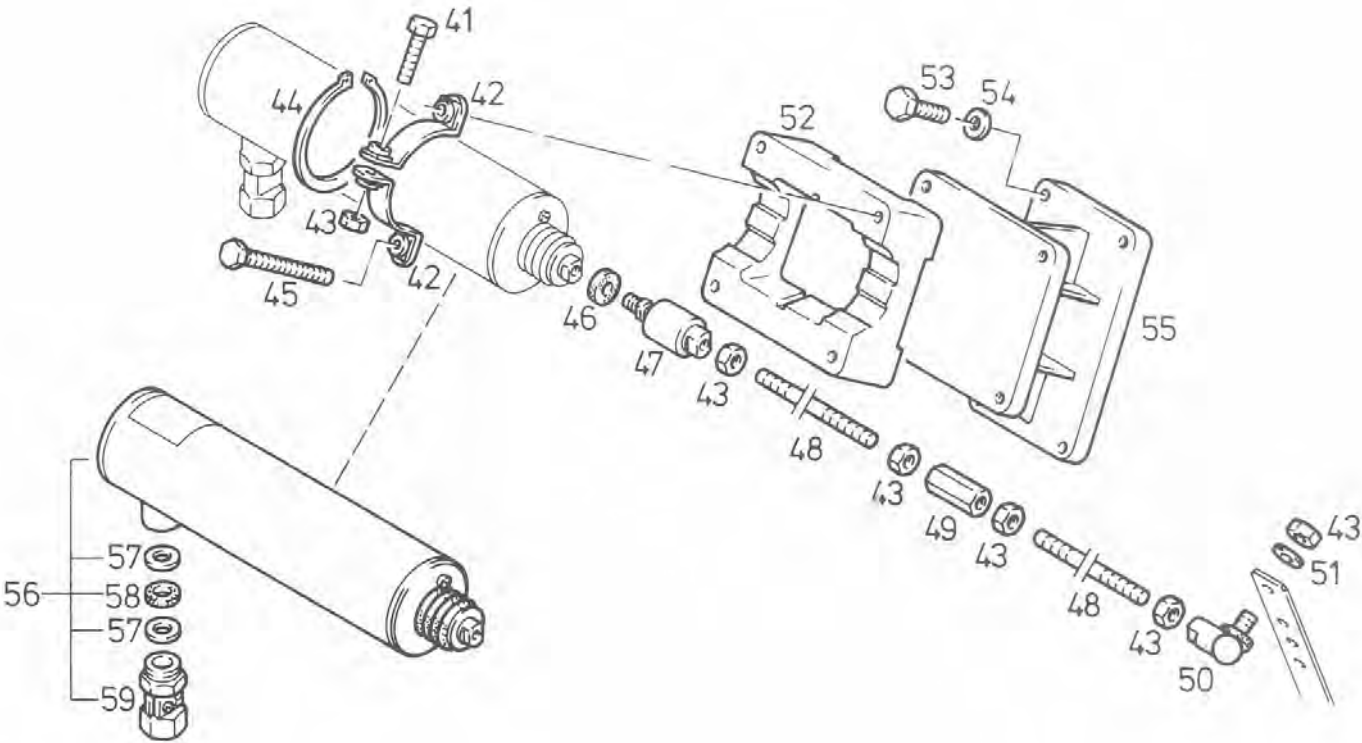


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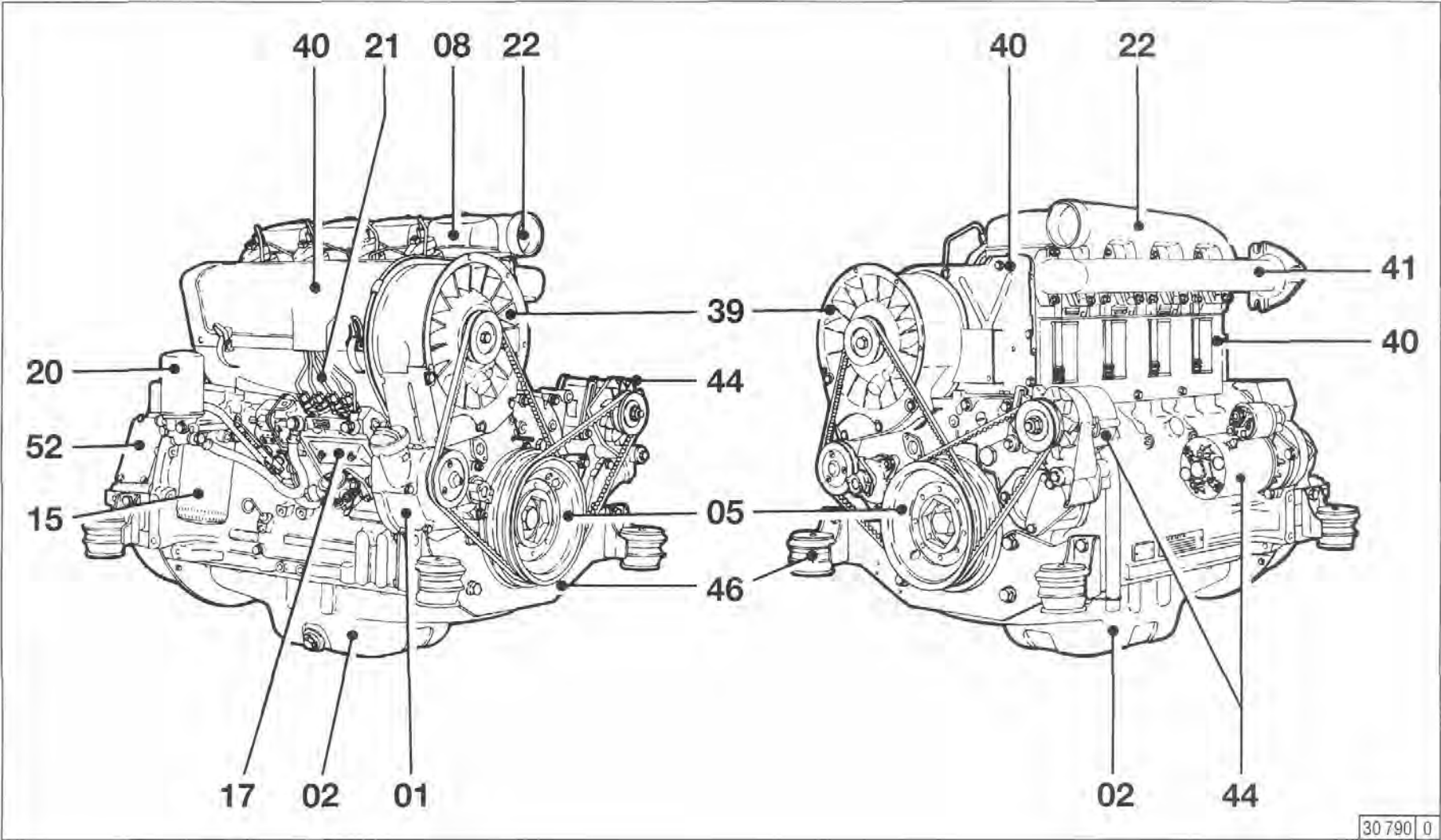





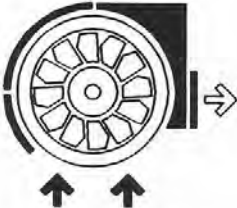


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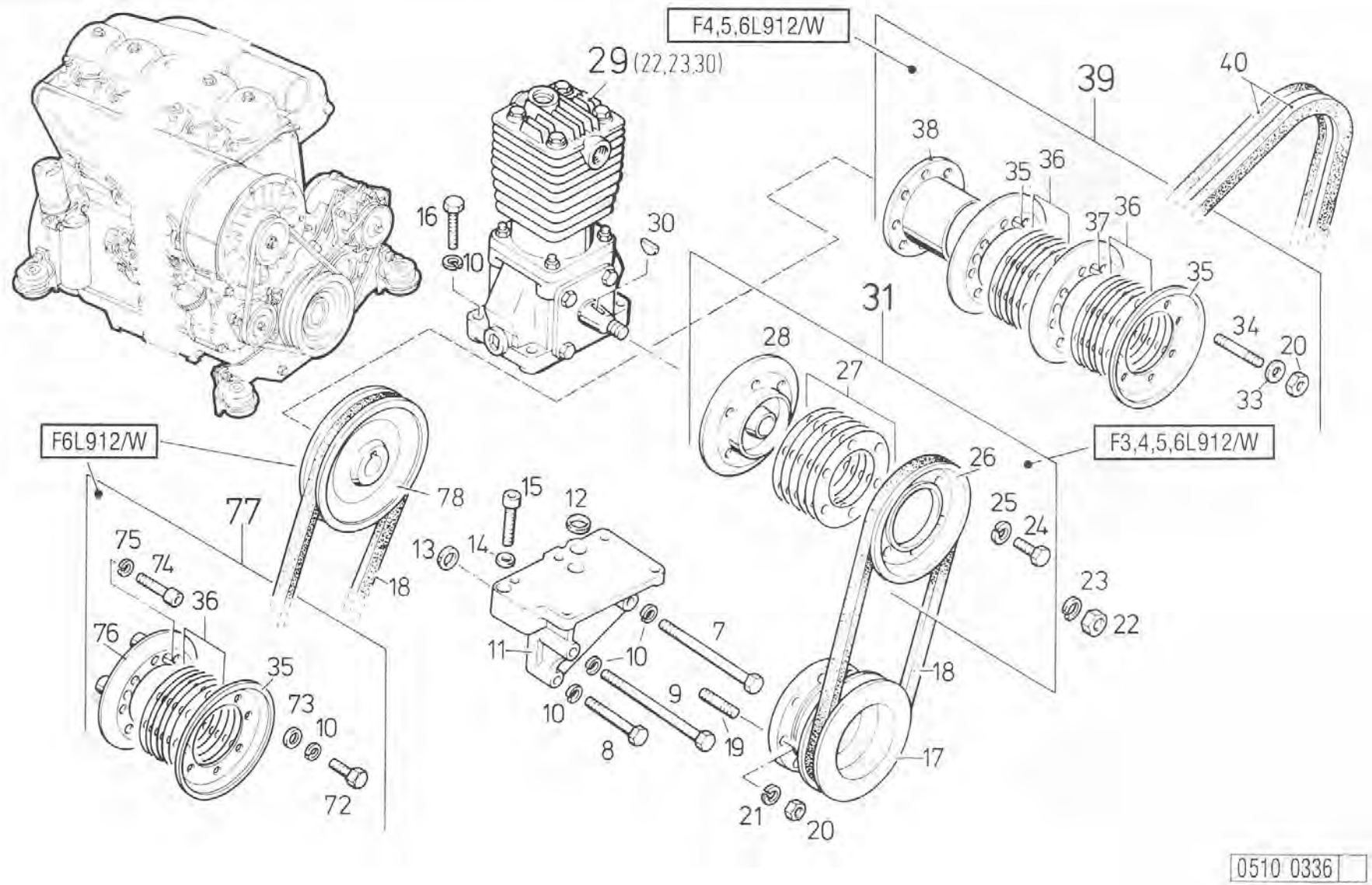
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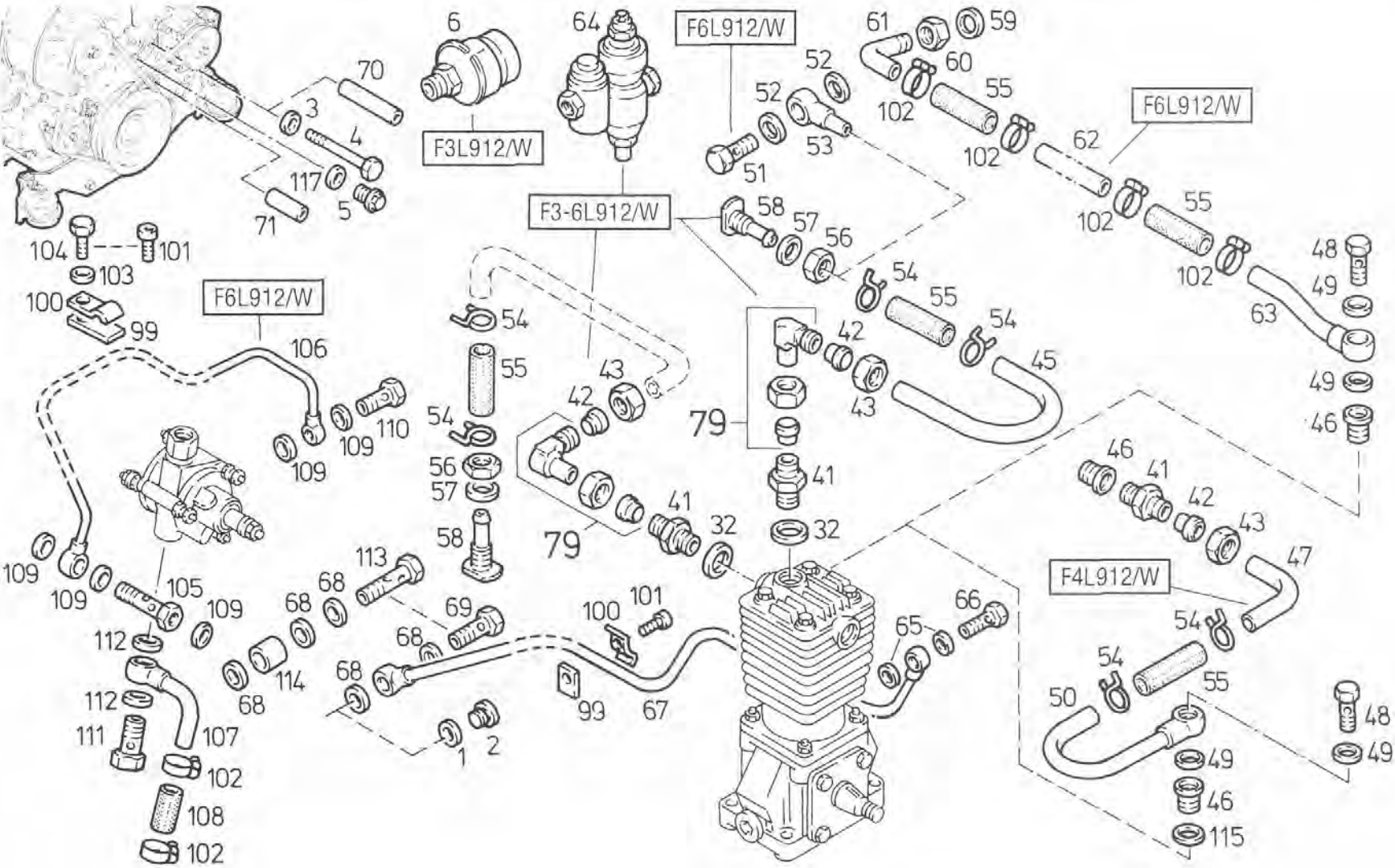




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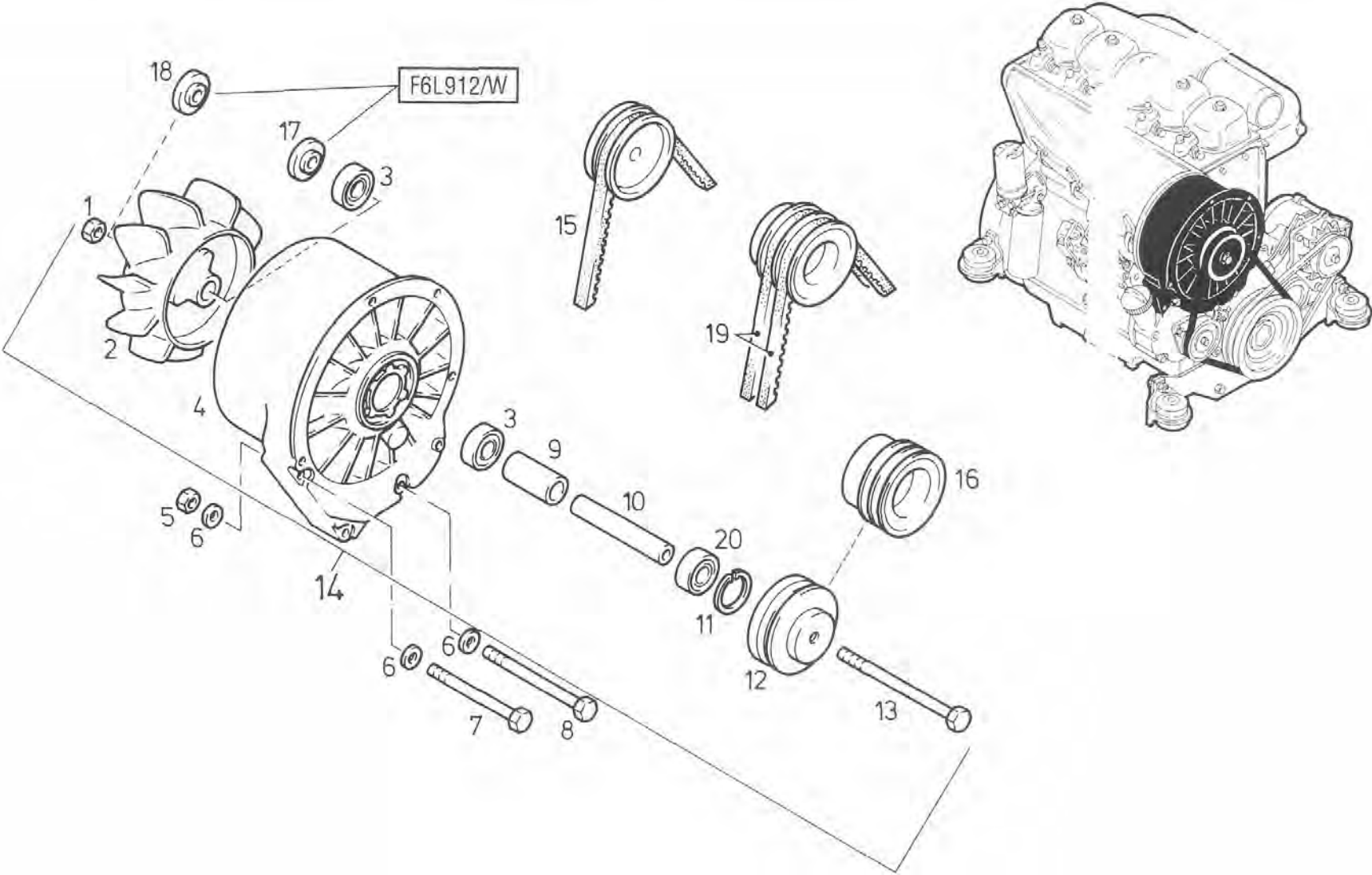




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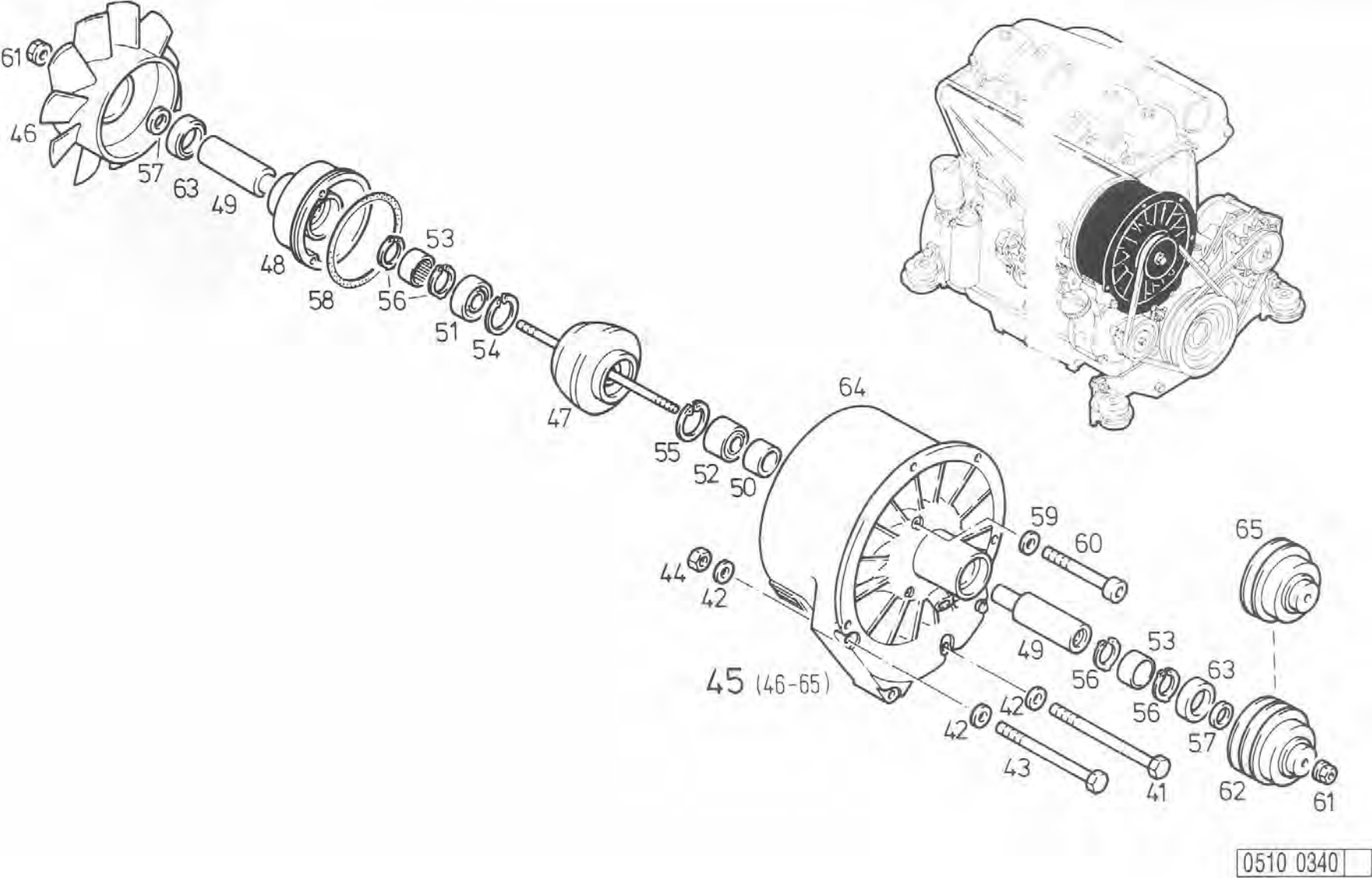




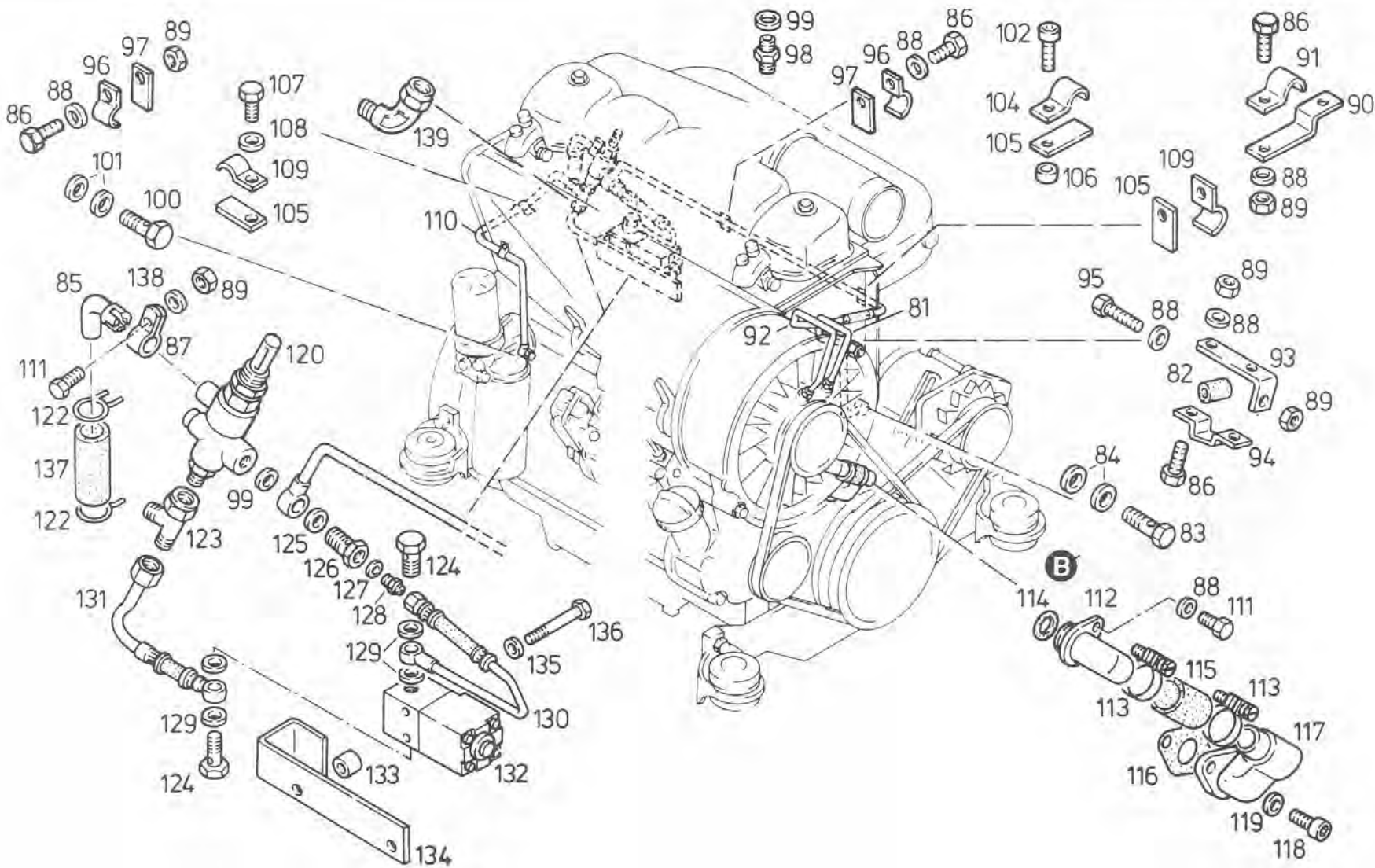




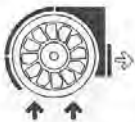
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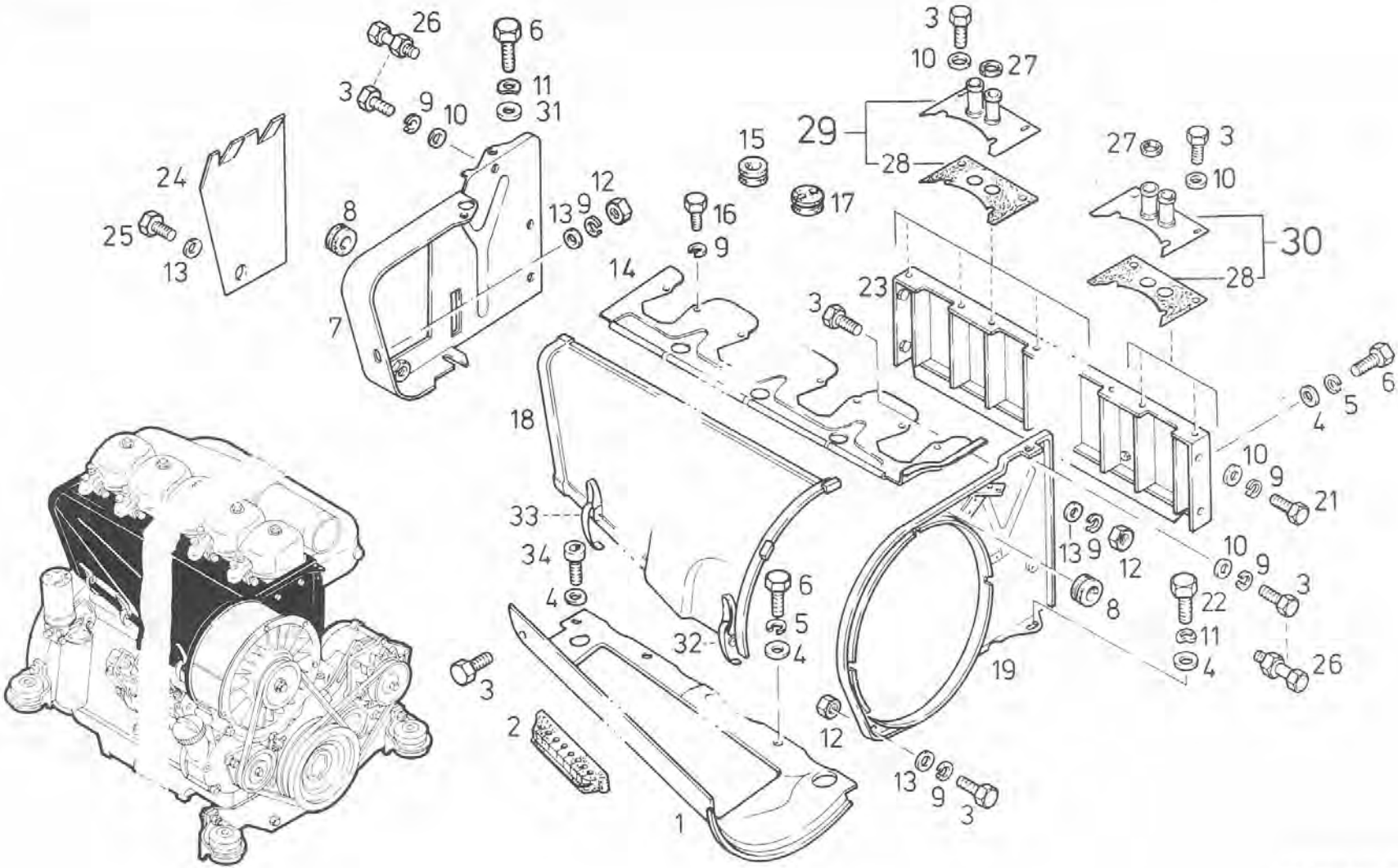






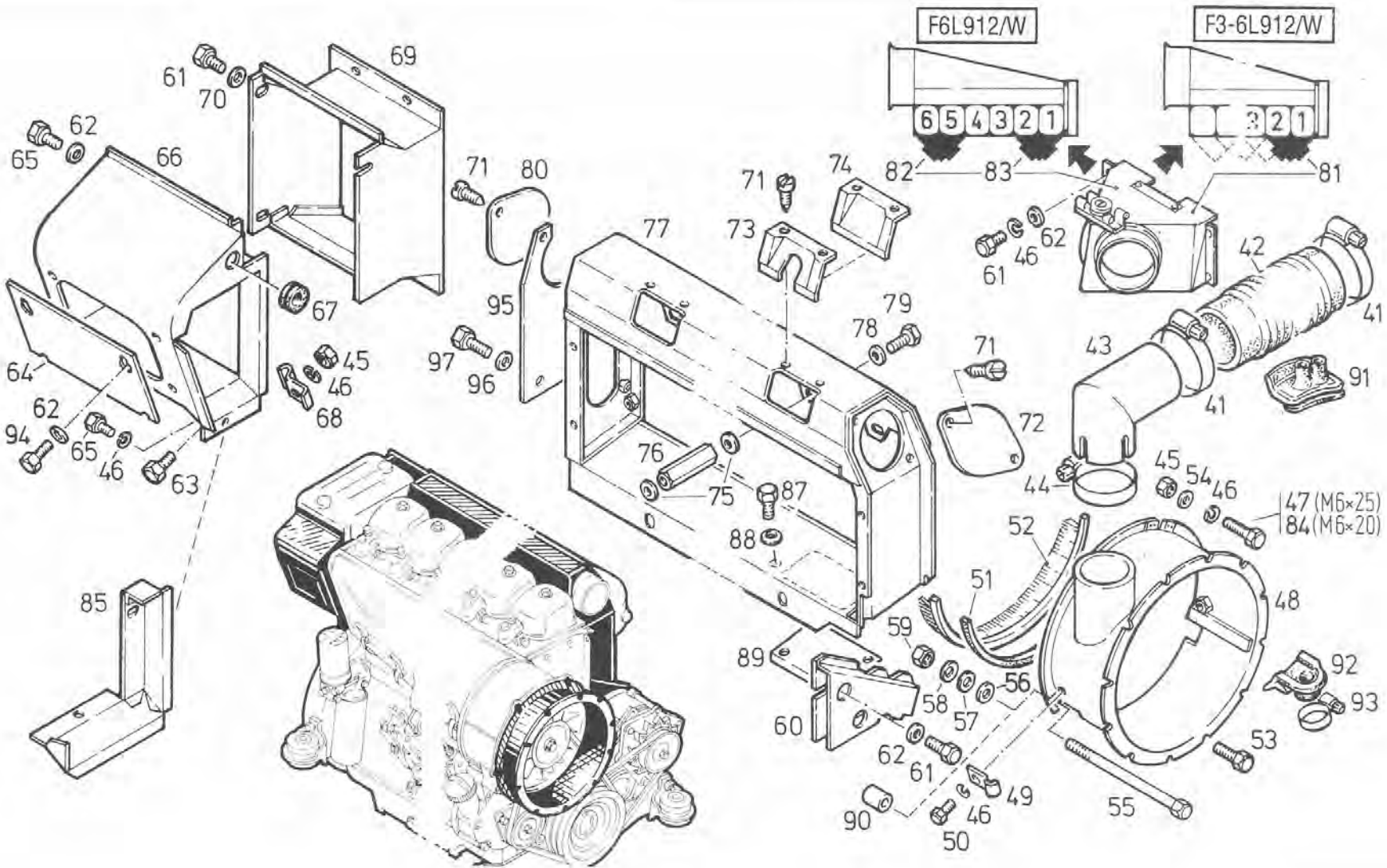
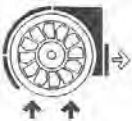


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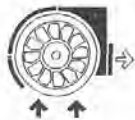


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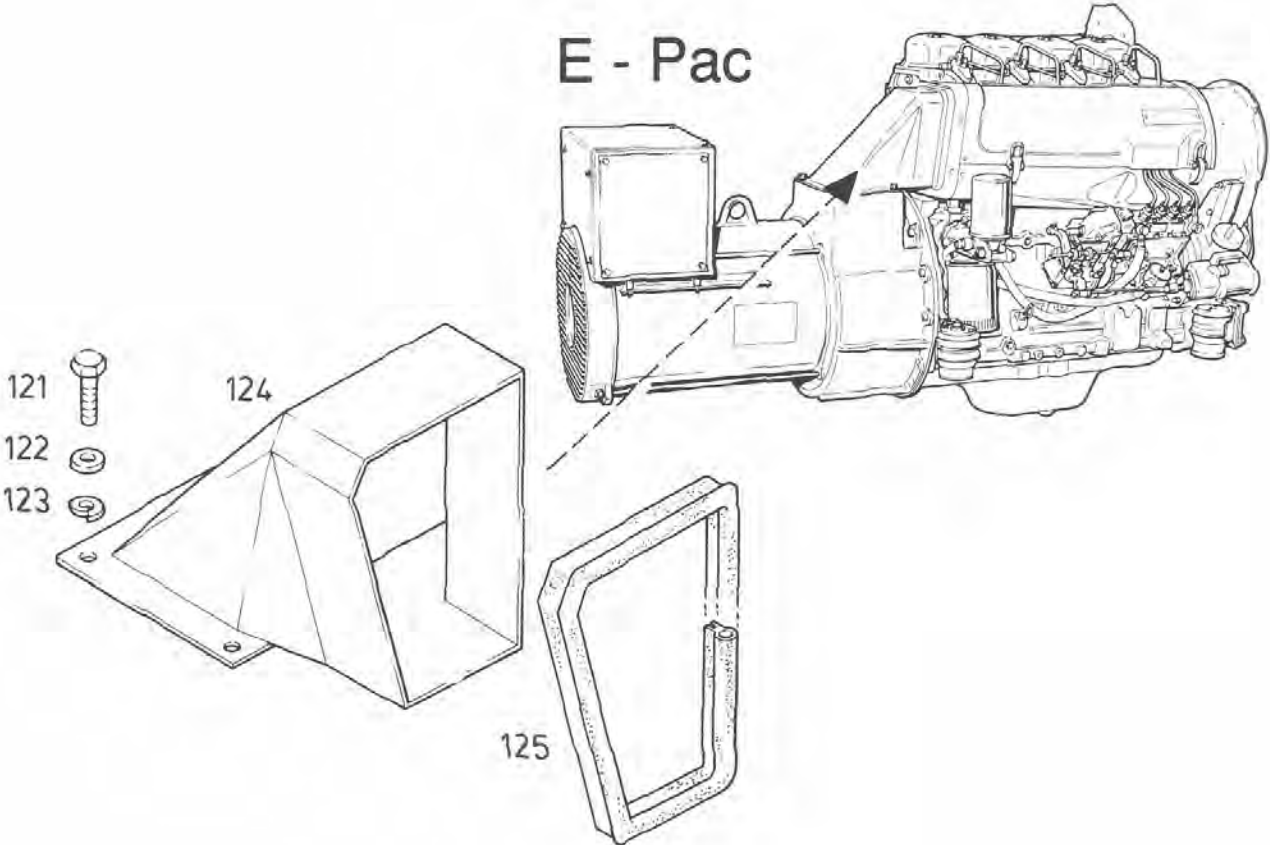






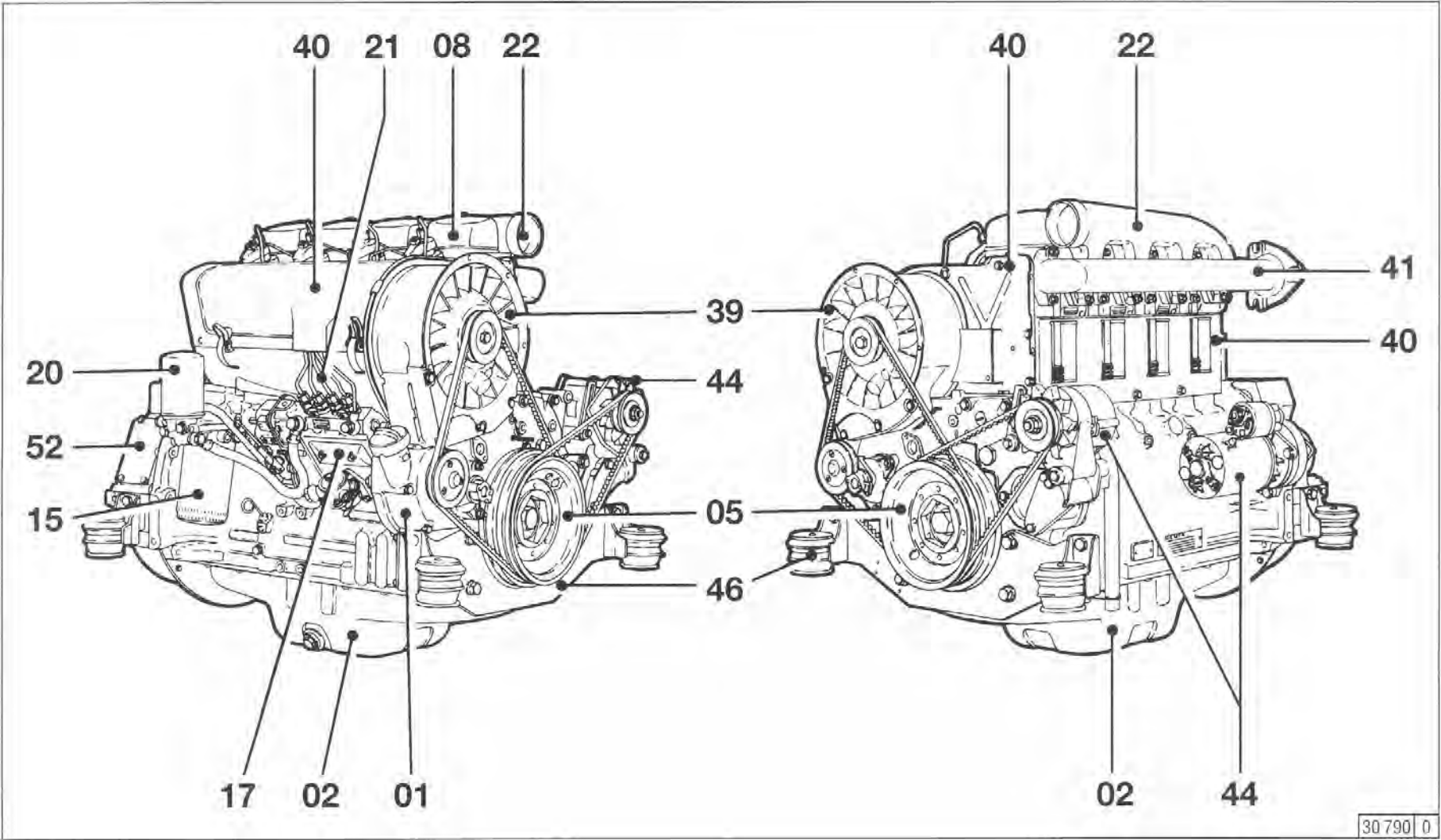


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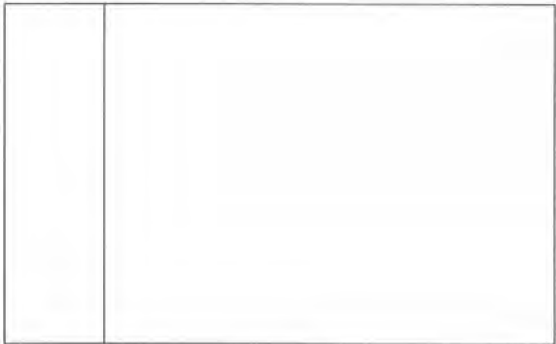
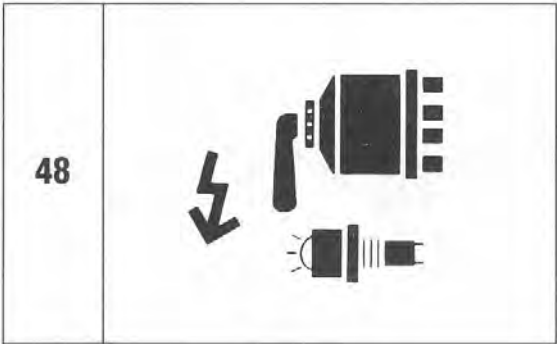
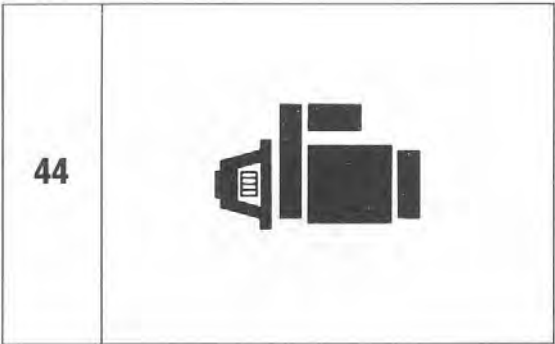
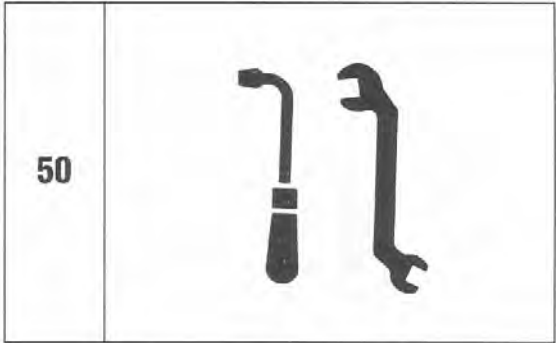
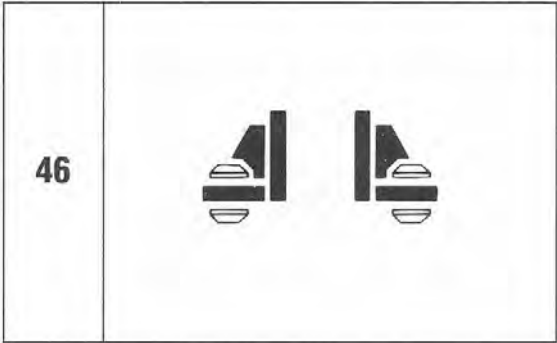
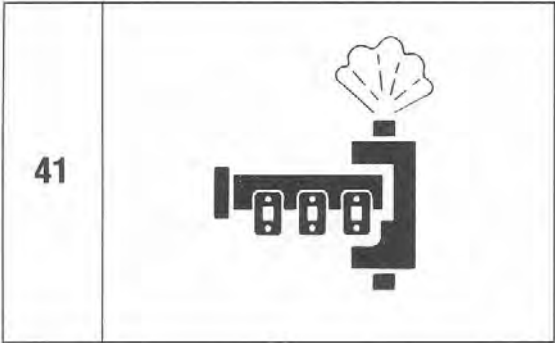


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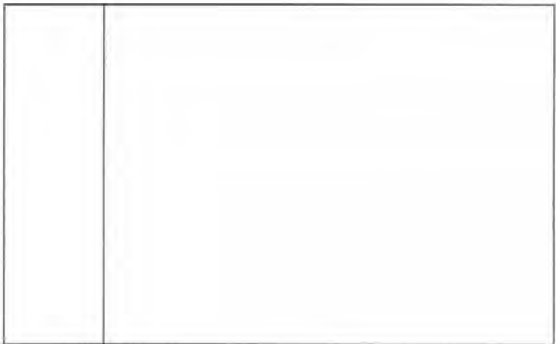
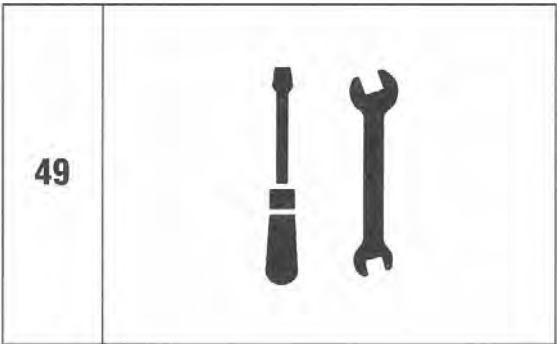
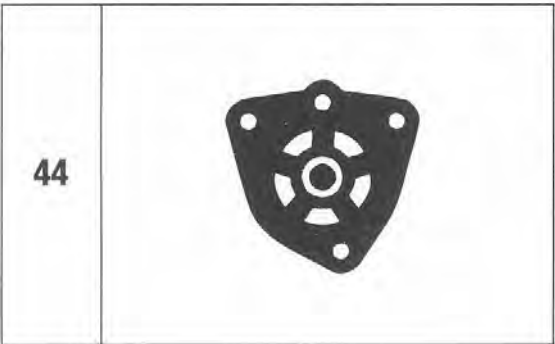








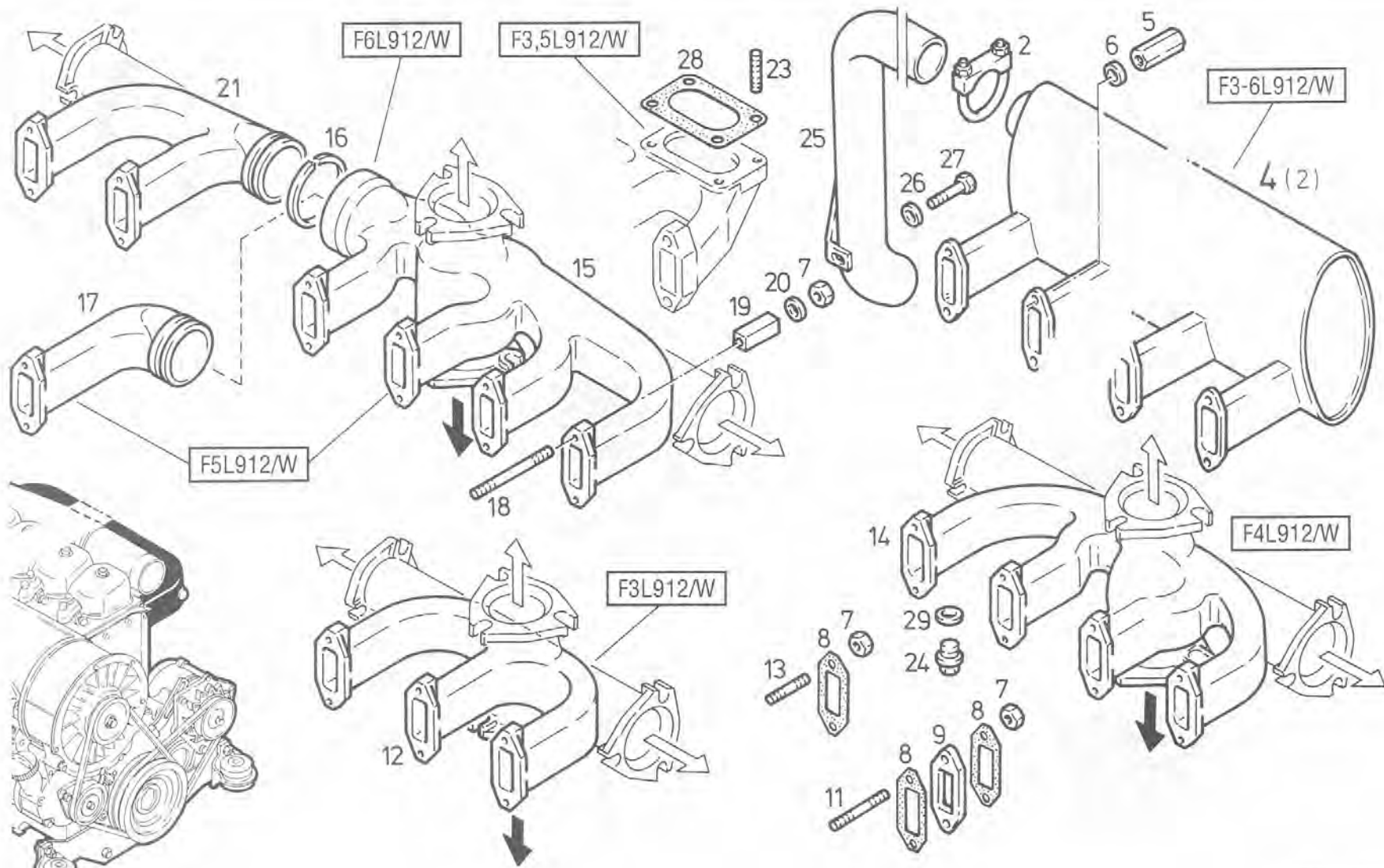
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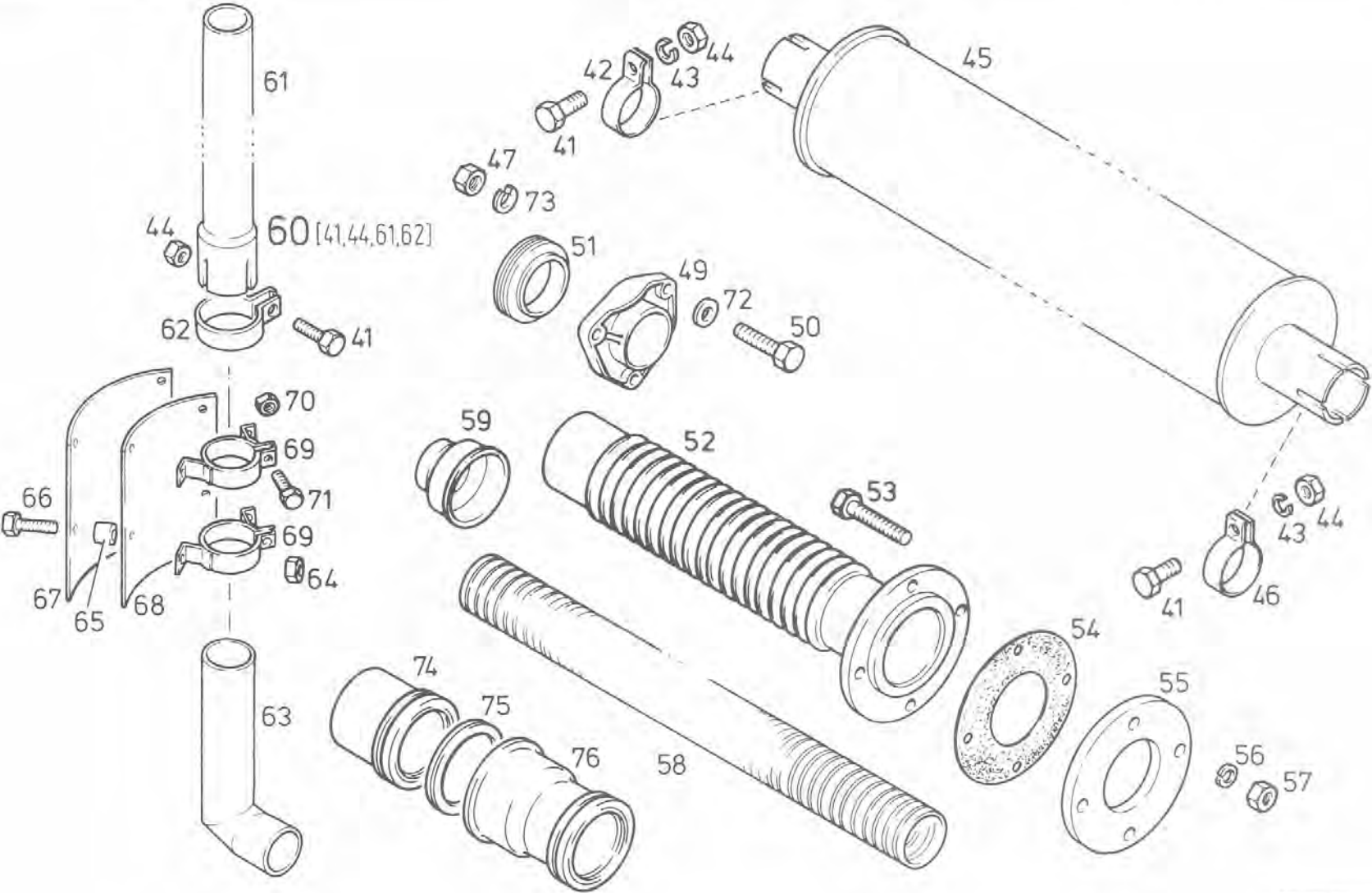


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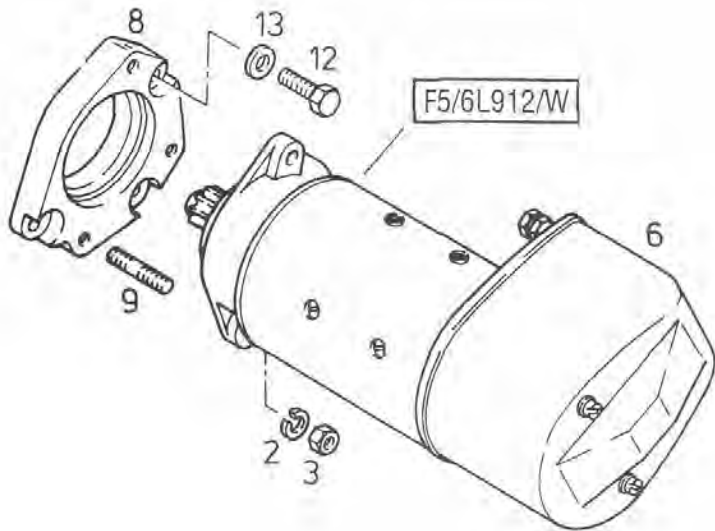
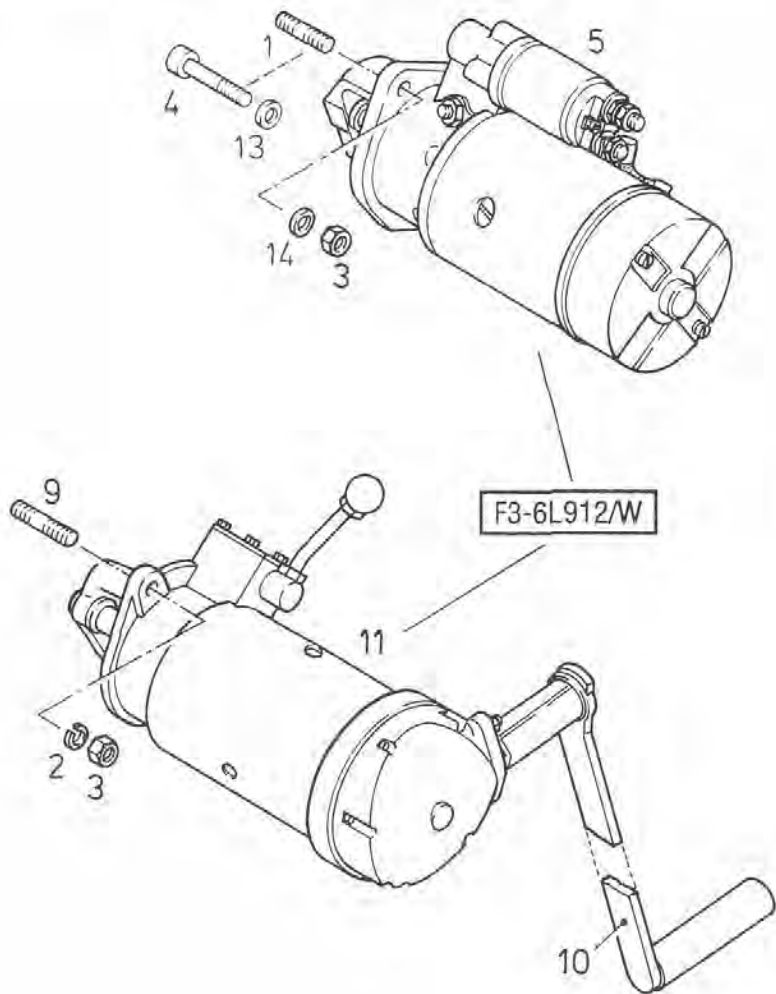
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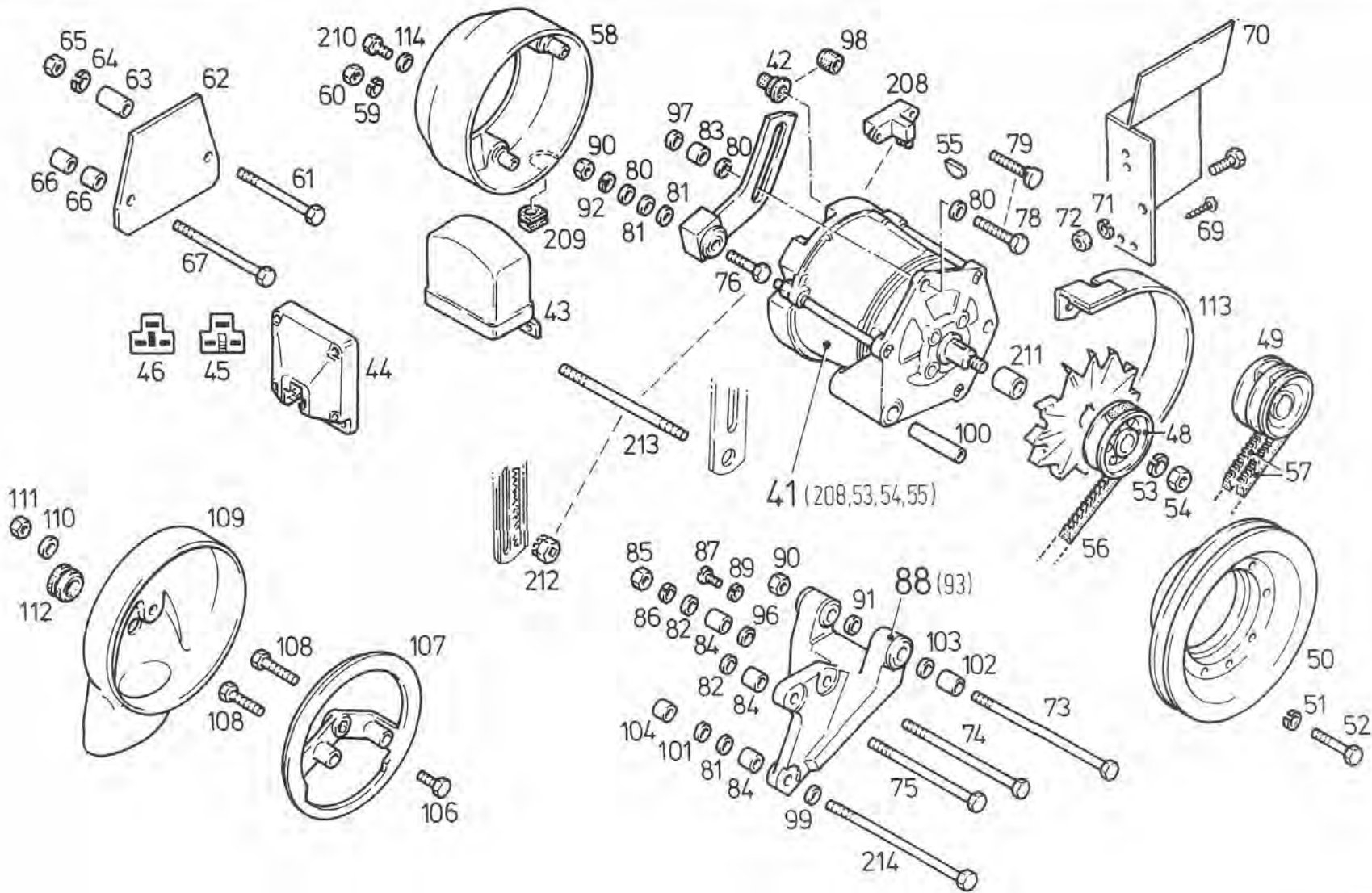


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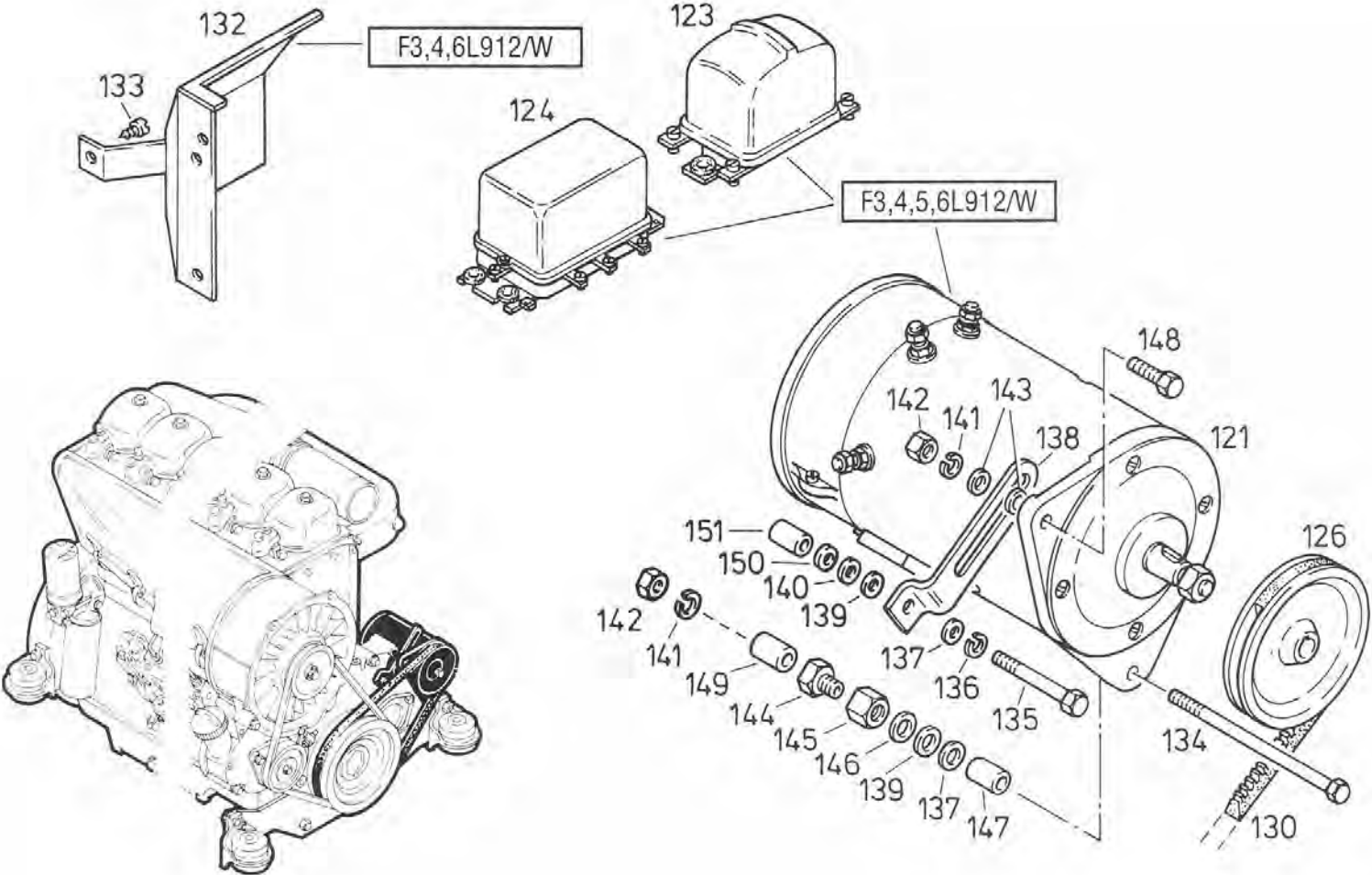


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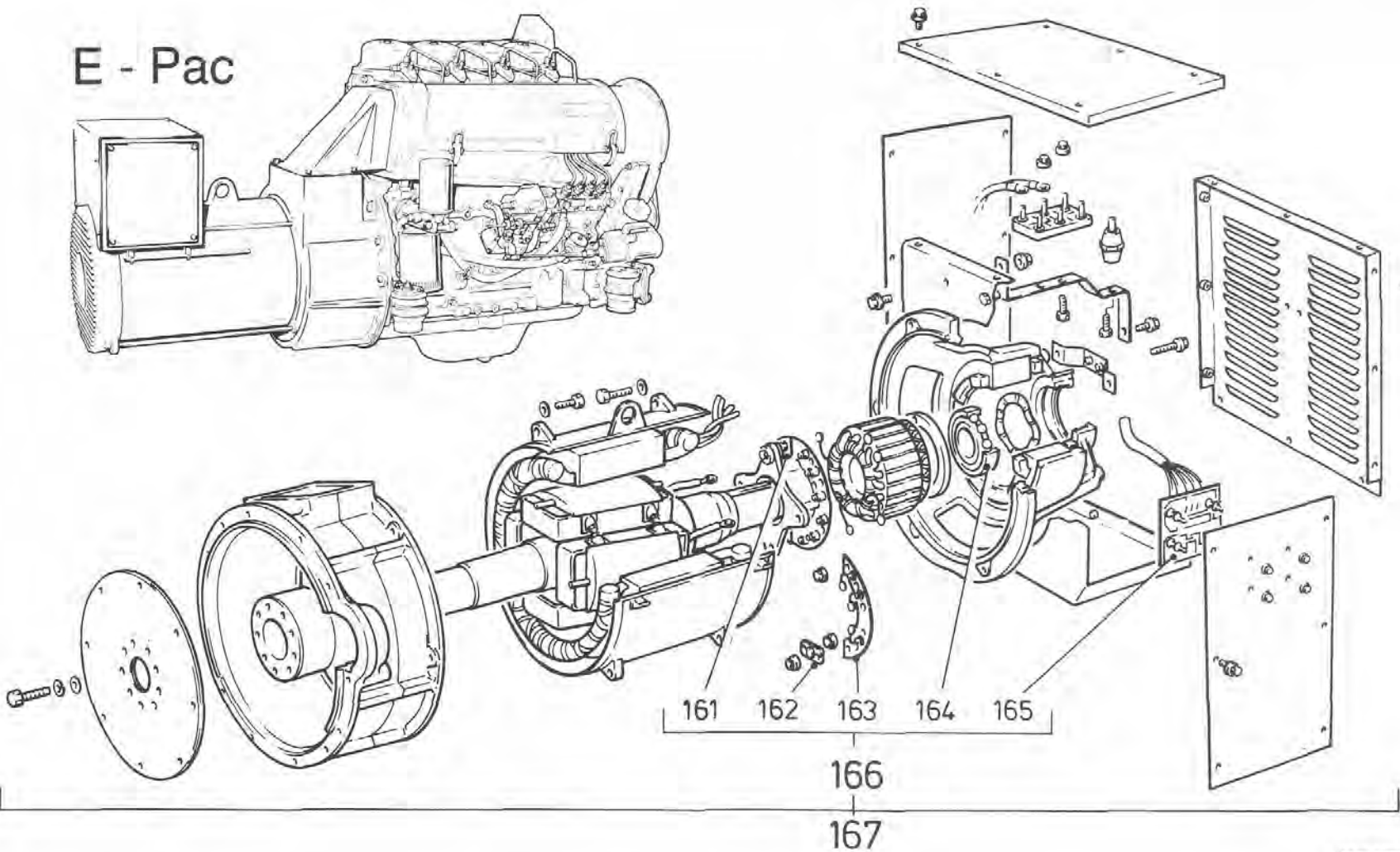


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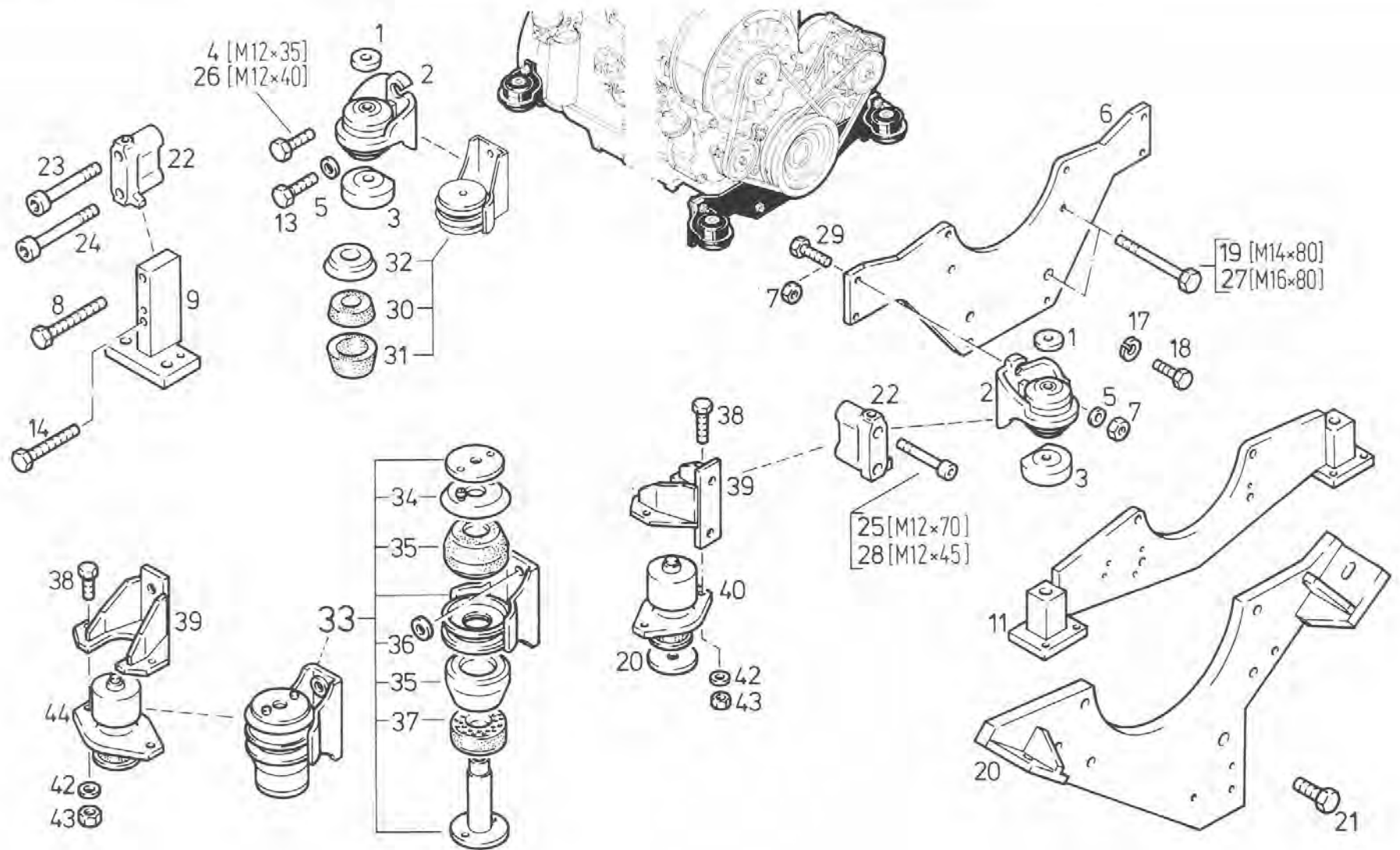
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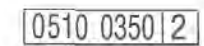
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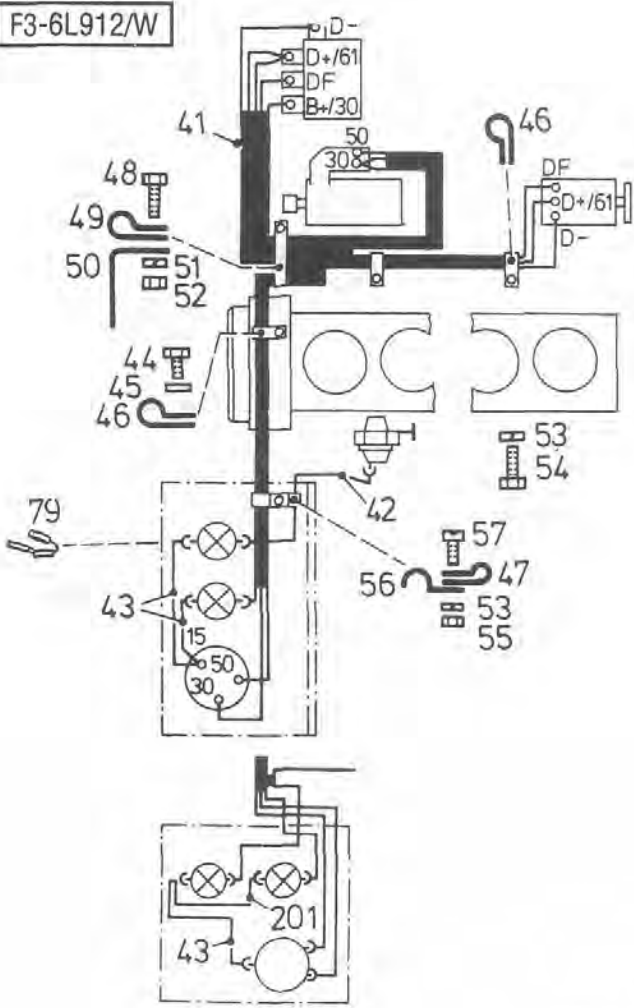
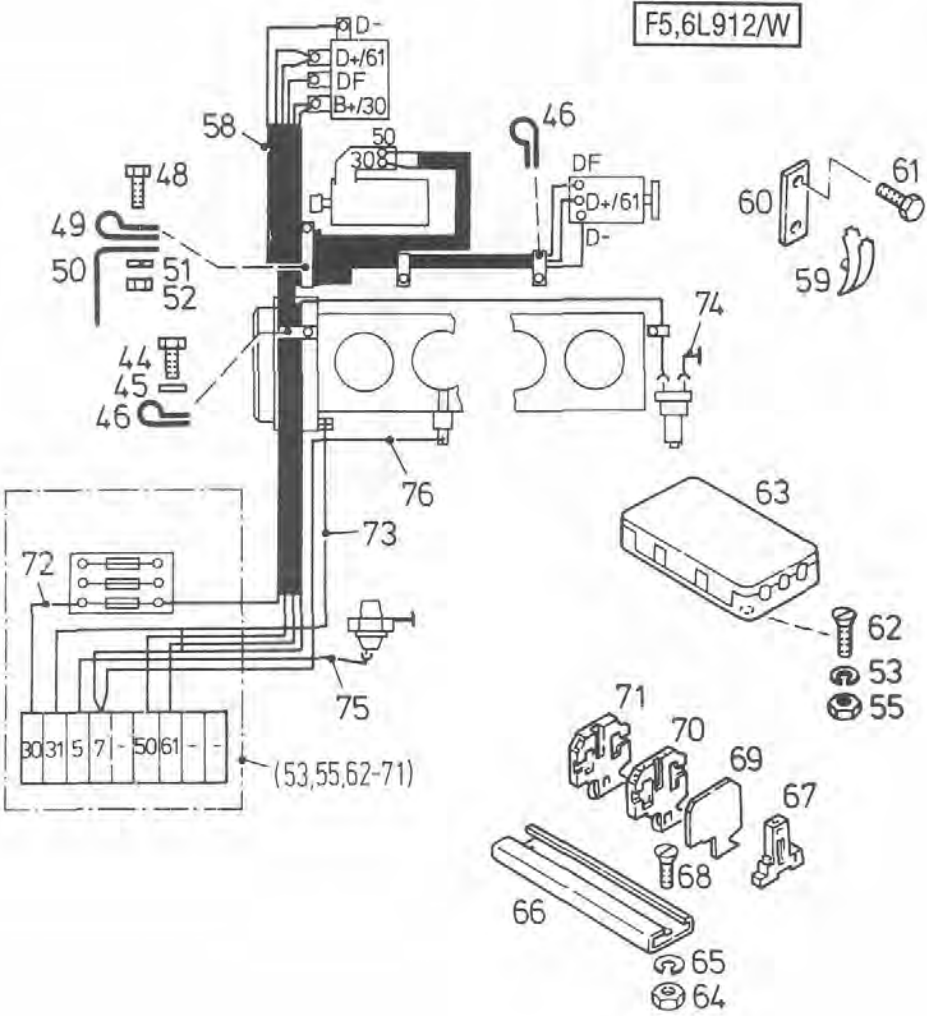


Page 155 of 393

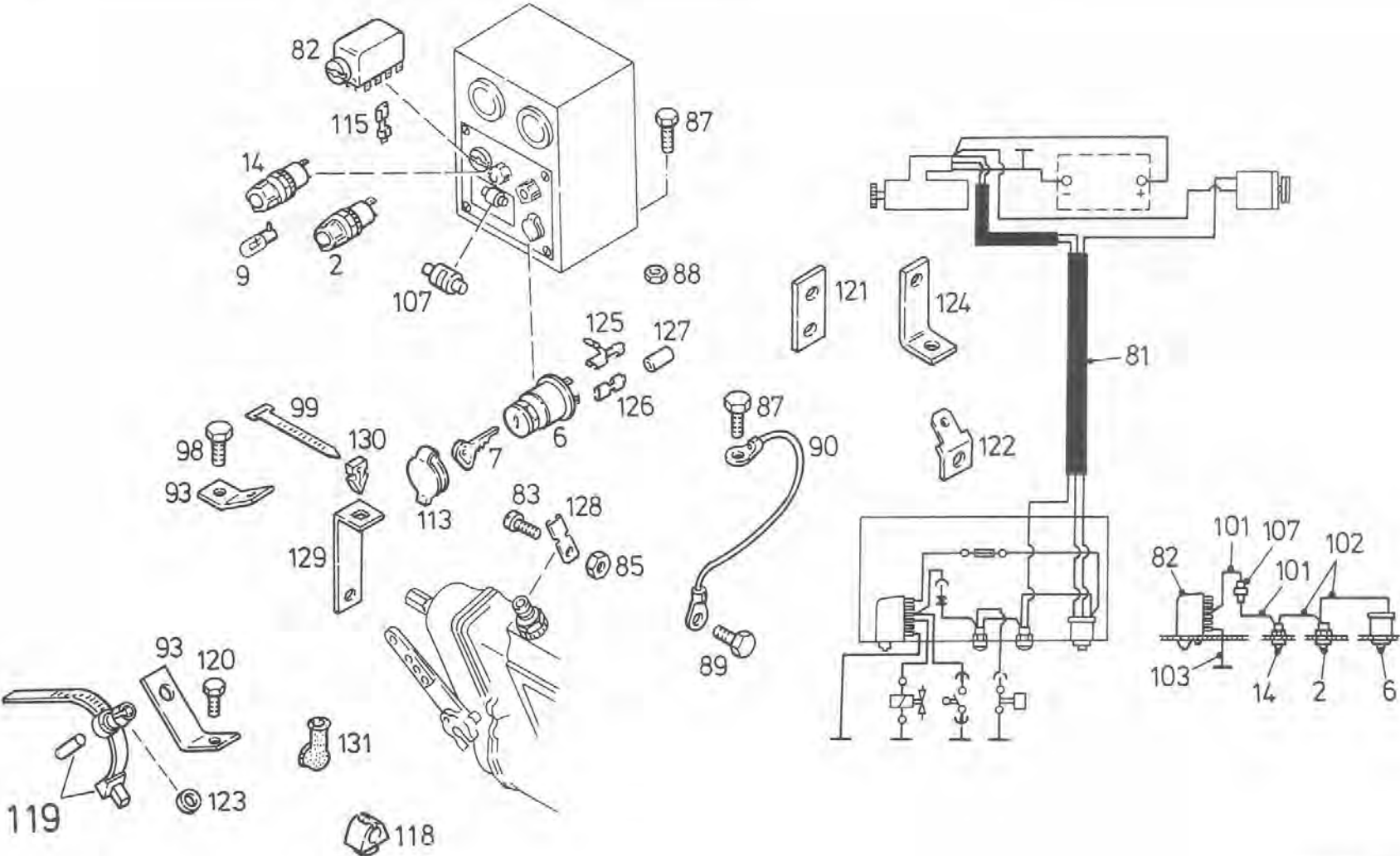






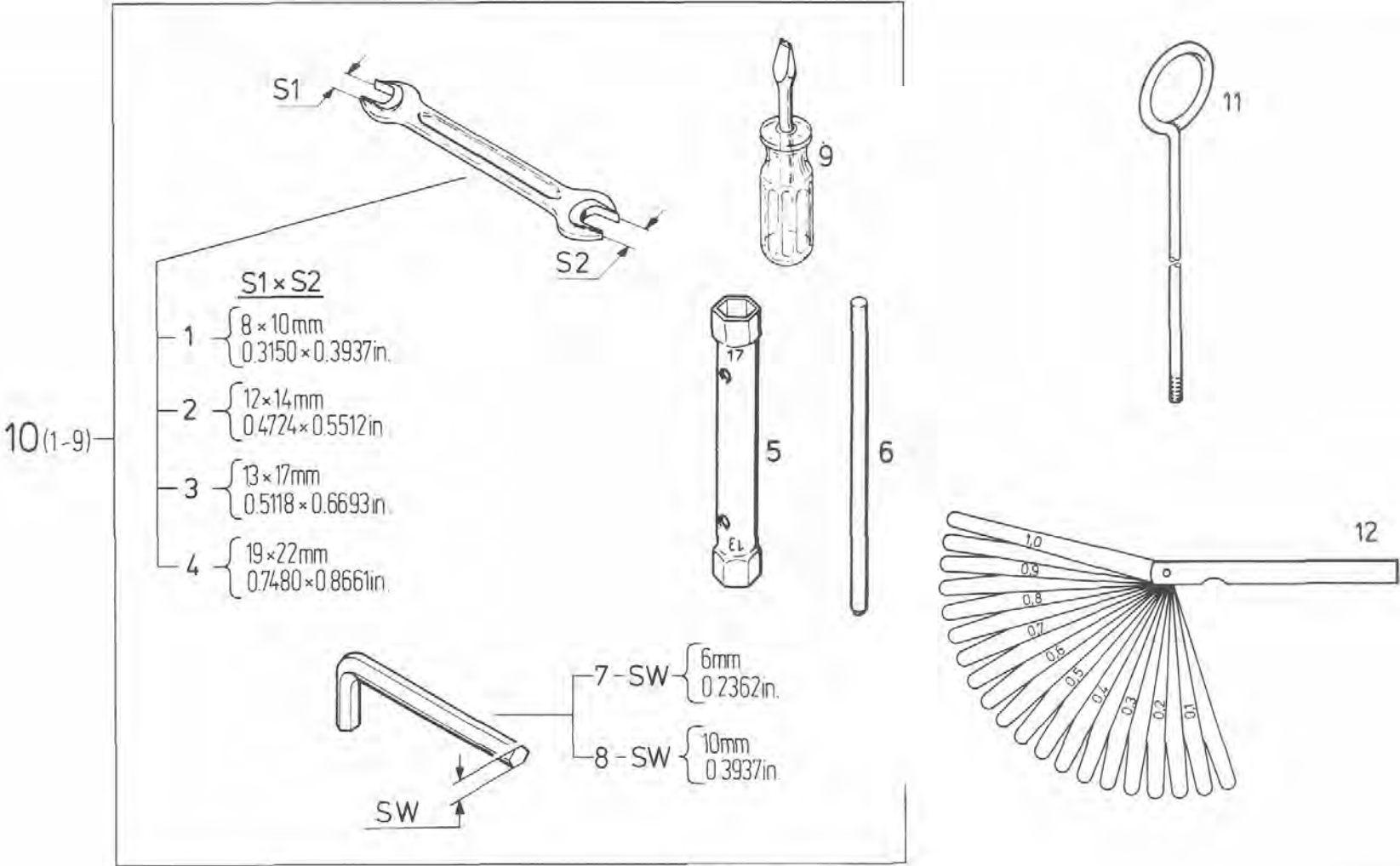




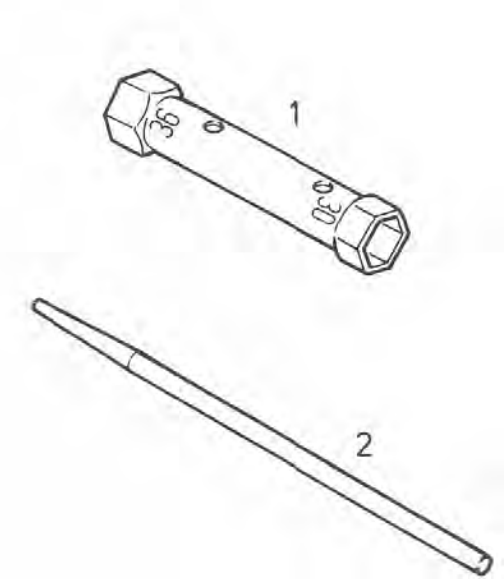


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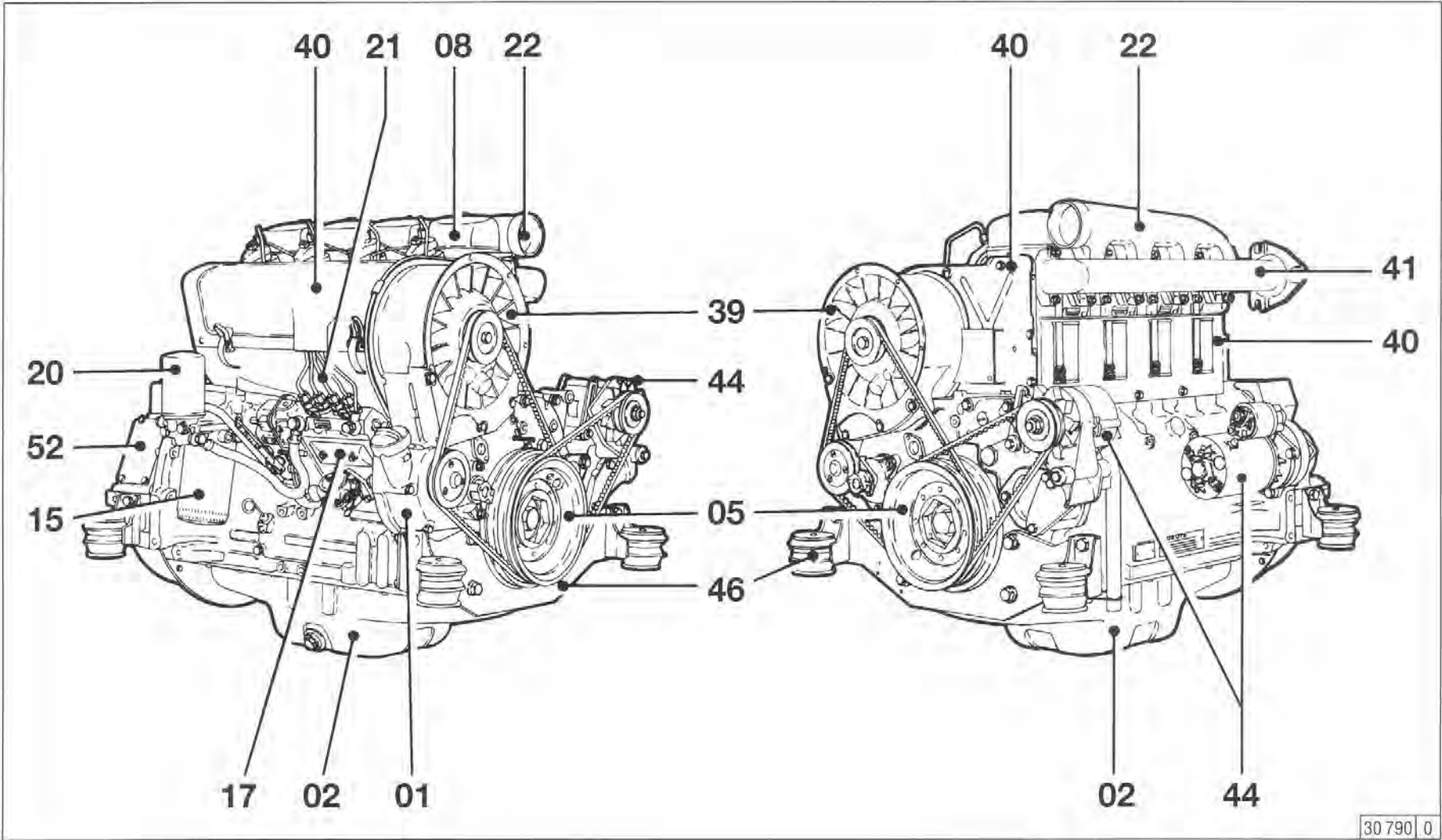







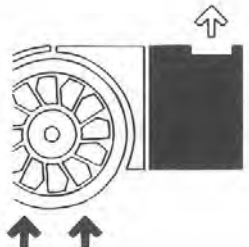
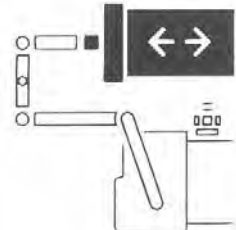
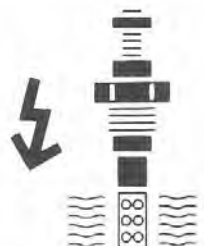


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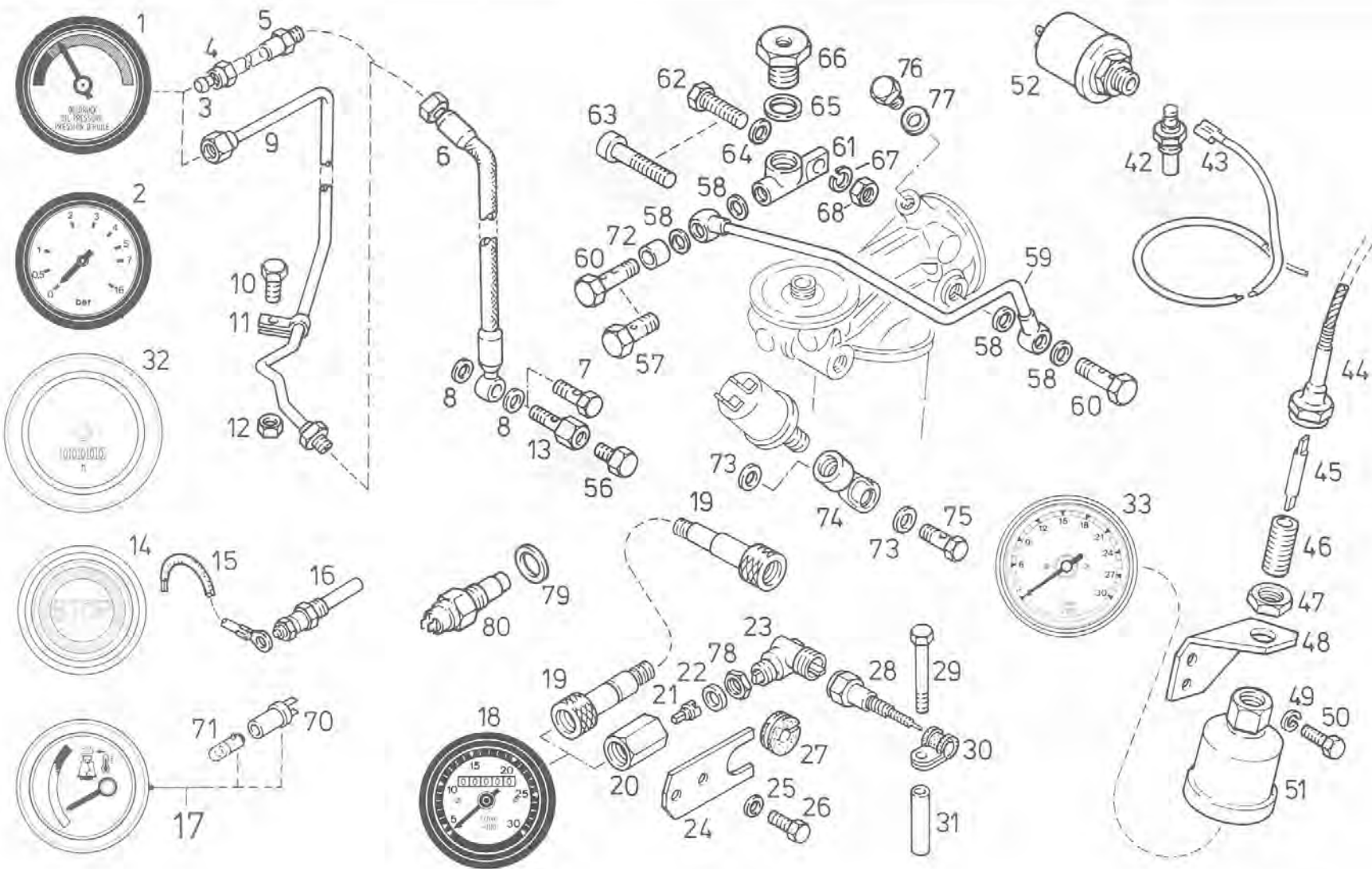






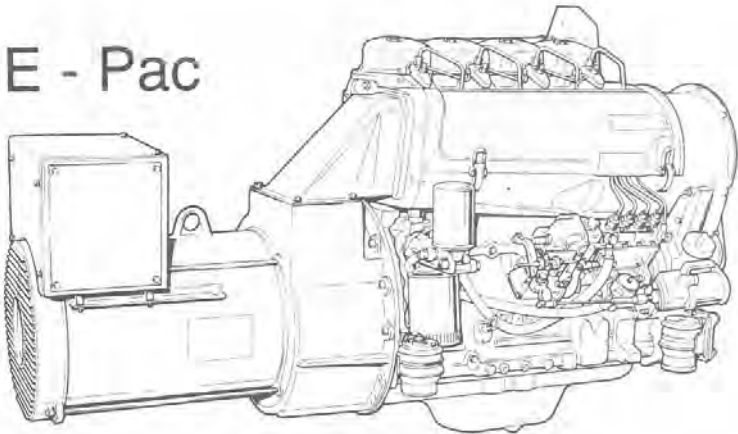
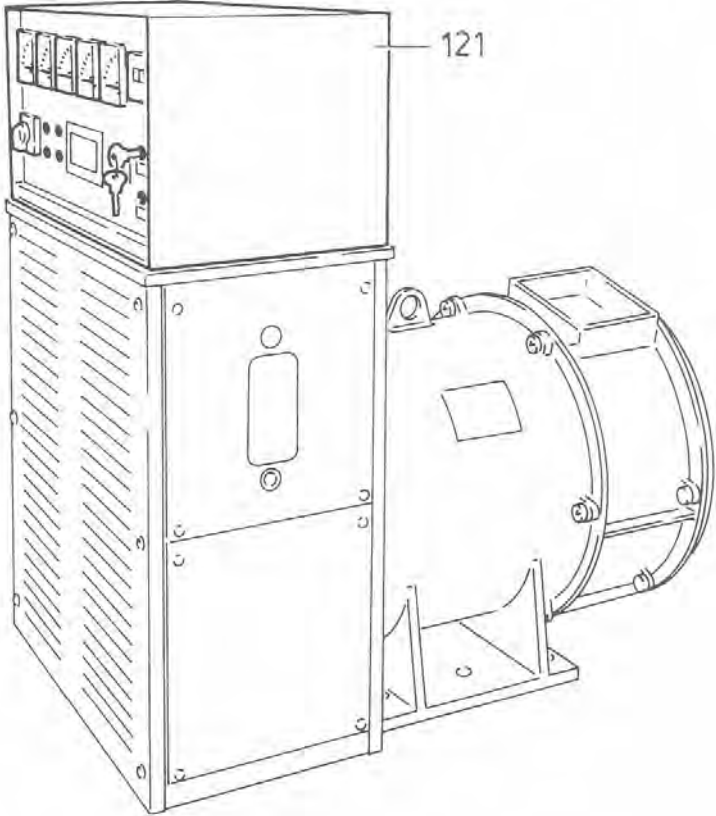
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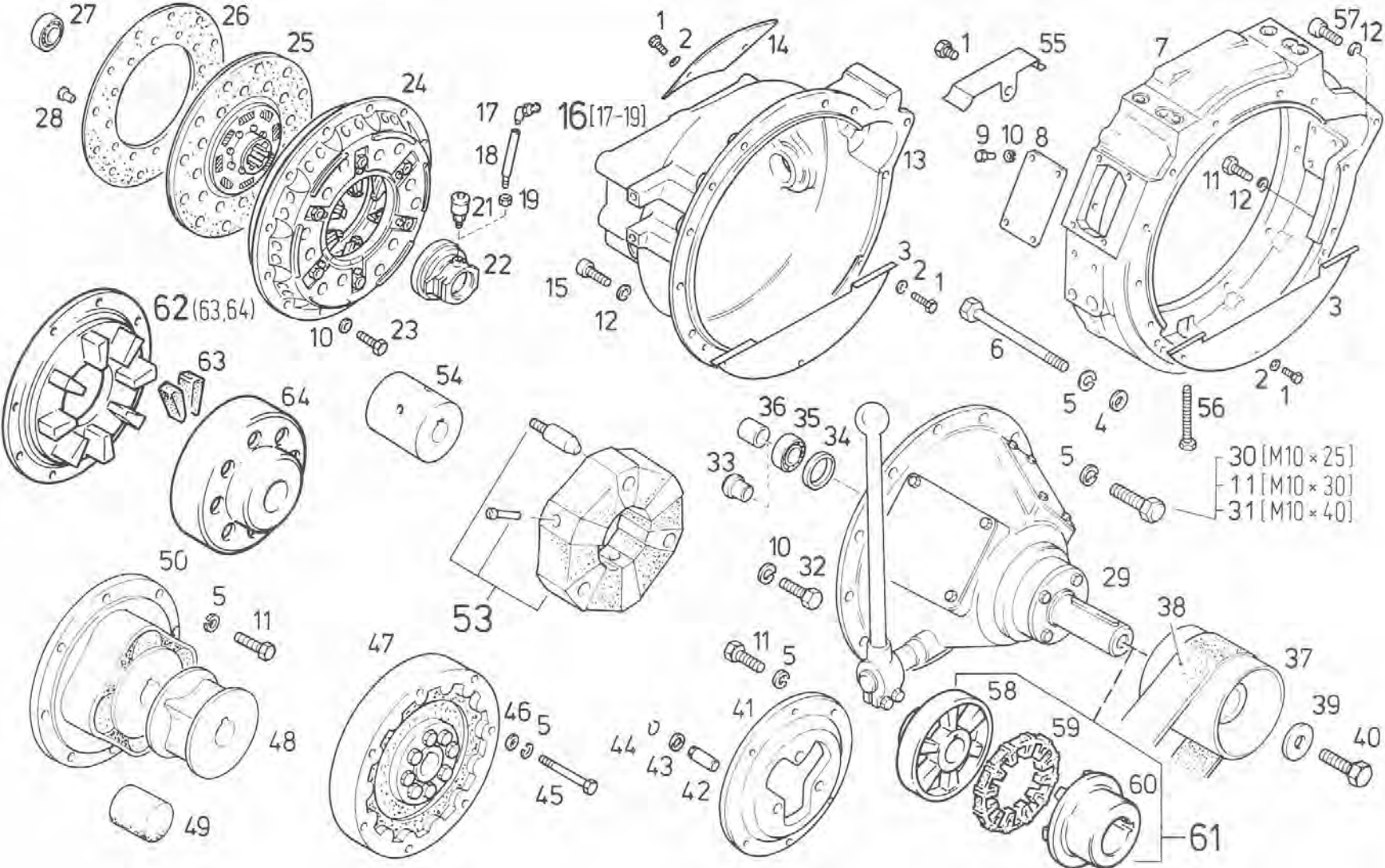
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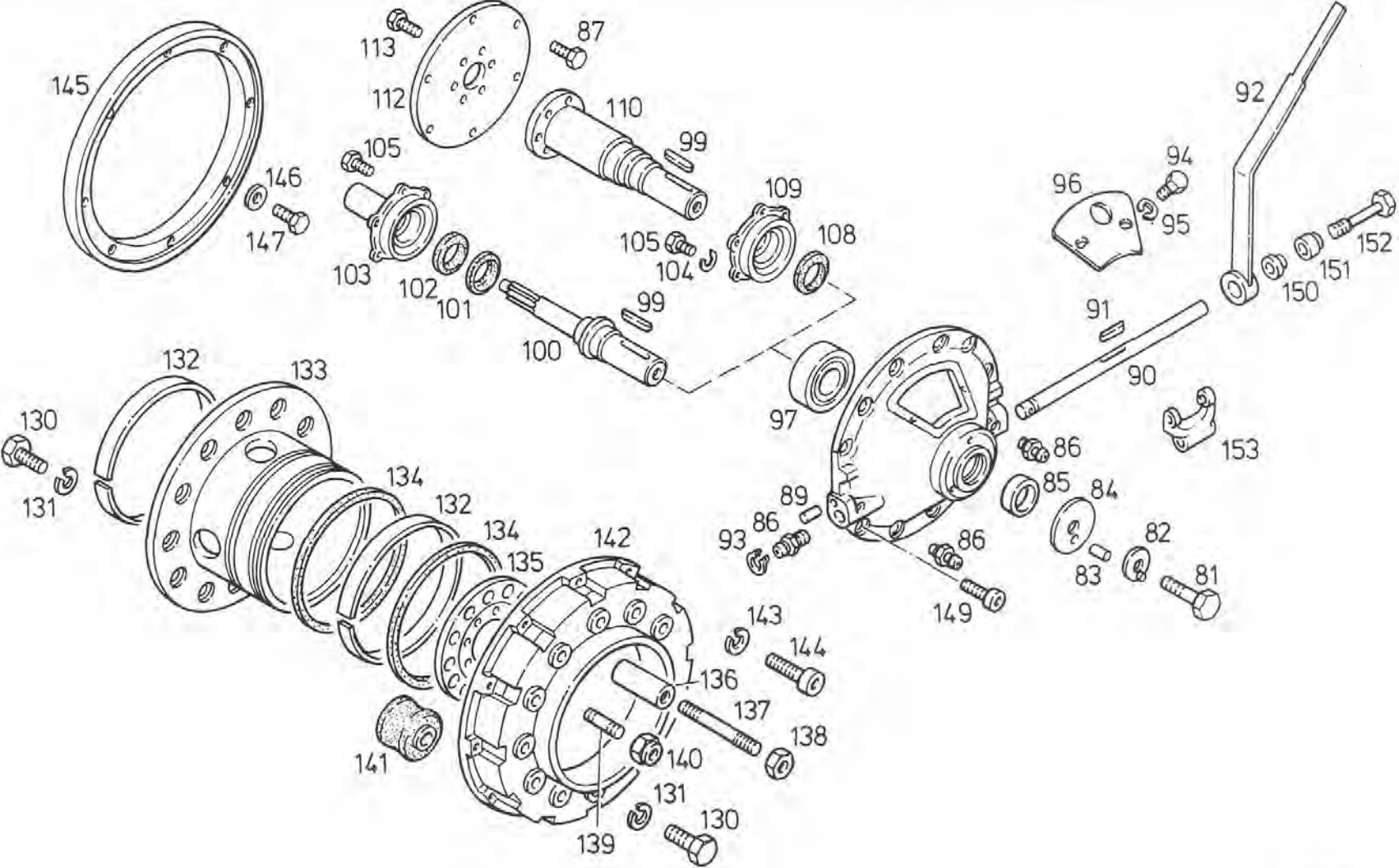
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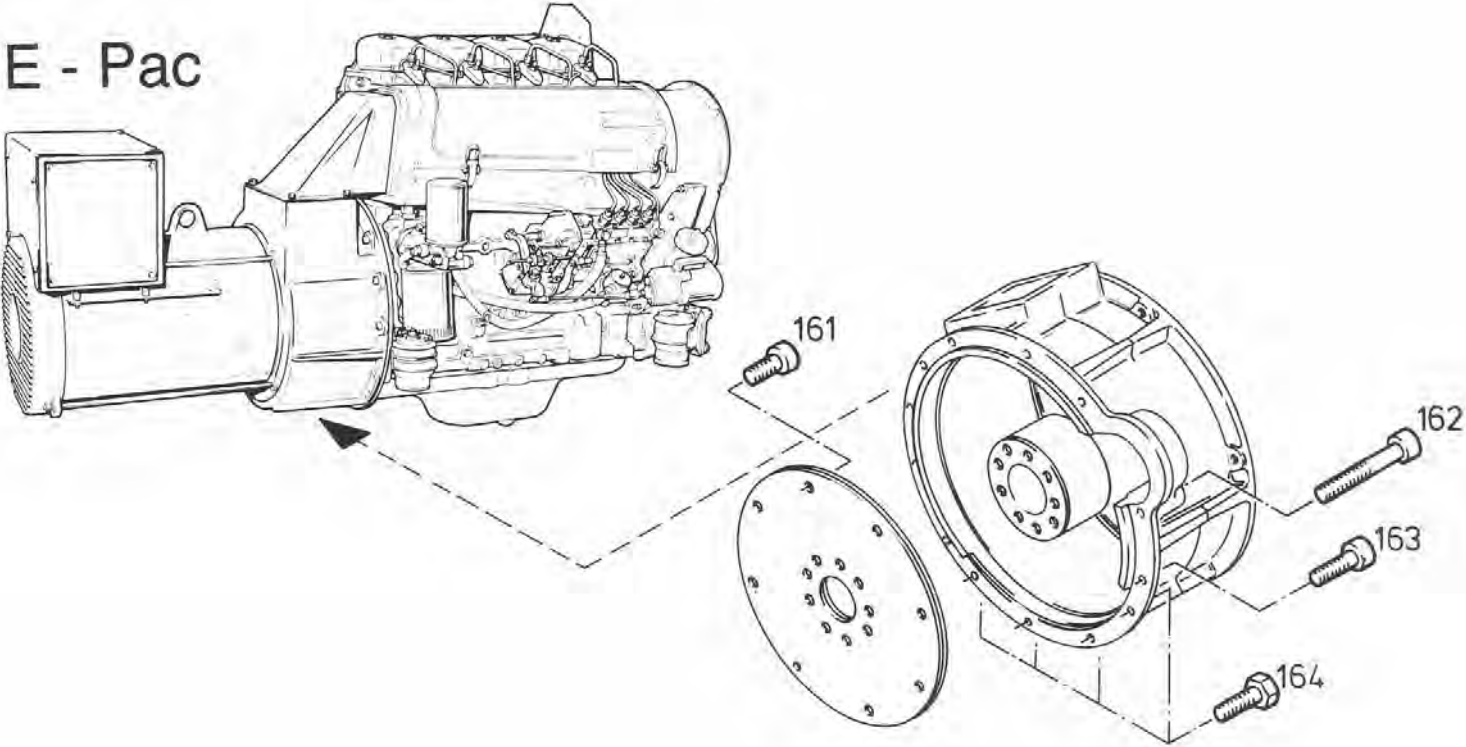
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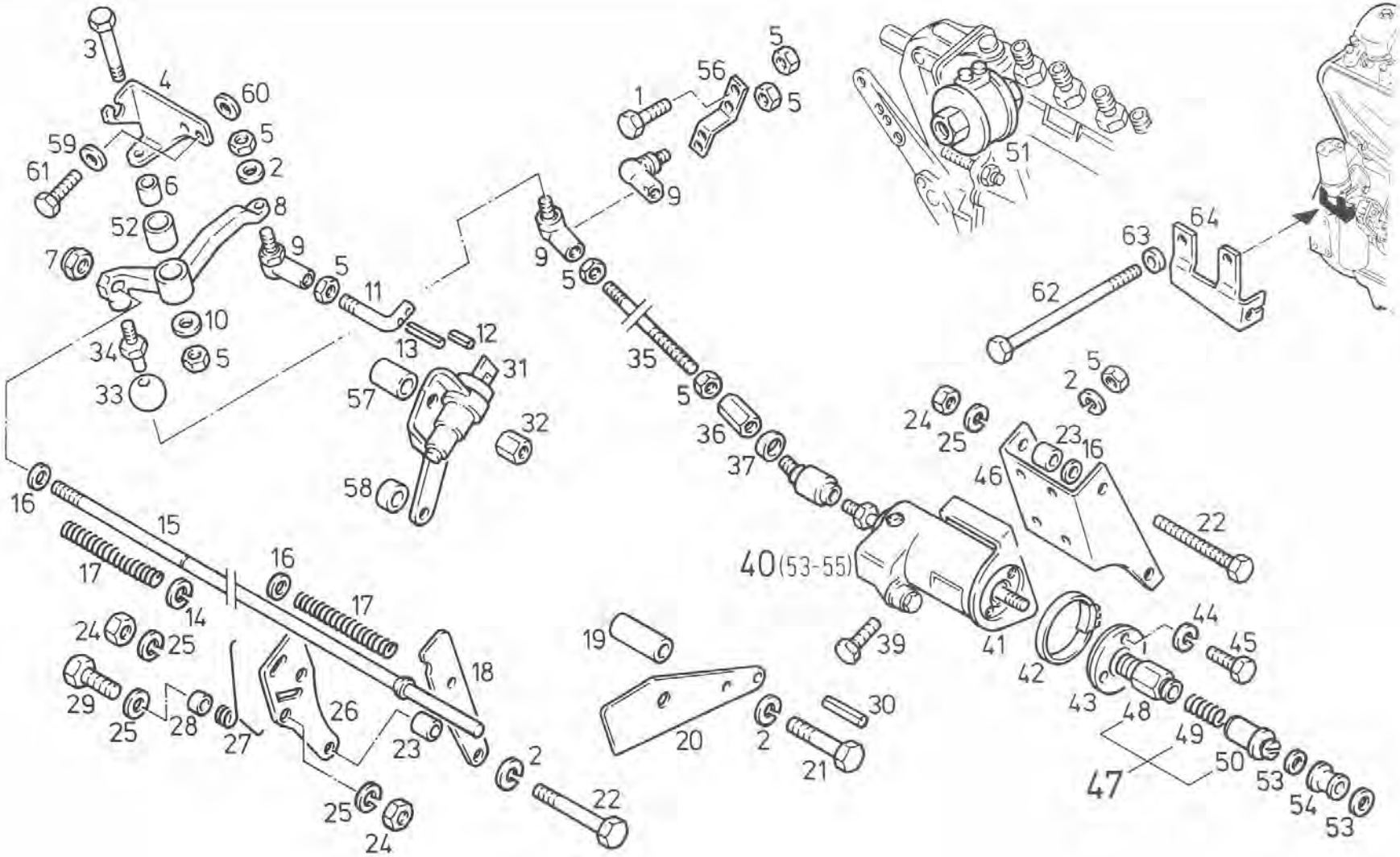
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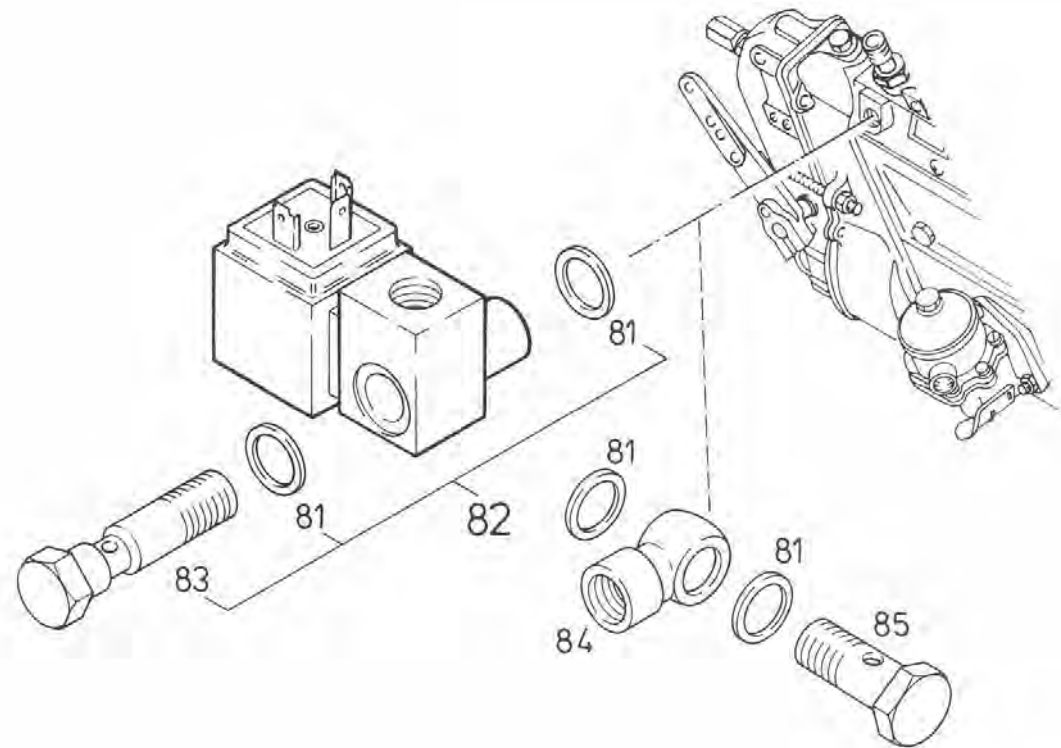
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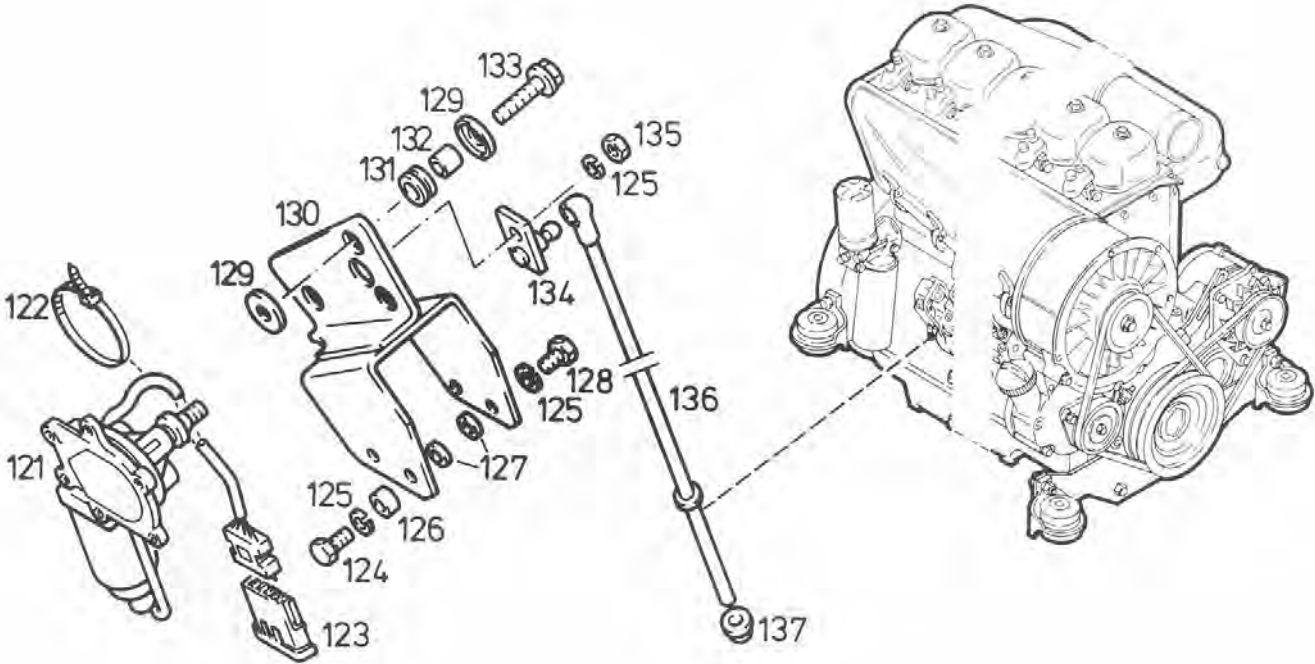


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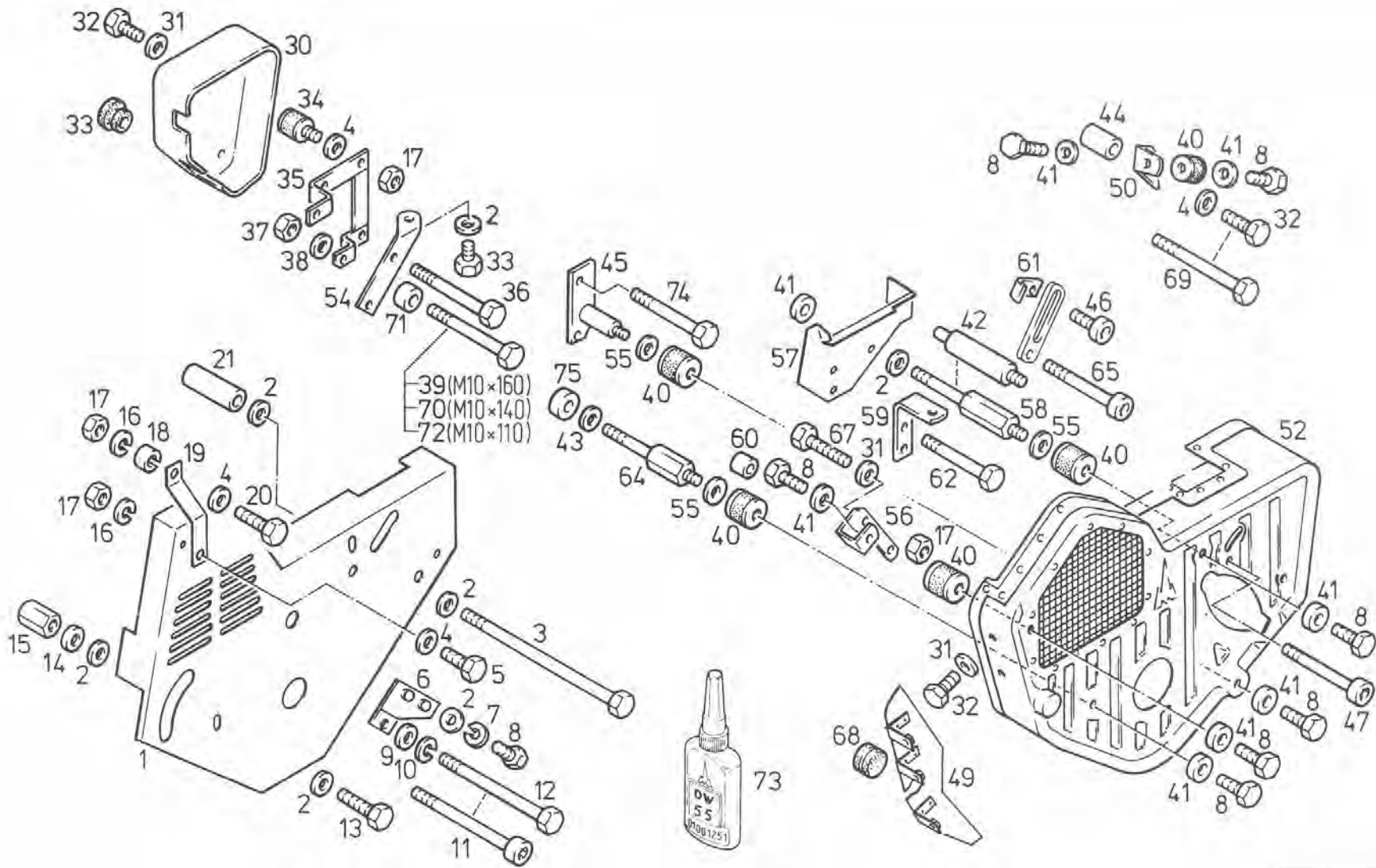






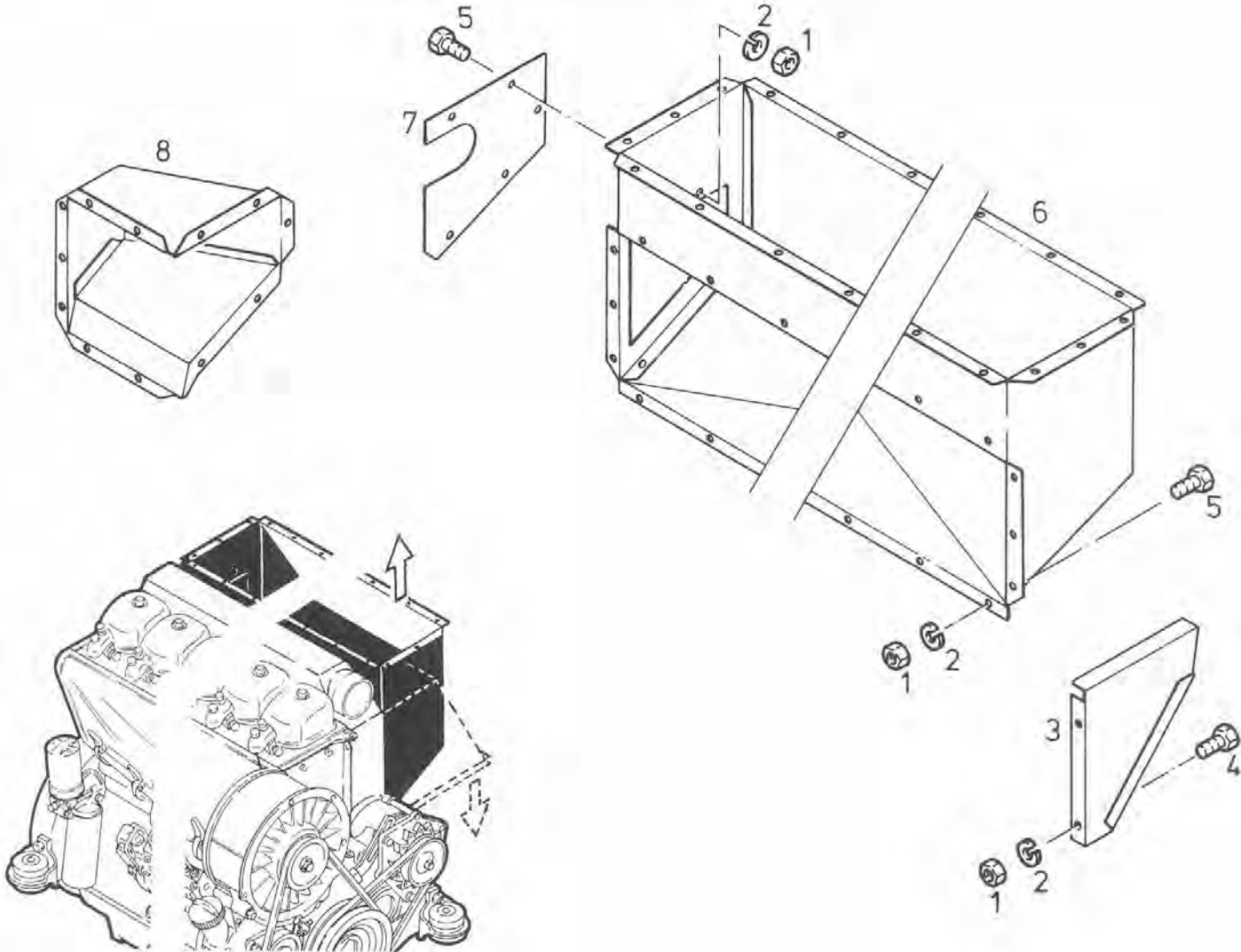
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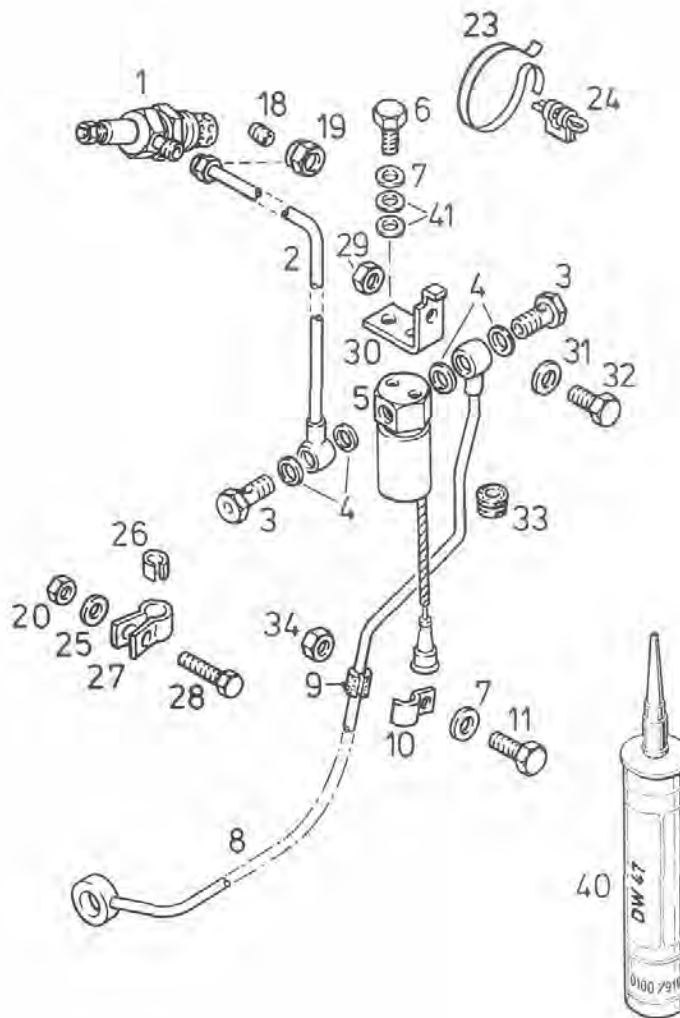
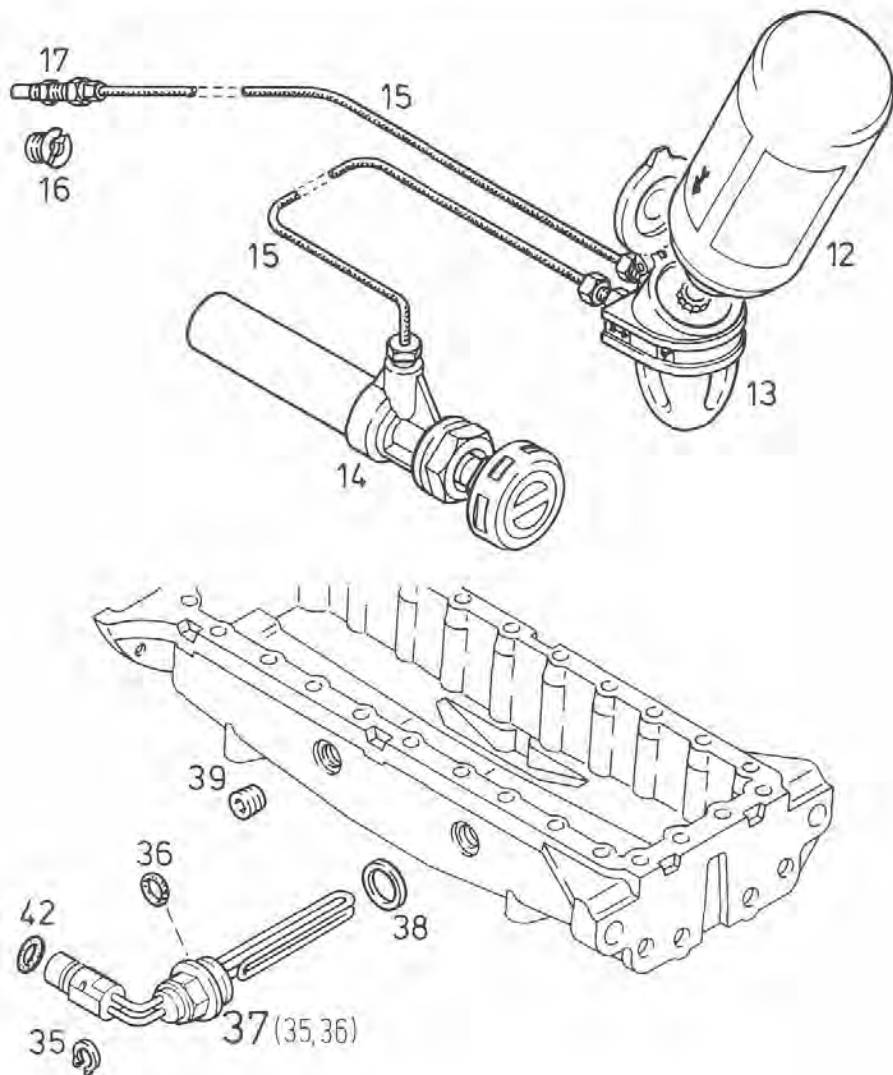
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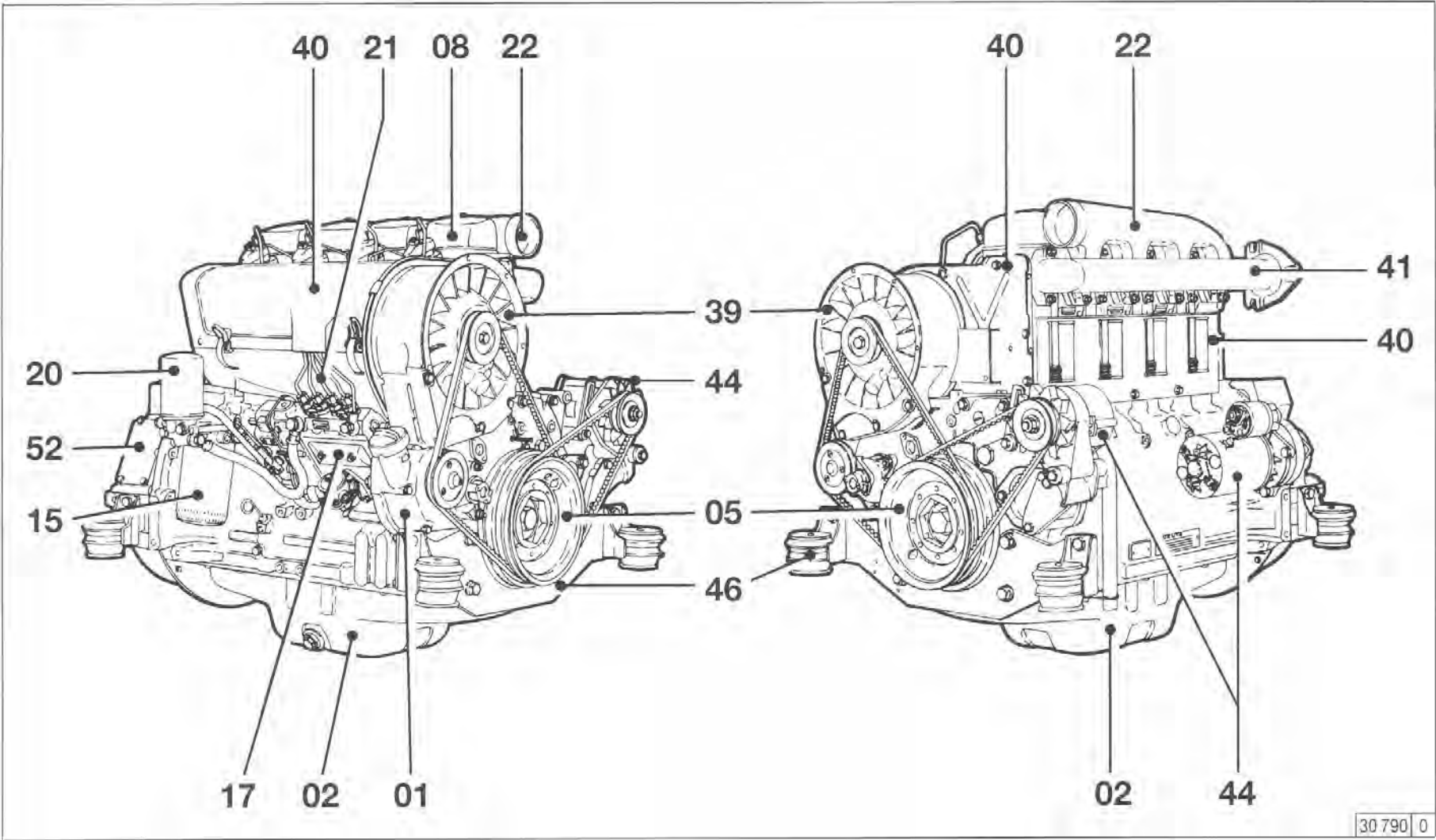
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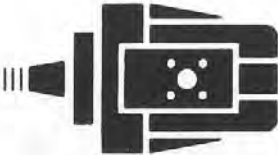
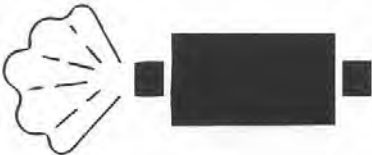

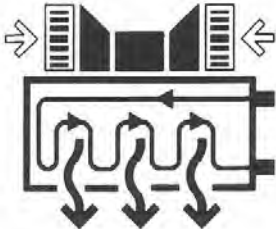


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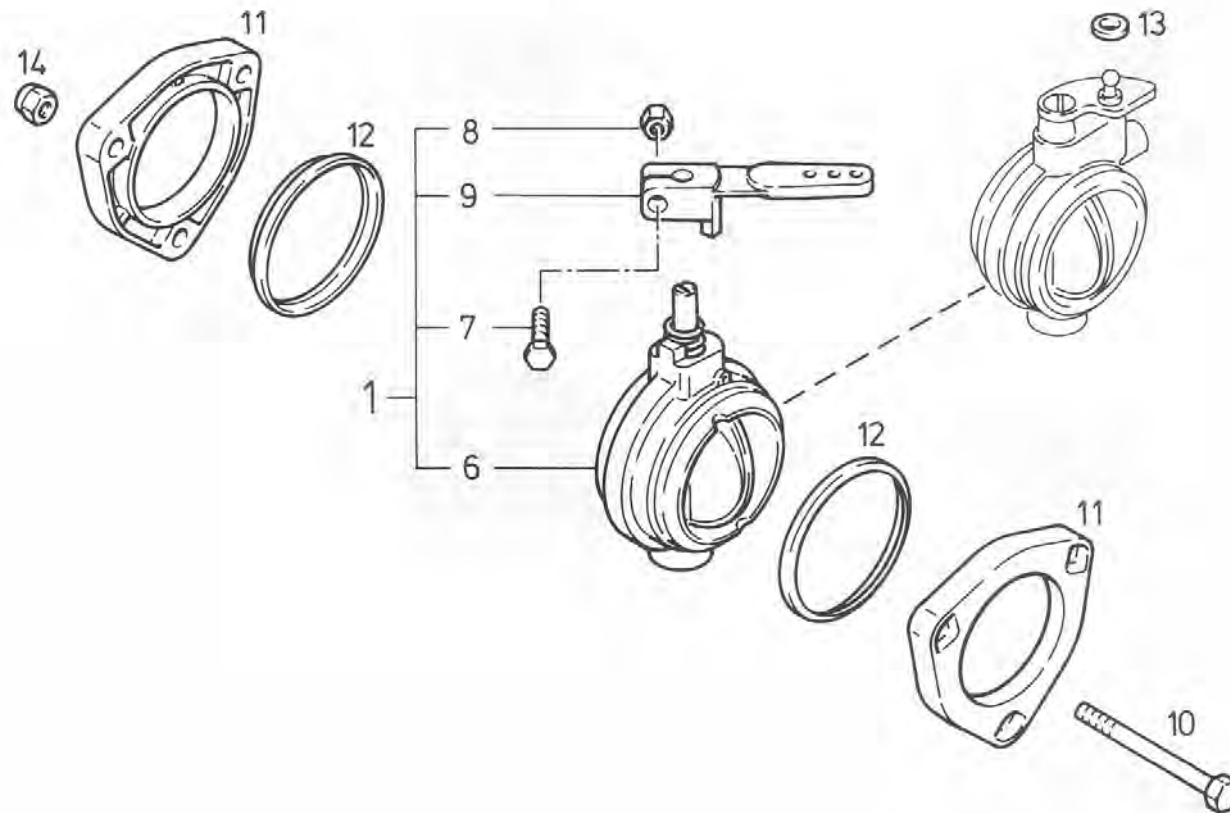






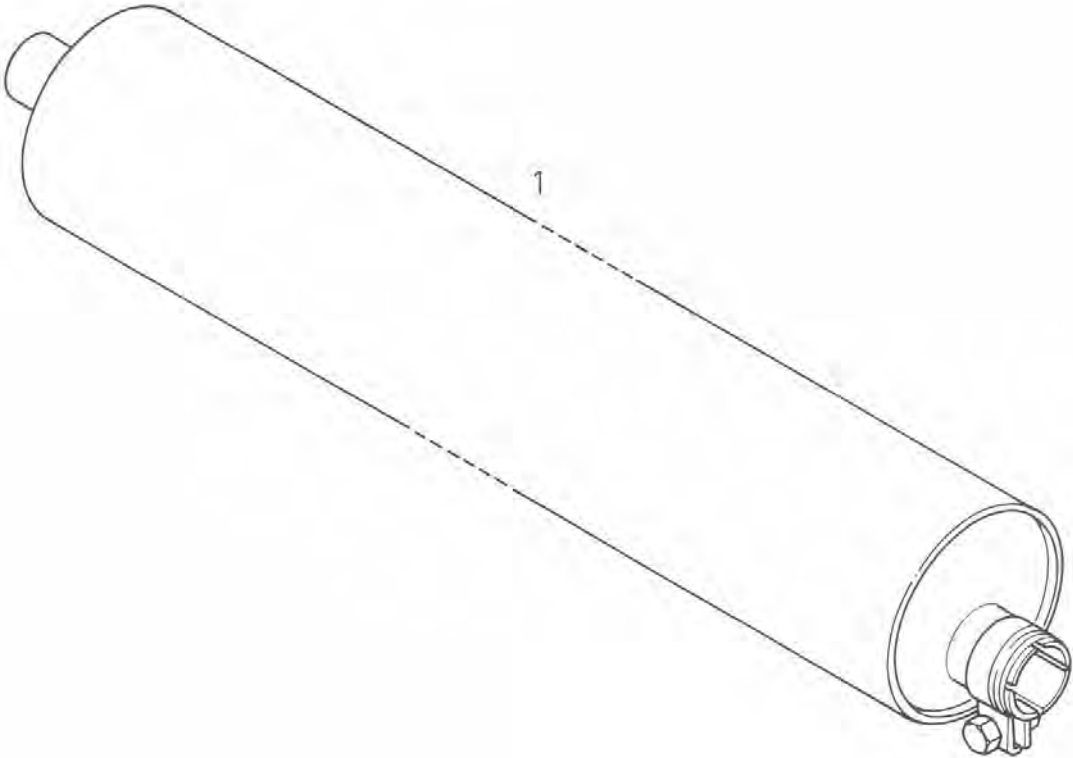
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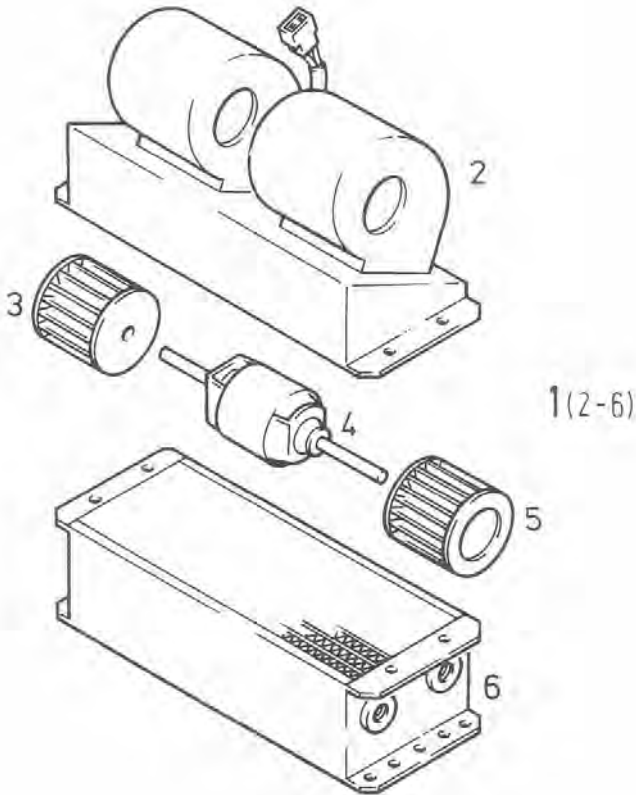
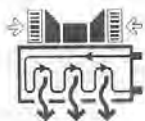
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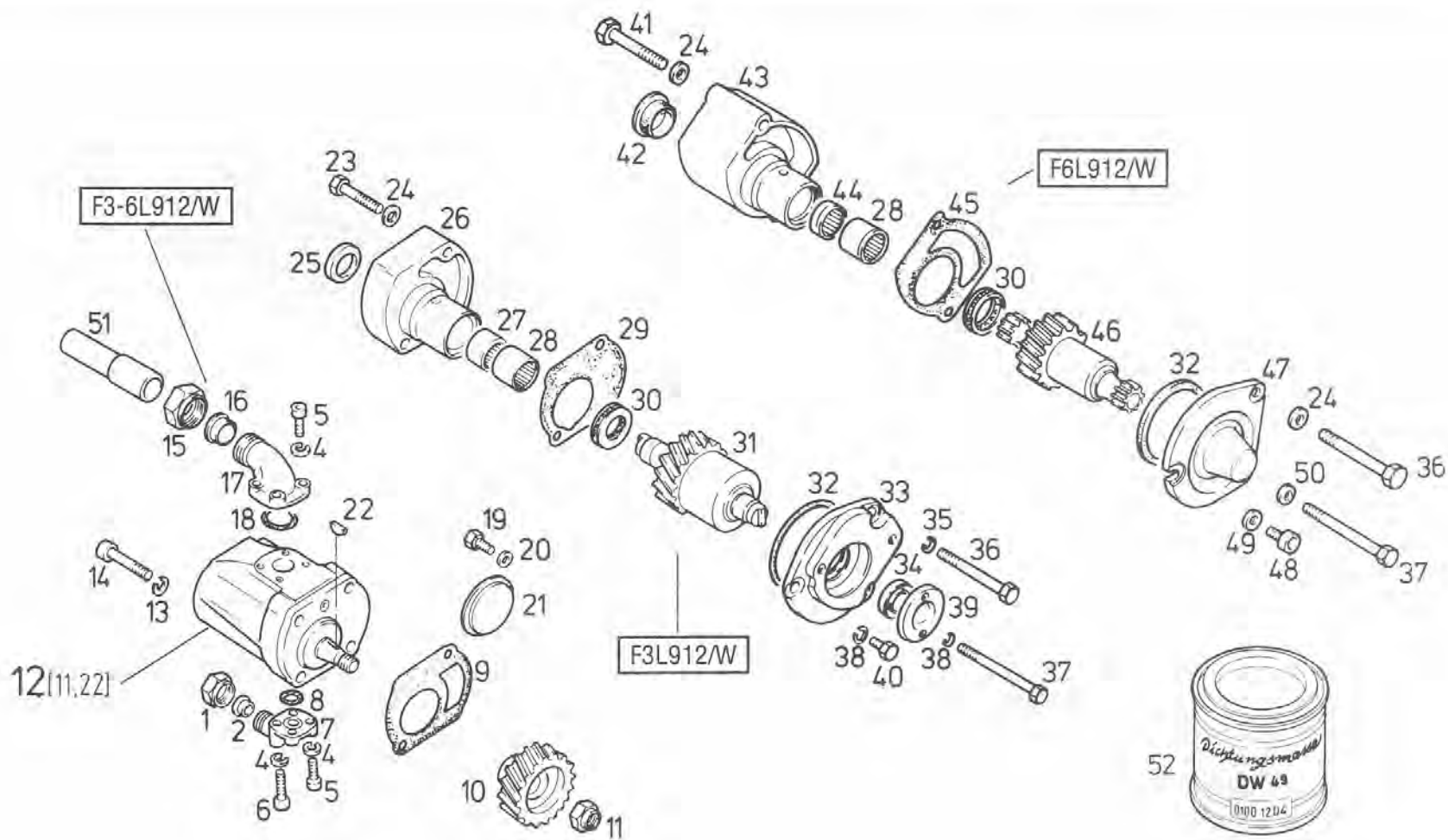
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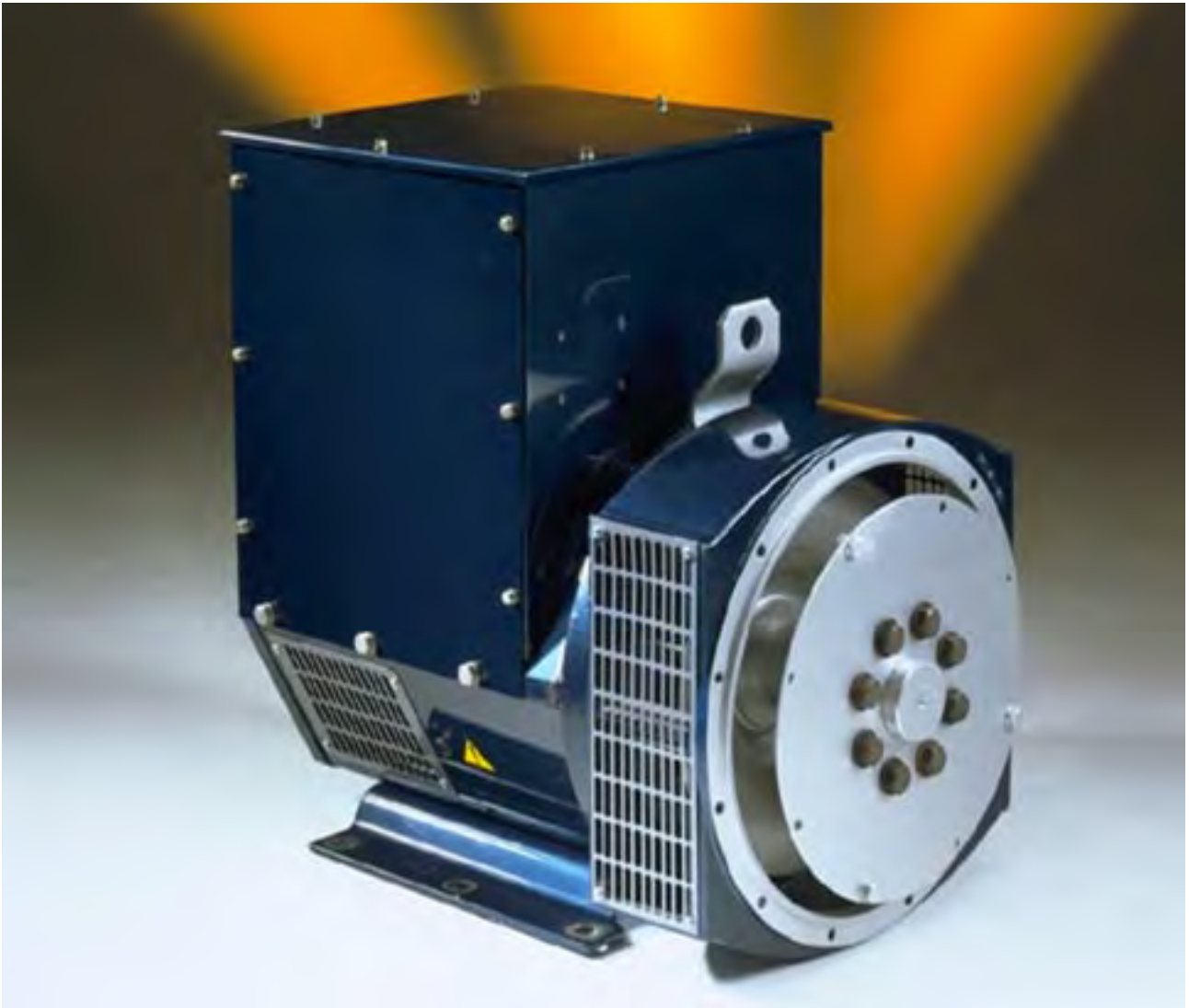
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# SP181

## Section 4 - Stamford Alternator





# **Installation, Service & Maintenance Manual**

**for AC generators with the following prefixes:**

**UCI; UCM; UCD 224 & 274 .**



## SAFETY PRECAUTIONS

Before operating the generating set, read the generating set operation manual and this generator manual and become familiar with it and the equipment.

### SAFE AND EFFICIENT OPERATION CAN ONLY BE ACHIEVED IF THE EQUIPMENT IS CORRECTLY OPERATED AND MAINTAINED.

Many accidents occur because of failure to follow fundamental rules and precautions.

### ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH.

- Ensure installation meets all applicable safety and local electrical codes. Have all installations performed by a qualified electrician.
- Do not operate the generator with protective covers, access covers or terminal box covers removed.
- Disable engine starting circuits before carrying out maintenance.
- Disable closing circuits and/or place warning notices on any circuit breakers normally used for connection to the mains or other generators, to avoid accidental closure.

Observe all **IMPORTANT**, **CAUTION**, **WARNING**, and **DANGER** notices, defined as:

**Important !** Important refers to hazard or unsafe method or practice which can result in product damage or related equipment damage.

**Caution !** Caution refers to hazard or unsafe method or practice which can result in product damage or personal injury.



**Warning !**

Warning refers to a hazard or unsafe method or practice which **CAN** result in severe personal injury or possible death.



**Danger !**

Danger refers to immediate hazards which **WILL** result in severe personal injury or death.

Due to our policy of continuous improvement, details in this manual which were correct at time of printing, may now be due for amendment. Information included must therefore not be regarded as binding.



## FOREWORD

The function of this book is to provide the user of the Stamford generator with an understanding of the principles of operation, the criteria for which the generator has been designed, and the installation and maintenance procedures. Specific areas where the lack of care or use of incorrect procedures could lead to equipment damage and/or personal injury are highlighted, with **WARNING** and/or **CAUTION** notes, and it is **IMPORTANT** that the contents of this book are read and understood before proceeding to fit or use the generator.

The Service, Sales and technical staff of Newage International are always ready to assist and reference to the company for advice is welcomed.




**Warning !**

**Incorrect installation, operation, servicing or replacement of parts can result in severe personal injury or death, and/or equipment damage.**

**Service personnel must be qualified to perform electrical and mechanical service.**

### EC DECLARATION OF INCORPORATION

All Stamford generators are supplied with a declaration of incorporation for the relevant EC legislation, typically in the form of a label as below.



### EC DECLARATION OF INCORPORATION

IN ACCORDANCE WITH THE SUPPLY OF MACHINERY (SAFETY) REGULATIONS 1992  
AND THE SUPPLY OF MACHINERY (SAFETY) (AMENDMENT) REGULATIONS 1994  
IMPLEMENTING THE EC MACHINERY DIRECTIVE 89/392/EEC AS AMENDED BY 91/368/EEC.

THIS **STAMFORD A.C. GENERATOR** WAS  
MANUFACTURED BY OR ON BEHALF OF  
**NEWAGE INTERNATIONAL LTD**  
BARNACK ROAD STAMFORD LINCOLNSHIRE ENGLAND.

THIS COMPONENT MACHINERY MUST NOT BE PUT INTO SERVICE UNTIL THE  
MACHINERY INTO WHICH IT IS TO BE INCORPORATED HAS BEEN DECLARED IN  
CONFORMITY WITH THE PROVISIONS OF THE SUPPLY OF MACHINERY (SAFETY)  
REGULATIONS 1995/MACHINERY DIRECTIVE.

**FOR AND ON BEHALF OF NEWAGE INTERNATIONAL LIMITED**

**NAME:** LAWRENCE HAYDOCK  
**POSITION:** TECHNICAL DIRECTOR  
**SIGNATURE:**

THIS COMPONENT MACHINERY CARRIES THE CE MARK FOR COMPLIANCE WITH THE STATUTORY  
REQUIREMENTS FOR THE IMPLEMENTATION OF THE FOLLOWING DIRECTIVES

**WARNING!** The EMC Directive 89/336/EEC  
This Component Machinery shall not be used in the Residential, Commercial and  
Light Industrial environment unless it also conforms to the relevant standard  
(EN 50081 - 1) REFER TO FACTORY FOR DETAILS

ii) The Low Voltage Directive 73/23/EEC as amended by 93/68/EEC

Under the EC Machinery Directive section 1.7.4. It is the responsibility of the generator set builder to ensure the generator identity is clearly displayed on the front cover of this book.



## ELECTROMAGNETIC COMPATIBILITY

### Additional Information

#### European Union

#### Council Directive 89/336/EEC

For installations within the European Union, electrical products must meet the requirements of the above directive, and Newage ac generators are supplied on the basis that:

- They are to be used for power-generation or related function.
- They are to be applied in one of the following environments:

Portable (open construction - temporary site supply)  
Portable (enclosed - temporary site supply)  
Containerised (temporary or permanent site supply)  
Ship-borne below decks (marine auxiliary power)  
Commercial vehicle (road transport / refrigeration etc)  
Rail transport (auxiliary power)  
Industrial vehicle (earthmoving, cranes etc)  
Fixed installation (industrial - factory / process plant)  
Fixed installation (residential, commercial and light industrial - home / office / health)  
Energy management (Combined heat and power and/or peak lopping)  
Alternative energy schemes

- The standard generators are designed to meet the 'industrial' emissions and immunity standards. Where the generator is required to meet the residential, commercial and light industrial emissions and immunity standards reference should be made to Newage document reference N4/X/011, as additional equipment may be required.
- The installation earthing scheme involves connection of the generator frame to the site protective earth conductor using a minimum practical lead length.
- Maintenance and servicing with anything other than factory supplied or authorised parts will invalidate any Newage liability for EMC compliance.
- Installation, maintenance and servicing is carried out by adequately trained personnel fully aware of the requirements of the relevant EC directives.



# CONTENTS

## SAFETY PRECAUTIONS

|                  |   |                |
|------------------|---|----------------|
| <b>FOREWORD</b>  |   | <b>1</b>       |
| <b>CONTENTS</b>  |   | <b>2&amp;3</b> |
| <b>SECTION 1</b> | <b>INTRODUCTION</b>   | <b>4</b>       |
| 1.1              | INTRODUCTION  | 4              |
| 1.2              | DESIGNATION   | 4              |
| 1.3              | SERIAL NUMBER LOCATION<br>AND IDENTITY NUMBER LOCATION                              | 4              |
| 1.4              | RATING PLATE AND CE MARKING   | 4              |
| <b>SECTION 2</b> | <b>PRINCIPLE OF OPERATION</b>   | <b>5</b>       |
| 2.1              | SELF-EXCITED AVR CONTROLLED GENERATORS  | 5              |
| 2.2              | PERMANENT MAGNET GENERATOR (PMG) EXCITED -<br>AVR CONTROLLED GENERATORS             | 5              |
| 2.3              | AVR ACCESSORIES   | 5              |
| 2.4              | TRANSFORMER CONTROLLED GENERATORS   | 5              |
| <b>SECTION 3</b> | <b>APPLICATION OF THE GENERATOR</b>   | <b>6</b>       |
| <b>SECTION 4</b> | <b>INSTALLATION - PART 1</b>  | <b>8</b>       |
| 4.1              | LIFTING   | 8              |
| 4.2              | ASSEMBLY  | 8              |
| 4.2.1            | NO FOOT OPTION  | 8              |
| 4.2.2            | TWO BEARING GENERATORS  | 9              |
| 4.2.3            | SINGLE BEARING GENERATORS   | 9              |
| 4.3              | EARTHING  | 9              |
| 4.4              | PRE-RUNNING CHECKS  | 9              |
| 4.4.1            | INSULATION CHECK  | 9              |
| 4.4.2            | DIRECTION OF ROTATION   | 10             |
| 4.4.3            | VOLTAGE AND FREQUENCY   | 10             |
| 4.4.4            | AVR SETTINGS  | 10             |
| 4.4.4.1          | TYPE SX460 AVR  | 10             |
| 4.4.4.2          | TYPE SX440 AVR  | 10             |
| 4.4.4.3          | TYPE SX421 AVR  | 11             |
| 4.4.4.4          | TYPE MX341 AVR  | 11             |
| 4.4.4.5          | TYPE MX321 AVR  | 11             |
| 4.4.5            | TRANSFORMER CONTROLLED<br>EXCITATION SYSTEM (Series 5)                              | 12             |
| 4.5              | GENERATOR SET TESTING   | 12             |
| 4.5.1            | TEST METERING/CABLING   | 12             |
| 4.6              | INITIAL START-UP  | 12             |
| 4.7              | LOAD TESTING  | 13             |
| 4.7.1            | AVR CONTROLLED GENERATORS - AVR ADJUSTMENTS   | 13             |
| 4.7.1.1          | UFRO (Under Frequency Roll Off)<br>(AVR Types SX460, SX440, SX421, MX341 and MX321) | 13             |
| 4.7.1.2          | EXC TRIP (Excitation Trip)  | 14             |
| 4.7.1.3          | OVER/V (Over Voltage)   | 14             |
| 4.7.1.4          | TRANSIENT LOAD SWITCHING ADJUSTMENTS  | 14             |
| 4.7.1.5          | RAMP BUILD UP TIME  | 15             |
| 4.7.2            | TRANSFORMER CONTROLLED GENERATORS -<br>TRANSFORMER ADJUSTMENT                       | 15             |
| 4.8              | ACCESSORIES   | 15             |
| <b>SECTION 5</b> | <b>INSTALLATION - PART 2</b>  | <b>16</b>      |
| 5.1              | GENERAL   | 16             |
| 5.2              | GLANDING  | 16             |
| 5.3              | EARTHING  | 16             |
| 5.4              | PROTECTION  | 16             |
| 5.5              | COMMISSIONING   | 16             |



# CONTENTS

|                  |         |   |           |
|------------------|---------|---|-----------|
| <b>SECTION 6</b> |         | <b>ACCESSORIES</b>  | <b>17</b> |
|                  | 6.1     | REMOTE VOLTAGE ADJUST (ALL AVR TYPES)                                       | 17        |
|                  | 6.2     | PARALLEL OPERATION  | 17        |
|                  | 6.2.1   | DROOP   | 17        |
|                  | 6.2.1.1 | SETTING PROCEDURE   | 18        |
|                  | 6.2.2   | ASTATIC CONTROL   | 18        |
|                  | 6.3     | MANUAL VOLTAGE REGULATOR (MVR) -<br>MX341 and MX321 AVR                     | 18        |
|                  | 6.4     | OVERVOLTAGE DE-EXCITATION BREAKER<br>SX421 and MX321 AVR                    | 18        |
|                  | 6.4.1   | RESETTING THE BREAKER   | 19        |
|                  | 6.5     | CURRENT LIMIT - MX321 AVR   | 19        |
|                  | 6.5.1   | SETTING PROCEDURE   | 19        |
|                  | 6.6     | POWER FACTOR CONTROLLER (PFC3)  | 20        |
| <b>SECTION 7</b> |         | <b>SERVICE AND MAINTENANCE</b>  | <b>21</b> |
|                  | 7.1     | WINDING CONDITION   | 21        |
|                  | 7.1.1   | WINDING CONDITION ASSESSMENT  | 21        |
|                  | 7.1.2   | METHODS OF DRYING OUT GENERATORS  | 21        |
|                  | 7.2     | BEARINGS  | 23        |
|                  | 7.3     | AIR FILTERS   | 23        |
|                  | 7.3.1   | CLEANING PROCEDURE  | 23        |
|                  | 7.4     | FAULT FINDING   | 23        |
|                  | 7.4.1   | SX460 AVR - FAULT FINDING   | 23        |
|                  | 7.4.2   | SX440 AVR - FAULT FINDING   | 24        |
|                  | 7.4.3   | SX421 AVR - FAULT FINDING   | 24        |
|                  | 7.4.4   | TRANSFORMER CONTROL - FAULT FINDING   | 24        |
|                  | 7.4.5   | MX341 AVR - FAULT FINDING   | 25        |
|                  | 7.4.6   | MX321 AVR - FAULT FINDING   | 25        |
|                  | 7.4.7   | RESIDUAL VOLTAGE CHECK  | 26        |
|                  | 7.5     | SEPARATE EXCITATION TEST PROCEDURE  | 26        |
|                  | 7.5.1   | GENERATOR WINDINGS, ROTATING DIODES and<br>PERMANENT MAGNET GENERATOR (PMG) | 26        |
|                  | 7.5.1.1 | BALANCED MAIN TERMINAL VOLTAGES   | 26        |
|                  | 7.5.1.2 | UNBALANCED MAIN TERMINAL VOLTAGES   | 27        |
|                  | 7.5.2   | EXCITATION CONTROL TEST   | 27        |
|                  | 7.5.2.1 | AVR FUNCTION TEST   | 27        |
|                  | 7.5.2.2 | TRANSFORMER CONTROL   | 28        |
|                  | 7.5.3   | REMOVAL AND REPLACEMENT OF COMPONENT<br>ASSEMBLIES                          | 28        |
|                  | 7.5.3.1 | REMOVAL OF PERMANENT MAGNET GENERATOR (PMG)                                 | 28        |
|                  | 7.5.3.2 | REMOVAL OF BEARINGS   | 28        |
|                  | 7.5.3.3 | REMOVAL OF ENDBRACKET AND EXCITER STATOR                                    | 28        |
|                  | 7.5.3.4 | REMOVAL OF THE ROTOR ASSEMBLY   | 29        |
|                  | 7.6     | RETURNING TO SERVICE  | 29        |
| <b>SECTION 8</b> |         | <b>SPARES AND AFTER SALES SERVICE</b>                                       | <b>30</b> |
|                  | 8.1     | RECOMMENDED SPARES  | 30        |
|                  | 8.2     | AFTER SALES SERVICE   | 30        |
| <b>SECTION 9</b> |         | <b>PARTS IDENTIFICATION</b>   | <b>32</b> |
|                  |         | TYPICAL SINGLE BEARING GENERATOR (Fig. 11)                                  | 33        |
|                  |         | TYPICAL TWO BEARING GENERATOR (Fig. 12)                                     | 35        |
|                  |         | TYPICAL TWO BEARING (SERIES 5) GENERATOR (Fig. 13)                          | 37        |
|                  |         | ROTATING RECTIFIER ASSEMBLY (Fig. 14)                                       | 38        |



# SECTION 1

## INTRODUCTION

### 1.1 INTRODUCTION

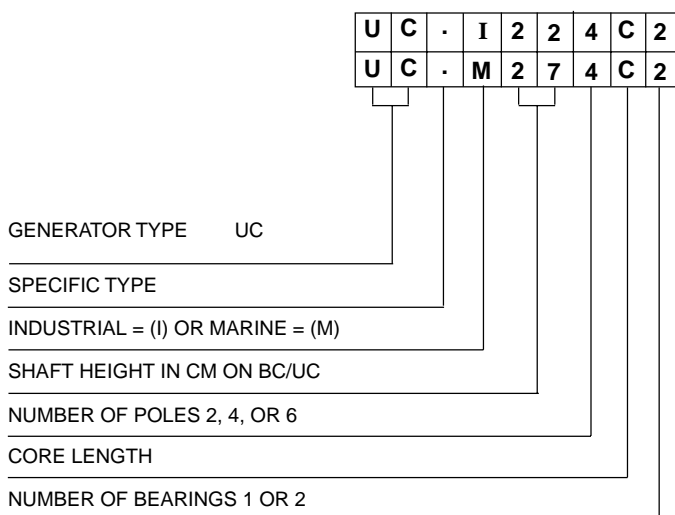
The UC22/27 range of generators is of brushless rotating field design, available up to 660V/50Hz (1500 rpm) or 60Hz (1800 rpm), and built to meet BS5000 Part 3 and international standards.

All the UC22/27 range are self-excited with excitation power derived from the main output windings, using either the SX460/SX440/SX421 AVR. The UC22 is also available with specific windings and a transformer controlled excitation system.

A permanent magnet generator (PMG) powered excitation system is available as an option using either the MX341 or MX321 AVR.

Detailed specification sheets are available on request.

### 1.2 DESIGNATION



### 1.3 SERIAL NUMBER LOCATION AND IDENTITY NUMBER LOCATION

Each generator is metal stamped with it's own unique serial number, the location of this number is described below.

UCI and UCM generators have their serial number stamped into the upper section of the drive end frame to end bracket adaptor ring, shown as item 31 in the parts lists at the back of this book.

UCD generators have their serial number stamped into the top of the drive end adaptor /fan shroud casting. If for any reason this casting is removed, it is imperative that care is taken to refit it to the correct generator to ensure correct identification is retained.

Inside the terminal box two adhesive rectangular labels have been fixed, each carrying the generators unique identity number. One label has been fixed to the inside of the terminal box sheet metal work, and the second label fixed to the main frame of the generator.

### 1.4 RATING PLATE

The generator has been supplied with a self adhesive rating plate label to enable fitting after final assembly and painting.

It is intended that this label will be stuck to the outside of the terminal box on the left hand side when viewed from the N.D.E. To assist with squarely positioning the label, location protrusions have been made in the sheet metalwork.

A CE Mark label is also supplied loose for fitment after final assembly and painting. This should be attached to an external surface of the Generator at a suitable location where it will not be obscured by the customer's wiring or other fittings.

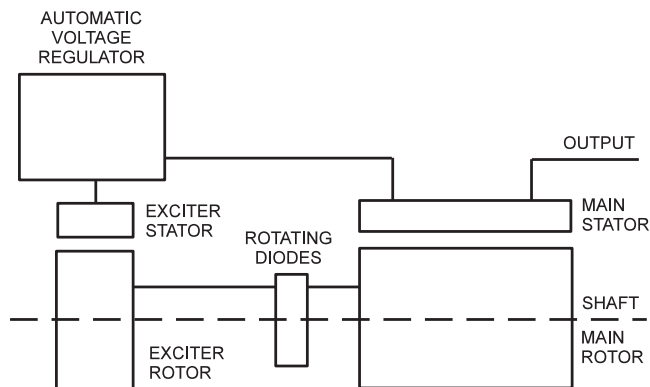
The surface in the area where a label is to be stuck must be flat, clean, and any paint finish be fully dry before attempting to attach label. Recommended method for attaching label is peel and fold back sufficient of the backing paper to expose some 20 mm of label adhesive along the edge which is to be located against the sheet metal protrusions. Once this first section of label has been carefully located and stuck into position the backing paper can be progressively removed, as the label is pressed down into position. The adhesive will achieve a permanent bond in 24 hours.



## SECTION 2

### PRINCIPLE OF OPERATION

#### 2.1 SELF-EXCITED AVR CONTROLLED GENERATORS

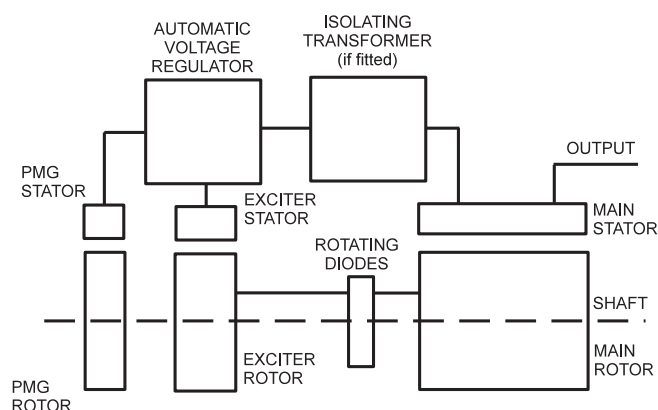


The main stator provides power for excitation of the exciter field via the SX460 (SX440 or SX421) AVR which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

The SX460 or SX440 AVR senses average voltage on two phases ensuring close regulation. In addition it detects engine speed and provides voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine.

The SX421 AVR in addition to the SX440 features has three phase rms sensing and also provides for over voltage protection when used in conjunction with an external circuit breaker (switchboard mounted).

#### 2.2 PERMANENT MAGNET GENERATOR (PMG) EXCITED - AVR CONTROLLED GENERATORS



The permanent magnet generator (PMG) provides power for excitation of the exciter field via the AVR (MX341 or MX321) which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived, via an isolating transformer in the case of MX321 AVR, from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

The PMG system provides a constant source of excitation power irrespective of main stator loading and provides high motor starting capability as well as immunity to waveform distortion on the main stator output created by non linear loads, e.g. thyristor controlled dc motor.

The MX341 AVR senses average voltage on two phases ensuring close regulation. In addition it detects engine speed and provides an adjustable voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine. It also provides over-excitation protection which acts following a time delay, to de-excite the generator in the event of excessive exciter field voltage.

The MX321 provides the protection and engine relief features of the MX341 and additionally incorporates 3 phase rms sensing and over-voltage protection.

The detailed function of all the AVR circuits is covered in the load testing (subsection 4.7).

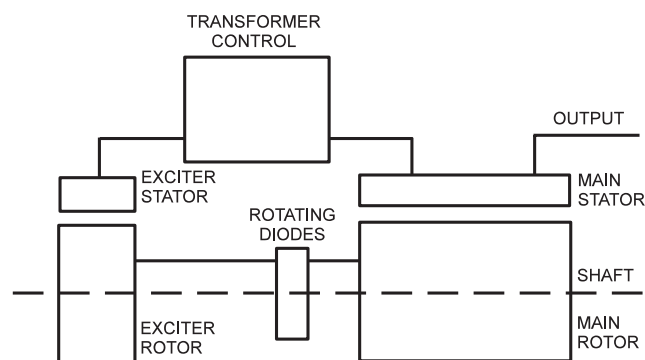
#### 2.3 AVR ACCESSORIES

The SX440, SX421, MX341 and MX321 AVRs incorporate circuits which, when used in conjunction with accessories, can provide for parallel operation either with 'droop' or 'astatic' control, VAR/ PF control and in the case of the MX321 AVR, short circuit current limiting.

Function and adjustment of the accessories which can be fitted inside the generator terminal box are covered in the accessories section of this book.

Separate instructions are provided with other accessories available for control panel mounting.

#### 2.4 TRANSFORMER CONTROLLED GENERATORS



The main stator provides power for excitation of the exciter field via a transformer rectifier unit. The transformer combines voltage and current elements derived from the main stator output to form the basis of an open-loop control system, which is self regulating in nature. The system inherently compensates for load current magnitude and power factor and provides short circuit maintenance in addition to a good motor starting performance.

Three phase generators normally have a three phase transformer control for improved performance with unbalanced loads but a single phase transformer option is available.

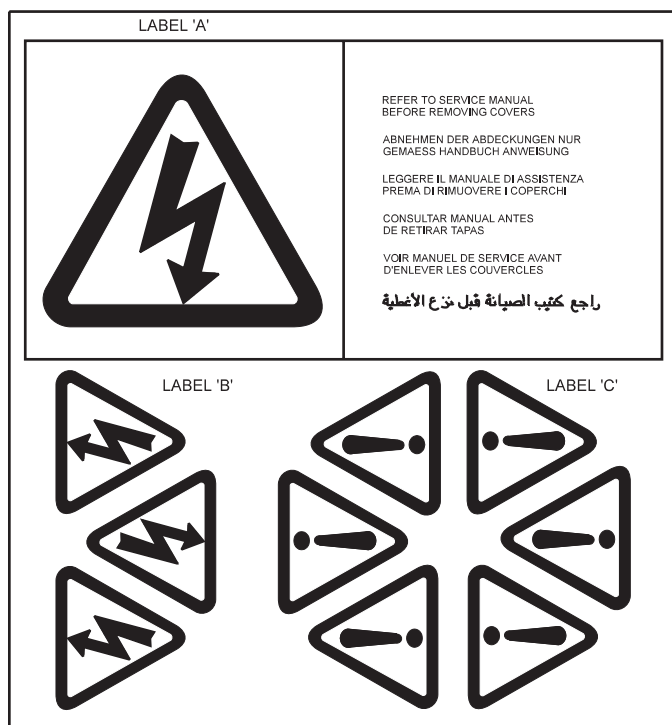
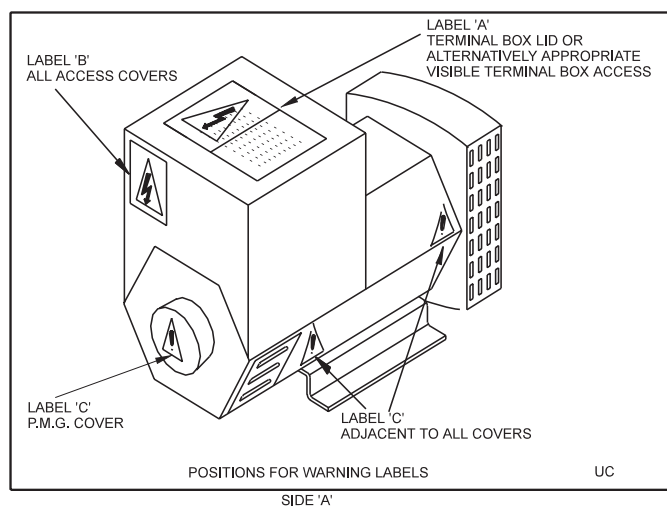
No accessories can be provided with this control system.



## SECTION 3

### APPLICATION OF THE GENERATOR

The generator is supplied as a component part for installation in a generating set. It is not, therefore, practicable to fit all the necessary warning/hazard labels during generator manufacture. The additional labels required are packaged with this Manual, together with a drawing identifying their locations. (See below).



It is the responsibility of the generating set manufacturer to ensure that the correct labels are fitted, and are clearly visible.

The generators have been designed for use in a maximum ambient temperature of 40°C and altitude less than 1000m above sea level in accordance with BS5000.

Ambients in excess of 40°C and altitudes above 1000m can be tolerated with reduced ratings - refer to the generator nameplate for rating and ambient. In the event that the generator is required to operate in an ambient in excess of the nameplate value or at altitudes in excess of 1000 metres above sea level, refer to the factory.

The generators are of air-ventilated screen protected drip-proof design and are not suitable for mounting outdoors unless adequately protected by the use of canopies. Anti-condensation heaters are recommended during storage and for standby duty to ensure winding insulation is maintained in good condition.

When installed in a closed canopy it must be ensured that the ambient temperature of the cooling air to the generator does not exceed that for which the generator has been rated.

The canopy should be designed such that the engine air intake to the canopy is separated from the generator intake, particularly where the radiator cooling fan is required to draw air into the canopy. In addition the generator air intake to the canopy should be designed such that the ingress of moisture is prohibited, preferably by use of a 2 stage filter.

The air intake/outlet must be suitable for the air flow given in the following table with additional pressure drops less than or equal to those given below:

| Frame | Air Flow    |             | Additional (intake/outlet) Pressure Drop |
|-------|-------------|-------------|--|
|       | 50Hz        | 60Hz        |  |
| UC22  | 0.216m³/sec | 0.281m³/sec | 6mm water gauge                          |
|       | 458cfm      | 595cfm      | 0.25"                                    |
| UCD22 | 0.25m³/sec  | 0.31m³/sec  | 6mm water gauge                          |
|       | 530cfm      | 657cfm      | 0.25"                                    |
| UC27  | 0.514m³/sec | 0.617m³/sec | 6mm water gauge                          |
|       | 1090cfm     | 1308cfm     | 0.25"                                    |
| UCD27 | 0.58m³/sec  | 0.69m³/sec  | 6mm water gauge                          |
|       | 1230cfm     | 1463cfm     | 0.25"                                    |

**Important ! Reduction in cooling air flow or inadequate protection to the generator can result in damage and/or failure of windings.**

Dynamic balancing of the generator rotor assembly has been carried out during manufacture in accordance with BS 6861 Part 1 Grade 2.5 to ensure vibration limits of the generator are in accordance with BS 4999 Part 142.

The main vibration frequencies produced by the generator are as follows:-

|        |          |       |
|--------|----------|-------|
| 4 pole | 1500 rpm | 25 Hz |
| 4 pole | 1800 rpm | 30 Hz |

However, vibrations induced by the engine are complex and contain frequencies of 1.5, 3, 5 or more times the fundamental frequency of vibration. These induced vibrations can result in generator vibration levels higher than those derived from the generator itself. It is the responsibility of the generating set designer to ensure that the alignment and stiffness of the bedplate and mountings are such that the vibration limits of BS5000 Part 3 are not exceeded.



In standby applications where the running time is limited and reduced life expectancy is accepted, higher levels than specified in BS5000 can be tolerated, up to a maximum of 18mm/sec.

Two bearing generators open coupled require a substantial bedplate with engine/generator mounting pads to ensure a good base for accurate alignment. Close coupling of engine to generator can increase the overall rigidity of the set. For the purposes of establishing set design the bending moment at the engine flywheel housing to generator adaptor interface should not exceed 1000ft.lb. (140 kgm). A flexible coupling, designed to suit the specific engine/generator combination, is recommended to minimise torsional effects.

Belt driven applications of two bearing generators require the pulley diameter and design to be such that the side load or force applied to the shaft is central to the extension and does not exceed the values given in the table below:-

| Frame | Side Load |      | Shaft extension mm |
|-------|-----------|------|--------------------|
|       | kgf       | N    |                    |
| UC22  | 408       | 4000 | 110                |
| UC27  | 510       | 5000 | 140                |

In instances where shaft extensions greater than specified in the table have been supplied reference must be made to the factory for appropriate loadings.

Alignment of single bearing generators is critical and vibration can occur due to the flexing of the flanges between the engine and generator. As far as the generator is concerned the maximum bending moment at this point must not exceed 1000ft.lb. (140 kgm). A substantial bedplate with engine/generator mounting pads is required.

It is expected that the generator will be incorporated into a generating set operating in an environment, where the maximum shock load experienced by the generator will not exceed 3g. in any plane. If shock loads in excess of 3g are to be encountered, anti-vibration mountings must be incorporated into the generating set to ensure they absorb the excess.

The maximum bending moment of the engine flange must be checked with the engine manufacturer.

Generators can be supplied without a foot, providing the option for customers own arrangement. See SECTION 4.2.1 for assembly procedure.

Torsional vibrations occur in all engine-driven shaft systems and may be of a magnitude to cause damage at certain critical speeds. It is therefore necessary to consider the torsional vibration effect on the generator shaft and couplings.

It is the responsibility of the generator set manufacturer to ensure compatibility, and for this purpose drawings showing the shaft dimensions and rotor inertias are available for customers to forward to the engine supplier. In the case of single bearing generators coupling details are included.

**Important ! Torsional incompatibility and/or excessive vibration levels can cause damage or failure of generator and/or engine components.**

The terminal box is constructed with removable panels for easy adaptation to suit specific glanding requirements. Within the terminal box there are insulated terminals for line and neutral connections and provision for earthing. Additional earthing points are provided on the generator feet.

The neutral is NOT connected to the frame.

The main stator winding has leads brought out to the terminals in the terminal box.



**Warning !**

**No earth connections are made on the generator and reference to site regulations for earthing must be made. Incorrect earthing or protection arrangements can result in personal injury or death.**

Fault current curves (decrement curves), together with generator reactance data, are available on request to assist the system designer to select circuit breakers, calculate fault currents and ensure discrimination within the load network.



**Warning !**

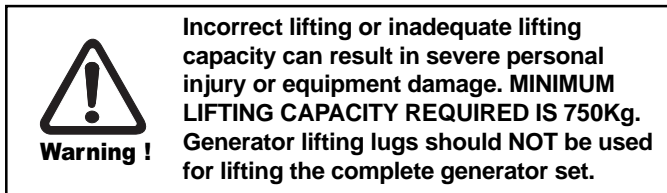
**Incorrect installation, service or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.**



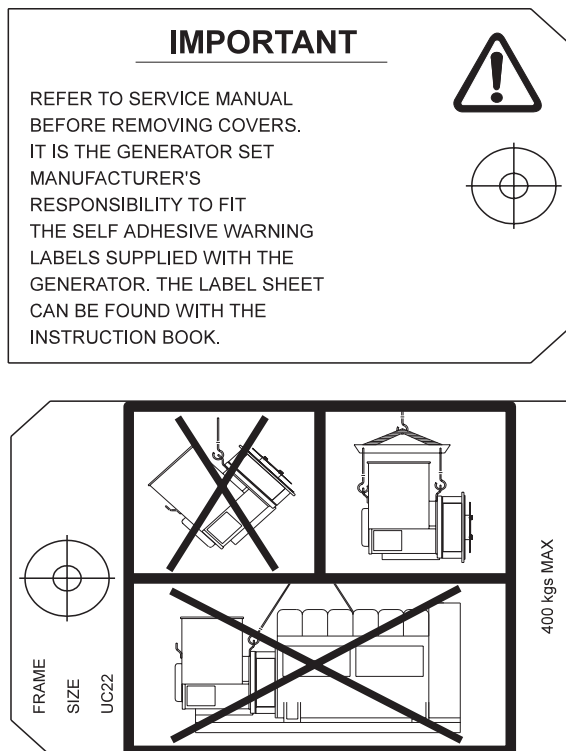
## SECTION 4

### INSTALLATION - PART 1

#### 4.1 LIFTING



Two lifting lugs are provided for use with a shackle and pin type lifting aid. Chains of suitable length and lifting capacity must be used. Lifting points are designed to be as close to the centre of gravity of the generator as possible, but due to design restrictions it is not possible to guarantee that the generator frame will remain horizontal while lifting. Care is therefore needed to avoid personal injury or equipment damage. The correct lifting arrangement is shown on the label attached to the lifting lug. (See sample below).



Single bearing generators are supplied fitted with a rotor retaining bar at the non-drive end of the shaft.

To remove retaining bar:

1. Remove the four screws holding the sheet metal cover at the non drive end and remove cover
2. Remove central bolt holding the retaining bar to the shaft
3. Refit sheet metal cover.

Once the bar is removed, to couple the rotor to engine, the rotor is free to move in the frame, and care is needed during coupling and alignment to ensure the frame is kept in the horizontal plane.

Generators fitted with a PMG excitation system are not fitted with retaining bar. Refer to frame designation to verify generator type (subsection 1.2)

#### 4.2 ASSEMBLY

During the assembly of the generator to the engine it will be necessary firstly to carefully align, then rotate, the combined generator rotor - engine crankshaft assembly, as part of the construction process, to allow location, insertion and tightening of the coupling bolts. This requirement to rotate the combined assemblies exists for both single and two bearing units.

During the assembly of single bearing units it is necessary to align the generator's coupling holes with the engine flywheel holes; it is suggested that two diametrically opposite location dowel pins are fitted to the engine flywheel, over which the generator coupling can slide into final location into the engine flywheel spigot recess. The dowels must be removed and replaced by coupling bolts before the final bolt tightening sequence.

While fitting and tightening the coupling bolts it will be necessary to rotate the engine crankshaft - generator rotor assembly. Care should be taken to ensure that rotation is carried out in an approved manner that ensures safe working practice when reaching inside the machine to insert or tighten coupling bolts, and that no component of the assembly is damaged by non-approved methods of assembly rotation.

Engine manufacturers have available a proprietary tool or facility designed to enable manual rotation of the crankshaft assembly. This must always be used, having been engineered as an approved method of assembly rotation, engaging the manually driven pinion with the engine flywheel starter ring-gear.

**Caution !** Before working inside the generator, during the aligning and fitting of coupling bolts, care should be taken to lock the assembly to ensure there is no possibility of rotational movement.

#### 4.2.1 NO FOOT OPTION

Generators can be supplied without a foot providing the option for customers own arrangement.

For details of mounting this arrangement, see the general arrangement drawing supplied with the generator. Alternatively refer to Newage International for a copy of the latest general arrangement drawing showing the 'NO FOOT OPTION' appropriate to your generator.



## 4.2.2 TWO BEARING GENERATORS

A flexible coupling should be fitted and aligned in accordance with the coupling manufacturer's instruction.

If a close coupling adaptor is used the alignment of machined faces must be checked by offering the generator up to the engine. Shim the generator feet if necessary. Ensure adaptor guards are fitted after generator/engine assembly is complete. Open coupled sets require a suitable guard, to be provided by the set builder.

In the case of belt driven generators, ensure alignment of drive and driven pulleys to avoid axial load on the bearings. Screw type tensioning devices are recommended to allow accurate adjustment of belt tension whilst maintaining pulley alignment. Side loads should not exceed values given in SECTION 3.

Belt and pulley guards must be provided by the set builder.

**Important ! Incorrect belt tensioning will result in excessive bearing wear.**

**Caution ! Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.**

## 4.2.3 SINGLE BEARING GENERATORS

Alignment of single bearing generators is critical. If necessary shim the generator feet to ensure alignment of the machined surfaces.

For transit and storage purposes the generator frame spigot and rotor coupling plates have been coated with a rust preventative. This MUST BE removed before assembly to engine.

A practical method for removal of this coating is to clean the mating surface areas with a de-greasing agent based on a petroleum solvent.

**Care should be taken not to allow any cleaning agent to come into prolonged contact with skin.**

The sequence of assembly to the engine should generally be as follows:

1. On the engine check the distance from the coupling mating face on the flywheel to the flywheel housing mating face. This should be within +/-0.5mm of nominal dimension. This is necessary to ensure that a thrust is not applied to the a.c. generator bearing or engine bearing.
2. Check that the bolts securing the flexible plates to the coupling hub are tight and locked into position. Torque tightening is 24.9kgfm (244Nm; 180 lb ft).
- 2a. **UCD224 Only**  
Torque tightening is 15.29 kgfm (150Nm; 110 lb ft).

3. Remove covers from the drive end of the generator to gain access to coupling and adaptor bolts.
4. Check that coupling discs are concentric with adaptor spigot. This can be adjusted by the use of tapered wooden wedges between the fan and adaptor. Alternatively the rotor can be suspended by means of a rope sling through the adaptor opening.
5. Offer the a.c. generator to engine and engage both coupling discs and housing spigots at the same time, finally pulling home by using the housing and coupling bolts. Use heavy gauge washers between bolt head and discs on disc to flywheel bolts.
6. Tighten coupling disc to flywheel. Refer to engine manual for torque setting of disc to flywheel bolts.
7. Remove wooden wedges.

**Caution ! Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.**

## 4.3 EARTHING

The generator frame should be solidly bonded to the generating set bedplate. If antivibration mounts are fitted between the generator frame and its bedplate a suitably rated earth conductor (normally one half of the cross sectional area of the main line cables) should bridge across the antivibration mount.



**Warning !**

**Refer to local regulations to ensure that the correct earthing procedure has been followed.**

## 4.4 PRE-RUNNING CHECKS

### 4.4.1 INSULATION CHECK

Before starting the generating set, both after completing assembly and after installation of the set, test the insulation resistance of windings.

The AVR should be disconnected during this test.

A 500V Megger or similar instrument should be used. Disconnect any earthing conductor connected between neutral and earth and megger an output lead terminal U, V or W to earth. The insulation resistance reading should be in excess of 5MΩ to earth. Should the insulation resistance be less than 5MΩ the winding must be dried out as detailed in the Service and Maintenance section of this Manual.

**Important ! The windings have been H.V. tested during manufacture and further H.V. testing may degrade the insulation with consequent reduction in operating life. Should it be necessary to demonstrate H.V. testing, for customer acceptance, the tests must be carried out at reduced voltage levels i.e. Test Voltage= 0.8 (2 X Rated Voltage + 1000)**



#### 4.4.2 DIRECTION OF ROTATION

The generator is supplied to give a phase sequence of U V W with the generator running clockwise looking at the drive end (unless otherwise specified at the time of ordering). If the generator phase rotation has to be reversed after the generator has been despatched apply to factory for appropriate wiring diagrams.

#### UCI224, UCI274, UCM224, UCM274

Machines are fitted with bi-directional fans and are suitable for running in either direction of rotation.

#### UCD224, UCD274

Machines are fitted with uni-directional fans and are suitable for running in one direction only.

#### 4.4.3 VOLTAGE AND FREQUENCY

Check that the voltage and frequency levels required for the generating set application are as indicated on the generator nameplate.

Three phase generators normally have a 12 ends out reconnectable winding. If it is necessary to reconnect the stator for the voltage required, refer to diagrams in the back of this manual.

#### 4.4.4 AVR SETTINGS

To make AVR selections and adjustments remove the AVR cover and refer to 4.4.4.1, 4.4.4.2, 4.4.4.3, 4.4.4.4 or 4.4.4.5 depending upon type of AVR fitted. Reference to the generator nameplate will indicate AVR type (SX460, SX440, SX421, MX341 or MX321).

Most of the AVR adjustments are factory set in positions which will give satisfactory performance during initial running tests. Subsequent adjustment may be required to achieve optimum performance of the set under operating conditions. Refer to 'Load Testing' section for details.

##### 4.4.4.1 TYPE SX460 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 1 for location of selection links.

##### 1. Frequency selection

50Hz operation LINK C-50  
60Hz operation LINK C-60

##### 2. External hand trimmer selection

No external hand trimmer LINK 1-2

External hand trimmer required - REMOVE LINK 1-2 and connect trimmer across terminals 1 and 2.

##### 3. AVR Input Selection

High voltage (220/240V) Input NO LINK  
Low voltage (110/120V) Input LINK 3-4

Refer to diagram in the back of this manual to determine wiring.

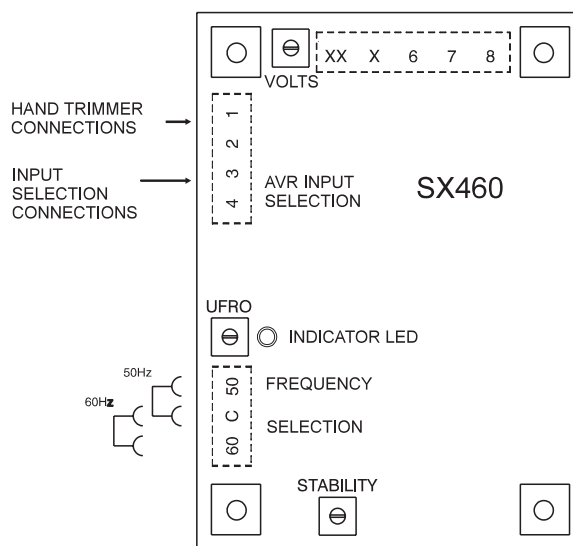


Fig. 1

##### 4.4.4.2 TYPE SX440 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 2 for location of selection links.

##### 1. Frequency selection terminals

50Hz operation LINK C-50  
60Hz operation LINK C-60

##### 2. Stability selection terminals

Frame UC22 LINK A-C  
Frame UC27 LINK B-C

##### 3. Sensing selection terminals

LINK 2-3  
LINK 4-5  
LINK 6-7

##### 4. Excitation Interruption Link

LINK K1-K2

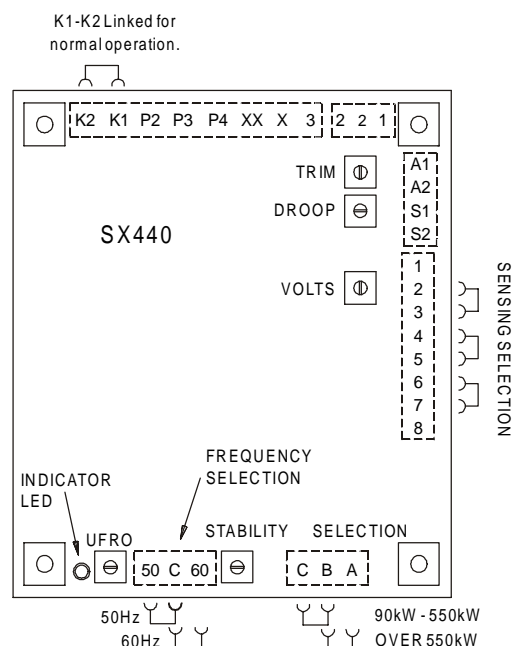


Fig. 2



#### 4.4.4.3 TYPE SX421 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 3 for location of selection links.

##### 1. Frequency selection terminals

50Hz operation LINK C-50

60Hz operation LINK C-60

##### 2. Stability selection terminals

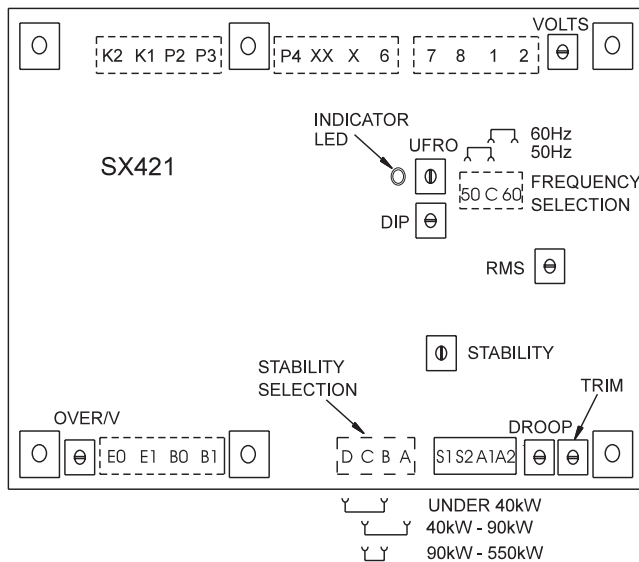
Depending upon kW output LINK B-D

or LINK A-C

or LINK B-C

##### 3. Terminals K1 - K2

Excitation circuit breaker closed



**Fig. 3**

#### 4.4.4.4 TYPE MX341 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 4 for location of setting links.

##### 1. Frequency selection terminals

50Hz operation LINK 2-3

60Hz operation LINK 1-3

##### 2. Stability selection terminals

Frame UC22 LINK A-C

Frame UC27 LINK B-C

##### 3. Sensing selection terminals \*

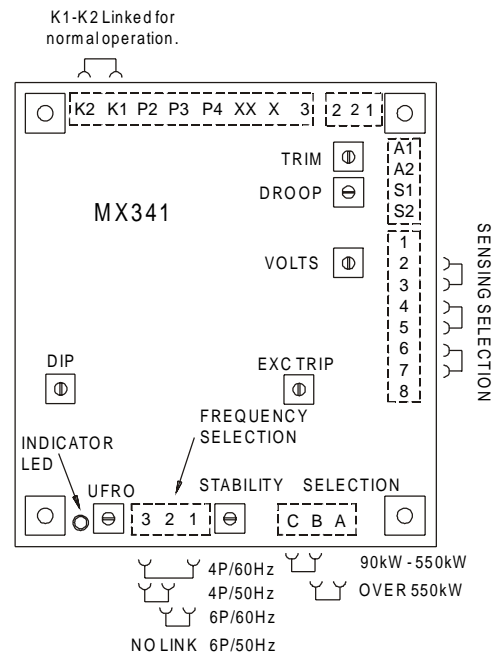
LINK 2-3

LINK 4-5

LINK 6-7

##### 4. Excitation Interruption Link

LINK K1-K2

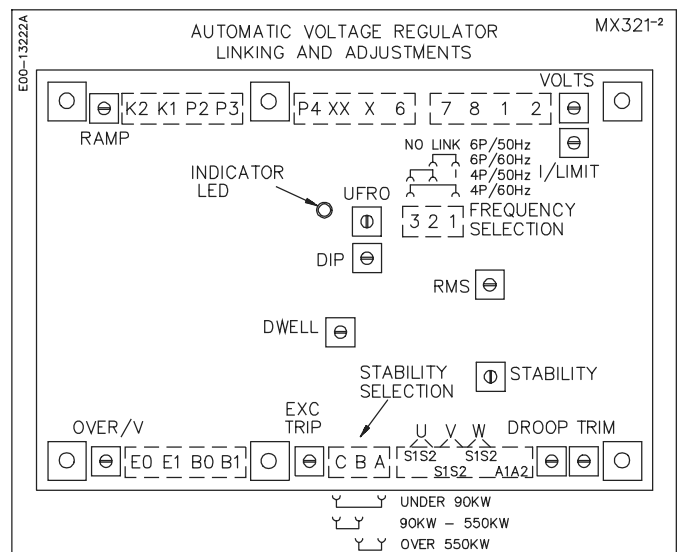


**Fig. 4**

#### 4.4.4.5 TYPE MX321 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 5 for location of setting links.



**Fig. 5**

##### 1. Frequency selection terminals

50Hz operation LINK 2-3

60Hz operation LINK 1-3

##### 2. Stability selection terminals

Frame UC22 LINK A-C

Frame UC27 LINK B-C

##### 3. Terminals K1 - K2

Excitation circuit breaker closed.

If this option not fitted, K1 - K2 linked at auxiliary terminal block.



#### 4.4.5 TRANSFORMER CONTROLLED EXCITATION SYSTEM (Series 5)

This control system is identified with the digit 5 as the last digit of the frame size quoted on the nameplate.

The excitation control is factory set for the specific voltage shown on the nameplate and requires no adjustment.

#### 4.5 GENERATOR SET TESTING



##### Warning !

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments.

##### 4.5.1 TEST METERING/CABLING

Connect any instrument wiring and cabling required for initial test purposes with permanent or spring-clip type connectors.

Minimum instrumentation for testing should be line - line or line to neutral voltmeter, Hz meter, load current metering and kW meter. If reactive load is used a power factor meter is desirable.

**Important !** When fitting power cables for load testing purposes, ensure cable voltage rating is at least equal to the generator rated voltage. The load cable termination should be placed on top of the winding lead termination and clamped with the nut provided.

**Caution !** Check that all wiring terminations for internal or external wiring are secure, and fit all terminal box covers and guards. Failure to secure wiring and/or covers may result in personal injury and/or equipment failure.

#### 4.6 INITIAL START-UP



##### Warning !

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.

On completion of generating set assembly and before starting the generating set ensure that all engine manufacturer's pre-running procedures have been completed, and that adjustment of the engine governor is such that the generator will not be subjected to speeds in excess of 125% of the rated speed.

**Important !** Overspeeding of the generator during initial setting of the speed governor can result in damage to the generator rotating components.

In addition remove the AVR access cover (on AVR controlled generators) and turn VOLTS control fully anti-clockwise. Start the generating set and run on no-load at nominal frequency. Slowly turn VOLTS control potentiometer clockwise until rated voltage is reached. Refer to Fig. 6a, 6b, 6c, 6d or 6e for control potentiometer location.

**Important !** Do not increase the voltage above the rated generator voltage shown on the generator nameplate.

The STABILITY control potentiometer will have been pre-set and should normally not require adjustment, but should this be required, usually identified by oscillation of the voltmeter, refer to Fig. 6a, 6b, 6c, 6d or 6e for control potentiometer location and proceed as follows:-

1. Run the generating set on no-load and check that speed is correct and stable
2. Turn the STABILITY control potentiometer clockwise, then turn slowly anti-clockwise until the generator voltage starts to become unstable.

The correct setting is slightly clockwise from this position (i.e. where the machine volts are stable but close to the unstable region).

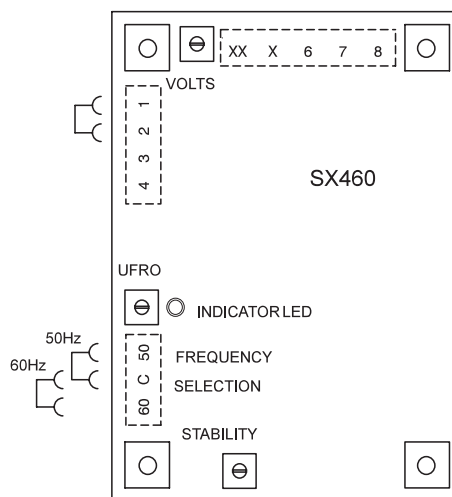


Fig. 6a

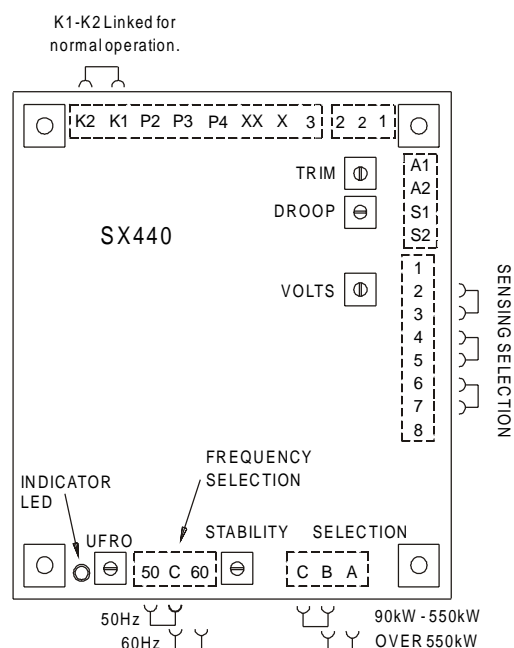


Fig. 6b



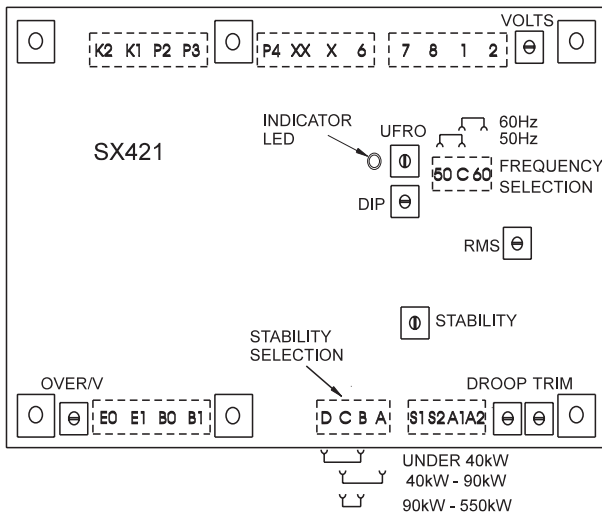


Fig. 6c

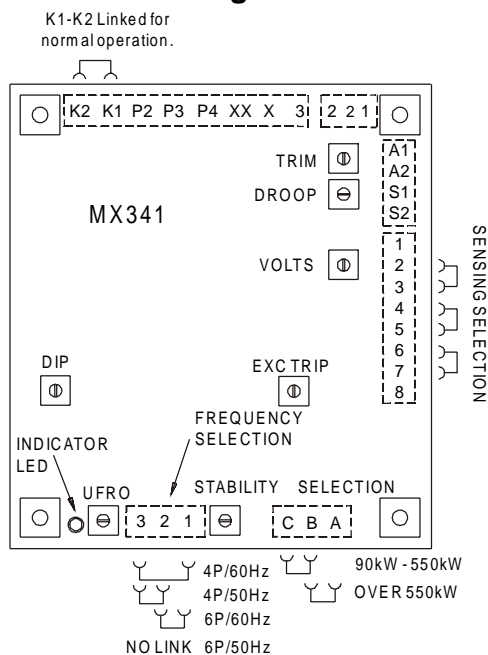


Fig. 6d

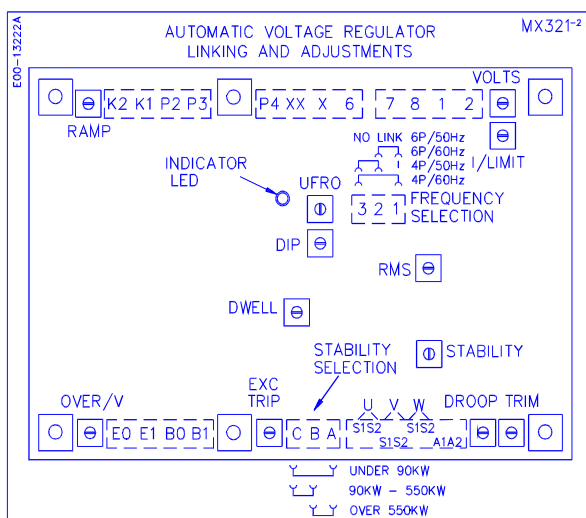


Fig. 6e

## 4.7 LOAD TESTING



**Warning !**

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.

### 4.7.1 AVR CONTROLLED GENERATORS - AVR ADJUSTMENTS

Refer to Fig. 6a, 6b, 6c, 6d or 6e for control potentiometer locations.

Having adjusted VOLTS and STABILITY during the initial start-up procedure, other AVR control functions should not normally need adjustment.

If however, poor voltage regulation on-load or voltage collapse is experienced, refer to the following paragraphs on each function to a) check that the symptoms observed do indicate adjustment is necessary, and b) to make the adjustment correctly.

#### 4.7.1.1 UFRO (Under Frequency Roll Off) (AVR Types SX460, SX440, SX421, MX341 and MX321)

The AVR incorporates an underspeed protection circuit which gives a voltage/speed (Hz) characteristic as shown:

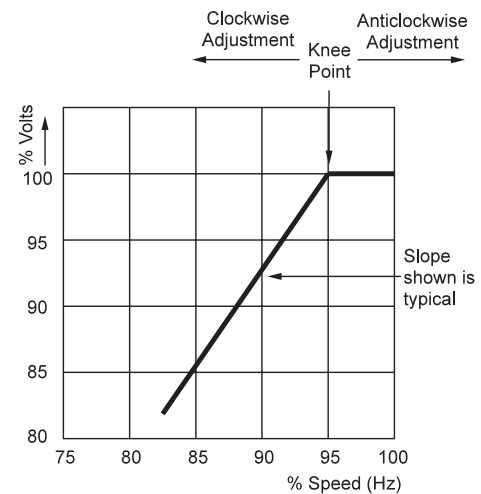


Fig. 7

The UFRO control potentiometer sets the "knee point".

Symptoms of incorrect setting are a) the light emitting diode (LED) indicator, just above the UFRO Control potentiometer, being permanently lit when the generator is on load, and b) poor voltage regulation on load, i.e. operation on the sloping part of the characteristic.

Clockwise adjustment lowers the frequency (speed) setting of the "knee point" and extinguishes the LED. For Optimum setting the LED should illuminate as the frequency falls just below nominal frequency, i.e. 47Hz on a 50Hz generator or 57Hz on a 60Hz generator.

#### Important !

With AVR Types MX341 and MX321. If the LED is illuminated and no output voltage is present, refer to EXC TRIP and/or OVER/V sections below.



#### 4.7.1.2 EXC TRIP (Excitation Trip)

##### AVR Types MX341 and MX321

An AVR supplied from a permanent magnet generator inherently delivers maximum excitation power on a line to line or line to neutral short circuit or large overload. In order to protect the generator windings the AVR incorporates an over excitation circuit which detects high excitation and removes it after a pre-determined time, i.e. 8-10 seconds.

Symptoms of incorrect setting are the generator output collapses on load or small overload, and the LED is permanently illuminated.

The correct setting is 70 volts +/-5% between terminals X and XX.

#### 4.7.1.3 OVER/V (Over Voltage)

##### AVR Type SX421, MX321

Over voltage protection circuitry is included in the AVR to remove generator excitation in the event of loss of AVR sensing input.

The MX321 has both internal electronic de-excitation and provision of a signal to operate an external circuit breaker.

The SX421 only provides a signal to operate an external breaker, which MUST be fitted if over voltage protection is required.

Incorrect setting would cause the generator output voltage to collapse at no-load or on removal of load, and the LED to be illuminated.

The correct setting is 300 volts +/-5% across terminals E1, E0. Clockwise adjustment of the OVER/V control potentiometer will increase the voltage at which the circuit operates.

#### 4.7.1.4 TRANSIENT LOAD SWITCHING ADJUSTMENTS

##### AVR Types SX421, MX341 and MX321

The additional function controls of DIP and DWELL are provided to enable the load acceptance capability of the generating set to be optimised. The overall generating set performance depends upon the engine capability and governor response, in conjunction with the generator characteristics.

It is not possible to adjust the level of voltage dip or recovery independently from the engine performance, and there will always be a 'trade off' between frequency dip and voltage dip.

#### DIP

##### AVR Types SX421, MX341 and MX321

AVR Types SX421, MX341 and MX321

The dip function control potentiometer adjusts the slope of the voltage/speed (Hz) characteristic below the knee point as shown below:

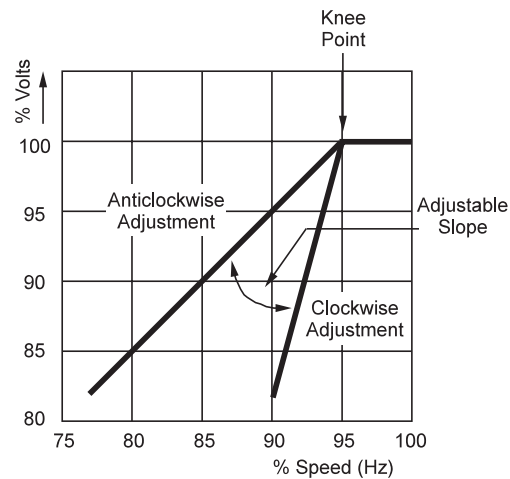


Fig. 8

#### DWELL

##### AVR Type MX321

The dwell function introduces a time delay between the recovery of voltage and recovery of speed.

The purpose of the time delay is to reduce the generator kW below the available engine kW during the recovery period, thus allowing an improved speed recovery.

Again this control is only functional below the "knee point", i.e. if the speed stays above the knee point during load switching there is no effect from the DWELL function setting.

Clockwise adjustment gives increased recovery time.

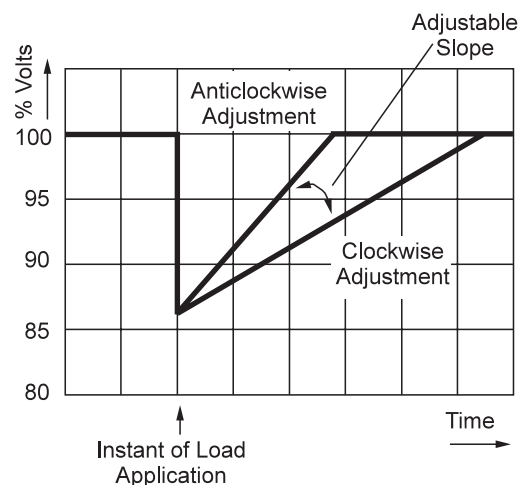


Fig. 9

The graphs shown above are representations only, since it is impossible to show the combined effects of voltage regulator and engine governor performance.



#### 4.7.1.5 RAMP

##### AVR Type MX321

The RAMP potentiometer enables adjustment of the time taken for the generator's initial build up to normal rated voltage during each start and run up to speed. The potentiometer is factory set to give a ramp time of three seconds, which is considered to be suitable for most applications. This time can be reduced to one second by turning the pot. fully counter clockwise, and increased to eight seconds by turning the pot. fully clockwise.

#### 4.7.2 TRANSFORMER CONTROLLED GENERATORS - TRANSFORMER ADJUSTMENT

Normally no adjustment is required but should the no-load voltage and/or on-load voltage be unacceptable, adjustment of the transformer air gap can be made as follows.

Stop the generator. Remove transformer cover box. (Normally left hand side of the terminal box when viewed from the non drive end).

Slacken the three transformer mounting bolts along the top of the transformer.

Start the set with a voltmeter connected across the main output terminals.

Adjust the air gap between the transformer top lamination section and the transformer limbs to obtain required voltage on no-load. Slightly tighten the three mounting bolts. Switch load 'on' and 'off' two or three times. Application of load will normally raise the voltage setting slightly. With the load 'off' recheck the no-load voltage.

Readjust air gap and finally tighten mounting bolts.

Refit the access cover.



**Warning !**

**Failure to refit covers can result in operator personal injury or death.**

#### 4.8 ACCESSORIES

Refer to the "ACCESSORIES" - Section 6 of this Manual for setting up procedures related to generator mounted accessories.

If there are accessories for control panel mounting supplied with the generator refer to the specific accessory fitting procedures inserted inside the back cover of this book.



## **SECTION 5**

### **INSTALLATION - PART 2**

#### **5.1 GENERAL**

The extent of site installation will depend upon the generating set build, e.g. if the generator is installed in a canopied set with integral switchboards and circuit breaker, on site installation will be limited to connecting up the site load to the generating set output terminals. In this case reference should be made to the generating set manufacturer's instruction book and any pertinent local regulations.

If the generator has been installed on a set without switchboard or circuit breaker the following points relating to connecting up the generator should be noted.

#### **5.2 GLANDING**

The terminal box is most conveniently glanded on either the right or left hand side. Both panels are removable for drilling/punching to suit glands/or glanding boxes. If single core cables are taken through the terminal box side panel an insulated or non-magnetic gland plate should be fitted.

Incoming cables should be supported from either below or above the box level and at a sufficient distance from the centre line of the generating set so as to avoid a tight radius at the point of entry into the terminal box panel, and allow movement of the generator set on its anti-vibration mountings without excessive stress on the cable.

Before making final connections, test the insulation resistance of the windings. The AVR should be disconnected during this test.

A 500V Megger or similar instrument should be used. Should the insulation resistance be less than 5MΩ the windings must be dried out as detailed in the Service and Maintenance section of this manual.

When making connections to the terminals the incoming cable termination should be placed on top of the winding lead termination(s) and clamped with the nut provided.

**Important ! To avoid the possibility of swarf entering any electrical components in the terminal box, panels must be removed for drilling.**

#### **5.3 EARTHING**

The neutral of the generator is not bonded to the generator frame as supplied from the factory. An earth terminal is provided inside the terminal box adjacent to the main terminals. Should it be required to operate with the neutral earthed a substantial earth conductor (normally equivalent to one half of the section of the line conductors) must be connected between the neutral and the earth terminal inside the terminal box. Additional earth terminals are provided on the generator feet. These should be already bonded to the generating set bedplate by the generating set builder, but will normally be required to be connected to the site earth system.

**Caution ! Reference to local electricity regulations or safety rules should be made to ensure correct earthing procedures have been followed.**

#### **5.4 PROTECTION**

It is the responsibility of the end user and his contractors/sub-contractors to ensure that the overall system protection meets the needs of any inspectorate, local electricity authority or safety rules, pertaining to the site location.

To enable the system designer to achieve the necessary protection and/or discrimination, fault current curves are available on request from the factory, together with generator reactance values to enable fault current calculations to be made.



**Incorrect installation and/or protective systems can result in personal injury and/or equipment damage. Installers must be qualified to perform electrical installation work.**

#### **5.5 COMMISSIONING**

Ensure that all external cabling is correct and that all the generating set manufacturer's pre-running checks have been carried out before starting the set.

The generator AVR controls will have been adjusted during the generating set manufacturer's tests and should normally not require further adjustment.

Should malfunction occur during commissioning refer to Service and Maintenance section 'Fault Finding' procedure (subsection 7.4).



## SECTION 6

### ACCESSORIES

Generator control accessories may be fitted, as an option, in the generator terminal box. If fitted at the time of supply, the wiring diagram(s) in the back of this book shows the connections. When the options are supplied separately, fitting instructions are provided with the accessory.

The following matrix indicates availability of accessories with the differing AVR's.

Note the SX460 is not suitable for operation with accessories.

| AVR Model | Parallel-ing Droop or Astatic | Manual Voltage Regulator | VAr/PF Control | Current Limit |
|-----------|-------------------------------|--------------------------|----------------|---------------|
| SX440     | ✓                             | ✗                        | ✓              | ✗             |
| SX421     | ✓                             | ✗                        | ✓              | ✗             |
| MX341     | ✓                             | ✓                        | ✓              | ✗             |
| MX321     | ✓                             | ✓                        | ✓              | ✓             |

#### 6.1 REMOTE VOLTAGE ADJUST (ALL AVR TYPES)

A remote voltage adjust (hand trimmer) can be fitted.

**SX460** Remove link 1-2 on the AVR and connect adjuster to terminals 1 and 2.

**SX440, SX421** Remove link 1-2 at the auxiliary terminals  
**MX341 and MX321** and connect adjuster to terminals 1 and 2.

#### 6.2 PARALLEL OPERATION

Understanding of the following notes on parallel operation is useful before attempting the fitting or setting of the droop kit accessory. When operating in parallel with other generators or the mains, it is essential that the phase sequence of the incoming generator matches that of the busbar and also that all of the following conditions are met before the circuit breaker of the incoming generator is closed on to the busbar (or operational generator).

1. Frequency must match within close limits.
2. Voltages must match within close limits.
3. Phase angle of voltages must match within close limits.  
A variety of techniques, varying from simple synchronising lamps to fully automatic synchronisers, can be used to ensure these conditions are met.

**Important !** Failure to meet conditions 1, 2, and 3 when closing the circuit breaker, will generate excessive mechanical and electrical stresses, resulting in equipment damage.

Once connected in parallel a minimum instrumentation level per generator of voltmeter, ammeter, wattmeter (measuring total power per generator), and frequency meter is required in order to adjust the engine and generator controls to share kW in relation to engine ratings and kVAr in relation to generator ratings.

It is important to recognise that:

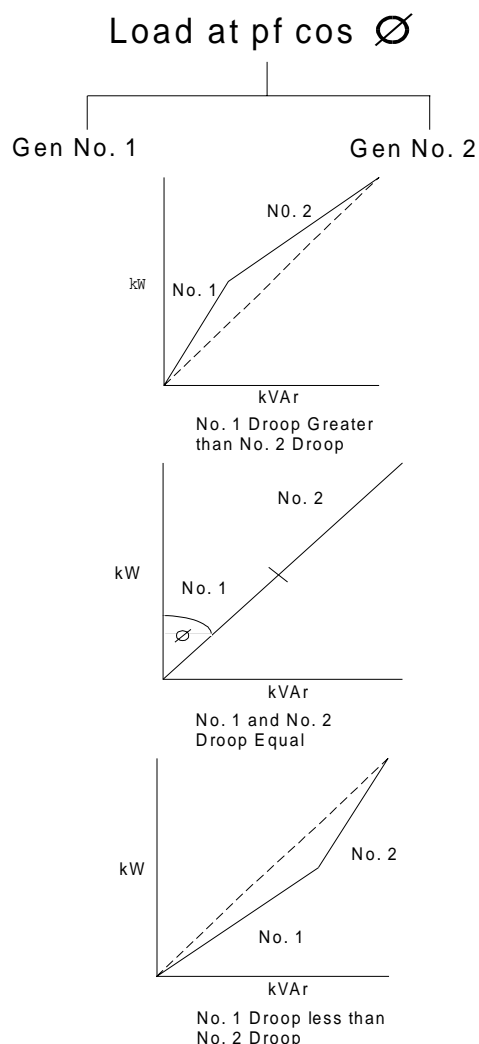
1. True kW are derived from the engine, and speed governor characteristics determine the kW sharing between sets  
and
2. kVAr are derived from the generator, and excitation control characteristics determine the kVAr sharing.  
Reference should be made to the generating set manufacturer's instructions for setting the governor controls.

##### 6.2.1 DROOP

The most commonly used method of kVAr sharing is to create a generator voltage characteristic which falls with decreasing power factor (increasing kVAr). This is achieved with a current transformer (C.T.) which provides a signal dependent on current phase angle (i.e. power factor) to the AVR.

The current transformer has a burden resistor on the AVR board, and a percentage of the burden resistor voltage is summed into the AVR circuit. Increasing droop is obtained by turning the DROOP control potentiometer clockwise.

The diagrams below indicate the effect of droop in a simple two generator system:-





Generally 5% droop at full load current zero p.f. is sufficient to ensure kVAR sharing.

If the droop accessory has been supplied with the generator it will have been tested to ensure correct polarity and set to a nominal level of droop. The final level of droop will be set during generating set commissioning.

The following setting procedure will be found to be helpful.

### 6.2.1.1 SETTING PROCEDURE

Depending upon available load the following settings should be used - all are based on rated current level.

|                |                        |                 |
|----------------|------------------------|-----------------|
| 0.8 P.F. LOAD  | (at full load current) | SET DROOP TO 3% |
| Zero P.F. LOAD | (at full load current) | SET DROOP TO 5% |

Setting the droop with low power factor load is the most accurate. Run each generator as a single unit at rated frequency or rated frequency + 4% depending upon type of governor and nominal voltage. Apply available load to rated current of the generator. Adjust 'DROOP' control potentiometer to give droop in line with above table. Clockwise rotation increases amount of droop. Refer to Fig 9a, 9b, 9c or 9d for potentiometer locations.

#### Note 1)

Reverse polarity of the C.T. will raise the generator voltage with load. The polarities S1-S2 shown on the wiring diagrams are correct for clockwise rotation of the generator looking at the drive end. Reversed rotation requires S1-S2 to be reversed.

#### Note 2)

The most important aspect is to set all generators equal. The precise level of droop is less critical.

#### Note 3)

A generator operated as a single unit with a droop circuit set at rated load 0.8 power factor is unable to maintain the usual +/- 0.5% regulation. A shorting switch can be connected across S1-S2 to restore regulation for single running.

**Important ! LOSS OF FUEL to an engine can cause its generator to motor with consequent damage to the generator windings. Reverse power relays should be fitted to trip main circuit breaker. LOSS OF EXCITATION to the generator can result in large current oscillations with consequent damage to generator windings. Excitation loss detection equipment should be fitted on trip main circuit breaker.**

### 6.2.2 ASTATIC CONTROL

The 'droop' current transformer can be used in a connection arrangement which enables the normal regulation of the generator to be maintained when operating in parallel.

This feature is only supplied from the factory as a fitted droop kit, however, if requested at the time of order, the diagrams inside the back cover of this book will give the necessary site connections. The end user is required to provide a shorting switch for the droop current transformer secondary.

Should the generator be required to be converted from standard droop to 'astatic' control, diagrams are available on request.

The setting procedure is exactly the same as for DROOP. (Subsection 6.2.1.1)

**Important ! When using this connection arrangement a shorting switch is required across each C.T. burden (terminals S1 and S2.) The switch must be closed a) when a generating set is not running and b) when a generating set is selected for single running.**

### 6.3 MANUAL VOLTAGE REGULATOR (MVR) - MX341 and MX321 AVR

This accessory is provided as an 'emergency' excitation system, in the event of an AVR failure.

Powered from the PMG output the unit is manually set, but automatically controls the excitation current, independent of generator voltage or frequency.

The unit is provided with 'MANUAL', 'OFF', 'AUTO' switching facility.

#### 'MANUAL'

- position connects the exciter field to the MVR output. Generator output is then controlled by the operator adjusting the excitation current.

#### 'OFF'

- disconnects the exciter field from both MVR and the normal AVR.

#### 'AUTO'

- connects the exciter field to the normal AVR and the generator output is controlled at the pre-set voltage under AVR control.

Switching mode of operation should be carried out with the generator set stationary to avoid voltage surges on the connected load, although neither the MVR nor AVR will be damaged should the switching be carried out with the set running.

### 6.4 OVERVOLTAGE DE-EXCITATION BREAKER SX421 and MX321 AVR

This accessory provides positive interruption of the excitation power in the event of overvoltage due to loss of sensing or internal AVR faults including the output power device.

With the MX321 AVR this accessory is supplied loose for fitting in the control panel.

In the case of the SX421 the circuit breaker is always supplied and will normally be fitted in the generator.

**Important ! When the circuit breaker is supplied loose, the AVR is fitted with a link on terminals K1-K2 to enable operation of the AVR. When connecting the circuit breaker this link must be removed.**



### 6.4.1 RESETTING THE BREAKER

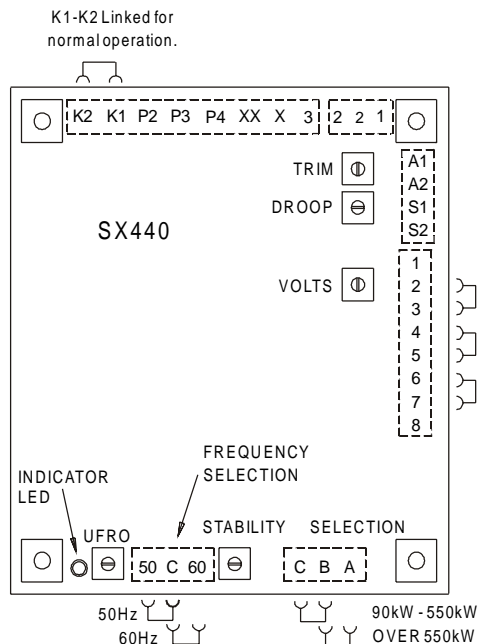
In the event of operation of the circuit breaker, indicated by loss of generator output voltage, manual resetting is required. When in the "tripped" state the circuit breaker switch lever shows "OFF". To reset move the switch lever to the position showing "ON".

When fitted in the generator, access to the breaker is gained by removal of the AVR access cover.

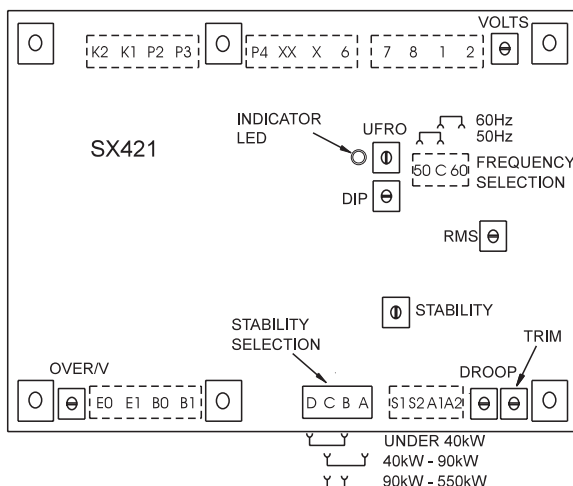


**Terminals which are LIVE with the generating set running are exposed when the AVR access cover is removed. Resetting of the circuit breaker MUST be carried out with the generating set stationary, and engine starting circuits disabled.**

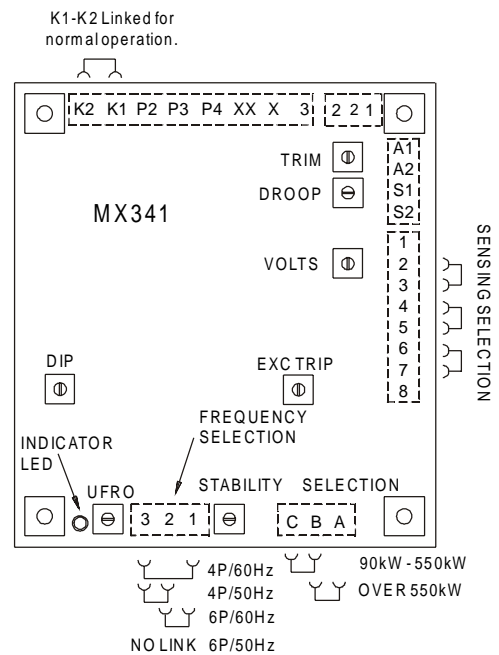
The circuit breaker is mounted on the AVR mounting bracket either to the left or to the right of the AVR depending upon AVR position. After resetting the circuit breaker replace the AVR access cover before restarting the generating set. Should resetting of the circuit breaker not restore the generator to normal operation, refer to subsection 7.5.



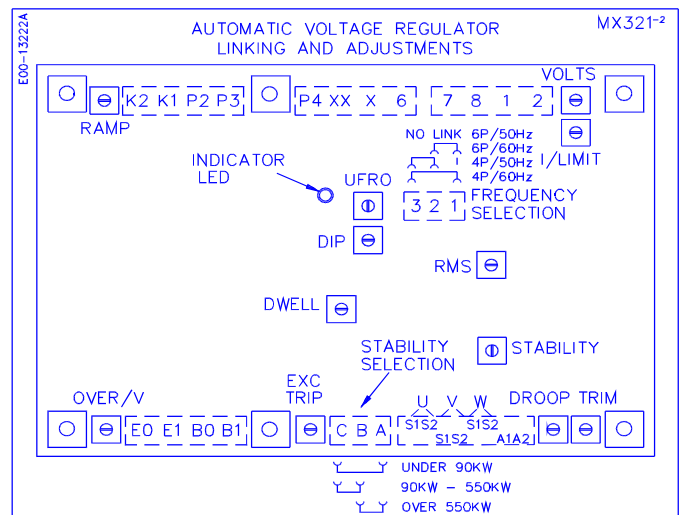
**Fig. 9a**



**Fig. 9b**



**Fig. 9c**



**Fig. 9d**

### 6.5 CURRENT LIMIT - MX321 AVR

These accessories work in conjunction with the AVR circuits to provide an adjustment to the level of current delivered into a fault. One current transformer (CT) per phase is fitted to provide current limiting on any line to line or line to neutral fault.

Note: The W phase CT can also provide "DROOP". Refer to 6.2.1.1 for setting droop independent of current limit.

Adjustment means is provided with the "I/LIMIT" control potentiometer on the AVR. Refer to Fig. 9d for location. If current limit transformers are supplied with the generator the limit will be set in accordance with the level specified at the time of order, and no further adjustment will be necessary. However, should the level need to be adjusted, refer to the setting procedure given in 6.5.1.

#### 6.5.1 SETTING PROCEDURE

Run the generating set on no-load and check that engine governor is set to control nominal speed.



Stop the generating set. Remove the link between terminals K1-K2 at the auxiliary terminal block and connect a 5A switch across the terminals K1-K2.

Turn the "I/LIMIT" control potentiometer fully anticlockwise. Short circuit the stator winding with a bolted 3 phase short at the main terminals. An AC current clip-on ammeter is required to measure the winding lead current.

With the switch across K1-K2 open start the generating set.

Close the switch across K1-K2 and turn the "I/LIMIT" control potentiometer clockwise until required current level is observed on the clip-on ammeter. As soon as correct setting is achieved open the K1-K2 switch.

Should the current collapse during the setting procedure, the internal protective circuits of the AVR will have operated. In this event shut down the set and open the K1-K2 switch. Restart the set and run for 10 minutes with K1-K2 switch open, to cool the generator windings, before attempting to resume the setting procedure.

**Important ! Failure to carry out the correct COOLING procedure, may cause overheating and consequent damage to the generator windings.**

## 6.6 POWER FACTOR CONTROLLER (PFC3)

This accessory is primarily designed for those generator applications where operation in parallel with the mains supply is required.

Protection against loss of mains voltage or generator excitation is not included in the unit and the system designer must incorporate suitable protection.

The electronic control unit requires both droop and kVAr current transformers. When supplied with the generator, wiring diagrams inside the back cover of this manual show the connections and the additional instruction leaflet provided gives details of setting procedures for the power factor controller (PFC3).

The unit monitors the power factor of the generator current and adjusts excitation to maintain the power factor constant.

This mode can also be used to control the power factor of the mains if the point of current monitoring is moved to the mains cables. Refer to the factory for appropriate details.

It is also possible to operate the unit to control kVAr of the generator if required. Refer to the factory for appropriate details.



## SECTION 7

### SERVICE AND MAINTENANCE

As part of routine maintenance procedures, periodic attention to winding condition (particularly when generators have been idle for a long period) and bearings is recommended. (Refer to subsections 7.1 and 7.2 respectively).

When generators are fitted with air filters regular inspection and filter maintenance is required. (Refer to subsection 7.3).

#### 7.1 WINDING CONDITION



**Warning !**

**Service and fault finding procedures present hazards which can result in severe personal injury or death. Only personnel qualified to perform electrical and mechanical service should carry out these procedures. Ensure engine starting circuits are disabled before commencing service or maintenance procedures. Isolate any anti-condensation heater supply.**

#### Guidance of Typical Insulation Resistance [IR] Values

The following is offered as general information about IR values and is aimed at providing guidance about the typical IR values for generators from new through to the point of refurbishment.

##### New Machines

The generators Insulation Resistance, along with many other critical factors, will have been measured during the alternator manufacturing process. The generator will have been transported with an appropriate packaging suitable for the method of delivery to the Generating Set assemblers works. Where we expect it to be stored in a suitable location protected from adverse environmental conditions.

However, absolute assurance that the generator will arrive at the Gen-set production line with IR values still at the factory test levels of above 100 MΩ cannot be guaranteed.

##### At Generating Set Manufacturers Works

The generator should have been transported and stored such that it will be delivered to the assembly area in a clean dry condition. If held in appropriate storage conditions the generator IR value should typically be 25 MΩ.

If the unused/new generators IR values fall below 10 MΩ then a drying out procedure should be implemented by one of the processes outlined below before being despatched to the end customer's site. Some investigation should be undertaken into the storage conditions of the generator while on site.

##### Generators in Service

Whilst It is known that a generator will give reliable service with an IR value of just 1.0 MΩ. For a relatively new generator to be so low it must have been subjected to inappropriate operating or storage conditions.

Any temporarily reduction in IR values can be restored to expected values by following one of the drying out procedures.

#### 7.1.1 WINDING CONDITION ASSESSMENT

**Caution ! The AVR should be disconnected and the Resistance Temperature Detector (R.T.D.) leads grounded during this test.**

The condition of the windings can be assessed by measurement of insulation resistance [IR] between phase to phase, and phase to earth.

Measurement of winding insulation should be carried out: -

1. As part of a periodic maintenance plan.
2. After prolonged periods of shutdown.
3. When low insulation is suspected, e.g. damp or wet windings.

Care should be taken when dealing with windings that are suspected of being excessively damp or dirty. The initial measurement of the [IR] Insulation Resistance should be established using a low voltage (500V) megger type instrument. If manually powered the handle should initially be turned slowly so that the full test voltage will not be applied, and only applied for long enough to very quickly assess the situation if low values are suspected or immediately indicated.

Full megger tests or any other form of high voltage test should not be applied until the windings have been dried out and if necessary cleaned.

#### Procedure for Insulation Testing

Disconnect all electronic components, AVR, electronic protection equipment etc. Ground the [RTD's] Resistance Temperature Detection devices if fitted. Short out the diodes on the rotating diode assembly. Be aware of all components connected to the system under test that could cause false readings or be damaged by the test voltage.

Carry out the insulation test in accordance with the 'operating instructions for the test equipment.

The measured value of insulation resistance for all windings to earth and phase to phase should be compared with the guidance given above for the various 'life stages' of a generator. The minimum acceptable value must be greater than 1.0 MΩ.

**If low winding insulation is confirmed use one or more of the methods, given below, for drying the winding should be carried out.**

#### 7.1.2 METHODS OF DRYING OUT GENERATORS

##### Cold Run

Consider a good condition generator that has not been run for some time, and has been standing in damp, humid conditions. It is possible that simply running the gen set unexcited - AVR terminals K1 K2 open circuit - for a period of say 10 minutes will sufficiently dry the surface of the windings and raise the IR sufficiently, to greater than 1.0 MΩ, and so allow the unit to be put into service.



## Blown Air Drying

Remove the covers from all apertures to allow the escape of the water-laden air. During drying, air must be able to flow freely through the generator in order to carry off the moisture.

Direct hot air from two electrical fan heaters of around 1 – 3 kW into the generator air inlet apertures. Ensure the heat source is at least 300mm away from the windings to avoid over heating and damage to the insulation.

Apply the heat and plot the insulation value at half hourly intervals. The process is complete when the parameters covered in the section entitled, 'Typical Drying Out Curve', are met.

Remove the heaters, replace all covers and re-commission as appropriate.

If the set is not to be run immediately ensure that the anti-condensation heaters are energised, and retest prior to running.

## Short Circuit Method

**NOTE:** This process should only be performed by a competent engineer familiar with safe operating practices within and around generator sets of the type in question.

Ensure the generator is safe to work on, initiate all mechanical and electrical safety procedures pertaining to the genset and the site.

Bolt a short circuit of adequate current carrying capacity, across the main terminals of the generator. The shorting link should be capable of taking full load current.

Disconnect the cables from terminals "X" and "XX" of the AVR.

Connect a variable dc supply to the "X" (positive) and "XX" (negative) field cables. The dc supply must be able to provide a current up to 2.0 Amp at 0 - 24 Volts.

Position a suitable ac ammeter to measure the shorting link current.

Set the dc supply voltage to zero and start the generating set. Slowly increase the dc voltage to pass current through the exciter field winding. As the excitation current increases, so the stator current in the shorting link will increase. This stator output current level must be monitored, and not allowed to exceed 80% of the generators rated output current.

After every 30 minutes of this exercise:

Stop the generator and switch off the separate excitation supply, and measure and record the stator winding IR values, and plot the results. The resulting graph should be compared with the classic shaped graph. This drying out procedure is complete when the parameters covered in the section entitled 'Typical Drying Out Curve' are met.

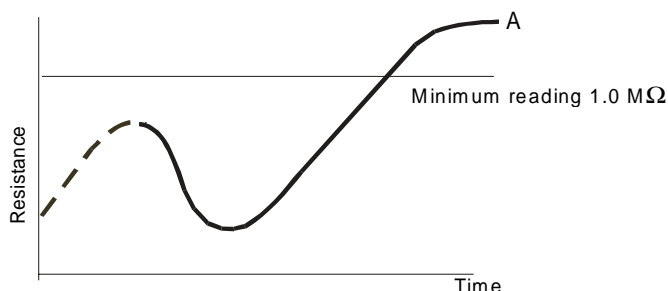
Once the Insulation Resistance is raised to an acceptable level - minimum value 1.0 MΩ – the dc supply may be removed and the exciter field leads "X" and "XX" re-connected to their terminals on the AVR.

Rebuild the genset, replace all covers and re-commission as appropriate.

If the set is not to be run immediately ensure that the anti-condensation heaters are energised, and retest the generator prior to running.

## TYPICAL DRYING OUT CURVE

Whichever method is used to dry out the generator the resistance should be measured every half-hour and a curve plotted as shown. (fig 6.)



**Fig. 9**

The illustration shows a typical curve for a machine that has absorbed a considerable amount of moisture. The curve indicates a temporary increase in resistance, a fall and then a gradual rise to a steady state. Point 'A', the steady state, must be greater than 1.0 MΩ. (If the windings are only slightly damp the dotted portion of the curve may not appear).

For general guidance expect that the typical time to reach point 'A' will be:

- 1 hour for a BC16/18,
- 2 hours for a UC22/27
- 3 hours for an HC4,5,6&7

Drying should be continued after point "A" has been reached for at least one hour.

It should be noted that as winding temperature increases, values of insulation resistance may significantly reduce. Therefore, the reference values for insulation resistance can only be established with windings at a temperature of approximately 20°C.

If the IR value remains below 1.0 MΩ, even after the above drying methods have been properly conducted, then a Polarisation Index test [PI] should be carried out.

If the minimum value of 1.0 MΩ for all components cannot be achieved rewinding or refurbishment of the generator will be necessary.

**The generator must not be put into service until the minimum values can be achieved.**

**Important ! The short circuit must not be applied with the AVR connected in circuit. Current in excess of the rated generator current will cause damage to the windings.**

After drying out, the insulation resistances should be rechecked to verify minimum resistances quoted above are achieved. On re-testing it is recommended that the main stator insulation resistance is checked as follows:-  
Separate the neutral leads

|        |         |                  |                   |
|--------|---------|------------------|-------------------|
| Ground | V and W | phase and megger | U phase to ground |
| Ground | U and W | phase and megger | V phase to ground |
| Ground | U and V | phase and megger | W phase to ground |

If the minimum value of 1.0MΩ is not obtained, drying out must be continued and the test repeated.



## 7.2 BEARINGS

All bearings are supplied sealed for life and are, therefore, not regreasable.

**Important ! The life of a bearing in service is subject to the working conditions and the environment.**

**Important ! Long stationary periods in an environment where there is vibration can cause false brinnelling which puts flats on the ball and grooves on the races.  
Very humid atmospheres or wet conditions can emulsify the grease and cause corrosion.**

**Important ! High axial vibration from the engine or misalignment of the set will stress the bearing.**

The bearing, in service, is affected by a variety of factors that together will determine the bearing life. We recommend that the health of the bearings be monitored, using 'spike energy' vibration monitoring equipment. This will allow the timely replacement of bearings, that exhibit a deteriorating trend, during a major engine overhaul.

If excessive heat, noise or vibration is detected, change the bearing as soon as practicable. Failure to do so could result in bearing failure.


In the event that 'spike energy' vibration monitoring equipment is not available, it is strongly recommend that consideration be given to changing the bearing during each 'major engine overhaul'.

Belt driven application will impose an additional load on bearings. The bearing life will therefore be significantly affected. It is important that the side load limits given in SECTION 3 are not exceeded and the health of the bearing is monitored more closely.

## 7.3 AIR FILTERS

The frequency of filter maintenance will depend upon the severity of the site conditions. Regular inspection of the elements will be required to establish when cleaning is necessary.

### 7.3.1 CLEANING PROCEDURE

|  |  |
|--|--|
|  <p><b>Danger !</b></p> | <p><b>Removal of filter elements enables access to LIVE parts.<br/>Only remove elements with the generator out of service.</b></p> |
|--|--|

Remove the filter elements from the filter frames. Immerse or flush the element with a suitable detergent until the element is clean. Dry elements thoroughly before refitting.

## 7.4 FAULT FINDING

**Important ! Before commencing any fault finding procedure examine all wiring for broken or loose connections.**

Four types of excitation control system, involving four types of AVR, can be fitted to the range of generators covered by this manual. The systems can be identified by a combination of AVR type, where applicable, and the last digit of the generator frame size designation. Refer to the generator nameplate then proceed to the appropriate subsection as indicated below:-

| DIGIT | EXCITATION CONTROL  | SUBSECTION |
|-------|---------------------|------------|
| 6     | SX460 AVR           | 7.4.1      |
| 4     | SX440 AVR           | 7.4.2      |
| 4     | SX421 AVR           | 7.4.3      |
| 5     | Transformer control | 7.4.4      |
| 3     | MX341 AVR           | 7.4.5      |
| 3     | MX321 AVR           | 7.4.6      |

### 7.4.1 SX460 AVR - FAULT FINDING

|   |  |
|---|--|
| No voltage build-up when starting set           | <ol style="list-style-type: none"> <li>1. Check speed</li> <li>2. Check residual voltage. Refer to subsection 7.4.7.</li> <li>3. Follow Separate Excitation Test Procedure to check generator and AVR.</li> </ol>                    |
| Unstable voltage either on no-load or with load | <ol style="list-style-type: none"> <li>1. Check speed stability.</li> <li>2. Check stability setting. Refer to subsection 4.6.</li> </ol>  |
| High voltage either on no-load or with load     | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check that generator load is not capacitive (leading power factor).</li> </ol>  |
| Low voltage no-load                             | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check link 1-2 or external hand trimmer leads for continuity.</li> </ol>  |
| Low voltage on-load                             | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check UFRO setting. Refer to subsection 4.7.1.1.</li> <li>3. Follow Separate Excitation Procedure to check generator and AVR. Refer to subsection 7.5.</li> </ol> |



**7.4.2 SX440 AVR - FAULT FINDING**

|  |  |
|--|--|
| No voltage build-up when starting set.           | <ol style="list-style-type: none"> <li>1. Check link K1-K2 on auxiliary terminals.</li> <li>2. Check speed.</li> <li>3. Check residual voltage. Refer to subsection 7.4.7.</li> <li>4. Follow Separate Excitation Test Procedure to check generator and AVR. Refer to subsection 7.5.</li> </ol> |
| Unstable voltage either on no-load or with load. | <ol style="list-style-type: none"> <li>1. Check speed stability.</li> <li>2. Check stability setting. Refer to subsection 4.6.</li> </ol>  |
| High voltage either on no-load or with load      | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check that generator load is not capacitive (leading power factor).</li> </ol>  |
| Low voltage no-load                              | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check link 1-2 or external hand trimmer leads for continuity.</li> </ol>  |
| Low voltage on-load                              | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check UFRO setting. Refer to subsection 4.7.1.1.</li> <li>3. Follow Separate Excitation Procedure to check generator and AVR. Refer to subsection 7.5.</li> </ol>   |

**7.4.3 SX421 AVR - FAULT FINDING**

|   |   |
|---|---|
| No voltage build-up when starting set           | <ol style="list-style-type: none"> <li>1. Check circuit breaker 'ON'. Refer to subsection 6.4.1.</li> <li>2. Check speed.</li> <li>3. Check residual voltage. Refer to subsection 7.4.7.</li> <li>4. Follow Separate Excitation Procedure to check generator and AVR. Refer to subsection 7.5.</li> </ol> |
| Unstable voltage either on no-load or with load | <ol style="list-style-type: none"> <li>1. Check speed stability.</li> <li>2. Check stability setting. Refer to subsection 4.6.</li> </ol>   |
| High voltage either on no-load or with load     | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check link 1-2 or external hand trimmer leads for continuity. Check continuity of leads 7-8 and P3-P2 for continuity.</li> <li>3. Check that generator load is not capacitive (leading power factor).</li> </ol>                       |
| Low voltage no-load                             | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check link 1-2 or external hand trimmer leads for continuity.</li> </ol>   |

|   |  |
|---|--|
| Low voltage on-load                           | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check UFRO setting. Refer to subsection 4.7.1.1.</li> <li>3. Follow Separate Excitation to check generator and AVR. Refer to subsection 7.5.</li> </ol> |
| Excessive voltage/speed dip on-load switching | <ol style="list-style-type: none"> <li>1. Check governor response.</li> <li>2. Refer to generating set manual. Check 'DIP' setting. Refer to subsection 4.7.1.4.</li> </ol>  |

**7.4.4 TRANSFORMER CONTROL - FAULT FINDING**

|                                       |  |
|---------------------------------------|--|
| No voltage build-up when starting set | <ol style="list-style-type: none"> <li>1. Check transformers rectifiers.</li> <li>2. Check transformer secondary winding for open circuit.</li> </ol>  |
| Low voltage                           | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check transformer air gap setting. Refer to subsection 4.7.2.</li> </ol>  |
| High voltage                          | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. Check transformer air gap setting. Refer to subsection 4.7.2.</li> <li>3. Check transformer secondary winding for short circuited turns.</li> </ol> |
| Excessive voltage drop on-load        | <ol style="list-style-type: none"> <li>1. Check speed drop on-load.</li> <li>2. Check transformer rectifiers. Check transformer air gap setting. Refer to subsection 4.7.2.</li> </ol>                                 |



**7.4.5 MX341 AVR - FAULT FINDING**

|   |  |
|---|--|
| No voltage build-up when starting set           | <ol style="list-style-type: none"> <li>1. Check link K1-K2 on auxiliary terminals.</li> <li>2. Follow Separate Excitation Test Procedure to check machine and AVR. Refer to subsection 7.5.</li> </ol>     |
| Loss of voltage when set running                | <ol style="list-style-type: none"> <li>1. First stop and re-start set. If no voltage or voltage collapses after short time, follow Separate Excitation Test Procedure. Refer to subsection 7.5.</li> </ol> |
| Generator voltage high followed by collapse     | <ol style="list-style-type: none"> <li>1. Check sensing leads to AVR.</li> <li>2. Refer to Separate Excitation Test Procedure. Refer to subsection 7.5.</li> </ol>   |
| Voltage unstable either on no-load or with load | <ol style="list-style-type: none"> <li>1. Check speed stability.</li> <li>2. Check "STAB" setting. Refer to Load Testing section for procedure. Refer to subsection 4.6.</li> </ol>                        |
| Low voltage on-load                             | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. If correct check "UFRO" setting. Refer to subsection 4.7.1.1.</li> </ol>  |
| Excessive voltage/speed dip on load switching   | <ol style="list-style-type: none"> <li>1. Check governor response. Refer to generating set manual. Check "DIP" setting. Refer to subsection 4.7.1.4.</li> </ol>  |
| Sluggish recovery on load switching             | <ol style="list-style-type: none"> <li>1. Check governor response. Refer to generating set manual.</li> </ol>  |

**7.4.6 MX321 AVR - FAULT FINDING**

|   |  |
|---|--|
| No voltage build-up when starting set           | <ol style="list-style-type: none"> <li>1. Check link K1-K2 on auxiliary terminals. Follow Separate Excitation Test Procedure to check machine and AVR. Refer to subsection 7.5.</li> </ol>                 |
| Voltage very slow to build up                   | <ol style="list-style-type: none"> <li>1. Check setting of ramp potentiometer. Refer to 4.7.1.5.</li> </ol>  |
| Loss of voltage when set running                | <ol style="list-style-type: none"> <li>1. First stop and re-start set. If no voltage or voltage collapses after short time, follow Separate Excitation Test Procedure. Refer to subsection 7.5.</li> </ol> |
| Generator voltage high followed by collapse     | <ol style="list-style-type: none"> <li>1. Check sensing leads to AVR.</li> <li>2. Refer to Separate Excitation Test Procedure. Refer to subsection 7.5.</li> </ol>   |
| Voltage unstable either on no-load or with load | <ol style="list-style-type: none"> <li>1. Check speed stability.</li> <li>2. Check "STAB" setting. Refer to Load Testing section for procedure. Refer to subsection 4.6.</li> </ol>                        |
| Low voltage on-load                             | <ol style="list-style-type: none"> <li>1. Check speed.</li> <li>2. If correct check "UFRO" setting. Refer to subsection 4.7.1.1.</li> </ol>  |
| Excessive voltage/speed dip on load switching   | <ol style="list-style-type: none"> <li>1. Check governor responses. Refer to generating set manual. Check "DIP" setting. Refer to subsection 4.7.1.4.</li> </ol>   |
| Sluggish recovery on load switching             | <ol style="list-style-type: none"> <li>1. Check governor response. Refer to generating set manual. Check "DWELL" setting. Refer to Load Testing section 4.7.1.4.</li> </ol>                                |



### 7.4.7 RESIDUAL VOLTAGE CHECK

This procedure is applicable to generators with either SX460 or SX440 or SX421 AVR.

With the generator set stationary remove AVR access cover and leads X and XX from the AVR.

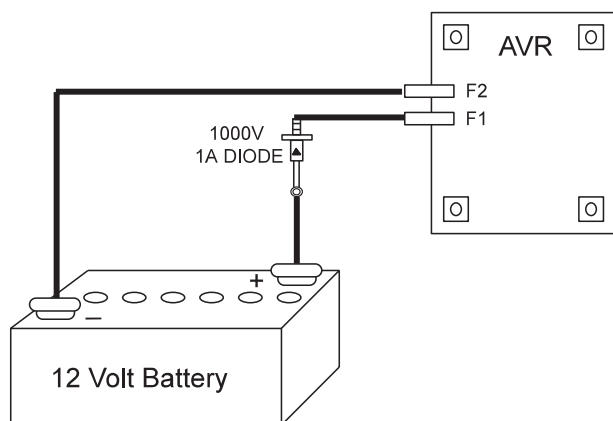
Start the set and measure voltage across AVR terminals 7-8 on SX460 AVR or P2-P3 on SX440 or SX421 AVR.

Stop the set, and replace leads X and XX on the AVR terminals. If the measured voltage was above 5V the generator should operate normally.

If the measured voltage was under 5V follow the procedure below.

Using a 12 volt d. c. battery as a supply clip leads from battery negative to AVR terminal XX, and from battery positive through a diode to AVR terminal X. See Fig. 10.

**Important ! A diode must be used as shown below to ensure the AVR is not damaged.**



**Fig. 11**

**Important ! If the generating set battery is used for field flashing the generator main stator neutral must be disconnected from earth.**

Restart the set and note output voltage from main stator, which should be approximately nominal voltage, or voltage at AVR terminals 7 and 8 on SX460, P2-P3 on SX440 or SX421 which should be between 170 and 250 volts.

Stop the set and unclip battery supply from terminals X and XX. Restart the set. The generator should now operate normally. If no voltage build-up is obtained it can be assumed a fault exists in either the generator or the AVR circuits. Follow the SEPARATE EXCITATION TEST PROCEDURE to check generator windings, rotating diodes and AVR. Refer to subsection 7.5.

### 7.5 SEPARATE EXCITATION TEST PROCEDURE

The generator windings, diode assembly and AVR can be checked using the appropriate following section.

#### 7.5.1 GENERATOR WINDINGS, ROTATING DIODES and PERMANENT MAGNET GENERATOR (PMG)

##### 7.5.2 EXCITATION CONTROL TEST.

### 7.5.1 GENERATOR WINDINGS, ROTATING DIODES and PERMANENT MAGNET GENERATOR (PMG)

**Important ! The resistances quoted apply to a standard winding. For generators having windings or voltages other than those specified refer to factory for details. Ensure all disconnected leads are isolated and free from earth.**

**Important ! Incorrect speed setting will give proportional error in voltage output.**

#### CHECKING PMG

Start the set and run at rated speed.

Measure the voltages at the AVR terminals P2, P3 and P4. These should be balanced and within the following ranges:-

50Hz generators - 170-180 volts  
60Hz generators - 200-216 volts

Should the voltages be unbalanced stop the set, remove the PMG sheet metal cover from the non drive end bracket and disconnect the multipin plug in the PMG output leads. Check leads P2, P3, P4 for continuity. Check the PMG stator resistances between output leads. These should be balanced and within +/-10% of 2.3 ohms. If resistances are unbalanced and/or incorrect the PMG stator must be replaced. If the voltages are balanced but low and the PMG stator winding resistances are correct - the PMG rotor must be replaced.

#### CHECKING GENERATOR WINDINGS AND ROTATING DIODES

This procedure is carried out with leads X and XX disconnected at the AVR or transformer control rectifier bridge and using a 12 volt d.c. supply to leads X and XX.

Start the set and run at rated speed.

Measure the voltages at the main output terminals U, V and W. If voltages are balanced and within +/-10% of the generator nominal voltage, refer to 7.5.1.1.

Check voltages at AVR terminals 6, 7 and 8. These should be balanced and between 170-250 volts.

If voltages at main terminals are balanced but voltage at 6, 7 and 8 are unbalanced, check continuity of leads 6, 7 and 8. Where an isolating transformer is fitted (MX321 AVR) check transformer windings. If faulty the transformer unit must be replaced.

If voltages are unbalanced, refer to 7.5.1.2.

##### 7.5.1.1 BALANCED MAIN TERMINAL VOLTAGES

If all voltages are balanced within 1% at the main terminals, it can be assumed that all exciter windings, main windings and main rotating diodes are in good order, and the fault is in the AVR or transformer control. Refer to subsection 7.5.2 for test procedure.

If voltages are balanced but low, there is a fault in the main excitation windings or rotating diode assembly. Proceed as follows to identify:-



## Rectifier Diodes

The diodes on the main rectifier assembly can be checked with a multimeter. The flexible leads connected to each diode should be disconnected at the terminal end, and the forward and reverse resistance checked. A healthy diode will indicate a very high resistance (infinity) in the reverse direction, and a low resistance in the forward direction. A faulty diode will give a full deflection reading in both directions with the test meter on the 10,000 ohms scale, or an infinity reading in both directions.

On an electronic digital meter a healthy diode will give a low reading in one direction, and a high reading in the other.

## Replacement of Faulty Diodes

The rectifier assembly is split into two plates, the positive and negative, and the main rotor is connected across these plates. Each plate carries 3 diodes, the negative plate carrying negative biased diodes and the positive plate carrying positive biased diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective plate. When fitting the diodes to the plates they must be tight enough to ensure a good mechanical and electrical contact, but should not be overtightened. The recommended torque tightening is 4.06 - 4.74Nm (36-42lb in).

## Surge Suppressor

The surge suppressor is a metal-oxide varistor connected across the two rectifier plates to prevent high transient reverse voltages in the field winding from damaging the diodes. This device is not polarised and will show a virtually infinite reading in both directions with an ordinary resistance meter. If defective this will be visible by inspection, since it will normally fail to short circuit and show signs of disintegration. Replace if faulty.

## Main Excitation Windings

If after establishing and correcting any fault on the rectifier assembly the output is still low when separately excited, then the main rotor, exciter stator and exciter rotor winding resistances should be checked (see Resistance Charts), as the fault must be in one of these windings. The exciter stator resistance is measured across leads X and XX. The exciter rotor is connected to six studs which also carry the diode lead terminals. The main rotor winding is connected across the two rectifier plates. The respective leads must be disconnected before taking the readings.

Resistance values should be within +/-10% of the values given in the table below:-

| Frame Size | Main Rotor | Exciter Stator |         |          | Exciter Rotor |
|------------|------------|----------------|---------|----------|---------------|
|            |            | Type 1         | Type 2* | Type 3** |               |
| UC22C      | 0.59       | 21             | 28      | 138      | 0.142         |
| UC22D      | 0.64       | 21             | 28      | 138      | 0.142         |
| UC22E      | 0.69       | 20             | 30      | 155      | 0.156         |
| UC22F      | 0.83       | 20             | 30      | 155      | 0.156         |
| UC22G      | 0.94       | 20             | 30      | 155      | 0.156         |
| UC27C      | 1.12       | 20             | -       | -        | 0.156         |
| UC27D      | 1.26       | 20             | -       | -        | 0.156         |
| UC27E      | 1.34       | 20             | -       | -        | 0.182         |
| UC27F      | 1.52       | 20             | -       | -        | 0.182         |
| UC27G      | 1.69       | 20             | -       | -        | 0.182         |
| UC27H      | 1.82       | 20             | -       | -        | 0.182         |
| UCD27J     | 2.08       | 20             | -       | -        | 0.182         |
| UCD27K     | 2.08       | 20             | -       | -        | 0.182         |

\* Used with 1 phase transformer controlled 3 phase or 1 phase generators.

\*\* Used with 3 phase transformer controlled 3 phase generators.

## 7.5.1.2 UNBALANCED MAIN TERMINAL VOLTAGES

If voltages are unbalanced, this indicates a fault on the main stator winding or main cables to the circuit breaker. NOTE: Faults on the stator winding or cables may also cause noticeable load increase on the engine when excitation is applied. Disconnect the main cables and separate the winding leads U1-U2, U5-U6, V1-V2, V5-V6, W1-W2, W5-W6 to isolate each winding section. (U1-L1, U2-L4 on single phase generators).

Measure each section resistance - values should be balanced and within +/-10% of the value given below:-

| AVR CONTROLLED GENERATORS |                     |            |            |            |
|---------------------------|---------------------|------------|------------|------------|
| Frame Size                | SECTION RESISTANCES |            |            |            |
|                           | Winding 311         | Winding 17 | Winding 05 | Winding 06 |
| UC22C                     | 0.09                | 0.14       | 0.045      | 0.03       |
| UC22D                     | 0.065               | 0.1        | 0.033      | 0.025      |
| UC22E                     | 0.05                | 0.075      | 0.028      | 0.02       |
| UC22F                     | 0.033               | 0.051      | 0.018      | 0.012      |
| UC22G                     | 0.028               | 0.043      | 0.014      | 0.01       |
| UC27C                     | 0.03                | 0.044      | 0.016      | 0.011      |
| UC27D                     | 0.019               | 0.026      | 0.01       | 0.007      |
| UC27E                     | 0.016               | 0.025      | 0.009      | 0.008      |
| UC27F                     | 0.012               | 0.019      | 0.007      | 0.005      |
| UC27G                     | 0.01                | 0.013      | 0.006      | 0.004      |
| UC27H                     | 0.008               | 0.014      | 0.004      | 0.004      |
| UCD27J                    | 0.006               | 0.009      | -          | -          |
| UCD27K                    | 0.006               | 0.009      | -          | -          |

| TRANSFORMER CONTROLLED GENERATORS |                                       |       |       |       |       |
|-----------------------------------|---------------------------------------|-------|-------|-------|-------|
| Frame Size                        | SECTION RESISTANCES, 3 PHASE WINDINGS |       |       |       |       |
|                                   | 380V                                  | 400V  | 415V  | 416V  | 460V  |
|                                   | 50Hz                                  | 50Hz  | 50Hz  | 60Hz  | 60Hz  |
| UC22C                             | 0.059                                 | 0.078 | 0.082 | 0.055 | 0.059 |
| UC22D                             | 0.054                                 | 0.056 | 0.057 | 0.049 | 0.054 |
| UC22E                             | 0.041                                 | 0.05  | 0.053 | 0.038 | 0.041 |
| UC22F                             | 0.031                                 | 0.032 | 0.033 | 0.025 | 0.031 |
| UC22G                             | 0.022                                 | 0.026 | 0.028 | 0.021 | 0.022 |

Measure insulation resistance between sections and each section to earth.

Unbalanced or incorrect winding resistances and/or low insulation resistances to earth indicate rewinding of the stator will be necessary. Refer to removal and replacement of component assemblies subsection 7.5.3.

## 7.5.2 EXCITATION CONTROL TEST

### 7.5.2.1 AVR FUNCTION TEST

All types of AVR's can be tested with this procedure:

1. Remove exciter field leads X & XX (F1 & F2) from the AVR terminals X & XX (F1 & F2).
2. Connect a 60W 240V household lamp to AVR terminals X & XX (F1 & F2).
3. Set the AVR VOLTS control potentiometer fully clockwise.
4. Connect a 12V, 1.0A DC supply to the exciter field leads X & XX (F1 & F2) with X (F1) to the positive.



5. Start the generating set and run at rated speed.
6. Check that the generator output voltage is within +/-10% of rated voltage.

Voltages at AVR terminals 7-8 on SX460 AVR or P2-P3 on SX440 or SX421 AVR should be between 170 and 250 volts. If the generator output voltage is correct but the voltage on 7-8 (or P2-P3) is low, check auxiliary leads and connections to main terminals.

Voltages at P2, P3, P4 terminals on MX341 and MX321 should be as given in 7.5.1.

The lamp connected across X-XX should glow. In the case of the SX460, SX440 and SX421 AVRs the lamp should glow continuously. In the case of the MX341 and MX321 AVRs the lamp should glow for approximately 8 secs. and then turn off. Failure to turn off indicates faulty protection circuit and the AVR should be replaced. Turning the "VOLTS" control potentiometer fully anti-clockwise should turn off the lamp with all AVR types.

Should the lamp fail to light the AVR is faulty and should be replaced.

**Important ! After this test turn VOLTS control potentiometer fully anti-clockwise.**

### 7.5.2.2 TRANSFORMER CONTROL

The transformer rectifier unit can only be checked by continuity, resistance checks and insulation resistance measurement.

#### Two phase transformer

Separate primary leads T1-T2-T3-T4 and secondary leads 10-11. Examine windings for damage. Measure resistances across T1-T3 and T2-T4. These will be a low value but should be balanced. Check that there is resistance in the order of 8 ohms between leads 10 and 11. Check insulation resistance of each winding section to earth and to other winding sections.

Low insulation resistance, unbalanced primary resistance, open or short circuited winding sections, indicates the transformer unit should be replaced.

#### Three phase transformer

Separate primary leads T1-T2-T3 and secondary leads 6-7-8 and 10-11-12.

Examine windings for damage. Measure resistances across T1-T2, T2-T3, T3-T1. These will be low but should be balanced. Check that resistances are balanced across 6-10, 7-11 and 8-12 and in the order of 18 ohms.

Check insulation resistance of each winding section to earth and to other winding sections.

Low insulation resistance, unbalanced primary or secondary winding resistances, open or short circuited winding sections indicates the transformer unit should be replaced.

#### Rectifier units - Three phase and single phase

With the leads 10-11-12-X and XX removed from the rectifier unit (lead 12 is not fitted on single phase transformer rectifier units), check forward and reverse resistances between terminals 10-X, 11-X, 12-X, 10-XX, 11-XX and 12-XX with a multimeter.

A low forward resistance and high reverse resistance should be read between each pair of terminals. If this is not the case the unit is faulty and should be replaced.

## 7.5.3 REMOVAL AND REPLACEMENT OF COMPONENT ASSEMBLIES

METRIC THREADS ARE USED THROUGHOUT

**Caution ! When lifting single bearing generators, care is needed to ensure the generator frame is kept in the horizontal plane. The rotor is free to move in the frame and can slide out if not correctly lifted. Incorrect lifting can cause serious personal injury.**

### 7.5.3.1 REMOVAL OF PERMANENT MAGNET GENERATOR (PMG)

1. Remove 4 screws holding the sheet metal cylindrical cover at the non-drive end and remove the cover.
2. Disconnect the in line connector from the PMG stator (3 wires go to this connector). It may be necessary to cut off the nylon cable tie first.
3. Remove the 4 threaded pillars and clamps holding the PMG stator onto the end bracket.
4. Tap the stator out of the 4 spigots and withdraw. The highly magnetic rotor will attract the stator. Take care to avoid contact which may damage the windings.
5. Remove the bolt in the centre from the rotor shaft and pull off the rotor. It may be necessary to gently tap the rotor away. Take care to tap gently and evenly - the rotor has ceramic magnets which are easily broken by shock.

**Important ! The rotor assembly must not be dismantled.**

Replacement is a reversal of the above procedure.

### 7.5.3.2 REMOVAL OF BEARINGS

**Important ! Position the main rotor so that a full pole face of the main rotor core is at the bottom of the stator bore.**

NOTE: Removal of the bearings may be effected either after the rotor assembly has been removed OR more simply by removal of endbracket(s). Refer to 7.5.3.3. and 7.5.3.4.

The bearings are pre-packed with grease and sealed for life.

The bearing(s) are a press fit and can be removed from the shaft with 3 leg or 2 leg manual or hydraulic bearing pullers.

**SINGLE BEARING ONLY:** Before trying to pull off the bearing remove the small circlip retaining it.

When fitting new bearings use a bearing heater to expand the bearing before fitting to the shaft. Tap the bearing into place ensuring that it contacts the shoulder on the shaft.

Refit the retaining circlip on single bearing generators.

### 7.5.3.3 REMOVAL OF ENDBRACKET AND EXCITER STATOR

1. Remove exciter leads X+, XX- at the AVR.
2. Slacken 4 bolts (2 each side) situated on horizontal centre line holding the terminal box.
3. Remove 2 bolts holding lifting lug, at the non-drive end, and remove lug.



4. Remove sheet metal cylindrical cover (4 screws) over PMG (if fitted)  
or  
Remove shallow sheet metal cover (4 screws) at the non-drive end.
5. Ease up the terminal box and support clear of the non-drive endbracket.
6. Remove 6 bolts holding the non-drive endbracket to the stator bar assembly. The endbracket is now ready for removal.
7. Replace the lifting lug onto the endbracket and sling the endbracket on a hoist to facilitate lifting.
8. Tap the endbracket around its perimeter to release from the generator. The endbracket and exciter stator will come away as a single assembly.
9. Remove the 4 screws holding the exciter stator to the endbracket and gently tap the exciter stator to release it. Replacement is a reversal of the above procedure.

#### 7.5.3.4 REMOVAL OF THE ROTOR ASSEMBLY

Remove the permanent magnet generator. Refer to 7.5.3.1 or

Remove the four screws holding the sheet metal cover at the non drive end and remove cover.

**Caution ! With the PMG rotor removed single bearing generator rotors are free to move in the frame. Ensure frame is kept in the horizontal plane when lifting.**

#### TWO BEARING GENERATORS

1. Remove 2 screws holding the sheet metal cover around the adaptor at the drive end and remove the cover.
2. Remove the bolts holding the adaptor to the endbracket at the drive end.
3. Tap off the adaptor. It may be preferred to sling the adaptor first depending on its size and weight.
4. Remove the screens and louvres (if fitted) at each side on the drive end.

Now ensure that the rotor is positioned with a full pole face at the bottom centre line. This is to avoid damage to the bearing exciter, or rotor winding, by limiting the possible rotor downward movement to the air gap length.

5. Remove 6 bolts holding drive endbracket onto adaptor ring DE. The boltheads face towards the non-drive end. The top bolt passes through the centre of the lifting lug.
6. Tap the drive endbracket away from the adaptor ring DE and withdraw the endbracket.
7. Ensure the rotor is supported at the drive end on a sling.
8. Tap the rotor from the non-drive end to push the bearing clear of the endbracket and its position within an 'O' ring.
9. Continue to push the rotor out of the stator bore, gradually working the sling along the rotor as it is withdrawn, to ensure that it is fully supported all the time.

#### SINGLE BEARING GENERATORS

1. Remove the screws, screens and louvres (if fitted) at each side on drive end adaptor.
2. **UCI224, UCI274, UCM224, UCM274, UCD274 Only**

Remove 6 bolts holding the adaptor at the drive end. It may be preferred to sling the adaptor on a hoist. The bolt heads face towards the non-drive end. The top bolt passes through the centre of the lifting lug.

##### 2a. UCD224 Only

Remove 6 bolts holding the adaptor at the drive end. It may be preferred to sling the adaptor on a hoist.

##### 3. UCI224, UCI274, UCM224, UCM274, UCD274 Only

Tap the adaptor away from stator bar adaptor ring.

##### 3a. UCD224 Only

Tap the adaptor away from stator bar assembly.

#### ALL SINGLE BEARING GENERATORS

4. Ensure the rotor is supported at drive end on a sling.
5. Tap the rotor from the non-drive end to push the bearing clear of the endbracket and its position within an 'O' ring.
6. Continue to push the rotor out of the stator bore, gradually working the sling along the rotor as it is withdrawn, to ensure that it is fully supported at all times.

Replacement of rotor assemblies is a reversal of the procedures above.

Before commencing re-assembly, components should be checked for damage and bearing(s) examined for loss of grease.

Fitting of new bearing(s) is recommended during major overhaul.

Before replacement of a single bearing rotor assembly, check that the drive discs are not damaged, cracked or showing other signs of fatigue. Also check that the holes in the discs for drive fixing screws are not elongated.

Damaged or worn components must be replaced.

**Caution ! When major components have been replaced, ensure that all covers and guards are securely fitted, before the generator is put into service.**

#### 7.6 RETURNING TO SERVICE

After rectification of any faults found, remove all test connections and reconnect all control system leads.

Restart the set and adjust VOLTS control potentiometer on AVR controlled generators by slowly turning clockwise until rated voltage is obtained.

Refit all terminal box covers/access covers and reconnect heater supply.

**Caution ! Failure to refit all guards, access covers and terminal box covers can result in personal injury of death.**



## **SECTION 8**

### **SPARES AND AFTER SALES SERVICE**

#### **8.1 RECOMMENDED SPARES**

Service parts are conveniently packaged for easy identification. Genuine parts may be recognised by the Nupart name.

We recommend the following for Service and Maintenance. In critical applications a set of these service spares should be held with the generator.

##### **AVR Controlled Generators**

|    |  |             |                  |
|----|--|-------------|------------------|
| 1. | Diode Set (6 diodes with surge suppressor) | <b>RSK</b>  | <b>2001</b>      |
| 2. | AVR SX440                                  | <b>E000</b> | <b>24030</b>     |
|    | AVR SX460                                  | <b>E000</b> | <b>24602</b>     |
|    | AVR SX421                                  | <b>E000</b> | <b>24210</b>     |
|    | AVR MX321                                  | <b>E000</b> | <b>23212</b>     |
|    | AVR MX341                                  | <b>E000</b> | <b>23410</b>     |
| 3. | Non drive end Bearing                      | <b>UC22</b> | <b>051 01032</b> |
|    |  | <b>UC27</b> | <b>051 01049</b> |
| 4. | Drive end Bearing                          | <b>UC22</b> | <b>051 01044</b> |
|    |  | <b>UC27</b> | <b>051 01050</b> |

##### **Transformer Controlled Generators (UC22 Only)**

|    |  |             |                  |
|----|--|-------------|------------------|
| 1. | Diode Set (6 diodes with surge suppressor) | <b>RSK</b>  | <b>2001</b>      |
| 2. | Diode Assembly                             | <b>E000</b> | <b>22006</b>     |
| 3. | Non drive end Bearing                      | <b>UC22</b> | <b>051 01032</b> |
| 4. | Drive end Bearing                          | <b>UC22</b> | <b>051 01044</b> |

When ordering parts the machine serial number or machine identity number and type should be quoted, together with the part description. For location of these numbers see paragraph 1.3.

Orders and enquiries for parts should be addressed to:

Newage International Limited  
Nupart Department  
PO Box 17, Barnack Road  
STAMFORD  
Lincolnshire  
PE9 2NB  
ENGLAND

Telephone: 44 (0) 1780 484000

Fax: 44 (0) 1780 766074

Or any of our subsidiary companies listed on the back cover.

#### **8.2 AFTER SALES SERVICE**

A full technical advice and on-site service facility is available from our Service Department at Stamford or through our Subsidiary Companies. A repair facility is also available at our Stamford Works.







## PARTS LIST

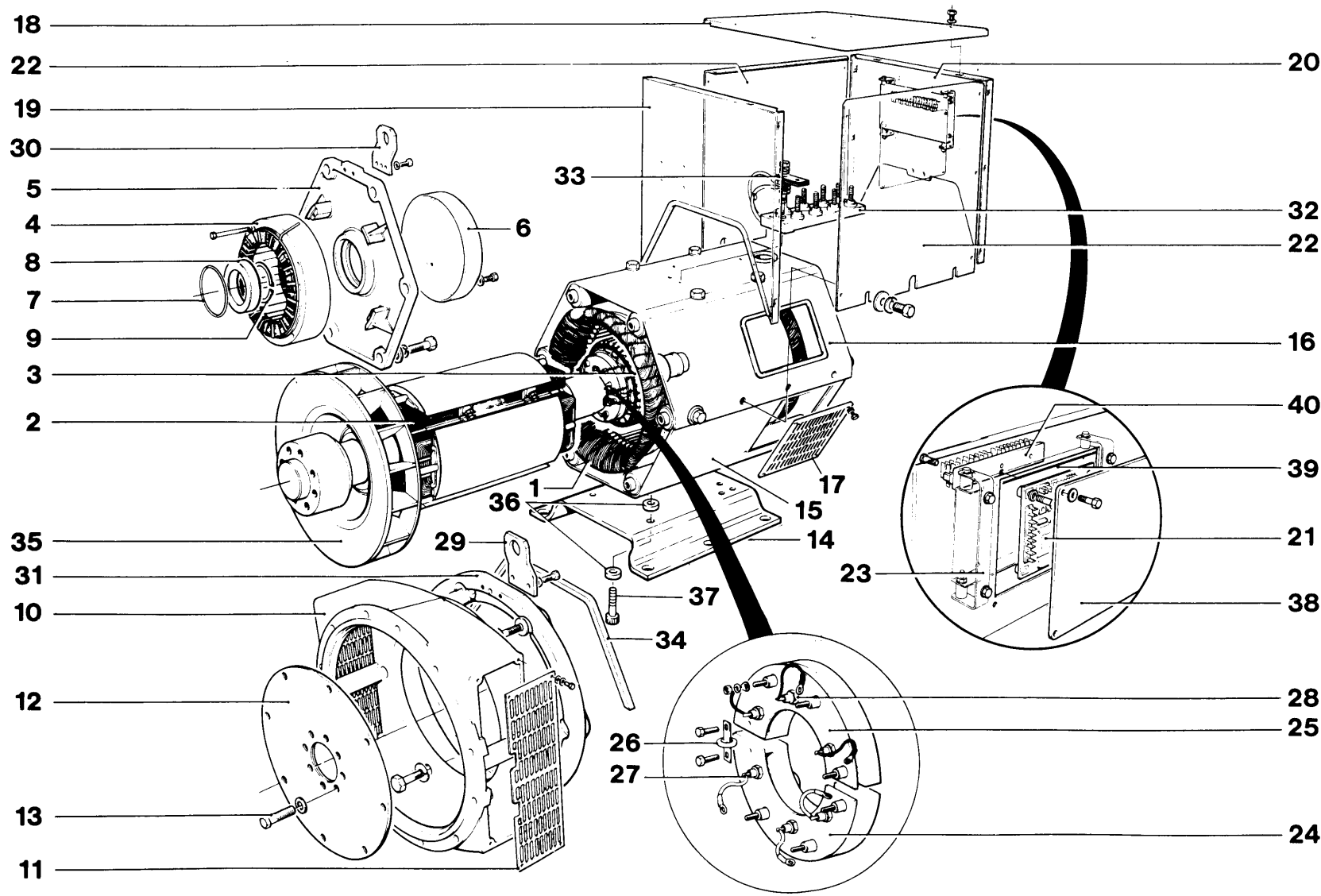
### TYPICAL SINGLE BEARING GENERATOR

| Plate Ref. | Description                       | Plate Ref. | Description                          |
|------------|-----------------------------------|------------|--------------------------------------|
| 1          | Stator                            | 25         | Main Rectifier Assembly - Reverse    |
| 2          | Rotor                             | 26         | Varistor                             |
| 3          | Exciter Rotor                     | 27         | Diode - Forward Polarity             |
| 4          | Exciter Stator                    | 28         | Diode - Reverse Polarity             |
| 5          | N.D.E. Bracket                    | 29         | Lifting Lug - D.E.                   |
| 6          | Cover N.D.E.                      | 30         | Lifting Lug - N.D.E.                 |
| 7          | Bearing 'O' Ring N.D.E.           | 31         | Frame to Endbracket Adaptor Ring     |
| 8          | Bearing N.D.E.                    | 32         | Main Terminal Panel                  |
| 9          | Bearing Circlip N.D.E.            | 33         | Terminal Link                        |
| 10         | D.E. Bracket/Engine Adaptor       | 34         | Edging Strip                         |
| 11         | D.E. Screen                       | 35         | Fan                                  |
| 12         | Coupling Disc                     | 36         | Foot Mounting Spacer                 |
| 13         | Coupling Bolt                     | 37         | Cap Screw                            |
| 14         | Foot                              | 38         | AVR Access Cover                     |
| 15         | Frame Cover Bottom                | 39         | AVR Anti-Vibration Mounting Assembly |
| 16         | Frame Cover Top                   | 40         | Auxiliary Terminal Assembly          |
| 17         | Air Inlet Cover                   |            |                                      |
| 18         | Terminal Box Lid                  |            |                                      |
| 19         | Endpanel D.E.                     |            |                                      |
| 20         | Endpanel N.D.E.                   |            |                                      |
| 21         | AVR                               |            |                                      |
| 22         | Side Panel                        |            |                                      |
| 23         | AVR Mounting Bracket              |            |                                      |
| 24         | Main Rectifier Assembly - Forward |            |                                      |

N.D.E.      Non Drive End  
 D.E.        Drive End  
 PMG        Permanent Magnet Generator  
 AVR         Automatic Voltage Regulator



**Fig. 11.**  
**TYPICAL SINGLE BEARING GENERATOR**





## PARTS LIST

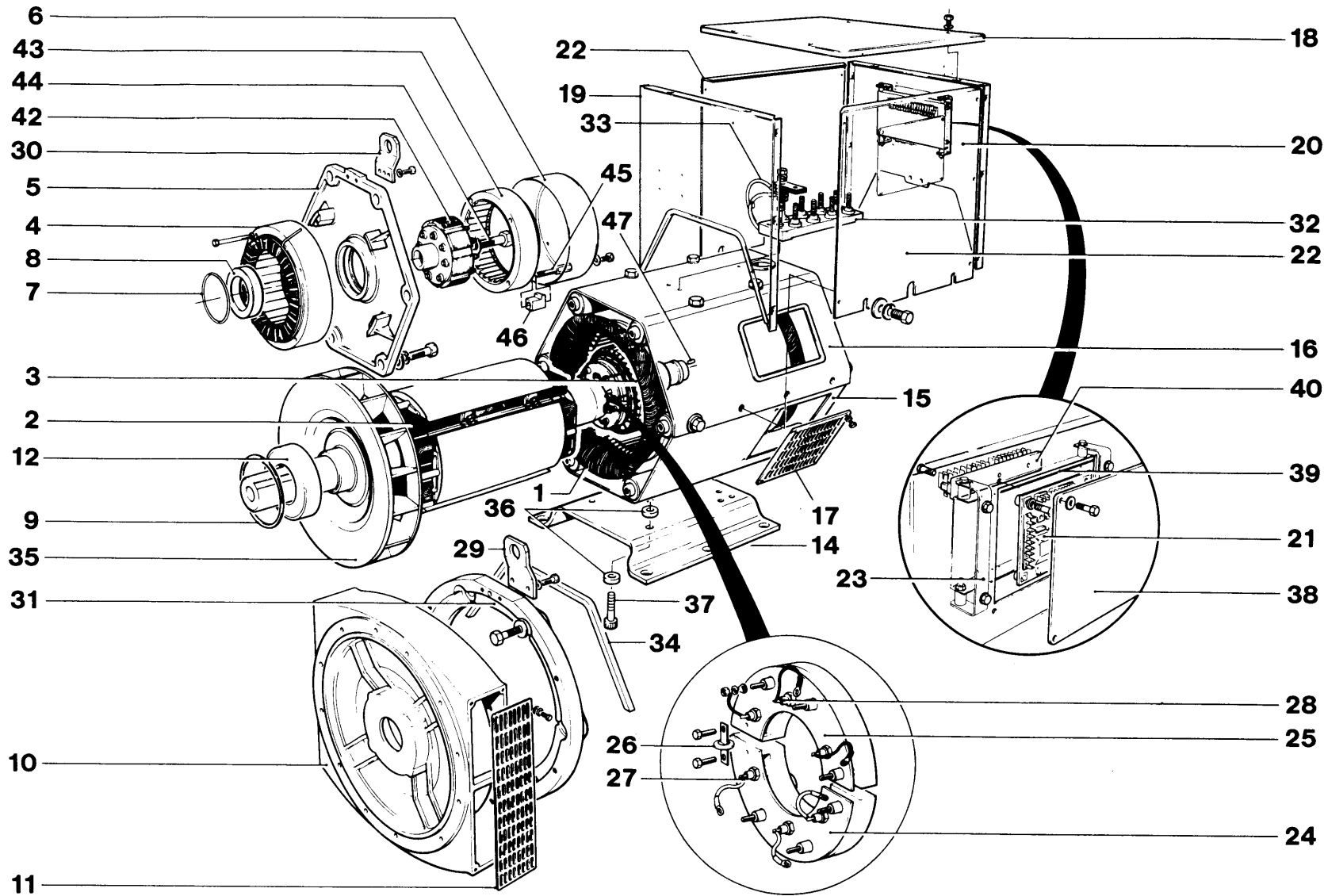
### TYPICAL TWO BEARING GENERATOR

| Plate Ref. | Description                       | Plate Ref. | Description                       |
|------------|-----------------------------------|------------|-----------------------------------|
| 1          | Stator                            | 25         | Main Rectifier Assembly - Reverse |
| 2          | Rotor                             | 26         | Varistor                          |
| 3          | Exciter Rotor                     | 27         | Diode - Forward Polarity          |
| 4          | Exciter Stator                    | 28         | Diode - Reverse Polarity          |
| 5          | N.D.E. Bracket                    | 29         | Lifting Lug - D.E.                |
| 6          | Cover N.D.E.                      | 30         | Lifting Lug - N.D.E.              |
| 7          | Bearing 'O' Ring N.D.E.           | 31         | Frame to Endbracket Adaptor Ring  |
| 8          | Bearing N.D.E.                    | 32         | Main Terminal Panel               |
| 9          | Bearing Wave Washer D.E.          | 33         | Terminal Link                     |
| 10         | D.E. Bracket                      | 34         | Edging Strip                      |
| 11         | D.E. Screen                       | 35         | Fan                               |
| 12         | Bearing D.E.                      | 36         | Foot Mounting Spacer              |
| 14         | Foot                              | 37         | Cap Screw                         |
| 15         | Frame Cover Bottom                | 38         | AVR Access Cover                  |
| 16         | Frame Cover Top                   | 39         | AVR Anti-Vibration Mount          |
| 17         | Air Inlet Cover                   | 40         | Auxiliary Terminal Assembly       |
| 18         | Terminal Box Lid                  | 42         | PMG Exciter Rotor                 |
| 19         | Endpanel D.E.                     | 43         | PMG Exciter Stator                |
| 20         | Endpanel N.D.E.                   | 44         | PMG Bolt                          |
| 21         | AVR                               | 45         | PMG Pillar                        |
| 22         | Side Panel                        | 46         | PMG Clamp                         |
| 23         | AVR Mounting Bracket              | 47         | PMG Dowel                         |
| 24         | Main Rectifier Assembly - Forward |            |                                   |

N.D.E.      Non Drive End  
 D.E.        Drive End  
 PMG        Permanent Magnet Generator  
 AVR         Automatic Voltage Regulator



**Fig. 12.**  
**TYPICAL TWO BEARING GENERATOR**





## PARTS LIST

### TYPICAL TWO BEARING (SERIES 5) GENERATOR

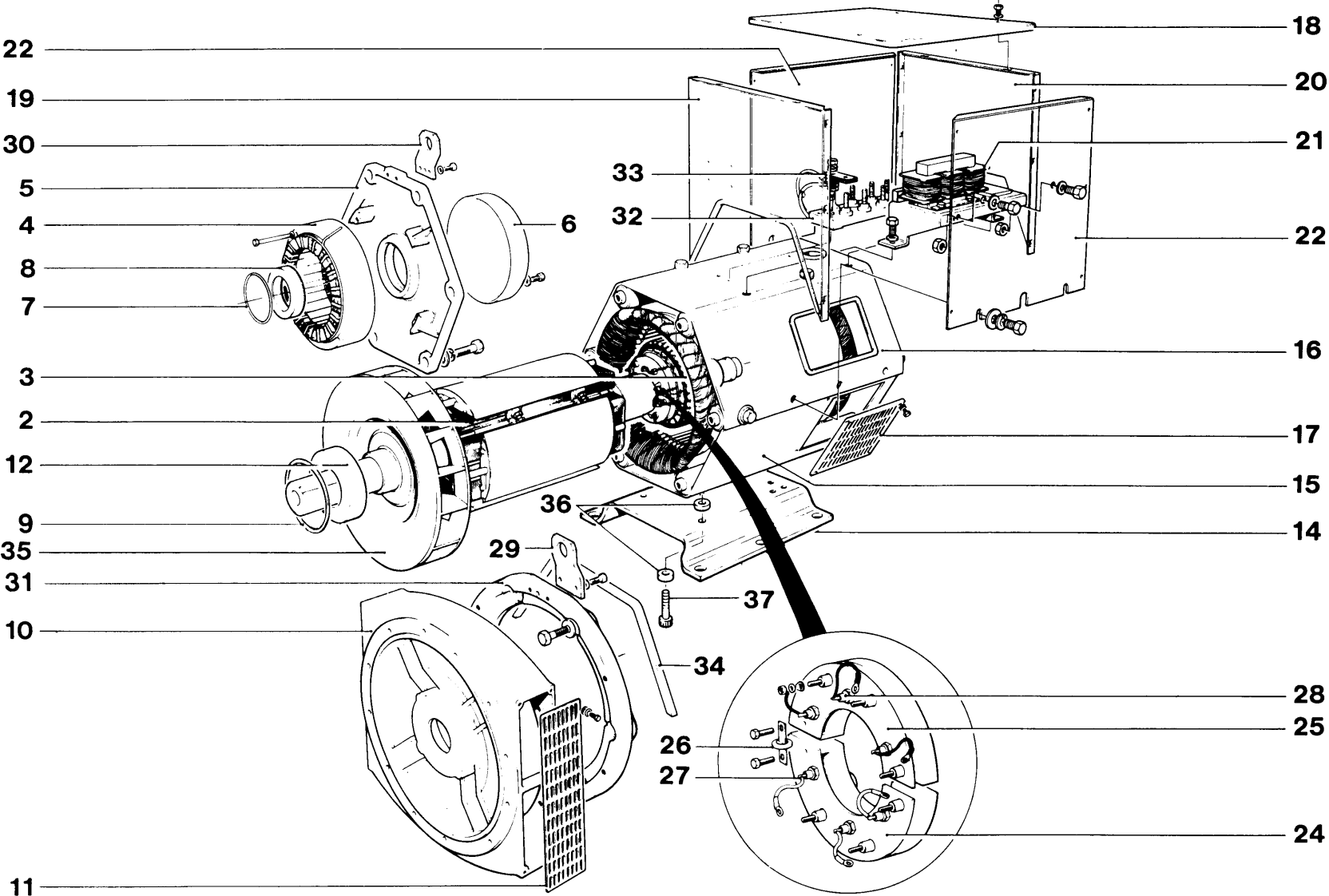
| Plate Ref. | Description                       | Plate Ref. | Description                       |
|------------|-----------------------------------|------------|-----------------------------------|
| 1          | Stator                            | 25         | Main Rectifier Assembly - Reverse |
| 2          | Rotor                             | 26         | Varistor                          |
| 3          | Exciter Rotor                     | 27         | Diode - Forward Polarity          |
| 4          | Exciter Stator                    | 28         | Diode - Reverse Polarity          |
| 5          | N.D.E. Bracket                    | 29         | Lifting Lug - D.E.                |
| 6          | Cover N.D.E.                      | 30         | Lifting Lug - N.D.E.              |
| 7          | Bearing 'O' Ring N.D.E.           | 31         | Frame to Endbracket Adaptor Ring  |
| 8          | Bearing N.D.E.                    | 32         | Main Terminal Panel               |
| 9          | Bearing Wave Washer D.E.          | 33         | Terminal Link                     |
| 10         | D.E. Bracket                      | 34         | Edging Strip                      |
| 11         | D.E. Screen                       | 35         | Fan                               |
| 12         | Bearing D.E.                      | 36         | Foot Mounting Spacer              |
| 13         |                                   | 37         | Cap Screw                         |
| 14         | Foot                              |            |                                   |
| 15         | Frame Cover Bottom                |            |                                   |
| 16         | Frame Cover Top                   |            |                                   |
| 17         | Air Inlet Cover                   |            |                                   |
| 18         | Terminal Box Lid                  |            |                                   |
| 19         | Endpanel D.E.                     |            |                                   |
| 20         | Endpanel N.D.E.                   |            |                                   |
| 21         | Series 5 Control Gear             |            |                                   |
| 22         | Side Panel                        |            |                                   |
| 23         |                                   |            |                                   |
| 24         | Main Rectifier Assembly - Forward |            |                                   |

N.D.E.  
D.E.

Non Drive End  
Drive End



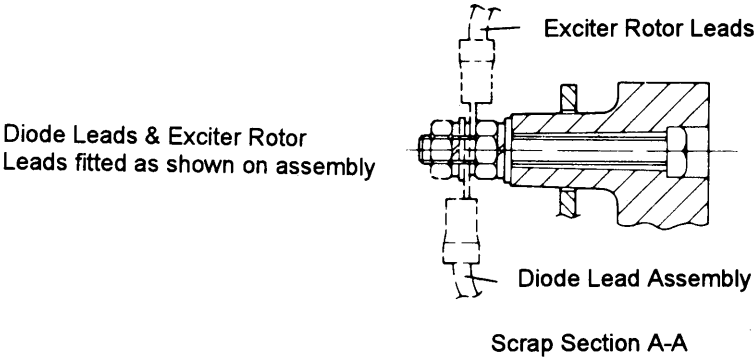
**Fig. 13.**  
**TYPICAL TWO BEARING (SERIES 5) GENERATOR**



37



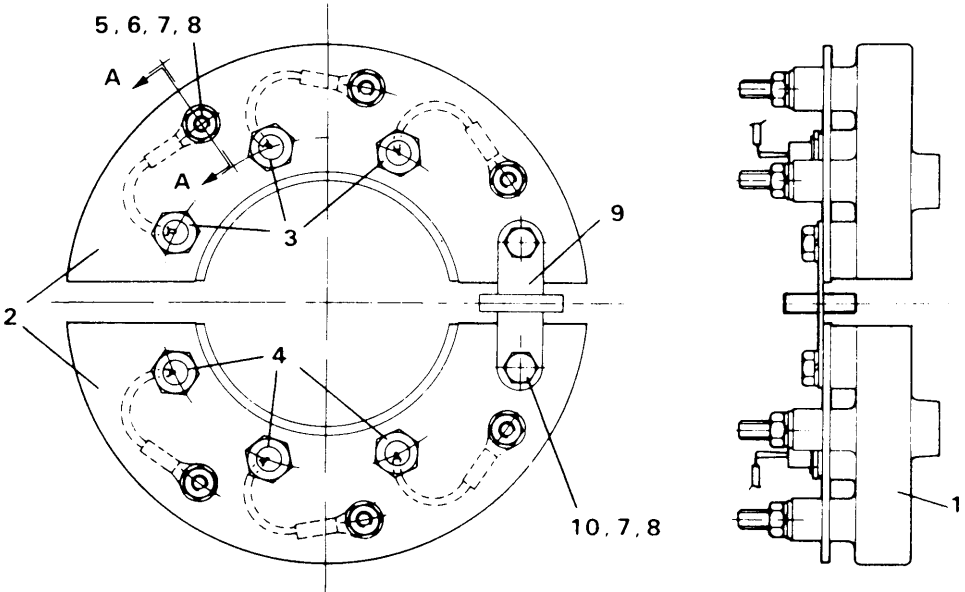
**Fig. 14.**  
**ROTATING RECTIFIER ASSEMBLY**



| Plate Ref. | Description  | Qty |
|------------|--------------|-----|
| 1          | Hub          | 1   |
| 2          | Fin          | 2   |
| 3          | Diode (fwd)  | 3   |
| 4          | Diode (rev)  | 3   |
| 5          | Hx. Screw    | 6   |
| 6          | Hx. Nut      | 6   |
| 7          | Pl. Washer   | 8   |
| 8          | SC. L/Washer | 8   |
| 9          | Varistor     | 1   |
| 10         | Hx. Screw    | 2   |

NOTES:  
Fitting of Diodes.

1. Underside of diodes to be smeared with Midland Silicone 'Heat Sink' compound type MS2623. This compound **must not** be applied to the diode threads.
2. Diodes to be tightened to a torque of 2.03 - 2.37 Nm.
3. For Nupart rectifier service kit see page 28.









This manual is available in the following languages on request:  
English, French, German, Italian and Spanish.

Denne manual er til rådighed på følgende sprog: engelsk, fransk, tysk, italiensk og spansk.

Denne håndboken er tilgjengelig på de følgende språkene: engelsk, fransk, tysk, italiensk og spansk.

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## A.C. GENERATOR WARRANTY

### WARRANTY PERIOD

#### A.C. Generators

In respect of a.c. generators the Warranty Period is eighteen months from the date when the goods have been notified as ready for despatch by N.I. or twelve months from the date of first commissioning (whichever is the shorter period).

### DEFECTS AFTER DELIVERY

We will make good by repair or, at our option, by the supply of a replacement, any fault which under proper use appears in the goods within the period specified on Clause 12, and is found on examination by us to be solely due to defective material and workmanship; provided that the defective part is promptly returned, carriage paid, with all identification numbers and marks intact, or our works or, if appropriate to the Dealer who supplied the goods.

Any part repaired or replaced, under warranty, will be returned by N.I. free of charge (via sea freight if outside the UK).

We shall not be liable for any expenses which may be incurred in removing or replacing any part sent to us for inspection or in fitting any replacement supplied by us. We shall be under no liability for defects in any goods which have not been properly installed in accordance with N.I. recommended installation practices as detailed in the publications 'N.I. Installation, Service and Maintenance Manual' and 'N.I. Application Guidelines', or which have been improperly stored or which have been repaired, adjusted or altered by any person except ourselves or our authorised agents, or in any second-hand goods, proprietary articles or goods not of our own manufacture although supplied by us, such articles and goods being covered by the warranty (if any) given by the separate manufacturers.

Any claim under this clause must contain fully particulars of the alleged defect, the description of the goods, the date of purchase, and the name and address of the Vendor, the Serial Number (as shown on the manufacturers identification plate) or for Spares the order reference under which the goods were supplied.

Our judgement in all cases of claims shall be final and conclusive and the claimant shall accept our decision on all questions as to defects and the exchange of a part or parts.

Our liability shall be fully discharged by either repair or replacement as above, and in any event shall not exceed the current list price of the defective goods.

Our liability under this clause shall be in lieu of any warranty or condition implied by law as to the quality or fitness for any particular purpose of the goods, and save as expressly provided in this clause we shall not be under any liability, whether in contract, tort or otherwise, in respect of defects in goods delivered or for any injury, damages or loss resulting from such defects or from any work undone in connection therewith.

MACHINE SERIAL NUMBER



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# SP181

## Section 5 - GE Fanuc PLC





## GE Fanuc Automation

### Series 90™-30 PLCs

The **Series 90™-30 PLCs** are a family of controllers, I/O systems and specialty modules designed to meet the demand for versatile industrial solutions. With its single overall control architecture, the Series 90-30 has been the PLC of record in over 200,000 applications, such as high-speed packaging, material handling, complex motion control, water treatment, continuous emissions monitoring, mining, food processing, elevator control, injection molding and many more.



**Thanks to its modular design, the Series 90-30 offers unmatched versatility. Configure just the system you need, saving critical space and reducing cost.**

**With over 100 I/O modules, the Series 90-30 PLC can be adapted to a wide range of applications.**

- Digital interfaces for push buttons, switches, proximity sensors, relays, contactors and many other devices
- Analog modules with varying degrees of resolution for flow, temperature or pressure applications
- Direct connect wiring or remote termination
- Local or remote I/O systems

**Series 90-30 Ethernet communications provide** a real-time link between the plant floor and the boardroom. You can begin with an Ethernet-enabled CPU, or at a later date, choose from our selection of rack-mounted Ethernet modules. The Series 90-30 Ethernet module supports both SRTP and Modbus TCP/IP application protocols.

**The scalable processing power in the Series 90-30 CPU** creates a clear upgrade path. Create the system that's ideal today, while leaving open the option of creating a more powerful system tomorrow — without having to change your application software.

**Motion control integrated into the Series 90-30** fosters high performance point-to-point applications.

**A variety of Series 90-30 field bus interfaces** enables distributed control and/or I/O. Choose from Ethernet EGD, Profibus-DP™, Genius®, DeviceNet™ and Interbus-S™ modules. Field Bus interface modules are easy to install and quick to configure. Plug them into an existing system or design a new system around them.

**Ease of programming is a strong suit of the Series 90-30.** Choose the programming options that meet your needs: Windows®-based IEC programming, advanced C or State Logic®. Floating point math, PID, indirect addressing, array moves and sequencing are just a few of the over 200 instructions available.

**The Series 90-30 stands out among small controls for offering redundancy options.** The Series 90-30 is the low-cost solution for high availability applications, with redundant CPUs and power supplies.

**Easy trouble shooting and machine setup using a handheld PDA.** CIMPLICITY® Machine Edition Logic Developer PDA software allows you to interface a Palm® handheld device to your Series 90-30 controller. With Logic Developer PDA, you can monitor/change data, view diagnostics, force ON/OFF, and configure machine setup — saving you time and increasing productivity.



## Ordering Information

| Description                            | Catalog Number |  | Catalog Number |  |
|--|----------------|--|----------------|--|
| Discrete Input Modules                 | IC693MDL230    | 120 VAC Isolated Input (8 Points)  | IC693MDL646    | 24 VDC Input, Neg/Pos Logic, 1 msec Filter (16 Points)   |
|  | IC693MDL231    | 240 VAC Isolated Input (8 Points)  | IC693MDL648    | 48 VDC Input, Neg/Pos Logic, 1 msec filter, Neg/Pos Logic (16 Points)  |
|  | IC693MDL240    | 120 VAC Input (16 Points)  | IC693MDL653    | 24 VDC Input, Neg/Pos Logic, 2msec Filter (32 Points)  |
|  | IC693MDL241    | 24 VAC/VDC Input (16 Points)   | IC693MDL654    | 5/12 VDC (TTL) Input, Neg/Pos Logic, (32 Points)   |
|  | IC693MDL632    | 125 VDC Input (8 Points)   | IC693MDL655    | 24 VDC Input, Neg/Pos Logic, 1 ms, (32 Points)   |
|  | IC693MDL634    | 24 VDC Input, Neg/Pos Logic (8 Points)   | IC693ACC300    | Input Simulator Module (8 Points)  |
|  | IC693MDL645    | 24 VDC Input, Neg/Pos Logic (16 Points)  |                |  |
| Discrete Output Modules                | IC693MDL310    | 120 VAC Output, 0.5 Amp (12 Points)  | IC693MDL740    | 12/24 VDC Output, 0.5 Amp, Positive Logic (16 Points)  |
|  | IC693MDL330    | 120/240 VAC Output, 2 Amp (8 Points)   | IC693MDL741    | 12/24 VDC Output, 0.5 Amp, Negative Logic (16 Points)  |
|  | IC693MDL340    | 120 VAC Output, 0.5 Amp (16 Points)  | IC693MDL742    | 12/24 VDC Output, 1 Amp, Positive Logic (16 Points), Fused   |
|  | IC693MDL390    | 120/240 VAC Isolated Output, 2 Amp (5 Points)  | IC693MDL748    | 48 VDC Output, 0.5 Amps, Positive Logic (8 Points)   |
|  | IC693MDL730    | 12/24 VDC Output, 2 Amp, Positive Logic (8 Points)   | IC693MDL750    | 12/24 VDC Output, Negative Logic (32 Points)   |
|  | IC693MDL731    | 12/24 VDC Output, 2 Amp, Negative Logic (8 Points)   | IC693MDL751    | 12/24 VDC Output, Positive Logic (32 Points)   |
|  | IC693MDL732    | 12/24 VDC Output, 0.5 Amp, Positive Logic (8 Points)   | IC693MDL752    | 5/12/24 VDC (TTL) Output, Negative Logic, (32 Points)  |
|  | IC693MDL733    | 12/24 VDC Output, 0.5 Amp, Negative Logic (8 Points)   | IC693MDL753    | 12/24 VDC Output, Positive Logic (32 Points)   |
|  | IC693MDL734    | 125 VDC Output, (6 Points)   |                |  |
|  |                |  |                |  |
| Relay Output Module                    | IC693MDL930    | Relay Output, Isolated, 4 Amp (8 Points)   | IC693MDL940    | Relay Output, 2 Amp (16 Points)  |
|  | IC693MDL931    | Relay Output, 8 Amp Form B/C contacts, Isolated in 2 Groups of 4 (8 Points)  |                |  |
| Mixed Discrete Module                  | IC693MDR390    | Mixed I/O, 24 VDC Input (8 points), Relay Output (8 points)  | IC693MAR590    | Mixed I/O, 120 VAC Input (8 Points), Relay Output (8 Points)   |
| Analog Input Modules                   | IC693ALG220    | Analog Input, Voltage/Current, 4 Channels  | IC693ALG222    | Analog Input, Voltage 16 Single/8 Differential Channels  |
|  | IC693ALG221    | Analog Input, Current, 4 Channels  | IC693ALG223    | Analog Input, Current, 16 Single Channels  |
| Analog Output Modules                  | IC693ALG390    | Analog Output, Voltage, 2 Channels   | IC693ALG392    | High Density Analog Output (8 Channels)  |
|  | IC693ALG391    | Analog Output, Current, 2 Channels   |                |  |
| Mixed Analog Modules                   | IC693ALG442    | Analog Combo Module 4IN/20OUT  |                |  |
| Motion Modules                         | IC693APU300    | High Speed Counter (HSC)   | IC693APU305    | High Speed Counter with Gray Code Encoder or an A QUAD B Encoder Input   |
|  | IC693APU301    | Axis Positioning Module (APM), 1 Axis  | IC693DSM302    | Digital Servo Motion Controller, 2 Axis  |
|  | IC693APU302    | Axis Positioning Module (APM), 2 Axis  | IC693DSM314    | Digital Servo Motion Controller, 1-2 Axis of Digital Servo or 1-4 Axis Analog Servo  |
| Specialty Modules                      | IC693MDL760    | Solenoid Valve Output (11 Points)/24 VDC Output, 0.5 Amp, Positive Logic (5 Points)                                    | IC693PTM101    | Power Transducer Module, CT and PT Interface 120/240 VAC (1m cable)  |
|  | IC693PCM301    | Programmable Coprocessor Module, 192 KB (47 KB Basic or C Program), 2 Serial Ports                                     | IC693TCM302    | Temperature Control Module, (8) TC In and (8) 24 VDC Solid State Outputs   |
|  | IC693PCM311    | Programmable Coprocessor Module, 640 KB (640 KB Basic or C Program), 2 Serial Ports                                    | IC693TCM303    | Temperature Control Module Extended Temperature Range, (8) TC In and (8) 24 VDC Solid State Outputs  |
|  | IC693PTM100    | Power Transducer Module, CT and PT Interface 120/240 VAC (0.5m Cable)  |                |  |
| Communications Modules                 | IC693BEM331    | Genius Bus Controller (Supports I/O and Datagrams)   | IC693PBM200    | Profibus DP Master Module  |
|  | IC693CMM302    | Communication Module, Genius (1 Kbyte) GCM+ (No Datagram Support)  | IC693PBM201    | Profibus DP Slave Module   |
|  | IC693CMM311    | Communications Module, CCM, RTU, SNP, and SNPx Protocols   | IC693DNM200    | DeviceNet Master Module  |
|  | IC693CMM321    | Ethernet Interface TCP/IP Module, 10Mbps (Supports SRTP and Modbus TCP/IP, No EGD)                                     | IC693DNS201    | DeviceNet Slave Module   |
| Controllers                            | IC693CPU311    | 5-Slot Base with CPU in Base (6KBytes User Program), Not Expandable  | IC693PCPU360   | CPU 360 Module (240KBytes Configurable User Memory, 4K I/O, 8 Racks), No Built-In Serial Ports, Logic Execution is .22msec/K   |
|  | IC693CPU313    | 5-Slot Base with Turbo CPU in Base (Logic Execution is .6 msec), 1K Registers, (12KBytes User Program), Not Expandable | IC693PCPU363   | CPU 363 Module (240KBytes Configurable User Memory 4K I/O, 8 Racks), 2 Built-In Serial Ports, Logic Execution is .22msec/K   |
|  | IC693CPU323    | 10-Slot Base with Turbo CPU in Base (Logic Execution is .6 msec) 12Kbytes User Program, Not Expandable                 | IC693PCPU364   | CPU 364 Module (240KBytes Configurable User Memory 4K I/O, 8 Racks), No Built-In Serial Ports, Built-In 10Mbps Ethernet, Supports SRTP, Channels and EGD, Logic Execution is .22msec/K                     |
|  | IC693CPU350    | CPU 350 Module (32KBytes User Memory, 4K I/O, 8 Racks), No Built-In Serial Ports, Logic Execution is .22msec/K         | IC693PCPU374   | CPU 374 Module (240KBytes Configurable User Memory), No Built-In Serial Ports, Built-In 10/100Mbps with Built-In Switch, Ethernet Supports SRTP, EGD and No Channel Support; Logic Execution is .22msec/K. |
|  |                |  |                |  |
| Backplanes                             | IC693CHS391    | Base, CPU, 10 Slots, Use with CPU331/CSE331 and above  | IC693CHS397    | Base, CPU, 5 Slots (use with CPU331/CSE331 and above)  |
|  | IC693CHS392    | Base, Expansion, 10 Slots  | IC693CHS398    | Base, Expansion, 5 Slots   |
|  | IC693CHS393    | Base, Remote Expansion, 10 Slots (700 ft.)   | IC693CHS399    | Base, Remote Expansion, 5 Slots (700 ft.)  |
| Power Supplies                         | IC693PWR321    | Power Supply, 120/240 VAC, 125 VDC, Standard, 30 Watts   | IC693PWR332    | Power Supply, 12 VDC, High Capacity, 30 Watts  |
|  | IC693PWR322    | Power Supply, 24/48 VDC, Standard, 30 Watts  | IC693ACC340    | Redundant Power Supply Base (RPSB) with 0.1 meter cable to connect to Power Supply Adapter Module  |
|  | IC693PWR328    | Power Supply, 48 VDC, Standard, 30 Watts   | IC693ACC341    | Redundant Power Supply Base with 0.5 meter cable to connect to Power Supply Adapter Module   |
|  | IC693PWR330    | Power Supply, 120/240 VAC, 125 VDC, High Capacity, 30 Watts  | IC693ACC350    | Redundant Power Supply Adapter (RPSA) Module. The RPSA replaces the power supply on a CPU base or expansion base and connects to a Redundant Power Supply Base.  |
|  | IC693PWR331    | Power Supply, 24 VDC, High Capacity, 30 Watts  |                |  |
| Accessories                            | IC693ACC301    | Replacement Battery, CPU & PCM (Qty. 2)  | IC693CBL301    | Rack to Rack Expansion Cable, 2 Meters   |
|  | IC693ACC302    | High Capacity Battery Pack   | IC693CBL302    | Rack to Rack Expansion Cable, 15 Meters  |
|  | IC200ACC003    | EZ Program Store Flash Device (for CPU374 only)  | IC693CBL312    | Rack to Rack Expansion Cable, 0.15 Meters, Shielded  |
|  | IC693ACC310    | Filler Module, Blank Slot  | IC693CBL313    | Rack to Rack Expansion Cable, 8 Meters   |
|  | IC693CBL300    | Rack to Rack Expansion Cable, 1 Meter  | IC693CBL314    | Rack to Rack Expansion Cable, 15 Meters, Shielded  |
| Programming and Trouble Shooting Tools | IC646MPP001    | Logic Developer - PLC Professional   | IC646MPH101    | Logic Developer PDA Software Tool with Cable Adapter   |
|  | IC646MPS001    | Logic Developer - PLC Standard   |                |  |

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## GE Fanuc Automation

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USA and the Americas 1-800-648-2001 or (434) 978-5100

Europe and Middle East (352) 727979-1

Asia Pacific 86-21-3222-4555

### Additional Resources

For detailed technical specifications and product ordering information, please visit the GE Fanuc e-catalog at:

**www.gefanuc.com**





# ***GE Fanuc Automation***

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## ***Programmable Control Products***

### ***Series 90<sup>TM</sup>-30 PLC Installation and Hardware Manual***

GFK-0356Q

*August 2002*



GFL-002

## *Warnings, Cautions, and Notes as Used in this Publication*

### **Warning**

**Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.**

**In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.**

### **Caution**

**Caution notices are used where equipment might be damaged if care is not taken.**

### **Note**

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

This document is based on information available at the time of its publication. While efforts have been made to be accurate, the information contained herein does not purport to cover all details or variations in hardware or software, nor to provide for every possible contingency in connection with installation, operation, or maintenance. Features may be described herein which are not present in all hardware and software systems. GE Fanuc Automation assumes no obligation of notice to holders of this document with respect to changes subsequently made.

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|----------------------|------------------|-------------|--------------|
| Alarm Master         | Field Control    | Modelmaster | Series 90    |
| CIMPLICITY           | GEnet            | Motion Mate | Series One   |
| CIMPLICITY Control   | Genius           | PowerMotion | Series Six   |
| CIMPLICITY PowerTRAC | Genius PowerTRAC | ProLoop     | Series Three |
| CIMPLICITY 90-ADS    | Helpmate         | PROMACRO    | VuMaster     |
| CIMSTAR              | Logicmaster      | Series Five | Workmaster   |

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## *RFI Standards*

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The Series 90-30 PLC and its associated modules have been tested and found to meet or exceed the requirements of FCC Rule, Part 15, Subpart J. The Federal Communications Commission (FCC) requires the following note to be published according to FCC guidelines.

### **NOTE**

This equipment generates, uses, and can radiate radio frequency energy and if not installed in accordance with this instruction manual, may cause harmful interference to radio communications. It has been tested and found to comply with the limits for a Class A digital device pursuant to Part 15 of the FCC Rules, which are designed to provide reasonable protection against harmful interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

The following note is required to be published by the Canadian Department of Communications.

### **NOTE**

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the radio interference regulations of the Canadian Department of Communications.

The following statements are required to appear in the *Series 90\_-30 Installation Manual* and the *Series 90\_-30 I/O Specifications Manual* for Class I Div 2 Hazardous Locations.

1. EQUIPMENT LABELED WITH REFERENCE TO CLASS I, GROUPS A, B, C, and D, DIV. 2 HAZARDOUS LOCATIONS IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C, D OR NON-HAZARDOUS LOCATIONS ONLY.
2. WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2:
3. WARNING - EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NON-HAZARDOUS.
4. ALL UNUSED SLOTS IN ALL BASEPLATES MUST BE POPULATED WITH FILLER MODULES, IC693ACC310, OR EQUIVALENT.







## Preface

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This manual describes the GE Fanuc Series 90-30 Programmable Logic Controller (PLC). It contains a description of hardware components and provides basic hardware installation procedures. The Series 90-30 PLC is a member of the Series 90\_ family of Programmable Logic Controllers from GE Fanuc.

For a list of product standards, refer to data sheet GFK-0867B or later, *GE Fanuc Approvals, Standards, General Specifications* which lists all of the standards for GE Fanuc products. Installation instructions in this manual are provided for installations that do not require special procedures for noisy or hazardous environments. For installations that must conform to more stringent requirements (such as CE Mark), see GFK-1179, *Installation Requirements for Conformance to Standards*.

## What's New in This Manual

- Added the model 374 CPU, which supports connection to an Ethernet network through two built-in 10BaseT/100BaseTx auto-negotiating full-duplex Ethernet ports. Models 364 (release 9.10 and later) and 374 are the only Series 90-30 CPUs that support Ethernet Global Data. Note that the CPU374 is supported only by the Windows®-based programmers.
- Other corrections and clarifications as necessary.

## Related Publications

For more information on Series 90-30 products, refer to these publications. (For a publication to product catalog number cross-reference refer to Appendix G):

GFK-0255 - Series 90™ PCM and Support Software User's Manual

GFK-0256 - MegaBasic™ Programming Reference Manual

GFK-0293 - Series 90™ -30 High Speed Counter User's Manual

GFK-0401 - Workmaster® II PLC Programming Unit Guide to Operation

GFK-0402 - Series 90™ -30 and 90-20 PLC Hand-Held Programmer User's Manual

GFK-0412 - Genius® Communications Module User's Manual

GFK-0466 - Logicmaster 90™ Series 90™ -30/20/Micro Programming Software User's Manual

GFK-0467 - Series 90™ -30/20/Micro Programmable Controllers Reference Manual

GFK-0487 - Series 90™ PCM Development Software (PCOP) User's Manual

GFK-0499 - CIMPLICITY® 90-ADS Alphanumeric Display System User's Manual



## *Preface*

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GFK-0582 - Series 90™ PLC Serial Communications User's Manual  
 GFK-0631 - Series 90™ -30 I/O LINK Interface User's Manual  
 GFK-0641 - CIMPPLICITY® 90-ADS Alphanumeric Display System Reference Manual  
 GFK-0664 - Series 90™-30 PLC Axis Positioning Module Programmer's Manual  
 GFK-0685 - Series 90™ Programmable Controllers Flow Computer User's Manual  
 GFK-0695 - Series 90™-30 Enhanced Genius) Communications Module User's Manual  
 GFK-0726 - Series 90™-30 PLC State Logic Processor User's Guide  
 GFK-0732 - Series 90™-30 PLC ECLiPS User's Manual  
 GFK-0747 - Series 90™-30 PLC OnTOP User's Guide  
 GFK-0750 - OnTop for Series 90™-30 (State Logic) Program User's Manual  
 GFK-0781 - Motion Mate™ APM300 for Series 90™-30 PLC Follower Mode User's Manual  
 GFK-0823 - Series 90™ -30 I/O LINK Master Module User's Manual  
 GFK-0828 - Series 90™ -30 Diagnostic System User's Manual  
 GFK-0840 - Motion Mate™ APM300 for Series 90™ -30 PLC Standard Mode User's Manual  
 GFK-0867 - GE Fanuc Product Agency Approvals, Standards, General Specifications  
 GFK-0898 - Series 90™ -30 PLC I/O Module Specifications  
 GFK-1028 - Series 90™ -30 I/O Processor Module User's Manual  
 GFK-1034 - Series 90™ -30 Genius® Bus Controller User's Manual  
 GFK-1037 - Series 90™ -30 FIP Remote I/O Scanner User's Manual  
 GFK-1056 - Series 90™ -30 State Logic Control System User's Manual  
 GFK-1186 - TCP/IP Ethernet Communications for the Series 90\_-30 PLC Station Manager Manual  
 GFK-1179 - Series 90™ PLC Installation Requirements for Conformance to Standards  
 GFK-1464 - Motion Mate DSM302 for Series 90™-30 PLCs User's Manual  
 GFK-1466 - Temperature Control Module for the Series 90™-30 PLC User's Manual  
 GFK-1541 - TCP/IP Ethernet Communications for the Series 90™ PLC User's Manual



## *Contents*

|                  |   |            |
|------------------|---|------------|
| <b>Chapter 1</b> | <b>Overview of the Series 90-30 PLC .....</b>                                 | <b>1-1</b> |
|                  | The Basic Parts of a Series 90-30 PLC.....                                    | 1-1        |
|                  | Assembling a Basic Series 90-30 PLC System .....                              | 1-2        |
|                  | What else would be needed to make this basic system functional? .....         | 1-6        |
|                  | What if the application requires more than five modules? .....                | 1-6        |
|                  | What if the application requires more than ten modules? .....                 | 1-7        |
|                  | What is the Difference Between Expansion and Remote baseplates?.....          | 1-8        |
|                  | What if I need to cover more than 700 feet (213 meters)? .....                | 1-9        |
| <b>Chapter 2</b> | <b>Installation .....</b>   | <b>2-1</b> |
|                  | Receiving your Products - Visual Inspection .....                             | 2-1        |
|                  | Pre-installation Check .....  | 2-1        |
|                  | Warranty Claims.....  | 2-1        |
|                  | Working with Series 90-30 Modules.....  | 2-2        |
|                  | Module Features .....   | 2-2        |
|                  | Installing a Module.....  | 2-3        |
|                  | Removing a Module .....   | 2-4        |
|                  | Installing a Module's Terminal Board .....                                    | 2-5        |
|                  | Removing a Module's Terminal Board.....                                       | 2-6        |
|                  | I/O Module Terminal Board Posts .....   | 2-7        |
|                  | Installing and Removing Terminal Boards with Holding Screws .....             | 2-7        |
|                  | Baseplate Mounting.....   | 2-8        |
|                  | Mounting a Baseplate to a Panel .....   | 2-8        |
|                  | Mounting a Baseplate to a 19" Rack .....                                      | 2-8        |
|                  | Grounding Procedures .....  | 2-11       |
|                  | System Grounding Procedures .....   | 2-11       |
|                  | Ground Conductors .....   | 2-11       |
|                  | Series 90-30 PLC Equipment Grounding.....                                     | 2-12       |
|                  | Baseplate Safety Grounding.....   | 2-12       |
|                  | Grounding 19" Rack-Mounted Baseplates .....                                   | 2-13       |
|                  | Programmer Grounding.....   | 2-13       |
|                  | Module Shield Grounding .....   | 2-14       |
|                  | Shield Grounding Information for CPUs with External Port Connections.....     | 2-14       |
|                  | CPU351 and 352 Shield Grounding .....   | 2-14       |
|                  | CPU363, CPU364, and CPU374 Shield Grounding.....                              | 2-16       |
|                  | Additional Modules with Shield Grounding Requirements .....                   | 2-16       |
|                  | General Wiring Guidelines .....   | 2-17       |
|                  | Discrete I/O Module Connection Methods.....                                   | 2-18       |
|                  | Connections to I/O Module Terminal Boards .....                               | 2-18       |
|                  | Terminal Block Quick Connect Installation for 16-Point Discrete Modules ..... | 2-19       |
|                  | Installation of 32-Point Discrete, 50-Pin Connector Modules .....             | 2-19       |
|                  | Using Weidmuller #912263 Terminal Block .....                                 | 2-19       |
|                  | Using a Generic Terminal Block or Strip.....                                  | 2-20       |
|                  | Direct Method .....   | 2-20       |
|                  | Installation of Discrete 32-Point, Dual 24-Pin Connector Modules.....         | 2-20       |
|                  | Using a TBQC.....   | 2-20       |



## Contents

---

|   |            |
|---|------------|
| With a Generic Terminal Block/Strip.....                                      | 2-20       |
| Direct Method .....   | 2-21       |
| General Wiring Methods for Analog Modules.....                                | 2-21       |
| Analog Input Module Wiring Methods .....                                      | 2-21       |
| Using a Generic Terminal Block or Strip.....                                  | 2-21       |
| Direct Method .....   | 2-21       |
| TBQC not Recommended for Analog Modules.....                                  | 2-22       |
| Analog Output Module Wiring .....   | 2-22       |
| General .....   | 2-22       |
| Using a Generic Terminal Block or Strip.....                                  | 2-22       |
| Direct Method .....   | 2-22       |
| TBQC not Recommended for Analog Modules.....                                  | 2-22       |
| AC Power Source Connections.....  | 2-23       |
| AC Input Wiring to AC/DC Power Supplies .....                                 | 2-23       |
| Power Supply Overvoltage Protection Devices.....                              | 2-24       |
| Special Installation Instructions for Floating Neutral (IT) Systems .....     | 2-25       |
| Definition of Floating Neutral Systems.....                                   | 2-25       |
| Use These Special Installation Instructions for Floating Neutral Systems..... | 2-26       |
| DC Power Source Connections.....  | 2-27       |
| DC Input Wiring to AC/DC and DC-Only Power Supplies .....                     | 2-27       |
| +24 VDC Output (All Supplies).....  | 2-27       |
| Basic Installation Procedure .....  | 2-28       |
| <b>Chapter 3   Baseplates .....</b>   | <b>3-1</b> |
| Baseplate Types .....   | 3-1        |
| Common Baseplate Features .....   | 3-1        |
| Two Baseplate Sizes.....  | 3-2        |
| Baseplate Terms.....  | 3-3        |
| CPU Baseplates.....   | 3-4        |
| Embedded CPU Baseplates (Figures 3-2 and 3-3) .....                           | 3-4        |
| Modular CPU Baseplates (Figures 3-4 and 3-5) .....                            | 3-6        |
| Expansion Baseplates (Figures 3-6 and 3-7) .....                              | 3-7        |
| Remote Baseplates (Figures 3-8 and 3-9).....                                  | 3-8        |
| I/O Bus Expansion Cables.....   | 3-10       |
| Differences Between Remote and Expansion Racks.....                           | 3-11       |
| Mixing Expansion and Remote Baseplates in a System .....                      | 3-11       |
| Termination Requirement for Expansion or Remote System .....                  | 3-12       |
| Powering Down Individual Expansion or Remote Baseplates .....                 | 3-12       |
| Series 90-30 PLC Backplane .....  | 3-12       |
| Rack Number DIP Switch on Expansion and Remote Baseplates.....                | 3-13       |
| Expansion and Remote Baseplates Connection Example.....                       | 3-15       |
| Baseplate Mounting Dimensions.....  | 3-16       |
| Embedded CPU (311, 313, and 323) Baseplate Dimensions .....                   | 3-16       |
| Modular CPU, Expansion, and Remote Baseplate Dimensions.....                  | 3-18       |



## Contents

---

|   |            |
|---|------------|
| Load Ratings, Temperature, and Mounting Position .....                  | 3-19       |
| Baseplate Adapter Brackets for 19" Rack Mounting.....                   | 3-20       |
| Baseplate Comparison Table.....   | 3-22       |
| <b>Chapter 4      Power Supplies.....</b>                               | <b>4-1</b> |
| Power Supply Categories.....  | 4-1        |
| Power Supply Feature Comparison.....                                    | 4-1        |
| AC/DC Input Power Supplies .....  | 4-2        |
| IC693PWR321 Standard Power Supply, 120/240 VAC or 125 VDC Input .....   | 4-2        |
| IC693PWR330 High Capacity Power Supply, 120/240 VAC/125 VDC Input ..... | 4-4        |
| Field Wiring Connections for the AC/DC Input Power Supplies.....        | 4-5        |
| Isolated 24 VDC Supply Output Connections.....                          | 4-6        |
| DC Input Only Power Supplies.....                                       | 4-7        |
| IC693PWR322 Standard Power Supply, 24/48 VDC Input .....                | 4-7        |
| Calculating Input Power Requirements for IC693PWR322 .....              | 4-8        |
| IC693PWR328 Standard Power Supply, 48 VDC Input.....                    | 4-10       |
| Calculating Input Power Requirements for IC693PWR328.....               | 4-11       |
| Input Power/Current Calculation for IC693PWR328 Power Supply .....      | 4-12       |
| IC693PWR331 High Capacity Power Supply, 24 VDC Input .....              | 4-13       |
| Current Derating for Higher Temperatures .....                          | 4-14       |
| Calculating Input Power Requirements for IC693PWR331.....               | 4-15       |
| Field Wiring Connections to the DC Input-Only Power Supplies .....      | 4-15       |
| Common Series 90-30 Power Supply Features.....                          | 4-16       |
| Status Indicator Lights on all Power Supplies.....                      | 4-16       |
| Input Overvoltage Protection Devices.....                               | 4-16       |
| Output Voltage Connections to Backplane (All Supplies).....             | 4-17       |
| Overcurrent Protection (all Supplies).....                              | 4-18       |
| Timing Diagram .....  | 4-18       |
| CPU Serial Port Connector on Power Supply (All Supplies).....           | 4-19       |
| CPU Serial Port Information .....                                       | 4-19       |
| Backup Battery for RAM Memory (All Supplies).....                       | 4-20       |
| <b>Chapter 5      CPUs .....</b>  | <b>5-1</b> |
| CPU Types for Series 90-30 PLCs .....                                   | 5-1        |
| Embedded CPUs.....  | 5-1        |
| Modular CPUs.....   | 5-2        |
| General CPU Features .....  | 5-3        |
| Microprocessor.....   | 5-3        |
| CPU Serial Port (Connector on Power Supply).....                        | 5-3        |
| Memory Volatility.....  | 5-4        |
| RAM Memory .....  | 5-5        |
| RAM Memory Backup/Backup Battery Information .....                      | 5-5        |
| Programmable Read-Only Memory (PROM) Types.....                         | 5-5        |
| Uses of PROM devices in the 90-30 CPUs .....                            | 5-5        |



## Contents

---

|   |      |
|---|------|
| CPU Firmware.....   | 5-6  |
| Determining CPU Revision Levels (Versions) .....                        | 5-7  |
| EPROM and EEPROM User Program Storage Options.....                      | 5-8  |
| Comparing EPROM and EEPROM Features.....                                | 5-8  |
| Procedure for Creating an EPROM.....                                    | 5-9  |
| Flash Memory.....   | 5-9  |
| Series 90-30 CPU Capacities.....  | 5-10 |
| User Memory Addresses (References).....                                 | 5-10 |
| Difference Between a Memory Address and a Nickname.....                 | 5-10 |
| User Memory Reference Types.....  | 5-11 |
| Application Program Compatibility .....                                 | 5-12 |
| CPU Time-of-Day (TOD) Clock Accuracy.....                               | 5-12 |
| Breakfree SNP Protocol .....  | 5-13 |
| 350–374 CPUs.....   | 5-13 |
| Compatibility With Hand-Held Programmer (HHP) and Memory Card.....      | 5-13 |
| 350–374 CPU Advanced Features.....                                      | 5-14 |
| Details of 350 – 374 CPU Advanced Features .....                        | 5-14 |
| Hardware Features of the 350–364 CPUs.....                              | 5-18 |
| CPU350 and CPU360 Hardware Features .....                               | 5-18 |
| CPU Firmware Upgrade.....   | 5-18 |
| CPU351, CPU352, and CPU363 Hardware Features.....                       | 5-19 |
| CPU Firmware Upgrade.....   | 5-19 |
| Keyswitch.....  | 5-19 |
| Shield Ground Connection Tab.....                                       | 5-20 |
| Serial Ports .....  | 5-20 |
| Serial Port Front Panel Connectors .....                                | 5-20 |
| Serial Port Status LEDs.....  | 5-20 |
| Protocols Supported .....   | 5-21 |
| Pin Assignments for CPU351, CPU352, and CPU363 Serial Ports 1 & 2 ..... | 5-22 |
| CPU364 Hardware Features.....   | 5-23 |
| LED Indicators .....  | 5-23 |
| Ethernet Restart Pushbutton .....                                       | 5-23 |
| Keyswitch.....  | 5-24 |
| Front Panel Connectors .....  | 5-24 |
| Shield Ground Connection Tab.....                                       | 5-24 |
| Firmware Upgrade.....   | 5-24 |
| CPU374 Hardware Features.....   | 5-25 |
| LED Indicators .....  | 5-25 |
| Ethernet Restart Pushbutton .....                                       | 5-25 |
| Keyswitch.....  | 5-26 |
| Front Panel Connectors .....  | 5-26 |
| Shield Ground Connection Tab.....                                       | 5-26 |
| Firmware Upgrade.....   | 5-26 |
| CPU Data Sheets.....  | 5-27 |
| CPU311                      Catalog Number IC693CPU311 .....            | 5-28 |
| CPU313                      Catalog Number IC693CPU313 .....            | 5-29 |
| CPU323                      Catalog Number IC693CPU323 .....            | 5-30 |
| CPU331                      Catalog Number IC693CPU331 .....            | 5-31 |



## Contents

---

|                  |  |            |
|------------------|--|------------|
| CPU340           | Catalog Number IC693CPU340 .....                                 | 5-32       |
| CPU341           | Catalog Number IC693CPU341 .....                                 | 5-33       |
| CPU350           | Catalog Number IC693CPU350 .....                                 | 5-34       |
| CPU351           | Catalog Number IC693CPU351 .....                                 | 5-35       |
| CPU352           | Catalog Number IC693CPU352 .....                                 | 5-36       |
| CPU360           | Catalog Number IC693CPU360 .....                                 | 5-37       |
| CPU363           | Catalog Number IC693CPU363 .....                                 | 5-38       |
| CPU364           | Catalog Number IC693CPU364 .....                                 | 5-39       |
| CPU374           | Catalog Number IC693CPU374 .....                                 | 5-40       |
| <b>Chapter 6</b> | <b>Memory Backup/Battery Backup .....</b>                        | <b>6-1</b> |
|                  | Backup Battery for RAM Memory (All Supplies).....                | 6-1        |
|                  | Battery Replacement Instructions .....                           | 6-2        |
|                  | Battery Replacement/Memory Protection Factors .....              | 6-3        |
|                  | The Importance of Backing up Your Program.....                   | 6-3        |
|                  | Factors Affecting Battery Life .....                             | 6-4        |
|                  | Low Battery Warning Methods.....                                 | 6-4        |
|                  | Operating Without a Memory Backup Battery .....                  | 6-6        |
|                  | RAM Memory Battery Backup Connection Path .....                  | 6-8        |
|                  | Super Capacitor Memory Backup.....                               | 6-8        |
|                  | Maintaining RAM Memory During Storage or Shipment of a CPU.....  | 6-9        |
|                  | Modular CPUs.....  | 6-9        |
|                  | Embedded CPUs .....  | 6-9        |
|                  | Battery Accessory Kit (IC693ACC315).....                         | 6-9        |
|                  | Battery Accessory Kit Installation.....                          | 6-10       |
|                  | External Battery Module (IC693ACC302) .....                      | 6-10       |
|                  | Batteries in Power Supplies on Expansion or Remote Racks .....   | 6-11       |
| <b>Chapter 7</b> | <b>Input/Output Modules .....</b>                                | <b>7-1</b> |
|                  | Basic I/O Module Types .....                                     | 7-1        |
|                  | Discrete I/O Modules .....                                       | 7-2        |
|                  | Discrete I/O Module Point Density .....                          | 7-2        |
|                  | Standard Density Discrete I/O Module Features .....              | 7-2        |
|                  | Wiring Standard Density (16-Point or Less) Discrete Modules..... | 7-4        |
|                  | Discrete Relay Output Module Protection .....                    | 7-4        |
|                  | High Density (32-Point) Discrete Module Features .....           | 7-4        |
|                  | Wiring Methods for 32-Point Discrete I/O Modules.....            | 7-6        |
|                  | Modules with Single 50-Pin Connector .....                       | 7-6        |
|                  | Modules with Dual 24-Pin Connectors .....                        | 7-7        |
|                  | Analog Module Features .....                                     | 7-8        |
|                  | Wiring Methods for Analog Modules .....                          | 7-9        |
|                  | Analog Input Module Wiring Methods .....                         | 7-9        |
|                  | Analog Output Module Wiring .....                                | 7-10       |
|                  | I/O Module Power Supply Current Draw .....                       | 7-10       |



## Contents

---

|   |            |
|---|------------|
| I/O Module Wire Routing.....                                    | 7-11       |
| Grouping Modules to Keep Wires Segregated .....                 | 7-11       |
| IC693DVM300 Digital Valve Driver Module.....                    | 7-12       |
| Indicator LEDs .....  | 7-12       |
| DVM Specifications .....  | 7-13       |
| Fuses.....  | 7-13       |
| <b>Chapter 8      Option Modules .....</b>                      | <b>8-1</b> |
| Third-Party Option Modules and the Accompany Program .....      | 8-1        |
| Option Modules Discussed in this Chapter.....                   | 8-1        |
| IC693CMM301 Genius Communications Module (GCM).....             | 8-2        |
| Status LEDs.....  | 8-3        |
| GCM Documentation .....   | 8-3        |
| IC693CMM302 Enhanced Genius Communications Module (GCM+) .....  | 8-4        |
| Status LEDs.....  | 8-5        |
| GCM+ Documentation.....   | 8-5        |
| IC693BEM331 Genius Bus Controller (GBC) .....                   | 8-6        |
| Number of Genius Bus Controllers .....                          | 8-7        |
| Status LEDs.....  | 8-7        |
| Compatibility.....  | 8-7        |
| Series 90-30 PLC .....  | 8-7        |
| Series Six PLC .....  | 8-7        |
| Genius Hand-Held Monitor.....                                   | 8-8        |
| Hand-Held Programmer .....                                      | 8-8        |
| Genius I/O Blocks .....   | 8-8        |
| Genius Bus .....  | 8-8        |
| Diagnostics .....   | 8-8        |
| Datagrams.....  | 8-9        |
| Global Data.....  | 8-9        |
| Sending Global Data .....                                       | 8-9        |
| Receiving Global Data .....                                     | 8-9        |
| Genius Bus Controller Documentation .....                       | 8-9        |
| IC693BEM340 FIP Bus Controller (FBC) Module.....                | 8-10       |
| Status LEDs.....  | 8-11       |
| Serial Port.....  | 8-11       |
| FIP Bus Connectors.....   | 8-11       |
| IC693BEM330 FIP Remote I/O Scanner Module .....                 | 8-12       |
| Features of the Remote I/O Scanner.....                         | 8-12       |
| FIP Bus Interface.....  | 8-13       |
| Module Description.....   | 8-13       |
| Connectors.....   | 8-14       |
| LEDs.....   | 8-14       |
| FIP Remote I/O Scanner Documentation:.....                      | 8-14       |
| IC693APU301/302 Motion Mate Axis Positioning Module (APM) ..... | 8-15       |



## Contents

---

|   |            |
|---|------------|
| APM Cables .....  | 8-16       |
| Motion Mate APM Module Documentation .....                      | 8-16       |
| IC693DSM302 Motion Mate Digital Servo Module (DSM302) .....     | 8-17       |
| Features .....  | 8-18       |
| IC693DSM302 Documentation .....                                 | 8-18       |
| IC693DSM314 Motion Mate Digital Servo Module (DSM314) .....     | 8-20       |
| Features .....  | 8-21       |
| IC693DSM314 Documentation .....                                 | 8-22       |
| IC693APU300 High Speed Counter (HSC) Module .....               | 8-23       |
| IC693BEM320 I/O LINK Interface (Slave) Module .....             | 8-24       |
| IC693BEM321 I/O LINK Master Module .....                        | 8-25       |
| Compatibility .....   | 8-26       |
| IC693APU305 I/O Processor Module .....                          | 8-27       |
| Module Features .....   | 8-28       |
| IC693CMM321 Ethernet Interface Module .....                     | 8-29       |
| IC693PCM300/301/311 Programmable Coprocessor Module (PCM) ..... | 8-31       |
| IC693CMM311 Communications Coprocessor Module (CMM) .....       | 8-34       |
| IC693ADC311 Alphanumeric Display Coprocessor (ADC) .....        | 8-35       |
| IC693TCM302/303 Temperature Control Modules (TCM) .....         | 8-37       |
| Connections .....   | 8-37       |
| LED Indicators .....  | 8-38       |
| Internal Fuse .....   | 8-38       |
| Automatic Data Transfers Between TCM and PLC .....              | 8-38       |
| Comparison of TCM302 and TCM303 Modules .....                   | 8-39       |
| IC693PTM100/101 Power Transducer (PTM) .....                    | 8-40       |
| Difference Between PTM100 and PTM101 .....                      | 8-40       |
| Capabilities .....  | 8-40       |
| Operating Modes .....   | 8-40       |
| Automatic Data Transfers Between PTMPM and PLC .....            | 8-41       |
| Compatibility .....   | 8-41       |
| Dimensions .....  | 8-42       |
| PTMPM Indicator LEDs .....                                      | 8-42       |
| General Mounting Information .....                              | 8-42       |
| Baseplate Type and Allowable Number of PTMPM Modules .....      | 8-43       |
| Power Supply Requirement .....                                  | 8-43       |
| Memory Requirement .....  | 8-43       |
| Configuration .....   | 8-43       |
| Ordering Information .....                                      | 8-43       |
| Documentation .....   | 8-43       |
| <b>Chapter 9 State Logic Products .....</b>                     | <b>9-1</b> |
| State Logic Overview .....                                      | 9-1        |
| State Logic Products .....                                      | 9-1        |
| Baseplates and Power Supply, I/O, and Option Modules .....      | 9-1        |



## Contents

---

|   |      |
|---|------|
| AD693CMM301 State Logic Serial Communications Module (SCM)..... | 9-2  |
| Description .....   | 9-2  |
| OK LED .....  | 9-2  |
| Reset Button .....  | 9-2  |
| Serial Connector .....  | 9-3  |
| Cable Information.....  | 9-3  |
| State Logic SCM Documentation.....                              | 9-3  |
| IC693SLP300 State Logic Processor Module .....                  | 9-4  |
| Description .....   | 9-4  |
| SLP Features.....   | 9-5  |
| Memory .....  | 9-5  |
| Installation.....   | 9-5  |
| Status Light.....   | 9-6  |
| Pushbutton.....   | 9-6  |
| Battery .....   | 9-7  |
| Cable Information.....  | 9-7  |
| Hardware Specifications.....                                    | 9-7  |
| State Logic Processor (SLP) Documentation .....                 | 9-7  |
| State Logic CPUs.....   | 9-8  |
| Features of State Logic CPUs.....                               | 9-8  |
| Model CSE311, CSE313 and CSE323 Embedded CPU Baseplates .....   | 9-9  |
| Model CSE331 and CSE340 Modular CPUs.....                       | 9-10 |
| CPU Serial Port Connector on Power Supply .....                 | 9-11 |
| Configuring the State Logic CPUs .....                          | 9-11 |
| State Logic CPU Firmware and PROM Configurations .....          | 9-13 |
| State Logic CPU Data Sheets .....                               | 9-13 |
| CSE311                      Catalog Number IC693CSE311 .....    | 9-14 |
| CSE313                      Catalog Number IC693CSE313 .....    | 9-15 |
| CSE323                      Catalog Number IC693CSE323 .....    | 9-16 |
| CSE331                      Catalog Number IC693CSE331 .....    | 9-17 |
| CSE340                      Catalog Number IC693CSE340 .....    | 9-18 |

## **Chapter 10      Cables ..... 10-1**

|   |       |
|---|-------|
| Cable Data Sheets .....   | 10-7  |
| IC647CBL704 Workstation Interface to Series 90 CPU (SNP Port) Cable ..... | 10-8  |
| Function of cable.....  | 10-8  |
| IC690CBL701 PCM, ADC, CMM to Workmaster (PC-XT) Cable.....                | 10-12 |
| Function of cable.....  | 10-12 |
| Cable Specifications .....  | 10-12 |
| Wiring Diagram.....   | 10-12 |
| PCM to Programmer Cable Installation .....                                | 10-13 |
| IC690CBL702 PC-AT to PCM, ADC, CMM Cable .....                            | 10-14 |
| Function of cable.....  | 10-14 |
| Cable Specifications .....  | 10-14 |



## Contents

---

|  |       |
|--|-------|
| Wiring Diagram.....  | 10-14 |
| PCM to Programmer Cable Installation .....                               | 10-15 |
| IC690CBL705 Workmaster II (PS/2) to PCM, ADC, CMM Cable .....            | 10-16 |
| Function of cable.....   | 10-16 |
| Cable Specifications .....   | 10-16 |
| Wiring Diagram.....  | 10-16 |
| PCM to Programmer Cable Installation .....                               | 10-17 |
| IC690CBL714A Multidrop Cable .....                                       | 10-18 |
| Purpose .....  | 10-18 |
| Specifications .....   | 10-18 |
| IC690CBL714A Multi-Drop Cable Wiring Diagram.....                        | 10-19 |
| Connection Diagrams for IC690CBL714A Cable.....                          | 10-20 |
| IC693CBL300/301/302/312/313/314 I/O Bus Expansion Cables .....           | 10-22 |
| Description .....  | 10-22 |
| Cable Lengths.....   | 10-22 |
| Function of Cables .....   | 10-22 |
| Connecting the Cables.....   | 10-23 |
| Important Notes About I/O Bus Expansion Cables.....                      | 10-23 |
| Cable Application Suggestions.....                                       | 10-23 |
| Using Standard Cables .....  | 10-23 |
| Using Custom Built cables .....  | 10-24 |
| Building Custom Length I/O Bus Expansion Cables .....                    | 10-24 |
| Two Types of Custom Built Cables .....                                   | 10-24 |
| Components Needed to Build Custom Length I/O Bus Expansion Cables .....  | 10-24 |
| Expansion Port Pin Assignments.....                                      | 10-25 |
| I/O Expansion Bus Termination.....                                       | 10-25 |
| Shield Treatment .....   | 10-26 |
| Alert for Users of Early Remote Baseplate Versions .....                 | 10-26 |
| Making a 100% Shielded Cable .....                                       | 10-27 |
| Wiring Diagrams .....  | 10-28 |
| Application Examples .....   | 10-31 |
| Expansion System Cable Connections .....                                 | 10-31 |
| Remote and Expansion System Cable Connection Example.....                | 10-31 |
| IC693CBL303 Hand-Hand Programmer and Converter (IC690ACC900) Cable ..... | 10-33 |
| Function of cable .....  | 10-33 |
| Cable Specifications .....   | 10-33 |
| Wiring Diagram.....  | 10-34 |
| Connecting the Cable .....   | 10-34 |
| IC693CBL304/305 Port Expansion (WYE) Cables for PCM, ADC, and CMM.....   | 10-35 |
| Function of cable .....  | 10-35 |
| Cable Specifications .....   | 10-35 |
| Wiring Information.....  | 10-36 |
| IC693CBL306/307 Extension Cables (50-Pin) for 32 Point Modules.....      | 10-38 |
| Function of cable .....  | 10-38 |
| Cable Specifications .....   | 10-38 |
| IC693CBL308/309 I/O Cables (50-Pin) for 32 Point Modules .....           | 10-40 |
| Specifications .....   | 10-40 |
| Wiring Information.....  | 10-40 |



## Contents

---

|  |             |
|--|-------------|
| IC693CBL310 I/O Interface Cable (24-Pin) for 32 Point Modules.....                                     | 10-42       |
| Function of cable.....   | 10-42       |
| Replacement/Obsolescence Information.....  | 10-43       |
| Connector Depth for Cable IC693CBL310.....   | 10-43       |
| IC693CBL311/317/319/320 I/O Interface Cables for Power Mate APM Modules.....                           | 10-45       |
| Function of cable.....   | 10-45       |
| Specifications.....  | 10-45       |
| Wiring Information.....  | 10-46       |
| IC693CBL315 I/O Interface Cable (24-Pin) for 32 Point Modules.....                                     | 10-49       |
| Function of cable.....   | 10-49       |
| Building Custom Length Cables for 24-Pin Connectors.....   | 10-49       |
| Replacement/Obsolescence Information.....  | 10-51       |
| Connector Depth for IC693CBL315.....   | 10-51       |
| IC693CBL316 Serial Cable, 9-Pin D-Shell to RJ-11 Connector.....  | 10-53       |
| Description.....   | 10-53       |
| Typical Applications.....  | 10-53       |
| IC693CBL321/322/323 I/O Faceplate Connector to Terminal Block Connector, 24-Pin.....                   | 10-54       |
| Function of cable.....   | 10-54       |
| Cable Specifications.....  | 10-54       |
| Connector Depth.....   | 10-55       |
| IC693CBL327/328 I/O Interface Cables with Right Angle 24-Pin Connector.....                            | 10-57       |
| Description.....   | 10-57       |
| Applications.....  | 10-57       |
| Specifications.....  | 10-58       |
| Connector Depth for Cables IC693CBL327/328.....  | 10-58       |
| Building Custom Length 24-pin Connector Cables.....  | 10-59       |
| Connector Depth for Custom Built Cables.....   | 10-60       |
| Possible Uses for These Cables (Factory or Custom Built).....  | 10-61       |
| IC693CBL329/330/331/332/333/334 Cables 24-Pin I/O Faceplate Connector to Terminal Block Connector..... | 10-62       |
| Description.....   | 10-62       |
| Connector Depth.....   | 10-63       |
| Applications.....  | 10-64       |
| IC693CBL340/341 PTM Interface Cables.....  | 10-65       |
| Documentation.....   | 10-67       |
| <b>Chapter 11 Programmer Hardware Products.....</b>  | <b>11-1</b> |
| Products Discussed in this Chapter.....  | 11-1        |
| IC640WMI310/320 Work Station Interface Boards.....   | 11-2        |
| Replacing Workmaster Computers.....  | 11-3        |
| IC690ACC900 RS-422/RS-485 to RS-232 Converter.....   | 11-3        |
| IC690ACC901 Miniconverter Kit.....   | 11-4        |
| IC693PRG300 Hand-Held Programmer (HHP).....  | 11-5        |
| HHP Features.....  | 11-6        |



## Contents

---

|                   |  |             |
|-------------------|--|-------------|
|                   | HHP Memory Card (IC693ACC303).....                               | 11-6        |
|                   | HHP Modes of Operation.....                                      | 11-6        |
|                   | Documentation .....  | 11-6        |
|                   | IC693PIF301/400 Personal Computer Interface (PCIF) Cards .....   | 11-7        |
|                   | IC655CCM590 Isolated Repeater/Converter .....                    | 11-8        |
|                   | IC690ACC903 Port Isolator .....                                  | 11-8        |
| <b>Chapter 12</b> | <b>System Design .....</b>                                       | <b>12-1</b> |
|                   | Introduction.....  | 12-1        |
|                   | Step 1: Planning Your System.....                                | 12-1        |
|                   | Step 2: Determining I/O Requirements .....                       | 12-1        |
|                   | Additional I/O Module Selection Factors.....                     | 12-2        |
|                   | Step 3: Selecting Option Modules.....                            | 12-2        |
|                   | Step 4: Selecting a CPU .....                                    | 12-4        |
|                   | Step 5: Selecting Baseplates.....                                | 12-5        |
|                   | Step 6: Selecting Power Supplies .....                           | 12-6        |
|                   | Reducing PLC Module Count by Using Other GE Fanuc Products ..... | 12-7        |
|                   | Designing For Safety .....                                       | 12-8        |
|                   | Protection From Electrical Shock.....                            | 12-8        |
|                   | Fire Prevention .....  | 12-8        |
|                   | Protection From Mechanical Hazards .....                         | 12-8        |
|                   | Protection From Electrical Failure .....                         | 12-8        |
|                   | Protection From Design Changes or Overrides .....                | 12-9        |
|                   | Safety Documentation .....                                       | 12-10       |
|                   | Guarding Against Unauthorized Operation.....                     | 12-10       |
|                   | Labeling, Guarding, and Lighting Issues.....                     | 12-10       |
|                   | Equipment Accessibility Issues .....                             | 12-10       |
|                   | Number of Modules Per Series 90-30 PLC System.....               | 12-11       |
|                   | Calculating Power Supply Loading .....                           | 12-12       |
|                   | Load Requirements for Hardware Components .....                  | 12-12       |
|                   | Power Supply Loading Calculation Examples .....                  | 12-14       |
|                   | Scan (Sweep) Time Calculation.....                               | 12-15       |
|                   | Major Design Factors Affecting Scan Time.....                    | 12-16       |
|                   | Where to Find Scan Time Information.....                         | 12-16       |
|                   | Calculating PLC Heat Dissipation .....                           | 12-17       |
|                   | System Layout Guidelines .....                                   | 12-17       |
|                   | Benefits of a Good Layout - Safe, Reliable, and Accessible.....  | 12-17       |
|                   | PLC Rack Location and Clearance Requirement.....                 | 12-17       |
|                   | Location of Modules in the PLC Racks .....                       | 12-18       |
|                   | Allowable Module Locations .....                                 | 12-19       |
|                   | Series 90-30 PLC Layout Example.....                             | 12-20       |
|                   | PLC Mounting Position .....                                      | 12-21       |
|                   | Recommended Upright Mounting Orientation.....                    | 12-21       |
|                   | Derated Horizontal Mounting Orientation .....                    | 12-21       |



## Contents

---

|                   |  |             |
|-------------------|--|-------------|
| <b>Chapter 13</b> | <b>Maintenance and Troubleshooting .....</b>                       | <b>13-1</b> |
|                   | Troubleshooting Features of Series 90-30 Hardware.....             | 13-1        |
|                   | Indicator Lights (LEDs) and Terminal Board .....                   | 13-1        |
|                   | Module LED Indicators .....  | 13-2        |
|                   | Troubleshooting Features of Programming Software .....             | 13-3        |
|                   | Ladder Screens .....   | 13-3        |
|                   | Configuration Screens .....  | 13-3        |
|                   | Fault Tables .....   | 13-3        |
|                   | System Status References.....                                      | 13-3        |
|                   | Reference Tables .....   | 13-4        |
|                   | Override feature.....  | 13-4        |
|                   | Sequential Event Recorder (SER), DOIO functional instruction ..... | 13-4        |
|                   | Replacing Modules .....  | 13-5        |
|                   | Series 90-30 Product Repair .....                                  | 13-5        |
|                   | Module Fuse List.....  | 13-6        |
|                   | Spare/Replacement Parts .....                                      | 13-7        |
|                   | Preventive Maintenance Suggestions.....                            | 13-8        |
|                   | Getting Additional Help and Information.....                       | 13-9        |
| <b>Appendix A</b> | <b>Serial Ports and Cables .....</b>                               | <b>A-1</b>  |
|                   | RS-422 Interface .....   | A-1         |
|                   | Cable and Connector Specifications.....                            | A-2         |
|                   | Series 90 PLC Serial Port .....                                    | A-3         |
|                   | Workmaster Serial Port.....  | A-4         |
|                   | RS-232/RS-485 Converter .....                                      | A-7         |
|                   | IC690ACC901 Miniconverter Kit.....                                 | A-7         |
|                   | IC690ACC900 Obsolete Converter.....                                | A-7         |
|                   | Serial Cable Diagrams .....  | A-8         |
|                   | RS-232 Point-to-Point Connections .....                            | A-8         |
|                   | RS-422 Point-to-Point Connection.....                              | A-10        |
|                   | Multidrop Connections.....   | A-10        |
| <b>Appendix B</b> | <b>IC690ACC900 Converter .....</b>                                 | <b>B-1</b>  |
|                   | Features .....   | B-1         |
|                   | Functions.....   | B-1         |
|                   | Location in System .....   | B-2         |
|                   | Installation.....  | B-2         |
|                   | Cable Description.....   | B-3         |
|                   | RS-232 Interface Pin Assignments.....                              | B-4         |
|                   | RS-422/RS-485 Interface Pin Assignments .....                      | B-5         |
|                   | Logic Diagram .....  | B-6         |
|                   | Jumper Configuration .....   | B-7         |



## Contents

---

|                   |  |            |
|-------------------|--|------------|
|                   | Example of Cable Configurations .....                        | B-9        |
| <b>Appendix C</b> | <b>IC655CCM690 Isolated Repeater/Converter .....</b>         | <b>C-1</b> |
|                   | Description of the Isolated Repeater/Converter.....          | C-1        |
|                   | Logic Diagram of the Isolated Repeater/Converter .....       | C-3        |
|                   | Pin Assignments for the Isolated Repeater/Converter .....    | C-4        |
|                   | System Configurations.....                                   | C-5        |
|                   | Simple Multidrop Configuration .....                         | C-6        |
|                   | Complex Multidrop Configuration.....                         | C-6        |
|                   | Rules for Using Repeater/Converters in Complex Networks..... | C-7        |
|                   | Cable Diagrams.....  | C-8        |
| <b>Appendix D</b> | <b>IC690ACC901 Miniconverter Kit.....</b>                    | <b>D-1</b> |
|                   | Description of Miniconverter .....                           | D-1        |
|                   | Pin Assignments.....   | D-2        |
|                   | Pin Assignments, RS-232 Port .....                           | D-2        |
|                   | Pin Assignments, RS-422 Port .....                           | D-2        |
|                   | System Configurations.....                                   | D-3        |
|                   | Cable Diagrams (Point-To-Point).....                         | D-3        |
| <b>Appendix E</b> | <b>IC690ACC903 Port Isolator .....</b>                       | <b>E-1</b> |
|                   | Connectors .....   | E-2        |
|                   | Logic Diagram .....  | E-3        |
|                   | Installation.....  | E-4        |
|                   | Specifications.....  | E-7        |
| <b>Appendix F</b> | <b>Calculating Series 90-30 Heat Dissipation .....</b>       | <b>F-1</b> |
|                   | Overview.....  | F-1        |
|                   | Information Required.....                                    | F-1        |
|                   | Procedure .....  | F-2        |
|                   | Step 1: Basic Method to Calculate Module Dissipation.....    | F-2        |
|                   | Step 2: Calculation for PLC Power Supplies.....              | F-3        |
|                   | Step 3: Output Calculations for Discrete Output Modules..... | F-3        |
|                   | Step 4: Input Calculations for Discrete Input Modules .....  | F-4        |
|                   | Step 5: Final Calculation .....                              | F-6        |
|                   | Other Information Related to Enclosure Sizing.....           | F-6        |
| <b>Appendix G</b> | <b>Catalog Number to Publication Cross-Reference .....</b>   | <b>G-1</b> |
|                   | General System Information .....                             | G-2        |
|                   | Analog I/O Modules .....                                     | G-2        |
|                   | Baseplates .....   | G-2        |
|                   | Communications Modules .....                                 | G-3        |



## Contents

---

|  |            |
|--|------------|
| CPU Modules, CPU311-CPU341 .....                                   | G-3        |
| CPU Modules, CPU350 - CPU374 .....                                 | G-4        |
| Digital Valve Driver Module .....                                  | G-5        |
| Discrete I/O Modules .....   | G-5        |
| Genius Modules .....   | G-6        |
| Motion Modules .....   | G-6        |
| Other Option Modules .....   | G-6        |
| Power Supply Modules .....   | G-7        |
| Programming Device .....   | G-7        |
| State Logic Products .....   | G-7        |
| Publication Revision Letters .....                                 | G-8        |
| Other Sources of Information .....                                 | G-8        |
| <b>Appendix H    Terminal Block Quick Connect Components .....</b> | <b>H-1</b> |
| Terminal Block Quick Connect Components for 16-Point Modules ..... | H-2        |
| Terminal Blocks .....  | H-2        |
| Cable Current Rating .....   | H-2        |
| Cable Selection and Cross-Reference .....                          | H-3        |
| I/O Face Plate for 16-Point Modules .....                          | H-3        |
| I/O Face Plate Installation .....                                  | H-3        |
| Module Wiring Information .....                                    | H-4        |
| Cable Information .....  | H-4        |
| Connector Pin Orientation and Connection to Module Terminal .....  | H-5        |
| Terminal Block Information .....                                   | H-5        |
| IC693ACC329 TBQC Terminal Block .....                              | H-6        |
| IC693ACC330 TBQC Terminal Block .....                              | H-7        |
| IC693ACC331 TBQC Terminal Block .....                              | H-8        |
| IC693ACC332 TBQC Terminal Block .....                              | H-9        |
| IC693ACC333 TBQC Terminal Block .....                              | H-10       |
| Terminal Block Quick Connect Components for 32-Point Modules ..... | H-11       |
| Terminal Block .....   | H-12       |
| Cable Selection and Cross-Reference .....                          | H-12       |
| Cable Current Rating .....   | H-12       |
| Cable Data .....   | H-13       |
| Terminal Block Data .....  | H-13       |
| IC693ACC337 TBQC Terminal Block .....                              | H-13       |
| <b>Appendix I    SNP Multidrop .....</b>                           | <b>I-1</b> |
| SNP Multidrop Overview .....                                       | I-1        |
| Multidrop Cables .....   | I-2        |
| Limitations .....  | I-2        |
| Cable and Connector Specifications .....                           | I-2        |
| MultiDrop Cable Wiring Diagram .....                               | I-3        |



## *Contents*

---

|                   |  |            |
|-------------------|--|------------|
|                   | SNP Multidrop Examples .....   | I-4        |
|                   | Configuring and Connecting a Programmer to a Multidrop Network .....       | I-5        |
|                   | Assigning a PLC SNP ID to a PLC with Logicmaster .....                     | I-6        |
|                   | Connecting your Logicmaster Programmer to a PLC on a Multidrop System..... | I-6        |
|                   | SNP Multidrop Troubleshooting.....   | I-7        |
| <b>Appendix J</b> | <b>Ethernet Transceivers .....</b>   | <b>J-1</b> |
|                   | IC649AEA102 Ethernet 10BASE-T Transceiver .....                            | J-1        |
|                   | Power Requirement .....  | J-1        |
|                   | LED Indicator Lights.....  | J-1        |
|                   | IC649AEA103 Ethernet 10BASE2 Transceiver.....                              | J-2        |
|                   | Power Requirement .....  | J-2        |
|                   | LED Indicator Light .....  | J-2        |
| <b>Appendix K</b> | <b>Tables and Formulas .....</b>   | <b>K-1</b> |
|                   | AWG to Metric Wire Size Conversion .....                                   | K-2        |
|                   | Temperature Conversion .....   | K-3        |
|                   | Formulas.....  | K-3        |
|                   | Conversion Information .....   | K-4        |
|                   | English and Metric Equivalents.....  | K-5        |
| <b>Appendix L</b> | <b>44A420084-001 EMI Line Filter.....</b>                                  | <b>L-1</b> |
|                   | 44A720084-001 Optional EMI Line Filter .....                               | L-1        |
|                   | 44A720084-001 Line Filter Mounting Dimensions.....                         | L-3        |



## Contents

---

|   |      |
|---|------|
| Figure 1-1. Five-Slot CPU Baseplate .....   | 1-3  |
| Figure 1-2. Power Supply Module.....  | 1-3  |
| Figure 1-3. CPU Module .....  | 1-4  |
| Figure 1-4. I/O Module.....   | 1-4  |
| Figure 1-5. Assembling the System.....  | 1-5  |
| Figure 1-6. A Basic System.....   | 1-6  |
| Figure 1-7. Ten-Slot Rack .....   | 1-6  |
| Figure 1-8. I/O Bus Expansion Cable.....  | 1-7  |
| Figure 1-9. Connecting Expansion and Remote Baseplates .....                            | 1-8  |
| Figure 1-10. Connecting PLCs Using GBC or CMM Modules .....                             | 1-9  |
| Figure 2-1. Features of Series 90-30 Module .....                                       | 2-2  |
| Figure 2-2. Installing a Module .....   | 2-3  |
| Figure 2-3. Removing a Module.....  | 2-4  |
| Figure 2-4. Installing an I/O Module's Terminal Board.....                              | 2-5  |
| Figure 2-5. Removing a Module's Terminal Board .....                                    | 2-6  |
| Figure 2-6. Terminal Board with Holding Screws .....                                    | 2-7  |
| Figure 2-7. IC693ACC308 Front Mount Adapter Bracket Installation.....                   | 2-9  |
| Figure 2-8. Dimensions for 19-inch Rack Mounting Using IC693ACC308 Adapter Bracket..... | 2-9  |
| Figure 2-9. IC693ACC313 Recessed Mount Adapter Bracket.....                             | 2-10 |
| Figure 2-10. Recommended System Grounding.....  | 2-11 |
| Figure 2-11. Baseplate Grounding.....   | 2-12 |
| Figure 2-12. CPU 351 or 352 - Attaching Shield Ground Wire .....                        | 2-14 |
| Figure 2-13. CPU 351 or 352 - Mounting the Shield Grounding Bracket and Wire .....      | 2-15 |
| Figure 2-14. CPU 363, CPU364, or CPU374 - Attaching Ground Wire.....                    | 2-16 |
| Figure 2-15. Power Supply Terminal Boards.....  | 2-24 |
| Figure 2-16. Overvoltage Protection Devices and Jumper Strap.....                       | 2-24 |
| Figure 3-1. Common Baseplate Features.....  | 3-2  |
| Figure 3-2. Models IC693CPU311 and IC693CPU313 (5-Slot) Embedded CPU Baseplates .....   | 3-5  |
| Figure 3-3. Model IC693CPU323 (10-slot) Embedded CPU Baseplate .....                    | 3-5  |
| Figure 3-4. IC693CHS397 5-Slot Modular CPU Baseplate.....                               | 3-6  |
| Figure 3-5. IC693CHS391 10-Slot Modular CPU Baseplate.....                              | 3-6  |
| Figure 3-6. IC693CHS398 5-Slot Expansion Baseplate.....                                 | 3-7  |
| Figure 3-7. IC693CHS392 10-Slot Expansion Baseplate.....                                | 3-8  |
| Figure 3-8. IC693CHS399 5-Slot Remote Baseplate .....                                   | 3-9  |
| Figure 3-9. IC693CHS393 10-Slot Remote Baseplate .....                                  | 3-9  |
| Figure 3-10. I/O Bus Expansion Cables .....   | 3-10 |



## Contents

---

|   |      |
|---|------|
| Figure 3-11. Rack Number Selection Switch (Shown with Rack 2 Selected).....                                 | 3-13 |
| Figure 3-12. Example of Connecting Expansion Baseplates.....  | 3-14 |
| Figure 3-13. Example of Connecting Expansion and Remote Baseplates.....                                     | 3-15 |
| Figure 3-14. Model 311 and 313 5-Slot Baseplate Dimensions and Spacing Requirements .....                   | 3-16 |
| Figure 3-15. Model 323 10-Slot Baseplate Dimensions and Spacing Requirements .....                          | 3-17 |
| Figure 3-16. Modular CPU, Expansion, and Remote 5-Slot Baseplate Dimensions and Spacing Requirements .....  | 3-18 |
| Figure 3-17. Modular CPU, Expansion, and Remote 10-Slot Baseplate Dimensions and Spacing Requirements ..... | 3-18 |
| Figure 3-18. IC693ACC308 Front Mount Adapter Bracket Installation.....                                      | 3-20 |
| Figure 3-19. Dimensions for 19" Rack Mounting Using IC693ACC308 Adapter Bracket .....                       | 3-21 |
| Figure 3-20. IC693ACC313 Recessed Mount Adapter Bracket.....  | 3-21 |
| Figure 4-1. Standard AC/DC Input Power Supply - IC693PWR321 .....   | 4-2  |
| Figure 4-2. High Capacity AC/DC Input Power Supply - IC693PWR330 .....                                      | 4-4  |
| Figure 4-3. Overvoltage Protection Devices and Jumper Strap.....  | 4-6  |
| Figure 4-4. Series 90-30 24/48 VDC Input Power Supply - IC693PWR322 .....                                   | 4-7  |
| Figure 4-5. Typical Efficiency Curve for 24/48 VDC Power Supply .....                                       | 4-8  |
| Figure 4-6. Series 90-30 48 VDC Input Power Supply - IC693PWR328 .....                                      | 4-10 |
| Figure 4-7. Typical Efficiency Curve for IC693PWR328 Power Supply .....                                     | 4-11 |
| Figure 4-8. Series 90-30 24 VDC Input High Capacity Power Supply - IC693PWR331 .....                        | 4-13 |
| Figure 4-9. 5 VDC Current Output Derating for Temperatures above 50°C (122°F) .....                         | 4-14 |
| Figure 4-10. Overvoltage Protection Devices and Jumper Strap.....   | 4-17 |
| Figure 4-11. Interconnection of Power Supplies .....  | 4-17 |
| Figure 4-12. Timing Diagram for all Series 90-30 Power Supplies .....                                       | 4-18 |
| Figure 4-13. Serial Port Connector .....  | 4-19 |
| Figure 4-14. Backup Battery for RAM Memory .....  | 4-20 |
| Figure 5-1. Models 311 and 313 (5-Slot) Embedded CPU Baseplates.....  | 5-2  |
| Figure 5-2. IC693CHS397 5-Slot Modular CPU Baseplate.....   | 5-3  |
| Figure 5-3. CPU Serial Port Connector on Power Supply.....  | 5-4  |
| Figure 5-4. CPUs 351, 352, and 363 .....  | 5-19 |
| Figure 6-1. Backup Battery for RAM Memory .....   | 6-1  |
| Figure 6-2. Installing the Battery Accessory Kit .....  | 6-10 |
| Figure 7-1. Example of Series 90-30 Standard Density Discrete Output Module.....                            | 7-3  |
| Figure 7-2. Example of 32-Point I/O Module (IC693MDL654) With Dual Connectors .....                         | 7-5  |
| Figure 7-3. Example of 32-Point I/O Module (IC693MDL653) With Single Connector .....                        | 7-5  |
| Figure 7-4. 50-PIN, 32 Point I/O Module Connection Method.....  | 7-6  |
| Figure 7-5. Example of Series 90-30 Analog Current Output Module.....                                       | 7-9  |
| Figure 7-6. IC693DVM300 Digital Valve Driver Module.....  | 7-12 |



## Contents

---

|   |       |
|---|-------|
| Figure 8-1. The IC693CMM301 GCM Module .....  | 8-2   |
| Figure 8-2. Genius Bus Wiring Schematic .....   | 8-3   |
| Figure 8-3. Example of Genius Communications Network.....                                 | 8-3   |
| Figure 8-4. Enhanced Genius Communications Module.....                                    | 8-4   |
| Figure 8-5. Genius Bus Controller Module .....  | 8-6   |
| Figure 8-6. Example of FIP I/O System Configuration.....                                  | 8-10  |
| Figure 8-7. Series 90-30 FIP Bus Controller .....   | 8-11  |
| Figure 8-8. Example of FIP Remote I/O Scanner System Configuration.....                   | 8-12  |
| Figure 8-9. FIP Bus Interface Module.....   | 8-13  |
| Figure 8-10. Motion Mate APM Module .....   | 8-15  |
| Figure 8-11. Example of Motion Mate APM Servo System .....                                | 8-16  |
| Figure 8-12. Motion Mate DSM302 Module .....  | 8-17  |
| Figure 8-13. Motion Mate DSM314 Module .....  | 8-20  |
| Figure 8-14. High Speed Counter (HSC) .....   | 8-23  |
| Figure 8-15. Example of a Series 90-30 PLC in a Fanuc I/O LINK Configuration .....        | 8-24  |
| Figure 8-16. Example of I/O LINK Master System Configuration.....                         | 8-25  |
| Figure 8-17. I/O Processor Module .....   | 8-27  |
| Figure 8-18. Ethernet Interface Module .....  | 8-29  |
| Figure 8-19. Programmable Coprocessor Module (PCM).....                                   | 8-31  |
| Figure 8-20. Communications Control Module.....   | 8-34  |
| Figure 8-21. Alphanumeric Display Coprocessor Module (ADC).....                           | 8-35  |
| Figure 8-22. IC693TCM302/303 Temperature Control Module (TCM).....                        | 8-37  |
| Figure 8-23. IC693PTM100/101 Components.....  | 8-41  |
| Figure 8-24. IC693PTM100/101 Component Mounting.....                                      | 8-42  |
| Figure 9-1. AD693CMM301 State Logic Serial Communications Module.....                     | 9-2   |
| Figure 9-2. IC693CBL305 WYE Cable .....   | 9-3   |
| Figure 9-3. IC693SLP300 State Logic Processor Module for Series 90-30.....                | 9-4   |
| Figure 9-4. State Logic Processor Module User Details .....                               | 9-6   |
| Figure 9-5. Model CSE311 or CSE313 5-Slot Embedded CPU Baseplate .....                    | 9-9   |
| Figure 9-6. Model CSE323 10-Slot Embedded CPU Baseplate.....                              | 9-9   |
| Figure 9-7. CPU Models CSE 331 or CSE 340.....  | 9-10  |
| Figure 9-8. Serial Port Connector .....   | 9-11  |
| Figure 10-1. Serial Port to Work Station Interface Board Cable Connection .....           | 10-8  |
| Figure 10-2. Series 90 PLC to Workmaster II Serial Cable .....                            | 10-9  |
| Figure 10-3. Example of Multidrop Configuration with Converter .....                      | 10-10 |
| Figure 10-4. Series 90 PLC to Programmer 8-Wire Multidrop, Serial Data Configuration..... | 10-11 |
| Figure 10-5. PCM, ADC, or CMM to Workmaster or PC-XT Serial Cable .....                   | 10-12 |



## Contents

---

|   |       |
|---|-------|
| Figure 10-6. PCM to Workmaster Computer or PC-XT Personal Computer .....                              | 10-13 |
| Figure 10-7. PCM, ADC, or CMM to Workmaster or PC-AT Serial Cable .....                               | 10-14 |
| Figure 10-8. PCM to PC-AT Personal Computer .....   | 10-15 |
| Figure 10-9. PCM, ADC, or CMM to Workmaster II or PS/2 Serial Cable.....                              | 10-16 |
| Figure 10-10. PCM to Workmaster II Computer or PS/2 Computer .....                                    | 10-17 |
| Figure 10-11. Connecting Diagram for Multidrop Cable IC690CBL714A.....                                | 10-19 |
| Figure 10-12. Multidrop Arrangement for Series 90-30 Redundant System.....                            | 10-20 |
| Figure 10-13. Connecting CPU and APM to Programmer with IC690CBL714A Cable.....                       | 10-20 |
| Figure 10-14. Multidrop Arrangement for Series 90-70 TMR Redundant System.....                        | 10-21 |
| Figure 10-15. Detail of I/O Bus Expansion Cables .....  | 10-22 |
| Figure 10-16. How to use Split-Ring Ferrules for Foil and Braided Cable Shield.....                   | 10-26 |
| Figure 10-17. Point-To-Point Cable Wiring for Continuous Shield Custom Length Cables .....            | 10-28 |
| Figure 10-18. Point-To-Point Cable Wiring Diagram for Applications Requiring Less Noise Immunity..... | 10-28 |
| Figure 10-19. Earlier Versions of Remote Baseplate Custom WYE Cable Wiring Diagram .....              | 10-29 |
| Figure 10-20. Current Remote baseplate (IC693CHS393/399) Custom Wye Cable Wiring Diagram ....         | 10-30 |
| Figure 10-21. Example of Connecting Expansion Baseplates .....  | 10-31 |
| Figure 10-22. Example of Connecting Expansion and Remote Baseplates.....                              | 10-32 |
| Figure 10-23. Wiring Connections for IC693CBL303 and Custom-Built Cables.....                         | 10-34 |
| Figure 10-24. Hand-Held Programmer Cable Connection to a Series 90-30 PLC .....                       | 10-34 |
| Figure 10-25. Wye Cable.....  | 10-35 |
| Figure 10-26. Wye Cable Connections.....  | 10-36 |
| Figure 10-27. 32 Point I/O Module to Weidmuller Terminal Block Assembly .....                         | 10-39 |
| Figure 10-28. IC693CBL310 Cable .....   | 10-42 |
| Figure 10-29. Dimensions for Depth of Connector in front of PLC.....                                  | 10-44 |
| Figure 10-30. I/O Connector Cable Specifications.....   | 10-45 |
| Figure 10-31. IC693CBL315 Cable .....   | 10-49 |
| Figure 10-32. Dimensions for Depth of Connector in front of PLC.....                                  | 10-52 |
| Figure 10-33. IC693CBL316A Serial Cable Illustration and Connector Pinouts .....                      | 10-53 |
| Figure 10-34. Connector Orientation on I/O Faceplate .....  | 10-55 |
| Figure 10-35. I/O Faceplate to Terminal Block Cable .....   | 10-55 |
| Figure 10-36. Dimensions for Depth of Connector in front of PLC.....                                  | 10-56 |
| Figure 10-37. C693CBL327/328 Cables .....   | 10-57 |
| Figure 10-38. Dimension for Depth of Connector for IC693CBL327/328 .....                              | 10-58 |
| Figure 10-39. Dimensions for Depth of Connector in front of PLC for Custom Built Cables.....          | 10-61 |
| Figure 10-40. IC693CBL329/330/331/332/333/334 Cables .....  | 10-62 |
| Figure 10-41. Dimension for Depth of Connector.....   | 10-63 |
| Figure 10-42. Figure IC693CBL340/341 PTM Interface Cables .....                                       | 10-65 |



## Contents

---

|   |       |
|---|-------|
| Figure 10-43. PTM Component Mounting and Cable Connection.....                          | 10-65 |
| Figure 11-1. WSI Board for the Workmaster II Computer.....                              | 11-2  |
| Figure 11-2. Location of WSI in a Series II 90-30 PLC System.....                       | 11-2  |
| Figure 11-3. Example of IC690ACC900 Converter Connection.....                           | 11-3  |
| Figure 11-4. IC690ACC901 Series 90 SNP Port to RS-232 Adapter.....                      | 11-4  |
| Figure 11-5. Hand-Held Programmer for the Series 90-30 PLC.....                         | 11-5  |
| Figure 11-6. Example of PCIF Interface to Series 90-30 I/O.....                         | 11-7  |
| Figure 12-1. Hard-Wired MCR Circuit Example.....  | 12-9  |
| Figure 12-2. Allowable Location of Modules.....   | 12-19 |
| Figure 12-3. Series 90-30 Example Layout.....   | 12-20 |
| Figure 12-4. Recommended PLC Mounting Orientation.....                                  | 12-21 |
| Figure 12-5. Derated PLC Mounting Orientation.....                                      | 12-21 |
| Figure 13-1. Relationship of Indicator Lights to Terminal Board Connections.....        | 13-1  |
| Figure A-1. Series 90 PLC, RS-422 Serial Port Connector Configuration.....              | A-3   |
| Figure A-2. Workmaster RS-232 Serial Port Connector Configuration.....                  | A-4   |
| Figure A-3. IBM-AT/XT Serial Port.....  | A-5   |
| Figure A-4. IBM-AT (compatibles) Personal Computer to Series 90 PLCs.....               | A-9   |
| Figure A-5. Workmaster or IBM-XT (compatibles) Personal Computer to Series 90 PLCs..... | A-9   |
| Figure A-6. Typical RS-422, Host to PLC Connection, with Handshaking.....               | A-10  |
| Figure A-7. Workmaster II/Series 90 PLC Multidrop Connection.....                       | A-11  |
| Figure A-8. Workmaster/Series 90 PLC Multidrop Connection.....                          | A-12  |
| Figure A-9. IBM-AT/Series 90 PLC Multidrop Connection.....                              | A-12  |
| Figure A-10. IBM-XT/Series 90 PLC Multidrop Connection.....                             | A-13  |
| Figure B-1. Front and Rear View of Converter.....                                       | B-2   |
| Figure B-2. Typical Configuration with Series 90-70 PLC.....                            | B-3   |
| Figure B-3. Typical Configuration with Series 90-30 PLC.....                            | B-4   |
| Figure B-4. RS-422/RS-485 to RS-232 Converter Logic Diagram.....                        | B-6   |
| Figure B-5. Location of Jumpers for User Options.....                                   | B-7   |
| Figure C-1. Isolated/Repeater Converter.....  | C-2   |
| Figure C-2. RS-422 Isolated Repeater/RS-232 Converter Logic Diagram.....                | C-3   |
| Figure C-3. Example RS-422 Isolated Repeater/RS-232 Converter Connection.....           | C-5   |
| Figure C-4. Simple System Configuration Using the Isolated Repeater/Converter.....      | C-6   |
| Figure C-5. Complex System Configuration Using the Isolated Repeater/Converter.....     | C-6   |
| Figure C-6. Cable A; RS-232 CMM To Converter.....                                       | C-8   |
| Figure C-7. Cable B; RS-422 CMM To Converter.....                                       | C-8   |
| Figure C-8. Cable C; RS422 Twisted Pair.....  | C-9   |
| Figure C-9. Cable D; RS-422 Twisted Pair.....   | C-10  |



## Contents

---

|  |      |
|--|------|
| Figure C-10. Cable E; RS-232 Converter to CMM.....   | C-10 |
| Figure D-1. Series 90 SNP to RS-232 Miniconverter .....  | D-1  |
| Figure D-2. Miniconverter to PC-AT .....   | D-3  |
| Figure D-3. Miniconverter to Workmaster II, PC-XT, PS/2 .....                                  | D-3  |
| Figure D-4. Miniconverter to 9-Pin Workmaster or PC-XT Computer.....                           | D-4  |
| Figure E-2. IC690ACC903 Block Diagram .....  | E-3  |
| Figure E-3. RS-485 Port Isolator in PLC Network.....   | E-4  |
| Figure E-4. Mounting Port Isolator to Panel .....  | E-4  |
| Figure E-5. Multidrop Configuration Connecting Devices with 15-Pin Ports and 25-Pin Ports..... | E-5  |
| Figure E-6. Cable for Supplying External Power Through the Port Isolator.....                  | E-6  |
| Figure H-1. Typical TBQC Terminal Block.....   | H-1  |
| Figure H-2. TBQC Faceplate.....  | H-5  |
| Figure H-3. IC693ACC329 TBQC Terminal Block.....   | H-6  |
| Figure H-4. IC693ACC330 TBQC Terminal Block.....   | H-7  |
| Figure H-5. IC693ACC331 TBQC Terminal Block.....   | H-8  |
| Figure H-6. IC693ACC332 TBQC Terminal Block.....   | H-9  |
| Figure H-7. IC693ACC333 TBQC Terminal Block.....   | H-10 |
| Figure H-8. IC693MDL654 32-Point Module.....   | H-11 |
| Figure H-9. IC693ACC337 TBQC Terminal Block.....   | H-13 |
| Figure I-1. Series 90-30 Multidrop Example.....  | I-1  |
| Figure I-2. Multidrop Cable Wiring Diagram .....   | I-3  |
| Figure I-3. Connecting CPU and APM to Programmer with IC690CBL714A Cable.....                  | I-4  |
| Figure I-4. Multidrop Arrangement for Series 90-70 TMR Redundant System.....                   | I-4  |
| Figure I-5. Multidrop Arrangement for Series 90-30 Redundant System .....                      | I-5  |
| Figure J-1. IC649AEA102 Ethernet 10BASE-T Transceiver .....                                    | J-1  |
| Figure J-2. IC649AEA103 Ethernet 10BASE2 Transceiver .....                                     | J-2  |
| Figure L-1. 44A720084-001 Line Filter Connections to Series 90-30 Power Supply .....           | L-2  |
| Figure L-2. Equivalent Circuit for 44A720084-001 Line Filter .....                             | L-2  |
| Figure L-3. 44A720084-001 Line Filter Mounting Dimensions .....                                | L-3  |



## Contents

---

|   |       |
|---|-------|
| Table 3-1. Rack Number Selection Switch Settings.....                                 | 3-13  |
| Table 3-2. Series 90-30 Baseplate Comparison.....                                     | 3-22  |
| Table 4-1. Power Supply Comparison.....   | 4-1   |
| Table 4-2. IC693PWR321 Power Supply Capacities .....                                  | 4-2   |
| Table 4-3. Specifications for IC693PWR321 Standard AC/DC Input Power Supply.....      | 4-3   |
| Table 4-4. IC693PWR330 Power Supply Capacities .....                                  | 4-4   |
| Table 4-5. Specifications for IC693PWR330 High Capacity AC/DC Input Power Supply..... | 4-5   |
| Table 4-6. IC693PWR322 Power Supply Capacities .....                                  | 4-7   |
| Table 4-7. Specifications for IC693PWR322 Power Supply.....                           | 4-8   |
| Table 4-8. IC693PWR328 Power Supply Capacities .....                                  | 4-10  |
| Table 4-9. Specifications for IC693PWR328 Power Supply.....                           | 4-11  |
| Table 4-10. IC693PWR331 Power Supply Capacities .....                                 | 4-13  |
| Table 4-11. Specifications for IC693PWR331 Power Supply.....                          | 4-14  |
| Table 5-1. CPU Firmware and PROM Configurations.....                                  | 5-6   |
| Table 5-2. EPROM and EEPROM Catalog Numbers .....                                     | 5-9   |
| Table 5-3. Series 90-30 CPU Capacities .....  | 5-10  |
| Table 5-4. Range and Size of User References for CPU Models 311-341.....              | 5-11  |
| Table 5-5. Range and Size of User References for CPU Models 350 through 374.....      | 5-12  |
| Table 5-6. Port 1 (RS-232) .....  | 5-22  |
| Table 5-7. Port 2 (RS-485) .....  | 5-22  |
| Table 7-1. IC693DVM300 Specifications.....  | 7-13  |
| Table 7-2. IC693DVM300 Connections.....   | 7-14  |
| Table 7-3. Series 90-30 Discrete I/O Modules .....                                    | 7-15  |
| Table 7-4. Series 90-30 Analog I/O Modules.....                                       | 7-16  |
| Table 8-1. Comparison of TCM302 and TCM303 .....                                      | 8-39  |
| Table 9-1. System Specifications for Series 90-30 State Logic CPUs .....              | 9-12  |
| Table 10-1. Series 90-30 Cable Cross-Reference.....                                   | 10-1  |
| Table 10-2. Expansion Port Pin Assignments .....                                      | 10-25 |
| Table 10-3. Wire List for 32 Point I/O Cables .....                                   | 10-40 |
| Table 10-4. Wire List for 24-Pin Connectors .....                                     | 10-43 |
| Table 10-5. Catalog Numbers for 24-Pin Connector Kits .....                           | 10-46 |
| Table 10-6. I/O Cable Wire Coding for IC693CBL311 and IC693CBL319.....                | 10-47 |
| Table 10-7. I/O Cable Wire Coding for IC693CBL317 and IC693CBL320.....                | 10-48 |
| Table 10-8. Catalog Numbers for 24-Pin Connector Kits .....                           | 10-50 |
| Table 10-9. Wire List for 24-Pin Connectors .....                                     | 10-51 |
| Table 10-10. Catalog Numbers for 24-Pin Connector Kits .....                          | 10-59 |



## Contents

---

|   |       |
|---|-------|
| Table 10-11. Wire List for 24-Pin Connectors .....  | 10-60 |
| Table 10-12. TBQC Cable Cross-Reference Table .....                                       | 10-63 |
| Table 11-1. Personal Computer Interface Card Comparison Table.....                        | 11-7  |
| Table 12-1. Power Supply Feature Comparison Table.....                                    | 12-6  |
| Table 12-2. Maximum Number of Modules Per System.....                                     | 12-11 |
| Table 12-3. Load Requirements (in milliamps).....   | 12-12 |
| Table 13-1. Fuse List for Series 90-30 Modules .....                                      | 13-6  |
| Table 13-2. Spare/Replacement Parts.....  | 13-7  |
| Table A-1. Connector/Cable Specifications .....   | A-2   |
| Table A-2. Series 90 PLC, RS-422 Serial Port Pin-out .....                                | A-4   |
| Table A-3. Workmaster RS-232 Serial Port Pins-out.....                                    | A-5   |
| Table A-4. IBM-AT/XT Serial Port Pins-out .....   | A-6   |
| Table B-1. RS-232 Interface for Converter .....   | B-4   |
| Table B-2. RS-422/RS-485 Interface for Converter.....                                     | B-5   |
| Table B-3. Jumper Configuration for RS-422/RS-485 to RS-232 Converter.....                | B-8   |
| Table B-4. Specifications for IC690ACC900 Converter.....                                  | B-9   |
| Table C-1. Isolated Repeater/Converter Pin Assignments .....                              | C-4   |
| Table D-1. Miniconverter RS-232 Port .....  | D-2   |
| Table D-2. Miniconverter RS-422 Port .....  | D-2   |
| Table D-3. Miniconverter Specifications .....   | D-4   |
| RS-485 Connectors.....  | E-2   |
| Table H-1. TBQC Terminal Block Selection Table .....                                      | H-2   |
| Table I-1. Connector and Cable Specifications .....                                       | I-2   |
| Table K-1. Standard ASCII (American Standard Code for Information Interchange) Codes..... | K-1   |
| Table K-2. AWG to Metric Wire Size Conversion .....                                       | K-2   |
| Table K-3. Celsius to Fahrenheit Conversion.....  | K-3   |
| Table K-4. General Conversions .....  | K-4   |
| Table K-5. Length Equivalents.....  | K-5   |
| Table K-6. Area Equivalents .....   | K-5   |
| Table K-7. Volume Equivalents I.....  | K-6   |
| Table K-8. Volume Equivalents II.....   | K-6   |



# Chapter 1

## *Overview of the Series 90-30 PLC*

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The Series 90™-30 Programmable Logic Controller (PLC) is a member of the GE Fanuc Series 90 PLC family.

### **The Basic Parts of a Series 90-30 PLC**

The Series 90-30 PLC is very versatile because (1) it is programmable, and (2) it is assembled from a wide variety of modular, plug-together components. Therefore, by choosing the correct components and developing an appropriate program, the PLC can be used for an almost unlimited variety of applications. Although there are many choices of individual hardware components to use in a system, there are just a few basic categories. Each of these component categories is covered in detail in a separate chapter in this manual. They are introduced in this chapter so you can see how they fit together:

- Baseplates
- Power Supplies
- CPUs
- I/O Modules
- Option Modules
- Cables

#### **Baseplates**

The baseplates are the foundation of the PLC system because most other components mount on them. As a basic minimum, every system has at least one baseplate, which usually contains the CPU (in which case, it is referred to as “the CPU Baseplate”). Many systems require more modules than can be mounted on one baseplate, so there are also Expansion and Remote baseplates that connect together. The three categories of baseplates, CPU, Expansion, and Remote, are available in two sizes, 5-slot and 10-slot, named according to the number of modules they can hold.

#### **Power Supply Modules**

Every baseplate must have its own power supply. The power supply always mounts in a baseplate’s left-most slot. There are several power supply models available to meet a variety of requirements.



## **CPUs**

The CPU is the manager of the PLC. Every PLC system must have one. A CPU uses the instructions in its firmware and application program to direct the PLC's operation and to monitor the system to make sure there are no basic faults. Some Series 90-30 CPUs are built into baseplates, but most are contained in plug-in modules. In some cases, the CPU resides in a Personal Computer using a Personal Computer Interface Card that interfaces to Series 90-30 Input, Output, and Option modules.

## **Input and Output (I/O) Modules**

These modules enable the PLC to interface with input and output field devices such as switches, sensors, relays, and solenoids. They are available in both discrete and analog types.

## **Option Modules**

These modules extend the capability of the PLC beyond the basic functions. These provide such things as communications and networking options, motion control, high speed counting, temperature control, interfacing to operator interface stations, etc.

## **Cables**

These connect the PLC components together or to other systems. Many standard prefabricated cables are available from GE Fanuc. They are primarily used to:

- Interconnect baseplates
- Connect a programmer to the CPU or to an option module
- Connect option modules to field devices or other systems.

## **Assembling a Basic Series 90-30 PLC System**

Let's assemble, on paper, a basic system using the following components:

- Baseplate
- Power Supply module
- CPU module
- Some I/O modules

We'll start with the **baseplate**. To keep it simple, we'll use a 5-slot size. Note that a 5-slot baseplate actually has six slots, but the power supply slot is not numbered. Note also, that this baseplate has a CPU slot, which is slot number 1, and it has an expansion connector on the right end, which is used for connecting to another baseplate if the system has more than one baseplate.



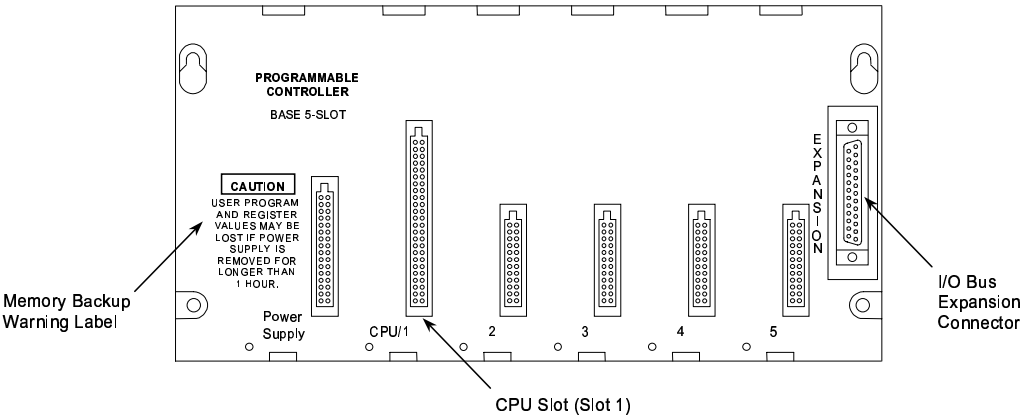


Figure 1-1. Five-Slot CPU Baseplate

Next, we'll add a **power supply** module. It mounts in the unnumbered slot on the left end of the baseplate. This slot has a unique connector that will only fit a power supply module.

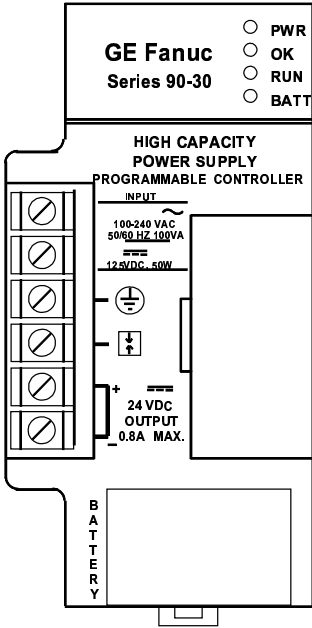


Figure 1-2. Power Supply Module



1

Then add a **CPU module**. A CPU module can only mount in baseplate slot 1, next to the power supply. Slot 1 has a unique connector that will only fit CPU or special Option modules.

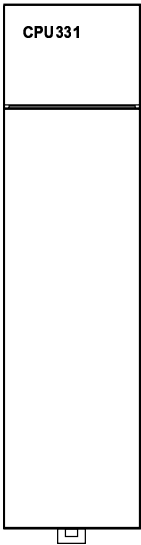


Figure 1-3. CPU Module

To finish, we will add some **I/O modules** to baseplate slots 2 through 5.

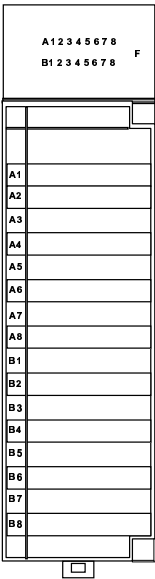


Figure 1-4. I/O Module



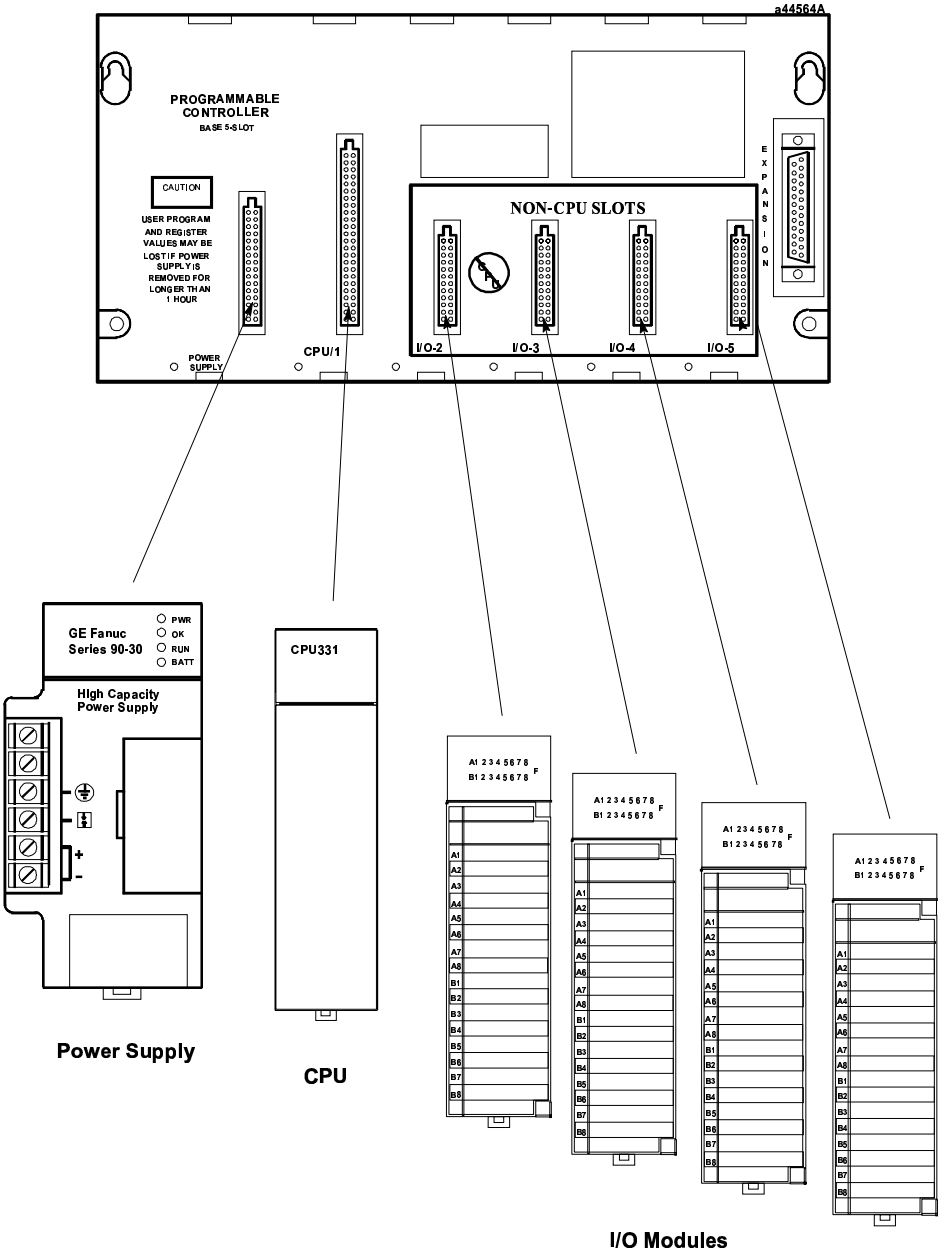


Figure 1-5. Assembling the System



When assembled, the system will look like this:

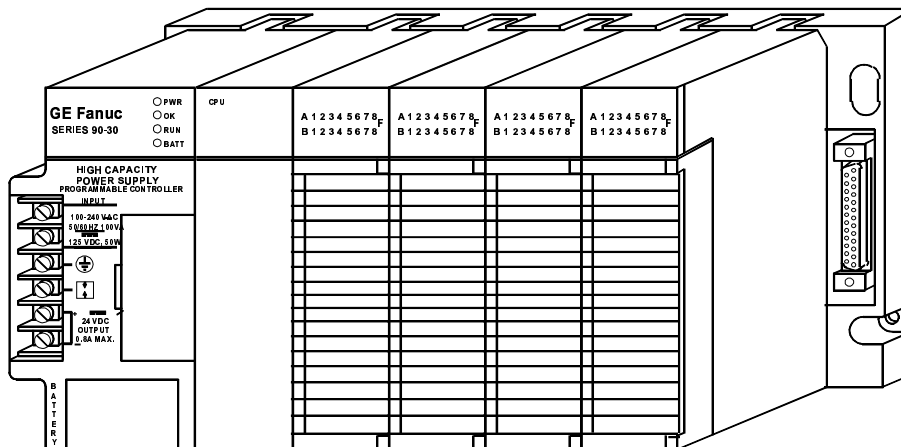


Figure 1-6. A Basic System

An assembly of baseplate and modules such as this one is called a “Rack.”

### What else would be needed to make this basic system functional?

To make this basic system functional, you would need:

- **Mounting.** Safe, secure mounting for the PLC in a protective enclosure.
- **Wiring.** This includes properly installed incoming power to the power supply, as well as wiring from the I/O modules to field devices such as switches, sensors, solenoids, relays, etc.
- **Program.** An application program for the PLC to run. This is developed with GE Fanuc PLC programming software.

### What if the application requires more than five modules?

You could use a 10-slot baseplate, shown in the next picture:

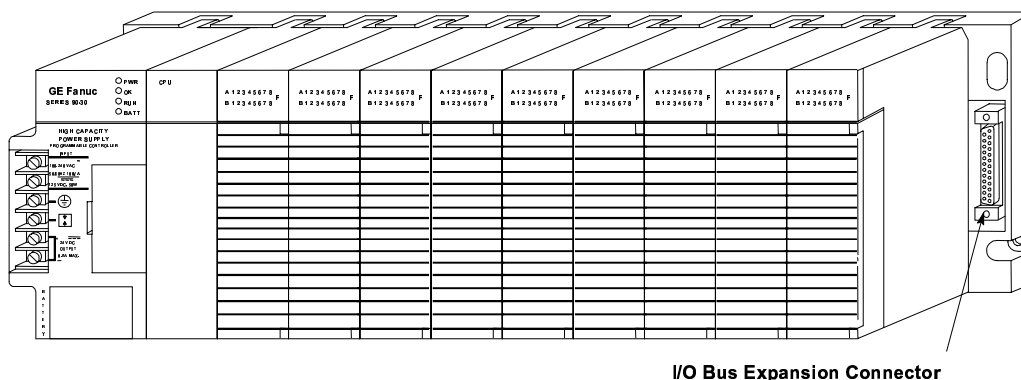


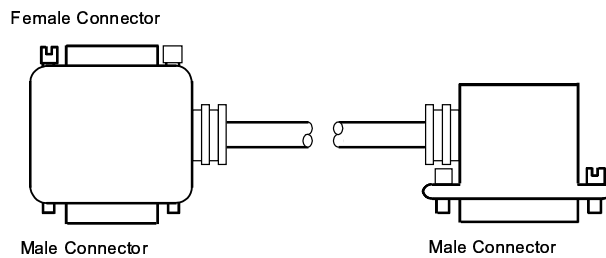
Figure 1-7. Ten-Slot Rack



## What if the application requires more than ten modules?

You can add one or more Expansion or Remote racks to this system. Some CPUs can support up to seven additional racks. If you added seven additional 10-slot racks, you could have 70 more modules.

Racks are interconnected in a “daisy-chain” cabling arrangement. This interconnection system is called the “I/O Expansion Bus.” The connections are made from one baseplate’s I/O Bus Expansion Connector (shown in the figure above) to the next one’s. The I/O Bus Expansion Cables, shown below, have a double connector on one end to facilitate these connections.



**Figure 1-8. I/O Bus Expansion Cable**



The next figure shows a system that has a CPU baseplate, one Expansion rack and three Remote racks. Notice that the last rack, the one at the end of the I/O Expansion Bus, must be terminated. A convenient way of terminating the bus is with an IC693ACC307 I/O Bus Terminator Plug, as shown.

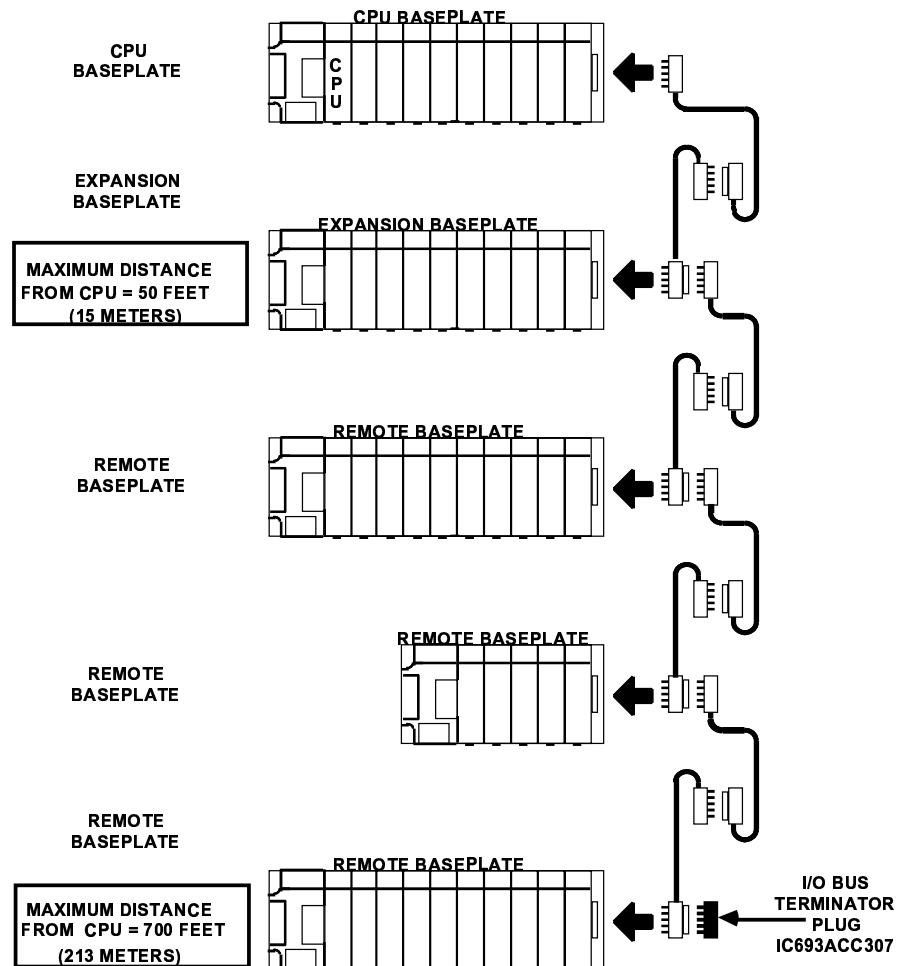


Figure 1-9. Connecting Expansion and Remote Baseplates

## What is the Difference Between Expansion and Remote baseplates?

The main factor to consider is distance. How far will the baseplate be from the CPU baseplate? If the cabling distance from the CPU baseplate is 50 feet (15 meters) or less, use an Expansion baseplate. The Expansion baseplate is preferable because of its higher communication speed with the CPU baseplate. However, if a baseplate must be located where it requires a cabling distance from the CPU rack in excess of 50 feet, an Expansion baseplate will not work - a Remote baseplate must be used. The limit for a Remote baseplate is a cabling distance of 700 feet (213 meters) from the CPU baseplate to the farthest Remote baseplate.



What if I need to cover more than 700 feet (213 meters)?

You can cover much greater distances by using Series 90-30 communications option modules. For example, Genius Bus Controller Modules (GBC) can communicate at distances up to 7,500 feet (2,286 meters) over a shielded twisted-pair cable, as shown in Example 1 below. Or, serial communications with Communications Coprocessor Modules (CMM) using the RS-485 standard can cover up to 4,000 feet (1,219 meters), as shown in Example 2 below. And virtually unlimited communication distances can be attained with modems and telephone lines or radio transmitters. Also, there are numerous networking options available such as Ethernet or WorldFIP.

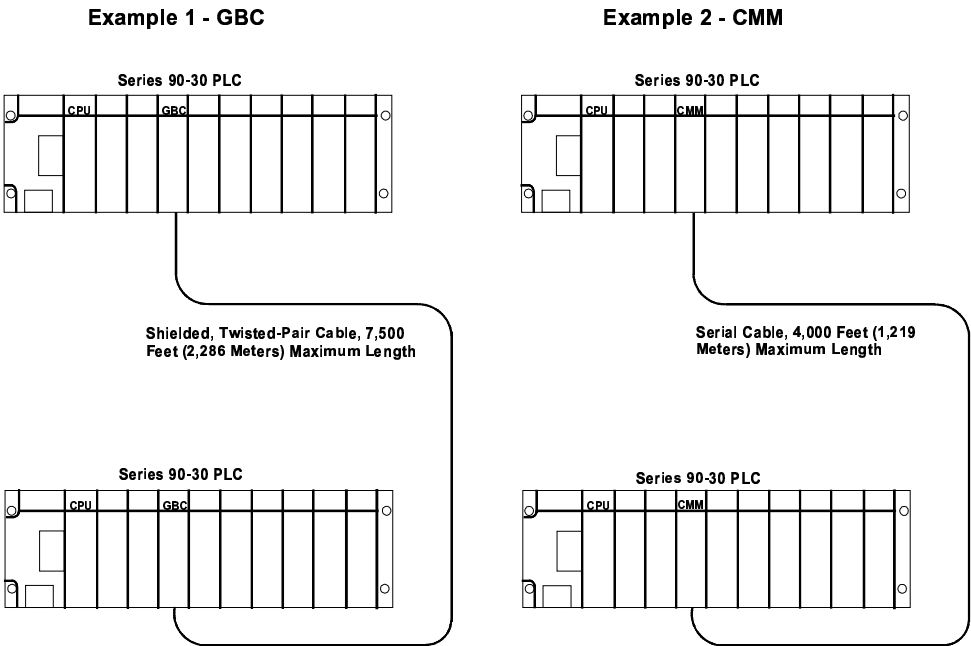


Figure 1-10. Connecting PLCs Using GBC or CMM Modules



# Chapter 2

## Installation

This chapter discusses installation details only. Other information about the products such as hardware descriptions and specifications, is covered in the applicable chapters.

### Important Note

*Series 90-30 PLCs must be mounted in a protective enclosure.*

*The installation instructions described in this chapter apply to PLC installations that do not require special procedures for noisy or hazardous environments. For installations that must conform to more stringent requirements (such as CE Mark), see **GFK-1179, Installation Requirements for Conformance to Standards**. Also see **GFK-0867, GE Fanuc Product Agency Approvals, Standards, General Specifications**.*

### Receiving your Products - Visual Inspection

When you receive your Series 90-30 PLC system, carefully inspect all shipping containers for damage that may have occurred during shipping. If any part of the system is damaged, notify the carrier immediately. The damaged shipping container should be saved as evidence for inspection by the carrier.

As the consignee, it is your responsibility to register a claim with the carrier for damage incurred during shipment. However, GE Fanuc will fully cooperate with you if such action is necessary.

### Pre-installation Check

After unpacking Series 90-30 PLC racks, cables, modules, etc., **record all serial numbers**. Serial numbers are printed on the module packaging. Serial numbers are required to make a claim during the warranty period of the equipment. All software product registration cards should be completed and returned to GE Fanuc. See “Module Features” in this chapter for location of module serial numbers. See “Common Baseplate Features” in chapter 3 for location of baseplate serial numbers.

You should verify that all components of the system have been received and that they agree with your order. If the parts received do not agree with your order, call Programmable Control Customer Service at 1-800-432-7521. A Customer Service representative will provide further instructions.

If you require assistance with your installation, GE Fanuc’s Technical Support department offers expert help. Call the support number for your area from the list in Chapter 13, “Maintenance and Troubleshooting.” The GE Fanuc web site support address is [www.gefanuc.com/support/plc](http://www.gefanuc.com/support/plc).

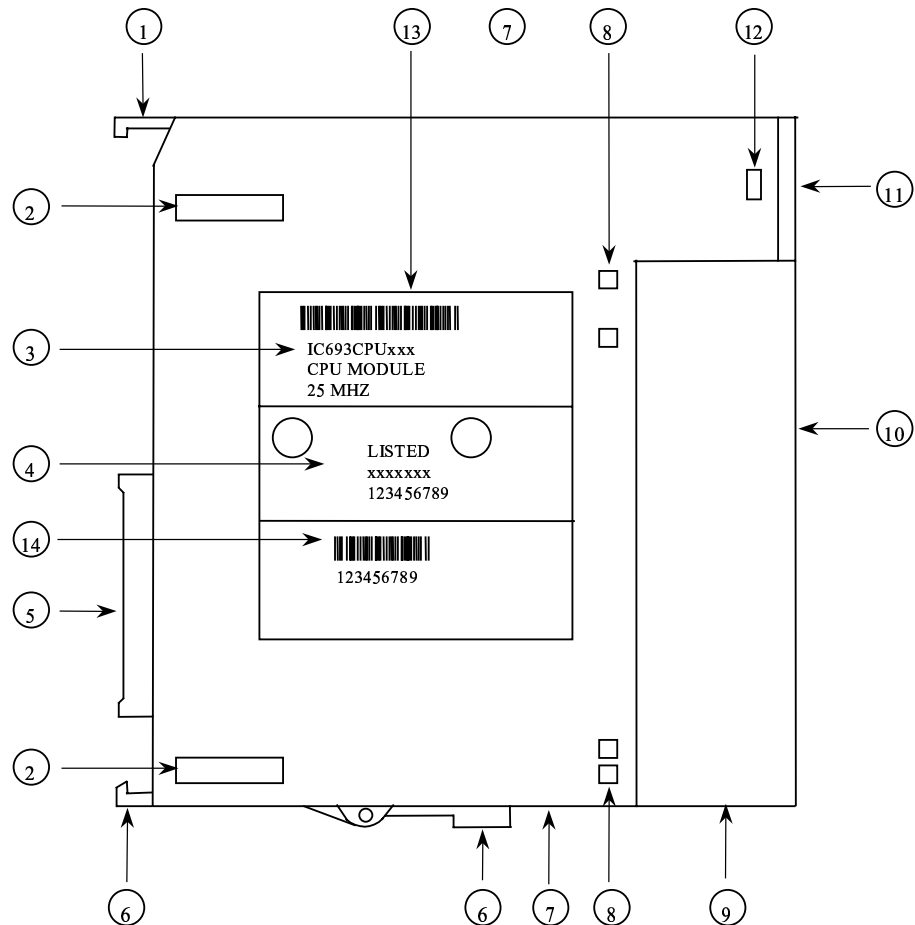
### Warranty Claims

Record the serial number of the defective item and contact your distributor for instructions.



## Working with Series 90-30 Modules

### Module Features



**Figure 2-1. Features of Series 90-30 Module**

1. Pivot hook
2. Circuit board holding tabs (two on each side of module)
3. Catalog number and description section of label (Includes MAC address for CPU374.)
4. Certification (UL, CE, etc.) section of label
5. Module connector - plugs into baseplate backplane connector
6. Release lever - spring loaded
7. Ventilation openings in module case (top and bottom)
8. Front cover holding tabs (two on each side of module)
9. Front cover (shown) or terminal board (for I/O modules).
10. Front cover faceplate or hinged cover for terminal board.
11. Lens cap (some modules do not have).
12. Lens cap holding tabs (one on each side of module)
13. Module label
14. Serial Number - used to determine module warranty status. (On some modules, the Serial Number may be on a small tag on the back of the module.)



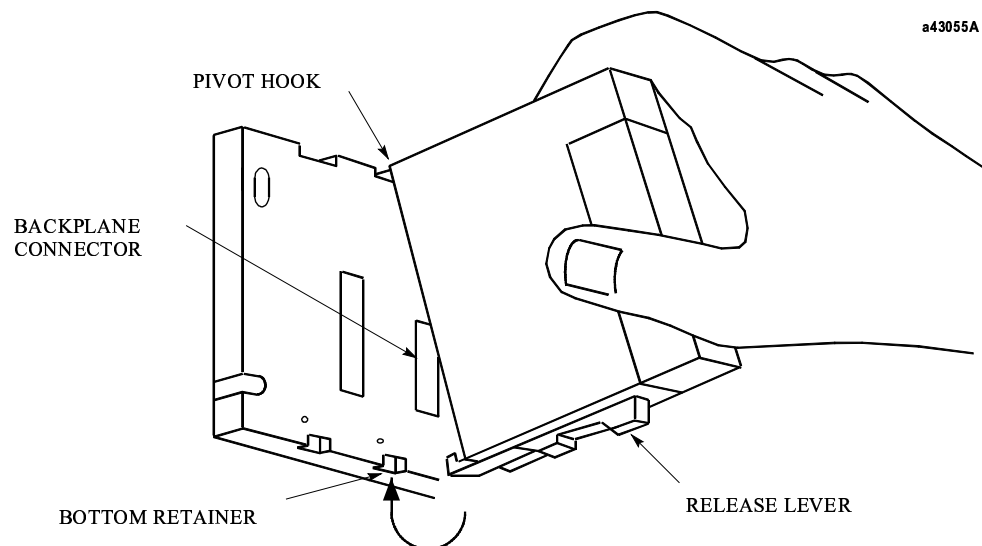
## Installing a Module

### Warning

**Do not insert or remove modules with power applied. This could cause the PLC to stop or malfunction. Injury to personnel and damage to the module or baseplate may result. Also, attempts to force a module into an improper slot type will result in damage to the module and/or the baseplate. Modules will mount in the correct slot type easily, with a minimum of force.**

Use the following instructions as a guide when inserting a module into a baseplate slot.

- Check that module catalog number matches slot configuration. Each slot is, or will be, assigned a particular module type during configuration. A Power Supply module must be installed in the left end unnumbered slot only, and a CPU module and some special Option modules can only be installed in Slot 1 of a CPU baseplate. I/O Modules and most Option modules install in slots numbered 2 and higher.
- Grasp the module firmly with terminal board toward you and with rear pivot hook facing away from you.
- Align the module with the desired baseplate slot and connector. Tilt the module upwards so that top rear pivot hook of the module engages the baseplate's top module retainer.
- Swing the module downward until the module's connector engages the baseplate's backplane connector, and the release lever on the bottom of the module snaps into place in the baseplate's bottom module retainer.
- Visually inspect the module to be sure that it properly seated.



**Figure 2-2. Installing a Module**

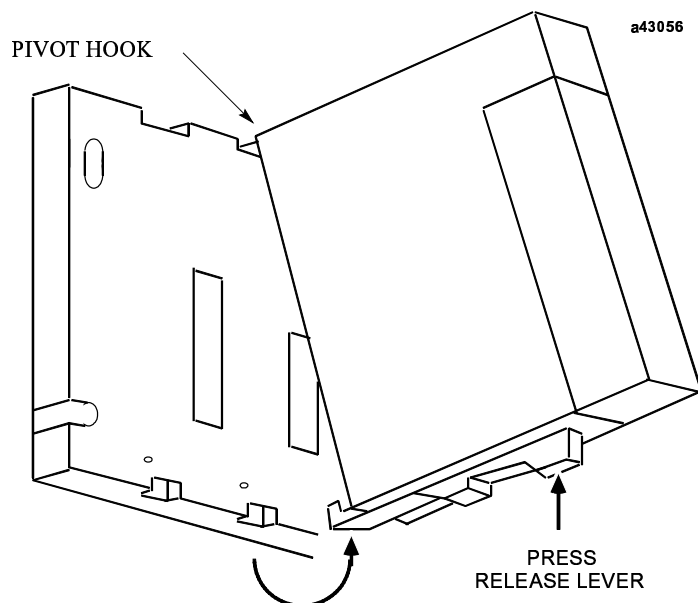


## Removing a Module

### Warning

**Do not insert or remove modules with power applied. This could cause the PLC to stop or malfunction. Injury to personnel and damage to the module or baseplate may result. Also potentially dangerous voltages from user devices may be present on a module's screw terminals even though power to the rack is turned off. Care must be taken any time that you are handling the module's removable terminal board or any wires connected to it.**

- If the module has wiring, remove the module's terminal board (NOTE: You do not have to unwire the terminal board) or cables. The procedure for removing a terminal board is described later in this section.
- Locate the release lever at the bottom of the module and firmly press it up, towards the module.
- While holding the module firmly at its top and fully depressing release lever, swing (pivot) the module upward (release lever must be free of its retaining slot).
- Disengage pivot hook at the top rear of the module by moving the module up and away from the baseplate.



**Figure 2-3. Removing a Module**

### Note

Modules in expansion or remote baseplates can be added, removed, or replaced while the PLC is in RUN mode if power is first removed from the expansion or remote baseplate. I/O data to/from this baseplate will not be updated while power is removed.



## Installing a Module's Terminal Board

Note: Modules IC693MDL730F (and later) and IC693MDL731F (and later) have special terminal boards that are equipped with holding screws. For Installation and Removal instructions, please see the section “Installing and Removing Terminal Boards with Holding Screws” later in this chapter.

To install a terminal board (circled numbers refer to drawing below):

- Hook the pivot hook ①, located on the bottom of the terminal board, to the lower slot on the module.
- Push the terminal board toward the module ② until it snaps into place.
- Open the terminal board cover ③ and ensure that the latch on the module is securely holding the terminal board in place.

### Caution

Compare the module catalog number on the label on the back of the hinged door (see Figure 2-6) and the label on the side of the module (see below) to ensure that they match. If a wired terminal board is installed on the wrong module type, damage to the module may occur when the system is powered up.

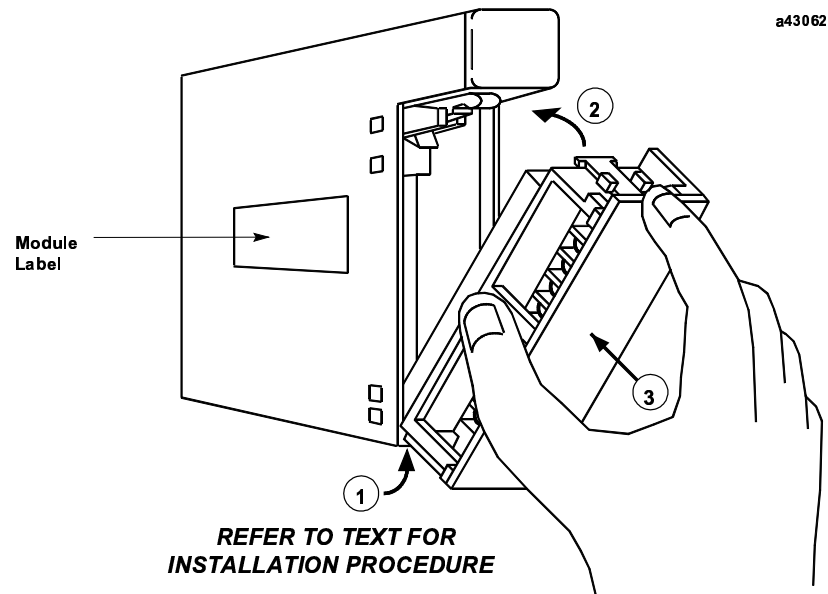


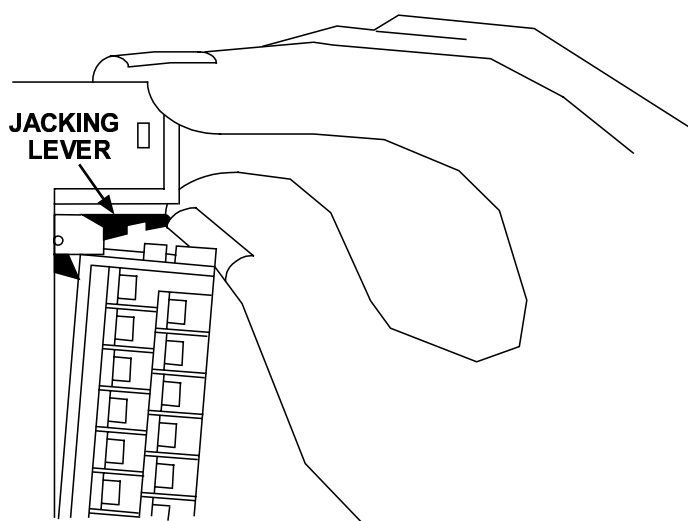
Figure 2-4. Installing an I/O Module's Terminal Board



## Removing a Module's Terminal Board

To remove a terminal board:

- Open the plastic terminal board cover.
- Push up on the jacking lever to release the terminal block.



- Grasp pull-tab and pull it towards you until contacts have separated from module housing and bottom pivot hook has disengaged.

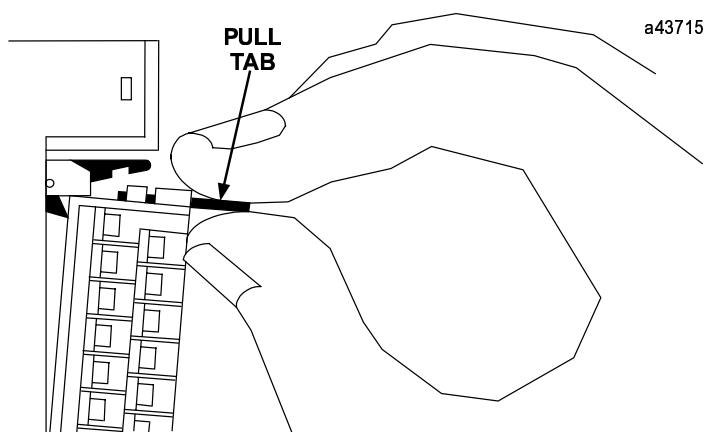


Figure 2-5. Removing a Module's Terminal Board

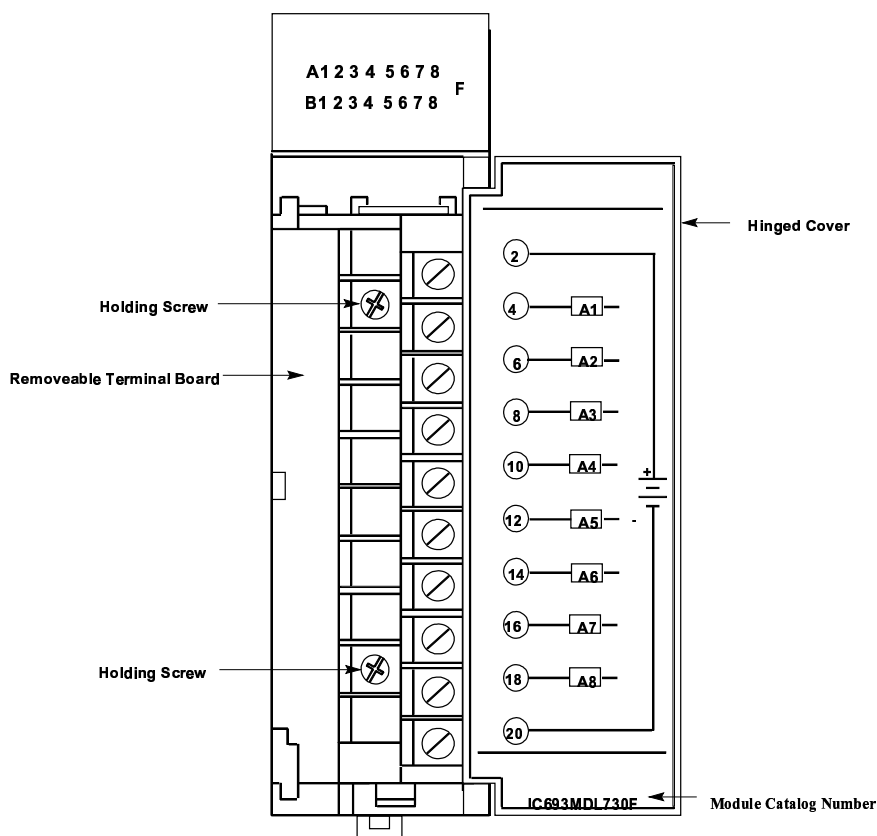


## I/O Module Terminal Board Posts

The terminal board has three posts on the left side. The top and bottom posts hold the terminal board cover in place. The middle post keeps the terminal board wiring in place. If you do not require it to hold the wiring in place, the middle post can be easily snapped off. (Be careful that you do not inadvertently snap it off if you need it to keep your wiring in place.)

## Installing and Removing Terminal Boards with Holding Screws

Discrete output modules IC693MDL730F (and later) and IC693MDL731F (and later) have a special terminal board that is equipped with holding screws, shown in the figure below. These screws prevent the terminal board-to-module connections from deteriorating in applications where the PLC is subjected to severe vibration.



**Figure 2-6. Terminal Board with Holding Screws**

- **Removing:** To Remove these terminal boards, first loosen the two holding screws on the front of the terminal board, then follow the standard removal instructions in the section “Removing an I/O Module’s Terminal Board.” The holding screws are held captive in the terminal board and do not have to be completely removed.
- **Installing:** To install these terminal boards, follow the standard installation instructions in the section “Installing an I/O Module’s Terminal Board,” then tighten the two holding screws to 8 to 10 inch-pounds (1 Newton-meter) of torque.



## Baseplate Mounting

### Warning

**Be sure to follow baseplate grounding instructions in this chapter. Failure to properly ground the PLC can result in improper operation, damage to equipment, and injury to personnel.**

## Mounting a Baseplate to a Panel

- Use four good-quality 8-32 x 1/2 (4 x 12mm) machine screws, lock washers and flat washers. Install the screws in four tapped holes. The “Baseplates” chapter has the applicable dimensions and mounting clearances. Alternately, 10-slot baseplates can be mounted in standard 19-inch racks by using the appropriate adapter. This is also discussed in the “Baseplates” chapter.
- A vertical mounting orientation is preferred for maximum heat dissipation. Other mounting orientations will require derating the Power Supply current capabilities. See Chapter 12, “System Design,” for details.
- All baseplates must be grounded. The “Baseplate Safety Grounding” section of this chapter has details.
- The Rack Number Selection switch must be set on each Expansion or Remote baseplate. A CPU baseplate does not require this switch. Rack numbers should be assigned by the system designer. Failure to set the Rack Number Selection switches properly will result in system malfunction. See the “Baseplates” chapter for details on setting these switches.

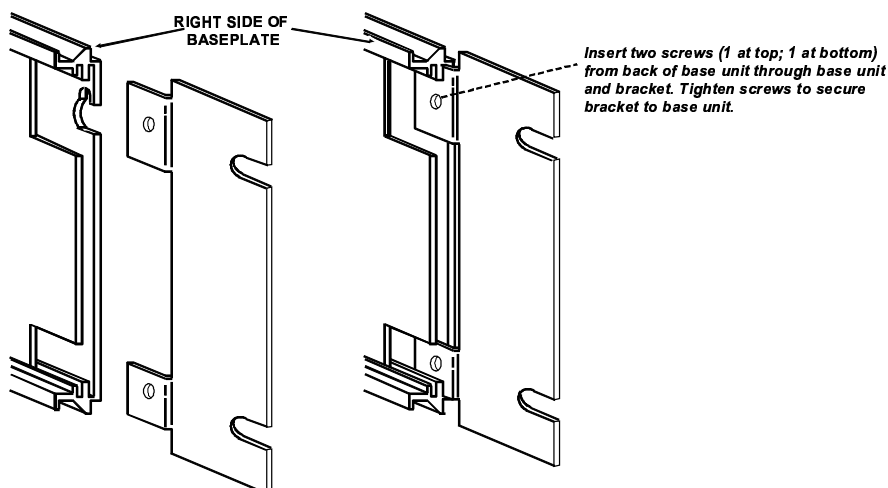
## Mounting a Baseplate to a 19" Rack

Two optional Baseplate Adapter Brackets allow a 10-slot baseplate to be mounted in a 19 inch rack. Each baseplate installation requires only one of the adapter brackets.

- **IC693ACC308 Front Mount Adapter Bracket.** Used to mount a baseplate to the front face of a 19" rack. Install the adapter bracket by inserting the tabs at the top and bottom of the adapter bracket into the corresponding slots at the top and bottom of the plastic baseplate cover. NOTE: Although Figure 2-7 shows the plastic baseplate cover removed, this is for illustration purposes only. It is not necessary to remove the cover to install the bracket. With the bracket in place, insert and tighten the two screws (included with the bracket) through the back of the baseplate holes into the threaded holes in the bracket.



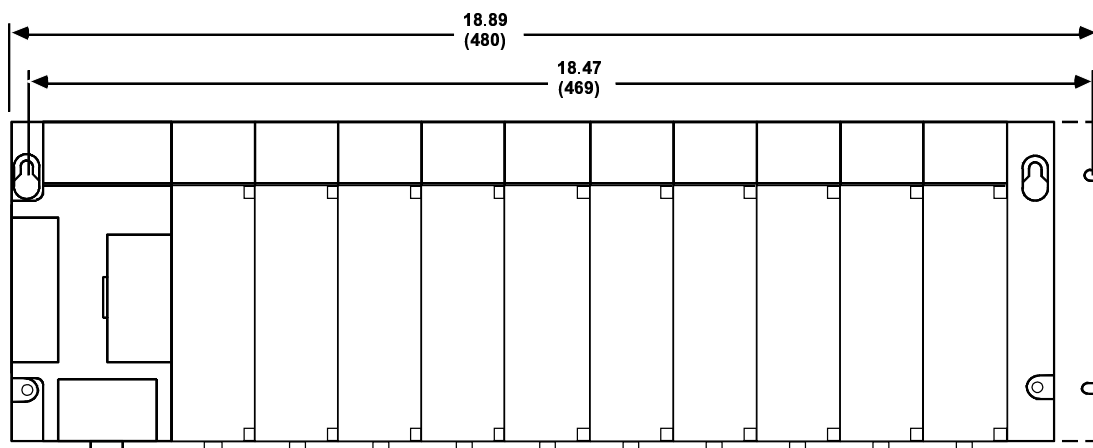
- **IC693ACC313 Recessed Mount Adapter Bracket.** Used to recess mount a baseplate inside a 19" rack. A baseplate mounts on the rear panel of this adapter bracket using four 8-32 (4mm) screws, nuts, lock washers, and flat washers. The Adapter Bracket bolts through its four slotted holes to the face of the 19" rack using applicable hardware (lock washers recommended).



**Note:** Baseplate is shown with cover removed for illustration purposes. It is not necessary to remove the baseplate cover to install the bracket.

**Figure 2-7. IC693ACC308 Front Mount Adapter Bracket Installation**

Dimensions for rack mounting a 10-slot baseplate with the IC693ACC308 Front Mount Adapter Bracket are shown in the following figure.



DIMENSIONS IN INCHES (MILLIMETERS IN PARENTHESES)

**Figure 2-8. Dimensions for 19-inch Rack Mounting Using IC693ACC308 Adapter Bracket**



2

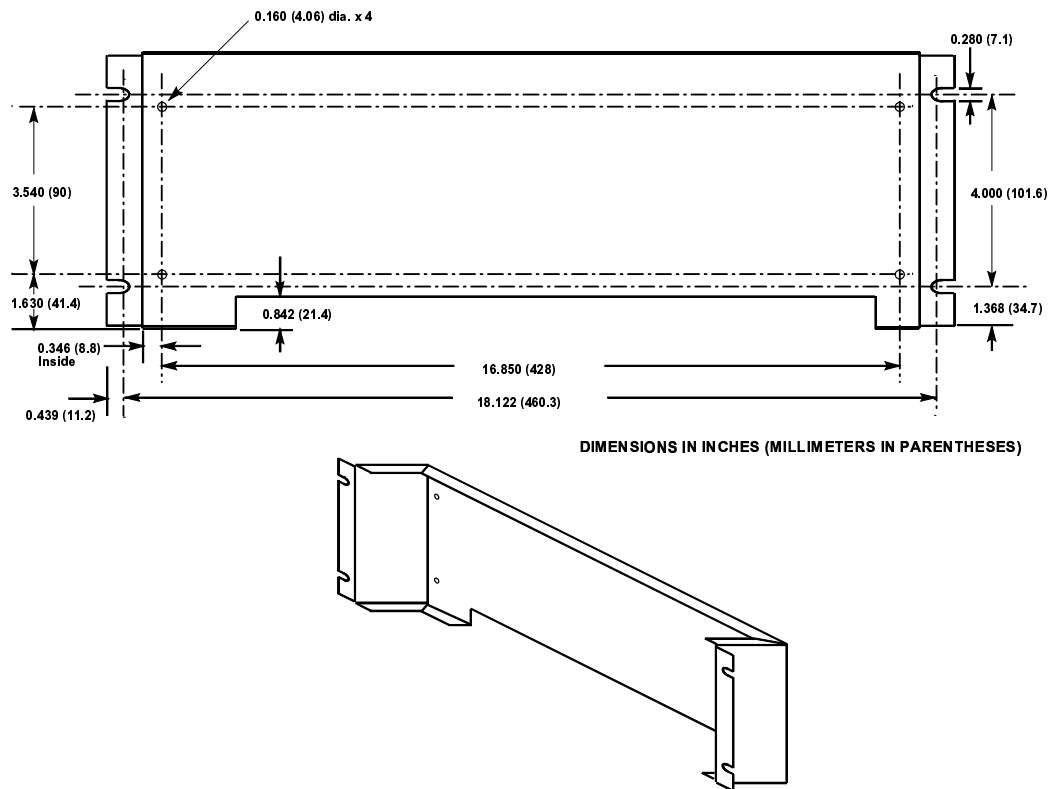


Figure 2-9. IC693ACC313 Recessed Mount Adapter Bracket



## Grounding Procedures

### System Grounding Procedures

#### Warning

In addition to the following grounding information, we strongly urge that you follow all applicable codes that apply to your area. For example, in the United States, most areas have adopted the National Electrical Code standard and specify that all wiring conform to its requirements. In other countries, different codes will apply. For maximum safety to personnel and property you must follow these codes. Failure to do so can mean injury or death to personnel, damage to property, or both.

All components of a programmable logic control system and the devices it is controlling must be properly grounded. This is particularly important for the following reasons.

- A low resistance path from all parts of a system to earth minimizes exposure to shock in the event of short circuits or equipment malfunction.
- The Series 90-30 PLC system requires proper grounding for correct operation.

### Ground Conductors

- Ground conductors should be connected in a tree fashion with branches routed to a central earth ground point, shown in the figure below. This ensures that no ground conductor carries current from any other branch. This method is shown in the following figure.
- Ground conductors should be as short and as large in size as possible. Braided straps or ground cables (typically green insulation with a yellow tracer - AWG #12 (3.3 mm<sup>2</sup>) or larger) can be used to minimize resistance. Conductors must always be large enough to carry the maximum short circuit current of the path being considered.

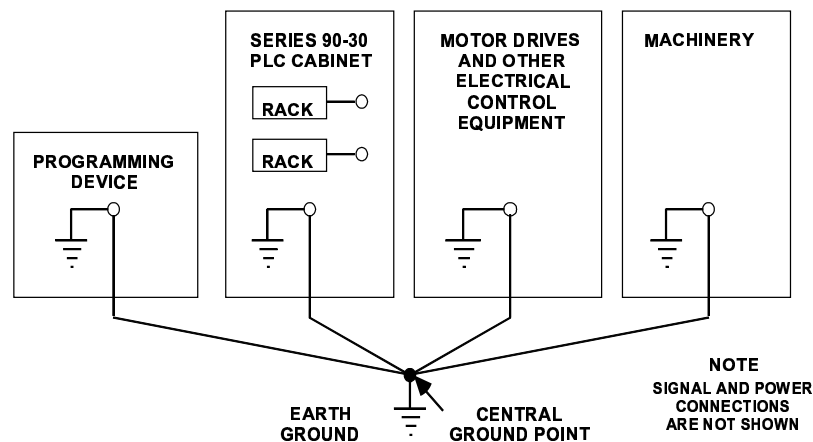


Figure 2-10. Recommended System Grounding



## Series 90-30 PLC Equipment Grounding

Equipment grounding recommendations and procedures are listed below. These grounding procedures must be properly followed for safe, proper operation of your Series 90-30 PLC system.

### Baseplate Safety Grounding

The following recommendations are offered, but applicable safety codes for your area or equipment type should also be consulted. The baseplate's metal back must be grounded using a separate conductor; the baseplate mounting screws are not considered to an acceptable ground connection by themselves. Use a minimum AWG #12 (3.3 mm<sup>2</sup>) wire with a ring terminal and star lock washer under the head of one of the baseplate's two lower mounting holes. These two holes have openings to the side to allow connecting a wire and ring terminal under the head of a mounting screw. Connect the other end of this ground wire to a tapped hole in the panel that the baseplate is mounted to, using a machine screw, star lock washer, and flat washer. Alternately, if your panel has a ground stud, it is recommended you use a nut and star lock washer for each wire on the ground stud to ensure adequate grounding. Where connections are made to a painted panel, the paint should be removed so clean, bare metal is exposed at the connection point. Terminals and hardware used should be rated to work with the aluminum baseplate material.

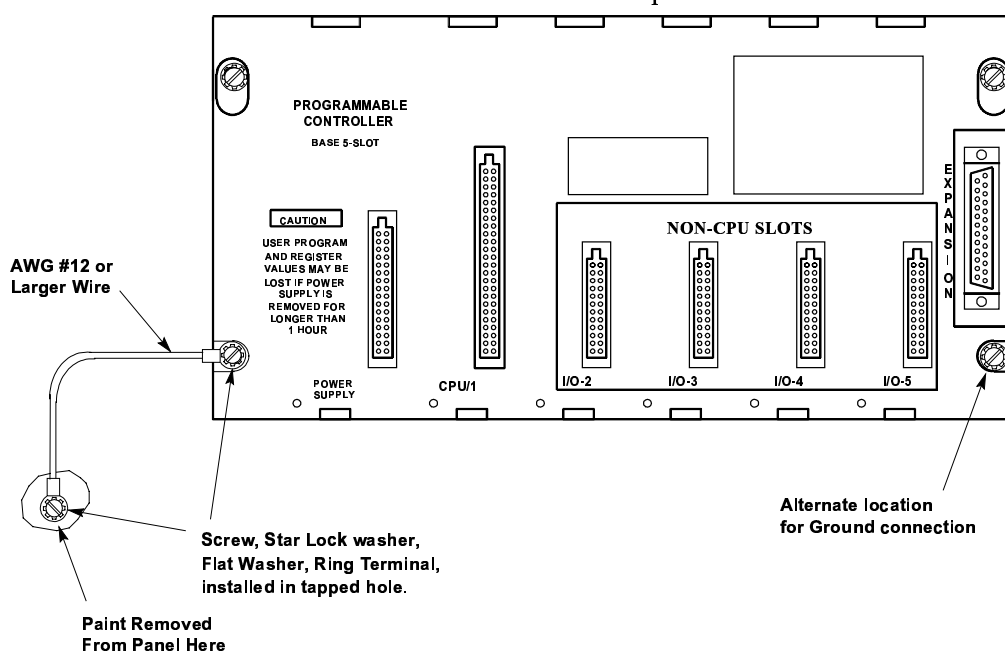


Figure 2-11. Baseplate Grounding

### Warning

**All baseplates must be grounded to minimize electrical shock hazard. Failure to do so can result in severe personal injury.**



All baseplates grouped together in a Series 90-30 PLC system must have a common ground connection. This is especially important for baseplates that are not mounted in the same control cabinet.

## Grounding 19" Rack-Mounted Baseplates

There are two Adapter Brackets used for mounting a 10-slot Series 90-30 baseplate to a 19" Rack. Regardless of which of the two Adapter Brackets is used, the 19" Rack should be grounded as per the instructions in "System Grounding Procedures," including Figure 2-10. (For details on the Adapter Brackets, see the "Mounting a Baseplate to a 19" Rack" section earlier in this chapter.)

Nineteen-Inch Rack-mounted PLC baseplates should be grounded according to the guidelines in the "Baseplate Safety Grounding" section, using a separate ground wire from the PLC baseplate as shown in the previous figure (Fig. 2-11).

- If using the **Recessed Mount Adapter Bracket (IC693ACC313)**, the ground wire can be installed as shown in Figure 2-11 with the ground attached to the Recessed Mount Adapter Bracket. An additional ground wire connecting the Adapter Bracket to a solid chassis ground on the 19" Rack should be installed. Use the same or equivalent hardware and paint removal scheme as shown in Figure 2-11.
- If using the **Surface Mount Adapter Bracket (IC693ACC308)**, the ground wire should be run from the baseplate as shown in Figure 2-11, to a solid chassis ground on the 19" Rack. Use the same or equivalent hardware and paint removal scheme as shown in Figure 2-11.

## Programmer Grounding

For proper operation, the computer (programmer) running the PLC software must have a ground connection in common with the CPU baseplate. Normally, this common ground connection is provided by ensuring that the programmer's power cord is connected to the same power source (with the same ground reference point) as the baseplate. If it is not possible to ensure this common ground scheme, use a port isolator (IC690ACC903) between the programmer and PLC serial connection. If the programmer ground is at a different potential than the PLC ground, a shock hazard could exist. Also, damage to the ports or converter (if used) could occur when the programmer serial cable is connected between the two.

### Warning

**Failure to follow programmer grounding recommendations could result in personal injury, equipment damage, or both.**



## Module Shield Grounding

In general, the aluminum PLC baseplate is used for module shield grounding. On some Series 90-30 modules, shield connections to the user terminal connector on the module are routed to the baseplate through the module's backplane connector. Other modules, such as CPUs 351, 352, 363, 364, and 374 require a separate shield ground. These are discussed in the next several sections.

### Shield Grounding Information for CPUs with External Port Connections

CPUs with external port connections, the 351, 352, 363, 364, and 374 must have a separate shield ground connection to provide shielding for these ports. Because the design of the ground connection for the CPU351 and 352 is different from that of the CPU363, 364, and 374, each grounding method is discussed in a separate section.

### CPU351 and 352 Shield Grounding

The CPU 351 or 352 module must be connected to frame ground at the slot where it is installed. Two methods are provided for making this ground connection. Each CPU comes with an EMC Grounding Kit (44A737591-G01) that contains a ground wire, grounding bracket, and screws.

1. The connection from the CPU to frame ground can be made using the ground wire (part number 44A735970-001R01) that comes with the module in the EMC Grounding Kit. This wire has a stab-on connector on one end for connection to a mating terminal on the bottom of the CPU, and a ring terminal on the other end for connection to a grounded enclosure. Where the ring terminal contacts a painted enclosure panel, either a star lock washer can be installed between the terminal and the panel to cut through the paint, or the paint can be scraped away down to clean, bare metal to ensure a good contact. **Note: The star lock washer method is suitable for a shield ground, but not suitable for a safety ground.**

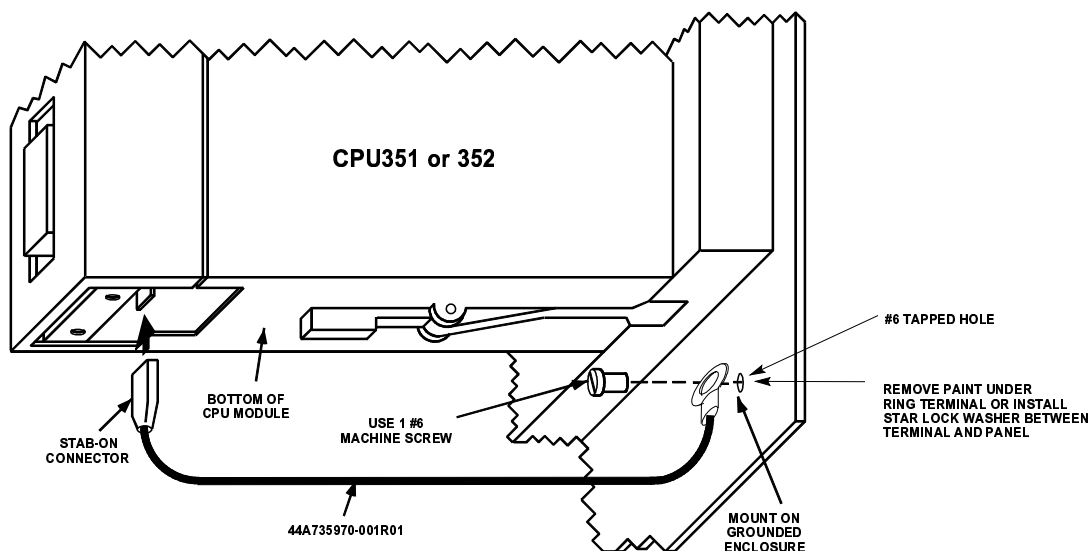
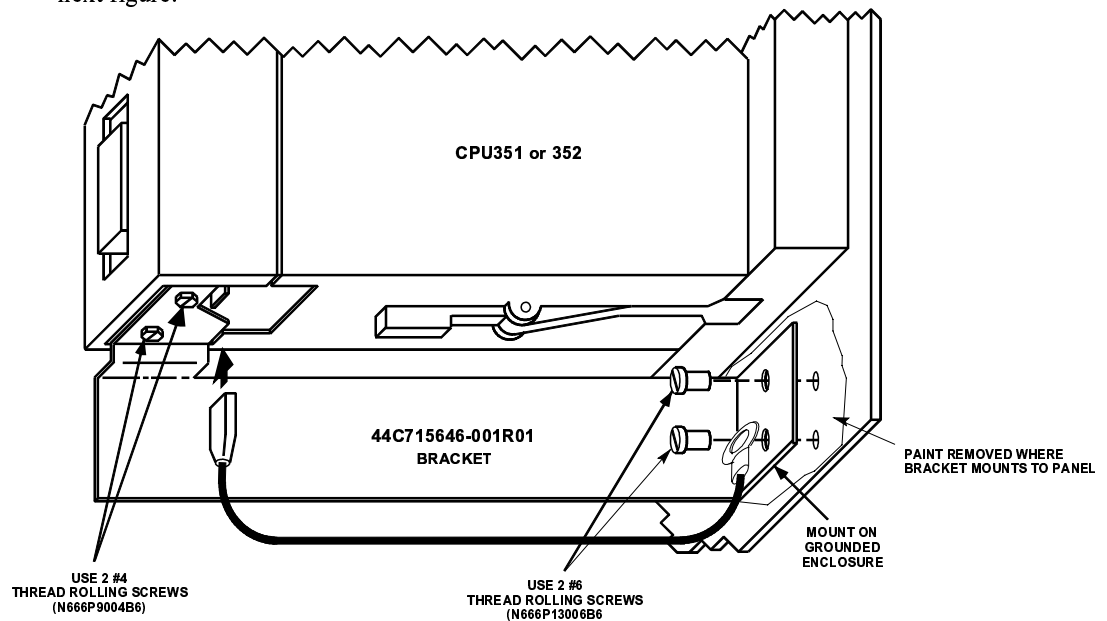


Figure 2-12. CPU 351 or 352 - Attaching Shield Ground Wire



2. The second method, which can be used for systems in noisy environments consists of installing the green ground wire **and** the optional grounding bracket (part number 44C715646-001R01). This bracket attaches to the CPU using two #4 thread-rolling screws (part number N666P9004B6) and to the grounded enclosure using two #6 thread-rolling screws (part number N666P13006B6). Two holes must be drilled in the enclosure for mounting this bracket. Also, if the bracket will be attached to a painted surface, the paint should be removed down to bare metal under the bracket to ensure good contact between the bracket and the surface. See the next figure.



**Figure 2-13. CPU 351 or 352 - Mounting the Shield Grounding Bracket and Wire**

**Note:** When the grounding bracket is used, pin 1 of the cable connector that plugs into the Port 2 connector should not be connected. A metal connector shell must be used on the cable for this port, and the cable shield must be terminated at the metal shell instead of pin 1 of the connector.



## CPU363, CPU364, and CPU374 Shield Grounding

The CPU363, CPU364, and CPU374 modules must be connected to frame ground at the slot where they are installed. Each module comes with a grounding wire for this purpose. These modules do not support or require the use of a grounding bracket. If the ring terminal on the grounding wire is to be mounted to a painted surface, remove the paint under the ring terminal to ensure good contact, or place a star lock washer between the ring terminal and the painted surface. See the next figure.

**Note:** The star lock washer method is suitable for a shield ground, but not suitable for a safety ground.

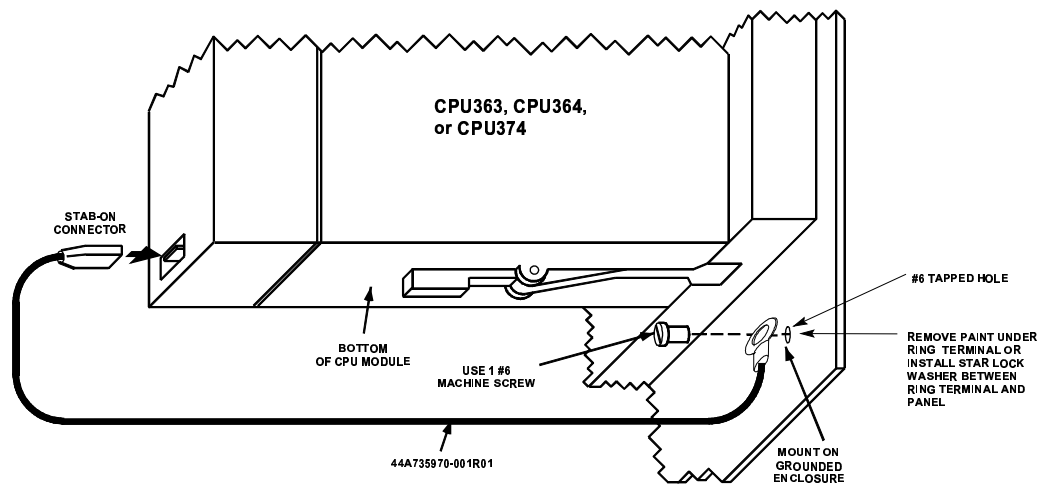


Figure 2-14. CPU 363, CPU364, or CPU374 - Attaching Ground Wire

## Additional Modules with Shield Grounding Requirements

Some of the Series 90-30 Option modules, such as the FIP Remote I/O Scanner (IC693BEM330), and DSM modules (IC693DSM302 and IC693DSM314) also have shield grounding requirements. These modules come equipped with suitable grounding hardware. Please refer to each module's user's manual for grounding instructions. Appendix G contains a product to publication cross-reference to help you identify the correct manual.



## General Wiring Guidelines

### Warning

**In addition to the following wiring suggestions, we strongly urge that you follow all wiring and safety codes that apply to your area or your type of equipment. For example, in the United States, most areas have adopted the National Electrical Code standard and specify that all wiring conform to its requirements. In other countries, different codes will apply. For maximum safety to personnel and property you must follow these codes. Failure to do so can lead to personal injury or death, property damage or destruction, or both.**

### Color Coding Wires

These color codes are commonly used in industrial equipment manufactured in the United States. They are cited here as a reference. Where they are in conflict with codes that apply to your area or your type of equipment, you should follow your applicable codes instead. Besides satisfying code requirements, wire color coding makes testing and troubleshooting safer, faster, and easier.

- Green or green with stripe- Ground
- Black - Primary AC
- Red - Secondary AC
- Blue - DC
- White - Common or neutral
- Yellow - Secondary power source not controlled by the main disconnect. Alerts maintenance personnel that there may be power present (from an external source) even if the equipment is disconnected from its main power source.

### Wire Routing

To reduce noise coupling among PLC wires, it is recommended you keep electrically noisy wiring, such as AC power wiring and Discrete Output Module wiring, physically separated from low-level signal wiring such as DC and Analog Input module wiring or communications cables. This can be accomplished by grouping separately, where practical, the following categories of wiring:

- **AC power wiring.** This includes the AC input to the PLC power supply, as well as other AC devices in the control cabinet.
- **Analog Input or Output Module wiring.** This should be shielded to further reduce noise coupling. See the *Series 90-30 I/O Module Specifications Manual*, GFK-0898 for details.
- **Discrete Output Module wiring.** These often switch inductive loads that produce noise spikes when switched off.
- **DC Input Module wiring.** Although suppressed internally, these low-level inputs should be further protected against noise coupling by observing these wiring practices.
- **Communications Cables.** Wiring such as Genius Bus or serial cables should be kept away from noise-producing wiring.



Where AC or Output wiring bundles must pass near noise-sensitive signal wiring bundles, avoid running them beside each other. Route them so that, if they have to cross, they do so at a right angle. This will minimize coupling between them.

### Grouping Modules to Keep Wires Segregated

If practical, grouping similar modules together in the PLC racks can help keep wiring segregated. For example, one rack could contain only AC modules, and a different rack only DC modules, with further grouping in each rack by input and output types. For smaller systems, as an example, the left end of a rack could contain Analog modules, the middle could contain DC modules, and the right end could contain AC modules.

## Discrete I/O Module Connection Methods

- For modules with 16 points or less, the standard method is to use the removable terminal board which comes with these modules. The removable terminal board makes it easy to prewire field wiring to the user supplied input and output devices, and to replace modules in the field without disturbing existing field wiring.
- Some discrete 16-point I/O modules can be used with an optional Terminal Block Quick Connect (TBQC) assembly. This assembly contains a module faceplate, with built-in connector, that replaces the removable terminal board. The assembly also contains a DIN-rail mounted terminal block and a cable to connect the module to the terminal block. The advantage of this method is that it saves about two hours of wiring time per module compared with hand wiring from a module's removable terminal board to a user-supplied, panel-mounted terminal block or strip.
- Older 32-point I/O modules have one 50-pin connector on the front of the module that is either connected by a cable with a connector on each end to a Weidmuller panel-mounted terminal block (Weidmuller catalog no. 912263), or is connected by a cable with stripped, tinned leads to a user-supplied terminal block or strip.
- Newer 32-point I/O modules have two 24-pin connectors on the front of the module. These module may be wired in one of three ways. (1) Use a pair of cables (IC693CBL327/328 - see data sheet in "Cables" chapter) to connect the module to a user-supplied, panel-mounted terminal block or strip. These cables have a 24-pin connector on one end, and stripped, tinned leads with wire markers on the other end. (2) Use a pair of dual-connector cables to connect the module to a Terminal Block Quick Connect (TBQC) terminal block (IC693ACC377). See Appendix H for details. (3) Make your own custom cables. Instructions are found in the IC693CBL327/328 data sheet in Chapter 10.

## Connections to I/O Module Terminal Boards

Series 90-30 PLC I/O terminal boards have either 10 or 20 screw terminals that will accept from two AWG #22 (0.36 mm<sup>2</sup>) to two AWG #16 (1.3 mm<sup>2</sup>), or one AWG #14 (2.1 mm<sup>2</sup>) copper 90°C (194°F) wire(s). Each terminal can accept solid or stranded wires, but the wires into any given terminal should be the same type (both solid or both stranded) to ensure a good connection. Wires are routed to and from the terminals out of the bottom of the terminal board cavity. The suggested torque for the I/O terminal board connection screws is from 9.6 in-lbs to 11.5 in-lbs (1.1–1.3 Newton-meters).



For 24 volt DC input modules, an internal 24 volt power connection is provided on the terminal board to supply a limited number of input devices. Also, a 24 volt DC output is available on the power supply module's terminal board to supply a limited number of output devices.

## Terminal Block Quick Connect Installation for 16-Point Discrete Modules

The Terminal Block Quick Connect (TBQC) Assembly is an option for certain Series 90-30 discrete I/O modules. See Appendix H for more information.

- Remove standard terminal board from module.
- Install TBQC faceplate (it has a 24-pin connector).
- Mount the TBQC terminal block. It has a 24-pin connector and a terminal strip, and mounts on a standard 35 mm DIN-rail.
- Connect a TBQC cable between the TBQC faceplate connector on the module and the connector on the TBQC terminal block.
- Wire I/O devices to the terminal block.

## Installation of 32-Point Discrete, 50-Pin Connector Modules

These 50-Pin modules are an older design and are not generally used on new systems, unless to fulfill standardization requirements. They are mainly used as replacements for existing installations. For new installations, we recommend the dual 24-pin connector style because they have additional features not found on the older modules (LED indicators, TBQC), and it is much easier to fabricate custom-length cables for them. Installation information is provided here for the convenience of those still using these modules.

### Using Weidmuller #912263 Terminal Block

Note: The TBQC is not available for these modules, but you may purchase a Weidmuller #912263 from your electronics distributor for this application.

- Mount the Weidmuller#912263 terminal block. It has a 50-pin connector and a terminal strip, and mounts on a standard 35 mm DIN-rail.
- Connect an IC693CBL306/307 cable between the module's faceplate connector and the connector on the Weidmuller terminal block. See Chapter 10 for cable data.
- Wire I/O devices to the terminal block. See the *Series 90-30 PLC I/O Module Specifications Manual*, GFK-0898, for pin-out information.



## Using a Generic Terminal Block or Strip

- Mount terminal block/strip to the enclosure panel.
- Connect an IC693CBL308 or 309 cable, or a custom made cable, to the module's faceplate connector and wire the stripped ends of the cable to the terminal block/strip. See Chapter 10 for cable data.
- Wire I/O devices to the terminal block/strip.

## Direct Method

- Connect an IC693CBL308 or 309 cable, or a custom made cable, to the module's faceplate connector and wire the stripped ends of the cable directly to the field devices. See Chapter 10 for cable data. See the Series 90-30 PLC I/O Module Specifications Manual, GFK-0898, for pin-out information.

## Installation of Discrete 32-Point, Dual 24-Pin Connector Modules

### Using a TBQC

- Mount two TBQC terminal blocks. Each has a 24-pin connector and a terminal strip, and mounts on a standard 35 mm DIN-rail.
- Connect a pair of TBQC cables (IC693CBL329 - 334) between the module's faceplate connector and the connectors on the two TBQC terminal blocks. Note that both a right side and left side cable is required. See Appendix H for a list of cables.
- Wire I/O devices to the terminal blocks. See the Series 90-30 PLC I/O Module Specifications Manual, GFK-0898, for pin-out information.

The Terminal Block Quick Connect (TBQC) Assembly is an option for certain Series 90-30 discrete I/O modules. See Appendix H for more information.

### With a Generic Terminal Block/Strip

- Mount terminal block/strip to the enclosure panel.
- Connect an IC693CBL327/328 cables, or a custom made cables, to the module's faceplate connectors, and wire the stripped ends of the cables to the terminal block/strip. Note that both a right side and left side cable is required. See Appendix H for a list of cables. See Chapter 10 for cable data sheets.
- Wire I/O devices to the terminal block/strip. See the Series 90-30 PLC I/O Module Specifications Manual, GFK-0898, for pin-out information.



## Direct Method

- Connect an IC693CBL327/328 cable, or a custom made cable, to the module's faceplate connectors, and wire the stripped ends of the cable directly to the field devices. See Chapter 10 for cable data. See the *Series 90-30 PLC I/O Module Specifications Manual*, GFK-0898, for pin-out information.

## General Wiring Methods for Analog Modules

Twisted, shielded instrumentation cable is strongly recommended for analog module input or output signal connections. Proper grounding of the shield is also important. For maximum electrical noise suppression, the cable shield should only be grounded at one end of the cable. For Input modules, ground the end that is in the noisiest environment (which often is at the field device end). For Output modules, ground at the module end. See GFK-0898, *Series 90-30 PLC I/O Module Specifications*, for more shield grounding information.

## Analog Input Module Wiring Methods

Correcting electrical noise problems can sometimes be a trial-and-error routine. However, in general, it is generally best to ground the cable shield as close to the source of the noise as possible, which is usually at the device end. In troubleshooting noise problems, sometimes it is beneficial to experiment with the shield grounding point location. Remember, the cable shield should be grounded at one end only. Also, it is best to keep the length of stripped cable leads as short as possible to minimize the length of unshielded conductors that will be exposed to the noisy environment. See the *Series 90-30 PLC I/O Module Specifications Manual*, GFK-0898 for additional details.

## Using a Generic Terminal Block or Strip

- Mount a terminal strip inside the control enclosure and run a shielded cable from the terminal strip to each input circuit on the module's terminal board terminals.
- Connect each cable's shield to the metal panel next to the terminal strip. Do not connect the shields at the module end (cut shield off at module end of cable and insulate with shrink tubing).
- Wire the field device to the terminal strip with a shielded cable, grounding the shield at the device end only (cut shield off at terminal strip end of cable and insulate with shrink tubing). Also, keep the length of exposed (outside of shield) leads at the terminal strip and device ends as short as possible.

## Direct Method

- Run a shielded cable from the field device (transducer, potentiometer, etc.) directly to the module.
- Connect the conductors to the applicable screws on the module's terminal board.



- Ground the shield at the field device end, exposing a minimum amount of conductor to the noisy environment. Do not connect the shield at the module end (cut shield off at module end of cable and insulate with shrink tubing).

## TBQC not Recommended for Analog Modules

The Terminal Block Quick Connect (TBQC) Assembly is not recommended for use with analog modules due to cable shielding requirements.

## Analog Output Module Wiring

### General

Each output should be connected using a good quality shielded wire with the cable shield grounded at the module end. See GFK-0898, *Series 90-30 PLC I/O Module Specifications*, for more information.

### Using a Generic Terminal Block or Strip

- Mount a terminal strip inside the control enclosure and run a shielded cable from the terminal strip to each output circuit on the module's terminal board terminals.
- Ground each cable's shield at the module end only. Do not connect the shields at the terminal strip end (cut shields off at terminal strip end of cables and insulate with shrink tubing).
- Wire the field device to the terminal strip with shielded cables, grounding the shields at the terminal strip end only (cut shields off at field device end of cables and insulate with shrink tubing). Also, keep the length of exposed (outside of shield) leads at the terminal strip and device ends as short as possible.

### Direct Method

- Run a shielded cable from each field device (transducer, potentiometer, etc.) directly to the module.
- Connect the conductors to the applicable screws on the module's terminal board.
- Ground the shield at the module end only, exposing a minimum amount of conductor to the noisy environment. Do not connect the shield at the device end (cut shield off at device end of cable and insulate with shrink tubing).

## TBQC not Recommended for Analog Modules

The Terminal Block Quick Connect (TBQC) Assembly is not recommended for use with analog modules due to cable shielding requirements.



## AC Power Source Connections

### AC Input Wiring to AC/DC Power Supplies

#### Warning

**If the same AC power source is used to provide AC power to other baseplates in a Series 90-30 PLC System, ensure that all AC input connections are identical at each rack. Do not cross Line 1 (L1) and Line 2 (L2). A resulting difference in potential can injure personnel or cause damage to equipment. Each baseplate must be connected to a common ground.**

**Ensure that the protective cover is installed over all terminal boards. During normal operation with an AC power source either 120 VAC or 240 VAC is present on the AC Power Supply. The cover protects against accidental shock hazard which could cause severe or fatal injury to the operator or maintenance personnel.**

Both the Standard (IC693PWR321) and High Capacity (IC693PWR330) AC/DC power supplies currently have six terminals for user connections. Early versions of some Series 90-30 power supplies had five terminals (see next figure). The wiring methods for both five-terminal and six-terminal types is similar, except that step 3 below does not apply to the five-terminal type.

The power supply terminal boards will accept one AWG #14 (2.1 mm<sup>2</sup>) or two AWG #16 (1.3 mm<sup>2</sup>) copper 75\_ C (167\_ F) wires. Each terminal can accept solid or stranded wires, but the wires in any given terminal should be the same type. The suggested torque for the power supply terminal board is 12 in-lbs (1.36 Newton-meters). Open the door protecting the terminal board and make the following connections from the AC power source, and ground connections (system grounding requirements are described in detail later in this chapter).

1. These are wide range supplies that can operate from an AC power source within the nominal range of 100 VAC to 240 VAC at 50/60 Hz. This may vary -15% to +10% for a total maximum range of 85 VAC to 264 VAC. These are auto-ranging supplies that do not require jumper or switch settings for selection of power source voltage.
2. Connect the hot and neutral wires or lines L1 and L2 to the upper two terminals on the terminal board. Connect the safety ground wire to the ground terminal, which is the third terminal from the top, and is marked with a ground symbol.
3. For power supplies with six terminals, the factory jumper between the 3rd and 4th terminals (see figure below), should be left in place for normal installations. However, this jumper must be removed and external surge suppressors installed in installations with a "Floating Neutral" input. Please see the section "Special Instructions for Floating Neutral (IT) Systems" later in this chapter for details.
4. After all connections to Power Supply terminal board have been completed, the protective cover plate should be carefully reinstalled.



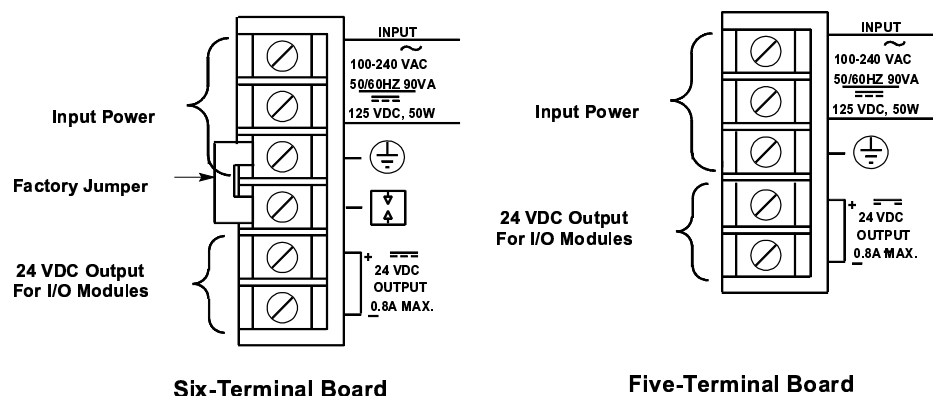


Figure 2-15. Power Supply Terminal Boards

## Power Supply Overvoltage Protection Devices

The overvoltage protection devices for this power supply are connected internally to pin 4 on the user terminal board. This pin is normally connected to frame ground (pin 3) with the supplied jumper strap which is installed at the factory. If overvoltage protection is not required *or* is supplied upstream, this feature can be disabled by leaving pin 4 unconnected by removing the jumper strap. Also, this jumper must be removed and external surge suppressors installed in installations with a “Floating Neutral” input, please see the following section “Special Instructions for Floating Neutral (IT) Systems” later in this chapter.

If you want to Hi-pot test this supply, overvoltage protection *must be disabled* during the test by removing the terminal board strap. Re-enable overvoltage protection after testing by reinstalling the strap.

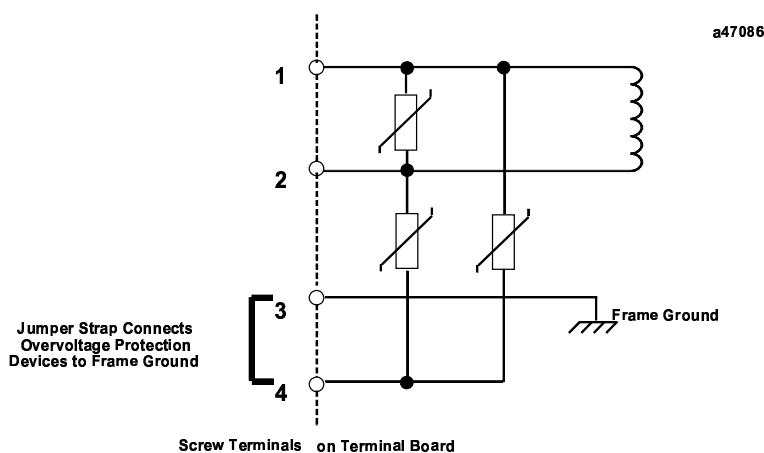


Figure 2-16. Overvoltage Protection Devices and Jumper Strap



## Special Installation Instructions for Floating Neutral (IT) Systems

When the AC input power supplies listed below are installed in a system where the Neutral line is **not** referenced to Protective Earth Ground, these special installation instructions must be followed to prevent damage to the power supply.

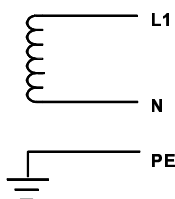
IC693PWR321S (or later version)

IC693PWR330A (or later version)

### Definition of Floating Neutral Systems

A *Floating Neutral System* is a system of power distribution wiring where Neutral and Protective Earth Ground are **not** tied together by a negligible impedance. In Europe this is referred to as an IT system (see IEC950). In a *Floating Neutral System*, voltages measured from input terminals to protective earth ground may exceed the 264 Volts AC maximum input voltage specified in the power supply specifications in Chapter 24 in this manual.

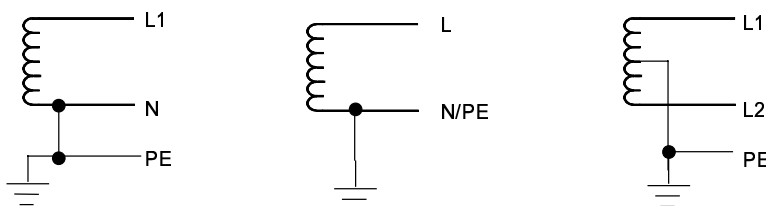
#### Example of Floating Neutral System



This system **must** be installed using the special installation instructions on the following page.

Systems in which one leg of the power distribution wiring is tied to Protective Earth or a tap between two legs of the power distribution wiring is tied to Protective Earth are **not** *Floating Neutral Systems*.

#### Examples of Non-Floating Neutral System



These non-floating neutral systems **do not** require these special installation instructions.



## Use These Special Installation Instructions for Floating Neutral Systems

1. The input power terminals should be wired according to the instructions in the “AC Power Source Connections” section of this chapter.
2. The factory installed jumper between terminals 3 and 4 of the Power Supply module **must** be removed if using one of the Power Supplies that have this feature. See the “Overvoltage Protection Devices” section of the “Power Supplies” chapter for details.
3. Voltage surge protection devices, such as MOVs, **MUST** be installed between the following terminals:
  - From L1 to earth ground
  - From L2 (Neutral) to earth ground

The voltage surge devices must be rated such that the system is protected from power line transients that exceed  $Line\ voltage + 100V + (N-PE)_{MAX}$ .

The expression  $N-PE$  refers to the voltage potential between neutral and Protective Earth (PE) ground.

For example, in a 240 Volt AC system with neutral floating 50V above earth ground, the transient protection should be rated at:

$$240V + 100V + 50V = 390V$$



## DC Power Source Connections

### DC Input Wiring to AC/DC and DC-Only Power Supplies

DC Input power can range from 12 to 30 VDC for the 24 VDC supply, 18 to 56 VDC for the 24/48 VDC supply or 100 to 150 VDC for the 125 VDC supply. All Series 90-30 power supplies have DC input capabilities. The following connection information applies to all of them:

Connect the + and - wires from the power source to the top terminals on the terminal board (+ to the top terminal, - to the second terminal). Connect the third terminal from the top to system ground.

### +24 VDC Output (All Supplies)

The bottom two terminals are connected to the isolated 24 volt DC output that can be used to supply power to input circuits (within power limitations of the supply).

#### Warning

**If the same DC input power source is used to provide power to two or more power supplies in a Series 90-30 PLC System, ensure that connection polarity is identical at each rack (top terminal + and second terminal -). Do not cross the Positive (+) and Negative (-) lines. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each baseplate must be connected to a common system ground, described earlier in this chapter.**



## Basic Installation Procedure

**Note:** Series 90-30 PLCs must be mounted in a protective enclosure. The enclosure should be capable of properly dissipating the heat produced by all of the devices mounted inside it. For details on calculating heat dissipation, refer to Appendix F.

The system design, which includes producing the layout and wiring drawings, should be completed before beginning the installation procedure. This section offers a basic step-by-step approach to installing a Series 90-30 PLC system. Some steps refer to earlier sections of this chapter for additional details. An attempt was made to place the steps in an order that will make the process as efficient as possible. However, due to the wide variance in system designs, this order may not be the most efficient for your system, so you may wish modify this procedure to fit your needs.

1. Gather the schematics, layouts, prints, and other information for the job.

### Warning

**To avoid the possibility of electrical shock to personnel or damage to your PLC, we recommend that you shut off all power to the system before mounting and wiring the PLC. Also, keep all electronic components away from the area while drilling and tapping to keep metal chips and filings out of these sensitive components.**

2. From the layout drawing, determine where the baseplate(s) will be mounted. Lay out the hole locations, either using the dimensions given on your layout drawing or from the “Baseplates” chapter of this manual.
3. Mark the hole locations for the baseplate safety ground wire (see “Baseplate Safety Ground” in this chapter).
4. Mark the hole locations for module shield ground connections (if any). See “Module Shield Ground” (and accompanying sections) in this chapter for instructions.
5. Finish laying (marking hole locations) out the rest of the system. This includes any terminal blocks you will be using. DIN-rail mounted terminal blocks for some of the 32-point I/O modules are manufactured by Weidmuller. DIN-rail mounted GE Fanuc Terminal Block Quick Connect (TBQC) assemblies are optional for some of the 16-point and 32-point discrete I/O modules. If using these TBQCs, refer to Appendix H for data. Also, APM and DSM modules use DIN-rail mounted terminal blocks.

### Note

We recommend drilling and tapping all holes before mounting any components. This will avoid getting chips and filings in the components.

6. Drill and tap the marked holes. For baseplate mounting, use 8-32 or 4mm size.
7. Mount the baseplates. Use good quality 8-32 x 1/2 inch or 4 x 12mm size screws. We recommend using star lock washers and flat washers under the screw heads (star lock washer should be located between screw head and flat washer) to ensure a tight baseplate ground connection, and to keep the screws from loosening. Connect each baseplate ground wire as shown in the “Baseplate Safety Ground” section of this chapter.
8. If you have Expansion or Remote racks, determine the correct rack number for each one, then set the rack numbers using the Rack Number Selection dual in-line package (DIP) switch on



the baseplate. Please refer to the “Baseplates” chapter for details on setting these DIP switches. Rack numbers should be assigned by the system programmer because they correspond to system configuration settings and program memory addressing.

9. If you have more than one baseplate (rack), connect the I/O Bus Expansion Cables between the I/O Bus Expansion Connectors, which are located on the right end of the baseplates. The cables are connected in a “daisy-chain” arrangement from one baseplate to the other. This is made possible by the fact that the cables have a dual connector on one end. Therefore, when the cable is plugged into a baseplate connector, the second connector on that end of the cable provides a socket for connecting to the next cable. The data sheet for the I/O Bus Expansion cables (IC693CBL300 etc.) in the “Cables” chapter has sample wiring figures.
10. On the last I/O Bus Expansion Connector, plug in an I/O Bus Expansion Terminator, Catalog Number IC693ACC307 (unless using a cable with built-in terminator resistors, which would either be GE Fanuc cable IC693CBL302, or your own custom-built cable).
11. Install the modules in their correct slots using your system layout drawings. (The label on the side of each module identifies the module type and catalog number.) Refer to the section “Installing Modules” if you are not familiar with how to do this.
12. Connect cables to Option modules. Route cables away from noise-producing wires. See the “Wire Routing” section of this chapter.
13. Be sure to follow the information in the “Wiring Guidelines” section of this chapter to protect the system from electrical noise. Install the power wires to the Power Supply and I/O modules:
  - **I/O modules with removable terminal boards.** You can wire the terminal boards in-place on the modules or remove them from the modules before wiring. Although removing them may help make wiring easier (a previous section “Working with Removable Terminal Boards” shows how to remove a terminal board), care should be taken to avoid mixing them (each terminal board has the catalog number of the module printed on it, and the hinged cover has a wiring diagram for that module type). If you are using wire duct, routing each module’s wires through the opening in the duct directly under the module will help to keep each terminal board in its correct position.
  - **I/O Modules with terminal blocks.** Some modules use terminal blocks that mount to the enclosure panel. This includes all 32-point modules and, can include other I/O modules if they are fitted with the optional Terminal Block Quick Connect Assembly. Connect the terminal blocks to the connectors on the modules with the provided cables.
14. Connect the signal (switches, sensors, solenoids, etc.) wires to the terminal boards, or terminal blocks/strips. If wiring to terminal boards, these can be removed for ease of wiring, if desired. See the section “Removing a Module’s Terminal Board.”
15. When finished wiring the I/O terminal boards (if used and if you removed them for ease of wiring), re-install them on the modules, being careful to match each one with the correct module.





## ***GE Fanuc Automation***

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*Programmable Control Products*



## ***GE Fanuc Automation***

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*P.O. Box 8106  
Charlottesville, VA 22906*

**GFZ-0085**

## ***Series 90<sup>TM</sup>-30 Programmable Controller***

*Troubleshooting Guide*





## ***GE Fanuc Automation***

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***Programmable Control Products***

### ***Series 90<sup>TM</sup>-30 Programmable Controller Troubleshooting Guide***

***GFZ-0085***

***August 1993***



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| Alarm Master | CIMSTAR              | Helpmate    |
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| GEnet        | Logicmaster          | Series One  |
| Series 90    | CIMPLICITY 90–ADS    | Genius      |
| Modelmaster  | Series Three         | VuMaster    |
| ProLoop      | CIMPLICITY PowerTRAC | Series Five |
| Workmaster   | Genius Power TRAC    |             |

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## General Warnings When Troubleshooting

Stand clear of controlled equipment when power is applied. If the problem is intermittent, sudden unexpected machine motion could occur, causing injury. Also reference NFPA 70E Part II for additional guidelines for safety practices.

Never reach into a machine to operate a switch since unexpected motion could occur, causing injury.

Remove all electrical power at the Main Power Disconnect to ensure total power removal.

Always remove power before inserting or removing modules, or before connecting I/O cabling.



This guide describes a logical sequence for troubleshooting your Series 90–30 programmable controller. It includes the procedure for changing or adding a EPROM or EEPROM to your CPU. The Series 90–30 PLC is a member of the Series 90<sup>TM</sup> family of programmable logic controllers from GE Fanuc Automation.

## Revisions to this Troubleshooting Guide

This is the first release of this Troubleshooting Guide. Included are models CPU 311, 313, 321, 323, 331 and 341.

## Related Publications

*Series 90<sup>TM</sup>–30 Programmable Controller Installation Manual* (GFK–0356).

*Series 90<sup>TM</sup>–30 and 90–20 PLC Hand–Held Programmer User's Manual* (GFK–0402)

*Logicmaster<sup>TM</sup> 90 Series 90–30 and 90–20 Programming Software User's Manual* (GFK–0466)

*Series 90<sup>TM</sup>–30/90–20 Programmable Controllers Reference Manual* (GFK–0467)

## We Welcome Your Comments and Suggestions

At GE Fanuc Automation, we strive to produce quality technical documentation. After you have used this troubleshooting guide, please take a few moments to write us with your comments and suggestions. Our address is: Manager Technical Publications, GE Fanuc Automation. PO Box 8106, Charlottesville, VA 22906

*Drake C. Fink*  
Sr. Staff Systems Engineer



# SYMBOLS USED IN THIS GUIDE

Sinnamon Road Sinnamon Park SPS SP181 Backup Generator Operation and Maintenance Manual (SE Power)

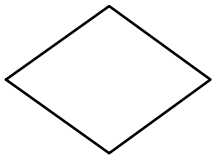


BEGIN AT THIS SYMBOL  
ON THE FIRST CHART.

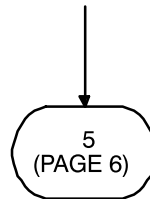


FOLLOW THE PATH WITH  
THE CORRECT ANSWER IN  
THE DIRECTION OF THE  
ARROW

SYMBOLS USED THROUGHOUT THE GUIDE  
ARE GEOMETRICALLY CODED



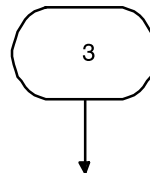
A DIAMOND ASKS A  
QUESTION



A NUMBERED BUBBLE WITH  
AN ARROW INTO THE BUBBLE  
INDICATES THAT THE  
PROCEDURE IS CONTINUED  
AT A CORRESPONDINGLY  
NUMBERED BUBBLE ON THE  
INDICATED PAGE NUMBER.



A RECTANGLE TELLS  
YOU TO DO SOMETHING



A NUMBERED BUBBLE WITH  
AN ARROW OUT OF THE  
BUBBLE INDICATES THE  
START OF A PROCEDURE ON  
THAT PAGE.



## Adding or Changing the EEPROM in the 90™–30

Application programs are normally developed in the CPU's RAM memory and executed from RAM memory. If additional program integrity is desired, or operation of the PLC without a battery is desired, an optional EEPROM or EPROM can be installed in a spare socket (labeled PROGRAM PROM) on the Model 311/313 backplane or in a socket on the model 331/341 CPU module. EEPROMs can be written to and read from. EPROMs can be read when installed in the PLC; however, they must be written to using an external PROM programming device.

Following is the procedure for adding or changing the EEPROM or EPROM. For clarity, the term PROM is used to refer to either an EEPROM or an EPROM.

1. Remove power from the system.
2. If 311/313
  - Remove all modules, including the power supply.
  - Remove the plastic cover.
3. If 331/341:
  - Remove CPU from backplane.
  - Remove front plate and bezel. Unsnap circuit board and remove from case.
4. If the socket is the type which has a screw near the top edge (some versions of 311/331), loosen screw at top of PROM socket (CCW twist;).
5. If present, remove old PROM from socket. Replace with or install new PROM. Orient the PROM so the end with a notch (the top of the prom) is toward the top edge of the backplane. Pin 1 of the prom is the first pin on the left as you move counter-clockwise from the notch. On the 311/331, correct installation orients the notch toward the screw.
6. When present, tighten screw at top of PROM socket (CW twist).
7. If 311/313:
  - Replace the plastic cover.
  - Replace all modules, including the power supply.

### 8. If 331 CPU:

- Assure jumper JP1, located at the bottom of the PROM socket, is in the 1–2 position for EPROM and the 3–2 position for EEPROM. This informs the CPU firmware which type of device is present.

### 9. If 331/341 CPU:

- Replace circuit board in case.
- Reinstall front plate and bezel.
- Replace CPU in backplane.



## Changing the EEPROM (continued)

10. Apply power. The PLC follows the flowchart found in the "Power-Up Sequence" figure in the Power-Up and Power-Down Section of the *Series 90-30/90-20 Programmable Controllers Reference Manual* (GFK-0467) to determine if a program will be loaded from PROM to RAM.
11. For the EEPROM to be used by the CPU, the CPU configuration must be set to use EEPROM as the "Program Source". You may use the LM90 Configuration software or the HHP to accomplish this.
12. To store the program in RAM, you may use either the Hand-Held Programmer or Logicmaster 90-30, Rev 3.5 or higher. Refer to the instructions in the *HHP User's Manual* (GFK-0402) for HHP. To use Logicmaster 90-30, follow these instructions:
  - Start the LM90-30 Programmer Package
  - Activate the Utilities Menu (F9)
  - Select the EEPROM function (F10)
  - Select the WRITE operation
  - Verify the items you want to write to EEPROM are selected.
  - Press ENTER to start the operation. Refer to the *Logicmaster 90 Series 90-30 and 90-20 Programming Software User's Manual* (GFK-0466) for more information.

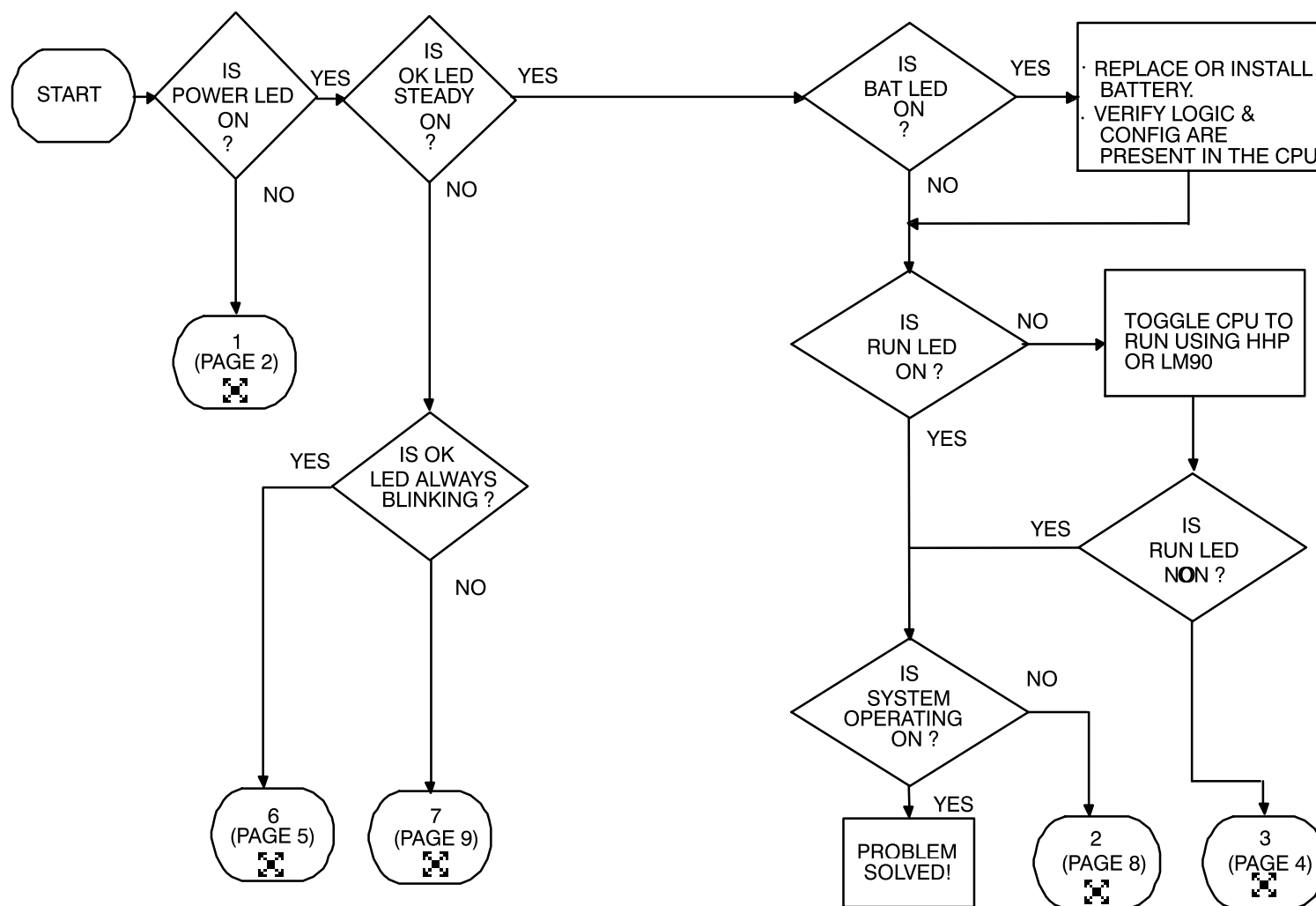


## Notes and Precautions

1. **WARNING:** Do not discard the lithium–manganese dioxide battery in fire. Do not attempt to discharge the battery. The battery may burst or burn or release hazardous materials. Dispose of the battery as you would any hazardous material.
2. **CAUTION:** After a power fault, the system will come back on in the mode (*STOP, RUN/ENABLED, RUN/DISABLED*) in which it was operating before power loss, unless the power up configuration specifies a particular mode.
3. Not having a battery installed will not prevent the PLC from running. It will generate a PLC fault on power cycle that prevents the PLC from entering *RUN* mode automatically. Clearing this fault will enable the PLC to be placed in *RUN* mode.
4. To short the 'super cap' on a 311/321 PLC:
  - Remove power from the system.
  - Remove all modules, including the power supply.
  - Remove the plastic face plate.
  - Find component C20 along the left edge of the module. This is the 'super cap'. Short the positive (+) and negative (–) leads of this device.
  - Replace the plastic face plate.
  - Replace all modules.
  - Restore power to the system.
5. Supply (input) voltage tolerances for Series 90–30 power supplies:
 

|              |  |
|--------------|--|
| IC693PWR321: | 100 to 240 VAC<br>100 to 250 VDC (125 VDC nominal)                   |
| IC693PWR322: | 18 to 56 VDC, 21 VDC<br>minimum to start<br>24 VDC OR 48 VDC nominal |
6. Total cable length must not exceed 50 feet between a CPU rack and an expansion rack. Length must not exceed 700 feet between a CPU rack and a remote rack. No termination plug is needed on a one–rack system.



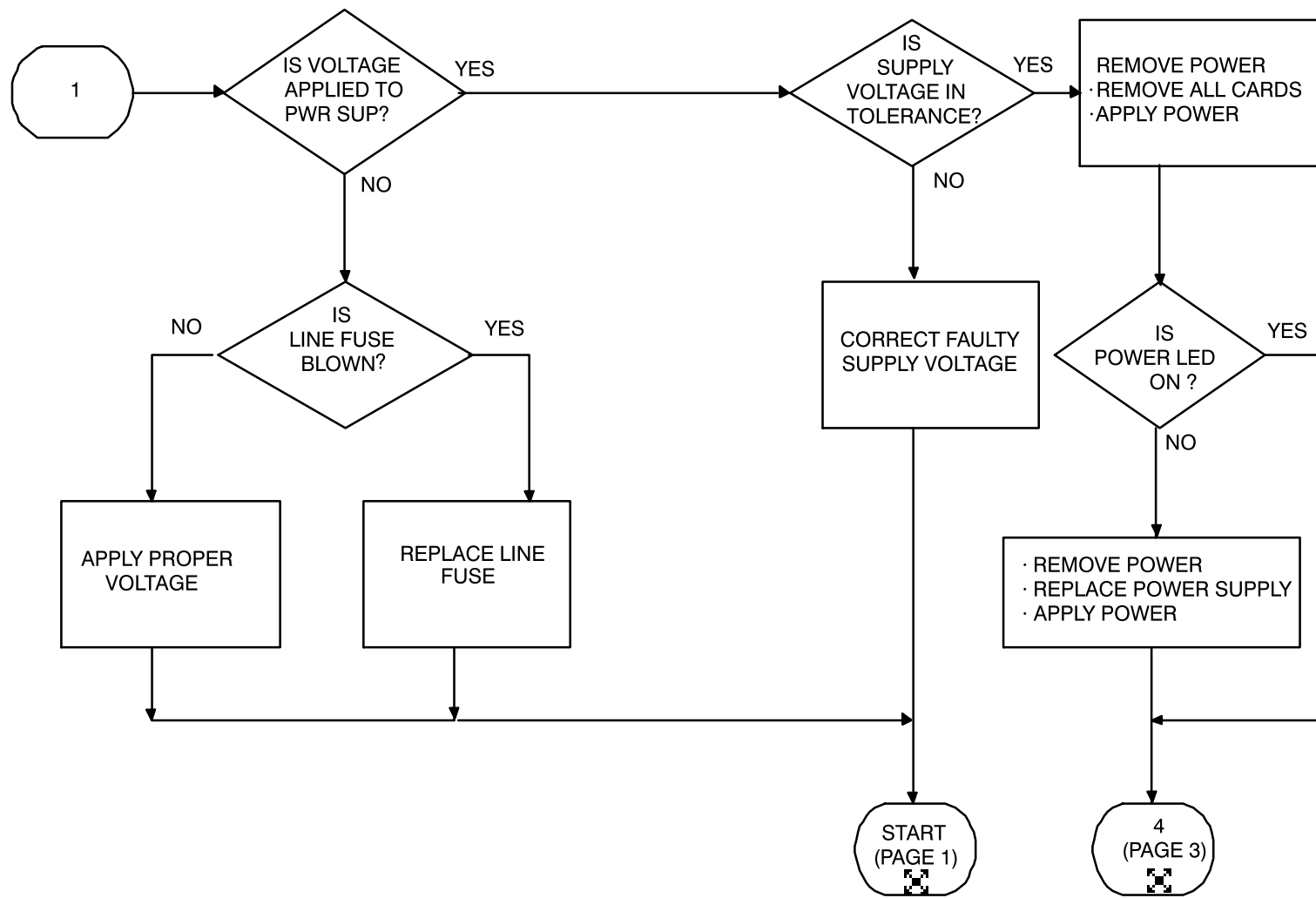


PAGE 1

(Refer to the Preface for information on safety considerations, related publications and the symbols used in this guide.)

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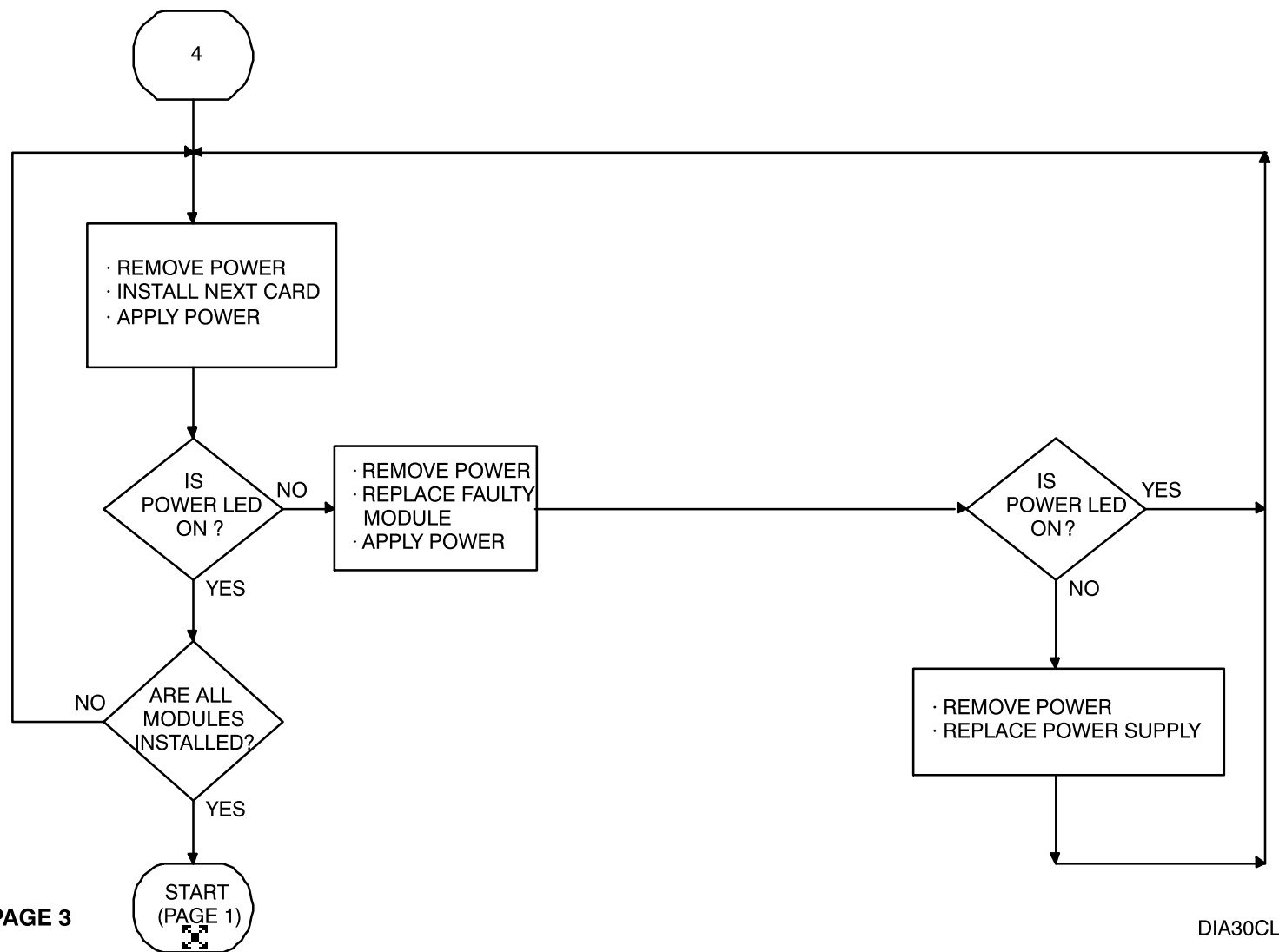




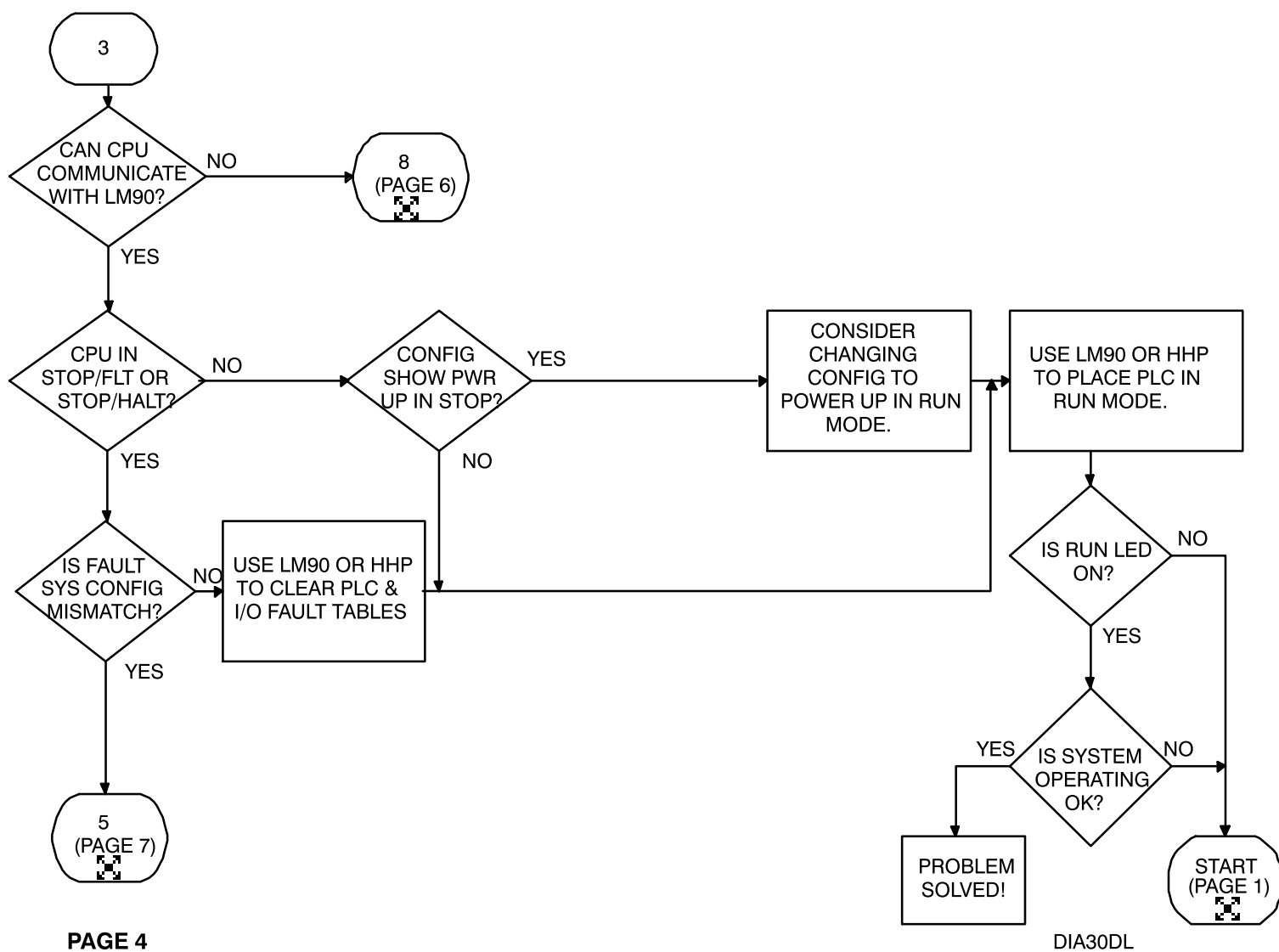
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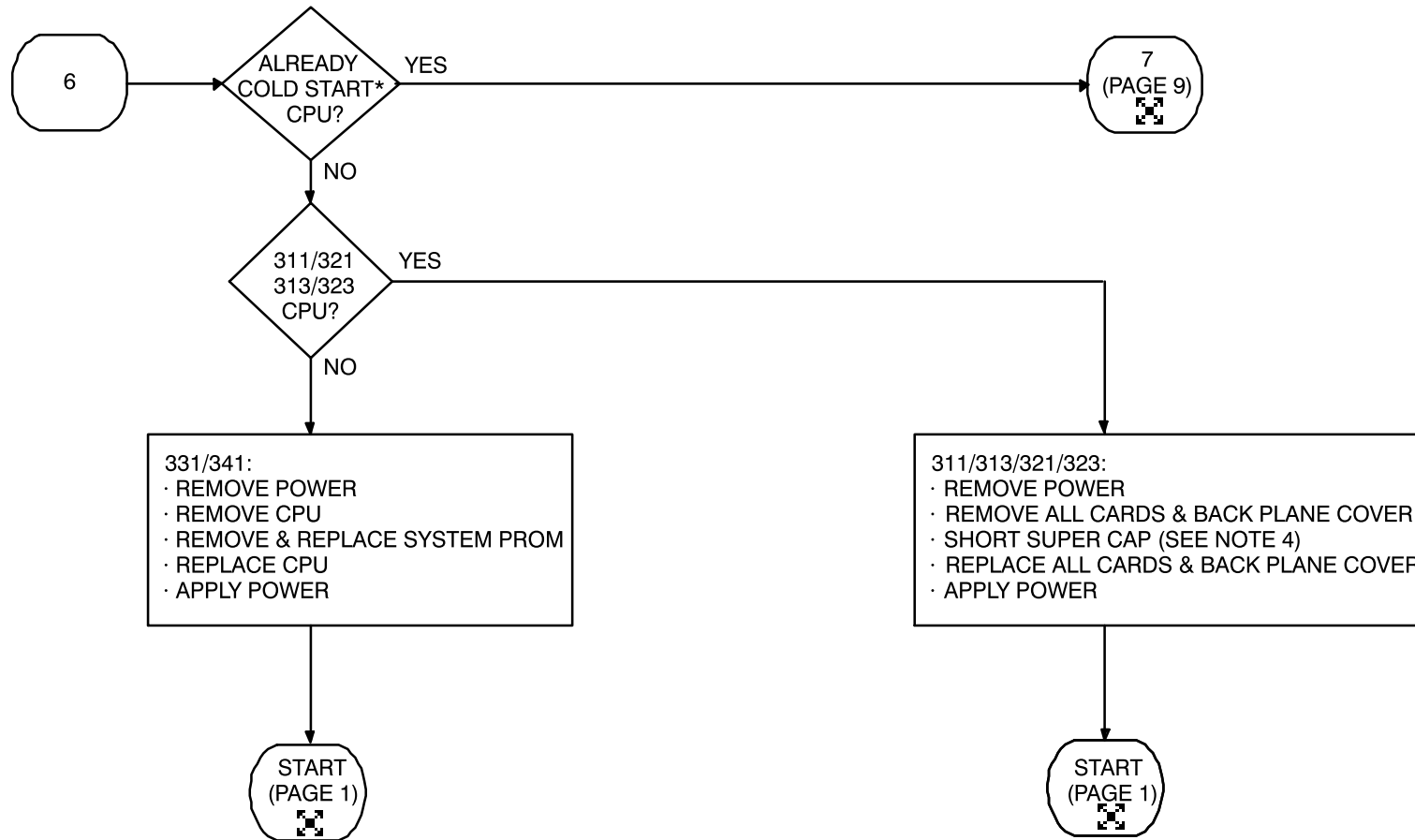










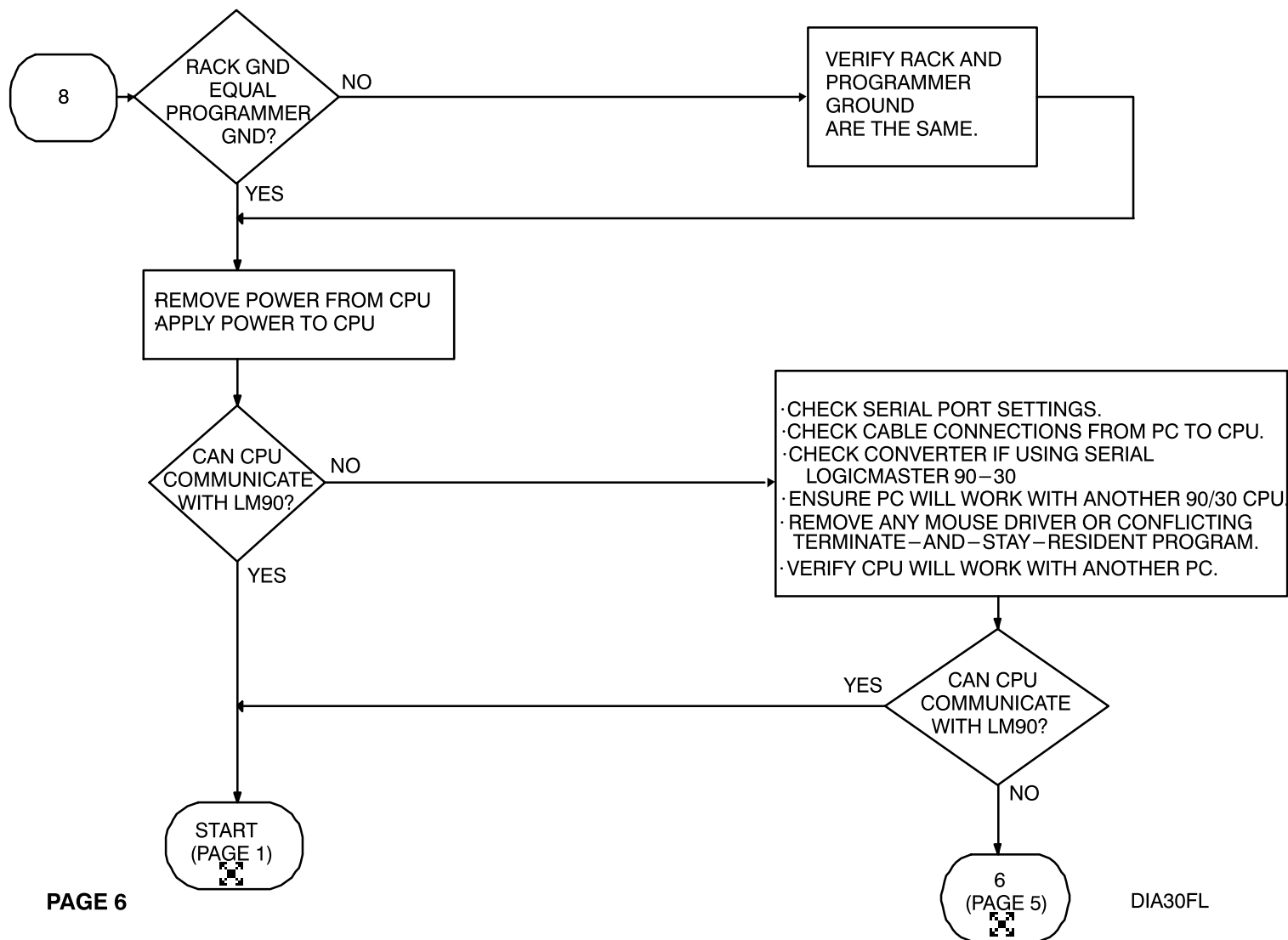


\*COLD START DELETES THE CONTENTS OF THE CPU'S MEMORY AND RESTORES COMMUNICATION PARAMETERS (BAUD RATE, PARITY, ETC.) TO THEIR DEFAULT VALUES.

PAGE 5

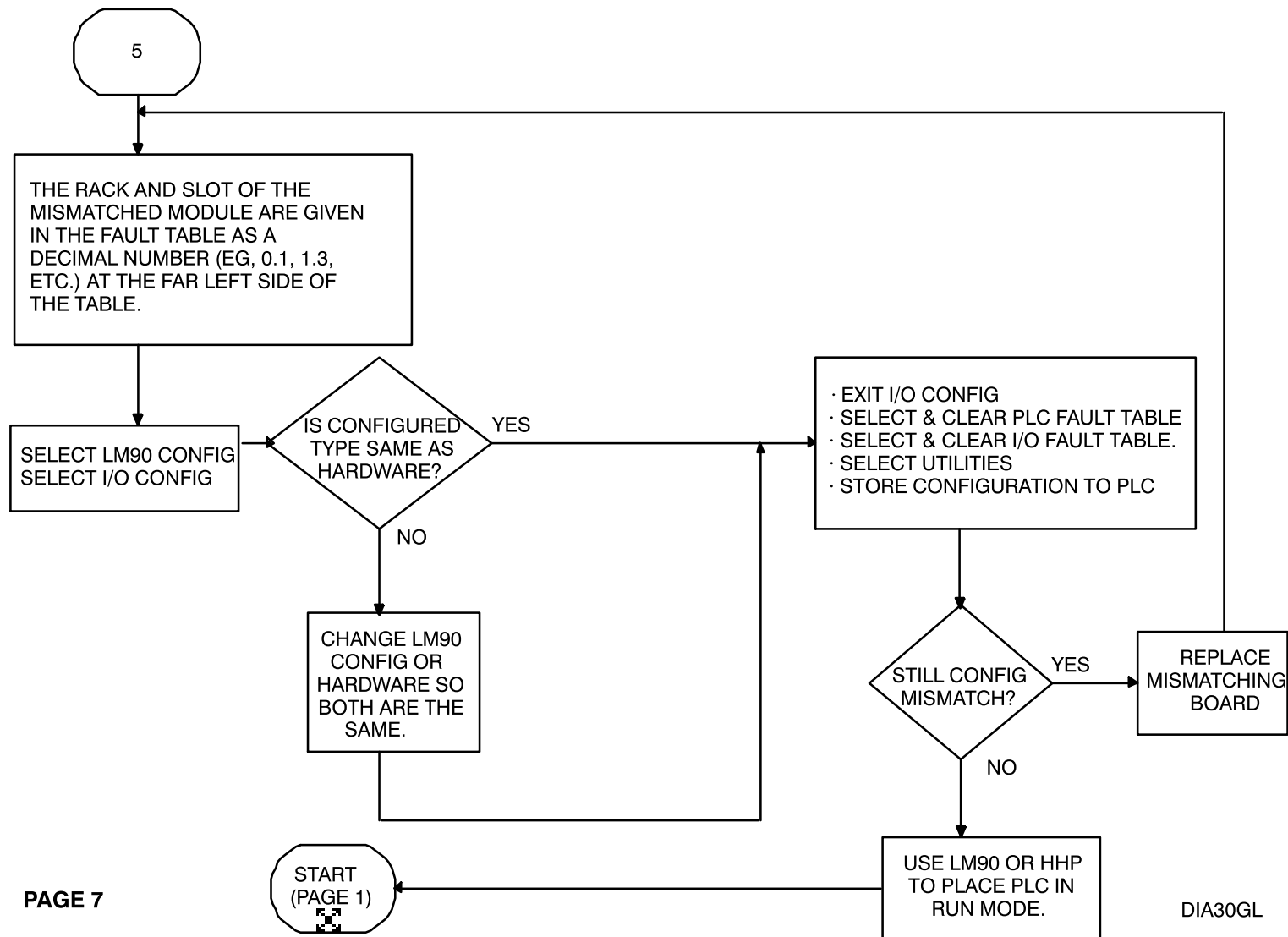
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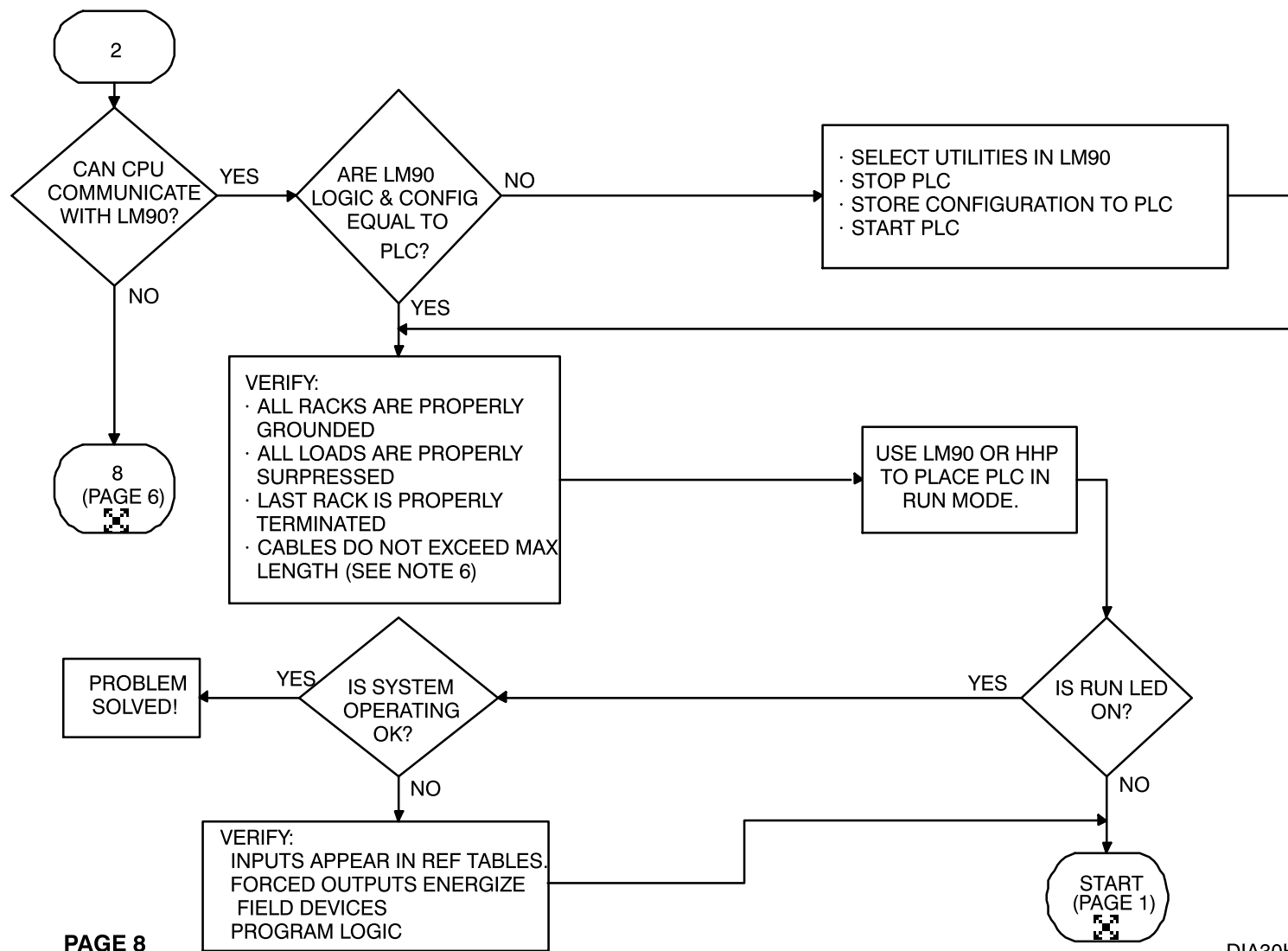


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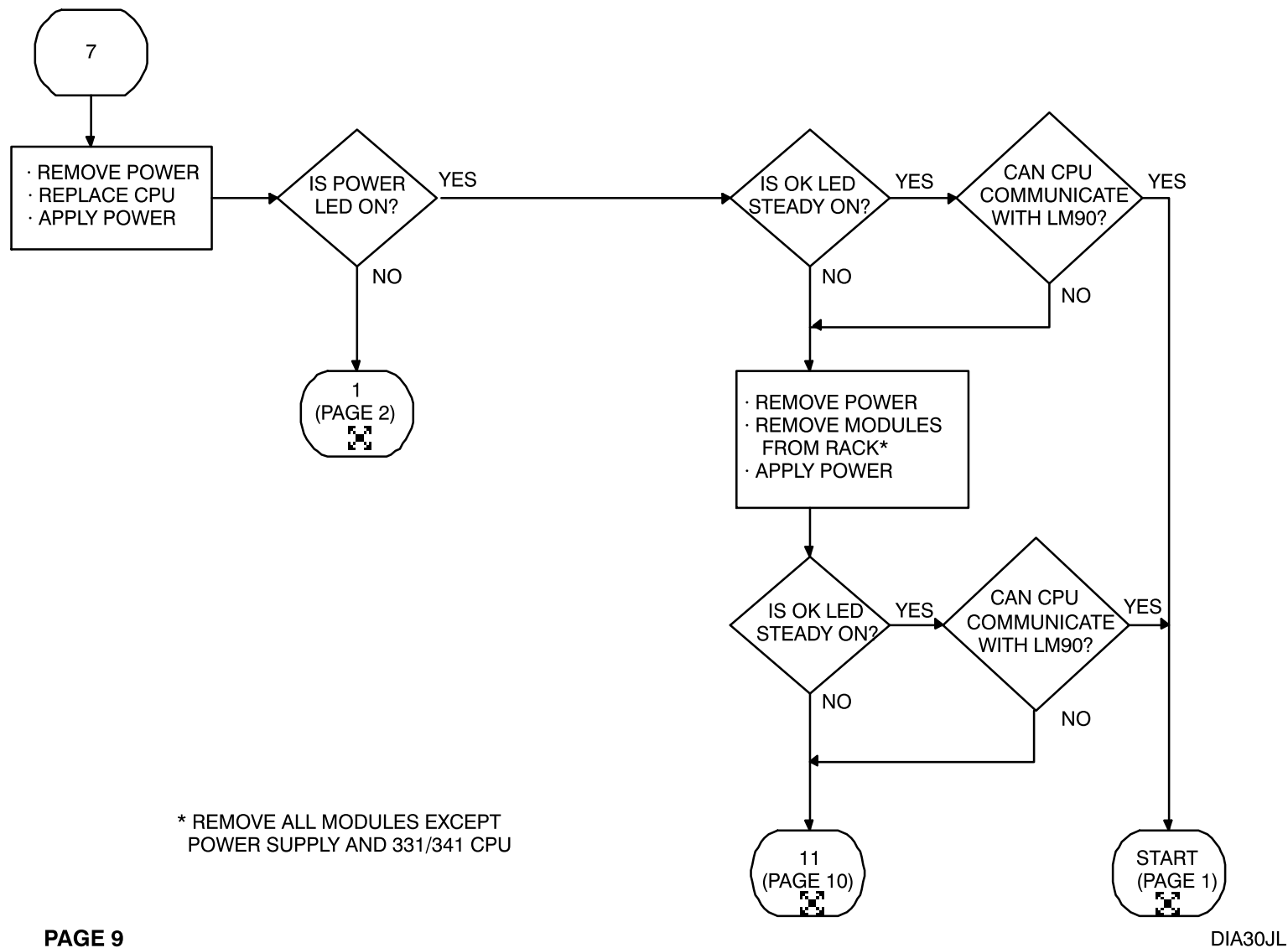






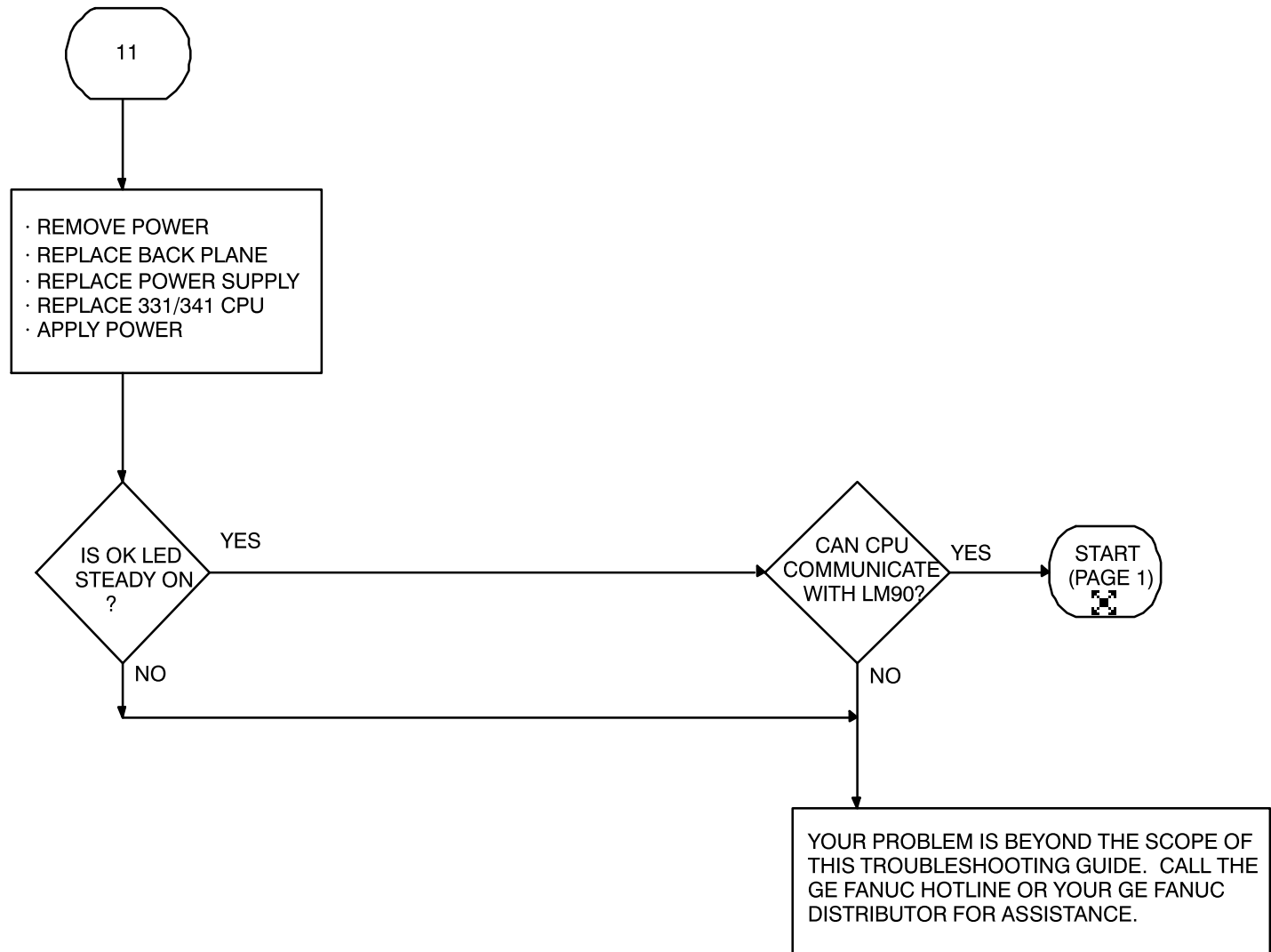
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PAGE 9





DIA30KL

PAGE 10



# SP181

## Section 6 - Functional Description





**DIESEL STANDBY GENERATOR**

**LOCAL CONTROL PANEL**

**FUNCTIONAL DESCRIPTION**

**FOR**

**Brisbane City Council**

19th May 2003



## ABBREVIATIONS

G1      Generator 1 Diesel



## 1. **GENERAL**

- 1.1. The PLC for the above operation is a GE Fanuc IC693CPU350. This program has been designed for the use on G1. The operation below controls G1.
- 1.2. A mode selector switch selects how G1 shall operate :
  - 1.2.1. Off
  - 1.2.2. Manual Mode
  - 1.2.3. Test Mode.
  - 1.2.4. Automatic Mode.

## 2. **MANUAL MODE**

- 2.1. To operate G1 in MANUAL Mode.
- 2.2. Select this operation by turning the AUTO – TEST – MAN- OFF selector switch to the MANUAL position.
- 2.3. Press the MANUAL START push button to start the generator.
- 2.4. The generator will begin to crank.
  - 2.4.1. If it fails to start within the 10 seconds, the starter motor is stopped and a delay of 10 seconds before it will attempt to restart.
  - 2.4.2. The generator set is allowed 3 attempts to start.
  - 2.4.3. If it fails to start on the third attempt, the generator is locked out on FAIL TO START Alarm.
  - 2.4.4. When the generator starts, the starter motor is stopped by a stop cranking input which measures the speed of the generator.
  - 2.4.5. Once the generator has started, there is a 10 second time delay for the oil pressure to stabilise.
  - 2.4.6. If the oil pressure is not up to pressure after the 10 second time delay, the generator shall shut down on LOW OIL PRESS Alarm.
  - 2.4.7. Once the generator is running there is a 5 second warm up time before it is ready to accept load.



2.5. To Manual Transfer to Generator in the MANUAL Mode.

2.5.1. Start the generator and wait for the generator to run up to speed and voltage and ready to accept load.

2.5.2. Press the MANUAL TRANSFER TO GEN push button.

2.5.3. The MAINS ATS shall Open.

2.5.4. After a 30 second delay the GEN ATS shall Close.

2.5.5. If the MAINS ATS fails to Open.

2.5.5.1. After a 5 second delay an Alarm shall be generated and the MAINS CONNECTED indicator shall flash to indicate the Alarm.

2.5.5.2. The system shall return back to MAINS ATS operation.

2.5.6. If the GEN ATS fails to Close.

2.5.6.1. After a 5 second delay an Alarm shall be generated and the GENERATOR CONNECTED indicator shall flash to indicate the Alarm.

2.5.6.2. The system shall return back to MAINS ATS operation.

2.6. To Manual Transfer to Mains in the MANUAL Mode.

2.6.1. The GENERATOR ATS is Closed.

2.6.2. Press the MAN TRANSFER TO MAINS push button.

2.6.3. The GEN ATS shall Open.

2.6.4. After a 30 second delay the MAINS ATS shall Close.

2.6.5. If the GEN ATS fails to Open.

2.6.5.1. After a 5 second delay an Alarm shall be generated and the GENERATOR CONNECTED indicator shall flash to indicate the Alarm.

2.6.5.2. The system shall return back to GEN ATS operation.

2.6.6. If the MAINS ATS fails to Close.



2.6.6.1. After a 5 second delay an Alarm shall be generated and the MAINS CONNECTED indicator shall flash to indicate the Alarm.

2.6.6.2. The system shall return back to GEN ATS operation.

2.7. To stop the generator in the MANUAL Mode.

2.7.1. When the generator is running, it may be stopped by pressing the MANUAL STOP push button.

2.7.2. If the generator is still GEN ATS operation. The MANUAL TRANSFER TO MAINS is initiated.

2.7.3. When the GEN ATS is Open, the generator will enter the cool down time of 1 second.

2.7.4. After the cool down time, the generator will shut down.

2.7.5. Once the generator has shut down there is a 15 second delay before it may be restarted. This is to ensure the engine has mechanically stopped.



### 3. **NON-PERMANENT SITE, MANUAL MODE**

- 3.1. To operate G1 in a Non-Permanent Site Location in MANUAL Mode.
- 3.2. Connect the generator cables to the site generator CB ensuring the site generator CB is OFF. See BCC procedures.
- 3.3. A plug with shorting links is required to be installed. It is required to be plugged into the 27 Pin Station Plug.
  - 3.3.1. Pins 11 and 12 are required to be connected. This is to indicate that the Mains ATS is Closed. If they are not connected a MAINS ATS Alarm shall be indicated.
- 3.4. Select from the AUTO – TEST – MAN- OFF selector switch to the MANUAL position.
- 3.5. Press the MANUAL START push button to start the generator.
- 3.6. The generator will begin to crank.
  - 3.6.1. If it fails to start within the 10 seconds, the starter motor is stopped and a delay of 10 seconds before it will attempt to restart.
  - 3.6.2. The generator set is allowed 3 attempts to start.
  - 3.6.3. If it fails to start on the third attempt, the generator is locked out on FAIL TO START Alarm.
  - 3.6.4. When the generator starts, the starter motor is stopped by a stop cranking input which measures the speed of the generator.
  - 3.6.5. Once the generator has started, there is a 10 second time delay for the oil pressure to stabilise.
  - 3.6.6. If the oil pressure is not up to pressure after the 10 second time delay, the generator shall shut down on LOW OIL PRESS Alarm.
  - 3.6.7. Once the generator is running there is a 5 second warm up time before it is ready to accept load.
- 3.7. To connect the generator to the site load.
  - 3.7.1. Manually switch over to the generator supply via the site CB's. See BCC procedures.
  - 3.7.2. Do not use the MANUAL TRANSFER TO GEN or the MAN TRANSFER TO MAINS push buttons.



3.8. To disconnect the generator from the site load.

3.8.1. Manually switch over to the mains supply via the site CB's. See BCC procedures.

3.8.2. Do not use the MANUAL TRANSFER TO GEN or the MAN TRANSFER TO MAINS push buttons.

3.9. To stop the generator in the MANUAL Mode.

3.9.1. When the generator is running, it may be stopped by pressing the MANUAL STOP push button.

3.9.2. The generator will enter the cool down time of 1 second.

3.9.3. After the cool down time, the generator will shut down.

3.9.4. Once the generator has shut down there is a 15 second delay before it may be restarted. This is to ensure the engine has mechanically stopped.



## 4. TEST OPERATION

- 4.1. To operate the generator in the TEST Mode.
- 4.2. Select this operation by turning the AUTO – TEST – MAN- OFF selector switch to the TEST position.
- 4.3. If the selector is changed to MAN while the generator is operating on TEST, the system shall change to MANUAL TRANSFER TO GEN.
- 4.4. The generator shall begin to crank.
  - 4.4.1. If it fails to start within the 10 seconds, the starter motor is stopped and a delay of 10 seconds before it will attempt to restart.
  - 4.4.2. The generator is allowed 3 attempts to start.
  - 4.4.3. If it fails to start on the third attempt, the generator is faulted on FAIL TO START Alarm.
- 4.5. When the generator starts, the starter motor is stopped by a stop cranking input which measures the speed of the generator.
- 4.6. The MAINS ATS shall Open.
- 4.7. Once the generator has started, there is a 10 second time delay for the oil pressure to stabilise.
- 4.8. If the oil pressure is not up to pressure after the 10 second time delay, the generator shall shut down on LOW OIL PRESS Alarm.
- 4.9. Once the generator is running there is a 5 second warm up time before it is ready to accept load.
- 4.10. After the warm up time has expired and the MAINS ATS has been open for 30 seconds the GEN ATS shall Close.
- 4.11. If the MAINS ATS fails to Open.
  - 4.11.1. After a 5 second delay an Alarm shall be generated and the MAINS CONNECTED indicator shall flash to indicate the Alarm.
  - 4.11.2. The system shall shut down and return back to MAINS ATS operation.
- 4.12. If the GEN ATS fails to Close.



- 4.12.1. After a 5 second delay an Alarm shall be generated and the GENERATOR CONNECTED indicator shall flash to indicate the Alarm.
- 4.12.2. The system shall shut down and return back to MAINS ATS operation.
- 4.13. To stop the generator in the TEST Mode.
  - 4.13.1. Select this operation by turning the AUTO – TEST – MAN- OFF selector switch to the AUTO or OFF position.
  - 4.13.2. The GEN ATS shall Open.
  - 4.13.3. After a 30 second delay the MAINS ATS shall Close.
  - 4.13.4. If the GEN ATS fails to Open.
    - 4.13.4.1. After a 5 second delay an Alarm shall be generated and the GENERATOR CONNECTED indicator shall flash to indicate the Alarm.
    - 4.13.4.2. The system shall return back to GEN ATS operation.
  - 4.13.5. If the MAINS ATS fails to Close.
    - 4.13.5.1. After a 5 second delay an Alarm shall be generated and the MAINS CONNECTED indicator shall flash to indicate the Alarm.
    - 4.13.5.2. The system shall return back to GEN ATS operation.
  - 4.13.6. When the GEN ATS is Open, the generator will enter the cool down time of 5 minutes.
  - 4.13.7. After the cool down time, the generator will shut down.
  - 4.13.8. If a Mains Failure occurs during the cool down period the generator shall transfer back to the GENERATOR ATS without shutting down.
  - 4.13.9. Once the generator has shut down there is a 15 second delay before it may be restarted. This is to ensure the engine has mechanically stopped.



## 5. **AUTOMATIC OPERATION**

- 5.1. To operate the generator in the AUTO Mode.
- 5.2. Select this operation by turning the AUTO – TEST – MAN- OFF selector switch to the AUTO position.
- 5.3. The Phase Failure Relay from the clients switch board shall give a Start Signal for the generators to run.
- 5.4. The Remote Start Command.
  - 5.4.1. The generator shall begin to crank.
    - 5.4.1.1. If it fails to start within the 10 seconds, the starter motor is stopped and a delay of 10 seconds before it will attempt to restart.
    - 5.4.1.2. The generator is allowed 3 attempts to start.
    - 5.4.1.3. If it fails to start on the third attempt, the generator is faulted on FAIL TO START Alarm.
  - 5.4.2. When the generator starts, the starter motor is stopped by a stop cranking input which measures the speed of the generator.
  - 5.4.3. The MAINS ATS shall Open.
  - 5.4.4. Once the generator has started, there is a 10 second time delay for the oil pressure to stabilise.
  - 5.4.5. If the oil pressure is not up to pressure after the 10 second time delay, the generator shall shut down on LOW OIL PRESS Alarm.
  - 5.4.6. Once the generator is running there is a 5 second warm up time before it is ready to accept load.
  - 5.4.7. After the warm up time has expired and the MAINS ATS has been open for 30 seconds the GEN ATS shall Close.
  - 5.4.8. If the MAINS ATS fails to Open.
    - 5.4.8.1. After a 5 second delay an Alarm shall be generated and the MAINS CONNECTED indicator shall flash to indicate the Alarm.



5.4.8.2. The system shall shut down and return back to MAINS ATS operation.

5.4.9. If the GEN ATS fails to Close.

5.4.9.1. After a 5 second delay an Alarm shall be generated and the GENERATOR CONNECTED indicator shall flash to indicate the Alarm.

5.4.9.2. The system shall shut down and return back to MAINS ATS operation.

5.5. To stop the generator in the AUTO Mode.

5.5.1. The Phase Failure Relay from the clients switch board shall give a Stop Signal for the generators to run.

5.5.2. The Remote Stop Command.

5.5.3. There is a 2 minute proving time for the Phase Failure Relay.

5.5.4. After the 2 minute proving time the GEN ATS shall Open.

5.5.5. After a 30 second delay the MAINS ATS shall Close.

5.5.6. If the GEN ATS fails to Open.

5.5.6.1. After a 5 second delay an Alarm shall be generated and the GENERATOR CONNECTED indicator shall flash to indicate the Alarm.

5.5.6.2. The system shall return back to GEN ATS operation.

5.5.7. If the MAINS ATS fails to Close.

5.5.7.1. After a 5 second delay an Alarm shall be generated and the MAINS CONNECTED indicator shall flash to indicate the Alarm.

5.5.7.2. The system shall return back to GEN ATS operation.

5.5.8. When the GEN ATS is Open, the generator will enter the cool down time of 5 minutes.

5.5.9. After the cool down time, the generator will shut down.

5.5.10. If a Mains Failure occurs during the cool down period the generator shall transfer back to the GENERATOR ATS without shutting down.



- 5.5.11. Once the generator has shut down there is a 15 second delay before it may be restarted. This is to ensure the engine has mechanically stopped.



## 6. FAULT OPERATION

### 6.1. Emergency Stop Operation.

6.1.1. Operation of the Emergency Stop push button immediately shuts down the generator and Opens the Generator CB. The Emergency Stop is latched, and requires manual resetting to release the Emergency Stop push button.

6.1.2. After the Emergency Stop push button is released, a fault reset will need to be initiated to reset the PLC.

### 6.2. HIGH HIGH Alarm Operation.

6.2.1. The Generator CB is Opened immediately.

6.2.2. The generator is shut down immediately.

6.2.3. The following alarms will initiate a HIGH HIGH Alarm condition :-

6.2.3.1. Emergency Stop Fault

6.2.3.2. MEN Fault

6.2.3.3. Low Oil Pressure Shutdown Fault, 10 Seconds Startup Delay

6.2.3.4. High Engine Temperature Shutdown Fault, 30 Second Startup Delay

6.2.3.5. Low Radiator Level Fault, 5 Second Delay

6.2.3.6. Over Speed Fault

### 6.3. HIGH Alarm Operation

6.3.1. The Generator CB is Opened immediately.

6.3.2. Once the generator circuit breaker is opened, the generator will run through its normal cool down time and shut down.

6.3.3. The following alarms will initiate a HIGH Alarm condition:-

6.3.3.1. Generator Under Speed Fault, 5 Second Delay

6.3.3.2. Alternator Under Voltage Fault, 5 Second Delay

6.3.3.3. Alternator Over Voltage Fault, 5 Second Delay



6.3.3.4. Generator CB Tripped Fault

6.3.3.5. Alternator High Temperature Fault, 30 Second Startup Delay

6.4. MEDIUM Alarm Operation.

6.4.1. A Normal Shutdown shall be Initiated.

6.4.2. If the GEN ATS does not Open then the Generator CB is Opened.

6.4.3. The following alarms will initiate a MEDIUM Alarm condition :-

6.4.3.1. Fuel Empty Level Fault, 5 Second Delay

6.4.3.2. Fail To Start Fault, 3 Attempts

6.5. LOW Alarm Operation.

6.5.1. A Warning has occurred on the generator. The generator will not shut down.

6.5.2. The following alarms will initiate a LOW Alarm condition :-

6.5.2.1. Low Oil Pressure Warning Alarm, 10 Seconds Startup Delay

6.5.2.2. High Engine Temperature Warning Alarm, 30 Second Startup Delay

6.5.2.3. Fuel Low Level Alarm, 5 Second Delay

6.5.2.4. Battery Charger AC Supply Failed Alarm, 60 Second Delay

6.5.2.5. Control Battery Low Volts Alarm, 30 Second Delay

6.5.2.6. Start Battery Low Volts Alarm, 60 Second Delay



# NTB Design

Folder Name..... BCC\_4000\_2  
Nickname..... C4000\_2  
Location..... C:\Program Files\GE Fanuc Automation\VersaPro  
                              \Project\BCC\_4000\_2  
Created..... 27-Jun-03, 16:36:03  
Modified..... 03-Jul-03, 18:02:02  
Description..... BCC, Standby Generator, 4000

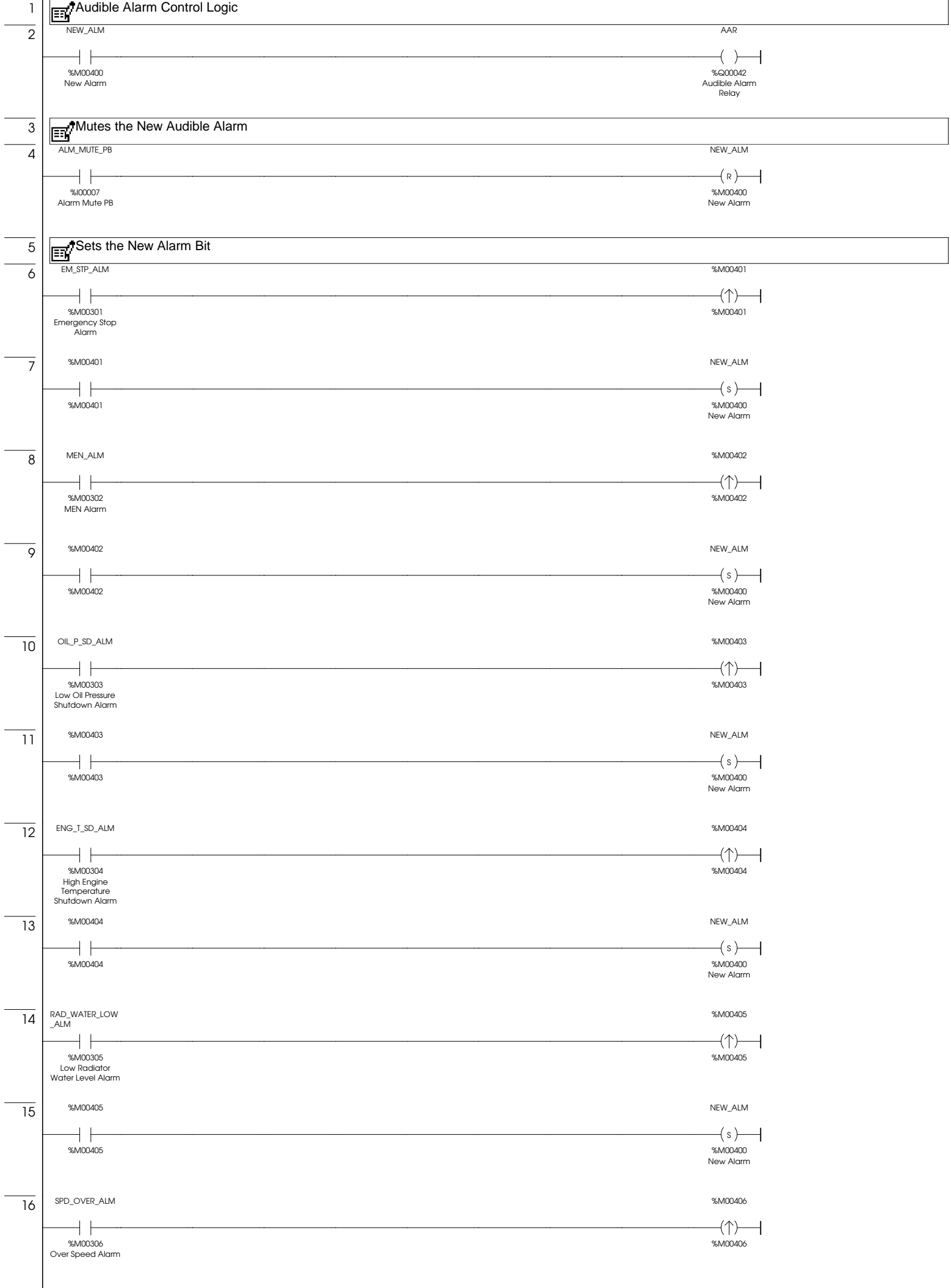


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Description:.....Control Logic for the Audiable Alarm Logic.

Block Type:.....Ladder





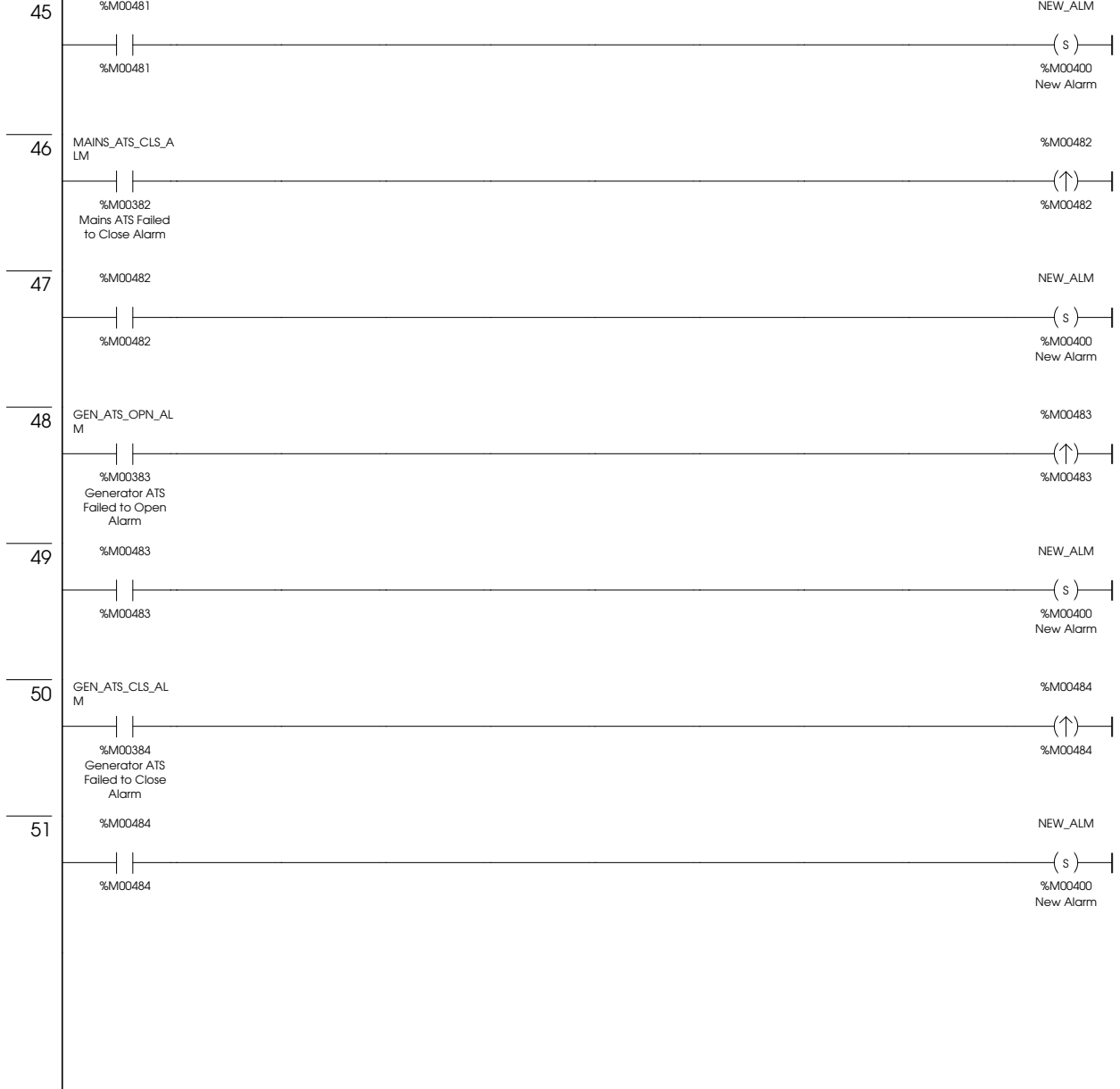














Block Name:.....ALARM.blk

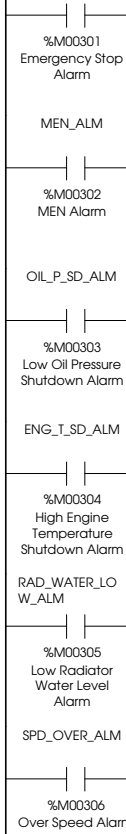
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Block Type:.....Ladder

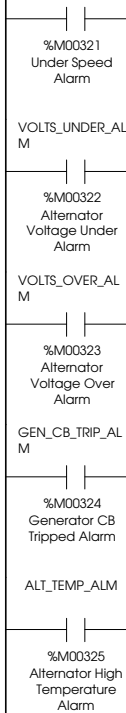




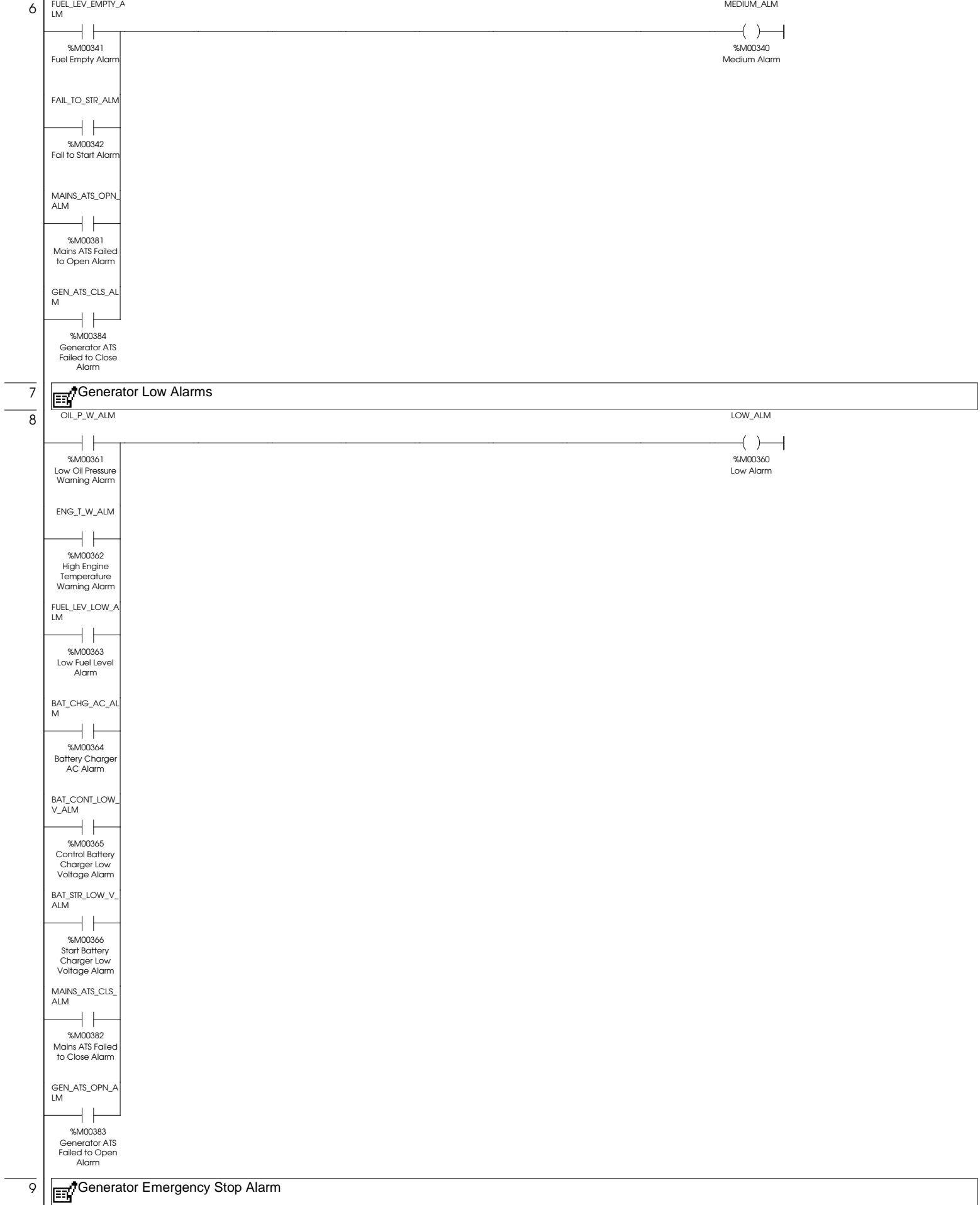
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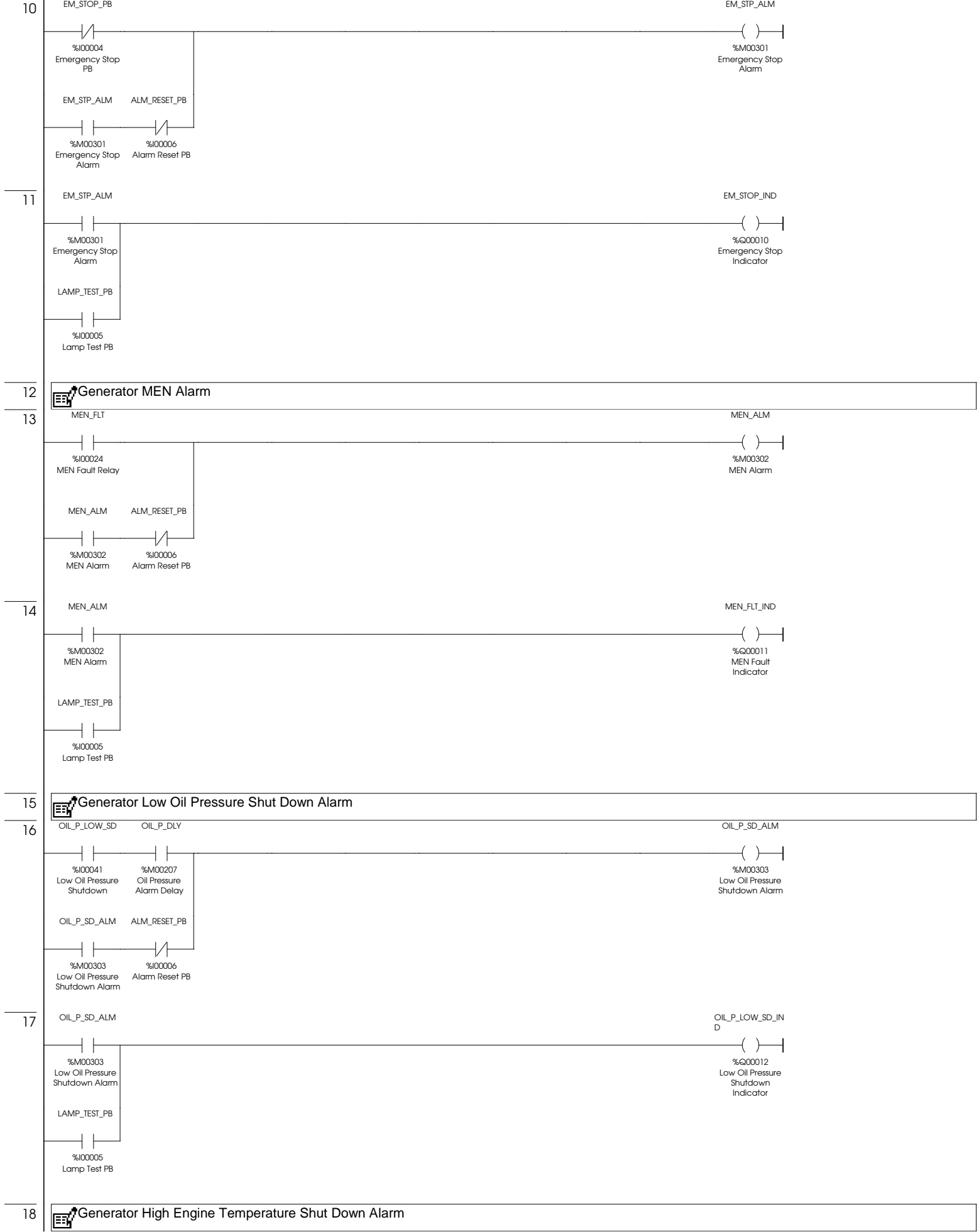
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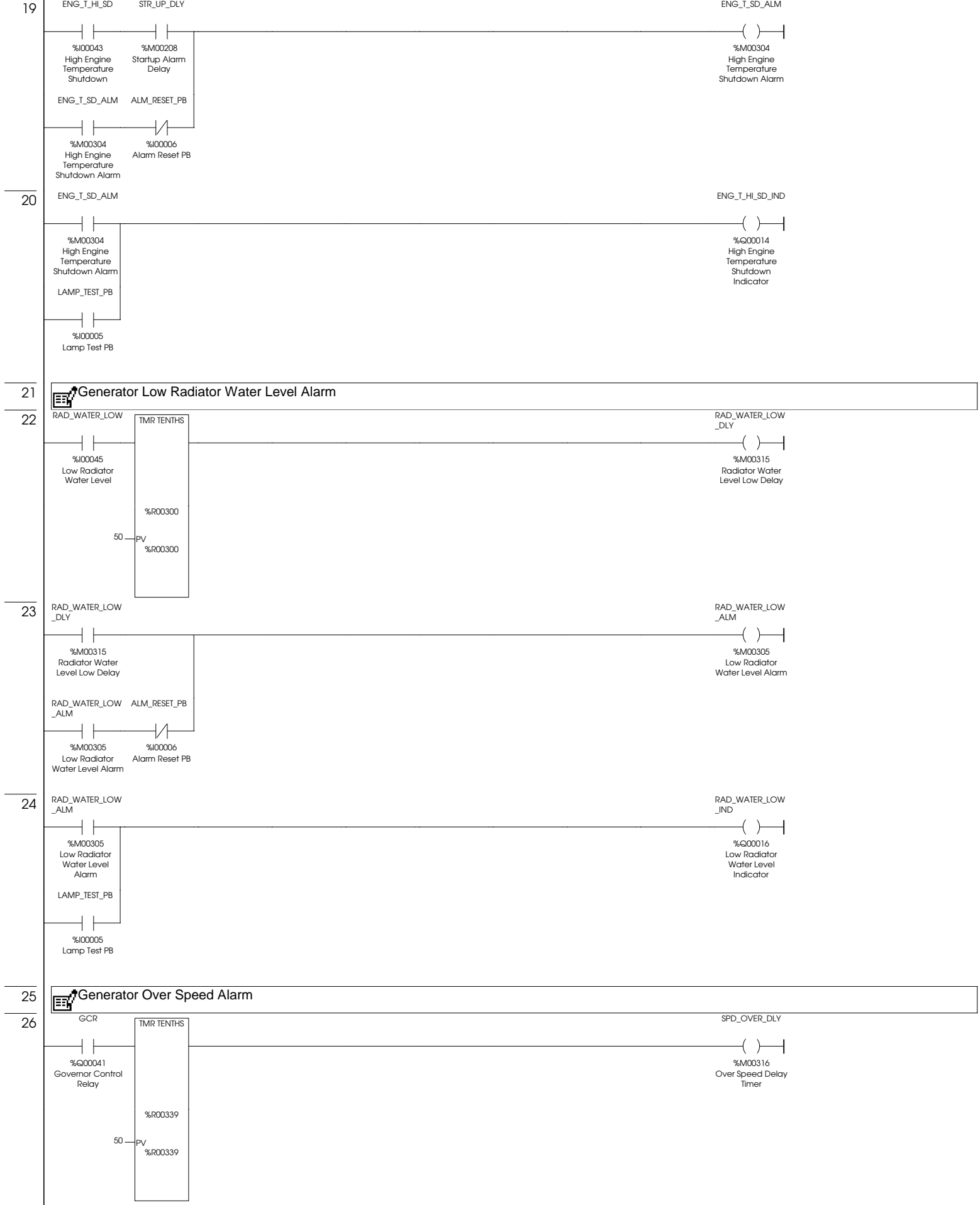




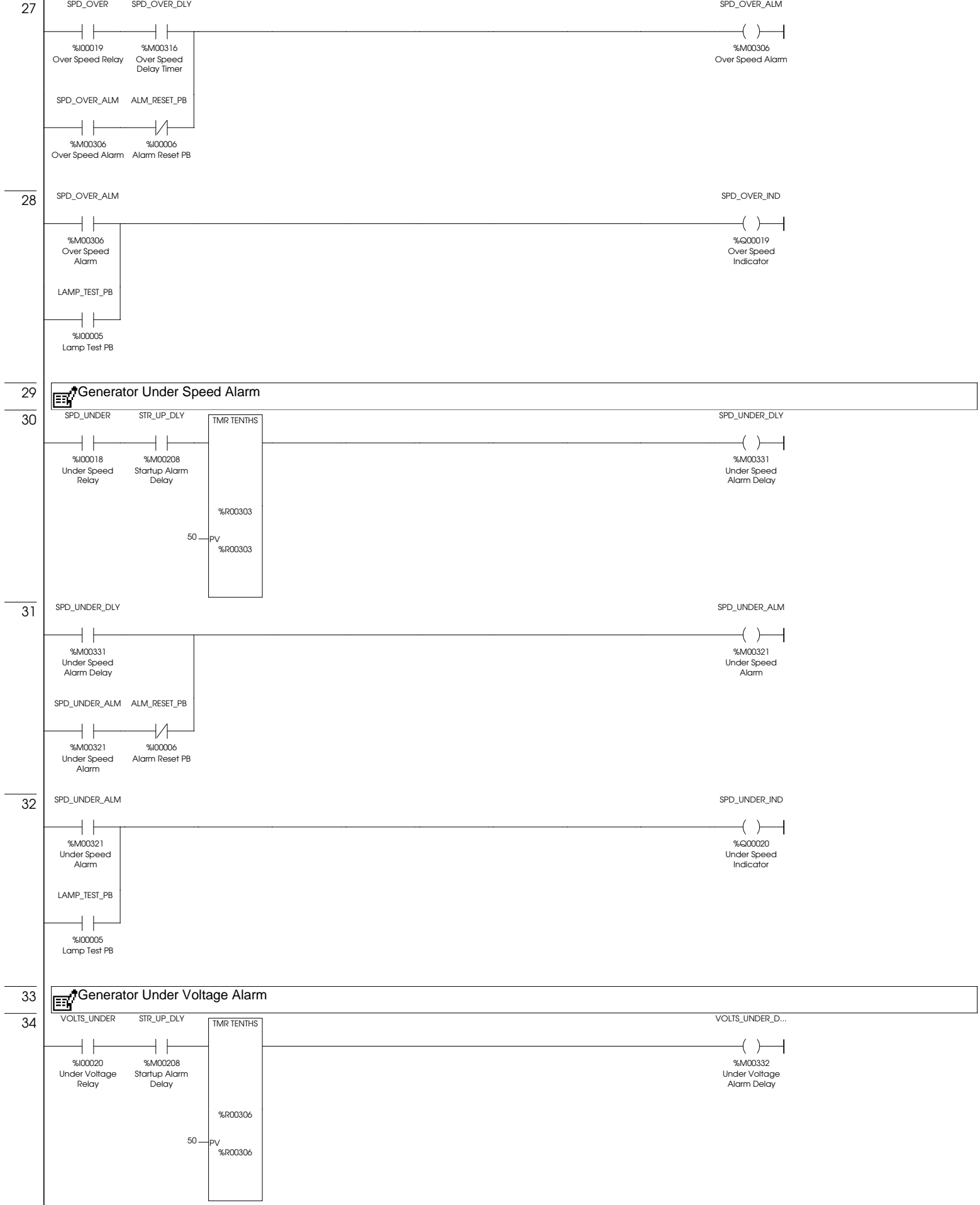




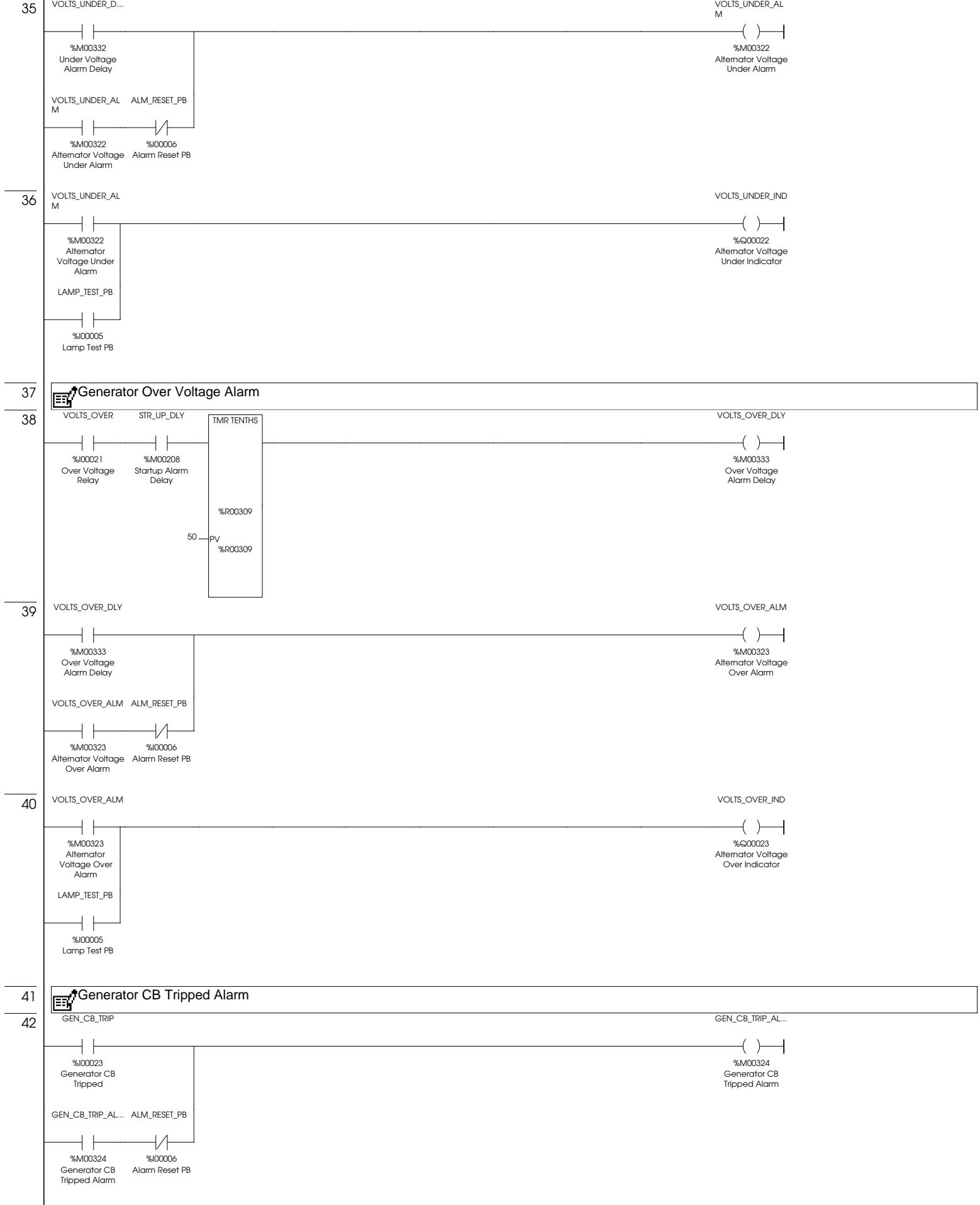




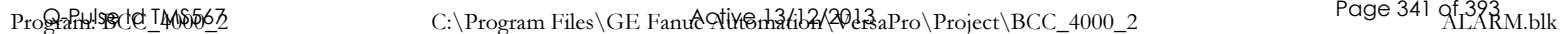




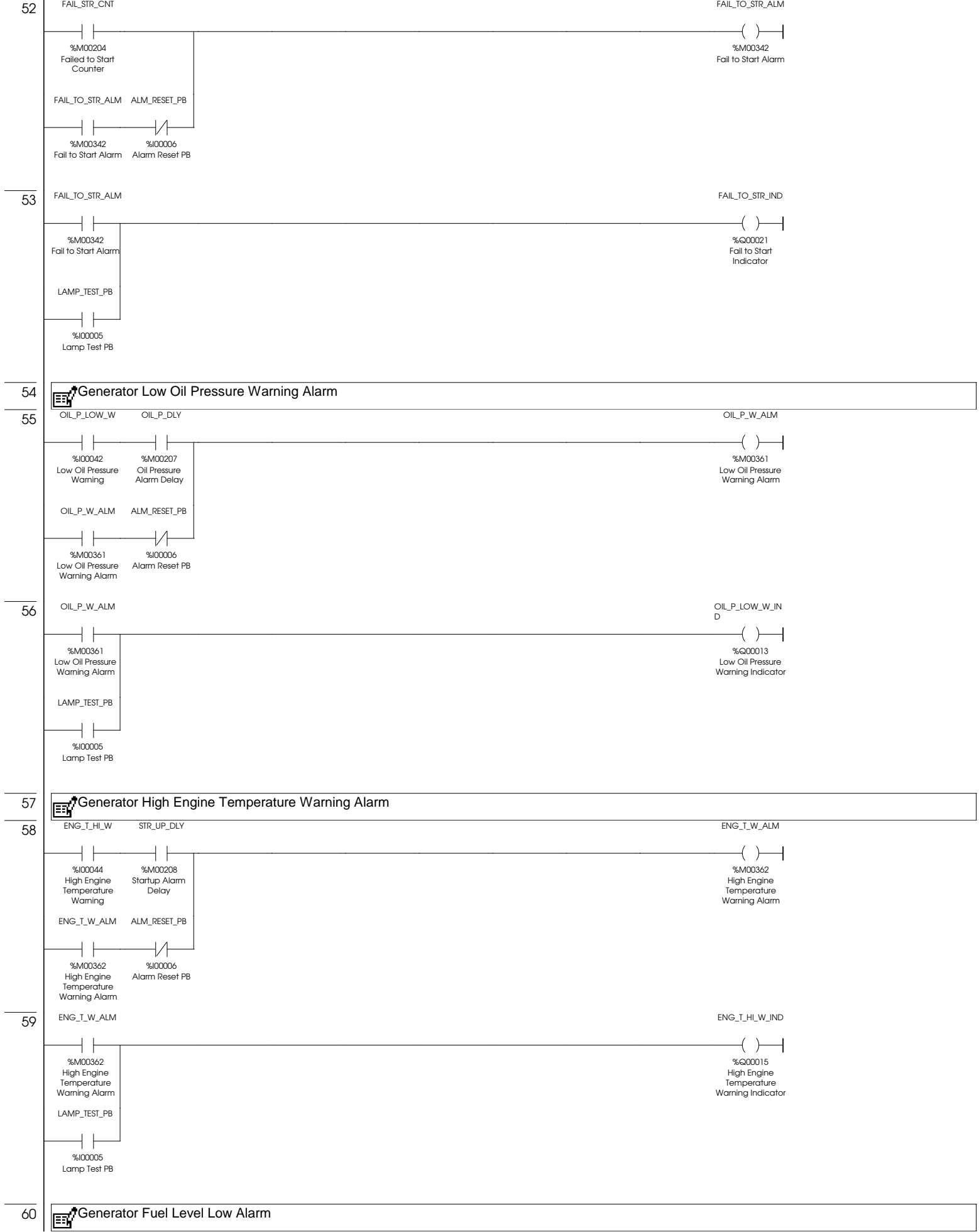




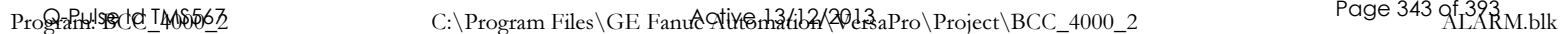




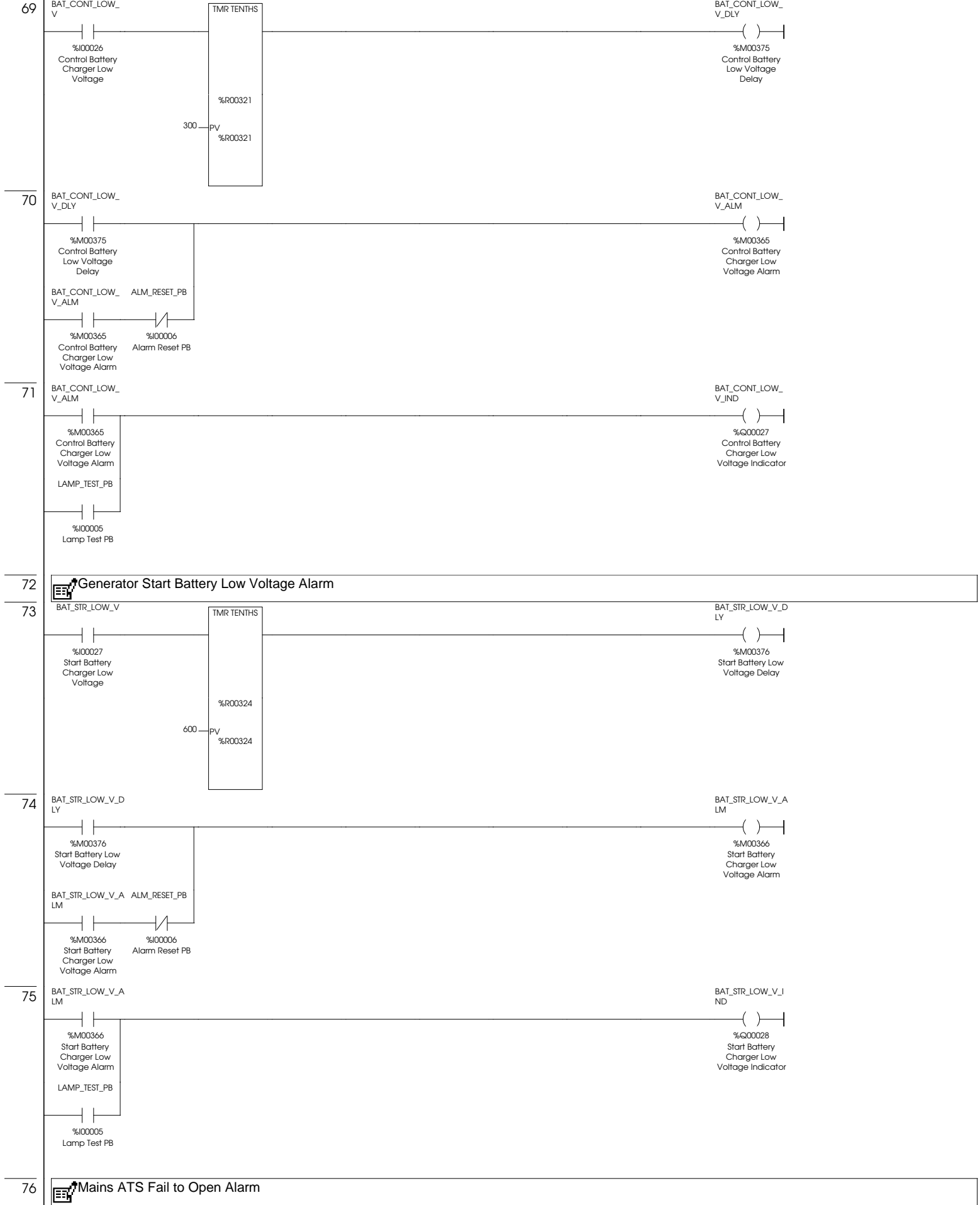




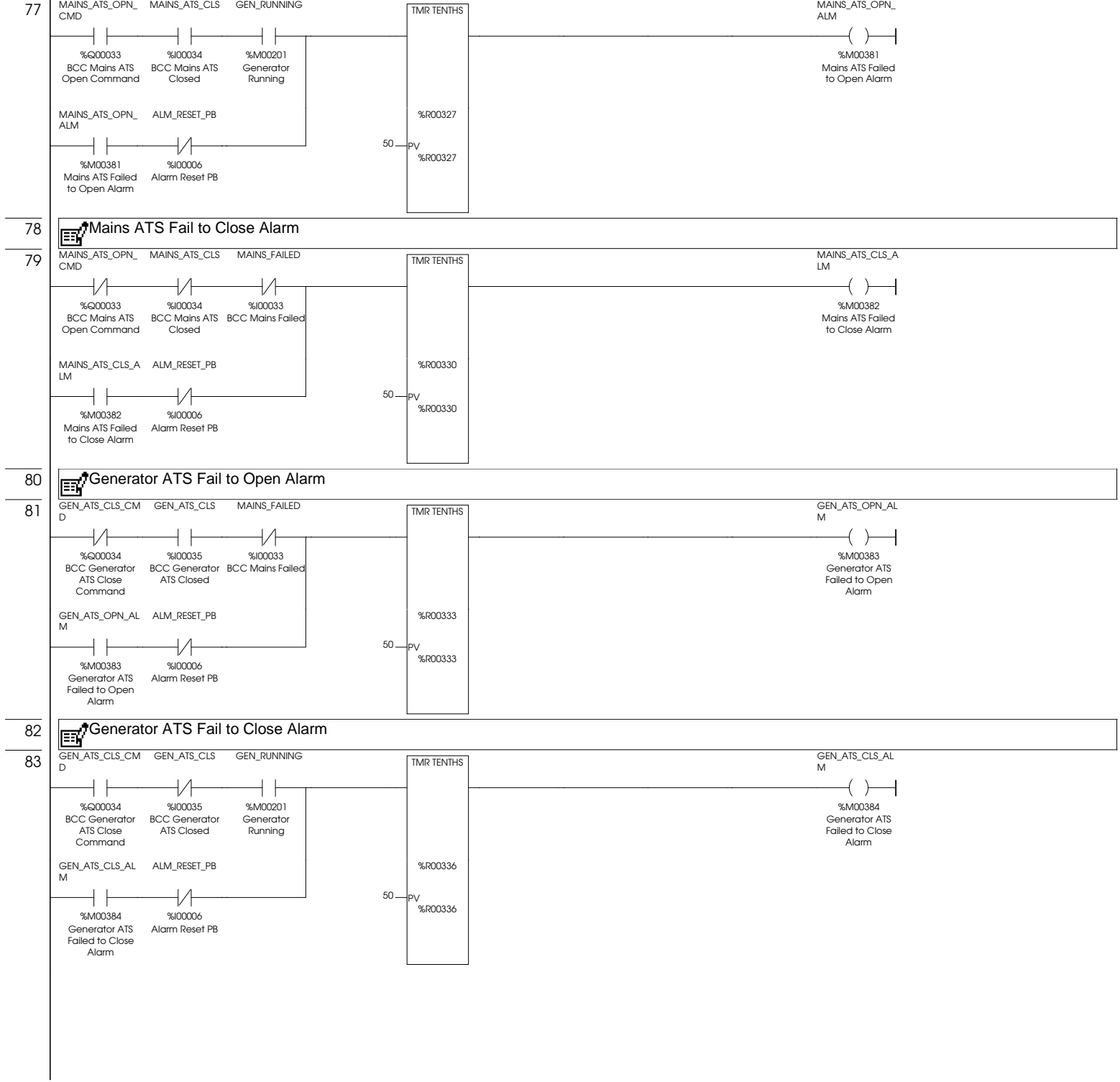












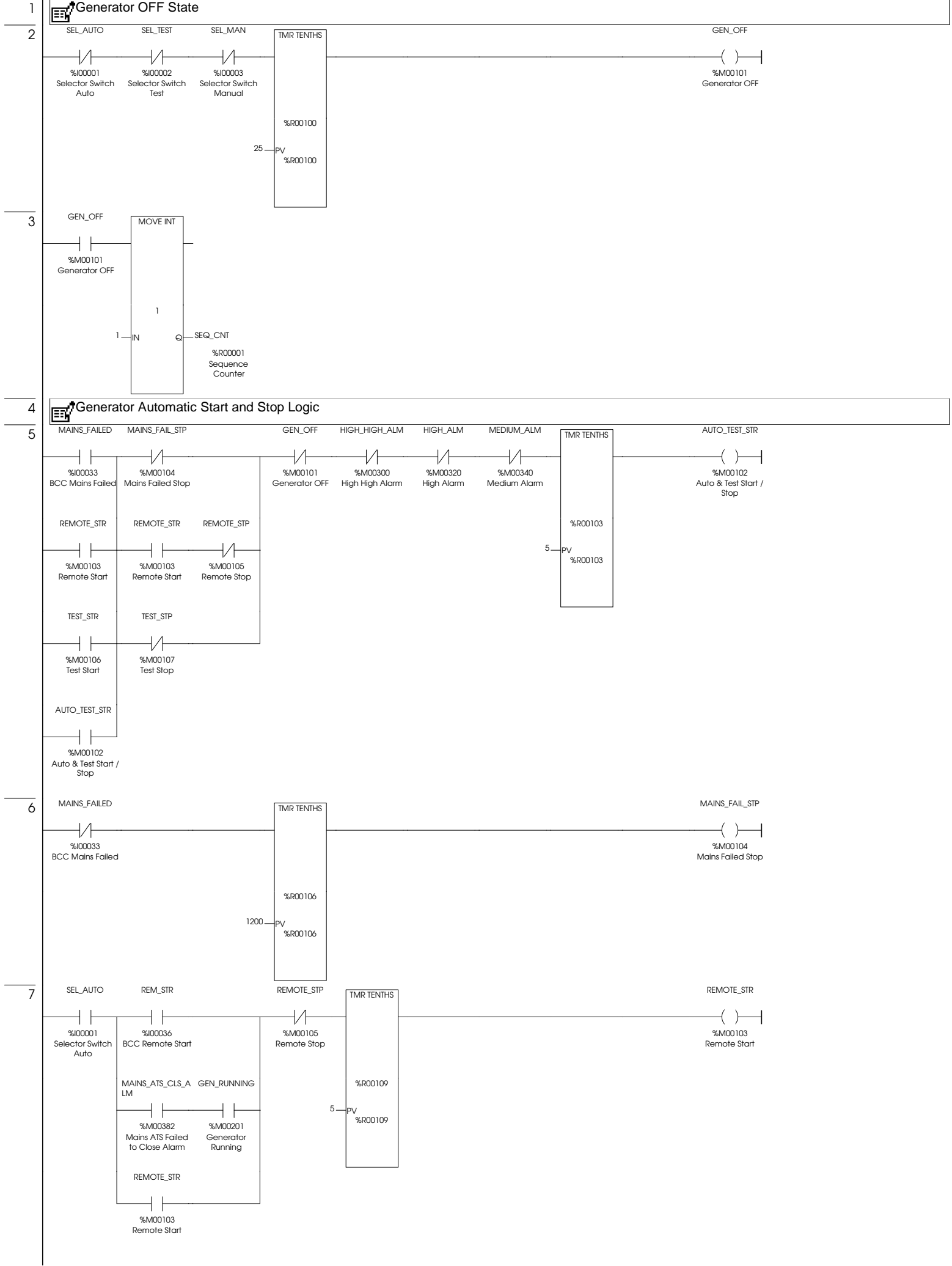


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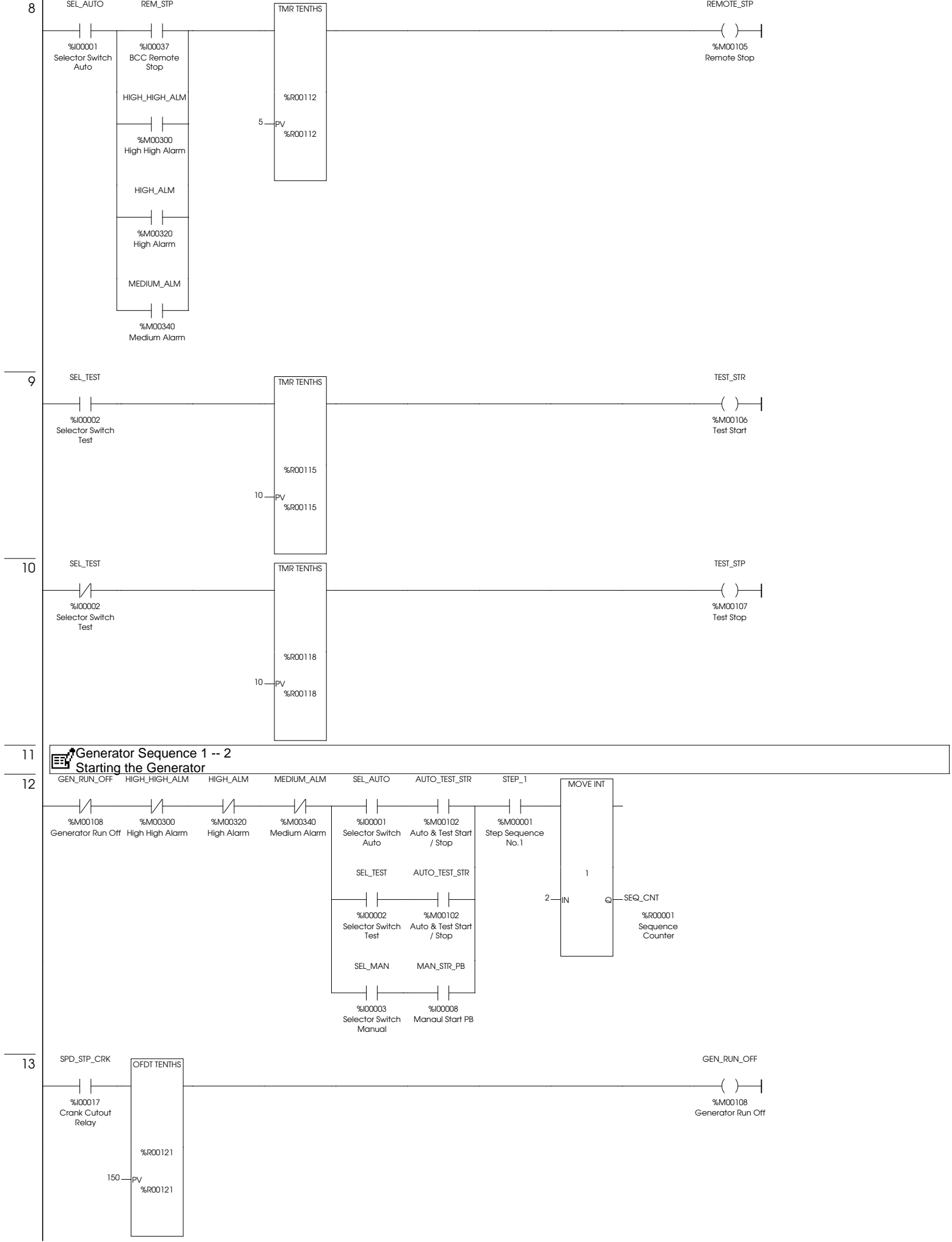
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Block Type:.....Ladder

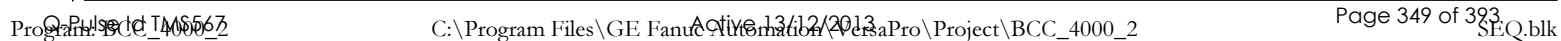




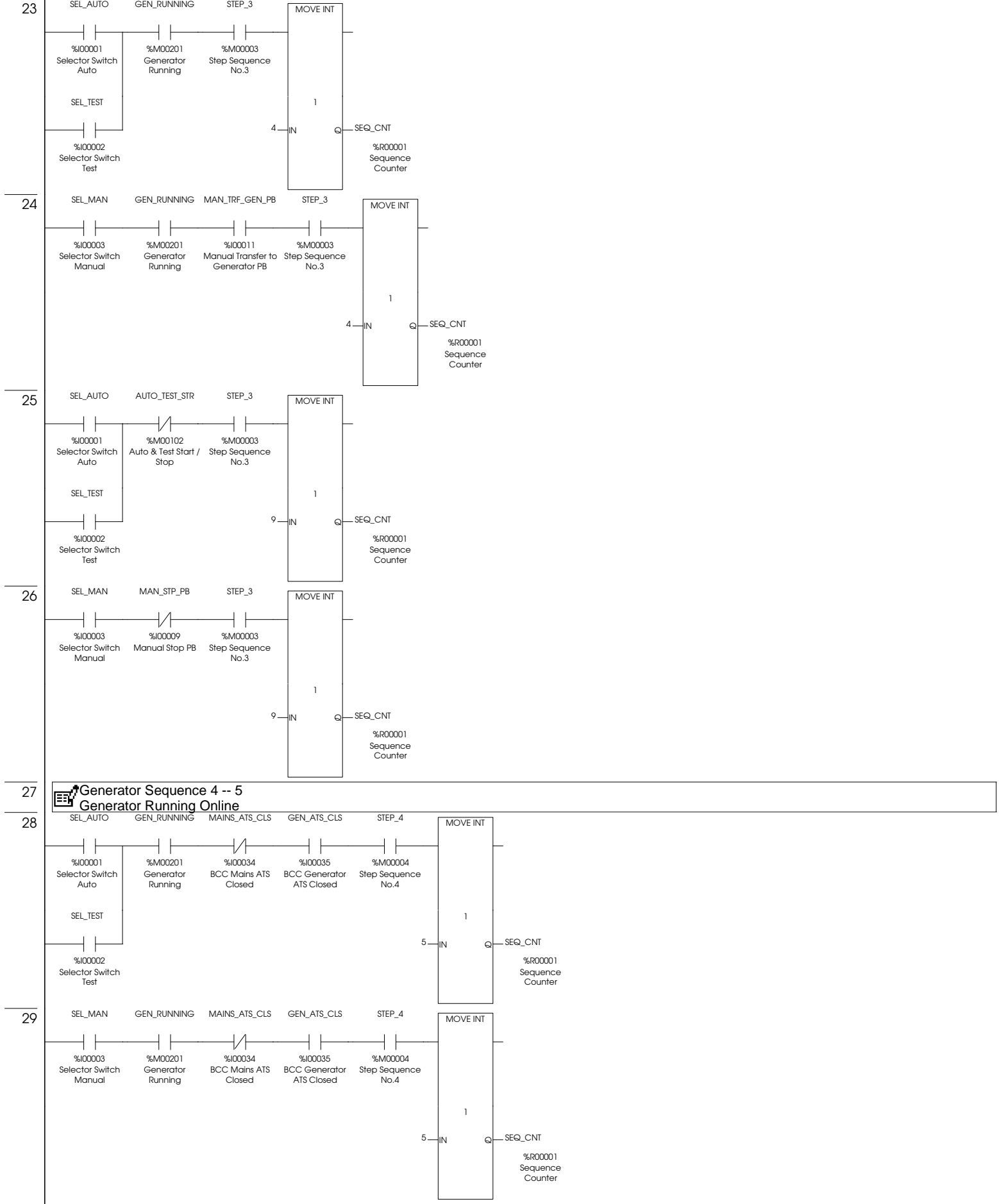




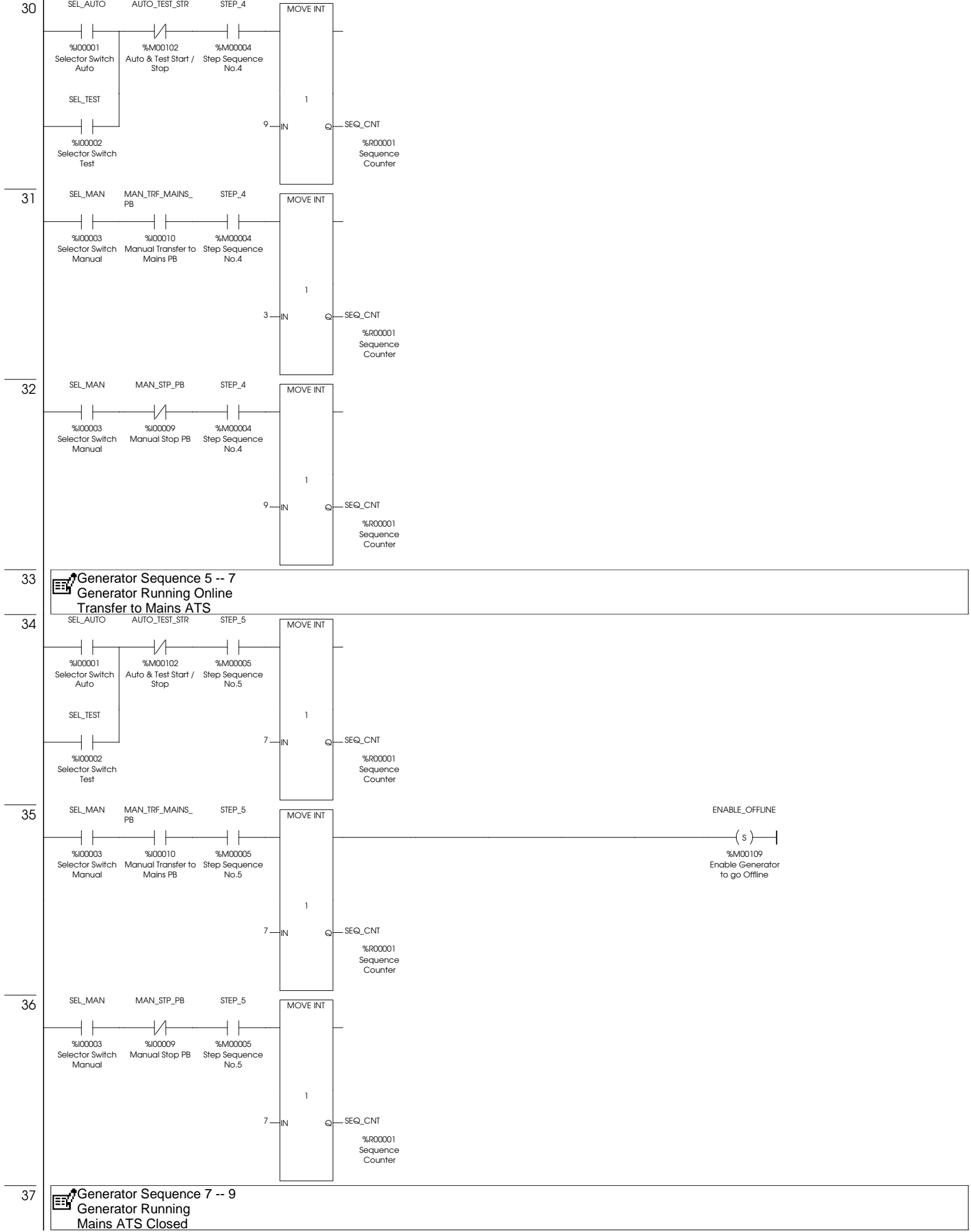




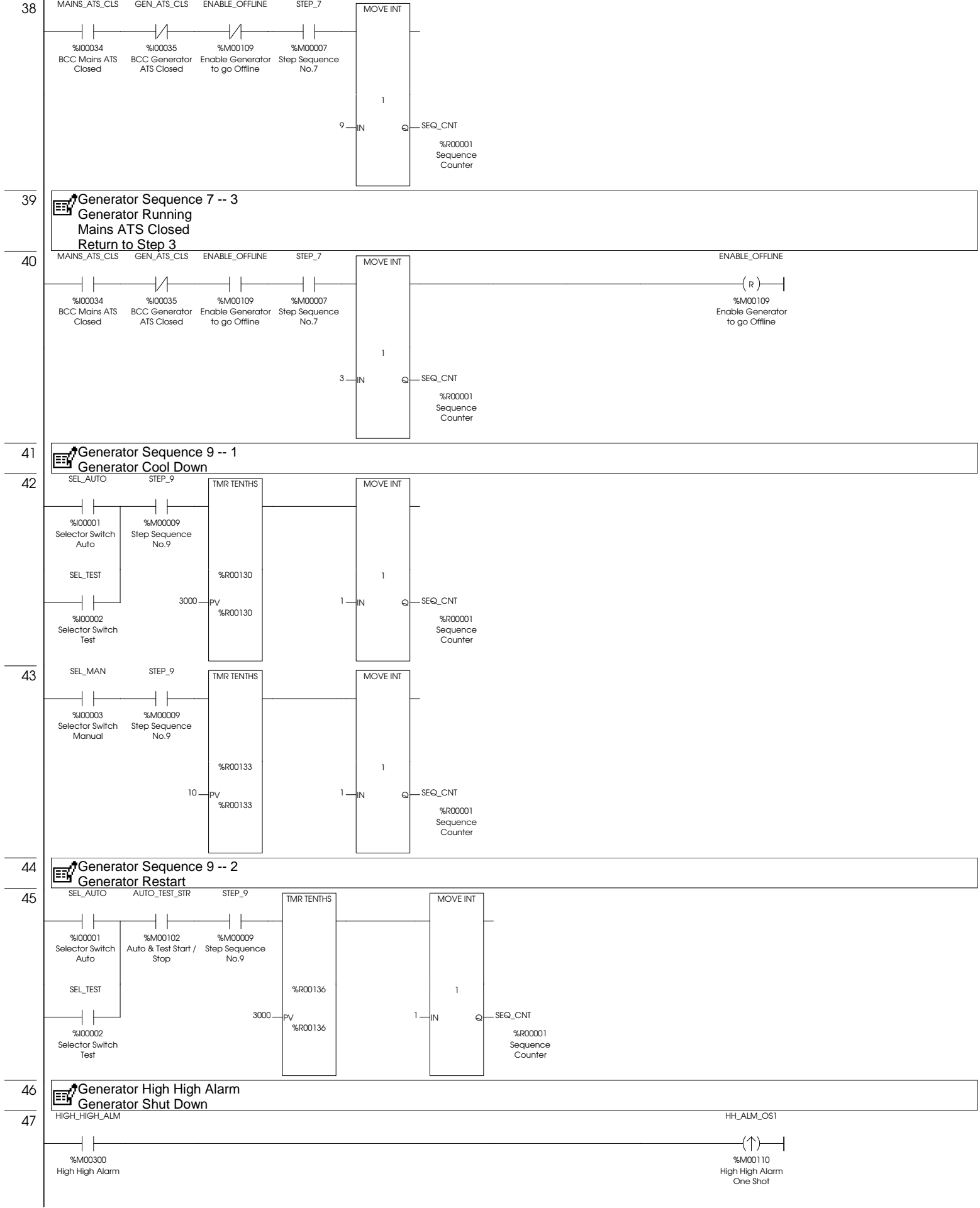




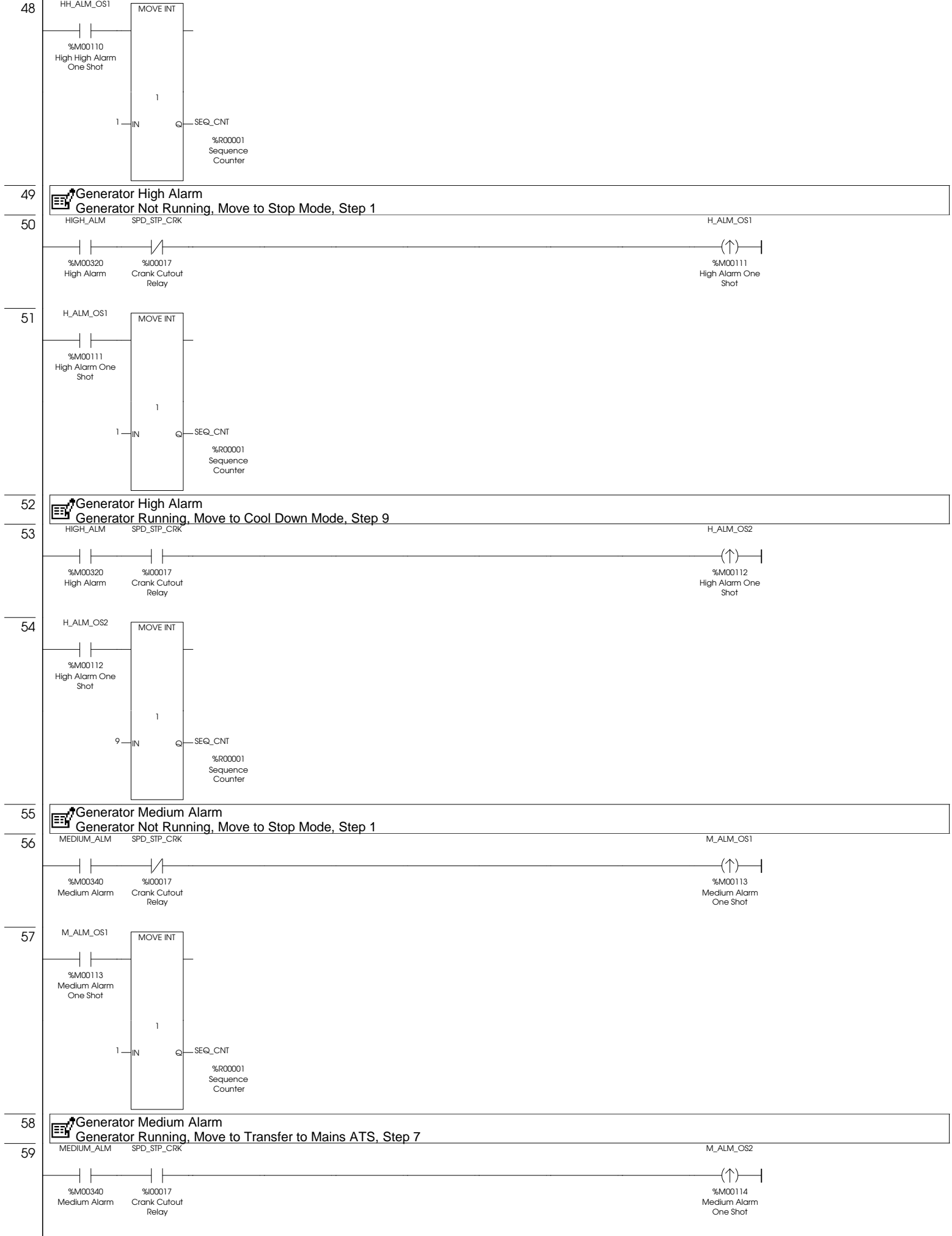




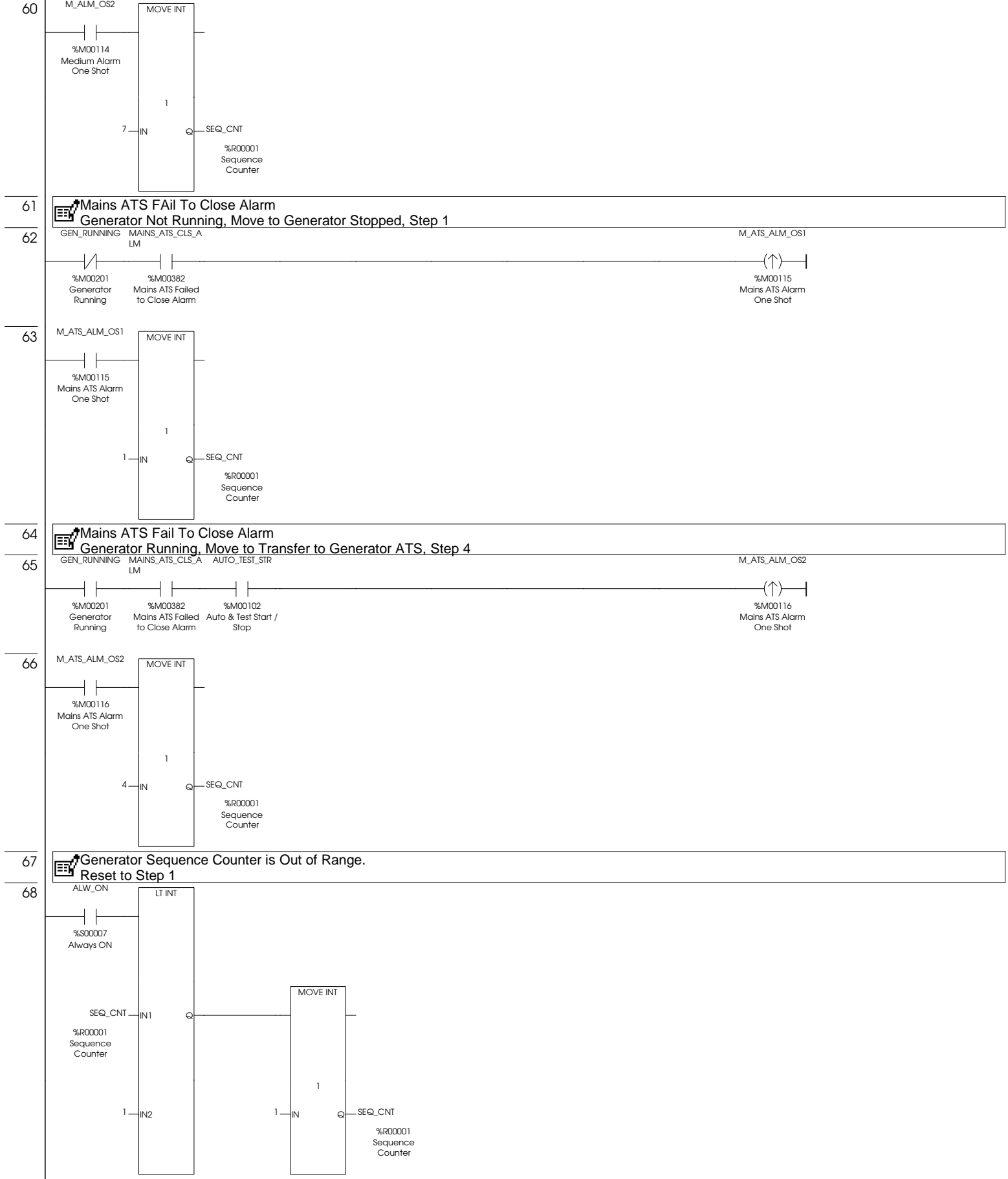












61

⚙

Mains ATS Fail To Close Alarm

Generator Not Running, Move to Generator Stopped, Step 1

62

GEN\_RUNNING

MAINS\_ATS\_CLS\_A  
LM

M\_ATS\_ALM\_OS1

%M00201  
Generator  
Running

%M00382  
Mains ATS Failed  
to Close Alarm

(↑)

%M00115  
Mains ATS Alarm  
One Shot

63

M\_ATS\_ALM\_OS1

MOVE INT

1

1 IN

Q

SEQ\_CNT

%R00001  
Sequence  
Counter

%M00115  
Mains ATS Alarm  
One Shot

64

⚙

Mains ATS Fail To Close Alarm

Generator Running, Move to Transfer to Generator ATS, Step 4

65

GEN\_RUNNING

MAINS\_ATS\_CLS\_A  
LM

AUTO\_TEST\_STR

M\_ATS\_ALM\_OS2

%M00201  
Generator  
Running

%M00382  
Mains ATS Failed  
to Close Alarm

%M00102  
Auto & Test Start /  
Stop

(↑)

%M00116  
Mains ATS Alarm  
One Shot

66

M\_ATS\_ALM\_OS2

MOVE INT

1

4 IN

Q

SEQ\_CNT

%R00001  
Sequence  
Counter

%M00116  
Mains ATS Alarm  
One Shot

67

⚙

Generator Sequence Counter is Out of Range.

Reset to Step 1

68

ALW\_ON

LT INT

SEQ\_CNT

%R00001  
Sequence  
Counter

1 IN2

MOVE INT

1

1 IN

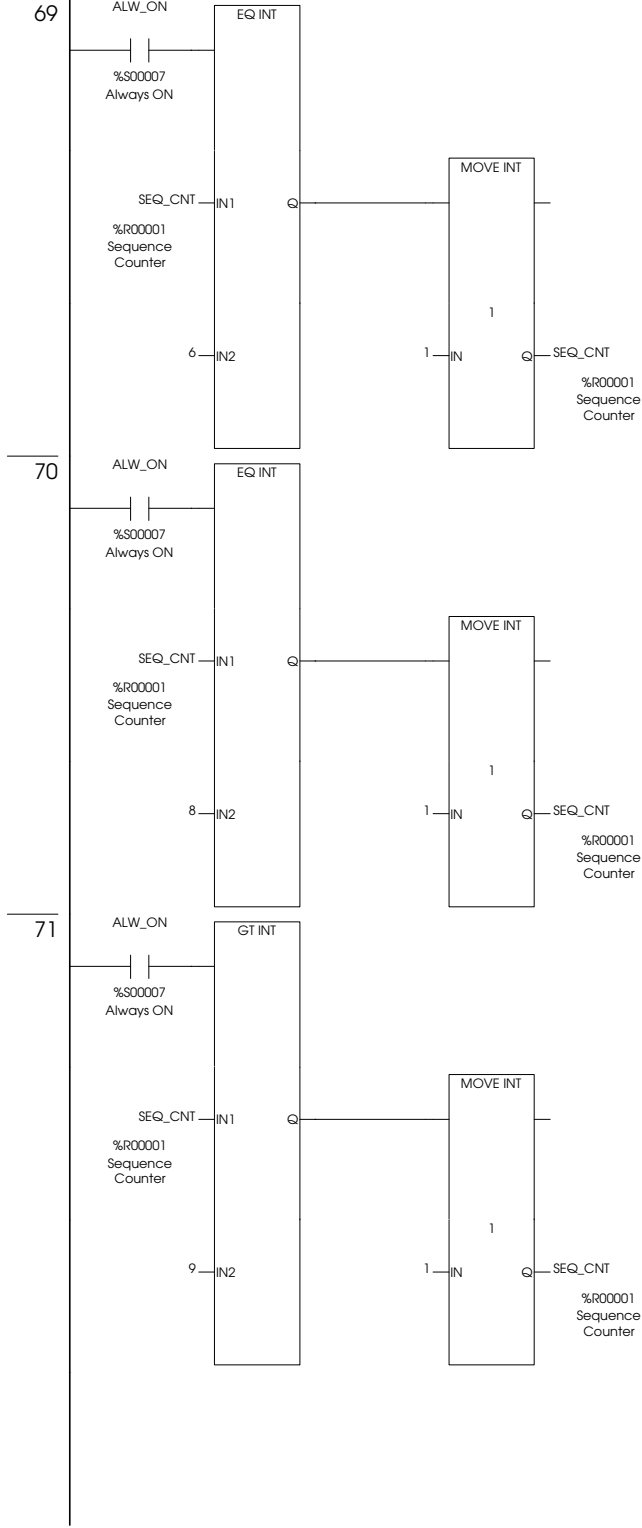
Q

SEQ\_CNT

%R00001  
Sequence  
Counter

%S00007  
Always ON

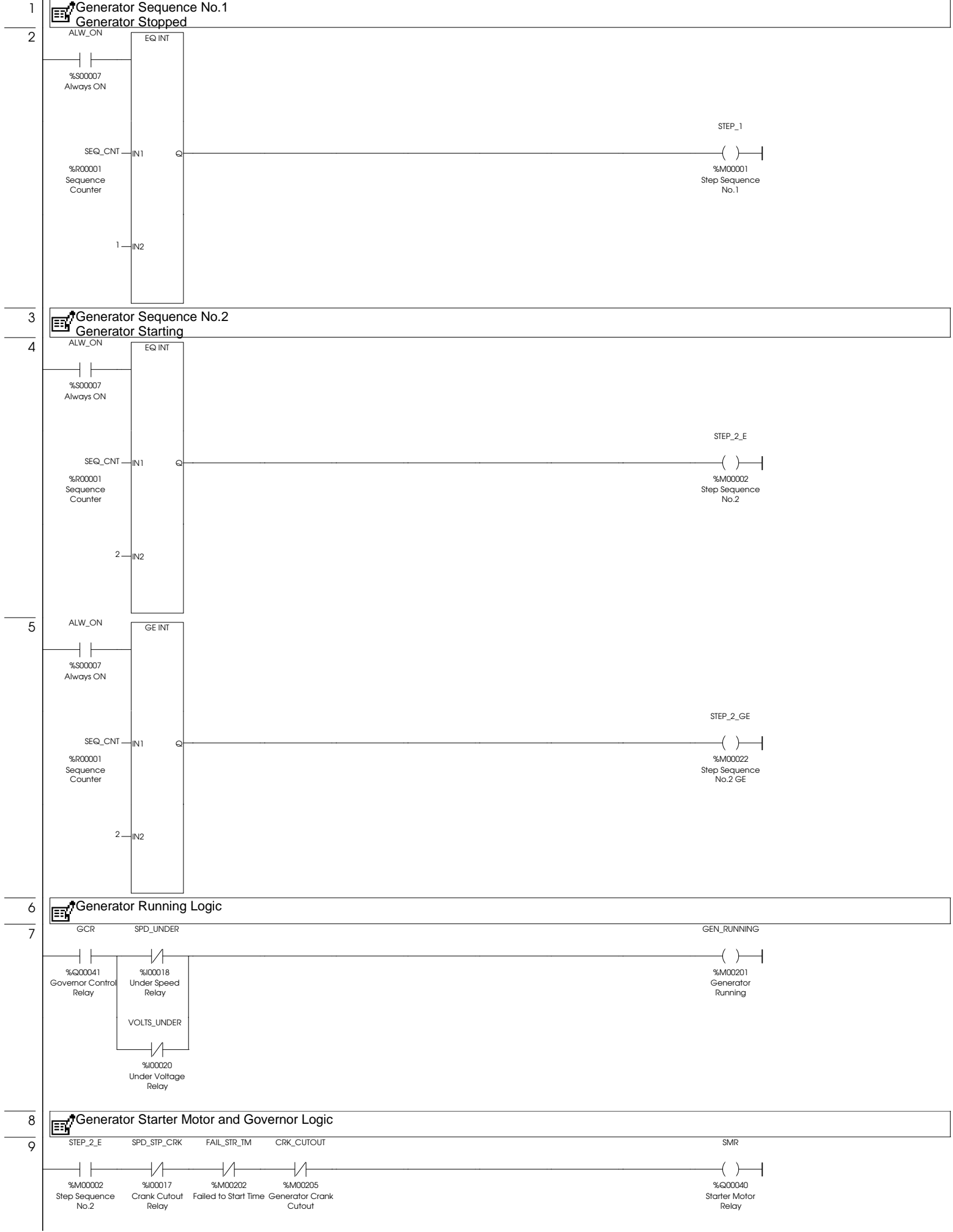




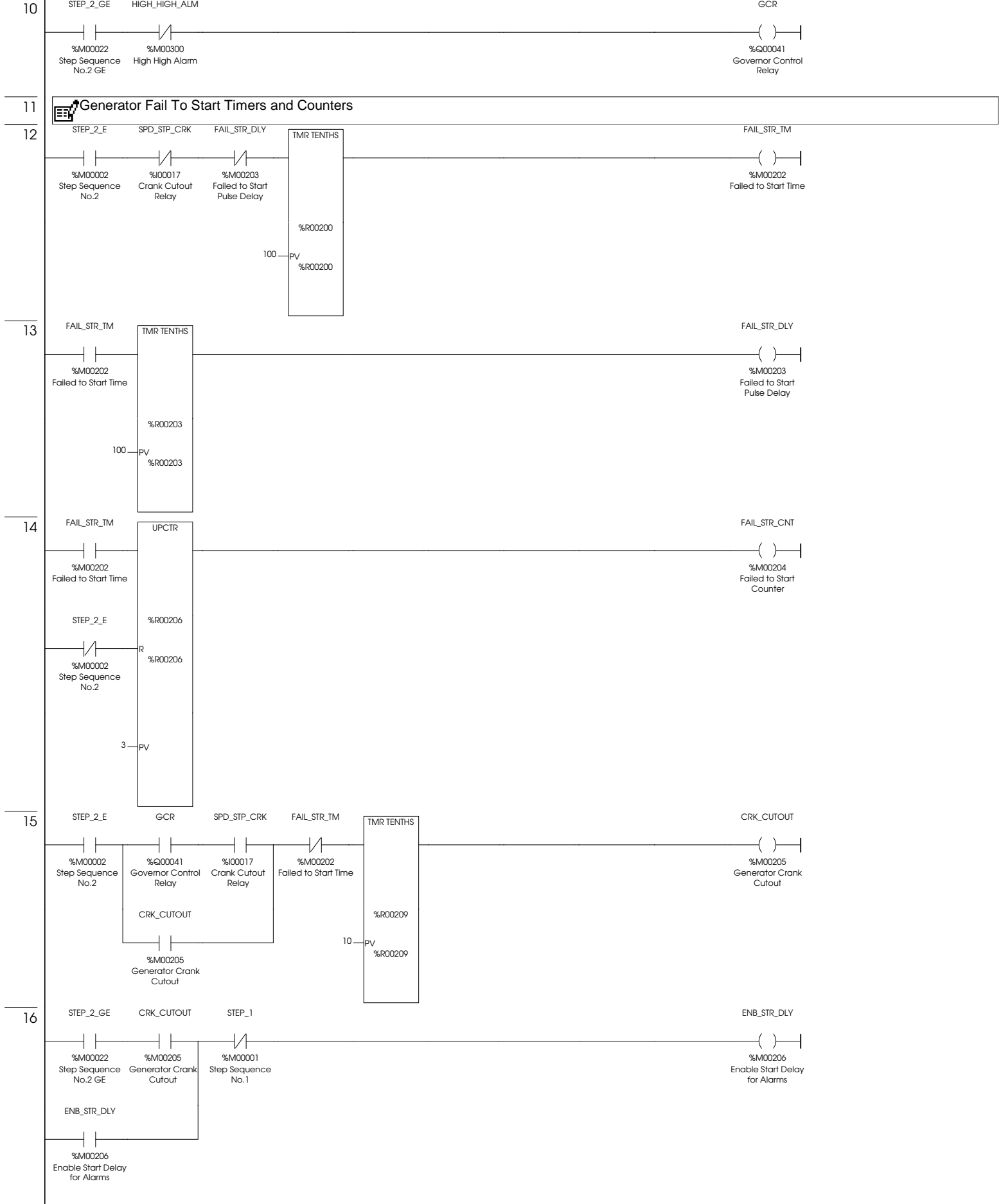


Block Name:..... MAIN.blk  
Description:..... Control Logic for the Generator Sequence Steps.  
Block Type:..... Ladder

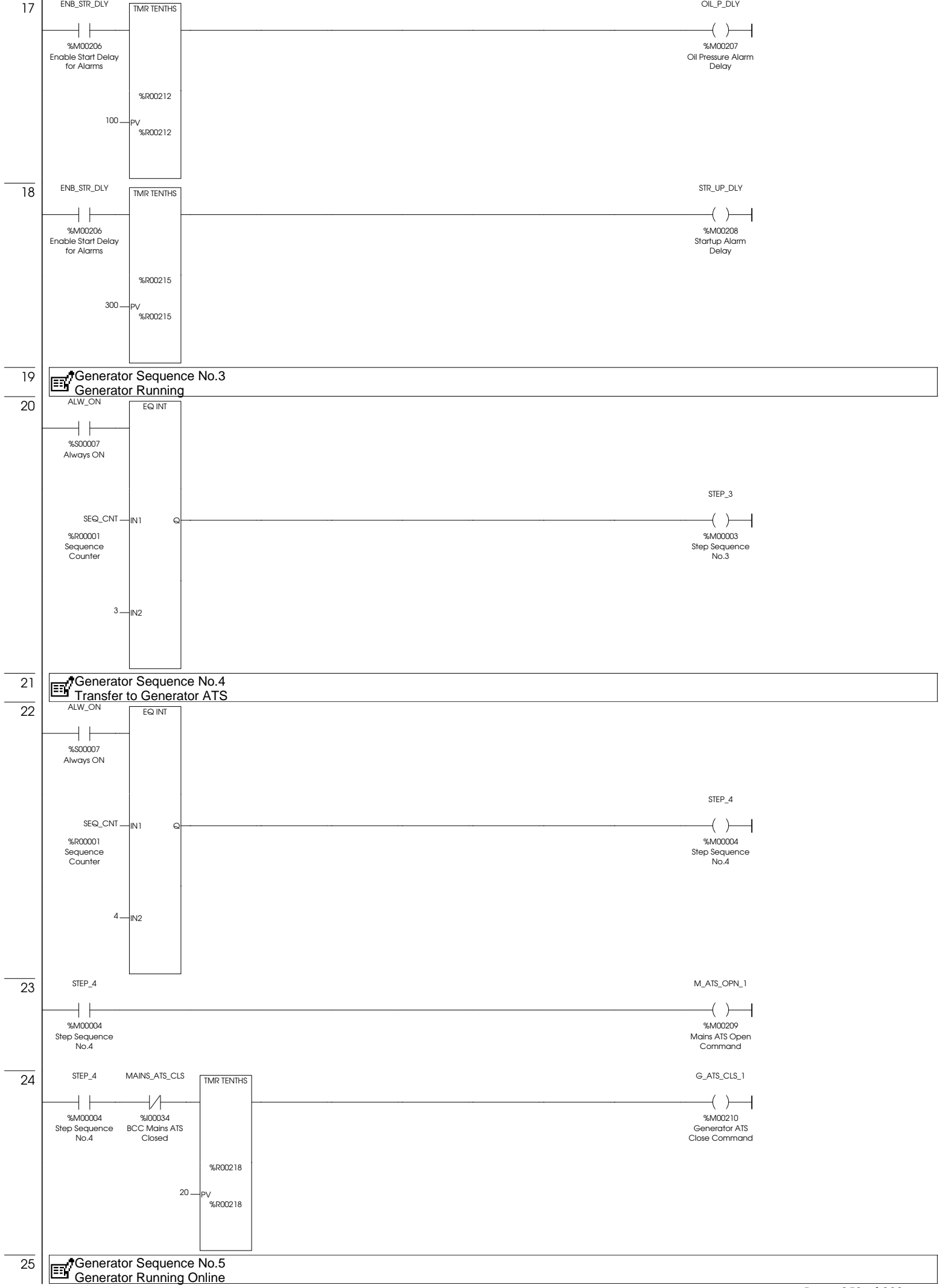




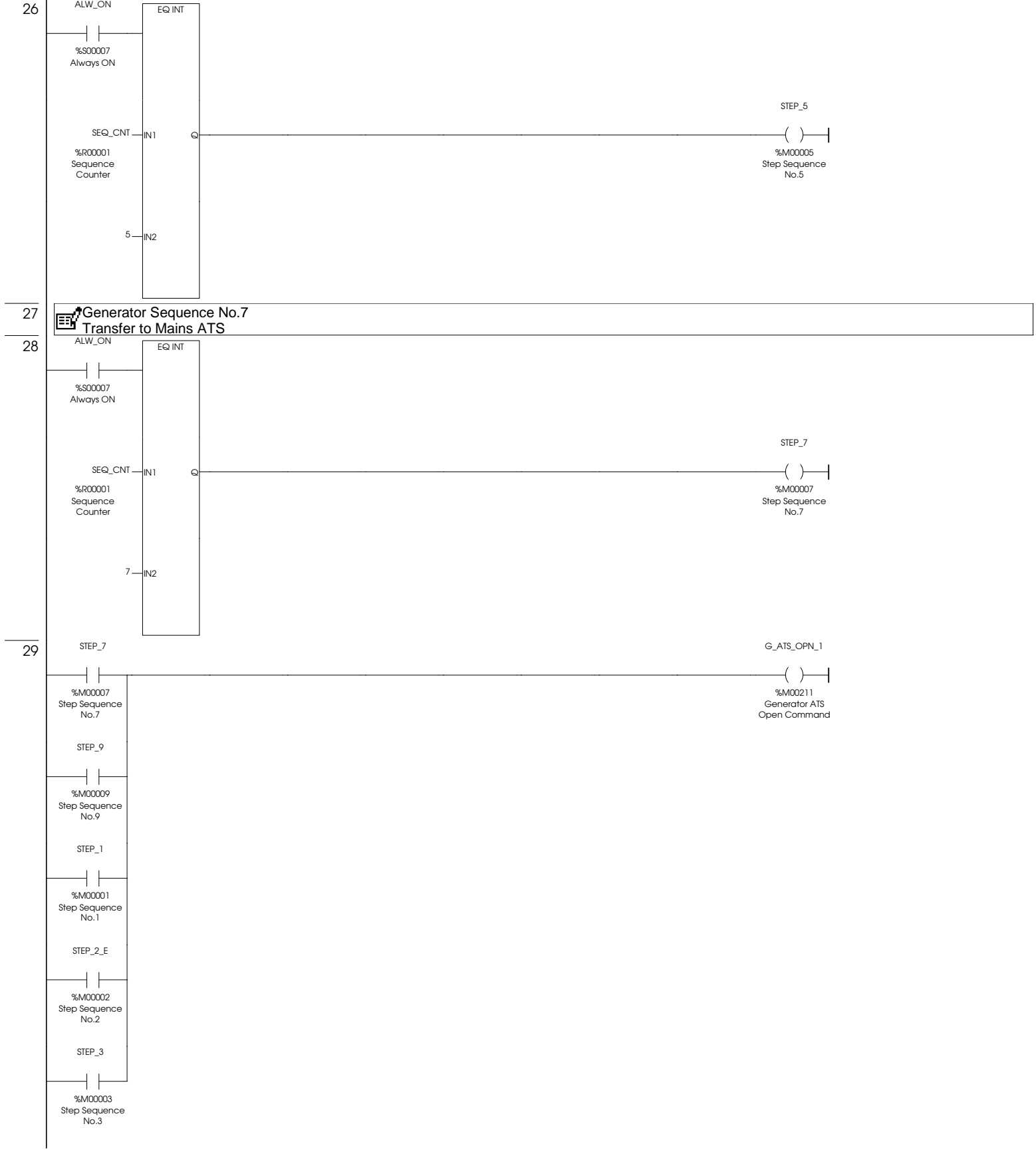




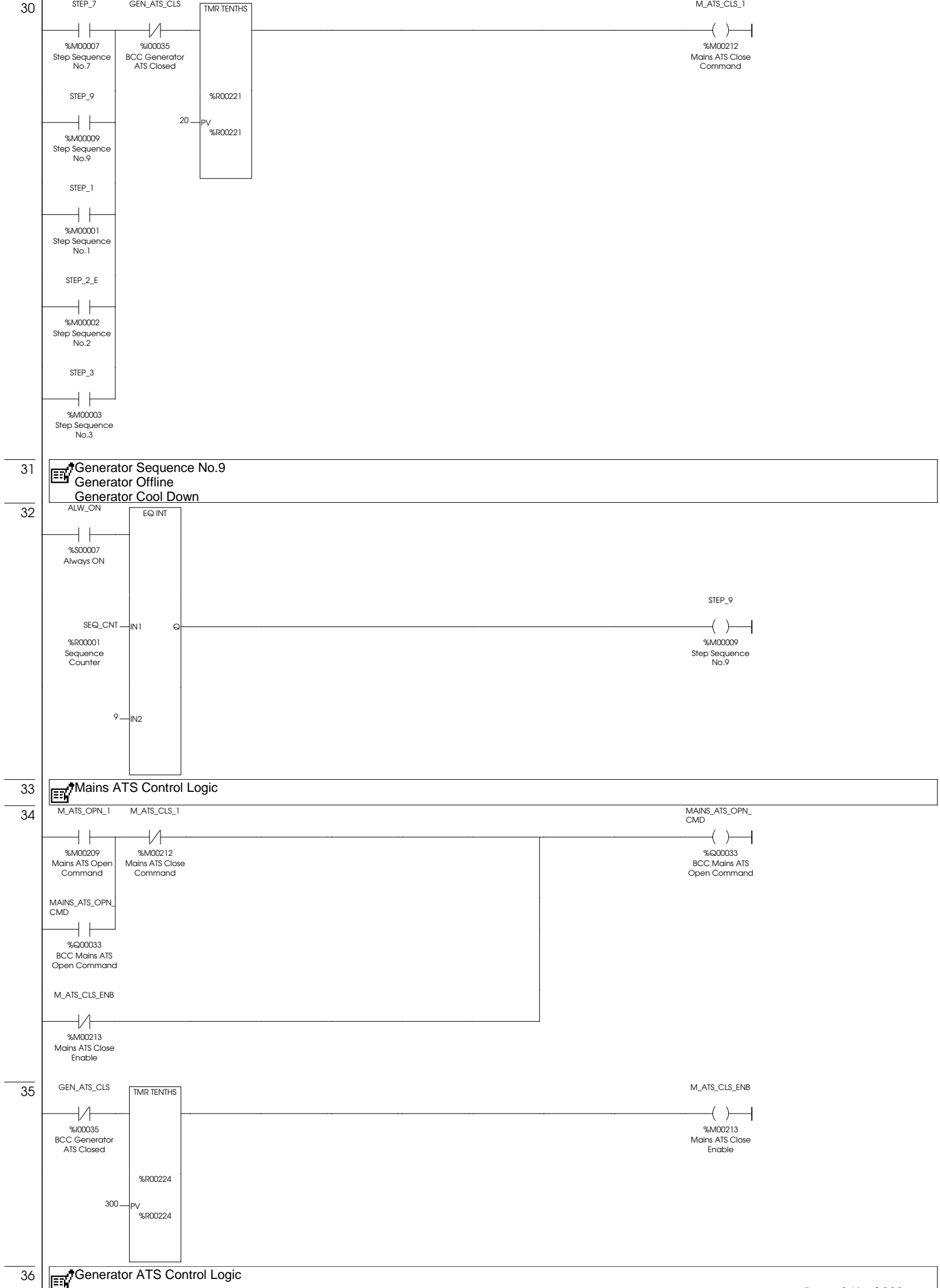




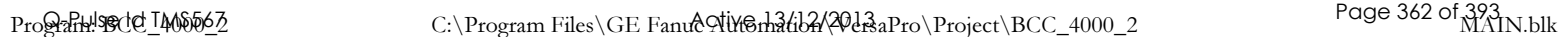




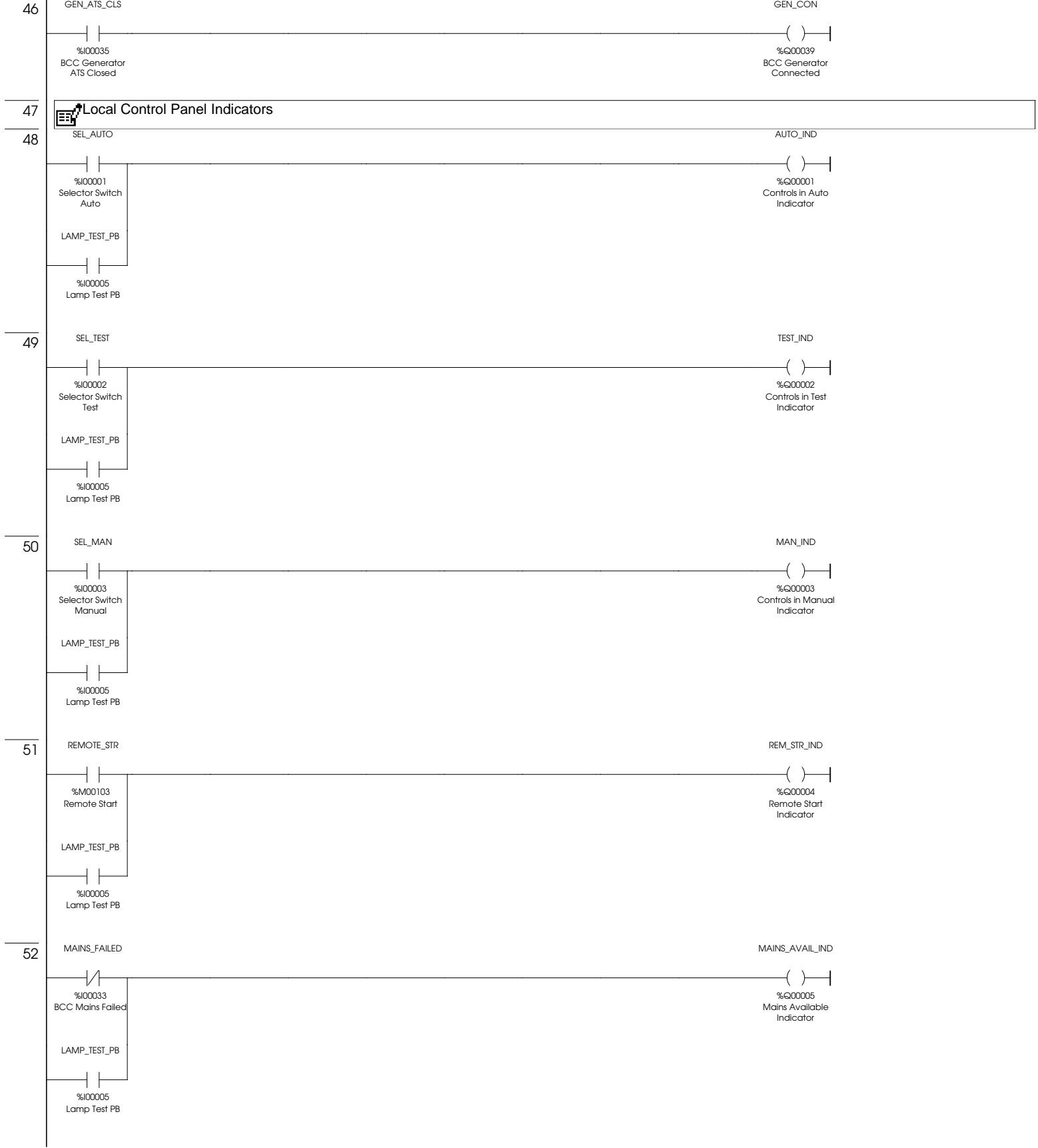




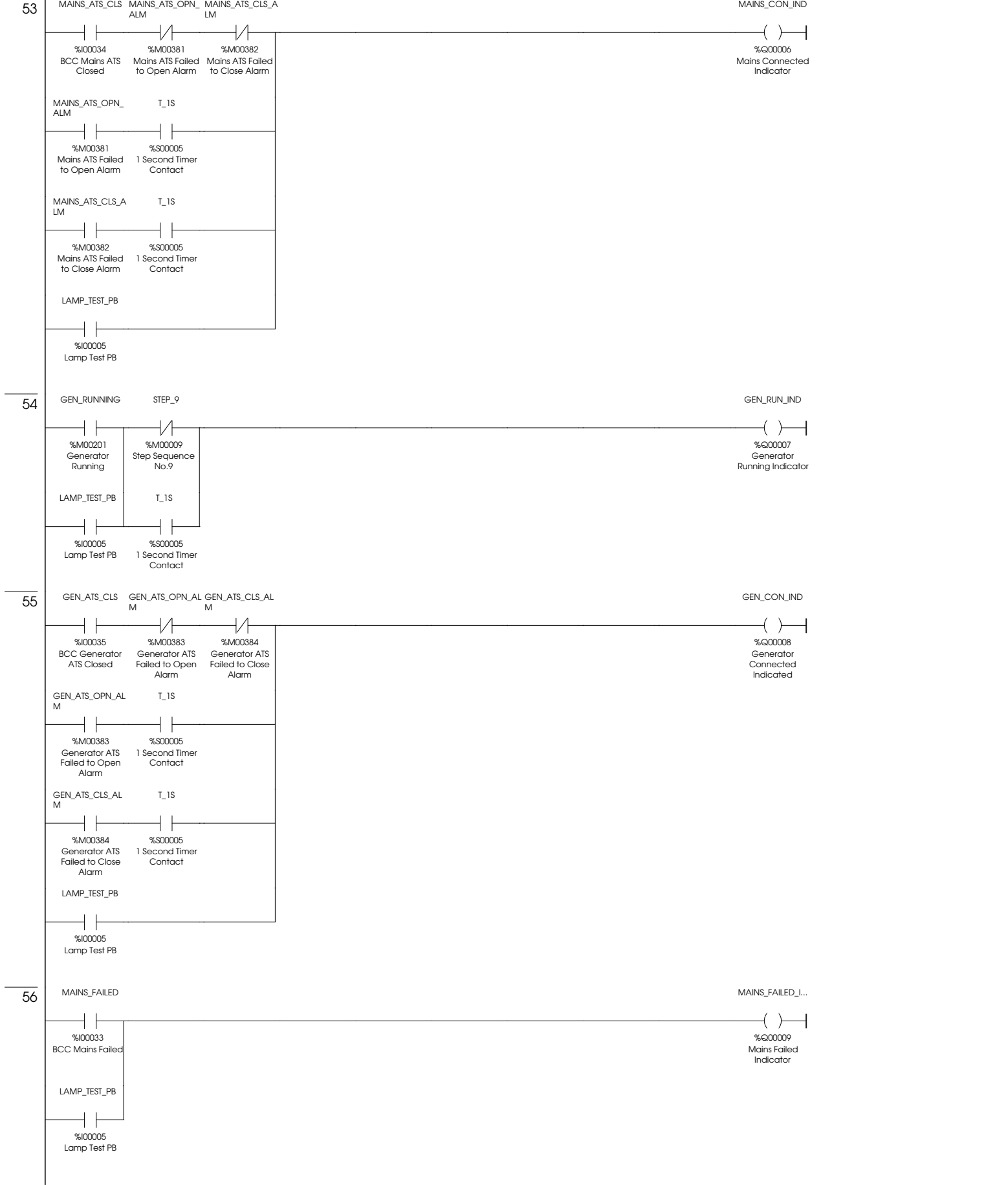




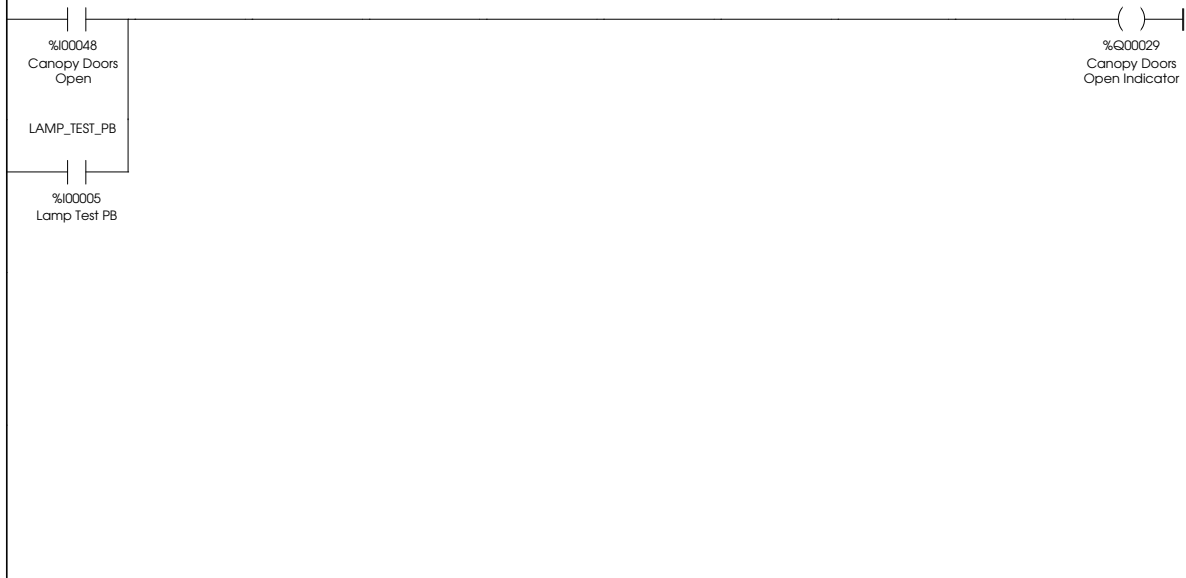








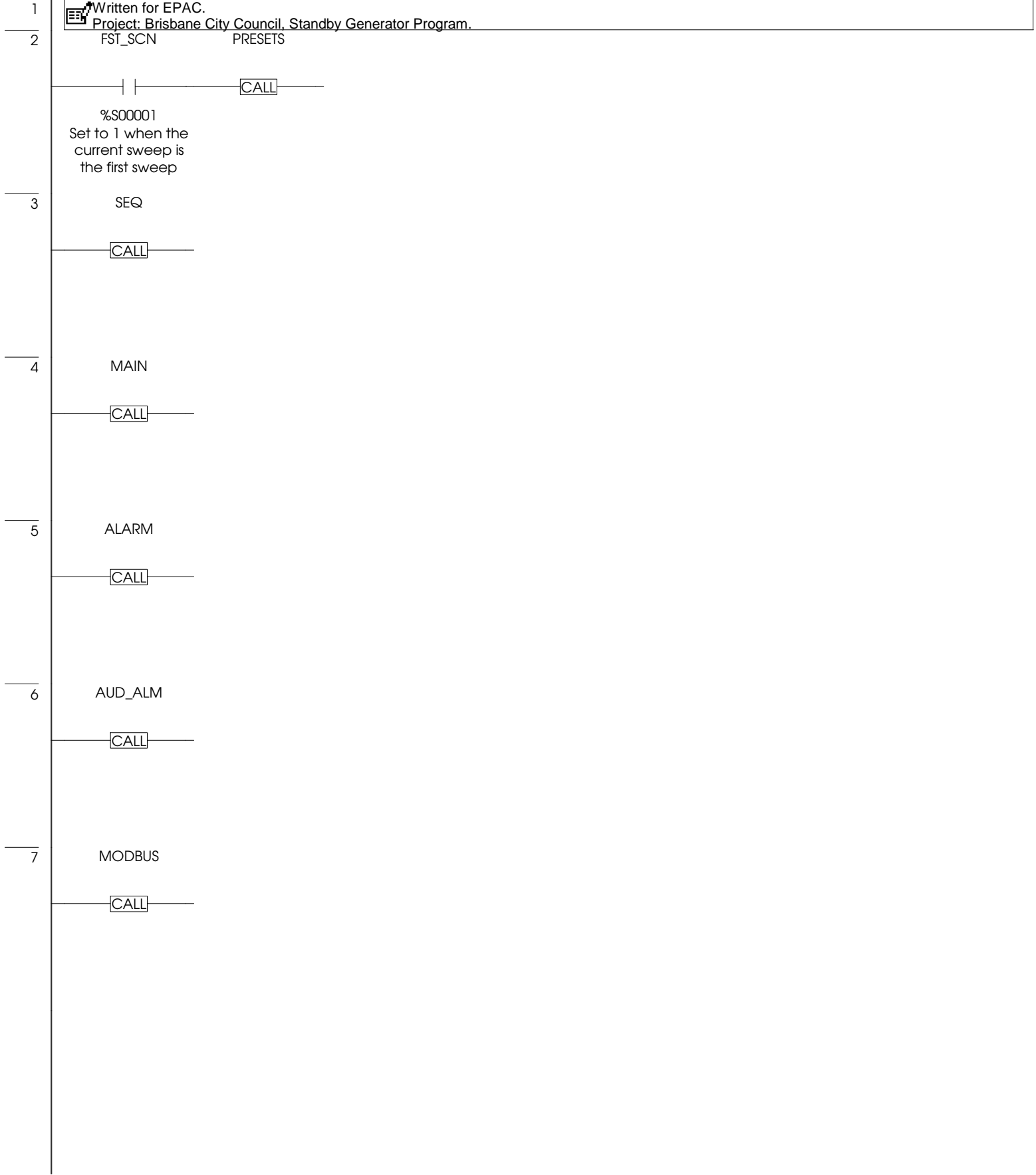


CAN\_DOORS\_OPE  
N



Block Name:.....\_MAIN.blk  
Description:..... Control Logic for the Call for Sub Routines.  
Block Type:.....Ladder







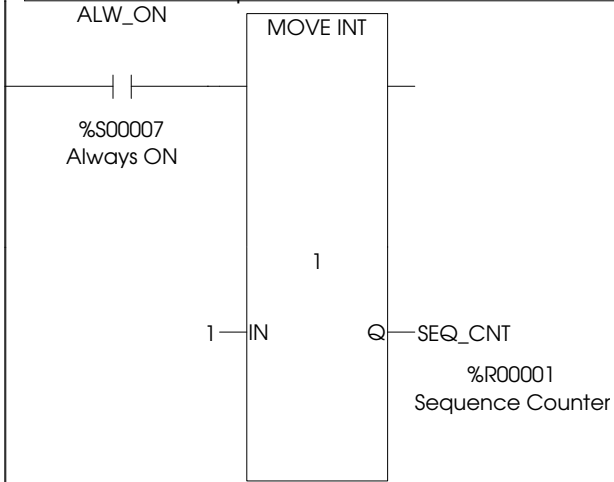
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Description:.....Control Logic Generator Presets.

Block Type:.....Ladder



Presets Routine  
Move 1 to the Sequence Counter



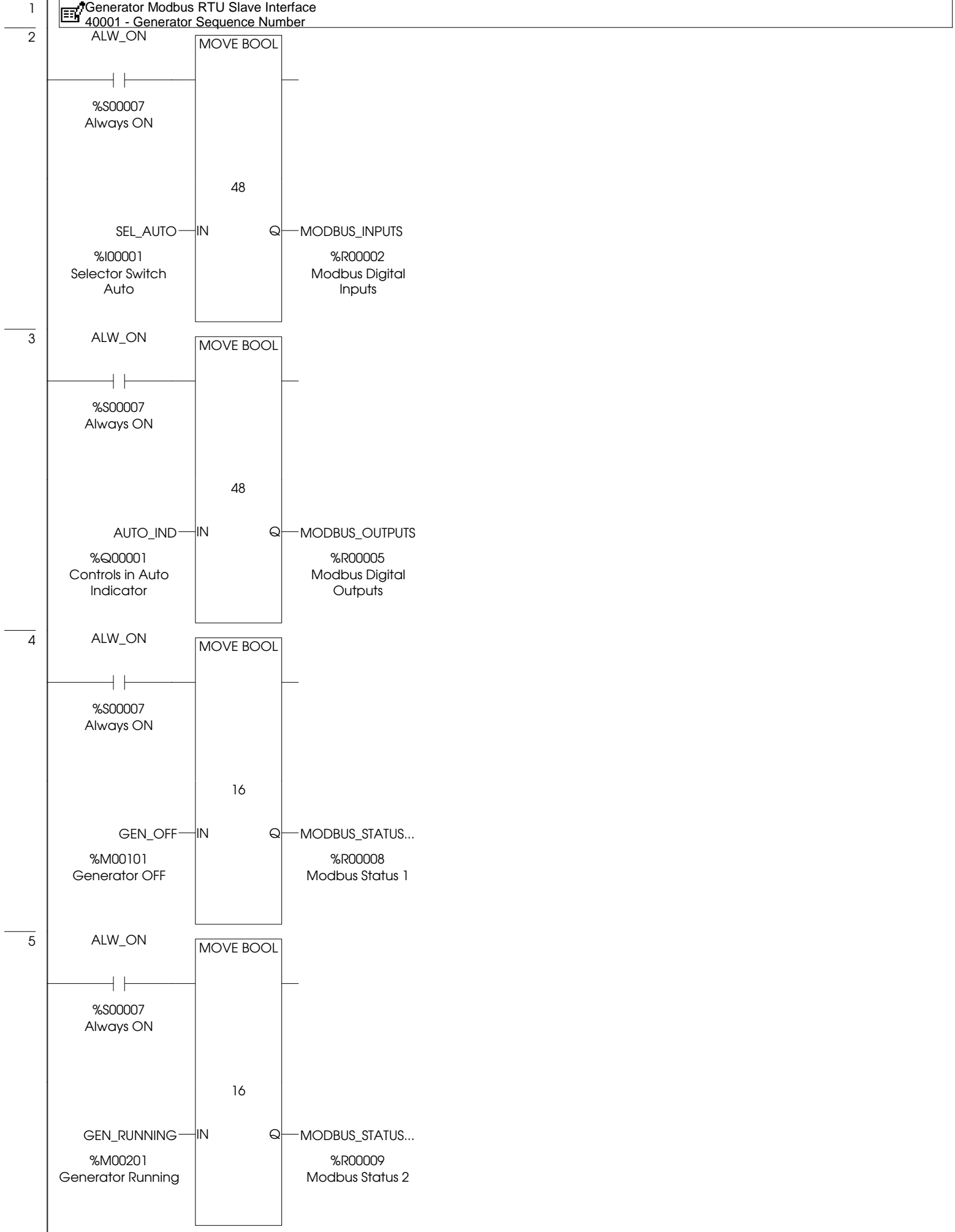




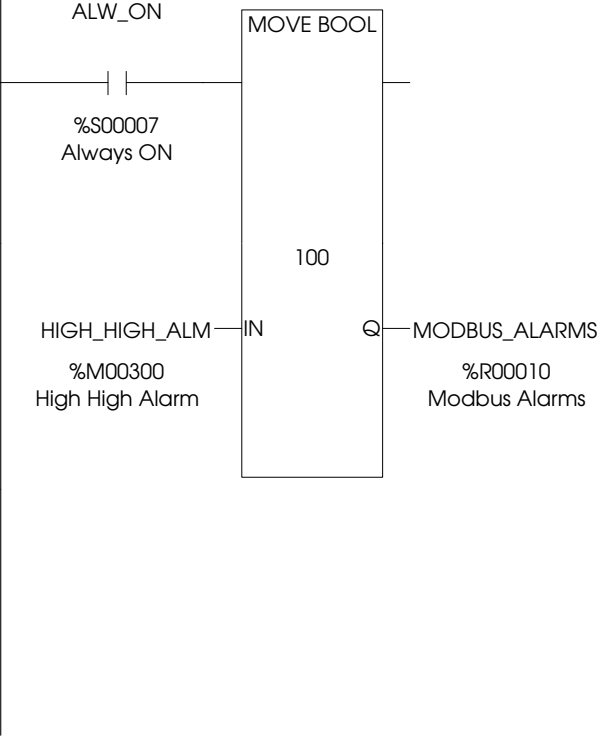


Block Name:.....MODBUS.blk  
Description:..... Control Logic for the Modbus RTU Communications Data.  
Block Type:.....Ladder











| GLOBAL VARIABLES |      |     |         |                                     |            |        |     |     |     |
|------------------|------|-----|---------|-------------------------------------|------------|--------|-----|-----|-----|
| Name             | Type | Len | Address | Description                         | Stored Val | Scope  | Ret | Ovr | Ext |
| SEL_AUTO         | BIT  | 1   | %I00001 | Selector Switch Auto                |            | Global | R   |     |     |
| SEL_TEST         | BIT  | 1   | %I00002 | Selector Switch Test                |            | Global | R   |     |     |
| SEL_MAN          | BIT  | 1   | %I00003 | Selector Switch Manual              |            | Global | R   |     |     |
| EM_STOP_PB       | BIT  | 1   | %I00004 | Emergency Stop PB                   |            | Global | R   |     |     |
| LAMP_TEST_PB     | BIT  | 1   | %I00005 | Lamp Test PB                        |            | Global | R   |     |     |
| ALM_RESET_PB     | BIT  | 1   | %I00006 | Alarm Reset PB                      |            | Global | R   |     |     |
| ALM_MUTE_PB      | BIT  | 1   | %I00007 | Alarm Mute PB                       |            | Global | R   |     |     |
| MAN_STR_PB       | BIT  | 1   | %I00008 | Manual Start PB                     |            | Global | R   |     |     |
| MAN_STP_PB       | BIT  | 1   | %I00009 | Manual Stop PB                      |            | Global | R   |     |     |
| MAN_TRF_MAINS_PB | BIT  | 1   | %I00010 | Manual Transfer to Mains PB         |            | Global | R   |     |     |
| MAN_TRF_GEN_PB   | BIT  | 1   | %I00011 | Manual Transfer to Generator PB     |            | Global | R   |     |     |
| SPD_STP_CRK      | BIT  | 1   | %I00017 | Crank Cutout Relay                  |            | Global | R   |     |     |
| SPD_UNDER        | BIT  | 1   | %I00018 | Under Speed Relay                   |            | Global | R   |     |     |
| SPD_OVER         | BIT  | 1   | %I00019 | Over Speed Relay                    |            | Global | R   |     |     |
| VOLTS_UNDER      | BIT  | 1   | %I00020 | Under Voltage Relay                 |            | Global | R   |     |     |
| VOLTS_OVER       | BIT  | 1   | %I00021 | Over Voltage Relay                  |            | Global | R   |     |     |
| ALT_TEMP         | BIT  | 1   | %I00022 | Alternator High Temperature Relay   |            | Global | R   |     |     |
| GEN_CB_TRIP      | BIT  | 1   | %I00023 | Generator CB Tripped                |            | Global | R   |     |     |
| MEN_FLT          | BIT  | 1   | %I00024 | MEN Fault Relay                     |            | Global | R   |     |     |
| BAT_CHG_AC       | BIT  | 1   | %I00025 | Battery Charger AC Relay            |            | Global | R   |     |     |
| BAT_CONT_LOW_V   | BIT  | 1   | %I00026 | Control Battery Charger Low Voltage |            | Global | R   |     |     |
| BAT_STR_LOW_V    | BIT  | 1   | %I00027 | Start Battery Charger Low Voltage   |            | Global | R   |     |     |
| MAINS_FAILED     | BIT  | 1   | %I00033 | BCC Mains Failed                    |            | Global | R   |     |     |
| MAINS_ATS_CLS    | BIT  | 1   | %I00034 | BCC Mains ATS Closed                |            | Global | R   |     |     |
| GEN_ATS_CLS      | BIT  | 1   | %I00035 | BCC Generator ATS Closed            |            | Global | R   |     |     |
| REM_STR          | BIT  | 1   | %I00036 | BCC Remote Start                    |            | Global | R   |     |     |
| REM_STP          | BIT  | 1   | %I00037 | BCC Remote Stop                     |            | Global | R   |     |     |
| OIL_P_LOW_SD     | BIT  | 1   | %I00041 | Low Oil Pressure Shutdown           |            | Global | R   |     |     |
| OIL_P_LOW_W      | BIT  | 1   | %I00042 | Low Oil Pressure Warning            |            | Global | R   |     |     |
| ENG_T_HI_SD      | BIT  | 1   | %I00043 | High Engine Temperature Shutdown    |            | Global | R   |     |     |
| ENG_T_HI_W       | BIT  | 1   | %I00044 | High Engine Temperature Warning     |            | Global | R   |     |     |
| RAD_WATER_LOW    | BIT  | 1   | %I00045 | Low Radiator Water Level            |            | Global | R   |     |     |
| FUEL_LEV_LOW     | BIT  | 1   | %I00046 | Low Fuel Level                      |            | Global | R   |     |     |
| FUEL_LEV_EMPTY   | BIT  | 1   | %I00047 | Fuel Empty                          |            | Global | R   |     |     |
| CAN_DOORS_OPEN   | BIT  | 1   | %I00048 | Canopy Doors Open                   |            | Global | R   |     |     |
| STEP_1           | BIT  | 1   | %M00001 | Step Sequence No.1                  |            | Global |     |     |     |
| STEP_2_E         | BIT  | 1   | %M00002 | Step Sequence No.2                  |            | Global |     |     |     |
| STEP_3           | BIT  | 1   | %M00003 | Step Sequence No.3                  |            | Global |     |     |     |
| STEP_4           | BIT  | 1   | %M00004 | Step Sequence No.4                  |            | Global |     |     |     |
| STEP_5           | BIT  | 1   | %M00005 | Step Sequence No.5                  |            | Global |     |     |     |
| STEP_6           | BIT  | 1   | %M00006 | Step Sequence No.6                  |            | Global |     |     |     |
| STEP_7           | BIT  | 1   | %M00007 | Step Sequence No.7                  |            | Global |     |     |     |
| STEP_8           | BIT  | 1   | %M00008 | Step Sequence No.8                  |            | Global |     |     |     |
| STEP_9           | BIT  | 1   | %M00009 | Step Sequence No.9                  |            | Global |     |     |     |
| STEP_2_GE        | BIT  | 1   | %M00022 | Step Sequence No.2 GE               |            | Global |     |     |     |
| GEN_OFF          | BIT  | 1   | %M00101 | Generator OFF                       |            | Global |     |     |     |
| AUTO_TEST_STR    | BIT  | 1   | %M00102 | Auto _Test Start / Stop             |            | Global |     |     |     |
| REMOTE_STR       | BIT  | 1   | %M00103 | Remote Start                        |            | Global |     |     |     |
| MAINS_FAIL_STP   | BIT  | 1   | %M00104 | Mains Failed Stop                   |            | Global |     |     |     |
| REMOTE_STP       | BIT  | 1   | %M00105 | Remote Stop                         |            | Global |     |     |     |
| TEST_STR         | BIT  | 1   | %M00106 | Test Start                          |            | Global |     |     |     |
| TEST_STP         | BIT  | 1   | %M00107 | Test Stop                           |            | Global |     |     |     |
| GEN_RUN_OFF      | BIT  | 1   | %M00108 | Generator Run Off                   |            | Global |     |     |     |
| ENABLE_OFFLINE   | BIT  | 1   | %M00109 | Enable Generator to go Offline      |            | Global |     |     |     |
| HH_ALM_OS1       | BIT  | 1   | %M00110 | High High Alarm One Shot            |            | Global |     |     |     |
| H_ALM_OS1        | BIT  | 1   | %M00111 | High Alarm One Shot                 |            | Global |     |     |     |
| H_ALM_OS2        | BIT  | 1   | %M00112 | High Alarm One Shot                 |            | Global |     |     |     |
| M_ALM_OS1        | BIT  | 1   | %M00113 | Medium Alarm One Shot               |            | Global |     |     |     |
| M_ALM_OS2        | BIT  | 1   | %M00114 | Medium Alarm One Shot               |            | Global |     |     |     |
| M_ATS_ALM_OS1    | BIT  | 1   | %M00115 | Mains ATS Alarm One Shot            |            | Global |     |     |     |
| M_ATS_ALM_OS2    | BIT  | 1   | %M00116 | Mains ATS Alarm One Shot            |            | Global |     |     |     |
| GEN_RUNNING      | BIT  | 1   | %M00201 | Generator Running                   |            | Global |     |     |     |
| FAIL_STR_TM      | BIT  | 1   | %M00202 | Failed to Start Time                |            | Global |     |     |     |
| FAIL_STR_DLY     | BIT  | 1   | %M00203 | Failed to Start Pulse Delay         |            | Global |     |     |     |
| FAIL_STR_CNT     | BIT  | 1   | %M00204 | Failed to Start Counter             |            | Global |     |     |     |
| CRK_CUTOUT       | BIT  | 1   | %M00205 | Generator Crank Cutout              |            | Global |     |     |     |
| ENB_STR_DLY      | BIT  | 1   | %M00206 | Enable Start Delay for Alarms       |            | Global |     |     |     |
| OIL_P_DLY        | BIT  | 1   | %M00207 | Oil Pressure Alarm Delay            |            | Global |     |     |     |
| STR_UP_DLY       | BIT  | 1   | %M00208 | Startup Alarm Delay                 |            | Global |     |     |     |



| GLOBAL VARIABLES   |      |     |         |   |            |        |     |     |     |
|--------------------|------|-----|---------|---|------------|--------|-----|-----|-----|
| Name               | Type | Len | Address | Description                               | Stored Val | Scope  | Ret | Ovr | Ext |
| M_ATS_OPN_1        | BIT  | 1   | %M00209 | Mains ATS Open Command                    |            | Global |     |     |     |
| G_ATS_CLS_1        | BIT  | 1   | %M00210 | Generator ATS Close Command               |            | Global |     |     |     |
| G_ATS_OPN_1        | BIT  | 1   | %M00211 | Generator ATS Open Command                |            | Global |     |     |     |
| M_ATS_CLS_1        | BIT  | 1   | %M00212 | Mains ATS Close Command                   |            | Global |     |     |     |
| M_ATS_CLS_ENB      | BIT  | 1   | %M00213 | Mains ATS Close Enable                    |            | Global |     |     |     |
| G_ATS_CLS_ENB      | BIT  | 1   | %M00214 | Generator ATS Close Enable                |            | Global |     |     |     |
| HIGH_HIGH_ALM      | BIT  | 1   | %M00300 | High High Alarm                           |            | Global |     |     |     |
| EM_STP_ALM         | BIT  | 1   | %M00301 | Emergency Stop Alarm                      |            | Global |     |     |     |
| MEN_ALM            | BIT  | 1   | %M00302 | MEN Alarm                                 |            | Global |     |     |     |
| OIL_P_SD_ALM       | BIT  | 1   | %M00303 | Low Oil Pressure Shutdown Alarm           |            | Global |     |     |     |
| ENG_T_SD_ALM       | BIT  | 1   | %M00304 | High Engine Temperature Shutdown Alarm    |            | Global |     |     |     |
| RAD_WATER_LOW_ALM  | BIT  | 1   | %M00305 | Low Radiator Water Level Alarm            |            | Global |     |     |     |
| SPD_OVER_ALM       | BIT  | 1   | %M00306 | Over Speed Alarm                          |            | Global |     |     |     |
| RAD_WATER_LOW_DLY  | BIT  | 1   | %M00315 | Radiator Water Level Low Delay            |            | Global |     |     |     |
| SPD_OVER_DLY       | BIT  | 1   | %M00316 | Over Speed Delay Timer                    |            | Global | R   |     |     |
| HIGH_ALM           | BIT  | 1   | %M00320 | High Alarm                                |            | Global |     |     |     |
| SPD_UNDER_ALM      | BIT  | 1   | %M00321 | Under Speed Alarm                         |            | Global |     |     |     |
| VOLTS_UNDER_ALM    | BIT  | 1   | %M00322 | Alternator Voltage Under Alarm            |            | Global |     |     |     |
| VOLTS_OVER_ALM     | BIT  | 1   | %M00323 | Alternator Voltage Over Alarm             |            | Global |     |     |     |
| GEN_CB_TRIP_ALM    | BIT  | 1   | %M00324 | Generator CB Tripped Alarm                |            | Global |     |     |     |
| ALT_TEMP_ALM       | BIT  | 1   | %M00325 | Alternator High Temperature Alarm         |            | Global |     |     |     |
| SPD_UNDER_DLY      | BIT  | 1   | %M00331 | Under Speed Alarm Delay                   |            | Global |     |     |     |
| VOLTS_UNDER_DLY    | BIT  | 1   | %M00332 | Under Voltage Alarm Delay                 |            | Global |     |     |     |
| VOLTS_OVER_DLY     | BIT  | 1   | %M00333 | Over Voltage Alarm Delay                  |            | Global |     |     |     |
| MEDIUM_ALM         | BIT  | 1   | %M00340 | Medium Alarm                              |            | Global |     |     |     |
| FUEL_LEV_EMPTY_ALM | BIT  | 1   | %M00341 | Fuel Empty Alarm                          |            | Global |     |     |     |
| FAIL_TO_STR_ALM    | BIT  | 1   | %M00342 | Fail to Start Alarm                       |            | Global |     |     |     |
| FUEL_LEV_EMPTY_DLY | BIT  | 1   | %M00351 | Fuel Level Empty Alarm Delay              |            | Global |     |     |     |
| LOW_ALM            | BIT  | 1   | %M00360 | Low Alarm                                 |            | Global |     |     |     |
| OIL_P_W_ALM        | BIT  | 1   | %M00361 | Low Oil Pressure Warning Alarm            |            | Global |     |     |     |
| ENG_T_W_ALM        | BIT  | 1   | %M00362 | High Engine Temperature Warning Alarm     |            | Global |     |     |     |
| FUEL_LEV_LOW_ALM   | BIT  | 1   | %M00363 | Low Fuel Level Alarm                      |            | Global |     |     |     |
| BAT_CHG_AC_ALM     | BIT  | 1   | %M00364 | Battery Charger AC Alarm                  |            | Global |     |     |     |
| BAT_CONT_LOW_V_ALM | BIT  | 1   | %M00365 | Control Battery Charger Low Voltage Alarm |            | Global |     |     |     |
| BAT_STR_LOW_V_ALM  | BIT  | 1   | %M00366 | Start Battery Charger Low Voltage Alarm   |            | Global |     |     |     |
| FUEL_LEV_LOW_DLY   | BIT  | 1   | %M00373 | Fuel Level Low Alarm Delay                |            | Global | R   |     |     |
| BAT_CHG_AC_DLY     | BIT  | 1   | %M00374 | Battery Charger AC Failure Delay          |            | Global | R   |     |     |
| BAT_CONT_LOW_V_DLY | BIT  | 1   | %M00375 | Control Battery Low Voltage Delay         |            | Global | R   |     |     |
| BAT_STR_LOW_V_DLY  | BIT  | 1   | %M00376 | Start Battery Low Voltage Delay           |            | Global | R   |     |     |
| MAINS_ATS_OPN_ALM  | BIT  | 1   | %M00381 | Mains ATS Failed to Open Alarm            |            | Global |     |     |     |
| MAINS_ATS_CLS_ALM  | BIT  | 1   | %M00382 | Mains ATS Failed to Close Alarm           |            | Global |     |     |     |
| GEN_ATS_OPN_ALM    | BIT  | 1   | %M00383 | Generator ATS Failed to Open Alarm        |            | Global |     |     |     |
| GEN_ATS_CLS_ALM    | BIT  | 1   | %M00384 | Generator ATS Failed to Close Alarm       |            | Global |     |     |     |
| NEW_ALM            | BIT  | 1   | %M00400 | New Alarm                                 |            | Global | R   |     |     |
| %M00401            | BIT  | 1   | %M00401 | **No Description**                        |            | Global | R   |     |     |
| %M00402            | BIT  | 1   | %M00402 | **No Description**                        |            | Global | R   |     |     |
| %M00403            | BIT  | 1   | %M00403 | **No Description**                        |            | Global | R   |     |     |
| %M00404            | BIT  | 1   | %M00404 | **No Description**                        |            | Global | R   |     |     |
| %M00405            | BIT  | 1   | %M00405 | **No Description**                        |            | Global | R   |     |     |
| %M00406            | BIT  | 1   | %M00406 | **No Description**                        |            | Global | R   |     |     |
| %M00421            | BIT  | 1   | %M00421 | **No Description**                        |            | Global | R   |     |     |
| %M00422            | BIT  | 1   | %M00422 | **No Description**                        |            | Global | R   |     |     |
| %M00423            | BIT  | 1   | %M00423 | **No Description**                        |            | Global | R   |     |     |
| %M00424            | BIT  | 1   | %M00424 | **No Description**                        |            | Global | R   |     |     |
| %M00425            | BIT  | 1   | %M00425 | **No Description**                        |            | Global | R   |     |     |



| GLOBAL VARIABLES   |      |     |         |                              |            |        |     |     |     |
|--------------------|------|-----|---------|------------------------------|------------|--------|-----|-----|-----|
| Name               | Type | Len | Address | Description                  | Stored Val | Scope  | Ret | Ovr | Ext |
| %M00441            | BIT  | 1   | %M00441 | **No Description**           |            | Global | R   |     |     |
| %M00442            | BIT  | 1   | %M00442 | **No Description**           |            | Global | R   |     |     |
| %M00461            | BIT  | 1   | %M00461 | **No Description**           |            | Global | R   |     |     |
| %M00462            | BIT  | 1   | %M00462 | **No Description**           |            | Global | R   |     |     |
| %M00463            | BIT  | 1   | %M00463 | **No Description**           |            | Global | R   |     |     |
| %M00464            | BIT  | 1   | %M00464 | **No Description**           |            | Global | R   |     |     |
| %M00465            | BIT  | 1   | %M00465 | **No Description**           |            | Global | R   |     |     |
| %M00466            | BIT  | 1   | %M00466 | **No Description**           |            | Global | R   |     |     |
| %M00481            | BIT  | 1   | %M00481 | **No Description**           |            | Global | R   |     |     |
| %M00482            | BIT  | 1   | %M00482 | **No Description**           |            | Global | R   |     |     |
| %M00483            | BIT  | 1   | %M00483 | **No Description**           |            | Global | R   |     |     |
| %M00484            | BIT  | 1   | %M00484 | **No Description**           |            | Global | R   |     |     |
| AUTO_IND           | BIT  | 1   | %Q00001 | Controls in Auto Indicator   |            | Global |     |     |     |
| TEST_IND           | BIT  | 1   | %Q00002 | Controls in Test Indicator   |            | Global |     |     |     |
| MAN_IND            | BIT  | 1   | %Q00003 | Controls in Manual Indicator |            | Global |     |     |     |
| REM_STR_IND        | BIT  | 1   | %Q00004 | Remote Start Indicator       |            | Global |     |     |     |
| MAINS_AVAIL_IND    | BIT  | 1   | %Q00005 | Mains Available Indicator    |            | Global |     |     |     |
| MAINS_CON_IND      | BIT  | 1   | %Q00006 | Mains Connected Indicator    |            | Global |     |     |     |
| GEN_RUN_IND        | BIT  | 1   | %Q00007 | Generator Running Indicator  |            | Global |     |     |     |
| GEN_CON_IND        | BIT  | 1   | %Q00008 | Generator Connected          |            | Global |     |     |     |
|                    |      |     |         | Indicated                    |            |        |     |     |     |
| MAINS_FAILED_IND   | BIT  | 1   | %Q00009 | Mains Failed Indicator       |            | Global |     |     |     |
| EM_STOP_IND        | BIT  | 1   | %Q00010 | Emergency Stop Indicator     |            | Global |     |     |     |
| MEN_FLT_IND        | BIT  | 1   | %Q00011 | MEN Fault Indicator          |            | Global |     |     |     |
| OIL_P_LOW_SD_IND   | BIT  | 1   | %Q00012 | Low Oil Pressure Shutdown    |            | Global |     |     |     |
|                    |      |     |         | Indicator                    |            |        |     |     |     |
| OIL_P_LOW_W_IND    | BIT  | 1   | %Q00013 | Low Oil Pressure Warning     |            | Global |     |     |     |
|                    |      |     |         | Indicator                    |            |        |     |     |     |
| ENG_T_HI_SD_IND    | BIT  | 1   | %Q00014 | High Engine Temperature      |            | Global |     |     |     |
|                    |      |     |         | Shutdown Indicator           |            |        |     |     |     |
| ENG_T_HI_W_IND     | BIT  | 1   | %Q00015 | High Engine Temperature      |            | Global |     |     |     |
|                    |      |     |         | Warning Indicator            |            |        |     |     |     |
| RAD_WATER_LOW_IND  | BIT  | 1   | %Q00016 | Low Radiator Water Level     |            | Global |     |     |     |
|                    |      |     |         | Indicator                    |            |        |     |     |     |
| FUEL_LEV_EMPTY_IND | BIT  | 1   | %Q00017 | Fuel Empty Indicator         |            | Global |     |     |     |
| FUEL_LEV_LOW_IND   | BIT  | 1   | %Q00018 | Low Fuel Level Indicator     |            | Global |     |     |     |
| SPD_OVER_IND       | BIT  | 1   | %Q00019 | Over Speed Indicator         |            | Global |     |     |     |
| SPD_UNDER_IND      | BIT  | 1   | %Q00020 | Under Speed Indicator        |            | Global |     |     |     |
| FAIL_TO_STR_IND    | BIT  | 1   | %Q00021 | Fail to Start Indicator      |            | Global |     |     |     |
| VOLTS_UNDER_IND    | BIT  | 1   | %Q00022 | Alternator Voltage Under     |            | Global |     |     |     |
|                    |      |     |         | Indicator                    |            |        |     |     |     |
| VOLTS_OVER_IND     | BIT  | 1   | %Q00023 | Alternator Voltage Over      |            | Global |     |     |     |
|                    |      |     |         | Indicator                    |            |        |     |     |     |
| ALT_TEMP_IND       | BIT  | 1   | %Q00024 | Alternator High Temperature  |            | Global |     |     |     |
|                    |      |     |         | Indicator                    |            |        |     |     |     |
| GEN_CB_TRIP_IND    | BIT  | 1   | %Q00025 | Generator CB Tripped         |            | Global |     |     |     |
|                    |      |     |         | Indicator                    |            |        |     |     |     |
| BAT_CHG_AC_IND     | BIT  | 1   | %Q00026 | Battery Charger AC Indicator |            | Global |     |     |     |
| BAT_CONT_LOW_V_IND | BIT  | 1   | %Q00027 | Control Battery Charger Low  |            | Global |     |     |     |
|                    |      |     |         | Voltage Indicator            |            |        |     |     |     |
| BAT_STR_LOW_V_IND  | BIT  | 1   | %Q00028 | Start Battery Charger Low    |            | Global |     |     |     |
|                    |      |     |         | Voltage Indicator            |            |        |     |     |     |
| CAN_DOORS_OPEN_IND | BIT  | 1   | %Q00029 | Canopy Doors Open Indicator  |            | Global |     |     |     |
| MAINS_ATS_OPN_CMD  | BIT  | 1   | %Q00033 | BCC Mains ATS Open           |            | Global |     |     |     |
|                    |      |     |         | Command                      |            |        |     |     |     |
| GEN_ATS_CLS_CMD    | BIT  | 1   | %Q00034 | BCC Generator ATS Close      |            | Global |     |     |     |
|                    |      |     |         | Command                      |            |        |     |     |     |
| GEN_SD_ALM         | BIT  | 1   | %Q00035 | BCC Generator Shutdown       |            | Global |     |     |     |
|                    |      |     |         | Alarm                        |            |        |     |     |     |
| GEN_W_ALM          | BIT  | 1   | %Q00036 | BCC Generator Warning        |            | Global |     |     |     |
|                    |      |     |         | Alarm                        |            |        |     |     |     |
| FUEL_LOW           | BIT  | 1   | %Q00037 | BCC Low Fuel                 |            | Global |     |     |     |
| GEN_RUN            | BIT  | 1   | %Q00038 | BCC Generator Running        |            | Global |     |     |     |
| GEN_CON            | BIT  | 1   | %Q00039 | BCC Generator Connected      |            | Global |     |     |     |
| SMR                | BIT  | 1   | %Q00040 | Starter Motor Relay          |            | Global |     |     |     |
| GCR                | BIT  | 1   | %Q00041 | Governor Control Relay       |            | Global |     |     |     |
| AAR                | BIT  | 1   | %Q00042 | Audible Alarm Relay          |            | Global |     |     |     |
| SDAR               | BIT  | 1   | %Q00043 | Generator Shunt Trip Relay   |            | Global |     |     |     |
| SEQ_CNT            | WORD | 1   | %R00001 | Sequence Counter             |            | Global |     | R   |     |
| MODBUS_INPUTS      | WORD | 1   | %R00002 | Modbus Digital Inputs        |            | Global |     | R   |     |
| MODBUS_OUTPUTS     | WORD | 1   | %R00005 | Modbus Digital Outputs       |            | Global |     | R   |     |
| MODBUS_STATUS_1    | WORD | 1   | %R00008 | Modbus Status 1              |            | Global |     | R   |     |
| MODBUS_STATUS_2    | WORD | 1   | %R00009 | Modbus Status 2              |            | Global |     | R   |     |
| MODBUS_ALARMS      | WORD | 1   | %R00010 | Modbus Alarms                |            | Global |     | R   |     |
| %R00100            | WORD | 3   | %R00100 | **No Description**           |            | Global |     | R   |     |
| %R00103            | WORD | 3   | %R00103 | **No Description**           |            | Global |     | R   |     |



| GLOBAL VARIABLES |      |     |         |  |            |        |     |     |     |
|------------------|------|-----|---------|--|------------|--------|-----|-----|-----|
| Name             | Type | Len | Address | Description  | Stored Val | Scope  | Ret | Ovr | Ext |
| %R00106          | WORD | 3   | %R00106 | **No Description**   |            | Global | R   |     |     |
| %R00109          | WORD | 3   | %R00109 | **No Description**   |            | Global | R   |     |     |
| %R00112          | WORD | 3   | %R00112 | **No Description**   |            | Global | R   |     |     |
| %R00115          | WORD | 3   | %R00115 | **No Description**   |            | Global | R   |     |     |
| %R00118          | WORD | 3   | %R00118 | **No Description**   |            | Global | R   |     |     |
| %R00121          | WORD | 3   | %R00121 | **No Description**   |            | Global | R   |     |     |
| %R00124          | WORD | 3   | %R00124 | **No Description**   |            | Global | R   |     |     |
| %R00127          | WORD | 3   | %R00127 | **No Description**   |            | Global | R   |     |     |
| %R00130          | WORD | 3   | %R00130 | **No Description**   |            | Global | R   |     |     |
| %R00200          | WORD | 3   | %R00200 | **No Description**   |            | Global | R   |     |     |
| %R00203          | WORD | 3   | %R00203 | **No Description**   |            | Global | R   |     |     |
| %R00206          | WORD | 3   | %R00206 | **No Description**   |            | Global | R   |     |     |
| %R00209          | WORD | 3   | %R00209 | **No Description**   |            | Global | R   |     |     |
| %R00212          | WORD | 3   | %R00212 | **No Description**   |            | Global | R   |     |     |
| %R00215          | WORD | 3   | %R00215 | **No Description**   |            | Global | R   |     |     |
| %R00218          | WORD | 3   | %R00218 | **No Description**   |            | Global | R   |     |     |
| %R00221          | WORD | 3   | %R00221 | **No Description**   |            | Global | R   |     |     |
| %R00224          | WORD | 3   | %R00224 | **No Description**   |            | Global | R   |     |     |
| %R00227          | WORD | 3   | %R00227 | **No Description**   |            | Global | R   |     |     |
| %R00230          | WORD | 3   | %R00230 | **No Description**   |            | Global | R   |     |     |
| %R00300          | WORD | 3   | %R00300 | **No Description**   |            | Global | R   |     |     |
| %R00303          | WORD | 3   | %R00303 | **No Description**   |            | Global | R   |     |     |
| %R00306          | WORD | 3   | %R00306 | **No Description**   |            | Global | R   |     |     |
| %R00309          | WORD | 3   | %R00309 | **No Description**   |            | Global | R   |     |     |
| %R00312          | WORD | 3   | %R00312 | **No Description**   |            | Global | R   |     |     |
| %R00315          | WORD | 3   | %R00315 | **No Description**   |            | Global | R   |     |     |
| %R00318          | WORD | 3   | %R00318 | **No Description**   |            | Global | R   |     |     |
| %R00321          | WORD | 3   | %R00321 | **No Description**   |            | Global | R   |     |     |
| %R00324          | WORD | 3   | %R00324 | **No Description**   |            | Global | R   |     |     |
| %R00327          | WORD | 3   | %R00327 | **No Description**   |            | Global | R   |     |     |
| %R00330          | WORD | 3   | %R00330 | **No Description**   |            | Global | R   |     |     |
| %R00333          | WORD | 3   | %R00333 | **No Description**   |            | Global | R   |     |     |
| %R00336          | WORD | 3   | %R00336 | **No Description**   |            | Global | R   |     |     |
| %R00339          | WORD | 3   | %R00339 | **No Description**   |            | Global | R   |     |     |
| FST_SCN          | BIT  | 1   | %S00001 | Set to 1 when the current sweep is the first sweep         |            | Global | R   |     |     |
| LST_SCAN         | BIT  | 1   | %S00002 | Reset from 1 to 0 when the current sweep is the last sweep |            | Global | R   |     |     |
| T_10MS           | BIT  | 1   | %S00003 | 0.01 Second Timer Contact                                  |            | Global | R   |     |     |
| T_100MS          | BIT  | 1   | %S00004 | 0.1 Second Timer Contact                                   |            | Global | R   |     |     |
| T_1S             | BIT  | 1   | %S00005 | 1 Second Timer Contact                                     |            | Global | R   |     |     |
| T_1M             | BIT  | 1   | %S00006 | 1 Minute Timer Contact                                     |            | Global | R   |     |     |
| ALW_ON           | BIT  | 1   | %S00007 | Always ON  |            | Global | R   |     |     |
| ALW_OFF          | BIT  | 1   | %S00008 | Always OFF   |            | Global | R   |     |     |
| PLC_BAT          | BIT  | 1   | %S00014 | Set to indicate a bad battery in the CPU                   |            | Global | R   |     |     |
| %R00133          | WORD | 3   | %R00133 | **No Description**   |            | Global | R   |     |     |
| %R00136          | WORD | 3   | %R00136 | **No Description**   |            | Global | R   |     |     |



GLOBAL SUMMARY OF HIGHEST USED REFERENCE ADDRESSES

| MEMORY AREA          | ADDRESS   |
|----------------------|-----------|
| Analog Input (%AI)   | None Used |
| Analog Output (%AQ)  | None Used |
| Input (%I)           | %I00048   |
| Output (%Q)          | %Q00048   |
| Internal Memory (%M) | %M00484   |
| Register (%R)        | %R00341   |
| Genius Global (%G)   | None Used |
| Genius Global (%GA)  | None Used |
| Genius Global (%GB)  | None Used |
| Genius Global (%GC)  | None Used |
| Genius Global (%GD)  | None Used |
| Genius Global (%GE)  | None Used |
| Temporary (%T)       | None Used |
| System (%S)          | %S00007   |
| System (%SA)         | None Used |
| System (%SB)         | None Used |
| System (%SC)         | None Used |
| Program (%P)         | None Used |



Table of Contents

Block: AUD\_ALM.blk

Properties..... 2

Logic..... 3

Block: ALARM.blk

Properties..... 7

Logic..... 8

Block: SEQ.blk

Properties..... 19

Logic..... 20

Block: MAIN.blk

Properties..... 29

Logic..... 30

Block: \_MAIN.blk

Properties..... 39

Logic..... 40

Block: PRESETS.blk

Properties..... 41

Logic..... 42

Block: MODBUS.blk

Properties..... 44

Logic..... 45

Variable Declarations Table..... 47

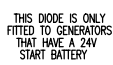
Summary of Highest Used Reference Addresses..... 51



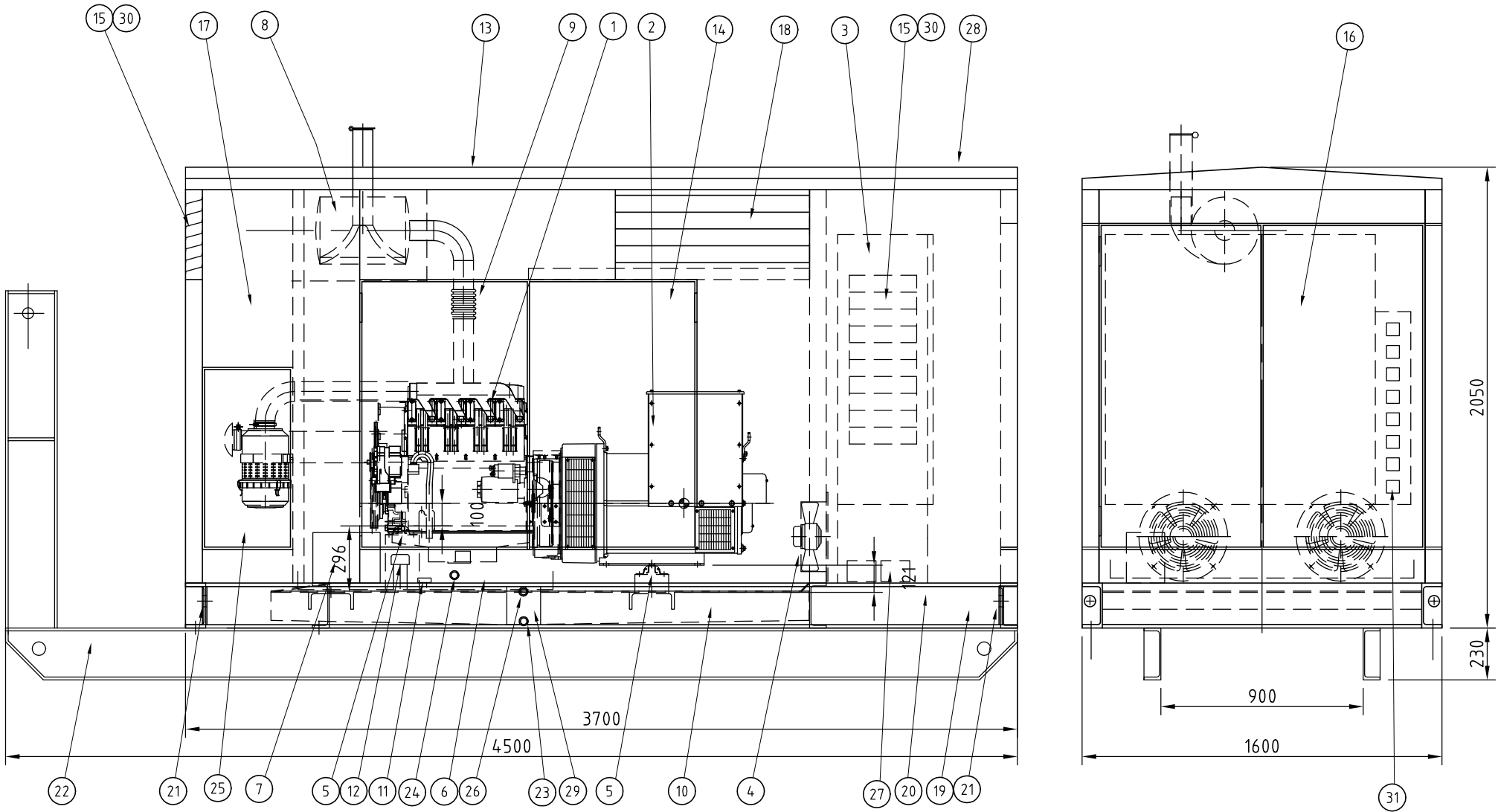
# SP181

## Section 7 - Drawings









| LEGEND |                                    |
|--------|------------------------------------|
| ITEM   | DESCRIPTION                        |
| 1      | ENGINE DEUTZ F4L912                |
| 2      | ALTERNATOR STAMFORD UC274F         |
| 3      | CONTROL SWITCHBOARD                |
| 4      | VENTILATION FAN (2)                |
| 5      | A/V MOUNTS (4 OFF)                 |
| 6      | ENGINE DRIP TRAY                   |
| 7      | STARTING BATTERY (382)             |
| 8      | EXHAUST SILENCER (COWL TS30PR)     |
| 9      | EXHAUST PIPE FLEXIBLE Ø75          |
| 10     | FUEL TANK BASE FRAME 300 L         |
| 11     | FUEL GAUGE (MECHANICAL)            |
| 12     | FUEL FILL POINT (INSIDE ENCLOSURE) |
| 13     | ACOUSTIC ENCLOSURE (70dbA @ 7m)    |
| 14     | SIDE ACCESS DOORS (2 OFF)          |
| 15     | AIR INLET GRILL                    |
| 16     | SWITCHBOARD ACCESS DOOR            |
| 17     | PLENUM CHAMBER                     |
| 18     | AIR OUTLET GRILL                   |
| 19     | CABLE ENTRY ZONE                   |
| 20     | ANCHOR POINT                       |
| 21     | LIFTING POINTS                     |
| 22     | TRANSPORT SKID                     |
| 23     | FUEL TANK DRAIN (LOCKABLE)         |
| 24     | OIL DRAIN (LOCKABLE)               |
| 25     | AIR CLEANER ACCESS DOOR            |
| 26     | CATCHMENT TRAY DRAIN               |
| 27     | CONTROL BATTERIES (2x12 VOLT)      |
| 28     | BATTERY CHARGING SOLAR PANEL       |
| 29     | DRAIN POINT LOCKABLE COVER         |
| 30     | INSECT SCREEN                      |
| 31     | OUTPUT & CONTROL SOCKETS T.B.A.    |

NOTE  
ENCLOSURE COLOUR : MIST GREEN  
BASE TANK COLOUR : MIST GREEN  
SKID BASE COLOUR : MIST GREEN

APPROVED FOR  
CONSTRUCTION

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| Rev. | Date   | DESIGN REVIEW | REV'D P.MGR | APP'D P.MGR | Amendment              |
|------|--------|---------------|-------------|-------------|------------------------|
| 0    | 2.6.03 |               |             |             | ISSUE FOR CONSTRUCTION |
| A    | 2.5.03 |               |             |             | APPROVAL ISSUE         |

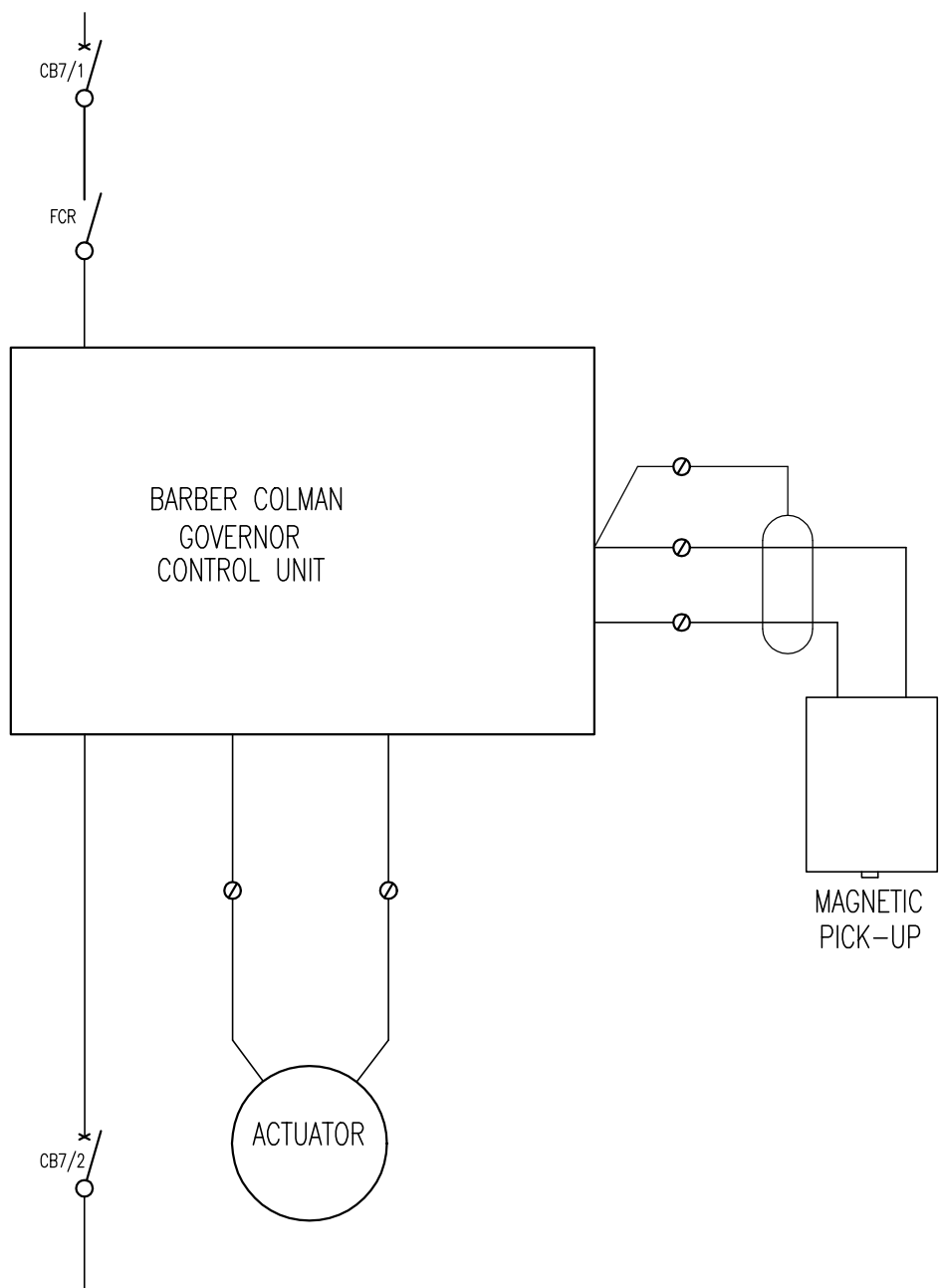


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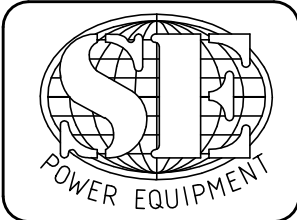
| Client<br>BRISBANE WATER                      |               |                             |                              |
|---|---------------|-----------------------------|------------------------------|
| Project<br>SEWAGE PUMP STATION BACKUP GENSETS |               |                             |                              |
| Drafter<br>RSL                                | Draft Check   | Reviewed<br>Project Manager | Approved<br>Project Director |
| Designed<br>RSL                               | Design Review |                             |                              |

| Title<br>SP181 SINNAMON ROAD<br>ARRANGEMENT |                |                               |            |                  |      |
|---|----------------|-------------------------------|------------|------------------|------|
| Scale<br>1:20                               | No in set<br>1 | SE Ref No.<br>14291           | SE Job No. | S.E. Drawing No. | AMDT |
| Engineer's Ref. No.                         |                | Client Ref No.<br>30140-02/03 |            | 14291-004        | 0    |



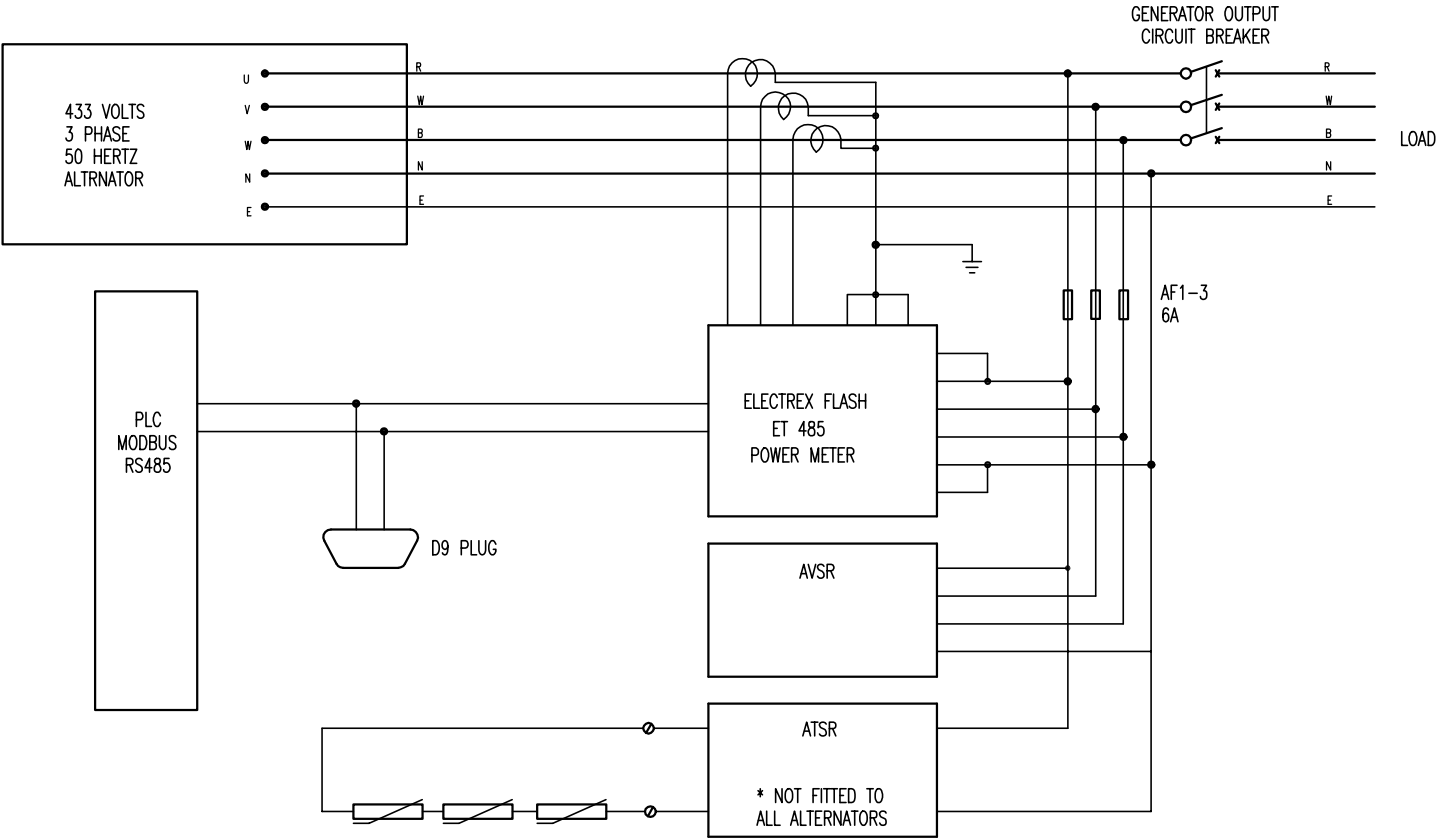


0 1.8.03 AS BUILT




|  |  |                          |                           |                  |
|--|--|--------------------------|---------------------------|------------------|
| EQUIPMENT DATA SHEET   |  | REV No:<br>0             | PROJECT No:<br>14 291-606 | DATE:<br>1.08.03 |
| TITLE: BCC BRISBANE WATER<br>PUMP STATION BACKUP GENSET<br>BARBER COLMAN GOVERNOR CONTROLS |  | REF:                     | PREPARED<br>BY: HJR / RSL | CHECKED<br>BY:   |
|  |  | APPROVED FOR ISSUE<br>JP |                           | SCALE:<br>1:1    |





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|      |        |               |             |             |           |
|------|--------|---------------|-------------|-------------|-----------|
| Rev. | Date   | DESIGN REVIEW | REV'D P.MGR | APP'D P.MGR | Amendment |
| 0    | 1.8.03 |               |             |             | AS BUILT  |

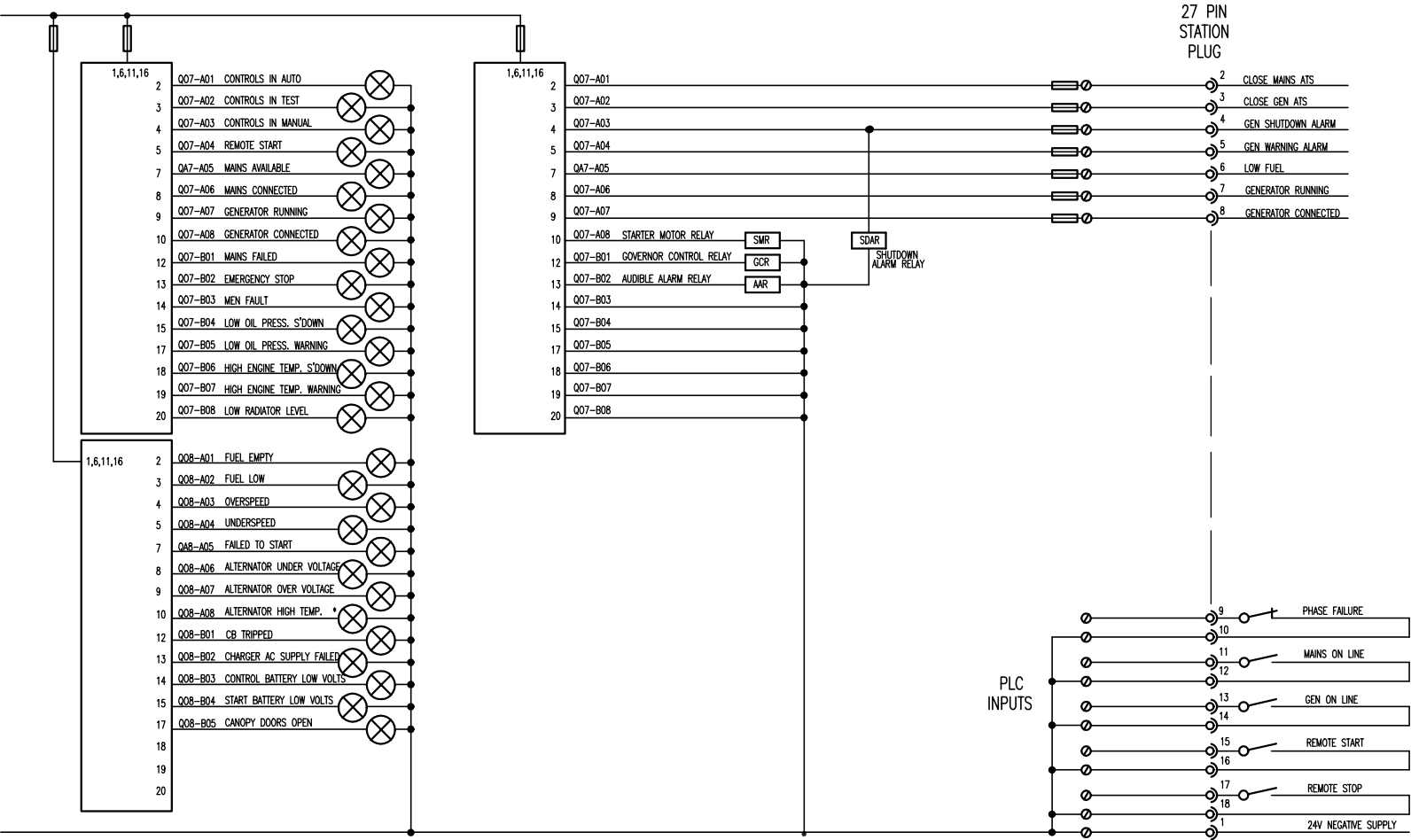


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|                                       |               |                             |                              |
|---------------------------------------|---------------|-----------------------------|------------------------------|
| Client<br>BCC BRISBANE WATER          |               |                             |                              |
| Project<br>PUMP STATION BACKUP GENSET |               |                             |                              |
| Drafter<br>HJR / RSL                  | Draft Check   | Reviewed<br>Project Manager | Approved<br>Project Director |
| Designed<br>JP                        | Design Review | JP                          | JP                           |


|                    |                |                     |           |                  |      |                      |  |
|--------------------|----------------|---------------------|-----------|------------------|------|----------------------|--|
| Title              |                |                     |           |                  |      | ELECTRICAL SCHEMATIC |  |
| Scale<br>1:1       | No in set<br>5 | SE Ref No.<br>14291 | SE Job No | S.E. Drawing No. | AMDT |                      |  |
| Engineer's Ref. No |                | Client Ref No.      |           | 14291-604-393 0  |      |                      |  |
|                    |                |                     |           |                  |      | Page 384 of 393      |  |





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|      |        |               |             |             |           |
|------|--------|---------------|-------------|-------------|-----------|
| Rev. | Date   | DESIGN REVIEW | REV'D P.MGR | APP'D P.MGR | AS BUILT  |
| 0    | 1.8.03 |               |             |             | Amendment |

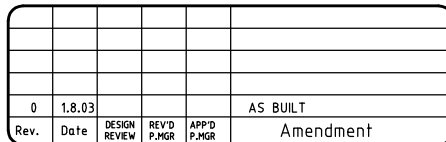


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|  |                              |                                   |                                    |
|--|------------------------------|-----------------------------------|------------------------------------|
| Client<br>BCC BRISBANE WATER<br>PUMP STATION BACKUP GENSET |                              |                                   |                                    |
| Drafter<br>HJR / RSL<br>Designed<br>JPB                    | Draft Check<br>Design Review | Reviewed<br>Project Manager<br>JP | Approved<br>Project Director<br>JP |

|                               |                |                     |            |                                      |           |
|-------------------------------|----------------|---------------------|------------|--------------------------------------|-----------|
| Title<br>ELECTRICAL SCHEMATIC |                |                     |            |                                      |           |
| Scale<br>1:1                  | No in set<br>5 | SE Ref No.<br>14291 | SE Job No. | S.E. Drawing No.<br>14291-385 of 393 | AMDT<br>0 |
| Engineer's Ref. No.           |                | Client Ref No.      |            |                                      |           |





|                      |               |                             |                              |
|----------------------|---------------|-----------------------------|------------------------------|
| Client               |               | BCC BRISBANE WATER          |                              |
| Project              |               | PUMP STATION BACKUP GENSET  |                              |
| Drafter<br>HJR / RSL | Draft Check   | Reviewed<br>Project Manager | Approved<br>Project Director |
| Designed<br>09/13    | Design Review | JP                          | JP                           |

|                     |                |                      |            |                  |  |  |                      |  |  |  |  |  |  |
|---------------------|----------------|----------------------|------------|------------------|--|--|----------------------|--|--|--|--|--|--|
| Title               |                |                      |            |                  |  |  | ELECTRICAL SCHEMATIC |  |  |  |  |  |  |
| Scale<br>1:1        | No in set<br>5 | SE Ref. No.<br>14291 | SE Job No. | S.E. Drawing No. |  |  | AMDT                 |  |  |  |  |  |  |
| Engineer's Ref. No. |                | Client Ref. No.      |            | 14291            |  |  | 36802                |  |  |  |  |  |  |
|                     |                |                      |            | Page             |  |  | 388 of 393           |  |  |  |  |  |  |



# SP181

## Section 8 - Test Reports



47 Proprietary Street, Tingalpa, Qld 4173  
Telephone: (07) 3890 1744  
PO Box 3306 Tingalpa B.C. Qld 4173

## SEP 009/B

DATE: 1/8/03.  
JOB NO: 14291  
ENG. SERIAL NO: 8668556  
ALT. SERIAL NO: 37144

[illegible]

TESTING OFFICER: JOHN ROTH.





47 Proprietary Street  
Tingalpa Q 4173  
BRISBANE AUSTRALIA

# DIESEL GENERATOR SET LOAD TEST REPORT

SEP 0064/D

CLIENT: BLIS WATER SP181 DATE: 1/08/03  
SERIAL NO: 0307014 JOB NO/CONTRACT NO: 14291  
ENGINE TYPE: F4L912 ENG. SERIAL NO: 8668556  
ALTERNATOR TYPE: 274F ALT. SERIAL NO: 37144  
GOVERNOR TYPE: BARBER COLEMAN STARTER MOTOR: DEUTZ  
OVERSPEED TYPE: 4 UNDERSPEED TYPE: BARBER  
SHUTDOWN SOLENOID: 4 HIGH WATER: N/A  
LOW OIL PRESSURE SHUTDOWN: DEUTZ

A: 44.4 + 10% KW: 32 + 10%

TECHNICIAN: \_\_\_\_\_ INSPECTOR: PAUL HLAVKA *PH*

| TIME                     | 1000              | 1030        | 1100        | 1130        | 1200        | 1230        | 1235        |  |  |  |
|--------------------------|-------------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|
| OIL PRESSURE             | 500               | 350         | 200         | 150         | 150         | 140         | 280         |  |  |  |
| OIL TEMPERATURE          | 0                 | 100         | 110         | 110         | 110         | 115         | 90          |  |  |  |
| JACKET WATER TEMPERATURE | NA                |             |             |             |             |             |             |  |  |  |
| TEMP'S                   | 0                 | 44.2        | 44.2        | 44.2        | 44.2        | 44.2        | 0           |  |  |  |
| VOLTS                    | 242<br>242<br>243 | ✓<br>✓<br>✓ | ✓<br>✓<br>✓ | ✓<br>✓<br>✓ | ✓<br>✓<br>✓ | ✓<br>✓<br>✓ | ✓<br>✓<br>✓ |  |  |  |
| AMBIENT TEMPERATURE      | 20                | 20          | 20          | 20          | 20          | 20          | 20          |  |  |  |
| HZ                       | 50.1              | 50.1        | 50.1        | 50.1        | 50.1        | 50.1        | 50.1        |  |  |  |
| KW                       | 0                 | 32          | 32          | 32          | 32          | 32          | 0           |  |  |  |
| LOAD%                    | 0                 | 100%        | 100%        | 100%        | 100%        | 100%        | 0           |  |  |  |
| REMARKS                  |                   |             |             |             |             |             |             |  |  |  |





47 Proprietary Street  
Tingalpa Q 4173  
BRISBANE AUSTRALIA

SEP 0013

FINAL INSPECTION CHECKLIST

This form is to be completely filled out before any generating set leaves the factory.

It is to be signed by the person doing the inspection and by their immediate supervisor. In the case of a non-standard job it must also be signed by the Special Projects Manager or the Engineering Manager.

A copy of this form is to be sent out with the plant concerned.

Please neatly tick in the boxes provided where applicable and note any comments in the space provided.

MODEL: SP181 SERIAL NO: 0307014 ENGINE NO: 8668556  
JOB NO: 14291 DATE: 4/8/03 CUSTOMER: B.W.

BASE

- (1) All welds continuous, neat and clean.
- (2) All bolts tightened.
- (3) Bearers completely secured.
- (4) No sharp corners.

|                                     |
|-------------------------------------|
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |

RADIATOR

- (1) Radiator correctly mounted.
- (2) All pipework included and secure.
- (3) Drain plug in place.
- (4) Water removed from radiator.
- (5) Clamps on hoses tight.

|                                     |
|-------------------------------------|
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |

ENGINE

- (1) Fan is correctly mounted.
- (2) All guards in place and secure.
- (3) Wiring loom is correct to drawing, securely fixed and marked and is terminated in an appropriate terminal box.
- (4) Battery leads attached and secure and long enough for termination to battery.
- (5) Air cleaner is properly mounted.
- (6) Magnetic pickup is fitted and set to correct depth.
- (7) Exhaust pipe and silencer (where required) are fitted correctly.
- (8) Dip stick in place.
- (9) Oil removed from engine.
- (10) All fuel and oil unions completely tightened.
- (11) All ordered options are fitted and function correctly.
- (12) All parts secure, no damage.
- (13) All earths less than 0.1 ohms.
- (14) Cables and hoses secure for transport.

|                                     |
|-------------------------------------|
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |

CONTROL SYSTEM (where applicable)

- (1) Control functions as ordered.
- (2) Control is mounted correctly.
- (3) All leads, terminals, fuses, printed circuit boards and switchgear are completely secure and marked correctly.
- (4) Dust seals are fitted around doors.
- (5) Doors hinged correctly.
- (6) All earths less than 0.1 ohms.
- (7) Red Danger labels in cubicle.

|                                     |
|-------------------------------------|
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |



CONTROL SYSTEM (cont)

- (8) Perspex shield secure, clean and no sharp corners.
- (9) Cables correct, no damage.
- (10) Locks and keys satisfactory.

|                                     |
|-------------------------------------|
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |

ALTERNATOR

- (1) Alternator is correctly mounted.
- (2) Alternator leads are correctly mounted inside terminal box and marked correctly.
- (3) A.V.R. is mounted, connected properly and set to correct setting.
- (4) Coupling and adaptor are properly fastened between engine and alternator with correct size and tensile grade bolts.
- (5) All options ordered are fitted and function properly.
- (6) Alternator is correctly wired for the appropriate voltage as per either Order or Bills of Material.
- (7) Earth stud fitted.

|                                     |
|-------------------------------------|
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |

FINISH

- (1) Plant is painted to correct colour.
- (2) All blemishes in finish, especially paint runs, are completely removed.

|                                     |
|-------------------------------------|
| <input checked="" type="checkbox"/> |
| <input checked="" type="checkbox"/> |

GENERAL INSPECTION

- (1) Genset is manufactured to correct engine/alternator/radiator/bases configuration as specified on Bill of Materials.
- (2) All documents are in a sealed plastic bag and secured inside alternator terminal box.
  - a) Engine Handbook
  - b) Alternator Handbook
  - c) Warranty Card
  - d) Packing List
  - e) Test Sheet
- (3) No Oil/No Water label is attached to positive battery lead.
- (4) All labels are straight and in correct location.

|                                     |
|-------------------------------------|
| <input checked="" type="checkbox"/> |
| <input type="checkbox"/>            |
| <input type="checkbox"/>            |
| <input type="checkbox"/>            |
| <input type="checkbox"/>            |
| <input type="checkbox"/>            |
| <input type="checkbox"/>            |
| <input checked="" type="checkbox"/> |

SIGNED: PAUL HLAVKA INSPECTOR

\_\_\_\_\_  
QUALITY ASSURANCE

COMMENTS: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_





GENERATOR SET

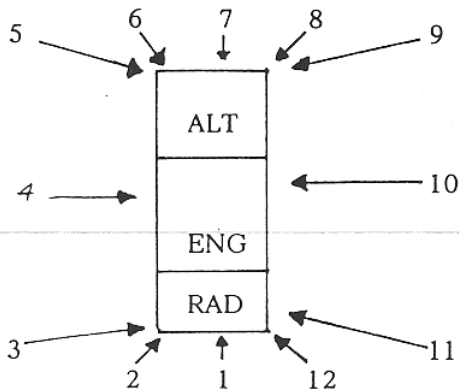
SEP 0023/D

## SOUND PRESSURE LEVEL TEST REPORT

47 Proprietary Street  
Tingalpa Q 4173  
BRISBANE AUSTRALIA

CLIENT: BLIS WATER SP181 DATE: \_\_\_\_\_  
 SERIAL NO: 0307014 JOB NO: 14291  
 ENGINE TYPE: F4L912 ENG. SERIAL NO: 8668556  
 ALTERNATOR TYPE: 274F ALT. SERIAL NO: 37144  
 SOUND LEVEL INSTRUMENT: RION-NL

## Remarks:

Distance: 7 mHeight: 1.5 m

Position Layout

| POSITION | SOUND LEVEL<br>dB(A) | LOAD % |    |    |     |     |
|----------|----------------------|--------|----|----|-----|-----|
|          |                      | 25     | 50 | 75 | 100 | 110 |
| 1        | 65                   |        |    |    |     |     |
| 2        | 64                   |        |    |    |     |     |
| 3        | 64                   |        |    |    |     |     |
| 4        | 64                   |        |    |    |     |     |
| 5        | 63.9                 |        |    |    |     |     |
| 6        | 67                   |        |    |    |     |     |
| 7        | 63.9                 |        |    |    |     |     |
| 8        | 64                   |        |    |    |     |     |
| 9        | 64                   |        |    |    |     |     |
| 10       | 64                   |        |    |    |     |     |
| 11       | 64                   |        |    |    |     |     |
| 12       | 64                   |        |    |    |     |     |
| Average  |                      |        |    |    |     |     |

QUALITY ASSURANCE OFFICER: \_\_\_\_\_

CUSTOMER TESTING OFFICER: \_\_\_\_\_

TESTING OFFICER: PAUL HIAVKAWITNESS TESTING OFFICER: DAVID COOPER





47 Proprietary Street  
Tingalpa Qld 4173  
PH: (07) 3890 1744

SEP0084

## TRANSIENT LOAD RESPONSE TEST SHEET

Transient response for load changes: Load PF 0.8

|                         | 0-25 | 0-50 | 0-75 | 0-100 | 100-0 | 75-0 | 50-0 | 25-0 |
|-------------------------|------|------|------|-------|-------|------|------|------|
| % Change Electrical kW  |      |      |      |       |       |      |      |      |
| Change in Electrical kW |      |      |      |       |       |      |      |      |
| % Change HZ             |      |      |      | 4     | 4     |      |      |      |
| % Change Volts          |      |      |      | 5     | 5     |      |      |      |
| Recovery secs           |      |      |      | 5     | 4     |      |      |      |

Client: BUS. WATER

Job No: 14291

S/N: 0307014