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23706

“A total solution Company”

MUSTEHKAM CONSTRUCTION

26th March 2009

To,
Chief, Procurement Services Unit
Operational Support Services Branch
Programme Support & General Management Division
United Nations Industrial Development Organization
Wagramer Strasse 5, P.O. Box 300 A-1400 Vienna
Austria

Subject: Submission of Final Report For UNIDO Project EE/PAK/04/001 “Design, Supply, Installation and commissioning of an environmental conditioning system (ECS), a 3 phase voltage stabilizer and a diesel generator for the NPSL in Pakistan”

Dear Madam,

We are pleased to inform you that the said project has been handed over to NPSL.

Please see the certificate of acceptance & our final report attached herewith.

Also attached is our final invoice – invoice # 05/2009. We would appreciate quick action from your side with reference to the release of our payment.

It was a pleasure working with UNIDO and we deeply appreciate the cooperation extended to us by Mr. Zawdu Felleke (CTO UNIDO, Islamabad) and Mr. Badar-Ul-Islam (UNIDO, Islamabad). We look forward to doing further business with you.

Thanks & Regards,

MUSTEHKAM CONSTRUCTION

A. F. Khan
Manager Projects

MUSTEHKAM CONSTRUCTION

MC

"A total solution Company"

Final Report

Certificate of Acceptance of Work & Summary of Work Performed, Technical Drawings and Technical Manuals

As per,

UNIDO Project EE/PAK/04/001
"Design, Supply, Installation and Commissioning of an Environmental Conditioning System (ECS), a 3-Phase Voltage Stabilizer and a Diesel Generator for the NPSL in Pakistan"

Report Submission Date: 26th March, 2009

Submitted By:

Mustehkam Construction
Street 38, Office 35,
F-10/4, Islamabad
Pakistan

Submittals:

1 Electronic Copy & 1 Hard Copy of the Final Report
04 Nos. Duplicate Hard Copies of the Final Report
Chief, Procurement Services Unit
Operational Support Services Branch
Programme Support and General Maintenance Division
United Nations Industrial Development Organization (UNIDO)
Wagramer Strasse 5, P.O.Box 300
A-1400 Vienna
Austria

CC: 1 Electronic Copy & 1 Hard Copy Submitted to:
Mr. Zawdu Felleke
Chief Technical Advisor
Trade Related Technical Assistance (TRTA)
United Nations Industrial Development Organization (UNIDO)
Field Office,
Office # 35, Collage Road,
F-7/2, Islamabad
Pakistan

MUSTEHKAM CONSTRUCTION

MUSTEHKAM CONSTRUCTION

Contents:

MUSTEHKAM CONSTRUCTION

NPSL

Government of Pakistan
Ministry of Science & Technology
Pakistan Council of Scientific and Industrial Research

NATIONAL PHYSICAL AND STANDARDS LABORATORY

Dated: March 25, 2009

Mr. Ikram Rashid,
Managing Director,
M/s Mustehkum Construction (Pvt.) Ltd.,
House No.35, St. No.38, Sector F-10/4,
Islamabad

Subject: **Acceptance of Upgraded Metrology Laboratory of NPSL (PCSIR) under UNIDO Project # EE/PAK/04/001**

Enclose please find the acceptance letter for installation of Environmental Conditioning System by your firm in upgraded Matrology Laboratories under TRTA programme of UNIDO (EU).

With regards.

Yours truly,

25/03/09
(Rao Jamil-ur-Rehman)
Project Director

Copy to: Mr. Zawdu Feleke,
Chief Technical Advisor, UNIDO

NPSL

Government of Pakistan
Ministry of Science & Technology
Pakistan Council of Scientific and Industrial Research

NATIONAL PHYSICAL AND STANDARDS LABORATORY

Date: 25-03-2009

CERTIFICATE OF ACCEPTANCE

We hereby confirm that the installation of the Environmental Conditioning System (ECS) at the NPSL upgraded metrology laboratories has been successfully completed by the supplier/contractor, M/s Musthekam Construction, as per the Terms of Reference (TOR) issued by UNIDO.

The ECS has been commissioned and rendered operational to full satisfaction of NPSL, according to the requirement of TOR.

25/03/09
Project Director, NPSL/PCSIR

Director General, NPSL/PCSIR

Table Of Contents

Overview of The Project

This project is an integral part of the assistance provided to Pakistan by UNIDO (United Nations Industrial Development Organization) to enhance our industrial competitiveness through European Union's Trade Related Technical Assistance Project (TRTA).

Its major objective is to enhance national capabilities in the areas of Standards, Metrology, Testing and Quality (SMTQ). It aims to upgrade NPSL's (National Physical & Standards Laboratory) measurement services in the fields of Mass, Pressure, Length, Temperature and Electricity. This would lead to the accreditation of NPSL's measurement services to ISO17025 and international traceability of its measurements.

This project entails the provision of new metrology equipment, training of metrological staff and an Environmental Conditioning System (ECS) which could accurately control the temperature, humidity, air flow and air quality in the laboratories.

The scope of UNIDO's contract with Mustehkam Construction covered the design and installation of the ECS and its support equipment.

*REFERENCE DRAWING: DWG 1 In Drawings Section

Work Performed By Mustehkam Construction

As per UNIDO project EE/PAK/04/001 – Design, Supply, Installation and Commissioning of an Environmental Conditioning System (ECS), a 3 Phase Voltage Stabilizer and a Diesel Generator for NPSL in Pakistan – Mustehkam Construction has performed the following tasks;

Design Of The ECS:

The ECS was designed by Mustehkam Construction in collaboration with Weiss Klimatechnik GmbH, Germany. Our designed system catered for all requirements put forward by the TOR (Terms of Reference – as designed by Keith Berry, the consultant for NPSL) in an efficient and effective way.

Our proposed design was studied in detail by UNIDO, NPSL and PCSIR and approval was given after a few minor changes such as the substitution of electric heaters for gas fired boilers etc.

perforated ceiling, wall cladding materials which would reduce the risk of dust and insects, water and dust proof flooring to reduce the risk of dust, insects and moisture entering the controlled area also lights specifically designed for clean rooms and controlled environments such as ours.

*REFERENCE DRAWING: DWG 2 In Drawings Section

INSTALLATION OF THE ENVIRONMENTAL CONDITIONING SYSTEM:

Our system is capable of controlling Humidity, Temperature and Air Quality (clean class 10,000) as specified in the TOR (Terms of Reference) and is based on the following components which were successfully installed, operated and commissioned by Mustehkam Construction;

	ECS Equipment Installed	Reference Drawings
1	Chillers 40hp x 2 (Sabro) Local	DWG 3 & DWG E2
2	Hot water Generator 20hp x 2 (Sabro) Local	
3	Chilled/Hot water Pumps (Meco) Local	
4	AHU's 600-800 cfm x 17 (Sabro) Local	
5	Air Filters – American/Italian – Aluminum/Bag/Hepa 17 sets	
6	Microprocessor Controllers Johnson Controls Imported – Locally supported Software Johnson Controls Imported – Locally supported	DWG 6, 7, 8 & 9

All ECS equipment can be operated through the microprocessor controller (DDC) installed in the control room. Set point of Temperature / Humidity can also be selected as per requirement.

All ECS equipment was installed, operated and commissioned by Mustehkam Construction. Tests were successfully conducted jointly by UNIDO, NPSL and Mustehkam Construction, refer to Annexure 1.

JONCHN AUTOMATIC VOLTAGE REGULATOR (80KVA):

AVR – Automatic Voltage Regulators are used to protect sensitive loads from unstable mains and to provide proper operating of load.

Characteristics:

- High efficiency (above 98%)
- Non wave distortion

- Steady voltage regulation
- Suitable for any load (receptivity, capacity, sensible load)
- Support transient over-loading
- Continuous operation
- Manual/auto switch conveniently
- Over-voltage, over-current and many other protections

The AVR and its components (including all hardware and wiring etc.) was successfully installed, operated and commissioned by Mustehkam Construction and has been taken over by NPSL.

*REFERENCE DRAWING: DWG E1 & E2

F.G. WILSON GENERATOR (60KVA)

A 60 kVA prime power genset imported from Britain has been successfully installed, operated and commissioned by Mustehkam Construction to provide continuous support to the ECS in case of regular power failure. This equipment was successfully installed, operated and commissioned by Mustehkam Construction and has been taken over by NPSL.

*REFERENCE DRAWING: DWG E1 & E2

NOTE: Also installed with the Genset and AVR were allied equipment like breakers, wiring, distribution boxes, ATS panel, magnetic contactors etc.

AIR SHOWER

Although not a part of the contract, an air shower was designed and installed by Mustehkam Construction on the request of a previous Chairman of PCSIR, Dr. Javed Arshad Mirza. This too has been handed over to NPSL.

The self contained air shower facility has been designed to serve as an air shower resulting in displacing dust particles from head to toe with medium range of air pressure through twelve air jets. It will recycle the air which is produced through a German soundless blower motor at 2800 RPM.

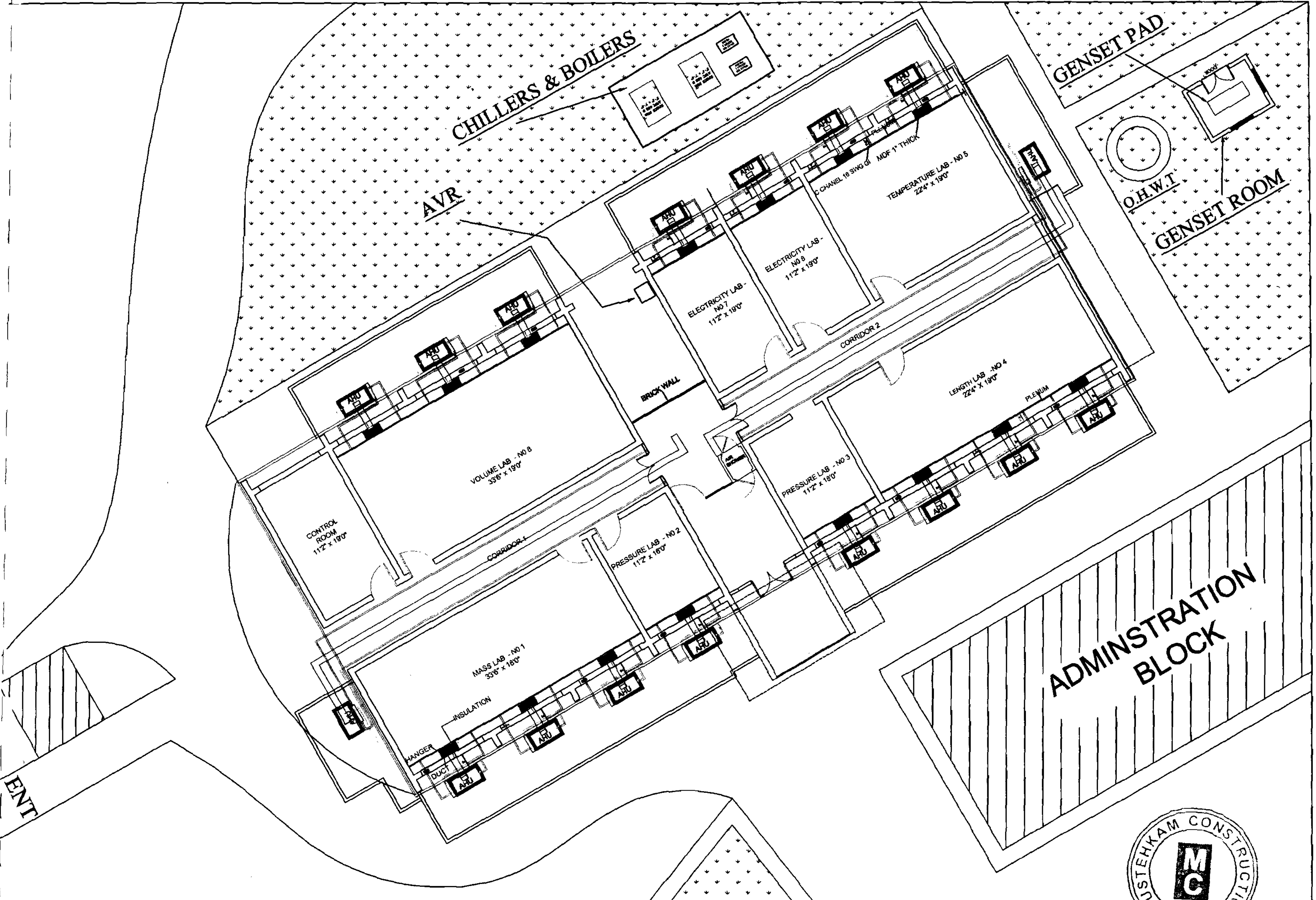
*REFERENCE DRAWING: DWG 10 & 11

TRAINING

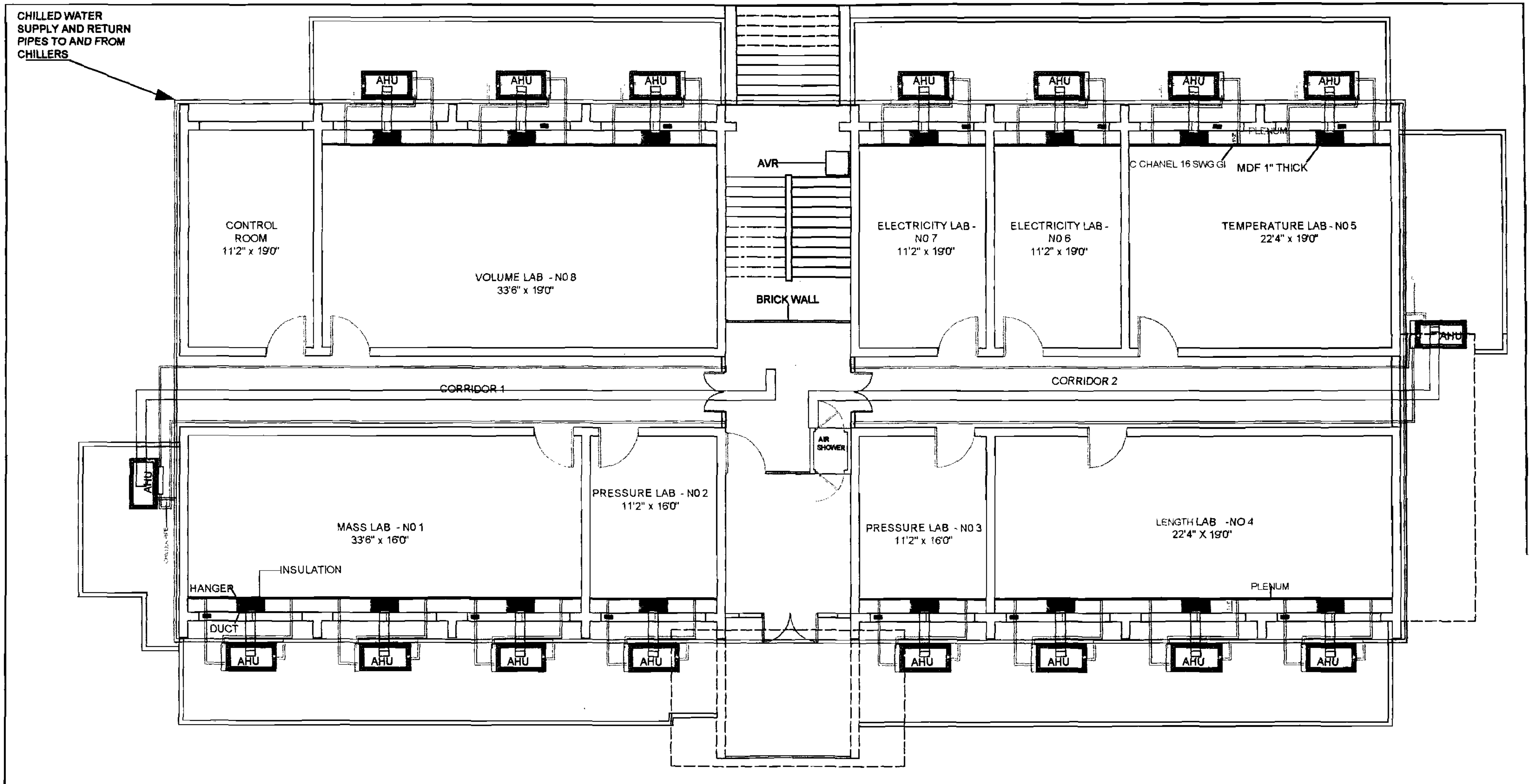
A week long training session was successfully conducted at site by our Engineers, Mr. Zahid Mehmood (HVAC), Major Atiq-Ur-Rehman (Electrical) and Mr. Pervez (Johnson Controls). Approximately 20 personnel attended the session, of which Mr. S. Jamil Asghar Naqvi (Incharge ECS Controller), Mr. Mohammed Naveed-Ur-

Rehman (Senior ECS Controller) and Mr. Naveed Ahmed (ECS Controller) were given intensive on job training for a period of one year by our HVAC Engineer Mr. Zahid Mehmood.

DRAWING SECTION



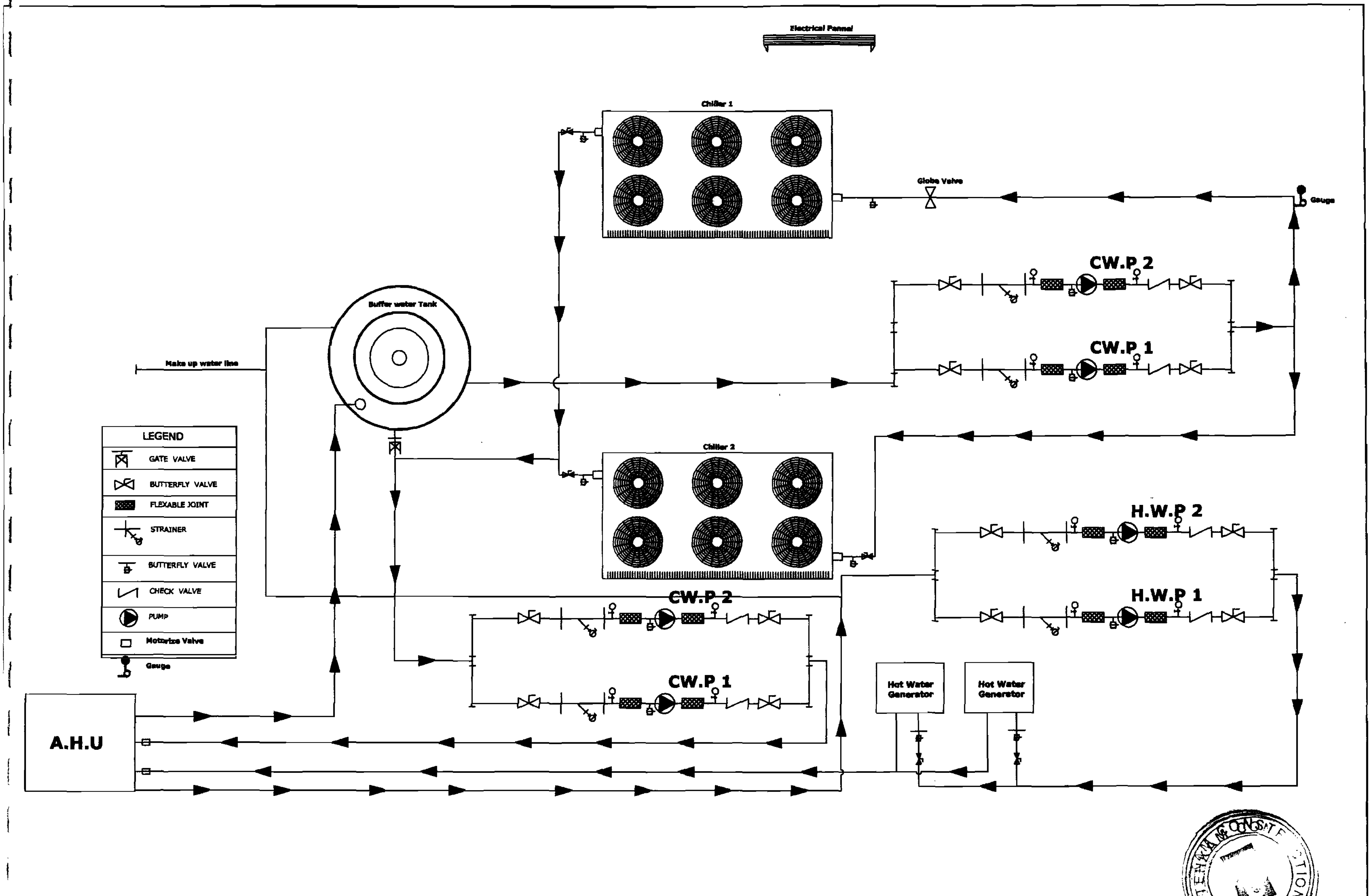
ITLE: PROJECT OVER VIEW	SITE: NPSI	UNIDO PROJECT EE/PAK/04/001	DRAWING NO: DWG 01	SCALE: NOT TO SCALE	DATE: 24 MAR 2009	MC	MUSTEHKAM CONSTRUCTION # 35, STREET 38, F-10/4 ISLAMABAD



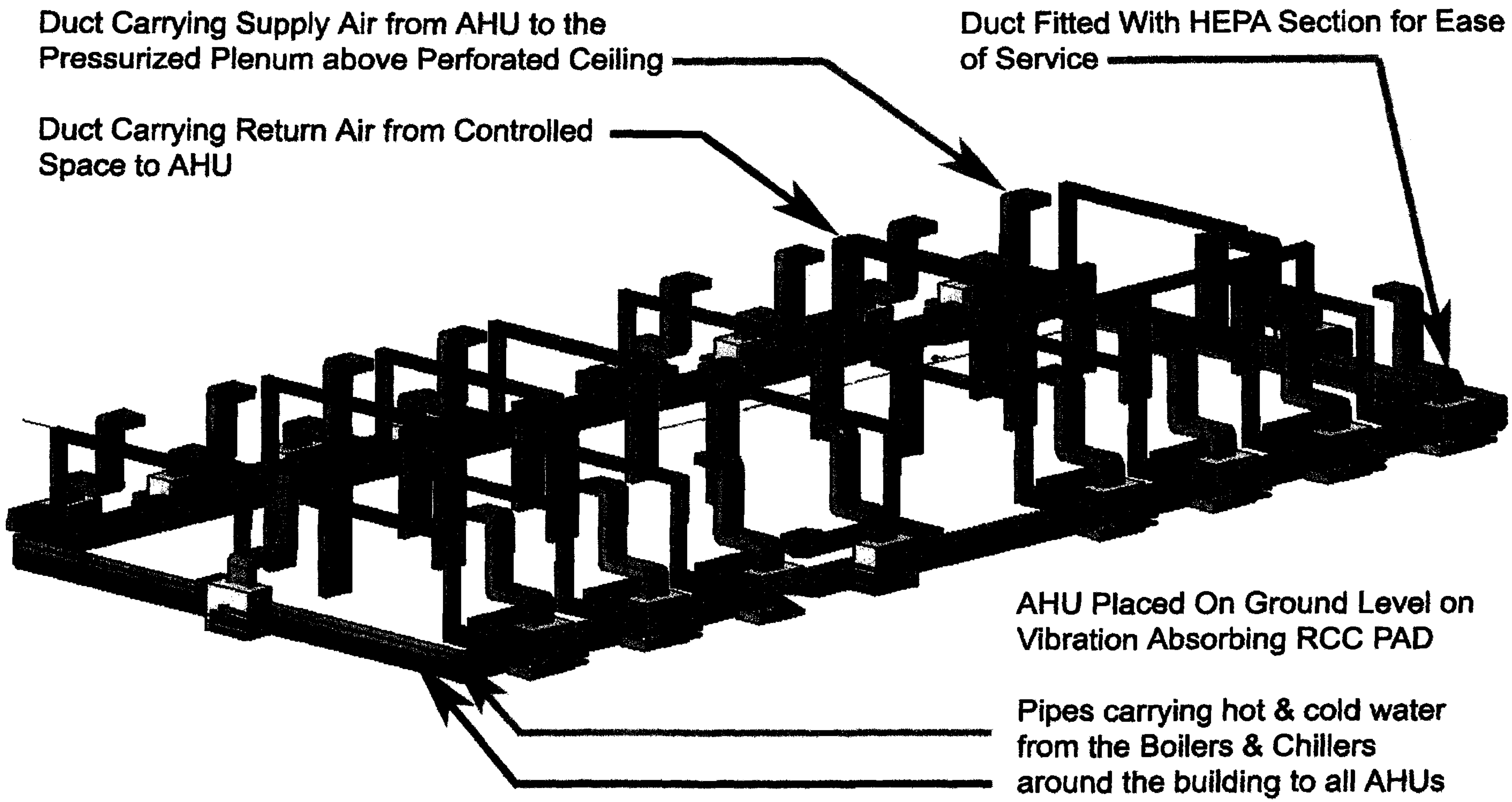
TITLE: ECS OVER VIEW	SITE: NPSL	UNIDO PROJECT EE/PAK/04/001	SCALE: NOT TO SCALE	DRAWING NO: DWG 02	DATE: 24 MAR 2009	MC	MUSTEHKAM CONSTRUCTION # 35, STREET 38, F-10/4 ISLAMABAD

LEGEND

FOUNDATION	RETURN AIR PLANUM
RETURN AIR DUCT	DUCT
CHILLER PIPE	LAB DOOR
SUPPLY AIR DUCT	MDF
EXHAUST PORTS	



ITLE: ECS SYSTEM PIPING SCHEMATIC	SITE: NPSL	UNIDO PROJECT EE/PAK/04/001	SCALE: NOT TO SCALE	DRAWING NO: DWG 03	DATE: 24 MAR 2009	MC MUSTEHKAM CONSTRUCTION # 35, STREET 38, F-10/4 ISLAMABAD



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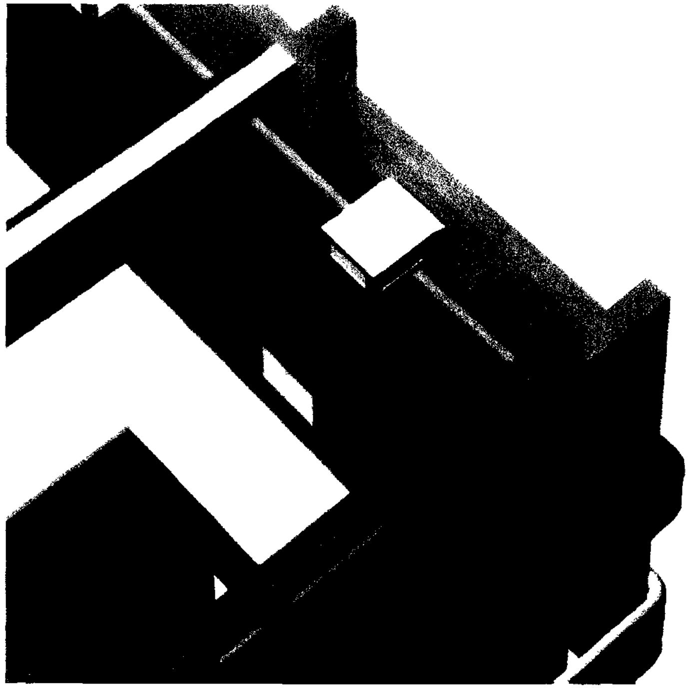
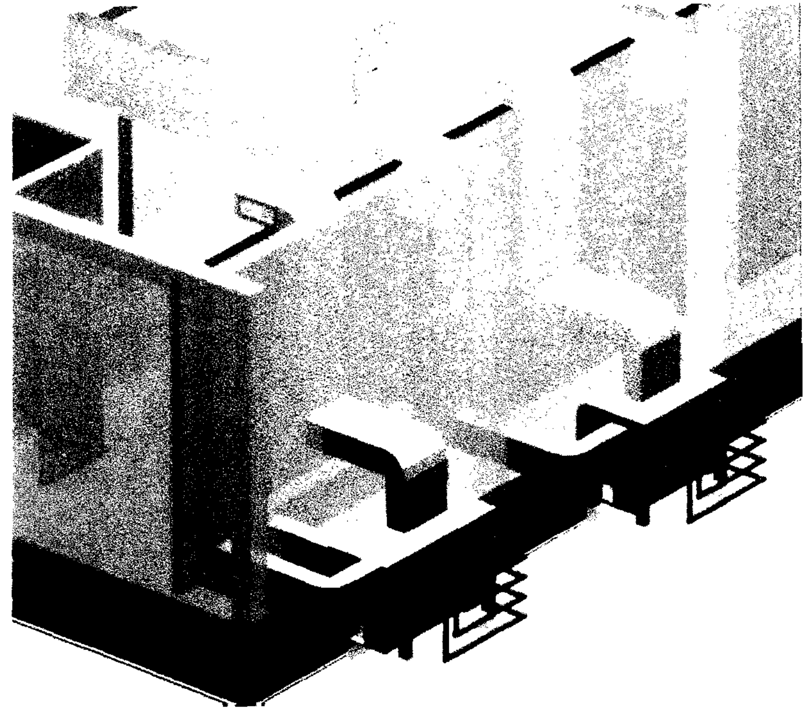
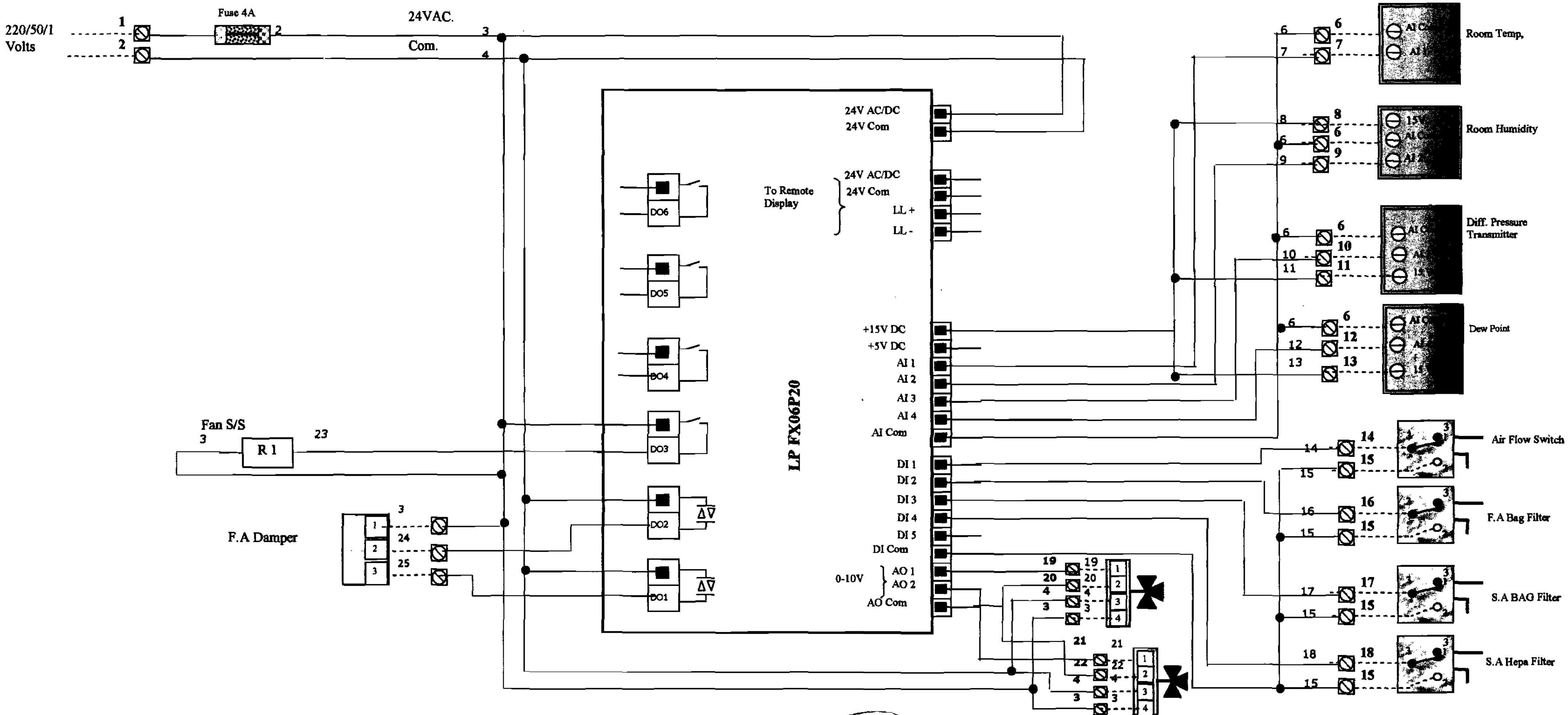
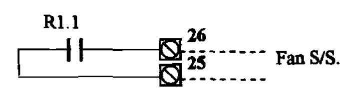
AHU SETUP OVERVIEW	NPSL	EE/PAK/04/001	NOT TO SCALE	DWG 04	24 March 2009	MC Mustehkam Construction # 35, Street 38, F-10/4 ISLAMABAD



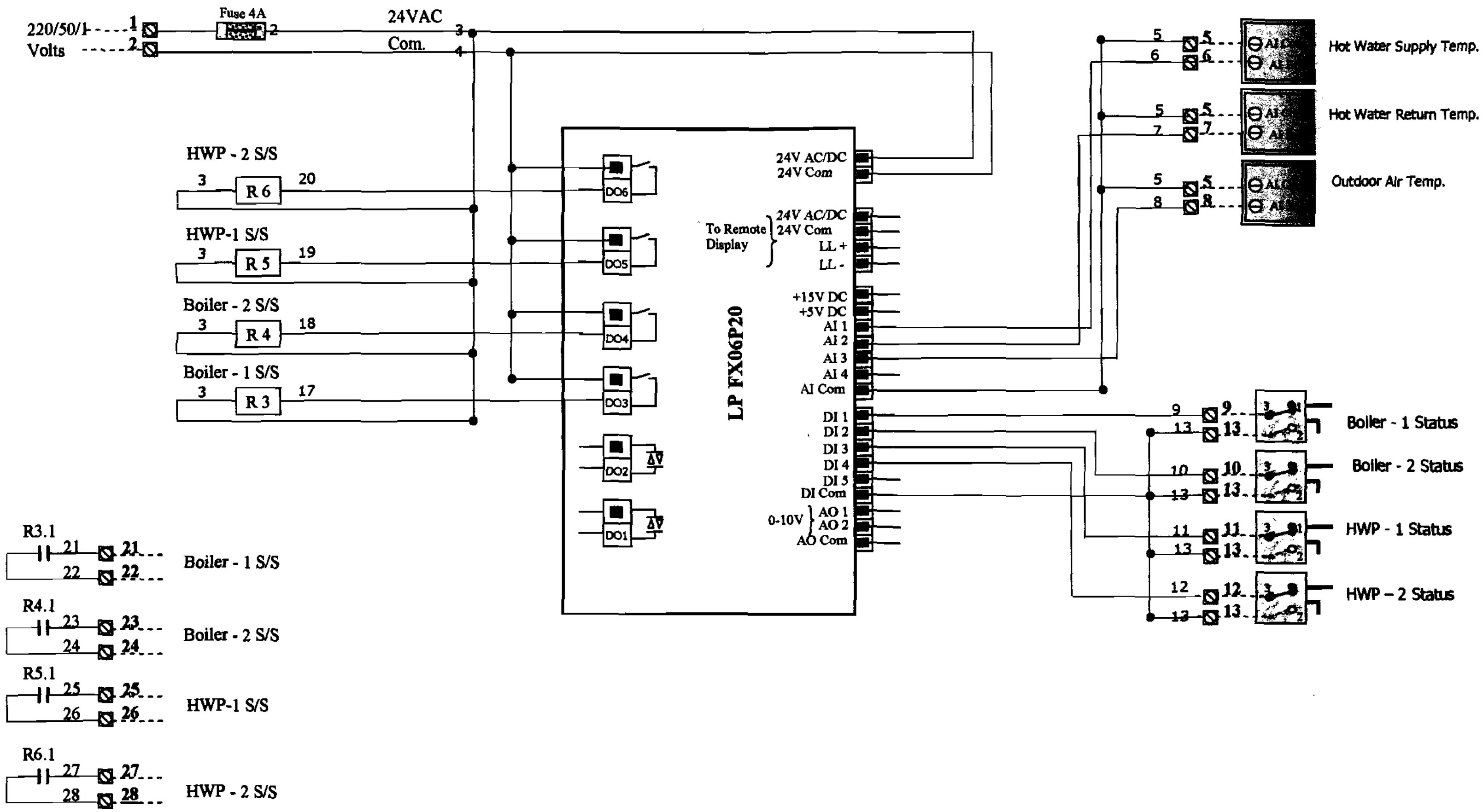


Title:	Site:	UNIDO PROJECT:	Scale:	Drawing No:	Date:	
DUCT & AHU SETUP	NPSL	EE/PAK/04/001	NOT TO SCALE	DWG 05	24 March 2009	Mustehkam Construction # 35, Street 38, F-10/4 ISLAMABAD

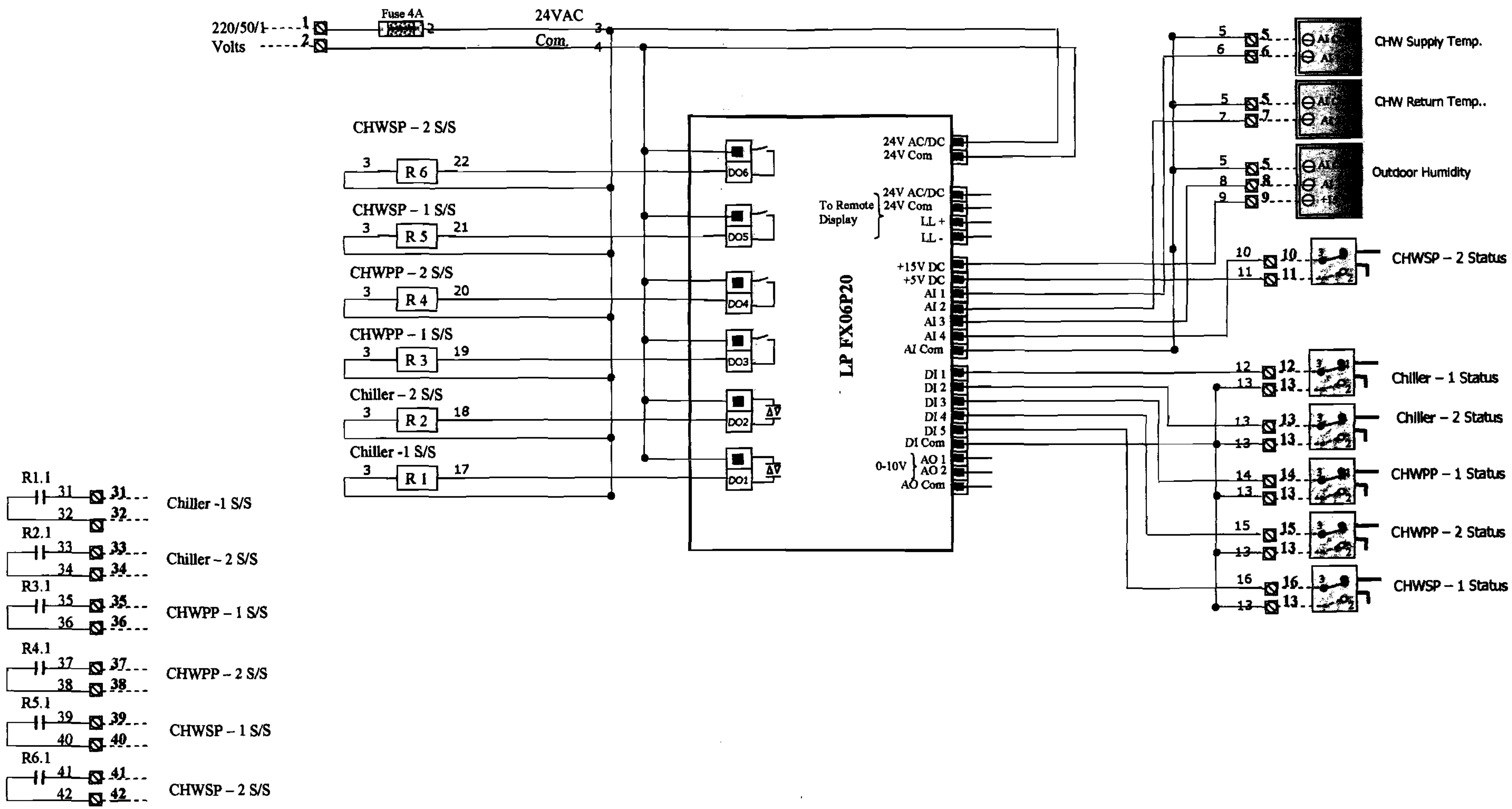




MUSTEHKAM CONSTRUCTION			
Project : UNIDO EE /PAK/04/001		**Wiring Diagram For AHU's (7 Nos)**	
Date : June 23, 2007	**Drawn by :** L.J	**Checked By :** N.A.	**Drw No.:** DWG 06



MUSTEHKAM CONSTRUCTION			
Project : UNIDO EE/PAK/04/001		**Wiring Diagram For Plant Room (Controller – 1)**	
Date : October 30, 2007	**Drawn by :** L.J	**Checked By :** N.A.	**Drw No.:** DWG 07

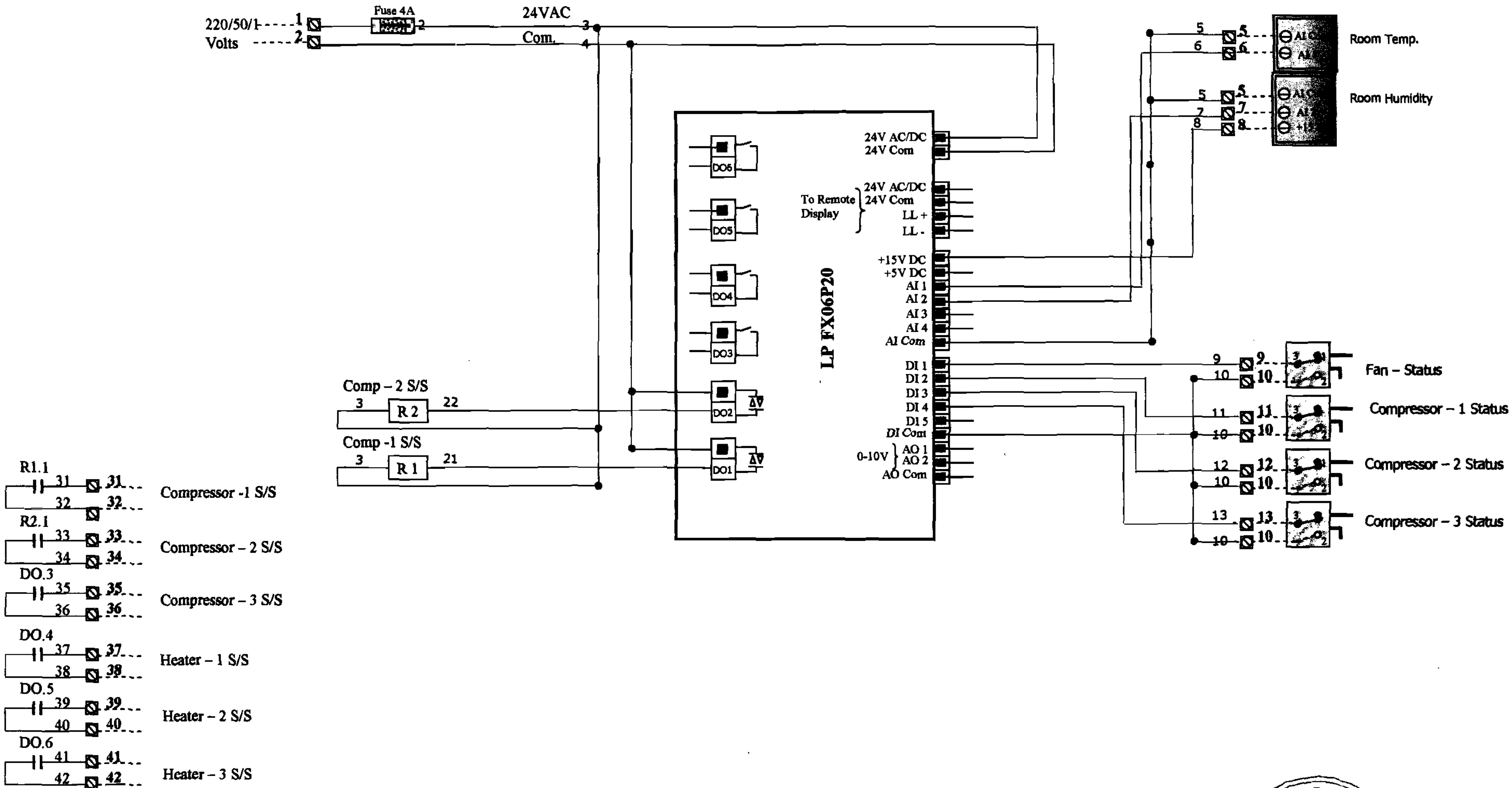


MUSTEHKAM CONSTRUCTION

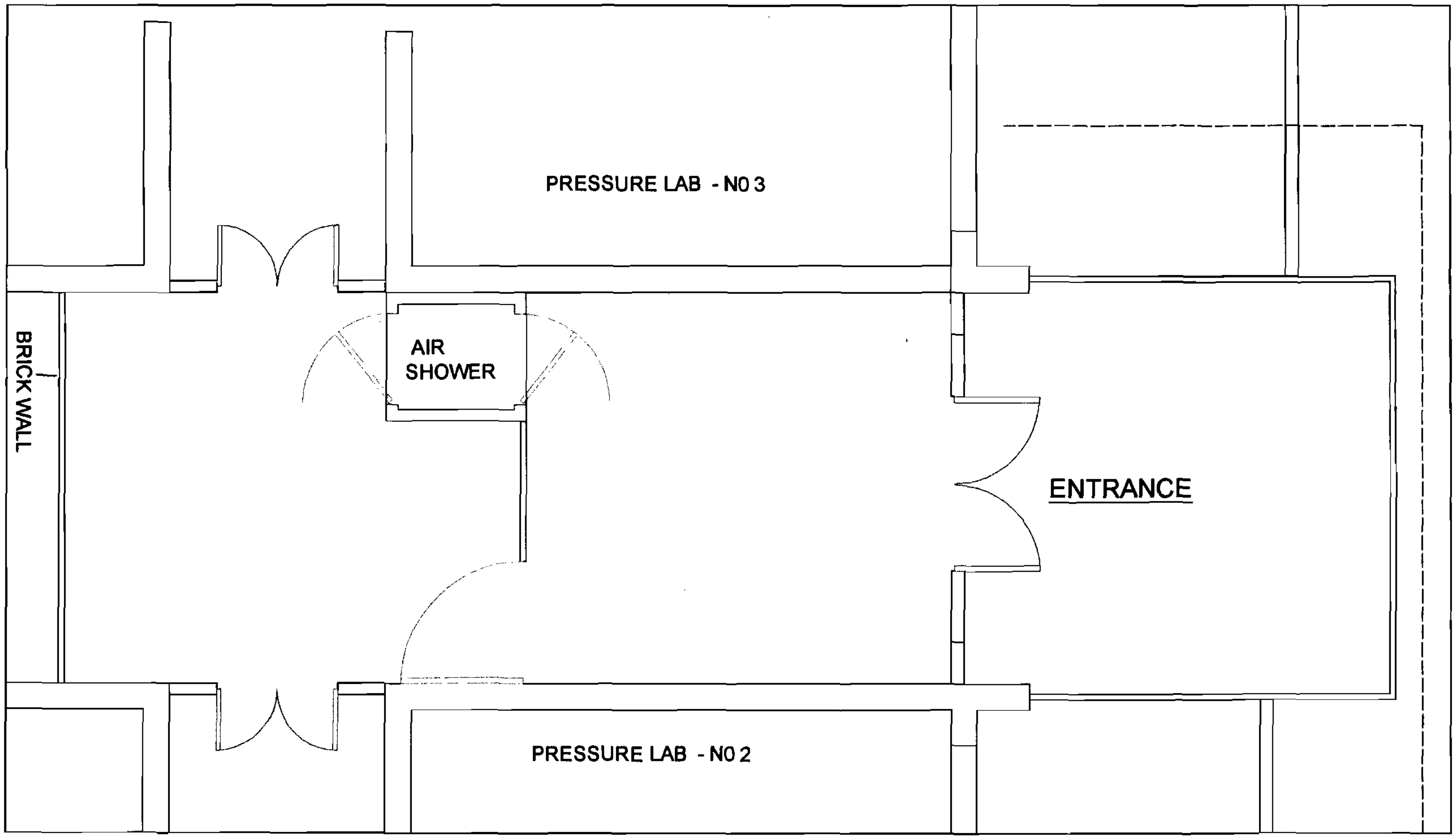
Project : UNIDO EE/PAK/04/001	**Wiring Diagram** **For** **Plant Room (Controller – 2)**

Date : October 30, 2007	**Drawn by :** L.J	**Checked By :** N.A.	**Drw No.:** DWG 08

MUSTEHKAM CONSTRUCTION
MC

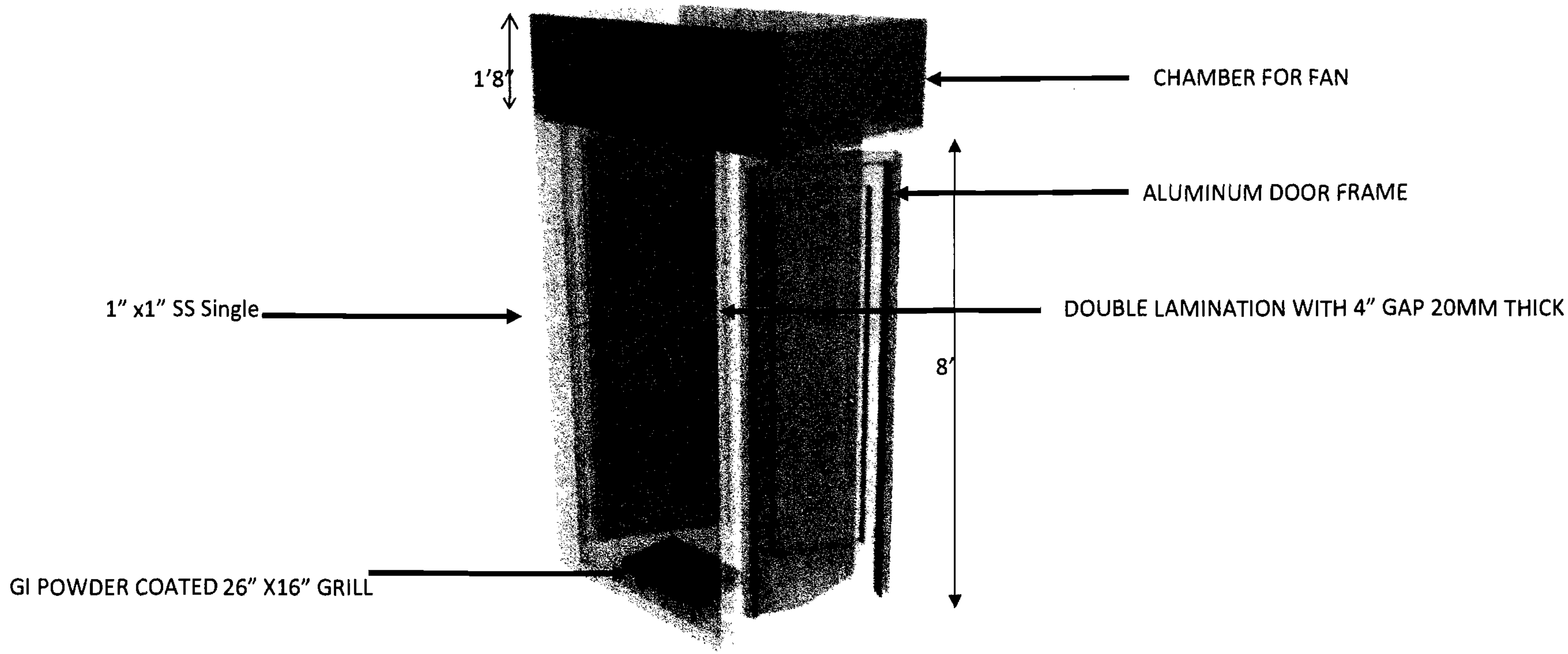


MUSTEHKAM CONSTRUCTION			
Project : UNIDO EE/PAK/04/001		**Wiring Diagram** For AHU	
Date : November 03, 2007	**Drawn by :** L.J	**Checked By :** N.A.	**Drw No.:** DWG 09

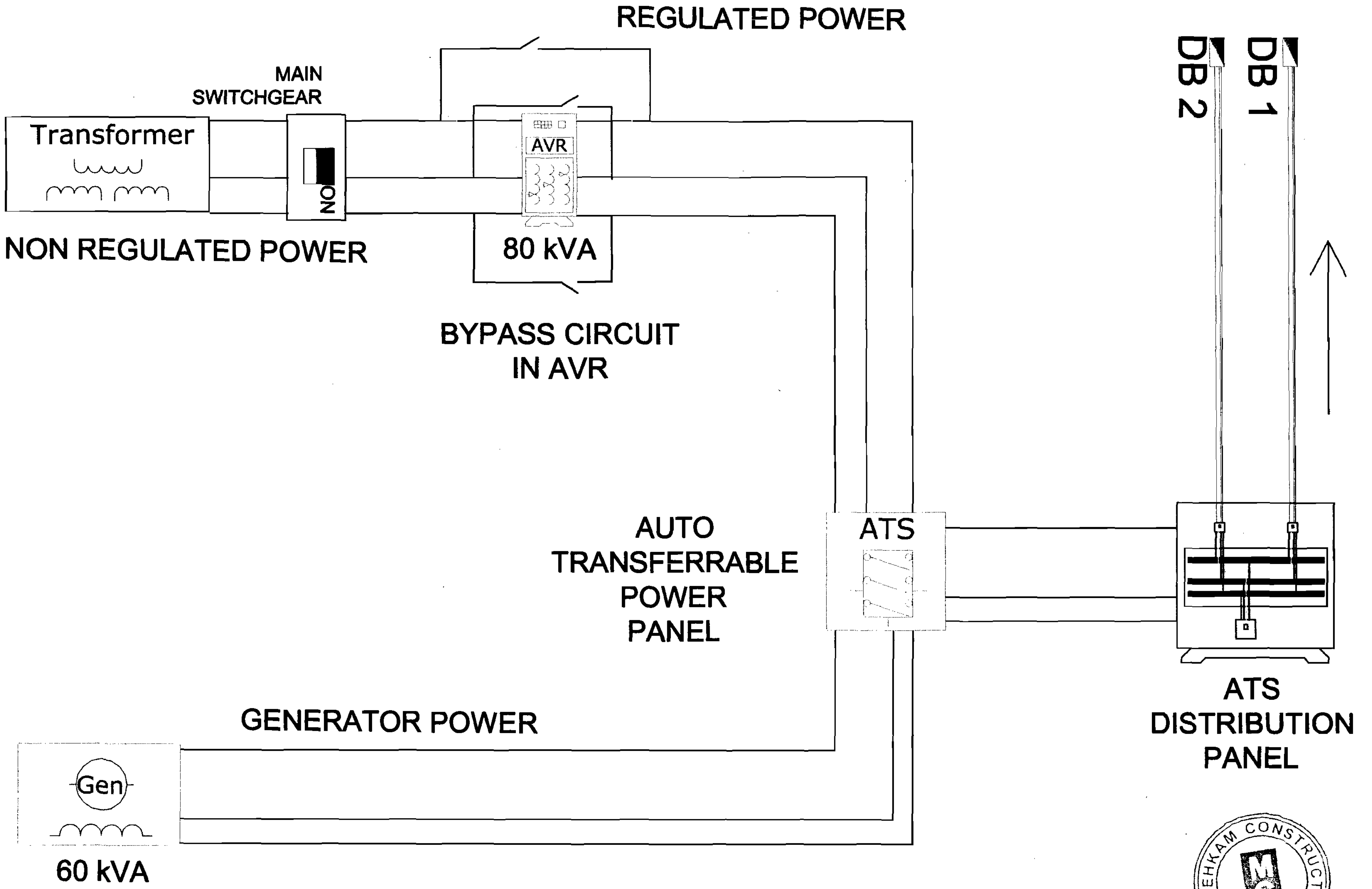


TITLE: AIR SHOWER PLACEMENT	SITE: NPSL	UNIDO PROJECT EE/PAK/04/001	SCALE: NOT TO SCALE	DRAWING NO: DWG 10	DATE: 24 MAR 2009	MC	MUSTEHKAM CONSTRUCTION # 35, STREET 38, F-10/4 ISLAMABAD

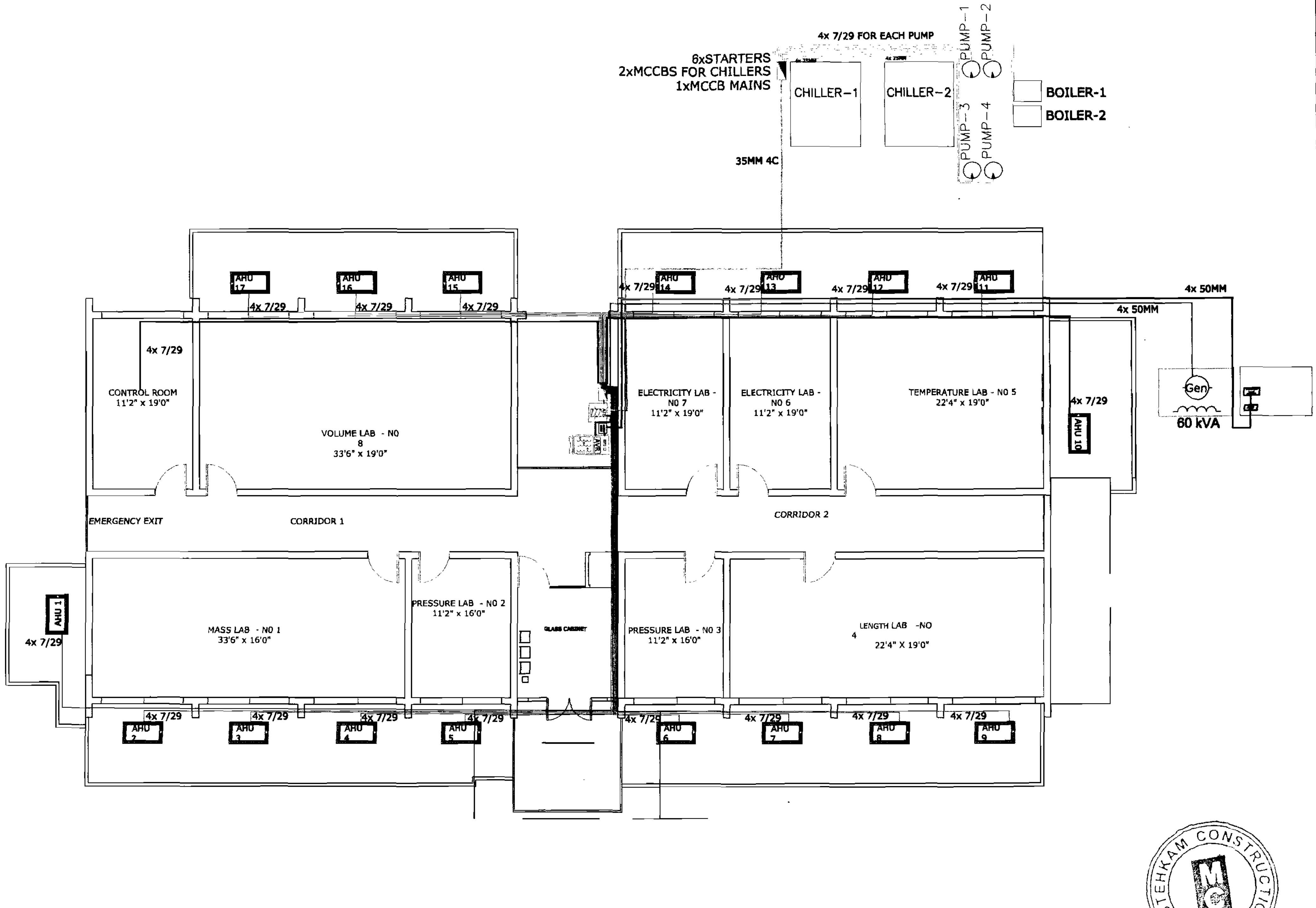
MUSTEHKAM CONSTRUCTION



Title:	Site:	UNIDO PROJECT:	Scale:	Drawing No:	Date:	
AIR SHOWER	NPSL	EE/PAK/04/001	NOT TO SCALE	DWG 11	24 March 2009	MC Mustehkam Construction # 35, Street 38, F-10/4 ISLAMABAD



TITLE: ELECTRILAL LAYOUT PLAN	SITE: NPSL	UNIDO PROJECT EE/PAK/04/001	SCALE: NOT TO SCALE	DRAWING NO: DWG(E) 01	DATE: 24 MAR 2009	MC	MUSTEHKAM CONSTRUCTION # 35, STREET 38, F-10/4 ISLAMABAD



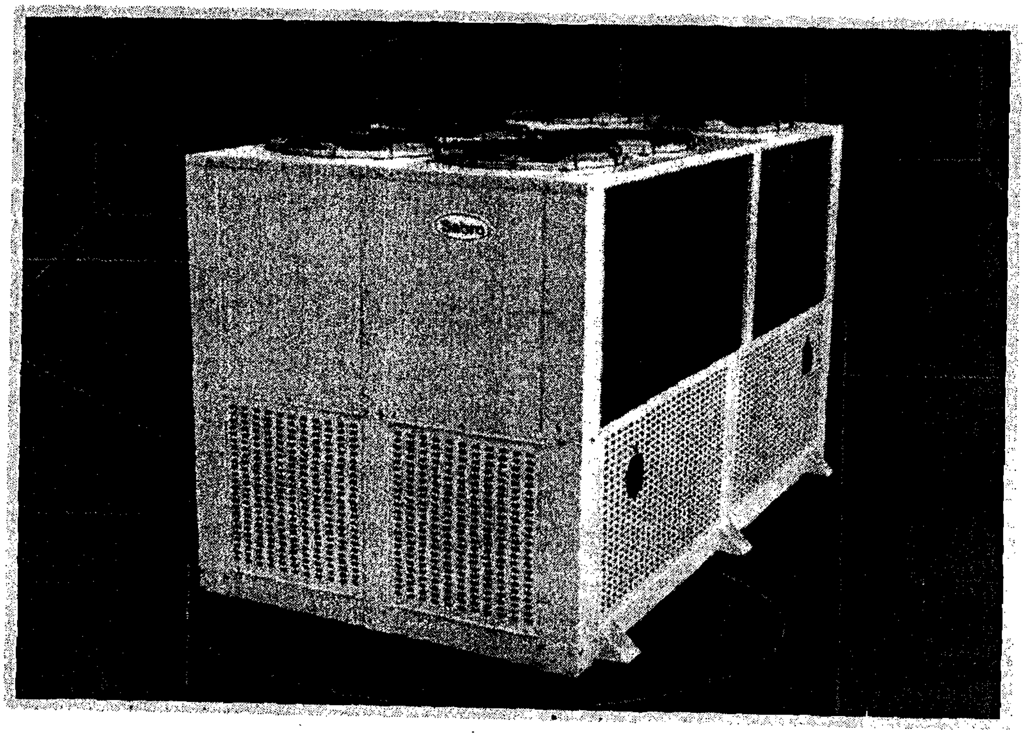
TITLE: CABLE ROUTE DRAWING	SITE: NPSL	UNIDO PROJECT EE/PAK/04/001	SCALE: NOT TO SCALE	DRAWING NO: DWG (E)02	DATE: 24 MAR 2009	MC MUSTEHKAM CONSTRUCTION # 35, STREET 38, F-10/4 ISLAMABAD

AIR COOLED WATER CHILLERS

TECHNICAL MANUAL

AIR COOLED WATER CHILLERS

OWNER'S MANUAL



Thankyou for choosing OUR BRAND NAME.

please read this OWNER'S MANUAL HANDBOOK prior to installing and keep it for further refrence.

INSTALLATION

CAUTION: before installing the unit, ensure that the power supply matches the power requirement of the unit.

SELECTION OF LOCATION AND SPACE

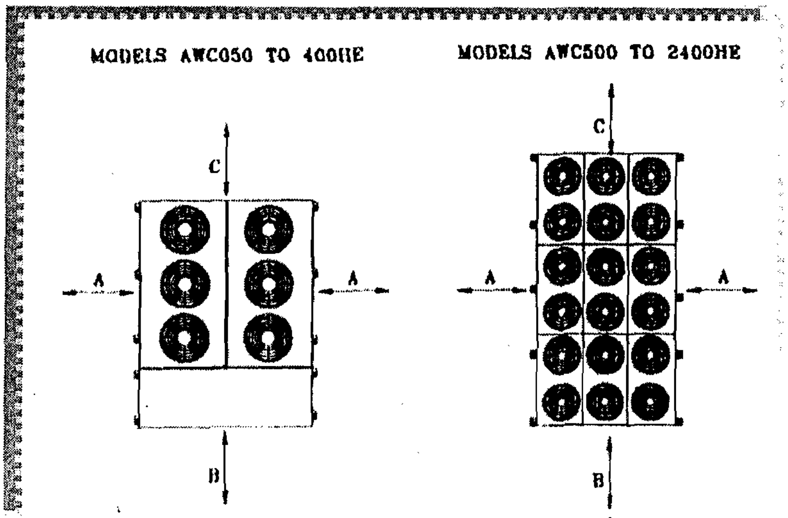
As condenser cooling medium is air, the heat transfer depends on the air circulation over the condensers. The recirculated/obstructed condenser air tends to raise the condenser temperature. As condensing temperature rises, evaporating temperature rises and cooling capacity drops. In order to achieve maximum cooling capacity the location selected for the unit should fulfill the following requirements:

Install the unit in such a way that hot air discharged by the condenser fan(s) cannot be drawn in again. Also allow sufficient space for maintenance around the unit (see INSTALLATION CLEARANCE requirements below)

A properly leveled place, capable of bearing the weight of unit and isolating noise and vibration. See specifications for weights of units.

In case of installation of unit at roof, proper advice may be taken from civil consultant about the weight bearing capacity of roof.

A place suitable for piping, wiring and maintenance etc.



MODELS	A	B	C
AWC 050 TO AWC 150	1000 MM	1500 MM	500 MM
AWC200 TO AWC400HE	1000 MM	2000 MM	500 MM
AWC500 TO AWC600	1500 MM	2000 MM	1500 MM
AWC700 TO AWC2400H	2000 MM	1000 MM	2000 MM

SUPPLY AND RETURN WATER PIPING

The units are provided with male pipe threaded water supply/return connections(for models AWC050 TO AWC500)or flanged water supply/return connections(for models AWC600 TO AWC2400HE).supply and return piping should be designed and laid to suite individual site requirements, however following points must be considered during installation:

-the chilled water piping should be so designed that the circulating water pump discharges water into the chiller shell. Make sure that supply and return pipes are not adversely connected.

~the pump should be of capacity to make up for the total head loss and required water flow of the chiller. One water pump of same capacity is connected in parallel for standby operation.

~models AWC1400HE, 1600, 1600HE, 2400, 2400HE are supplied with multi supply/return water connections. It is recommended that these connections are site manifold in one common supply header and one common return header. This is essential for adequate capacity control and water flow through the chiller shell.

~piping supports should be provided to refrain it from applying improper force to the chiller shell. Hand stop valves should be provided in all lines for ease of servicing.

~water regulating valves should be provided at pump outlet, to regulate the flow of water as per design.

~Drain connection should be provided at all low points to permit complete drainage of system.

~Air purging valves should be provided for removing of air from the piping system, at all points wherever the possibility of air trapping is.

Proper strainer should be provided on the inlet lines of the pump to remove the foreign materials. A strainer is also recommended on the inlet line of the chiller.

~temperature and pressure gauges should be provided on supply and return water lines of chiller to monitor the operation of unit.

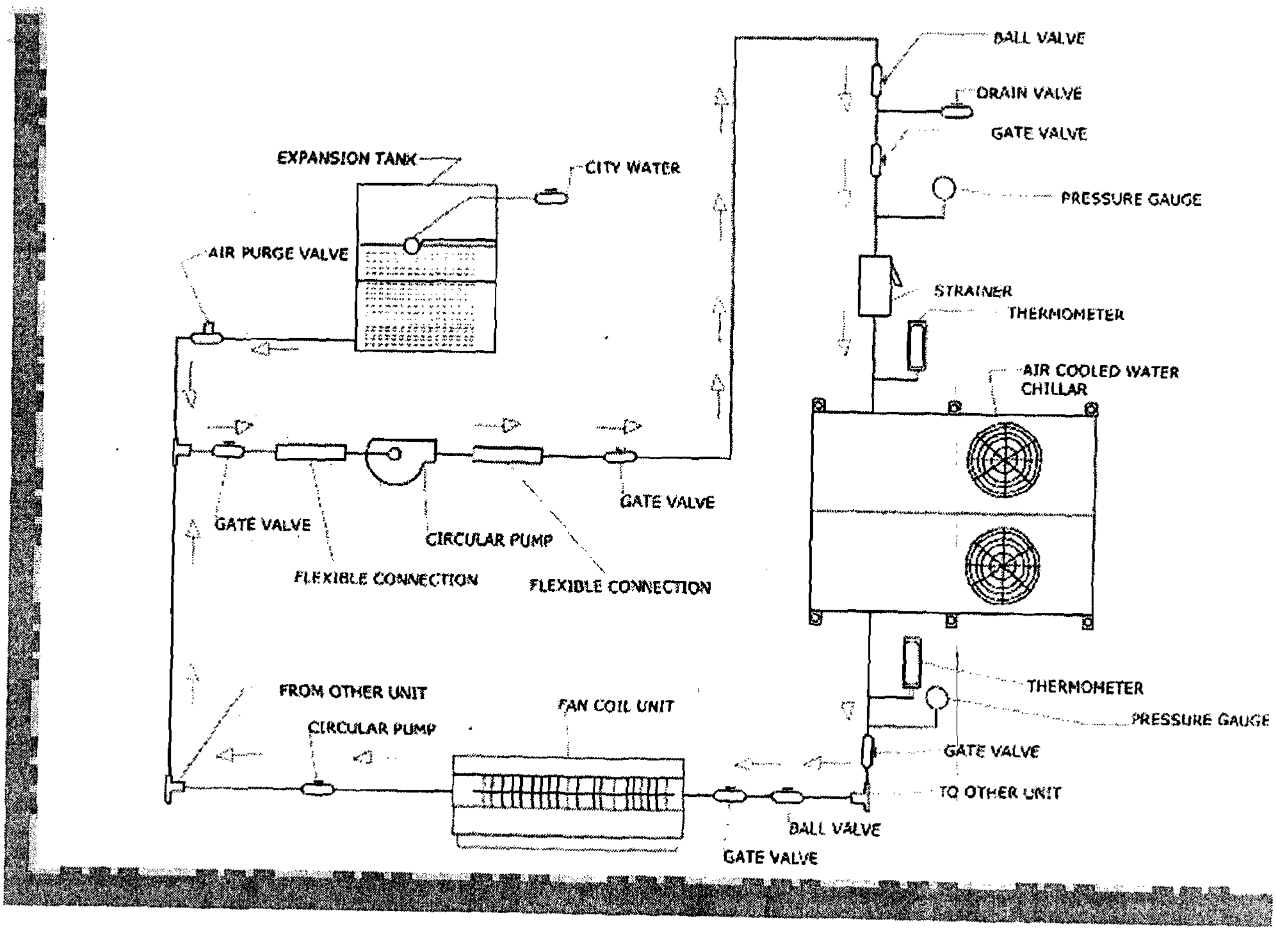
~All water piping should be thoroughly flushed to free it from any foreign material. Care must be taken that no foreign material is flushed in to or through the chiller shell.

~Flexible joints may be used at pump suction and discharge lines to prevent the transmission of vibration and noise.

~Starter and pumps should be interlocked with unit's control panel) to prevent the operation of unit without start up of pumps.

An expansion tank should be provided with the system to maintain system pressure by allowing water to expand when water temperature increases. The regulation of pressure will be maintained by expansion and contraction of an adequate volume of air trapped in the upper portion of the expansion tank. The tank should be installed at a location slightly higher than the highest pipe line of the system, and should be provided with makeup water connection to maintain the water level and drainage connection etc.

A typical layout plan of piping system is provided UNDERNEATH for an idea



WIRING

Wiring regulation on wire diameters differ from country to country. Please refer to your LOCAL ELECTRICAL CODES for field wiring rules. Be sure that installation complies with such rules and regulations.

GENERAL PRECAUTIONS

Ensure that the rated voltage of the unit corresponds to the name plate, before carrying out wiring. See section 5-5-1 for electrical requirement of each model.

Provide a power outlet each to be used exclusively for each unit. A POWER DISCONNECTS SWITCH AND A CIRCUIT BREAKER FOR OVER-CURRENT PROTECTION SHOULD BE PROVIDED IN THE EXCLUSIVE LINE.

The unit must be grounded to prevent possible hazards due to insulation failures.

All wiring must be firmly connected.

Any wiring should not touch the hot refrigerant piping, compressor or any moving parts of fan motors etc.

CAUTION

The compressors of units are equipped with CRANKCASE HEATERS. The crank case heater is wired through a normally close contact of compressor contactor. This heater keeps the compressor oil warm that will prevent excessive absorption of refrigerant during shutdown periods.

The crankcase heater should be energized during all the times when the compressor is not running, except during prolonged shutdown or during servicing. In these cases crankcase heater should be energized 24 hours before starting of unit.

To energize the crankcase heater switch on the main power supply. Ensure that the unit is at off position before connecting the main power supply.

MAIN POWER SUPPLY

The units are internally wired in accordance with applicable electrical codes. The wiring for field installed control panel should comply with relevant electricity code. the field installed electrical panel should consist of indication lights for three phases, main circuit breaker, ampere meter and volt meter etc to verify the operation of unit.

The power supply should be 380/415 volts, 3 phase, 50 HZ cycle. The voltage supplied to the unit during operation must be within+-10% of rated voltage and phase to phase voltage should be balanced within 2% of each other. The local authorities should be contacted for correction of any improper voltage or phase imbalance. Under no circumstances the unit is operated on improper line voltage or with excessive phase imbalance as this may cause damage to the equipment.

Connect the main power and earth wires to unit terminals, utilizing opening of wiring in accordance with the wiring diagram provided with the unit. In case of remote mounting type control panel, install the panel near main circuit breaker. See electrical diagram affixed with the panel for number of wires and connections.

Ensure that all wires are firmly connected and there is no lose connection.

OPERATING INSTRUCTIONS

PRE START CHECKS

Ensure that all afore mentioned steps in this technical manual are fully followed.
Ensure that adequate space is available around the unit for maintenance work.
Ensure that the unit is clear and free of all foreign materials, such as tools etc.
Ensure that the piping work is in accordance with the standard practice and all lines are flushed to ensure that there is no foreign material in the system.
Ensure that the expansion tank and all piping system are filled with water. Also ensure that the piping is leak tested and all valves in water piping system are opened
Ensure that the drain line is properly connected and trap has been provided.
Ensure that the available power at the main circuit breaker is in accordance with the prescribed data on the unit's name plate.
Ensure that field wiring is of adequate size and there wiring connections are properly tightened.
Ensure that main circuit breaker is of proper size and the unit is properly grounded.
Ensure that the crankcase heater has been energized and the crankcase of compressor is sufficiently warmed.
Rotate the condenser fan by hand to check for free rotation.
Check condenser fan rotation by manually pushing the contact checking knob of contactors. In case of reverse rotation; change any two phases with each other. The rotation would come to a specified direction.

INITIAL START UP

After ensuring the pre start checks and study of operation control guide, proceed with following steps for initial start up:
Set the temperature knob of main thermostat at minimum setting. Set COOL/HEAT switch at cool (if applicable)
Switch on chilled water pump the pump motor will start running
-Check the amps of pump motor and compare with name plate data
-Check for any abnormal noise or vibration
-check for correct motor direction
-ensure that water is flowing
-check the water inlet temperature to chiller
Start the air conditioners such as air handling unit, fan coil unit or machine etc.
-check the water inlet temperature and record
-check the air inlet temperature and record
Switch on compressor motor the condenser fans will start immediately followed by compressor start up after approximately 3 minutes interval.
Check the amperes of compressor motor and compare with the catalog data.
Check for any abnormal noise or vibration
In multi compressor units switch ON compressor motors one by one. Their compressor fans will start immediately, followed by compressor startup after approximately 3 minutes interval.
Check the amperes of each compressor motor and compare with catalog data.
Check for any abnormal noise or vibration of each compressor motor
Check the functioning of thermostat by moving temp knob to maximum temp, the compressor should stop. Again set the temperature knob to minimum

temperature, the compressor will start after approximately 3 minutes delay. In multi compressor units, the compressors will start sequence wise.
After operating the unit for about 3 to 4 hours shut off the main switch.
Check all wiring connections
Check setting/adjustments of refrigerant accessories.
Following the above procedure, again start the unit and perform recommended checks
Also check for under mentioned before putting the unit for continuous operation.
Check working voltage, phase balance and running current
Check that the safety devices are functioning properly.
Check and record the water inlet/outlet temperature and compare with requirement.
After putting the unit on final continuous operation, set the temp. Knob of thermostat to desired temperature, for automatic operation of the unit. Please note that the sensor of main thermostat is mounted at return water connection. So the temperature knob should be se at 1°C below the reqd. return water temperature.

FUNCTION OF SAFETY DEVICES
The units are equipped with an electronic panel mounted thermostat. This thermostat has a built in time delay device which protects the compressor from damage due to frequent stop/start function. So in case the unit is switched OFF and ON frequently or the main electric supply goes OFF and restored immediately the compressor will be started after delay of 2.5 to 3 minutes. However in multi compressors units the compressors will start sequence wise.
The compressor motor and condenser fan motors are provided with a thermal overload relay to protect them from overload operation. Manual rest button on overload relays is required to be pushed, whenever they are tripped. Before restarting the unit, the cause of tripping should be removed. The compressors are provided with dual pressure controls to protect them from any abnormal operating conditions. Manual reset button on dual pressure control is required to be pushed whenever it is tripped due to high discharge pressure. The low pressure side is auto reset type.
To check the high side function of dual pressure control increase the discharge pressure of compressor by manually tripping the condenser water pump. The compressor should be stopped when discharge pressure reaches above the setting point start the condenser water pump and reset the dual pressure switch, the compressor will start working.
To check the low side function of dual pressure control decrease the suction pressure of compressor by gradually closing the liquid line valve keeping compressor running the compressor should be stopped when suction pressure reaches below the setting point. Open the liquid line valve the compressor should start working automatically when suction pressure reaches above the setting point.
Manual reset button on oil pressure switch is required to be pushed (semi compressors only) whenever it is tripped due to loss of oil pressure.
To check the function of oil pressure switch, remove the main supply of compressor from overload. Set the compressor switch to on position the

contactor of compressor will be energized and de-energized after approximately 45 minutes.
The units are equipped with low temperature thermostats to prevent the unit from operating at excessively low leaving water temperature, due to malfunctioning or wrong setting of main thermostat.
To check its functions decrease the chilled water temperature by gradually decreasing the water flow rate (the main thermostat should be set at minimum setting), the compressor should be stopped when leaving water temperature reaches below the setting of thermostat. Increase the flow of water, the compressor will start functioning when the temperature of water reaches above the setting.
The units are equipped with freeze protection thermostats to prevent the unit from operating at excessively low water temperature in the cooler, due to malfunctioning or wrong setting of main thermostat and low temperature thermostat. Manual reset button is required to be pushed, whenever the unit is tripped from freeze protection thermostat due to any reason. Before restarting the unit, the cause of tripping should be removed.
To check its function, decrease the chilled water temperature by gradually decreasing the water flow rate (the main thermostat should be set at minimum setting and a jumper to be provided at low temperature thermostat), the compressor should be stopped when water temperature in the cooler reaches below the setting of thermostat. Increase the flow of water, and push the reset button, the compressor will start functioning when temperature of water reaches above the setting.

SERVICING AND MAINTENANCE

To ensure the long life trouble free and smooth operation of SABRO water cooled packaged air conditioners, it is necessary to maintain the equipment for good running conditions. The following section indicates the minimum recommended maintenance which must be performed at specified intervals of time.

ALL ELECTRICAL POWERS SHOULD BE SWITCHED OFF BEFORE PROCEEDING WITH ANY MAINTENANCE OR INSPECTION WORK.

COMPONENTS	MAINTENANCE PROCEDURE	RECOMMENDED SCHEDULE
Condenser coils	1. Check and remove dirt which is clogged b/w fins. 2. Check and remove obstacles which hinder air flow in and out of unit.	Every three months More frequently If required
Cooler shell	1.check and clean with diluted solution of water and cleansing agent/descaler Note: cleaning requirements depends upon water conditions and method of water treatment. Follow instructions of cleaning agent manufacturer's recommendations for rescaling procedure.	Every three months
Condenser fans	1.check for rigid mounting 2.check for unusual noise 3.check for correct rotation	As necessary
Fan motors lubrication	1. All motors are factory lubricated and sealed at factory.	No maintenance
Electrical	1.check voltage, current and wiring Check loose(faulty)connections and tighten them	Every two months
Compressor lubrication	Oil is factory charged. not necessary to add oil if circuit remains sealed	No maintenance
Refrigerant circuit	No maintenance needed if circuit remains sealed.however,check for refrigerant leak at joints and fittings etc.	Every six months

PRE START UP MAINTENANCE (AFTER EXTENDED SHUT DOWN)

-All above maintenance works

-the crankcase heater of compressor should be energized 24 hrs bef. starting of unit.

The design of units allows servicing to be carried out readily and easily. Almost every part is accessible by opening rear door/panels at evaporator and condenser section.

Under normal circumstances, the units only require a check and cleaning of condenser coil surface once quarterly. However if a unit is installed in areas which are subjected to much oil mist and dust, the coils must be regularly cleaned by qualified air conditioning service technicians. To ensure sufficient heat exchange and proper operation. Otherwise the system life span may be shortened.

CAUTION

Do not charge OXYGEN, ACETYLENE OR OTHER FLAMEABLE AND POISINOUS GASES into the unit when performing a leakage test or an air tight test. These gases could cause severe explosion and damage if exposed to high temperature and pressure.

It is recommended that only nitrogen or refrigerant to be charged when performing the leakage or airtight tests.

TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	SUGGESTED ACTION
NO COOLING (compressor does not start)		
Improper power supply	1.no voltage or low voltage 2.single phase in operation	1.obtain correct voltage 2.obtain correct supply
Blown fuses	1.loose connection 2.shortened components	1.replace fuses/tighten fuses 2.replace faulty component
Condenser fan motor is not working	1.faulty contactor 2.burnt motor 3.defective operation switch	1.Repair or replace contactor 2.repair or replace motor 3.repair or replace switch
Condenser fan motor is tripped from overload relay.	1.high or low voltage 2.single phase/phase imbalance 3. Incorrect setting of relay. 4.faulty relay	1.obtain correct voltage 2.obtain correct supply 3.correct the setting 4.repair /replace the relay
Compressor Is not working	1.faulty contactor 2.burnt motor 3.defective operation switch	1.Repair or replace contactor 2.repair or replace motor 3.repair or replace switch
Compressor Is tripped from overload relay.	1.High or low voltage 2.single phase/phase imbalance 3.incorrect setting of relay 4.faulty relay	1.obtain correct voltage 2.obtain correct supply 3.correct the setting 4.repair /replace the wiring 5.repair or replace the switch
Compressor tripped from dual pressure switch	1.extremely high discharge pressure or low suction pressure	1.see "high discharge pressure" OR "low suction pressure"
Compressor tripped from oil press. switch(with semi hermetic compressors only)	1.less oil charge or oil leaked 2.clogged filter 3.faulty oil pump 4.incorrect setting of switch 5.faulty switch	1.add oil 2.clean oil filter 3.repair or replace the pump 4.correct the setting 5.repair or replace the switch

IN SUFFICIENT COOLING :(Compressor operating)

High disch.pressure	1.faulty cooling tower fan motor 2.low/no condenser water flow 3.over charged refrigerant 4.air in the system 5.restriction in liquid line 6.high suction pressure	1.Repair or replace the motor 2.Provide sufficient water flow 3.Purge the refrigerant 4. Recharge the system after vacuum. 5.Remove the restriction 6.See high suction pressure
Low discharge pressure	1.condenser cooling water is extremely low 2.low refrigerant charge 3.faulty compressor valves 4.low suction pressure.	1. Install low temp control in the cooling tower system. 2.add sufficient quantity of refrigerant 3.repair or replace the compressor 4.see low suction pressure
High suction pressure	1. High inlet air temp. at evaporator 2.excessive fresh air 3.leakage in the ducting 4.faulty compressor valves 5.overcharged refrigerant 6.high discharge pressure	1.check room load 2.reduce the fresh air 3.check and correct the duct system 4.repair and replace the compressor 5.purge the refrigerant See high discharge pressure
Low suction pressure	1.dirty air filters 2.dirty evaporator coils 3.less air flow 4.faulty fan motor 5.restricted liquid or suction line 6.low refrigerant charge 7.low discharge pressure	1.clean the filters 2.clean the coils 3.check duct system & fan drive 4.repair and replace the motor 5.remove the restriction 6.add sufficient qty of refrigerant 7.see low discharge pressure

SUFFICIENT COOLING:(Noisy operation)

Noisy compressor	1.shipping bracket/bolts are not removed 2.overcharged refrigerant 3.low suction pressure 4.defective compressor parts	1.check and remove the shipping bracket/bolts 2.purge the refrigerant 3.see low suction pressure 4.repair or replace the compressor
Noisy condenser fan	1.unbalanced fan 2.faulty motor bearings 3.loose mounting brackets 4.loose fixing screws	1.balance the fan 2.replace the bearing 3.tighten the brackets 4.tighten the screws
Other noises	1.loose cabinet screws 2.unleveled /week unit foundation 3.foreign material placed on unit	1.tighten the screw 2.check and correct the foundation 4.remove the foreign material

SPARE PARTS LIST
MODEL: AWC 050,075,120

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**1 No.**	**12.**	**Time delay relay**	**1 No.**
2.	Crank case heater	1 No.	13.	Main thermostat	1 No.
3.	Compressor service valve	1 Set.	14.	Low temp. thermostat	1 No.
4.	Contactor for compressor	1 No.	15.	Freeze protection thermostat	1 No.
5.	Overload relay for compressor	1 No.	16.	Flow switch	1 No.
6.	Condenser fan	1 No.	17.	Dual pressure control	1 No.
7.	Condenser fan motor	1 No.	18.	Fuse	2 Nos.
8.	Condenser fan mountings	1 Set.	19.	Filter drier	1 No.
9.	Contactor for cond. fan	1 No.	20.	Thermostatic expansion valve	1 No.
10.	Overload relay for cond. fan	1 No.	21.		
11.	Phase failure relay	1 No.	22.		

MODEL: AWC 100, 150

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**2Nos.**	**12.**	**Time delay relay**	**2Nos.**
2.	Crank case heater	2Nos.	13.	Main thermostat	1 No.
3.	Compressor service valve	2 Sets.	14.	Low temp. thermostat	1 No.
4.	Contactor for compressor	2Nos.	15.	Freeze protection thermostat	1 No.
5.	Overload relay for compressor	2Nos.	16.	Flow switch	1 No.
6.	Condenser fan	2Nos.	17.	Dual pressure control	2 Nos.
7.	Condenser fan motor	2Nos.	18.	Fuse	2 Nos.
8.	Condenser fan mountngs	2 Sets.	19.	Filter drier	2 Nos.
9.	Contactor for cond. fan	2Nos.	20.	Thermostatic expansion valve	2 Nos.
10.	Overload relay for cond. fan	2Nos.	21.	Solenoid valve	2 Nos.
11.	Phase failure relay	1 No.	22.		

MODEL: AWC 200,240

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**2Nos.**	**12.**	**Time delay relay**	**2Nos.**
2.	Crank case heater	2Nos.	13.	Main thermostat	1 No.
3.	Compressor service valve	2Sets.	14.	Low temp. thermostat	1 No.
4.	Contactor for compressor	2Nos.	15.	Freeze protection thermostat	1 No.
5.	Overload relay for compressor	2Nos.	16.	Flow switch	1 No.
6.	Condenser fan	4Nos.	17.	Dual pressure control	2Nos.
7.	Condenser fan motor	4Nos.	18.	Fuse	2 Nos.
8.	Condenser fan mountings	4Sets.	19.	Filter drier	2Nos.
9.	Contactor for cond. fan	4Nos.	20.	Thermostatic expansion valve	2Nos.
10.	Overload relay for cond. fan	4Nos.	21.	Solenoid valve	2Nos.
11.	Phase failure relay	1 No.	22.		

MODEL: AWC 300

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**1No.**	**12.**	**Time delay relay**	**1No.**
2.	Crank case heater	1No.	13.	Main thermostat	1No.
3.	Compressor service valve	1Set	14.	Low temp. thermostat	1No.
4.	Contactor for compressor	1No.	15.	Freeze protection thermostat	1No.
5.	Overload relay for compressor	1No.	16.	Flow switch	1No.
6.	Condenser fan	4 Nos.	17.	Dual pressure control	1No.
7.	Condenser fan motor	4 Nos.	18.	Fuse	2 Nos.
8.	Condenser fan mountings	4 Sets.	19.	Filter drier	1No.
9.	Contactor for cond. fan	4 No.	20.	Thermostatic expansion valve	1No.
10.	Overload relay for cond. fan	4 Nos.	21.	Solenoid valve	1No.
11.	Phase failure relay	1 No.	22.	Oil protection control	1No.

MODEL: AWC 300D

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**2No.**	**12.**	**Time delay relay**	**2Nos.**
2.	Crank case heater	2No.	13.	Main thermostat	1 No.
3.	Compressor service valve	2Sets.	14.	Low temp. thermostat	1 No.
4.	Contactor for compressor	2Nos.	15.	Freeze protection thermostat	1 No.
5.	Overload relay for compressor	2Nos.	16.	Flow switch	1 No.
6.	Condenser fan	4Nos.	17.	Dual pressure control	2Nos.
7.	Condenser fan motor	4Nos.	18.	Fuse	2 Nos.
8.	Condenser fan mountings	4Sets.	19.	Filter drier	2Nos.
9.	Contactor for cond. fan	4Nos.	20.	Thermostatic expansion valve	2Nos.
10.	Overload relay for cond. fan	4Nos.	21.	Solenoid valve	2Nos.
11.	Phase failure relay	1 No.	22.	Oil protection control	2Nos.

MODEL: AWC 350/350HE /400 / 400HE

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**1No.**	**13.**	**Main thermostat**	**1 No.**
2.	Crank case heater	1No.	14.	Low temp. thermostat	1 No.
3.	Compressor service valve	1Set	15.	Freeze protection thermostat	1 No.
4.	Contactor for comprsr.	2Nos.	16.	Flow switch	1 No.
5.	Overload relay for comprsr.	1No.	17.	Dual pressure control	1 No.
6.	Condenser fan	6Nos.	18.	Fuse	1No.
7.	Condenser fan motor	6Nos.	19.	Filter drier	1No.
8.	Condenser fan mountings	6Sets.	20.	Thermostatic expansion valve	1No.
9.	Contactor for cond. fan	6Nos.	21.	Solenoid valve	1No.
10.	Overload relay for condfan.	6Nos.	22.	Low ambient control	1No.
11.	Phase failure relay	1 No.			
12.	Time delay relay	2Nos.			

MODEL: AWC 400D, 500

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**2Nos.**	**12.**	**Time delay relay**	**2Nos.**
2.	Crank case heater	2Nos.	13.	Main thermostat	1 No.
3.	Compressor service valve	2Sets.	14.	Low temp. thermostat	1 No.
4.	Contactor for compressor	2Nos.	15.	Freeze protection thermostat	1 No.
5.	Overload relay for compressor	2Nos.	16.	Flow switch	2Nos.
6.	Condenser fan	6Nos.	17.	Dual pressure control	2Nos.
7.	Condenser fan motor	6Nos.	18.	Fuse	2 Nos.
8.	Condenser fan mountings	6Sets.	19.	Filter drier	2Nos.
9.	Contactor for cond. fan	6Nos.	20.	Thermostatic expansion valve	2Nos.
10.	Overload relay for cond. fan	6Nos.	21.	Solenoid valve	2Nos.
11.	Phase failure relay	1 No.	22.	Oil protection control	2Nos.

MODEL: AWC 600

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**2Nos.**	**12.**	**Time delay relay**	**2Nos.**
2.	Crank case heater	2Nos.	13.	Main thermostat	1 No.
3.	Compressor service valve	2 Sets.	14.	Low temp. thermostat	1 No.
4.	Contactor for compressor	2Nos.	15.	Freeze protection thermostat	1 No.
5.	Overload relay for compressor	2Nos.	16.	Flow switch	1 No.
6.	Condenser fan	8Nos.	17.	Dual pressure control	2 Nos.
7.	Condenser fan motor	8Nos.	18.	Fuse	2 Nos.
8.	Condenser fan mountings	8Sets.	19.	Filter drier	2 Nos.
9.	Contactor for cond. fan	8Nos.	20.	Thermostatic expansion valve	2 Nos.
10.	Overload relay for cond. fan	8Nos.	21.	Solenoid valve	2 Nos.
11.	Phase failure relay	1 No.	22.	Oil protection control	2Nos.

MODEL: AWC700, 700HE, 800,800HE

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**2Nos.**	**13.**	**Main thermostat**	**1 No.**
2.	Crank case heater	2Nos.	14.	Low temp. thermostat	1 No.
3.	Compressor service valve	2Sets.	15.	Freeze protection thermostat	2Nos.
4.	Contactor for compressor	4Nos.	16.	Flow switch	1 No.
5.	Overload relay for compressor	2Nos.	17.	Dual pressure control	2Nos.
6.	Condenser fan	12Nos.	18.	Fuse	2Nos.
7.	Condenser fan motor	12Nos.	19.	Filter drier	2Nos.
8.	Condenser fan mountings	12Sets.	20.	Thermostatic expansion valve	2Nos.
9.	Contactor for cond. fan	12Nos.	21.	Solenoid valve	2Nos.
10.	Overload relay for cond. fan	12Nos.	22.	Oil protection control	2Nos.
11.	Phase failure relay	1 No.		Low ambient control	2Nos.
12.	Time delay relay	1 No.			

MODEL: AWC 1050, 1050HE, 1200, 1200HE

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**3Nos.**	**13.**	**Main thermostat**	**1 No.**
2.	Crank case heater	3Nos.	14.	Low temp. thermostat	1 No.
3.	Compressor service valve	3Sets.	15.	Freeze protection thermostat	3Nos.
4.	Contactor for comprsor	6Nos.	16.	Flow switch	1 No.
5.	Overload relay for comprsr	3Nos.	17.	Dual pressure control	3Nos.
6.	Condenser fan	18Nos.	18.	Fuse	2Nos.
7.	Condenser fan motor	18Nos.	19.	Filter drier	3Nos.
8.	Condenser fan mountings	18Sets	20.	Thermostatic expansion valve	3Nos.
9.	Contactor for cond. fan	18Nos.	21.	Solenoid valve	3Nos.
10.	Overload relay for cond. fan	18Nos.	22.	Oil protection control	3 Nos.
11.	Phase failure relay	1 No.	23.	Low ambient control	3 Nos.
12.	Time delay relay	6Nos.			

MODEL: AWC 1400, 1400HE, 1600, 1600HE

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**4Nos.**	**13.**	**Main thermostat**	**1 No.**
2.	Crank case heater	4Nos.	14.	Low temp. thermostat	2Nos.
3.	Compressor service valve	4Sets.	15.	Freeze protection thermostat	2Nos.
4.	Contactor for compressor	8Nos.	16.	Flow switch	2Nos.
5.	Overload relay for compressor	4Nos.	17.	Dual pressure control	4Nos.
6.	Condenser fan	24Nos.	18.	Fuse	2 Nos.
7.	Condenser fan motor	24Nos.	19.	Filter drier	4Nos.
8.	Condenser fan mountings	24Sets.	20.	Thermostatic expansion valve	4Nos.
9.	Contactor for cond. fan	24Nos.	21.	Solenoid valve	4Nos.
10.	Overload relay for cond. fan	24Nos.	22.	Oil protection control	4Nos.
11.	Phase failure relay	2Nos.	23.	Low ambient control	4Nos.
12.	Time delay relay	8Nos.			

MODEL: AWC 2400, 2400HE

S.NO.	Part Description	Qty	S.NO.	Part Description	Qty
1.	**Compressor**	**6Nos.**	**13.**	**Main thermostat**	**2Nos.**
2.	Crank case heater	6Nos.	14.	Low temp. thermostat	3Nos.
3.	Compressor service valve	6Set.	15.	Freeze protection thermostat	3Nos.
4.	Contactor for compressor	12Nos.	16.	Flow switch	3Nos.
5.	Overload relay for compressor	6Nos.	17.	Dual pressure control	6Nos.
6.	Condenser fan	36Nos.	18.	Fuse	4Nos.
7.	Condenser fan motor	36Nos.	19.	Filter drier	6Nos.
8.	Condenser fan mountings	36Sets.	20.	Thermostatic expansion valve	6Nos.
9.	Contactor for cond. fan	36Nos.	21.	Solenoid valve	6Nos.
10.	Overload relay for cond. fan	36Nos.	22.	Oil protection switch	6Nos.
11.	Phase failure relay	2Nos.	23.	Low ambient control	6Nos.
12.	Time delay relay	12Nos.			

NOTES:

HOT WATER BOILER

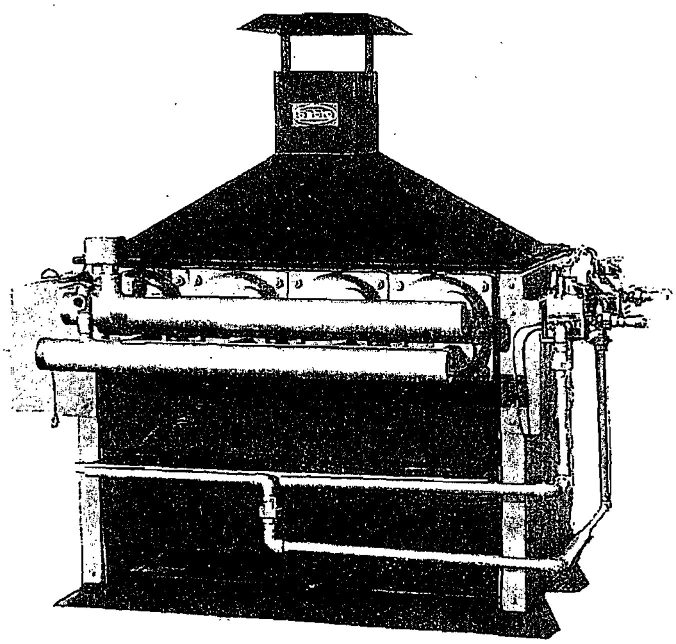
TECHNICAL MANUAL

(24)

TECHNICAL MANUAL

Series HB

Natural Gas fired, Hot Water Generators



Sabro
Airconditioning

T-1200-01

CONTENTS

1. SPECIAL FEATURES

. APPLICATION

The SABRO hot water generators, operated at natural gas, are a source of providing hot water supply to all type of air conditioning applications. The hot water from generators is circulated through Fan coil units, Air handling units or Heat exchanger etc., requiring hot water for heating.

The function of unit is fully automated by use of an intermittent pilot ignition system (Except **model HB070, which is provided with manual control)**. Lighting of the pilot is automatically performed by electronic spark ignition each time the thermostat call for heat. The intermittent pilot ignition system saves the gas by automatically shutting the pilot off when there is no call for heat. An electric supply connection is required to operate the control system of the unit.

Note: As model HB070 is provided with manual operation control, hence sections about intermittent pilot ignition system on following pages, are for model HB200 and HB400 only.

The units are required to be installed in an open space due to its natural draft air circulation design. However it may be installed inside a plant room, provided a sufficient fresh air circulation is ensured. The system is most suitable for installation parallel to a chiller unit, for winter heating. The same piping, pumps, air handling unit, fan coil unit or heat exchanger may be used for space heating.

The units are factory assembled and internally wired, the only works required at site are to connect natural gas supply connection, water piping with pumps and control power supply etc. Maintenance of unit is very easy. All components, piping and wiring is easily accessible by opening excess panels. Unit's heat exchanger shell are provided with removable heads for excess to coil tubes and maintenance work etc.

. SAFETY DEVICES (In models HB200 and HB400 only)

--- Water **Flow switch**, to protect the unit from any damage due to lack of water flow.

--- **Limit Thermostats** , to shut off the gas control valve in case of excessively high temperature of water due to non functioning or incorrect setting of main thermostat.

--- **Main Thermostat** , to set the desired temperature of water and for automatic ON/OFF function of gas control valve according to water temperatures.

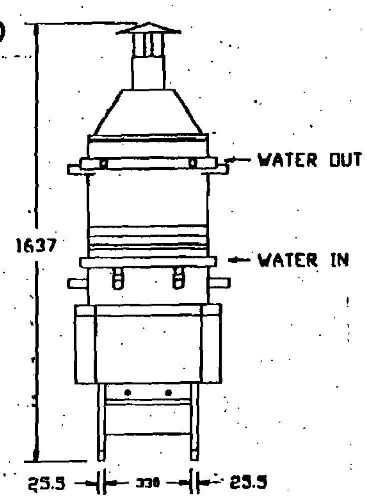
--- Combination **Temperature and Pressure relief valve**, to protect the unit from any damage due to abnormally high temperature or pressure inside the heat exchanger.

2. SPECIFICATIONS

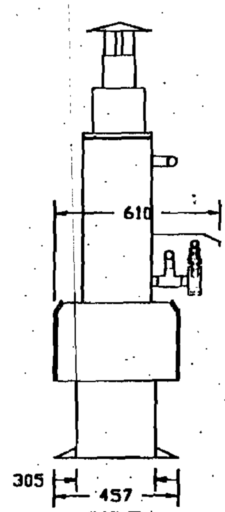
MODEL		HB 070	HB 200	HB 400
Heating Capacity	Btu/Hr.	70000	175000	350000
	Kcal/Hr.	17639	44097	88195
Gas consumption		96 Cft	255 Cft	510 Cft
Gas pressure		7.0 In. Wc		
Gas connection		1/2"	3/4"	3/4" X 2
Power Supply.		Not required	220 / 240-1-50HZ	
Control circuit		Not required	24 Volts	
Gas control system		Manual	Intermittent pilot ignition	
Heating surface		Integral finned copper tubes		
Insulation		4" Glass wool		
Internal surface protection		Asbestos sheets		
Water flow rate	US Gpm.	14	35	70
Water inlet / outlet temperature		140°F / 150°F		
Water inlet / outlet connections	Type	Male Piping Thread		
	Size In.	1" / 1"	2" / 2"	4" / 4"
Dimensions. mm (in.)	Height	1637 (64.4)	1346 (53.0)	1511 (59.5)
	Width	546 (21.5)	984 (38.7)	1500 (59.0)
	Depth	610 (24.0)	1149 (45.2)	1213 (47.8)
Weight.	K.G.	85	160	300

3. OUTLINES AND DIMENSIONS

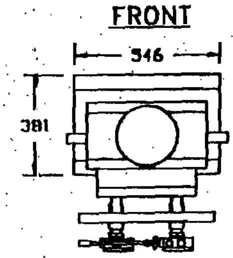
MODEL : HB 070



FRONT

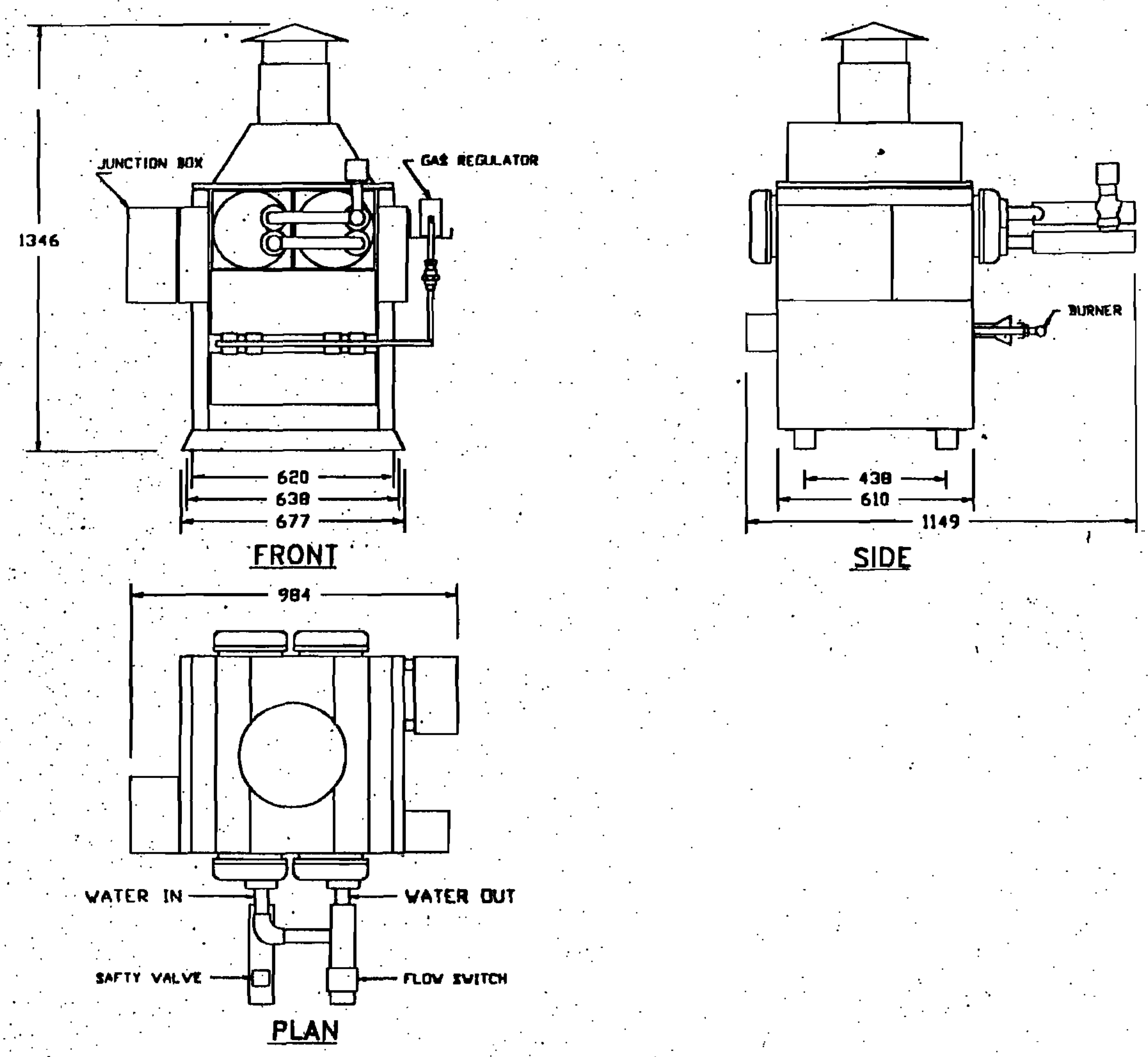


SIDE

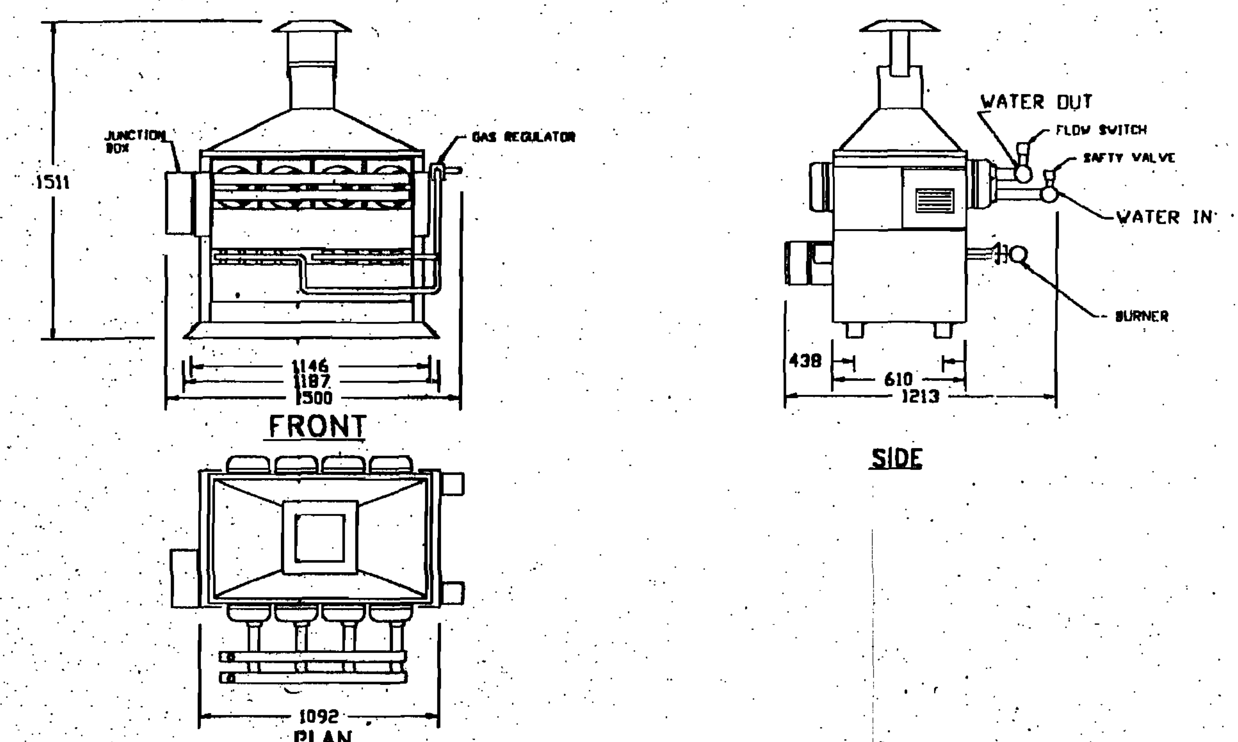


PLAN

MODEL : HB 200



MODEL : HB 400



4. INSTALLATION

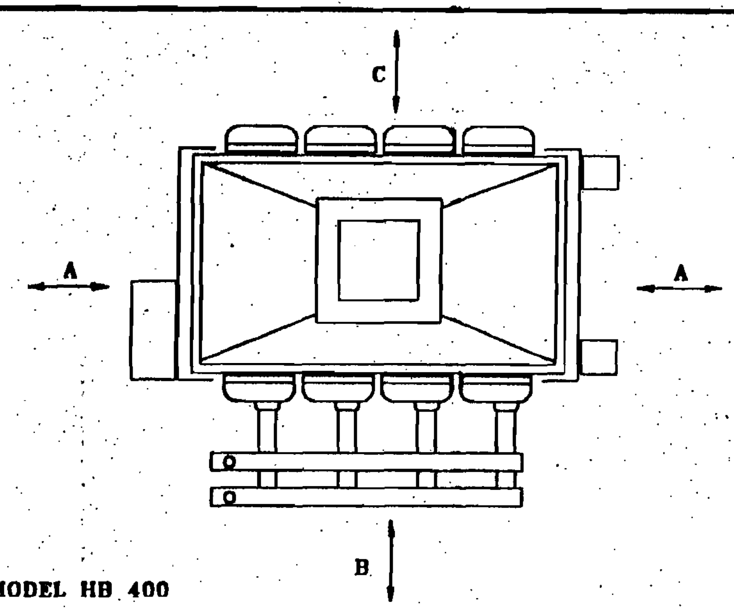
CAUTION : Before installing the unit, ensure that the gas and power supply matches the gas and power requirement of the unit.

4-1 SELECTION OF LOCATION AND SPACE

As the unit is designed on natural air circulation, proper operation of burners depend on sufficient supply of oxygen. So, preferably the unit is required to be install in an open space. Ensure sufficient fresh air supply in the room and exhaust of flue gases, if the unit is installed in a plant room.

Following requirements are also to be considered while selecting a location for installation:

- Allow sufficient space for maintenance and air circulation, around the unit (see INSTALLATION CLEARANCE requirements below).
- A properly leveled place, capable of bearing the weight of unit. See specifications at page.2 for weight of units.
- In case of installation of unit at roof, proper advice may be taken from civil consultant about the weight bearing capacity of roof.
- A place suitable for piping, wiring, and maintenance etc.



SHOWN MODEL HB 400

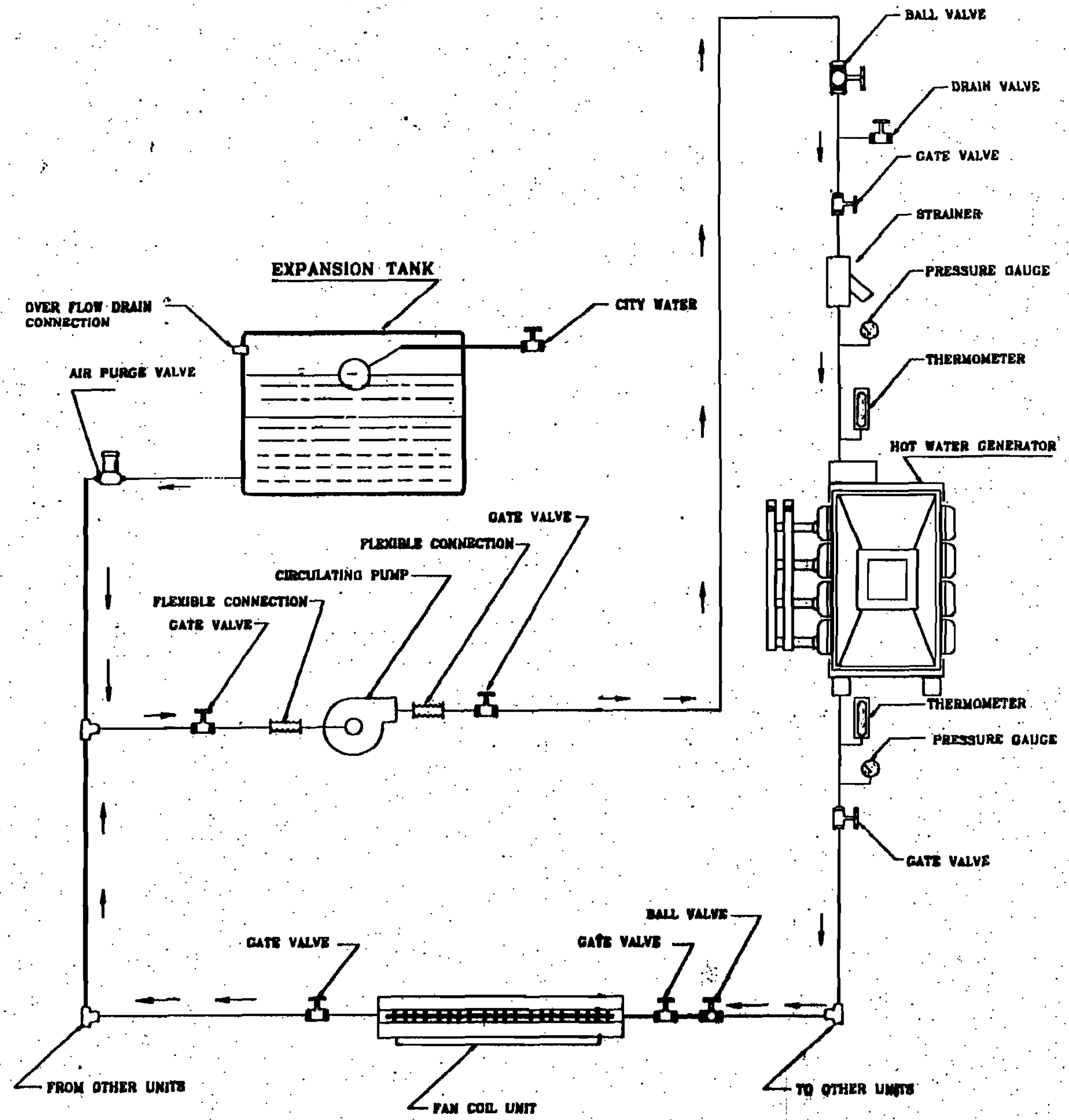
MODELS	A	B	C
HB 070	500 MM	1000 MM	200 MM
HB 200	500 MM	1000 MM	1000 MM
HB 400	500 MM	1000 MM	1000 MM

4-2 SUPPLY AND RETURN WATER PIPING

The units are provided with Male Pipe Threaded water supply / return connections. Supply and return water piping should be designed and laid to suit individual site requirements, however following points must be considered during installation:

- The water piping should be so designed that the circulating water pump discharges water in to the hot water generator. Make sure that supply and return pipes are not adversely connected.
- The pump should be of sufficient capacity to make up for the total head loss and required water flow of the unit. One water pump of same capacity to be connected in parallel for standby operation.
- Piping supports should to be provided to refrain from applying improper force to the chiller shell.
- Hand stop valves should be provided in all lines for ease of servicing.
- Water regulating valves should be provided at pump outlet, to regulate the flow of water as per design.
- Drain connection should be provided at all low points to permit complete drainage of system.
- Air purging valves should be provided for removing air in the piping system, where there is a possibility of air trapping.
- Proper strainer should be provided on the inlet line of the pumps to remove the foreign materials. A strainer is also recommended on the inlet line of the unit.
- Temperature and pressure gauges should be provided on supply and return water lines of unit, to monitor the operation.
- All piping should be properly insulated to prevent the wastage of heating.
- All water piping should be thoroughly flushed to free it from any foreign material. Care must be taken that no foreign material is flushed into or through the unit.
- Flexible joints may be used at pump suction and discharge lines to prevent the transmission of vibration and noise.
- An expansion tank should be provided with the system to maintain system pressure by allowing water to expand when water temperature increases. The regulation of pressure will be maintained by expansion and contraction of an adequate volume of air trapped in the upper portion of the expansion tank. The tank should be installed at a location slightly higher than the highest pipe line of the system, and should be provided with makeup water connection to maintain the water level and drainage connection etc.

A typical layout plan of piping system is provided hereunder for an idea.



4-3 GAS PIPING

The units are provided with Male Pipe Threaded gas supply connections. Gas piping should be designed and laid according to local codes and to suit individual site requirements, however following points must be considered during installation:

- Use new, properly reamed pipe free from chips.
- Apply a moderate amount of pipe compound on pipe at all joints / fittings.
- Install a manual gas stop valve in the gas pipe line near to the unit, so that the gas supply can be stopped immediately in case of emergency or during maintenance etc.

4-4 WIRING (Not required with model HB070)

. Wiring regulation on wire diameters differ from country to country. Pease refer to your LOCAL ELECTRICAL CODES for field wiring rules. Be sure that installation comply with such rules and regulations.

GENERAL PRECAUTIONS

. Ensure that the rated voltage of the unit corresponds to the name plate, before carrying out proper wiring according to the wiring diagram.

. Provide a power outlet to be used exclusively for each unit. A power supply disconnect switch should be provided with the unit.

. The unit must be **Grounded** to prevent possible hazards due to insulation failures.

. All wiring must be firmly connected.

. Any wiring must not touch the hot water piping.

POWER SUPPLY

. The units are internally wired in accordance with applicable electrical codes. The main Power wiring to be connected through field installed control panel and should comply with relevant electricity code. The field installed electrical panel should consist of pump ON/OFF switches, unit ON/OFF switches, indication light for power supply, and volt meters etc.

. The power supply should be 220/240 Volts, 1 Phase, 50 HZ cycle. The voltage supplied to the unit during operation must be with in ± 10% of the rated vantage. The local authorities should be contacted for correction of any improper voltage. Under no circumstances, the unit be operated on improper line vantage, as this may cause damage to the equipment.

. Connect the main power and earth wires to unit terminals, utilizing openings of panel in accordance with the wiring diagram provided with the unit.

. Ensure that all wires are firmly connected, and there is not any loose connection.

NOTE:
The control circuit in unit is provided with a 24V step down transformer because all the controls / accessories are suitable for working on 24V supply.

5. OPERATING INSTRUCTIONS

WARNING

- This unit is equipped with an automatic pilot ignition system, do not attempt to use a match to relight pilot or main burner; burn injury or electric shock may result.

5-1 PRE START CHECKS

- Ensure that steps mentioned in Installation section are fully followed.
- Ensure that the unit is properly mounted on the foundations and is levelled.
- Ensure that adequate space is available around the unit for free air circulation and maintenance work.
- Ensure that the unit is clear and free of all foreign materials, such as tools etc.
- Ensure that gas piping is in accordance with the standard practice and all piping joints are leak tested.
- Ensure that the water piping work is in accordance with the standard practice and all lines are flushed to ensure that there is not any foreign material in the system.
- Ensure that Expansion tank and all piping system is filled with water. Also ensure that all piping is leak tested and all valves in water piping system are open.
- Ensure that the available power is in accordance with the prescribed data on the unit's name plate and field wiring is of adequate size and their wiring connections are properly tightened.
- Ensure that main circuit breaker is of proper size and the unit is properly grounded.

. GAS LEAK TEST

- With the power off, open manual shut off valve in the gas line to the unit.
- Paint all pipe connections upstream of the gas control with a rich soap and water solution. Bubbles indicate a gas leak.
- If a gas leak is detected, tighten the pipe connections.
- Stand clear while lighting main burner to prevent injury caused from hidden gas leaks, which could cause flashback in the unit vestibule. Light the main burner.
- With the main burner in operation, paint all pipe connections and gas control inlet and outlet with rich soap and water solution.
- If another gas leak is detected, tighten adopter screws, joints, and pipe connections.

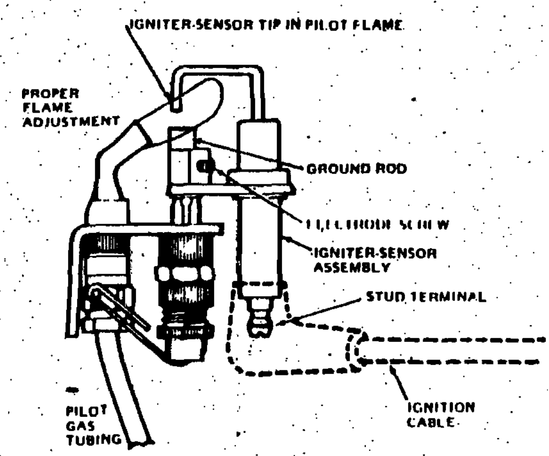
- Replace the part if the gas leak cannot be stopped.

. Adjustment of GAS INPUT to MAIN BURNER

- Do not exceed the input gas flow rating than mentioned on catalog.
- With the main burner operating, check the gas control flow rate using the meter clocking method. Make sure that the only gas flow through the meter is that of the unit being tested, all other appliances and their pilots are turned off and there is no gas leakage in the piping system.
- Remove the pressure regulator adjustment cap and screw.
- Using a screw driver, turn the inner adjustment screw clockwise to increase or counter clockwise to decrease the flow of gas through main burner.
- Always replace the cap screw and tighten firmly.
- If gas input to main burner cannot be achieved by adjusting the gas control, check the gas control inlet pressure using a manometer at the inlet pressure tap of the gas control valve. If the inlet gas pressure is in normal range (3.0 ~ 5.0 In Wc), replace the gas control. Otherwise take the necessary steps to provide proper gas pressure to the gas control.

. Adjustment of PILOT FLAME

- For proper working of ignition control system, the pilot flame should envelop 3/8" to 1/2" of the ground rod and tip of the igniter sensor. Refer sketch below for the adjustment of pilot flame.



- Remove the pilot adjustment cover screw on the gas control valve.
- Using a screw driver, turn the inner adjustment screw clockwise to decrease or counter clockwise to increase the pilot flame.
- Always replace the cover screw after adjustment and tighten firmly.

Note: For operating instructions of HB070, see label mounted on the manual valve.

5-2 INITIAL START UP

After ensuring the pre start checks, proceed with following steps for initial start up:

WARNING

- If you smell gas or suspect a gas leak, turn off gas at the manual service valve and evacuate the building (If installed inside the building). Do not try to light any appliance and do not touch any electrical switch or telephone in the building until no spilled gas remains.
- Perform the gas leak test after initial installation and any time work is done to the gas piping.

☼ Set the temperature knob of main thermostat at maximum setting. Set the COOL / HEAT switch of main thermostat at HEAT (If applicable).

☼ Switch ON water pump, the pump motor should start running.
- ▸ Check the amperes of the pump motor, and compare with name plate data.
- ▸ Check for any abnormal noise or vibration.
- ▸ Check for correct rotation direction.
- ▸ Ensure that water is flowing.
- ▸ Check the water inlet temperature to unit.

☼ Move the unit operation switch to ON position.

☼ Following the call for heat, the module energizes the first pilot valve operator. The first pilot valve opens, which allows gas to flow to the pilot burner. At the same time, the electronic spark generator in the module produces a high voltage spark pulse output. The voltage generates a spark at the igniter sensor that lights the pilot.
- ▸ Ensure pilot lights smoothly when gas reaches the pilot burner.

Note: If the pilot does not light, or the pilot flame current is not sufficient, the module will not energize the second (main) valve and the main burner will not light. After 90 seconds maximum, the system shut off and the pilot valve closes; trial for ignition restarts after a minimum of 5 minutes. Ignition, shut off, and wait sequence repeats until pilot lights or call for heat ends.

☼ When the pilot flame is established, a flame rectification circuit is completed between the sensor and burner ground. The flame sensing circuit in the module detects the flame current, shuts off the spark generator and energizes the second main valve operator, The second main valve opens and gas flows to the main burner, where it is ignited by the pilot burner.
- ▸ Ensure main burner lights smoothly without flashback.
- ▸ Ensure main burner operates smoothly without floating or, lifting.

Note:
- When the call for heat ends, both operators are de-energized, and both valves in the gas control close.
- HB 400 is equipped with two ignition controls and valves which operates simultaneously.
- At the time of initial starting, some condensation may formed on the outer surface of heat exchanger due presence of low temperature water. This condensation will stop automatically when temperature of water rises to operating conditions.

- ☼ Check the functioning of thermostat by moving temperature knob to minimum temperature, the main burner and pilot flame should go off. Again set the temperature knob to maximum temperature, and watch for normal operating sequence.
  - ► Check and record the water inlet / outlet temperatures and compare with requirement.

- ☼ After putting the unit on final continuous operation, set the temperature knob of thermostat to desired temperature, for automatic operation of the unit. Please note that the sensor of main thermostat is mounted at return water connection. So the temperature knob should be set at 1°C above the required return water temperature.

- ☼ Start the air conditioners such as Air handling unit, Fan coil unit or machine etc.
  - ► Check the water inlet temperature and record.
  - ► Check the air inlet temperature and record.

6. SERVICING AND MAINTENANCE

To ensure the long life, trouble free and smooth operation of Sabro hot water generators, it is necessary to maintain the equipment for good running conditions. The following section indicates the minimum recommended maintenance, which must be performed at specified intervals of time.

ALL ELECTRICAL POWERS SHOULD BE SWITCHED OFF BEFORE PROCEEDING WITH ANY MAINTENANCE OR INSPECTION WORK.

Components	Maintenance Procedure	Recommended Schedule
Heat exchanger (Water side)	1. Check and clean with diluted solution of water and cleaning agent / de scaler. Note: Cleaning requirement depends upon water conditions and method of water treatment. Follow instructions of cleaning agent manufacturer's recommendations for de-scaling procedure.	Every 6 months
Heat exchanger (Flame side)	1. Check and clean the carbon with the help of a steel wire brush. Also use pressurized water for deep cleaning.	Every 6 months
Burners	1. Check and clean the holes of burners.	Every 6 months
Electrical	1. Check faulty contacts caused by loose connections, foreign matters etc. Tighten loose connections.	Every 2 months
Gas piping	1. Perform gas leak test, and repair if detected.	At the start of season or whenever any work done on piping.
Water piping	1. Check for any water leakage and repair if detected. 2. Check the insulation and replace damaged one.	At the start of season or whenever any work done on piping.

7. TROUBLE SHOOTING

Perform the initial startup steps before going for trouble shooting.

TROUBLE	POSSIBLE CAUSE	SUGGESTED ACTION

No. Heating: (Unit does not operate)

Improper power supply	1. No voltage or low voltage	1. Obtain correct voltage
Blown fuses	1. Loose connection	1. Replace fuses / tightened connections
Water circulating pump is not working	1. Faulty starter 2. Burnt motor 3. Defective operation switch	1. Repair or replace the starter 2. Repair or replace the motor 3. Repair or replace the switch
Flow switch is not operating.	1. Insufficient water flow 2. Faulty switch	1. Obtain correct water flow 2. Repair or replace the switch
Intermittent pilot ignition system is not working.	1. Faulty components.	1. Repair or replace the components.
Burners does not operates.	1. Unsatisfactory pilot flame. 2. Insufficient gas pressure. 3. Faulty gas control valve.	1. Obtain correct pilot flame. 2. Obtain correct gas pressure. 3. Repair or replace the control

In sufficient Heating: (Unit operating)

Burner flame is not smooth	1. Insufficient gas pressure	1. Obtain correct gas pressure
Leaving water temperature is lower than design.	1. Wrong thermostat setting. 2. Too low return water temperature. 3. Scaled heat exchanger	1. Correct the setting. 2. Check room loads 3. Clean the heat exchanger

7-1 IGNITION SYSTEM CHECKS

- Check ignition cable.
  - Ensure cable does not run in contact with any metal surfaces.
  - Ensure connections to the ignition module, igniter and igniter sensor are clean and tight.
  - Ensure ignition cable provided good continuity.

- Check ignition grounding.
  - Ensure for good metal to metal contact between the pilot burner bracket and the main burner.
  - Ensure that connections of ground lead from module to pilot burner are clean and tight and lead is not damaged or deteriorated.
  - Ensure the ceramic flame rod is not cracked or exposed to extreme heat.
  - Ensure the flame rod and bracket is in correct mounting position.

- Check spark ignition circuit.
  (A short jumper made of ignition cable or heavily insulated wire will be required)

WARNING
WHEN PERFORMING THE FOLLOWING STEPS, DO NOT TOUCH STRIPPED END OF JUMPER OR SPARK TERMINAL. THE IGNITION CIRCUIT GENERATES 1000 VOLTS AND ELECTRIC SHOCK CAN RESULT.

- Close the manual gas valve and disconnect the ignition cable at the SPARK terminal on the module.

- Energize the module and immediately touch one end of the jumper firmly to the GND terminal on the module. Move the free end of the jumper slowly towards the SPARK terminal until a spark is established.

- Pull the jumper slowly away from the terminal and note the length of the gap when sparking stops. If the gap is less than 1/8", verify the voltage at module input terminal. Replace the module if voltage is okay.

- Check spark ignition circuit.

  - Open the manual gas valve and set the thermostat to call for heat.
  - Watch the pilot burner during ignition sequence and see if ignition spark continues after the pilot is lit. If so replace the ignition module.
  - If pilot lights and the spark stops but the main burner does not light. Ensure proper pilot flame. Obtain the correct pilot flame if required.

  - If pilot flame is proper, all connections wiring and gas pressures are correct, replace the gas control valve.

8. SPARE PARTS LIST

MODEL: HB 070

S.No.	Part Description	Qty.	S.No.	Part Description	Qty.
1.	Gas control valve (Manual)	1 No.	3.	Gas burner nozzles	2 Nos.
2.	Temp-Press relief valve	1 No.			

MODEL: HB 200

S.No.	Part Description	Qty.	S.No.	Part Description	Qty.
1.	Gas control valve	1 No.	7.	Temp-Press relief valve	1 No.
2.	Intermittent pilot module	1 No.	8.	Transformer	1 No.
3.	Igniter-sensor assembly	1 Set	9.	Fuses	1 No.
4.	Main thermostat	1 No.	10.	Gas burner nozzles	4 Nos.
5.	Limit thermostat	1 No.			
6.	Flow switch	1 No.			

MODEL: HB 400

S.No.	Part Description	Qty.	S.No.	Part Description	Qty.
1.	Gas control valve	2 Nos.	7.	Temp-Press relief valve	1 No.
2.	Intermittent pilot module	2 Nos.	8.	Transformer	1 No.
3.	Igniter-sensor assembly	2 Sets.	9.	Fuses	1 No.
4.	Main thermostat	1 No.	10.	Gas burner nozzles	8 Nos.
5.	Limit thermostat	1 No.			
6.	Flow switch	1 No.			

AHU'S

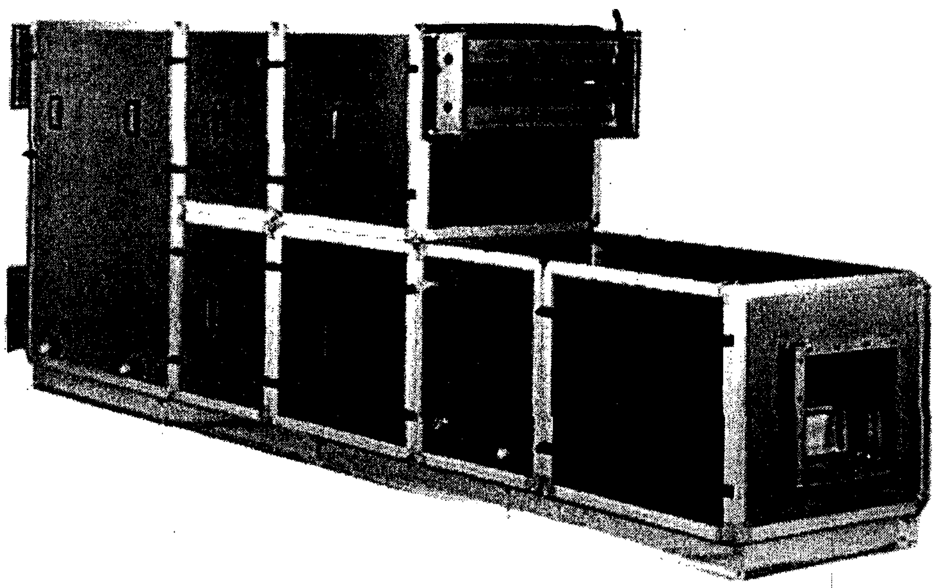
TECHNICAL MANUAL

TECHNICAL MANUAL

Sabro

Series AHU

Central Station Air Handling Unit



Thankyou for choosing OUR BRAND NAME.

Please read this OWNER'S MANUAL HANDBOOK prior to installing and keep it for further refrence.

CONTENTS

GENERAL:

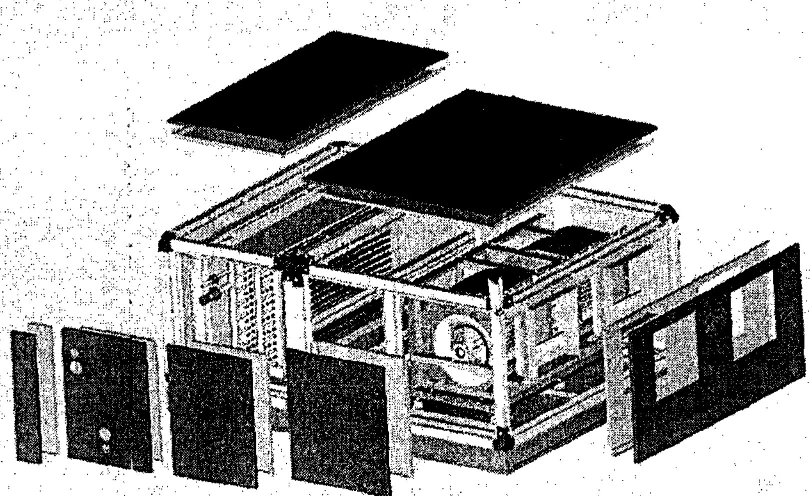
SABRO Central station air handling units are designed to provide central air conditioning i.e. cooling, heating, humidifying, pre-heating, re-heating, mixing and filtering etc. with a set of standard. Optional component section.
SABRO Central station air handling units are manufactured in following construction arrangements, with M.S. Sheets as standard or with G.I. sheets on requirement.

HDT:	Horizontal Draw Through unit.
VDT:	Vertical Draw Through unit.
SZBT:	Single Zone Blow Through unit.
MZBT:	Multi Zone Blow Through unit.
M:	Modular construction.
DS:	Double skinned construction.

The units are shipped assembled in a suitable packing enabling the safer transportation / rigging to the unit foundation. Units may be shipped in section on request, for ease of handling at site. Modular units can be shipped assembled, in sections or disassembled as required, for assembling of disassembled units, separate instruction sheets are provided with the units.

INTIAL CHECK UP:

Immediately upon receiving, the unit should be inspected for any apparent / outward damage. If damage is evident, that should be informed to factory for necessary repairs etc. Claims for damages should accordingly be lodged with the insurance company.



INSTALLATION SPACE:

It is essential to locate a proper place for the installation of unit. Sufficient space must be provided on the sides of unit for ease of maintenance, like filter removal, excess to motor electric connections, and coil removal etc. See unit data to access the requirement.
The following checks must be made before installation of the units, to determine the roper installation location.

- Be sure that the roof or concrete ground slab is strong enough to provide sound foundation for the unit.
- There should be adequate space around the unit for maintenance work.
- Proper provision for condensate drains line.
- Adequate electrical power source to meet the unit's requirement.

After having selection of proper location for the unit, proceed with the actual installation.

INSTALLATION

FOUNDATION:

The surface for the placement of unit should be properly leveled, flat and strong enough.
In case the unit is to be installed on roof top, carefully check the strength of roof. In this regards, properwdvise may be taken from Civil Engineer.

For installation of the unit at ground level, a concrete or iron base of 3 to 6 inches above the ground level must be provided to avoid blocking of dirt at the bottom of the unit. One piece concrete slab is recommended for this purpose. Please refer to catalogue for the foundation detail of unit.

LIFTING / RIGGING:

The unit should be unloaded at a place nearest to the location of installation, and kept packed till placement on foundations, to avoid any damage.

A fork lifter is highly recommended for the placement of unit on its foundations. However the units may be rolled lifted and moved with ropes etc. Proper eye bolts and spreader bars are recommended for safety of unit.

Please refer to catalogue for the weight of units.

SUPPLY AND RETURN AIR DUCTING:

SABRO, Air Handling Units are designed to distribute the conditioned air through ducts. Fanged connections are provided on the unit for both supply and return air duct connections. Care must be taken to follow standard duct fabrication practice to avoid un-necessary noise and friction loss etc.

- Flexible connections should be provided between the flanges and main supply and return air ducts, to eliminate sound and vibration transmission from unit to ducts. The recommended length of flexible connections is 2" to 4". Usually, leak proof canvas cloth is used for this purpose.

- There may be a possible difference in the size of air ducts and the connection size of unit. A reduction piece of duct with the ratio of 1 : 4 in length is recommended for connection.

- Turns on ducts, closer to units, should be avoided.

- Metal to metal contact of unit with ducts, pips, conduits, and supports etc. should be avoided.

- To prevent air leakage, duct seams should be sealed. Supply air duct should be insulated and provided with cover and vapor barrier. Return air ducts not need to be insulated if passing through conditioned space. Ducts exposed to outdoor conditions should be weather proof.

- The opening from where the outside duct enters the building, should be sealed with weather proof stripping to prevent the entrance of rain or dust in to the building.

SUPPLY AND RETURN PIPING:

The piping to and from the Air Handling Units should be designed to suit the individual installation. The piping should be in accordance with local code requirements, however following considerations be observed.

- Gate valves at water inlet and outlet should be provided for maintenance etc.

- Globe valve at water outlet should also be provided for balancing of water flow through the coil.

- A stainer be installed in the water inlet line just ahead of Air Handling Unit.

- Thermometer wells should be located at the coil inlet and outlet, to aid the performance and service work.

- Ports for pressure gauges with ball valves should be provided to check the pressure drop through coil.

ELECTRICAL WIRING

All wiring must be in accordance with local code requirements. However, following care must be taken for safety, from operational point of view:

- The size of cable must be sufficient to handle the total amperage load of the unit.
- A main circuit breaker must be installed at an easily approachable place to disconnect the main power supply, in case of emergency or during the maintenance.
- Proper size of earth wire should be connected between the unit and main earth point.
- Ensure that all wires are firmly connected, and there is not any loose connection.

FANS:

SABRO Air Handling Units are equipped with forward curved centrifugal type blower fans. As the fan motors are of 3-Phase, please check the rotation of blowers as per aero provided on the housy of unit. In case of reverse rotation, change any two phases with each other; the rotation will comes to specified direction.

FAN SPEED ADJUSTMENT:

Sabro Air Handling Units are equipped with adjustable motor pulley and adjustable motor base to adjust the fan speed. Please consult catalog for Fan RPM and motor requirement at different static pressures and air flow rates. However motor pulley has a margin of $\pm$10% to adjust the fan RPM for achieving accurate air flow rates at site. To change the fan RPM, adjust the motor pulley as follow:

- Remove the belts form fan and motor pulleys.
- Loosen the L-Key screw fixed on the flange of moveable pulley.
- To increase the fan speed, turn the moveable pulley flange towards the fixed pulley flange. And to reduce the fan speed, turn the moveable pulley flange away from the fixed pulley flange. Check fan RPM with the help of an RPM meter.
- Tighten the L-Key screw of moveable pulley. Ensure the L-Key screw is positioned over the flat surface of the fixed pulley.
- Fix the belts on pulleys, and adjust belt tension with the help of adjustable motor base.

OPERATION INSTRUCTION:

PRE START CHECK:

Following checks should be made, before putting the unit in operation:

- Ensure that the unit is properly mounted on the foundations and is leveled.
- Ensure the adequate space is available around the unit for maintenance work.
- Ensure the unit is clear and free of all foreign materials, such as tools etc.
- Ensure that the duct work is in accordance with the standard practice and filters are properly installed in place.
- Ensure that the drain line is properly connected and trap has been provided.
- Ensure the available power at the main circuit breaker is in accordance with the prescribed data on the unit's name plate.
- Ensure the field wiring is of adequate size and their wiring connections are properly tightened.
- Ensure that main circuit breaker is of proper size.
- Ensure that the unit is properly grounded.
- Rotate the blower by hand, to check for free rotation.
- Check blower fan rotation by manually pushing the contact checking knob of contactor. In case of reverse rotation, change any two phases with each other; the rotation will comes to specified direction.
- Ensure proper belt tension of blower.
- Ensure the proper alignment of blower / motor pulleys.

INITIAL START UP:

After ensuring the above checks, proceed with following steps for initial star up:

- Switch ON the main circuit breaker, the glowing power lights indicates that the main supply is ON, and all three phases are coming.
    - Check incoming Voltage of all three phases with a volt meter.
- Push / Move the unit operation switch to ON position; the blower fan will start running.
    - Check the amperes of the fan motor, and compare with motor data.
    - Check for any abnormal noise or vibration.
- Check the functioning of thermostat in relation to function of bypass valve, bypass damper motor, or mixing box dampers motor if installed.
- After operating the unit for about 3 to 4 Hrs, shut off the main switch.
- Once again check all wiring connections of electrical components, fan motor alignment, and setting / adjustment of other accessories, before putting the unit on final continuous operation.
- After putting the unit on final continuous operation, set the temperature knob of thermostat to desired temperature, for automatic operation of the unit.

MAINTENANCE:

To ensure the long life, trouble free and smooth operation of SABRO Air Handling Units, it is necessary to maintain the equipment for good running conditions. The following section indicates the minimum recommended maintenance, which must be performed at specified intervals of time.

ALL ELECTTRICAL POWERS SHOULD E SWITCHED OFF BEFORE PROCEEDING WITH ANY, AINTENANCE OR INSPECTIONWORK.

AIR FILTERS:

The air filters of unit shall be inspected twice a month, or more frequently, depending upon the each site conditions. The dirt of filters can be cleaned, first by tapping them lightly on smooth place and than by washing with neutral detergent mixed in lukewarm water. Do not install the wet air filters in the unit. Under no circum stances, the unit be operated without with out air filters. For better efficiency and long life of system, a spray of viscous oil should be perform on filters, before installation in to the system

NOTE: The dirty air filters will result in reduced air flow and cooling effect.

COILS:

As coils are used as heat transfer media, accumulation of dirt on these coils reduces their heat transfer efficiency, which effects the efficiency of unit. Therefore, coils should be kept clean. Use brush, vacuum cleaner or other suitable method to clean the coils. Care must be taken during the coil cleaning, so that the fins may not get damaged or bent. When ever, the unit is shut OFF for an extended period, the duct immediately above the unit must be cleaned before starting the unit.

FAN MOTOR LUBRICATION:

The fan motor bearing should be checked regularly. The originally installed bearing are permanently lubricated, however if bearings are field replaced, check their lubrication instructions.

FAN SHAFT BEARINGS:

The fan shaft bearings permanently lubricated and are mounted on rubber housing. No further lubrication is required in the field, if the same were not replaced.

PULLEY ALIGNMENT:

Check and adjust pulley alignment and belt tension. Replace worn out belts. Do not over-tighten the fan belt.

CONDENSTAE DRAIN:

Check and clean the condensate drain pan and drain line from any dirt and foreign material.

ELECTRICAL PANEL / ACCESSORIES:

Inspect all the electrical connections and fight the loose ones.

JOHNSON CONTROLS

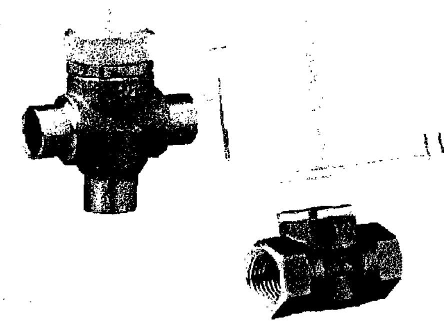
TECHNICAL MANUAL

JOHNSON CONTROLS

VG5000 Forged Brass Valves

Introduction

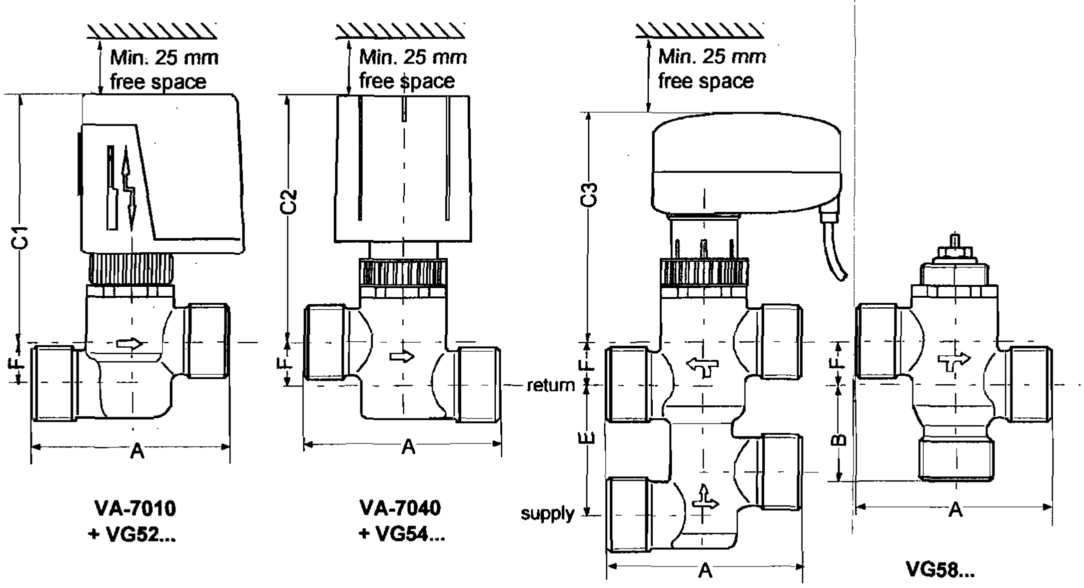
The VG5000 forged brass valve series is primarily designed to regulate the flow of water in response to the demand of a controller in zone and terminal unit applications.
They can be used in combination with VA-7010 electric ON/OFF actuator, VA-7040 thermal actuator and or VA-7450 floating or proportional actuator.
The valves are available in 2-way PDTC (Normally Open), 2-way PDTO (Normally Closed), 3-way mixing and 3-way mixing with built-in Normally Open bypass configurations.



VG5000 3-way mixing with VA-7450 (left)
VG5000 2-way valve with VA-7010 (right)

Features and Benefits	
❑ **2-way PDTO (NC), PDTC (NO) and 3-way configurations**	Flexible applications
❑ **3-way with built-in bypass configuration**	Reduces piping installation time and cost
❑ **Selectable flow characteristic in combination with VA-7452 actuator series**	Provides desired controllability
❑ **Forged brass body, stainless steel stem and spring**	Ensure long life and it is compact
❑ **Rubber compound plug for bubble-tight shut-off**	Maximises energy saving
❑ **Field adjustable Kvs for select body styles**	Reduce stock and offers flexibility
❑ **Actuator can be field installed after piping**	Simplifies installation in confined location
❑ **Built-in return spring**	Allows the valve to return to normal position when actuator is not mounted or when VA-7010 / VA-7040 actuator is de-energised

Ordering data



VA-7010 + VG52...

VA-7040 + VG54...

VA-7450 + VG55...

VG58...

Threaded Male Connection

Body Type	Ordering code	Connection Size	Factory Set Kvs and alternative adjustable Kvs 1	2	3	Close-Off Pressure (kPa)	Dimensions (mm) A z =1 z =9	B z =1 z =9	C1 (VA-7010)	C2 (VA-7040)	C3 (VA-7450)	E	F
2-way PDTC (NO)	VG52z0AC	½"	0.4	0.25	-	200	68	-	96	95	90	-	11
	VG52z0BC	½"	0.4	0.25	-	200	68	-	96	95	90	-	11
	VG52z0CC	½"	1	0.63	-	200	68	-	96	95	90	-	11
	VG52z0DC	½"	1	0.63	-	200	68	-	96	95	90	-	11
	VG52z0EC	½"	1.6	-	-	100	72	-	98	97	92	-	13.5
	VG52z0JC	¾"	2.5	-	-	140	74		98	97	92	-	15
	VG52z0KC	¾"	3.5	-	-	100	74		98	97	92	-	15
2-way PDTO (NC)	VG54z0AC	½"	0.4	0.25	-	200	68	-	96	95	90	-	11
	VG54z0BC	½"	0.4	0.25	-	200	68	-	96	95	90	-	11
	VG54z0CC	½"	1	0.63	-	200	68	-	96	95	90	-	11
	VG54z0DC	½"	1	0.63	-	200	68	-	96	95	90	-	11
	VG54z0EC	½"	1.6	1	0.63	100	72	-	98	97	92	-	13.5
	VG54z0JC	¾"	3.5	2.5	1.6	100	74		98	97	92	-	15
	VG54z0KC	¾"	3.5	2.5	1.6	100	74		98	97	92	-	15
3-way Mixing	VG58z0AC	½"	0.25			200	68	26.5	96	95	90	-	11
	VG58z0BC	½"	0.4			200	68	26.5	96	95	90	-	11
	VG58z0CC	½"	0.63			200	68	26.5	96	95	90	-	11
	VG58z0DC	½"	1			200	68	26.5	96	95	90	-	11
	VG58z0EC	½"	1.6			100	72	34.5	98	97	92	-	13.5
	VG58z0JC	¾"	2.5			100	74	36	98	97	92	-	15
	VG58z0KC	¾"	3.5			100	74	36	98	97	92	-	15

Threaded Male Connection (continued...)

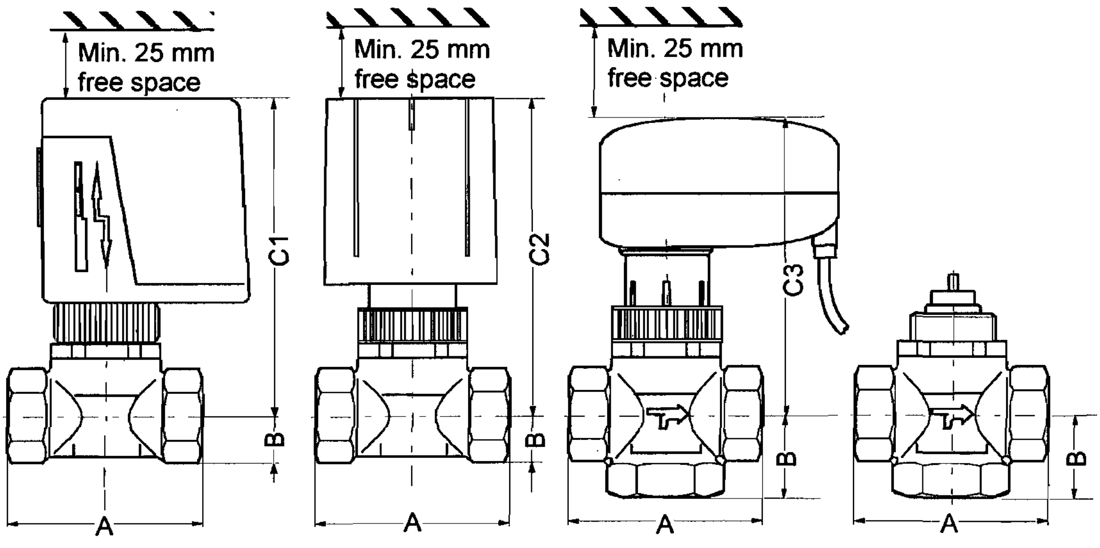
Body Type	Ordering code	Connection size	Factory Set Kvs (Kv on Bypass port of 3-Way mixing+ built-in bypass valves)	Close -Off Pressure (kPa)	Dimensions (mm)						
					A	B	C1 (VA-7010)	C2 (VA-7040)	C3 (VA-7450)	E	F
3-way + built-in NO bypass	VG55z0AC	½"	**0.25** (0.25)	200	68	-	96	95	90	40	11
	VG55z0PC	½"	**0.4** (0.25)	200	68	-	96	95	90	40	11
	VG55z0BC	½"	**0.4** (0.4)	200	68	-	96	95	90	40	11
	VG55z0QC	½"	**0.63** (0.4)	200	68	-	96	95	90	40	11
	VG55z0CC	½"	**0.63** (0.63)	200	68	-	96	95	90	40	11
	VG55z0RC	½"	**1** (0.63)	200	68	-	96	95	90	40	11
	VG55z0DC	½"	**1.0** (1.0)	200	68	-	96	95	90	40	11
	VG55z0SC	½"	**1.6** (1.0)	100	72	-	96	95	90	40	13.5
	VG55z0EC	½"	**1.6** (1.6)	100	72	-	96	95	90	40	13.5
	VG55z0TC	¾"	**2.5** (1.6)	100	74	-	98	97	92	40	15
	VG55z0JC	¾"	**2.5** 2.5)	100	74	-	98	97	92	40	15
	VG55z0UC	¾"	**3.0** (2.5)	100	74	-	98	97	92	40	15
	VG55z0KC	¾"	**3.0** (3.0)	100	74	-	98	97	92	40	15

Threads

Z=1 BSP parallel

Z=9 Compression fitting (only for Bodies with connection size ½")

BSP taper and SAE Flare connections are also available, on request only.



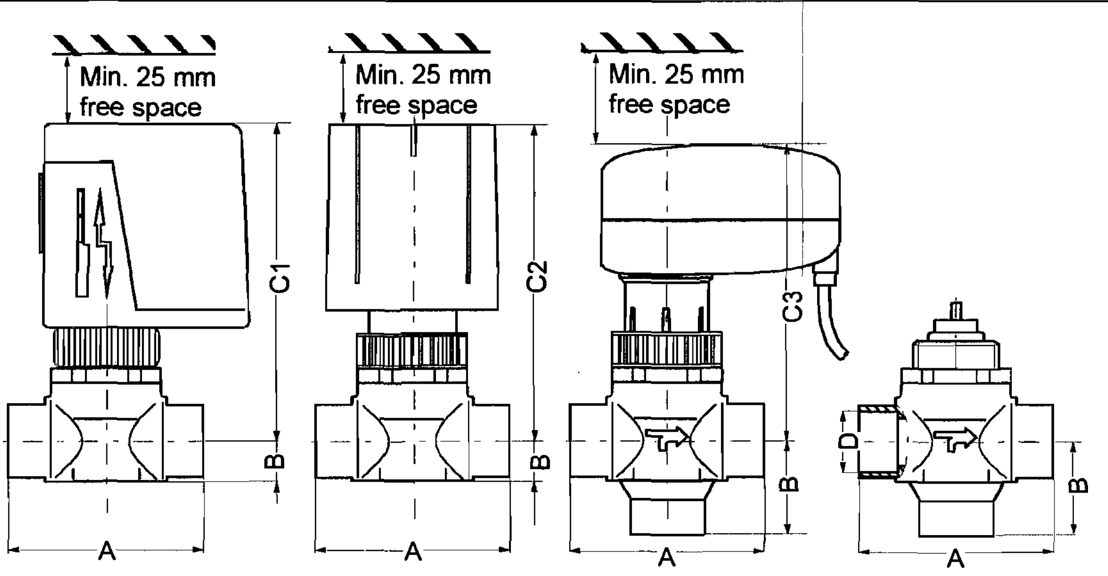
VA-7010 **VA-7040** **VA-7450**

Threaded Female Connection

Body Type	Ordering code	Connection Size	Factory Set Kvs and alternative adjustable Kvs			Close-Off Pressure (kPa)	Dimensions (mm)				
			1	2	3		A	B	C1 (VA-7010)	C2 (VA-7040)	C3 (VA-7450)
2-way PDTC (NO)	VG52y0CC	½"	1.6	1	**0.63**	200	55	15	100	99	94
	VG52y0DC	½"	1.6	**1**	0.63	200	55	15	100	99	94
	VG52y0EC	½"	**1.6**	1	0.63	200	55	15	100	99	94
	VG52y0JC	¾"	**2.5**	-	-	140	66	19	103	102	97
	VG52y0KC	¾"	**3.5**	-	-	100	66	19	103	102	97
	VG52y0MC	1"	**5.5**	-	-	62	90	24	106	105	100
2-way PDTO (NC)	VG54y0CC	½"	1.6	1	**0.63**	200	55	15	100	99	94
	VG54y0DC	½"	1.6	**1**	0.63	200	55	15	100	99	94
	VG54y0EC	½"	**1.6**	1	0.63	200	55	15	100	99	94
	VG54y0JC	¾"	3.5	**2.5**	1.6	100	66	19	103	102	97
	VG54y0KC	¾"	**3.5**	2.5	1.6	100	66	19	103	102	97
	VG54y0MC	1"	**5.5**	4	2.5	62	90	24	106	105	100
3-way Mixing	VG58y0CC	½"	**0.63**			200	55	29	100	99	94
	VG58y0DC	½"	**1**			200	55	29	100	99	94
	VG58y0EC	½"	**1.6**			200	55	29	100	99	94
	VG58y0JC	¾"	**2.5**			100	66	33.5	103	102	97
	VG58y0KC	¾"	**3.5**			100	66	33.5	103	102	97
	VG58y0MC	1"	**5.5**			62	90	37.5	106	105	100

Threads

y = 0: BSP parallel
y = 2: BSP taper
y = 4: NPT



VA-7010 **VA-7040** **VA-7450**

Sweat Connection

Body Type	Ordering code	Connection Size	Factory Set Kvs and alternative adjustable Kvs			Close-Off Pressure (kPa)	Dimensions (mm)					
			1	2	3		A	B	C1 (VA-7010)	C2 (VA-7040)	C3 (VA-7450)	D
2-way PDTC (NO)	VG5270CC	½"	1	0.63	0.4	300	61	13	100	99	94	15.98
	VG5270DC	½"	1	0.63	0.4	300	61	13	100	99	94	15.98
	VG5270EC	½"	1.6	1	0.63	200	61	13	100	99	94	15.98
	VG5270JC	¾"	2.5	-	-	140	78	16.5	103	102	97	22.3
	VG5270KC	¾"	3.5	-	-	100	78	16.5	103	102	97	22.3
	VG5270LC	1"	4	-	-	85	95	17	106	105	100	28.7
	VG5270MC	1"	5.5	-	-	62	95	17	106	105	100	28.7
2-way PDTO (NC)	VG5470CC	½"	1.45	1	0.63	200	61	13	100	99	94	15.98
	VG5470DC	½"	1.45	1	0.63	200	61	13	100	99	94	15.98
	VG5470EC	½"	1.45	1	0.63	200	61	13	100	99	94	15.98
	VG5470JC	¾"	3.2	2.5	1.6	100	78	16.5	103	102	97	22.3
	VG5470KC	¾"	3.2	2.5	1.6	100	78	16.5	103	102	97	22.3
	VG5470MC	1"	5	4	2.5	62	95	17	106	105	100	28.7
3-way Mixing	VG5870EC	½"	1.45			200	61	30.5	100	99	94	15.98
	VG5870KC	¾"	3.2			100	78	39	103	102	98	22.3
	VG5870MC	1"	5			62	95	47.5	106	105	100	28.7

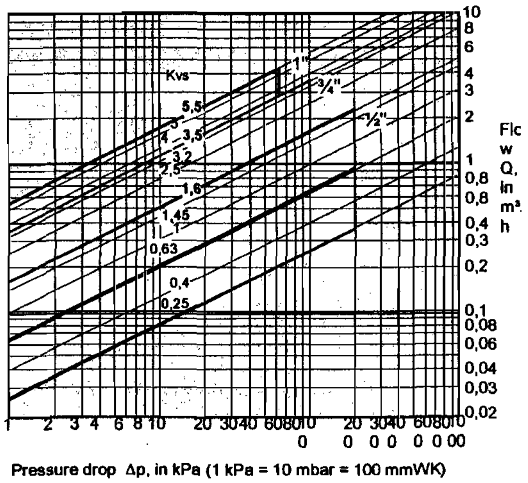
Spare parts

VG5000-1 **Packing kit**, incl. nut and "O"-ring

The Packing can be replaced without removing water from the piping system.

Valve selection

The valve size for water applications can be defined using the diagrams below, where the intersection of the pressure drop over the completely open valve and the flow has to stay within the white area.



Kvs selection diagram in SI units, full seat

Operation

When the stem of the valve is moved down by the actuator against the return spring, it opens the N.C. port or closes the N.O. port of a valve.

Valve Type	Stem movement / flow (▶ = flow, ▷ = no flow)	
2-way NO, PDTC *)	Actuator spindle down	Actuator spindle up
2-way NC, PDTO *)	Actuator spindle down	Actuator spindle up
Return / Supply — 3-way + NO ByPass	Actuator spindle down	Actuator spindle up
3-way, mixing	Actuator spindle down	Actuator spindle up

*) PDTC = Push down to close
PDTO = Push down to open

Valve - Actuators combinations

The VG5000 valve series are designed to be used with the VA-7010 series electric on/off, VA-7040 thermal and VA-7450 electronic modulating actuators. The ordering data for these actuators are as follows:

- **VA-7010 Series Electric Actuator**

VA-7010-810□

Supply voltage	
1	24 VAC
3	230 VAC

- **VA-7040 Series Thermal Actuator**

VA-7040- 2□

Supply voltage	
1	24 VAC or 24 VDC
3	230 VAC

- **VA-7450 Series Electronic Actuator**

VA-7450-1001
3-point actuator, 24 VAC power supply

VA-7452-1001
0..10 VDC input actuator
fixed settings: linear characteristic, direct action, 2-way PDTO (NC) or 3-way NC port

VA-7452-9001
configurable actuator with voltage input 0..10, 0..5 or 5..10 VDC
See "VA-7450" bulletin for more information.

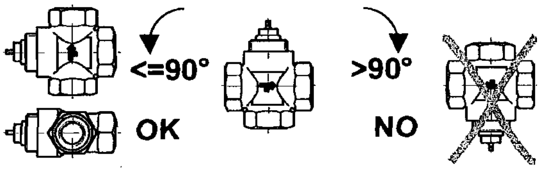
Mounting instructions

When mounting the VG5000 series valves, please follow the instructions below:

- The valve must be piped for flow in the direction indicated by the arrow on the body, so that the plug will seat against the flow.

> **WARNING**
> The water quality should meet VDI 2035 or similar requirements for HVAC applications. Use of the valve with other media must be approved by Johnson Controls.

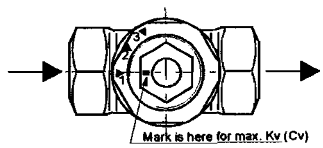
- The valve should be piped using the proper tools.
- The valve with actuator should be mounted within 90° of the vertical position, free of dripping water and easy accessible for the electric connections.



- The actuator should never be used as a lever to move the valve.
- The actuator should always be free of thermal insulation material and there should be left at least 25 mm space above the actuator for mounting and removal purposes as indicated under **Dimensions**.

Adjustments

The Kvs value can be adjusted on some models (see "**Ordering Data**" table) by setting the screw on top of the valve in any of five selection marks.



The Kvs values of the five positions for the different valve sizes are stated in the "**Ordering Data**" table.

Specifications

Models:	VG52xx	VG54xx	VG55xx	VG58xx
Body type:	2-way PDTC (NO)	2-way PDTO (NC)	3-way with built-in NO bypass	3-way mixing
Body rating:	PN 16 Nominal, 20 bar (300 psi) maximum rated pressure			
Flow characteristic:	On/Off in combination with VA-7010 actuator series On/Off in combination with VA-7040 actuator series Linear or equal percentage with VA-7450 actuator series			
Medium:	Hot and cold water for HVAC systems meets Quality Standards VDI 2035 or equivalent			
Connection size:	½"	¾"	1"	
Max. pressure drop Δp:	200 kPa	100 kPa	62 kPa	
Kvs and max. closeoff pressure:	See "Ordering Data" table			
Body Connections:	Gas BSP Parallel (ISO 228/1, BS 2779, DIN 259) Compression fittings (EN 1254-2) NPT American Standard Pipe Thread (ANSI B1.20.1) Gas BSP Taper (ISO R7/1, BS 21, DIN 2999) Sweat Female (ANSI B16.18)			
Nominal Stroke:	3 mm			
Connection to actuator:	M28 x 1.5			
Materials:				
body, packing nut, cage	Brass			
stem	AISI 303 Stainless steel			
spring	Stainless steel			
plug	Rubber EPT			
packing	(2) "O" Ring EPT			
Leakage:	max 0,01% of Kvs			
Fluid Temperature Limits	2...95 °C			
Ambient Temperature Limits:	2...50 °C			
Max. weight in g excl. packaging:	½"	¾"	1"	
2-way NO:	280	390	690	
2-way NC:	330	420	670	
3-way mixing:	370	480	790	
3-way + built-in bypass:	500	550	-	

The performance specifications are nominal and conform to acceptable industry standards. For application at conditions beyond these specifications, consult the local Johnson Controls office. Johnson Controls, Inc. shall not be liable for damages resulting from misapplication or misuse of its products.

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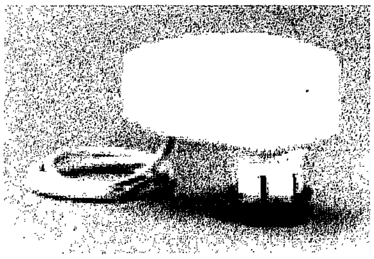
JOHNSON CONTROLS

Controls Group 507 E. Michigan Street
P.O. Box 423, Milwaukee, WI 53202
Code No. LIT-1900135

VA-7450 Series

Electric Valve Actuators



VA-7450 Electric Valve Actuator

Description

The VA-7450 Electric Valve Actuators provide floating or proportional control, and can easily be field mounted with a threaded coupling onto VG4000 and VG5000 Series Zone Valves in HVAC applications. The compact design of this actuator makes it suitable for installation in confined spaces, such as fan coil applications.

Features

- automatic calibration simplifies installation and requires no calibration
- compact design allows installation in confined spaces
- can be mounted after valve body is installed, simplifying installation and allowing application flexibility
- can be rotated after mounting, providing easier wiring by locating the wiring entry in any direction
- light-emitting diode (LED) operating status display reduces commissioning time and displays operating status
- motor time-out feature provides higher reliability by deactivating the actuator motor at the end of stroke

Accessories (Order Separately)

Code Number	Description
VA-7450-8900	Manual Override Ring for Use with VG4000 and VG5000 Series Valve Bodies

Repair Parts

Replace unit

To Order

Specify the code number from the following Selection Chart.

Selection Chart

Code Number	Description
VA-7450-10011	24 VAC Electric Floating Control Actuator
VA-7452-90011	0 to 10 VDC Electric Proportional Control Actuator

Specifications

VA-7450 Series Electric Valve Actuators	
Power Requirements	24 VAC ± 15% at 50/60 Hz; 5.0 VA at Maximum Power Supply; Class 2
Input Signal	Floating: 24 VAC, 50/60 Hz Proportional: 0 to 10 VDC
Input Signal Adjustments	Floating: None Proportional: Input Signal: 0 to 10, 0 to 5, or 5 to 10 VDC Direction: Direct (Drive Down) or Reverse (Drive Up) with Signal Increase Valve Types: Two-Way PDTC (N.O.), Two-Way PDTO (N.C.), or Three-Way Mixing Factory Settings: 0 to 10 VDC, DA, Two-Way PDTC
Input Impedance	Floating: 3,900 Ohms Proportional: 80,000 Ohms
Electrical Connections	24 AWG Wire; 20 in. (508 mm) Long Cable
Mechanical Connection	Threaded Coupling for VG4000 and VG5000 Series Valves
Operating Status Indication	LED
Enclosure	NEMA 1, IP40 (EN 60529)
Output Force	21.5 lb (96 N) Minimum
Stroke	0.20 in. (5 mm) Maximum
Full Stroke Time	65 Seconds
Cycles	100,000 Full Stroke Cycles
Audible Noise Rating	25 dBA Maximum at 1 m
Ambient Operating Conditions	32 to 122°F (0 to 50°C), Non-Condensing
Ambient Storage Conditions	-4 to 149°F (-20 to 65°C), Non-Condensing
Dimensions (H x W x D)	2.74 x 1.85 x 2.91 in. (69.5 x 47 x 74 mm)
Agency Listings	UL 873 Listed, File E27734, Guide XAPX, Plenum Rated CSA C22.2 No. 139 Certified, File LR85083, Class 3221 01
CE Conformity	EMC Directive (89/336 EU)

JOHNSON CONTROLS

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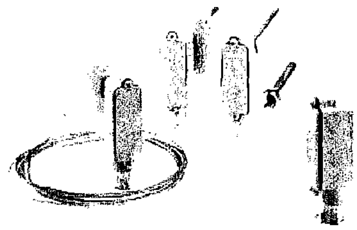
Code No. LIT-1922240

TE-6300 Series

Temperature Sensor



TE-6300 Series Temperature Sensors

Description

The TE-6300 Temperature Sensor line offers an economical solution for a wide variety of temperature sensing needs, including wall mount, outdoor air, duct, well, or duct averaging applications. Sensors are available in the following types: 1,000 ohm thin-film nickel, 1000 ohm nickel averaging, 1,000 ohm thin-film platinum, 2,200 ohm thermistor, and 1,000 and 100 ohm platinum equivalent averaging. Each sensor is packaged with the necessary mounting accessories. maximizing ordering and installation ease, and This simplified ordering and installation, to reduce cost and commissioning time.

Features

- full line of sensors
- inexpensively priced
- single assembly ordering
- conduit-friendly mounting
- standard PVC enclosures
- stainless steel sensor probe

Applications

See Selection Chart/Sensor Application Matrix on the next page.

To Order

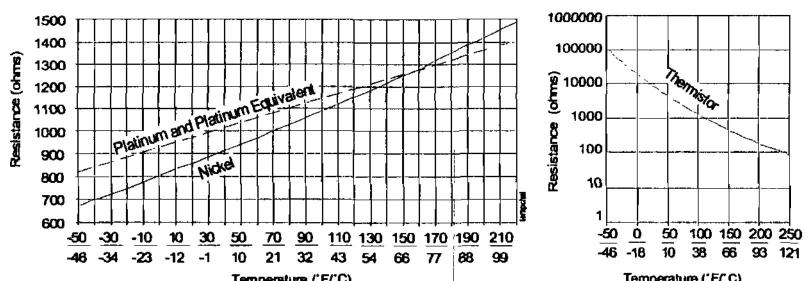
Specify the code number from the Selection Chart on the following page.

Nominal Temperature vs Resistance for Nickel, Platinum (and Platinum Equivalent)*, and Thermistor Sensors

Temperature °F	Temperature °C	Resistance (Ohms) Nickel	Platinum	Thermistor
-50	-46	674	821	109872
-40	-40	699	843	75466
-30	-34	725	865	52571
-20	-29	751	887	37116
-10	-23	777	908	26539
0	-18	803	930	19208
10	-12	830	952	14062
20	-7	858	974	10408
30	-1	885	996	7784
40	4	914	1017	5880
50	10	942	1039	4484
60	16	971	1061	3450
70	21	1000	1082	2678
80	27	1030	1104	2095
90	32	1060	1125	1652
100	38	1090	1147	1313
110	43	1121	1168	1051
120	49	1152	1190	847
130	54	1184	1211	687
140	60	1216	1232	561
150	66	1248	1254	461
160	71	1281	1257	380
170	77	1314	1296	316
180	82	1348	1317	264
190	88	1382	1339	221
200	93	1417	1360	187
210	99	1452	1381	158
220	104	1487	1402	135

Specifications

TE-6300 Series Temperature Sensor	
Accuracy	
Nickel	±0.34°F @ 70°F (±0.18°C @ 21°C)
Nickel Averaging	±3.0°F @ 70°F (±1.67°C @ 21°C)
Platinum	±0.65°F @ 70°F (±0.36°C @ 21°C) DIN Class B
Platinum Equivalent	Approximately ±1.08°F @ 70°F (±0.56°C @ 21°C)
Thermistor	±0.36°F (±0.2°C) in the range of 32 to 158°F (0 to 70°C)
Temperature Limits	Probe Assembly: -50 to 220°F (-46 to 82°C); Conduit Box: -50 to 122°F (-46 to 50°C)



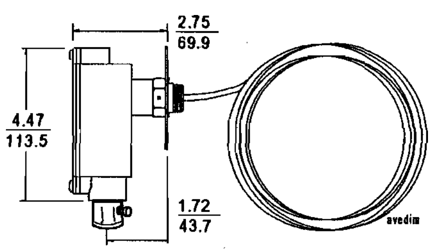
Temperature vs Resistance for the Nickel, Platinum, Platinum Equivalent *, and Thermistor Sensors

* For 100 ohm platinum equivalent sensors, divide the resistance values for the 1,000 ohm platinum sensors by 10.

Product Overview

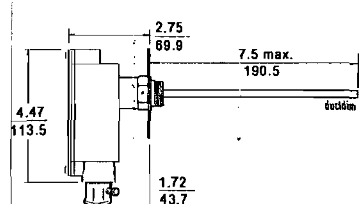
Duct averaging sensor includes:

- 8 or 17 ft nickel sensor, or 10 or 20 ft platinum sensor
- quick-mount sensor holder
- metal mounting plate with four screws and locknut
- conduit enclosure with cover
- 1/2 in. EMT conduit connector
- two wire nuts



Duct probe sensor includes:

- 8 in. nickel, platinum, or thermistor sensor
- quick mount sensor holder
- metal mounting plate with fourscrews and locknut
- conduit enclosure with cover
- 1/2 in. EMT conduit adapter
- two wire nuts



JOHNSON CONTROLS

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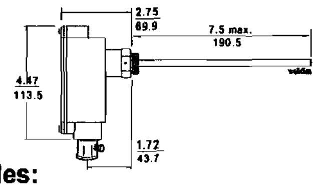
Code No. LIT-1922240

TE-6300 Series Temperature Sensor (Continued)

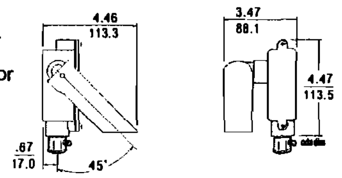
Well insertion sensor includes:

- 6 in. or 8 in. nickel or platinum, 8 in. thermistor
- quick mount sensor holder
- conduit enclosure with cover
- 1/2 in. EMT conduit connector
- wire nuts (2)



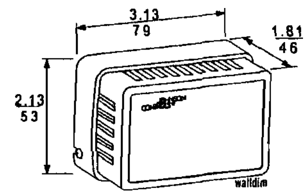
Outdoor air sensor includes:

- 3 in. nickel, platinum, or thermistor sensor
- outdoor air shield
- conduit enclosure with cover
- 1/2 in. EMT conduit connector
- wire nuts (2)



Wall mount sensor includes:

- nickel, platinum, or thermistor sensor
- white T-4000 style cover and base with silver faceplate and horizontal logo
- mounting screws (2)
- wall anchors (2)
- wire nuts (2)



Dimensions are given as in./mm

Repair Parts

Code No.	Description
TE-6300-601	8 in. nickel probe
TE-6300-602	8 in. platinum probe
TE-6300-603	3 in. nickel probe
TE-6300-604	3 in. platinum probe
TE-6300-605	Quick-mount sensor holder (10 / package)
TE-6300-606	8 in. thermistor probe
TE-6300-607	3 in. thermistor probe
TE-6300-609	Threadless sensor holder (10 / package)
ADP11A-600R	EMT conduit adapter (10 / package)
T-4000-3139 [a]	White Thermostat Cover

(a) Refer to *T-4000 Series Accessories.*

Accessories (Optional)

Code No.	Description
ADP11A-601R	BX adapter (10 / package)
TE-6001-8	Element holder for mounting an averaging sensor (10 / package)
TE-1800-9600	Mounting hardware for mounting wall mount unit to a handi-box
TE-6300-101	12 in. nickel probe that can be cut to the appropriate length
TE-6300-104	12 in. thermistor probe that can be cut to the appropriate length
TE-6300-102	12 in. platinum probe that can be cut to the appropriate length
TQ-6000-1	4-20 mA output transmitter for use with the 100 ohm platinum sensor
WZ-1000-2	6-1/2 in. length, stainless steel well, thermal compound included
WZ-1000-4	6-1/2 in. length, stainless steel well
WZ-1000-5 [a]	4-11/16 in. length, brass well (for TE-631AP-1 and TE-632AP-1 only)

(a) Use the TE-631AP-1 or TE-632AP-1 with these wells.

Selection Chart

Application	Suggested Sensor	Description	Application Notes
Wall Mount	TE-6314P-1 TE-6324P-1 TE-6344P-1	Nickel sensor Platinum sensor 2,2000 ohm thermistor	2-screw wall plate provided for surface mounting. White cover provided. (See *Repair Parts* chart above for additional covers available.)
Outdoor Air	TE-6313P-1 TE-6323P-1 TE-6343P-1	Nickel, 3 in. probe Platinum, 3 in. probe 2,2000 ohm thermistor, 3 in. probe	Used to sense outside ambient temperature to determine efficient heating and cooling strategies.
Duct Probe	TE-6311P-1 TE-6321P-1 TE-6341P-1	Nickel, 8 in. probe Platinum, 8 in. probe 2,2000 ohm thermistor, 8 in. probe	4-screw mounting plate provided for duct mounting. Can also be used for plenums. Ideal in freezer lockers or where sensor mounting should be located outside of the sensed area. 12 in. probe is available for use in larger ducts.
Duct Averaging	TE-6315P-1 TE-6316P-1 TE-6327P-1 TE-6326P-1 TE-6337P-1 TE-6338P-1	Nickel, 8 ft averaging element Nickel, 17 ft averaging element Platinum, 1,000 ohm, 10 ft averaging element Platinum, 1,000 ohm, 20 ft averaging element Platinum, 100 ohm, 10 ft averaging element Platinum, 100 ohm, 20 ft averaging element	4-screw mounting plate provided for duct mounting. Used in duct where average temperature is needed. Approximately 1 ft of sensor is recommended for each sq ft of duct cross section. TE-6001-8 element holder is recommended when installing an averaging sensor in a duct.
Well Insertion	TE-6312P-1 TE-6322P-1 TE-6342P-1 TE-631AP-1 TE-632AP-1	Nickel, 8 in. probe, threaded holder Platinum, 8 in. probe, threaded holder 2,2000 ohm thermistor, 8 in. probe, threaded holder Note: The 8 in. probes are to be used **only** with the WZ-1000-2 and WZ-1000-4. Nickel, 6 in. probe, thraadless holder Platinum, 6 in. probe, threadless holder Note: The 6 in. probes can to be used only with the WZ-1000-5.	Threaded sensor holder has 1/2 in. NPT threads; threadless holder accommodates set screws. Thermal well should be mounted at an angle so condensation will run out of the well. If not possible, seal the sensor holder and the wiring end of the sensor probe with RTV silicone rubber. 12 in. probe is available for use in longer wells. Compatible Johnson Controls thermal wells are listed in the *Accessories (Optional)* chart above.

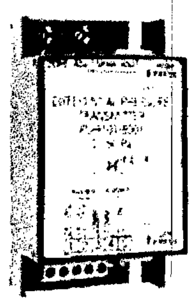
Note: Well sensor probe lengths are longer than accessory well lengths because part of the probe is in the conduit box and sensor holder.

The performance specifications are nominal and conform to acceptable industry standards. For applications at conditions beyond these specifications, consult the local Johnson Controls office. Johnson Controls, Inc. shall not be liable for damages resulting from misapplication or misuse of its products.

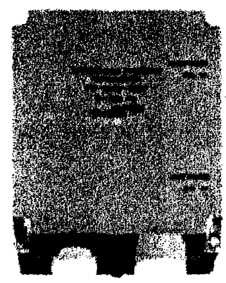
Differential pressure transmitter PS-9101

Introduction

The PS-9101 Differential pressure is designed to measure the difference between two sensed pressures to produce 0…10 V DC proportional output.
The differential pressure, as sensed by the sensing ports, is applied to both sides of a mass air flow sensor, directed across the surface of the sensing element.
The output voltage varies in proportion to the differential temperature of sensing elements, as a consequence of increasing/decreasing the mass air flow through the inlet and outlet ports caused by sensed differential pressure.



PS-9101-800x Transmitter (IP20)



PS-9101-850x Transmitter (IP54)

Features and Benefits	
❑ **Model available in 3 differential pressure ranges**	Covers most of HVAC applications
❑ **Models for Din Rail mounting**	Easier installation
❑ **Models with splash proof dust tight case**	Electronic base can be mounted in many environments
❑ **Fast response (< 50 ms)**	Can be used in critical applications such as VAV
❑ **MTBF of sensor 20 years**	Long lasting reliability

Ordering data

PS-9101-8 □ 0 □

	Operating range
1	0...750 Pa
2	0...330 Pa
3	0...130 Pa

	Protection Class
0	IP 20
5	IP54

Accessories

A-4000-8001	In line filter
PS-9101-8900	DIN rail mounting kit
FT-G18A-8001	Remote mounting probe kit

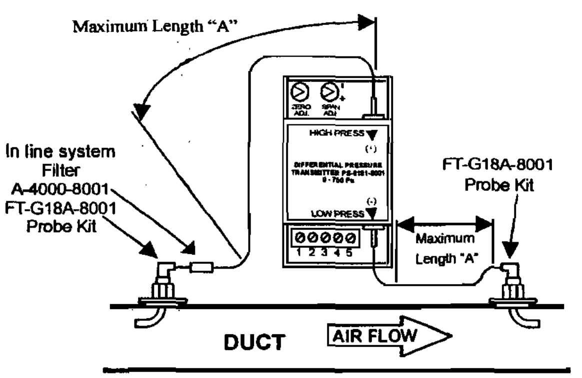
Operation

Typical applications of the PS-9101 include pressure sensing in ducts, and air flow velocity sensing for VAV terminal units.
The PS-9101 can be used separately, or as a part of a digital VAV control system (DC-9100/DR-9100). By subtracting the measured static air pressure from the measured total air pressure, the PS-9101 senses air velocity pressure. This value is sent to the DC-9100/DR-9100 controller in form of 0 to 10 VDC signal. The DC/DR-9100 controller interprets the PS-9101 signal to determine the position of the VAV damper motor actuator for the required air flow

Repairs and Replacements

Repairs should not be made in the field. Defective devices should be returned to the factory. For a replacements, contact the nearest Johnson Controls wholesaler or branch office.
Replace the Inline Filter A-4000-8001 when dark red colour appears on outer.

Mounting instructions

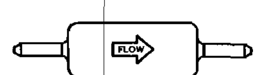


VAV Box Mounting

Make sure no compressed air is applied to either connector. Do no mount the control where ambient temperature falls below 0°C or exceeds +60°C.
If either the low or high pressure input ports are not used, protect the open port from other external air velocities or direct impingement which will produce erroneous signals.

1) For mounting the PS-9101, use the 35 mm DIN Rail System. Kit PS-9101-8900 can be used for duct mounting.
2) Use FT-G18A-8001 remote mounting probe kits for remote sensing locations. Run plastic tubing from the high and/or low pressure connectors to the sensing point. Use tubing with an inner diameter of at least

   4.3 mm (0.170 inch) and an outer diameter of 6.3 mm (1/4 inch).
3) **Use Inline Filter A-4000-8001 on the side of inlet high supply pressure. Replace In line filter when dark red color appears on outer surface.**



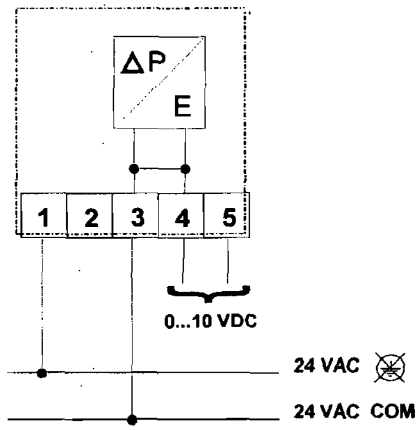
Inline Filter A-4000-8001

4) Factory calibration is with inline system filter and 2 m lengths of plastic tubing. With the maximum allowable sum of the two tube lengths shown in the table below, the nominal range decreases by 25%.

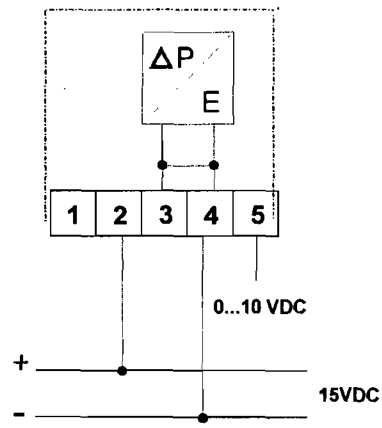
RANGE	Max Sum of Two Tube Lengths
0 – 130 Pa	10 meters
0 – 330 Pa	15 meters
0 – 750 Pa	20 meters

Wiring diagram

Disconnect the power supply before wiring connections are made to prevent possible electrical shock or damage to the equipment. Make all wiring connections in accordance with the National Electrical Code and Local regulations. Make all wiring connection before applying power. Improper wiring may cause permanent damage. Refer to the installation wiring diagrams for correct hook-up.

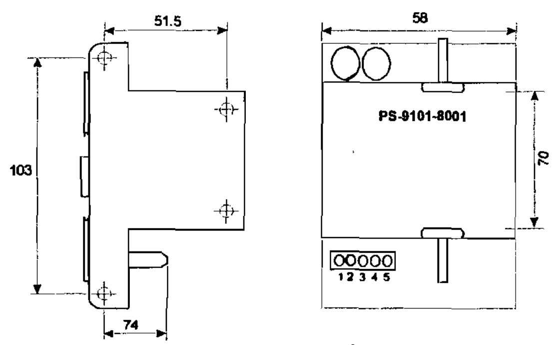


PS-9101 with 24 VAC supply voltage

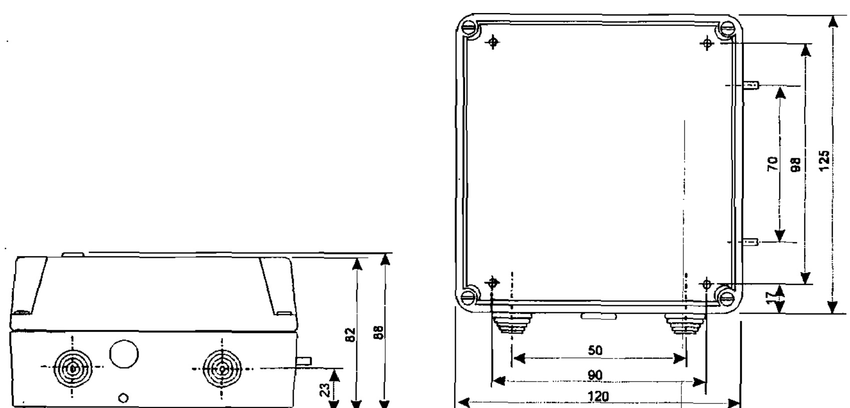


PS-9101 with 15 VDC supply voltage

Dimensions



PS-9101-800x IP20



PS-9101-850x IP54

Specifications

Supply voltage	15 VDC ±10% (Available from controller) or 24 VAC +10%; -15%
Output Signal	0 to 10 VDC linear to differential pressure
Ambient Op. Limits	0 to 60° C, 10 to 90% RH (non condensing)
Pressure	34.5 kPa max
Mounting	DIN Rail / wall
Air connection	4 x 6 mm plastic tube
Power consumption	350 mW (24mA at 15VDC)
Output load	Min. 5 k Ohms / Max. 2 mA
ΔP Ranges	See Ordering data
Repeatability & Hyst.	1%
Linearity	± 2% from 0 to 500 Pa ± 5% from 500 to 750 Pa
Adjustment	1 potentiometer for 0 point, 0-25% of range 1 potentiometer for span adjustment, ± 50% of nominal range (max 750 Pa)
Output Voltage shift	0-25°C + 0.08% °C 25-55 °C – 0.08% °C
Response Time	50 ms max.
Electrical connection	Terminal block for 2.5 mm^2 (maximum) section wire
Housing material	Polypropylene
Enclosure protection class	IP 20, IP54, (IEC 60529)
Weight	0,1 kg
Storage Temp. limits	-40 to +70 °C
CE Compliance	EMC (89/336 EEC) according to the standard EN 50081-1 and EN 50082-1

The performance specifications are nominal and conform to acceptable industry standards. For application at conditions beyond these specifications, consult the local Johnson Controls office.
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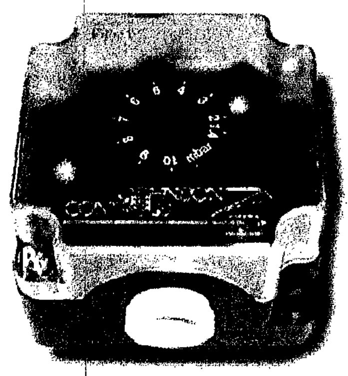
Printed in Europe

Series P233A/F series
Sensitive (differential) Pressure Switch for Air

Introduction

This (differential) pressure switch is used to sense flow of air, single or differential air pressure.
Typical applications include:
- *Detect clogged filter*
- *Detect frost or ice build-up on air conditioning coils*
- *Air proving in heating or ventilation ducts.*
- *Maximum airflow controller for variable air volume system.*
- *Detect blocked flue or vent*
- *Monitor fan operation*



Series P233A Sensitive Pressure switch for Air

Description

This switch senses a change in the (differential) pressure (either velocity pressure or pressure drop across a restriction) as the airflow changes. The (differential) pressure is applied to the two sides of a diaphragm in the control. The spring-loaded diaphragm moves and actuates the switch. The series P233A/F can also be used to detect small positive gauge pressure by using only the high-pressure connection and leaving the low-pressure port open. Or to detect a vacuum by using only the low pressure connection and leaving the high-pressure port open to ambient pressure.

Feature and Benefits	
❑ **One switch to measure relative pressure, vacuum or differential pressure**	Provides versatility to match various applications
❑ **Various accessories available**	Provides flexibility
❑ **Compact and durable construction**	Provides durability in combination with neutral gases
❑ **Easy mounting and wiring, various mounting possibilities**	Reduce installation time
❑ **Standard PG 11 nipple and optional DIN 43650 connector**	Provides flexibility in wiring connections
❑ **Accurate and stable switch point**	Provides high accuracy and repeatability
❑ **SPDT contact standard**	Can be used for "normally open" or "normally closed" applications

Note

> These controls are designed for use only as operating controls. Where an operating control failure would result in personal injury or loss of property it is the responsibility of the installer to add devices or systems that protect against, or warn of, control failure.

Contact function

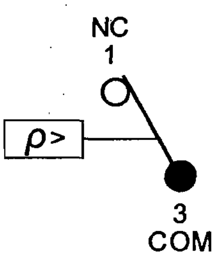


Fig. 1

Adjustment

The scale values indicate the approximate switching point at increasing pressure (contacts 3-1 to open). If accurate setting is required, the approximate setting on the scale should be corrected by using a pressure gauge.

Mounting

- *Select a location where vibrations are minimal.*
- When mounting in horizontal positions the following corrections should be taken into account.

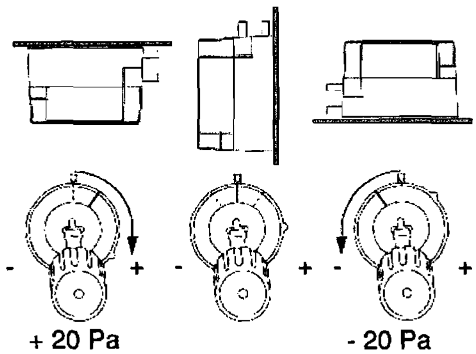


Fig. 2

Repair and replacement

Repair is not possible. In case of a defective or improperly functioning control, please check with your nearest supplier. When contacting the supplier for a replacement you should state the type/model number of the control. This number can be found on the side of the control.

Type number selection table

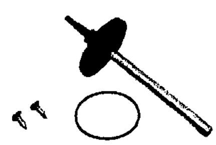
Order number	Setpoint range	Accessories incl.	Remarks
P233A-4-AAC	0,5 to 4 mbar	No	
P233A-4-AAD	0,5 to 4 mbar	No	Bulk pack
P233A-4-AHC	0,5 to 4 mbar	GMT008N600R + BKT024N002R	
P233A-4-AKC	0,5 to 4 mbar	FTG015N602R (2x) + 2m tube 4/7 mm	
P233A-4-PAC	50 to 400 Pa	No	
P233A-4-PAD	50 to 400 Pa	No	Bulk pack
P233A-4-PHC	50 to 400 Pa	GMT008N600R + BKT024N002R	
P233A-4-PKC	50 to 400 Pa	FTG015N602R (2x) + 2m tube 4/7 mm	
P233A-6-AAD	0,5 to 6 mbar	No	Bulk pack
P233A-10-AAC	1,4 to 10 mbar	No	
P233A-10-AAD	1,4 to 10 mbar	No	Bulk pack
P233A-10-AHC	1,4 to 10 mbar	GMT008N600R + BKT024N002R	
P233A-10-AKC	1,4 to 10 mbar	FTG015N602R (2x) + 2m tube 4/7 mm	
P233A-10-PAC	140 to 1000 Pa	No	
P233A-10-PHC	140 to 1000 Pa	GMT008N600R + BKT024N002R	
P233A-10-PKC	140 to 1000 Pa	FTG015N602R (2x) + 2m tube 4/7 mm	
P233A-50-AAC	6 to 50 mbar	No	
P233F-P3-AAD	0,3 mbar fixed setting	No	Bulk pack

Accessories

BKT024N002R
Mounting Bracket for P233A/F

GMT008N600R
Duct mounting kit

Including:
2m PVC tube 4/7 mm
2 grommets (drilling hole 16mm)



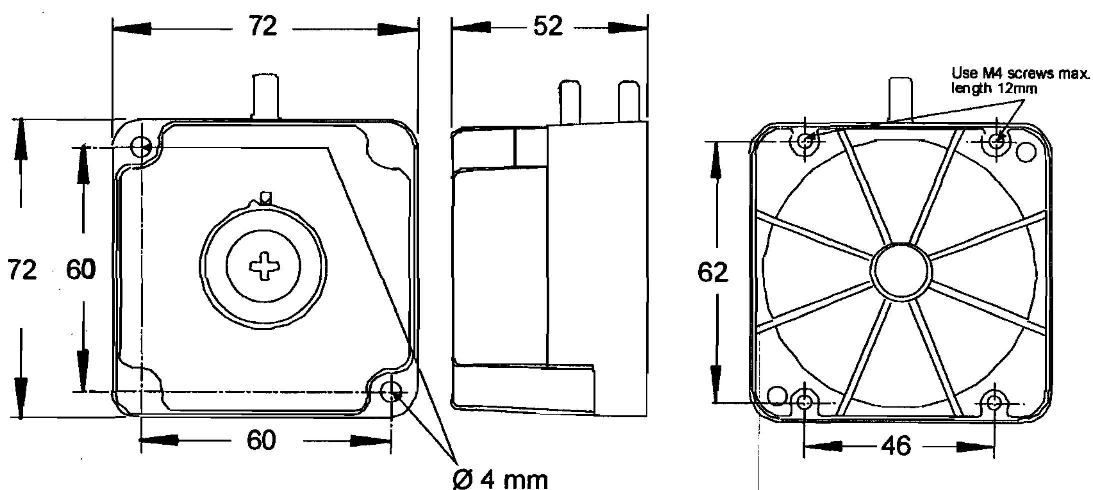
FTG015N602R
Duct mounting kit (straight)

Including:
2 mounting screws
O-ring

FTG015N603R
Duct mounting kit (bent)

Including:
2 mounting screws
O-ring

Dimensions (mm)



Specifications

	Setpoint range 0,5 to 4mbar	Setpoint range 1,4 to 10mbar	Setpoint range 6 to 50mbar
Differential (fixed)	≤ 0,25mbar	≤ 0,5mbar	≤ 1,2mbar
Sample media	Air, non-inflammable gases, non-aggressive gases		
Max. continuous overpressure	300 mbar		
Calibration position	With diaphragm vertical. (For horizontal position make corrections as mentioned in fig 2)		
Calibration temperature	20°C		
Operating temp. Limits	-15 to +60 °C		
Storage temperature	-35 to 60°C		
Operating/storage humidity	10 to 95%RH, non condensing		
Material	Cover: Polycarbonate Case: Glass reinforced polycarbonate Bottom: Glass reinforced polycarbonate Diaphragm: Nitrile butadiene rubber Switch: Brass, Phosphorbronze, Silvernickel		
Weight	115 g 330 9 For models including grommet and bracket		
Contact rating (SPDT contact)	I_{max} at 250Vac: 5A at cosφ=1; 2A at cosφ=0,6		
Life cycle	At I_{max}: 200.000 operations (@ 60°C) 50.000 operations (@ -15°C)		
Electrical connections	Screw terminals, wire diameter 0,5 to 4mm^2 (Connector according DIN 43650 optional)		
Protection class	IP 54		
Approvals	73/23/EEC 89/336/EEC 90/396/EEC		

Note: 1mbar = 100 Pa = 9.8 mm WC

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JOHNSON CONTROLS

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Order No. PD-P233A/F-E

JOHNSON CONTROLS

Controls Group 507 E. Michigan Street
P.O. Box 423, Milwaukee, WI 53202
Code No. LIT-1922030

M9100 Series

Electric Non-Spring Return Actuators

M9100

Description

The M9100 Series direct-mount line of electric actuators operates on 24 VAC or VDC power. The M9100 actuators are available for use with on-off, floating, proportional, or resistive controllers. These bidirectional actuators do not require a damper linkage, and are easily installed on a round shaft up to a 3/4 in. (20 mm) diameter or a square shaft up to 5/8 in. (16 mm). They can be direct or remote mounted to a damper, or mounted to a valve using one of the M9000-5xx Valve Linkage Kits.

A single M9100 model delivers up to 280 lb·in (32 N·m) of torque. In addition to the GGx and the HGx proportional models, the AGx floating models are now available for tandem use with the repostion of a jumper. When used in tandem, all of these models deliver twice the torque or 560 lb·in (64 N·m). The angle of rotation is mechanically adjustable from 0 to 90° in 5-degree increments. Integral auxiliary switches are available to indicate end-stop position or to perform switching functions at any angle within the selected rotation range. Position feedback is available through switches, a potentiometer, or a 0 (2) to 10 VDC signal.

Features

- six torques: 70 to 560 lb·in (8 to 64 N·m) offer the most suitable choice for the application
- four control inputs meet the needs of most applications
- output position feedback provides simple closed-loop control with accurate position sensing
- electronic stall detection ensures higher reliability by deactivating the actuator motor when a stall condition is detected
- master/slave option (all models except M9108) allows synchronized operation for tandem applications
- zero and span adjustment (HGx models) allows sequential operation of dampers from a single input signal of 0 (2) to 10 VDC, 0 (4) to 20 VDC, or 0 (4) to 20 mA
- jumper-selectable rotation direction and manual gear release simplify installation, setup, and field adjustments
- NPT threaded housing provides easy connection for electrial fittings

Accessories

Refer to the accessories chart on Pa ge3.

Applications

M9100 actuators are designed to position air dampers and valves in HVAC systems. Applications include:

- positioning return air or exhaust dampers
- controlling face and bypass dampers
- positioning blades for variable volume fans
- positioning VG1000 Series ball valves and VG7000 Series globe valves when used with the M9000-5xx Valve Linkage

Refer to the manufacturer's information to properly size the damper, valve, and/or actuator. Spring return actuators, such as Johnson Controls M9206 and M9216 Series actuators, are recommended for use with outdoor air dampers in cold climates.

These compact M9100 actuators use a DC motor with stall detection circuitry that operates throughout the entire stroke. The GGx, HGx, and JGx models employ noise-filtering techniques on the control signal to eliminate repositioning due to line noise.

Rotation is mechanically limited to 93° by integral end-stops. The position of the actuator is visually indicated from 0 to 90° on the cover. An anti-rotation bracket prevents lateral movement of the actuator. Pressing the spring-loaded gear release on the actuator cover disengages the gear train and allows manual repositioning of the coupler.

To Order

Specify the code number from the following selection chart.

Selection Chart

M9100 Series Electric Non-Spring Return Actuators	70 lb·in (8 N·m)										140 lb·in (16 N·m)										210 lb·in (24 N·m)										280 lb·in (32 N·m)				
	M9108-AGA-2	M9108-AGC-2	M9108-AGD-2	M9108-AGE-2	M9108-GGA-2	M9108-GGC-2	M9108-HGA-2	M9108-HGC-2	M9108-JGA-2	M9108-JGC-2	M9116-AGA-2	M9116-AGC-2	M9116-AGD-2	M9116-AGE-2	M9116-GGA-2	M9116-GGC-2	M9116-HGA-2	M9116-HGC-2	M9116-JGA-2	M9116-JGC-2	M9124-AGA-2	M9124-AGC-2	M9124-AGD-2	M9124-AGE-2	M9124-GGA-2	M9124-GGC-2	M9124-HGA-2	M9124-HGC-2	M9124-JGA-2	M9124-JGC-2	M9132-AGA-2	M9132-AGC-2	M9132-AGE-2	M9132-GGA-2	M9132-GGC-2
On/Off Control	■	■	■	■							■	■	■	■							■	■	■	■							■	■	■		
Floating Control	■	■	■	■							■	■	■	■							■	■	■	■							■	■	■		
Proportional Control					■	■	■	■							■	■	■	■							■	■	■	■						■	■
VDC and mA Input with Zero and Span							■	■									■	■									■	■							
Resistive Input Control									■	■									■	■									■	■					
Feedback																																			
135 ohm Potentiometer			■										■										■												
1,000 ohm Potentiometer				■										■										■									■		
0 to 10 VDC					■	■	■	■	■	■					■	■	■	■	■	■					■	■	■	■	■	■				■	■
2 Auxiliary Switches		■				■		■		■		■				■		■		■		■				■		■		■		■			■
Tandem Operation															■	■	■	■			■	■	■	■	■	■	■	■			■	■	■	■	■

Note: Two actuators with the same torque and control input may be configured in tandem. Do not use actuators with two different torque ratings.

JOHNSON CONTROLS

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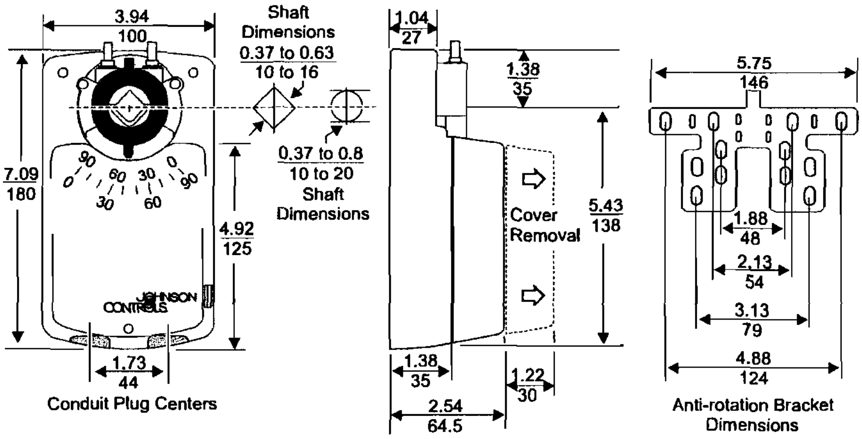
P.O. Box 423, Milwaukee, WI 53202
Code No. LIT-1922030

M9100 Series Electric Non-Spring Return Actuators (Continued)



Dimensions, in./mm

Specifications

M9100 Series Electric Non-spring Return Actuators	
Power Requirements	M9108 and M9116-AGx: 20 to 30 VAC at 50/60 Hz or 24 VDC ±10%; 6.5 VA supply minimum All other models: 20 to 30 VAC at 50/60 Hz or 24 VDC ±10%; 7.5 VA supply minimum
Input Signal	AGx: 24 VAC at 50/60 Hz or 24 VDC GGx and HGx: 0 (2) to 10 VDC, 0 (4) to 20 VDC, or 0 (4) to 20 mA JGx: Potentiometer value is 100 ohms minimum to 10,000 ohms maximum
Input Signal Adjustments	AGx: Factory Setting, Terminals 1 and 2, CW rotation; Terminals 1 and 3, CCW rotation GGx and HGx (Voltage Input or Current Input): Jumper selectable: 0 (2) to 10 VDC, 0 (4) to 20 VDC, or 0 (4) to 20 mA Adjustable: Zero, 0 to 6 VDC, 0 to 12 VDC, or 0 to 12 mA Span, 2 to 10 VDC, 4 to 20 VDC, or 4 to 20 mA Factory Setting: 0 to 10 VDC, 0 to 20 mA, CW rotation with signal increase GGx, HGx, and JGx: Action is jumper selectable Direct (CW) or Reverse (CCW) with signal increase.
Input Impedance	GGx and HGx: Voltage Input, 205,000 ohms for 0 (2) to 10V and 410,000 ohms for 0 (4) to 20V; Current Input, 500 ohms JGx: 1.8 Megohms
Feedback Signal	AGD: 135 ohm feedback potentiometer AGE: 1,000 ohm feedback potentiometer GGx and HGx: 0 to 10 VDC or 2 to 10 VDC for 90° (1 mA at 10 VDC) Corresponds to input signal span selection. JGx: 0 to 10 VDC for 90° (1 mA at 10 VDC)
Auxiliary Switch Rating	xGC: Two SPDT rated at 24 VAC 1.5A inductive, 3.0A resistive, 35 VA maximum per switch, Class 2
Mechanical Output (Running Torque)	M9108: 70 lb·in (8 N·m) for a single unit; not intended for tandem use M9116: 140 lb·in (16 N·m) for one unit, 280 lb·in (32 N·m) for two in tandem (GGx, HGx) M9124: 210 lb·in (24 N·m) for one unit, 420 lb·in (48 N·m) for two in tandem (AGx, GGx, HGx) M9132: 280 lb·in (32 N·m) for one unit, 560 lb·in (64 N·m) for two in tandem (AGx, GGx)
Audible Noise Rating	45 dBA at 1 m
Rotation Range	0 to 90° in 5-degree increments, mechanically limited to 93°
Rotation Time	M9108: 30 seconds at 50% rated load, 25 to 50 seconds for 0 to 70 lb·in (0 to 8 N·m) M9116: 80 seconds at 50% rated load, 70 to 115 seconds for 0 to 140 lb·in (0 to 16 N·m) M9124: 130 seconds at 50% rated load, 115 to 175 seconds for 0 to 210 lb·in (0 to 24 N·m) M9132: 140 seconds at 50% rated load, 115 to 185 seconds for 0 to 280 lb·in (0 to 32 N·m)
Electrical Connection	M9124 and M9132-AGx: 1/4 in. spade terminals All Other Models: Screw terminals for 22 to 14 AWG; maximum of two 18, 20, or 22 AWG per terminal
Mechanical Connection	3/8 to 3/4 in. (10 to 20 mm) diameter round shaft or 3/8 to 5/8 in. (10 to 16 mm) square shaft
Enclosure	NEMA 2, IP42
Ambient Conditions	Operating: -4 to 122°F (-20 to 50°C); 0 to 95% RH, non-condensing Storage: -40 to 186°F (-40 to 86°C); 0 to 95% RH, non-condensing
Dimensions (H x W x D)	7.09 x 3.94 x 2.54 in. (180 x 100 x 64.5 mm)
Shipping Weight	2.9 lb (1.3 kg)
Agency Compliance	UL 873 Listed, File E27734, CCN XAPX CSA C22.2 No. 139 Certified, File LR85083, Class 3221 02 CE Mark, EMC Directive 89/336/EEC

JOHNSON CONTROLS

Controls Group 507 E. Michigan Street
P.O. Box 423, Milwaukee, WI 53202
Code No. LIT-1922030

M9100 Series Electric Non-Spring Return Actuators (Continued)

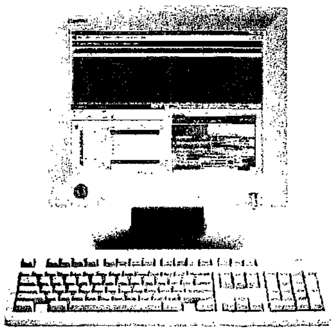
Accessories

Code Number	Description
DMPR-KR003 [a]	Sleeve Pin Kit for Johnson Controls round dampers with a 5/16 in. diameter shaft
DMPR-KC003 [a]	Blade Pin Extension without Bracket for Johnson Controls CD-1300 direct-mount applications
DMPR-KC254	Inside Frame Mounting Kit for damper applications requiring the actuator within the airstream
M9000-103	14 VA Transformer, 120/24 VAC, 60 Hz, Class 2
M9000-104	14 VA Transformer, 230/24 VAC, 60 Hz, Class 2
M9000-105	Pluggable 3-terminal block
M9000-151	Base Mount Linkage Kit for remote inside duct mounting (not intended for M9132 actuators or any tandem application)
M9000-153	Crank Arm Kit for remote mounting (not intended for M9132 actuators or any tandem application)
M9000-154	1 in. Jackshaft Coupler for mounting on a 1 in. diameter damper shaft
M9000-155	Manual Handle for positioning a damper or valve when power is removed from an M9100 actuator
M9000-158	Mounting Kit to tandem mount two M9116 GGx or HGx models; two M9124 AGx, GGx, or HGx; or two M9132 AGx or GGx models on a damper
M9000-200	Commissioning Tool provides a control signal to drive proportional, floating, or on/off actuators.
M9000-500	Valve Linkage Kit for mounting M9116 and M9216 actuators to 1/2 to 2 in. VG7000 Series globe valves
M9000-510	Valve Linkage Kit for mounting M9108, M9116, and M9124 actuators to 1/2 through 1-1/4 in. 2-way and 1/2 and 3/4 in. 3-way VG1000 Series ball valves
M9000-511	Valve Linkage Kit for mounting M9124 actuators to 1-1/2 in. 2-way and 3-way VG1000 Series ball valves, and M9116 and M9124 actuators to 1 and 1-1/4 in. 3-way VG1000 Series ball valves

(a) Furnished with the damper and can be ordered separately.

Product Bulletin M3i
Rev.2.0

M3integral



The Metasys M3i Workstation is one of the Johnson Controls solution for Small Integrated Building and Flat LON where a truly Operator Workstation (OWS) is required. Thanks to the performance of the system Operators can interact with graphic interface, manage environments, monitor energy usage, command light, optimise control strategies and respond to emergency conditions, quickly and easily. The workstation can directly connect to both Johnson Controls and other producers (third party) devices.

Using the most recent technology M3i Workstation connectivity includes fire detection, intrusion, access control and many other systems that make a building functional and safe (Variable Speed Drivers, PLCs, meters etc).

This is made possible through a multi-protocol structure, which can be used for Johnson Controls N2 and Modbus protocols, as well for LonWorks®, BACnet interoperable standards and IT solutions as SNMP traps.

M3i intrinsic flexible communication capability can be further enhanced by the addition of hardware and software interconnection modules for other protocols (standard and proprietary) such as the Metasys Integrator MIG-300 that extend the connectivity to hundreds of devices available on market.

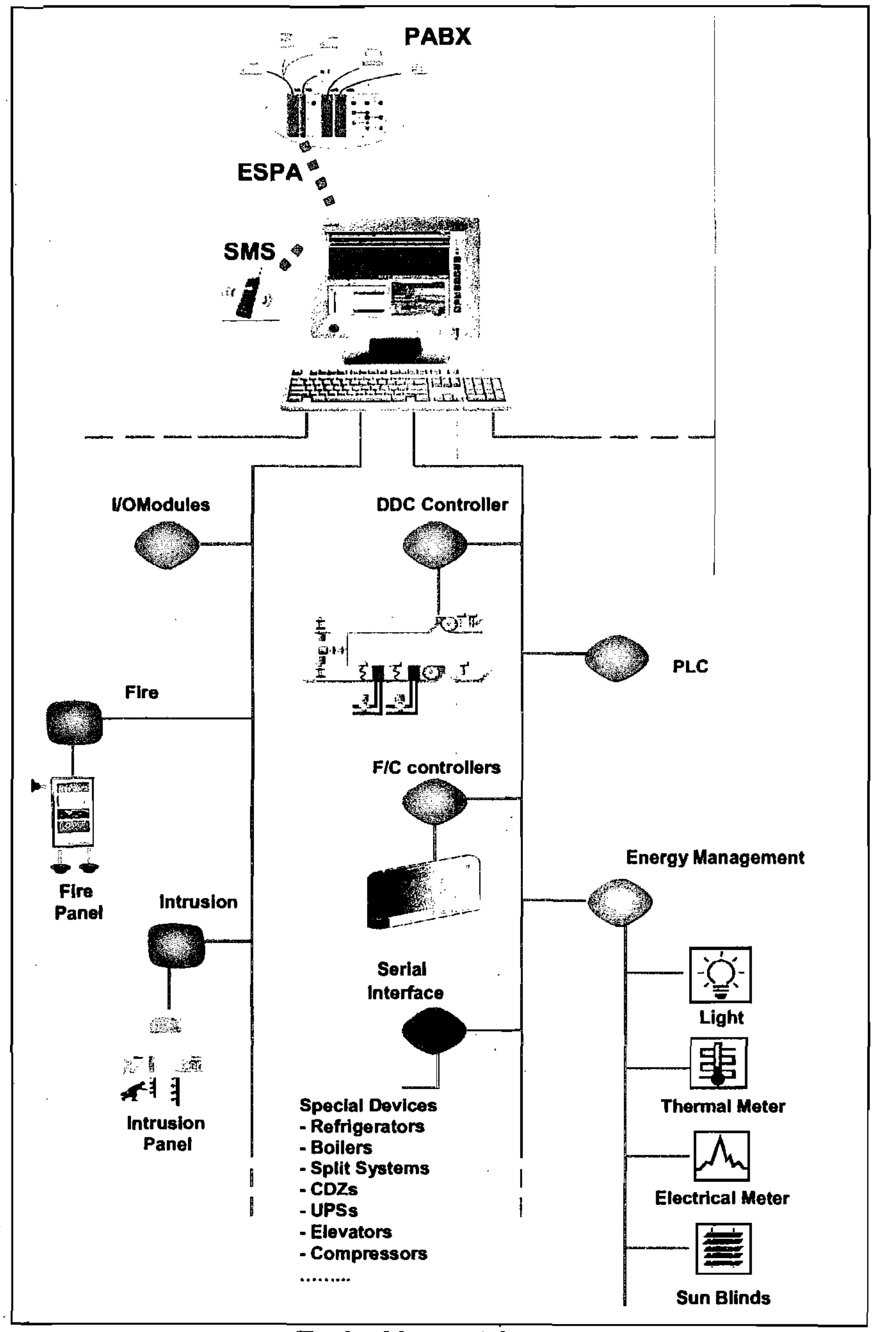
The intuitive user interface of the M3i Workstation includes a dynamic graphic representation of a building and its systems, allowing users to easily interact with building plants.

According to its Active-X compliance, the graphics interface can use panels to allow simultaneous display of trend data, alarms and time schedule programs.

Features and Advantages	
❑ **Based on latest Technology**	State-of-the-art technology standards for compatibility and expendability: ActiveX, ODBC etc.
❑ **Wide range of devices connectivity**	N2 and Modbus devices, capability to integrate Chillers, PLCs as well as other third-party products.
❑ **Alarm management**	Immediate alarms displaying tin a graphic way as well as through M-Alarm summarizing tables.
❑ **Measurement sampling**	Trend data collection for a graphical and tabular analysis of plant performance.
❑ **ESE**	Automates the plants activities through time schedules programs
❑ **Dynamic graphic maps**	Animated symbols guarantee a clear interpretation of the plant status
❑ **Sending of notices**	Alarms dispatching through SMS, e-mails and in SNMP mode to remote operators.

The M3i Workstation multimedia package option allows alarms reporting to remote users using industry standard protocols such as SMS or ESPA 4.4.4 as well as SNMP-protocol messages for the Network Management Integration.

Thanks to the Metasys® M3i Workstation small buildings can have a state-of-the-art monitoring and control solution using a simple but capable Operator Workstation is required.



Typical Layout 1

JOHNSON CONTROLS

A System directed towards global control in small buildings

Even small buildings have a complex plant-engineering reality which includes mechanical parts (Fan Coils and control units), electrical sections and, often, security integration to detect fire and break-in.

The M3i Workstation provides an easy and flexible connection with different devices present in a building, allowing the global supervision of all the building plants.

An extended multi-protocol communication engine can directly connect to both Johnson Controls and Third party devices. This allows an easy way to control data coming from Johnson Controls System 91 series of controllers (DX, TC...), Johnson Controls LonWorks® Controllers (DX-9200, LN Series, FX Platform and all the LonMark® Certified Product), N2Open Certified Devices, as well as other equipment that use Industry-standard protocols such as Modbus.

The M3i Workstation provides to the users all the relevant information needed for the building management, like display and print summaries of the buildings state and alarms, modify control parameters and strategies, analyze operational data (trend), obtain dynamical graphic representations for simplified and effective handling of alarm situations.

Additional M3i Workstation can be added to the main one using the LAN Network. The real-time information of the building is simultaneously updated on all PCs enabling both workstations to manage the plants.

The Access to the System is protected by a UserID and Password Authentication system.

Workstation features

The M3i Workstation is interactive and flexible, optimizing the effectiveness of a building management system.

The working environment is based on a Workspace concept that is customizable, simple, and fast, allowing dynamic navigation between the applications that compose the building management system. One of the Workspace pages is fully dedicated to the visualization of the real-time and historical Alarms, reporting all the events that need a fast reaction by the Operator. The working folders are ActiveX™ server documents that offer an incomparable Flexibility as well as uniform interaction between applications.

The M3i Workstation main components are:

- A Textual Workspace: This shows the building information in a text mode easy to navigate using a tree structure.
- A Graphics Workspace: This displays building information in graphic form.
- A Trend Workspace: This displays recorded trend data in either tabular or graphic mode.
- An Alarm Workspace: This displays current alarms, in tabular mode, depending on the events severity.

The building graphic representation and its systems are made through Johnson Controls M-Graphics software.

Using the high-resolution colour graphics, the operators are informed about any abnormal conditions by a dynamic representation of the monitored systems and with appropriate messages.

It is possible to change from a whole building representation to a specified floor or area with a simple click on the mouse.

The M3i Workstation can display floor maps or plants details with real time data. By clicking on the symbols that represent the different components of a particular system, the operator can carry out any necessary adjustments to correct a possible problem. The operator interface is completed with M-Alarm to manage alarms and M-Trend to create and display historical trend data.

In case alarms report are required at a remote location, an additional software module allows this information to be send as SMS messages or transferred via ESPA 4.4.4 protocol to compatible pager systems.

Finally, the optional Metastore module allows the creation of advanced and complete reports based on trend data stored by the M3i Workstation.

N2 Bus Controllers

The N2 Bus is a local communication network that connects the building devices with the M3i Workstation.

N2 Bus installation is very easy and cost effective it just needs a 3-wire cable.

M3i Workstation supports N2 System 9100 devices as well as N2Open devices like Metasys Integrator (MIG), AHU, UNT, devices using VND protocol and FX devices with a N2 interface.

An automatic tool to import data from DX, FX engineering tools and 3rd party communication drivers (VCT Tables) is available to facilitate database creation.

Device/point list duplication (for mass copying of fan coil unit data for example) is supplied as well. Import and export features are provided to optimize engineering efforts.

LonWorks® devices

The M3i Workstation provides connectivity to LonWorks® networks, using a solution based on the Echelon™ LNS Technology and available in two sizes one for small systems and one for large Flat systems.

Using this connectivity solution M3i Workstation integrates System 91 (DX9200), LN and IRC Product Series in the Global Building Management System as well as any other 3rd party LonWorks® product like Multimeter, VAV box and Gateway.

A Plug-in configuration tool will automatically generate the tag database allowing the configuration of the M3i Workstation features for Alarms and Event analysis and Trend collection.

Modbus devices

Modbus (Modicon®) and J-bus (April®) protocols are industry standard communications protocols, which set a hierarchical master/slave structure, typically based on a serial transmission.

The interface allows point-to-point (RS232) or multipoint (RS485/RS422) mode connections.

The protocol is supported in RTU mode and in ASCII mode over serial cable and/or over Ethernet network (MODBUS/IP).

Support of this protocol, as default in the M3i Workstation, allows it to connect third-party devices that may be installed in a building without the need to use special protocol converters.

As an additional option, the EDE can provide a direct link as Modbus (serial or IP) device, so it provides an effective method of integration into 3rd party systems.

Fire and Security Panel Connection

Thanks to the usage of recent technologies and market standards M3i Workstation interfaces a wide range of 3rd party product like Fire Alarm Systems, Intrusion Panel and CCTV System (Johnson Controls DVN System).

The interface allows point-to-point (RS232) and multipoint (RS485/RS422) connections

The protocol is supported over Serial cable or over Ethernet network (Serial Tunnelling).

Those protocols are directly supported by the M3i Workstation software and managed in the same way of all the other information coming from Johnson Controls device ensuring a uniformed way to represent real-time data and alarms.

Standard connectivity solutions for M3i are supplied with a tool that automatically import tags and labels from the Fire or Intrusion Panel proprietary database, to optimize engineering time and configuration process.

M-Bus

The M-Bus protocol is a standard protocol for reading of counter devices like Heating or Electrical energy counters.

The data exchange follows a Master-Slave structure.

M3i Workstation can integrate this controller using RS232- M-Bus converters to link large amount of M-Bus devices (max 255 per bus) or N2 M-Bus modules (connecting up to 8 meters) that enable to integrate it as standard Johnson Controls N2 devices.

Metastore optional package can be used for generate Custom Report about Energy or Water consumption.

EIBus

EIB, European Installation Bus, now changed into KNX (Konnex convergence), is the world's leading system for "intelligent" electrical installation networking.

The bus cable installed in addition to the supply cable combines devices and systems (e.g. heating, lighting or ventilation) which previously functioned separately from one another.

EIB devices can be connected to the M3i Workstation using EIB to N2 that enable to Integrate it as standard Johnson Controls N2 devices or using an RS232/EIB interface or IP/EIB interface.

Metasys Integrator and Metasys Compatible Certified Products

Thanks to long experience in the field of building integrated systems dating back to the early 90's, JCI has developed hundreds of integration drivers for special equipment and devices supporting only proprietary protocols. These devices can be connected with the M3i Workstation via the Metasys Integrator: for example electrical analyzers, calorie counters, UPS, PLC, emergency lights, chillers, independent CDZ, lights, etc...

Some major manufacturers of devices for buildings have, over time, developed support of the JCI N2Open protocol in their devices; these devices are called 3rd party devices.

These devices can be directly connected to N2-bus to become part of M3i Workstation. Vendors implemented Johnson Controls N2 protocol over a wide range of product like Multimeter, Energy Counter, Variable Speed Driver, and many other products.

This simplifies the system topology and reduces the total cost of ownership for our customers. The M3i Workstation can connect to a large range of such products available on the building automation market today.

For full details about Vendor name and products please contact your local Johnson Controls representative.

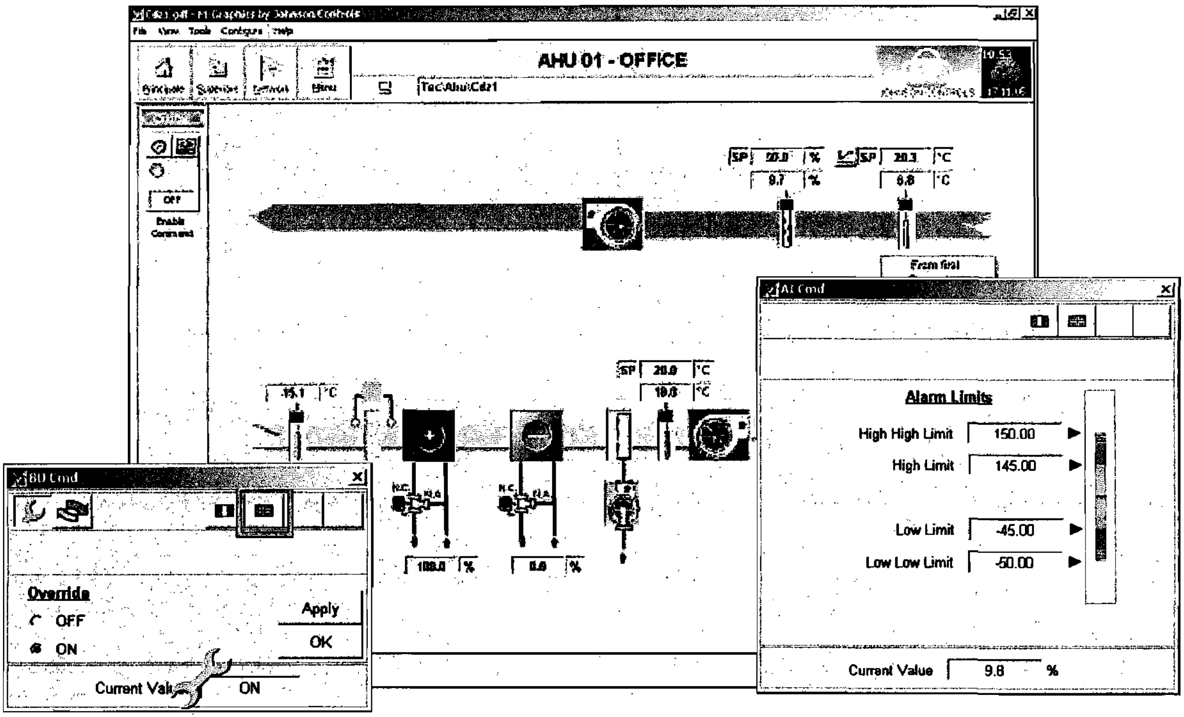
Other types of connectivity

The M3i Workstation is open to many types of integration based on proprietary and standard protocols such as BACnet.

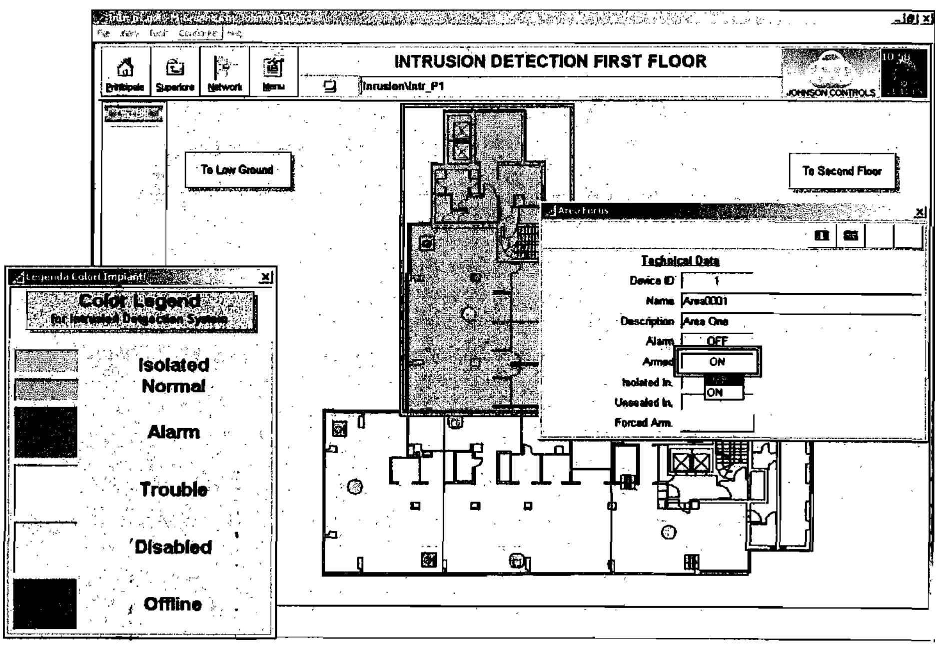
These integrations are evaluated case by case by our Centre of Excellence for Integration Developments (SIS Europe) to verify the integration feasibility and to guarantee that the best technical solution will be applied.

Contact your local Branch to verify the availability of the integration you require.

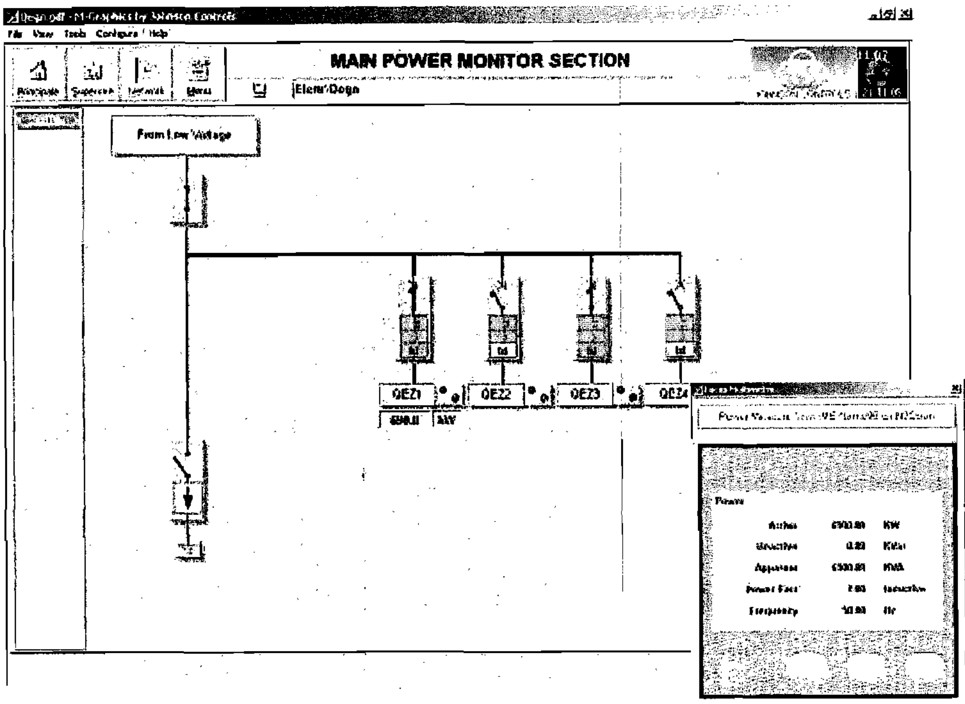
The graphical user interface



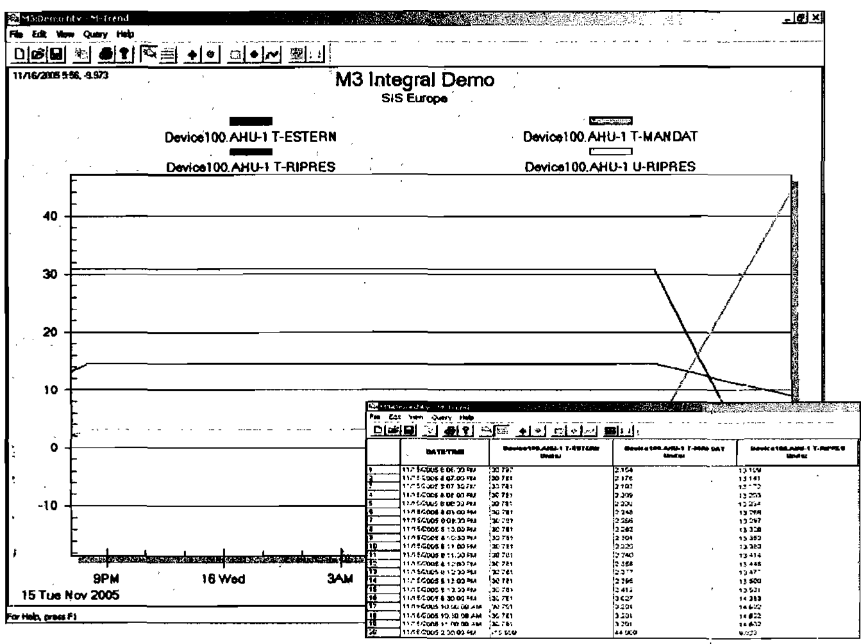
Typical graphical screen for system control. A simple click of the mouse is enough to open command Windows or Pop-Up or relevant data that building operators may need.



Typical floor representation, showing relevant information about the state of building security, Fire Alarm System status and, if required, the temperature of the spaces shown. Each display may has access to a legend pop up that can help even inexperienced operators interpret the display.



Here is a typical example of UPS and switchboard control. The electrical analyzer integration allows the display of instantaneous values and states as well as the total of the energy consumed. Thanks to the dynamic graphics, it is possible to identify at glance open switches or those in thermal overload.



Analysis of system performance can be made through M-Trend, which offers data comparative screens in graphic or tabular form.

Table 1: Functionality

SW Module	Description	Goal
M3i Workspace	Workspace to manage the navigation among the software modules, which compose the system, including N2, N2Open and Modbus communication drivers.	Allows the operator to interface with system.
M-Graphics	This allows monitoring, control and analysis of systems through dynamic graphic screens. It allows for system navigation throughout buildings monitoring systems. It supports launching and interaction of ActiveX applications for the integration of electronic documents and service films.	Easy and intuitive interface to the building and its systems.
M-Password	This controls system access according to customizable profiles based on the user and the permitted activities (monitoring only, control, modification, and administrator) with an individually assigned UserID and Password.	Assures secure system access by defining the authority levels from the daily operator to the Facility Manager.
M-Alarm	This displays system alerts or alarms in tabular form, showing priority and state as well as description and name of the alarm. Besides, by a simple click of the mouse, its display can be customized by a privileged user to for example change the sorting criteria for the alarm display Upon request, it is possible to open an electronic spreadsheet specific for alarm point automatically in order to give operating instructions or to add possible comments.	Keeps the building operator constantly informed of any critical situations so that appropriate action may be taken.
ESE	It manages hourly, daily, weekly and monthly programs taking into consideration holiday, and/or special day yearly calendar. Emergency-time programs can temporarily force the occupation periods.	Occupation period management with relevant automatic plant activation/deactivation.
M-Collector	Collect trend samples through active communication drivers configured on M3i Workstation.	Manages data collection on time base and transfer them in Trend database
M-Trend	Allows collected data viewing using charts or table format	Allows the operator to analyze historical building performance to optimize energy consumption as well as to reduce the maintenance charges.
METASTORE Option	Advanced trend analysis tools which allows specific points to be to group and displayed according to definable time spans. It can automatically produce reports in both electronic and paper format on a definable periodic basis.	Produces advanced reports in multiple formats (MS Excel or Borland DB) for an in-depth and when required offline data analysis.
ANX Option	This allows for system alarms to be sent via SMS and ESPA. The message includes date and time, description of the alarmed point as well as its state and priority. To send an SMS it is necessary to use a GSM modem.	Allows alarms to be sent to remote personnel ensuring that the correct personnel are informed of critical or important situations independent of their location.
SNMP Option	This allows the workstation to , report a arms back to a Server Farm handler found in IT environments	Integrates the system into IT infrastructure
Connectivity Option	OLE module for Process Control usually specialized in direct import of data coming from specific devices, for instance fire stations.	Allows the integration of special devices.
MIG-Driver Option	Module for protocol conversion to use with Metasys Integrator for the integration of special devices.	Allows the integration of devices with proprietary protocol (UPS, chillers or PLCs).

JOHNSON CONTROLS

Features

Table 2: Technical specifications for PC M3i Workstation

Product	M3i Workstation
Recommended PC platform	PC Pentium 4, 3,0 GHz, expansion board for second serial port if necessary for required application and not available on PC
Memory	Recommended 1GB RAM
Hard Disk Drive	Minimum 80 GB
Floppy Disk Drive	3.5 in. 1.44 MB diskette drive
CD-RW	Multiform CD writer 8x - 4x - 32x
Video card	Minimum 32 MB VRAM
Operating environment	Windows 2000 SP3 or higher
Monitor	Recommended 17" CRT or 15" LCD, resolution 1024 x 768
Software	Workstation

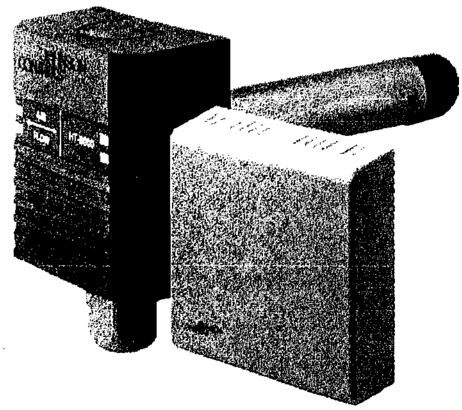
Series HT-9000
Electronic Humidity Transmitter

Introduction

The Johnson Controls humidity transmitter is based on a new "state of the art" humidity sensing element. It measures humidity over the entire range of 0 to 100% RH (non condensing) and has a wide operating temperature range. Its fast response, reliable long-term performance makes this transmitter well suited for refrigeration and HVAC installations.

This range also includes models with an integrated temperature sensing element.

It is recommended to use the humidity transmitter with Johnson Controls controllers such as the TC/SC/DC/DX-9100 series and System 27 Nova / MS series or with other systems having compatible input and output voltages.



HT-9000 Electronic Humidity Transmitter

Description

The basic principle of this new humidity transmitter is a polymer capacitance type element in which capacitance changes proportionally to a change in humidity. This well proven technology is now combined with the signal processing electronics onto a single chip.

The sensing element incorporates a protective coating which resists the effects of surface contamination.

Feature and Benefits	
❑ **Room Models suitable for universal voltage supply**	Increase compatibility to a larger range of controllers within HVAC/R industry
❑ **Senses over the entire range of 0 to 100%RH (non condensing)**	Increases compatibility within a wider range of applications
❑ **Transmitter can resist many hostile environments**	Suitable for a wide range of applications.
❑ **Temperature measurement option**	Eliminates the need for a separate temperature transmitter
❑ **Polymer humidity sensing element is integrated onto a chip**	Provides stability, repeatability and linear response
❑ **Duct and room enclosures are available**	Enhances compatibility with a wide range of equipment

Ordering data

HT- 9 [ ] [ ][ ] - [ ][ ][ ]

Duct mounting
1D1 = Rod length 153 mm

Room
URW = Room White (RAL 9010)

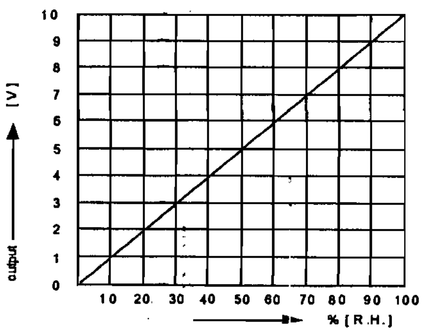
Temperature Output
00 = No temperature Output
01 = 0 to 10 VDC (range 0 to 40° C)
02 = 0 to 10 VDC (range 0 to 60° C), only for room enclosure models
03 = NTC K2 (2252 Ω)
05 = Pt 100
06 = Pt 1000
09 = A99

Humidity Output
0 = 0 to 10 VDC

Note

All HT Series humidity transmitters are designed for use only in conjunction with operating controls. Where an operating control failure would result in personal injury and/or loss of property, it is the responsibility of the installer to add devices or systems that protect against, or warn of control failure.
To avoid damage to the HT-9000 humidity transmitter, do not mount the unit in a location where high concentrations of corrosive vapours are present.

Humidity output curve



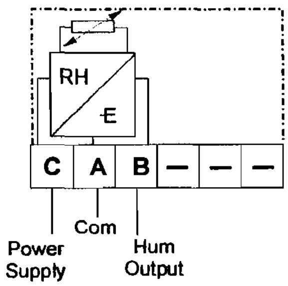
Humidity output voltage curve

Temp. versus resistance table

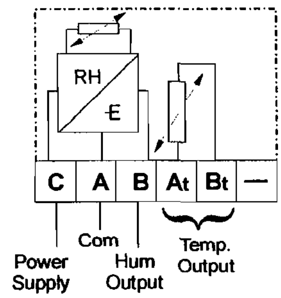
Temp. (°C)	Resistance (Ω)			
	A99	Pt100	Pt1000	NTC K2
0	854	100.0	1000	7352.8
5	888	102.0	1020	5717.8
10	924	103.9	1039	4481.5
15	960	105.8	1058	3537.9
20	997	107.8	1078	2812.8
25	1035	109.7	1097	2252.0
30	1074	111.7	1117	1814.4
35	1113	113.6	1136	1470.6
40	1154	115.5	1155	1199.6
45	1195	117.5	1175	-
50	1238	119.4	1194	-
55	1281	121.3	1213	-
60	1325	123.2	1232	-

Wiring

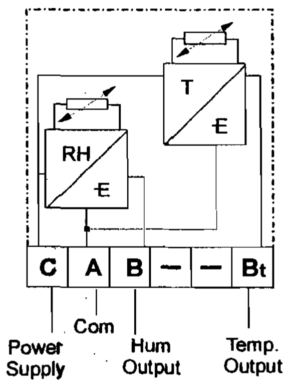
HT-90xx-URW
(Room sensors)



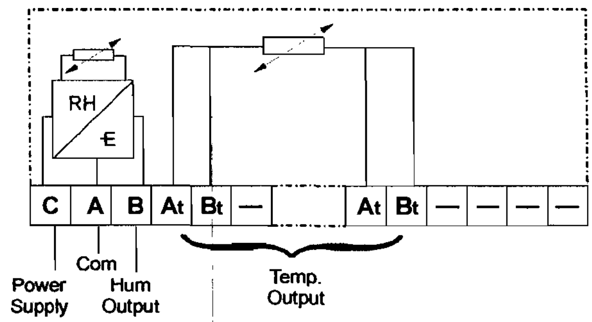
No temperature Output



NTC K2, A99, Pt 1000
temperature passive output

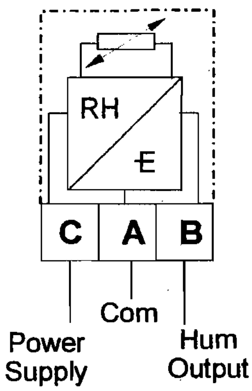


0...10 VDC temperature Output

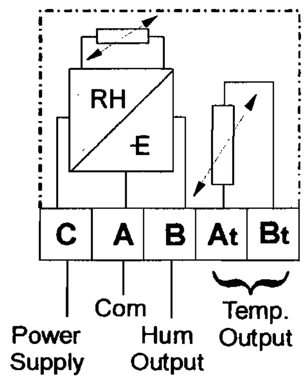


Pt100 temperature passive Output

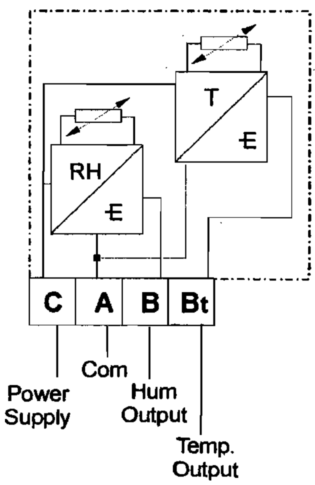
HT-90xx-1D1
(Models for duct mounting)



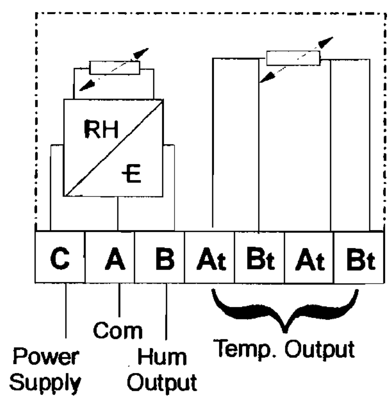
No temperature Output



NTC K2, A99, Pt 1000
temperature passive output

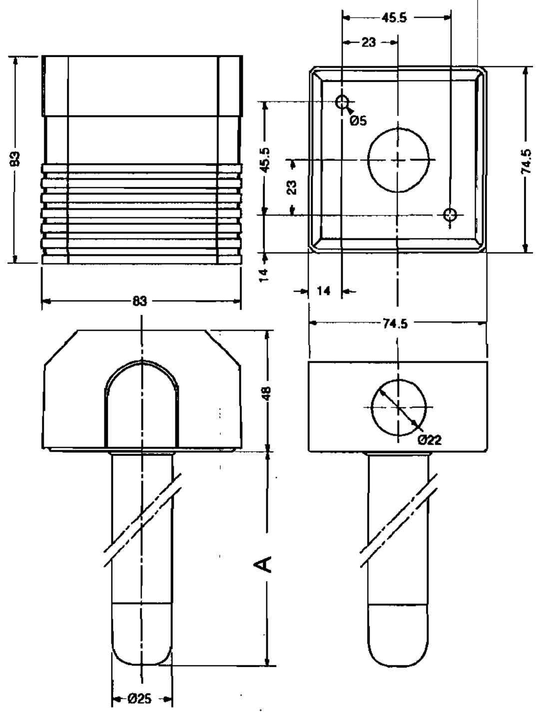


0...10 VDC temperature Output

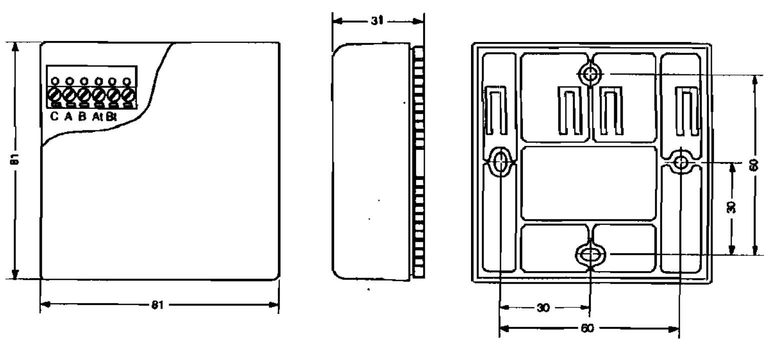


Pt100 temperature passive Output

Dimensions (in mm)



HT-90xx-1D1 A = 153



HT-90xx-URW

Specifications

	HT-90xx-URW		HT-90xx-1D1
Humidity range:	0 to 100% RH		
Humidity output signal:	0 to 10 VDC linear		
Supply voltage:	12 to 30 VDC 24 VAC ±15%		12 to 17 VDC
Accuracy: Humidity Transmitter:	± 4% R.H. from 10 to 90% R.H. ± 6% R.H. from 0 to 10 % R.H. and 90 to 100% R.H.		
Accuracy: Temperature Sensor:	A99 type NTC K2 Pt 100/Pt 1000 0 to 10 VDC	± 0.5 K (between 0 and 60°C) ± 0.2 K (between 0 and 40°C) As specified in IEC751 Class A ± 0.7 K (between 0 and 40°C)	
Power consumption at 24 VAC nominal (no load):	Only RH transmitter With temp. Transmitter	0.3 W 0.5 W	
Output load:	≥ 5 kΩ		
Humidity response time:	Room enclosure Duct enclosure	40 sec. in still air 20 sec. in 3 m/s moving air	
Ambient operating : conditions:	0...60°C non condensing in any part of the sensor HT-90xx-1D1: minimum air flow 3 m/s		
Protection:	Room enclosure Duct enclosure	IP30 (EN60529) IP30 (EN60529)	
Materials:	Room enclosure Duct enclosure	self extinguishing ABS + PC polycarbonate LEXAN 950 and anodised aluminium 6061-F	
Weight:	Room enclosure Duct enclosure	0.12 kg 0.20 kg	
Terminal blocks:	Room models Duct models	plug in connectors accepting 1.5 mm² wires fixed connectors accepting 2.5 mm² wires	
CE Compliance:	EMC (89/336 EEC) according to the standard EN 50081-1 and EN 50082-1		

The performance specifications are nominal and conform to acceptable industry standards. For applications at conditions beyond these specifications, consult the local Johnson Controls office or representative. Johnson Controls shall not be liable for damages resulting from misapplication or misuse of its products.

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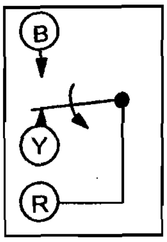
JOHNSON CONTROLS

Controls Group 507 E. Michigan Street
P.O. Box 423, Milwaukee, WI 53202
Code No. LIT-1922335

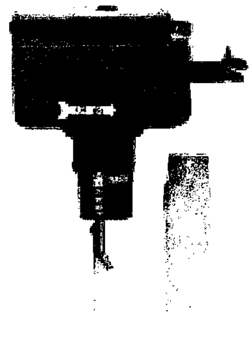
F61 Series

Flow Switch (Standard Flow Rate – SPDT)

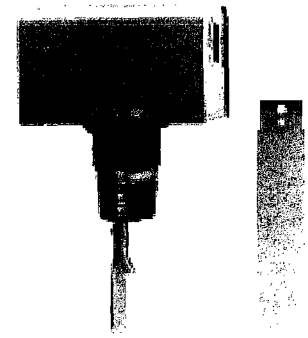
Series F61



Action on Increase of Flow



F61MB-1



F61KB-11

Description

The F61 Series Flow Switches are Single-Pole, Double-Throw (SPDT) flow switches used on fluid lines carrying water, ethylene glycol, or other fluids not classified as hazardous. They can be wired to energize one device and de-energize another device powered from the same source when fluid flow either exceeds or drops below the set flow rate.

The F61MG type flow switches are used for low-energy loads to operate small relays, solenoid valves, and electronic control circuits. These flow switches have gold-plated contacts for improved electrical performance in low voltage, low current circuits.

Features

- stainless steel paddle has three segments for use in pipes from 1 in. to 3 in. (25 mm to 75 mm) diameter
- paddle segments can be removed or trimmed as needed
- F61KB-11 and F61MB-1 include a 6 in. (152 mm) paddle for pipes 4 in. to 6 in. (102 mm to 152 mm)
- gold-plated contacts on F61MG-1 reduce intermittent contact problems in low-voltage and low-current circuits

Applications

- use on lines carrying water or ethylene glycol
- not for use with hazardous fluids or in hazardous atmospheres

To Order

Specify the code number from the following selection chart.

Selection Chart

Code Number	Enclosure	Bellows	Paddle
F61KB-11	NEMA 1	Phosphor Bronze	Stainless Steel; 3-piece Paddle (3 in., 2 in., and 1 in. Segments) Installed; 6 in. Paddle Supplied Uninstalled
F61LB-1	NEMA 1	Phosphor Bronze	Stainless Steel; 3-piece Paddle (3 in., 2 in., and 1 in. Segments) Installed
F61MB-1	NEMA 3R	Phosphor Bronze	Stainless Steel; 3-piece Paddle (3 in., 2 in., and 1 in. Segments) Installed; 6 in. Paddle Supplied Uninstalled
F61MB-5	NEMA 3R	Stainless Steel	Stainless Steel; 3-piece Paddle (3 in., 2 in., and 1 in. Segments) Installed; 6 in. Paddle Supplied Uninstalled
F61MG-1 [a]	NEMA 3R	Phosphor Bronze	Stainless Steel; 3-piece Paddle (3 in., 2 in., and 1 in. Segments) Installed; 6 in. Paddle Supplied Uninstalled

(a) Gold-Plated Contacts

Replacement Kits

Code Number	Description
KIT21A-600	Stainless Steel 3-piece Paddle (3 in., 2 in., and 1 in. Segments)
KIT21A-601	Stainless Steel 6 in. Paddle
PLT52A-600R	Stainless Steel 3-piece Paddle (3 in., 2 in., and 1 in. Segments) and 6 in. Paddle
CVR62A-600R	Replacement Cover Assembly for F61MB-1, F61MB-5, and F61LB-1

Electrical Ratings for F61KB, F61LB, and F61MB Models

Electrical Ratings	120 VAC	208 VAC	240 VAC	277 VAC
Horsepower	1	1	1	-
Full Load Amperes	16.0	8.8	8.0	-
Locked Rotor Amperes	96.0	52.8	48.0	-
Non-Inductive Amperes	16.0	16.0	16.0	16.0
Pilot Duty	125 VA at 24/277 VAC			

Electrical Ratings for F61MG Models

Electrical Ratings	120 VAC
Full Load Amperes	1
Locked Rotor Amperes	6
Non-Inductive Amperes	2
Pilot Duty	125 VA at 24/277 VAC

JOHNSON CONTROLS

Controls Group 507 E. Michigan Street
P.O. Box 423, Milwaukee, WI 53202
Code No. LIT-1922335

F61 Series Flow Switch (Standard Flow Rate – SPDT) (Continued)

Typical Flow Rates

F61KB, F61LB, and F61MB Models, 1-3 in. paddles

GPM (m^3/hr) Required to Actuate Switch											
Pipe Size (in.)		**1**	**1-1/4** (a)	**1-1/2** (a)	**2**	**2-1/2** (b)	**3**	**4** (c)	**5** (c)	**6** (c)	**8** (c)
Minimum Adjustment	**Flow Increase (R to Y Closes)**	4.2 (0.95)	5.8 (1.32)	7.5 (1.70)	13.7 (3.11)	18.0 (4.09)	27.5 (6.24)	65.0 (14.8)	125.0 (28.4)	190.0 (43.2)	375.0 (85.2)
	Flow Decrease (R to B Closes)	2.5 (0.57)	3.7 (0.84)	5.0 (1.14)	9.5 (2.16)	12.5 (2.84)	19.0 (4.32)	50.0 (11.4)	101.0 (22.9)	158.0 (35.9)	320.0 (72.7)
Maximum Adjustment	**Flow Increase (R to Y Closes)**	8.8 (2.0)	13.3 (3.02)	19.2 (4.36)	29.0 (6.6)	34.5 (7.84)	53.0 (12.0)	128.0 (29.1)	245.0 (55.6)	375.0 (85.2)	760.0 (172.6)
	Flow Decrease (R to B Closes)	8.5 (1.93)	12.5 (2.84)	18.0 (4.09)	27.0 (6.13)	32.0 (7.27)	50.0 (11.4)	122.0 (27.7)	235 (53.4)	360.0 (81.8)	730.0 (165.8)

(a) Flow rates for two inch paddle trimmed to fit pipe.
(b) Flow rates for three inch paddle trimmed to fit pipe.
(c) Flow rates are calculated for factory-installed set of one, two, and three inch paddles.

F61KB, F61LB, and F61MB Models, 6 in. paddles

GPM (m^3/hr) Required to Actuate Switch					
Pipe Size (in.)		**4**	**5**	**6**	**8**
Minimum Adjustment	**Flow Increase (R to Y Closes)**	37.0 (8.40)	57.0 (12.9)	74.0 (16.81)	205.0 (46.56)
	Flow Decrease (R to B Closes)	27.0 (6.13)	41.0 (9.31)	54.0 (12.26)	170.0 (38.61)
Maximum Adjustment	**Flow Increase (R to Y Closes)**	81.0 (13.4)	118.0 (26.80)	144.0 (32.70)	415.0 (94.26)
	Flow Decrease (R to B Closes)	76.0 (17.3)	111.0 (25.21)	135.0 (30.66)	400.0 (90.85)

Note: Flow rates for these sizes are calculated. Where paddle size is larger than pipe size, flow rates are for 6 in. paddle trimmed to fit pipe.

F61MG Models, 1 to 3 in. paddles

GPM (m^3/hr) Required to Actuate Switch											
Pipe Size (in.)		**1**	**1-1/4** (a)	**1-1/2** (a)	**2**	**2-1/2** (b)	**3**	**4** (c)	**5** (c)	**6** (c)	**8** (c)
Minimum Adjustment	**Flow Increase (R to Y Closes)**	3.8 (0.9)	5.3 (1.2)	6.9 (1.6)	12.7 (2.88)	16.7 (3.79)	24.3 (5.52)	61.0 (13.8	118.0 (26.80)	183.0 (41.56)	362.0 (82.22)
	Flow Decrease (R to B Closes)	2.5 (0.6)	3.7 (0.8)	5.0 (1.1)	9.5 (2.2)	12.5 (2.84)	19.0 (4.32)	50.0 (11.4)	101.0 (22.94)	158.0 (35.88)	320.0 (72.68)
Maximum Adjustment	**Flow Increase (R to Y Closes)**	8.7 (2.0)	13.1 (2.98)	18.8 (4.27)	28.9 (6.56)	33.7 (7.65)	52.1 (11.8)	126.0 (28.62)	243.0 (55.19)	372.0 (84.49)	753.0 (171.0)
	Flow Decrease (R to B Closes)	8.5 (1.9)	12.5 (2.84)	18.0 (4.09)	27.0 (6.13)	32.0 (7.27)	50.0 (11.4)	122.0 (27.71)	235.0 (55.37)	360.0 (81.76)	730.0 (165.8)

(a) Flow rates for two inch paddle trimmed to fit pipe.
(b) Flow rates for three inch paddle trimmed to fit pipe.
(c) Flow rates are calculated for factory-installed set of one, two, and three inch paddles.

F61MG Models, 6 in. paddles

GPM (m^3/hr) Required to Actuate Switch					
Pipe Size (in.)		**4**	**5**	**6**	**8**
Minimum Adjustment	**Flow Increase (R to Y Closes)**	35.0 (7.95)	53.0 (12.0)	69.0 (15.7)	197.0 (44.74)
	Flow Decrease (R to B Closes)	27.0 (6.13)	41.0 (9.31)	54.0 (12.3)	170.0 (38.61)
Maximum Adjustment	**Flow Increase (R to Y Closes)**	80.0 (18.2)	116.0 (26.34)	142.0 (32.25)	412.0 (93.58)
	Flow Decrease (R to B Closes)	76.0 (17.3)	111.0 (25.21)	135.0 (30.66)	400.0 (90.85)

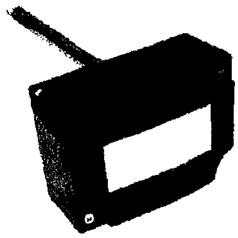
Note: Flow rates for these sizes are calculated. Where paddle size is larger than pipe size, flow rates are for 6 in. paddle trimmed to fit pipe.

Specifications

F61 Series Standard Flow Rate Switch				
Maximum Fluid Pressure		150 psig (1034 kPa)		
		F61KB, F61LB		**F61MB, F61MG**
Fluid Temperature	Minimum	32°F (0°C)		-20°F (-29°C)
	Maximum	250°F (121°C) for all models		
Wiring Connections		Screw Type Terminals		Four Color-coded No. 14 AWG Solid Conductor Wire Leads, 7 in. (178 mm) Long
Pipe Connector		1 in. 11-1/2 NPT Threads		
		F61KB	**F61LB, F61MB, F61MG**	
Conduit Connection		One 7/8 in. (22 mm) Hole for 1/2 in. Conduit with 1-3/32 in. (28 mm) Knockout Ring for 3/4 in. Conduit	Female Hub for 1/2 in. Conduit, 1/2-14 NPSM Threads	
Paddle		Installed Stainless Steel 3-piece Paddle (3 in., 2 in., and 1 in. Segments); Stainless Steel 6 in. Paddle Supplied w/ F61MB and F61KB		
Switch		SPDT Snap-acting Pennswitch		
		F61KB	**F61LB**	**F61MB, F61MG**
Enclosure	**Case**	0.062 in. (1.57 mm) Steel	0.062 in. (1.57 mm) Cold Drawn Steel	0.062 in. (1.57 mm) Cold Drawn Steel
	Cover	0.028 in. (.7 mm) Steel (NEMA 1)	0.062 in. (1.57 mm) Cold Drawn Steel, (NEMA 1)	0.062 in. (1.57 mm); Cold Drawn Steel, Gasketed (NEMA 3R Rain-tight)
Agency Listings	**UL Listed**	E5368, CCN NMFT	E5368, CCN NMFT	E5368, CCN NMFT
	CSA Certified	LR948, Class 3211 06,Class 4613 02, Class 1222 01	Not CSA Certified	LR948, Class 3211 06
Shipping Weight		2.8 lb (1.3 kg)		

AX-RH200/210

Duct RH & T Transmitter



Product Overview

The AX-RH200 / 210 Duct mounted RH & T Sensors are designed for high accuracy Relative Humidity and Temperature measurement with the 200 range having analogue output on the RH and optional thermistor on the temperature and the 210 range having analogue output of both values. The units are extremely reliable and have excellant stability and a quick response time. There are three accuracy ranges available 2%, 3% and 5%.

Features

- 2% , 3 % and 5% accuracy versions available
- High stability and reliability
- 0-5Vdc, 0-10Vdc and 4-20mA Variants
- Optional Thermistor output for temperature

Product Specifications

RH Accuracy:	2%, 3% and 5% options (between 5% and 95%RH)
Temperature Accuracy:	+/- 0.1°C
Sensor Type:	Thermoset Polymer based Capacitive
Sensor Protection:	60 micron HPDE cover
Stability (long term):	+/-1% RH at 50% RH in 5 years
Repeatability:	+/- 0.5% RH
Hysteresis:	+/-1% of span max
Response Time:	15 seconds @ 25°C
Power Supply:	24Vac/dc +/- 10%
Output: **RH200**	RH output analogue 4-20mA or 0-5/10Vdc
	Temperature (optional) - thermistor or PT1000 RTD
RH210	RH & T 4-20mA or 0-5/10Vdc
Output Ranges:	
RH	0 to 95%
Temperature	0°C to +70°C (others available on request)
Electrical Connections:	Screw terminals for 18 to 22 AWG wire
Ambient Temp:	0°C to +70°C , 0-95% RH
Dimensions:	
Housing	115 x 80 x 52 mm
Probe	230(L) x 14mm Ø (max.)
Materials:	
Housing	ABS (other option available at additional cost)
Probe	Stainless Steel
Option:	LCD display built into housing
Protection:	IP65
Weight:	0.32kg
Country of Origin:	Canada.

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Order Codes

if RH200-x -T range please specify thermistor

AX-RH200-5	**Duct RH Transmitter 5% accuracy**
AX-RH200-3	**Duct RH Transmitter 3% accuracy**
AX-RH200-2	**Duct RH Transmitter 2% accuracy**
AX-RH200-5-T	**Duct RH Transmitter 5% accuracy T = thermistor -specify**
AX-RH200-3-T	**Duct RH Transmitter 3% accuracy T = thermistor -specify**
AX-RH200-2-T	**Duct RH Transmitter 2% accuracy T = thermistor -specify**
AX-RH210-5	**Duct RH & T Transmitter 5% accuracy**
AX-RH210-3	**Duct RH & T Transmitter 3% accuracy**
AX-RH210-2	**Duct RH & T Transmitter 2% accuracy**

Installation

Antistatic precautions must be observed when handling these sensors. The PCB contains circuitry that can be damaged by static discharge. Transmitters should only be fitted to a system after airflow calibration has been carried out and preferably following full fan running of at least several days, in order that the main contaminants have been removed from the stagnant system.

1. Select a location in the duct where dust & contaminants are at a minimum (i.e. after filters etc.) and which will give a representative sample of the prevailing air condition.
2. Drill a 5/8" (or larger) hole in the return air duct. Remove the protective plastic sleeve from the probe and place it through the hole and secure the enclosure to the duct with sheetmetal screws. Orientation of the enclosure and probe will have no effect on the operation of the device.
3. Feed the cable through the waterproof gland and terminate the cores at the terminal block. Leaving some slack inside the unit, tighten the cable gland onto the cable to ensure water tightness.
4. Replace the lid after the electrical connections have been made.
5. Ensure that the voltage is within the specified tolerances.
6. Allow 3 minutes before checking functionality.
7. Allow 30 minutes before carrying out pre-commissioning checks.

Electrical Connection

The transmitter should be connected to the controller using 18 to 22 AWG wire. The duct models require four wires (power, common, RH and Temperature output signals) for voltage and AC operation while only three wires (power, RH and Temperature output signals) are required for DC 4-20mA loop-powered operation.. The use of shielded cable is optional but recommended for the highest noise immunity. Do not route signal wires in the same conduit with power cables as signal degradation may occur. The controller Analog Input (AI) must be selected to match the transmitter output before power is applied. The AI type must be a high impedance voltage input for use with 0-1, 0-5 or 0-10 Vdc transmitters, or a current input with 250 or 500 ohm impedance. All transmitters have an operating range of 0 -70 °C (32 – 158 °F) except the O.S.A. which is -40 – 85 °C (-40 – 185 °F). The transmitter board should not be mounted where temperatures will exceed these values. See the connection diagram for more details.
If the unit comes with a remote sensor, the sensor is connected to the transmitter board by a 5-pin plug to a 14-pin connector. Should this plug become disconnected, it is to be reconnected to the pins indicated by the markings on the board, with the green stripes on the plug facing the middle of the board. Do not mix and match sensors and boards as the boards are calibrated to the sensor it is shipped with. Changing sensors will have a significant effect on the accuracy of the product.

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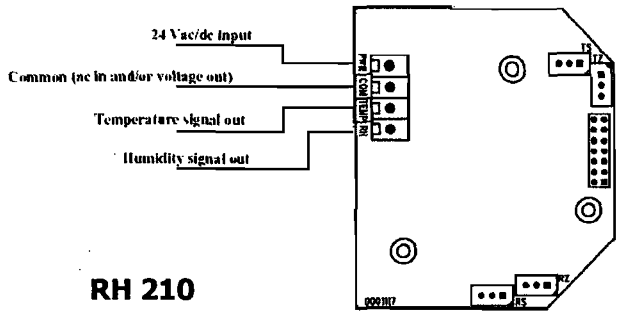
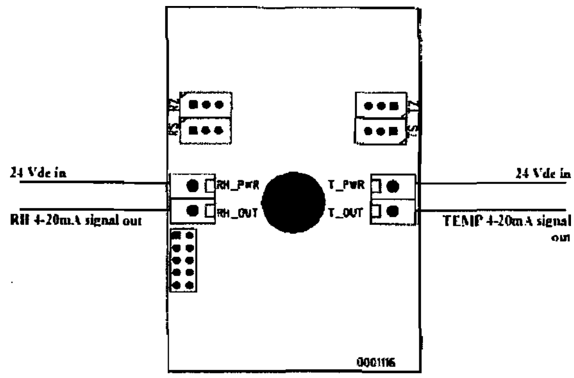
AXIO

Output Selection

Remove power to the transmitter before changing between voltage and current output signal types. Ensure the wiring is correct for the selected output signal type. Use caution when changing jumper positions as not to damage the circuit board, any components or the sensing elements. The unit comes factory set for current output. To change the output signal to voltage, carefully remove the 3-position shorting jumper and replace it in the 'VOLTAGE' position. Place the two position shorting jumper in the correct position for the required span (10 = 0 to 10 Vdc, 5 = 0 to 5Vdc, 1 = 0 to 1 Vdc). NOTE: the voltage span jumper does not function when the output signal is set to 'CURRENT'.



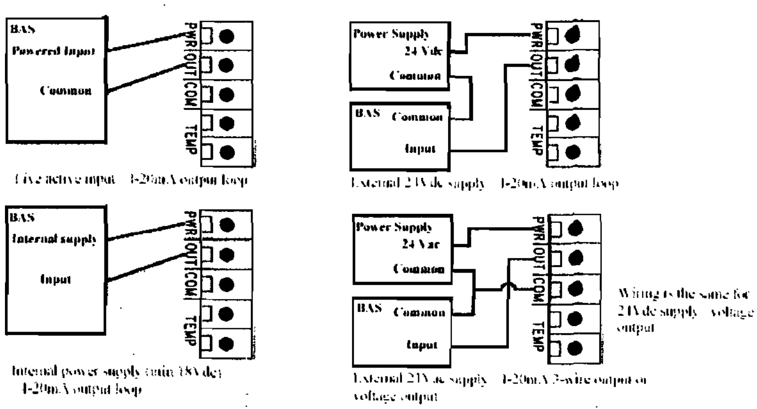
RH 210

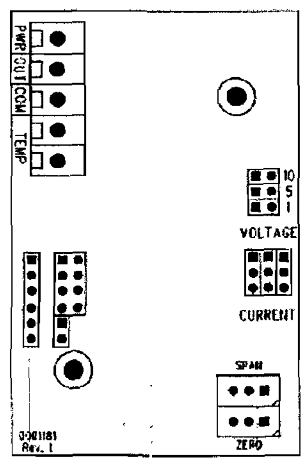


RH 200

Warning

Relative humidity transmitters are sensitive electronic devices and care should be taken at all times to ensure that they are not exposed to extreme ambient conditions or incorrect electrical connection. Transmitters should not be exposed to direct moisture contact (e.g. rain) and saturation of the transmitter at very high humidity should be avoided wherever possible.





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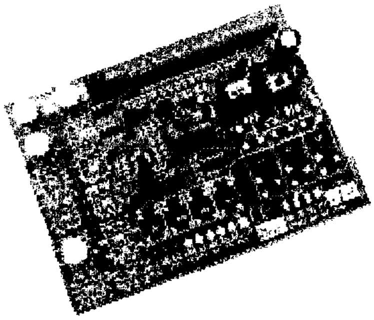
AX-CR-UV2-V-DP-EN

Dewpoint & Enthalpy Calculation Module

AXIO



Product Overview

The AX-CR-UV2-V-DP-EN is a low cost calculation module which takes analogue inputs of RH and Temperature and outputs both Dewpoint and Enthalpy . The module is 24Vac/dc powered and is is DIN rail mounting

Features

- Low cost accurate Dewpoint & Enthalpy Calculation
- 0-10Vdc or 4-20mA output
- 24Vac/dc
- DIN rail mounting

Product Specification

Power Supply:		24Vac/dc +/- 15%
Input:	RH	4-20mA or 0-10Vdc (0-100% RH)
	Temperature	4-20mA or 0-10Vdc (-20/+50 deg C)
Output Signal:	Dewpoint	0(4)-20mA or 0(2)-10Vdc (-30/+50deg C)
	Enthalpy	0(4)-20mA or 0(2)-10Vdc (-10/+275 KJoules)
RH Range:		0-100%
Temperature Range:		-20/+50 degC
Accuracy:		1%
Dimensions:		144 x 104 x 70mm
Ambient Range:		-10C to + 50 deg C
Protection:		IP20
CE Conformity:		EN 50 081-2
		EN 50 082-1
Country of Origin:		United Kingdom

Order Codes

AX-CR-UV2-V-DP-EN **Dewpoint & Enthalpy Calculation Module**

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Tel: +44 (0)1420 487788 Fax: +44 (0)1420 487799
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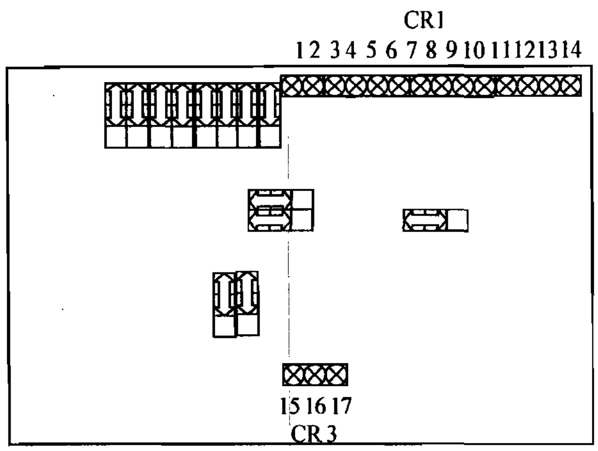
Connections:

CR1 Top row

Inputs



1	Supply to sensor
2	0-10V or 4-20mA input temperature
3	0V
4	Supply to sensor
5	0-10V or 4-20mA input RH
6	0V
7	Not used
8	Not used
9	Not used
10	Not used
11	Not used
12	Not used
13	24Vac/dc supply
14	Supply 0V

CR3 Bottom row

Outputs

15	0-10V/0-20mA	Dewpoint -30/+50C
16	0V	
17	0-10V/0-20mA	Enthalpy -10/275KJ

Jumpers	Off	On	
J2	0-10V/0-20mA	2-10V/4-20mA	Output range Dewpoint
J3	0-10V/0-20mA	2-10V/4-20mA	Output range Enthalpy
J4	0-10V/0-20mA	2-10V/4-20mA	Input range Temperature
J5	0-10V/0-20mA	2-10V/4-20mA	Input range RH
J8	run	test, output 100%	
J16	0-20mA	0-10V	Output Dewpoint
J17	0-20mA	0-10V	Output Enthalpy

	Down	Up	
J14	0-10V	0-20mA	Output Dewpoint
J15	0-10V	0-20mA	Output Enthalpy
	Left	**Right**	
J11	24Vdc	Input supply	Supply V to CR1 1& 4
J12	0-20mA	0-10V	Temperature input
J13	0-20mA	0-10V	RH input

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FX06 Field Controller

The FX06 is a compact field controller in the Facility Explorer range of products. The controller is designed specifically for commercial Heating, Ventilating, Air Conditioning and Refrigeration (HVAC/R) applications.

The FX06 is a high performance controller with a powerful 16-bit microprocessor and state-of-the-art software for the precise control of many types of mechanical and electrical equipment. The controller has 17 physical inputs and outputs and supports a wide range of temperature sensors and actuating devices. Active sensors for the measurement of humidity, pressure, and other variables are also supported. The FX06 also includes an on board real-time clock to support the start-stop scheduling of equipment and real-time based control sequences.

The FX06 has an attractive Liquid Crystal Display (LCD) with a set of graphic status icons used in the most common HVAC/R applications. The controller also supports a remote panel or wall mounted Medium User Interface (MUI).

Communication modules are available to enable the controller to be integrated into an N2 Open or LONWORKS® network of a building automation system. For stand-alone applications, the FX06 field controller also features communications services to transmit event notification messages via Short Messaging Service (SMS).

The FX06 field controller is fully configurable or programmable, using the FX Tools software package, for a wide range of commercial HVAC/R applications including multi-compressor and scroll compressors, close control units, fan coil units, and unit ventilators.

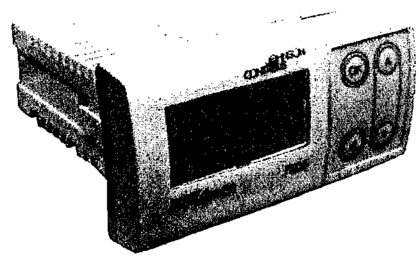


Figure 1: FX06 Controller

Features and Benefits	
❑ **Freely Programmable Controller**	Suitable for a wide range of HVAC or refrigeration control applications using the extensive programming features of the FX Tools software package
❑ **Network Communication Module Options**	Provide cost effective solutions for both stand-alone and networked applications
❑ **Remote Communication Services**	Enable automatic reporting of critical events/alarms by Short Message Service (SMS) for stand-alone applications
❑ **Integral Liquid Crystal Display (LCD) User Interface with Four Control Buttons**	Provides on board user access to the controlled system parameters and clear representation of the application status using alpha-numeric display characters and graphic icons
❑ **On Board Real-Time Clock**	Enables real-time scheduling of control activities
❑ **Software Selectable Analog Inputs**	Allow choice of temperature and other sensors according to the control range and application
❑ **Analog Outputs with Pulse Width Modulated (PWM) Option**	Interface to a wide range of actuators and drives
❑ **Models with Various Output Configurations of Solid State Triacs and Line Voltage Relays**	Provide cost effective control of refrigeration, unitary, and small air handling unit equipment

Code No. LIT-12011165

Onboard Inputs and Outputs

The FX06 controller has 17 physical inputs and outputs:

- 4 Analog Inputs (AIs) (software configurable)
  - A99 temperature
  - PT1000 temperature
  - NTC 10 K temperature
  - Ratiometric (0.5-4.5 VDC)
  - 0-10 VDC
- 5 Digital (Binary) Inputs (DIs)
  - for voltage free contacts
  - with a pulse counter on DI1
- 6 Digital (Binary) Outputs (DOs) (model dependent)
  - 6 Relays (line voltage contacts)
  - 2 Triacs (24V), 3 Interlocked Relays, 1 Free Relay
  - 2 Triacs (24V), 4 Free Relays
- 2 Analog Outputs (AOs) (model dependent)
  - 2 x 0-10 VDC
  - 1 x 0-10 VDC and 1 x PWM (Pulse Width Modulation) (100Hz)

Integral LCD User Interface

The integral LCD user interface of the FX06 features:

- 2 display rows with 4 alpha-numeric characters (13 segment)
- blue or red colored background
- graphic status icons: compressor, alarm, high pressure, low pressure, maintenance, heat, cool, defrost and electric heat symbols
- 4 buttons for user control functions
- navigation menu for user guidance

The integral user interface is fully configurable within the application design and typically provides:

- display of status information
- display, clear and acknowledgement of active alarms
- background lighting with red color when an alarm condition exists
- display and modification of setpoints
- display and modification of configuration parameters

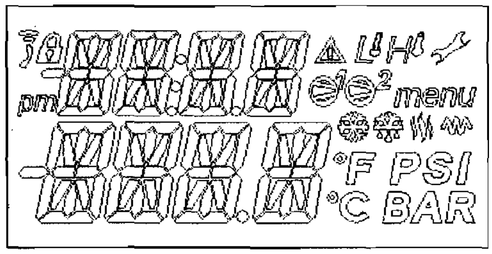


Figure 2: Detail of the LCD

Remote User Interface

The FX06 also supports a remote user interface (MUI). The MUI has a 4 x 20 character, backlit LCD screen, 6 buttons and 10 status Light-Emitting Diodes (LEDs). The display including its navigation menu is completely configurable within the FX06 application design. The following mounting styles are available:

- Panel Mount: Can be mounted up to 3 m (10 ft) from the FX06 controller. This user interface is powered at 24 VAC through the FX06. A flat telephone cable is available for the connection of the power supply and data communications to the FX06 controller.
- Wall Mount: Can be mounted up to 300 m (1,000 ft) from the FX06. This user interface must be independently powered. The data communication requires a 3-wire shielded cable (not provided) for the connection to the remote display to the FX06 controller.

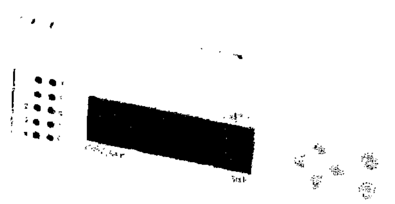


Figure 3: Panel or Wall Mount User Interface

Communication Module Options

The FX06 controllers can operate stand-alone or be fitted with optional communication modules to allow connection and integration into a supervisory system. Communication modules are easily attached onto the lower part of the FX06 controller.

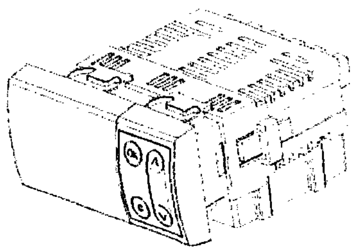


Figure 4: FX06 with Communication Module

N2 Open Network

When fitted with an N2 Open Communication Module, the FX06 controller can be connected to the N2 Open bus of a building automation system, allowing access to its control system variables and parameters.

LONWORKS® Network

When fitted with a LONWORKS Communication Module, the FX06 can be integrated into a LONWORKS compatible building automation system, allowing peer-to-peer communication with other LONWORKS compatible devices and access to system parameters.

Communication Services

RS232C Serial Card

The RS232C Serial Communication Module enables the FX06 controller to be connected to a Global System for Mobile communications (GSM) modem for alarms/events notification.

Short Message Service (SMS)

The FX06 Field Controller can be programmed to send out text messages in SMS format when connected to a GSM modem with an appropriate transmitter and antenna. SMS messages can be sent to a telephone service center or directly to a mobile telephone. Messages are sent when an event goes into the active or alarm state and can be directed to a prioritized list of destinations.

Real-Time Clock

The FX06 controller has an embedded real-time clock that supports all real-time functions including the display of time and date on the user interface and the time stamping of events.

The real-time clock also enables the time scheduling of start and stop commands and setpoint changes to the plant that is being monitored and controlled. Scheduled commands may be configured to execute on one or more days of the week, and an exception day calendar allows for alternative time schedules on holidays or during special periods in the year. Time schedules may be displayed and edited on a remote user interface.

The real-time clock is battery backed with an average battery capacity of more than 10 days without power at room temperature.

Alarm Management

The FX06 controller detects and displays alarms that are associated with up to 20 data points or variables in the control application.

Application alarms indicate to the user that the controlled equipment requires attention or that the controlled conditions are not within the expected limits. Examples of alarms include:

- analog value is outside of a desired range
- status value represents a condition that is not normal

Active alarms may be viewed, acknowledged, or cleared via the integral or remote user interface.

Room Command Module

The Room Command Module is designed for use with the FX field controllers, including the FX06. All models feature an internal temperature sensor and a dial allowing the occupant to adjust the temperature setpoint value or request a warmer or cooler setpoint. Certain models also have a dial to enable the occupant to override the speed of a three-speed fan.

The push button and LED indicator are configurable within the application. A typical application is to configure the push button to allow initiation of a temporary occupancy period, at nights or weekends for example, and the LED to provide occupancy status indication.

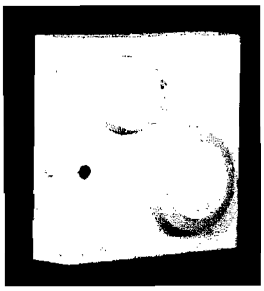


Figure 5: Room Command Module

The Room Command Module for North America is marked with dual temperature units (°F and °C).

FX Tools

FX Tools is a software suite used to program, download, test, and commission the Facility Explorer devices, including the FX06 field controller. FX Tools software is available in two versions: FX Tools Express and FX Tools Pro. They comprise one or more of the following, depending on the version:

- FX Builder Express: Used to select a standard application and configure it using a graphical user interface.
- FX Builder: Used to program an FX06 controller. FX Builder provides complete flexibility in programming the FX06 controller.
- FX CommPro: Used to download, test, and commission an FX06 controller on an N2 Open bus.
- FX CommPro LON: Used to download, test, and commission an FX06 controller on a LONWORKS network.

Programming Key

The FX06 is a fully programmable or configurable controller and the application can be downloaded to the controller via computer with FX Tools or uploaded/downloaded via the FX Programming Key.

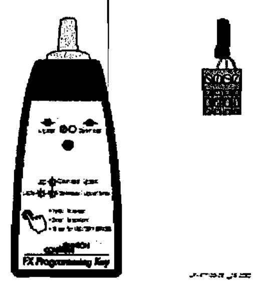


Figure 6: FX Programming Key

> **IMPORTANT:** Use this FX06 controller only as an operating control. Where failure or malfunction of the FX06 could lead to personal injury or damage to the controlled equipment or other property, additional precautions must be designed into the control system. Incorporate and maintain other devices such as supervisory or alarm systems or safety or limit controls that are intended to warn of, or protect against, failure or malfunction of the FX06 controller.

FX06 Field Controller Dimensions

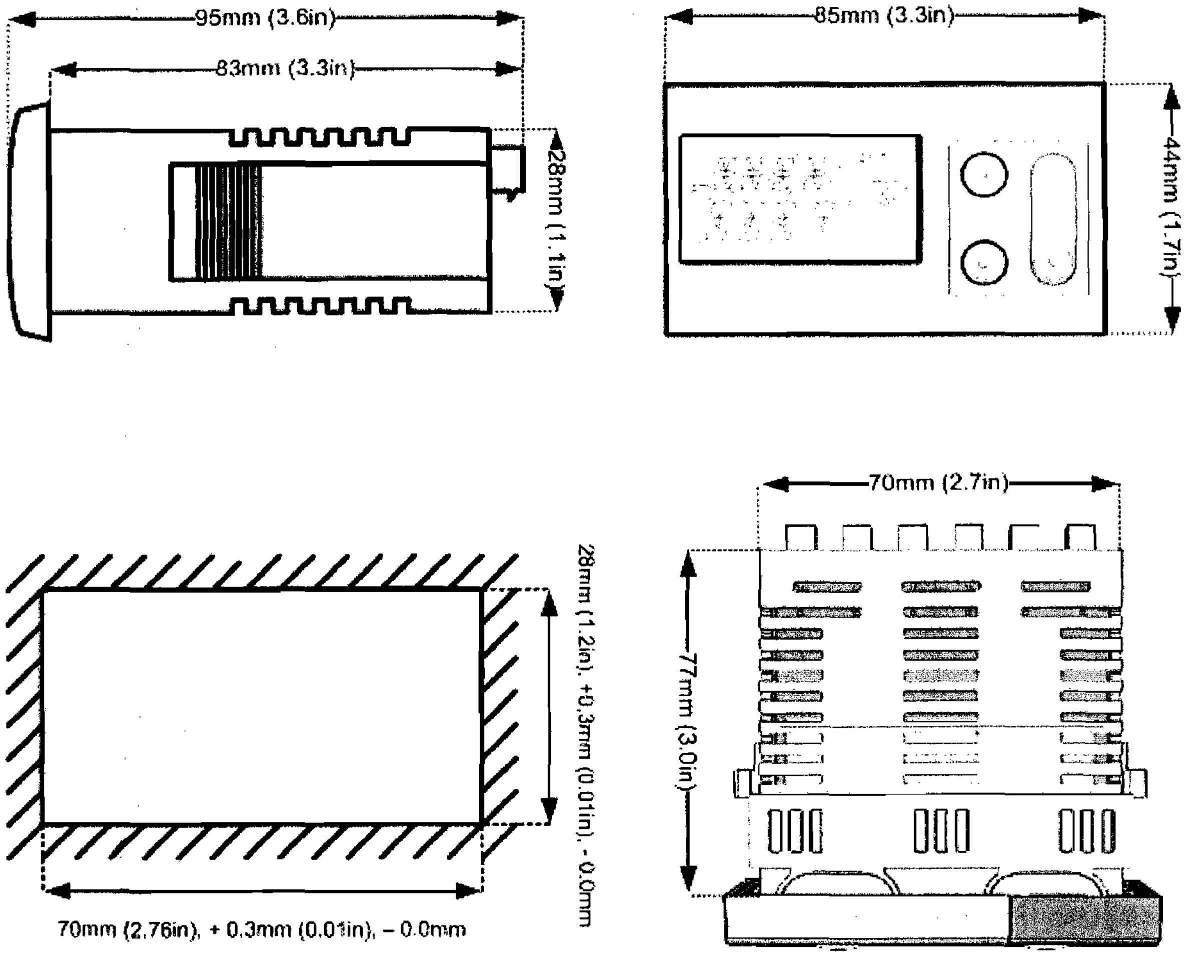


Figure 7: FX06 Controller and Panel Cut-Out Dimensions

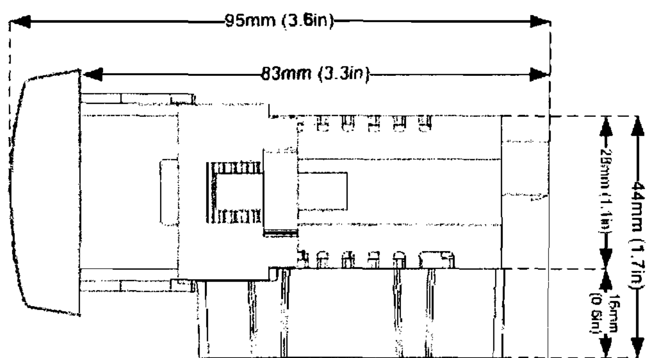


Figure 8: FX06 Dimensions Including Communication Module

Ordering Codes

Tables 1 through 6 give ordering information for the FX06 Controllers, FX06 Accessories, Room Command Modules and Configuration Software.

Table 1: FX06 Field Controller Ordering Information

Product Code Number	Description
LP-FX06P00-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (Relays)
LP-FX06P00-000D	FX06 Controller: 2 AOs (0-10V), 6 BOs (Relays), Bulk package
LP-FX06P01-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (Relays), N2 Open Module, 1 cable set
LP-FX06P02-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (Relays), LONWORKS Module, 1 cable set
LP-FX06P03-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (Relays), RS232C Module, 1 cable set
LP-FX06P10-000C	FX06 Controller: 2 AOs (1 0-10V,1 PWM (Factory setting)), 6 BOs (Relays)
LP-FX06P10-000D	FX06 Controller: 2 AOs (1 0-10V,1 PWM (Factory setting)), 6 BOs (Relays), Bulk Package
LP-FX06P11-000C	FX06 Controller: 2 AOs (1 0-10V,1 PWM (Factory setting)), 6 BOs (Relays), N2 Open Module, 1 cable set
LP-FX06P12-000C	FX06 Controller: 2 AOs (1 0-10V,1 PWM (Factory setting)), 6 BOs (Relays), LONWORKS Module, 1 cable set
LP-FX06P13-000C	FX06 Controller: 2 AOs (1 0-10V,1 PWM (Factory setting)), 6 BOs (Relays), RS232C Module, 1 cable set
LP-FX06P20-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (4 Relays, 2 Triacs)
LP-FX06P20-000D	FX06 Controller: 2 AOs (0-10V), 6 BOs (4 Relays, 2 Triacs), Bulk package
LP-FX06P21-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (4 Relays, 2 Triacs), N2 Open Module, 1 cable set
LP-FX06P22-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (4 Relays, 2 Triacs), LONWORKS Module, 1 cable set
LP-FX06P23-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (4 Relays, 2 Triacs), RS232C Module, 1 cable set
LP-FX06P30-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (3 Interlocked Relays, 1 Free Relay, 2 Triacs)
LP-FX06P30-000D	FX06 Controller: 2 AOs (0-10V), 6 BOs (3 Interlocked Relays, 1 Free Relay, 2 Triacs), Bulk package
LP-FX06P31-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (3 Interlocked Relays, 1 Free Relay, 2 Triacs), N2 Open Module, 1 cable set
LP-FX06P32-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (3 Interlocked Relays, 1 Free Relay, 2 Triacs), LONWORKS Module, 1 cable set
LP-FX06P33-000C	FX06 Controller: 2 AOs (0-10V), 6 BOs (3 Interlocked Relays, 1 Free Relay, 2 Triacs) RS232C Module, 1 cable set

Table 2: Communication Module Ordering Information

Product Code Number	Description
LP-NET061-000C	N2 Open Communication Module
LP-NET062-000C	LONWORKS® Communication Module
LP-NET063-000C	RS232C Communication Module

Table 3: Accessories Ordering Information

Product Code Number	Description
LP-KIT006-010C	Cable set for LP-FX06Px0-000C OEM models delivered without a cable set.
LP-KIT007-005C	*Link cable for the connection of the FX06 to the Panel Mount MUI display – 3 m (9.8 ft)*
LP-KIT100-000C	FX Programming Key
DT-9100-8901	Power Supply Adapter for Programming Key: 230 VAC/12 VDC

Table 4: Room Command Modules (80mm x 80mm, °C) Available in Europe

Product Code Number	Description
TM-2140-0000	Room Sensor Module, temperature sensor only
TM-2150-0000	Room Sensor Module, occupancy button and LED
TM-2160-0000	Room Sensor Module, 12-28°C setpoint dial, occupancy button and LED
TM-2160-0002	Room Sensor Module, 12-28°C setpoint dial, occupancy button and LED, fan speed override
TM-2160-0005	Room Sensor Module, +/- setpoint dial, occupancy button and LED
TM-2160-0007	Room Sensor Module, +/- setpoint dial, occupancy button and LED, fan speed override
TM-2190-0000	Room Sensor Module, 12-28°C setpoint dial
TM-2190-0005	Room Sensor Module, +/- setpoint dial

Table 5: Room Command Modules (80mm x 120mm, °F/°C) Available in North America

Product Code Number	Description
TM-2141-0000	Room Sensor Module, temperature sensor only
TM-2151-0000	Room Sensor Module, occupancy button and LED
TM-2161-0000	Room Sensor Module, 54-82°F/12-28°C setpoint dial, occupancy button and LED
TM-2161-0002	Room Sensor Module, 54-82°F/12-28°C setpoint dial, occupancy button and LED, fan speed override
TM-2161-0005	Room Sensor Module, +/- setpoint dial, occupancy button and LED
TM-2161-0007	Room Sensor Module, +/- setpoint dial, occupancy button and LED, fan speed override
TM-2191-0000	Room Sensor Module, 54-82°F/12-28°C setpoint dial
TM-2191-0005	Room Sensor Module, +/- setpoint dial

Table 6: User Interfaces Ordering Information

Product Code Numbers	Description
LP-DIS60P10-0C	Remote Medium User Interface (MUI) - Panel Mount
LP-DIS60P11-0C	Remote Medium User Interface (MUI) - Wall Mount

Table 7: Software Ordering Information

Product Code Number	Description
LP-FXTPRO-0	FX Tools Pro CD-Rom (FX Builder, FX Builder Express, FX CommPro N2, FX CommPro Lon)
LP-FXTEXP-0	FX Tools Express CD-Rom (FX Builder Express, FX CommPro N2)

Technical Specifications

Table 8: FX06 Field Controller (Part 1 of 2)

<table>
<tr><td>Product Codes</td><td colspan="3">LP-FX06xxx-xxxC</td></tr>
<tr><td>Power Requirements</td><td colspan="3">24 VAC/VDC ±15%, 50/60 Hz – SELV (Europe) – Class 2 North America</td></tr>
<tr><td>Power Consumption</td><td colspan="3">7 VA maximum</td></tr>
<tr><td>Housing Material</td><td colspan="3">ABS + polycarbonate, self-extinguishing: UL 94-5VB flammability rating</td></tr>
<tr><td>Protection Class</td><td colspan="3">Front Plate (when mounted in panel) IP55; Rear Enclosure IP20</td></tr>
<tr><td>Ambient Operating Conditions</td><td colspan="3">-20°C (-4°F) to 50°C (122°F)
10 to 95 % RH (noncondensing)</td></tr>
<tr><td>Ambient Storage Conditions</td><td colspan="3">-40°C (-40°F) to +70°C (158°F)
10 to 95 % RH (noncondensing)</td></tr>
<tr><td>Power Supply Outputs</td><td colspan="3">24VAC/DC for panel mount MUI (from controller power supply input)
15 VDC 20 mA power supply for active sensors
5 VDC 15 mA power supply for ratio-metric sensors</td></tr>
<tr><td rowspan="8">Analog Inputs</td><td colspan="3">16 bit resolution – not isolated</td></tr>
<tr><td>Sensor Type</td><td>Range</td><td>Accuracy at 20°C (68°F)
(sensor not included)</td></tr>
<tr><td>A99</td><td>-40 to 100°C (-40 to 212°F)</td><td>±0.5°C (±1°F)</td></tr>
<tr><td>NTC 10K</td><td>-20 to 70°C (-4 to 158°F)</td><td>±0.5°C (±1°F)</td></tr>
<tr><td>PT1000 Extended</td><td>-40 to 160°C (-40 to 320°F)</td><td>±1°C (±1.8°F)</td></tr>
<tr><td>Ni1000</td><td>-40 to 120°C (-40 to 248°F)</td><td>±1°C (±1.8°F)</td></tr>
<tr><td>Active Voltage</td><td>0-10 VDC</td><td>±0.1 VDC</td></tr>
<tr><td>Active Ratio-metric</td><td>0.5-4.5 VDC</td><td>±0.05 VDC</td></tr>
<tr><td>Display Range and Resolution</td><td colspan="3">-999 to 999 or -99.9 to 99.9</td></tr>
<tr><td>Digital Inputs:</td><td colspan="3">Voltage free contacts
Transition counter function on DI1 at 50Hz (minimum 10ms ON and minimum 10ms OFF)</td></tr>
<tr><td rowspan="2">Analog Outputs:</td><td colspan="2">0…10 VDC, max. 3 mA, 16 bit resolution - not isolated</td><td>For actuating and control devices</td></tr>
<tr><td colspan="2">Pulse Width Modulation (PWM) Signal at 100Hz cycle frequency with 15 VDC/10 mA reference signal</td><td>For fan speed controllers with PWM input</td></tr>
<tr><td colspan="4">Continued on next page . . .</td></tr>
</table>

FX06 Field Controller Technical Specifications (Part 2 of 2)

Relay Outputs	Dielectric test voltage on open relay contact: 1,000 VAC RMS Maximum relay switching rate at nominal load: 6 operations/min Rated circuit breaking capacity at 250 VAC: 500 VA			
Digital Outputs for Selected Models	**Model**	**Channel**	**Type**	**Remark/Application**
	FX06P0x / P1x	DO1 – DO6	SPST 3(1)A, 250 VAC relay	Each relay contact is independent with its own common terminal.
	FX06P2x / P3x	DO1, DO2	0.5A / 24 VAC triacs	3-point incremental actuators, thermal actuators, etc
		DO3 – DO6	SPST 3(1)A, 250 VAC relay	On the **FX06P2x** models, each relay contact is independent with its own common terminal. On the **FX06P3x** model, DO3, DO4, DO5 relays are physically interlocked such that only one output can be closed at one time. Application: 3-speed fan motors. The DO6 relay is independent.
Connections	Molex® connectors. Mating connectors and cables provided with controller or available to order. See *Order Codes*.			
Dimensions (H x W x D)	See Figures 5 and 6.			
Compliance	**Europe:** 73/23/EEC, Low Voltage Directive: EN 60730 89/336/EEC, EMC Directive: EN 61000-6-3, EN 61000-6-2 **United States:** FCC Compliant to CFR 47, Part 15, Subpart B, Class A **Canada:** Industry Canada, ICES-003			
UL/CSA Listing	**United States:** UL916, Energy Management Equipment Open (PAZX) and UL873 Recognized, Temperature Indicating and Regulating Equipment (XAPX2) **Canada:** UL916, Energy Management Equipment Open (PAZX7) and UL873 Recognized, Temperature Indicating and Regulating Equipment (XAPX8)			

The performance specifications are nominal and conform to acceptable industry standards. For application at conditions beyond these specifications, consult the local Johnson Controls office. Johnson Controls, Inc. shall not be liable for damages resulting from misapplication or misuse of its products.

JOHNSON CONTROLS

Controls Group Global Headquarters
507 E. Michigan Street
P.O. Box 423
Milwaukee, WI 53201

Published in U.S.A. and Europe

AVR 80 KVA

Brochure

JONCHN AUTOMATIC VOLTAGE REGULATOR (80KVA):

AVR – Automatic Voltage Regulators are used to protect sensitive loads from unstable mains and to provide proper operating of load.

Characteristics:

- High efficiency (above 98%)
- Non wave distortion
- Steady voltage regulation
- Suitable for any load (receptivity, capacity, sensible load)
- Support transient over-loading
- Continuous operation for a long time
- Manual/auto switch conveniently
- Over-voltage, over-current and many other protections

The main components of the equipment are a three-phase 'booster' transformer, a motorized autotransformer with continuously variable transformer ration (voltage regulator) and an electronic control circuit.

Such control circuit compares the output voltage value to the adjusted one. When the percentage variation is too high, the control drives the voltage regulator gear motor. By doing so the regulator rollers change their position thus varying the voltage drawn and supplied to the booster transformer primary winding.

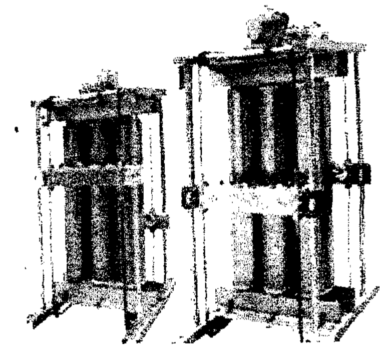
Being the secondary voltage of the booster transformer in phase or in position to the supply, the voltage drawn from the regulator is added or subtracted to the mains voltage, thus compensating its variations

MAIN TECHNICAL FEATURES

a. Input voltage bracket	304-456V
b. Output voltage	380(± 1-3%) to regulate
c. Stabilizing precision	1-5% to control
d. Working frequency	50 or 60Hz
e. Resistant intensity	AC 2000V
f. Insulating resistance	More than 2M Ω
g. Protection voltage of over-voltage	418 ± 3V
h. Protection voltage of lack-voltage	342± 3V

The AVR and its components (including wiring, lifting, shifting) was successfully installed, operated and commissioned by Mustehkam Construction and has been taken over by NPSL.

60 KVA Stabilizer



OVERVIEW

SBW,DBW Series Fully Automatic High Rated Compensatory A.C Stabilizer(hereafter named stabilizer)are designed to serve for A.C Voltage stable introducing and absorbing advanced technology. Automatic adjustment, stable output voltage when voltage wave caused by voltage fluction of outside power supply network or load changing.

This series stabilizer are suitable for any places voltage need to regulate, such as electric equipment, automatic manufacturing glide lines, testing equipment, moving staircase, medical equipment, computer rooms, middle air conditioner, life machine, whipping machine etc., which are separately used in the following departments: mine enterprise, oil field, railway, hospital, post office, hotel, building, science research etc.

FEATURES

- High efficiency(above 95%)
- No wave-aberration produce
- Placidity voltage regulation
- Suitable for any loading(block, holding, sensibility loading)
- Support short over-loading
- Working long duration
- Convenience control by hand/automatic switch operation
- Multi-function to protect over-voltage, over-current

FEATURES

Range of input voltage	304~456V
Output voltage	380V (±1~5% To CONTROL)
Regular precision	1~5% TO EXACT
Working frequency	50 OR 60HZ
Electricity-resistance strength	A.C 2000V
Insulated resistance	>2MΩ
Over-voltage protection	418±3V

FG Wilson Genset

Technical Manual

GENERATING SET
TECHNICAL OPERATION
AND MAINTENANCE MANUAL

Document: TPDCM3 - GB
Issue Date: 12/02
Part Number: 277-580

TABLE OF CONTENTS

1. INTRODUCTION

This generating set is one of a family of heavy duty industrial generating sets designed to be ready to run when it arrives, requiring only the addition of coolant, fuel and battery acid. Years of diesel generating set experience has gone into the set to produce a quality source of electrical power that is efficient and reliable.

This Technical Operation and Maintenance Manual has been prepared to assist in maintenance and operation of the generating set. Using this manual in conjunction with the Engine Manual, Alternator Manual and the Generating Set Operator's Manual, will help to ensure that the generating set keeps operating at maximum performance and efficiency for a long life. Please note that in dirty or dusty environments more attention must be paid to frequent servicing to keep the set running properly.

Always ensure that adjustments and repairs are done by personnel who are authorised to do the work and have been properly trained.

Every generating set is uniquely defined by a model number and serial number indicated on a rating plate generally affixed to the alternator housing. This information is required when ordering spare parts or when service or warranty work is required. See Section 3.1 for further information.

2. SAFETY

2.1 General

The generating set is designed to be safe when used in the correct manner. Responsibility for safety, however, rests with the personnel who install, use and maintain the set. The following safety precautions, if followed, will minimise the possibility of accidents. Before performing any procedure or operating technique, it is up to the user to ensure that it is safe. The generating set should only be operated by personnel who are authorised and trained.

WARNING:

! Read and understand all safety precautions and warnings before operating or performing maintenance on the generating set.

! Failure to follow the instructions, procedures, and safety precautions in this manual may increase the possibility of accidents and injuries.

! Never start the generating set unless it is safe to do so.

! Do not attempt to operate the generating set with a known unsafe condition.

! If the generating set is unsafe, fit danger notices and disconnect the battery negative (-) lead so that it cannot be started until the condition is corrected.

! Disconnect the battery negative (-) lead prior to attempting any repairs or cleaning inside the enclosure, if equipped.

! Install and operate this generating set only in full compliance with relevant National, Local, or Federal Codes, Standards or other requirements.

2.2 Installation, Handling, and Towing

Chapter 4 of this manual covers procedures for installation, handling, and towing of generating sets. That chapter should be read before installing the generating set, moving/lifting the generating set, or towing a mobile set. The following safety precautions should be noted:

WARNING:

! Make electrical connections in compliance with relevant Electrical Codes, Standards or other requirements. This includes requirements for grounding and ground/earth faults.

! For stationary generating sets with remote fuel storage systems, make sure such systems are installed in compliance with relevant Codes, Standards or other requirements.

! Engine exhaust emissions are hazardous to personnel. The exhaust for all indoor generating sets must be piped outdoors via leak-free piping in compliance with relevant Codes, Standards and other requirements. Ensure hot exhaust silencers, piping and turbochargers, if equipped, are clear of combustible material and are guarded for personnel protection per safety requirements. Ensure that fumes from the exhaust outlet will not be a hazard.

! Never lift the generating set by attaching to the engine or alternator lifting lugs. Use a sling with a "spreader bar" connected to the baseframe.

! Ensure the lifting rigging and supporting structure is in good condition and has a capacity suitable for the load.

! Keep all personnel away from the generating set when it is suspended.

! Make sure all personnel are out of the generating set canopy or container, if equipped, before closing and latching enclosure doors.

! When towing a mobile generating set, observe all Codes, Standards or other regulations and traffic laws. These include those regulations specifying required equipment and maximum and minimum speeds. Ensure brakes, if fitted, are in good order.

! Do not permit personnel to ride in or on the mobile generating set. Do not permit personnel to stand or ride on the drawbar or to stand or walk between the generating set and the towing vehicle

! Do not install or use the generating set in any classification of hazardous environment unless it has been specifically designed for that environment.

2.3 Fire and Explosion

Fuels and fumes associated with generating sets can be flammable and potentially explosive. Proper care in handling these materials can dramatically limit the risk of fire or explosion. However, safety dictates that fully charged BC and ABC fire extinguishers are kept on hand. Personnel must know how to operate them.

WARNING:

! Ensure the generating set room is properly ventilated.

! Keep the room, the floor and the generating set clean. When spills of fuel, oil, battery electrolyte or coolant occur, they should be cleaned up immediately.

! Never store flammable liquids near the engine.

! Store oily rags in covered metal containers.

! Do not smoke or allow sparks, flames or other sources of ignition around fuel or batteries. Fuel vapours are explosive. Hydrogen gas generated by charging batteries is also explosive.

- Turn off or disconnect the power to the battery charger before making or breaking connections with the battery.
- Keep grounded conductive objects, such as tools, away from exposed live electrical parts, such as terminals, to avoid arcing. Sparks and arcing might ignite fuel or vapours.
- Avoid refilling the fuel tank while the engine is running.
- Do not attempt to operate the generating set with any known leaks in the fuel system.
- The excessive build-up of unburned fuel gases in the exhaust system can create a potentially explosive condition. This build-up can occur after repeated failed start attempts, air flap valve testing, or hot engine shutdown. Open exhaust system purge plugs, if equipped, and allow the gases to dissipate before attempting to restart the generating set.

2.4 Mechanical

The generating set is designed with guards for protection from moving parts. Care must still be taken to protect personnel and equipment from other mechanical hazards when working around the generating set.

WARNING:

- Do not attempt to operate the generating set with safety guards removed. While the generating set is running do not attempt to reach under or around the guards to do maintenance or for any other reason.
- Keep hands, arms, long hair, loose clothing and jewellery away from pulleys, belts and other moving parts.

  Attention: Some moving parts can not be seen clearly when the set is running.
- Keep access doors on enclosures, if equipped, closed and locked when not required to be open.
- Avoid contact with hot oil, hot coolant, hot exhaust gases, hot surfaces and sharp edges and corners.
- Wear protective clothing including gloves and hat when working around the generating set.
- Do not remove the radiator filler cap until the coolant has cooled. Then loosen the cap slowly to relieve any excess pressure before removing the cap completely.
- Ethyl Ether starting aids **must not** be used on engines with combustion air preheating devices or on engines manufactured by the Detroit Diesel Corporation (DDC). In general these starting aids are not recommended on any engine. They will reduce the efficient working life of the engine.

2.5 Chemical

Fuels, oils, coolants, lubricants and battery electrolyte used in this generating set are typical of the industry. However, they can be hazardous to personnel if not treated properly.

WARNING:

- Do not swallow or have skin contact with fuel, oil, coolant, lubricants or battery electrolyte. If swallowed, seek medical treatment immediately. Do not induce vomiting if fuel is swallowed. For skin contact, wash with soap and water.
- Do not wear clothing that has been contaminated by fuel or lube oil.
- Wear an acid resistant apron and face shield or goggles when servicing the battery. If electrolyte is spilled on skin or clothing, flush immediately with large quantities of water.

2.6 Noise

Generating sets that are not equipped with sound attenuating enclosures can produce noise levels in excess of 105 dBA. Prolonged exposure to noise levels above 85 dBA is hazardous to hearing.

WARNING:

- Ear protection must be worn when operating or working around an operating generating set.

2.7 Electrical

Safe and efficient operation of electrical equipment can be achieved only if the equipment is correctly installed, operated and maintained.

WARNING:

- The generating set must be connected to the load only by trained and qualified electricians who are authorised to do so, and in compliance with relevant Electrical Codes, Standards and other regulations. Where required, their work should be inspected and accepted by the inspection agency prior to operating the generating set.
- Ensure the generating set, including a mobile set, is effectively grounded/earthed in accordance with all relevant regulations prior to operation.
- The generating set should be shutdown with the battery negative (-) terminal disconnected prior to attempting to connect or disconnect load connections.
- Do not attempt to connect or disconnect load connections while standing in water or on wet or soggy ground.
- Do not touch electrically energised parts of the generating set and/or interconnecting cables or conductors with any part of the body or with any non insulated conductive object.
- Replace the generating set terminal box cover as soon as connection or disconnection of the load cables is complete. Do not operate the generating set without the cover securely in place.
- Connect the generating set only to loads and/or electrical systems that are compatible with its electrical characteristics and that are within its rated capacity.
- Be sure all electrical power is disconnected from electrical equipment being serviced.
- Keep all electrical equipment clean and dry. Replace any wiring where the insulation is cracked, cut, abraded or otherwise degraded. Replace terminals that are worn, discoloured or corroded. Keep terminals clean and tight.
- Insulate all connections and disconnected wires.
- Use only Class BC or Class ABC extinguishers on electrical fires.

2.8 First Aid For Electric Shock

WARNING:

! Do not touch the victim's skin with bare hands until the source of electricity has been turned off.

- Switch off power, if possible.
- Otherwise pull the plug or pull the cable away from the victim.
- If this is not possible, stand on dry insulating material and pull the victim clear of the conductor, preferably using insulated material such as dry wood.
- If victim is breathing, turn the victim into the recovery position described below.
- If victim is unconscious, perform resuscitation as required:

OPEN THE AIRWAY:

1. Tilt the victim's head back and lift the chin upwards.
2. Remove objects from the mouth or throat (including false teeth, tobacco, or chewing gum).

BREATHING:

1. Check that the victim is breathing by looking, listening and feeling for the breath.

CIRCULATION:

1. Check for pulse in the victim's neck.

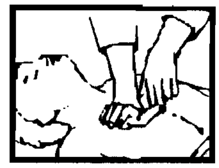
IF NO BREATHING BUT PULSE IS PRESENT:

1. Pinch the victim's nose firmly.
2. Take a deep breath and seal your lips around the victim's lips.
3. Blow slowly into the mouth watching for the chest to rise. Let the chest fall completely. Give breaths at a rate of 10 per minute.

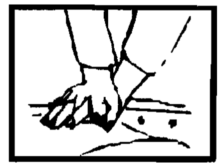
4. If the victim must be left to get help, give 10 breaths first and then return quickly and continue.
5. Check for pulse after every 10 breaths.
6. When breathing restarts, place the victim into the recovery position described later in this section.

IF NO BREATHING AND NO PULSE:

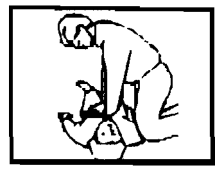
1. Call or telephone for medical help.
2. Give two breaths and start chest compression as follows:



3. Place heel of hand 2 fingers breadth above ribcage/breastbone junction.
4. Place other hand on top and interlock fingers.

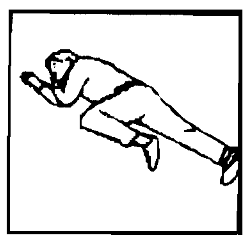


5. Keeping arms straight, press down 4-5 cm (1.5-2 inch) 15 times at a rate of 80 per minute.
6. Repeat cycle (2 breaths, 15 compressions) until medical help takes over.



7. If condition improves, confirm pulse and continue with breaths. Check for pulse after every 10 breaths.
8. When breathing restarts, place the victim into the recovery position described below.

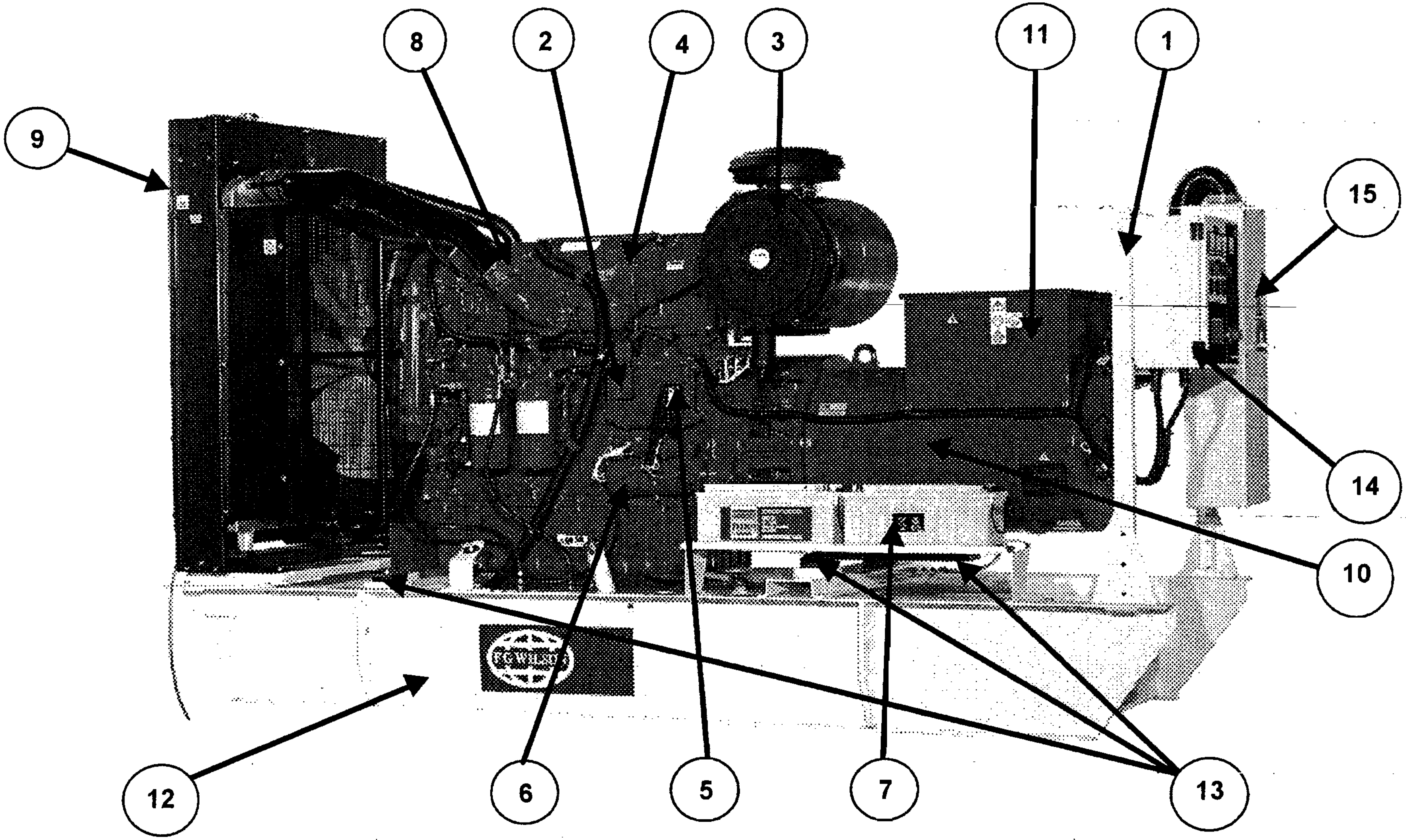
RECOVERY POSITION:



1. Turn the victim onto the side.
2. Keep the head tilted with the jaw forward to maintain the open airway.
3. Make sure the victim cannot roll forwards or backwards.
4. Check for breathing and pulse regularly. If either stops, proceed as above.

WARNING:

! Do not give liquids until victim is conscious.



Item	Description
1.	Generating Set Rating Label (generally affixed on rear of panel stand)
2.	Diesel Engine
3.	Air Filter
4.	Turbo Charger (if equipped)
5.	Engine Governor
6.	Starter Motor
7.	Battery/Battery Rack
8.	Battery Charging Alternator(located on reverse side)
9.	Radiator
10.	Alternator
11.	Terminal Box
12.	Baseframe and Fuel Tank
13.	Vibration Isolators
14.	Control Panel
15.	Output Circuit Breaker

Figure 3.1: Typical Generating Set Configuration

3. GENERAL DESCRIPTION

3.1 Generating Set Description and Identification

This generating set has been designed as a complete package to provide superior performance and reliability. Figure 3.1 identifies the major components. This figure is of a typical generating set. However, every set will be slightly different due to the size and configuration of the major components. This section briefly describes the parts of the generating set. Further information is provided in later sections of this manual.

Each generating set is provided with a Rating Label (item 1) generally affixed to the alternator housing. This label contains the information needed to identify the generating set and its operating characteristics. This information includes, but is not limited to, the model number, serial number, output characteristics such as voltage, phase and frequency, output rating in kVA and kW, and rating type (basis of the rating). For reference, this information is repeated on the Technical Data Sheet provided with this manual. The model and serial numbers uniquely identify the generating set and are needed when ordering spare parts or obtaining service or warranty work for the set.

3.2 Diesel Engine

The diesel engine powering the generating set (item 2) has been chosen for its reliability and the fact that it has been specifically designed for powering generating sets. The engine is of the heavy duty industrial type with 4 stroke or 2 stroke compression ignition and is fitted with all accessories to provide a reliable power supply. These accessories include, among others, a cartridge type dry air filter (item 3), a turbocharger fitted on some engines (item 4), and a mechanical or electronic close control engine speed governor (item 5).

3.3 Engine Electrical System

The engine electrical system is negative ground/earth and either 12 or 24 volts DC depending on the size of the set. This system includes an electric engine starter (item 6), battery and battery rack (item 7) which may also be located on the floor next to the set for some of the larger generating sets, and a battery charging alternator (item 8). Most sets are provided with lead-acid batteries which are discussed more fully in Section 10, however other types of batteries may be fitted if they had been specified.

3.4 Cooling System

The engine cooling system is comprised of a radiator (item 9), a high capacity pusher fan and a thermostat. The alternator has its own internal fan to cool the alternator components. Note that the air is "pushed" through the radiator so that the cooling air is drawn past the alternator, then past the engine and finally through the radiator.

3.5 Alternator

The output electrical power is normally produced by a screen protected and drip-proof, self-exciting, self-regulating, brushless alternator (item 10) fine tuned to the output of this generating set. Mounted on top of the alternator is a sheet steel terminal box (item 11).

3.6 Fuel Tank and Baseframe

The engine and alternator are coupled together and mounted on a heavy duty steel baseframe (item 12). Except for the largest sets, this baseframe includes a fuel tank with a capacity of approximately 8 hours operation at full load. An extended capacity fuel tank of approximately 24 hours operation may be fitted. Where a fuel tank is not provided with the baseframe, a separate fuel tank must be provided.

3.7 Vibration Isolation

The generating set is fitted with vibration isolators (item 13) which are designed to reduce engine vibration being transmitted to the foundation on which the generating set is mounted. These isolators are fitted between the engine/alternator feet and the baseframe. Alternately, on larger models the engine/alternator is rigidly mounted on the baseframe and the vibration isolators are supplied loose to be fitted between the baseframe and the foundation.

3.8 Silencer and Exhaust System

An exhaust silencer is provided loose for installation with the generating set. The silencer and exhaust system reduce the noise emission from the engine and can direct exhaust gases to safe outlets.

3.9 Control System (Identification)

One of several types of control systems and panels (item 14) may be fitted to control the operation and output of the set and to protect the set from possible malfunctions. Section 9 of this manual provides detailed information on these systems and will aid in identification of the control system fitted on the generating set.

3.10 Output Circuit Breaker

To protect the alternator, a suitably rated circuit breaker (item 15) selected for the generating set model and output rating is supplied mounted in a steel enclosure. In some cases the output circuit breaker may be incorporated in the automatic transfer system or control panel.

4. INSTALLATION, HANDLING, TOWING AND STORAGE

4.1 General

This section discusses factors important in the effective and safe installation of the generating set. Further information is available in the **Generating Set Installation Manual** which is available upon request.

4.2 Enclosures

Installation and handling is greatly simplified when the generating set has been equipped with an enclosure. Two basic types may be fitted. The first type is a close fitting canopy enclosure. This may be a weatherproof version or designed for sound attenuation. The other enclosure type is a walk-in type container, similar to a shipping container. It may also be weatherproof or sound attenuated.

These enclosures provide a self contained generating set system that is easily transportable and requires minimal installation. They also automatically give protection from the elements and protection from unauthorised access.

WARNING:

- ! **Make sure all personnel are out of the canopy or container, if equipped, before closing and latching enclosure doors.**
- ! **Before closing canopy or enclosure doors, ensure all obstructions (especially hands and fingers) are clear to prevent damage or injury.**

Because the canopied generating sets are easily transportable and may be installed and operated in a temporary location, many of the fixed installation details given in this chapter may not apply. The following considerations must be still given when temporarily installing the generating set:

- Locating the generating set where it will be protected from damage and away from exhaust fumes from other engines or other airborne contaminants such as dust, lint, smoke, oil mist or vapours.
- Locating the generating set on firm, level ground that will support the weight of the generating set and avoid movement due to the vibration of the operating set.
- Ensuring that fumes from the exhaust outlet will not be a hazard especially when wind is taken into account.
- Electrical grounding of the generating set at all times.
- Providing access to refill the fuel tank when required.
- Protecting electrical cables installed between the generating set and the load. If these are laid on the ground ensure they are boxed in or covered to prevent damage or injury to personnel.

If the enclosed generating set is installed inside a building, adequate fresh cooling air must be provided and the engine exhaust and hot coolant air exhaust must be ducted outside the building. The ducting and exhaust pipework must be designed to minimise back pressure which would have a detrimental effect on generating set performance.

4.3 Moving the Generating Set

The generating set baseframe is specifically designed for ease of moving the set. Improper handling can seriously damage components.

Using a forklift, the generating set can be lifted or carefully pushed/pulled by the baseframe. If pushing, do not push the baseframe directly with fork. Always use wood between forks and the baseframe to spread the load and prevent damage. If the set will be regularly moved, it should be fitted with the optional "Oil Field Skid" which provides fork lift pockets in the baseframe along with eyes for pulling. The smaller sets have fork lift pockets in the baseframe as standard.

WARNING:

! **Never lift the generating set by attaching to the engine or alternator lifting lugs.**

! **Ensure the lifting rigging and supporting structure is in good condition and is suitably rated.**

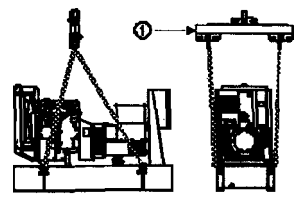
! **Keep all personnel away from the generating set when it is suspended.**

For ease of lifting, canopied sets have a single point lifting facility as standard.

For walk-in type enclosures lifting attachment is by means of corner fittings on the enclosure. Generating sets in these enclosures are fitted with restraining angles to rigidly attach the engine and alternator to the baseframe during transit. Ensure the restraints are fitted securely in place before moving the generating set. Once the generating set has been moved these restraints must be removed before attempting to operate the set.

For a single lift such as lifting the set to install it, the lift points provided on the baseframe may be used. Points of attachment should be checked for cracked welds or loose nuts and bolts before lifting. A spreader bar is required to prevent damaging the set (see Figure 4.1). It should be positioned over the centre of gravity (nearer the engine), not the centre of the set, to allow a vertical lift. Guide ropes should be used to prevent twisting or swinging of the set once it has been lifted clear of the ground - do not attempt to lift in high winds. Place the generating set down on a level surface capable of supporting its weight. This manner of lifting should only be used for a single lift for installation.

Generating sets to be air lifted by helicopter should be lifted by sling.



Item	Description
1.	Spreader Bar

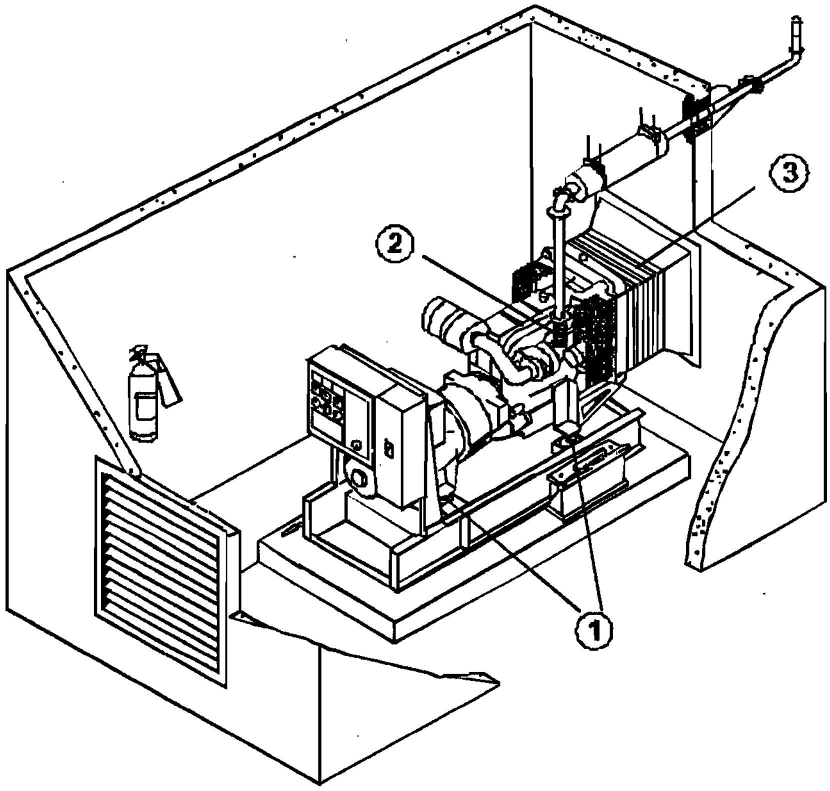
Figure 4.1: Proper Lifting Arrangement for Installing the Set

4.4 Location

Selecting a location for the generating set can be the most important part of any installation procedure. The following factors are important in determining the location:

- Adequate ventilation.
- Protection from the elements such as rain, snow, sleet, wind driven precipitation, flood water, direct sunlight, freezing temperatures, or excessive heat.
- Protection from exposure to airborne contaminants such as abrasive or conductive dust, lint, smoke, oil mist, vapours, engine exhaust fumes or other contaminants.
- Protection from impact from falling objects such as trees or poles, or from motor vehicles or lift trucks.
- Clearance around the generating set for cooling and access for service: at least 1 metre (3.3 feet) around the set and at least 2 metres (6.6 feet) headroom above the set.
- Access to move the entire generating set into the room. Air inlet and outlet vents can often be made removable to provide an access point.
- Limited access to unauthorised personnel.

If it is necessary to locate the generating set outside of the building, the generating set should be enclosed in a weatherproof canopy or container-type housing which is
available for all sets. These enclosures are also useful for temporary installations inside or outside the building.



Item	Description
1.	Vibration Isolators
2.	Flexible Exhaust Coupling
3.	Flexible Air Discharge Duct

Figure 4.2: Typical Installation Highlighting Vibration Reduction Techniques

4.5 Foundations and Vibration Isolation

The generating set is shipped assembled on a rigid baseframe that precisely aligns the alternator and engine and needs only be bolted down to a suitably prepared surface (see Figure 4.2).

4.5.1 Foundation: A reinforced concrete pad makes the best foundation for the generating set. It provides a rigid support to prevent deflection and vibration. Typically the foundation should be 150 mm to 200 mm (6 to 8 inches) deep and at least as wide and long as the generating set. The ground or floor below the foundation should be properly prepared and should be structurally suited to carry the weight of the foundation pad and the generating set. (If the generating set is to be installed above the ground floor the building structure must be able to support the weight of the generating set, fuel storage and accessories.) Relevant building codes should be consulted and complied with. If the floor may be wet from time to time, such as in a boiler room, the pad should be raised above the floor. This will provide a dry footing for the generating set and for those who connect, service or operate it. It will also minimise corrosive action on the baseframe.

4.5.2 Vibration Isolation: To minimise engine vibrations being transmitted to the building, the generating set is fitted with vibration isolators. On small and medium sized sets these isolators are fitted between the engine/alternator feet and the baseframe. This allows the frame to be rigidly bolted to the foundation. On larger sets the coupled engine/alternator is rigidly attached to the baseframe and the vibration isolators are supplied loose for fitting between the baseframe and the foundation. In all cases the sets should be securely bolted to the ground (either through the baseframe or through the vibration isolators) to prevent movement.

Vibration isolation is also required between the generating set and its external connections. This is achieved by use of flexible connections in the fuel lines, exhaust system, radiator air discharge duct, electrical conduit for control and power cables and other externally connected support systems (see Figure 4.2).

On mobile sets the generating set should be mounted using “captivation mounts”. These mounts minimise vibration and include a captivation feature that prevents the set breaking away in case of road accident.

4.6 Combustion Air Inlet

Air for engine combustion must be clean and as cool as possible. Normally this air can be drawn from the area surrounding the generating set via the engine mounted air filter.

However, in some cases due to dust, dirt, or heat, the air around the set is unsuitable. In these cases an inlet duct should be fitted. This duct should run from the source of clean air (outside the building, another room, etc.) to the engine mounted air filter. Do not remove the air filter and mount it at a remote location as this can increase the possibility of dirt leaking through the ductwork and into the engine inlet. To ensure that this type of installation will not have a detrimental effect on the operation of the generating set, the design of the inlet duct should be approved by the factory.

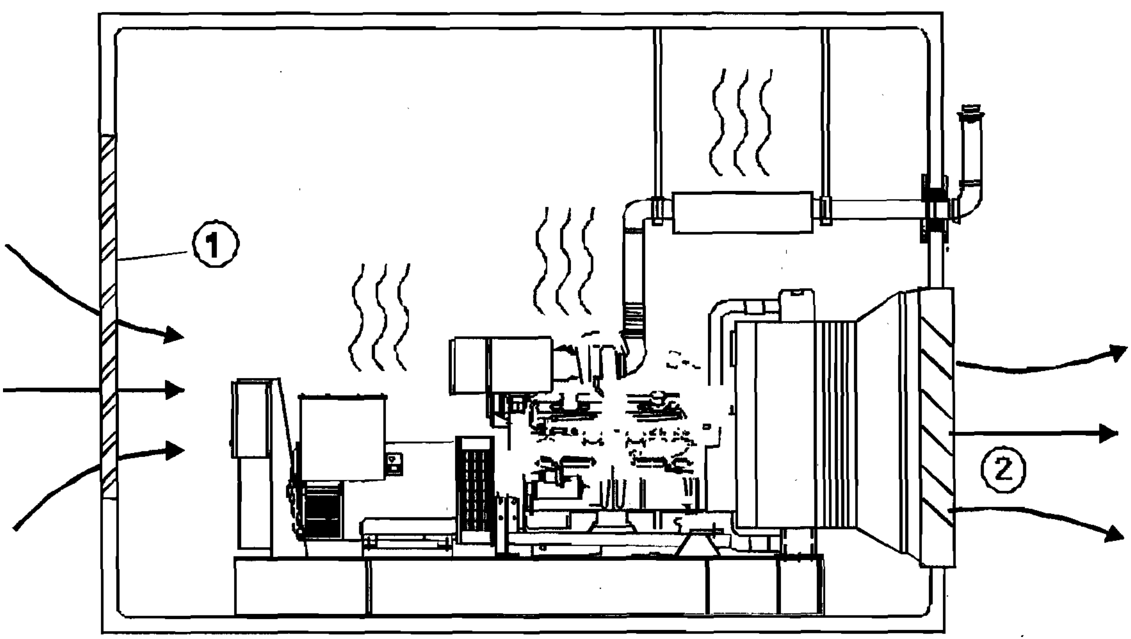
4.7 Cooling and Ventilation

The engine, alternator, and exhaust piping radiate heat which can result in a temperature high enough to adversely effect the performance of the generating set. It is therefore important that adequate ventilation is provided to keep the engine and alternator cool. Proper air flow, as shown in Figure 4.3, requires that the air comes in at the alternator end of the set, passes over the engine, through the radiator and out of the room via a flexible exhaust duct. Without the ducting of the hot air outside the room, the fan will tend to draw that hot air around and back through the radiator, reducing the cooling effectiveness.

The air inlet and exit openings should be large enough to ensure free flow of air into and out of the room. As a rough guide the openings should each be at least 1.5 times the area of the radiator core.

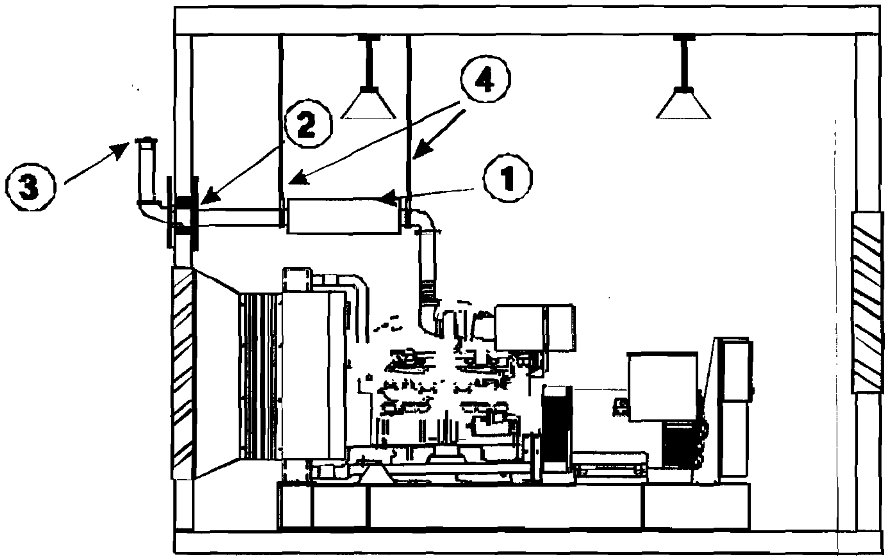
Both the inlet and exit openings should have louvres for weather protection. These may be fixed but preferably should be movable in cold climates so that while the generating set is not operating the louvres can be closed. This will allow the room to be kept warm which will assist starting and load acceptance. For automatic starting generating sets, if the louvres are movable they must be automatically operated. They should be programmed to open immediately upon starting the engine. The force of radiator air should not be depended upon to open the louvre vanes unless the system has been specifically designed for this.

When a remote radiator or heat exchanger cooling system is used, the radiated heat from the generating set must still be removed from the room.



Item	Description
1.	Air Inlet Opening
2.	Air Exit Opening

Figure 4.3: Air Ventilation



Item	Description
1.	Exhaust Silencer
2.	Wall Sleeve and Expansion Joint
3.	Rain Cap
4.	Silencer/Pipework Supports

Figure 4.4: Typical Exhaust System Installation

4.8 Exhaust

The purpose of the engine exhaust system is to direct the exhaust outside to a location and height where the fumes and odours will not become an annoyance or hazard, and to reduce noise. A suitable exhaust silencer must be incorporated into the exhaust piping to reduce the noise level from the engine. It can be fitted either inside or outside the building (see Figure 4.4). Canopied generating sets include exhaust system within the enclosure.

Open generating sets will generally be supplied with a loose industrial class silencer, a stub pipe and a bellows (if required). An optional "Overhead Mounting Kit" includes a bend, silencer support brackets and a bellows (if not standard). An optional "Silencer Installation Kit" includes the wall sleeve, bend and rain cap for directing the exhaust outside (see Figure 4.4). In all cases, the straight sections of pipe and screw rods for the support brackets are supplied by the customer.

WARNING:

! **Engine exhaust emissions are hazardous to personnel.**

! **The engine exhaust for all indoor generating sets must be piped outdoors via leak-free piping in compliance with relevant Codes, Standards and other requirements.**

! **Ensure hot exhaust silencers, piping and turbochargers, if fitted, are clear of combustible material and are guarded for personnel protection per safety requirements.**

! **Ensure that fumes from the exhaust outlet will not be a hazard.**

In designing an exhaust system, the primary consideration is to not exceed the allowable back pressure permitted by the engine manufacturer. Excessive back pressure seriously affects engine output, durability and fuel consumption. To limit the back pressure the exhaust piping should be as short and straight as possible. Any required bends should have a curve radius of at least 1.5 times the inside diameter of the pipe. Any designed exhaust extensions over 3 metres should be approved by the factory.

Other exhaust design criteria are as follows:

- Exhaust components including turbochargers can be very hot and must be guarded where they could be accidentally touched.
- A flexible connection between the exhaust manifold and the piping system should be used to prevent transmission of engine vibration to the piping and the building and to allow for thermal expansion and any slight misalignment of the piping. (See Figure 4.2)
- Ensure that the silencer and all pipes are well supported to limit strain on the connectors which could result in cracks or leaks.
- Exhaust system components located within the generator room should be insulated to reduce heat radiation and noise levels. Pipes and the silencer, whether located inside <u>or</u> outside the building, should be located well clear of any combustible material.
- Any long horizontal or vertical piping should slope away from the engine and include drain traps at their lowest points to prevent water from reaching the engine or silencer.
- On generating sets above 150 kVA the silencer installation must include a purge plug for venting of the exhaust system in the event of difficult starting. The plug should be located adjacent to the exhaust flange and positioned to allow access.
- Where the pipe goes through a wall there should be a sleeve in the opening to absorb vibration and isolate combustible material from the hot pipes (See Figure 4.4). There may also be an expansion joint in the pipe to compensate for lengthwise thermal expansion or contraction.
- The outer end of the exhaust pipe, if horizontal, should be cut at 60° to the horizontal or should be fitted with a rain hood or cap, if vertical, to prevent rain or snow from entering the exhaust system.
- The exhaust pipe must not be connected to exhausts from other generating sets or other equipment, such as a furnace or boiler.

4.9 Fuel System

The fuel system for the generating set must be capable of delivering a clean and continuous supply of fuel to the engine. For most installations, this will include a small day tank (usually incorporated in the baseframe), a bulk storage tank and the associated pumps and plumbing.

WARNING:

! **For stationary generating sets with remote fuel storage systems, make sure such systems are installed in compliance with relevant Codes, Standards or other requirements.**

! **Do not smoke or allow sparks, flames or other sources of ignition around fuel. Fuel vapours and oil vapours are explosive.**

4.9.1 Day Tank: Day tanks provide a readily available supply of fuel directly to the generating set and should therefore be located within the generator room. The steel baseframe of all but the largest sets are designed with a steel or polyethylene day tank built in with the engine fuel lines connected. These "basetanks" provide for at least 8 hours operation at full load or approximately 24 hours if an extended capacity basetank has been fitted.

<u>WARNING:</u>

! **Never connect a remote fuel system to polyethylene fuel tanks incorporated in the baseframe on smaller generating sets.**

4.9.2 Bulk Storage Tanks: For extended operation, a separate bulk fuel storage tank is required. Especially for standby generating sets it is not advisable to depend on regular delivery of fuel. The emergency that requires use of the standby set may also interrupt the delivery of fuel.

The bulk tank should generally be located outside the building where it will be convenient for refilling, cleaning and for inspection. It should not, however, be exposed to freezing weather because fuel flow will be restricted as viscosity increases with cold temperatures. The tank may be located either above or below ground.

A vent must be installed on the bulk tank to relieve the air pressure created by filling the tank or created by evaporation and expansion. It will also prevent a vacuum as the fuel is consumed. The tank bottom should be rounded and placed on a 2° tilt to assure a concentrated settling of water and sediment. A sludge drain valve should be installed at the low point to allow removal of water and sediment on a regular basis. Underground tanks should have this water and sediment pumped out regularly.

4.9.3 Fuel Lines: The fuel lines can be of any fuel compatible material such as steel pipe or flexible hoses that will tolerate environmental conditions.

WARNING:

! **Do not use galvanised pipe or fittings for the fuel system.**

Fuel delivery and return lines should be at least as large as the fitting sizes on the engine, and overflow piping should be one size larger. For longer runs of piping or low ambient temperatures the size of these lines should be increased to ensure adequate flow. Flexible piping should be used to connect to the engine to avoid damage or leaks caused by engine vibration.

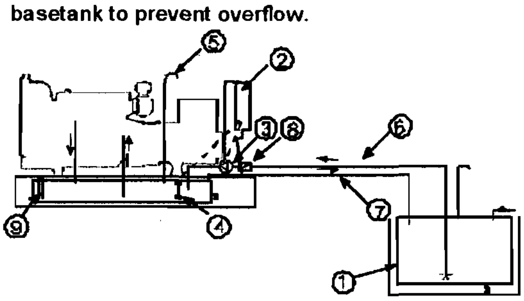
The fuel delivery line should pick up fuel from a point no lower than 50 mm (2") from the bottom at the high end of the tank (away from the drain plug).

4.9.4 Remote Fuel Systems: Most sets are supplied equipped with a diesel fuel tank in the baseframe. Certain installations, however, require the addition of remote fuel supplies. The manufacturer recommends the 5 types of systems detailed below. It must be noted that polyethylene fuel tanks are not compatible with remote fuel systems, so a metal fuel tank must be fitted.

Fuel System 1: For installations where the bulk tank is located below floor level a pumped fuel supply from the bulk tank to the basetank is required (see Figure 4.5).

The basetank must include an overflow, extended vent, sealed gauges and no manual fill. All other connections on top of the tank must be sealed to prevent leakage. A 2001 Series control system (or above) is required.

The position of the fuel tank should take into account that the maximum suction lift of the fuel transfer pump is 3 metres and that the maximum restriction caused by the friction losses in the return fuel line should not exceed 2 psi. A 1.4m extended vent pipe will be required on the basetank to prevent overflow.



Item	Description	Item	Description
1.	Below Floor Level Bulk Tank	6.	Supply Line
2.	Control Panel	7.	Return Line
3.	AC Fuel Pump	8.	Strainer
4.	Fuel Level Switches	9.	Level Gauge
5.	Extended Vent		

Figure 4.5: Typical Layout with Fuel System 1

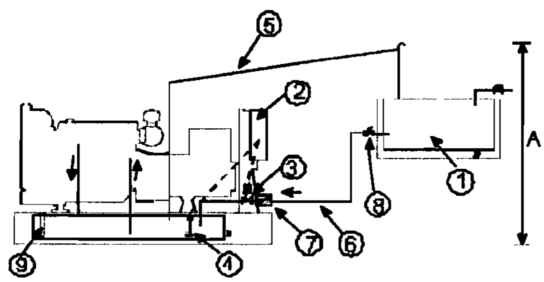
The manufacturer's kit for Fuel System 1 includes an AC fuel pump with mounting bracket, fuel strainer, 4 position float switch and controls for the fuel pump mounted in the generating set control panel. In addition, with this kit the basetank is modified by the removal of the manual fill facility. All other items including fuel lines, bulk tank, extended vent, etc. are supplied by the installer.

Fuel System 2: Where the location of the bulk tank is higher than the generating set, a gravity fuel supply from the bulk tank to the basetank is required (see Figure 4.6).

The basetank must include an overflow, extended vent, sealed gauges and no manual fill. All other connections on top of the tank must be sealed to prevent leakage. A 2001 Series control system (or above) is required.

"Distance "A" in Figure 4.6 is limited to 1400mm for all metal basetanks except for models P550E1 - P880E where this distance can be increased to 3700mm.

The manufacturer's kit for Fuel System 2 includes a DC motorised valve with mounting bracket, fuel strainer, 4 position float switch and controls for the motorised valve mounted in the generating set control panel. In addition, with this kit the basetank is modified by the removal of the manual fill facility. All other items including fuel lines, bulk tank, etc. are supplied by the installer.



Item	Description	Item	Description
1.	High Level Bulk Tank	6.	Supply Line
2.	Control Panel	7.	Strainer
3.	DC Motorised Valve	8.	Isolating Valve
4.	Fuel Level Switch	9.	Level Gauge
5.	Return Line (Continuous Rise)		

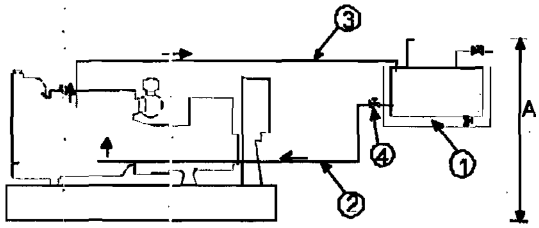
Figure 4.6: Typical Layout with Fuel System 2

Fuel System 3: It is possible to have the engine supplied directly from a high level bulk tank, bypassing the basetank incorporated in the baseframe (see Figure 4.7).

Distance 'A' in Figure 4.7 is limited to:

Model	Height
P27 - P275HE	3300mm
GEP30 - GEH200	3300mm
P300P1 - P550E1	4000mm
P600 - P880E	3700mm
P910 - P2200E	2500mm
Caterpillar (3500 Series)	3000mm
Paxman	3600mm

Note: These are maximum heights. These heights may need to be reduced depending on further restriction caused by pipeline sizes, length and obstruction in the return line.



Item	Description
1.	High Level Bulk Tank
2.	Supply Line
3.	Return Line
4.	Isolating Valve

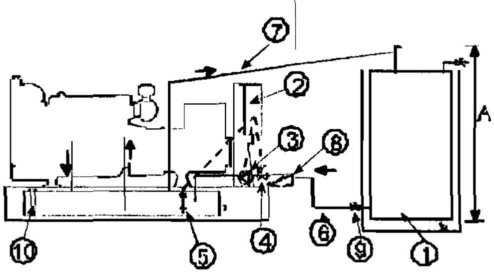
Figure 4.7: Typical Layout with Fuel System 3

Fuel System 4: Some installations may require a system where fuel is pumped from a free standing bulk tank (see Figure 4.8). This pumped system would only be used if gravity feed is not possible from the bulk tank to the basetank.

The basetank must include an overflow, extended vent, sealed gauges and no manual fill. All other connections on top of the tank must be sealed to prevent leakage. A 2001 Series control system (or above) is required.

"Distance "A" in Figure 4.8 is limited to 1400mm for all metal basetanks except models P550E1 - P880E where this distance is extended to 3700mm. Note that the maximum restriction caused by friction losses and height of the return line should not exceed 2 psi.

The manufacturer's kit for installing this system includes an AC fuel pump with mounting bracket, a DC motorised valve with mounting bracket, fuel strainer, 4 position float switch and controls for the fuel pump and motorised valve mounted in the generating set control panel. In addition, with this kit the basetank is modified by the removal of the manual fill facility. All other items including fuel lines, bulk tank, etc. are supplied by the installer.



Item	Description	Item	Description
1.	Above Ground Bulk Tank	6.	Supply Line
2.	Control Panel	7.	Return Line (Continuous Rise)
3.	AC Fuel Pump	8.	Strainer
4.	Motorised Valve	9.	Isolating Valve
5.	Fuel Level Switch	10.	Level Gauge

Figure 4.8: Typical Layout with Fuel System 4

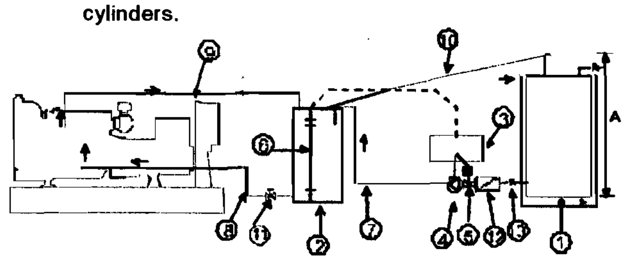
Fuel System 5: In some installations it is necessary to use a separate day tank supplied via a pumped system from a bulk tank (see Figure 4.9).

The day tank should be designed to take into account the head 'A' of the bulk tank and the friction losses in the overflow line. Normally the tank design head is approximately 3 metres although this will vary with each layout. The day tank should be designed generally in accordance with BS799 Part 5 to take account of the design head. The day tank should be positioned, relative to the engine, as per the following maximum limits.

Distance 'A' in Figure 4.9 is limited to:

Model	Height
P27 - P275HE	3300mm
P300P1 - P550E1	4000mm
P600 - P880E	3700mm
P910 - P2200E	2500mm
Caterpillar (3500 Series)	3000mm
Paxman	3600mm

In the event that the bulk tank overfills the day tank, engines with unit injector systems may experience leakage into the cylinders. It is essential that before restarting the engine this fuel is removed from the cylinders.



Item	Description	Item	Description
1.	Bulk Tank	8.	Supply Line to Engine
2.	Day Tank	9.	Return Line from Engine
3.	Fuel System Control Panel	10.	Overflow/Vent (Rising Continuously)
4.	AC Fuel Pump	11.	Isolating Valve
5.	DC Motorised Valve	12.	Strainer
6.	Fuel Level Switch	13.	Isolating Valve
7.	Supply Line to Day Tank		

Figure 4.9: Typical Layout with Fuel System 5

The exact specification for the manufacturers kit for this type of complex fuel system will vary depending on the installation. When designed, the kit will include pumps, valves, controls etc. and the installer will supply the fuel line, bulk tanks, vents etc.

4.10 Fire Precautions

When designing the generating set installation the following points should be considered:

- The room should be designed so that there is an easy escape route for operating personnel in the event of fire within the room.
- Supply a Class BC or Class ABC fire extinguisher and/or fire extinguishing system.
- Gravity operated fire valves released by temperature operated fusible links mounted above the engine can be installed in the fuel lines.

4.11 Starting Batteries

WARNING:

! Do not smoke or allow sparks, flames or other sources of ignition around batteries. Hydrogen gas generated by charging batteries is explosive.

The starting batteries should be located as close as possible to the generating set while still being accessible for servicing. This will prevent electrical losses from long cables that could impact on the engine starting capability of the batteries. See Section 10.

4.12 Electrical Connection

Onsite electrical installation will generally consist only of connecting up the site load to the generating set output terminals. Only fully qualified and experienced electrical technicians should carry out electrical installation, service and repair work.

WARNING:

! **Make electrical connections in compliance with relevant Electrical Codes, Standards or other requirements. This includes requirements about grounding and ground/earth faults.**

4.12.1 Cabling: Due to movement of generating sets on their vibration mounts, the electrical connection to the set should be made with flexible cable. This will prevent transmission of vibrations and possible damage to the alternator or circuit breaker terminals. If flexible cabling can not be used throughout the installation then a link box should be installed close to the set with a flexible connection to the set.

The cable should be protected by laying it in a duct or cable tray. However, the duct or tray should never be rigidly connected to the generating set. When bending cable, reference must be made to the recommended minimum bending radius.

The cable must be suitable for the output voltage of the generating set and the rated current of the set. In determining the size, allowances should be made for ambient temperature, method of installation, proximity of other cables, etc. When single core cables are used the gland plates must be of non-ferrous material such as aluminium, brass or a non-metallic material such as tufnol. Alternatively slots can be cut between gland holes of cables to prevent circulating (eddy) currents in magnetic gland plates.

All connections should be carefully checked for integrity. Phase rotation must be checked for compatibility with the installation. This is vitally important when connection is made to an automatic transfer switch, or if the machine is to be paralleled.

4.12.2 Protection: The cables connecting the generating set with the distribution system are protected by means of a circuit breaker to automatically disconnect the set in case of overload or short circuit.

4.12.3 Loading: When planning the electrical distribution system it is important to ensure that a balanced load is presented to the generating set. If loading on one phase is substantially higher than the other phases it will cause overheating in the alternator windings, imbalance in the phase to phase output voltage and possible damage to sensitive 3 phase equipment connected to the system. Ensure that no individual phase current exceeds the current rating of the generating set. For connection to an existing distribution system, it may be necessary to reorganise the distribution system to ensure these loading factors are met.

4.12.4 Power Factor: The power factor (cos Φ) of the connected load should be determined. Power factors below 0.8 lagging (inductive) can overload the generator. The set will provide its kilowatt rating and operate satisfactorily from 0.8 lagging to unity power factor (1.0).

Particular attention must be given to installations with automatic or manual power factor correction equipment such as capacitors to ensure that a leading power factor is never present. This will lead to voltage instability and may result in damaging overvoltages. Generally, whenever the generating set is supplying the load any power factor correction equipment should be switched off.

4.12.5 Grounding Requirements: Regulations vary for different locations. The frame of the generating set must be positively connected to an earth ground. Since the set is mounted on vibration isolators, the ground connection must be flexible to avoid possible breakage due to vibration. On the majority of self contained sets the ground connection is located inside the circuit breaker box.

Ground connection cables or straps should have at least full load current carrying capacity and meet applicable regulations.

4.12.6 Alternator Reconnection: Most alternators can be reconnected to suit different output voltages. The reconnection procedures are given in the Alternator Manual. Ensure that all other components such as circuit breakers, current transformers, cables and ammeters are suitable before operating at a different voltage.

4.12.7 Parallel Running: Extra equipment must be fitted for the standard generating sets to be operated in parallel with other generating sets or with mains power.

4.12.8 Insulation Test: Before starting the generating set after installation, test the insulation resistance of the windings. The Automatic Voltage Regulator (AVR) should be **disconnected** and the rotating diodes either shorted out with temporary links or disconnected. Any control wiring must also be disconnected.

A 500V Megger or similar instrument should be used. Disconnect any earthing conductor connected between neutral and earth and megger an output terminal to earth. The insulation resistance should be in excess of 5MΩ to earth. Should the insulation resistance be less than 5MΩ the winding must be dried out. See the Alternator Manual for procedures.

4.13 Acoustic Silencing

Control of generating set noise is becoming very important in most installations. There is a range of options available to control the noise level.

WARNING:

! **Ear protection must be worn when operating or working around an operating generating set.**

4.13.1 Exhaust Silencers: As discussed in Section 4.8 the exhaust silencer will decrease sound levels from the engine. Varying degrees of sound attenuation are available from different types of silencers. These levels are often described by terms such as industrial, residential, critical or supercritical.

4.13.2 Enclosures: Section 4.2 discusses enclosures that are available in either weatherproof or sound attenuating versions. These enclosures can be designed to meet a specific sound level requirement.

4.13.3 Other Sound Attenuation: For installations in buildings there are other types of equipment such as acoustic louvers, splitter vents and fan silencers, as well as sound absorbing wall coverings, that can be used to reduce the noise levels of generating sets.

4.14 Towing (Portable Generating Sets)

4.14.1 Preparing to Tow: Inspect all components of the coupling equipment on the towing vehicle and the generating set for defects such as excessive wear, corrosion, cracks, bent metal, or loose bolts. Ensure that the towing vehicle is rated for towing a load of at least the weight of the mobile generating set plus a 10% safety factor.

Couple the towing vehicle to the trailer and ensure the coupling device is engaged, closed and locked. Attach electrical connector for indicator lights, etc. Attach chains, if provided, by crossing them under the drawbar and attaching to the towing vehicle. Attach any "break away" safety wire, if fitted.

Fully retract the front screw jack, if equipped, and secure with the pin or locking device. Lock the front castor wheel, if equipped, in the full up position. Ensure that the rear stabiliser jacks, if equipped, are raised and locked.

Inspect tyres for condition and proper inflation. Check all tail lights, if equipped, are operating properly and that all reflectors are clean and functional.

Ensure load and grounding/earthing cables are disconnected and that all windows, access doors, and tool box covers are closed, latched and locked. Ensure any external fuel pipes are disconnected.

Release trailer parking brakes, if equipped, and remove any blocks or chocks under the wheels.

4.14.2 Towing: Whenever towing a mobile generating set, remember that the set may approach or exceed the weight of the towing vehicle so manoeuvrability and stopping distance will be affected.

WARNING:

- ! **When towing a mobile generating set, observe all Codes, Standards or other regulations and traffic laws. These include those regulations specifying required equipment and maximum and minimum speeds.**
- ! **Ensure brakes, if fitted, are in good order.**
- ! **Do not permit personnel to ride in or on the mobile generating set. Do not permit personnel to stand or ride on the drawbar or to stand or walk between the generating set and the towing vehicle.**

Avoid gradients in excess of 15° (27%) and avoid potholes, rocks or other obstructions and soft or unstable terrain.

Ensure the area behind and under the mobile set is clear before reversing.

4.14.3 Parking: Park the set on a dry level area that can support it's weight. If it must be located on a slope, park it across the grade so that it does not tend to roll downhill. Do not park the set on grades exceeding 15° (27%).

Set the parking brake and block or chock both sides of all wheels. Lower front screw jack, castor wheel and/or rear stabiliser jacks, as fitted.

Unhook chains, if equipped, from the towing vehicle, disconnect electrical connection, disconnect the coupling device and move the towing vehicle clear of the mobile generating set.

4.15 Storage

Long term storage can have detrimental effects on both the engine and alternator. These effects can be minimised by properly preparing and storing the generating set.

4.15.1 Engine Storage: The engine should be put through an engine "preservation" procedure that includes cleaning the engine and replacing all the fluids with new or preserving fluids. See the Engine Manual for the proper procedure.

4.15.2 Alternator Storage: When an alternator is in storage, moisture tends to condense in the windings. To minimise condensation, store the generating set in a dry storage area. If possible use space heaters to keep the windings dry.

After removing the generating set from storage, perform an insulation check as discussed in Section 4.12.8. If the readings are lower than prior to storage, it may be necessary to dry out the windings. See the Alternator Manual for procedures.

If the megger reading is below 1MΩ after drying, the insulation has deteriorated and should be reconditioned.

4.15.3 Battery Storage: While the battery is stored, it should receive a refreshing charge every 12 weeks (8 weeks in a tropical climate) up to a fully charged condition.

5. OPERATION

5.1 General

The generating set is equipped with an advanced electronic control system. This will be one of a range of systems such as a 1001, 2001, 4001 or 4001E control system. See Section 9 of this manual to identify which system is fitted on the generating set and for a functional description of each.

These control systems allow the operator to manually or automatically control the generating set. They have protection circuits to sound an optional alarm and even shutdown the set if problems occur. Details of the capabilities of each system are contained in Section 9.

The following procedures detail the steps required to prepare the set for operation, start and stop it for the first time after installation, and start and stop it normally. Section 5.2, Pre-Start Checks are applicable with all control systems. Section 5.3 and 5.4 cover operation of the Keystart Control Systems (1001 Series). Section 5.5, 5.6 and 5.7 cover operation of the Autostart Control Systems (2001, 4001 and 4001E Series).

5.2 Pre-Start Checks (applicable to all control systems)

The following checks should be performed prior to starting the generating set:

WARNING:

! **For generating sets in walk-in type enclosures ensure that all vibration isolator restraints are removed before starting the generating set.**

! **As generating sets with autostart control panels (2001 Series or above) can be remotely started without warning, always ensure the control panel is switched off before carrying out any checks.**

1. Ensure the Control Switch/Key Switch is Off.

WARNING:

! **Do not remove the radiator cap when the coolant is hot. Do not add large amounts of cold coolant to a hot system as serious damage could result.**

2. Check the engine oil and coolant levels - replenish as necessary.

Note:

- Diesel engines normally consume lube oil at a rate of .25% to 1% of the fuel consumption.
- When adding coolant to the radiator system, always pour slowly to help prevent air from becoming trapped in the engine.

WARNING:

! **When filling the fuel tank, do not smoke or use an open flame in the vicinity.**

3. Check the fuel level - fill as necessary.

WARNING:

! **Before tightening fan belts, disconnect the battery negative (-) lead to ensure the engine cannot be accidentally started.**

4. Check the condition and tension of the fan and engine alternator belts - tighten as necessary.
5. Check all hoses for loose connections or deterioration - tighten or replace as necessary.
6. Check the battery terminals for corrosion - clean as necessary.

WARNING:

! **When working with the batteries, do not smoke or use an open flame in the vicinity. Hydrogen gas from batteries is explosive.**

! **Do not short the positive and negative terminals together.**

7. Check the battery electrolyte level - fill with distilled water as necessary. If the battery is new and has never been wet charged, fill with suitable premixed electrolyte and charge as per instructions in Section 10.2.2.
8. Check the control panel and the generating set for heavy accumulation of dust and dirt - clean as necessary. These can pose an electrical hazard or give rise to cooling problems.
9. Check the air filter restriction indicator, if fitted - replace the filter as necessary.
10. Clear the area around the generating set of any insecure items that could inhibit operation or cause injury. Ensure cooling air ventilation screens are clear.
11. Visually check the entire generating set for signs of leaks from the fuel system, cooling system or lubrication seals.
12. Periodically drain exhaust system condensate traps, if equipped.
13. Ensure the Alternator Output Circuit Breaker is in the "OFF" (handle down) position.

5.3 Initial Startup/Shutdown - Key Start Panel (1001 Series)

The following procedure should be used when starting a generating set equipped with a 1001 Series Key Start Control System for the first time or when it has been out of service for a time for maintenance purposes:

Note:

- The generating set may be stopped at any time by turning the Key Switch to Position "O" (Off).

1. Complete Pre-Start checks as per Section 5.2.
2. Connect the batteries to the engine, positive lead first then the negative lead.
3. Prime the lube oil system by first removing one wire from the fuel solenoid or actuator. This prevents the engine from starting. Then crank the engine by turning the Key Switch to Position "↷" (Start) for 5 to 7 seconds. Return the Key Switch to Position "O" (Off). Repeat the cranking attempt up to 4 times, if required, until oil pressure is registered on the gauge. Should the oil pressure still not have built up after 4 cranking attempts, investigate the reason for lack of oil pressure prior to further cranking. Reconnect the wire to the fuel solenoid or actuator.

WARNING:

! **Excessive cranking with an unprimed fuel system may cause a build-up of unburned fuel gases in the exhaust system which could be potentially explosive.**

4. Prime the fuel system using the hand priming pump and bleed entrapped air from the fuel filter - see Engine Manual for details.

5. **Start:** Turn the Key Switch from Position "O" (Off) through Position "I" (On) to Position "" (Thermo) to activate the thermostart, if fitted. Hold for 7 seconds to preheat the induction air. After this time, the Key Switch should be further turned to Position "" (Start) to crank the engine. When the engine starts, release the Key Switch immediately allowing it to return to Position "I" (On).

   Do not crank the engine for more than 5 to 7 seconds should the engine fail to start. Allow an interval of 10 seconds and always turn Key Switch to Position "O" (Off) between cranking attempts. If, after 4 cranking attempts, the engine still has not started, refer to the trouble shooting guide in Section 9 or the Engine Manual to determine the cause of failure to start.

WARNING:

! **Unburned fuel gases can build-up in the exhaust system after multiple failed attempted starts. Unscrew the plugs on the exhaust outlet elbows or stub pipes and allow the unburned fuel to dissipate. Once all signs of unburned fuel (white smoke) have disappeared and any other problems causing the failure to start have been rectified, replace the plugs and repeat the cranking procedure.**

WHEN ENGINE HAS STARTED

6. After approximately 1 minute shutdown the generating set by turning the Key Switch to Position "O" (Off). Remove the radiator cap and wait 5 minutes for the system to settle and any trapped air to escape. Re-check the coolant level and refill as necessary.

Note:

- A newly filled coolant system can have air locks that must be cleared by running the engine for a short time and the system refilled prior to extended running of the engine.

7. Restart the engine following the procedure in step 5 above.

8. Check for any abnormal noise or vibration.

9. Check for fluid leakage or leaks in the exhaust system.

10. Check the control panel for indications of abnormal operation, particularly abnormally high temperature or abnormally low oil pressure. The oil pressure should be in the normal range within about 10 seconds of starting.

11. Check the control panel for output voltage and frequency. The voltage is factory set and should indicate the rated voltage. The **no load** frequency is approximately 52 Hz for 50 Hz units and approximately 62 Hz for 60 Hz units. Adjustments should only be carried out by a qualified technician.

    Three means of voltage adjustment are available:-

    Fine adjustment is achieved by varying the setting of the speed potentiometer on the control panel, if fitted.

    Coarse adjustment is achieved by varying the setting of a potentiometer mounted inside the automatic voltage regulator which is fitted to the alternator terminal box.

    Gross adjustment to completely change the voltage setting of the alternator is achieved by reconnecting the alternator windings at the alternator terminal box. Details of these connections can be found in the Alternator Manual.

WARNING:

! **Do not close the circuit breaker during the phase rotation check if load cables have already been connected.**

12. While the generating set is producing voltage, check the phase rotation of the set by connecting a phase rotation meter to the terminals on the generator side of the circuit breaker. This check should be carried out by a qualified technician.

13. **Shutdown:** To shutdown the generating set turn the Key Switch to Position "O" (Off).

WARNING:

! **Always switch off the circuit breaker, shut down the generating set and disconnect the battery negative (-) lead prior to connection or disconnection of the load cables.**

14. The load cables can now be connected to the generating set in preparation for normal operation.

5.4 Normal Startup/Shutdown - Key Start Panel (1001 Series)

The following procedure should be used for subsequent starts on a generating set equipped with a 1001 Series Key Start Control System:

Note:

- The generating set may be stopped at any time by turning the Key Switch to Position "O" (Off).

1. Complete Pre-Start checks as per Section 5.2.

2. Check the battery voltage by turning the Key Switch from Position "O" (Off) to Position "I" (On) and reading the battery voltmeter. A fully charged battery will indicate 12 to 14 volts on a 12 volt system or 24 to 28 volts on a 24 volt system. Return the Key Switch to Position "O" (Off).

Note:

- The engine will not start if any fault indicators are illuminated. Reset the control system by turning the Key Switch to Position "O" (Off). Ensure the faults have been corrected prior to attempting to start the generating set.

WARNING:

! **The Key Switch must not be turned to position "" or position "", while the engine is running.**

3. **Start:** Turn the Key Switch from Position "O" (Off) through Position "I" (On) to Position "**ΩΩΩ**" (Thermo) to activate the thermostart, if fitted. Hold for 7 seconds to preheat the induction air. After this time, the Key Switch should be further turned to Position "**↻**" (Start) to crank the engine. When the engine starts, release the Key Switch immediately allowing it to return to Position "I" (On).

   Do not crank the engine for more than 5 to 7 seconds should the engine fail to start. Allow an interval of 10 seconds and always turn the Key Switch to Position "O" (Off) between cranking attempts. If, after 4 cranking attempts, the engine still has not started, refer to the trouble shooting guide in Section 9 or the Engine Manual to determine the cause of failure to start.

WARNING:

! **Unburned fuel gases can build-up in the exhaust system after multiple failed attempted starts. Unscrew the plugs on the exhaust outlet elbows or stub pipes and allow the unburned fuel to dissipate. Once all signs of unburned fuel (white smoke) have disappeared and any other problems causing the failure to start have been rectified, replace the plugs and repeat the cranking procedure.**

WHEN ENGINE HAS STARTED

4. Check for any abnormal noise or vibration.
5. Check for fluid leakage or leaks in the exhaust system.
6. Check the control panel for indications of abnormal operation, particularly abnormally high temperature or abnormally low oil pressure. The oil pressure should be in the normal range within about 10 seconds of starting.
7. Switch the Alternator Output Circuit Breaker to "ON" (handle up).

Note:

- Load can now be applied to the generating set. However the maximum step load that can be accepted in any one step is dependent on the operating temperature of the set. With the generator cold (not more than 20°C (68°F)) the maximum step load acceptance is approximately 50% of rated output. However with the set at normal operating temperature (approximately 80°C (176°F)) the maximum step load can be 70-100% of the rated load depending on the generating set model. Typically generating sets up to 100 kVA can accept a 100% load.

8. **Shutdown:** To shut the generating set down, turn off the load by switching the Alternator Output Circuit Breaker to "OFF" (handle down). Allow the generating set to run without load for a few minutes to cool. Then turn the Key Switch to Position "O" (Off). The generating set will shutdown.

   In case of an emergency where immediate shutdown is necessary, the Key Switch should be turned to Position "O" (Off) immediately without disconnecting the load.

Note:

- Turning the Key Switch to Position "O" (Off) will also reset the protective circuits after a fault has been detected. Ensure that the fault has been rectified prior to restarting the generating set.

5.5 Initial Startup/Shutdown - Autostart Panel (2001, 4001, or 4001 E Series)

The following procedure should be used when manually starting a generating set equipped with a 2001, 4001 or 4001E Series Autostart Control System for the first time or when it has been out of service for a time for maintenance purposes:

Note:

- The generating set may be stopped at any time by pushing the Emergency Stop Pushbutton or turning the Control Switch to "STOP".
- Pressing the Emergency Stop Pushbutton also illuminates the "OVERSPEED" fault lamp even though an overspeed has not occurred. Prior to restarting the set, the Emergency Stop Pushbutton must be released by turning it clockwise. The fault lamp must also be reset by turning the Control Switch to "STOP".

1. Complete Pre-Start checks as per Section 5.2.
2. Connect the batteries to the engine, positive lead first then the negative lead.
3. Prime the lube oil system by first removing one wire from the fuel solenoid or actuator. This prevents the engine from starting. Turn the Control Switch to "RUN". The engine will automatically crank. When oil pressure is registered on the gauge, turn the Control Switch back to "OFF" and reconnect the wire to the fuel solenoid or actuator. Should the oil pressure still not have built up after 3 automatic cranking attempts and illumination of the "FAIL TO START" fault lamp, investigate the reason for lack of oil pressure prior to further cranking attempts.

WARNING:

! **Excessive cranking with an unprimed fuel system may cause a build-up of unburned fuel gases in the exhaust system which could be potentially explosive.**

4. Prime the fuel system using the hand priming pump and bleed entrapped air from the fuel filter - see Engine Manual for details.
5. **Start:** Ensure the Emergency Stop Pushbutton and any remote Stop Pushbuttons are released. Turn the Control Switch to "RUN". If the engine is cold, prior to turning the Control Switch to "RUN" push in the thermostart button, if fitted, for 15 seconds and then turn the Control Switch to "RUN". Continue holding the thermostart button in until the engine fires.

   The engine will automatically crank up to 3 times or until the engine fires. If the engine does not fire, the control system locks-out on "FAIL TO START" and illuminates a fault lamp on the control panel. If this happens refer to the trouble shooting guide in Section 9 or the Engine Manual to determine the cause of failure to start.

WARNING:

! **Unburned fuel gases can build-up in the exhaust system after multiple failed attempted starts. Unscrew the plugs on the exhaust**

outlet elbows or stub pipes and allow the unburned fuel to dissipate. Once all signs of unburned fuel (white smoke) have disappeared and any other problems causing the failure to start have been rectified, replace the plugs and repeat the cranking procedure.

WHEN ENGINE HAS STARTED

6. After approximately 1 minute shutdown the generating set by pressing the Emergency Stop Pushbutton or by turning the Control Switch to "STOP". Remove the radiator cap and wait 5 minutes for the system to settle and any trapped air to escape. Re-check the coolant level and refill as necessary.

Note:

- A newly filled coolant system can have air locks that must be cleared by running the engine for a short time and the system refilled prior to extended running of the engine.

7. Restart the engine following the procedures in step 5 above.
8. Check for any abnormal noise or vibration.
9. Check for fluid leakage or leaks in the exhaust system.
10. Check the control panel for indications of abnormal operation, particularly abnormally high temperature or abnormally low oil pressure. The oil pressure should be in the normal range within about 10 seconds of starting.
11. Check the control panel for output voltage and frequency. The voltage is factory set and should indicate the rated voltage. The **no load** frequency is approximately 52 Hz for 50 Hz units and approximately 62 Hz for 60 Hz units. Adjustments should only be carried out by a qualified technician.

    Three means of voltage adjustment are available:-

    Fine adjustment is achieved by varying the setting of a speed Potentiometer on the control panel, if fitted.

    Coarse adjustment is achieved by varying the setting of a Potentiometer mounted inside the automatic voltage regulator which is fitted to the alternator terminal box.

    Gross adjustment to completely change the voltage setting of the alternator is achieved by reconnecting the alternator windings at the alternator terminal box. Details of these connections can be found in the Alternator Manual.

WARNING:

! **Do not close the circuit breaker during the phase rotation check if load cables have already been connected.**

12. While the generating set is producing voltage, check the phase rotation of the set by connecting a phase rotation meter to the terminals on the generator side of the circuit breaker. This check should be carried out by a qualified technician.
13. **Shutdown:** To shutdown the generating set press the Emergency Stop Pushbutton or turn the Control Switch to "STOP".
14. To check any remote start facilities ensure the Emergency Stop Pushbutton and any remote Stop Pushbuttons are released and turn the Control Switch to "AUTO".

    Apply the remote start signal and the engine should automatically go through its startup sequence as previously described. Remove the remote start signal and the engine should stop.

Note:

- On 4001 and 4001E Series Control System a Run On Timer will allow the set to run for a short duration to cool prior to stopping automatically.

  To shutdown the generating set remove the remote start signal, press the Emergency Stop Pushbutton or turn the Control Switch to "STOP".

WARNING:

! **Always switch off the circuit breaker, shut down the generating set and disconnect the battery negative (-) lead prior to connection or disconnection of the load cables.**

15. The load cables can now be connected to the generating set in preparation for normal operation.

5.6 Normal Manual Startup/Shutdown - Autostart Panel (2001, 4001 or 4001E Series)

The following procedure should be used for subsequent manual starts on a generating set equipped with a 2001, 4001 or 4001E Series Autostart Control System:

Note:

- The generating set may be stopped at any time by pushing the Emergency Stop Pushbutton or turning the Control Switch to "STOP".
- Pressing the Emergency Stop Pushbutton also illuminates the "OVERSPEED" fault lamp even though an overspeed has not occurred. Prior to restarting the set, the Emergency Stop Pushbutton must be released by turning it clockwise. The fault lamp must also be reset by turning the Control Switch to "STOP".

1. Complete Pre-Start checks as per Section 5.2.

Note:

- The engine will not start if any fault indicators are illuminated. Reset the control system by turning the Control Switch to "STOP". Ensure the faults have been corrected prior to attempting to start the generating set.

2. **Manual Start:** Ensure the Emergency Stop Pushbutton and any remote Stop Pushbuttons are released. Turn the Control Switch to "RUN". If the engine is cold, prior to turning the Control Switch to "RUN" push in the thermostart button, if fitted, for 15 seconds and then turn the Control Switch to "RUN". Continue holding the thermostart button in until the engine fires.

   The engine will automatically crank up to 3 times or until the engine fires. If the engine does not fire, the control system locks-out on "FAIL TO START" and illuminates a fault lamp on the control panel. If this happens refer to the trouble shooting guide in Section 9 or the Engine Manual to determine the cause of failure to start.

WARNING:

! **Unburned fuel gases can build-up in the exhaust system after multiple failed attempted starts. Unscrew the plugs on the exhaust outlet elbows or stub pipes and allow the unburned fuel to dissipate. Once all signs of unburned fuel (white smoke) have disappeared and any other problems causing the failure to start have been rectified, replace the plugs and repeat the cranking procedure.**

WHEN ENGINE HAS STARTED

3. Check for any abnormal noise or vibration.
4. Check for fluid leakage or leaks in the exhaust system.
5. Check the control panel for indications of abnormal operation, particularly abnormally high temperature or abnormally low oil pressure. The oil pressure should be in the normal range within about 10 seconds of starting.
6. Switch the Alternator Output Circuit Breaker to "ON" (handle up).

Note:

- Load can now be applied to the generating set. However the maximum step load that can be accepted in any one step is dependent on the operating temperature of the set. With the generator cold (not more than 20°C (68°F)) the maximum step load acceptance is approximately 50% of rated output. However with the set at normal operating temperature

  (approximately 80°C (176°F)) the maximum step load can be 70-100% of the rated power depending on the generating set model. Typically generating sets up to 100 kVA can accept a 100% load.

7. **Shutdown:** To shut the generating set down, turn off the load by switching the Alternator Output Circuit Breaker to "OFF" (handle down). Allow the generating set to run without load for a few minutes to cool. Then turn the Control Switch to "STOP". The generating set will shutdown.

   In case of an emergency where immediate shutdown is necessary, the Emergency Stop Pushbutton should be pushed immediately without disconnecting the load.

5.7 Automatic Startup/Shutdown - Autostart Panel (2001, 4001 or 4001E Series)

The following procedure should be used for preparing a generating set equipped with a 2001, 4001 or 4001E Series Autostart Control System to be started from a remote location.

Note:

- The generating set may be stopped at any time by pushing the Emergency Stop Pushbutton or turning the Control Switch to "STOP".
- Pressing the Emergency Stop Pushbutton also illuminates the "OVERSPEED" fault lamp even though an overspeed has not occurred. Prior to restarting the set, the Emergency Stop Pushbutton must be released by turning it clockwise. The fault lamp must also be reset by turning the Control Switch to "STOP".

1. Complete Pre-Start checks as per Section 5.2.

Note:

- The engine will not be able to start if any fault indicators are illuminated. Reset the control system by turning the Control Switch to "STOP". Ensure the faults have been corrected prior to attempting to start the generating set.

2. **Automatic Start:** Ensure the Emergency Stop Pushbutton and any remote Stop Pushbuttons are released. Turn the Control Switch to "AUTO".
3. Switch the Alternator Output Circuit Breaker to "ON" (handle up).

The generating set is now ready to automatically start when it receives a remote start signal. When the start signal is removed it will automatically stop.

Note:

- On 4001 and 4001E Series Control Systems a Run On Timer will allow the set to run for a short duration to cool prior to stopping automatically.

6. GENERATING SET MAINTENANCE

6.1 General

A good maintenance programme is the key to long generating set life. Maintenance and service should only be carried out by qualified technicians. Records of this work should be kept to aid in developing an efficient maintenance programme.

In general, the generating set should be kept clean. Do not permit liquids such as fuel or oil film to accumulate on any internal or external surfaces or on, under or around any acoustic material, if fitted. Wipe down surfaces using an aqueous industrial cleaner. Do not use flammable solvents for cleaning purposes.

Any acoustic material with a protective covering that has been torn or punctured should be replaced immediately to prevent accumulation of liquids or oil film within the material.

6.2 Preventative Maintenance

Depending on the application of the generating set, requirement for preventative maintenance will vary. The preventative maintenance requirements associated with the engine are detailed in the Engine Manual which should be reviewed in conjunction with this section. Maintenance intervals for the engine may be more frequent than those shown in this section.

6.2.1 Daily or at Each Startup: (For standby sets these procedures may be performed weekly.) A walk around inspection should be performed on a daily basis and prior to starting the engine. The pre-start checks contained in Section 5.2 should be performed during this walk around. Procedures for performing the checks on the engine can be found in the Engine Manual which may contain additional requirements to those in Section 5.2.

6.2.2 Every Two Weeks: (For standby sets that have not been run.) Perform an operational check on the generating set by starting and running the set for only 5 minutes.

WARNING:

! **Do not run diesel engines at low loads for long periods.**

6.2.3 Every Month: (For standby sets that have not been run on load.) Perform an operational and load check on the generating set by starting and running the set on at least 50% load for 1 to 2 hours.

6.2.4 Every Six Months or 250 Hours: Repeat the daily procedures plus the following:

1. Check all control system safety devices by electrically simulating faults.
2. Clean all battery cap vents.
3. Tighten all exhaust connections.
4. Tighten all electrical connections.
5. Perform other engine maintenance as specified in the Engine Manual.
6. Start the engine and observe the instrument panel to ensure that all gauges and meters are operating properly.
7. If a spark arrestor has been fitted, this should be removed and thoroughly cleaned to remove any carbon build-up.

6.2.5 Alternator Preventative Maintenance: There is no routine maintenance required on the alternator, however periodic inspection of the alternator winding condition and periodic cleaning is recommended. See Section 8.2, Alternator Maintenance, and the Alternator Manual.

6.2.6 Engine Preventative Maintenance: See the Engine Manual provided with this manual for information on regular maintenance required to keep the engine operating efficiently.

6.3 Removal of Engine and/or Alternator

The following procedures should be used for removal of the engine and/or alternator.

1. Isolate and disconnect electrical power supply to auxiliary equipment such as a water heater.
2. Isolate the battery charger supply. Disconnect the battery (negative lead first) and remove if necessary.
3. If the generating set is equipped with a canopy, remove the fixing bolts on each side, disconnect the exhaust system and then remove the canopy.
4. Isolate and disconnect the control panel and remove together with stand from the generating set, ensuring that all cables have been adequately identified to facilitate reconnection.
5. If the engine and alternator are both to be removed, they may be lifted out as one unit using the lifting eyes provided on both the engine and alternator. First the bolts holding the engine/alternator to the baseframe have to be removed.

6.3.1 Engine Removal Only:

1. If only the engine is to be removed, the wiring loom should first be removed from the engine.
2. If the alternator is fitted with only one set of feet then the front end of the alternator will have to be firmly supported before removing the engine.
3. Remove the bolts holding the engine to the base. It may also be advantageous to loosen the alternator mounting bolts.
4. Remove the alternator fan guards.
5. Support the rotor assembly using a sling or wooden supports taking care not to damage the fan.
6. Remove the bolts between the flexible coupling and the engine flywheel.
7. Support the rear of the engine using an overhead crane or similar device.
8. Remove the coupling housing bolts.
9. The engine is now moved forward until it is clear of the alternator and may be lifted away from the base.

6.3.2 Alternator Removal Only:

1. If the alternator only is to be removed, the rear of the engine must be firmly supported.
2. Remove the wiring loom.
3. Remove the bolts holding the alternator to the baseframe. Loosen the engine bolts as well.
4. Remove the alternator fan covers and support the rotor and the front of the alternator. Ensure that the rotor is positioned with a pole at the bottom centre line. This is to avoid any damage to the bearing or exciter by limiting the rotor movement to that of the air gap.
5. Uncouple the alternator from the engine as per Section 6.3.1.
6. Support the alternator using a sling or similar device and slide the complete alternator back on the base before lifting.

7. ENGINE DESCRIPTION AND MAINTENANCE

7.1 Engine Description

7.1.1 General: The engine that powers the generating set is an industrial, heavy duty diesel engine that has been selected for its reliability and efficiency in operation. It is specifically designed and optimised to power generating sets. The engine is either a 4 stroke or 2 stroke compression ignition type with all the accessories necessary to provide a reliable power supply. Full details of the engine and associated equipment is provided in the Engine Manual. This section gives a brief discussion of the major systems and how they are integrated into the generating set.

If regular preventative maintenance is performed as per the Engine Manual, the diesel engine will continue to provide reliable power for many years.

7.1.2 Cooling System: The engine cooling system is comprised of a radiator, high capacity pusher fan, a mechanically driven water pump and a thermostat. The fan is a pusher type that pushes the air through the radiator. This system provides for cooling of the surface heat of the engine and alternator, and internal cooling of the engine by the water circulating in the radiator. The alternator also has an integral fan that circulates cool air inside the housing. The thermostat maintains coolant temperature at a level for efficient operation of the engine.

It is important to pay careful attention to air flow around the generating set to ensure proper cooling. Following the installation instructions in Section 4.7 should ensure satisfactory performance.

7.1.3 Engine Governing: The engine governor is either a mechanical or electronic device designed to maintain a constant engine speed in relation to load requirements. The engine speed is directly related to the frequency of the alternator output, so any variation in engine speed will effect the frequency of the power output.

The governor senses engine speed and controls the fuel rate. As load increases on the alternator the governor will increase fuel flow to the engine. As load is reduced the governor reduces fuel flow.

For 2806/2306 engines, droop mode can be obtained by linking cables 317 & 318. These cables are located beside the Electronic Control Module (this should be carried out by a qualified technician).

7.1.4 Fuel System: On most generating sets, the engine fuel system is connected directly to a fuel tank that is built into the baseframe. This tank is designed to provide sufficient fuel for approximately 8 hours operation at full load unless an extended capacity tank has been fitted. In this case approximately 24 hours operation is possible.

The basetank is provided with fittings to facilitate either manual or automatic filling from a larger bulk storage tank. See Section 4.9 for a discussion of the entire fuel system.

On larger sets, the baseframe does not include a fuel tank so the engine fuel system must be connected to a separate tank located next to the set.

7.1.5 Exhaust System: Exhaust systems are provided to reduce the noise level of the engine and to direct the exhaust gases to where they will not be a hazard.

On smaller sets the exhaust silencer and piping are mounted directly on the engine. On larger engines the exhaust system is supplied loose for installation on site.

7.1.6 Air Flap Valve: An air flap valve, if fitted, prevents overspeeds due to ingestion of gas or fumes by cutting off the air supply. Functional testing of these combustion air intake valves should not be performed on engines on load. A functional test should only be carried out when the engine is not running. If it is necessary to demonstrate air valves closing when the engine is running this should be done at no load. The engine should absolutely **not** be restarted immediately afterwards.

WARNING:

! **The closing of the air flap valve while the engine is running can cause oil carry over into the exhaust system which is highly volatile. The engine should be left for a period of time to allow these gases to dissipate.**

7.1.7 Starting Aids: Ethyl Ether starting aids are not recommended. They will reduce the efficient working life of the engine.

7.2 Engine Maintenance

The Engine Manual supplied with this manual contains detailed information on maintaining the engine. It also includes a comprehensive Trouble Shooting guide for engine faults.

7.3 Radiator Maintenance

7.3.1 General Notes: Corrosion in the radiator can be a prime cause of failure. This is prompted by air in the water. Always ensure pipe connections are free of leaks and bleed air from top of the radiator regularly to keep the system "air free".

Radiators should not be left standing in a partially filled condition. Radiators left partly filled with water will suffer much more rapidly from the effects of corrosion. For an inoperative generating set, either drain the radiator completely or ensure that it is maintained full. Wherever possible, radiators should be filled with distilled or naturally soft water, dosed with suitable corrosion inhibitors.

WARNING:

! **Radiator coolant is normally very hot and under pressure. Do not work on the radiator or disconnect pipework until it has cooled. Do not work on the radiator or remove any guarding while the fan is in motion.**

7.3.2 External Cleaning: In dusty or dirty conditions the radiator fins can become blocked with loose debris, insects, etc. and this fouling will have an effect on the performance of the radiator.

For regular removal of light deposits use a low pressure steam jet. More difficult deposits may need a detergent with a low pressure hot water hose. Spray steam jet or water from the front of the radiator towards the fan. Spraying in the opposite direction will force debris further into the core. Covering the engine/alternator during this process will keep them clean.

Stubborn deposits, which cannot be removed by the above methods may require removal of the radiator and immersion in a heated alkali degreasing solution for about 20 minutes and then washing off with a hot water hose.

7.3.3 Internal Cleaning: If, due to leaky joints for instance, indiscriminate topping-up with hard water has been carried out for some time, or if the generating set has been run without inhibitors the system may become fouled by scale.

To descale the radiator, use the following procedure:

1. Drain the water system and disconnect and blank off the pipe connections to the engine.
2. Prepare a 4% solution of inhibited acid solvent and fresh water. Add the acid to the water, never vice versa.
3. Allow several minutes for mixing, then heat the solution to 49°C (120°F) maximum.
4. Run the solution slowly into the radiator via the filler cap or a branch in the manifold. Effervescence will occur. When it ceases, fill the radiator completely with the heated solvent.
5. Allow to stand for several minutes; then drain the solvent back into the original container through the bottom manifold or drain plug.
6. Examine the interior of the headers. If scale remains repeat the process outlined above with the solvent strength increased to 8%.
7. After descaling the acid solution has to be neutralised as follows:-

   Fill the mixing container with fresh water, heat to boiling point then add common washing soda crystals at the following strength: 0.5 kg of soda to 20 litres water (1 lb. soda to 4 gallons water). Fill the radiator with this solution, then drain it back into the container.
8. Flush the radiator in this manner several times, finally leaving the radiator full for at least an hour. Drain until empty and wash out the radiator with hot fresh water.
9. Before putting the radiator into service again, fill with water and apply a test pressure equal to twice that of the working pressure. Examine carefully for any leaks which may have been revealed by descaling.
10. Prior to recommissioning, the coolant must be dosed with any necessary corrosion inhibitors and/or the correct proportion of antifreeze.

8. ALTERNATOR DESCRIPTION AND MAINTENANCE

8.1 Alternator Description

8.1.1 General: The alternator fitted on the generating set is of the brushless self-excitation type which eliminates the maintenance associated with slip rings and brushes. The control system consists of an automatic voltage regulator, protective circuits and the necessary instruments to allow monitoring of the output of the generating set.

8.1.2 Construction/Major Components: The alternator unit is completely self-contained and is designed and constructed to provide trouble free operation, ease of maintenance and long service life.

The stator core is produced from insulated low loss electrical grade sheet steel laminations. These are built and welded under a fixed pressure to give an extremely rigid core to withstand vibrations and load impulses. The complete wound stator is, after impregnation, pressed into the frame and pinned into position.

A high grade precision machined shaft carries the rotor assembly which comprises the alternator rotating field systems, the exciter rotator/rotating diode system and the cooling fan. The rotor is mechanically wedged and supported on the winding end to allow an overspeed of up to 2250 RPM. The complete rotor assembly is dynamically balanced to ensure vibration-free running.

At the drive end of the rotor assembly a cast-aluminium centrifugal fan draws cooling air through screened/louvered covers at the non drive end and discharges it through similar side mounted covers at the drive end.

8.1.3 Alternator Method of Operation: The electrical power produced by the generating set is derived from a closed loop system consisting principally of the exciter rotor, the main revolving field and the automatic voltage regulator (See Figure 8.1).

The process begins when the engine starts to rotate the internal components of the alternator. The residual magnetism in the main rotor (item 1) produces a small alternating voltage (AC) in the main stator (item 2). The automatic voltage regulator (item 3) rectifies this voltage (converts it to DC) and applies it to the exciter stator (item 4).

This DC current to the exciter stator creates a magnetic field which, in turn, induces an AC voltage in the exciter rotor (item 5). This AC voltage is converted back to DC by the rotating diodes (item 6).

When this DC voltage appears at the main rotor, a stronger magnetic field than the original residual field is created which induces a higher voltage in the main stator.

This higher voltage circulates through the system inducing an even higher DC voltage back at the main rotor. This cycle continues to build up the voltage until it approaches the proper output level of the generating set. At this point the automatic voltage regulator begins to limit the voltage being passed to the exciter stator which, in turn, limits the overall power output (item 7) of the alternator.

This build-up process takes place in less than one second.

8.1.4 Automatic Voltage Regulator: The Automatic Voltage Regulator (AVR) maintains a no load to full load steady state voltage to tight tolerances. The AVR has a volts/hertz characteristic which proportionally reduces the regulated voltage at reduced speeds. This feature aids the engine during sudden large additions of load.

8.2 Alternator Maintenance

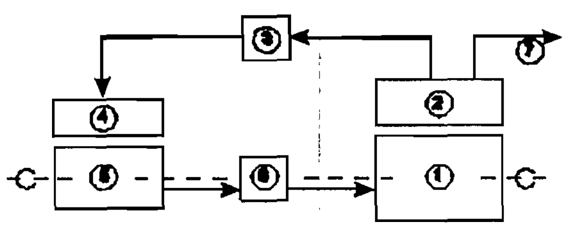
Although maintenance is rarely required, periodic inspection and cleaning is recommended.

Perform a winding insulation test according to procedures provided in the Alternator Manual before the initial start, after generating set storage, and every 3 to 6 months depending on humidity levels (more often in higher humidity). In high humidity areas, installing space heaters to operate when the generating set is not running will help keep the windings dry.

The alternator air filters, if fitted, should be inspected regularly depending on site conditions. If cleaning is necessary, remove the filter elements from the filter frames. Immerse or flush the element with a suitable detergent agent until the element is clean. Dry the elements thoroughly before refitting.

Additionally the alternator unit should be cleaned on a regular basis. The frequency of such cleanings depends on the environmental conditions of the operating site. The following procedure should be followed when cleaning is necessary: Disconnect all power. Wipe dust, dirt, oil, water and any other liquids from the external surfaces of the alternator unit and from the ventilation screens. These materials can work their way into the windings and may cause overheating or insulation breakdown. Dust and dirt is best removed using a vacuum cleaner. Do not use compressed air, steam or high pressure water!

The separate Alternator Manual provided with this manual contains more detailed information on alternator maintenance. It also includes a trouble shooting guide for alternator faults.



Item	Description	Item	Description
1.	Main Rotor	5.	Exciter Rotor
2.	Main Stator	6.	Rotating Diodes
3.	Automatic Voltage Regulator	7.	Power Output
4.	Exciter Stator		

Figure 8.1: Block Diagram of Alternator Operation

9. CONTROL SYSTEM DESCRIPTION AND TROUBLE SHOOTING

9.1 Control System Description and Identification

9.1.1 Description: An advanced electronic control system has been designed and installed to control and monitor the generating set. Depending on the requirements of the set, one of several different standard control systems may be fitted. These include the 1001 Series Keystart System, 2001 Series Autostart System, 4001 Series Deluxe Autostart System and the 4001E Series Enhanced Deluxe Autostart System. Other more specialised systems may be installed for specific installations in which case separate documentation is provided.

These control systems consist of three major components working together - a control panel, an engine interface module (EIM), and an alternator output circuit breaker.

The control panel provides a means of starting and stopping the generating set, monitoring its operation and output, and automatically shutting down the set in the event of a critical condition arising such as low oil pressure or high engine coolant temperature. A 1001, 2001, 4001 or 4001E Series Panel is installed as appropriate for the requirements of the generating set installation.

The Engine Interface Module is a sealed, engine mounted module that provides switching relays for the Starter Motor Solenoid, Glow Plug and Fuel Solenoid. Each of these circuits is protected with individual fuses mounted in the module. Individual LED's illuminate when each circuit is energised. The Engine Interface Module is available in three models depending on the type of control panel being used - the 12 volt EIM SR, the 12 volt EIM Plus and the 24 volt EIM Plus. The table below indicates which EIM module is used on which generating sets:

Panel Fitted	Sets up to 150kVA (12 volt systems)	Sets above 150kVA (24 volt systems)
1001	12 Volt EIM SR	24 Volt EIM Plus
2001	12 Volt EIM Plus	24 Volt EIM Plus
4001	12 Volt EIM Plus	24 Volt EIM Plus
4001E	12 Volt EIM Plus	24 Volt EIM Plus

The power output circuit breaker serves to protect the alternator by automatically disconnecting the load in the event of overload or short circuit. It also provides a means of switching the generating set output.

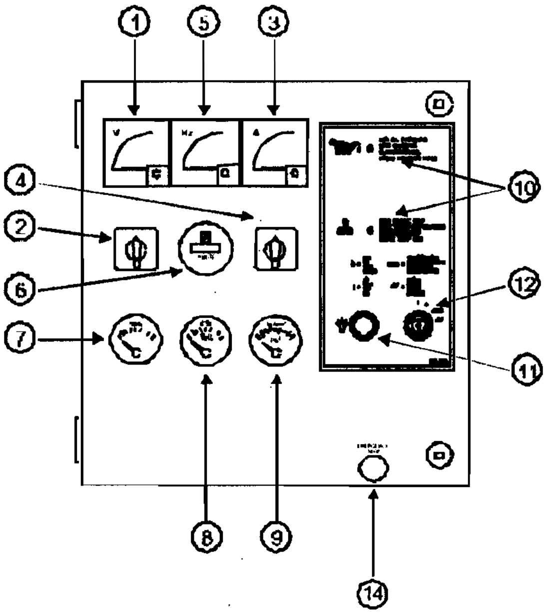
9.1.2 Identification: Figure 9.1 shows each of the control panels to aid in identifying the system fitted on the generating set. The 1001 Series Panel, being a "Key Start" panel has a removable key to control the system. Only two fault lamps are provided on this panel. The 2001 Series Panel has a Control Switch, instead of a Key Switch, located below 5 fault lamps. The 4001 Series Panel is similar to the 2001 except the Control Switch is located below the gauges and there are 7 fault lamps. The 4001E Series Panel also has the Control Switch located below the gauges but has up to 16 fault lamps.

9.1.3 Panel Equipment: Before starting or running the generating set, the operator should become fully acquainted with the instruments and controls. The instruments should be observed from time to time while the generating set is running so that any abnormal readings can be detected before problems arise.

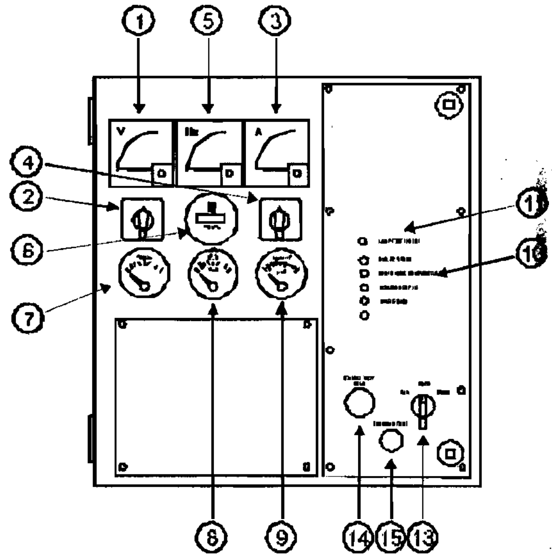
Figure 9.1 shows typical diagrams of each of the control panels. Addition of optional equipment will add items to the panel so the panel fitted on the generating set may be slightly different from the typical ones shown. The following descriptions explain the function of each item on the panels:

<u>Item</u> <u>Description</u>

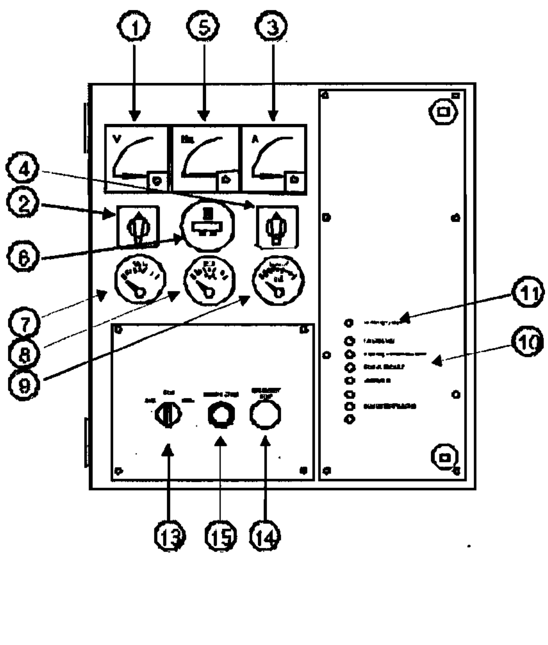
1. AC VOLTMETER - A voltmeter that indicates the AC voltage generated at the alternator output terminals. The reading indicated on the voltmeter will vary depending on the connections made inside the alternator terminal box, the setting of the voltage regulator and the position of the voltmeter selector switch (item 2). It should not, however, vary while the set is operating. In the event of alternator excitation failing, the output voltage will fall to approximately 20 to 40 volts. If the meter gives no reading while the generating set is running, ensure that the AC voltmeter selector switch is not in the OFF position.
2. AC VOLTMETER SELECTOR SWITCH - A selector switch allowing the operator to select voltage reading between phases or between a phase and neutral. The OFF position allows the voltmeter "zero" position to be checked while the generating set is running.
3. AC AMMETER - An ammeter that indicates the AC electrical current being delivered which is dependant on the connected load. A separate reading from each of the phases is possible using the ammeter selection switch (item 4). If the meter gives no reading while the generating set is running, ensure that the AC ammeter selector switch is not in the OFF position.
4. AC AMMETER SELECTOR SWITCH - A selector switch allowing the operator to select a current reading from each of the phases. The OFF position allows the ammeter "zero" position to be checked while the generating set is running.
5. FREQUENCY METER - A meter that indicates the output frequency of the generating set. The engine maintains a relatively constant speed under governor control so as to provide the proper operating frequency of 50 Hz or 60 Hz when the generating set is operating at full rated load. At partial load the frequency will be slightly higher than normal, depending on the droop of the governor. In practice, no load frequencies of approximately 52 and 62 Hz for 50 Hz and 60 Hz respectively, are considered normal. The frequencies will fall, as the set is loaded, to 50 Hz and 60 Hz at full load.
6. HOURS RUN METER - A meter that indicates the total number of hours of generating set operation to aid in maintenance.
7. ENGINE WATER TEMPERATURE GAUGE - A temperature gauge connected to a sensor in the engine to monitor engine coolant temperature. The normal operating temperature should be approximately 85°C (185°F).
8. DC BATTERY VOLTMETER - A voltmeter that indicates the state of charge of the battery. When the engine is at standstill the normal battery voltage will be 12 to 14 volts on a 12 volt system and 24 to 28 volts on a 24 volt system. During starting, the needle will drop to about 70% of normal and oscillate as the engine cranks. Once the engine has started, the needle should return



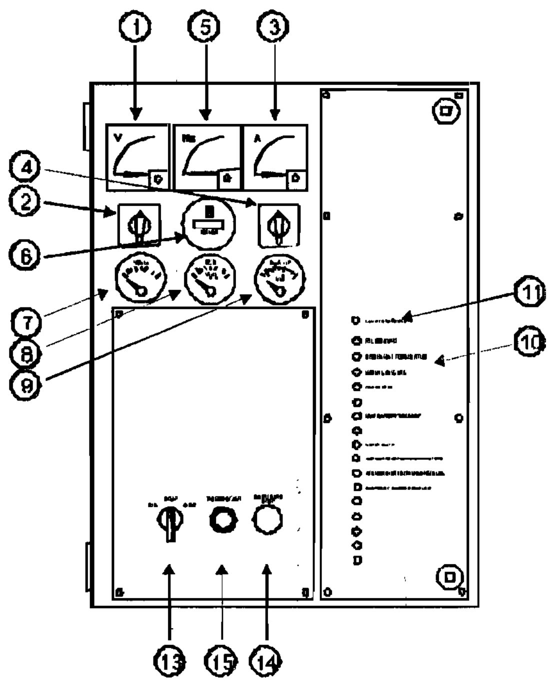
1001 Series Control Panel



2001 Series Control Panel



4001 Series Control Panel



4001E Series Control Panel

Figure 9.1 Design of Typical Control Panels to its normal value. If the battery charging alternator is charging correctly, the voltage reading will always be higher with the generating set running than when it is stopped.

9. ENGINE OIL PRESSURE GAUGE - A gauge to monitor engine oil pressure from the moment the engine is cranked. The proper oil pressure rating should be approximately 35 to 60 p.s.i. for 50 Hz and 45 to 65 p.s.i. for 60 Hz. On cold engines the oil pressure will be significantly higher until the engine warms up.
10. FAULT INDICATOR LAMPS - Fault lamps that illuminate to indicate that the protective circuitry has sensed the indicated condition. The lamp should be red on conditions for which the system will initiate a shutdown of the set. For alarms, the lamp can be red or amber.
11. LAMP TEST PUSHBUTTON - A button to test the fault lamps and to reset an alarm warning lamp and circuitry after an alarm has been initiated.
12. KEY SWITCH (1001 Series Only) - A four position switch that provides a means of controlling or interrupting the battery supply to the control system, thermostart and starter motor.

    Position "O" Off/Reset
    Power is turned off and protection circuitry is reset in this position.

    Position "I" On
    DC power is supplied to the control system and the fault protection timer relay is initiated.

    Position "" Thermostart
    DC power is supplied to the thermostart circuit, if fitted.

    Position "" Start
    DC power is supplied to the starter motor to crank the engine. The thermostart circuit is also powered, if fitted.

13. CONTROL SWITCH (2001, 4001 and 4001E Series Only) - A three position switch that provides a means of controlling the generating set functions.

    Position 1 "RUN"
    The auto start function is initiated to immediately start and run the generating set.

    Position 2 "STOP"
    The genset is shut down if running, and automatic start is inhibited. The fault protection circuitry is reset in this position.

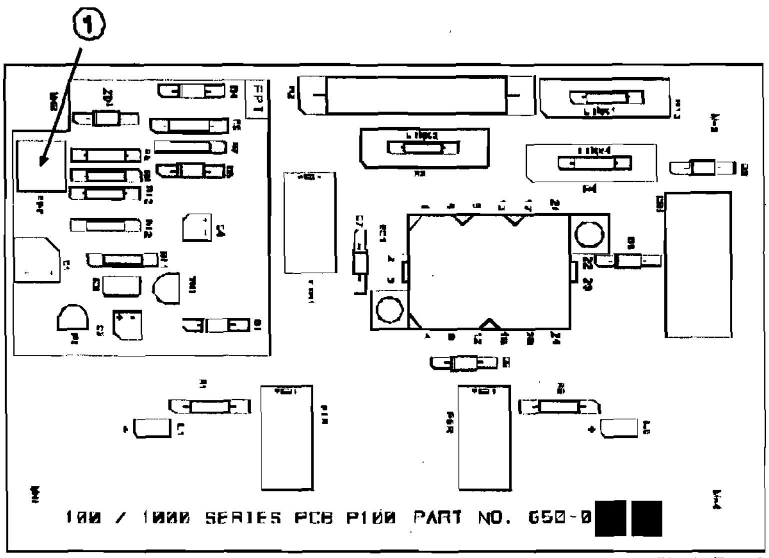
    Position 3 "AUTO"
    The control circuitry is ready to initiate an automatic start upon receiving a remote start signal.

14. EMERGENCY STOP PUSHBUTTON - A red lock-down pushbutton that immediately shuts down the generating set and will inhibit start until the pushbutton has been released by turning it clockwise. Pressing this button also illuminates the "OVERSPEED" fault lamp even though an overspeed has not occurred. Prior to restarting the set, this fault lamp must be reset by turning the Control Switch to "STOP", or by turning the key switch on 1001 Series Control Panel to position "O" (off).
15. THERMOSTART PREHEAT BUTTON (2001, 4001 and 4001E Series Only) - A button to power the thermostart preheat circuit, if fitted.

9.2 Functional Description 1001 Series Control System

The 1001 Series Control System provides for manual starting and stopping of the generating set and provides protection for the engine against both high engine coolant temperature and low oil pressure.

The control system is of the relay timer type based on a Printed Circuit Board (P.C.B.). The P.C.B. is off board fuse protected and controls the starting, stopping and fault protection of the engine. Figure 9.2 shows the layout of the 1001 Series P.C.B.



(Not to Scale)

Item	Description
1.	FPT: Fault Protection Timer Adjust Range: 1-70 seconds Set: 15 ± 1 second

Figure 9.2: Layout of the 1001 Series P.C.B.

9.2.1 Function (1001 Series): Section 5 of this manual provides detailed guidance and checklists for the operation of the generating set. This section provides a more detailed description of the functions of the control system during operation.

During starting, turning the Key Switch from Position "O" (Off) to Position "I" (On) applies voltage to the P.C.B. and energises Control Relay CR. With relay CR energised, contact CR/1 closes to energise the fuel control solenoid and the engine gauges.

WARNING:

! The Key Switch must not be turned to position "" (Thermo) or "" (Start) while the engine is running.

During start, turning the Key Switch through Position "I" (On) to Position "" (Thermo) activates the thermostart, if fitted. This preheats the induction air and should be held for 7 seconds. Turning the Key Switch further to Position "" (Start) provides power to the starter motor which cranks the engine. The starter motor will be disengaged when the Key Switch is released so it must be held in this position until the engine starts and then immediately released and allowed to return to Position "I" (On).

To prevent overheating of the starter motor the engine should not be cranked for more than 5 to 7 seconds. An interval of 10 seconds should be allowed between start attempts. If the engine has not started after 4 attempts, refer to the trouble shooting guide or Engine Manual to determine the cause of failure to start.

Turning the Key Switch past Position "I" (On) initiates the Fault Protection Timer (FPT) relay. This timer is set at 15 seconds but is adjustable on the P.C.B. Until the FPT times out the high engine coolant temperature and low oil pressure protective circuits are inhibited. This will keep the low oil pressure of a starting engine from causing the protection circuits to initiate a shutdown during start.

Should the oil pressure not have reached the proper specified operating point by the time FPT times out or, when running, should the pressure drop below this level, the protective circuitry will initiate a shutdown. The "LOW OIL PRESSURE" fault lamp will illuminate. Start up will be inhibited and no attempt should be made to start the set until the cause of the fault has been traced and remedied. High engine coolant temperature (and/or low coolant level on some larger models) will also shut down the generating set in the same way and will illuminate the "HIGH ENGINE TEMP" fault lamp.

WARNING:

! If at any time the generating set stops because of a fault, the fault should be rectified before trying to restart the generator.

These protective circuits will prevent start of the generating set until they are reset. Turning the Key Switch to Position "O" (Off) resets the protective circuits of the control system.

Once the generating set is running properly, the electrical load is applied to the set by switching the alternator output circuit breaker to "ON" (handle in the up position).

When shutting down the generating set, the load should be turned off by switching the alternator output circuit breaker to "OFF" (handle down). The engine should be allowed to cool prior to stopping it. After a few minutes the Key Switch is turned to *Position* "O" (Off) which shuts the generating set down.

In case of emergency where immediate shutdown is necessary, the Key Switch should be turned to Position "O" (Off) immediately without first disconnecting the load.

9.2.2 Protective Circuits (1001 Series): Engine coolant temperature is monitored by the high temperature switch located on the engine. This is a normally open switch designed to close at 95°C (203°F). On closing, relay R1 energises and self latches, illuminating the red coloured fault lamp labelled "HIGH ENGINE TEMPERATURE". The second set of contacts on R1 (R1/2) opens to break the circuit that was energising the control relay (CR). This closes the fuel solenoid valve, shutting down the engine. The fault lamp will remain illuminated and the engine locked out until the fault has been acknowledged and reset by turning the Key Switch to Position "O" (Off). On some larger models a low coolant level sensor will also cause the generating set to shut down and will also illuminate the "HIGH ENGINE TEMPERATURE" fault lamp even though the temperature may be in the normal range.

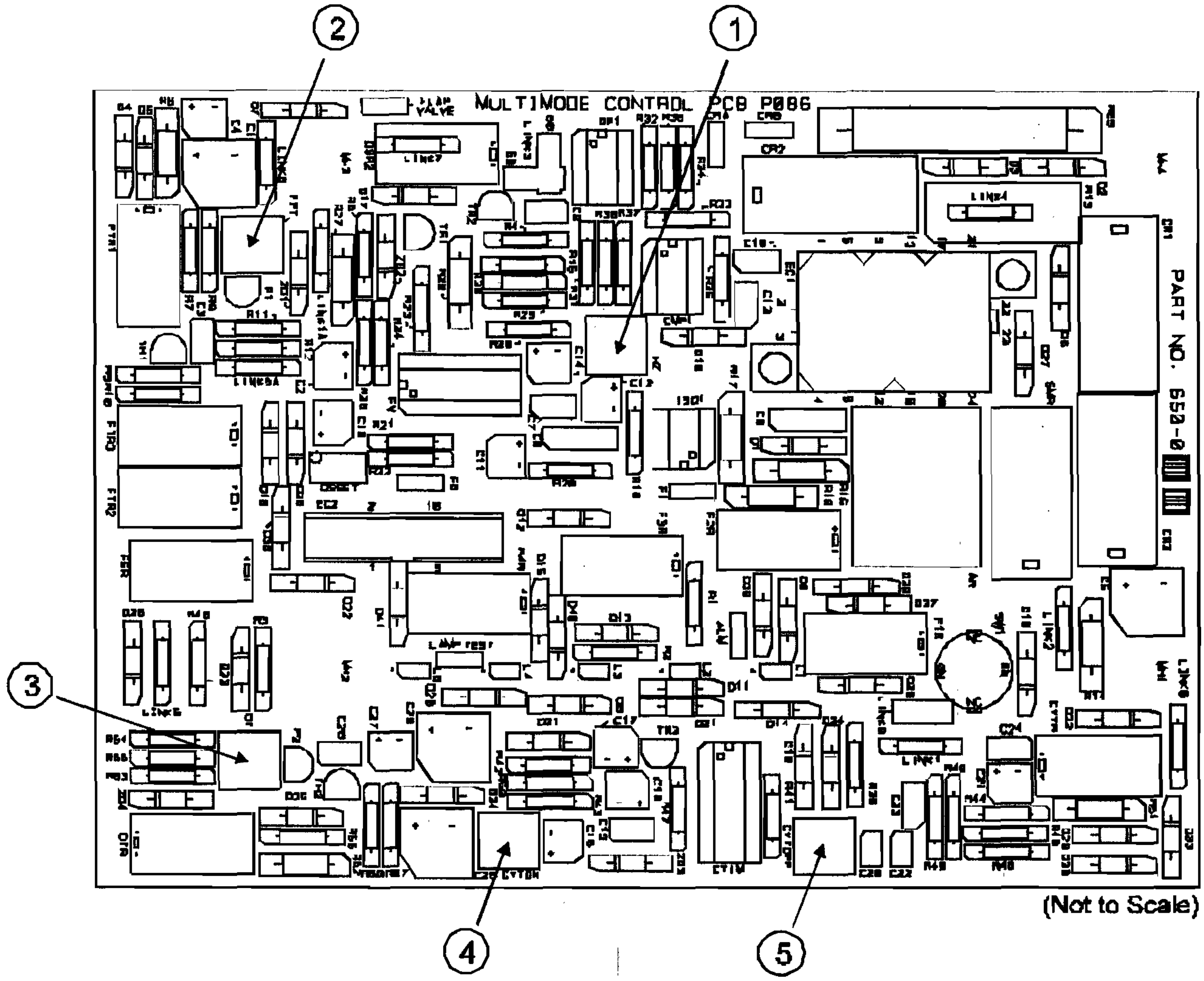
Engine lubricating oil pressure is also monitored to check for an excessively low pressure condition. This is monitored by an engine mounted, normally closed, switch that opens under normal running conditions. Should the oil pressure fall to or below about 22 p.s.i. (1.6 bar) the switch will close. This in turn energises relay R5 which self latches, illuminating the "LOW OIL PRESSURE" fault lamp. The second set of contacts (R5/2) opens de-energising the CR relay. This causes the fuel solenoid valve to close and the engine to shutdown. Reset is effected by turning the Key Switch to Position "O" (Off).

9.3 Functional Description 2001, 4001 and 4001E Series Control Systems

The 2001, 4001 and 4001E Series Control Systems provide for automatic starting and stopping of the generating set from a remote signal as well as manual starting and stopping. This makes it appropriate for standby generating systems. Protection is provided by the control system against high engine coolant temperature, low oil pressure, fail to start and overspeed. On the 4001 and 4001E Series Control Systems alarm protection is also provided for Low Battery Voltage. On 4001E Series Control Systems there are additional alarms for Approaching Low Oil Pressure, Approaching High Engine Temperature, Battery Charger Failure and Not in Auto Mode.

These control systems are of the relay timer type based on a double sided Printed Circuit Board (P.C.B.). The P.C.B. is off board fuse protected and controls the starting, stopping and fault protection of the engine. Figures 9.3, 9.4 and 9.5 show the layout of the 2001 Series P.C.B., the 4001 Series P.C.B. and the 4001E Series Expansion P.C.B. respectively.

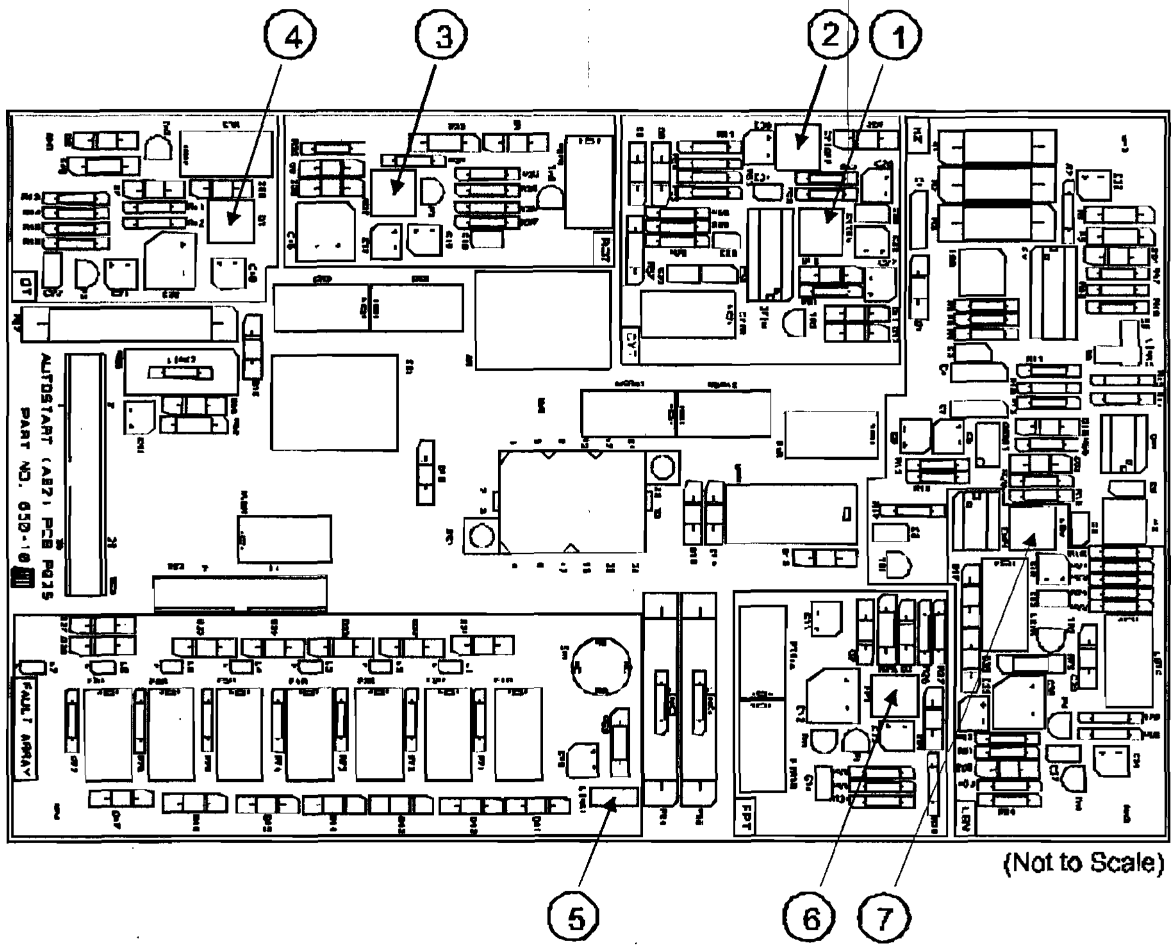
Since these control systems are designed for automatic starting, they are fitted with connections for remote control. Included are terminals for Remote Emergency Stop and an interface to an Intelligent Load Transfer Panel. Additionally, the 4001 and 4001E Series Control Systems are fitted with an interface to Remote Annunciators which are described in Section 9.4.8.



Item	Description
1.	HZ: Frequency Meter Calibrate
2.	FPT: Fault Protection Timer Adjust Range: 1-70 seconds Set: 15 ± 1 second
3.	DT: Duration Timer (sets duration of cranking sequence) Range: 1-90 seconds Set: 27.5 ± 2.5 seconds

Item	Description
4.	CYTON: Crank On Period Range: 0.25-20 seconds Set: 5 ± 1 second
5.	CYTOFF: Crank Off Period Range: 0.25-20 seconds Set: 5 ± 1 second

Figure 9.3: Layout of the 2001 Series P.C.B.

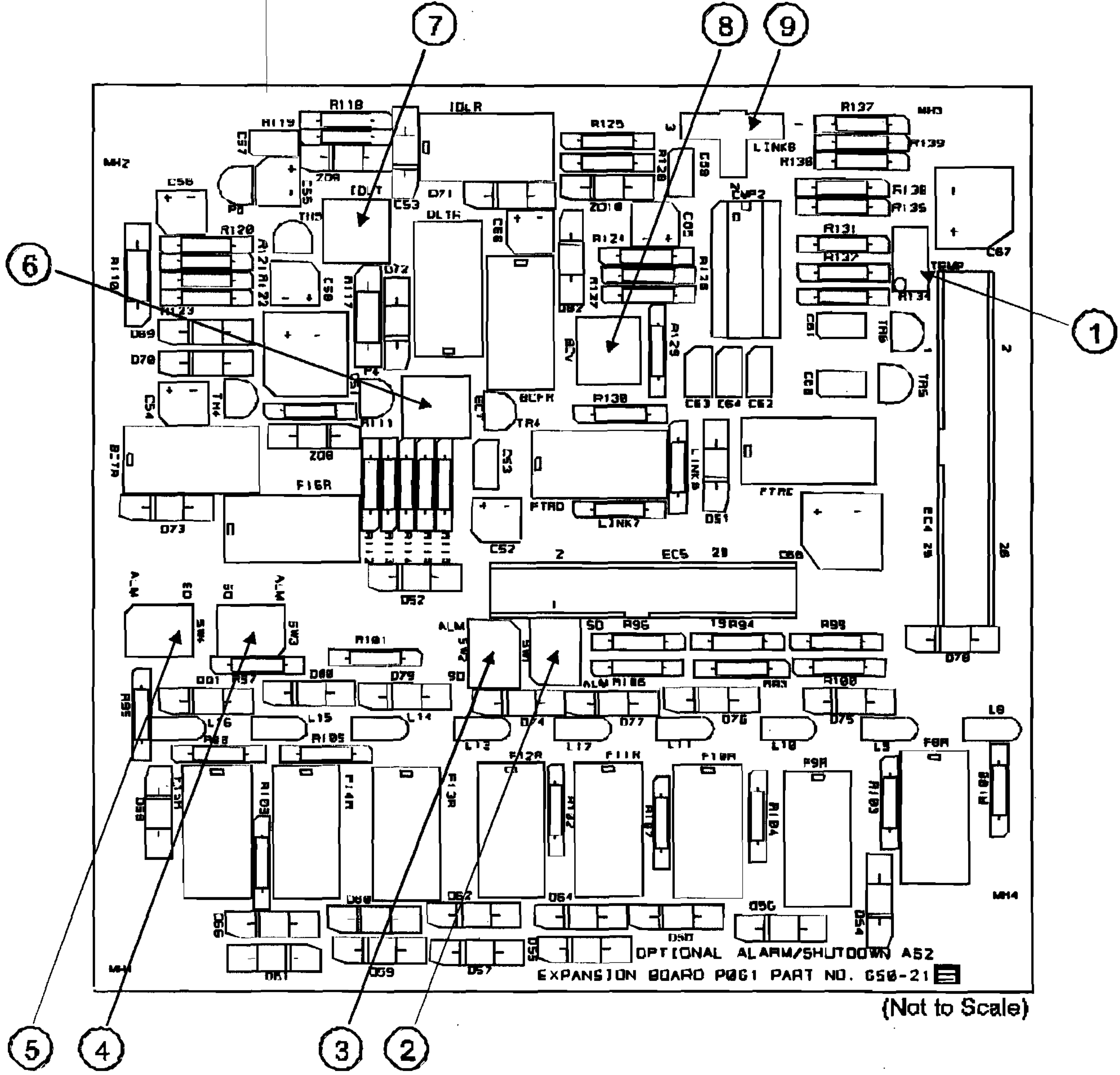


(Not to Scale)

Item	Description
1.	HZ: Frequency Meter Calibrate
2.	CYTON: Crank On Period Range: 1-20 seconds Set: 5 ± 1 second
3.	CYTOFF: Crank Off Period Range: 1-20 seconds Set: 5 ± 1 second
4.	ROT: Run On Timer (sets cool down period) Range: 3-330 seconds Set: 240 ± 15 seconds

Item	Description
5.	DT: Duration Timer (sets duration of cranking sequence) Range: 1-65 seconds Set: 27.5 ± 2.5 seconds
6.	LINK 1: Remove for 4001 E system where expansion board is used
7.	FPT: Fault Protection Timer Adjust. Range: 1-70 seconds Set: 15 ± 1 second
8.	LBV: Low Battery Voltage Monitor Adjust Set: 10.75 volts for 12 volt systems 22.75 volts for 24 volt systems

Figure 9.4: Layout of the 4001 Series P.C.B.



Item	Description
1.	TEMP: Approaching High Engine Temperature Set Point Set: 90°C ± 1°C
2.	SW1: Shutdown/Alarm Selector for Fault L12
3.	SW2: Shutdown/Alarm Selector for Fault L13
4.	SW3: Shutdown/Alarm Selector for Fault L14
5.	SW4: Shutdown/Alarm Selector for Fault L15
6.	BCT: Battery Charger Timer Set Range: 3-330 seconds Set: 180 ± 15 seconds
7.	IDLT: Input Delay Timer Set Range: 0.25-30 seconds Set: 1 ± 0.5 seconds
8.	BCV: Battery Charger Failure Detection Set Point Set: 11.75 volts for 12 volt systems 22.25 volts for 24 volt systems
9.	LINK 6: Battery Charger Failure Operating Mode

Figure 9.5: Layout of the 4001E Series Expansion P.C.B.

9.3.1 Function (2001, 4001 and 4001E Series): Section 5 of this manual provides detailed guidance and checklists for the operation of the generating set. This section provides a more detailed description of the functions of the control system during operation.

When the Control Switch is turned to "RUN" or a remote start signal is received with the Control Switch in the "AUTO" position, the control system will initiate its automatic start sequence. The fuel control solenoid is turned on providing fuel to the engine. The starter motor is then energised via the auxiliary start solenoid (ASS) to crank the engine. If the engine does not start after a preset duration (CYTON) then a delay of a preset duration (CYTOFF) will elapse before cranking again.

If the engine fails to fire after 3 start attempts then the "FAIL TO START" fault lamp will illuminate. The number of starts is dependant on the setting of CYTON, CYTOFF and the Duration Timer DT. With CYTON and CYTOFF set at 5 seconds and DT set at 27.5 seconds, this gives 3 crank attempts before FAIL TO START - 5 seconds on, 5 seconds off, 5 seconds on, 5 seconds off, 5 seconds on, 2½ seconds off, "FAIL TO START". Refer to the trouble shooting guide or Engine Manual to determine the cause of failure to start. Start will be inhibited until the protection circuits of the control system are reset by turning the Control Switch to "STOP". All time periods are approximate.

When the engine fires and is above cranking speed the starter motor is automatically disengaged. This condition is detected from the W/L terminal of the engine driven battery charging alternator. In addition, when the generator is providing voltage a back up signal is sent to cancel the start sequence. The voltage of the alternator is detected via relay AR.

Note:

- As soon as the generator starts, the power supply to the engine auxiliaries is disconnected via contactor HC, when fitted. Whenever the generator stops contactor HC re-energises and reconnects the supply to the auxiliaries.

The beginning of the start sequence initiates the Fault Protection Timer (FPT) relay. Until the FPT times out (factory set at 15 seconds) the low oil pressure and high engine coolant temperature protective circuits are inhibited. This will keep the low oil pressure of a starting engine from causing the protection circuits to initiate a shutdown.

Should the oil pressure not have reached the proper specified operating point by the time FPT times out or, when running, should the pressure drop below this level, the protective circuitry will initiate a shutdown. The "LOW OIL PRESSURE" fault lamp will illuminate. Startup will be inhibited and no attempt should be made to start the set until the cause of the fault has been traced and remedied. High engine coolant temperature (and/or low coolant level on some larger models) will shut down the generating set and will illuminate the "HIGH ENGINE TEMPERATURE" fault lamp. An overspeed condition will, in the same way, shut down the set and illuminate the "OVERSPEED" fault lamp.

WARNING:

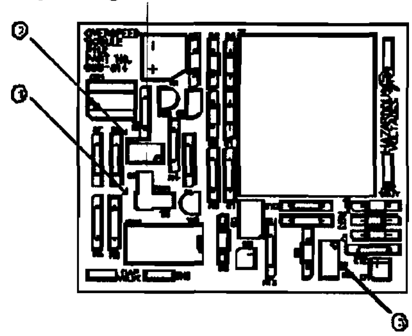
! **If at any time the generating set stops because of a fault, the fault should be rectified before trying to restart the generator.**

These protective circuits will prevent start of the generating set until they are reset. Turning the Control Switch to "STOP" resets the system.

Manually the generating set can be stopped at any time by pressing the Emergency Stop Pushbutton or by turning the Control Switch to "STOP". The set will also automatically shutdown when the remote start signal is removed. On 4001 and 4001E Control System the Run On Timer (ROT) will allow a cool down period at low power prior to shutdown.

9.3.2 Protective Circuits (2001, 4001 and 4001E Series): Engine coolant temperature is monitored by the high temperature switch located on the engine. This is normally an open switch designed to close at 95°C (203°F). On closing, a relay energises and self latches, which illuminates the "HIGH ENGINE TEMPERATURE" fault lamp. It also breaks the circuit energising the control relay (CR). This closes the fuel solenoid valve, shutting down the engine. The fault lamp will remain illuminated and the engine locked out until the fault has been acknowledged and reset by turning the Control Switch to "STOP". On some larger models a low coolant level sensor will also cause the generating set to shut down and will also illuminate the "HIGH ENGINE TEMPERATURE" fault lamp even though the temperature may be in the normal range.

Engine lubricating oil pressure is also monitored to check for an excessively low pressure condition. This is monitored by an engine mounted, normally closed, switch that opens under normal running conditions. Should the oil pressure fall to or below about 22 p.s.i. (1.6 bar) the switch will close. This in turn energises a relay which self latches, and illuminates the "LOW OIL PRESSURE" fault lamp. Again the relay CR is de-energised which causes the fuel solenoid valve to close and the engine to shutdown. Reset is effected by turning the Control Switch to "STOP".



Item	Description
1.	LINK FSEL: Frequency Select
2.	HZ2: 60 Hz Overspeed Set Point Set: 66 ± 0.5 Hz
3.	HZ1: 50 Hz Overspeed Set Point Set: 55 ± 0.5 Hz

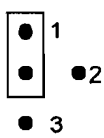
Figure 9.6: Overspeed Module P.C.B.

A separate overspeed module P.C.B. continually monitors the generator frequency. When the frequency exceeds the set point a shutdown is initiated and the "OVERSPEED" fault lamp will illuminate. The overspeed module is factory set at 55 Hz ± 0.5 Hz for 50 Hz systems and 66 Hz ± 0.5 Hz for 60 Hz systems. A plug link labelled FSEL on the overspeed module P.C.B. is used to select the operating frequency (similar plug links labelled LINK3 and LINK5 on the 2001 and 4001 P.C.B.'s respectively are no longer utilised). See Figure 9.6. The "OVERSPEED" fault lamp will also illuminate when the Emergency Stop Pushbutton has been pressed even though an overspeed has not occurred.

The Low Battery Voltage alarm which is fitted as standard on the 4001 and 4001E Series Control Systems detects the battery voltage and compares it to an adjustable reference (LBV) which is factory set at 10.75 volts for 12 volt systems and 22.75 volts for 24 volt systems. This alarm has a built in time delay to prevent spurious tripping such as when the engine is cranking.

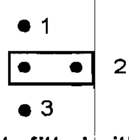
Four additional Alarm circuits are provided on the 4001E Series Control System. The Approaching Low Oil Pressure and Approaching High Engine Temperature alarms work off the sensors fitted for the gauges. The temperature alarm is factory set to go off at 90°C ± 1°C. The Not in Auto Mode Alarm senses the position of the Control Switch. The Battery Charger Failure Alarm detects low voltage from the charger. This level (BCV) is factory set at 11.75 volts for 12 volt systems and 22.25 volts for 24 volt systems. This alarm can be operated in one of 3 modes depending on the position of Link 6 on the 4001E Expansion P.C.B. (see diagrams below):

Mode 1: Link in Position 1



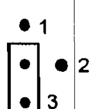
For generating sets with trickle charger and engine driven charging alternators. In this position the charger failure circuit only monitors when the engine is not running.

Mode 2: Link in Position 2



For generating sets fitted with AC powered chargers only (no engine driven charging alternator.)

Mode 3 Link in Position 3



For generating sets with no battery charger fitted. In this position the charger failure circuit is **disabled.**

The 2001 Series Control System has one additional channel beyond the standard that can be either a Shutdown circuit or an Alarm circuit depending on how it is programmed at the factory.

The 4001 Series Control System has one additional Shutdown circuit and one additional Alarm circuit beyond the standard. The use of these circuits is programmed at the factory.

The 4001E Series Control System has two additional Shutdown circuits, one additional Alarm circuit and four additional circuits that can be either Shutdown or Alarm circuit. Each of these is programmed at the factory.

The additional possible Shutdown circuits (not all available on all sets) include shutdown on:
High Lube Oil Temperature
Low Coolant Level
Low Fuel Level
Underspeed
Overvoltage
Undervoltage
Earth Fault
Earth Leakage
Combined Over/Under Voltage

The additional possible Alarm circuits (not all available on all sets) include alarms for:
Low Fuel Level
Low Coolant Temperature

For the 2001 Series Control System, the Fault Indicating Lamps are grouped on the control panel as follows:-
L1 Fail To Start Shutdown
L2 High Engine Temperature Shutdown
L3 Low Oil Pressure Shutdown
L4 Overspeed Shutdown
L5 Additional Shutdown or Alarm (programmed at factory)

For the 4001 Series Control System, the Fault Indicating Lamps are grouped on the control panel as follows:-
L1 Fail To Start Shutdown
L2 High Engine Temperature Shutdown
L3 Low Oil Pressure Shutdown
L4 Overspeed Shutdown
L5 Additional Shutdown
L6 Low Battery Alarm
L7 Additional Alarm

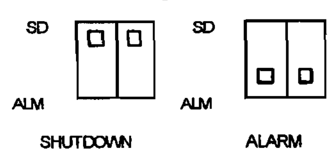
For the 4001E Series Control Systems nine additional Fault Indicating Lamps are included on the separate 4001E expansion P.C.B. which are grouped on the control panel as follows:-
L8 Not In Auto Alarm
L9 Approaching High Engine Temperature Alarm
L10 Approaching Low Oil Pressure Alarm
L11 Battery Charger Failure Alarm
L12 Programmable Channel 1
L13 Programmable Channel 2
L14 Programmable Channel 3
L15 Programmable Channel 4
L16 Additional Shutdown

Indicators L12-L14 are programmed for shutdown or alarm functions using the Dil switches on the P.C.B.

The DIL switches are assigned as follows:

Fault Channel	Dil Switch
L12	SW1
L13	SW2
L14	SW3
L15	SW4

The setting of these programmable Fault Indicator Lamps can be checked on the P.C.B. With both poles in "SD" position, the fault channel is configured as a shutdown. With both poles in "ALM" position, the fault channel is configured as an alarm.



9.4 Control System Options and Upgrades

A large variety of options may be fitted to customise the control system to a specific installation. The following sections cover the use and operation of some of these options.

9.4.1 Battery Trickle Chargers: These chargers are designed to ensure that the starter batteries maintain their charge even if the generating set is not operated for long periods.

The chargers are generally available with a 5 Amp nominal rating and are usually mounted within the control panel. A 10 Amp nominal rating battery charger may be fitted in some circumstances but would be located in a separate box placed adjacent to the control panel. These chargers require a continuous electrical power supply of either 220/240 volts AC or 120 volts AC depending on the charger.

Control switches for the chargers are not normally fitted to prevent inadvertent switching off of the charger. The control system will automatically disconnect the charger on startup of the generating set. While the engine is running the batteries are charged by the engine driven battery charging alternator.

As additional options, an "ON"/"OFF" switch and a battery charger boost control may be fitted. The boost control overrides the automatic control mechanism of the charger that would normally reduce charging level as the battery becomes charged. This can allow faster charging of the battery, however care must be taken to only use the boost control for a short time to avoid overcharging the battery and/or boiling the battery dry.

As an option, a battery charger ammeter may be fitted to the control panel in order for the operator to monitor the functioning of the battery charger.

9.4.2 Heaters: In addition to conventional space heaters that are useful in keeping the generating set warm and dry in cold or humid environments, three types of heater may be fitted on the generating set.

Immersion type heaters (engine heaters) may be fitted in the engine coolant system to ensure that the engine is easy to start and able to take load more quickly. These heaters are provided with an integral non-adjustable thermostat set at approximately 40°C (104°F). The power rating of the heaters (in kW) varies depending on the size of the set. Generally single 1 kW heaters are fitted to sets below 400 kVA. On larger machines two 1 kW or 1.5 kW heaters are fitted.

Alternator anti-condensation heaters (alternator heaters) may be fitted to the alternator stator winding to keep them dry in humid conditions. These are in the form of "heat-tracing" tape and operate at a relatively low temperature so they do not require a thermostat.

Panel anti-condensation heaters (panel heaters) may be fitted in the control panel to keep moisture levels down.

Each of these heater types require a continuous 220/240 volt AC power source.

Control switches are not normally fitted but may be fitted as an additional option. With or without control switches, the heaters are automatically disconnected on engine start-up.

9.4.3 Electric Fuel Transfer Pumps: Fuel transfer pumps are required when fuel must be transferred from a bulk storage tank to the generating set day tank. An AC pump requiring a 220/240 volt AC power supply may be fitted. These pumps are generally mounted on the baseframe and float switches are fitted in the day tank. Control relays, switches, lamps and overloads are fitted in the control panel.

The controls consist of two illuminated pushbuttons on the control panel door. The red button is a combined trip lamp and stop button. The green button is a run lamp and manual start pushbutton.

To operate the pump manually, ensure the red pushbutton is in the "ON" position (pulled out). Press and hold the green pushbutton to manually run the pump. The pump will only run in the manual mode while the green button is held in.

To operate the pump in automatic mode, just ensure that the red pushbutton is in the "ON" position (pulled out). A DC relay inside the panel (PR) is energised by a low level float switch in the day tank. This will start the pump running and will illuminate the green run lamp. A high level float switch in the day tank de-energises relay PR when the tank is full. This stops the pump and turns off the green run lamp.

An electrical overload is sensed if the pump draws significantly more current than normal. When this occurs the red lamp will illuminate.

Care must be taken to ensure that the pump is primed with fuel prior to operation to lubricate the seals. Also, the pump should never be run when the bulk tanks are empty or when valves on the fuel fill lines are closed.

9.4.4 Meters/Gauges: When more information is required than that which is provided by the standard panels, the following meters or gauges may be fitted to the control panel:

3 Ammeters mounted on the panel instead of one ammeter and a selector switch. This allows a continuous indication of the current flowing in each phase.

Kilowatt (kW) Meter to provide accurate readings of the load being supplied by the generating set. The meter is mounted on the control panel and the transducer is mounted inside the panel.

Combined Tachometer and Frequency Meter to replace the standard frequency meter. This meter allows both engine speed in revolutions per minute (RPM) and output frequency to be indicated on the front panel.

Lube Oil Temperature Gauge to monitor the lubricating oil temperature when the engine is operating. This is an electrical device powered by the generating set battery. The normal operating temperature should be approximately 90°-110°C (195°-230°F).

Ammeter for Battery Trickle Charger to monitor the current flow to the battery. It is used to observe the charging current being supplied by the battery trickle charger. When the batteries are fully charged this current will be small (less than 5 Amps) but with a partially discharged battery this current may be as high as 40 Amps.

9.4.5 Speed/Voltage Control: Three controls may be fitted to adjust the speed or voltage of the generating set.

The *speed adjust potentiometer* can only be used when the engine is controlled by an electronic governor. Clockwise adjustment increases the speed of the engine and anti-clockwise adjustment decreases it. The potentiometer is fitted with a dial mechanism which allows the potentiometer to be locked at the desired setting.

A *raise/lower switch* may be fitted on the control panel to control the speed of engines with mechanical or hydraulic governors. The governor must also be fitted with a motor operator. A "spring return to off" switch is then used to raise or lower the speed.

The *voltage adjust potentiometer* allows minor adjustments of voltage to be made from the control panel. About 3% adjustment is possible

9.4.6 Alarm Signalling: Three options may be fitted to the control panel to supplement the standard alarm indications of the alarm lamps:

A *panel mounted alarm siren* is DC operated and will sound when an alarm condition is indicated. An Alarm Mute pushbutton is fitted on the panel to silence the siren.

An *audible alarm siren supplied loose* is also DC powered and will sound when an alarm condition is indicated. It can be fitted at a convenient location. An Alarm Mute pushbutton is fitted on the panel to silence the siren.

A *set of volt free contacts for common alarm* change over in the event of an alarm condition. These are for connection to an existing alarm system. These contacts remain in the "alarm" state until the control system is reset.

9.4.7 Automatic Preheat Control: The thermostart induction air preheating operates automatically prior to and during engine cranking. The automatic cranking sequence will be delayed by the preheating period.

9.4.8 Remote Annunciator Panels: 8 or 16 channel remote annunciators may be fitted and connected to 4001 and 4001E Series Control Systems. These provide repeat indicators for the shutdown and alarm fault lamps on the control panel. They also include an audible alarm and alarm mute button. The connection is via a plug type terminal bar for easy installation.

Each channel is equipped with a LED that can display red, green or amber depending on the selection of the DIL switches. Each channel can also be selected to sound the audible alarm via a DIL switch.

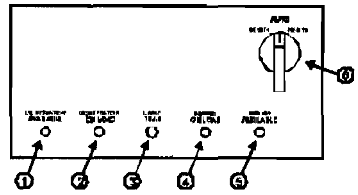
Two further options may be fitted with the remote annunciators: A Normal/Run switch allows manual starting of the set from the remote location and an Emergency Stop Pushbutton allows manual stopping.

9.4.9 X100 AMF Upgrade: When the generating set is installed to automatically provide standby power in the event of a mains failure, a load transfer switch is required. This switch transfers the load from the mains after a failure and puts the load on the operating generating set. After the mains are re-established, the load is transferred back to the mains.

To accomplish this, one option is to utilise a dedicated TC Series or TI Series Load Transfer Panel as discussed in Section 9.6. However, the X100 option provides this functionality in the control panel itself, so an independent transfer switch or a TX Series Load Transfer Panel can be used.

A 2001, 4001 or 4001E Series Panel fitted with the X100 option is often referred to as a 2101, 4101 or 4101E Series Panel, respectively.

The X100 upgrade adds a control P.C.B. to the control system as well as a static battery charger to maintain the generating set battery in a fully charged state. A 220/240 volt AC source is required to power the battery charger. The upgrade also adds a status display panel to the control panel as shown in Figure 9.7. This provides indication of Mains Available, Mains on Load, Generator Available and Generator on Load. A test switch is provided for maintenance.



Item	Description
1.	"Generator Available" Status Lamp
2.	"Generator On Load" Status Lamp
3.	Lamp Test Pushbutton
4.	"Mains on Load" Status Lamp
5.	"Mains Available" Status Lamp
6.	Test Switch

Figure 9.7: Typical X100 Status Display Panel

Functionally, the X100 option uses a mains fail signal from the mains monitoring relay to start the generating set. This signal is provided by the transfer contactor (if so equipped) or by the optional PRM1, Electronic Mains Monitoring Relay. The 'MAV' switch on the X100 P.C.B. enables acceptance of either a N/O or N/C signal (see Figure 9.8).

On receipt of the mains fail signal the Delay on Start timer (2MT) is energised. This timer avoids false engine starts due to momentary mains fluctuations. If the mains have not returned by the time 2MT has timed out then the mains contactor is opened and a start signal is given to the main control P.C.B. After the generating set is automatically started, the Delay on Transfer timer (AT) is activated to permit the generating set to stabilise before the standby contactor is closed. After AT is timed out, the standby contactor is closed, allowing the generating set to power the load.

On restoration of the mains power signalled by the mains monitoring relay, the Delay on Retransfer timer (1MT) is energised. 1MT allows a period of time to ensure that the mains supply is reliable prior to transferring the load back. When it is timed out the standby contactor is opened. Following the Dead Band Timer (DBT) timing out, the mains contactor will reclose. The DBT ensures that there is a definite delay between the standby contactor opening and the mains contactor closing. The Run On Timer (ROT) ensures that the generating set continues to run on no load to cool down before shutting down. The control system is then ready for the next mains failure.

The Test Switch mounted on the control panel allows 2 additional modes of operation:

"TEST 1" Test Off Load. This is used to start the generating set under automatic control but not to accept the load while mains power is available. The load transfer contactors do not operate.

"TEST 2" Test On Load. This simulates a full mains failure with the generating set starting up and taking the load even when mains power is available.

Two additional options may be fitted with X100:

PRM1 Electronic Mains Monitoring Relay - This relay is essential when an independent load transfer panel is not fitted with a mains monitoring relay or when a TX Series Load Transfer Panel is used.

PST1 Manual/Auto Retransfer Selector Circuit - This option, if fitted, enables the operator to manually control the timing of the retransfer of the load from the generating set to the restored mains supply. The controls comprise a Manual/Auto Retransfer Selector Switch and a Retransfer Button. On a mains failure, the generating set will start and accept load in the normal sequence. With the Retransfer Selector Switch in the "AUTO" position the load will be automatically retransferred back to the mains when available as described above. If the Retransfer Selector Switch is in the "MANUAL" position the retransfer timer is bypassed and, on restoration of the mains, the "Mains Available" indicator will illuminate but the generating set will continue to supply the load. When it is convenient the operator presses the Retransfer Button which causes the standby contactor immediately to open and, following the timing out of the Dead Band Timer, the mains contactor to close, reconnecting the load to the mains. The generating set will continue to run for the cool down period before shutting down and resetting.

9.4.10 Digital Instrumentation Option: On certain generating sets a digital instrumentation option may be fitted. This factory fitted option replaces the analogue AC instruments and associated selector switches which are normally fitted on the control panel (voltmeter, frequency meter, ammeter).

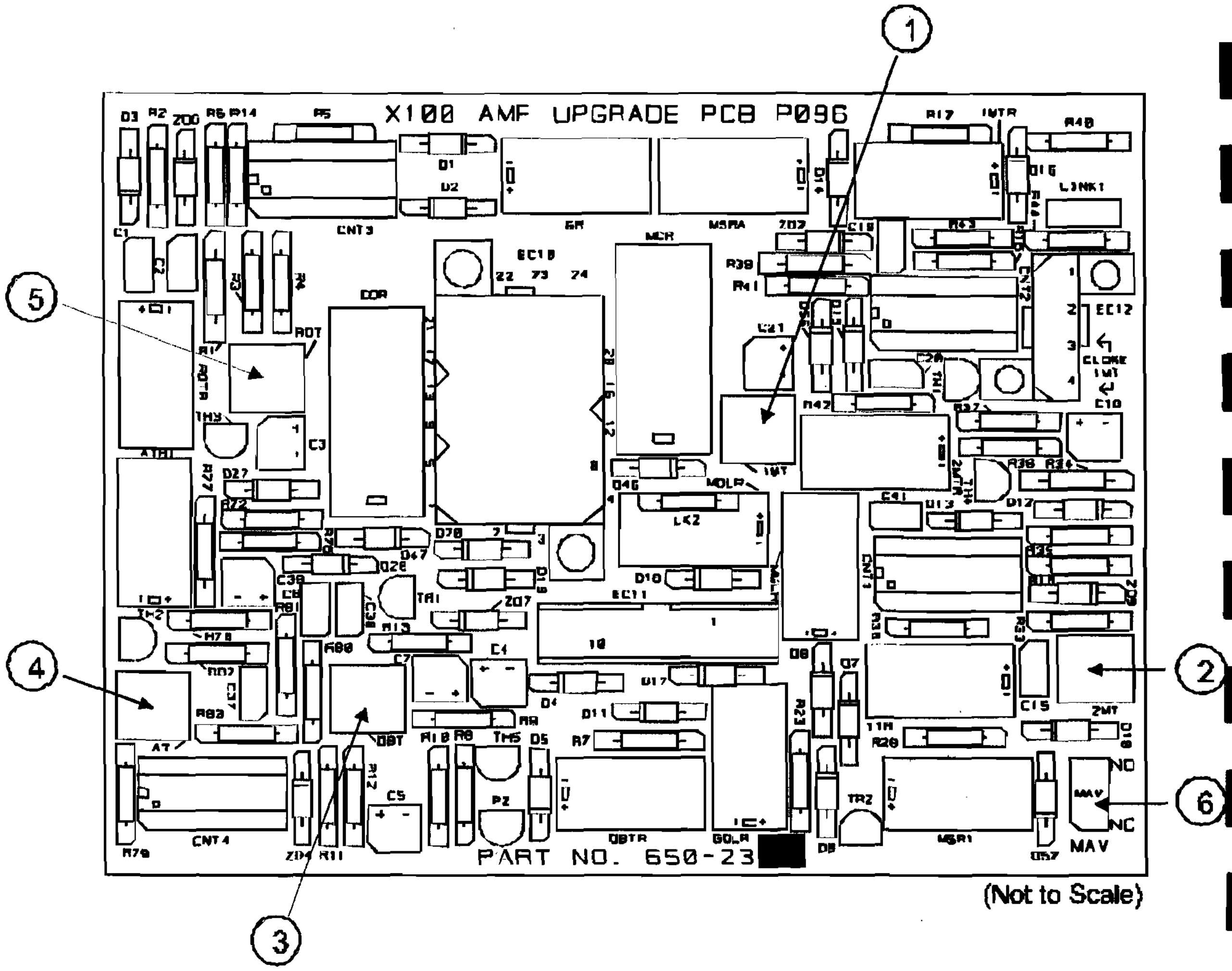
All the instrumentation is embodied in one P.C.B. On the front of the control panel are 3 windows which show voltage, frequency and current respectively. For 3 phase generating sets only, below the voltmeter and ammeter displays are LED indicators set out in two triangular formations. These give indication of which phase voltage or current is being measured.

In the case of the voltmeter one LED illuminated indicates the phase to neutral voltage for that particular phase. If two LED's are illuminated then the voltage shown is the phase to phase voltage for these two phases. Only one LED will be illuminated below the ammeter. This LED shows which phase the current display is indicating.

Stepping through the voltages and currents for monitoring purposes is achieved by pushing the "V-A" button. Each push cycles the voltage and current selection circuit. There are a total of 6 steps in the selection. If the V-A button is pressed after the 6th step then it returns back to the 1st selection and the cycle repeats.

Step	Displayed Voltage	Displayed Current
1	L1 - Neutral	L1
2	L2 - Neutral	L2
3	L3 - Neutral	L3
4	L1 - L2	L1
5	L2 - L3	L2
6	L1 - L3	L3

Further operation of the V-A button repeats the cycle.



(Not to Scale)

Item	Description
1.	1MT: Delay on Retransfer Timer Range: 160 seconds-28 minutes Set: 160 seconds
2.	2MT: Delay on Start Timer Range: 1-30 seconds Set: 5 ± 1 second
3.	DBT: Dead Band Timer Range: 0.1-5 seconds Set: 0.1 second
4.	AT: Delay on Retransfer Timer (Factory Set)
5.	ROT: Run on Timer (sets cool down period) Range: 8-315 seconds Set: 240 ± 15 seconds
6.	MAV: Switch selecting N/O or N/C Mains Monitoring signal.

Figure 9.8: Layout of the X100 P.C.B.

9.5 Control System Fault Finding/Trouble Shooting Guide

FAULT	SYMPTOM	REMEDY
Engine Fails to Start (1001 Series Only)	Engine Does Not Crank when Key Switch Turned to Position "↻" (Start)	1. Check operation of Key Switch. 2. Check no fault lamps illuminated. Reset, if required, after remedying indicated fault. 3. Check battery voltage on control panel. If voltage is not registering check fuses F4 and F5. If voltage is registering but is low then recharge the batteries with separate battery charger and reconnect to the set. (Ensure Key Switch is in Position 'O' (Off) when disconnecting and reconnecting the battery leads.) 4. Check supply to slave solenoid on starter motor - connect a DC voltmeter between this connection and the battery negative terminal. Try starting the engine using the Key Switch. If the meter registers a voltage then the starter motor or solenoid is faulty and must be replaced. If no voltage registers, check wiring from panel for loose connections or broken/shorted wires.
Engine Fails to Start (2001, 4001, or 4001E Series Only)	Engine Does Not Crank when Start Signal Given, Either Manually Via Control Switch or Automatic-ally Via a Remote Signal	1. Check all Emergency Stop Pushbuttons are released (including any remote buttons). If no remote stop is used, ensure "Remote Stop" terminals are linked. 2. Check that Control Switch is not off. 3. Check no fault lamps illuminated. Reset, if required, after remedying indicated fault. 4. Check battery voltage on control panel. If voltage is not registering check fuse F5. If voltage is registering but is low then recharge the batteries with separate battery charger and reconnect to the set. (Ensure the Control Switch is off when disconnecting and reconnecting the battery leads.) 5. Check supply to slave solenoid on starter motor - connect a DC voltmeter between this connection and the battery negative terminal. Try starting the engine manually by turning the Control Switch to RUN. If the meter registers a voltage then the starter motor or solenoid is faulty and must be replaced. If no voltage registers, check wiring from panel for loose connections or broken/shorted wires. 6. If wiring is not damaged then replace the P.C.B.
Engine Fails To Start (All control systems)	Engine Cranks But Does Not Fire or Engine Starts But Stops After 20 Seconds ("FAIL TO START" Fault Lamp Illuminates on 2001, 4001 or 4001E Panels.)	1. Check fuel level. 2. Check that Canopy External Emergency Stop Pushbuttons, if fitted, are not depressed (1001 Series). 3. Check wiring to the fuel control solenoid "FCS" and the voltage at the FCS. 4. Check fuses F1, F2, F3 on alternator side plate. 5. Check fuel lines and fuel filter for obstructions. 6. If white smoke comes from the exhaust then fuel is entering the engine but the engine is not firing. Refer to the Engine Manual for further checks. 7. If ambient temperature is low ensure thermostart aid is used, if fitted. 8. Check voltage output of P.C.B. to FCS. If signal not present, Replace the P.C.B. 9. On 2001, 4001 or 4001E panels, once the fault has been rectified, clear the fault lamp by turning the Control Switch to STOP.
Engine Stops Due to High Engine Temp. (or on some larger models due to Low Coolant Level) (All control systems)	"HIGH ENGINE TEMP" Fault Lamp Illuminates	1. Check engine was not overloaded. 2. Check radiator obstructions. 3. Check fan belt tension. 4. Check ambient temperature is within the design limits of the generating set. 5. After engine has cooled, check coolant level. Do not add large amounts of cold water to a hot engine as serious damage could result. 6. Refer to Engine Manual. 7. Once fault has been rectified, clear the fault lamp by turning the Key Switch to position "O" (Off) or turning the Control Switch to "STOP", as appropriate. 8. Cool the engine by starting and running it off-load for 10 minutes with the circuit breaker off (handle down).

FAULT	SYMPTOM	REMEDY
Engine Stops Due to Low Oil Pressure (All control systems)	"LOW OIL PRESSURE" Fault Lamp Illuminates	1. Check oil level. 2. Refer to Engine Manual. 3. Check oil pressure switch with test gauge. Replace if faulty. 4. Once fault has been rectified, clear the fault lamp by turning the Key Switch to position "O" (Off) or turning the Control Switch to "STOP", as appropriate.
Engine Stops Due to Overspeed (2001, 4001 or 4001E Series Only)	"OVERSPEED" Fault Lamp Illuminates	Note: The "OVERSPEED" fault lamp will also illuminate after the Emergency Stop Pushbutton has been depressed even though there has been no overspeed condition. The Emergency Stop Pushbutton and any remote stop buttons must be released before the fault can be cleared. 1. Check if governor speed setting lever has moved. Re-adjust if required. 2. If electronic governor is fitted check linkage for free movement. Adjust if required. 3. Refer to Engine Manual. 4. Replace the P.C.B. 5. Once fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP".
Engine Stops Due to High Lube Oil Temp (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"HIGH LUBE OIL TEMP" Fault Lamp Illuminates	1. See trouble shooting guide on "Engine Stops Due To High Engine Temp" to see if cooling system is operating efficiently. 2. After radiator has cooled, check coolant level. 3. Check oil level. 4. Ensure proper maintenance procedures have been carried out. 5. Refer to Engine Manual. 6. Once fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP".
Engine Stops Due to Low Coolant Level (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"LOW COOLANT LEVEL" Fault Lamp Illuminates	1. Allow engine to cool. 2. Check coolant level. Fill as required with correct coolant mixture. Do not add large amounts of cold water to a hot engine as serious damage could result. 3. Check radiator, engine and pipework for leaks. Repair as necessary. 4. Once fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP".
Engine Stops Due to Low Fuel Level (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"LOW FUEL LEVEL" Fault Lamp Illuminates	1. Check fuel level in day tank. Fill as necessary. 2. Check operation of the fuel transfer system , if fitted, as described in Section 9.4.3. 3. Once fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP".
Engine Stops Due to Underspeed (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"UNDERSPEED" Fault Lamp Illuminates	1. Ensure engine has not been overloaded. 2. Ensure there is an adequate supply of fuel to the engine. 3. Check if governor speed setting lever has moved. Re-adjust if required. 4. If electronic governor is fitted check linkage for free movement. Adjust if required. 5. Clear the fault by turning the Control Switch to "STOP" and restart the engine. 6. Ensure alternator is running at the correct voltage by checking on the panel meters. 7. With engine running set correct speed on the engine governor control. 8. Refer to the Engine Manual.

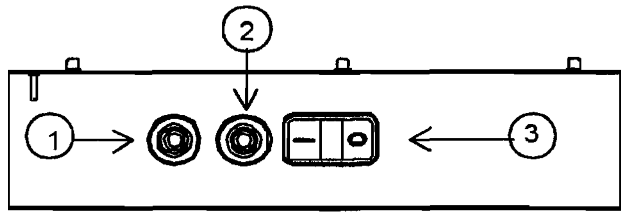
FAULT	SYMPTOM	REMEDY
Engine Stops Due to Overvoltage (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"OVERVOLTAGE" Fault Lamp Illuminates	1. Disconnect the alternator from the load by turning off the circuit breaker (handle down), reset the fault by turning the Control Switch to "STOP" and restart engine. 2. Check voltage on panel meters. If voltage is normal, ensure that the load is non-capacitive (power factor correction equipment may inadvertently lead to a capacitive load). 3. If voltage remains high and can not be adjusted to the normal level using the voltage adjust potentiometer, if fitted, then refer to the Alternator Manual.
Engine Stops Due to Under-voltage (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"UNDERVOLTAGE" Fault Lamp Illuminates	1. Disconnect the alternator from the load by turning off the circuit breaker (handle down), reset the fault by turning the Control Switch to "STOP" and restart engine. 2. Check voltage on panel meters. If voltage is normal check the load characteristics (i.e. ensure not overloaded). 3. If voltage remains low and can not be adjusted to the normal level using the voltage adjust potentiometer, if fitted, then check the voltage at the alternator terminals with an independent meter. If voltage is correct check wiring. 4 Check AVR. 5. Refer to Alternator Manual.
Engine Stops Due to Overvoltage /Under-voltage (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"OVERVOLTAGE/UNDER-VOLTAGE" Fault Lamp Illuminates	1. Disconnect the alternator from the load by turning off the circuit breaker (handle down), reset the fault by turning the Control Switch to "STOP" and restart engine. 2. Check voltage on panel meters. If voltage is normal check the load characteristics (i.e. not capacitive and not overloaded). 3. If voltage remains high or low and can not be adjusted to the normal level using the voltage adjust potentiometer, if fitted, then check the voltage at the alternator terminals with an independent meter. If voltage is correct check wiring. 4 Check AVR. 5. Refer to Alternator Manual.
Engine Stops Due to Earth Fault (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"EARTH FAULT" Fault Lamp Illuminates	1. Check all cable and wiring for bad connections or shorts to earth. 2. Check alternator windings - refer to Alternator Manual. 3. Once the fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP".
Engine Stops Due to Earth Leakage (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"EARTH LEAKAGE" Fault Lamp Illuminates	1. Check outgoing cable and wiring for faults. 2. Do not restart the generating set until fault has been found. 3. Once the fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP".
Alarm for Low Battery Voltage (4001 or 4001E Series Only)	"LOW BATTERY VOLTAGE" Alarm Lamp Illuminates	1. Check battery voltage at least 12 volts for a 12 volt system or at least 24 volts for a 24 volt system. 2. If voltage is low and generating set is not running then recharge the battery by connecting a separate battery charger to the disconnected battery or run the engine. 3. If voltage is low and generating set is running then the battery charging alternator is not charging. Stop the set and check the fan belt tension. 4. If fan belt tension is correct then check battery charging alternator - refer to Engine Manual. 5. If battery does not hold a charge then replace battery. 6. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Not in Automatic Mode (4001E Series Only)	"NOT IN AUTO MODE" Alarm Lamp Illuminates	1. Check Control Switch is in "AUTO". 2. Check Emergency Stop Pushbuttons are not pressed. 3. Check Circuit Breaker is on (handle up). 4. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.

FAULT	SYMPTOM	REMEDY
Alarm for Approaching High Engine Temp. (4001E Series Only)	"APPROACHING HIGH ENGINE TEMP" Alarm Lamp Illuminates	1. Check engine is not overloaded. 2. Check radiator and ventilation for obstructions. 3. Check ambient temperature is within the design limits of the generating set. 4. If the above are okay, reduce load and stop the set as soon as possible. Che the fan belt tension. 5. Refer to Engine Manual. 6. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Approaching Low Oil Pressure (4001E Series Only)	"APPROACHING LOW OIL PRESSURE" Alarm Lamp Illuminates	1. Check oil level with engine stopped as soon as possible. 2. Refer to Engine Manual. 3. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Battery Charger Failure (4001E Series Only)	"BATTERY CHARGER FAILURE" Alarm Lamp Illuminates	1. Check trickle charger is switched on and producing power. 2. Carry out checks as per low battery voltage alarm. 3. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Low Fuel Level (Optional Alarm - 2001, 4001 or 4001E Series Only)	"LOW FUEL LEVEL" Alarm Lamp Illuminates	1. Check fuel level in day tank. Fill as necessary. 2. Check operation of the fuel transfer system, if fitted, as described in Section 9.4.3. 3. Once the cause of the alarm has been rectified, clear the alarm lamp by pressi the "LAMP TEST" button.
Alarm for Low Coolant Temp. (Optional Alarm - 2001, 4001 or 4001E Series Only)	"LOW COOLANT TEMP" Alarm Lamp Illuminates	1. Check that the immersion heaters are switched on and are operating. 2. Once the cause of the alarm has been rectified, clear the alarm lamp by press the "LAMP TEST" button.
No Voltage Produced When Generating Set is Running (All control systems)	No Voltage On AC Voltmeter	1. Check voltmeter selector switch is not in the "OFF" position. 2. Check fuses F1, F2, and F3, usually located on the alternator terminal box. 3. Check voltage at alternator terminals with an independent meter. If voltage is correct check wiring between alternator and panel. Check voltmeter. Replace if necessary. 4. Check AVR and rotating diodes. Refer to Alternator Manual for details. 5. Check engine speed is correct.
Generating Set Does Not Go On Load (All control systems)	Generating Set is Running but the Load is Not Being Powered	1. Check circuit breaker is "ON" (handle up). 2. Check generating set is producing AC voltage. If not, see fault above.
Generating Set Does Not Stop Manually (All control systems)	Generating Set Continues Running After Being Switched Off	1. Check Key Switch or Control Switch position, as appropriate. 2. Check fuel control solenoid (FCS). Replace if necessary.
Generating Set Does Not Stop When In Auto Mode (2001, 4001 or 4001E Series Only)	Generating Set Does Not Stop After Remote Start Signal is Removed	Note: On 4001 and 4001E Series Control Systems the generating set does not stop immediately on removal of the remote start signal. Removal of this signal first initiates the cool down period. 1. Wait 5 minutes to ensure cool down period has elapsed (4001 and 4001E Series Control Systems Only). 2. Check that generating set stops when the Emergency Stop Pushbutton is depressed or the Control Switch is turned off. 3. If the set does not stop as in step 2 above then check the fuel control solenoi (FCS). Replace if necessary.

Electronic Engine Fault Detection Flash Codes

Perkins 1306-E87 electronic engines automatically record engine faults in the Electronic Control Module (ECM) to assist the operator or engineer in troubleshooting. The fault codes can be read using the red and amber lamps situated on the top of the relay box. The relay box can be found mounted on the alternator box below the AVR. The relevant codes can be identified using the fault-finding table below.

- Two types of codes may be observed: "active" and "inactive" codes. Active codes are new faults identified which must be rectified before the generating set is operated again. Inactive codes are all codes which have been previously logged.
- To operate the fault finding diagnostic codes, press and hold the red pushbutton. The lamps will flash in the following sequence: amber-red-amber-amber. Once this sequence has finished, while still holding the red button, press and release the green button. Observe the sequence of the flashing lamps.
- If there are no active codes retained in the memory of the ECM, the red lamp will flash once, then the amber lamp will flash three times.
- ECM, the red lamp will flash once. The active codes will then flash on the amber lamp. If there is more than one code there will be a short delay between codes.
- When all of the active codes have been shown, the red lamp will flash twice. Then, if there are any inactive codes retained, the amber lamp will flash a code. If there is more then one code there will be a short delay between codes.
- When the test is complete, the red lamp will flash three times.
- Make a note of any codes that are shown. Active codes will



become inactive if the test is done for a second time.

1. Red Lamp
2. Amber Lamp
3. Pushbuttons

Figure 9.9: 1306-E87 Electronic Engines Relay Box

Flash code	Condition description	Comments	Probable causes
111	No errors found	-	-
112	Electrical system voltage B+ out of range: high	ECM voltage is continuously more than 18V	Charging system fault
113	Electrical system voltage B+ out of range: low	ECM voltage is continuously less than 6.5V. Cause of no start / misfire	Low battery voltage. Loose connections. High resistance in circuit
114	Engine coolant temperature signal out of range: low	Defaults to 180°F (82°C). Signal voltage less than 0.127V	Short circuit to earth
115	Engine coolant temperature signal out of range: high	Defaults to 180°F (82°C). Signal voltage greater than 4.6V	Open circuit. Sensor failure
121	Manifold air pressure signal out of range: high	Defaults to ECM setting. Low power. Slow acceleration. Signal voltage greater than 4.6V	Sensor failure
122	Manifold air pressure signal out of range: low	Defaults to ECM setting. Low power. Slow acceleration. Signal voltage greater than 4.6v	Short circuit to earth. Sensor failure
123	Manifold air pressure fault: in range	Defaults to ECM setting. Low power. Slow acceleration	Hose or sensor for manifold air pressure blocked
124	Injection control pressure signal out of range: low	Defaults to open-loop control. Underrun at low idle. Signal voltage less than 0.039V	Short circuit to low. Open circuit. Sensor failure
125	Injection control pressure signal out of range: high	Defaults to open loop control Underrun at low idle. Signal voltage greater than 4.897V	Short circuit to high. Sensor failure
131	Speed control signal out of range: low	Signal voltage less than 0.152V. Engine at low idle only	Short circuit to earth. Open circuit. Sensor failure.
132	Speed control signal out of range: high	Signal voltage greater than 4.55V. Engine idle only	Short circuit to reference voltage or 12 volts. Sensor failure
133	Speed control signal fault: in range	Speed control position does not match the idle validation switch. Kept to 0% of Speed control position,	Speed control failure.
134*	Speed control position does not match the idle validation switch.	Kept to 0% of Speed control position	Speed control and idle validation switch failure
135*	ECM low idle validation switch faulty.	Speed control position does not match the idle validation switch. Kept to 50% of Speed control position. Engine speed limited	Idle validation switch failure
141*	Vehicle speed signal out of range: low	Speed sensor signal is less than 0.48V (0 Kmh/mph). Cruise control nor PTO not engaged. Engine speed limited	Sensor open circuit or short circuit to earth
142*	Vehicle speed signal out of range: high	Speed sensor signal is greater than 4.492V (0 Kmh/mph). Cruise control nor PTO not engaged	Short circuit to reference voltage or 12 volts

Flash code	Condition description	Comments	Probable causes
143	Wrong number of pulses per revolution from the camshaft position sensor	Intermittent signal	Poor connection or camshaft position sensor failure
144	Interference found at the camshaft position sensor	ECM found excessive external inputs	Interference. Injector unit voltage short circuit to earth
145	No signal from the camshaft position sensor but the injection control pressure has increased	Found by the ECM	Short circuit to earth. Open circuit. Sensor failure
152*	Barometric pressure signal out of range: low	Signal voltage less than 1.0V for more than 1 second. Defaults to 101 kPa (14.7 lb/in2) 1,0 kgf/cm2	Short circuit to earth low
154	Intake air temperature signal out of range: low	Signal voltage less than 0.127V. Defaults to 170°F (77°C)	Short circuit to earth
155	Intake air temperature signal out of range: high	Signal voltage greater than 4.6V. Defaults to 170°F (77°C)	Open circuit
211	Engine oil pressure signal out of range: low	Signal voltage less than 0.039V	Short circuit to earth low
212	Engine oil pressure signal out of range: high	Signal voltage greater than 4.9V	Short circuit to earth high or open circuit
213*	Remote speed control out of range: low	Remote speed control signal less than 0.249V	Open circuit
214*	Remote speed control out of range: high	Remote speed control signal greater than 4.5V	Short circuit to earth
221*	Cruise / PTO (or remote PTO) switch fault	Signal voltage incorrect, does not match the switch position	Short circuit or high resistance in the speed control circuit
222*	Brake switch circuit fault	Voltage to pins 43 and 44 on the ECM are not the same	Switch or relay faulty or incorrectly adjusted
225	Sensor for engine oil pressure faulty: in range	Signal greater than 276 kPa (40 lbf/in2) 2,8 kgf/cm2 with the engine start key in the "ON" position. Engine protection disabled	Faulty circuit connection. Sensor failure
231	ATA data link fault	ATA link open or short circuit. VPM fault	ATA device earthed or overloaded
236*	Engine coolant level switch fault	-	Sort circuit to earth or open circuit
241	Regulator for injection control pressure failed the output circuit test	Output circuit test in engine-off test only	Open circuit or short circuit to earth
244	Engine data link failed open circuit test	Output circuit test in engine-off test only	Open circuit or short circuit to earth
254	Open circuit test out of range: high	-	High voltage during open circuit test
255	Open circuit test out of range: low	-	Low voltage during open circuit test
311	Engine oil temperature signal out of range: low	Signal voltage less greater 4.8v Defaults to 212°F (100°C) No fast idle	Short circuit to earth
312	Engine oil temperature signal out of range: high	Signal voltage less than 0.2v Defaults to 212°F (100°C) No fast idle	Open circuit
313	Engine oil pressure below warning level	Oil warning light on	No oil or low oil level. Faulty regulator. Suction pipe blocked or damaged. Worn main bearings. Worn oil pump.
314	Engine oil pressure below critical level	Engine will stop, if this option is fitted	No oil or low oil level. Fault in regulato Suction pipe blocked or damaged. Worn main bearings. Worn oil pump.
315*	Engine speed exceeded warning limit	ECM recorded an engine speed greater than 3000 rev/min	Incorrect use of gears in automotive application
321	Engine coolant temperature above warning level	Coolant temperature greater than 224.6°F (107°C)	Cooling system fault
322	Engine coolant temperature too high	Coolant temperature greater than 233.6°F (112.5°C)	Cooling system fault
323*	Engine coolant level below warning level	ECM finds low coolant level	Coolant level low. Leakage of coolant
325	Power reduced to match cooling system performance	Engine power reduced	High altitude or high ambient temperature
334	Injection control pressure does not reach the correct pressure in the time allowed	Pressure does not match the output signal for a short period of time	Incorrect specification lubricating oil. Air in the lubricating oil. Leakage at the 'O' ring for the injector unit. Regulator fault.

Flash code	Condition description	Comments	Probable causes
335	Injection control pressure does not increase during engine Cranking	Less than 5,1 Mpa (725 lbf/in2) 51 kgf/cm2 after 10 seconds of cranking	Air in the lubricating oil. Fault in the high – pressure lubricating oil system
336	Injection control pressure does not reach the correct pressure	-	A leakage of lubricating oil or fault in the high –pressure lubricating oil system
421	Number 1 injector unit open circuit: high or low	Found by the ECM	Injector unit electrical wiring loom open circuit
422	Number 2 injector unit open circuit: high or low	Found by the ECM	Injector unit electrical wiring loom open circuit
423	Number 3 injector unit open circuit: high or low	Found by the ECM	Injector unit electrical wiring loom open circuit
424	Number 4 injector unit open circuit: high or low	Found by the ECM	Injector unit electrical wiring loom open circuit
425	Number 5 injector unit open circuit: high or low	Found by the ECM	Injector unit electrical wiring loom open circuit
426	Number 6 injector unit open circuit: high or low	Found by the ECM	Injector unit wiring loom open circuit
431	Number 1 injector unit short circuit: high or low	Found by the ECM	Injector unit electrical wiring loom shorted high to low
432	Number 2 injector unit short circuit: high or low	Found by the ECM	Injector unit electrical wiring loom shorted high to low
433	Number 3 injector unit short circuit: high or low	Found by the ECM	Injector unit electrical wiring loom shorted high to low
434	Number 4 injector unit short circuit: high or low	Found by the ECM	Injector unit electrical wiring loom shorted high to low
435	Number 5 injector unit short circuit: high or low	Found by the ECM	Injector unit electrical wiring loom shorted high to low
436	Number 6 injector unit short circuit: high or low	Found by the ECM	Injector unit electrical wiring loom shorted high to low
451	Number 1 injector unit short circuit to B+ or earth: high	Found by the ECM	Injector unit electrical wiring loom shorted to earth: low
452	Number 2 injector unit short circuit to B+ or earth: high	Found by the ECM	Injector unit electrical wiring loom shorted to earth: low
453	Number 3 injector unit short circuit to B+ or earth: high	Found by the ECM	Injector unit electrical wiring loom shorted to earth: low
454	Number 4 injector unit short circuit to B+or earth: high	Found by the ECM	Injector unit electrical wiring loom shorted to earth: low
455	Number 5 injector unit short circuit to B+ or earth: high	Found by the ECM	Injector unit electrical wiring loom shorted to earth: low
456	Number 6 injector unit short circuit to B+ or earth: high	Found by the ECM	Injector unit electrical wiring loom shorted to earth: low
451	Number 1 injector unit short circuit to earth	Found by the ECM	-
452	Number 2 injector unit short circuit to earth	Found by the ECM	-
453	Number 3 injector unit short circuit to earth	Found by the ECM	-
454	Number 4 injector unit short circuit to earth	Found by the ECM	-
455	Number 5 injector unit short circuit to earth	Found by the ECM	-
456	Number 6 injector unit short circuit to earth	Found by the ECM	-
461	Number 1 injector unit failed the contribution test	Found by the ECM	-
462	Number 2 injector unit failed the contribution test	Found by the ECM	-
463	Number 3 injector unit failed the contribution test	Found by the ECM	-
464	Number 4 injector unit failed the contribution test	Found by the ECM	-
465	Number 5 injector unit failed the contribution test	Found by the ECM	-

Flash code	Condition description	Comments	Probable causes
466	Number 6 injector unit failed the contribution test	Found by the ECM	-
513	Bank 1 open circuit: low	Injector units for cylinders 1,2 and 3 have an open circuit in the high voltage supply	Open circuit
514	Bank 2 open circuit: low	Injector units for cylinders 4, 5 and 6 have an open circuit in the high voltage supply	Open circuit
515	Bank 1 short circuit to earth or B+: low	Injector units for cylinders 1,2 and 3 have short circuit to earth or B+	Short circuit in wiring loom
521	Bank 2 short circuit to earth or B+: low	Injector units for cylinders 4, 5 and 6 have short circuit to earth or B+	Short circuit in wiring loom
524	Short circuit between bank 1 and bank 2	Short circuit between bank 1 and bank 2	Short circuit in wiring loom
525	Injector unit driver circuit fault ECM unable to supply sufficient voltage to injector units	Engine wiring loom fault.	Injector unit wiring loom fault. ECM fault
612	Incorrect ECM installed for the camshaft timing plate	No match between the ECM and the camshaft position sensor	Incorrect ECM fitted
614	Engine family rating code and ECM do not match	ECM programming fault	Components not compatible
621	Engine using default rating	Engine operates AL25 HP, default	ECM installed but not programmed
622	Engine using field default rating	Engine limited to 160 HP Options not available	ECM installed but not programmed
623	Invalid engine rating code	-	ECM not programmed correctly
624	Field default active	Programming problem	ECM fault
625	ECM fault	ECM software fault	Replace ECM
626	Unexpected ECM reset fault	Temporary ECM power failure	Battery connection fault
631	ROM self test fault	ECM failure	Internal ECM fault
632	RAM self test fault	ECM failure	Internal ECM fault
655	Programmable parameter list level incompatible	Programming problem. ECM memory problem	Programming fault
661	RAM programmable parameter list corrupt	Programming problem ECM memory problem	Programming fault
664	Calibration level incompatible	Programming problem	Programming problem
665	Programmable parameter memory content corrupt	ECM failure	Internal ECM fault

* These codes, if flashed, will not affect the operation of the engine in a generating set application:

Note:

The engine protection systems e.g. low oil pressure, high coolant temperature, are within the control of the generating set control panel. These sensors will shut the engine down before the ECM sensors.

9.6 Load Transfer Panels

When the generator set is installed to automatically provide standby power in the event of mains failure, a load transfer panel is required. This transfer panel is designed to sense when the mains have failed, signal the generator set to start, switch the load from the failed mains to the generator set and then switch it back after the mains are re- established. See Figure 9. 10.

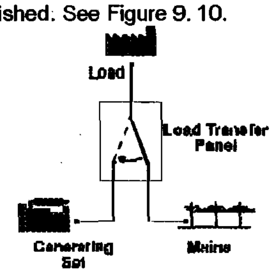


Figure 9.10: Function of a Load Transfer Panel

9.6.1 Microprocessor Controlled TI Load Transfer

Panel: The Microprocessor Controlled TI Load Transfer Panel is designed to work with the Autostart Control Systems (2001, 4001, 4001E, 6101, 6201, Access 4001 Series) to form an automatic mains failure system. Only a two-wire control interconnection is necessary between the generator set control panel and the Microprocessor Controlled TI panel making the installation very simple. The control system consists of a Printed Circuit Board (P.C.B.), status LED's, control switches, fuses, relays and a mechanically held switch. The Microprocessor Controlled TI P.C.B. (see Figure 9.12) controls all the detection and monitoring circuits. The P.C.B., switches and fuses are mounted on the back of a hinged drop down door which is on the front of the transfer panel.

The Microprocessor Controlled TI P.C.B. senses voltages between 50V and 280V.

The power transformers can operate between 170V and 310V.

Supply voltages greater than 310V can be supported with interposing voltage transformers.

System Operation: When the microprocessor controller is running correctly, the green system status "heartbeat" LED, identified by a ♡ symbol, will be flashing.

When the system is being powered up initially and the mains are healthy, Mains Available (MA) LED will light and the mains contactor will be energised immediately.

When the mains power falls below the voltage setting threshold the MA LED will go out. A Mains Fail Timer (2MT) is then started. This timer is designed to prevent momentary drops in mains voltage from causing the generator set to start. At the end of this timer (nominally set at 6 seconds), a signal is sent to the generating set control panel to start the engine. Once the engine is started and the alternator is producing voltage, the Alternator Timer (AT) is started. This timer (nominally set at 6 seconds) ensures that the alternator has stabilised prior to taking on load. At the end of timer AT, the generating set contactor closes so the generating set is powering the load. The "Generator on Load" LED will illuminate.

When the mains has been restored successfully for the duration of the Mains Return Timer (1MT), the generator switch will open and the mains switch closes so the mains are again powering the load. The Mains on Load LED will illuminate. When the generator switch opens, the generator keeps running to cool down until the generator receives a stop signal when the Run On Timer (ROT) has timed out.

Should the mains fail for longer than 2MT during this cool down period, the mains switch will open and the generator switch will close again.

Control Switches: The main control switch on the front of the panel has three positions: -

AUTO – The normal position for automatic operation.

TEST WITHOUT TRANSFER – For testing the generator set without connecting the load. This switch will start the generator immediately.

TEST WITH TRANSFER – For testing the generator set with the load connected. This switch simulates a mains failure by disconnecting a phase from the P.C.B. and the Microprocessor Controlled TI will operate as for a mains failure.

In addition to the main control switch there is a "Control Bypass" key switch for use by service personnel only. In the "normal" position the Microprocessor Controlled TI operates normally. The other two positions allow for the service personnel to manually connect the load to the operating generator set or to the mains supply. This switch would be used if the Microprocessor Controlled TI P.C.B. has been damaged or the timer settings are to be changed.

WARNING

! **The "Control Bypass" switch should only be operated by trained personnel due to the high voltages present inside the enclosure.**

Status LED's: The front of the door has the status LED's, maintenance switch and main control switch. There are four status LED's as shown in figure 9.11.

Pressing the Lamp Test Button, located on the front of the door, will illuminate them for testing.

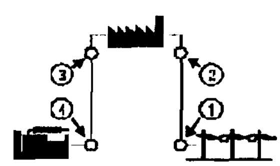


Figure 9.11: Microprocessor Controlled TI Series Load Transfer Panel Status Display

Item	Description
1.	"Mains Available" Status LED
2.	"Mains on Load" Status LED
3.	"Generator on Load" Status LED
4.	"Generator Available" Status LED

Manual Retransfer option: If the manual re-transfer option has been selected, two additional switches will be mounted on the Microprocessor Controlled TI door. One of these switches will allow the panel to be set in AUTO mode where the system operates as described above, or MANUAL mode whereby the Mains Return Timer 1MT is disabled and the re-transfer to mains is actuated by the second momentary– Manual re-transfer switch.

Factory settings: Note that the default settings for the Microprocessor Controlled TI PCB are as follows.

Timers

2MT	6s
AT	6s
1MT	2m 40s
DBT	7s
ROT	45s

Mains / generator voltage level threshold setting: The threshold voltage level can is set by the pots MA, MB, MC for the mains sensing and by GA, GB, GC for the generator voltage sensing. This level is factory set according to the operating voltage required but can be adjusted if required. The procedure to adjust the threshold voltage level is as follows (See Figure 9.12):

Mains

1. Connect a DC voltmeter between test points 'GND' and 'PHA'.
2. Adjust DC voltage using pot MA to desired level based on the *approximation* formula
   $V_{DC} = (V_{ac} * 0.028) - 0.361$
   e.g. for a mains fail voltage of 190V, set the DC voltage to 4.96V.
3. Repeat for the other two phases using test point 'PHB' and pot 'MB' for phase B and test point 'PHC' and pot 'MC' for phase C.

Generator

4. Connect a DC voltmeter between test points 'GND' and 'GENA'.
5. Adjust DC voltage using pot GA to desired level based on the *approximation* formula
   $V_{DC} = (V_{ac} * 0.028) - 0.361$
   e.g. for a generator failure voltage of 190V, set the DC voltage to 4.96V.
6. Repeat for the other two phases using test point 'GENB' and pot 'GB' for phase B and test point 'GENC' and pot 'GC' for phase

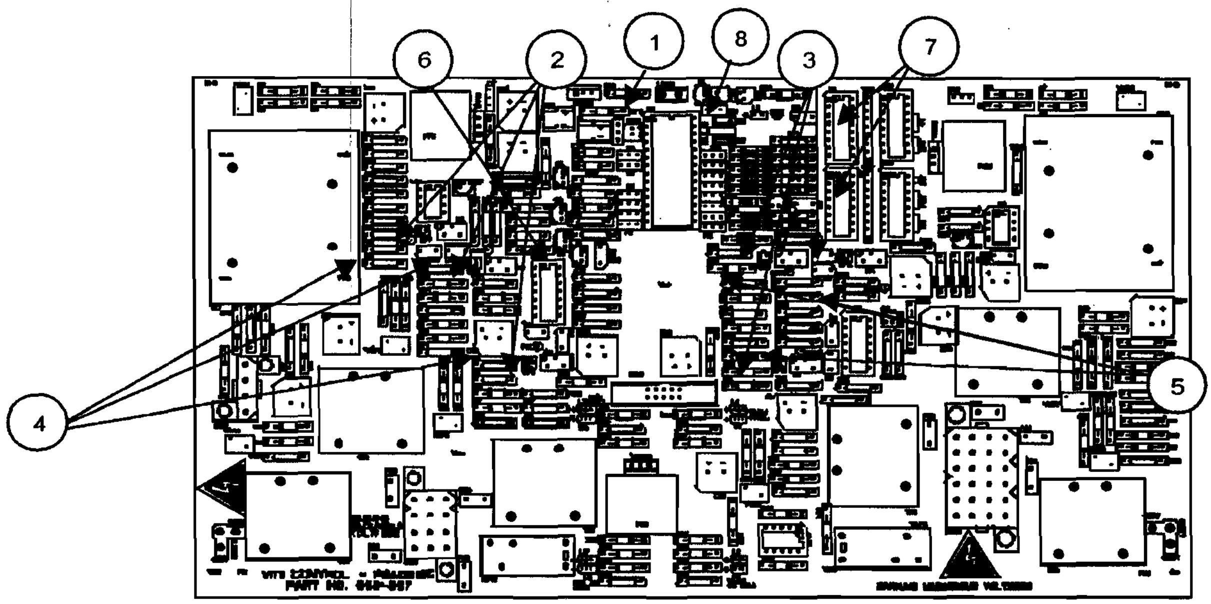


Figure 9.12: Layout of Microprocessor Controlled TI Series Load Transfer Panel P.C.B

Item	Description
1.	Link 4
2.	Mains Voltage Set Potentiometers MA, MB, MC
3.	Generator Voltage Set Potentiometers GA, GB, GC
4.	Mains Test Points PHA, PHB, PHC
5.	Generator Test Points GENA, GENB, GENC
6.	GND Test Point
7.	SW1, SW2 Timer Dip Switches
8.	System Status LED

Timer settings

There are 5 main timers used on the Microprocessor Controlled TI PCB. These are:

Timer name	Timer function	Timer details	Timer range
2MT	Mains fail timer	Time from mains failure to the issue of generator start signal	1s – 60s
AT	Alternator timer	Time from generator available to generator contactor close signal	0s – 60s
1MT	Mains return timer	Time from mains available to generator contactor open signal	2min40s – 28min
DBT	Dead band timer	Time between generator contactor open signal and mains contactor close signal and vice versa	0s – 15s
ROT	Run On Timer	Time from generator contactor open signal to gen stop signal	3s – 8min

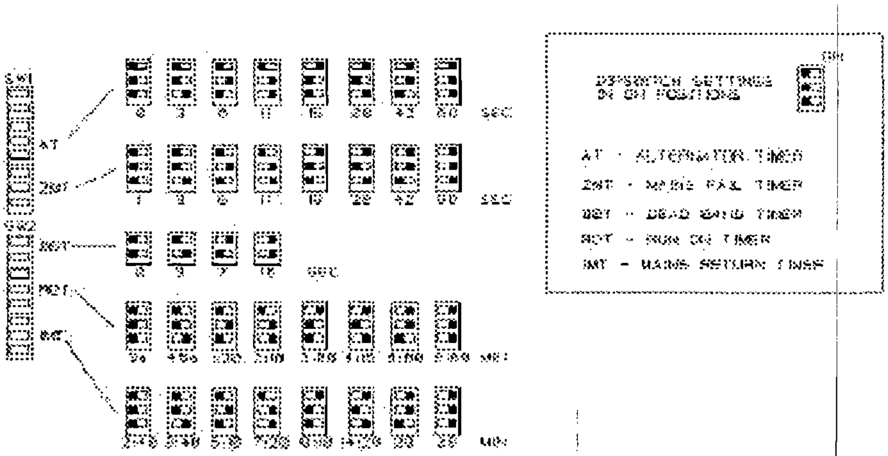
The timers are changed using on board DIP switches SW1 and SW2 and are defined according to the diagram below.

Procedure for changing the timer settings

1. Remove all power from the board.
2. Insert LINK 4 for 10 seconds to reset system.
3. Set timer DIP switches as required.
4. Remove LINK 4 and reconnect power to board.

Optional Remote Status Indication LED's:

If fitted, this option allows a remote indication of the status LED's that are mounted on the Microprocessor Controlled TI panel. A 10-way ribbon cable connected to connector EC11 on the Microprocessor Controlled TI P.C.B. sends the appropriate signals to a matching status display P.C.B.



Notes on Mechanically held Switch

1) The motorised switch is supplied by either the generating set or the mains. If either of these supplies are not present to switch will not operate and will remain in its original position.

2) Both generating set & mains can be isolated from the load if the switch is turned to the (O) position. The can only be done manually with the handle.

3) If there is a requirement to start the generating set off load after it has shut down due to a fault the switch can be manually placed to zero position. When the generating set is running again the switch will automatically motor back to the generating set position.

4) If a fault occurs in any part of the control system that prevents automatic operation of the switch, manual operation is possible. If the switch keeps motoring back to the unwanted position, pull out the main power supply fuses to the switch (F4 & F8).

9.6.2 TC Compact Load Transfer Panel: The TC Compact Load Transfer Panel is designed to work with the Autostart Control Systems (2001, 4001, and 4001E Series) to form an automatic mains failure system. Only a two wire control interconnection is necessary between the generating set control panel and the TC panel making the installation very simple.

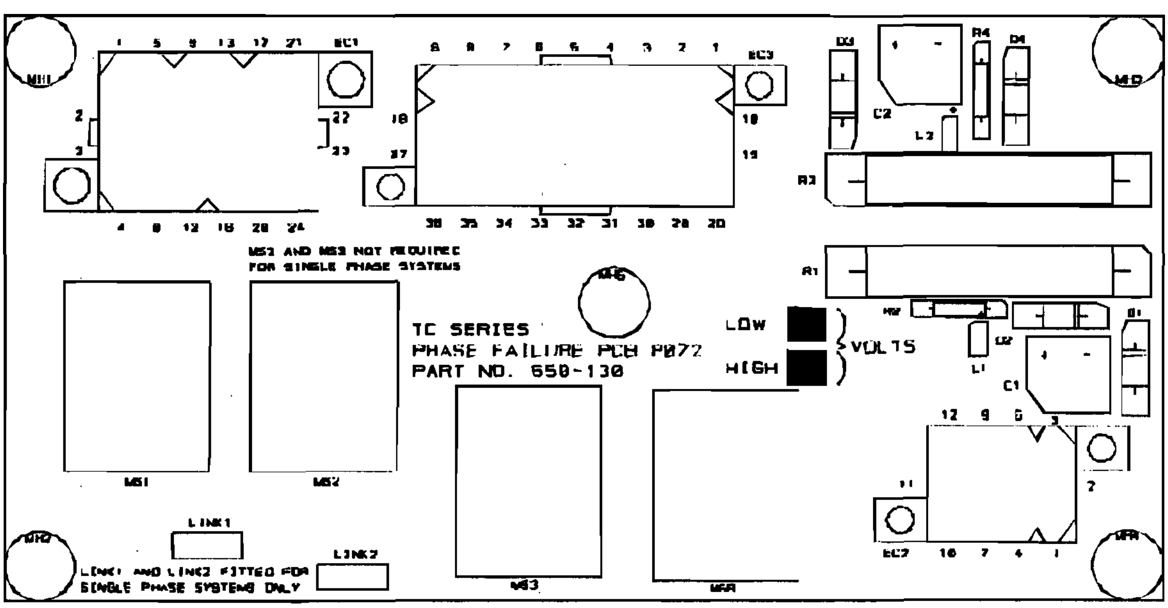
The control system consists of a P.C.B., control switch, a status panel and contactors. The P.C.B. and fuses are mounted on a removable access cover, and for ease of installation all the connections to the P.C.B. and fuses are by internal multi-pin plugs and sockets (see Figure 9.13).

Status Panel and Controls: The status panel has two indicator lamps. They show that the load is either connected to the mains supply or to the generating set. The controls consist of a Mode Selector Switch with three positions:-

AUTOMATIC MODE - The normal position for automatic operation.

TEST WITHOUT LOAD - For testing the generating set without connecting the load.

TEST WITH LOAD - For testing the generating set with the load connected.



(Not to Scale)

Figure 9.13: Layout of TC Series Load Transfer Panel P.C.B.

Functional Description: With the mains supplying electrical power to the load, the "Mains Supply" status lamp will be illuminated. When the mains fail as indicated by the Mains Voltage Sensing Relay, the mains contactor is opened and a start signal is sent to the generating set control panel. Once the generating set is operating and producing voltage the standby contactor is closed and the generating set supplies the load. The "Generator Supply" status lamp will be illuminated instead of the "Mains Supply" lamp.

On restoration of mains power the standby contactor will open and the mains contactor will close. The mains will be supplying the load so the "Mains Supply" lamp will come on. The start signal will also be removed allowing the generating set to shutdown.

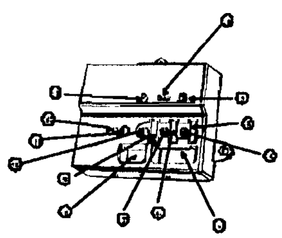
9.6.3 TX Load Transfer Panel: The TX Load Transfer Panel is designed for use with the X100 Option fitted to one of the Autostart Control Panels (2100, 4100 and 4100E) to form an automatic mains failure system. The TX Panel contains the contactors which switch the load between the mains supply and the generating set. The electronics to control the load transfer are contained in the X100 P.C.B. which is in the generating set control panel (see Section 9.4.9). Typically 15 wires are connected between the generating set and the TX panel.

The Status Panel has 3 indicator lights. They are "Mains On Load", "Mains Available" and "Generator On Load".

9.7 Engine Interface Module Description

The Engine Interface Module is a sealed, engine mounted module that provides switching relays for the Starter Motor Solenoid, Glow Plug and Fuel Solenoid. Each of these circuits is protected with individual fuses mounted in the module. Individual LED's illuminate when each circuit is energised.

This module is mounted on the engine with anti-vibration mounts and is easily connected to the engine via loom plugs. The fuses are automotive type. Use of the EIM means that heavy currents such as Fuel Solenoid power no longer go through the control panel enabling individual protection of each of the circuits. In addition to this the LED's will greatly aid in fault finding.



Item	Description	Item	Description
1.	Glow Plug Symbol	8.	Secondary Socket
2.	Fuel Symbol	9.	Starter Solenoid Fuse
3.	Fuel Solenoid Fuse	10.	Starter LED
4.	Fuel LED	11.	Overspeed Set-up LED
5.	Main Connector Socket	12.	Overspeed Adjuster
6.	Glow Plug Fuse	13.	Starter Symbol
7.	Glow Plug LED		

Figure 9.14: Engine Interface Module

9.7.1 Functional Description: There are three versions of the Engine Interface Module available - the 12 volt EIM SR, the 12 volt EIM Plus and the 24 volt EIM Plus.

The EIM SR is the basic level module that provides all the switching functionality. The EIM Plus provides the same functionality as the EIM SR plus the additional feature of Overspeed Sensing and an Overspeed Trip Adjuster. A magnetic pick-up on the engine flywheel housing provides the speed signal to the EIM Plus. When an overspeed situation is sensed, the EIM Plus signals the 2001, 4001 or 4001E generating set control panel to stop the engine. The Overspeed Trip Point can be easily set-up for 10% above the normal operating speed.

The overspeed feature on the EIM Plus, including the magnetic pickup is mandatory for all the Autostart control panels (2001, 4001 and 4001E). All generating sets above 150 kVA (with 24 volt engine electrical systems) are supplied with the EIM Plus and magnetic pickup as standard.

Status Indication: LED's on the module correspond to the Starter Motor Solenoid supply, the Glow Plug supply, (where used) and the Fuel Control Solenoid supply. Each illuminates to show that the indicated circuit is energised. A fourth LED (only operational on the EIM Plus) is used to set-up the Overspeed Trip Point.

Starter Motor Solenoid (EIM SR): When the Keyswitch is turned to start, a relay in the module is energised providing power to the Starter Motor Solenoid. When the Keyswitch is released the relay is de-energised, stopping the starter motor.

Starter Motor Solenoid (EIM Plus): During automatic cranking the module receives a signal from the magnetic pick-up. When the signal rises above 1090 Hz, the starter motor is disengaged and the EIM Plus switches a zero volt signal to the generating set control panel to indicate that the engine is running.

Should the crank speed be less than 12 Hz, the module will only allow a crank of 0.6 seconds.

If the engine speed falls below 350 Hz (i.e. the engine has stopped) the EIM Plus will allow cranking only after a 5 second delay (lockout) which compliments the generating set control panel's 3 attempt crank.

Glow Plug (pre-heat): When the relay is energised power is provided to the Glow Plug (where fitted).

Fuel Control Solenoid: The generating set control panel energises a relay in the module that provides power to the Fuel Control Solenoid allowing fuel flow to the engine.

Overspeed Signal (EIM Plus only): The EIM Plus monitors the speed signal from the magnetic pick-up. If the engine speed rises above a certain pre-setable value, the module sends a zero volt signal to the generating set control panel to activate the Overspeed Fault circuitry.

The Overspeed Set Point is factory set at 55Hz for 50Hz sets and 66Hz for 60Hz sets. This can be adjusted using the adjustment screw accessed through the hole beside the Overspeed Set-Up LED. While the engine is running at the rated speed (1500 rpm for 50Hz or 1800 rpm for 60Hz) the adjustment screw should be adjusted until the Overspeed Set-Up LED just goes out. This sets the overspeed value at 10% above the speed at which the generating set is operating.

Safety "Relay" Feature: The EIM SR and EIM Plus provide a safety check for any damaged contacts (i.e. welded contacts) using a "safety" relay. When the emergency stop pushbutton on the generating set control panel is pushed the EIM module automatically checks Fuel Control Solenoid and Starter Motor Solenoid to see if they are welded shut. A dimly lit LED on the module indicates the contacts are damaged and the module should be replaced.

9.8 Output Circuit Breaker Description

The alternator output circuit breaker is a moulded case circuit breaker (MCB/MCCB) of sufficient rating for the generating set output. Electrical output is switchable through this device, with "ON" being indicated by the handle being up. The breaker will carry its rated current continuously but will trip to mid-position if the rating on any one phase is exceeded for a period depending on the percentage overload and the circuit breaker characteristics. The breaker must then be switched "OFF" (handle down) before reclosing.

10. BATTERY DESCRIPTION AND MAINTENANCE

10.1 Battery Theory

10.1.1 General: The battery is an assembly of "cells" containing a number of plates, immersed in an electrically conductive fluid. The electrical energy from the battery comes from chemical reactions taking place within the cells. These reactions are reversible which means that the battery can be repeatedly charged and discharged.

10.1.2 Electrolyte: The electrically conductive fluid, called electrolyte, in a lead-acid battery is a diluted sulphuric acid solution. It aids the chemical reactions occurring at the plates and it acts as the carrier for the electrical current.

10.1.3 Specific Gravity: Specific gravity is a unit of measurement for determining the sulphuric acid content of the electrolyte which compares the weight of the electrolyte compared to the weight of pure water. At 25° C (77° F) a fully charged battery should have a specific gravity of 1.270. The lower the concentration of sulphuric acid, the lower the specific gravity.

As the battery is discharged, the chemical reactions lower the specific gravity of the electrolyte. Therefore, this measurement can be used as a guide to the state of charge of the battery.

10.1.4 Hydrometer: Specific gravity can be measured directly using a hydrometer. This device is a bulb-type syringe which will extract electrolyte from a cell in the battery. A glass float in the hydrometer barrel is calibrated to indicate the specific gravity.

Hydrometer readings should not be taken immediately after water is added to the cell. The water must be thoroughly mixed with the underlying electrolyte, by charging, before hydrometer readings are reliable. Also, if the reading is being taken immediately after the battery has been subjected to prolonged cranking, the reading will be higher than the true value. The water formed in the plates during the rapid discharge will not have had time to mix with the electrolyte above the plates.

10.1.5 High or Low Temperatures: In tropical climates (frequently above 32°C (90°F)) a fully charged battery with a lower specific gravity of 1.240 is used. This milder strength electrolyte increases the service life of the battery. If subjected to low temperatures the battery will not have the same cranking power due to the lower concentration of sulphuric acid, but this situation should not occur in tropical climates.

Batteries prepared for service in extremely cold weather use stronger electrolyte. In some instances specific gravity's of 1.290 to 1.300 are used. The cold cranking performance increases as the specific gravity increases.

10.1.6 Temperature Correction: The hydrometer is calibrated to indicate properly for a specified electrolyte temperature, often 25° C (77° F). For temperatures higher or lower than the reference temperature, a correction must be made. For each 5.5° C (10° F) above the reference add 0.004 to the reading. For each 5.5° C (10° F) below the reference, subtract 0.004 from the reading.

10.2 Battery Maintenance

WARNING:

! **Wear an acid resistant apron and face shield or goggles when servicing the battery. If electrolyte is spilled on skin or clothing, flush immediately with large quantities of water.**

10.2.1 Filling: The battery will often be shipped dry. Pre-mixed electrolyte of the correct specific gravity will have to be added.

Remove the vent plugs and fill each cell with the electrolyte until the level is 8 mm (5/16 inch) above the top edge of the separators. Allow the battery to stand for 15 minutes. Check and adjust the level as necessary.

10.2.2 Initial Charging: Within 1 hour of filling, the battery must be charged for 4 hours at the current indicated below. This will ensure that the acid is sufficiently mixed within the battery. Failure to give this charge at this time may impair the capacity of the battery.

Battery Reference	Charge Current (Amps)
E017	9
E312	14
E324	20

The above 4 hour charge period may need to be extended as follows: to 8 hours if the battery has been stored for 3 months or more at temperatures in excess of 30°C (86°F) or humidity above 80%; to 12 hours if the storage has exceeded 1 year.

If the charger output is not sufficient then a lower current, which should not be less than 1/3 of that given above, may be used but the time increased in proportion (8 hours at 7 Amps instead of 4 hours at 14 Amps).

At the end of the charging period, the electrolyte levels should be checked and restored if necessary by addition of sulphuric acid electrolyte at the correct specific gravity. The vents should then be replaced.

10.2.3 Topping Up: Normal operation and charging of the battery will cause some of the water to evaporate. This will require occasional topping up of the battery.

Clean the battery first to avoid contamination and remove the vent plugs. Add distilled water, until the level is 8 mm (5/16 inch) above the separators. Replace vent plugs.

10.3 Charging the Battery

WARNING:

! **Always ensure battery charging is carried out in a well ventilated area away from sparks and naked flames.**

! **Never operate a battery charger where unprotected from rain or snow. The charger should never be used near water.**

! **Always switch the charger off prior to disconnecting the battery.**

The engine driven alternator and or a static battery charger, if fitted, should maintain the batteries in a charged state. However, if the battery has recently been filled or recharging is required the battery may be disconnected from the generating set and connected to an external battery charger.

10.3.1 Charger and Battery Connections: The battery charger should be connected to a suitable mains supply (13 Amps minimum) using a plug connected as indicated below.

<u>Mains Connection</u>

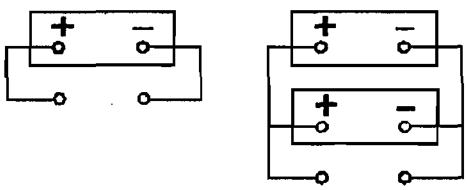
Live	Brown Lead
Neutral	Blue Lead
Earth	Green/Yellow Lead

Also ensure that the battery terminals are connected as indicated below:

<u>Battery Connection</u>

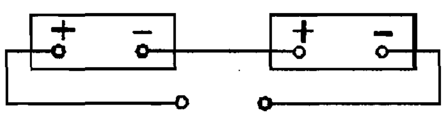
Positive (+) Terminal	Red Lead
Negative (-) Terminal	Black Lead

Connect the batteries to the charger as per the following chart:

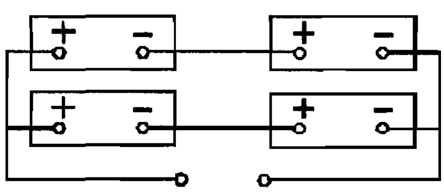


Single Battery Parallel

12 Volt Systems



Series



Series/Parallel

24 Volt Systems

10.3.2 Charger Operation: After the charger has been connected to the mains and the battery connected to the charger as indicated above, the charging procedure can be followed:

Remove the battery filler caps or vent cover during charging. Check electrolyte levels and adjust as necessary using distilled water.

Switch on the charger and observe rate of charge for normal operation. The charging rate depends on the Ampere-hour capacity of the battery, the condition of the battery and the present level of charge. The charging current will decrease as the battery starts charging and will continue to decrease as the battery voltage rises.

To check the state of charge, allow the battery to settle for a short period with the charger switched off. Then check the specific gravity of each cell using a hydrometer.

The battery charger should not overcharge or damage the batteries. High temperature, however, can damage the batteries. Care should be taken when charging batteries, especially in hot climates, that the battery temperature never rises above 45° C (113° F).

10.4 Battery Charging System Fault Finding/Trouble Shooting Chart

WARNING:

! **Removal of the battery charger cover will expose dangerously high voltage terminals.**

Symptom	Possible Fault	Remedy
No Charging Current	Incorrect or Bad Battery Connections	1. Check connections and clean terminals.
	Old or Sulphated Battery with Very Low Terminal Voltage	1. Remove battery and charge on specialist equipment.
	No Mains Supply	1. Check mains supply to charger.
	Blown Mains Fuse	1. Replace fuse.
	Faulty Diode Rectifier Unit	1. Remove output connections from each rectifier unit and test for output curr[illegible]t into a known load.
No Charging Current Shown on Indicator	Faulty Indicator	1. Check charging current with standard ammeter.
Charging Rate Too Low	Low Mains Voltage	1. Check mains voltage supply.
	Incorrect Mains Supply Tapping	1. Check the mains supply tapping with the supply voltage.
	Loose Heavy Current Connections	1. Check and tighten connections if necessary.
Charging Clamps Get Hot	Faulty Connections to the Battery	1. Clean terminals and reconnect.
	Loose Screws in Clamps	1. Clean and tighten screws in charging clamps.
Mains Supply Fuse Blows Repeatedly	Incorrect Fuse Rating	1. Replace with correct fuse.
	Wiring Short	1. Check and remake all connections.
Charging Rate Does Not Taper	Old or Damaged Battery	1. Charger is not faulty - battery will not rise to full charge voltage. Test batte[illegible] and replace as necessary.

10.5 Jump Starting Procedures

WARNING:

! Do not attempt to jump start a battery if the electrolyte is frozen or slushy. Bring the batteries up to at least 5° C (41° F) before attempting a jump start.

If the generating set battery has insufficient charge to start the generating set, a "jump start" from another battery is possible. Use the following procedures:

1. Remove all vent caps from the battery or batteries in the generating set. Do not permit dirt or foreign matter to enter the open cells.
2. Check the battery fluid level. If low add distilled water to bring it to the proper level.
3. Attempt to jump start only with a vehicle with a negative ground electrical system with the same voltage and that is equipped with a battery or batteries of comparable size or larger than those supplied with the generating set.
4. Bring the starting vehicle along side the generating set but do not allow metal to metal contact.
5. Place the starting vehicle in neutral or park, turn off all non-essential accessory loads and start the engine.
6. Connect one end of clean, heavy duty jumper cables to the positive battery terminal of the starting vehicle. If jump starting a 24 volt generating set and the starting vehicle is provided with two 12 volt batteries, then connect the jumper cable to the positive terminal of the battery that is not grounded.
7. Connect the other end of the same jumper cable to the positive terminal of the battery in the generating set. When jump starting 24 volt generating sets, connect to the positive terminal of the battery that is not grounded.
8. Connect one end of the other jumper cable to the grounded negative terminal of the battery in the starting vehicle. If jump starting a 24 volt generating set and the starting vehicle is provided with two 12 volt batteries, then connect the jumper cable to the negative terminal of the battery that is grounded.
9. Check the connections. Do not attempt to start a 24 volt generating set with one 12 volt battery in the starting vehicle. Do not apply 24 volts to one 12 volt battery in the generating set.
10. Connect the other end of this second jumper cable to a clean portion of the generating set engine block, away from fuel lines, the crank case breather opening or the battery.
11. With the engine of the starting vehicle running, start the generating set in accordance with the normal procedures. Avoid prolonged cranking.
12. Allow the generating set to warm up. When the set is warm and operating smoothly at normal RPM, disconnect the negative jumper cable from the engine block on the generating set. Then disconnect the other end of the same cable from the battery in the starting vehicle. Then disconnect the other cable for the positive terminal of the generating set battery and finally disconnect the cable from the starting vehicle battery.
13. Replace vent caps.

IMPORTANT NOTICE

THE FOLLOWING NOTICE IS INTENDED ONLY FOR UNITS SHIPPED INTO THE UNITED STATES OF AMERICA, CANADA OR U.S. POSSESSIONS (PUERTO RICO, VIRGIN ISLANDS, GUAM, AMERICAN SOMOA AND THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS)

For units marked as being intended for stationary use only, which are used in the United States of America, U.S. Possessions or Canada, the following restrictions apply.

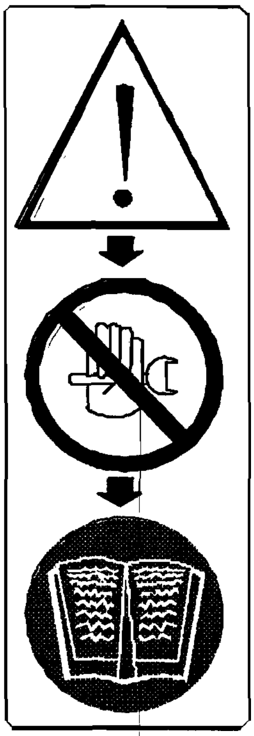
This generating set may only be used in stationary applications, as defined by the Environmental Protection Agency (EPA) Regulation in Title 40 of the Code of Federal Regulations (40 CFR Part 89.2(2)).

The definition of stationary, per the regulations, is that a) the unit will remain at a single site at a building, structure, facility or installation for more than 12 consecutive months, or b) will remain at a seasonal source during its full annual operating period, as defined in 40 CFR 89.2(2)(iii).

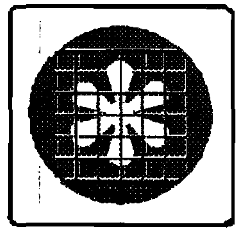
The following U.S. possessions must comply with U.S. EPA requirements: Puerto Rico, Virgin Islands, Guam, American Somoa, and the Commonwealth of the Northern Mariana Islands.

HAZARD LABEL LEGEND

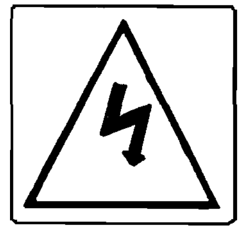
Some or all of these hazard warning labels will appear on your generating set:



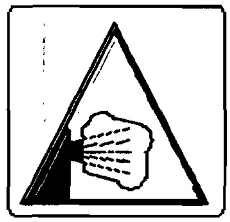
DO NOT TAMPER WITH UNLESS YOU HAVE READ THE INSTRUCTION MANUAL



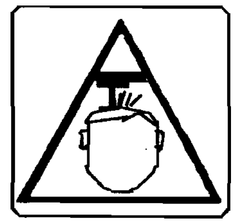
USE FAN GUARDS



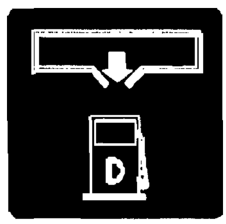
ELECTRIC SHOCK HAZARD



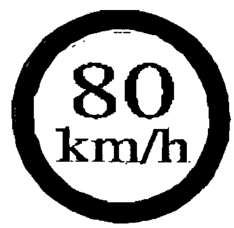
HOT EXHAUST GAS



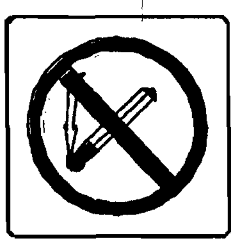
LOW OVERHEAD OBJECTS



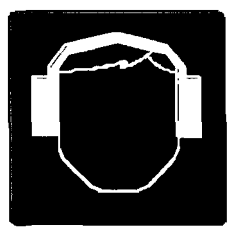
DIESEL FUEL SUPPLY LINE



RATED SPEED

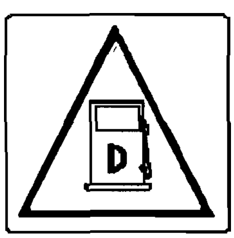


NO NAKED FLAMES



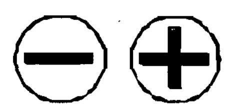
WEAR EAR PROTECTION

EMERGENCY/ PANIC EXIT

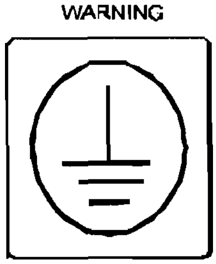


DIESEL FUEL WARNING

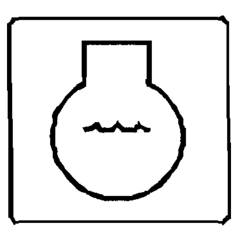
HOT SURFACES



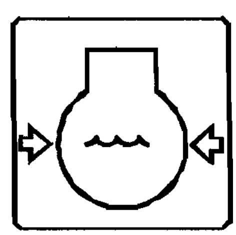
ELECTRIC TERMINALS



PROTECTIVE EARTH (GROUND)



ENGINE COOLANT



ENGINE COOLANT PRESSURE

INDEX

1 - RECEIPT

1.1 - Standards and Safety measures

Our alternators comply with most international standards and are compatible with:

- the recommendations of the **International Electrotechnical Commission** IEC 34-1, (EN 60034).
- the recommendations of the **International Standards Organisation** ISO 8528.
- the European Community directive on Electromagnetic Compatibility (EMC) 89/336/EEC.
- the European Community directives 73/23/EEC and 93/68/EEC (Low Voltage Directive).

They are CE marked with regard to the LVD (Low Voltage Directive) in their role as a machine component. A declaration of incorporation can be supplied on request.
Before using your generator for the first time, read with care the contents of this installation and maintenance manual, supplied with the machine. All operations performed on the generator should be undertaken by qualified personnel with specialist training in the commissioning, servicing and maintenance of electrical and mechanical machinery. This maintenance manual should be retained for the whole of the machine's life and be handed over with the contractual file.
The various operations described in this manual are accompanied by recommendations or symbols to alert the user to the risk of accidents. It is vital that you understand and take notice of the different safety symbols opposite.

WARNING

Safety symbol for an operation capable of damaging or destroying the machine or surrounding equipment.

Safety symbol for general danger to personnel.

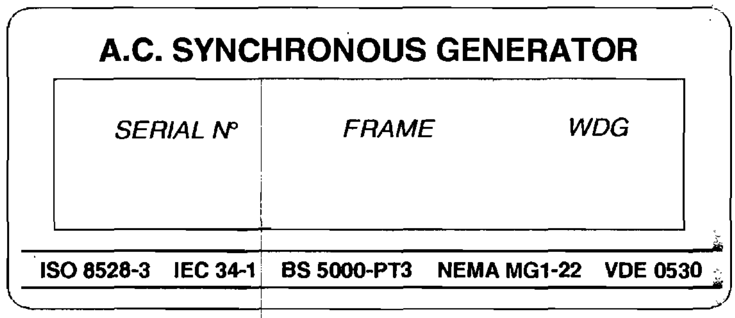
Safety symbol for electrical danger to personnel.

1.2 - Checks

On receipt of your alternator, check that it has not suffered any damage in transit.
If there are obvious signs of knocks, contact the transporter (you may be able to claim on their insurance) and after a visual check, turn the machine by hand (if twin bearing) to detect any malfunction.

1.3 - Identification

The alternator is identified by means of a nameplate (fig 1) fixed on the terminal box .
Make sure that the nameplate on the machine conforms to your order.
The machine name is defined according to various criteria (see below).



- Fig 1 -

1.4 - Storage

Whilst awaiting installation, the machines should be stored:

- away from humidity: in conditions of relative humidity of more than 90%, the machine insulation can drop very rapidly to just above zero at around 100% ; monitor the state of the anti-rust protection on unpainted parts.

For storage over an extended period, the machine can be placed in a sealed enclosure (heatshrunk plastic, for example) with dehydrating sachets inside, away from significant and frequent variations in temperature to avoid any condensation during storage.

2 - TECHNICAL CHARACTERISTICS

2.1 - Electrical characteristics

The 1000 series alternator is a machine without sliprings and revolving field brushes, wound as "2/3 pitch"; 12-wire, with class H insulation and a field excitation system available in either "SHUNT" fig 2 or "AREP" fig 3 version (see sections 2.3, 2.4). Interference suppression conforms with standard EN 55011, group 1, class B.

2.1.1 - Options

- Stator temperature detection probes
- Space heaters

2.2 - Mechanical characteristics

- Steel frame
- End shields in cast iron or aluminium
- Ball bearings greased for life
- Mounting arrangement

MD 35 STANDARD: single bearing, with standard feet and SAE coupling discs

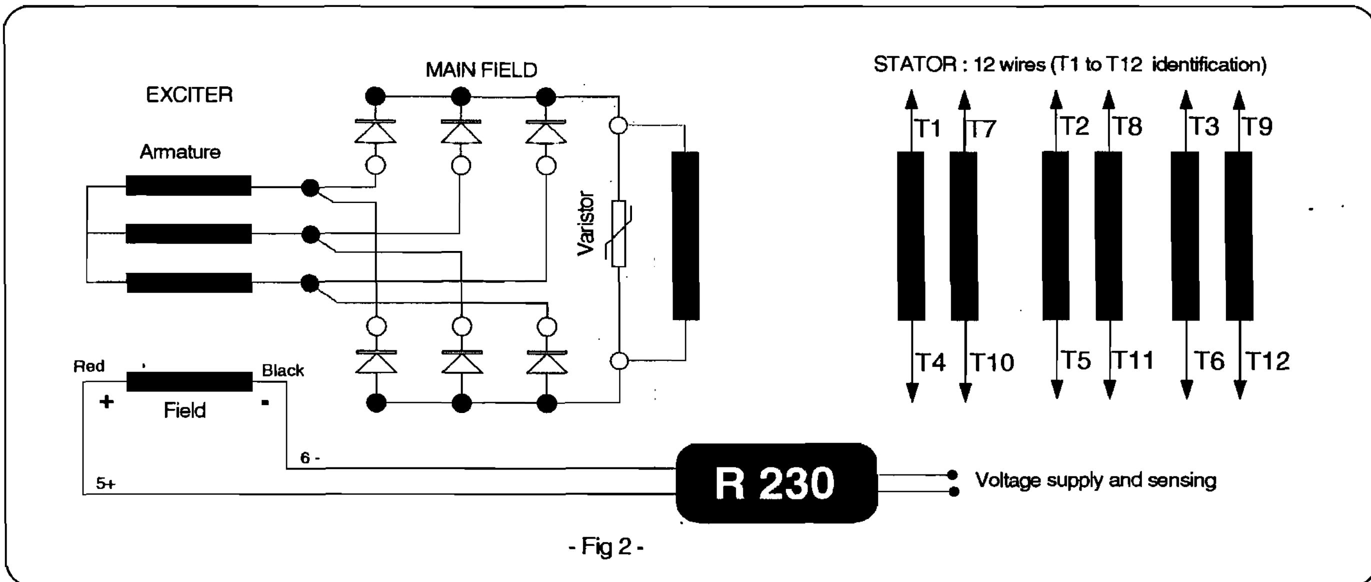
B 34 STANDARD: two bearing feet mounteed with standard bare shaft key wayed

- Drip-proof machine, self-cooled
- Degree of protection: IP 23

2.2.1 - Options

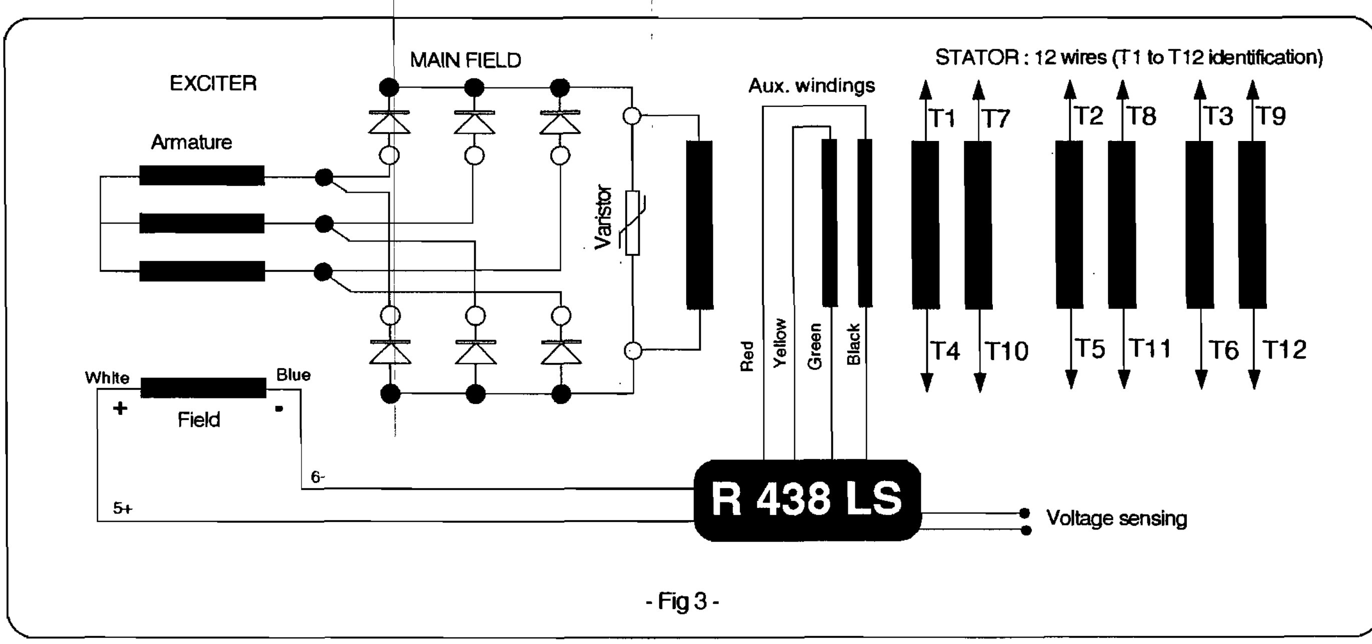
- Air input filter, air output labyrinth cowling

2.1.2 - System Shunt with A.V.R. R 230



- Fig 2 -

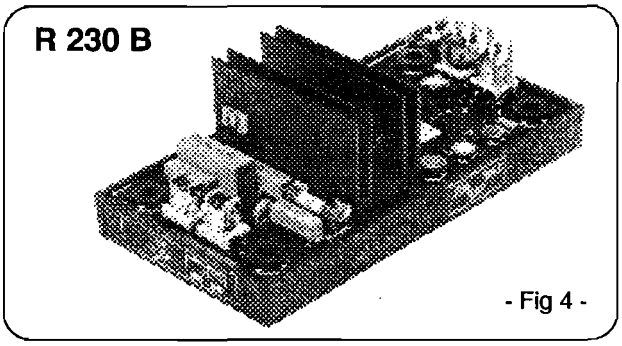
2.1.3 - System AREP with A.V.R. R 438 LS



- Fig 3 -

2.3 - SHUNT field excitation system

The alternator with Shunt field excitation is self-excited with a voltage regulator **R 230 B** "fig 4". The regulator monitors the exciter excitation current as a function of the alternator output voltage. Very simple in design, the alternator with Shunt excitation has no sustaining short-circuit capability.

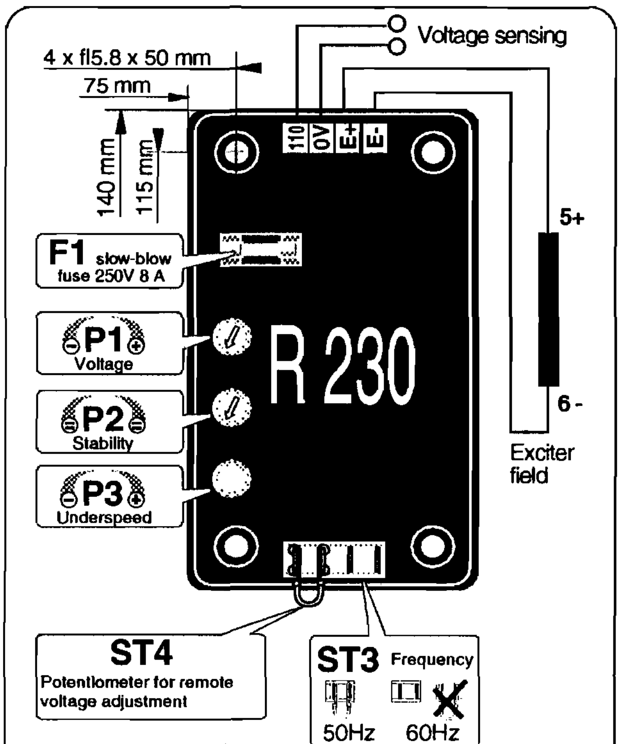


- Fig 4 -

2.3.1 - Characteristics (see Fig 5)

- Voltage regulation: around ± 0,5%
- Voltage detection range 85 to 139 V (50/60Hz)
- Rapid response time (500 ms) for a transient voltage variation amplitude of ± 20%
- Voltage setting **P1**
- Stability setting **P2**
- Power supply protected by 8 A fuse, slow-acting (tolerates 10 A for 10s).
- Frequency: 50 Hz with strap **ST3** - 60 Hz without strap **ST3**
- Factory set underspeed protection **P3** (see fig 6)

B version : internal development

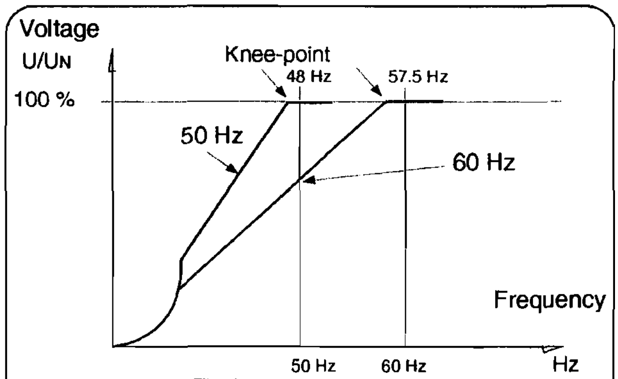


- Fig 5 -

2.3.2 - R 230 Regulator options:

Potentiometer for remote voltage adjustment, 1000 Ω / 0.5 W min : adjustment range ± 5%.

- Remove strap ST4 .



- Fig 6 -

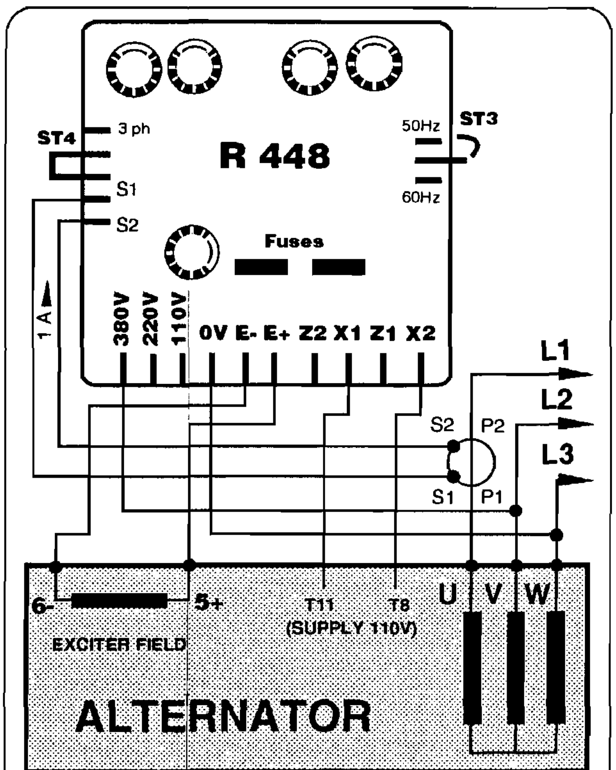
2.3.3 - Working with A.V.R. R 448

As an option the 448 A.V.R. can replace the R 230 on shunt alternator in order to get the following functions (see fig 7) :

- Parallel operation between alternators (with current transformers).
- Parallel operation with the mains (with current transformer and R 726 module).
- 3 phase detection (R 731 module).
- LAM function (integrated in the R448).

WARNING

This A.V.R. and associated modules must be installed outside the terminal box.



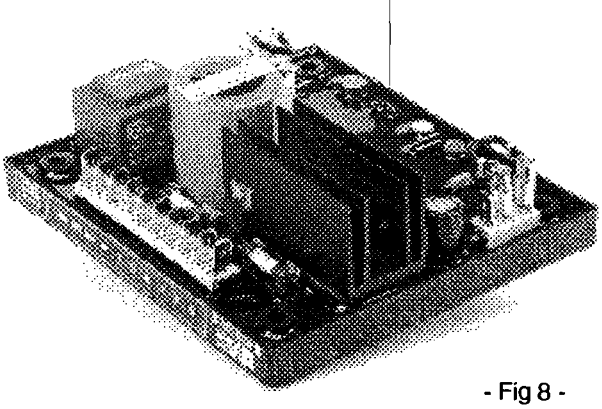
- Fig 7 -

For adjusting and fault detection refer to the section 4.5 of this notice (the function of R 438 and R 448 are the same).

2.4 - AREP field excitation system

With AREP excitation, the electronic A.V.R. **R 438 LS** (fig 8) is powered by two auxiliary windings which are independent of the voltage detection circuit. The first winding (X1,X2) has a voltage in proportion with the output voltage of the alternator (Shunt characteristic), the second (Z1,Z2) has a voltage in proportion with the stator current (compound characteristic: Booster effect). The power supply voltage is rectified and filtered before being used by the regulator monitoring transistor. This principle ensures that regulation is not affected by distortions generated by the load.

R 438 LS



- Fig 8 -

2.4.1 - R 438 regulator (fig 9)

- short-circuit current = 3 x IN for 10 seconds
- standard power supply; 2 auxiliary windings
- shunt power supply; max 48V - 50/60 Hz
- rated overload current: 8A - 10s
- electronic protection (overload, short-circuit opening on voltage detection): excitation ceiling current for 10 seconds then return to approx. 1A

The alternator must be stopped (or the power switched off) in order to reset the protection.

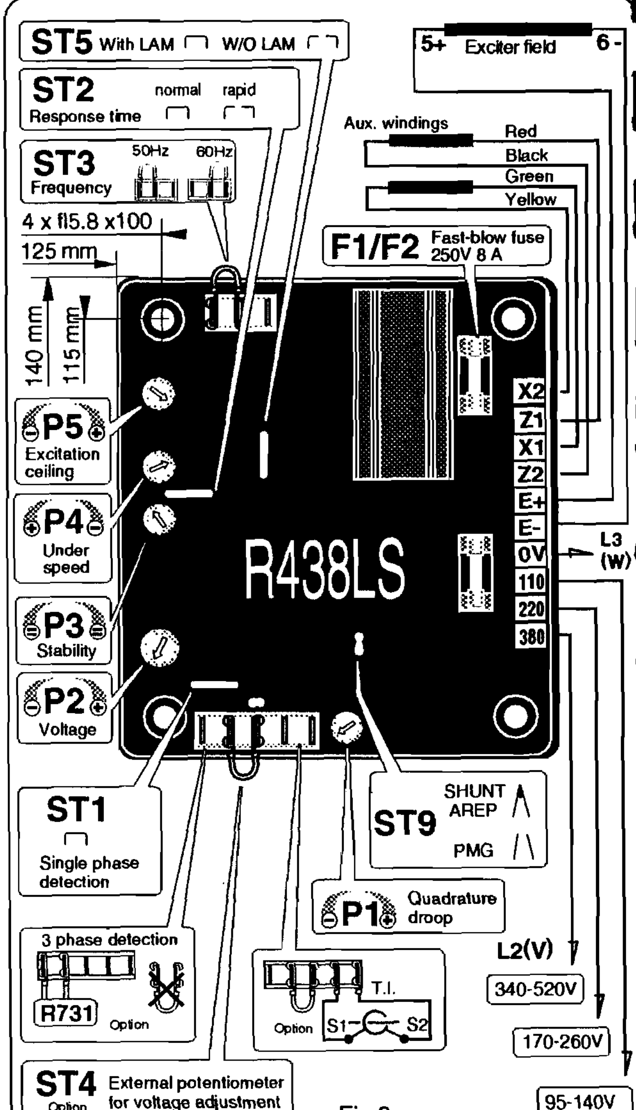
- Fuse F1 on input side (X1, X2)
- Fuse F2 on output side (E+, E-)
- voltage detection: 5 VA isolated via transformer

0-110 V terminals = 95 to 140 V
0-220 V terminals = 170 to 260 V
0-380 V terminals = 340 to 520 V

- rapid or normal response time via strap **ST2**
- voltage adjustment via potentiometer **P2**
  other voltages via step down transformer
- current detection: (parallel operation): C.T. 2.5 VA cl1, secondary 1A (Option)
- quadrature droop adjustment via potentiometer **P1**
- underspeed protection (U/f) and LAM: frequency threshold adjustable via potentiometer **P4**
- max. excitation current adjustment via **P5**: 4.5 to 10A
- 50/60 Hz selection via strap **ST3**

2.4.2 - R 438 LS A.V.R. options

- **Current transformer** for parallel operation
- Remote voltage **adjustment potentiometer**: 470 Ω, 0.5 W min: adjustment range ± 5% (range limited via internal voltage potentiometer **P2**). Remove ST4 to connect the potentiometer. (A 1 k Ω potentiometer can also be used to extend the adjustment range.)
- **R 731 external module**: detection of 3-phase voltage 200 to 500 V, compatible with parallel operation. Cut ST1 to connect the module; set the voltage via the module potentiometer. (The previous version module is not compatible with parallel operation).
- **R 726 module**: 3 functions (external mounting).
- • P.F. φ regulation (2F) and voltage matching prior to paralleling with the mains (3 F).
- • C.T. of ....../1A . 5 VA CL 1 (see schematic included with this manual).



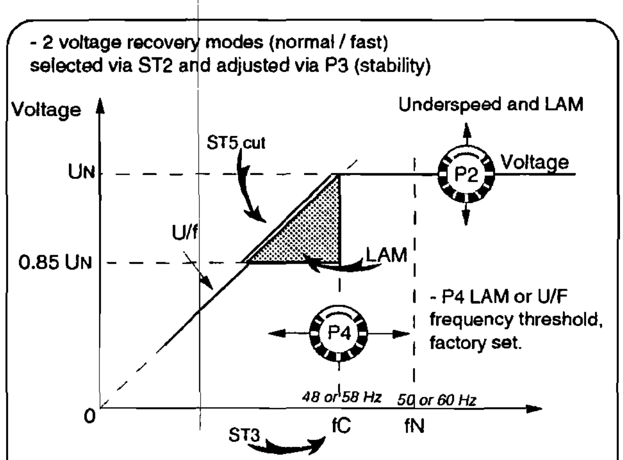
- Fig 9 -

WARNING

It is impossible to mount PMG on 1000 serie

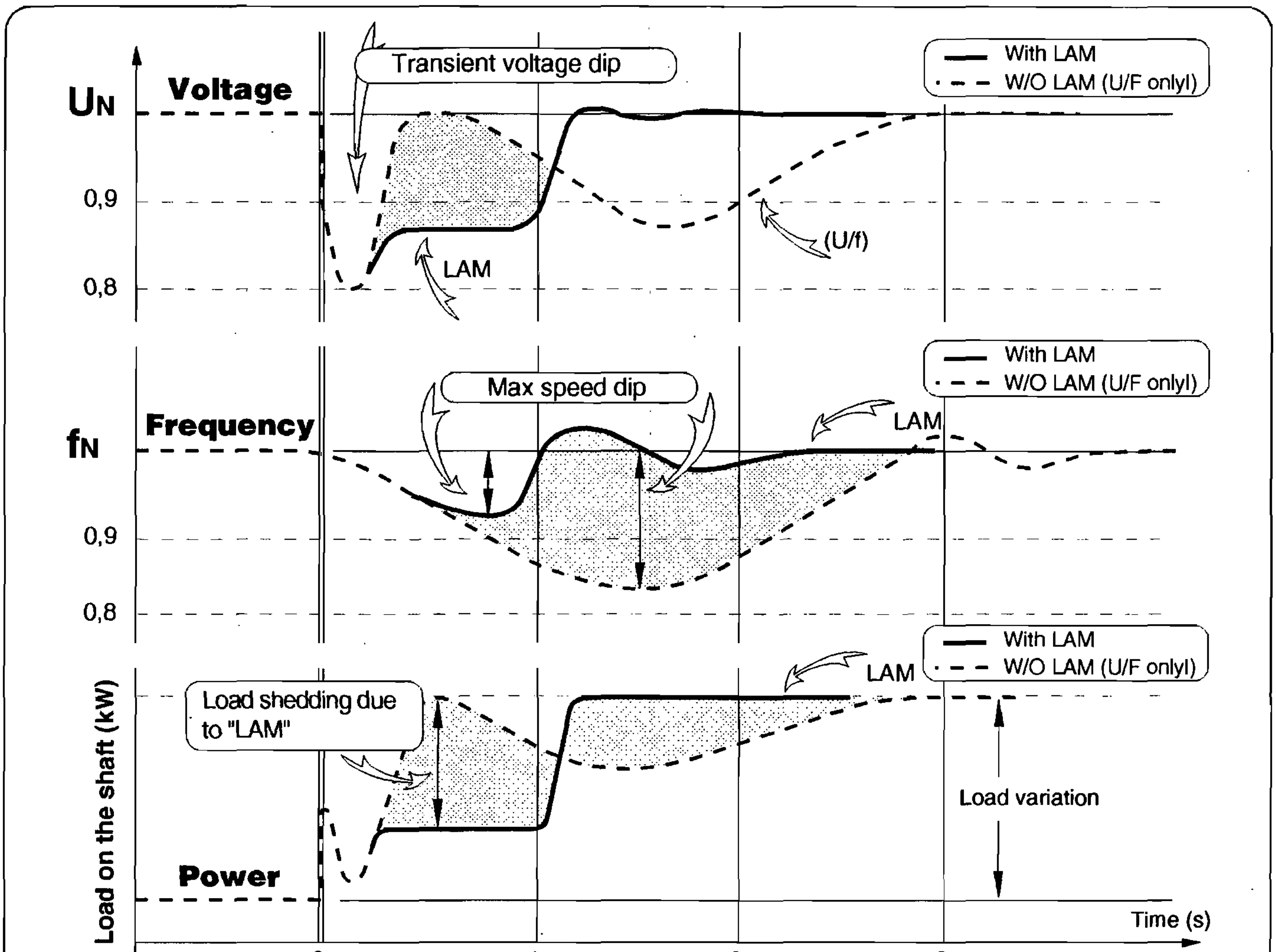
2.4.3 - LAM characteristics (Fig 10)

The LAM system is integrated as standard in the **R 438** regulator.
- Role of the "LAM" (Load Adjustment Module):
On load impact, the rotation speed of the generator set decreases. When it passes below the preset frequency threshold, the "LAM" causes the voltage to drop by approximately 15% and consequently the amount of active load applied is reduced by approximately 25%, until the speed reaches its rated value again.
Hence the "LAM" can be used either to reduce the speed variation (frequency) and its duration for a given applied load, or to increase the applied load possible for one speed variation (turbo-charged engine).
To avoid voltage oscillations, the trip threshold for the "LAM" function should be set approximately 2 Hz below the lowest frequency in steady state.
- LAM: action eliminated by cutting strap ST5



- Fig 10 -

Typical effects of the "LAM" with a diesel engine (see Fig 11)



- Fig 11 -

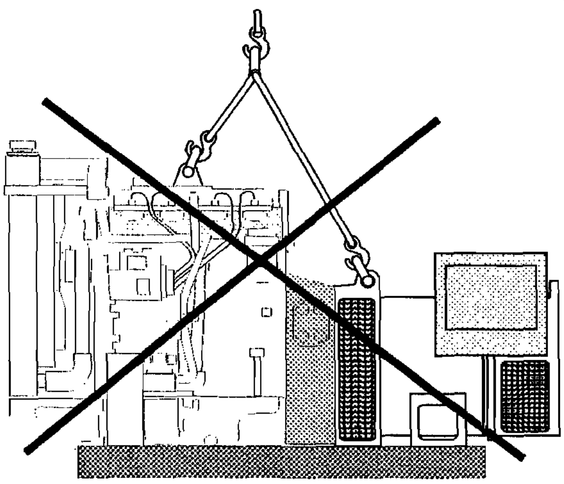
3 - INSTALLATION - COMMISSIONING

3.1 - Assembly

All mechanical handling operations must be undertaken using approved equipment.
While being handled, the machine should remain horizontal (when travelling bar removed).

3.1.1 - Handling

The generously-sized lifting rings are for handling the alternator alone. They must not be used to lift the genset. Choose a lifting system which respects the positioning of the rings (see fig 12).



- Fig 12 -

3.1.2 - Coupling

3.1.2.1 - Single bearing alternator

Before coupling to the prime mover, check that both are compatible by:
- Undertaking a torsional analysis of the transmission.
- Checking the dimensions of the flywheel and its housing, the flange, coupling discs and offset.

WARNING

When coupling the alternator to the prime mover, the holes of the coupling discs should be aligned with the flywheel holes by cranking the engine.
Do not use the alternator fan to turn the rotor.

Tighten the coupling discs screws to the recommended torque (see section 4.7.1) and check that there is lateral play on the crankshaft.

3.1.2.2 - Two-bearing alternator

- Semi-flexible coupling

Careful alignement of the machines by measuring the concentricity and parallelism of the two parts of the coupling is recommended, the difference between the teadings should not exceed the specified values (say 0,1 mm).

WARNING

This alternator has been balanced with a 1/2 key.

- Belt and pulley drive system

Check that the shafts are parallel, the pulleys aligned, and that the belt tension is correct.
The maximum permissible radial load at the middle of the shaft end is 350 da.N for a calculated service life "L10" of 20,000 hrs at 1800 min^{-1} or 3600 min^{-1}.
Note: For special belt-pulley drive systems, please consult the Sillac factory.

3.1.3 - Location

Ensure that the ambient temperature in the room where the alternator is placed cannot exceed 40°C for standard power ratings (for temperatures above 40°C, apply a derating coefficient). Fresh air, free from damp and dust, must be able to circulate freely around the air input louvres on the opposite side from the coupling. It is essential to prevent not only the recycling of hot air from the machine or engine, but also exhaust fumes.

3.2 - Inspection prior to first use

3.2.1 - Electrical checks

Under no circumstances should an alternator, new or otherwise, be operated if the isolation is less than 1 megohm for the stator and 100,000 ohms for the other windings.

There are two possible methods for restoring the above minimum values.

a) Dry out the machine for 24 hours in a drying oven at a temperature of approximately 110 °C.

b) Blow hot air into the air input, having made sure that the machine is rotating with the exciter field disconnected.

c) Run in short-circuit mode (disconnect the AVR)
- Short-circuit the output phases using connections capable of supporting the rated current (try not to exceed 6 A/mm2).
- Insert a clamp ammeter to monitor the current passing through the short-circuit connections.
- Connect a 48 Volt battery in series with a rheostat of approximately 10 ohms (50 Watts), to the exciter field terminals, respecting the polarity.
- Open fully all the alternator orifices.
- Run the alternator at rated speed . Adjust the exciter field current using the rheostat to obtain the rated output current in the short-circuit connections.

Note: Prolonged standstill: In order to avoid these problems, we recommend the use of space heaters, as well as turning over the machine from time to time. Space heaters are only really effective if they are working continuously while the machine is stopped.

3.2.2 - Physical and visual checks

Before starting the machine for the first time, check that:
- the fixing bolts on the feet are tight
- the cooling air is drawn in freely
- the protective louvres and housing are correctly in place
- the standard direction of rotation is clockwise as seen from the shaft end (phase rotation in order 1 - 2 - 3). For anti-clockwise rotation, swap 2 and 3.
- the winding connection corresponds to the site operating voltage (see section 3.3)

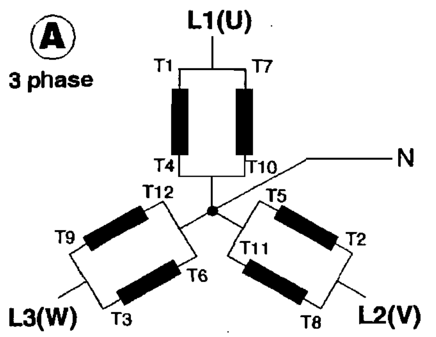
3.3 - Terminal connection diagrams

To modify the connection, change the position of the terminal cables (see fig 13 & 14). The winding code is specified on the nameplate.

Any intervention on the alternator terminals during reconnection or checks should be performed with the machine stopped.

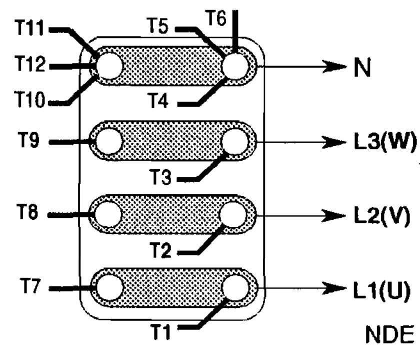
Connection codes | L.L voltage | Factory connection

A 3 phase

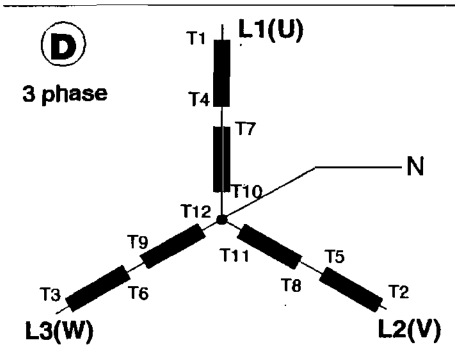


Winding	50 Hz	60 Hz
6	190 - 208	190 - 240
7	220 - 230	-
8	-	190 - 208

R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 220 V => (T2)

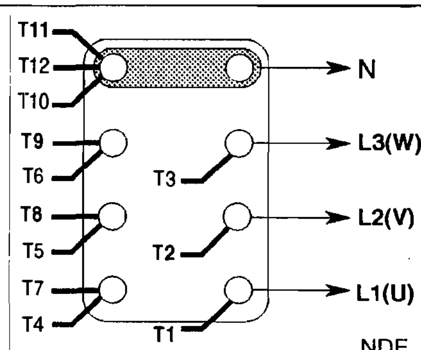


D 3 phase

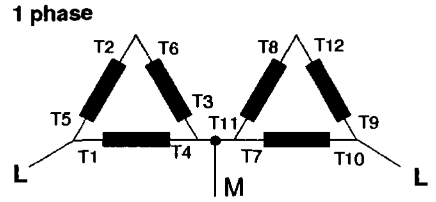


Winding	50 Hz	60 Hz
6	380 - 415	380 - 480
7	440 - 460	-
8	-	380 - 416

R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 380 V => (T2)



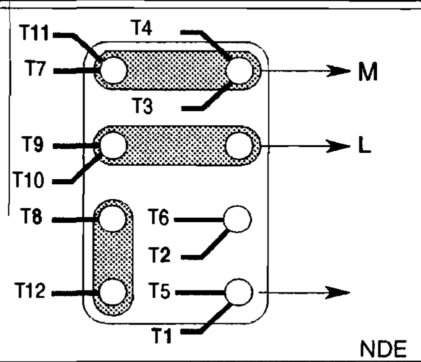
FF 1 phase



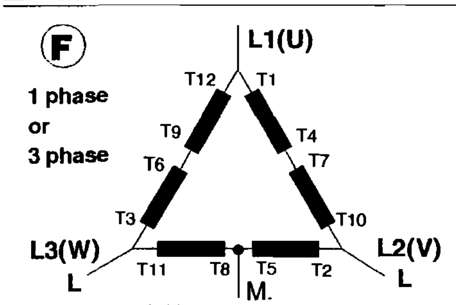
LM voltage = 1/2 LL voltage

Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

R 230 voltage detection :
0 => (T1) / 110 V => (T4)
R 438 LS voltage detection :
0 => (T10) / 220 V => (T1)



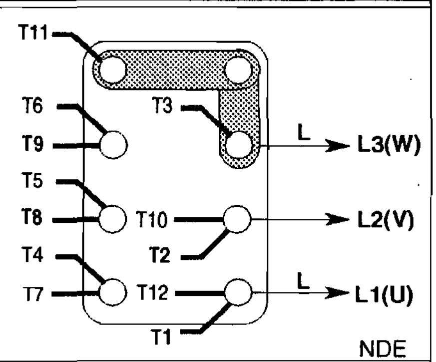
F 1 phase or 3 phase



LM voltage = 1/2 LL voltage

Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

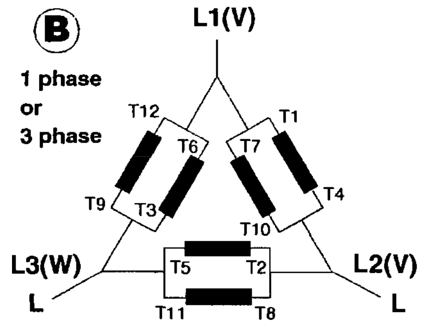
R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 220 V => (T2)



- Fig 13 -

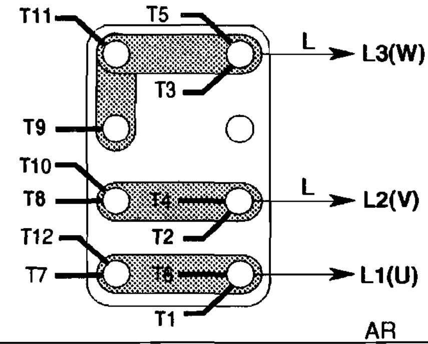
Connection codes	L.L voltage			Factory connection

B — 1 phase or 3 phase



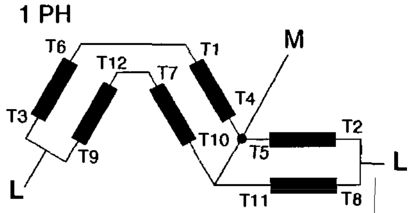
Winding	50 Hz	60 Hz
6	110 - 120	120
7	120 - 130	-
8	-	110 - 120

R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 110 V => (T2)



G — Connection not recommended

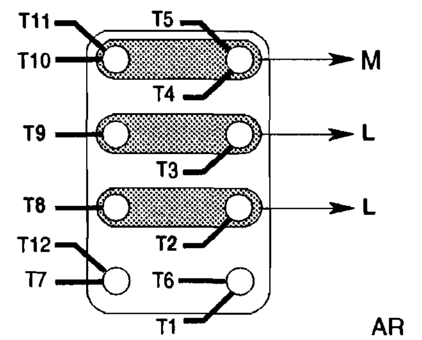
1 PH



LM voltage = 1/2 LL voltage

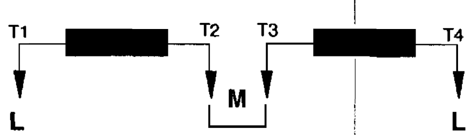
Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 220 V => (T2)



SINGLE PHASE 4 LEADS - DEDICATED WINDING

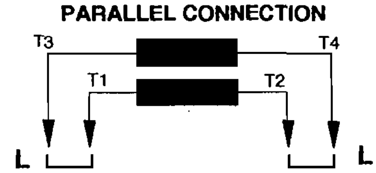
SERIES CONNECTION



Voltage 50/60 Hz			Output		
L - L	L - M	Connect	L	L	M
220 230 240	110 115 120	T2 - T3	T1	T4	T2 - T3

R 230 voltage detection : 0 => (T1) / 110 V => (T2)

PARALLEL CONNECTION



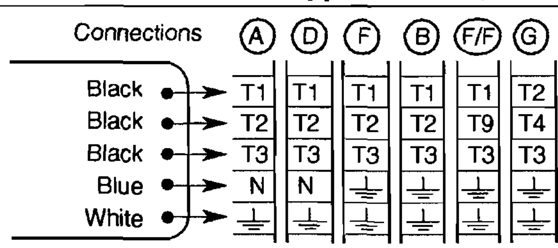
Voltage 50/60 Hz			Output		
L - L	L - M	Connect	L	L	M
110 115 120	- - -	T1 - T3 T2 - T4	T1-T3	T2 - T4	-

R 230 voltage detection : 0 => (T1) / 110 V => (T2)

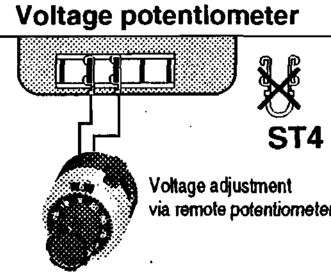
- Fig 14 -

3.3.1 - Connection diagram for options (fig 15)

R 791 T interference suppression kit (standard for CE marking)



Voltage potentiometer

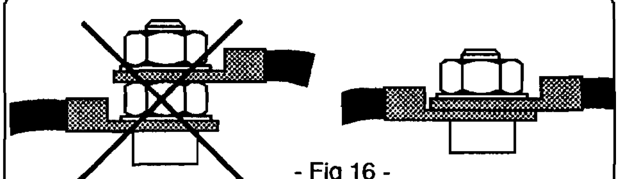


- Fig 15 -

3.3.2 - Connection checks

Electrical installations must comply with the current legislation in force in the country of use.

Check that:
- the differential circuit-breaker conforms to legislation on protection of personnel, in force in the country of use, and has been correctly installed on the alternator power output as close as possible to the alternator. (Disconnect the blue wire of the R 791 interference suppression module linking the neutral).
- any protective devices in place have not tripped,
- if there is an external regulator, the connections between the alternator and the cubicle are made in accordance with the connection diagram,
- there is no short-circuit between phase or phase-neutral between the alternator output terminals and the generator set control cabinet (part of the circuit not protected by circuit-breakers or cubicle relays)
- the machine should be connected with the terminal lugs on top of one another as shown in the terminal connection diagrams (see fig 16).



- Fig 16 -

3.3.3 - Electrical checks on the A.V.R.

- Check that all connections have been made properly as shown in the attached connection diagram.
- Check that the frequency selection strap "ST3" is on the correct frequency setting.
- Check whether strap ST4 or the remote adjustment potentiometer have been connected.
- Optional operating modes (R 438 LS)
• Strap ST1: cut to connect the R 731 3-phase detection module.
• Strap ST2: cut for rapid response time.
• Strap ST5: cut to suppress the function

3.4 - Commissioning

The machine can only be started up and used if the installation is in accordance with the instructions and advice defined in this manual.
The machine is tested and set at the factory. When first used with no load, make sure that the drive speed is correct and stable (see the nameplate). On application of the load, the machine should maintain its rated speed and voltage; however, in the event of abnormal operation, the machine setting can be altered (follow the adjustment procedure in section 3.5). If the machine still operates incorrectly, the cause of the malfunction must be located (see section 4.4) .

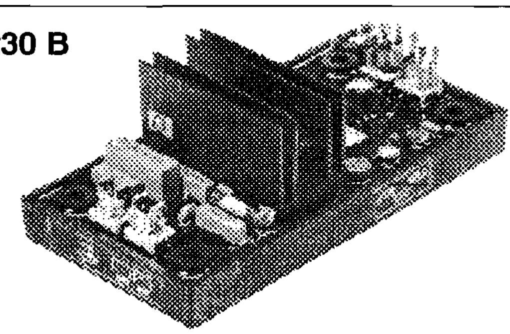
3.5 - Setting up

The various adjustments during tests must be made by a qualified engineer. Take care that the drive speed specified on the nameplate is reached before commencing adjustment. After operational testing, replace all access panels or covers.
The A.V.R. is used to make any adjustments to the machine.

3.5.1 - R 230 adjustments (Shunt system)

Initial potentiometer settings

R 230 B

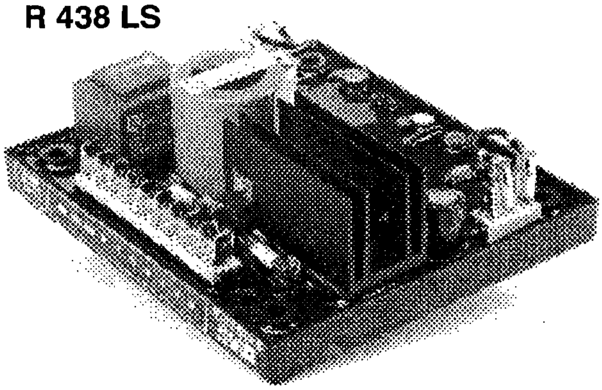


- Potentiometer **P1** (AVR voltage adjustment): fully anti-clockwise
- Remote voltage adjustment potentiometer: middle

Run the alternator at its rated speed: if the voltage does not increase, the magnetic circuit should be remagnetized (see section 4.5)
- Turn the AVR voltage adjustment potentiometer **P1** slowly until the output voltage rated value is obtained.
- Adjust the stability using **P2.**
- Sealed potentiometer **P3** is factory set at 48 Hz for 50 Hz and 57.5 Hz for 60 Hz.

3.5.2 - R 438 LS adjustments (AREP system)

R 438 LS



a) Initial potentiometer settings (see table >)
- remote voltage adjustment potentiometer: centre (ST4 strap removed)

b) Install a D.C. analogue voltmeter (needle dial) cal. 50V on terminals E+, E- and an A.C. voltmeter cal. 300 - 500 or 1000V on the alternator output terminals.

c) Make sure that the **ST3** strap is positioned on the desired frequency (50 or 60 Hz).

d) Voltage potentiometer **P2** at minimum, fully to anti-clockwise

e) Turn the V/Hz potentiometer **P4**, fully to clockwise.

f) Stability potentiometer **P3** approximately 1/3 of travel anti-clockwise.

g) Start the engine and set its speed to a frequency of 48 Hz for 50 Hz, or 58 for 60 Hz.

h) Adjust the output voltage to the desired value using **P2**.
- rated voltage UN for solo operation (eg. 400 V)
- or UN + 2 to 4% for parallel operation with C.T. (eg. 410V -)

If the voltage oscillates, use **P3** to make adjustments (try both directions) observing the voltage between E+ and E- (approx. 10V D.C.). The best response times are obtained at the limit of the instability. If no stable position can be obtained, try cutting or replacing the ST2 strap (normal /rapid).

i) Check LAM operation: **ST5** closed

j)Turn potentiometer **P4** slowly anti-clockwise until there is a significant voltage drop (approx. 15 %).

k) Vary the frequency (speed) of both parts between 48 or 58 Hz according to the operating frequency, and check the change in voltage previously observed (~ 15%).

l) Readjust the speed of the unit to its rated no-load value.

Action	Factory adjust.	Pot.
Voltage minimum fully CCW	400V - 50 Hz (0 - 380 V)	− + P2
Stability	Not adjusted (middle)	P3
THreshold/LAM or U/F Threshold for underspeed protection U/f and LAM function	ST3 on 50 Hz (factory=48 Hz) ST3 on 60 Hz (factory=58 Hz)	+ − P4
Quadrature voltage droop (Parallel operation with C.T.) - No droop fully CCW	Not adjusted (fully CCW)	− + P1
Ceiling excitation current Excitation current and short circuit current limitation, minimum fully CCW	10 A maximum	− + P5

3.5.2.1 - Adjustments in parallel operation

Before any intervention on the alternator, make sure that the speed quadrature droop is identical for all engine.

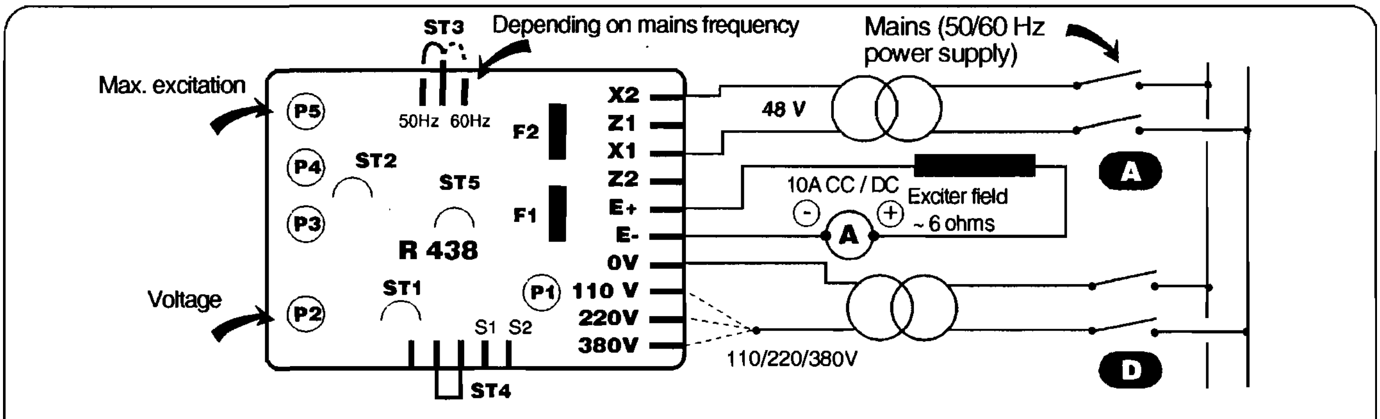
m) Preset for parallel operation (with C.T. connected to S1, S2 of connector J2)
- potentiometer P1 (quadrature droop) in centre position

Apply the rated load (P.F. = 0.8 inductive).
The voltage should drop by 2 to 3 %. If it increases, swap the 2 incoming wires of the C.T. secondary.

n) The no-load voltages should be identical for all the alternators intended to run in parallel.
- Couple the machines in parallel.
- By adjusting the **speed,** try to obtain **0 Kw** power exchange.
- By altering the voltage setting P2 or Rhe on one of the machines, try to cancel (or minimise) **the current** circulating between the machines.
- **From now on, do not touch the voltage settings.**

o) Apply the available load (the setting is only correct if a **reactive** load is available)
- By altering the **speed,** equalize the **KW** (or divide the rated power of the units proportionally)
- By altering the quadrature droop potentiometer **P1**, equalize or divide the **currents**.

3.5.2 .2 - Max. excitation adjustment (excitation ceiling)



- Fig 17 -

- quadrature droop adjustment of the current limit, potentiometer P5 (factory setting: 7.5 A, fuse rating: 6.3A - 10 seconds) Fig 17.

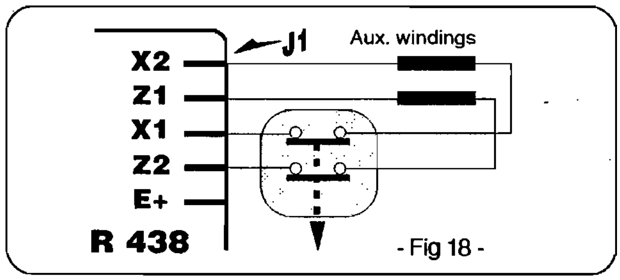
The factory setting corresponds to that of the excitation current required to obtain a 3-phase short-circuit current of approximately 3 x IN at 50 Hz for industrial power, unless otherwise specified.(*)
It is possible to reduce the maximum excitation level by a static method which is safer for the alternator and the network. Disconnect power supply wires X1,X2 and Z1,Z2, and the sensing leads (0-110V-220V-380V) on the alternator.

Connect the mains power supply (200-240V) as indicated (X1,X2: 48V). Install a 10A D.C. ammeter in series with the exciter field. Turn P5 fully C.C.W. to activate the power supply. If there is no output current from the A.V.R., turn potentiometer P2 (voltage) C.W. until the ammeter indicates a stable current. Switch the power supply off, then on again, turn P5 C.W until the required max. current is obtained (no more than 8 A).

Checking the internal protection:
Open switch (D): the excitation current should increase to its preset ceiling, remain at that level for about 10 seconds and then drop to below 1A.
To reset, switch off the power supply by opening switch (A).
Note: After setting the excitation ceiling as described, adjust the voltage again (see section 3.5.2.)

(*): A short-circuit current of 3 x IN is a legal requirement in most countries so as to offer selective protection.

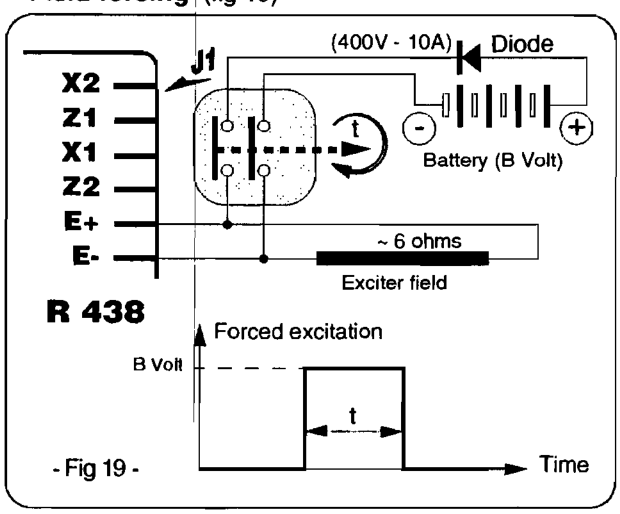
3.5.2 .3 - Special type of use
- Field de-energizing (fig 18)



- Fig 18 -

The exciter is switched off by disconnecting the AVR power supply (1 wire on each auxiliary winding) contact rating 10A - 250V A.C.
Connection is identical for resetting the AVR internal protection.

- Field forcing (fig 19)



- Fig 19 -

Applications	B volts	Time t
Guaranteed voltage build up	6 (1A)	1 - 2 s
Parallel operation, de-energized	6 (1A)	1 - 2 s
Parallel operation, at standstill	12 (2A)	5 - 10 s
Battery starting	24 (4A)	5 - 10 s
Sustained voltage on over load	24 (4A)	5 - 10 s

4 - SERVICING - MAINTENANCE

4.1 - Safety measures

Servicing or troubleshooting must be carried out strictly in accordance with instructions so as to avoid the risk of accidents and to maintain the machine in its original state.

All such operations performed on the alternator should be undertaken by personnel with training in commissioning, servicing and maintenance of electrical and mechanical components.

Before any intervention on the machine, ensure that it cannot be started by a manual or automatic system and that you have understood the operating principles of the system.

4.2 - Regular maintenance

4.2.1 - Checks after start-up

After approximately 20 hours of operation, check that all fixing screws on the machine are still tight, plus the general state of the machine and the various electrical connections in the installation.

4.2.2 - Cooling circuit

It is advisable to check that circulation of air is not reduced by partial blocking of the suction and discharge louvres: mud, fibre, grease, etc.

4.2.3 - Bearings

The bearings are greased for life: approximate life of the grease (depending on use) = 20,000 hours or 3 years. Monitor the temperature rise in the bearings, which should not exceed 60°C above the ambient temperature. Should this value be exceeded, the machine must be stopped and checks carried out.

4.2.4 Electrical servicing

- Cleaning product for the windings

WARNING

DO NOT USE: TRICHLORETHYLENE, PERCHLORETHYLENE, TRICHLOROETHANE and ANY ALKALINE PRODUCTS.

Certain strictly defined pure volatile degreasing products can be used, such as:

- **Normal petrol (without additives)**
- **Toluene (slightly toxic); flammable**
- **Benzene (or benzine, toxic); flammable**
- **Ciclohexare (non toxic); flammable**

Cleaning the stator, rotor, exciter and diode bridge

The isolating components and the impregnation system are not at risk of damage from solvents (see the list of authorised products above).

Avoid letting the cleaning product run into the slots.

Apply the product with a brush, sponging frequently to avoid accumulation in the housing. Dry the winding with a dry cloth. Let any traces evaporate before reassembling the machine.

After cleaning the alternator it is essential to check the isolation of the windings (see sections 3.2.2 and 4.7.2.).

4.2.5 Mechanical maintenance

WARNING

Water and/or Pressure wash are strictly prohibited. Any problem caused by such treatement are not covered by our warranty.

Degreasing : Use a brush and detergent (adapted to paint).

Dusting : Use an air gun.

If a machine is fitted with air inlet and outlet filters, in order to ensure correct ventilation, a regular cleaning of the filters must be done according to the environment conditions.

After cleaning the alternator, it is essential to check the insulation of the windings (see sections 3.2. and 4.8).

4.3 - Fault detection

If, when first commissioned, the alternator does not work normally, the source of the malfunction must be identified.

To do this, check that:

- the protective devices are fitted correctly
- all connections comply with the diagrams in the manuals supplied with the machine
- the speed of the unit is correct (see section 1.2.2)

Repeat the operations defined in section 3.

4.4 - Mechanical defects

Fault		Action
Bearing defect	Excessive overheating of one or both bearings (temp of bearings over 176 °F)(With of without abnormal bearing noise)	- If the bearing has turned blue or if the grease has turned black , change the bearing. - Bearing race badly locked (moving in its housing) -Bracket misalignment.
Overheating	Excessive overheating of alternator frame (temperature rise of more than 104° C above ambient)	- Air flow (Inlet - outlet) partially clogged or hot air is being recycled either from alternator or prime mover - Aternator Is functionning at too high a voltage (over 105 % of rated voltage on load). - Alternator overloaded.
Vibration problem	Too much vibration	Misalignment (coupling) - Defective mounting or play in coupling - Incorrect balancing of shaft (Engine - Alternator)
	Excessive vibration and humming noise coming from the alternator	Three phase alternator is single phase loaded in excess of acceptable level. - Short-circuit in the alternator stator
Abnormal noises	Alternator damaged by a significant impact which is followed by humming and vibration	- System short-circuit - Mis paralleling Possible consequences (according to the seriousness of the above faults): - Broken or damaged coupling. - Broken or bent shaft end. - Shifting and short circuit of main field rotor. - Fractured fan or coming loose on shaft. - Blown up rotating diodes, or and A.V.R.

4.5 - Electrical faults

Fault	Action	Symptoms	Cause
No voltage at no load or start up	Connect a battery of 4 to 12 volts to terminals E+ or E- respecting the polarity on the A.V.R.for 2 to 3 seconds	The alternator builds up and voltage is correct when the battery is removed	- Lack of residual magnetism
		The alternator builds up but voltage does not reach nominal value when the battery is removed	- Check the connection of the sensing leads to the A.V. R - Faulty rotating diode - Short-circuit on rotor windings
		The alternator builds up but voltage collapses when the battery is removed	- Faulty A.V.R. - Exciter windings shorted or open circuit (check winding) - Main field winding open circuit (check resistance)
Voltage too low	Check the prime mover speed	Correct speed	Check AVR connections (possible AVR failure) - Exciter field short-circuited - Rotating diode(s) burnt out - Main field rotor short-circuited - Check the resistance
		Speed too low	Increase the speed of prime mover (Do not touch the AVR voltage pot. (P2) before running at the correct speed)
Voltage too high	Adjust potentiometer voltage	No adjustment of voltage	AVR faulty
Voltage oscillations	Adjust the stability potentiometer on A.V.R.	If no effect : change recovery mode normal / rapid (ST2)	- Check speed for possible cyclic irregularity - Loose connections - Faulty A.V.R. - Speed below nominal on load (or LAM set too high)
Voltage correct on no load too low on load (*)	Run on no-load and check voltage between E+ and E-	Voltage between E+ and E- : < 6V(DC)	- Check speed (or LAM on R 438 set too high)
		Voltage between E+ and E- > 10 V (DC)	- Faulty rotating diodes faulty - Short-circuit in the main field. Check resistance. - Faulty exciter armature. Check resistance.
(*) **Warning**: During single-phase operation, check that the sensing wires from the AVR are connected to the correct output terminals.			
Voltage collapses during normal operation (**)	Check the AVR, the surge suppressor, the rotating diodes and replace any defective part	The output voltage does not return the rated value .	- Exciter winding open circuit - Faulty exciter armature - Faulty AVR - Main field rotor winding open circuit or short circuit
(**) **Warning**: The AVR internal protection may cut in (overload lost connection, short circuit)			

4.5.1 - Checking the windings

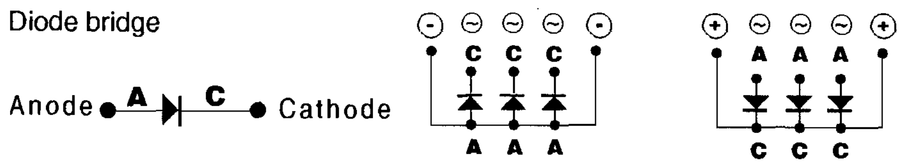
You can check the winding insulation making a high voltage test. In this case, you must disconnect all AVR wires.

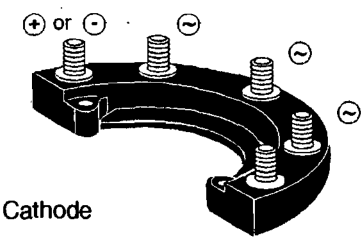
WARNING

Damages occuring to avr in such conditions will not be taken into account in a warranty claim.

4.5.1 - Checking the diode bridge (Fig 20)

Diode bridge





A diode in good condition enables the current to flow in only one direction from Anode to Cathode

- Fig 20 -

4.5.2 - Checking the windings and rotating diodes using separate excitation

During this procedure, make sure that the alternator is disconnected from any external load and inspect the terminal box to check that the connections are fully tightened.

1) Stop the unit, disconnect and isolate the AVR wires.
2) There are are two ways of carrying out a separate excitation (see fig 21.).

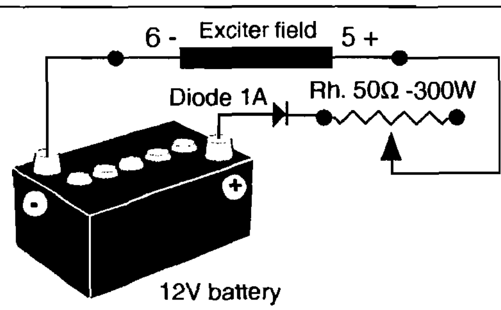
Assembly A: Connect a 12 V battery in series with a rheostat of approximately 50 ohms - 300 W and a diode on both exciter field wires (5+) and (6-).

Assembly B: Connect a "Variac" variable power supply and a diode bridge on both exciter field wires (5+) and (6-).
These two systems should have characteristics which are compatible with the exciter field excitation power of the machine (see the nameplate).

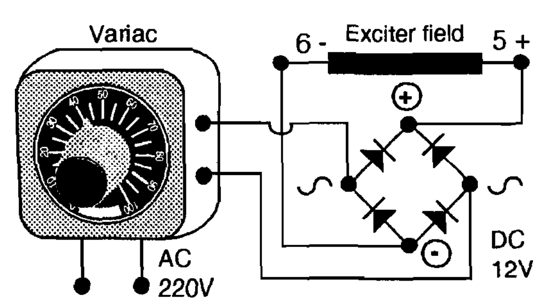
3) Run the unit at its rated speed.

4) Gradually increase the exciter field current by adjusting the rheostat or the variac and measure the output voltages on L1 - L2 - L3, checking the excitation voltage and current at no load and at full load (see machine nameplate or ask for the factory test report).

When the output voltage is at its rated value and balanced within 1%, for the rated excitation level and rated speed, then the machine is in good working order.
The fault must therefore come from the A.V.R. or its associated wiring (i.e. sensing, auxiliary windings)



ASSEMBLY A



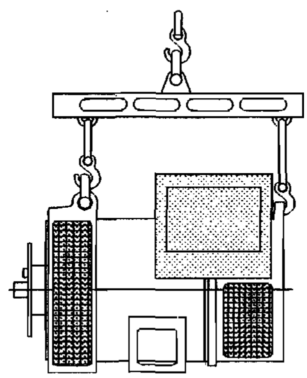
ASSEMBLY B

- Fig 21 -

4.6 - Dismantling, reassembly (see section 5.5.1. & 5.5.2.)

During the warranty period, this operation should only be carried out in a approved workshop or in our factory, otherwise the warranty may be invalidated.

The machine must be horizontal when handled (when travelling bar removed). See fig 22.



- Fig 22 -

4.6.1 - Tools required

To fully dismantle the machine, we recommend you have the tools listed below:
- 1 : ratchet spanner + extension
- 1 : torque wrench
- 1 : 7 mm flat spanner
- 1 : 8 mm flat spanner
- 1 : 10 mm flat spanner
- 1 : 12 mm flat spanner
- 1 : 8 mm socket
- 1 : 10 mm socket
- 1 : 13 mm socket
- 1 : 5 mm Allen key
- 1 : 6 mm Allen key
- 1 : TORX T20 bit
- 1 : TORX T30 bit
- 1 : puller (U35)
- 1 : puller (U32/350)

4.6.2 - Screw tightening torque

Identification	screw Ø	Torque N.m
Field term. block screw	M4	4 N.m
Field screw	M6	10 N.m
Diode bridge screw	M6	5 N.m
Diode nut	M5	4 N.m
Assembly rod	M8	20 N.m
Earthing screw	M6	5 N.m
Balancing bolt	M5	4 N.m
Discs/shaft screw	M10	66 N.m
Lifting screw	M8	4 N.m
Louvre screw	M6	5 N.m
Cover screw	M6	5 N.m

4.6.3 - Accessing connections and the regulation system

The terminals are accessed by removing the terminal box lid [48].
To access the adjustment potentiometers on the AVR, the side plate should be removed [367].

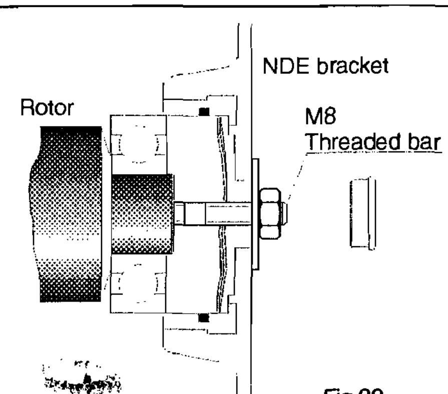
4.6.4 - Accessing, checking and replacing diodes

4.6.4.1- Dismantling

- Remove the terminal box lid [48].
- Remove the air intake louvre [51].
- Unscrew the fixing clamps on the power output cables, disconnect E+, E- on the exciter and R 791 module.
- Remove the 4 nuts on the tie rods.
- Remove the NDE bracket [36] using an extractor: eg. U.32 - 350 .
- Remove the surge suppressor [347].
- Remove the 4 fixing screws from the diode bridges on the armature.
- Disconnect the diodes.
- Check the 6 diodes using either an ohmmeter or a battery lamp (see section 4.5.1).

4.6.4.2- Reassembly

- Replace the diodes, respecting the polarity (see section 4.5.1). Replace the surge suppressor [347].
- Insert a new O ring in the bearing housing.
- Refit the NDE bracket (see fig 23) and pass the bundle



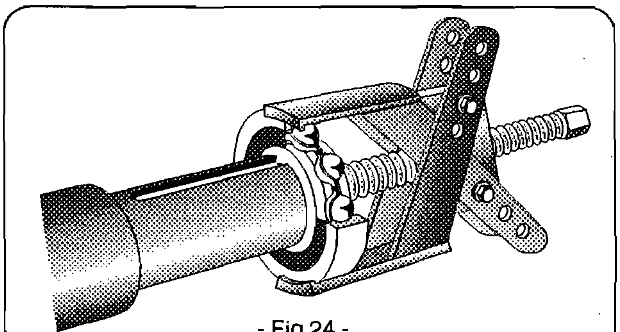
- Fig 23 -

of wires between the top bars of the flange.
- Replace the fixing clamps on the cables and the R 791 module.
- Refit the air intake louvre [51].
- Replace the terminal box lid [48].

4.6.5 - Replacing the NDE bearing on a single-bearing machine

4.6.5.1- Dismantling

- Dismantle the NDE bracket [36] (see section 4.6.4.1).
- Remove the bearing [70] using a puller.
(See fig 24)



- Fig 24 -

4.6.5.2- Reassembly

- Heat the inner slipring of a new bearing by induction or in a drying oven at 80 °C (do not use an oil bath) and fit it to the machine.
- Place the preloading wavy washer [79] in the flange and fit a new O ring seal [349].
- Replace the NDE bracket [36] (see section 4.6.4.2).

4.6.6 - Replacing the bearings on a two-bearing machine

4.6.6.1 - Dismantling

- Uncouple the alternator from the prime mover.
- Remove the 8 assembly screws.
- Remove the DE flange [30].
- Remove the NDE bracket (see section 4.6.4.1).
- Remove both bearings [60] and [70] using a puller.

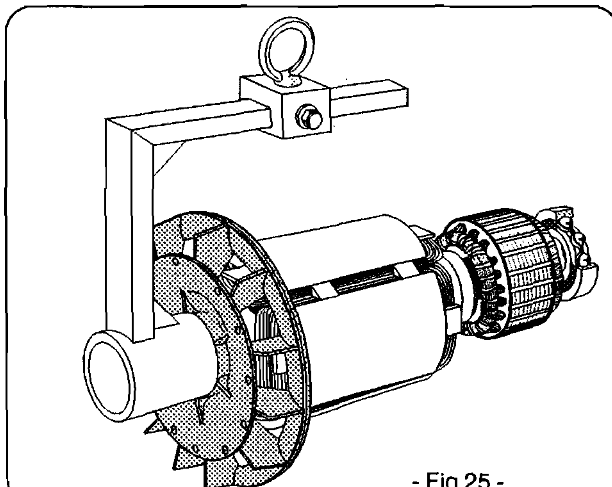
4.6.6.2 - Reassembly

- Fit new bearings after heating them by induction or in a drying oven at 80 °C (do not use an oil bath).
- Check that both the preloading wavy washer [79] and new O ring seal have been fitted [349] on the NDE bracket [36].
- Replace the DE flange [30], and tighten the 8 fixing screws.
- Check that the whole machine is correctly assembled and that all screws are fully tightened.

4.6.7 - Accessing the main field and stator

4.6.7.1 - Dismantling

Follow the procedure for dismantling bearings (see sections 4.6.5.1 and 4.6.6.1)
- Remove the coupling discs (single-bearing machine) or the DE flange (two-bearing machine) and insert a tube of the corresponding diameter on the shaft end or a support made according to fig 25.



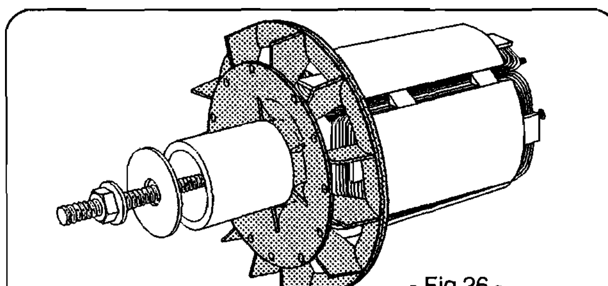
- Fig 25 -

- Rest the rotor on one of its poles, then slide it out. Use the tube as a lever arm to assist dismantling.
- After extraction, be careful with the fan. It is necessary to replace the fan in case of disassembling.

NOTE: If intervention is required on the main field (rewinding, replacement of components), the rotor assembly must be rebalanced.

4.6.7.2 - Reassembly

- Follow the dismantling procedure in reverse order.
Take care not to knock the windings when refitting the rotor in the stator.
- If you replace the fan, respect the assembly guide (fig 26). Use a tube and a screw.



- Fig 26 -

Follow the procedure for reassembling the bearings (see section 4.6.5.2 and 4.6.6.2).

After final adjustments, the access panels or cover should be refitted.

4.7 - Electrical characteristics table

Alternator - 2/4 - pole - 50/60 Hz - No. 6 standard winding. (400V for the excitation values)
The voltage and current values are given for no-load operation and operation at rated load with separate field excitation. All values are given at ± 10% (for exact values, consult the test report) and are subject to change without prior warning.

Alternator 2 pole with SHUNT excitation
Resistances at 20°C (Ω) - 50 / 60 Hz

1012	D	F	J	N	P
L/N stator	0,76	0,61	0,4	0,22	0,16
Rotor	3,13	3,27	3,53	4,06	4,66
Field	23,5	23,5	23,5	23,5	23,5
Armature	0,79	0,79	0,79	0,79	0,79

Alternator 2 pole with SHUNT excitation
Field excitation current i exc (A) - 400 V - 50 Hz:
Symbols : "i exc": excitation current of the exciter field.

1012	D	F	J	N	P
No-load	0,4	0,4	0,4	0,45	0,4
At rated load	1,7	1,7	1,7	1,7	1,7

For 60Hz machines the "i exc" values are approximately 5 to 10 % less.

Alternator 4 pole with SHUNT excitation
Resistances at 20°C (Ω) - 50 / 60 Hz

1014	H	L	N	Q	S
L/N stator	0,70	0,56	0,32	0,21	0,191
Rotor	2,06	2,3	2,71	3,35	3,7
Field	23,5	23,5	23,5	23,5	23,5
Armature	0,51	0,51	0,51	0,51	0,51

Alternator 4 pole with SHUNT excitation
Field excitation current I exc (A) - 400 V - 50 Hz:
Symbols : "i exc": excitation current of the exciter field.

1014	H	L	N	Q	S
No-load	0,6	0,55	0,6	0,55	0,5
At rated load	1,6	1,7	1,6	1,55	1,5

For 60Hz machines the "i exc" values are approximately 5 to 10 % less.

Alternator 4 pole with AREP excitation
Resistances at 20°C (Ω) - 50 / 60 Hz

1024	N	Q	S
L/N stator	0,35	0,22	0,2
Rotor	2,71	3,35	3,7
Auxil. wind. X1, X2	0,3	0,26	0,23
Auxil. wind. Z1, Z2	0,5	0,44	0,41
Field	6	6	6
Armature	0,5	0,5	0,5

Alternator 4 pole with AREP excitation
Field excitation current i exc (A) - 400 V - 50 Hz:
Symbols : "i exc": excitation current of the exciter field.

1024	N	Q	S
No-load	0,9	0,8	0,75
At rated load	2,4	2,35	2,3

For 60Hz machines the "i exc" values are approximately 5 to 10 % less.

5 - SPARE PARTS

5.1 - First maintenance parts

Emergency repair kits are available as an option.
They contain the following items:

No.	Description	Qty	1000 - SHUNT	Coding
198	Voltage regulator (AVR)	1	R 230 B	ESC 110 CU 003
343	Diode bridge assembly	1	LSA 411.1.59/60	ESC 025 MD 008
347	Surge suppressor	1	LSA 411.1.17A	CII 411 EQ 017
	AVR fuse	1	250 V - 8 A / slow	

No.	Description	Qty	1000 - AREP	Coding
198	Voltage regulator (AVR)	1	R 438 LS	ESC 220 CU 025
343	Diode bridge assembly	1	LSA 411.1.59/60	ESC 025 MD 008
347	Surge suppressor	1	LSA 411.1.17A	CII 411 EQ 017
	AVR fuse	2	250 V - 8 A / fast	

5.2 - Description of bearings

No.	Description	Qty	1000	Coding
60	D.E. bearing	1	6309 2RS/C3	RLT 045 TN 030
70	N.D.E. bearing	1	6305 2RS/C3	RLT 025 TN 030

5.3 - Technical support service

Our technical support service will be happy to provide any information you require.

When ordering spare parts, you should indicate the complete machine type, its serial number and the information indicated on the nameplate.

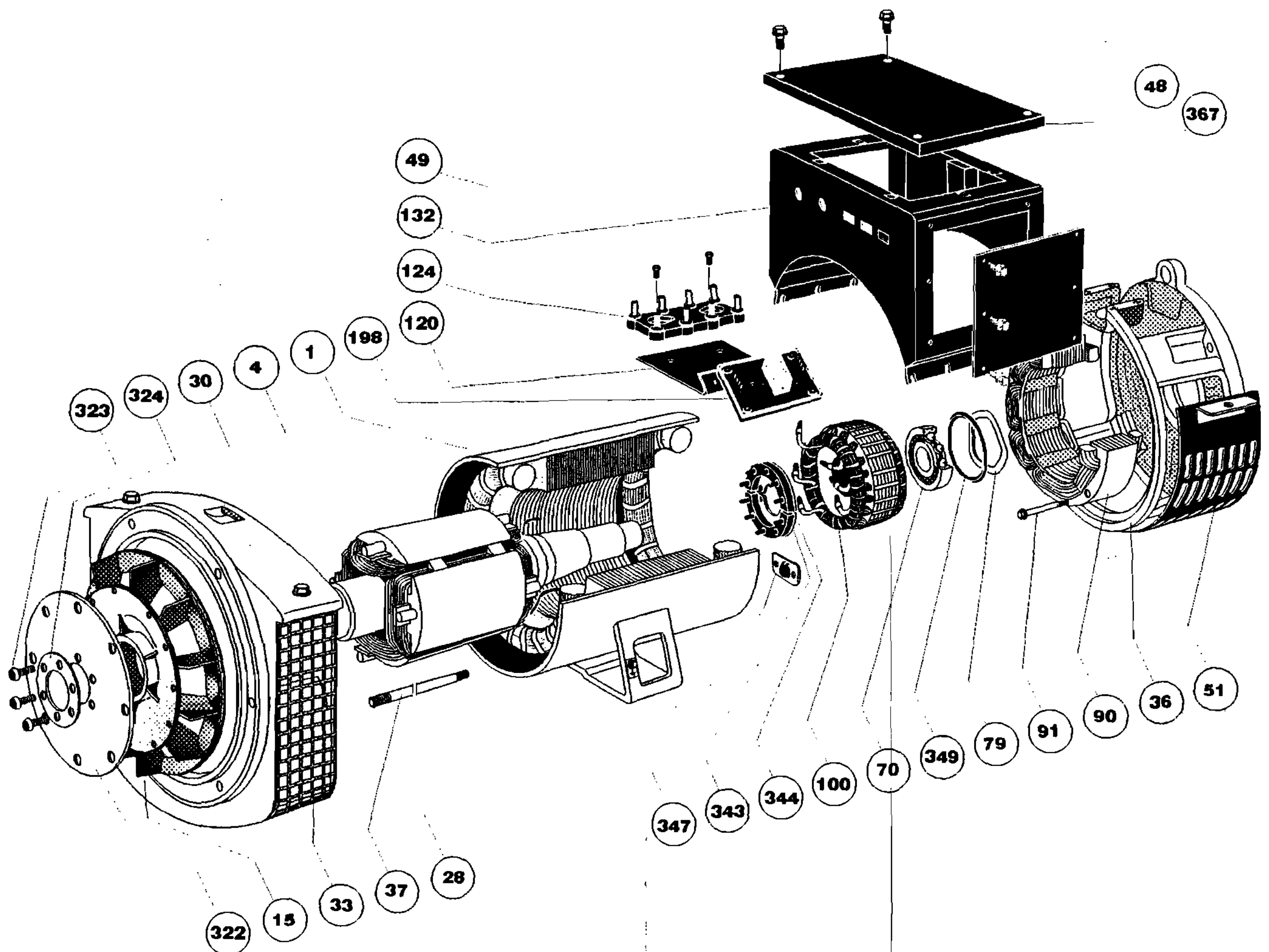
Address your enquiry to your usual contact

WARNING

Part numbers should be identified from the exploded views and their description in the parts list.
Our extensive network of "service stations" can dispatch the necessary parts without delay.
To ensure correct operation and the safety of our machines, we recommend the use of original manufacture spare parts.
In the event of failure to comply with this advice, the manufacturer cannot be held responsible for any damage.

5.5 - Exploded view, parts list.

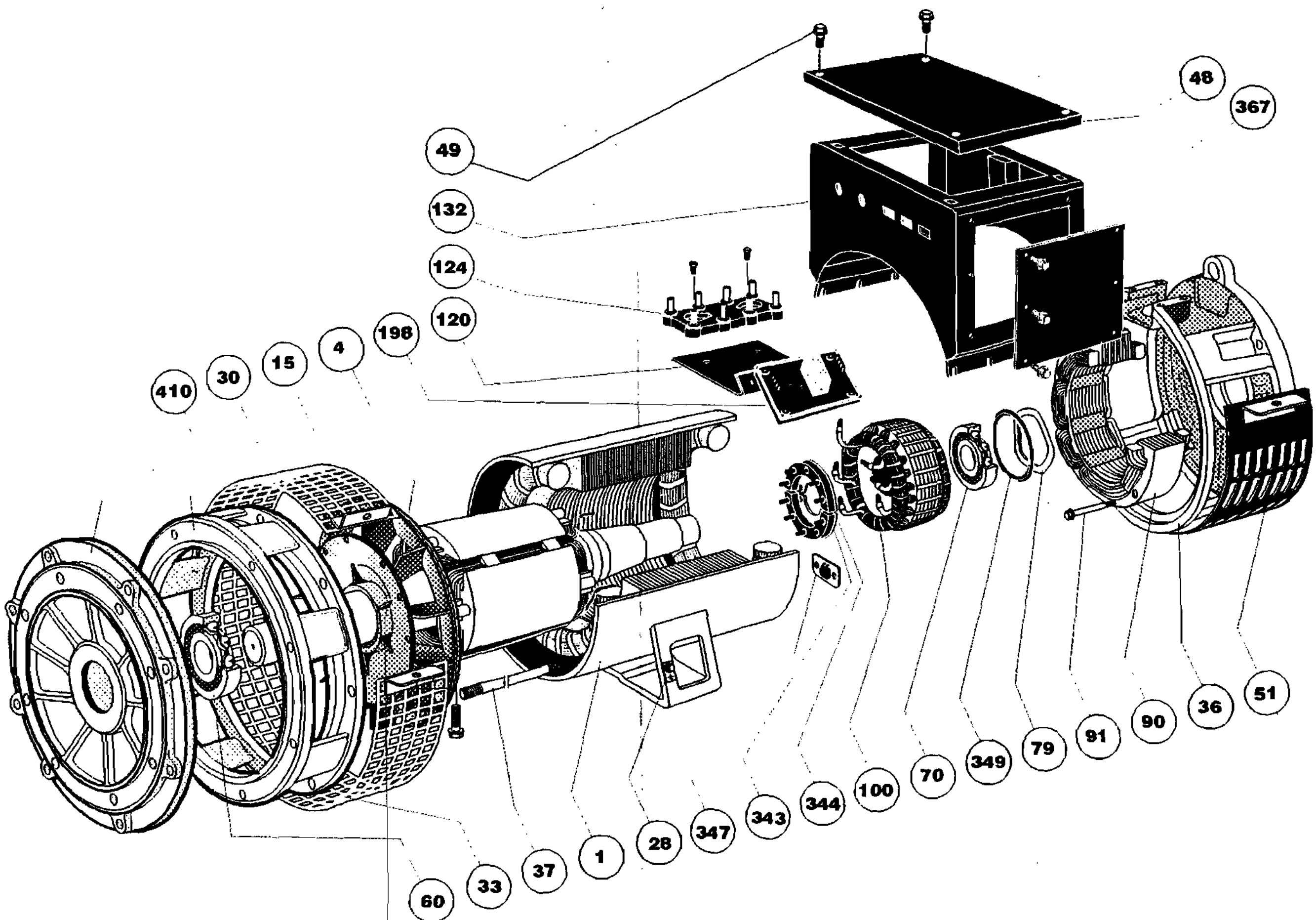
5.5.1 - 1000 single bearing, (Fig 27) with terminal box



- Fig 27 -

No.	Nbr.	Description	No.	Nbr.	Description
1	1	Stator assembly	100	1	Exciter armature
4	1	Rotor assembly	120	1	Terminal plate support (AREP)
15	1	Fan	124	1	Terminal plate
28	1	Earth terminal	132	1	Terminal box
30	1	DE flange	198	1	Regulator (AVR)
33	1	Air outlet louvre	322	1	Coupling disc
36	1	N.D.E. bracket	323	6	Fixing screw
37	4	Tie rod	324	1	Clamping washer
48	1	Terminal box lid	343	1	Direct diode assembly
49	20	Terminal box fixing screw	344	1	Reverse diode assembly
51	1	Air intake louvre	347	1	Surge suppressor
70	1	NDE bearing	367	2	Inspection door
79	1	Preloading wavy washer	349	1	O ring seal
90	1	Wound exciter field			
91	4	Field fixing screw			

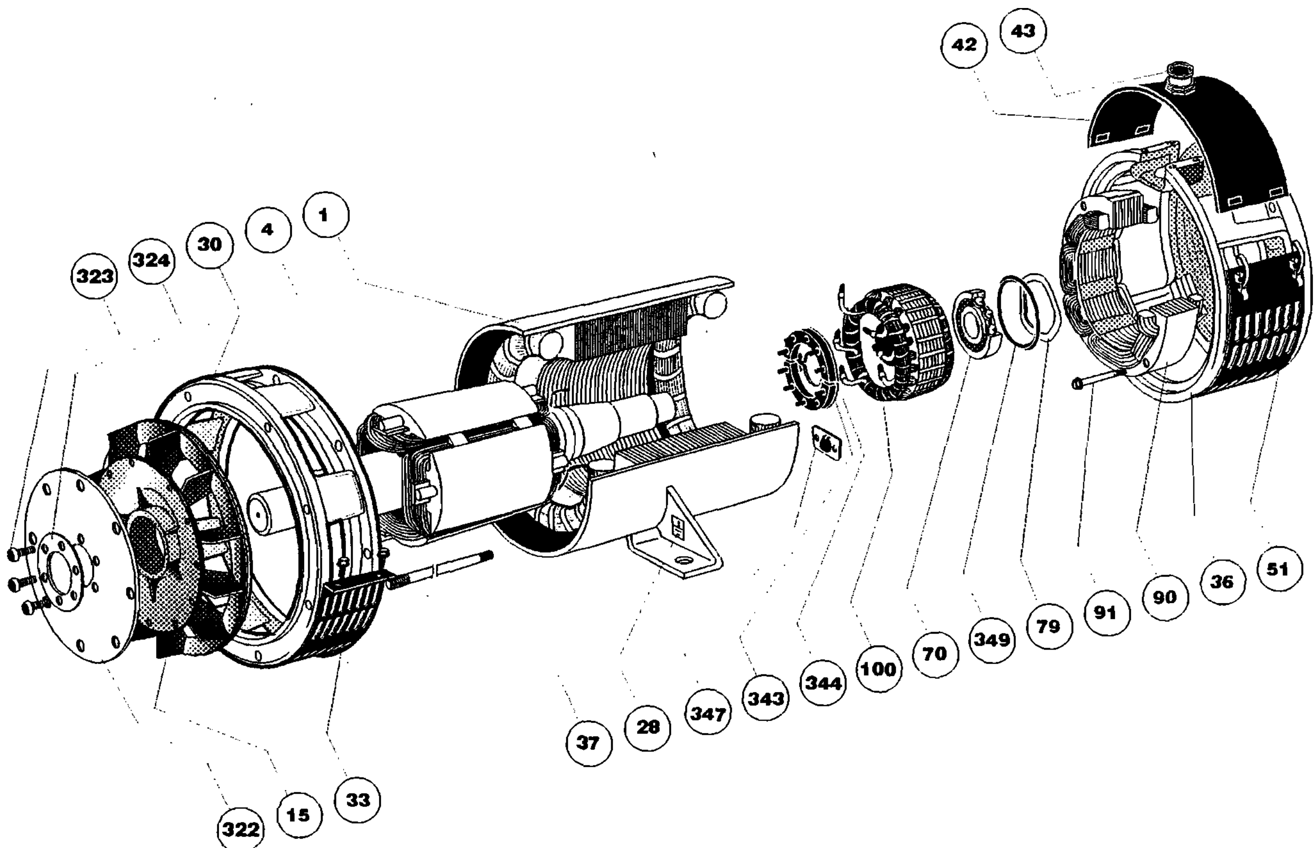
5.5.2 - 1000 two-bearing (Fig 28) with terminal box



- Fig 28 -

No.	Nbr.	Description	No.	Nbr.	Description
1	1	Stator assembly	91	4	Field fixing screw
4	1	Rotor assembly	100	1	Exciter armature
15	1	Fan	120	1	Terminal plate support (AREP)
28	1	Earth terminal	124	1	Terminal plate
30	1	DE flange	132	1	Terminal box
33	1	Air outlet louvre	198	1	Regulator (AVR)
36	1	N.D.E. bracket	343	1	Direct diode assembly
37	4	Tie rod	344	1	Reverse diode assembly
48	1	Terminal box lid	347	1	Surge suppressor
49	20	Terminal box fixing screw	367	2	Inspection door
51	1	Air intake louvre	349	1	O ring seal
60	1	DE bearing	410	1	DE flange
70	1	NDE bearing			
79	1	Preloading wavy washer			
90	1	Wound exciter field			

5.5.2 - 1000 Single bearing, (Fig 29) without terminal box



- Fig 29 -

No.	Nbr.	Description	No.	Nbr.	Description
1	1	Stator assembly	79	1	Preloading wavy washer
4	1	Rotor assembly	90	1	Exciter field
15	1	Turbine	91	4	Field fixing screw
28	1	Earth terminal	100	1	Exciter armature
30	1	DE flange	322	1	Coupling plate
33	1	Air outlet grille	323	6	Fixing screw
36	1	Exciter flange	324	1	Clamping washer
37	4	Fixing rod	343	1	Direct diode crescent
42	1	Cable gland support	344	1	Reverse diode crescent
43	1	Cable gland	347	1	Surge suppressor
51	1	Air intake grille	349	1	O ring seal
70	1	NDE bearing			

1 - RECEIPT

1.1 - Standards and Safety measures

Our alternators comply with most international standards and are compatible with:
- the recommendations of the **International Electrotechnical Commission** IEC 34-1, (EN 60034).
- the recommendations of the **International Standards Organisation** ISO 8528.
- the European Community directive on Electromagnetic Compatibility (EMC) 89/336/EEC.
- the European Community directives 73/23/EEC and 93/68/EEC (Low Voltage Directive).

They are CE marked with regard to the LVD (Low Voltage Directive) in their role as a machine component. A declaration of incorporation can be supplied on request.
Before using your generator for the first time, read with care the contents of this installation and maintenance manual, supplied with the machine. All operations performed on the generator should be undertaken by qualified personnel with specialist training in the commissioning, servicing and maintenance of electrical and mechanical machinery. This maintenance manual should be retained for the whole of the machine's life and be handed over with the contractual file.
The various operations described in this manual are accompanied by recommendations or symbols to alert the user to the risk of accidents. It is vital that you understand and take notice of the different safety symbols opposite.

WARNING

Safety symbol for an operation capable of damaging or destroying the machine or surrounding equipment.

Safety symbol for general danger to personnel.

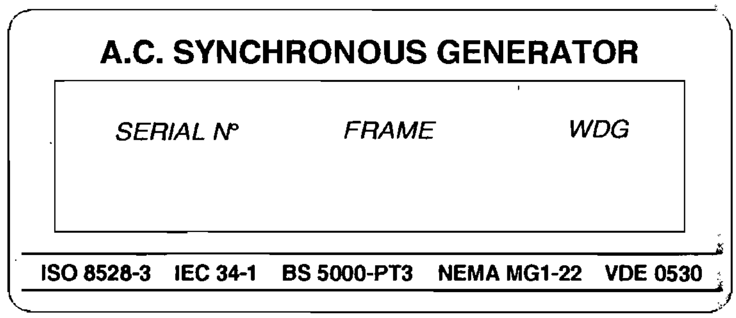
Safety symbol for electrical danger to personnel.

1.2 - Checks

On receipt of your alternator, check that it has not suffered any damage in transit.
If there are obvious signs of knocks, contact the transporter (you may be able to claim on their insurance) and after a visual check, turn the machine by hand (if twin bearing) to detect any malfunction.

1.3 - Identification

The alternator is identified by means of a nameplate (fig 1) fixed on the terminal box .
Make sure that the nameplate on the machine conforms to your order.
The machine name is defined according to various criteria (see below).



- Fig 1 -

1.4 - Storage

Whilst awaiting installation, the machines should be stored:
- away from humidity: in conditions of relative humidity of more than 90%, the machine insulation can drop very rapidly to just above zero at around 100% ; monitor the state of the anti-rust protection on unpainted parts.

For storage over an extended period, the machine can be placed in a sealed enclosure (heatshrunk plastic, for example) with dehydrating sachets inside, away from significant and frequent variations in temperature to avoid any condensation during storage.

2 - TECHNICAL CHARACTERISTICS

2.1 - Electrical characteristics

The 1000 series alternator is a machine without sliprings and revolving field brushes, wound as "2/3 pitch"; 12-wire, with class H insulation and a field excitation system available in either "SHUNT" fig 2 or "AREP" fig 3 version (see sections 2.3, 2.4). Interference suppression conforms with standard EN 55011, group 1, class B.

2.1.1 - Options

- Stator temperature detection probes
- Space heaters

2.2 - Mechanical characteristics

- Steel frame
- End shields in cast iron or aluminium
- Ball bearings greased for life
- Mounting arrangement

MD 35 STANDARD: single bearing, with standard feet and SAE coupling discs

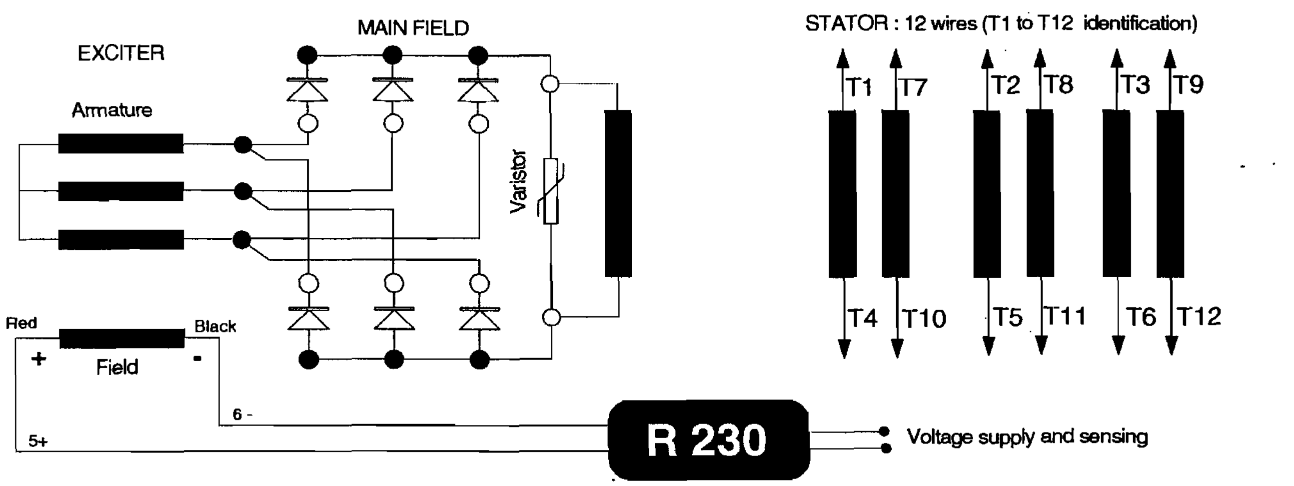
B 34 STANDARD: two bearing feet mounteed with standard bare shaft key wayed

- Drip-proof machine, self-cooled
- Degree of protection: IP 23

2.2.1 - Options

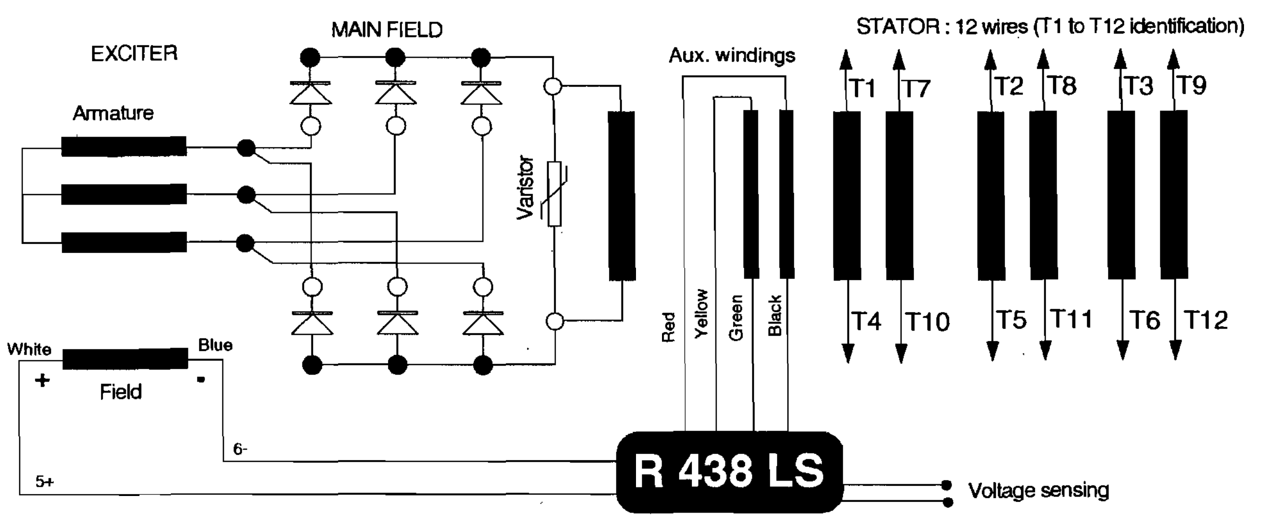
- Air input filter, air output labyrinth cowling

2.1.2 - System Shunt with A.V.R. R 230



- Fig 2 -

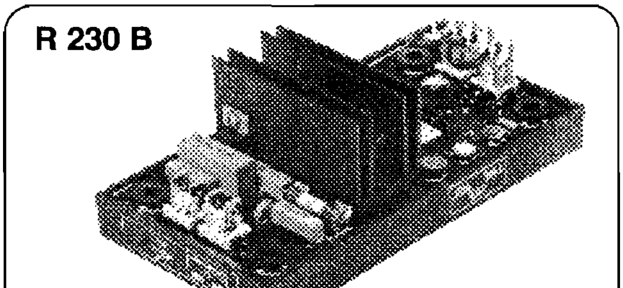
2.1.3 - System AREP with A.V.R. R 438 LS



- Fig 3 -

2.3 - SHUNT field excitation system

The alternator with Shunt field excitation is self-excited with a voltage regulator **R 230 B** "fig 4". The regulator monitors the exciter excitation current as a function of the alternator output voltage. Very simple in design, the alternator with Shunt excitation has no sustaining short-circuit capability.

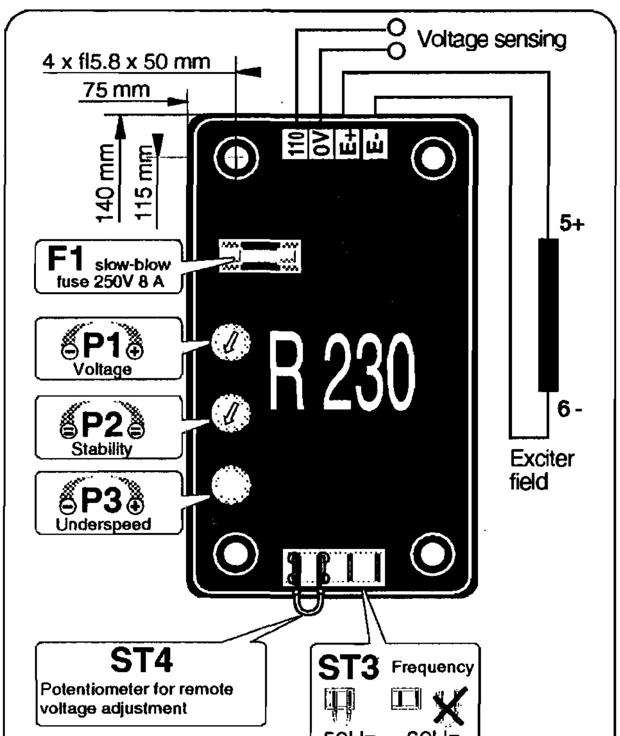


- Fig 4 -

2.3.1 - Characteristics (see Fig 5)

- Voltage regulation: around ± 0,5%
- Voltage detection range 85 to 139 V (50/60Hz)
- Rapid response time (500 ms) for a transient voltage variation amplitude of ± 20%
- Voltage setting **P1**
- Stability setting **P2**
- Power supply protected by 8 A fuse, slow-acting (tolerates 10 A for 10s).
- Frequency: 50 Hz with strap **ST3** - 60 Hz without strap **ST3**
- Factory set underspeed protection **P3** (see fig 6)

B version : internal development

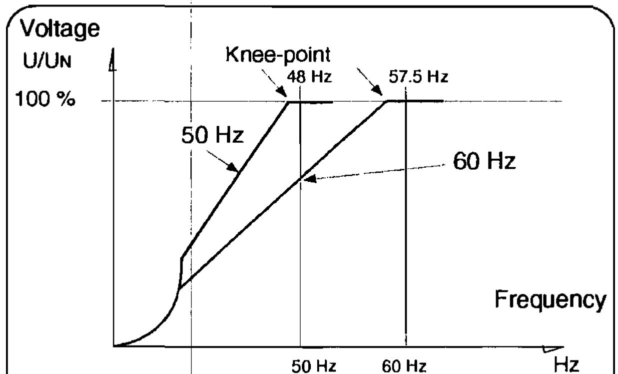


- Fig 5 -

2.3.2 - R 230 Regulator options:

Potentiometer for remote voltage adjustment, 1000 Ω / 0.5 W min : adjustment range ± 5%.

- Remove strap ST4 .



- Fig 6 -

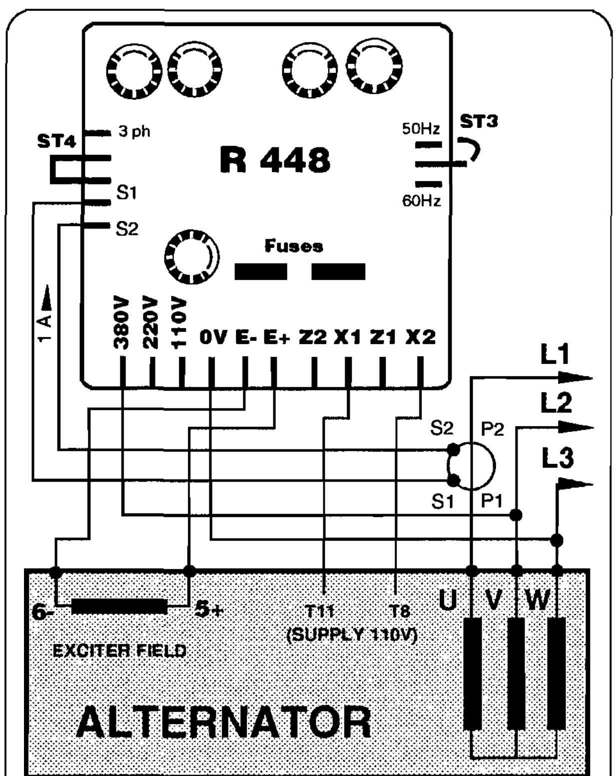
2.3.3 - Working with A.V.R. R 448

As an option the 448 A.V.R. can replace the R 230 on shunt alternator in order to get the following functions (see fig 7) :

- Parallel operation between alternators (with current transformers).
- Parallel operation with the mains (with current transformer and R 726 module).
- 3 phase detection (R 731 module).
- LAM function (integrated in the R448).

WARNING

This A.V.R. and associated modules must be installed outside the terminal box.



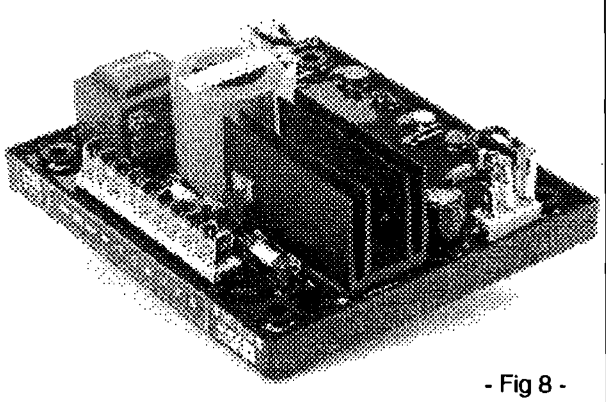
- Fig 7 -

For adjusting and fault detection refer to the section 4.5 of this notice (the function of R 438 and R 448 are the same).

2.4 - AREP field excitation system

With AREP excitation, the electronic A.V.R. **R 438 LS** (fig 8) is powered by two auxiliary windings which are independent of the voltage detection circuit. The first winding (X1,X2) has a voltage in proportion with the output voltage of the alternator (Shunt characteristic), the second (Z1,Z2) has a voltage in proportion with the stator current (compound characteristic: Booster effect). The power supply voltage is rectified and filtered before being used by the regulator monitoring transistor. This principle ensures that regulation is not affected by distortions generated by the load.

R 438 LS

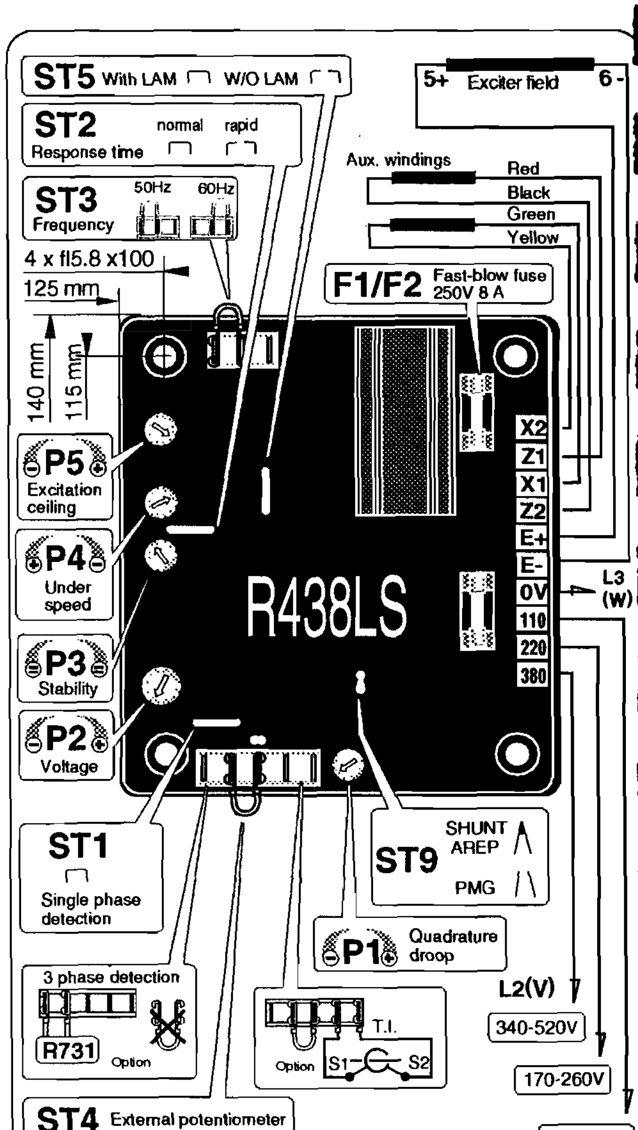


- Fig 8 -

2.4.1 - R 438 regulator (fig 9)
- short-circuit current = 3 x In for 10 seconds
- standard power supply; 2 auxiliary windings
- shunt power supply; max 48V - 50/60 Hz
- rated overload current: 8A - 10s
- electronic protection (overload, short-circuit opening on voltage detection): excitation ceiling current for 10 seconds then return to approx. 1A

<u>The alternator must be stopped (or the power switched off) in order to reset the protection.</u>
- Fuse F1 on input side (X1, X2)
- Fuse F2 on output side (E+, E-)
- voltage detection: 5 VA isolated via transformer
0-110 V terminals = 95 to 140 V
0-220 V terminals = 170 to 260 V
0-380 V terminals = 340 to 520 V
- rapid or normal response time via strap **ST2**
- voltage adjustment via potentiometer **P2**
  other voltages via step down transformer
- current detection: (parallel operation): C.T. 2.5 VA cl1, secondary 1A (Option)
- quadrature droop adjustment via potentiometer **P1**
- underspeed protection (U/f) and LAM: frequency threshold adjustable via potentiometer **P4**
- max. excitation current adjustment via **P5**: 4.5 to 10A
- 50/60 Hz selection via strap **ST3**

2.4.2 - R 438 LS A.V.R. options
- **Current transformer** for parallel operation
- Remote voltage **adjustment potentiometer**: 470 Ω, 0.5 W min: adjustment range ± 5% (range limited via internal voltage potentiometer **P2**). Remove ST4 to connect the potentiometer. (A 1 k Ω potentiometer can also be used to extend the adjustment range.)
- **R 731 external module**: detection of 3-phase voltage 200 to 500 V, compatible with parallel operation. Cut ST1 to connect the module; set the voltage via the module potentiometer. (The previous version module is not compatible with parallel operation).
- **R 726 module**: 3 functions (external mounting).
• P.F. φ regulation (2F) and voltage matching prior to paralleling with the mains (3 F).
• C.T. of ....../1A . 5 VA CL 1 (see schematic included with this manual).



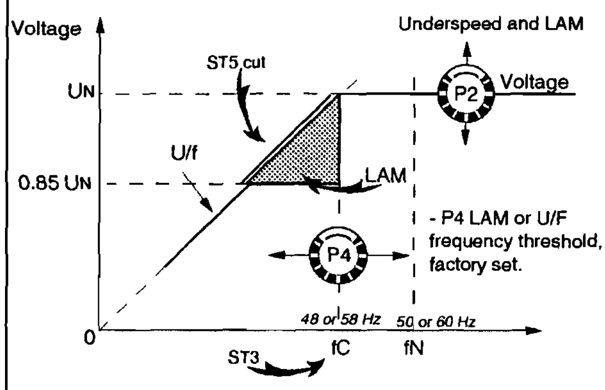
- Fig 9 -

WARNING

It is impossible to mount PMG on 1000 serie

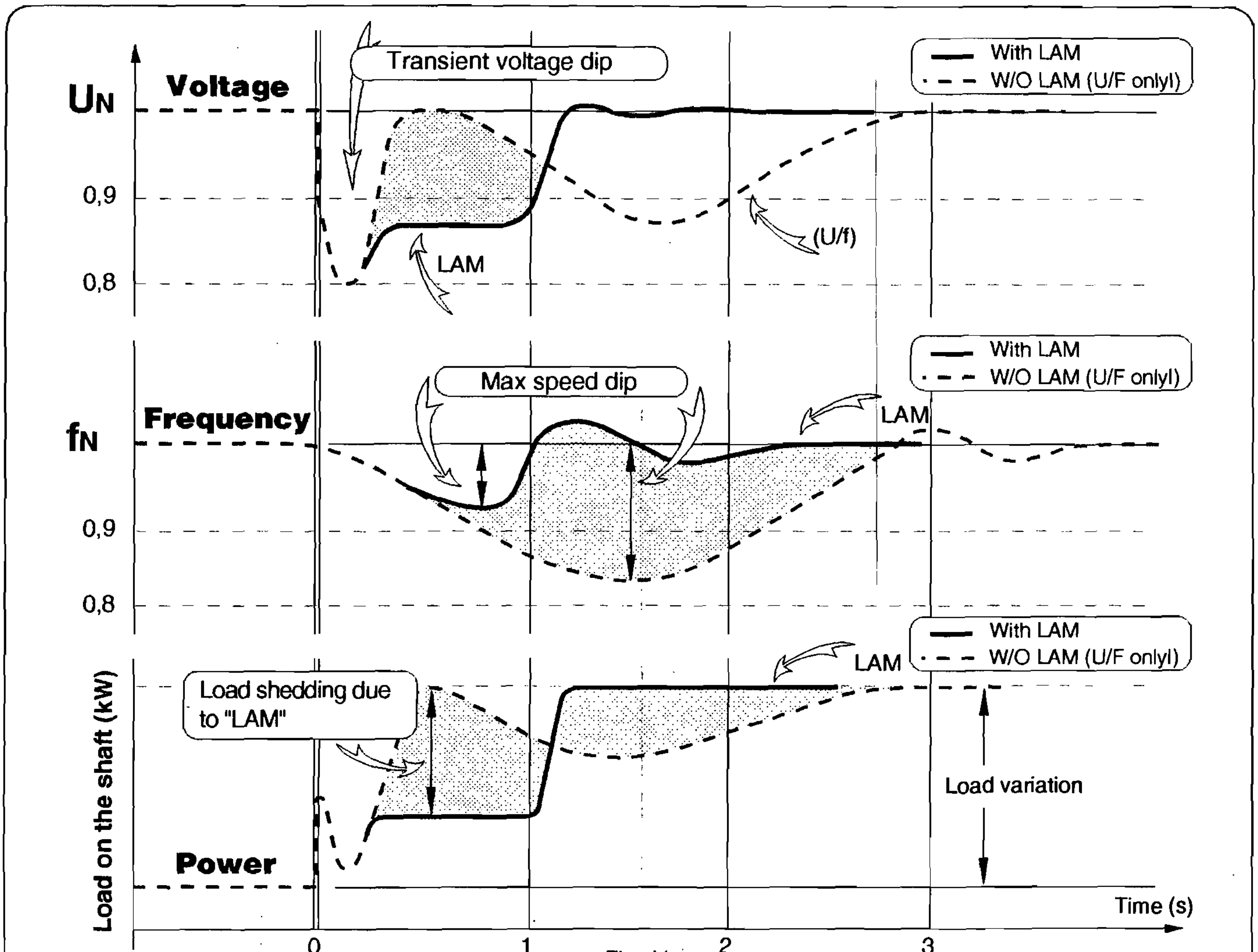
2.4.3 - LAM characteristics (Fig 10)

The LAM system is integrated as standard in the **R 438** regulator.
- Role of the "LAM" (Load Adjustment Module):
On load impact, the rotation speed of the generator set decreases. When it passes below the preset frequency threshold, the "LAM" causes the voltage to drop by approximately 15% and consequently the amount of active load applied is reduced by approximately 25%, until the speed reaches its rated value again.
Hence the "LAM" can be used either to reduce the speed variation (frequency) and its duration for a given applied load, or to increase the applied load possible for one speed variation (turbo-charged engine).
To avoid voltage oscillations, the trip threshold for the "LAM" function should be set approximately 2 Hz below the lowest frequency in steady state.
- LAM: action eliminated by cutting strap ST5



- Fig 10 -

Typical effects of the "LAM" with a diesel engine
(see Fig 11)



- Fig 11 -

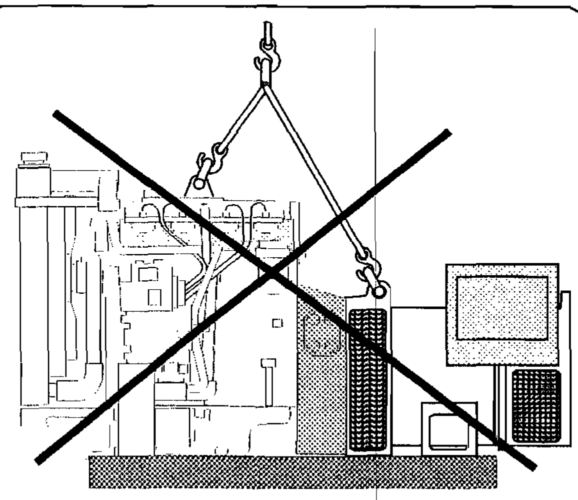
3 - INSTALLATION - COMMISSIONING

3.1 - Assembly

All mechanical handling operations must be undertaken using approved equipment.
While being handled, the machine should remain horizontal (when travelling bar removed).

3.1.1 - Handling

The generously-sized lifting rings are for handling the alternator alone. They must not be used to lift the genset. Choose a lifting system which respects the positioning of the rings (see fig 12).



- Fig 12 -

3.1.2 - Coupling

3.1.2.1 - Single bearing alternator

Before coupling to the prime mover, check that both are compatible by:
- *Undertaking* a torsional analysis of the transmission.
- Checking the dimensions of the flywheel and its housing, the flange, coupling discs and offset.

WARNING

When coupling the alternator to the prime mover, the holes of the coupling discs should be aligned with the flywheel holes by cranking the engine.
Do not use the alternator fan to turn the rotor.

Tighten the coupling discs screws to the recommended torque (see section 4.7.1) and check that there is lateral play on the crankshaft.

3.1.2.2 - Two-bearing alternator

- Semi-flexible coupling

Careful alignement of the machines by measuring the concentricity and parallelism of the two parts of the coupling is recommended, the difference between the teadings should not exceed the specified values (say 0,1 mm).

WARNING

This alternator has been balanced with a 1/2 key.

- Belt and pulley drive system

Check that the shafts are parallel, the pulleys aligned, and that the belt tension is correct.
The maximum permissible radial load at the middle of the shaft end is 350 da.N for a calculated service life "L10" of 20,000 hrs at 1800 min^{-1} or 3600 min^{-1}.
Note: For special belt-pulley drive systems, please consult the Sillac factory.

3.1.3 - Location

Ensure that the ambient temperature in the room where the alternator is placed cannot exceed 40°C for standard power ratings (for temperatures above 40°C, apply a derating coefficient). Fresh air, free from damp and dust, must be able to circulate freely around the air input louvres on the opposite side from the coupling. It is essential to prevent not only the recycling of hot air from the machine or engine, but also exhaust fumes.

3.2 - Inspection prior to first use

3.2.1 - Electrical checks

Under no circumstances should an alternator, new or otherwise, be operated if the isolation is less than 1 megohm for the stator and 100,000 ohms for the other windings.

There are two possible methods for restoring the above minimum values.
a) Dry out the machine for 24 hours in a drying oven at a temperature of approximately 110 °C.
b) Blow hot air into the air input, having made sure that the machine is rotating with the exciter field disconnected.
c) Run in short-circuit mode (disconnect the AVR)
- Short-circuit the output phases using connections capable of supporting the rated current (try not to exceed 6 A/mm2).
- Insert a clamp ammeter to monitor the current passing through the short-circuit connections.
- Connect a 48 Volt battery in series with a rheostat of approximately 10 ohms (50 Watts), to the exciter field terminals, respecting the polarity.
- Open fully all the alternator orifices.
- Run the alternator at rated speed . Adjust the exciter field current using the rheostat to obtain the rated output current in the short-circuit connections.

Note: Prolonged standstill: In order to avoid these problems, we recommend the use of space heaters, as well as turning over the machine from time to time. Space heaters are only really effective if they are working continuously while the machine is stopped.

3.2.2 - Physical and visual checks

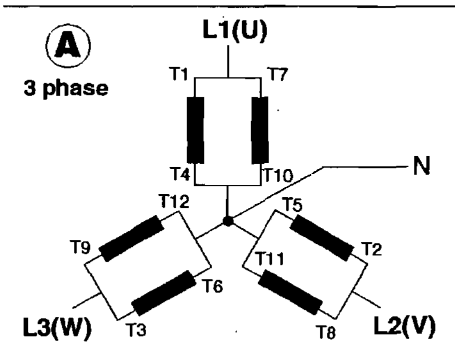
Before starting the machine for the first time, check that:
- the fixing bolts on the feet are tight
- the cooling air is drawn in freely
- the protective louvres and housing are correctly in place
- the standard direction of rotation is clockwise as seen from the shaft end (phase rotation in order 1 - 2 - 3). For anti-clockwise rotation, swap 2 and 3.
- the winding connection corresponds to the site operating voltage (see section 3.3)

3.3 - Terminal connection diagrams

To modify the connection, change the position of the terminal cables (see fig 13 & 14). The winding code is specified on the nameplate.

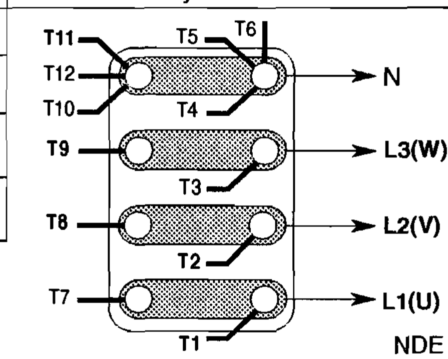
Any intervention on the alternator terminals during reconnection or checks should be performed with the machine stopped.

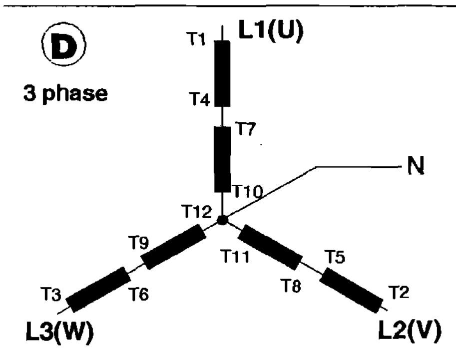
Connection codes | L.L voltage | Factory connection



Winding	50 Hz	60 Hz
6	190 - 208	190 - 240
7	220 - 230	-
8	-	190 - 208

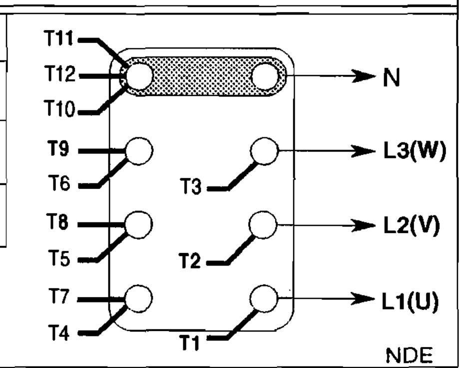
R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 220 V => (T2)

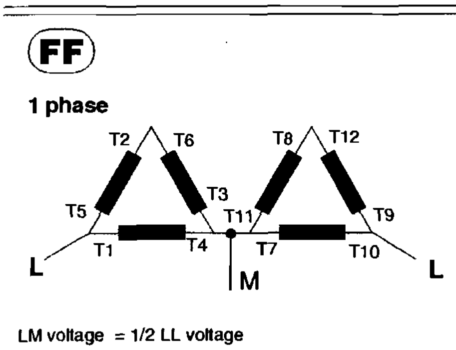




Winding	50 Hz	60 Hz
6	380 - 415	380 - 480
7	440 - 460	-
8	-	380 - 416

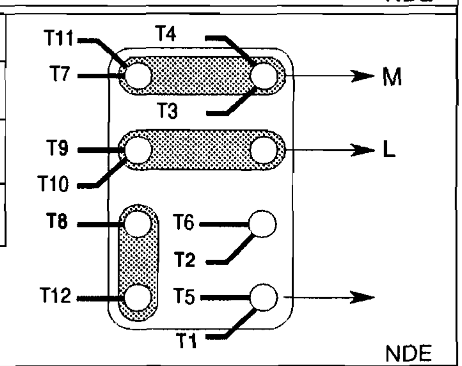
R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 380 V => (T2)

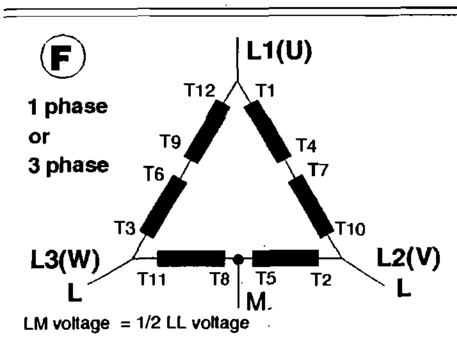




Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

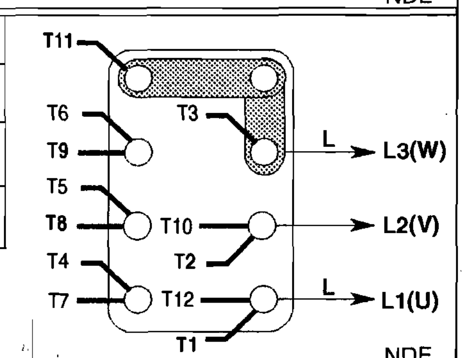
R 230 voltage detection :
0 => (T1) / 110 V => (T4)
R 438 LS voltage detection :
0 => (T10) / 220 V => (T1)





Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

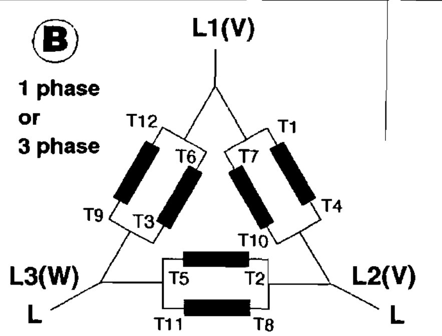
R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 220 V => (T2)



- Fig 13 -

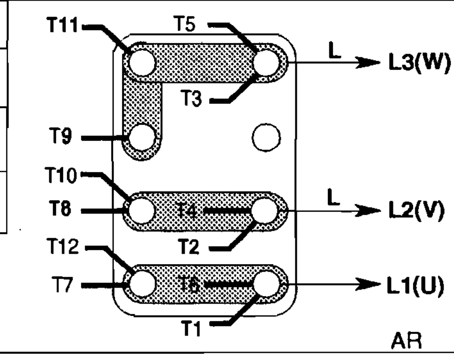
Connection codes	L.L voltage			Factory connection
	Winding	50 Hz	60 Hz	

B 1 phase or 3 phase



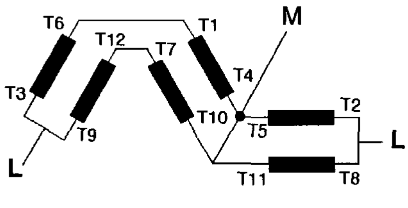
Winding	50 Hz	60 Hz
6	110 - 120	120
7	120 - 130	-
8	-	110 - 120

R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 110 V => (T2)



G 1 PH

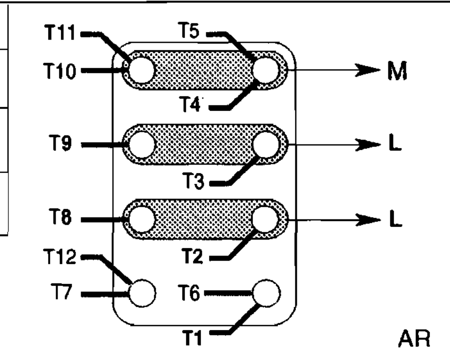
Connection not recommended



LM voltage = 1/2 LL voltage

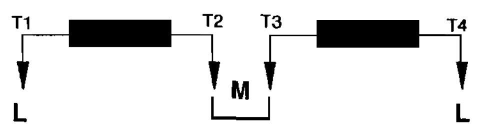
Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

R 230 voltage detection :
0 => (T8) / 110 V => (T11)
R 438 LS voltage detection :
0 => (T3) / 220 V => (T2)



SINGLE PHASE 4 LEADS - DEDICATED WINDING

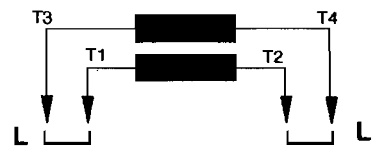
SERIES CONNECTION



Voltage 50/60 Hz			Output		
L - L	L - M	Connect	L	L	M
220 230 240	110 115 120	T2 - T3	T1	T4	T2 - T3

R 230 voltage detection : 0 => (T1) / 110 V => (T2)

PARALLEL CONNECTION



Voltage 50/60 Hz			Output		
L - L	L - M	Connect	L	L	M
110 115 120	- - -	T1 - T3 T2 - T4	T1-T3	T2 - T4	-

R 230 voltage detection : 0 => (T1) / 110 V => (T2)

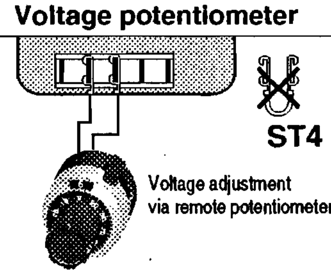
- Fig 14 -

3.3.1 - Connection diagram for options (fig 15)

R 791 T interference suppression kit (standard for CE marking)

Connections	A	D	F	B	F/F	G
Black	T1	T1	T1	T1	T1	T2
Black	T2	T2	T2	T2	T9	T4
Black	T3	T3	T3	T3	T3	T3
Blue	N	N	⏚	⏚	⏚	⏚
White	⏚	⏚	⏚	⏚	⏚	⏚

Voltage potentiometer

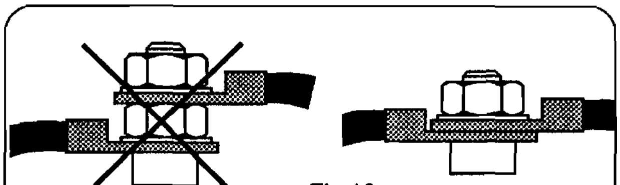


- Fig 15 -

3.3.2 - Connection checks

Electrical installations must comply with the current legislation in force in the country of use.

Check that:
- the differential circuit-breaker conforms to legislation on protection of personnel, in force in the country of use, and has been correctly installed on the alternator power output as close as possible to the alternator. (Disconnect the blue wire of the R 791 interference suppression module linking the neutral).
- any protective devices in place have not tripped,
- if there is an external regulator, the connections between the alternator and the cubicle are made in accordance with the connection diagram,
- there is no short-circuit between phase or phase-neutral between the alternator output terminals and the generator set control cabinet (part of the circuit not protected by circuit-breakers or cubicle relays)
- the machine should be connected with the terminal lugs on top of one another as shown in the terminal connection diagrams (see fig 16).



- Fig 16 -

3.3.3 - Electrical checks on the A.V.R.
- Check that all connections have been made properly as shown in the attached connection diagram.
- Check that the frequency selection strap "ST3" is on the correct frequency setting.
- Check whether strap ST4 or the remote adjustment potentiometer have been connected.
- Optional operating modes (R 438 LS)
• Strap ST1: cut to connect the R 731 3-phase detection module.
• Strap ST2: cut for rapid response time.
• Strap ST5: cut to suppress the function

3.4 - Commissioning

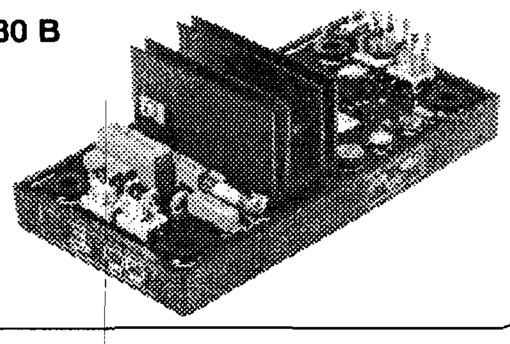
The machine can only be started up and used if the installation is in accordance with the instructions and advice defined in this manual.
The machine is tested and set at the factory. When first used with no load, make sure that the drive speed is correct and stable (see the nameplate). On application of the load, the machine should maintain its rated speed and voltage; however, in the event of abnormal operation, the machine setting can be altered (follow the adjustment procedure in section 3.5). If the machine still operates incorrectly, the cause of the malfunction must be located (see section 4.4) .

3.5 - Setting up

The various adjustments during tests must be made by a qualified engineer. Take care that the drive speed specified on the nameplate is reached before commencing adjustment. After operational testing, replace all access panels or covers.
The A.V.R. is used to make any adjustments to the machine.

3.5.1 - R 230 adjustments (Shunt system)
Initial potentiometer settings

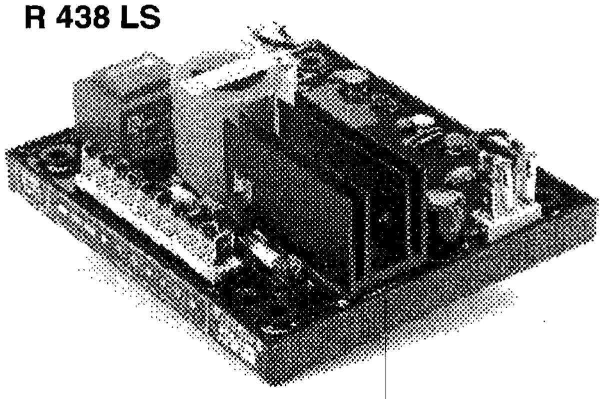
R 230 B



- Potentiometer **P1** (AVR voltage adjustment): fully anti-clockwise
- Remote voltage adjustment potentiometer: middle
Run the alternator at its rated speed: if the voltage does not increase, the magnetic circuit should be remagnetized (see section 4.5)
- Turn the AVR voltage adjustment potentiometer **P1** slowly until the output voltage rated value is obtained.
- Adjust the stability using **P2.**
- Sealed potentiometer **P3** is factory set at 48 Hz for 50 Hz and 57.5 Hz for 60 Hz.

3.5.2 - R 438 LS adjustments (AREP system)

R 438 LS



a) Initial potentiometer settings (see table >)
- remote voltage adjustment potentiometer: centre (ST4 strap removed)

b) Install a D.C. analogue voltmeter (needle dial) cal. 50V on terminals E+, E- and an A.C. voltmeter cal. 300 - 500 or 1000V on the alternator output terminals.

c) Make sure that the **ST3** strap is positioned on the desired frequency (50 or 60 Hz).

d) Voltage potentiometer **P2** at minimum, fully to anti-clockwise

e) Turn the V/Hz potentiometer **P4**, fully to clockwise.

f) Stability potentiometer **P3** approximately 1/3 of travel anti-clockwise.

g) Start the engine and set its speed to a frequency of 48 Hz for 50 Hz, or 58 for 60 Hz.

h) Adjust the output voltage to the desired value using **P2**.
- rated voltage UN for solo operation (eg. 400 V)
- or UN + 2 to 4% for parallel operation with C.T. (eg. 410V -)
If the voltage oscillates, use **P3** to make adjustments (try both directions) observing the voltage between E+ and E- (approx. 10V D.C.). The best response times are obtained at the limit of the instability. If no stable position can be obtained, try cutting or replacing the ST2 strap (normal /rapid).

i) Check LAM operation: **ST5** closed

j)Turn potentiometer **P4** slowly anti-clockwise until there is a significant voltage drop (approx. 15 %).

k) Vary the frequency (speed) of both parts between 48 or 58 Hz according to the operating frequency, and check the change in voltage previously observed (~ 15%).

l) Readjust the speed of the unit to its rated no-load value.

Action	Factory adjust.	Pot.
Voltage minimum fully CCW	400V - 50 Hz (0 - 380 V)	− + P2
Stability	Not adjusted (middle)	P3
THreshold/LAM or U/F Threshold for underspeed protection U/f and LAM function	ST3 on 50 Hz (factory=48 Hz) ST3 on 60 Hz (factory=58 Hz)	+ − P4
Quadrature voltage droop (Parallel operation with C.T.) - No droop fully CCW	Not adjusted (fully CCW)	− + P1
Ceiling excitation current Excitation current and short circuit current limitation, minimum fully CCW	10 A maximum	− + P5

3.5.2.1 - Adjustments in parallel operation

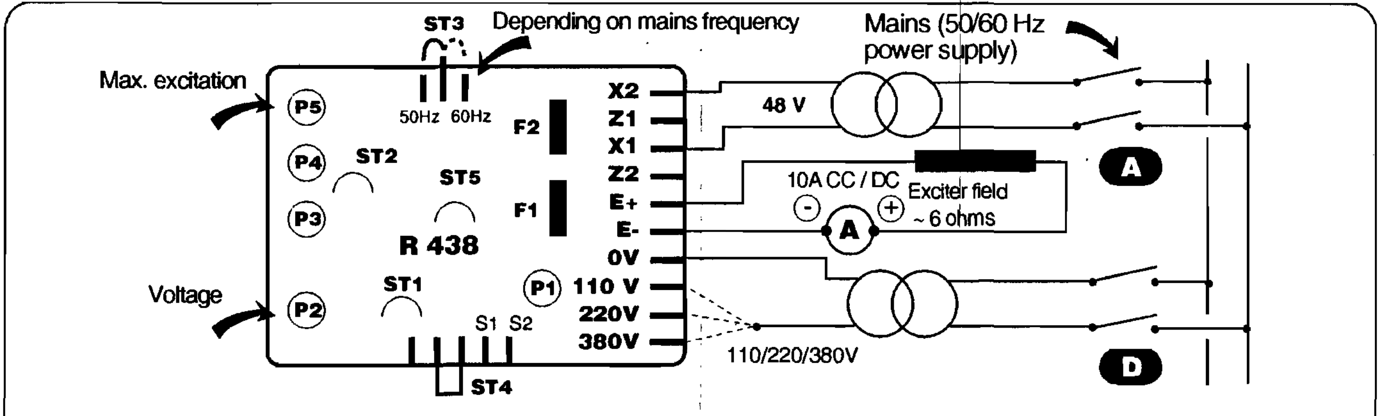
Before any intervention on the alternator, make sure that the speed quadrature droop is identical for all engine.

m) Preset for parallel operation (with C.T. connected to S1, S2 of connector J2)
- potentiometer P1 (quadrature droop) in centre position
Apply the rated load (P.F. = 0.8 inductive).
The voltage should drop by 2 to 3 %. If it increases, swap the 2 incoming wires of the C.T. secondary.

n) The no-load voltages should be identical for all the alternators intended to run in parallel.
- Couple the machines in parallel.
- By adjusting the **speed,** try to obtain **0 Kw** power exchange.
- By altering the voltage setting P2 or Rhe on one of the machines, try to cancel (or minimise) **the current** circulating between the machines.
- **From now on, do not touch the voltage settings.**

o) Apply the available load (the setting is only correct if a **reactive** load is available)
- By altering the **speed,** equalize the **KW** (or divide the rated power of the units proportionally)
- By altering the quadrature droop potentiometer **P1**, equalize or divide the **currents**.

3.5.2 .2 - Max. excitation adjustment (excitation ceiling)



- Fig 17 -

- quadrature droop adjustment of the current limit, potentiometer P5 (factory setting: 7.5 A, fuse rating: 6.3A - 10 seconds) Fig 17.

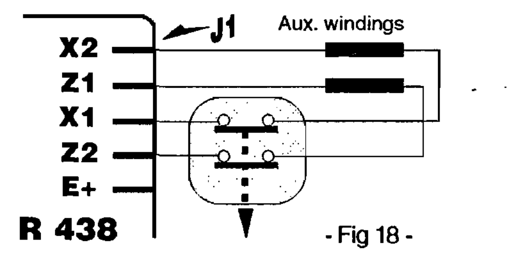
The factory setting corresponds to that of the excitation current required to obtain a 3-phase short-circuit current of approximately 3 x IN at 50 Hz for industrial power, unless otherwise specified.(*)
It is possible to reduce the maximum excitation level by a static method which is safer for the alternator and the network. Disconnect power supply wires X1,X2 and Z1,Z2, and the sensing leads (0-110V-220V-380V) on the alternator.

Connect the mains power supply (200-240V) as indicated (X1,X2: 48V). Install a 10A D.C. ammeter in series with the exciter field. Turn P5 fully C.C.W. to activate the power supply. If there is no output current from the A.V.R., turn potentiometer P2 (voltage) C.W. until the ammeter indicates a stable current. Switch the power supply off, then on again, turn P5 C.W until the required max. current is obtained (no more than 8 A).

Checking the internal protection:
Open switch (D): the excitation current should increase to its preset ceiling, remain at that level for about 10 seconds and then drop to below 1A.
To reset, switch off the power supply by opening switch (A).
Note: After setting the excitation ceiling as described, adjust the voltage again (see section 3.5.2.)

(*): A short-circuit current of 3 x IN is a legal requirement in most countries so as to offer selective protection.

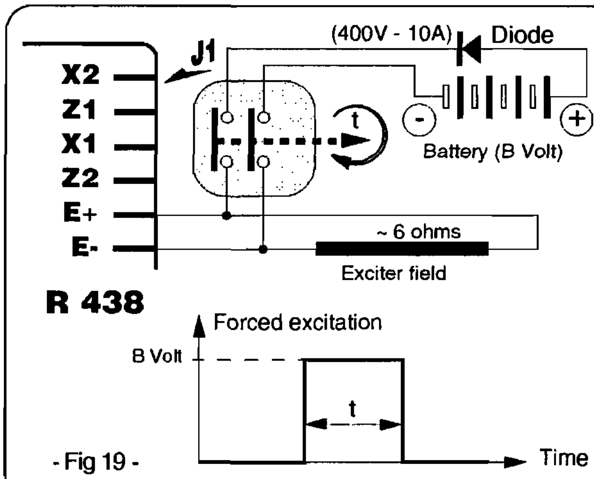
3.5.2 .3 - Special type of use
- Field de-energizing (fig 18)



- Fig 18 -

The exciter is switched off by disconnecting the AVR power supply (1 wire on each auxiliary winding) contact rating 10A - 250V A.C.
Connection is identical for resetting the AVR internal protection.

- Field forcing (fig 19)



- Fig 19 -

Applications	B volts	Time t
Guaranteed voltage build up	6 (1A)	1 - 2 s
Parallel operation, de-energized	6 (1A)	1 - 2 s
Parallel operation, at standstill	12 (2A)	5 - 10 s
Battery starting	24 (4A)	5 - 10 s
Sustained voltage on over load	24 (4A)	5 - 10 s

4 - SERVICING - MAINTENANCE

4.1 - Safety measures

Servicing or troubleshooting must be carried out strictly in accordance with instructions so as to avoid the risk of accidents and to maintain the machine in its original state.

All such operations performed on the alternator should be undertaken by personnel with training in commissioning, servicing and maintenance of electrical and mechanical components.

Before any intervention on the machine, ensure that it cannot be started by a manual or automatic system and that you have understood the operating principles of the system.

4.2 - Regular maintenance

4.2.1 - Checks after start-up

After approximately 20 hours of operation, check that all fixing screws on the machine are still tight, plus the general state of the machine and the various electrical connections in the installation.

4.2.2 - Cooling circuit

It is advisable to check that circulation of air is not reduced by partial blocking of the suction and discharge louvres: mud, fibre, grease, etc.

4.2.3 - Bearings

The bearings are greased for life: approximate life of the grease (depending on use) = 20,000 hours or 3 years. Monitor the temperature rise in the bearings, which should not exceed 60°C above the ambient temperature. Should this value be exceeded, the machine must be stopped and checks carried out.

4.2.4 Electrical servicing

- Cleaning product for the windings

WARNING

DO NOT USE: TRICHLORETHYLENE, PERCHLORETHYLENE, TRICHLOROETHANE and ANY ALKALINE PRODUCTS.

Certain strictly defined pure volatile degreasing products can be used, such as:

- **Normal petrol (without additives)**
- **Toluene (slightly toxic); flammable**
- **Benzene (or benzine, toxic); flammable**
- **Ciclohexare (non toxic); flammable**

Cleaning the stator, rotor, exciter and diode bridge

The isolating components and the impregnation system are not at risk of damage from solvents (see the list of authorised products above).

Avoid letting the cleaning product run into the slots.

Apply the product with a brush, sponging frequently to avoid accumulation in the housing. Dry the winding with a dry cloth. Let any traces evaporate before reassembling the machine.

After cleaning the alternator it is essential to check the isolation of the windings (see sections 3.2.2 and 4.7.2.).

4.2.5 Mechanical maintenance

WARNING

Water and/or Pressure wash are strictly prohibited. Any problem caused by such treatement are not covered by our warranty.

Degreasing : Use a brush and detergent (adapted to paint).

Dusting : Use an air gun.

If a machine is fitted with air inlet and outlet filters, in order to ensure correct ventilation, a regular cleaning of the filters must be done according to the environment conditions.

After cleaning the alternator, it is essential to check the insulation of the windings (see sections 3.2. and 4.8).

4.3 - Fault detection

If, when first commissioned, the alternator does not work normally, the source of the malfunction must be identified.

To do this, check that:

- the protective devices are fitted correctly
- all connections comply with the diagrams in the manuals supplied with the machine
- the speed of the unit is correct (see section 1.2.2)

Repeat the operations defined in section 3.

4.4 - Mechanical defects

Fault		Action
Bearing defect	Excessive overheating of one or both bearings (temp of bearings over 176 °F)(With of without abnormal bearing noise)	- If the bearing has turned blue or if the grease has turned black , change the bearing. - Bearing race badly locked (moving in its housing) -Bracket misalignment.
Overheating	Excessive overheating of alternator frame (temperature rise of more than 104° C above ambient)	- Air flow (inlet - outlet) partially clogged or hot air is being recycled either from alternator or prime mover - Aternator is functionning at too high a voltage (over 105 % of rated voltage on load). - Alternator overloaded.
Vibration problem	Too much vibration	Misalignment (coupling) - Defective mounting or play in coupling - Incorrect balancing of shaft (Engine - Alternator)
	Excessive vibration and humming noise coming from the alternator	Three phase alternator is single phase loaded in excess of acceptable level. - Short-circuit in the alternator stator
Abnormal noises	Alternator damaged by a significant impact which is followed by humming and vibration	- System short-circuit - Mis paralleling Possible consequences (according to the seriousness of the above faults): - Broken or damaged coupling. - Broken or bent shaft end. - Shifting and short circuit of main field rotor. - Fractured fan or coming loose on shaft. - Blown up rotating diodes, or and A.V.R.

4.5 - Electrical faults

Fault	Action	Symptoms	Cause
No voltage at no load or start up	Connect a battery of 4 to 12 volts to terminals E+ or E- respecting the polarity on the A.V.R.for 2 to 3 seconds	The alternator builds up and voltage is correct when the battery is removed	- Lack of residual magnetism
		The alternator builds up but voltage does not reach nominal value when the battery is removed	- Check the connection of the sensing leads to the A.V. R - Faulty rotating diode - Short-circuit on rotor windings
		The alternator builds up but voltage collapses when the battery is removed	- Faulty A.V.R. - Exciter windings shorted or open circuit (check winding) - Main field winding open circuit (check resistance)
Voltage too low	Check the prime mover speed	Correct speed	Check AVR connections (possible AVR failure) - Exciter field short-circuited - Rotating diode(s) burnt out - Main field rotor short-circuited - Check the resistance
		Speed too low	Increase the speed of prime mover (Do not touch the AVR voltage pot. (P2) before running at the correct speed)
Voltage too high	Adjust potentiometer voltage	No adjustment of voltage	AVR faulty
Voltage oscillations	Adjust the stability potentiometer on A.V.R.	If no effect : change recovery mode normal / rapid (ST2)	- Check speed for possible cyclic irregularity - Loose connections - Faulty A.V.R. - Speed below nominal on load (or LAM set too high)
Voltage correct on no load too low on load (*)	Run on no-load and check voltage between E+ and E-	Voltage between E+ and E- : < 6V(DC)	- Check speed (or LAM on R 438 set too high)
		Voltage between E+ and E- > 10 V (DC)	- Faulty rotating diodes faulty - Short-circuit in the main field. Check resistance. - Faulty exciter armature. Check resistance.
(*) **Warning:** During single-phase operation, check that the sensing wires from the AVR are connected to the correct output terminals.			
Voltage collapses during normal operation (**)	Check the AVR, the surge suppressor, the rotating diodes and replace any defective part	The output voltage does not return the rated value .	- Exciter winding open circuit - Faulty exciter armature - Faulty AVR - Main field rotor winding open circuit or short circuit
(**) **Warning**: The AVR internal protection may cut in (overload lost connection, short circuit)			

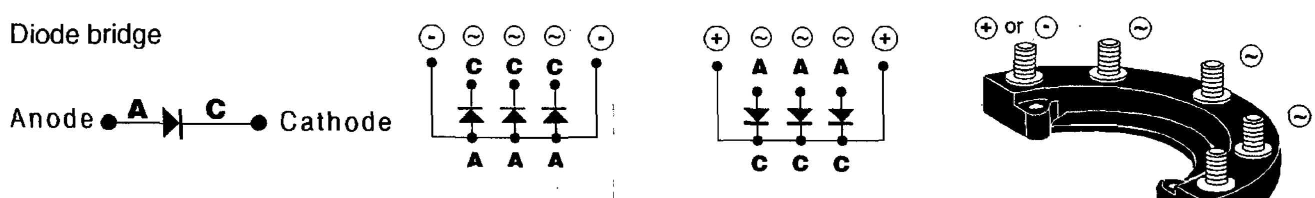
4.5.1 - Checking the windings

You can check the winding insulation making a high voltage test. In this case, you must disconnect all AVR wires.

WARNING

Damages occuring to avr in such conditions will not be taken into account in a warranty claim.

4.5.1 - Checking the diode bridge (Fig 20)



A diode in good condition enables the current to flow in only one direction from Anode to Cathode

- Fig 20 -

4.5.2 - Checking the windings and rotating diodes using separate excitation

During this procedure, make sure that the alternator is disconnected from any external load and inspect the terminal box to check that the connections are fully tightened.

1) Stop the unit, disconnect and isolate the AVR wires.
2) There are are two ways of carrying out a separate excitation (see fig 21.).

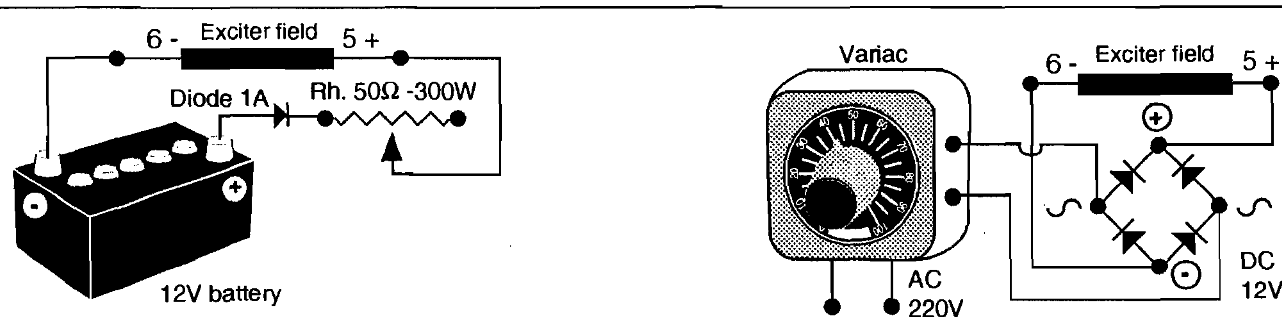
Assembly A: Connect a 12 V battery in series with a rheostat of approximately 50 ohms - 300 W and a diode on both exciter field wires (5+) and (6-).

Assembly B: Connect a "Variac" variable power supply and a diode bridge on both exciter field wires (5+) and (6-).
These two systems should have characteristics which are compatible with the exciter field excitation power of the machine (see the nameplate).

3) Run the unit at its rated speed.

4) Gradually increase the exciter field current by adjusting the rheostat or the variac and measure the output voltages on L1 - L2 - L3, checking the excitation voltage and current at no load and at full load (see machine nameplate or ask for the factory test report).

When the output voltage is at its rated value and balanced within 1%, for the rated excitation level and rated speed, then the machine is in good working order.
The fault must therefore come from the A.V.R. or its associated wiring (i.e. sensing, auxiliary windings)

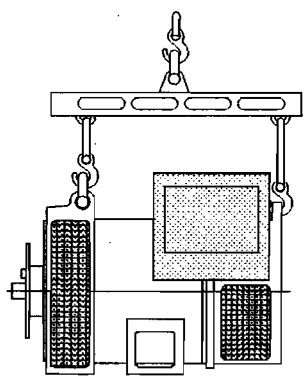


- Fig 21 -

4.6 - Dismantling, reassembly (see section 5.5.1. & 5.5.2.)

During the warranty period, this operation should only be carried out in a approved workshop or in our factory, otherwise the warranty may be invalidated.

The machine must be horizontal when handled (when travelling bar removed). See fig 22.



- Fig 22 -

4.6.1 - Tools required

To fully dismantle the machine, we recommend you have the tools listed below:
- 1 : ratchet spanner + extension
- 1 : torque wrench
- 1 : 7 mm flat spanner
- 1 : 8 mm flat spanner
- 1 : 10 mm flat spanner
- 1 : 12 mm flat spanner
- 1 : 8 mm socket
- 1 : 10 mm socket
- 1 : 13 mm socket
- 1 : 5 mm Allen key
- 1 : 6 mm Allen key
- 1 : TORX T20 bit
- 1 : TORX T30 bit
- 1 : puller (U35)
- 1 : puller (U32/350)

4.6.2 - Screw tightening torque

Identification	screw Ø	Torque N.m
Field term. block screw	M4	4 N.m
Field screw	M6	10 N.m
Diode bridge screw	M6	5 N.m
Diode nut	M5	4 N.m
Assembly rod	M8	20 N.m
Earthing screw	M6	5 N.m
Balancing bolt	M5	4 N.m
Discs/shaft screw	M10	66 N.m
Lifting screw	M8	4 N.m
Louvre screw	M6	5 N.m
Cover screw	M6	5 N.m

4.6.3 - Accessing connections and the regulation system

The terminals are accessed by removing the terminal box lid [48].
To access the adjustment potentiometers on the AVR, the side plate should be removed [367].

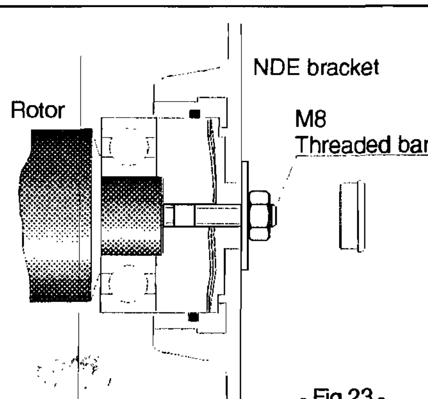
4.6.4 - Accessing, checking and replacing diodes

4.6.4.1- Dismantling

- Remove the terminal box lid [48].
- Remove the air intake louvre [51].
- Unscrew the fixing clamps on the power output cables, disconnect E+, E- on the exciter and R 791 module.
- Remove the 4 nuts on the tie rods.
- Remove the NDE bracket [36] using an extractor: eg. U.32 - 350 .
- Remove the surge suppressor [347].
- Remove the 4 fixing screws from the diode bridges on the armature.
- Disconnect the diodes.
- Check the 6 diodes using either an ohmmeter or a battery lamp (see section 4.5.1).

4.6.4.2- Reassembly

- Replace the diodes, respecting the polarity (see section 4.5.1). Replace the surge suppressor [347].
- Insert a new O ring in the bearing housing.
- Refit the NDE bracket (see fig 23) and pass the bundle

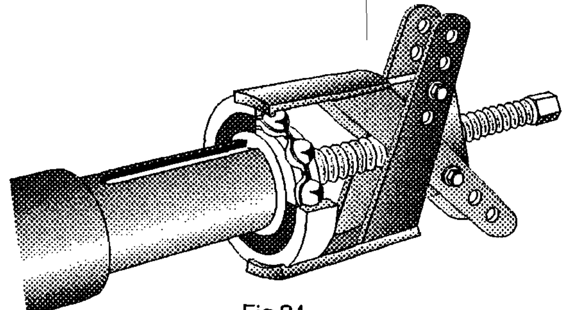


- Fig 23 -

of wires between the top bars of the flange.
- Replace the fixing clamps on the cables and the R 791 module.
- Refit the air intake louvre [51].
- Replace the terminal box lid [48].

4.6.5 - Replacing the NDE bearing on a single-bearing machine

4.6.5.1- Dismantling
- Dismantle the NDE bracket [36] (see section 4.6.4.1).
- Remove the bearing [70] using a puller.
(See fig 24)



- Fig 24 -

4.6.5.2- Reassembly
- Heat the inner slipring of a new bearing by induction or in a drying oven at 80 °C (do not use an oil bath) and fit it to the machine.
- Place the preloading wavy washer [79] in the flange and fit a new O ring seal [349].
- Replace the NDE bracket [36] (see section 4.6.4.2).

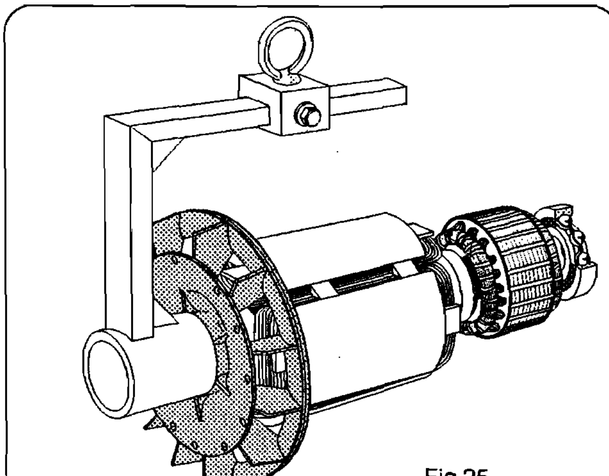
4.6.6 - Replacing the bearings on a two-bearing machine

4.6.6.1 - Dismantling
- Uncouple the alternator from the prime mover.
- Remove the 8 assembly screws.
- Remove the DE flange [30].
- Remove the NDE bracket (see section 4.6.4.1).
- Remove both bearings [60] and [70] using a puller.

4.6.6.2 - Reassembly
- Fit new bearings after heating them by induction or in a drying oven at 80 °C (do not use an oil bath).
- Check that both the preloading wavy washer [79] and new O ring seal have been fitted [349] on the NDE bracket [36].
- Replace the DE flange [30], and tighten the 8 fixing screws.
- Check that the whole machine is correctly assembled and that all screws are fully tightened.

4.6.7 - Accessing the main field and stator

4.6.7.1 - Dismantling
Follow the procedure for dismantling bearings (see sections 4.6.5.1 and 4.6.6.1)
- Remove the coupling discs (single-bearing machine) or the DE flange (two-bearing machine) and insert a tube of the corresponding diameter on the shaft end or a support made according to fig 25.

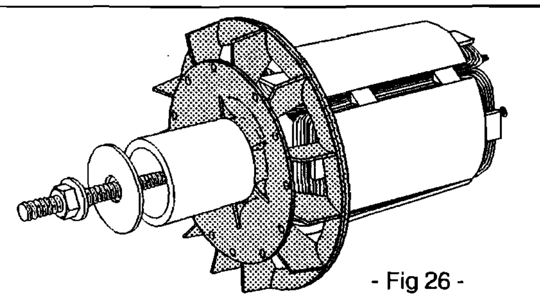


- Fig 25 -

- Rest the rotor on one of its poles, then slide it out. Use the tube as a lever arm to assist dismantling.
- After extraction, be careful with the fan. It is necessary to replace the fan in case of disassembling.

NOTE: If intervention is required on the main field (rewinding, replacement of components), the rotor assembly must be rebalanced.

4.6.7.2 - Reassembly
- Follow the dismantling procedure in reverse order.
Take care not to knock the windings when refitting the rotor in the stator.
- If you replace the fan, respect the assembly guide (fig 26). Use a tube and a screw.



- Fig 26 -

Follow the procedure for reassembling the bearings (see section 4.6.5.2 and 4.6.6.2).

After final adjustments, the access panels or covers should be refitted.

4.7 - Electrical characteristics table

Alternator - 2/4 - pole - 50/60 Hz - No. 6 standard winding. (400V for the excitation values)
The voltage and current values are given for no-load operation and operation at rated load with separate field excitation. All values are given at ± 10% (for exact values, consult the test report) and are subject to change without prior warning.

Alternator 2 pole with SHUNT excitation
Resistances at 20°C (Ω) - 50 / 60 Hz

1012	D	F	J	N	P
L/N stator	0,76	0,61	0,4	0,22	0,16
Rotor	3,13	3,27	3,53	4,06	4,66
Field	23,5	23,5	23,5	23,5	23,5
Armature	0,79	0,79	0,79	0,79	0,79

Alternator 2 pole with SHUNT excitation
Field excitation current i exc (A) - 400 V - 50 Hz:
Symbols : "i exc": excitation current of the exciter field.

1012	D	F	J	N	P
No-load	0,4	0,4	0,4	0,45	0,4
At rated load	1,7	1,7	1,7	1,7	1,7

For 60Hz machines the "i exc" values are approximately 5 to 10 % less.

Alternator 4 pole with SHUNT excitation
Resistances at 20°C (Ω) - 50 / 60 Hz

1014	H	L	N	Q	S
L/N stator	0,70	0,56	0,32	0,21	0,191
Rotor	2,06	2,3	2,71	3,35	3,7
Field	23,5	23,5	23,5	23,5	23,5
Armature	0,51	0,51	0,51	0,51	0,51

Alternator 4 pole with SHUNT excitation
Field excitation current i exc (A) - 400 V - 50 Hz:
Symbols : "i exc": excitation current of the exciter field.

1014	H	L	N	Q	S
No-load	0,6	0,55	0,6	0,55	0,5
At rated load	1,6	1,7	1,6	1,55	1,5

For 60Hz machines the "i exc" values are approximately 5 to 10 % less.

Alternator 4 pole with AREP excitation
Resistances at 20°C (Ω) - 50 / 60 Hz

1024	N	Q	S
L/N stator	0,35	0,22	0,2
Rotor	2,71	3,35	3,7
Auxil. wind. X1, X2	0,3	0,26	0,23
Auxil. wind. Z1, Z2	0,5	0,44	0,41
Field	6	6	6
Armature	0,5	0,5	0,5

Alternator 4 pole with AREP excitation
Field excitation current i exc (A) - 400 V - 50 Hz:
Symbols : "i exc": excitation current of the exciter field.

1024	N	Q	S
No-load	0,9	0,8	0,75
At rated load	2,4	2,35	2,3

For 60Hz machines the "i exc" values are approximately 5 to 10 % less.

5 - SPARE PARTS

5.1 - First maintenance parts

Emergency repair kits are available as an option.
They contain the following items:

No.	Description	Qty	1000 - SHUNT	Coding
198	Voltage regulator (AVR)	1	R 230 B	ESC 110 CU 003
343	Diode bridge assembly	1	LSA 411.1.59/60	ESC 025 MD 008
347	Surge suppressor	1	LSA 411.1.17A	CII 411 EQ 017
	AVR fuse	1	250 V - 8 A / slow	

No.	Description	Qty	1000 - AREP	Coding
198	Voltage regulator (AVR)	1	R 438 LS	ESC 220 CU 025
343	Diode bridge assembly	1	LSA 411.1.59/60	ESC 025 MD 008
347	Surge suppressor	1	LSA 411.1.17A	CII 411 EQ 017
	AVR fuse	2	250 V - 8 A / fast	

5.2 - Description of bearings

No.	Description	Qty	1000	Coding
60	D.E. bearing	1	6309 2RS/C3	RLT 045 TN 030
70	N.D.E. bearing	1	6305 2RS/C3	RLT 025 TN 030

5.3 - Technical support service

Our technical support service will be happy to provide any information you require.

When ordering spare parts, you should indicate the complete machine type, its serial number and the information indicated on the nameplate.

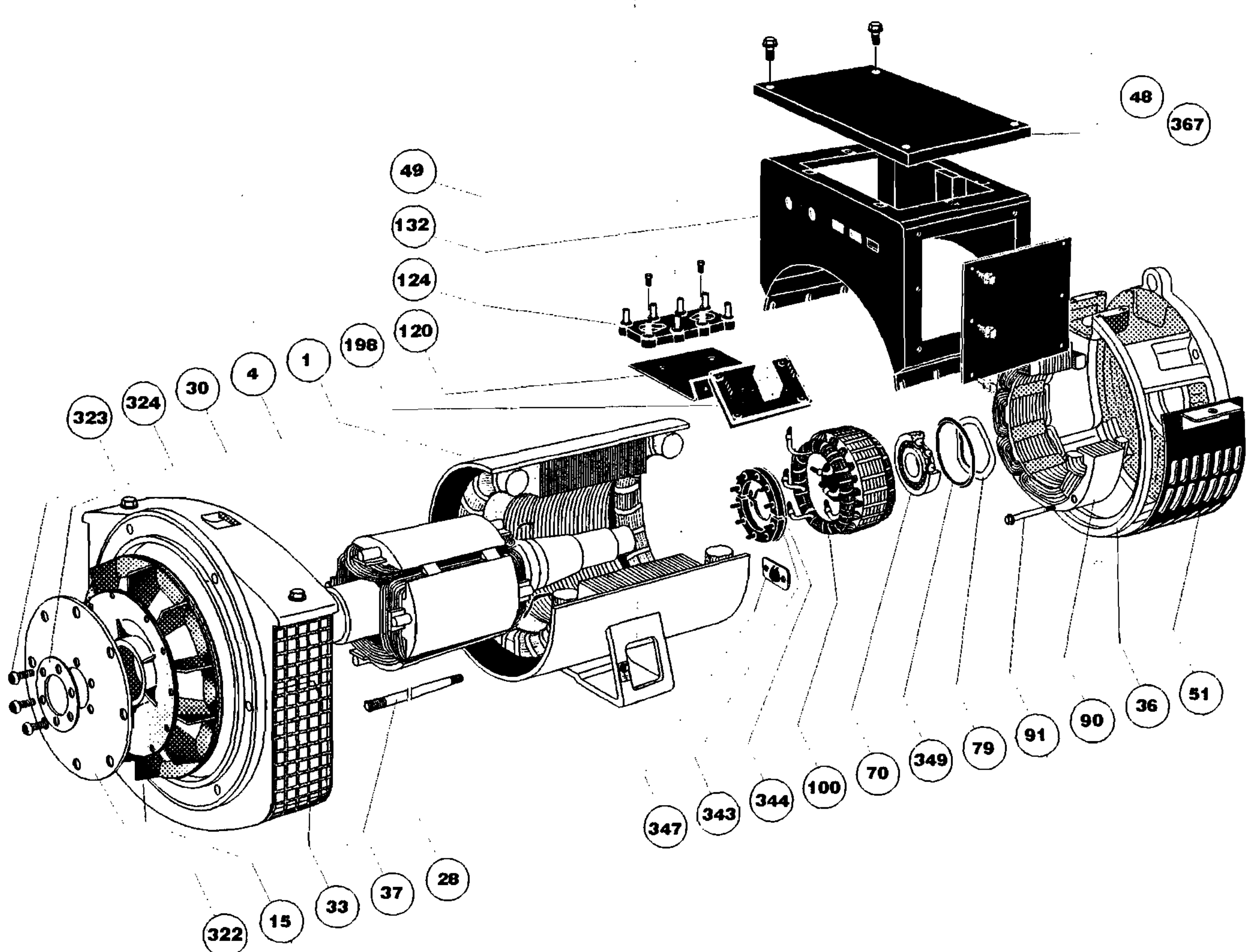
Address your enquiry to your usual contact

WARNING

Part numbers should be identified from the exploded views and their description in the parts list.
Our extensive network of "service stations" can dispatch the necessary parts without delay.
To ensure correct operation and the safety of our machines, we recommend the use of original manufacture spare parts.
In the event of failure to comply with this advice, the manufacturer cannot be held responsible for any damage.

5.5 - Exploded view, parts list.

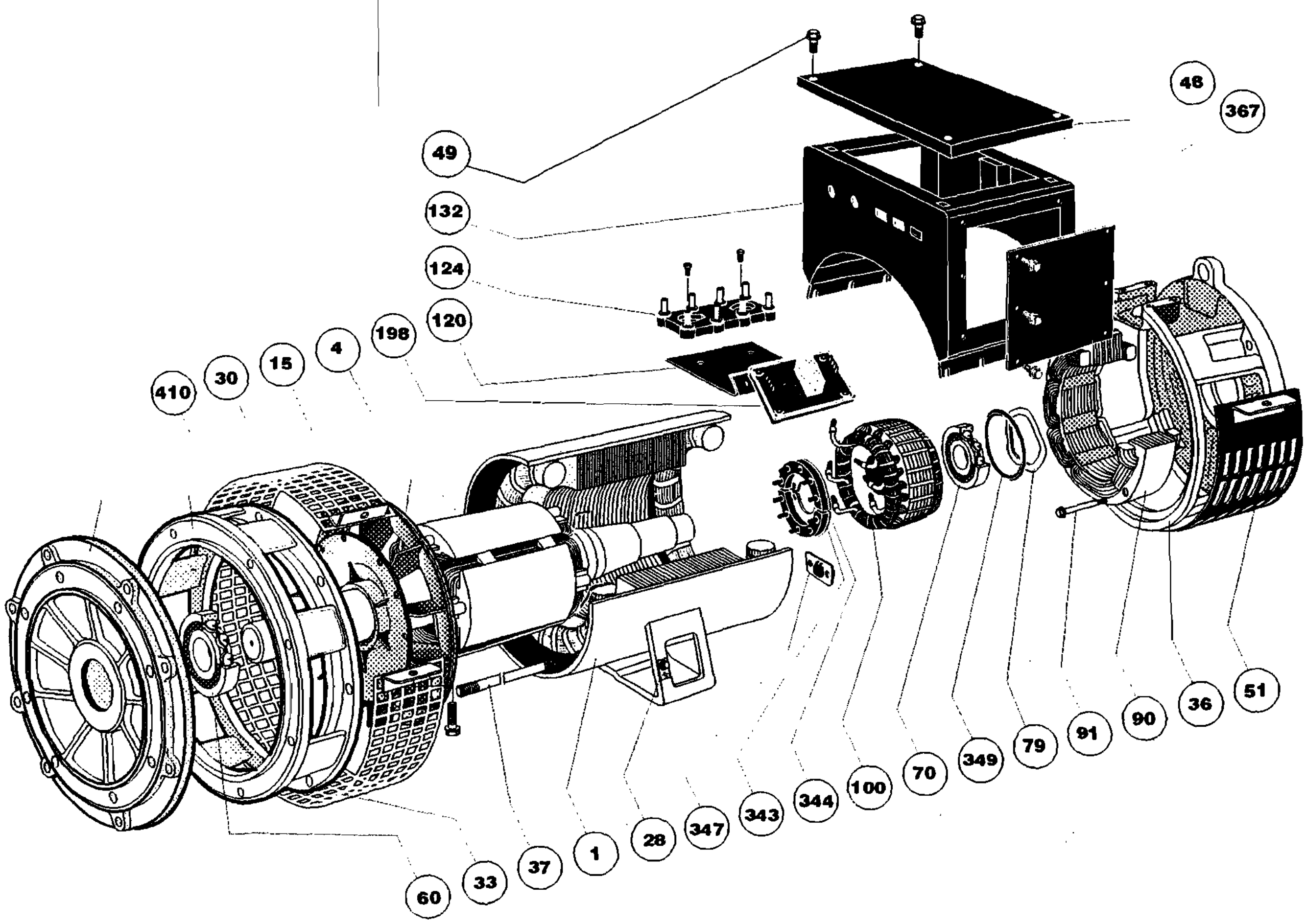
5.5.1 - 1000 single bearing, (Fig 27) with terminal box



- Fig 27 -

No.	Nbr.	Description	No.	Nbr.	Description
1	1	Stator assembly	100	1	Exciter armature
4	1	Rotor assembly	120	1	Terminal plate support (AREP)
15	1	Fan	124	1	Terminal plate
28	1	Earth terminal	132	1	Terminal box
30	1	DE flange	198	1	Regulator (AVR)
33	1	Air outlet louvre	322	1	Coupling disc
36	1	N.D.E. bracket	323	6	Fixing screw
37	4	Tie rod	324	1	Clamping washer
48	1	Terminal box lid	343	1	Direct diode assembly
49	20	Terminal box fixing screw	344	1	Reverse diode assembly
51	1	Air intake louvre	347	1	Surge suppressor
70	1	NDE bearing	367	2	Inspection door
79	1	Preloading wavy washer	349	1	O ring seal
90	1	Wound exciter field			
91	4	Field fixing screw			

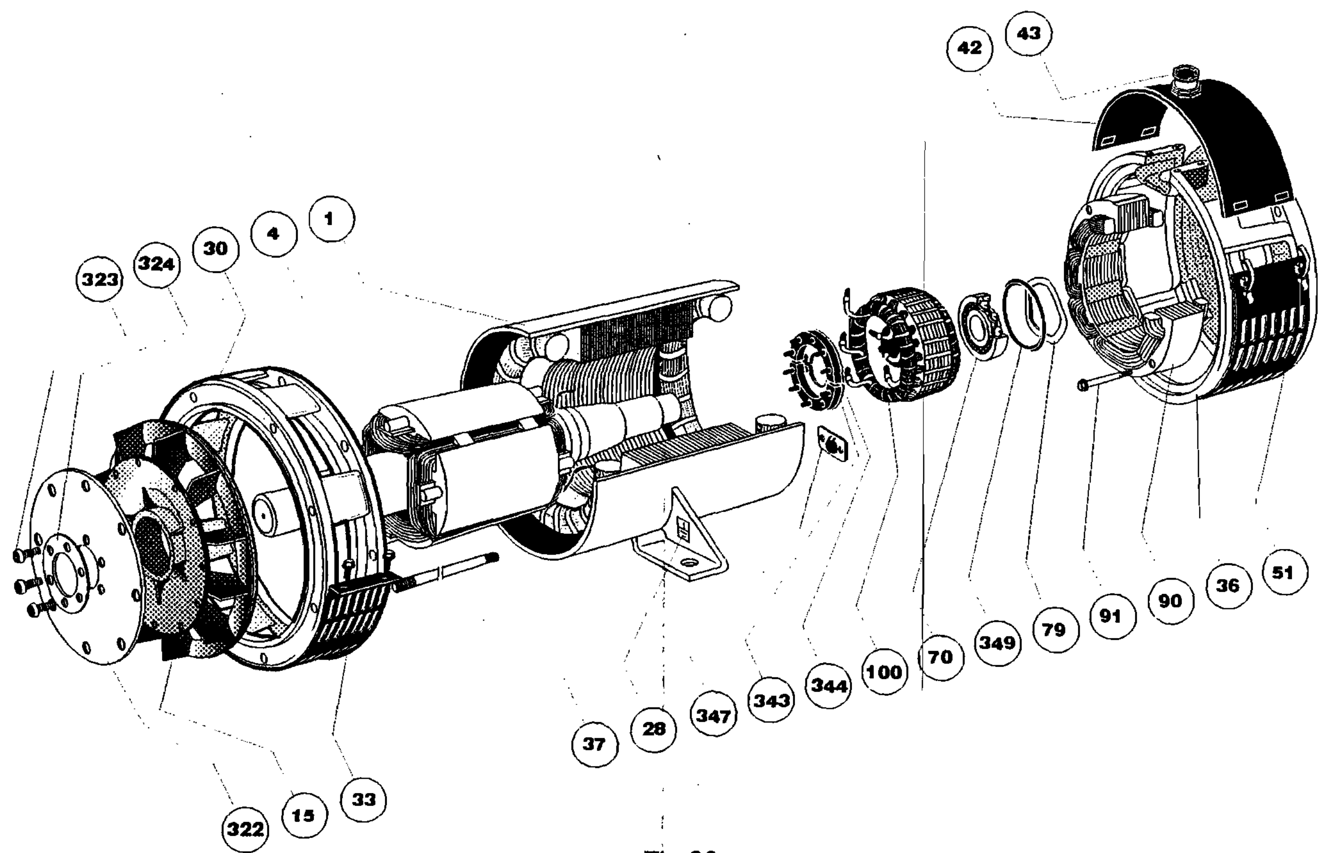
5.5.2 - 1000 two-bearing (Fig 28) with terminal box



- Fig 28 -

No.	Nbr.	Description	No.	Nbr.	Description
1	1	Stator assembly	91	4	Field fixing screw
4	1	Rotor assembly	100	1	Exciter armature
15	1	Fan	120	1	Terminal plate support (AREP)
28	1	Earth terminal	124	1	Terminal plate
30	1	DE flange	132	1	Terminal box
33	1	Air outlet louvre	198	1	Regulator (AVR)
36	1	N.D.E. bracket	343	1	Direct diode assembly
37	4	Tie rod	344	1	Reverse diode assembly
48	1	Terminal box lid	347	1	Surge suppressor
49	20	Terminal box fixing screw	367	2	Inspection door
51	1	Air intake louvre	349	1	O ring seal
60	1	DE bearing	410	1	DE flange
70	1	NDE bearing			
79	1	Preloading wavy washer			
90	1	Wound exciter field			

5.5.2 - **1000 Single bearing, (Fig 29) without terminal box**



- Fig 29 -

No.	Nbr.	Description	No.	Nbr.	Description
1	1	Stator assembly	79	1	Preloading wavy washer
4	1	Rotor assembly	90	1	Exciter field
15	1	Turbine	91	4	Field fixing screw
28	1	Earth terminal	100	1	Exciter armature
30	1	DE flange	322	1	Coupling plate
33	1	Air outlet grille	323	6	Fixing screw
36	1	Exciter flange	324	1	Clamping washer
37	4	Fixing rod	343	1	Direct diode crescent
42	1	Cable gland support	344	1	Reverse diode crescent
43	1	Cable gland	347	1	Surge suppressor
51	1	Air intake grille	349	1	O ring seal
70	1	NDE bearing			

Table of Contents

Foreword

Literature Information

This manual contains safety, operation instructions, lubrication and maintenance information. This manual should be stored in or near the engine area in a literature holder or literature storage area. Read, study and keep it with the literature and engine information.

English is the primary language for all Perkins publications. The English used facilitates translation and consistency.

Some photographs or illustrations in this manual show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this manual. Whenever a question arises regarding your engine, or this manual, please consult with your Perkins dealer or your Perkins distributor for the latest available information.

Safety

This safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance and repair on this product.

Operation

Operating techniques outlined in this manual are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

The operation section is a reference for operators. Photographs and illustrations guide the operator through procedures of inspecting, starting, operating and stopping the engine. This section also includes a discussion of electronic diagnostic information.

Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by service hours and/or calendar time maintenance intervals. Items in the maintenance schedule are referenced to detailed instructions that follow.

Recommended service should be performed at the appropriate intervals as indicated in the Maintenanc Interval Schedule. The actual operating environment of the engine also governs the Maintenance Interval Schedule. Therefore, under extremely severe, dusty, wet or freezing cold operating conditions, more frequent lubrication and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

The maintenance schedule items are organized for a preventive maintenance management program. If the preventive maintenance program is followed, a periodic tune-up is not required. The implementation of a preventive maintenance management program should minimize operating costs through cost avoidances resulting from reductions in unschedule downtime and failures.

Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. We recommend that the maintenance schedules be reproduced and displaye near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

Your authorized Perkins dealer or your Perkins distributor can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance Manual except for the interval and the maintenance items in that interval. Major repairs should only be carried out by Perkins authorized personnel. Your Perkins dealer or your Perkins distributor offers a variety of options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available. Consult with your Perkins dealer or your Perkins distributor for information regarding these options.

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. Battery posts, terminals and related accessories contain lead and lead compounds. **Wash hands after handling.**

Safety Section

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Safety Messages

There may be several specific warning signs on an engine. The exact location of the hazards and the description of the hazards are reviewed in this section. Please become familiar with all warning signs.

Ensure that all of the warning signs are legible. Clean the warning signs or replace the warning signs if the words cannot be read or if the pictures are not visible. When the warning signs are cleaned, use a cloth, water, and soap. Do not use solvent, gasoline, or other harsh chemicals to clean the warning signs. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the warning signs. The warning signs that are loosened could drop off of the engine.

Replace any damaged warning signs or missing warning signs. If a warning sign is attached to a part of the engine that is replaced, install a new warning sign on the replacement part. Perkins dealers or Perkins distributors can provide new warning signs.

Do not work on the engine and do not operate the engine unless the instructions and warnings in the Operation and Maintenance Manual are understood. Correct care is your responsibility. Failure to follow the instructions or failure to heed the warnings could result in injury or in death.

The warning labels that may be found on the engine are illustrated and described.

Ether

The warning label for ether is located on the top, the front, the rear, or the side of the engine.

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Never spray Ether starting aids into the air inlet.

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General Hazard Information

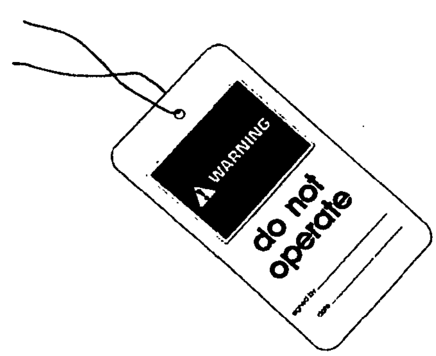

Illustration 1 g00104545

Attach a "Do Not Operate" warning tag or a similar warning tag to the start switch or to the controls before you service the equipment or before you repair the equipment.

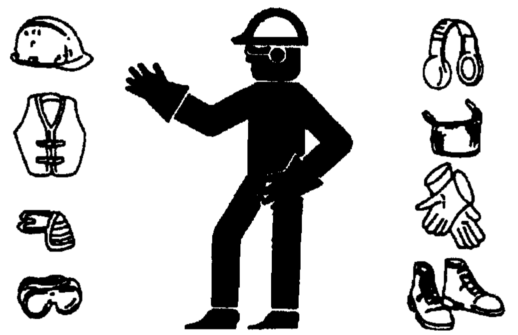

Illustration 2 g00702020

Wear a hard hat, protective glasses, and other protective equipment, as required.

Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.

Make sure that all protective guards and all covers are secured in place on the engine.

Keep the engine free from foreign material. Remove debris, oil, tools, and other items from the deck, from walkways, and from steps.

Never put maintenance fluids into glass containers. Drain all liquids into a suitable container.

Obey all local regulations for the disposal of liquids.

Use all cleaning solutions with care. Report all necessary repairs.

Do not allow unauthorized personnel on the equipment.

Note: Ensure that the power supply is disconnected before you work on the bus bar or the glow plugs.

Unless you are instructed otherwise, perform maintenance on the engine with the equipment in the servicing position. Refer to the OEM information for the procedure for placing the equipment in the servicing position.

Pressure Air and Water

Pressurized air and/or water can cause debris and/or hot water to be blown out. This could result in personal injury.

When pressurized air and/or water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield.

The maximum air pressure for cleaning purposes must be below 205 kPa (30 psi). The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

Fluid Penetration

Pressure can be trapped in the hydraulic circuit long after the engine has been stopped. The pressure can cause hydraulic fluid or items such as pipe plugs to escape rapidly if the pressure is not relieved correctly.

Do not remove any hydraulic components or parts until pressure has been relieved or personal injury may occur. Do not disassemble any hydraulic components or parts until pressure has been relieved or personal injury may occur. Refer to the OEM information for any procedures that are required to relieve the hydraulic pressure.

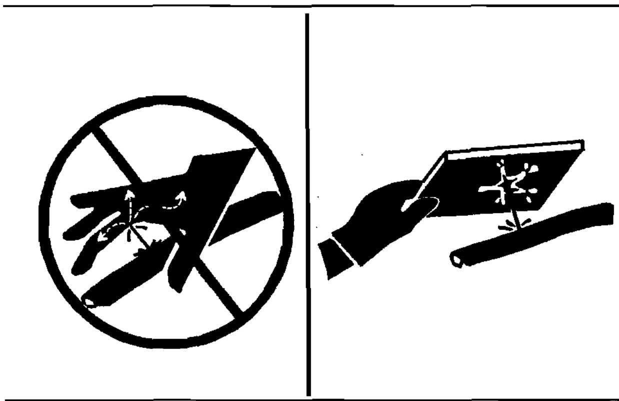

Illustration 3 g00687600

Always use a board or cardboard when you check for a leak. Leaking fluid that is under pressure can penetrate body tissue. Fluid penetration can cause serious injury and possible death. A pin hole leak can cause severe injury. If fluid is injected into your skin, you must get treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

Containing Fluid Spillage

Care must be taken in order to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the engine. Make provision to collect the fluid with a suitable container before any compartment is opened or before any component is disassembled.

- Only use the tools that are suitable for collecting fluids and equipment that is suitable for collecting fluids.

- Only use the tools that are suitable for containing fluids and equipment that is suitable for containing fluids.

Obey all local regulations for the disposal of liquids.

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Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine. Relieve all pressure in the air system, in the hydraulic system, in the lubrication system, in the fuel system, or in the cooling system before any lines, fittings or related items are disconnected.

Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant.

Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check the coolant level after the engine has stopped and the engine has been allowed to cool.

Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly in order to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Also, do not allow hot components to contact the skin.

Batteries

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or the eyes. Always wear protective glasses for servicing batteries. Wash hands after touching the batteries and connectors. Use of gloves is recommended.

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Fire Prevention and Explosion Prevention

Illustration 4 g00704000

All fuels, most lubricants, and some coolant mixtures are flammable.

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

A flash fire may result if the covers for the engine crankcase are removed within fifteen minutes after an emergency shutdown.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Perkins dealer and/or your Perkins distributor for additional information about suitable protection devices.

Remove all flammable combustible materials or conductive materials such as fuel, oil, and debris from the engine. Do not allow any flammable combustible materials or conductive materials to accumulate on the engine.

Store fuels and lubricants in correctly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in case of a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

Do not weld on lines or tanks that contain flammable fluids. Do not flame cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. All electrical wires must be correctly routed and securely attached. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and correctly maintained battery cables will help to prevent arcing or sparking.

Inspect all lines and hoses for wear or for deterioration. The hoses must be correctly routed. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Oil filters and fuel filters must be correctly installed. The filter housings must be tightened to the correct torque.

Illustration 5 g00704059

Use caution when you are refueling an engine. Do not smoke while you are refueling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refueling.

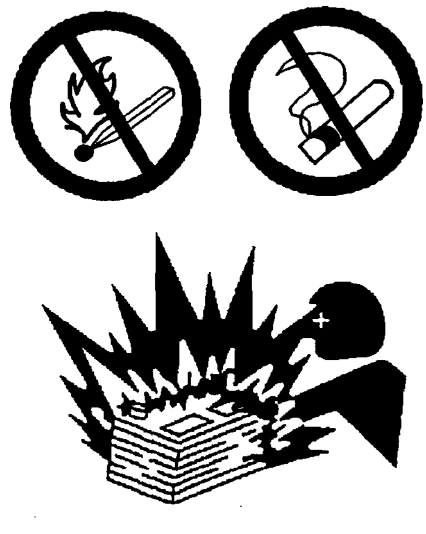

Illustration 6 g00704135

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.

Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Incorrect jumper cable connections can cause an explosion that can result in injury. Refer to the Operation Section of this manual for specific instructions.

Do not charge a frozen battery. This may cause an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

Lines, Tubes and Hoses

Do not bend high pressure lines. Do not strike high pressure lines. Do not install any lines that are bent or damaged.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Perkins dealer or your Perkins distributor for repair or for replacement parts.

Check lines, tubes and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. Tighten all connections to the recommended torque.

Replace the parts if any of the following conditions are present:

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible part of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly. During engine operation, this will help to prevent vibration, rubbing against other parts, and excessive heat.

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Crushing Prevention and Cutting Prevention

Support the component correctly when work beneath the component is performed.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating parts and of all moving parts. Leave the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw objects or cut objects.

When objects are struck, wear protective glasses in order to avoid injury to the eyes.

Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensure that no one will be injured by flying debris.

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Mounting and Dismounting

Inspect the steps, the handholds, and the work area before mounting the engine. Keep these items clean and keep these items in good repair.

Mount the engine and dismount the engine only at locations that have steps and/or handholds. Do not climb on the engine, and do not jump off the engine.

Face the engine in order to mount the engine or dismount the engine. Maintain a three-point contact with the steps and handholds. Use two feet and one hand or use one foot and two hands. Do not use any controls as handholds.

Do not stand on components which cannot support your weight. Use an adequate ladder or use a work platform. Secure the climbing equipment so that the equipment will not move.

Do not carry tools or supplies when you mount the engine or when you dismount the engine. Use a hand line to raise and lower tools or supplies.

i02157341

Before Starting Engine

NOTICE

For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

Overspeed shutdown should occur automatically. If automatic shutdown does not occur, press the emergency stop button in order to cut the fuel and/or air to the engine.

Inspect the engine for potential hazards.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work correctly, if equipped.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided in order to help prevent personal injury. The circuits are also provided in order to help prevent engine damage.

See the Service Manual for repairs and for adjustments.

i02207232

Engine Starting

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

If a warning tag is attached to the engine start switch or to the controls, DO NOT start the engine or move the controls. Consult with the person that attached the warning tag before the engine is started.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Start the engine from the operator's compartment or from the engine start switch.

Always start the engine according to the procedure that is described in the Operation and Maintenance Manual, "Engine Starting" topic in the Operation Section. Knowing the correct procedure will help to prevent major damage to the engine components. Knowing the procedure will also help to prevent personal injury.

To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working correctly, check the water temperature gauge and the oil temperature gauge during the heater operation.

Engine exhaust contains products of combustion which can be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

Note: The engine is equipped with an automatic device for cold starting for normal conditions of operation. If the engine will be operated in very cold conditions, then an extra cold starting aid may be required. Normally, the engine will be equipped with the correct type of starting aid for your region of operation.

The engines are equipped with a glow plug starting aid in each individual cylinder that heats the intake air in order to improve starting.

i01928905

Engine Stopping

Stop the engine according to the procedure in the Operation and Maintenance Manual, "Engine Stopping (Operation Section)" in order to avoid overheating of the engine and accelerated wear of the engine components.

Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. Do not use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.

Stop the engine if an overspeed condition occurs during the initial start-up of a new engine or an engine that has been overhauled. This may be accomplished by shutting off the fuel supply to the engine and/or shutting off the air supply to the engine.

i02176668

Electrical System

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative "–" jump start cable should be connected last from the external power source to the negative "–" terminal of the starting motor. If the starting motor is not equipped with a negative "–" terminal, connect the jump start cable to the engine block.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is started. Repair all frayed electrical wires before the engine is started. See the Operation and Maintenance Manual for specific starting instructions.

Grounding Practices

Correct grounding for the engine electrical system is necessary for optimum engine performance and reliability. Incorrect grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths.

Uncontrolled electrical circuit paths can result in damage to main bearings, to crankshaft bearing journal surfaces, and to aluminum components.

Engines that are installed without engine-to-frame ground straps can be damaged by electrical discharge.

To ensure that the engine and the engine electrical systems function correctly, an engine-to-frame ground strap with a direct path to the battery must be used. This path may be provided by way of a direct engine ground to the frame.

All grounds should be tight and free of corrosion. The engine alternator must be grounded to the negative "-" battery terminal with a wire that is adequate to handle the full charging current of the alternator.

Product Information Section

Model Views

i01928892

Model View Illustrations

1104 Engine Model Views

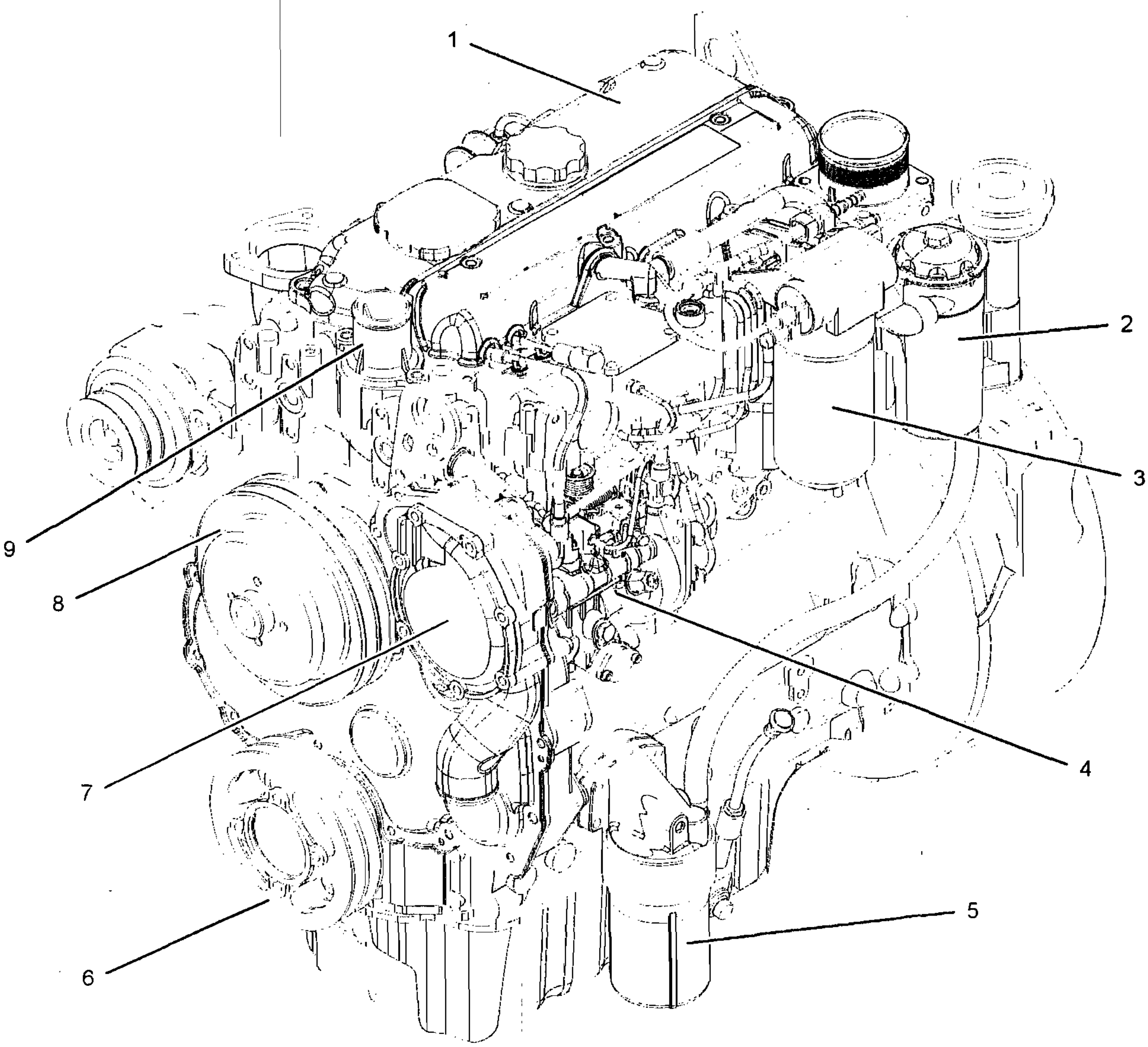

Illustration 7

g010122

(1) Valve mechanism cover
(2) Crankcase breather
(3) Fuel filter
(4) Fuel injection pump
(5) Engine oil filter
(6) Crankshaft pulley
(7) Water pump
(8) Fan pulley
(9) Water temperature regulator housing

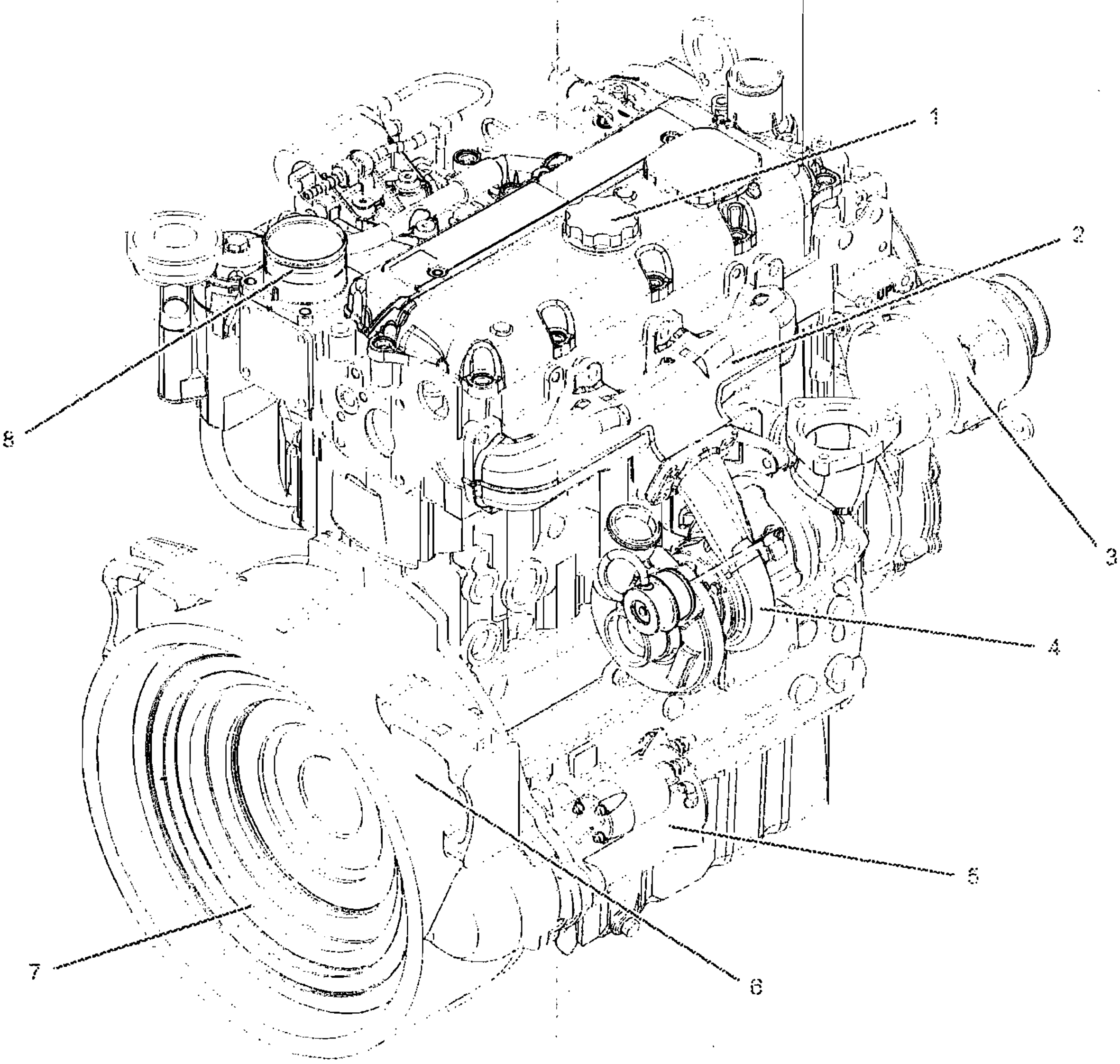

Illustration 8 g01012281

(1) Oil filler cap
(2) Exhaust manifold
(3) Alternator
(4) Turbocharger
(5) Starter motor
(6) Flywheel housing
(7) Flywheel
(8) Air intake

1103 Engine Model Views

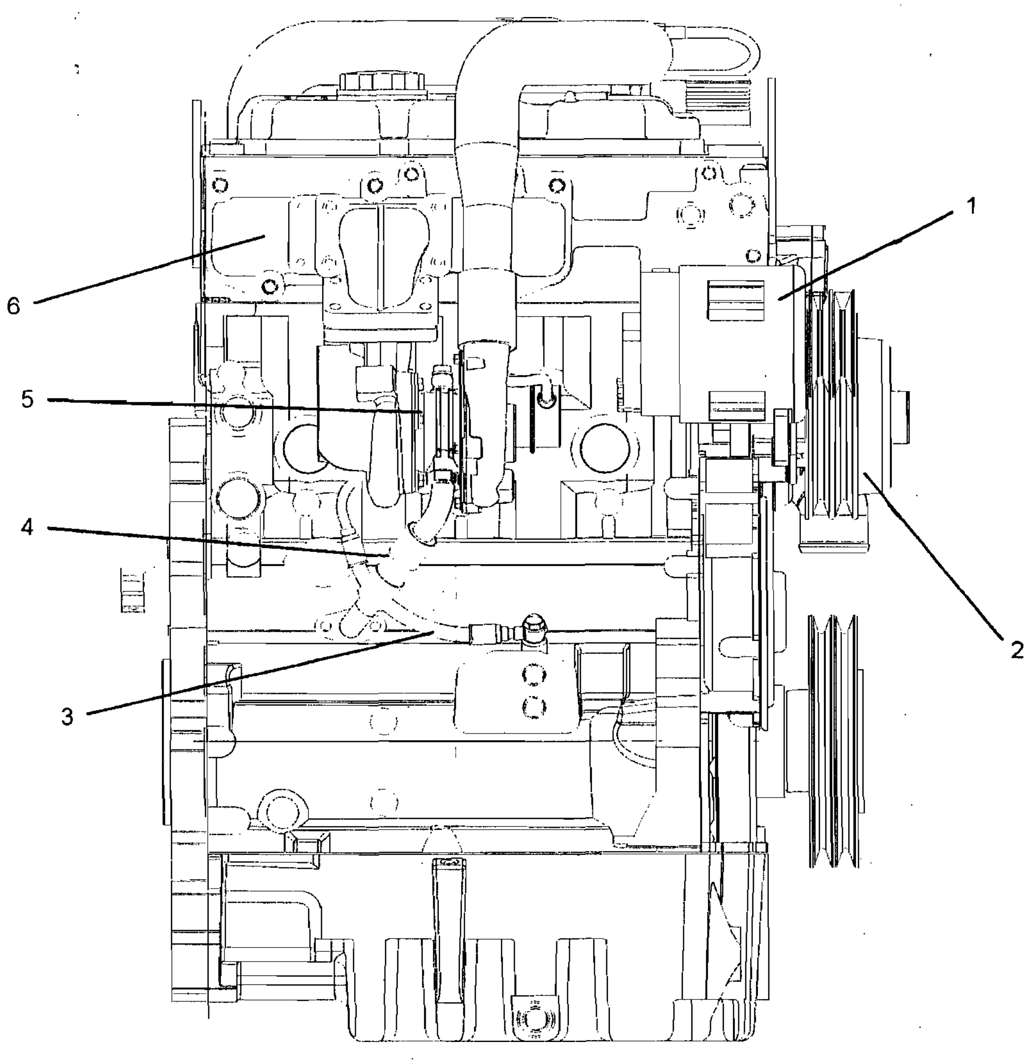

Illustration 9 g01011134

(1) Alternator
(2) Fan pulley
(3) Turbocharger oil supply
(4) Turbocharger oil drain
(5) Turbocharger
(6) exhaust manifold

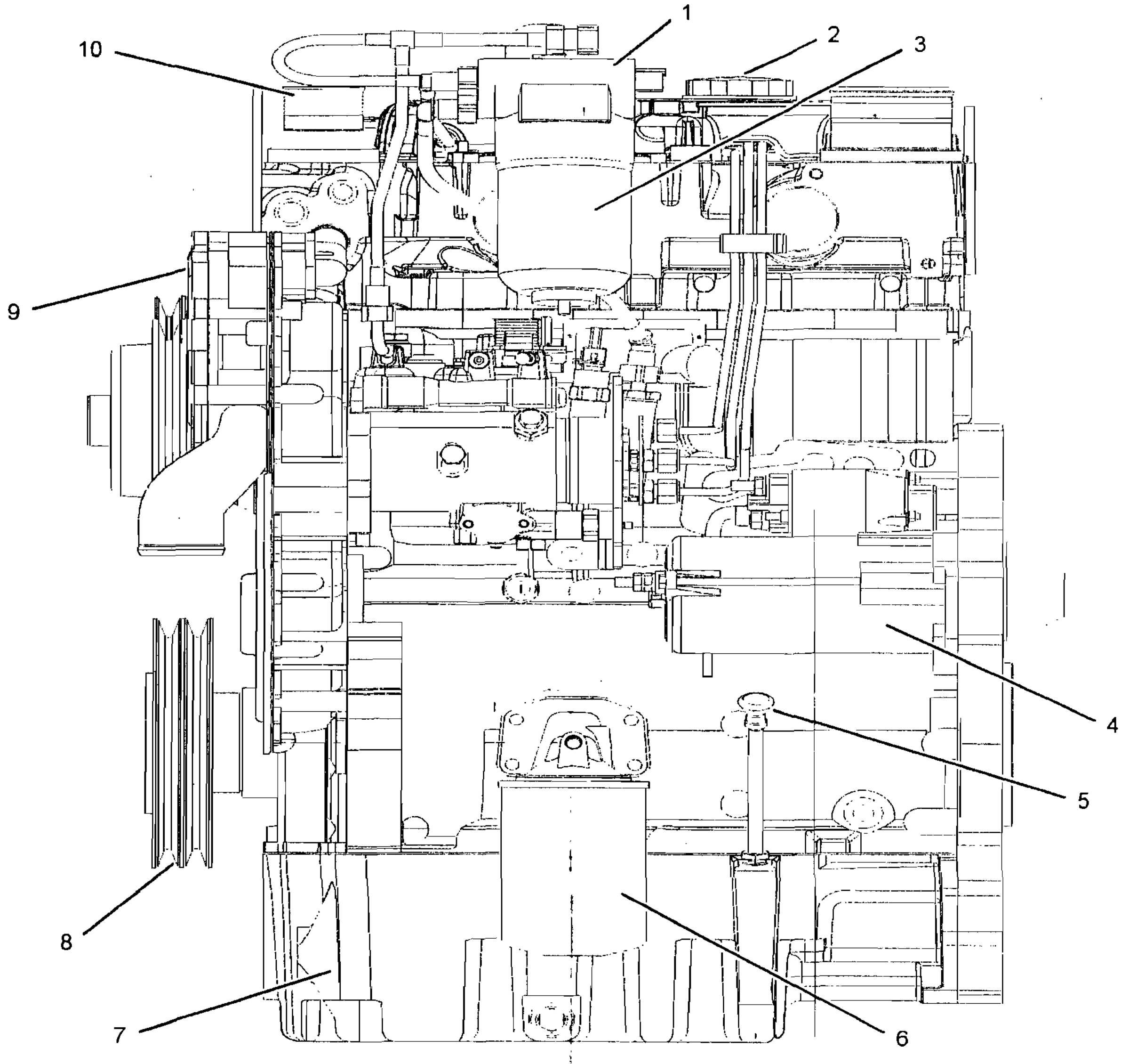

Illustration 10 g01011349

(1) Fuel transfer pump
(2) Oil filler cap
(3) Fuel filter
(4) Starter motor
(5) Dipstick
(6) Oil filter
(7) Oil pan
(8) Crankshaft pulley
(9) Water pump
(10) Water temperature regulator housing

i02196981

Engine Description

Perkins Engines are designed for the following applications: machine, genset, and industrial mobile equipment. The engines are available in the following types of aspiration:

- Turbocharged aftercooled
- Turbocharged
- Naturally aspirated

Engine Specifications

Note: The front end of the engine is opposite the flywheel end of the engine. The left and the right sides of the engine are determined from the flywheel end. The number 1 cylinder is the front cylinder.

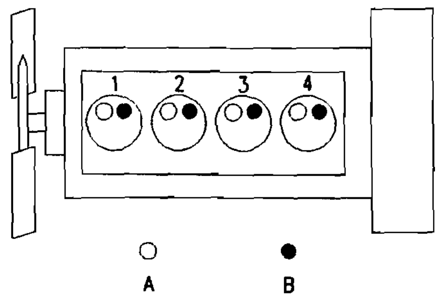

Illustration 11 g00984281

A typical example of the layout of the valves

(A) Inlet valves
(B) Exhaust valves

Table 1

1104 Industrial Engine Specifications	
Number of Cylinders	4 In-Line
Bore	105 mm (4.134 inch)
Stroke	127 mm (5.0 inch)
Aspiration	Turbocharged aftercooled Turbocharged Naturally aspirated
Compression Ratio	NA 19.25:1 NA T 18.23:1 T, TA
Displacement	4.4 L (268 in ^{3})
Firing Order	1 3 4 2
Rotation (flywheel end)	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.45 mm (0.018 inch)

Table 2

1103 Industrial Engine Specifications	
Number of Cylinders	3 In-Line
Bore	105 mm (4.134 inch)
Stroke	127 mm (5.0 inch)
Aspiration	Turbocharged Naturally aspirated
Compression Ratio	NA 19.25:1 T 18.25:1
Displacement	3.3 L (201 in^3)
Firing Order	1 2 3
Rotation (flywheel end)	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.45 mm (0.018 inch)

Table 3

1104 Genset Specifications	
Number of Cylinders	4 In-Line
Bore	105 mm (4.134 inch)
Stroke	127 mm (5.0 inch)
Aspiration	Turbocharged aftercooled Turbocharged Naturally aspirated
Compression Ratios	NA 19.25:1 T 17.25:1, T 18.23:1, TA 18.23:1
Displacement	4.4 L (268 in ^{3})
Firing Order	1 3 4 2
Rotation (flywheel end)	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.45 mm (0.018 inch)

Table 4

1103 Genset Specifications	
Number of Cylinders	3 In-Line
Bore	105 mm (4.134 inch)
Stroke	127 mm (5.0 inch)
Aspiration	Turbocharged Naturally aspirated
Compression Ratio	NA 19.25:1 T 17.25:1
Displacement	3.3 L (201 in^3)
Firing Order	1 2 3
Rotation (flywheel end)	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.45 mm (0.018 inch)

Engine Cooling and Lubrication

The cooling system consists of the following components:

- Gear-driven centrifugal water pump
- Water temperature regulator which regulates the engine coolant temperature
- Gear-driven oil pump (gear type)
- Oil cooler

The engine lubricating oil is supplied by a gear type pump. The engine lubricating oil is cooled and the engine lubricating oil is filtered. Bypass valves provide unrestricted flow of lubrication oil to the engine parts when oil viscosity is high. Bypass valves can also provide unrestricted flow of lubrication oil to the engine parts if the oil cooler should become plugged or if the oil filter element should become plugged.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to proper operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended fuels, lubrication oils, and coolants. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information on maintenance items.

Engine Service Life

Engine efficiency and maximum utilization of engine performance depend on the adherence to proper operation and maintenance recommendations. In addition, use recommended fuels, coolants and lubricants. Use the Operation and Maintenance Manual as a guide for required engine maintenance.

Expected engine life is generally predicted by the average power that is demanded. The average power that is demanded is based on fuel consumption of the engine over a period of time. Reduced hours of operation at full throttle and/or operating at reduced throttle settings result in a lower average power demand. Reduced hours of operation will increase the length of operating time before an engine overhaul is required.

Product Identification Information

i01940475

Engine Identification

Perkins engines are identified by a serial number. This number is shown on a serial number plate that is mounted on the left hand side of the engine block.

An example of an engine number is REU090001H.

RE ____________________Type of engine

U ______________Built in the United Kingdom

0900001 ____________Engine Serial Number

H __________________Year of Manufacture

Perkins dealers need these numbers in order to determine the components that were included with the engine. This permits accurate identification of replacement part numbers.

i01940474

Serial Number Plate

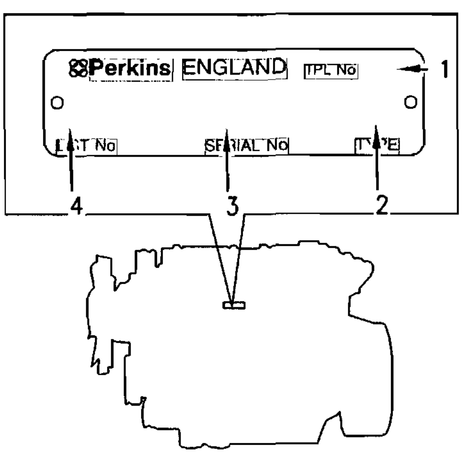

Illustration 12 g00994966

Typical serial number plate

(1) Temporary Parts List number
(2) Type
(3) Serial number
(4) List number

The Serial Number Plate is located on the left side of the cylinder block behind the high pressure pipes of the Fuel injection pump.

The following information is stamped on the Serial Number Plate: Engine serial number, Model, and Arrangement number.

i02164876

Reference Numbers

Information for the following items may be needed to order parts. Locate the information for your engine. Record the information in the appropriate space. Make a copy of this list for a record. Keep the information for future reference.

Record for Reference

Engine Model __________________

Engine Serial number ______________

Engine Low Idle rpm ______________

Engine Full Load rpm ______________

Primary Fuel Filter ______________

Water Separator Element ____________

Secondary Fuel Filter Element __________

Lubrication Oil Filter Element __________

Auxiliary Oil Filter Element __________

Total Lubrication System Capacity ________

Total Cooling System Capacity ________

Air Cleaner Element ____________

Fan Drive Belt ______________

Alternator Belt ______________

i0219795

Emissions Certification Film

Label for compliant engines

Examples of emissions labels

IMPORTANT ENGINE INFORMATION	Perkins
Engine Family: 3PKXL04.0AJ1 List: AP31478 Engine Type: 5633/2200 Displacement: 3.990	E 11 Refer to Manufacturer
Advertised kw:50. 0 @ RPM: 2200 Fuel Rate at adv kw: 56.0 mm3/stk Init. Timing:3 DEG BTDC idle RPM: 1000	e11*97/68CA*00*000*0089*01
Settings are to be made with engine at normal operating temperature with transmission in neutral. This engine conforms to 2003 U.S. EPA non - road and California off - road Regulations for large C.I. engines and is certified to operate on commercially available diesel fuel.	
Emission Control System: DDI | Valve Lash Cold (inch): Exhaust 0.018 Inlet 0.008	Engine Label
Hanger No. position	Label No. 3181A081

Illustration 13 g01127835

This label is installed on engines that comply with emissions.

Label for engines that are not compliant

EMISSIONS CONTROL INFORMATION	Perkins
ENGINE FAMILY: Text2 ENGINE DISPLACEMENT: 6. 0	MODEL YEAR: 2003
INFORMATION APPLICABLE TO USA ONLY This non - road engine does not comply with either federal non - road or California off - road engine emission regulation requirements. Sale or installation of this engine is a violation of federal and Californian law subject to civil penalty for any purpose other than as an EXPORT - ONLY or REPLACEMENT engine Export - only engine is indicated by an additional attached tag Replacement engine is for an engine manufactured prior to 1 Jan 2004	
	Label No. 3181A081

Illustration 14 g01119323

This label is installed on engines that have a variable speed. These engines do not comply with emissions.

EMISSIONS CONTROL INFORMATION Perkins

ENGINE FAMILY: 1104C - 44TA
ENGINE DISPLACEMENT: 4. 400

MODEL YEAR: 2003

FOLLOWING INFORMATION APPLICABLE TO USA ONLY
This non - road engine does not comply with either federal non - road
or California off - road engine emission regulation requirement.
Sale or installation of this engine can only be for
STATIONARY ENGINE
Use only as defined by CFR 40 PART 89.2.

Hanger No	Position (81)	Label 318A081

Illustration 15 g01119325

This label is installed on engines that have a fixed speed. These engines do not comply with emissions.

Operation Section

Lifting and Storage

i02164186

Engine Lifting

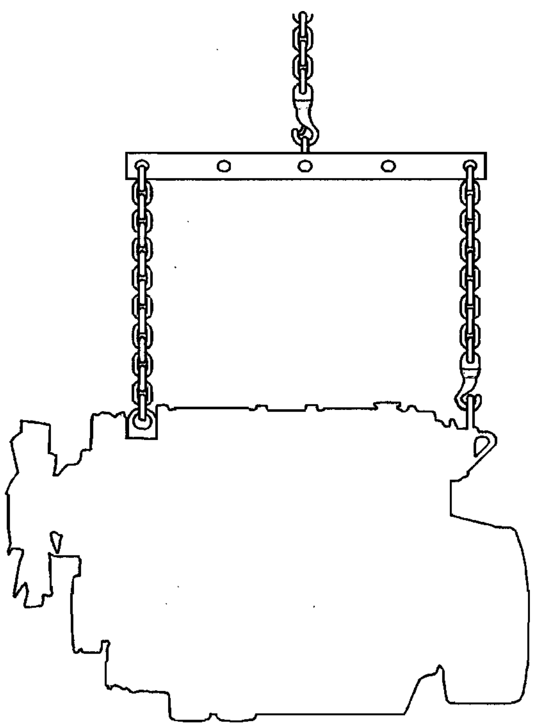

Illustration 16 g01097527

NOTICE
Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

When it is necessary to remove a component at an angle, only use a link bracket that is properly rated for the weight.

Use a hoist to remove heavy components. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other. The chains and cables should be perpendicular to the top of the object that is being lifted.

Some removals require lifting the fixtures in order to obtain correct balance and safety.

To remove the engine ONLY, use the lifting eyes that are on the engine.

Lifting eyes are designed and installed for specific engine arrangements. Alterations to the lifting eyes and/or the engine make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that correct lifting devices are provided. Consult your Perkins dealer or your Perkins distributor for information regarding fixtures for correct engine lifting.

i01930351

Engine Storage

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder walls. Rust on the cylinder walls will cause increased engine wear and a reduction in engine service life.

Lubrication System

To help prevent excessive engine wear, use the following guidelines:

Complete all of the lubrication recommendations that are listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

If an engine is out of operation and if use of the engine is not planned, special precautions should be made. If the engine will be stored for more than one month, a complete protection procedure is recommended.

Use the following guidelines :

- *Completely clean the outside of the engine.*
- Drain the fuel system completely and refill the system with preservative fuel. 1772204 POWERPART Lay-Up 1 can be mixed with the normal fuel in order to change the fuel into preservative fuel.
- If preservative fuel is not available, the fuel system can be filled with normal fuel. This fuel must be discarded at the end of the storage period together with the fuel filter elements.
- Operate the engine until the engine reaches normal operating temperature. Stop any leaks from fuel, lubricating oil or air systems. Stop the engine and drain the lubricating oil from the oil pan.

- Renew the canister(s) of the lubricating oil filter.

- Fill the oil pan to the Full Mark on the dipstick with new, clean lubricating oil. Add 1762811 POWERPART Lay-Up 2 to the oil in order to protect the engine against corrosion. If 1762811 POWERPART Lay-Up 2 is not available, use a preservative of the correct specification instead of the lubricating oil. If a preservative is used, this must be drained completely at the end of the storage period and the oil pan must be refilled to the correct level with normal lubricating oil.

Cooling System

To help prevent excessive engine wear, use the following guidelines:

NOTICE
Do not drain the coolant while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.

If freezing temperatures are expected, check the cooling system for adequate protection against freezing. See this Operation and Maintenance Manual, "General Coolant Information" (Maintenance Section).

NOTICE
To prevent frost damage, ensure that all the coolant is removed from the engine. This is important if the system is drained after it has been flushed with water, or if an antifreeze solution too weak to protect the system from frost has been used.

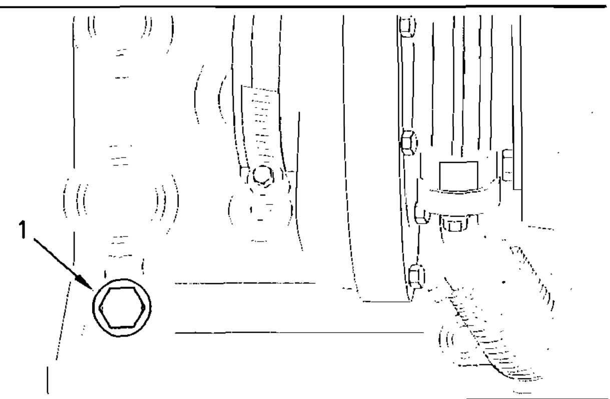

Illustration 17 g01003928

1. Ensure that the vehicle is on level ground.

2. Remove the filler cap of the cooling system.

3. Remove the drain plug (1) from the side of the cylinder block in order to drain the engine. Ensure that the drain hole is not restricted.

4. Open the tap or remove the drain plug at the bottom of the radiator in order to drain the radiator. If the radiator does not have a tap or a drain plug, disconnect the hose at the bottom of the radiator.

5. Flush the cooling system with clean water.

6. Fit the drain plugs and the filler cap. Close the tap or connect the radiator hose.

7. Fill the cooling system with an approved antifreeze mixture because this gives protection against corrosion. The maximum flow rate is 1 L (0.2200 Imp gal) per minute in order to fill the system.

Note: Certain corrosion inhibitors could cause damage to some engine components. Contact the Service Department of Perkins for advice.

8. Operate the engine for a short period in order to circulate the lubricating oil and the coolant in the engine.

9. Disconnect the battery. Put the battery into safe storage in a fully charged condition. Before the battery is put into storage, protect the terminals against corrosion.1734115 POWERPART Lay-Up 3 can be used on the terminals.

10. Clean the crankcase breather if one is installed. Seal the end of the pipe.

11. Remove the fuel injector nozzles and spray 1762811 POWERPART Lay-Up 2 for one or two seconds into each cylinder bore with the piston at BDC.

12. Slowly rotate the crankshaft for one complete revolution and then replace the fuel injector nozzles.

Induction System

- Remove the air filter assembly. If necessary, remove the pipes that are installed between the air filter assembly and the turbocharger. Spray 1762811 POWERPART Lay-Up 2 into the turbocharger. The duration of the spray is printed on the container. Seal the turbocharger with waterproof tape.

Exhaust System

- Remove the exhaust pipe. Spray 1762811 POWERPART Lay-Up 2 into the turbocharger. The duration of the spray is printed on the container. Seal the turbocharger with waterproof tape.

General Items

- If the lubricating oil filler is installed on the rocker cover, remove the filler cap. If the lubricating oil filler cap is not installed on the rocker cover, remove the rocker cover. Spray 1762811 POWERPART Lay-Up 2 around the rocker shaft assembly. Replace the filler cap or the rocker cover.

- Seal the vent of the fuel tank or the fuel filler cap with waterproof tape.

- Remove the alternator drive belts and put the drive belts into storage.

- In order to prevent corrosion, spray the engine with 1734115 POWERPART Lay-Up 3. Do not spray the area inside the alternator.

When the engine protection has been completed in accordance with these instructions, this ensures that no corrosion will occur. Perkins are not responsible for damage which may occur when an engine is in storage after a period in service.

Your Perkins dealer or your Perkins distributor can assist in preparing the engine for extended storage periods.

Gauges and Indicators

i02164190

Gauges and Indicators

Your engine may not have the same gauges or all of the gauges that are described. For more information about the gauge package, see the OEM information.

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings. Consult your Perkins dealer or your Perkins distributor for assistance.

NOTICE
If no oil pressure is indicated, STOP the engine. If maximum coolant temperature is exceeded, STOP the engine. Engine damage can result.

Engine Oil Pressure – The oil pressure should be greatest after a cold engine is started. The typical engine oil pressure with SAE10W30 is 207 to 413 kPa (30 to 60 psi) at rated rpm.

A lower oil pressure is normal at low idle. If the load is stable and the gauge reading changes, perform the following procedure:

1. Remove the load.

2. Reduce engine speed to low idle.

3. Check and maintain the oil level.

Jacket Water Coolant Temperature – Typical temperature range is 71 to 96°C (160 to 205°F). The maximum allowable temperature with the pressurized cooling system at 48 kPa (7 psi) is 110°C (230°F). Higher temperatures may occur under certain conditions. The water temperature reading may vary according to load. The reading should never exceed the boiling point for the pressurized system that is being used.

If the engine is operating above the normal range and steam becomes apparent, perform the following procedure:

1. Reduce the load and the engine rpm.

2. Inspect the cooling system for leaks.

3. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load.

Tachometer – This gauge indicates engine speed (rpm). When the throttle control lever is moved to the full throttle position without load, the engine is running at high idle. The engine is running at the full load rpm when the throttle control lever is at the full throttle position with maximum rated load.

NOTICE
To help prevent engine damage, never exceed the high idle rpm. Overspeeding can result in serious damage to the engine. The engine can be operated at high idle without damage, but should never be allowed to exceed high idle rpm.

Ammeter – This gauge indicates the amount of charge or discharge in the battery charging circuit. Operation of the indicator should be to the right side of "0" (zero).

Fuel Level – This gauge indicates the fuel level in the fuel tank. The fuel level gauge operates when the "START/STOP" switch is in the "ON" position.

Service Hour Meter – The gauge indicates operating time of the engine.

Engine Starting

i02194223

Before Starting Engine

Before the engine is started, perform the required daily maintenance and any other periodic maintenance that is due. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information.

- For the maximum service life of the engine, make a thorough inspection within the engine compartment before the engine is started. Look for the following items: oil leaks, coolant leaks, loose bolts, and excessive dirt and/or grease. Remove any excess dirt and/or grease buildup. Repair any faults that were identified during the inspection.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the alternator and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn wires or frayed wires.
- Check the fuel supply. Drain water from the water separator (if equipped). Open the fuel supply valve (if equipped).

NOTICE

All valves in the fuel return line must be open before and during engine operation to help prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage.

If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air pockets will be trapped in the engine. In these instances, prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" for more information on priming the fuel system.

WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

- Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" warning tag or similar warning tag attached to the start switch or to the controls.
- Ensure that the areas around the rotating parts are clear.
- All of the guards must be put in place. Check for damaged guards or for missing guards. Repair any damaged guards. Replace damaged guards and/or missing guards.
- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor is engaged. Check electrical cables and check the battery for poor connections and for corrosion.
- Reset all of the shutoffs or alarm components (if equipped).
- Check the engine lubrication oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the engine oil level gauge.
- Check the coolant level. Observe the coolant level in the header tank (if equipped). Maintain the coolant level to the "FULL" mark on the header tank.
- If the engine is not equipped with a header tank maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level in the sight glass.
- Observe the air cleaner service indicator (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.
- Ensure that any equipment that is driven by the engine has been disengaged from the engine. Minimize electrical loads or remove any electrical loads.

i02198348

Starting the Engine

⚠ WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

Refer to the OMM for your type of controls. Use the following procedure to start the engine.

1. If equipped, move the throttle lever to the full throttle position before you start the engine.

NOTICE
Do not crank the engine for more than 30 seconds. Allow the electric starting motor to cool for two minutes before cranking the engine again.

2. Turn the engine start switch to the START position. Hold the engine start switch in the START position and crank the engine.
3. When the engine starts, release the engine start switch.
4. If equipped, slowly move the throttle lever to the low idle position and allow the engine to idle. Refer to the Operation and Maintenance Manual, "After Starting Engine" topic.
5. If the engine does not start, release the engine start switch and allow the electric starting motor to cool. Then, repeat steps 2 through step 4.
6. Turn the engine start switch to the OFF position in order to stop the engine.

i02198092

Cold Weather Starting

⚠ WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

Startability will be improved at temperatures below −18 °C (0 °F) from the use of a jacket water heater or extra battery capacity.

When Group 2 diesel fuel is used, the following items provide a means of minimizing starting problems and fuel problems in cold weather: engine oil pan heaters, jacket water heaters, fuel heaters, and fuel line insulation.

Use the procedure that follows for cold weather starting.

1. If equipped, move the throttle lever to the full throttle position before you start the engine.
2. If equipped, turn the engine start switch to the HEAT position. Hold the engine start switch in the HEAT position for 6 seconds until the glow plug indicator light illuminates. This will activate the glow plugs and aid in the starting of the engine.

NOTICE
Do not crank the engine for more than 30 seconds. Allow the electric starting motor to cool for two minutes before cranking the engine again.

3. While the glow plug indicator light is illuminated, turn the engine start switch to the START position and crank the engine.

Note: If the glow plug indicator light illuminates rapidly for 2 to 3 seconds, or if the glow plug indicator light fails to illuminate, a malfunction exists in the cold start system. Do not use ether or other starting fluids to start the engine.

4. When the engine starts, release the engine start switch key.
5. If the engine does not start, release the engine start switch and allow the starter motor to cool. Then, repeat steps 2 through step 4.
6. If the engine is equipped with a throttle allow the engine to idle for three to five minutes, or allow the engine to idle until the water temperature indicator begins to rise. The engine should run at low idle smoothly until speed is gradually increased to high idle. Allow the white smoke to disperse before proceeding with normal operation.
7. Operate the engine at low load until all systems reach operating temperature. Check the gauges during the warm-up period.
8. Turn the engine start switch to the OFF position in order to stop the engine.

i02177935

Starting with Jump Start Cables

WARNING

Improper jump start cable connections can cause an explosion resulting in personal injury.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jump start cable ends to contact each other or the engine.

Note: If it is possible, first diagnose the reason for the starting failure. Make any necessary repairs. If the engine will not start only due to the condition of the battery, either charge the battery, or start the engine with jump start cables. The condition of the battery can be rechecked after the engine has been switched OFF.

NOTICE

Using a battery source with the same voltage as the electric starting motor. Use ONLY equal voltage for jump starting. The use of higher voltage will damage the electrical system.

Do not reverse the battery cables. The alternator can be damaged. Attach ground cable last and remove first.

When using an external electrical source to start the engine, turn the engine control switch to the "OFF" position. Turn all electrical accessories OFF before attaching the jump start cables.

Ensure that the main power switch is in the OFF position before attaching the jump start cables to the engine being started.

1. Turn the start switch to the OFF position. Turn off all the engine's accessories.
2. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.
3. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting the combustible gases that are produced by some batteries.
4. Start the engine.
5. Immediately after the stalled engine is started, disconnect the jump start cables in reverse order.

After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be replaced or charged to the correct voltage with a battery charger after the engine is stopped. Many batteries which are considered unusable are still rechargeable. Refer to Operation and Maintenance Manual, "Battery - Replace" and Testing and Adjusting Manual, "Battery - Test".

i01903609

After Starting Engine

Note: In temperatures from 0 to 60°C (32 to 140°F), the warm-up time is approximately three minutes. In temperatures below 0°C (32°F), additional warm-up time may be required.

When the engine idles during warm-up, observe the following conditions:

- Check for any fluid or for any air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under load. This is not possible in some applications.
- Operate the engine at low idle until all systems achieve operating temperatures. Check all gauges during the warm-up period.

Note: Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

Engine Operation

i02176671

Engine Operation

Correct operation and maintenance are key factors in obtaining the maximum life and economy of the engine. If the directions in the Operation and Maintenance Manual are followed, costs can be minimized and engine service life can be maximized.

The engine can be operated at the rated rpm after the engine reaches operating temperature. The engine will reach normal operating temperature sooner during a low engine speed (rpm) and during a low power demand. This procedure is more effective than idling the engine at no load. The engine should reach operating temperature in a few minutes.

Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

i01929404

Engine Warm-up

1. Run the engine at low idle for three to five minutes, or run the engine at low idle until the jacket water temperature starts to rise.

   More time may be necessary when the temperature is below −18°C (0°F).

2. Check all of the gauges during the warm-up period.

3. Perform a walk-around inspection. Check the engine for fluid leaks and air leaks.

4. Increase the rpm to the rated rpm. Check for fluid leaks and air leaks. The engine may be operated at full rated rpm and at full load when the temperature of the water jacket reaches 60°C (140°F).

i021642

Fuel Conservation Practices

The efficiency of the engine can affect the fuel economy. Perkins design and technology in manufacturing provides maximum fuel efficiency in all applications. Follow the recommended procedures in order to attain optimum performance for the life of the engine.

- Avoid spilling fuel.

Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.

- Be aware of the properties of the different fuels. Use only the recommended fuels.

- Avoid unnecessary idling.

Shut off the engine rather than idle for long periods of time.

- Observe the service indicator frequently. Keep the air cleaner elements clean.

- Maintain a good electrical system.

One damaged battery cell will overwork the alternator. This will consume excess power and excess fuel.

- Ensure that the drive belts are correctly adjusted. The drive belts should be in good condition.

- Ensure that all of the connections of the hoses are tight. The connections should not leak.

- Ensure that the driven equipment is in good working order.

- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

Engine Stopping

i01929389

Stopping the Engine

NOTICE
Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of the engine components.

If the engine has been operating at high rpm and/or high loads, run at low idle for at least three minutes to reduce and stabilize internal engine temperature before stopping the engine.

Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

Prior to stopping an engine that is being operated at low loads, operate the engine at low idle for 30 seconds before stopping. If the engine has been operating at highway speeds and/or at high loads, operate the engine at low idle for at least three minutes. This procedure will cause the internal engine temperature to be reduced and stabilized.

Ensure that the engine stopping procedure is understood. Stop the engine according to the shutoff system on the engine or refer to the instructions that are provided by the OEM.

- To stop the engine, turn the ignition key switch to the OFF position.

i01903586

Emergency Stopping

NOTICE
Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use emergency shutoff devices or controls for normal stopping procedure.

The OEM may have equipped the application with an emergency stop button. For more information about the emergency stop button, refer to the OEM information.

Ensure that any components for the external system that support the engine operation are secured after the engine is stopped.

i01903608

After Stopping Engine

Note: Before you check the engine oil, do not operate the engine for at least 10 minutes in order to allow the engine oil to return to the oil pan.

- Check the crankcase oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the oil level dipstick.
- If necessary, perform minor adjustments. Repair any leaks and tighten any loose bolts.
- Note the required service interval. Perform the maintenance that is in the Operation and Maintenance Manual, "Maintenance Interval Schedule".
- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

NOTICE
Only use antifreeze/coolant mixtures recommended in the Coolant Specifications that are in the Operation and Maintenance Manual. Failure to do so can cause engine damage.

- Allow the engine to cool. Check the coolant level.
- If freezing temperatures are expected, check the coolant for the correct antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the correct coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. This maintenance is outlined in the instructions from the OEM.

Cold Weather Operation

i02200467

Cold Weather Operation

Perkins Diesel Engines can operate effectively in cold weather. During cold weather, the starting and the operation of the diesel engine is dependent on the following items:

- The type of fuel that is used
- The viscosity of the engine oil
- The operation of the glow plugs or the operation of the air inlet heater
- Optional Cold starting aid

The purpose of this section will cover the following information:

- Explain potential problems that are caused by cold weather operation.
- Suggest steps which can be taken in order to minimize starting problems and operating problems when the ambient air temperature is colder than 0 to −55 °C (32 to −67 °F).

The operation and maintenance of an engine in freezing temperatures is complex. This is because of the following conditions: the unlimited differences in weather conditions, engine applications, and the supplies that are available in your area. These factors and recommendations from your Perkins dealer or your Perkins distributor are based on past proven practices. The information that is contained in this section should be combined in order to provide guidelines for cold weather operations.

Hints for Cold Weather Operation

- If the engine will start, operate the engine until a minimum operating temperature of 71 °C (160 °F) is achieved. Achieving operating temperature will help prevent the intake valves and exhaust valves from sticking.
- The cooling system and the lubrication system for the engine do not lose heat immediately upon shutdown. This means that an engine can be shut down for a few hours and the engine can still have the ability to start readily. If the engine is shut down for at least eight hours, the engine should be considered cooled to outside temperature.
- Install the correct lubricant in each compartment before the beginning of cold weather.
- Check all rubber parts (hoses, fan drive belts, etc) weekly.
- Check all electrical wiring and connections for any fraying or damaged insulation.
- Keep all batteries fully charged and warm.
- Fill the fuel tank at the end of each shift.
- Check the air cleaners and the air intake daily. Check the air intake more often when you operate in snow.

⚠ WARNING

Personal injury or property damage can resu from alcohol or starting fluids.

Alcohol or starting fluids are highly flammable an toxic and if improperly stored could result in inju or property damage.

⚠ WARNING

Do not use aerosol types of starting aids such a ether. Such use could result in an explosion an personal injury.

- For jump starting with cables in cold weather, refer to the Operation and Maintenance Manual, "Starting with Jump Start Cables." for instructions.

Viscosity of the Engine Lubricatio Oil

Correct engine oil viscosity is essential. Oil viscosity affects the amount of torque that is needed to crank the engine. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended viscosity of oil.

Recommendations for the Coolant

Provide cooling system protection for the lowest expected outside temperature. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended coolant mixture.

In cold weather, check the coolant often for the correct glycol concentration in order to ensure adequate freeze protection.

Engine Block Heaters

Engine block heaters (if equipped) heat the engine jacket water that surrounds the combustion chambers. This provides the following functions:

- Startability is improved.
- Warm up time is reduced.

An electric block heater can be activated once the engine is stopped. An effective block heater is typically a 1250/1500 W unit. Consult your Perkins dealer or your Perkins distributor for more information.

Idling the Engine

When idling after the engine is started in cold weather, increase the engine rpm from 1000 to 1200 rpm. This will warm up the engine more quickly. Maintaining an elevated low idle speed for extended periods will be easier with the installation of a hand throttle. The engine should not be "raced" in order to speed up the warm up process.

While the engine is idling, the application of a light load (parasitic load) will assist in maintaining the minimum operating temperature. The minimum operating temperature is 71 °C (160 °F).

Recommendations for Coolant Warm Up

Warm up an engine that has cooled below normal operating temperatures due to inactivity. This should be performed before the engine is returned to full operation. During operation in very cold temperature conditions, damage to engine valve mechanisms can result from engine operation for short intervals. This can happen if the engine is started and the engine is stopped many times without being operated in order to warm up completely.

When the engine is operated below normal operating temperatures, fuel and oil are not completely burned in the combustion chamber. This fuel and oil causes soft carbon deposits to form on the valve stems. Generally, the deposits do not cause problems and the deposits are burned off during operation at normal engine operating temperatures.

When the engine is started and the engine is stopped many times without being operated in order to warm up completely, the carbon deposits become thicker. This will cause the following problems:

- Free operation of the valves is prevented.
- Valves become stuck.
- Pushrods are bent.
- Other damage to valve train components can result.

For this reason, when the engine is started, the engine must be operated until the coolant temperature is 71 °C (160 °F) minimum. Carbon deposits on the valve stems will be kept at a minimum and the free operation of the valves and the valve components will be maintained.

In addition, the engine must be thoroughly warmed in order to keep other engine parts in better condition and the service life of the engine will be generally extended. Lubrication will be improved. There will be less acid and less sludge in the oil. This will provide longer service life for the engine bearings, the piston rings, and other parts. However, limit unnecessary idle time to ten minutes in order to reduce wear and unnecessary fuel consumption.

Purge Valve and Insulated Heater Lines

The engine is equipped with a water temperature regulator in order to allow the engine to reach the correct operating temperature quickly. The water temperature regulator remains in the closed position until the jacket water coolant temperature has reached the engine's operating temperature. The jacket water circulates from the top of the cylinder block, to the water temperature regulator housing, and back to the bottom of the cylinder block via the bypass. The water temperature regulator allows some flow of water and/or air to pass through the water temperature regulator in order to ensure a continuous flow of coolant within the cylinder block. This is achieved via a small "jiggle" valve in the water temperature regulator. The water temperature regulator moves to the open position when the jacket water coolant temperature has reached the correct operating temperature. The water temperature regulator moves to the open position in order to allow the passage of the coolant through the radiator to dissipate excess heat.

The above procedure is good for normal engine operating conditions in temperate climates. During periods of operations in a cold climate with a light engine load, the coolant must bypass the radiator in order to help prevent excessive cooling of the engine. Coolant that passes through the radiator must be minimized in order to maintain the engine operating temperature in cold weather.

Excessive cooling of the engine can be prevented by a valve that allows unnecessary coolant flow to be diverted from the water temperature regulator and back to the bottom of the engine block without passing through the radiator.

Note: Perkins discourages the use of all airflow restriction devices such as radiator shutters. Restriction of the airflow can result in the following: high exhaust temperatures, power loss, excessive fan usage, and reduction in fuel economy.

Cab heater lines for very cold weather are also beneficial. These lines provide more available heat from the coolant to the cab. The feed from the engine and the return lines from the cab should be insulated in order to reduce heat loss to the outside air.

Insulating the Air Inlet and Engine Compartment

When temperatures below −18 °C (−0 °F) will be frequently encountered, an air cleaner inlet that is located in the engine compartment may be specified. An air cleaner that is located in the engine compartment may also minimize the entry of snow into the air cleaner. Also, heat that is rejected by the engine helps to warm the intake air.

Additional heat can be retained around the engine by insulating the engine compartment.

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Fuel and the Effect from Cold Weather

Note: Only use grades of fuel that are recommended by Perkins. Refer to this Operation and Maintenance Manual, "Fluid Recommendations".

The following fuels can be used in this series of engine.

- Group 1
- Group 2
- Group 3
- Special Fuels

Perkins prefer only Group 1 and Group 2 fuels for use in this series of engines. Group 3 fuels include Low Temperature Fuels and Aviation Kerosene Fuels.

Note: Group 3 fuels reduce the life of the engine. The use of Group 3 fuels is not covered by the Perkins warranty.

Special fuels include Biofuel.

Group 1 fuels are the preferred Group of Fuels for general use by Perkins. Group 1 fuels maximize engine life and engine performance. Group 1 fuels are usually less available than Group 2 fuels. Frequently, Group 1 fuels are not available in colder climates during the winter.

Note: Group 2 fuels must have a maximum wear scar of 650 micrometers (HFRR to ISO 12156-1).

Group 2 fuels are considered acceptable for issues of warranty. This group of fuels may reduce the life of the engine, the engine's maximum power, and the engine's fuel efficiency.

When Group 2 diesel fuels are used the following components provide a means of minimizing problems in cold weather:

- Glow plugs (if equipped)
- Engine coolant heaters, which may be an OEM option
- Fuel heaters, which may be an OEM option
- Fuel line insulation, which may be an OEM option

There are three major differences between Group 1 fuels and Group 2 fuels. Group 1 fuels have the following different characteristics to Group 2 fuels.

- A lower cloud point
- A lower pour point
- A higher rating of kJ (BTU) per unit volume of fuel

The cloud point is the temperature when a cloud of wax crystals begins to form in the fuel. These crystals can cause the fuel filters to plug. The pour point is the temperature when diesel fuel will thicken. The diesel fuel becomes more resistant to flow through fuel pumps and through the fuel lines.

Be aware of these values when diesel fuel is purchased. Consider the average ambient air temperature for the engine's application. Engines that are fueled in one climate may not operate well if the engines are moved to another climate. Problems can result due to changes in temperature.

Before troubleshooting for low power or for poor performance in the winter, check the type of fuel that is being used.

Low temperature fuels may be available for engine operation at temperatures below 0 °C (32 °F). These fuels limit the formation of wax in the fuel at low temperatures. Wax in the fuel may prevent the flow of the fuel through the fuel filters.

For more information on cold weather operation, refer to the Operation and Maintenance Manual, "Cold Weather Operation and Fuel Related Components in Cold Weather".

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Fuel Related Components in Cold Weather

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off the fuel tanks after you operate the engine.

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Drain the water and sediment from any fuel storage tank at the following intervals: weekly, oil changes, and refueling of the fuel tank. This will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

Fuel Filters

It is possible that a primary fuel filter is installed between the fuel tank and the engine fuel inlet. After you change the fuel filter, always prime the fuel system in order to remove air bubbles from the fuel system. Refer to the Operation and Maintenance Manual in the Maintenance Section for more information on priming the fuel system.

The micron rating and the location of a primary fuel filter is important in cold weather operation. The primary fuel filter and the fuel supply line are the most common components that are affected by cold fuel.

Fuel Heaters

Note: The OEM may equip the application with fuel heaters. If this is the case, disconnect an electric type of fuel heater in warm weather in order to prevent overheating of the fuel. If the type of fuel heater is a heat exchanger, the OEM should have included a bypass for warm weather. Ensure that the bypass is operational during warm weather in order to prevent overheating of the fuel.

For more information about fuel heaters (if equipped), refer to the OEM information.

Maintenance Section

Refill Capacities

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Refill Capacities

Lubrication System

The refill capacities for the engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter. Refer to the Operation and Maintenance Manual, "Maintenance Section" for more information on Lubricant Specifications.

1104 Engine

Table 5

1104 Engine		
Compartment or System	**Liters**	**Quarts**
Standard Oil Sump for the Engine Crankcase (1)	6.5	7

(1) These values are the approximate capacities for the crankcase oil sump which include the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.

1103 Engine

Table 6

1103 Engine		
Compartment or System	**Liters**	**Quarts**
Standard Oil Sump for the Engine Crankcase (1)	6.5	7

(1) These values are the approximate capacities for the crankcase oil sump which include the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.

Cooling System

To maintain the cooling system, the Total Cooling System capacity must be known. The approximate capacity for the engine cooling system is listed below. External System capacities will vary among applications. Refer to the OEM specifications for the External System capacity. This capacity information will be needed in order to determine the amount of coolant/antifreeze that is required for the Total Cooling System.

1104 Engine

Table 7

1104 Naturally Aspirated Engine		
Compartment or System	**Liters**	**Quarts**
Engine Only	10.4	11
External cooling system capacity (OEM recommendation) (1)		
Total Cooling System (2)		

(1) The external cooling system includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler, and piping. Refer to the OEM specifications. Enter the value for the external system capacity in this row.

(2) The Total Cooling System includes the capacity for the engine cooling system plus the capacity for the external cooling system. Enter the total in this row.

Table 8

1104 Turbocharged Engine		
Compartment or System	**Liters**	**Quarts**
Engine Only	11.4	12
External cooling System capacity (OEM recommendation) (1)		
Total Cooling System (2)		

(1) The external cooling system includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler, and piping. Refer to the OEM specifications. Enter the value for the external cooling system capacity in this row.

(2) The Total Cooling System includes the capacity for the engine cooling system plus the capacity for the external cooling system. Enter the total in this row.

1103 Engine

Table 9

1103 Naturally Aspirated Engine without an oil cooler		
Compartment or System	**Liters**	**Quarts**
Engine Only	4.21	4
External cooling system capacity (OEM recommendation) (1)		
Total Cooling System (2)		

(1) The external cooling system includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler, and piping. Refer to the OEM specifications. Enter the value for the external system capacity in this row.
(2) The Total Cooling System includes the capacity for the engine cooling system plus the capacity for the external cooling system. Enter the total in this row.

Table 10

1103 Naturally Aspirated Engines and Turbocharged Engines with an oil cooler		
Compartment or System	**Liters**	**Quarts**
Engine Only	4.43	4.02
External cooling system capacity (OEM recommendation) (1)		
Total Cooling System (2)		

(1) The external cooling system includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler, and piping. Refer to the OEM specifications. Enter the value for the external system capacity in this row.
(2) The Total Cooling System includes the capacity for the engine cooling system plus the capacity for the external cooling system. Enter the total in this row.

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Fluid Recommendations

General Lubricant Information

Because of government regulations regarding the certification of exhaust emissions from the engine, the lubricant recommendations must be followed.

Engine Manufacturers Association (EMA) Oils

The "Engine Manufacturers Association Recommended Guideline on Diesel Engine Oil" is recognized by Perkins. For detailed information about this guideline, see the latest edition of EMA publication, "EMA DHD -1".

API Oils

The Engine Oil Licensing and Certification System by the American Petroleum Institute (API) is recognized by Perkins. For detailed information about this system, see the latest edition of the "API publication No. 1509". Engine oils that bear the API symbol are authorized by API.

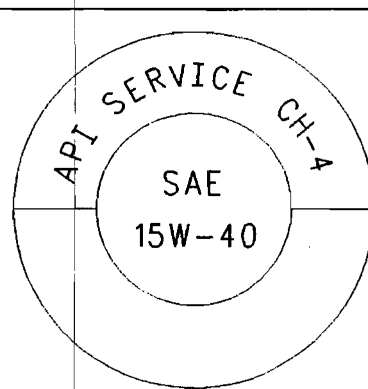

Illustration 18 g00546535

Typical API symbol

Diesel engine oils CC, CD, CD-2, and CE have not been API authorized classifications since 1 January 1996. Table 11 summarizes the status of the classifications.

Table 11

API Classifications	
Current	**Obsolete**
CF-4, CG-4, CH-4	CE
CF	CC, CD
CF-2(1)	CD-2(1)

(1) The classifications CD-2 and American Petroleum Institute CF-2 are for two-cycle diesel engines. Perkins does not sell engines that utilize CD-2 and API CF-2 oils.

Terminology

Certain abbreviations follow the nomenclature of "SAE J754". Some classifications follow "SAE J183" abbreviations, and some classifications follow the "EMA Recommended Guideline on Diesel Engine Oil". In addition to Perkins definitions, there are other definitions that will be of assistance in purchasing lubricants. Recommended oil viscosities can be found in this publication, "Fluid Recommendations/Engine Oil" topic (Maintenance Section).

Engine Oil

Commercial Oils

The performance of commercial diesel engine oils is based on American Petroleum Institute (API) classifications. These API classifications are developed in order to provide commercial lubricants for a broad range of diesel engines that operate at various conditions.

Only use commercial oils that meet the following classifications:

- EMA DHD-1 multigrade oil (preferred oil)
- API CH-4 multigrade oil (preferred oil)
- ACEAE3

In order to make the correct choice of a commercial oil, refer to the following explanations:

EMA DHD-1 – The Engine Manufacturers Association (EMA) has developed lubricant recommendations as an alternative to the API oil classification system. DHD-1 is a Recommended Guideline that defines a level of oil performance for these types of diesel engines: high speed, four stroke cycle, heavy-duty, and light duty. DHD-1 oils may be used in Perkins engines when the following oils are recommended: API CH-4, API CG-4, and API CF-4. DHD-1 oils are intended to provide superior performance in comparison to API CG-4 and API CF-4.

DHD-1 oils will meet the needs of high performance Perkins diesel engines that are operating in many applications. The tests and the test limits that are used to define DHD-1 are similar to the new API CH-4 classification. Therefore, these oils will also meet the requirements for diesel engines that require low emissions. DHD-1 oils are designed to control the harmful effects of soot with improved wear resistance and improved resistance to plugging of the oil filter. These oils will also provide superior piston deposit control for engines with either two-piece steel pistons or aluminum pistons.

All DHD-1 oils must complete a full test program with the base stock and with the viscosity grade of the finished commercial oil. The use of "API Base Oil Interchange Guidelines" are not appropriate for DHD-1 oils. This feature reduces the variation in performance that can occur when base stocks are changed in commercial oil formulations.

DHD-1 oils are recommended for use in extended oil change interval programs that optimize the life of the oil. These oil change interval programs are based on oil analysis. DHD-1 oils are recommended for conditions that demand a premium oil. Your Perkins dealer or your Perkins distributor has the specific guidelines for optimizing oil change intervals.

API CH-4 – API CH-4 oils were developed in order to meet the requirements of the new high performance diesel engines. Also, the oil was designed to meet the requirements of the low emissions diesel engines. API CH-4 oils are also acceptable for use in older diesel engines and in diesel engines that use high sulfur diesel fuel. API CH-4 oils may be used in Perkins engines that use API CG-4 and API CF-4 oils. API CH-4 oils will generally exceed the performance of API CG-4 oils in the following criteria: deposits on pistons, control of oil consumption, wear of piston rings, valve train wear, viscosity control, and corrosion.

Three new engine tests were developed for the API CH-4 oil. The first test specifically evaluates deposits on pistons for engines with the two-piece steel piston. This test (piston deposit) also measures the control of oil consumption. A second test is conducted with moderate oil soot. The second test measures the following criteria: wear of piston rings, wear of cylinder liners, and resistance to corrosion. A third new test measures the following characteristics with high levels of soot in the oil: wear of the valve train, resistance of the oil in plugging the oil filter, and control of sludge.

In addition to the new tests, API CH-4 oils have tougher limits for viscosity control in applications that generate high soot. The oils also have improved oxidation resistance. API CH-4 oils must pass an additional test (piston deposit) for engines that use aluminum pistons (single piece). Oil performance is also established for engines that operate in areas with high sulfur diesel fuel.

All of these improvements allow the API CH-4 oil to achieve optimum oil change intervals. API CH-4 oils are recommended for use in extended oil change intervals. API CH-4 oils are recommended for conditions that demand a premium oil. Your Perkins dealer or your Perkins distributor has specific guidelines for optimizing oil change intervals.

Some commercial oils that meet the API classifications may require reduced oil change intervals. To determine the oil change interval, closely monitor the condition of the oil and perform a wear metal analysis.

NOTICE
Failure to follow these oil recommendations can cause shortened engine service life due to deposits and/or excessive wear.

Total Base Number (TBN) and Fuel Sulfur Levels for Direct Injection (DI) Diesel Engines

The Total Base Number (TBN) for an oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the minimum TBN of the new oil must be 10 times the fuel sulfur level. The TBN is defined by "ASTM D2896". The minimum TBN of the oil is 5 regardless of fuel sulfur level. Illustration 19 demonstrates the TBN.

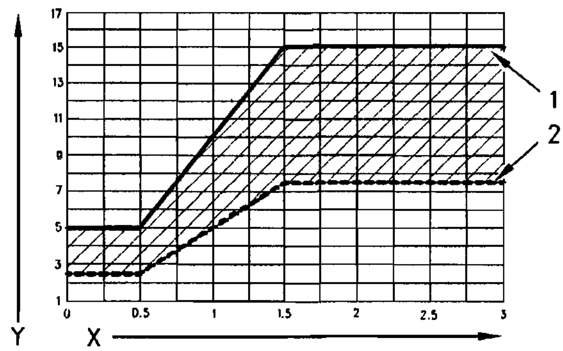

Illustration 19 g00799818

(Y) TBN by "ASTM D2896"
(X) Percentage of fuel sulfur by weight
(1) TBN of new oil
(2) Change the oil when the TBN deteriorates to 50 percent of the original TBN.

Use the following guidelines for fuel sulfur levels that exceed 1.5 percent:

- Choose an oil with the highest TBN that meets one of these classifications: EMA DHD-1 and API CH-4.
- Reduce the oil change interval. Base the oil change interval on the oil analysis. Ensure that the oil analysis includes the condition of the oil and a wear metal analysis.

Excessive piston deposits can be produced by an oil with a high TBN. These deposits can lead to a loss of control of the oil consumption and to the polishing of the cylinder bore.

NOTICE
Operating Direct Injection (DI) diesel engines with fuel sulphur levels over 0.5 percent will require shortened oil change intervals in order to help maintain adequate wear protection.

Table 12

Percentage of Sulfur in the fuel	Oil change interval
Lower than 0.5	Normal
0.5 to 1.0	0.75 of normal
Greater than 1.0	0.50 of normal

Lubricant Viscosity Recommendations for Direct Injection (DI) Diesel Engines

The correct SAE viscosity grade of oil is determined by the minimum ambient temperature during cold engine start-up, and the maximum ambient temperature during engine operation.

Refer to Table 13 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 13 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

Table 13

Engine Oil Viscosity		
EMA LRG-1 API CH-4 Viscosity Grade	Ambient Temperature	
	Minimum	Maximum
SAE 0W20	−40 °C (−40 °F)	10 °C (50 °F)
SAE 0W30	−40 °C (−40 °F)	30 °C (86 °F)
SAE 0W40	−40 °C (−40 °F)	40 °C (104 °F)
SAE 5W30	−30 °C (−22 °F)	30 °C (86 °F)
SAE 5W40	−30 °C (−22 °F)	40 °C (104 °F)
SAE 10W30	−20 °C (−4 °F)	40 °C (104 °F)
SAE 15W40	−10 °C (14 °F)	50 °C (122 °F)

Synthetic Base Stock Oils

Synthetic base oils are acceptable for use in these engines if these oils meet the performance requirements that are specified for the engine.

Synthetic base oils generally perform better than conventional oils in the following two areas:

- Synthetic base oils have improved flow at low temperatures especially in arctic conditions.
- Synthetic base oils have improved oxidation stability especially at high operating temperatures.

Some synthetic base oils have performance characteristics that enhance the service life of the oil. Perkins does not recommend the automatic extending of the oil change intervals for any type of oil.

Re-refined Base Stock Oils

Re-refined base stock oils are acceptable for use in Perkins engines if these oils meet the performance requirements that are specified by Perkins. Re-refined base stock oils can be used exclusively in finished oil or in a combination with new base stock oils. The US military specifications and the specifications of other heavy equipment manufacturers also allow the use of re-refined base stock oils that meet the same criteria.

The process that is used to make re-refined base stock oil should adequately remove all wear metals that are in the used oil and all the additives that are in the used oil. The process that is used to make re-refined base stock oil generally involves the process of vacuum distillation and hydrotreating the used oil. Filtering is adequate for the production of high quality, re-refined base stock oil.

Lubricants for Cold Weather

When an engine is started and an engine is operated in ambient temperatures below −20 °C (−4 °F), use multigrade oils that are capable of flowing in low temperatures.

These oils have lubricant viscosity grades of SAE 0W or SAE 5W.

When an engine is started and operated in ambient temperatures below −30 °C (−22 °F), use a synthetic base stock multigrade oil with an 0W viscosity grade or with a 5W viscosity grade. Use an oil with a pour point that is lower than −50 °C (−58 °F).

The number of acceptable lubricants is limited in cold weather conditions. Perkins recommends the following lubricants for use in cold weather conditions:

First Choice – Use oil with an EMA DHD-1 Recommended Guideline. Use a CH-4 oil that has an API license. The oil should be either SAE 0W20, SAE 0W30, SAE 0W40, SAE 5W30, or SAE 5W40 lubricant viscosity grade.

Second Choice – Use an oil that has a CH-4 additive package. Although the oil has not been tested for the requirements of the API license, the oil must be either SAE 0W20, SAE 0W30, SAE 0W40, SAE 5W30, or SAE 5W40.

NOTICE

Shortened engine service life could result if second choice oils are used.

Aftermarket Oil Additives

Perkins does not recommend the use of aftermarket additives in oil. It is not necessary to use aftermarket additives in order to achieve the engine's maximum service life or rated performance. Fully formulated, finished oils consist of base oils and of commercial additive packages. These additive packages are blended into the base oils at precise percentages in order to help provide finished oils with performance characteristics that meet industry standards.

There are no industry standard tests that evaluate the performance or the compatibility of aftermarket additives in finished oil. Aftermarket additives may not be compatible with the finished oil's additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil. This could produce sludge in the crankcase. Perkins discourages the use of aftermarket additives in finished oils.

To achieve the best performance from a Perkins engine, conform to the following guidelines:

- Select the correct oil, or a commercial oil that meets the "EMA Recommended Guideline on Diesel Engine Oil" or the recommended API classification.
- See the appropriate "Lubricant Viscosities" table in order to find the correct oil viscosity grade for your engine.
- At the specified interval, service the engine. Use new oil and install a new oil filter.
- Perform maintenance at the intervals that are specified in the Operation and Maintenance Manual, "Maintenance Interval Schedule".

S·O·S Oil analysis

Some engines may be equipped with an oil sampling valve. If S·O·S oil analysis is required the oil sampling valve is used to obtain samples of the engine oil. The S·O·S oil analysis will complement the preventive maintenance program.

The S·O·S oil analysis is a diagnostic tool that is used to determine oil performance and component wear rates. Contamination can be identified and measured through the use of the S·O·S oil analysis. The S·O·S oil analysis includes the following tests:

- The Wear Rate Analysis monitors the wear of the engine's metals. The amount of wear metal and type of wear metal that is in the oil is analyzed. The increase in the rate of engine wear metal in the oil is as important as the quantity of engine wear metal in the oil.

- Tests are conducted in order to detect contamination of the oil by water, glycol or fuel.

- The Oil Condition Analysis determines the loss of the oil's lubricating properties. An infrared analysis is used to compare the properties of new oil to the properties of the used oil sample. This analysis allows technicians to determine the amount of deterioration of the oil during use. This analysis also allows technicians to verify the performance of the oil according to the specification during the entire oil change interval.

Fuel Specifications

Fuel Recommendations

To get the correct power and performance from the engine, use a fuel of the correct quality. The recommended fuel specification for Perkins engines is shown below:

- Cetane number________45 minimum
- Viscosity________2,0 to 4.5 cSt at 40 °C (104 °F)
- Density________0.835 to 0.855 Kg/liter
- Sulfur________0.2% of mass, maximum
- Distillation________85% at 350 °C (662 °F)
- Lubricity________460 micrometers maximum wear scar on "ISO 12156 - 1"

Cetane number

This indicates the properties of ignition of the fuel. Fuel with a low cetane number can be the root cause of problems during cold start. This will affect combustion.

Viscosity

This is the resistance to flow of a fluid. If this resistance is outside the limits, the engine and the engine starting performance in particular can be affected.

Sulfur

High sulfur content of the fuel is not normally found in Europe, North America or Australasia. This can cause engine wear. When only high sulfur fuels are available, it will be necessary that high alkaline lubricating oil is used in the engine or that the lubricating oil change interval is reduced.

Distillation

This is an indication of the mixture of different hydrocarbons in the fuel. A high ratio of light weight hydrocarbons can affect the characteristics of combustion.

Lubricity

This is the capability of the fuel to prevent pump wear.

Diesel engines have the ability to burn a wide variety of fuels. These fuels are divided into four general groups:

- Group 1 (preferred fuels)
- Group 2 (permissible fuels)
- Group 3 (aviation kerosene fuels)
- Other fuels

Group 1 (preferred fuels): Specification

"DERV to EN590"

Note: Only use Arctic fuels when the temperature is below 0 °C (32 °F). Do not use Arctic fuels when the ambient temperature is above 0 °C (32 °F). To ensure that the time period between cranking the engine and first fire is kept to a minimum, only use fuel of the correct viscosity and at the correct temperature.

Gas oil to "BS2869 Class A2"

"ASTM D975 - 91 Class 2D" This can only be used if the fuel has the correct specification of lubricity.

"JIS K2204 (1992) Grades 1,2,3 and Special Grade 3" This can only be used if the fuel has the correct specification of lubricity.

Note: If low sulfur or low sulfur aromatic fuels are used, then fuel additives can be used to increase lubricity.

Group 2 (permissible fuels): Specification

These fuel specifications are considered acceptable for issues of warranty. However,these fuels may reduce the life of the engine, the engine's maximum power and the engine's fuel efficiency.

"ASTM D975 - 91 Class 1D"

"JP7, Mil T38219"

"NATO F63"

NOTICE
These fuels should have a wear scar value of 650 micrometers maximum *HFRR to ISO 12156 - 1.*

Group 3 (aviation kerosene fuels): Specification

These fuels need additives to achieve lubricity of 650 micrometers wear scar and the reliability of the fuel injection pump will be reduced. The fuel injection pump is not covered by a warranty, even when the additives are included.

"JP5 MIL T5624 (Avcat FSII, NATO F44"

"JP8 T83133 (Avtur FSII, NATO F34"

"Jet A"

"Jet A1, NATO F35, XF63"

Low temperature fuels

Special fuels for use in cold weather may be available for engine operation at temperatures below 0 °C (32 °F). These fuels limit the formation of wax in the fuel oil at low temperatures. If wax forms in the fuel oil, this could stop the flow of fuel oil through the filter.

Note: These fuels that lack lubricity may cause the following problems:

- Low engine power
- Difficult starting in hot conditions or in cold conditions
- White smoke
- Deterioration of emissions and misfire at certain operating conditions

Biofuel: Specification

Biofuel: A 5% mix of RME to EN14214 in conventional fuel is permitted.

NOTICE
Water emulsion fuels: These fuels are not permitted

Refer to the following fuel specifications for North America.

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel or gas oil.

The permissible fuels are crude oils or blended fuels. Use of these fuels can result in higher maintenance costs and in reduced engine service life.

Diesel fuels that meet the specifications in Table 14 will help to provide maximum engine service life and performance. In North America, diesel fuel that is identified as No. 2-D in "ASTM D975" generally meets the specifications. Table 14 is for diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

Table 14

Perkins Specifications for Distillate Diesel Fuel		
Specifications	**Requirements**	**ASTM Test**
Aromatics	35% maximum	"D1319"
Ash	0.02% maximum (weight)	"D482"
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	"D524"
Cetane Number	40 minimum (DI engines)	"D613"
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	-

(continued)

(Table 14, contd)

Copper Strip Corrosion	No. 3 maximum	"D130"
Distillation	10% at 282 °C (540 °F) maximum	"D86"
	90% at 360 °C (680 °F) maximum	
Flash Point	legal limit	"D93"
API Gravity	30 minimum	"D287"
	45 maximum	
Pour Point	6 °C (10 °F) minimum below ambient temperature	"D97"
Sulfur (1)	0.2% maximum	"D3605" or "D1552"
Kinematic Viscosity (2)	2.0 cSt minimum and 4.5 cSt maximum at 40 °C (104 °F)	"D445"
Water and Sediment	0.1% maximum	"D1796"
Water	0.1% maximum	"D1744"
Sediment	0.05% maximum (weight)	"D473"
Gum and Resins (3)	10 mg per 100 mL maximum	"D381"
Lubricity (4)	0.38 mm (0.015 inch) maximum at 25 °C (77 °F)	"D6079"

(1) Perkins fuel systems and engine components can operate on high sulfur fuels. Fuel sulfur levels affect exhaust emissions. High sulfur fuels also increase the potential for corrosion of internal components. Fuel sulfur levels above 0.5 percent may significantly shorten the oil change interval. For additional information, see this publication, "Fluid Recommendations/Engine Oil" topic (Maintenance Section).

(2) The values of the fuel viscosity are the values as the fuel is delivered to the fuel injection pumps. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain a 1.4 cSt viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters in order to bring down the viscosity to a 20 cSt viscosity.

(3) Follow the test conditions and procedures for gasoline (motor).

(4) The lubricity of a fuel is a concern with low sulfur fuel. To determine the lubricity of the fuel, use either the "ASTM D6078 Scuffing Load Wear Test (SBOCLE)" or the "ASTM D6079 High Frequency Reciprocating Rig (HFRR)" test. If the lubricity of a fuel does not meet the minimum requirements, consult your fuel supplier. Do not treat the fuel without consulting the fuel supplier. Some additives are not compatible. These additives can cause problems in the fuel system.

NOTICE

Operating with fuels that do not meet the Perkins recommendations can cause the following effects: Starting difficulty, poor combustion, deposits in the fuel injectors, reduced service life of the fuel system, deposits in the combustion chamber, and reduced service life of the engine.

NOTICE

Heavy Fuel Oil (HFO), Residual fuel, or Blended fuel must NOT be used in Perkins diesel engines. Severe component wear and component failures will result if HFO type fuels are used in engines that are configured to use distillate fuel.

In extreme cold ambient conditions, you may use the distillate fuels that are specified in Table 15. However, the fuel that is selected must meet the requirements that are specified in Table 14. These fuels are intended to be used in operating temperatures that are down to −54 °C (−65 °F).

Table 15

Distillate Fuels (1)	
Specification	**Grade**
"MIL-T-5624R"	JP-5
"ASTM D1655"	Jet-A-1
"MIL-T-83133D"	JP-8

(1) The fuels that are listed in this Table may not meet the requirements that are specified in the "Perkins Specifications for Distillate Diesel Fuel" Table. Consult the supplier for the recommended additives in order to maintain the correct fuel lubricity.

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in Table 15 must be at least 40. If the viscosity is below 1.4 cSt at 38 °C (100 °F), use the fuel only in temperatures below 0 °C (32 °F). Do not use any fuels with a viscosity of less than 1.2 cSt at 38 °C (100 °F). Fuel cooling may be required in order to maintain the minimum viscosity of 1.4 cSt at the fuel injection pump.

There are many other diesel fuel specifications that are published by governments and by technological societies. Usually, those specifications do not review all the requirements that are addressed in this specification. To ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in Table 14.

Cooling System Specifications

General Coolant Information

NOTICE
Never add coolant to an overheated engine. Engine damage could result. Allow the engine to cool first.

NOTICE
If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or drained completely to prevent damage.

NOTICE
Frequently check the specific gravity of the coolant for proper freeze protection or for anti-boil protection.

Clean the cooling system for the following reasons:

- Contamination of the cooling system
- Overheating of the engine
- Foaming of the coolant

NOTICE
Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

Many engine failures are related to the cooling system. The following problems are related to cooling system failures: Overheating, leakage of the water pump, and plugged radiators or heat exchangers.

These failures can be avoided with correct cooling system maintenance. Cooling system maintenance is as important as maintenance of the fuel system and the lubrication system. Quality of the coolant is as important as the quality of the fuel and the lubricating oil.

Coolant is normally composed of three elements: Water, additives, and glycol.

Water

Water is used in the cooling system in order to transfer heat.

Distilled water or deionized water is recommended for use in engine cooling systems.

DO NOT use the following types of water in cooling systems: Hard water, softened water that has been conditioned with salt, and sea water.

If distilled water or deionized water is not available, use water with the properties that are listed in Table 16.

Table 16

Perkins Minimum Acceptable Water Requirements	
Property	**Maximum Limit**
Chloride (Cl)	40 mg/L
Sulfate (SO_4)	100 mg/L
Total Hardness	170 mg/L
Total Solids	340 mg/L
Acidity	pH of 5.5 to 9.0

For a water analysis, consult one of the following sources:

- Local water utility company
- Agricultural agent
- Independent laboratory

Additives

Additives help to protect the metal surfaces of the cooling system. A lack of coolant additives or insufficient amounts of additives enable the following conditions to occur:

- Corrosion
- Formation of mineral deposits
- Rust
- Scale
- Foaming of the coolant

Many additives are depleted during engine operation. These additives must be replaced periodically.

Additives must be added at the correct concentration. Overconcentration of additives can cause the inhibitors to drop out-of-solution. The deposits can enable the following problems to occur:

- Formation of gel compounds
- Reduction of heat transfer
- Leakage of the water pump seal

- Plugging of radiators, coolers, and small passages

Glycol

Glycol in the coolant helps to provide protection against the following conditions:

- Boiling
- Freezing
- Cavitation of the water pump

For optimum performance, Perkins recommends a 1:1 mixture of a water/glycol solution.

Note: Use a mixture that will provide protection against the lowest ambient temperature.

Note: 100 percent pure glycol will freeze at a temperature of −23 °C (−9 °F).

Most conventional coolant/antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. See Tables 17 and 18.

Table 17

Ethylene Glycol		
Concentration	**Freeze Protection**	**Boil Protection**
50 Percent	−36 °C (−33 °F)	106 °C (223 °F)
60 Percent	−51 °C (−60 °F)	111 °C (232 °F)

NOTICE
Do not use propylene glycol in concentrations that exceed 50 percent glycol because of propylene glycol's reduced heat transfer capability. Use ethylene glycol in conditions that require additional protection against boiling or freezing.

Table 18

Propylene Glycol		
Concentration	**Freeze Protection**	**Anti-Boil Protection**
50 Percent	−29 °C (−20 °F)	106 °C (223 °F)

To check the concentration of glycol in the coolant, measure the specific gravity of the coolant.

Coolant Recommendations

The following two coolants are used in Perkins diesel engines:

Preferred – Perkins Extended Life Coolant (ELC)

Acceptable – A commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" specifications

NOTICE
Do not use a commercial coolant/antifreeze that only meets the ASTM D3306 specification. This type of coolant/antifreeze is made for light automotive applications.

Perkins recommends a 1:1 mixture of water and glycol. This mixture of water and glycol will provide optimum heavy-duty performance as a coolant/antifreeze. This ratio may be increased to 1:2 water to glycol if extra freezing protection is required.

Note: A commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" specifications MAY require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

In stationary engine applications and marine engine applications that do not require anti-boil protection or freeze protection, a mixture of SCA and water is acceptable. Perkins recommends a six percent to eight percent concentration of SCA in those cooling systems. Distilled water or deionized water is preferred. Water which has the recommended properties may be used.

Engines that are operating in an ambient temperature above 43 °C (109.4 °F) must use SCA and water. Engines that operate in an ambient temperature above 43 °C (109.4 °F) and below 0 °C (32 °F) due to seasonal variations consult your Perkins dealer or your Perkins distributor for the correct level of protection.

Table 19

Coolant Service Life	
Coolant Type	**Service Life**
Perkins ELC	12,000 Service Hours or Six Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985"	3000 Service Hours or Two Years
Perkins POWERPART SCA	3000 Service Hours or Two Years
Commercial SCA and Water	3000 Service Hours or Two Years

Extended Life Coolant (ELC)

Perkins provides Extended Life Coolant (ELC) for use in the following applications:

- Heavy-duty spark ignited gas engines
- Heavy-duty diesel engines
- Automotive applications

The anti-corrosion package for ELC is different from the anti-corrosion package for other coolants. ELC is an ethylene glycol base coolant. However, ELC contains organic corrosion inhibitors and antifoam agents with low amounts of nitrite. Perkins ELC has been formulated with the correct amount of these additives in order to provide superior corrosion protection for all metals in engine cooling systems.

ELC extends the service life of the coolant to 12000 service hours or six years. ELC does not require a frequent addition of a Supplemental Coolant Additive (SCA). An Extender is the only additional maintenance that is needed at 6000 service hours or one half of the ELC service life.

ELC is available in a 1:1 premixed cooling solution with distilled water. The Premixed ELC provides freeze protection to −36 °C (−33 °F). The Premixed ELC is recommended for the initial fill of the cooling system. The Premixed ELC is also recommended for topping off the cooling system.

ELC Concentrate is also available. ELC Concentrate can be used to lower the freezing point to −51 °C (−60 °F) for arctic conditions.

Containers of several sizes are available. Consult your Perkins dealer or your Perkins distributor for the part numbers.

ELC Cooling System Maintenance

Correct additions to the Extended Life Coolant

NOTICE
Use only Perkins products for pre-mixed or concentrated coolants.

Use only Perkins Extender with Extended Life Coolant.

Mixing Extended Life Coolant with other products reduces the Extended Life Coolant service life. Failure to follow the recommendations can reduce cooling system components life unless appropriate corrective action is performed.

In order to maintain the correct balance between the antifreeze and the additives, you must maintain the recommended concentration of Extended Life Coolant (ELC). Lowering the proportion of antifreeze lowers the proportion of additive. This will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

NOTICE
Do not use a conventional coolant to top-off a cooling system that is filled with Extended Life Coolant (ELC).

Do not use standard supplemental coolant additive (SCA). Only use ELC Extender in cooling systems that are filled with ELC.

Perkins ELC Extender

ELC Extender is added to the cooling system halfway through the ELC service life. Treat the cooling system with ELC Extender at 6000 hours or three years. Use Table 20 in order to determine the correct amount of ELC Extender that is required.

Containers of several sizes are available. Consult your Perkins dealer or your Perkins distributor for the part numbers.

Use the formula in Table 20 to determine the correct amount of ELC Extender for your cooling system. Refer to Operation and Maintenance Manual, "Refill Capacities" in order to determine the capacity of the cooling system.

Table 20

Formula For Adding ELC Extender To ELC
$V \times 0.02 = X$
V is the total capacity of the cooling system.
X is the amount of ELC Extender that is required.

Table 21 is an example for using the formula that is in Table 20.

Table 21

Example Of The Equation For Adding ELC Extender To ELC		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of ELC Extender that is Required (X)**
9 L (2.4 US gal)	× 0.02	0.18 L (0.05 US gal) or (6 fl oz)

NOTICE
When using Perkins ELC, do not use standard SCA's or SCA filters.

ELC Cooling System Cleaning

Note: If the cooling system is already using ELC, cleaning agents are not required to be used at the specified coolant change interval. Cleaning agents are only required if the system has been contaminated by the addition of some other type of coolant or by cooling system damage.

Clean water is the only cleaning agent that is required when ELC is drained from the cooling system.

After the cooling system is drained and after the cooling system is refilled, operate the engine while the cooling system filler cap is removed. Operate the engine until the coolant level reaches the normal operating temperature and until the coolant level stabilizes. As needed, add the coolant mixture in order to fill the system to the specified level.

Changing to Perkins ELC

To change from heavy-duty coolant/antifreeze to the Perkins ELC, perform the following steps:

NOTICE
Care must be taken to ensure that all fluids are contained during performance of inspection, maintenance, testing, adjusting and the repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant into a suitable container.
2. Dispose of the coolant according to local regulations.
3. Flush the system with clean water in order to remove any debris.
4. Use Perkins cleaner to clean the system. Follow the instruction on the label.
5. Drain the cleaner into a suitable container. Flush the cooling system with clean water.
6. Fill the cooling system with clean water and operate the engine until the engine is warmed to 49° to 66°C (120° to 150°F).

NOTICE
Incorrect or incomplete flushing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all the signs of the cleaning agent are gone.

7. Drain the cooling system into a suitable container and flush the cooling system with clean water.

Note: The cooling system cleaner must be thoroughly flushed from the cooling system. Cooling system cleaner that is left in the system will contaminate the coolant. The cleaner may also corrode the cooling system.

8. Repeat Steps 6 and 7 until the system is completely clean.
9. Fill the cooling system with the Perkins Premixed ELC.

ELC Cooling System Contamination

NOTICE
Mixing ELC with other products reduces the effectiveness of the ELC and shortens the ELC service life. Use only Perkins Products for premixed or concentrate coolants. Use only Perkins ELC extender with Perkins ELC. Failure to follow these recommendations can result in shortened cooling system component life.

ELC cooling systems can withstand contamination to a maximum of ten percent of conventional heavy-duty coolant/antifreeze or SCA. If the contamination exceeds ten percent of the total system capacity, perform ONE of the following procedures:

- Drain the cooling system into a suitable container. Dispose of the coolant according to local regulations. Flush the system with clean water. Fill the system with the Perkins ELC.

- Drain a portion of the cooling system into a suitable container according to local regulations. Then, fill the cooling system with premixed ELC. This should lower the contamination to less than 10 percent.
- Maintain the system as a conventional Heavy-Duty Coolant. Treat the system with an SCA. Change the coolant at the interval that is recommended for the conventional Heavy-Duty Coolant.

Commercial Heavy-Duty Coolant/ Antifreeze and SCA

NOTICE
Commercial Heavy-Duty Coolant which contains Amine as part of the corrision protection system must not be used.

NOTICE
Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the correct operating temperature. Cooling system problems can develop without water temperature regulators.

Check the coolant/antifreeze (glycol concentration) in order to ensure adequate protection against boiling or freezing. Perkins recommends the use of a refractometer for checking the glycol concentration.

Perkins engine cooling systems should be tested at 500 hour intervals for the concentration of Supplemental Coolant Additive (SCA).

Additions of SCA are based on the results of the test. An SCA that is liquid may be needed at 500 hour intervals.

Refer to Table 22 for part numbers and for quantities of SCA.

Table 22

Perkins Liquid SCA	
Part Number	**Quantity**
21825755	

Adding the SCA to Heavy-Duty Coolant at the Initial Fill

Commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" specifications MAY require an addition of SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

Use the equation that is in Table 23 to determine the amount of Perkins SCA that is required when the cooling system is initially filled.

Table 23

Equation For Adding The SCA To The Heavy-Duty Coolant At The Initial Fill
$V \times 0.045 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 24 is an example for using the equation that is in Table 23.

Table 24

Example Of The Equation For Adding The SCA To The Heavy-Duty Coolant At The Initial Fill		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of SCA that is Required (X)**
15 L (4 US gal)	× 0.045	0.7 L (24 oz)

Adding The SCA to The Heavy-Duty Coolant For Maintenance

Heavy-duty coolant/antifreeze of all types REQUIRE periodic additions of an SCA.

Test the coolant/antifreeze periodically for the concentration of SCA. For the interval, refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section). Test the concentration of SCA.

Additions of SCA are based on the results of the test. The size of the cooling system determines the amount of SCA that is needed.

Use the equation that is in Table 25 to determine the amount of Perkins SCA that is required, if necessary:

Table 25

Equation For Adding The SCA To The Heavy-Duty Coolant For Maintenance
$V \times 0.014 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 26 is an example for using the equation that is in Table 25.

Table 26

Example Of The Equation For Adding The SCA To The Heavy-Duty Coolant For Maintenance		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of SCA that is Required (X)**
15 L (4 US gal)	× 0.014	0.2 L (7 oz)

Cleaning the System of Heavy-Duty Coolant/Antifreeze

Perkins cooling system cleaners are designed to clean the cooling system of harmful scale and corrosion. Perkins cooling system cleaners dissolve mineral scale, corrosion products, light oil contamination and sludge.

- Clean the cooling system after used coolant is drained or before the cooling system is filled with new coolant.

- Clean the cooling system whenever the coolant is contaminated or whenever the coolant is foaming.

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Maintenance Interval Schedule

Ensure that the Safety Information, Warnings, and Instructions are read and understood before operation or maintenance procedures are performed.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must also be performed.

Note: Only engines that are equipped with the leak-off fuel injector require servicing every 3000 hours.

When Required

Battery - Replace 51
Battery or Battery Cable - Disconnect 52
Engine - Clean 57
Engine Air Cleaner Element (Dual Element) - Clean/Replace 58
Engine Air Cleaner Element (Single Element) - Inspect/Replace 60
Engine Oil Sample - Obtain 61
Fuel Injector - Test/Change 64
Fuel System - Prime 65
Severe Service Application - Check 72

Daily

Alternator and Fan Belts - Inspect/Adjust/ Replace 50
Cooling System Coolant Level - Check 56
Driven Equipment - Check 57
Engine Air Cleaner Service Indicator - Inspect 60
Engine Oil Level - Check 61
Fuel System Primary Filter/Water Separator - Drain 66
Walk-Around Inspection 74

Every 50 Service Hours or Weekly

Fuel Tank Water and Sediment - Drain 70

Every 500 Service Hours or 1 Year

Battery Electrolyte Level - Check 51
Engine Air Cleaner Element (Dual Element) - Clean/Replace 58
Engine Air Cleaner Element (Single Element) - Inspect/Replace 60
Engine Ground - Inspect/Clean 61
Engine Oil and Filter - Change 62
Fuel System Primary Filter (Water Separator) Element - Replace 67
Fuel System Secondary Filter - Replace 68
Hoses and Clamps - Inspect/Replace 71
Radiator - Clean .... 7[illegible]

Every 1000 Service Hours

Engine Valve Lash - Inspect/Adjust .... 6[illegible]

Every 2000 Service Hours

Aftercooler Core - Inspect .... 4[illegible]
Alternator - Inspect .... 5[illegible]
Engine Mounts - Inspect 61
Starting Motor - Inspect 73
Turbocharger - Inspect .... 7[illegible]
Water Pump - Inspect .... 7[illegible]

Every 2 Years

Cooling System Coolant - Change .... 5[illegible]

Every 3000 Service Hours

Fuel Injector - Test/Change 64

Every 3000 Service Hours or 2 Years

Cooling System Coolant (Commercial Heavy-Duty) - Change 52

Every 4000 Service Hours

Aftercooler Core - Clean/Test 49

Every 6000 Service Hours or 3 Years

Cooling System Coolant Extender (ELC) - Add 56

Every 12 000 Service Hours or 6 Years

Cooling System Coolant (ELC) - Change 54

i01853891

Aftercooler Core - Clean/Test

1. Remove the core. Refer to the OEM information for the correct procedure.

2. Turn the aftercooler core upside-down in order to remove debris.

NOTICE
Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

3. Back flush the core with a suitable cleaner.

4. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris.

5. Wash the core with hot, soapy water. Rinse the core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

6. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.

7. Inspect the core in order to ensure cleanliness. Pressure test the core. If necessary, repair the core.

8. Install the core. Refer to the OEM information for the correct procedure.

i01841503

Aftercooler Core - Inspect

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the aftercooler for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the aftercooler, if necessary.

For air-to-air aftercoolers, use the same methods that are used for cleaning radiators.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb".

Note: If parts of the aftercooler system are repaired or replaced, a leak test is highly recommended.

Inspect these items for good condition: Welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

i02176674

Alternator - Inspect

Perkins recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and correct battery charging. Inspect the ammeter (if equipped) during engine operation in order to ensure correct battery performance and/or correct performance of the electrical system. Make repairs, as required.

Check the alternator and the battery charger for correct operation. If the batteries are correctly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

i01929797

Alternator and Fan Belts - Inspect/Adjust/Replace

Inspection

To maximize the engine performance, inspect the belts for wear and for cracking. Replace belts that are worn or damaged.

For applications that require multiple drive belts, replace the belts in matched sets. Replacing only one belt of a matched set will cause the new belt to carry more load because the older belt is stretched. The additional load on the new belt could cause the new belt to break.

If the belts are too loose, vibration causes unnecessary wear on the belts and pulleys. Loose belts may slip enough to cause overheating.

To accurately check the belt tension, a suitable gauge should be used.

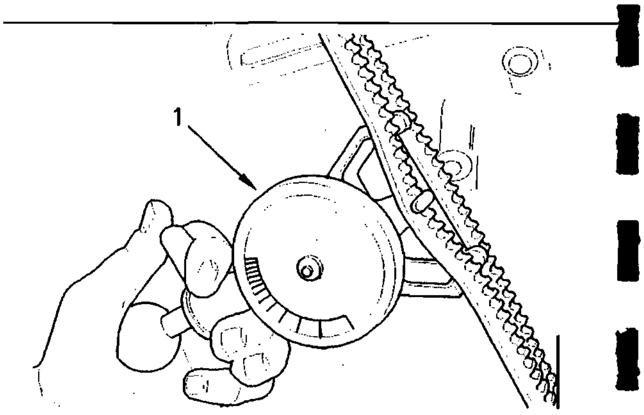

Illustration 20 g01003936

Typical example

(1) Burroughs Gauge

Fit the gauge (1) at the center of the longest free length and check the tension. The correct tension is 535 N (120 lb). If the tension of the belt is below 250 N (56 lb) adjust the belt to 535 N (120 lb).

If twin belts are installed, check and adjust the tension on both belts.

Adjustment

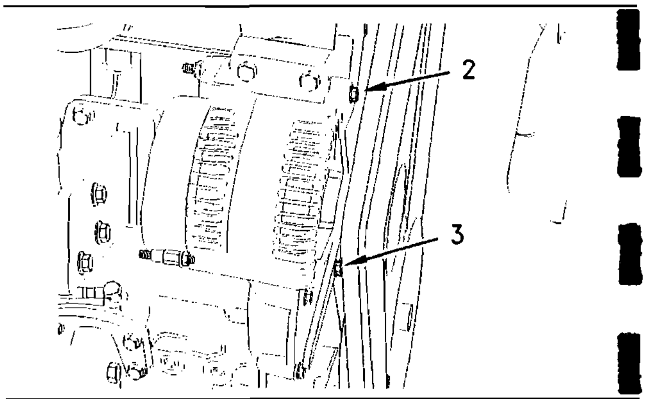

Illustration 21 g01003939

1. Loosen The alternator pivot bolt (2) and the bolt (3).
2. Move the alternator in order to increase or decrease the belt tension. Tighten the alternator pivot bolt and the link bolt to 22 N·m (16 lb ft).(1).

Replacement

Refer to the Disassembly and Assembly Manual for the installation procedure and the removal procedure for the belt.

i02150857

Battery - Replace

⚠ WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Switch the engine to the OFF position. Remove all electrical loads.

2. Turn off any battery chargers. Disconnect any battery chargers.

3. The NEGATIVE "-" cable connects the NEGATIVE "-" battery terminal to the NEGATIVE "-" terminal on the starting motor. Disconnect the cable from the NEGATIVE "-" battery terminal.

4. The POSITIVE "+" cable connects the POSITIVE "+" battery terminal to the POSITIVE "+" terminal on the starting motor. Disconnect the cable from the POSITIVE "+" battery terminal.

Note: Always recycle a battery. Never discard a battery. Return used batteries to an appropriate recycling facility.

5. Remove the used battery.

6. Install the new battery.

Note: Before the cables are connected, ensure that the engine start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE "+" battery terminal.

8. Connect the cable from the NEGATIVE "-" terminal on the starting motor to the NEGATIVE "-" battery terminal.

i02177936

Battery Electrolyte Level - Check

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are correctly charged, ammeter reading should be very near zero.

⚠ WARNING

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the "FULL" mark on the battery.

   If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

2. Check the condition of the electrolyte with a suitable battery tester.

3. Keep the batteries clean.

   Clean the battery case with one of the following cleaning solutions:

   - A mixture of 0.1 kg (0.2 lb) of baking soda and 1 L (1 qt) of clean water

   - A mixture of 0.1 L (0.11 qt) of ammonia and 1 L (1 qt) of clean water

   Thoroughly rinse the battery case with clean water.

   Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit correctly. Coat the clamps and the terminals with a suitable silicone lubricant or petroleum jelly.

i02150865

Battery or Battery Cable - Disconnect

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
2. Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, the negative side of two batteries must be disconnected.
3. Tape the leads in order to help prevent accidental starting.
4. Proceed with necessary system repairs. Reverse the steps in order to reconnect all of the cables.

i02203590

Cooling System Coolant (Commercial Heavy-Duty) - Change

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to Local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

Note: When the cooling system is cleaned, only clean water is needed.

Note: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

Drain

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

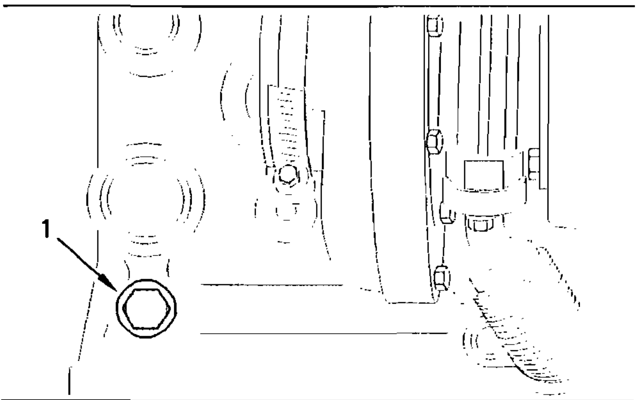

Illustration 22 g01003928

2. Open the drain cock or remove the drain plug (1) on the engine. Open the drain cock or remove the drain plug on the radiator.

   Allow the coolant to drain.

NOTICE
Dispose of used engine coolant or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Perkins to reclaim the coolant.

For information regarding the disposal and the recycling of used coolant, consult your Perkins dealer or your Perkins distributor.

Flush

1. Flush the cooling system with clean water in order to remove any debris.

2. Close the drain cock or install the drain plug in the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water. Install the cooling system filler cap.

4. Start and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain cock or remove the drain plug on the engine. Open the drain cock or remove the drain plug on the radiator. Allow the water to drain. Flush the cooling system with clean water.

Fill

1. Close the drain cock or install the drain plug on the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

2. Fill the cooling system with Commercial Heavy-Duty Coolant. Add Supplemental Coolant Additive to the coolant. For the correct amount, refer to the Operation and Maintenance Manual, “Fluid Recommendations” topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

3. Start and run the engine at low idle. Increase the engine rpm to high idle. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block. Stop the engine.

4. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level in the expansion bottle (if equipped) at the correct level.

5. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, use a suitable pressurizing pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

6. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i02203595

Cooling System Coolant (ELC) - Change

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to Local regulations and mandates.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

Note: When the cooling system is cleaned, only clean water is needed when the ELC is drained and replaced.

Note: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

Drain

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

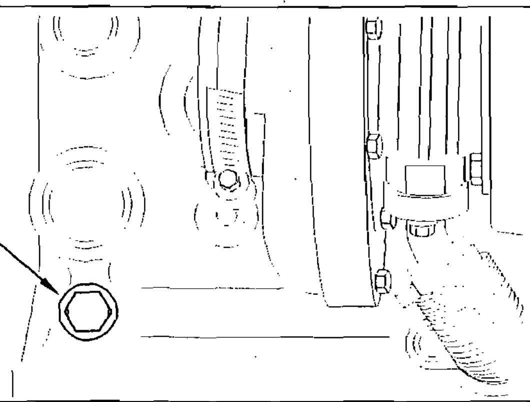

Illustration 23 g01003928

Typical example

2. Open the drain cock or remove the drain plug (1) on the engine. Open the drain cock or remove the drain plug on the radiator.

   Allow the coolant to drain.

NOTICE
Dispose of used engine coolant or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Perkins to reclaim the coolant.

For information regarding the disposal and the recycling of used coolant, consult your Perkins dealer or your Perkins distributor.

Flush

1. Flush the cooling system with clean water in order to remove any debris.

2. Close the drain cock or install the drain plug in the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water. Install the cooling system filler cap.

4. Start and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain cock or remove the drain plug on the engine. Open the drain cock or remove the drain plug on the radiator. Allow the water to drain. Flush the cooling system with clean water.

Fill

1. Close the drain cock or install the drain plug on the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

2. Fill the cooling system with Extended Life Coolant (ELC). Refer to the Operation and Maintenance Manual, "Fluid Recommendations" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

3. Start and run the engine at low idle. Increase the engine rpm to high idle. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block. Stop the engine.

4. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level in the expansion bottle (if equipped) at the correct level.

5. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, use a suitable pressurizing pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

6. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i01929799

Cooling System Coolant - Change

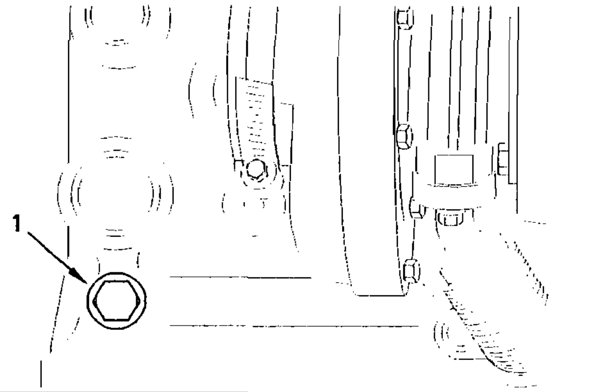

Illustration 24 g01003928

Drain plug

NOTICE
Do not drain the coolant while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.

Note: The radiator may not have been provided by Perkins. The following is a general procedure for changing the coolant. Refer to the OEM information for the correct procedure.

1. Ensure that the vehicle is on level ground.

2. Remove the filler cap of the cooling system.

3. Remove the drain plug (1) from the side of the cylinder block in order to drain the engine. Ensure that the drain hole is not restricted.

4. Open the radiator drain tap or remove the drain plug at the bottom of the radiator in order to drain the radiator. If the radiator does not have a radiator drain tap or a drain plug, disconnect the hose at the bottom of the radiator.

5. Flush the coolant system with clean water.

6. Install the drain plugs and close the radiator drain tap. Install the radiator hose if the radiator hose was previously removed.

7. Fill the system with an approved antifreeze mixture. The maximum flow rate is 1 L (0.2200 Imp gal) per minute in order to fill the system. Install the filler cap.

8. Run the engine and check for coolant leaks.

i02151264

Cooling System Coolant Extender (ELC) - Add

The Perkins Extended Life Coolant (ELC) does not need the frequent addition of Supplemental Coolant Additives (SCA) that are associated with conventional coolants. The Extender only needs to be added once.

Check the cooling system only when the engine is stopped and cool.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.

2. It may be necessary to drain enough coolant from the cooling system in order to add the Extender.

3. Add Extender according to the requirements for your engine's cooling system capacity. Refer to this Operation and Maintenance Manual, "Refill Capacities" in the Maintenance Section for the capacity of the cooling system for your engine. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" information for the Perkins ELC Extender.

4. Clean the cooling system filler cap. Inspect the gasket of the cooling system filler cap. If the gasket is damaged then replace the cooling system filler cap. Install the cooling system filler cap.

i02151299

Cooling System Coolant Level - Check

Engines With a Coolant Recovery Tank

Note: The cooling system may not have been provided by Perkins. The procedure that follows is for typical cooling systems. Refer to the OEM information for the correct procedures.

Check the coolant level when the engine is stopped and cool.

1. Observe the coolant level in the coolant recovery tank. Maintain the coolant level to "COLD FULL" mark on the coolant recovery tank.

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

2. Loosen filler cap slowly in order to relieve any pressure. Remove the filler cap.

3. Pour the correct coolant mixture into the tank. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for information on the correct mixture and type of coolant. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for the cooling system capacity. Do not fill the coolant recovery tank above "COLD FULL" mark.

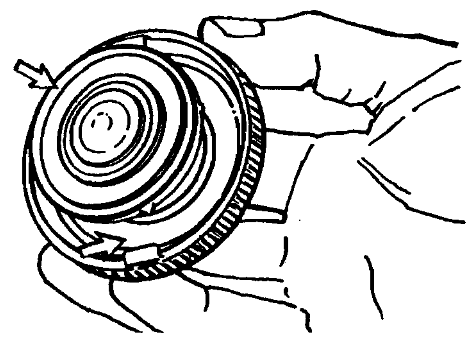

Illustration 25 g00103639

4. Clean filler cap and the receptacle. Reinstall the filler cap and inspect the cooling system for leaks.

Note: The coolant will expand as the coolant heats up during normal engine operation. The additional volume will be forced into the coolant recovery tank during engine operation. When the engine is stopped and cool, the coolant will return to the engine.

Engines Without a Coolant Recovery Tank

Check the coolant level when the engine is stopped and cool.

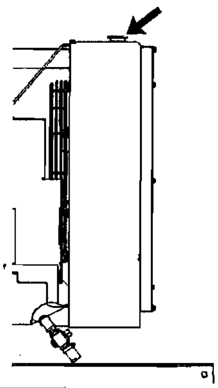

Illustration 26 g00285520

Cooling system filler cap

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly in order to relieve pressure.

2. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the correct level in the sight glass.

3. Clean the cooling system filler cap and check the condition of the filler cap gaskets. Replace the cooling system filler cap if the filler cap gaskets are damaged. Reinstall the cooling system filler cap.

4. Inspect the cooling system for leaks.

i00174798

Driven Equipment - Check

Refer to the OEM specifications for more information on the following maintenance recommendations for the driven equipment:

- Inspection
- Adjustment
- Lubrication
- Other maintenance recommendations

Perform any maintenance for the driven equipment which is recommended by the OEM.

i01930350

Engine - Clean

WARNING

Personal injury or death can result from high voltage.

Moisture can create paths of electrical conductivity.

Make sure that the electrical system is OFF. Lock out the starting controls and tag the controls "DO NOT OPERATE".

NOTICE

Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

NOTICE

Failure to protect some engine components from washing may make your engine warranty invalid. Allow the engine to cool for one hour before washing the engine.

Periodic cleaning of the engine is recommended. Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

Note: Caution must be used in order to prevent electrical components from being damaged by excessive water when the engine is cleaned. Pressure washers and steam cleaners should not be directed at any electrical connectors or the junction of cables into the rear of the connectors. Avoid electrical components such as the alternator and the starter. Protect the fuel injection pump from fluids in order to wash the engine.

i01915869

Engine Air Cleaner Element (Dual Element) - Clean/Replace

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

Servicing the Air Cleaner Elements

Note: The air filter system may not have been provided by Perkins. The procedure that follows is for a typical air filter system. Refer to the OEM information for the correct procedure.

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Refer to the OEM information for the correct air cleaner elements for your application.

- Check the precleaner (if equipped) and the dust bowl daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.

- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.

- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty air cleaner elements with clean air cleaner elements. Before installation, the air cleaner elements should be thoroughly checked for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

Dual Element Air Cleaners

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element. The primary air cleaner element can be used up to six times if the element is properly cleaned and properly inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable or washable. Refer to the OEM information for instructions in order to replace the secondary air cleaner element. When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

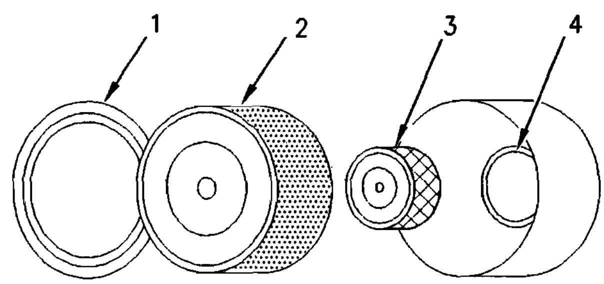

Illustration 27 g00736431

(1) Cover
(2) Primary air cleaner element
(3) Secondary air cleaner element
(4) Air inlet

1. Remove the cover. Remove the primary air cleaner element.

2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.

Note: Refer to "Cleaning the Primary Air Cleaner Elements".

3. Cover the air inlet with tape in order to keep dirt out.

4. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

5. Remove the tape for the air inlet. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.

6. Install the air cleaner cover.

7. Reset the air cleaner service indicator.

Cleaning the Primary Air Cleaner Elements

NOTICE
Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

Refer to the OEM information in order to determine the number of times that the primary filter element can be cleaned. When the primary air cleaner element is cleaned, check for rips or tears in the filter material. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the primary air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean primary air cleaner elements:

- Pressurized air
- Vacuum cleaning

Pressurized Air

Pressurized air can be used to clean primary air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

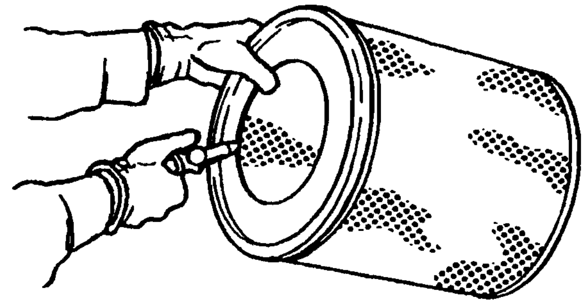

Illustration 28 g00281692

Note: When the primary air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of air directly at the primary air cleaner element. Dirt could be forced further into the pleats.

Note: Refer to "Inspecting the Primary Air Cleaner Elements".

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning primary air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

Note: Refer to "Inspecting the Primary Air Cleaner Elements".

Inspecting the Primary Air Cleaner Elements

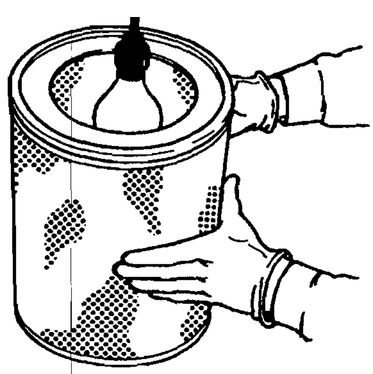

Illustration 29 g00281693

Inspect the clean, dry primary air cleaner element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the primary air cleaner element. Rotate the primary air cleaner element. Inspect the primary air cleaner element for tears and/or holes. Inspect the primary air cleaner element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the primary air cleaner element to a new primary air cleaner element that has the same part number.

Do not use a primary air cleaner element that has any tears and/or holes in the filter material. Do not use a primary air cleaner element with damaged pleats, gaskets or seals. Discard damaged primary air cleaner elements.

i02152042

Engine Air Cleaner Element (Single Element) - Inspect/Replace

Refer to Operation and Maintenance Manual, "Engine Air Cleaner Service Indicator-Inspect".

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

A wide variety of air cleaners may be installed for use with this engine. Consult the OEM information for the correct procedure to replace the air cleaner.

i01909507

Engine Air Cleaner Service Indicator - Inspect

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before the air cleaner element and the pressure that is measured after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the air cleaner element or in a remote location.

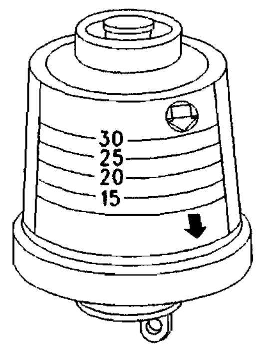

Illustration 30 g001037

Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated speed. The yellow core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be restricted.

The service indicator may need to be replaced frequently in environments that are severely dusty.

i01941505

Engine Ground - Inspect/Clean

Inspect the wiring harness for good connections.

Perkins use the starter motor in order to ground the engine. Check the connection on the starter motor at every oil change. Ground wires and straps should be combined at engine grounds. All grounds should be tight and free of corrosion.

- Clean the grounding stud on the starter motor and the terminals with a clean cloth.
- If the connections are corroded, clean the connections with a solution of baking soda and water.
- Keep the grounding stud and the strap clean and coated with suitable grease or petroleum jelly.

i02177938

Engine Mounts - Inspect

Note: The engine mounts may not have been supplied for this installation by Perkins. Refer to the OEM information for further information on the engine mounts and the correct bolt torque.

Inspect the engine mounts for deterioration and for correct bolt torque. Engine vibration can be caused by the following conditions:

- Incorrect mounting of the engine
- Deterioration of the engine mounts

Any engine mount that shows deterioration should be replaced. Refer to the OEM information for the recommended torques.

i01907673

Engine Oil Level - Check

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

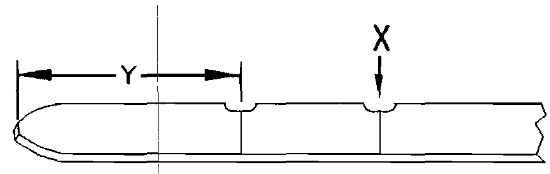

Illustration 31 g00998024

(Y) "ADD" mark. (X) "FULL" mark.

NOTICE

Perform this maintenance with the engine stopped.

Note: Ensure that the engine is either level or that the engine is in the normal operating position in order to obtain a true level indication.

Note: After the engine has been switched OFF, allow the engine oil to drain to the oil pan before checking the oil level.

1. Maintain the oil level between the "ADD" mark (Y) and the "FULL" mark (X) on the engine oil dipstick. Do not fill the crankcase above the "FULL" mark (X).

NOTICE

Operating your engine when the oil level is above the "FULL" mark could cause your crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduces the oil's lubricating characteristics and could result in the loss of power.

2. Remove the oil filler cap and add oil, if necessary. Clean the oil filler cap. Install the oil filler cap.

i02202699

Engine Oil Sample - Obtain

The condition of the engine lubricating oil may be checked at regular intervals as part of a preventive maintenance program. Perkins include an oil sampling valve as an option. The oil sampling valve (if equipped) is included in order to regularly sample the engine lubricating oil. The oil sampling valve is positioned on the oil filter head or the oil sampling valve is positioned on the cylinder block.

Perkins recommends using a sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when a sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

Obtain the Sample and the Analysis

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

In order to help obtain the most accurate analysis, record the following information before an oil sample is taken:

- The date of the sample
- Engine model
- Engine number
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

Ensure that the container for the sample is clean and dry. Also ensure that the container for the sample is clearly labelled.

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

The sample can be checked for the following: the quality of the oil, the existence of any coolant in the oil, the existence of any ferrous metal particles in the oil, and the existence of any nonferrous metal particles in the oil.

i01929323

Engine Oil and Filter - Change

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped. Drain the crankcase with the oil warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Oil

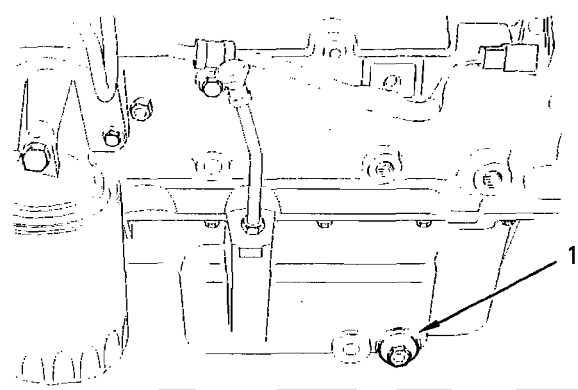

Illustration 32 g01003623

Oil drain plug

After the engine has been run at the normal operating temperature, stop the engine. Use one of the following methods to drain the engine crankcase oil:

- If the engine is equipped with a drain valve, turn the drain valve knob counterclockwise in order to drain the oil. After the oil has drained, turn the drain valve knob clockwise in order to close the drain valve.
- If the engine is not equipped with a drain valve, remove the oil drain plug (1) in order to allow the oil to drain. If the engine is equipped with a shallow sump, remove the bottom oil drain plugs from both ends of the oil pan.

After the oil has drained, the oil drain plugs should be cleaned and installed. If necessary, renew the O ring seal on the drain plug.

Some types of oil pans have oil drain plugs that are on both sides of the oil pan, because of the shape of the pan. This type of oil pan requires the engine oil to be drained from both plugs.

Replace the Spin-on Oil Filter

NOTICE
Perkins oil filters are manufactured to Perkins specifications. Use of an oil filter that is not recommended by Perkins could result in severe damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Perkins.

1. Remove the oil filter with a suitable tool.

Note: The following actions can be carried out as part of the preventive maintenance program.

2. Cut the oil filter open with a suitable tool. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

   Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of the engine.

   Nonferrous metals may indicate wear on the aluminum parts, brass parts or bronze parts of the engine. Parts that may be affected include the following items: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

   Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter.

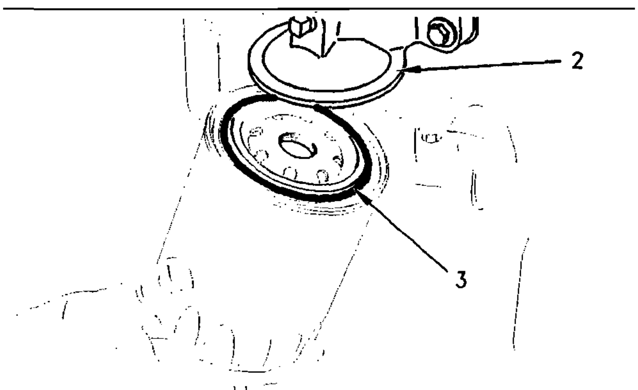

Illustration 33 g01003628

(2) Filter head
(3) O ring seal

3. Clean the sealing surface of the oil filter head (2). Ensure that the union (not shown) in the oil filter head is secure.

4. Apply clean engine oil to the O ring seal (3) on the oil filter.

NOTICE
Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

5. Install the oil filter. Tighten the oil filter by hand according to the instructions that are shown on the oil filter. Do not overtighten the oil filter.

Replace the Element for the Oil Filter

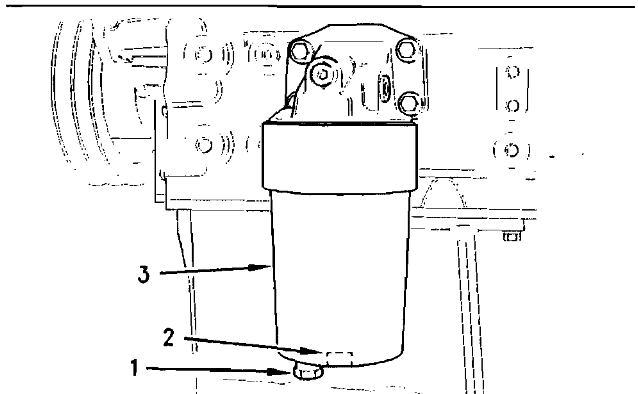

Illustration 34 g01003662

(1) Drain plug
(2) Square hole
(3) Filter bowl

1. Place a suitable container under the oil filter. Remove the drain plug (1) and the seal, from the oil filter.

2. Locate a suitable wrench into the square hole (2) in order to remove the filter bowl (3).

3. Remove the filter bowl (3) and remove the element from the filter bowl. Clean the filter bowl.

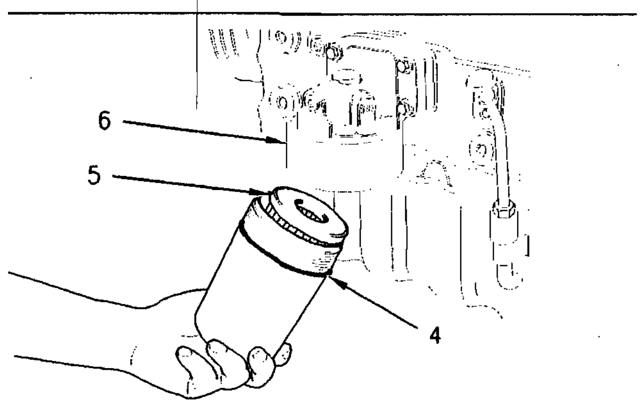

Illustration 35 g01003675

(4) O ring seal
(5) Element
(6) Filter head

4. Install a new O ring (4) onto the filter bowl and lubricate the O ring with clean engine oil. Install the filter element (5) into the filter bowl.

5. Install the filter bowl into the oil filter head (6). Tighten the filter bowl to the following torque 25 N·m (18 lb ft).

6. Install a new seal onto the drain plug (1) and install the drain plug into the oil filter. Tighten the drain plug to the following torque 12 N·m (8 lb ft).

Note: Some engines may have a horizontally mounted oil filter. This oil filter has a drain plug that is located in the oil filter head.

Fill the Engine Crankcase

1. Remove the oil filler cap. Refer to the Operation and Maintenance Manual for more information on lubricant specifications. Fill the crankcase with the proper amount of oil. Refer to the Operation and Maintenance Manual for more information on refill capacities.

NOTICE

If equipped with an auxiliary oil filter system or a remote oil filter system, follow the OEM or filter manufacturer's recommendations. Under filling or overfilling the crankcase with oil can cause engine damage.

NOTICE

To prevent crankshaft bearing damage, crank the engine with the fuel OFF. This will fill the oil filters before starting the engine. Do not crank the engine for more than 30 seconds.

2. Start the engine and run the engine at "LOW IDLE" for two minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filter for oil leaks.

3. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.

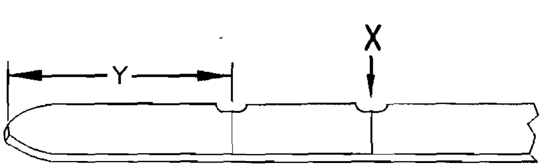

Illustration 36 g00998024

(Y) "ADD" mark. (X) "FULL" mark.

4. Remove the oil level gauge in order to check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the engine oil dipstick.

i02177110

Engine Valve Lash - Inspect/Adjust

This maintenance is recommended by Perkins as part of a lubrication and preventive maintenance schedule in order to help provide maximum engine life.

NOTICE

Only qualified service personel should perform this maintenance. Refer to the Service Manual or your authorized Perkins dealer or your Perkins distributor for the complete valve lash adjustment procedure.

Operation of Perkins engines with incorrect valve lash can reduce engine efficiency, and also reduce engine component life.

⚠ WARNING

Ensure that the engine can not be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

Ensure that the engine is stopped before measuring the valve lash. The engine valve lash can be inspected and adjusted when the temperature of the engine is hot or cold.

Refer to Systems Operation/Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust" for more information.

i02198352

Fuel Injector - Test/Change

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

NOTICE
If a fuel injector is suspected of operating outside of normal parameters it should be removed by a qualified technician. The suspect fuel injector should be taken to an authorised agent for inspection.

The fuel injector (1) in illustration 37 has no fuel return. The fuel injector (2) has a fuel return.

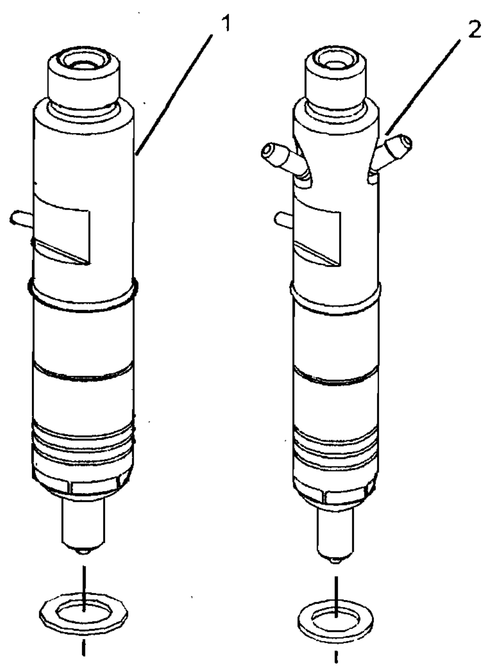

Illustration 37 g01110422

Typical fuel Injectors

The fuel injector (1) will need to be removed and the injector will need to be checked for performance.

The fuel injectors should not be cleaned as cleaning with incorrect tools can damage the nozzle. The fuel injectors should be renewed only if a fault with the fuel injectors occurs. Some of the problems that may indicate that new fuel injectors are needed are listed below:

- The engine will not start or the engine is difficult to start.
- Not enough power
- The engine misfires or the engine runs erratically.
- High fuel consumption
- Black exhaust smoke
- The engine knocks or there is vibration in the engine.
- Excessive engine temperature

Removal and Installation of the Fuel Injectors

WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

WARNING

Make sure that you wear eye protection at all times during testing. When fuel injection nozzles are tested, test fluids travel through the orifices of the nozzle tip with high pressure. Under this amount of pressure, the test fluid can pierce the skin and cause serious injury to the operator. Always keep the tip of the fuel injection nozzle pointed away from the operator and into the fuel collector and extension.

NOTICE
If your skin comes into contact with high pressure fuel, obtain medical assistence immediately.

Operate the engine at a fast idle speed in order to identify the faulty fuel injector. Individually loosen and tighten the union nut for the high pressure pipe to each fuel injector. Do not loosen the union nut more than half a turn. There will be little effect on the engine speed when the union nut to the faulty fuel injection nozzle is loosened. Refer to the Disassembly and Assembly Manual for more information. Consult your authorized Perkins dealer or your Perkins distributor for assistance.

i01929324

Fuel System - Prime

If air enters the fuel system, the air must be purged from the fuel system before the engine can be started. Air can enter the fuel system when the following events occur:

- The fuel tank is empty or the fuel tank has been partially drained.
- The low pressure fuel lines are disconnected.
- A leak exists in the low pressure fuel system.
- The fuel filter is replaced.
- A new injection pump is installed.

Use the following procedure in order to remove air from the fuel system:

1. Remove the cover for the fuel injectors. Refer to the Disassembly and Assembly Manual.
2. Turn the key switch to the RUN position. Leave the key switch in the RUN position for three minutes.
3. Turn the key switch to the OFF position.

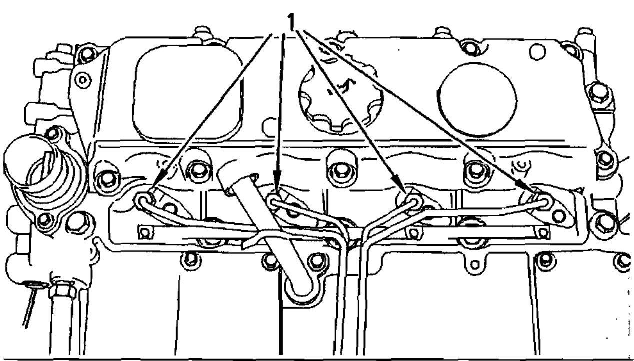

Illustration 38 g01003929

Injector nuts

Note: Damage to the fuel injection pump, to the battery, and to the starter motor can occur if the starter motor is used excessively to purge the air from the fuel system.

4. Loosen the flare nuts (1) for the high pressure fuel lines on all of the fuel injectors.

NOTICE

Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

5. Observe the connection at the flare nut. Operate the starting motor and crank the engine until the fuel is free of air.
6. Tighten the flare nuts (1) to a torque of 30 N·m (22 lb ft).
7. The engine is now ready to start. Operate the engine at low idle for a minimum of five minutes immediately after air has been removed from the fuel system.

Note: Running the engine for this period of time will help ensure that the pump is completely free of air.

i02211106

Fuel System Primary Filter/Water Separator - Drain

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE

The water separator is not a filter. The water separator separates water from the fuel. The engine should never be allowed to run with the water separator more than half full. Engine damage may result.

NOTICE

The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

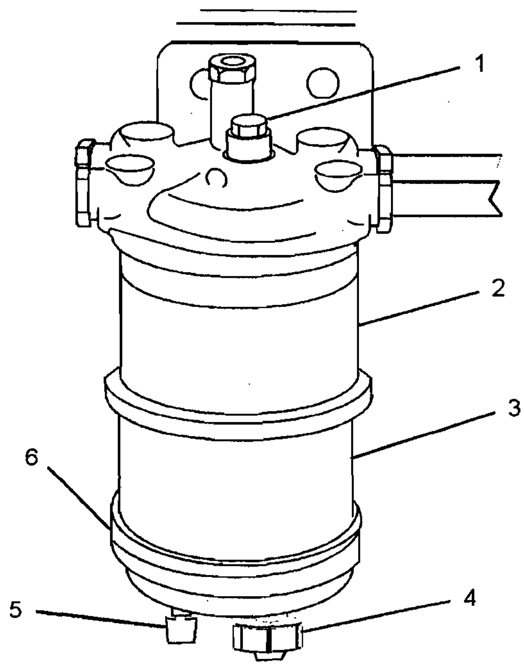

Illustration 39 g01118416

(1) Screw
(2) Element
(3) Glass bowl
(4) Sensor connection
(5) Drain
(6) Bottom cover

1. Place a suitable container below the water separator.

2. Open the drain (5). Allow the fluid to drain into the container.

3. When clean fuel drains from the water separator close the drain (5). Tighten the drain by hand pressure only. Dispose of the drained fluid correctly.

i02206563

Fuel System Primary Filter (Water Separator) Element - Replace

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

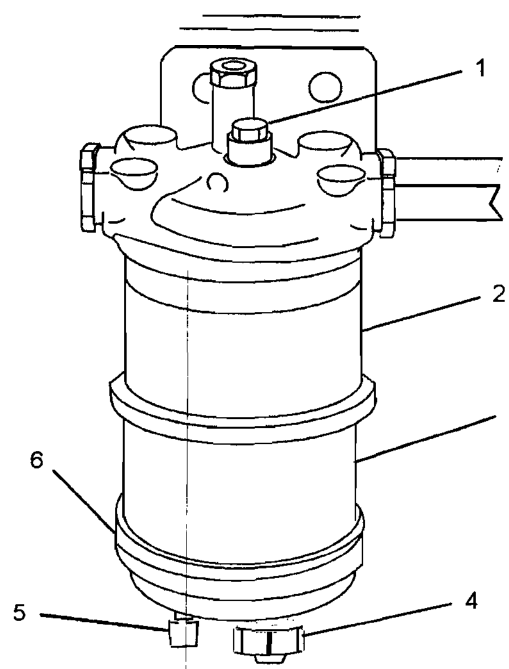

Illustration 40 g01118416

(1) Screw
(2) Element
(3) Glass bowl
(4) Sensor connection
(5) Drain
(6) Bottom cover

1. Turn the fuel supply valve (if equipped) to the OFF position.

2. Place a suitable container under the water separator. Clean the outside of the water separator.

3. Open the drain (5). Allow the fluid to drain into the container.

4. Tighten the drain (5) by hand pressure only.

5. Hold the element (2) and remove the screw (1). Remove the element and the glass bowl (3) from the base. Discard the old element.

6. Clean the glass bowl (4). Clean the bottom cover (6).

7. Install the new O ring seal. Install the bottom cover onto the new element. Install the assembly onto the base.

8. Install the screw (1) and tighten the screw to a torque of 8 N·m (6 lb ft).

9. Remove the container and dispose of the fuel safely.

10. Open the fuel supply valve.

11. Prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" for more information.

i02223550

Fuel System Secondary Filter - Replace

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

Element filter

Turn the valves for the fuel lines (if equipped) to the OFF position before performing this maintenance. Place a tray under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel immediately.

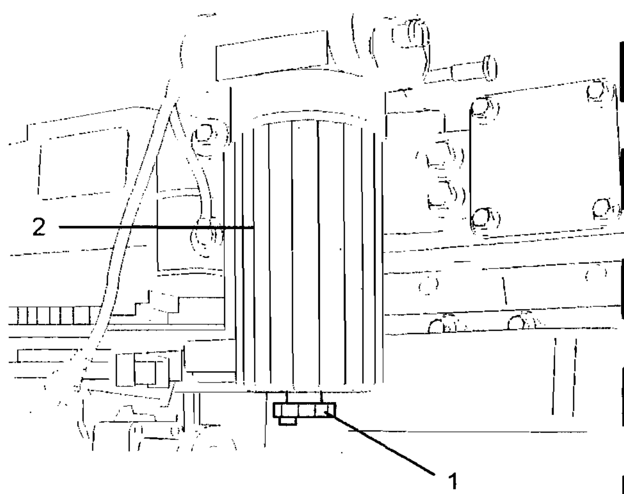

Illustration 41 g01010637

(1) Drain
(2) Filter bowl

1. Close the valves for the fuel lines (if equipped).

2. Clean the outside of the fuel filter assembly. Open the fuel drain (1) and drain the fuel into a suitable container.

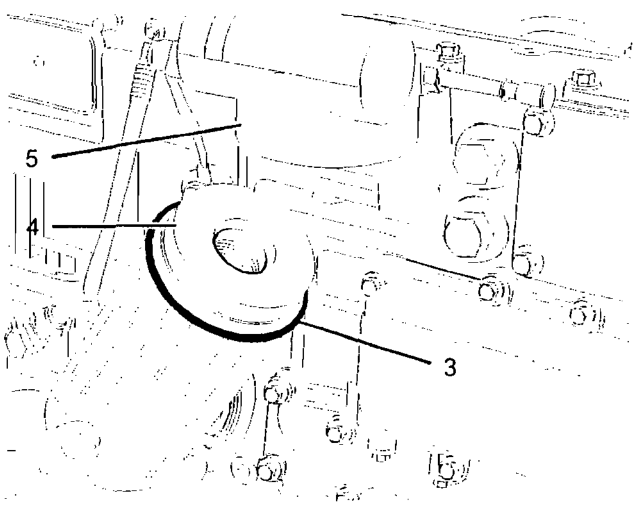

Illustration 42 g01010595

(3) O ring seal
(4) Element
(5) Filter head

3. Remove the filter bowl (2) from the filter head (5). Press on the element (4). Rotate the element counterclockwise in order to release the element for the filter bowl and remove the element from the bowl. Discard the used element.

4. Remove the O ring (3) from the filter bowl and clean the filter bowl. Check that the threads of the filter bowl are not damaged.

5. Install a new O ring seal (3) to the filter bowl (2).

6. Locate a new filter element (4) into the filter bowl. Press on the element and rotate the element clockwise in order to lock the element into the filter bowl.

7. Install the filter bowl (4) into the top of the filter head (5).

8. Tighten the filter bowl by hand until the filter bowl contacts the filter head. Rotate the filter bowl through 90 degrees.

Note: Do not use a tool to tighten the filter bowl.

9. Open the valves for the fuel lines (if equipped).

Spin-on filter

Turn the valves for the fuel lines (if equipped) to the OFF position before performing this maintenance. Place a tray under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel immediately.

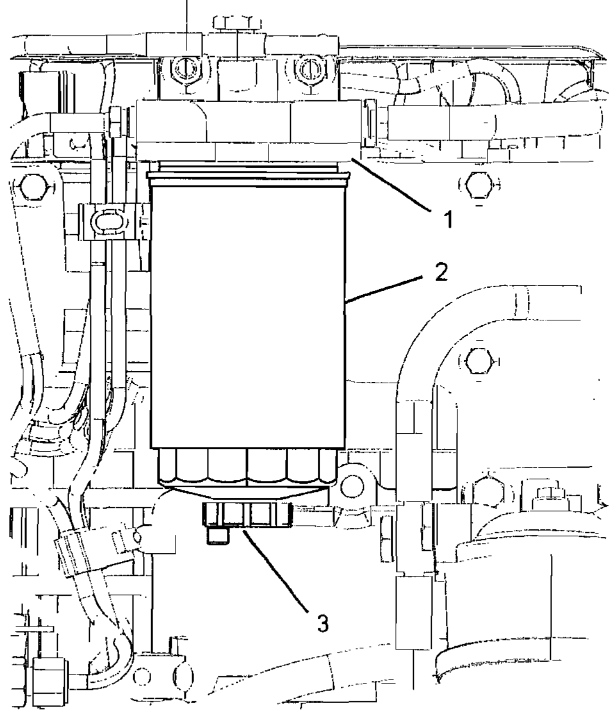

Illustration 43 g01121396

(1) Spin-on filter
(2) Drain

1. Clean the outside of the fuel filter assembly. Open the fuel drain (3) and drain the fuel into a suitable container.

2. Use a suitable tool in order to remove the spin-on filter (2) from the filter head (1).

3. Ensure that the fuel drain (3) on the new spin-on filter is closed.

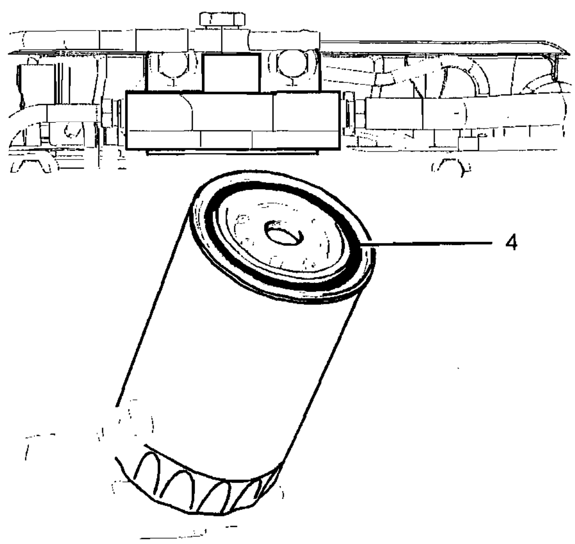

Illustration 44 g01121723

4. Lubricate the sealing ring (4) with clean fuel oil.
5. Install the spin-on filter (2) into the top of the filter head (1).
6. Tighten the spin-on filter by hand until the sealing ring contacts the filter head. Rotate the spin-on filter through 90 degrees.
7. Prime the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime".

i01938468

Fuel Tank Water and Sediment - Drain

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine or drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow five to ten minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank during the following conditions:

- Weekly
- Oil change
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i02169460

Hoses and Clamps - Inspect/Replace

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking
- Softness
- Loose clamps

Replace hoses that are cracked or soft. Tighten any loose clamps.

NOTICE
Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will harden. Hardening of the hoses will cause hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Replace the Hoses and the Clamps

Refer to the OEM information for further information on removing and replacing fuel hoses (if equipped).

The coolant system and the hoses for the coolant system are not usually supplied by Perkins. The following text describes a typical method of replacing coolant hoses. Refer to the OEM information for further information on the coolant system and the hoses for the coolant system.

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine. Allow the engine to cool.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

Note: Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.
4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.
7. Install the hose clamps with a torque wrench.

Note: For the correct coolant, see this Operation and Maintenance Manual, "Fluid Recommendations".

8. Refill the cooling system. Refer to the OEM information for further information on refilling the cooling system.

9. Clean the cooling system filler cap. Inspect the cooling system filler cap's seals. Replace the cooling system filler cap if the seals are damaged. Install the cooling system filler cap.

10. Start the engine. Inspect the cooling system for leaks.

i01907732

Radiator - Clean

The radiator is not usually supplied by Perkins. The following text describes a typical cleaning procedure for the radiator. Refer to the OEM information for further information on cleaning the radiator.

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: Damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the radiator, if necessary.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction to the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the radiator fins. Slowly move the air nozzle in a direction that is parallel with the radiator tube assembly. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

If the radiator is blocked internally, refer to the OEM Manual for information regarding flushing the cooling system.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and the drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: Welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

i0217688

Severe Service Application - Check

Severe service is the application of an engine that exceeds the current published standards for that engine. Perkins maintains standards for the following engine parameters:

- Performance such as power range, speed range, and fuel consumption
- Fuel quality
- Operational Altitude
- Maintenance intervals
- Oil selection and maintenance
- Coolant type and maintenance
- Environmental qualities
- Installation

Refer to the standards for the engine or consult your Perkins dealer or your Perkins distributor in order to determine if the engine is operating within the defined parameters.

Severe service operation can accelerate component wear. Engines that operate under severe conditions may need more frequent maintenance intervals in order to ensure maximum reliability and retention of full service life.

Due to individual applications, it is not possible to identify all of the factors which can contribute to severe service operation. Consult your Perkins dealer or your Perkins distributor for the unique maintenance that is necessary for the engine.

The operating environment, incorrect operating procedures and incorrect maintenance procedures can be factors which contribute to a severe service application.

Environmental Factors

Ambient temperatures – The engine may be exposed to extended operation in extremely cold environments or hot environments. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in very cold temperatures. Extremely hot intake air reduces engine performance.

Quality of the air – The engine may be exposed to extended operation in an environment that is dirty or dusty, unless the equipment is cleaned regularly. Mud, dirt and dust can encase components. Maintenance can be very difficult. The buildup can contain corrosive chemicals.

Buildup – Compounds, elements, corrosive chemicals and salt can damage some components.

Altitude – Problems can arise when the engine is operated at altitudes that are higher than the intended settings for that application. Necessary adjustments should be made.

Incorrect Operating Procedures

- Extended operation at low idle
- Frequent hot shutdowns
- Operating at excessive loads
- Operating at excessive speeds
- Operating outside the intended application

Incorrect Maintenance Procedures

- Extending the maintenance intervals
- Failure to use recommended fuel, lubricants and coolant/antifreeze

i02177969

Starting Motor - Inspect

Perkins recommends a scheduled inspection of the starting motor. If the starting motor fails, the engine may not start in an emergency situation.

Check the starting motor for correct operation. Check the electrical connections and clean the electrical connections. Refer to the Systems Operation, Testing and Adjusting Manual, "Electric Starting System - Test" for more information on the checking procedure and for specifications or consult your Perkins dealer or your Perkins distributor for assistance.

i02184788

Turbocharger - Inspect (If Equipped)

A regular visual inspection of the turbocharger is recommended. Any fumes from the crankcase are filtered through the air inlet system. Therefore, by-products from oil and from combustion can collect in the turbocharger compressor housing. Over time, this buildup can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE

Turbocharger bearing failures can cause large quantities of oil to enter the air intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of oil into a turbocharger under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occured.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is renewed.

A visual inspection of the turbocharger can minimize unscheduled downtime. A visual inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Removal and Installation

Note: The turbochargers that are supplied are nonserviceable.

For options regarding the removal, installation, and replacement, consult your Perkins dealer or your Perkins distributor. Refer to the Disassembly and Assembly Manual, "Turbocharger - Remove and Turbocharger - Install" for further information.

Inspecting

NOTICE
The compressor housing for the turbocharger must not be removed from the turbocharger for cleaning.

The actuator linkage is connected to the compressor housing. If the actuator linkage is moved or disturbed the engine may not comply with emmissions legislation.

1. Remove the pipe from the turbocharger exhaust outlet and remove the air intake pipe to the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.
2. Check for the presence of oil. If oil is leaking from the back side of the compressor wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the intake air (clogged air filters), which causes the turbocharger to slobber.
3. Inspect the bore of the housing of the turbine outlet for corrosion.
4. Fasten the air intake pipe and the exhaust outlet pipe to the turbocharger housing.

i02177973

Walk-Around Inspection

Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections and trash buildup. Make repairs, as needed:

- The guards must be in the correct place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE
Accumulated grease and/or oil on an engine is a fire hazard. Remove the accumulated grease and oil. Refer to this Operation and Maintenance Manual, "Engine - Clean" for more information.

- Ensure that the cooling system hoses are correctly clamped and that the cooling system hoses are tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pump for coolant leaks.

Note: The water pump seal is lubricated by the coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of the water pump and the installation of water pump and/or seal, refer to the Disassembly and Assembly Manual, "Water Pump - Remove and Install" for more information or consult your Perkins dealer or your Perkins distributor.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the rocker cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps and/or tie-wraps.
- Inspect the piping for the air intake system and the elbows for cracks and for loose clamps. Ensure that hoses and tubes are not contacting other hoses, tubes, wiring harnesses, etc.
- Inspect the alternator belts and any accessory drive belts for cracks, breaks or other damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt is replaced, the belt will carry more load than the belts that are not replaced. The older belts are stretched. The additional load on the new belt could cause the belt to break.

- Drain the water and the sediment from the fuel tank on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauge that can not be calibrated.

i01907756

Water Pump - Inspect

A failed water pump may cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head
- A piston seizure
- Other potential damage to the engine

Note: The water pump seal is lubricated by the coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and parts contract.

Visually inspect the water pump for leaks. Renew the water pump seal or the water pump if there is an excessive leakage of coolant. Refer to the Disassembly and Assembly Manual, "Water Pump - Remove and Install" for the disassembly and assembly procedure.

Warranty Section

Warranty Information

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Emissions Warranty Information

This engine may be certified to comply with exhaust emission standards and gaseous emission standards that are prescribed by the law at the time of manufacture, and this engine may be covered by an Emissions Warranty. Consult your authorized Perkins dealer or your authorized Perkins distributor in order to determine if your engine is emissions certified and if your engine is subject to an Emissions Warranty.

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FG Wilson WARRANTY Statement

This is a warranty which applies to Electric Power Generation Products sold by FG Wilson (herein after referred to as "the Company"). The products are warranted against defects in material and workmanship for a period of 12 months* (24 months for standby application limited to 500 hrs per annum) from the date of delivery to first user.

The Company's Responsibilities

If a defect in material or workmanship arises during the warranty period the Company will during normal working hours and through a place of business of a FG Wilson Dealer or other source approved by FG Wilson:

- Replace or at the Company's discretion repair the defective parts.
- Provide for reasonable and customary labour costs to correct the defect.
- Provide for the cost of service supplies such as coolant oil and filters which are made unserviceable by the defect.
- Provide travel labour, up to four hours and 250 miles round trip, if the engine is inoperative due to a defect and, in the opinion of the Company, it cannot reasonably be transported to an appropriate service location.

The User's Responsibilities

The User is responsible for:

- Installing, operating and maintaining the generator set in accordance with the manufacturer's instructions.
- Returning the Warranty Registration Form within one month of delivery.
- Ensuring initial startup is performed by an authorised representative of the company or it dealers. In exceptional circumstances, said startup will be waived but only if a Pre-Delivery Inspection has been completed. In such circumstances, warranty will be adjudged to have commenced one month and terminated 13 months after the date of shipment by the Company.
- Making the equipment available for repair as soon as the defect has become apparent.
- Accepting the Company's sole judgement as to whether the faulty part is defective in material or workmanship.
- Labour costs, except as stated under "The Company's Responsibilities," including costs beyond those required to disconnect the product from and reconnect the product to it's attached equipment, mountings and support systems.
- The costs and risks for transport/shipping and other charges associated with the replacement of the repair parts.
- Any costs in excess of the purchase price of the product.
- Other miscellaneous costs including but not limited to courier, travel, mileage, lodging, taxes, telephone calls, overtime, etc., except as stated under "The Company's Responsibilities."
- Completing any outstanding payments for the purchase of equipment, parts or services relating to the equipment under warranty.

Limitations

This warranty does not cover:

- Defects due to the user's improper installation, maintenance or use as adjudged by the Company
- Alterations or repairs not authorised by the Company in writing.
- Any operation in excess of the Company's rating or outside the stated site conditions.
- Normal wear and tear.
- Damage to parts, fixtures, housings, attachments and accessory items that are not part of the. Electric Power Generation Product.
- Any product specific hours limitations.

* Lister power generating set models have an additional running hour limitation as follows: – 5000 hrs at 1500/1800 rpm, 2000 hours at 3000 rpm and 1000 hours at 3600 rpm. Either the 12 months limitations or the running hour limitation is applicable, depending on which occurs first.

This warranty is expressly in lieu of all other warranties, express or implied, including, but not limited to, any warranty of merchantability or fitness for a particular purpose. All warranties which exceed the aforementioned obligations are hereby disclaimed by the Company and excluded from this warranty. The Company shall, under no circumstances, be held liable for any special direct, indirect, incidental or consequential damages. All claims made under this warranty should be made by contacting your local dealer or the Company who will outline the administration and scope.

Effective with sales to the first user on or after 1 September 2002

FG WILSON

WARRANTY REGISTRATION FORM

GENERATOR SET DATA

Generator Set Model / Serial No: ______________ / ______________ Duty: Standby / Prime

Engine Model / Serial No: ______________ / ______________ Volts:_________ V

Radiator Serial No: ____________________________ Rating: _______ kVA

Alternator Model / Serial No: ______________ / ______________ Phase:______

Control Panel Type / Serial No: ______________ / ______________ Frequency: _____Hz

Load Transfer Panel Type/ Serial No: ______________ / ______________

Electrical Drawing No: ____________________________

Date of Ex Factory Shipment: ____________________________

Warranty Period: 12 Months from start up

18 Months from factory shipment (includes 6 month shelf life)

END USER DATA

Company Name:____

Address:____

____

Generator Set Location: (if different)____

____

Date of Purchase: Day:_________ Month: _____ Year:________

Date of Start-Up: Day: _________ Month: _____ Year:________

Generator Set Duty: Prime / Standby Options: Skid / Trailer / Canopy / Attenuated

DISTRIBUTOR DATA

Distributor: ____

Address:____

____

Generator Set Location:_______ Miles / Kilometres from Distributor

I hereby confirm that the above generating set has been correctly installed at the above location.

Signed: ____________________ **Date:**____________ **Position:** ____________________

FG WILSON

WARRANTY REGISTRATION FORM

GENERATOR SET DATA

Generator Set Model / Serial No: ______________ / ______________ Duty: Standby / Prime

Engine Model / Serial No: ______________ / ______________ Volts:________ V

Radiator Serial No: ______________________________ Rating: ______ kVA

Alternator Model / Serial No: ______________ / ______________ Phase:______

Control Panel Type / Serial No: ______________ / ______________ Frequency: _____Hz

Load Transfer Panel Type/ Serial No: ______________ / ______________

Electrical Drawing No: ______________________________

Date of Ex Factory Shipment: ______________________________

Warranty Period: 12 Months from start up

18 Months from factory shipment (includes 6 month shelf life)

END USER DATA

Company Name:____

Address:____

____

Generator Set Location: (if different)____

____

Date of Purchase: Day:________ Month: _____ Year:_______

Date of Start-Up: Day: ________ Month: _____ Year:_______

Generator Set Duty: Prime / Standby Options: Skid / Trailer / Canopy / Attenuated

DISTRIBUTOR DATA

Distributor: ____

Address:____

____

Generator Set Location:_______ Miles / Kilometres from Distributor

I hereby confirm that the above generating set has been correctly installed at the above location.

Signed: ____________________ **Date:**____________ **Position:** ____________________

WARRANTY REGISTRATION FORM

GENERATOR SET DATA

Generator Set Model / Serial No: ______________ / ______________ Duty: Standby / Prime

Engine Model / Serial No: ______________ / ______________ Volts:________ V

Radiator Serial No: ____________________________ Rating: ______ kVA

Alternator Model / Serial No: ______________ / ______________ Phase:______

Control Panel Type / Serial No: ______________ / ______________ Frequency: _____Hz

Load Transfer Panel Type/ Serial No: ______________ / ______________

Electrical Drawing No: ____________________________

Date of Ex Factory Shipment: ____________________________

Warranty Period: 12 Months from start up

18 Months from factory shipment (includes 6 month shelf life)

END USER DATA

Company Name:____

Address:____

____

Generator Set Location: (if different)______________________________

____

Date of Purchase: Day:________ Month: _____ Year:_______

Date of Start-Up: Day: ________ Month: _____ Year:_______

Generator Set Duty: Prime / Standby Options: Skid / Trailer / Canopy / Attenuated

DISTRIBUTOR DATA

Distributor: ____

Address:____

____

Generator Set Location:______ Miles / Kilometres from Distributor

I hereby confirm that the above generating set has been correctly installed at the above location.

Signed: ____________________ **Date:**___________ **Position:** ____________________

PRE-DELIVERY INSPECTION

FG WILSON

GENERATOR SET DATA

Generator Set Model / Serial No:	____________ / ____________	Duty: Standby / Prime
Engine Model / Serial No:	____________ / ____________	Volts: ________ V
Radiator Serial No:	____________________________	Rating: _______ kVA
Alternator Model / Serial No:	____________ / ____________	Phase: _______
Control Panel Type / Serial No:	____________ / ____________	Frequency: ___ Hz
Load Transfer Panel Type/ Serial No:	____________ / ____________	✓ Inspection Satisfactory
Electrical Drawing No:	____________________________	✖ Refer to Comments
Date of Delivery to End User:	____________________________	N/A Not Applicable

LUBRICATION:

- Check all connections ☐ ____________
- Check oil level ☐ ____________
- Check protection switch ☐ ____________

FUEL:

- Check all connections (leaks, etc) ☐ ____________
- Check throttle and governor linkages ☐ ____________

AIR:

- Check air filter pipework ☐ ____________
- Check vent piping and connections ☐ ____________
- Check air flap and solenoid (if fitted) ☐ ____________

WATER:

- Check and adjust fan belts ☐ ____________
- Check antifreeze inhibitor and level (top up as necessary) ☐ ____________
- Check remote fans and pumps (if applicable) ☐ ____________
- Check radiator core and tanks (leaks, etc) ☐ ____________
- Check protection switch ☐ ____________

DC:

- Check and adjust alternator belts ☐ ____________
- Check acid level of battery (s) (top up as necessary) ☐ ____________
- Check condition of lugs and terminals ☐ ____________
- Check PCB lamps and wiring ☐ ____________

AC:

- Visually inspect windings ☐ ____________
- Check power connections ☐ ____________
- Check circuit breaker and connections ☐ ____________
- Check contactor panel connections and lamps (as applicable) ☐ ____________

HEATER: (If fitted)

- Check hose connections ☐ ____________
- Check operation ☐ ____________

OFF LOAD TEST:

Oil Pressure ____________ PSI/BAR Water Temperature ____________ °C/°F

Battery Charging Volts ____________ V AC Voltage ____________ V

Frequency ____________ Hz or RPM ____________ rpm

Other: ____________________________

SILENCER:

- Check system for fumes ☐ ____________

Comments: ____________________________

____

Distributor Name: ____________ **Signed:** ____________ **Date:** ____________

WHITE - END USER YELLOW – DEALER PINK – FGWILSON WARRANTY DEPT

PRE-DELIVERY INSPECTION

GENERATOR SET DATA

Generator Set Model / Serial No: ______________ / ______________

Engine Model / Serial No: ______________ / ______________

Radiator Serial No: ______________

Alternator Model / Serial No: ______________ / ______________

Control Panel Type / Serial No: ______________ / ______________

Load Transfer Panel Type/ Serial No: ______________ / ______________

Electrical Drawing No: ______________

Date of Delivery to End User: ______________

Duty: Standby / Prime

Volts: ________ V

Rating: _______ kVA

Phase: _______

Frequency: ___ Hz

✓	Inspection Satisfactory
✖	Refer to Comments
N/A	Not Applicable

LUBRICATION:

Check all connections
Check oil level
Check protection switch

FUEL:

Check all connections (leaks, etc)
Check throttle and govemor linkages

AIR:

Check air filter pipework
Check vent piping and connections
Check air flap and solenoid (if fitted)

WATER:

Check and adjust fan belts
Check antifreeze inhibitor and level (top up as necessary)
Check remote fans and pumps (if applicable)
Check radiator core and tanks (leaks, etc)
Check protection switch

DC:

Check and adjust alternator belts
Check acid level of battery (s) (top up as necessary)
Check condition of lugs and terminals
Check PCB lamps and wiring

AC:

Visually inspect windings
Check power connections
Check circuit breaker and connections
Check contactor panel connections and lamps (as applicable)

HEATER: (If fitted)

Check hose connections
Check operation

OFF LOAD TEST:

Oil Pressure ______________ PSI/BAR — Water Temperature ______________ °C/°F

Battery Charging Volts ______________ V — AC Voltage ______________ V

Frequency ______________ Hz or RPM ______________ rpm

Other: ______________

SILENCER:

Check system for fumes

Comments: ______________

Distributor Name: ______________ **Signed:** ______________ **Date:** ______________

WHITE - END USER YELLOW – DEALER PINK – FGWILSON WARRANTY DEPT

FG WILSON WARRANTY DEPARTMENT, OLD GLENARM ROAD, LARNE, CO.ANTRIM, BT40 IEJ, NORTHERN IRELAND

FGWPDI.DOC

PRE-DELIVERY INSPECTION

GENERATOR SET DATA

Generator Set Model / Serial No: ____________ / ____________

Engine Model / Serial No: ____________ / ____________

Radiator Serial No: ____________

Alternator Model / Serial No: ____________ / ____________

Control Panel Type / Serial No: ____________ / ____________

Load Transfer Panel Type/ Serial No: ____________ / ____________

Electrical Drawing No: ____________

Date of Delivery to End User: ____________

Duty: Standby / Prime

Volts: ________ V

Rating: ________ kVA

Phase: ________

Frequency: ____ Hz

✓	Inspection Satisfactory
✖	Refer to Comments
N/A	Not Applicable

LUBRICATION:

- Check all connections ☐ ____________
- Check oil level ☐ ____________
- Check protection switch ☐ ____________

FUEL:

- Check all connections (leaks, etc) ☐ ____________
- Check throttle and governor linkages ☐ ____________

AIR:

- Check air filter pipework ☐ ____________
- Check vent piping and connections ☐ ____________
- Check air flap and solenoid (if fitted) ☐ ____________

WATER:

- Check and adjust fan belts ☐ ____________
- Check antifreeze inhibitor and level (top up as necessary) ☐ ____________
- Check remote fans and pumps (if applicable) ☐ ____________
- Check radiator core and tanks (leaks, etc) ☐ ____________
- Check protection switch ☐ ____________

DC:

- Check and adjust alternator belts ☐ ____________
- Check acid level of battery (s) (top up as necessary) ☐ ____________
- Check condition of lugs and terminals ☐ ____________
- Check PCB lamps and wiring ☐ ____________

AC:

- Visually inspect windings ☐ ____________
- Check power connections ☐ ____________
- Check circuit breaker and connections ☐ ____________
- Check contactor panel connections and lamps (as applicable) ☐ ____________

HEATER: (If fitted)

- Check hose connections ☐ ____________
- Check operation ☐ ____________

OFF LOAD TEST:

Oil Pressure ____________ PSI/BAR   Water Temperature ____________ °C/°F

Battery Charging Volts ____________ V   AC Voltage ____________ V

Frequency ____________ Hz   or   RPM ____________ rpm

Other: ____________

SILENCER:

- Check system for fumes ☐ ____________

Comments: ____________

____

Distributor Name: ____________ **Signed:** ____________ **Date:** ____________

WHITE - END USER   YELLOW – DEALER   PINK – FGWILSON WARRANTY DEPT

COMMISSIONING SHEET

GENERATOR SET DATA

Generator Set Model / Serial No: ______________ / ______________

Engine Model / Serial No: ______________ / ______________

Radiator Serial No: ______________

Alternator Model / Serial No: ______________ / ______________

Control Panel Type / Serial No: ______________ / ______________

Load Transfer Panel Type/ Serial No: ______________ / ______________

Electrical Drawing No: ______________

Date of Commissioning: ______________

Duty: Standby / Prime

Volts: ________V

Rating: _______kVA

Phase: _______

Frequency: ___ Hz

✓ Inspection Satisfactory

✗ Refer to Comments

N/A Not Applicable

END USER DATA

Company Name: ______________

Address: ______________

____

Genset Location: ______________

____

Fuel System	☐	Fuse and Fuse Ratings	☐
Water Level and Additives	☐	Manuals/Drawings Available and Correct	☐
Lube Oil Level	☐	Load Test	☐
Battery Electrolyte Level	☐	Exhaust System	☐
Battery Terminals and Wiring	☐	Cooling System	☐
Belt Tensions	☐	Jacket Water/Oil Heater	☐
Radiator and Alternator Guards	☐	Crankcase Breather System	☐
Electrical Instruments	☐	Air Filtration System	☐
Engine Instruments	☐	Battery Charging System Engine/Trickle	☐
Engine Temperature	______ °C	Mains Fail System Functional Operation	☐
Engine Oil Pressure	Bar	Panel Functional Operation	☐
Earth Connections	☐	Changeover Panel Functional Operation	☐
Electrical Connections Power	☐	Main Circuit Breaker Functional Operation	☐
Electrical Connections Control	☐	Motor Controls	☐
Alarm and Shutdown Devices	☐	Synchronisisng Equipment	☐
Enclosure	☐	Vibration	☐
Phase Rotation	☐	Running Gear	☐

Comments: ______________

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IT IS THE RESPONSIBILITY OF THE END USER TO ENSURE ALL OILS ARE AS PER MANUFACTURER'S RECOMMENDATION AND A SERVICE PERIOD IS ESTABLISHED AND ADHERED TO AS FAILURE TO DO SO COULD RESULT IN WARRANTY BECOMING INOPERATIVE.

Machine satisfactorily commissioned and handed over subject to comments:

Distributor Name: ______________ **Signed:** ______________ **Date:** ______________

End User Signed: ______________

WHITE - END USER YELLOW – DEALER PINK – FGWILSON WARRANTY DEPT

COMMISSIONING SHEET

GENERATOR SET DATA

Generator Set Model / Serial No: ____________ / ____________
Engine Model / Serial No: ____________ / ____________
Radiator Serial No: ____________
Alternator Model / Serial No: ____________ / ____________
Control Panel Type / Serial No: ____________ / ____________
Load Transfer Panel Type/ Serial No: ____________ / ____________
Electrical Drawing No: ____________
Date of Commissioning: ____________

Duty: Standby / Prime
Volts: ________V
Rating: _______kVA
Phase: _______
Frequency: ____ Hz

✓	Inspection Satisfactory
×	Refer to Comments
N/A	Not Applicable

END USER DATA

Company Name: ____________

Address: ____________

____

Genset Location: ____________

____

Fuel System		Fuse and Fuse Ratings	
Water Level and Additives		Manuals/Drawings Available and Correct	
Lube Oil Level		Load Test	
Battery Electrolyte Level		Exhaust System	
Battery Terminals and Wiring		Cooling System	
Belt Tensions		Jacket Water/Oil Heater	
Radiator and Alternator Guards		Crankcase Breather System	
Electrical Instruments		Air Filtration System	
Engine Instruments		Battery Charging System Engine/Trickle	
Engine Temperature	______ °C	Mains Fail System Functional Operation	
Engine Oil Pressure	______ Bar	Panel Functional Operation	
Earth Connections		Changeover Panel Functional Operation	
Electrical Connections Power		Main Circuit Breaker Functional Operation	
Electrical Connections Control		Motor Controls	
Alarm and Shutdown Devices		Synchronisisng Equipment	
Enclosure		Vibration	
Phase Rotation		Running Gear	

Comments: ____________

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IT IS THE RESPONSIBILITY OF THE END USER TO ENSURE ALL OILS ARE AS PER MANUFACTURER'S RECOMMENDATION AND A SERVICE PERIOD IS ESTABLISHED AND ADHERED TO AS FAILURE TO DO SO COULD RESULT IN WARRANTY BECOMING INOPERATIVE.

Machine satisfactorily commissioned and handed over subject to comments:

Distributor Name: ____________ **Signed:** ____________ **Date:** ____________

End User Signed: ____________

WHITE - END USER YELLOW – DEALER PINK – FGWILSON WARRANTY DEPT

COMMISSIONING SHEET

GENERATOR SET DATA

Generator Set Model / Serial No:	____________ / ____________	Duty: Standby / Prime
Engine Model / Serial No:	____________ / ____________	Volts: ________V
Radiator Serial No:	____________	Rating: _______kVA
Alternator Model / Serial No:	____________ / ____________	Phase: _______
Control Panel Type / Serial No:	____________ / ____________	Frequency: ___ Hz
Load Transfer Panel Type/ Serial No:	____________ / ____________	✓ Inspection Satisfactory
Electrical Drawing No:	____________	× Refer to Comments
Date of Commissioning:	____________	N/A Not Applicable

END USER DATA

Company Name: ____

Address: ____

____

Genset Location: ____

____

Fuel System	☐	Fuse and Fuse Ratings	☐
Water Level and Additives	☐	Manuals/Drawings Available and Correct	☐
Lube Oil Level	☐	Load Test	☐
Battery Electrolyte Level	☐	Exhaust System	☐
Battery Terminals and Wiring	☐	Cooling System	☐
Belt Tensions	☐	Jacket Water/Oil Heater	☐
Radiator and Alternator Guards	☐	Crankcase Breather System	☐
Electrical Instruments	☐	Air Filtration System	☐
Engine Instruments	☐	Battery Charging System Engine/Trickle	☐
Engine Temperature	_____ °C	Mains Fail System Functional Operation	☐
Engine Oil Pressure	_____ Bar	Panel Functional Operation	☐
Earth Connections	☐	Changeover Panel Functional Operation	☐
Electrical Connections Power	☐	Main Circuit Breaker Functional Operation	☐
Electrical Connections Control	☐	Motor Controls	☐
Alarm and Shutdown Devices	☐	Synchronisisng Equipment	☐
Enclosure	☐	Vibration	☐
Phase Rotation	☐	Running Gear	☐

Comments: ____

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IT IS THE RESPONSIBILITY OF THE END USER TO ENSURE ALL OILS ARE AS PER MANUFACTURER'S RECOMMENDATION AND A SERVICE PERIOD IS ESTABLISHED AND ADHERED TO AS FAILURE TO DO SO COULD RESULT IN WARRANTY BECOMING INOPERATIVE.

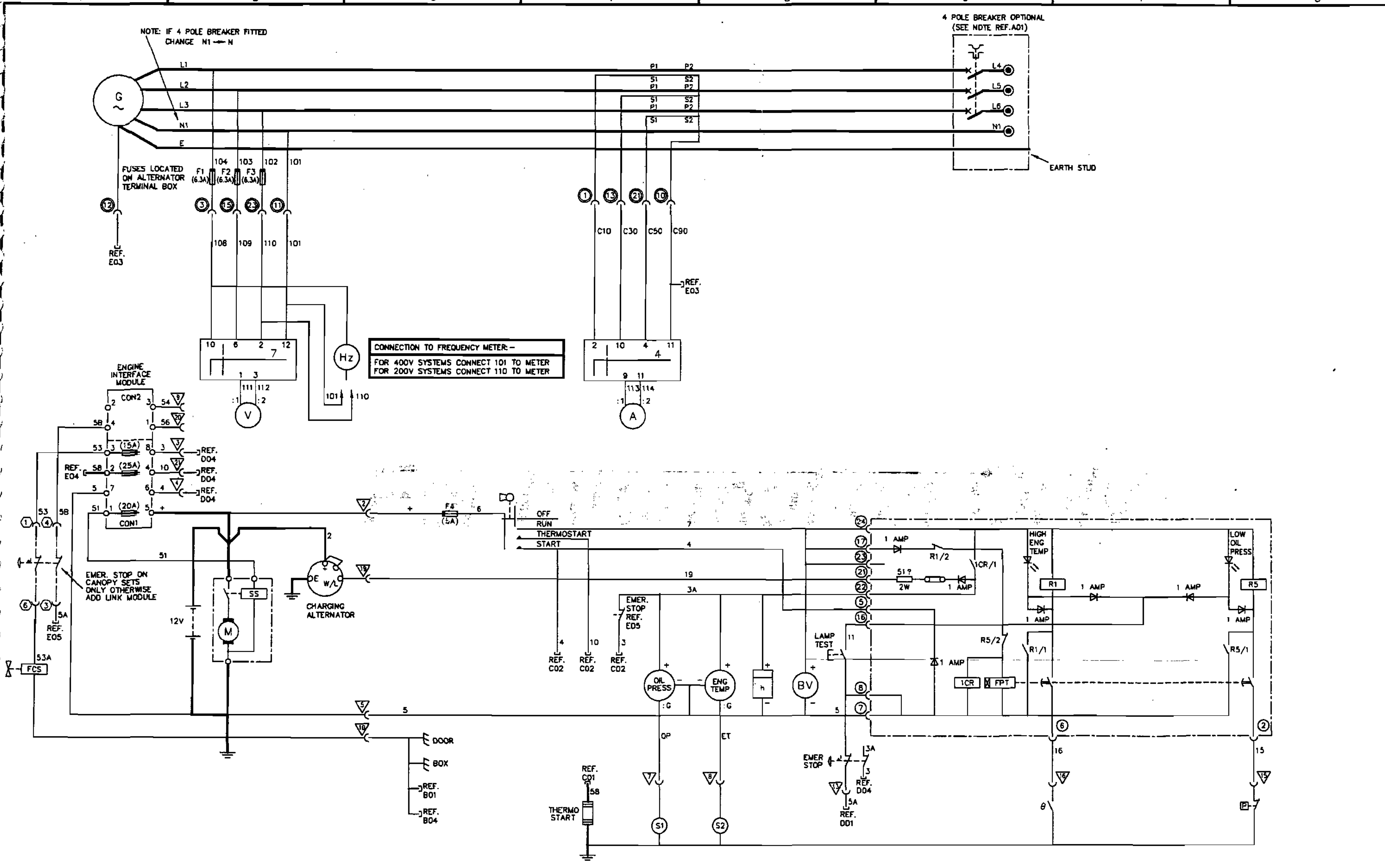
Machine satisfactorily commissioned and handed over subject to comments:

Distributor Name: ____________________ **Signed:** ____________________ **Date:** ____________

End User Signed: ____________________

WHITE - END USER YELLOW – DEALER PINK – FGWILSON WARRANTY DEPT

This Drawing when printed is only valid for 14 Days from this Date 20/10/2005



J	LOW VOLTAGE CONNECTION DETAIL AMENDED	21333	G.A.W.	22/01/03
H	WIRING TO EIM AMENDED	-	S.J.B	23-03-01
G	EMER. STOP LOOM ADDED	-	J.M.	21-03-01
F	DRAWING FRAME AMENDED	-	J.C.	28-05-98
ISSUE	DESCRIPTION	ECR/DCR	BY	DATE

⑤ 6 WAY CONNECTOR ON EMER. STOP LOOM	
O INTERNAL PANEL TERMINAL	D.C. CONNECTOR FROM ENGINE
◉ CUSTOMER POWER CONNECTION	A.C. CONNECTOR FROM ALTERNATOR
SPADE PIN CONNECTION ON ENGINE	⑧ PLUG/SOCKET ON P.C.B. 650-044

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DO NOT SCALE

DRN. BY	A.W.B
DATE	25-06-96
APPD. BY	
DATE	24/01/03

TITLE: WIRING DIAGRAM OF 1001 SERIES PANEL FOR 12V DC PERKINS ENGINE. (EIM-SR)

SHEET SIZE	ORIGINAL SCALE	DRAWING NO.	ISSUE
A3	N.T.S.	D18493	J

ANNEXURE 1

REPORT

ON

ENVIROMENTAL CONDITIONING SYSTEM

OF

NPSL

MARCH, 2009

Submmitted by: Rao Jamil-ur-Rehman
(Project Director)

PERFORMANCE TESTS CONDUCTED JOINTLY
BY
NPSL, MUSTEHKUM CONSTRUCTION, & UNIDO

(UNIDO Project No. EU/PAK/04/ 001. ECS for NPSL Metrological Laboratories 16-H-9 Islamabad)

Mass Standards Laboratory Room 01		
Description	**Design Conditions**	**Average of Observed Test Conditions**
Length x Breath x Height	34'-6" x 16'-0" x 9'-10"	34'-6" x 16'-0" x 9'-10"
Operational Temperature	20°C	20°C
Room Temperature setting possibility	18 °C-25 °C	18 °C-25 °C
Temperature uniformity in controlled volume	$\pm$0.5 °C	−0.5 + 0.0 °C
Temperature Stability in 24 Hours Period	$\pm$0.5 °C	−0.5 + 0.0 °C (Avg.19.68 °C)
Air Quality	Federal Standard – Class 10,000	< 10,000
Sound Level	Less Then 45dB(A)	< 45dB(A)
Relative Humidity	45% (RH) $\pm$ 5% (RH)	−2.7 + 1.4 %RH (Avg.44.75 %RH)
Lighting Level	750 lux	>750 lux
Over Pressure	10Pa	10,- 0.1 Pa(Avg. 9.94)
Fresh Air Supply	5% of re-circuiting Air	5%
Velocity of Air in Controlled Volume	Less Then 1.0 m/s	< 1.0 m/s
Heat Generated by Equipment & Lighting	1.2 k.W	1.2 k.W
Total Number of People Present	3	<5
Special Exhaust Port	1	1

SIC Lab:

17-03-09

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

DETAILED PERFORMANCE TESTS OF TEMPERATURE, HUMIDTY & PRESSURE
CONDUCTED JOINTLY BY
NPSL, MUSTEHKUM, & UNIDO

Laboratory: Mass Standards Lab

Room No: 01

Date	Time	As per ToR's Temp °C	Observed Temp °C on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab Temp °C	As per ToR's % RH	Observed % RH on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab % RH	As per ToR's Pa	Reading of the Tested Gauge	Reading of the Sensor mounted in the lab Pa	Outer Air	
											Temp °C	RH%
05-03-2009	10.00pm	20 ± 0.5	19.71	20.0	45 ± 5	43.34	45.3	10	9.9	9	25.9	35.3
	12.00pm	20 ± 0.5	19.92	20.0	45 ± 5	45.20	44.7	10	9.9	9	26.7	38.3
	14.00pm	20 ± 0.5	19.82	20.1	45 ± 5	46.41	45.2	10	9.9	10	27.5	37.2
	16.00pm	20 ± 0.5	19.87	20.2	45 ± 5	44.30	46.1	10	9.9	10	25.2	45.1
06-03-2009	10.00pm	20 ± 0.5	19.73	20.2	45 ± 5	44.10	45.0	10	10	9	27.2	36.5
	12.00pm	20 ± 0.5	19.64	20.1	45 ± 5	44.30	45.2	10	10	10	27.9	37.6
	14.00pm	20 ± 0.5	19.56	20.2	45 ± 5	42.30	45.3	10	9.9	8	27.1	39.4
	16.00pm	20 ± 0.5	19.50	20.0	45 ± 5	46.10	47.0	10	9.9	9	26.5	33.4
07-03-2009	10.00pm	20 ± 0.5	19.52	20.3	45 ± 5	43.92	43.0	10	9.9	8	27.1	37.2
	12.00pm	20 ± 0.5	19.52	20.2	45 ± 5	46.10	41.7	10	10	9	28.1	35.5
	14.00pm	20 ± 0.5	19.67	20.5	45 ± 5	46.70	44.5	10	10	8	25.8	42.2
	16.00pm	20 ± 0.5	19.65	20.2	45 ± 5	44.19	42.5	10	10	9	25.0	46.0

~~SIC Lab:~~ 17-03-09
Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

PERFORMANCE TESTS CONDUCTED JOINTLY
BY
NPSL, MUSTEHKUM CONSTRUCTION, & UNIDO

(UNIDO Project No. EU/PAK/04/ 001. ECS for NPSL Metrological Laboratories 16-H-9 Islamabad)

Volume Standards Laboratory Room 02		
Description	**Design Conditions**	**Average of Observed Test Conditions**
Length x Breath x Height	11'-6" x 16'-0" x 9'-10"	11'-6" x 16'-0" x 9'-10"
Operational Temperature	20°C	20°C
Room Temperature setting possibility	18 °C-25 °C	18 °C-25 °C
Temperature uniformity in controlled volume	±0.5 °C	+ 0.0 – 0.4 °C
Temperature Stability in 24 Hours Period	±0.5 °C	+0.0 –0.4 (Avg.19.75 °C)
Air Quality	Federal Standard – Class 10,000	< 10,000
Sound Level	Less Then 45dB(A)	< 45dB(A)
Relative Humidity	45% (RH) ± 5% (RH)	+1.2 – 1.9 % RH (Avg.44.35 %RH)
Lighting Level	750 lux	>750 lux
Over Pressure	10Pa	10, - 0.2 (Avg. 9.96 Pa)
Fresh Air Supply	5% of re-circuiting Air	5%
Velocity of Air in Controlled Volume	Less Then 1.0 m/s	< 1.0 m/s
Heat Generated by Equipment & Lighting	1.2 k.W	>1.2 k.W
Total Number of People Present	3	<5
Special Exhaust Port	1	1

SIC Lab: 17-03-09

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

DETAILED PERFORMANCE TESTS OF TEMPERATURE, HUMIDTY & PRESSURE
CONDUCTED JOINTLY BY
NPSL, MUSTEHKUM, & UNIDO

Laboratory: Volume Standards Lab

Room No: 02

Date	Time	As per ToR's Temp °C	Observed Temp °C on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab Temp °C	As per ToR's % RH	Observed % RH on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab % RH	As per ToR's Pa	Reading of the Tested Gauge	Reading of the Sensor mounted in the lab Pa	Outer Air	
											Temp °C	RH%
05-03-2009	10.00pm	20 ± 0.5	19.64	19.9	45 ± 5	44.90	46.5	10	9.9	10	25.9	35.3
	12.00pm	20 ± 0.5	19.73	19.8	45 ± 5	46.21	47.0	10	10	10	26.7	38.3
	14.00pm	20 ± 0.5	19.81	19.7	45 ± 5	45.40	47.3	10	9.9	9	27.5	37.2
	16.00pm	20 ± 0.5	19.54	19.8	45 ± 5	43.10	46.0	10	9.9	10	25.2	45.1
06-03-2009	10.00pm	20 ± 0.5	19.82	20.0	45 ± 5	44.30	43.3	10	9.9	10	27.2	36.5
	12.00pm	20 ± 0.5	19.71	20.0	45 ± 5	44.22	42.1	10	9.9	9	27.9	37.6
	14.00pm	20 ± 0.5	19.59	20.1	45 ± 5	43.30	42.5	10	9.8	9	27.1	39.4
	16.00pm	20 ± 0.5	19.80	20.2	45 ± 5	45.41	47.0	10	10	10	26.5	33.4
07-03-2009	10.00pm	20 ± 0.5	19.63	20.1	45 ± 5	43.77	42.0	10	9.8	9	27.1	37.2
	12.00pm	20 ± 0.5	19.89	20.2	45 ± 5	43.85	41.6	10	9.9	9	28.1	35.5
	14.00pm	20 ± 0.5	19.96	20.2	45 ± 5	43.70	42.2	10	9.9	9	25.8	42.2
	16.00pm	20 ± 0.5	19.84	20.2	45 ± 5	44.00	42.3	10	10	10	25.0	46.0

SIC Lab: 17-03-09

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

PERFORMANCE TESTS CONDUCTED JOINTLY
BY
NPSL, MUSTEHKUM CONSTRUCTION, & UNIDO

(UNIDO Project No. EU/PAK/04/ 001. ECS for NPSL Metrological Laboratories 16-H-9 Islamabad)

Pressure Standards Laboratory Room 03		
Description	**Design Conditions**	**Average of Observed Test Conditions**
Length x Breath x Height	11'-0" x 16'-0" x 9'-10"	11'-0" x 16'-0" x 9'-10"
Operational Temperature	20°C	20°C
Room Temperature setting possibility	18 °C-25 °C	18 °C-25 °C
Temperature uniformity in controlled volume	±0.5 °C	− 0.5 + 0.1 °C
Temperature Stability in 24 Hours Period	±0.5 °C	− 0.5 + 0.1 °C (Avg. 19.61 °C)
Air Quality	Federal Standard – Class 10,000	< 10,000
Sound Level	Less Then 45dB(A)	< 45dB(A)
Relative Humidity	45% (RH) ± 5% (RH)	+4.3 − 3.9 %RH (Avg.43.59 %RH)
Lighting Level	750 lux	>750 lux
Over Pressure	10Pa	10, - 0.1(Avg. 9.9 Pa)
Fresh Air Supply	5% of re-circuiting Air	5%
Velocity of Air in Controlled Volume	Less Then 1.0 m/s	< 1.0 m/s
Heat Generated by Equipment & Lighting	1.2 k.W	1.2 k.W
Total Number of People Present	3	3
Special Exhaust Port	1	1

SIC Lab: afzh CH

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

DETAILED PERFORMANCE TESTS OF TEMPERATURE, HUMIDTY & PRESSURE
CONDUCTED JOINTLY BY
NPSL, MUSTEHKUM, & UNIDO

Laboratory: Pressure Standards Lab

Room No: 03

Date	Time	As per ToR's Temp °C	Observed Temp °C on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab Temp °C	As per ToR's % RH	Observed % RH on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab % RH	As per ToR's Pa	Reading of the Tested Gauge	Reading of the Sensor mounted in the lab Pa	Outer Air Temp °C	Outer Air RH%
05-03-2009	10.00pm	20 ± 0.5	19.51	19.6	45 ± 5	41.10	42.9	10	9.9	11	25.9	35.3
	12.00pm	20 ± 0.5	19.64	19.7	45 ± 5	44.52	43.7	10	9.9	11	26.7	38.3
	14.00pm	20 ± 0.5	19.60	19.8	45 ± 5	43.80	42.9	10	9.9	10	27.5	37.2
	16.00pm	20 ± 0.5	19.50	19.7	45 ± 5	43.10	44.5	10	9.9	10	25.2	45.1
06-03-2009	10.00pm	20 ± 0.5	19.58	20.0	45 ± 5	43.21	44.5	10	9.8	11	27.2	36.5
	12.00pm	20 ± 0.5	19.53	20.0	45 ± 5	42.90	42.7	10	9.8	11	27.9	37.6
	14.00pm	20 ± 0.5	19.70	20.1	45 ± 5	43.40	42.5	10	9.9	10	27.1	39.4
	16.00pm	20 ± 0.5	20.10	20.0	45 ± 5	47.00	49.3	10	10	9	26.5	33.4
07-03-2009	10.00pm	20 ± 0.5	19.50	19.9	45 ± 5	43.67	41.9	10	9.9	11	27.1	37.2
	12.00pm	20 ± 0.5	19.50	20.1	45 ± 5	43.49	41.0	10	10	11	28.1	35.5
	14.00pm	20 ± 0.5	19.54	20.1	45 ± 5	43.00	41.3	10	9.8	9	25.8	42.2
	16.00pm	20 ± 0.5	19.53	20.1	45 ± 5	43.74	41.5	10	10	9	25.0	46.0

SIC Lab: a/rh CH

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

PERFORMANCE TESTS CONDUCTED JOINTLY
BY
NPSL, MUSTEHKUM CONSTRUCTION, & UNIDO

(UNIDO Project No. EU/PAK/04/ 001. ECS for NPSL Metrological Laboratories 16-H-9 Islamabad)

Length Standards Laboratory Room 04		
Description	**Design Conditions**	**Average of Observed Test Conditions**
Length x Breath x Height	34'-6" x 16'-0" x 9'-10"	34'-6" x 16'-0" x 9'-10"
Operational Temperature	20°C	20°C
Room Temperature setting possibility	18 °C-25 °C	18 °C-25 °C
Temperature uniformity in controlled volume	±0.5 °C	+ 0.2 – 0.2 °C
Temperature Stability in 24 Hours Period	±0.5 °C	+0.2 – 0.2 °C (Avg.19.74 °C)
Air Quality	Federal Standard – Class 10,000	< 10,000
Sound Level	Less Then 45dB(A)	< 45dB(A)
Relative Humidity	45% (RH) ± 5% (RH)	+2.8 – 2.8 %RH (Avg.46.31 %RH)
Lighting Level	750 lux	>750 lux
Over Pressure	10Pa	10,- 0.1 (Avg. 9.9 Pa)
Fresh Air Supply	5% of re-circuiting Air	5%
Velocity of Air in Controlled Volume	Less Then 1.0 m/s	< 1.0 m/s
Heat Generated by Equipment & Lighting	1.2 k.W	>1.2 k.W
Total Number of People Present	3	<5
Special Exhaust Port	1	1

SIC Lab: Masood Ahmed

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

DETAILED PERFORMANCE TESTS OF TEMPERATURE, HUMIDTY & PRESSURE
CONDUCTED JOINTLY BY
NPSL, MUSTEHKUM, & UNIDO

Laboratory: Length Standards Lab

Room No: 04

Date	Time	As per ToR's Temp °C	Observed Temp °C on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab Temp °C	As per ToR's % RH	Observed % RH on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab % RH	As per ToR's Pa	Reading of the Tested Gauge	Reading of the Sensor mounted in the lab Pa	Outer Air Temp °C	Outer Air RH%
05-03-2009	10.00pm	20 ± 0.5	19.84	20.0	45 ± 5	46.82	44.2	10	10	9	25.9	35.3
	12.00pm	20 ± 0.5	19.92	20.1	45 ± 5	47.50	45.3	10	10	9	26.7	38.3
	14.00pm	20 ± 0.5	19.71	20.1	45 ± 5	47.80	47.7	10	9.9	9	27.5	37.2
	16.00pm	20 ± 0.5	19.83	20.2	45 ± 5	47.93	46.6	10	10	10	25.2	45.1
06-03-2009	10.00pm	20 ± 0.5	19.81	19.9	45 ± 5	44.91	45.8	10	9.9	10	27.2	36.5
	12.00pm	20 ± 0.5	19.53	19.8	45 ± 5	43.81	45.7	10	9.8	9	27.9	37.6
	14.00pm	20 ± 0.5	20.10	19.8	45 ± 5	46.41	47.2	10	10	10	27.1	39.4
	16.00pm	20 ± 0.5	19.72	20.2	45 ± 5	47.80	48.0	10	9.9	9	26.5	33.4
07-03-2009	10.00pm	20 ± 0.5	19.67	19.9	45 ± 5	45.58	42.2	10	9.8	10	27.1	37.2
	12.00pm	20 ± 0.5	19.60	19.9	45 ± 5	46.00	44.7	10	9.9	10	28.1	35.5
	14.00pm	20 ± 0.5	19.58	20.0	45 ± 5	45.89	47.0	10	9.9	10	25.8	42.2
	16.00pm	20 ± 0.5	19.52	19.9	45 ± 5	45.25	46.2	10	9.9	11	25.0	46.0

SIC Lab: Masood A Cod

Project Director: [signature]

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

PERFORMANCE TESTS CONDUCTED JOINTLY
BY
NPSL, MUSTEHKUM CONSTRUCTION, & UNIDO

(UNIDO Project No. EU/PAK/04/ 001. ECS for NPSL Metrological Laboratories 16-H-9 Islamabad)

Temperature Standards Laboratory Room 05		
Description	**Design Conditions**	**Average of Observed Test Conditions**
Length x Breath x Height	22'-9" x 19'-0" x 9'-10"	22'-9" x 19'-0" x 9'-10"
Operational Temperature	23°C	23°C
Room Temperature setting possibility	18 °C-25 °C	18 °C-25 °C
Temperature uniformity in controlled volume	± 1.0 °C	+ 0.0 – 1 °C
Temperature Stability in 24 Hours Period	± 1.0 °C	+ 0.0 – 1 °C (Avg. 22 °C)
Air Quality	Federal Standard – Class 10,000	< 10,000
Sound Level	Less Then 45dB(A)	< 45dB(A)
Relative Humidity	45% (RH) ± 5% (RH)	+0 – 3 %RH (Avg. 42 %RH)
Lighting Level	750 lux	>750 lux
Over Pressure	10Pa	10, – 0.2 (Avg.9.8 Pa)
Fresh Air Supply	5% of re-circuiting Air	5%
Velocity of Air in Controlled Volume	Less Then 1.0 m/s	< 1.0 m/s
Heat Generated by Equipment & Lighting	4.2 k.W	4.2 k.W
Total Number of People Present	4	4
Special Exhaust Port	1	1

SIC Lab:

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

DETAILED PERFORMANCE TESTS OF TEMPERATURE, HUMIDTY & PRESSURE
CONDUCTED JOINTLY BY
NPSL, MUSTEHKUM, & UNIDO

Laboratory: Temperature Standards Lab

Room No: 05

Date	Time	As per ToR's Temp °C	Observed Temp °C on Certified Psychrometer (MC)	Reading of the Sensor mounted in the lab Temp °C	As per ToR's % RH	Observed % RH on Certified Psychrometer (MC)	Reading of the Sensor mounted in the lab % RH	As per ToR's Pa	Reading of the Tested Gauge	Reading of the Sensor mounted in the lab Pa	Outer Air	
											Temp °C	RH%
05-03-2009	10.00pm	23 ± 1	22.0	22.1	45± 5	42.0	45.0	10	9.8	10	25.9	35.3
	12.00pm	23 ± 1	22.0	22.1	45± 5	42.0	45.0	10	9.9	10	26.7	38.3
	14.00pm	23 ± 1	22.0	22.3	45± 5	42.0	42.0	10	9.8	10	27.5	37.2
	16.00pm	23 ± 1	22.0	22.5	45± 5	42.0	45.6	10	9.9	10	25.2	45.1
06-03-2009	10.00pm	23 ± 1	22.0	22.8	45± 5	42.0	45.7	10	9.8	9	27.2	36.5
	12.00pm	23 ± 1	22.0	22.8	45± 5	42.0	46.0	10	9.9	9	27.9	37.6
	14.00pm	23 ± 1	22.0	22.9	45± 5	42.0	42.00	10	9.9	8	27.1	39.4
	16.00pm	23 ± 1	22.0	22.7	45± 5	42.0	42.00	10	9.9	9	26.5	33.4
07-03-2009	10.00pm	23 ± 1	22.0	23.0	45± 5	42.0	46.7	10	10	9	27.1	37.2
	12.00pm	23 ± 1	22.0	23.0	45± 5	42.0	46.8	10	9.9	10	28.1	35.5
	14.00pm	23 ± 1	22.0	23.0	45± 5	42.0	46.9	10	9.8	10	25.8	42.2
	16.00pm	23 ± 1	22.0	23.0	45± 5	42.0	46.9	10	9.8	10	25.0	46.0

SIC Lab:

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

PERFORMANCE TESTS CONDUCTED JOINTLY
BY
NPSL, MUSTEHKUM CONSTRUCTION, & UNIDO

(UNIDO Project No. EU/PAK/04/ 001. ECS for NPSL Metrological Laboratories 16-H-9 Islamabad)

Electrical−1 Standards Laboratory Room 06		
Description	**Design Conditions**	**Average of Observed Test Conditions**
Length x Breath x Height	11'-0" x 19'-0" x 9'-10"	11'-0" x 19'-0" x 9'-10"
Operational Temperature	20°C	20°C
Room Temperature setting possibility	18 °C-25 °C	18 °C-25 °C
Temperature uniformity in controlled volume	±0.5 °C	+ 0.0 – 0.38 °C
Temperature Stability in 24 Hours Period	±0.5 °C	± 0.0 – 0.38 °C (Avg. 19.79 °C)
Air Quality	Federal Standard – Class 10,000	< 10,000
Sound Level	Less Then 45dB(A)	< 45dB(A)
Relative Humidity	45% (RH) ± 5% (RH)	+0 – 4.8 %RH (Avg. 41.85 %RH)
Lighting Level	750 lux	>750 lux
Over Pressure	10Pa	10, – 0.2 (Avg.9.8 Pa)
Fresh Air Supply	5% of re-circuiting Air	5%
Velocity of Air in Controlled Volume	Less Then 1.0 m/s	< 1.0 m/s
Heat Generated by Equipment & Lighting	2.5 k.W	1.2 k.W
Total Number of People Present	3	<5
Special Exhaust Port	1	1

SIC Lab:

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

DETAILED PERFORMANCE TESTS OF TEMPERATURE, HUMIDTY & PRESSURE
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Laboratory: Electrical-1 Standards Lab

Room No: 06

Date	Time	As per ToR's Temp °C	Observed Temp °C on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab Temp °C	As per ToR's % RH	Observed % RH on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab % RH	As per ToR's Pa	Reading of the Tested Gauge	Reading of the Sensor mounted in the lab Pa	Outer Air	
											Temp °C	RH%
05-03-2009	10.00pm	20 ± 0.5	19.62	20.2	45 ± 5	42.13	43.0	10	9.8	10	25.9	35.3
	12.00pm	20 ± 0.5	19.78	20.2	45 ± 5	43.16	43.1	10	9.8	9	26.7	38.3
	14.00pm	20 ± 0.5	19.91	20.3	45 ± 5	40.50	42.5	10	9.9	9	27.5	37.2
	16.00pm	20 ± 0.5	19.78	19.9	45 ± 5	41.91	41.7	10	10	10	25.2	45.1
06-03-2009	10.00pm	20 ± 0.5	19.63	20.3	45 ± 5	41.22	44.3	10	10	9	27.2	36.5
	12.00pm	20 ± 0.5	19.87	20.2	45 ± 5	40.11	43.6	10	9.9	9	27.9	37.6
	14.00pm	20 ± 0.5	19.92	20.5	45 ± 5	40.60	42.3	10	9.9	9	27.1	39.4
	16.00pm	20 ± 0.5	19.91	20.5	45 ± 5	40.30	42.2	10	9.8	9	26.5	33.4
07-03-2009	10.00pm	20 ± 0.5	19.71	20.0	45 ± 5	42.84	41.8	10	9.8	9	27.1	37.2
	12.00pm	20 ± 0.5	19.65	20.3	45 ± 5	41.72	40.4	10	9.9	9	28.1	35.5
	14.00pm	20 ± 0.5	19.80	20.5	45 ± 5	40.95	41.1	10	9.8	8	25.8	42.2
	16.00pm	20 ± 0.5	19.90	20.5	45 ± 5	42.72	40.6	10	9.8	9	25.0	46.0

SIC Lab:

Project Director:

Jamil Ahmad Chaudhry,
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NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

PERFORMANCE TESTS CONDUCTED JOINTLY
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(UNIDO Project No. EU/PAK/04/ 001. ECS for NPSL Metrological Laboratories 16-H-9 Islamabad)

Electrical–2 Standards Laboratory Room 07		
Description	**Design Conditions**	**Average of Observed Test Conditions**
Length x Breath x Height	11'-0" x 19'-0" x 9'-10"	11'-0" x 19'-0" x 9'-10"
Operational Temperature	20°C	20°C
Room Temperature setting possibility	18 °C-25 °C	18 °C-25 °C
Temperature uniformity in controlled volume	±0.5 °C	+ 0.25 – 0.47 °C
Temperature Stability in 24 Hours Period	±0.5 °C	+ 0.25 – 0.47 °C (Avg. 19.66 °C)
Air Quality	Federal Standard – Class 10,000	< 10,000
Sound Level	Less Then 45dB(A)	< 45dB(A)
Relative Humidity	45% (RH) ± 5% (RH)	+2.2 – 4.4 %RH (Avg. 44.07 %RH)
Lighting Level	750 lux	750 lux
Over Pressure	10Pa	10, – 0.1 (Avg.9.9 Pa)
Fresh Air Supply	5% of re-circuiting Air	5%
Velocity of Air in Controlled Volume	Less Then 1.0 m/s	< 1.0 m/s
Heat Generated by Equipment & Lighting	2.5 k.W	1.2 k.W
Total Number of People Present	3	<5
Special Exhaust Port	1	1

SIC Lab:

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

DETAILED PERFORMANCE TESTS OF TEMPERATURE, HUMIDTY & PRESSURE
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Laboratory: Electrical-2 Standard Lab

Room No: 07

Date	Time	As per ToR's Temp °C	Observed Temp °C on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab Temp °C	As per ToR's % RH	Observed % RH on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab % RH	As per ToR's Pa	Reading of the Tested Gauge	Reading of the Sensor mounted in the lab Pa	Outer Air Temp °C	Outer Air RH%
05-03-2009	10.00pm	20 ± 0.5	19.71	19.7	45 ± 5	45.30	46.1	10	9.9	9	25.9	35.3
	12.00pm	20 ± 0.5	19.66	19.7	45 ± 5	47.21	46.3	10	10	9	26.7	38.3
	14.00pm	20 ± 0.5	19.56	19.8	45 ± 5	47.71	45.7	10	10	9	27.5	37.2
	16.00pm	20 ± 0.5	19.53	19.8	45 ± 5	46.41	47.7	10	10	10	25.2	45.1
06-03-2009	10.00pm	20 ± 0.5	1964	19.9	45 ± 5	44.30	43.1	10	9.9	9	27.2	36.5
	12.00pm	20 ± 0.5	19.52	19.9	45 ± 5	43.00	43.2	10	10	9	27.9	37.6
	14.00pm	20 ± 0.5	19.68	20.0	45 ± 5	44.62	45.3	10	9.9	8	27.1	39.4
	16.00pm	20 ± 0.5	20.25	20.2	45 ± 5	42.81	42.1	10	9.9	9	26.5	33.4
07-03-2009	10.00pm	20 ± 0.5	19.52	20.0	45 ± 5	40.67	42.6	10	9.8	8	27.1	37.2
	12.00pm	20 ± 0.5	19.57	20.5	45 ± 5	41.44	41.7	10	9.9	8	28.1	35.5
	14.00pm	20 ± 0.5	19.56	20.5	45 ± 5	42.45	41.3	10	10	7	25.8	42.2
	16.00pm	20 ± 0.5	19.69	19.7	45 ± 5	42.92	40.8	10	10	8	25.0	46.0

SIC Lab:

Project Director:

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Director General
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PERFORMANCE TESTS CONDUCTED JOINTLY
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(UNIDO Project No. EU/PAK/04/ 001. ECS for NPSL Metrological Laboratories 16-H-9 Islamabad)

Time & Frequency Standards Laboratory Room 08		
Description	**Design Conditions**	**Average of Observed Test Conditions**
Length x Breath x Height	34'-6" x 16'-0" x 9'-10"	34'-6" x 16'-0" x 9'-10"
Operational Temperature	20°C	20°C
Room Temperature setting possibility	18 °C-25 °C	18 °C-25 °C
Temperature uniformity in controlled volume	±0.5 °C	+ 0.0 – 0.5 °C
Temperature Stability in 24 Hours Period	±0.5 °C	+ 0.0 – 0.5 °C (Avg. 19.63 °C)
Air Quality	Federal Standard – Class 10,000	< 10,000
Sound Level	Less Then 45dB(A)	< 45dB(A)
Relative Humidity	45% (RH) ± 5% (RH)	+2.6 – 3.7 %RH (Avg. 42.54 %RH)
Lighting Level	750 lux	750 lux
Over Pressure	10Pa	10, – 0.2 (Avg.9.8 Pa)
Fresh Air Supply	5% of re-circuiting Air	5%
Velocity of Air in Controlled Volume	Less Then 1.0 m/s	< 1.0 m/s
Heat Generated by Equipment & Lighting	2.5 k.W	1.2 k.W
Total Number of People Present	6	<5
Special Exhaust Port	1	1

SIC Lab:

Project Director:

Jamil Ahmad Chaudhry,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

Zawdu Felleke
Chief Technical Advisor,
UNIDO

DETAILED PERFORMANCE TESTS OF TEMPERATURE, HUMIDTY & PRESSURE
CONDUCTED JOINTLY BY
NPSL, MUSTEHKUM, & UNIDO

Laboratory: Time & Frequency Standards Lab

Room No: 08

Date	Time	As per ToR's Temp °C	Observed Temp °C on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab Temp °C	As per ToR's % RH	Observed % RH on Certified Thermo Hygrometer (NPSL)	Reading of the Sensor mounted in the lab % RH	As per ToR's Pa	Reading of the Tested Gauge	Reading of the Sensor mounted in the lab Pa	Outer Air	
											Temp °C	RH%
05-03-2009	10.00pm	20 ± 0.5	19.80	20.0	45 ± 5	41.54	42.7	10	10	9	25.9	35.3
	12.00pm	20 ± 0.5	19.59	20.1	45 ± 5	41.63	42.7	10	10	10	26.7	38.3
	14.00pm	20 ± 0.5	19.53	20.2	45 ± 5	41.72	43.1	10	10	9	27.5	37.2
	16.00pm	20 ± 0.5	19.67	20.2	45 ± 5	41.78	46.0	10	9.9	10	25.2	45.1
06-03-2009	10.00pm	20 ± 0.5	19.57	20.1	45 ± 5	41.89	42.2	10	10	10	27.2	36.5
	12.00pm	20 ± 0.5	19.62	20.1	45 ± 5	41.50	42.2	10	9.8	9	27.9	37.6
	14.00pm	20 ± 0.5	19.89	20.1	45 ± 5	41.31	42.3	10	9.8	9	27.1	39.4
	16.00pm	20 ± 0.5	19.80	20.3	45 ± 5	47.66	48.3	10	9.8	10	26.5	33.4
07-03-2009	10.00pm	20 ± 0.5	19.50	19.9	45 ± 5	42.51	41.0	10	9.9	9	27.1	37.2
	12.00pm	20 ± 0.5	19.52	20.1	45 ± 5	43.60	42.0	10	9.8	9	28.1	35.5
	14.00pm	20 ± 0.5	19.50	20.0	45 ± 5	43.00	41.0	10	9.8	8	25.8	42.2
	16.00pm	20 ± 0.5	19.57	20.1	45 ± 5	42.31	40.8	10	9.8	9	25.0	46.0

SIC Lab:

Project Director:

Jamil Ahmad Chaudhary,
Director General,
NPSL

Irfan Rasheed
Director, Mustehkum
Mustehkum Construction

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Chief Technical Advisor,
UNIDO