EMSD

One-day Training Course on "In-House Maintenance of Emergency Generator

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Part A:

法定要求 Statutory Requirements:

- ✧ Code of Practice for Minimum Fire Service Installations and Equipment
- ✧ Guidance Note on the Best Practicable Means For Electricity Works (Emergency Generator) BPM7/2 (96)

消防安全保護要求 Fire safety protection requirements:

- ✧ Emergency generator specification: (refer to Clause 5.8(a) of COP and Clause 2-4 of BPM):

1. Capable for full rated essential load in not more than 15 sec. from initiation.
2. Capable of continuously operating (5°c - 40°c, R.H. 100%)
3. Notices in English and Chinese "EMERGENCY GENERATOR" (應急發電機) and "NO SMOKING" (不准吸煙) shall be provided at the entrance to the emergency generator room. The characters of the notices shall be at least 120mm high.
4. A sign shall be provided for each generator set and affixed in a prominent position inside emergency generator room and main switch room to indicate the essential loading of fire service installations and fireman's lifts connected to the generator. The English and Chinese characters of the sign shall be at least 8mm and 15mm high respectively and the details are as follows:-

- Fuel Storage:

  The unit shall be complete with a fuel storage system capable of sustaining full load operation for a period of not less than 6 hours.

- Installation:

  The air supply and discharge shall be direct to outside air without any possible obstructions i.e. no fire, smoke or regulating dampers shall be fitted. Where the air supply and /or exhaust ductwork is not fully contained with the generator room but passes through adjacent rating as the required for either the generator room or the compartment through which it passes, whichever is the greater.

- Operation:

  Failure of one or more phases of the mains supply, or a reduction of voltage to less than 70% of normal, for a duration exceeding 1 second, shall initiate automatic starting of the emergency generator set.

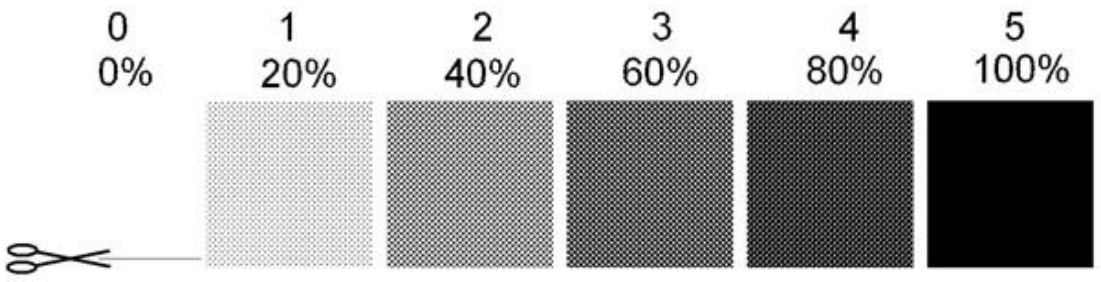
  Should the prime mover fail to start, a further attempt to start shall then be made. If it again fails to start, the starting sequence shall be locked out, an audible and visual alarm shall be given locally, at the fire control main panel, and it shall remain in this locked out condition until manually reset.

- Environmental protection requirements

  Emission Limits (Clause 2 of BPM)

  All emissions to air, other than steam or water vapour, shall be colourless, free from persistent mist or fume, and free from droplets;

  Emission not as dark as shade 1 on the Ringlmann Chart.



Fuel restriction (Clause 3 of BPM)

Comply with the Air Pollution Control (Fuel Restriction) Regulations;

指明污染物	排放限度 (每公升燃料的污染物（以克計算）)
二氧化硫	0.864
氮氧化物(以二氧化氮計)	2.4
可吸入懸浮粒子	0.12

Dispersion (Clause 4.4 of BPM):

Releases to air from chimney shall be directed vertically upwards and not restricted or deflected by the use of, for example, plates or rain caps. They should not be emitted into an enclosed space such as a courtyard, "light-well" or car park.

The chimney of an emergency generator shall be:

(a) at least 5 metres above ground;
(b) located in a well ventilated area; and
(c) located as far away as possible from nearby inhabitants, and at least 5 metres away from any public accessible place, or openable windows, car park, fresh air intake for the HVAC system or the generator room.

Materials Handling

Emissions of organic vapours;

Other noxious / offensive emissions

Operation & maintenance ((i) – (iii) Clause 5 of BPM and (iv) - (v) Clause 2.8 of COP)

i. Proper operation & maintenance of equipment;
ii. Generators should be operated only when:
    A. a failure or interruption in electricity supply.
    B. routine / emergency running tests
iii. Routine / Emergency running tests Residential premises:
    1400 hours – 1600 hours, except Saturdays, Sundays and public holidays;
    Non- residential premises: 1400 hours – 1600 hours, only on Sundays and public holidays.

iv. The emergency generator shall be maintained in efficient working order at all times and shall be inspected by a registered fire service installation contractor at least once in every 12 months.
Moreover, all units should be run once per month under load conditions for a period of not less than 30 minutes by the owner or his agent. During this running period all operating conditions should be checked. Following this running period functional tests should be carried out on all automatic and manual starting devices and safety controls.

v. A log book should be provided, and retained in the plant room, management office or building supervisor office, and should be kept up a date by the owner or his agent. The record should be made a t the time of occurrence and should include details of all operations; faults and corrective actions taken, routine servicing, maintenance and periodic operation etc.; including dates, times, hour meter readings, workings/supervisors names and signatures, etc. for the unit, batteries, compressors, etc.

Part B:

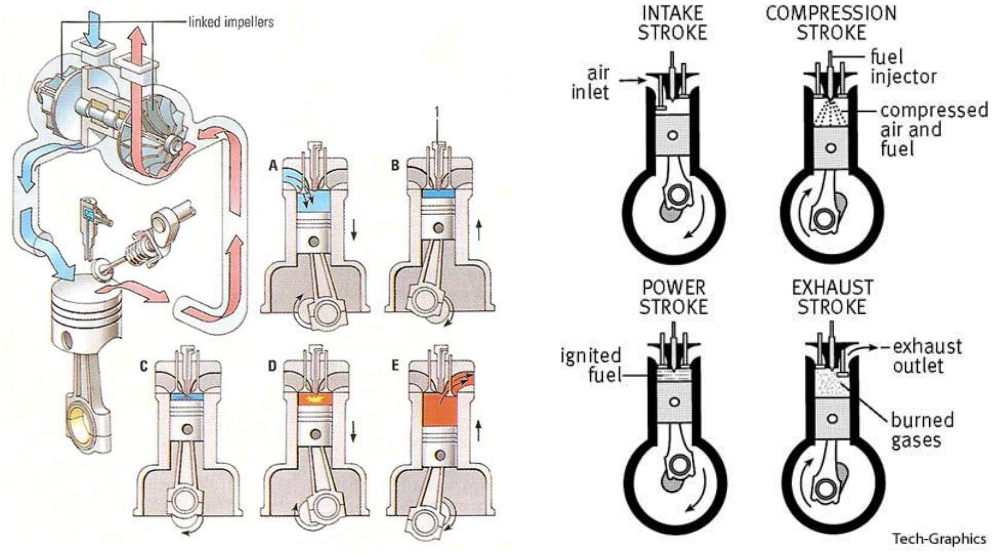
Basic operation principle of emergency generator set;

Function of major components including:

- ✧ Engine;
- ✧ Alternator;
- ✧ Silencer;
- ✧ Speed Governor;
- ✧ Exciter and voltage regulator;

柴油引擎(Diesel Engine)

- 靠壓縮空氣所產生的熱，點燃燃料. 燃料於最大壓縮力與最高壓縮熱時，噴入燃燒室內



四衝程引擎

四衝程引擎與二衝程比較:

四行程引擎與二行程引擎的優缺點
四行程引擎的優點：

- 它比汽油引擎有更高的燃燒率，平均比汽油引擎省油約 30%。
  柴油比汽油售價低廉（柴油大約只有汽油一半的價格）。
- 引擎構造堅固，壽命長，而且不需要怎樣保養。
- 扭力輸出比較平順，尤其是在低轉速是比汽油引擎有更強勁的扭力。
- 可靠性高
- 引擎功率 (Engine power): 由曲軸輸出可作功的動力, 單位為馬力

四行程引擎的缺點：

- 由於柴油引擎在極高壓縮比下工作，故構造必須更堅固紮實，造價較昂貴。
- 引擎重量大。 怠速運轉不及汽油引擎順滑。
- 運轉時噪音大。
- 加速反應比汽油引擎遲緩。不能高轉速，高性能柴油引擎大概只有四千多轉。
- 貨車或巴士用柴油引擎只有兩千五百多轉。排出較多的黑煙。

二行程引擎的優點：

- 結構簡單，沒有氣閥機構．而是由活塞本身來控制．
- 由於沒有氣閥，更容易達到高轉速．很多二行程引擎都可以輕易超過一萬轉

二行程引擎的缺點：

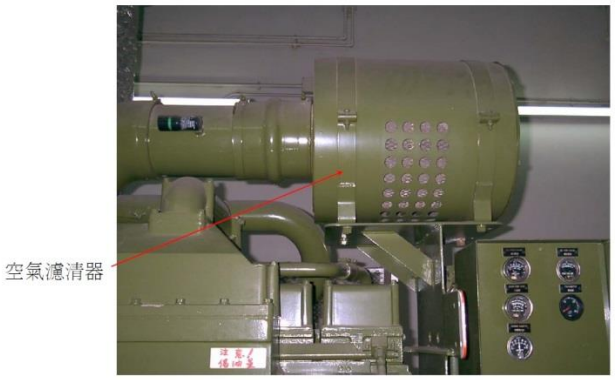
- 低轉時沒力，同時由於燃燒不完全以及在汽油中混入了潤滑劑，都造成排出的廢氣較多黑煙，造成空氣

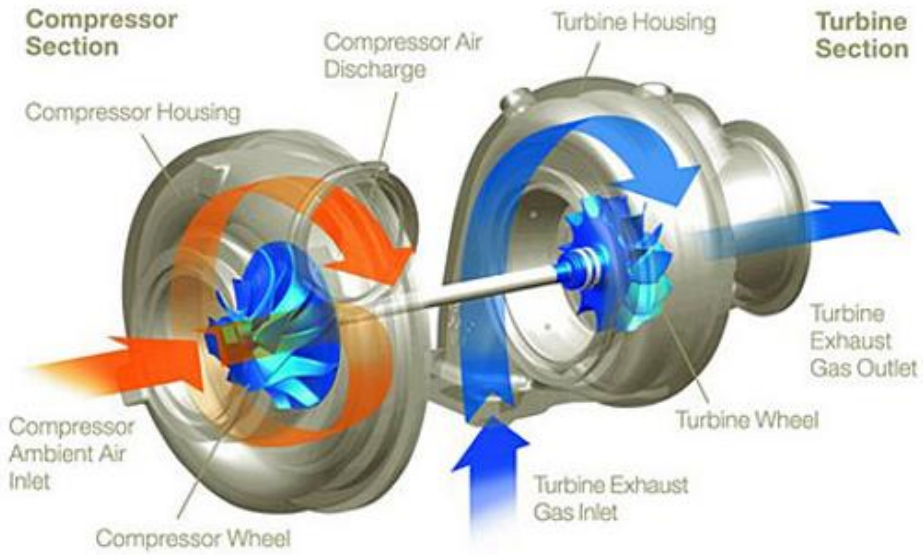
在整個引擎系統中，我們可以分為下列五大部分:

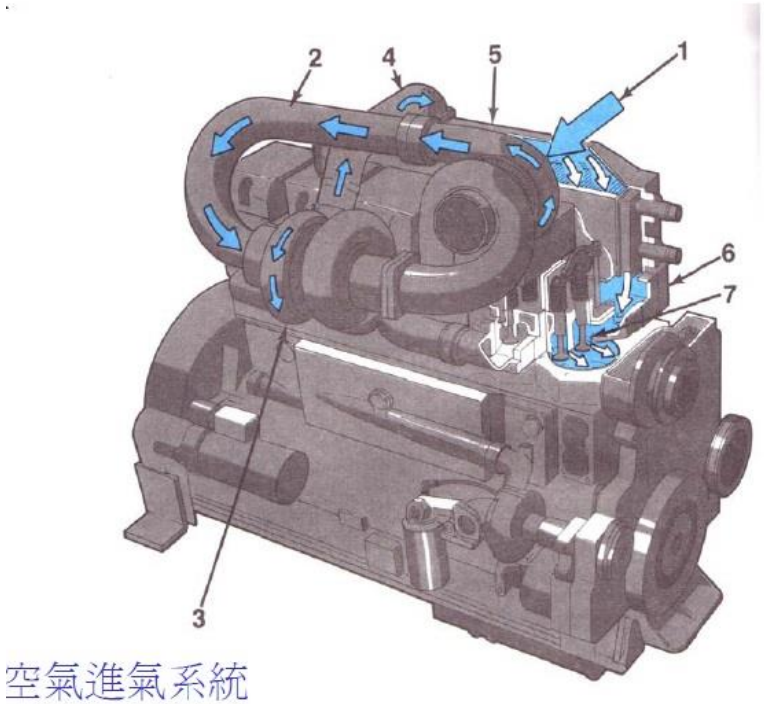
1. 空氣系統
2. 燃油系統
3. 潤滑系統
4. 冷卻系統
5. 電氣系統

- **空氣系統**

  空氣經空氣濾清器 (Air Filter)進燃燒室(Internal combustion engine)內燃燒，為了增大引擎的馬力，在空氣系統中會增加渦輪增壓器(Turbo). 渦輪增壓器是一種利用內燃機 (Internal Combustion Engine)運行所產生的廢氣驅動的空氣壓縮機 (Air-compressor).





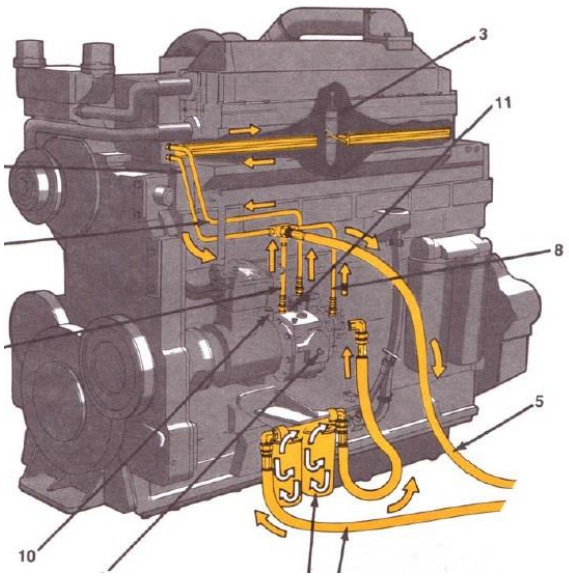


空氣進氣系統

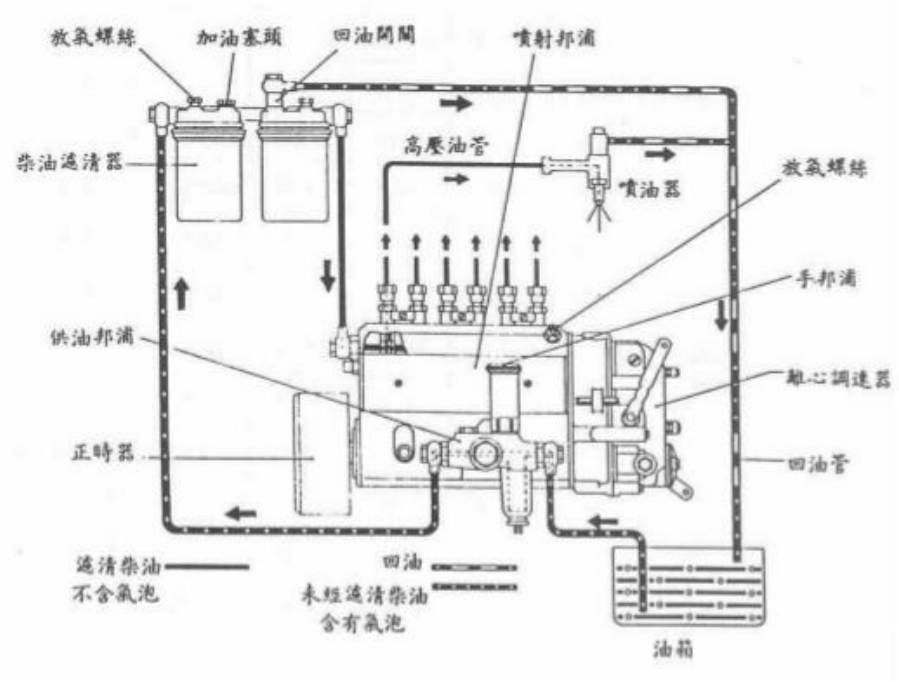
利用渦輪增壓器(Turbo)，可提高大約 30%以上的輸出功率

- **燃油系統**

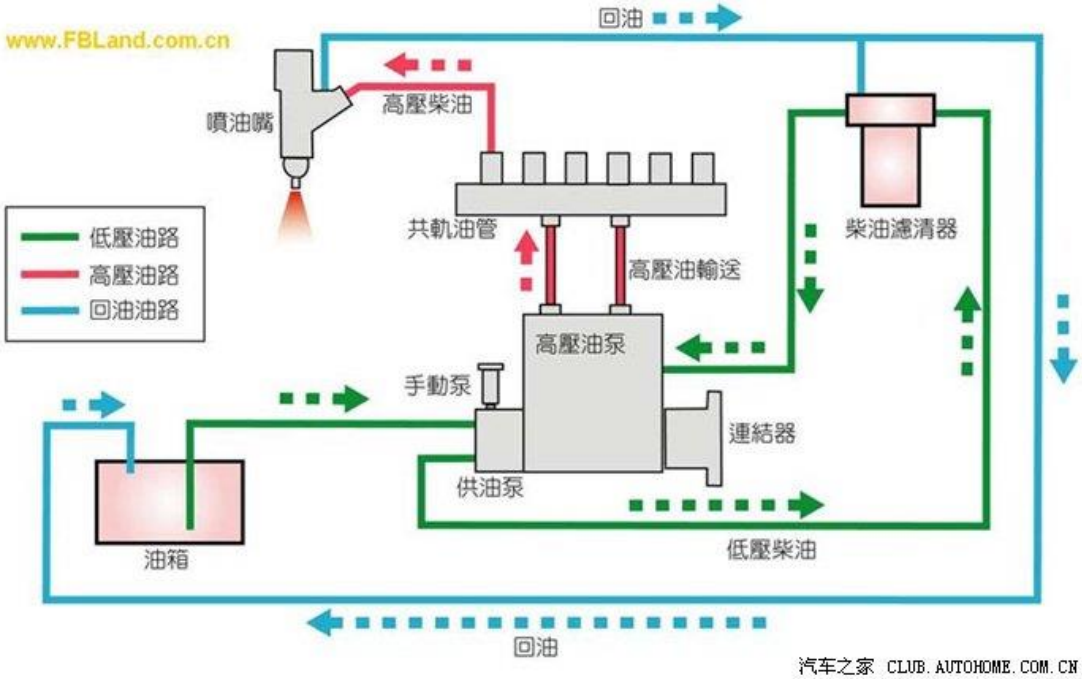
柴油流經濾清器進入油泵，油泵加壓後泵油到噴射器，噴射器在燃燒室噴出已霧化的柴油，經熱和壓力後自我爆炸，產生動力.

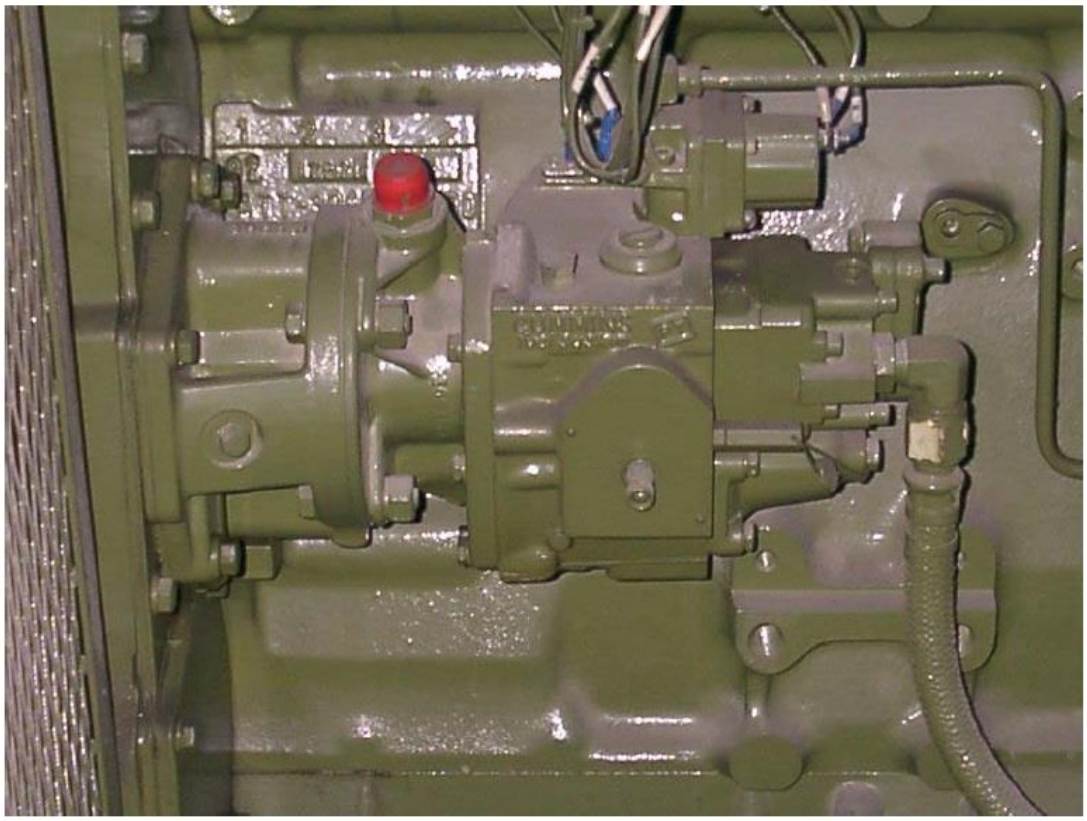


傳統式柴油引擎



共軌式燃油系統迴路





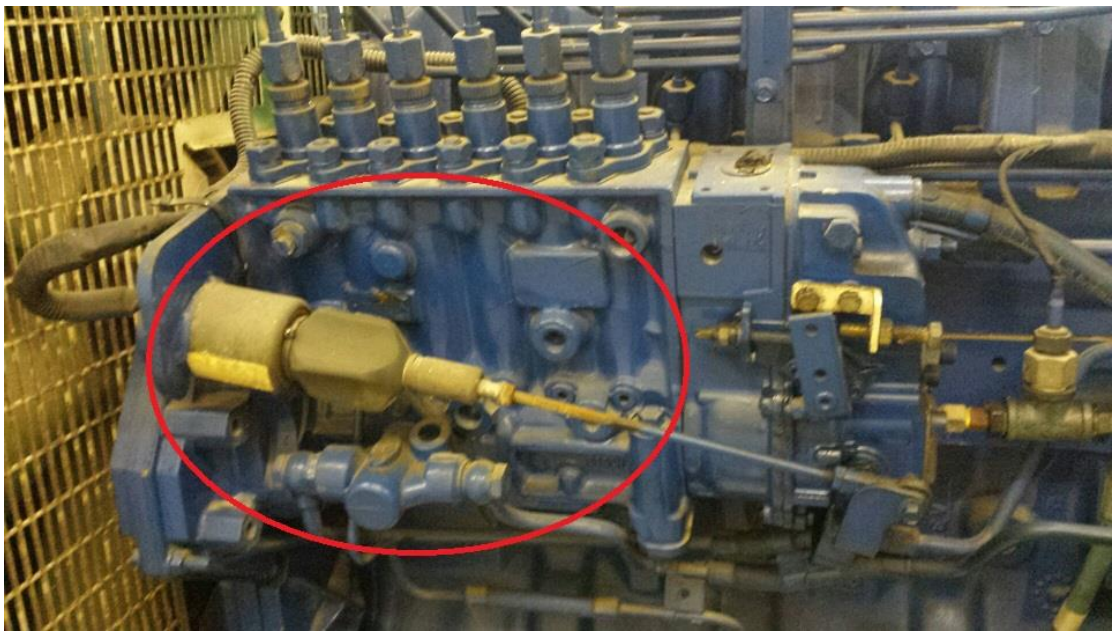
高壓油泵

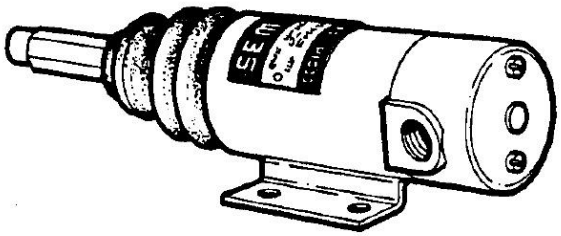

油軌 O-形環油封
汽油入口處
20 微米內建濾芯
電源接頭
復位彈簧
線圈
電磁閥
墊片
軸針
歧管 O-形環油封
軸針座
軸針護蓋
軸針孔

噴油嘴

為了改善頻率隨負荷而改變等問題, CUMMINS 柴油機公司研發一種 **電動供油系統口**

1. 電動泵閥門 Fuel stop solenoid

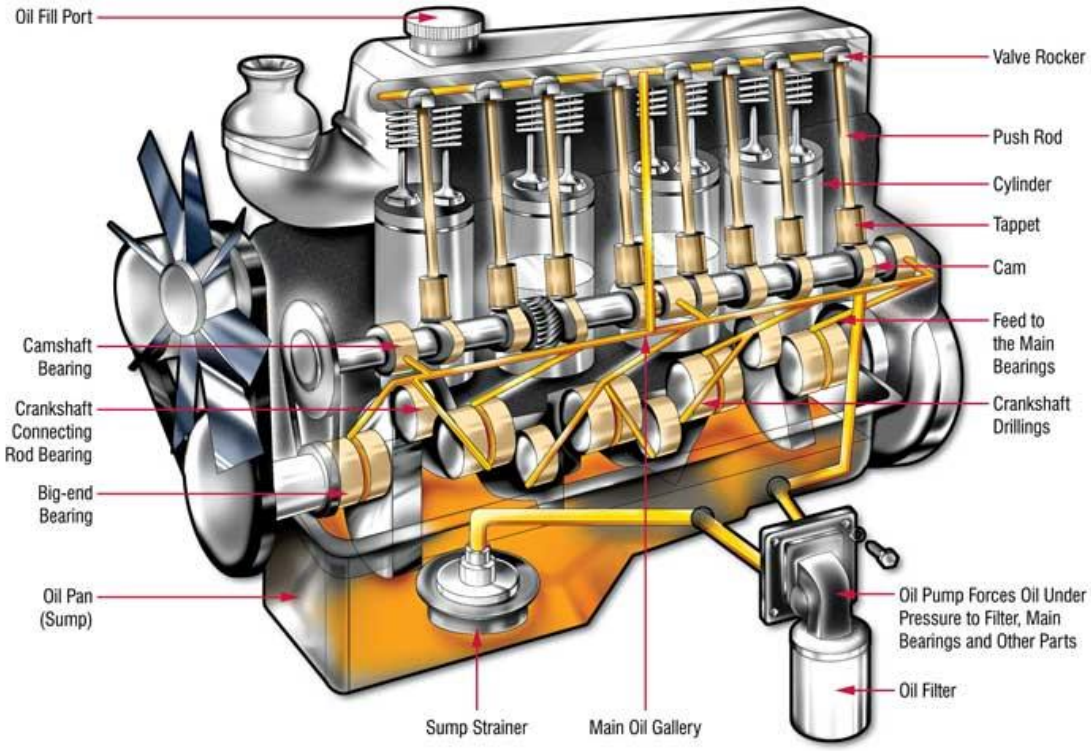




2. Electronic Fuel Control

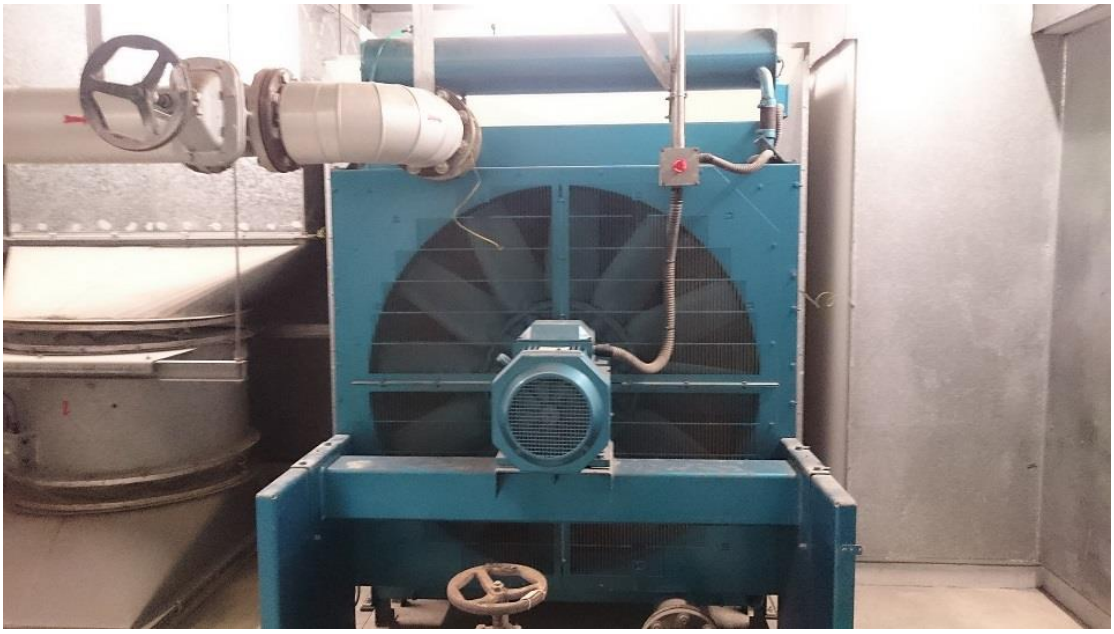
- **潤滑系統** (Lubrication System)

- 潤滑機油存放在引擎的底部 (馬肚)
- 當引擎運轉時，機油泵把潤滑油泵到引擎的所有部份，包括: 渦輪增壓器，噴油器，燃燒室，主軸等

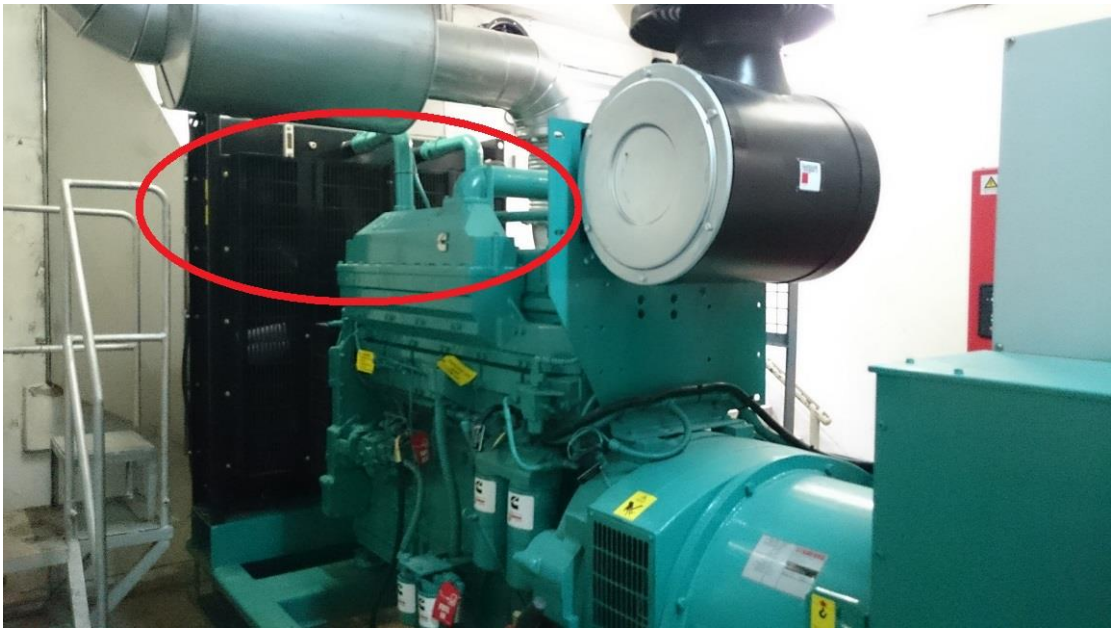


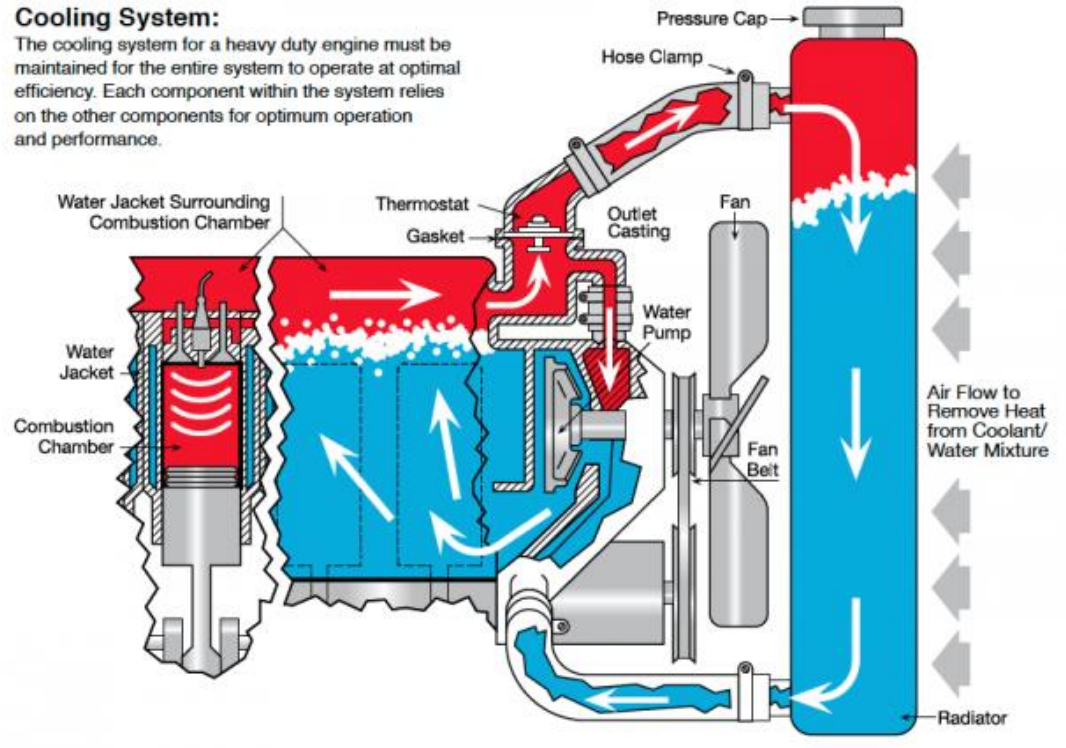
- **冷卻系統** (Cooling System)

1. 風冷

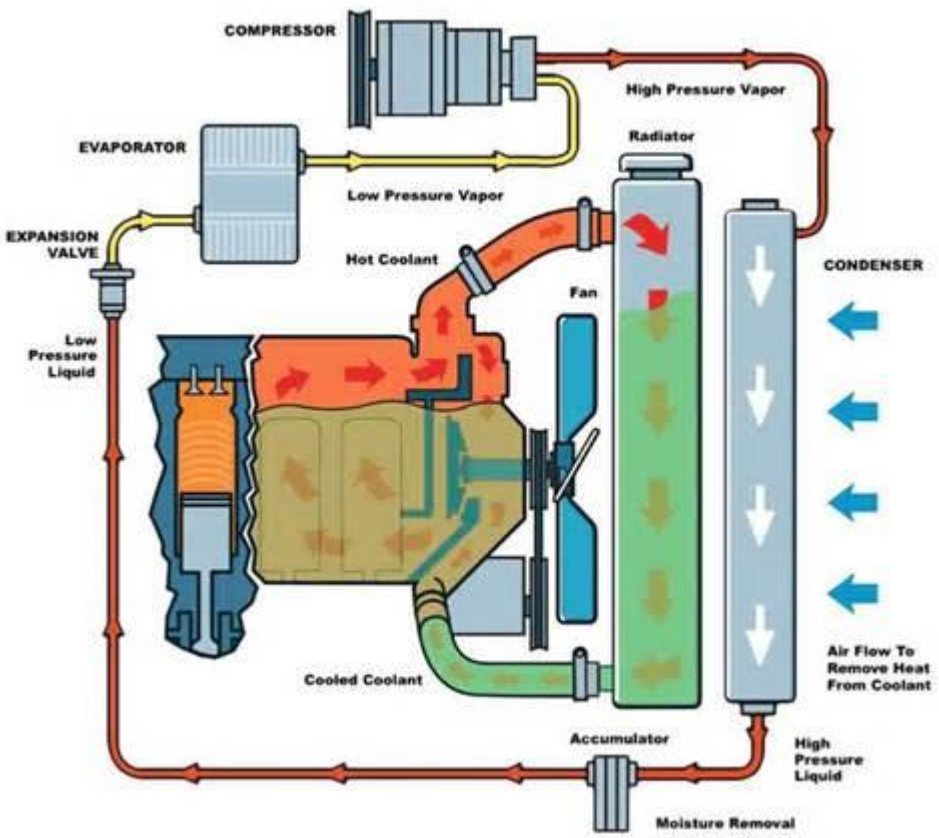


2. 水冷





3. 潤滑機油經熱交換器轉移熱至水系統



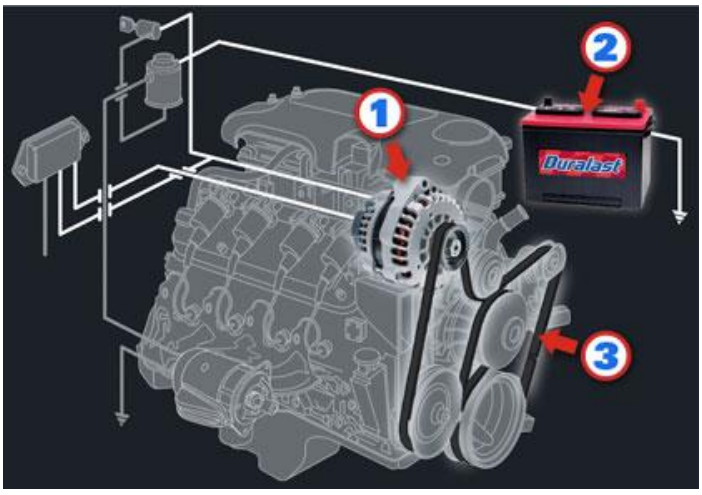
- **電氣系統**
  - 起動馬達 (Starting Motor)

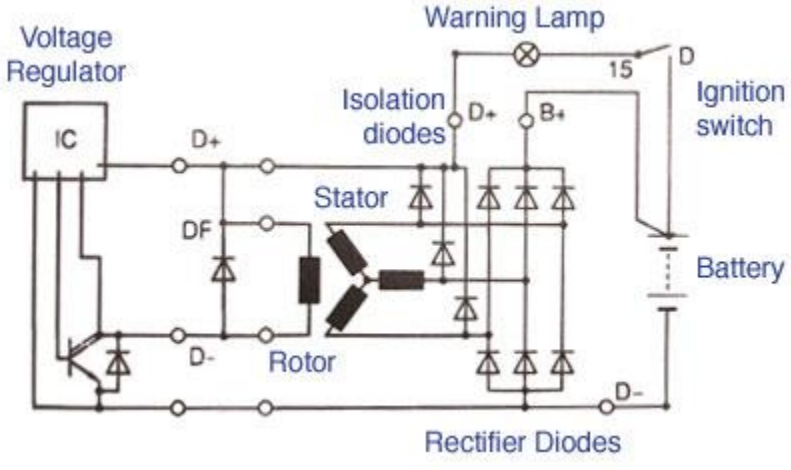
    負責帶動引擎末端的大飛輪 (Fly wheel) 轉動, 達至引擎能自行運轉後; 起動馬達須立即與大飛輪切離. 否則, 馬達會被柴油引擎帶動, 在超高速下運轉而損毀.

    用於柴油發電機的起動馬達, 工作電壓可分為直流 12V, 24V 及 48V. 而 24V 的最為普遍.

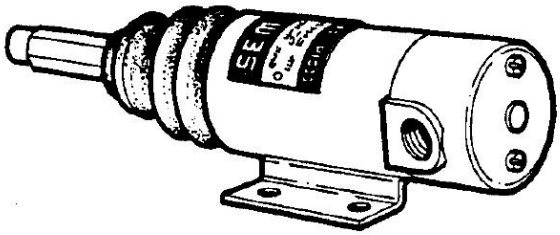
- 直流充電機 Charging alternator (Dynamo)

直流充電機是一台小形的直流發電機，主要功能是對電池充電，當發電機運行時，電池的電量會慢慢消耗；假如電池的電量耗盡時，發電機便會停下來.
除此之外，直流充電機亦可提供起動信號，以便控制線路能在發電機起動後，立刻切離起動馬達





- 電動泵閥門 Fuel stop solenoid



電動泵閥門俗稱 [死火制]

運作電壓	推進電流	保持電流
24V DC	45A	0.75A

- 起動電池 (Batteries)
  電池以性質,容量和模式分類. 性質可分為鹼性 (Nickel Cadmuim type) 或酸性 (Lead acid type) 兩種. 酸性電池 (Lead acid battery) 的電壓可分 6V 或 12V; 而每個鹼性電池 (Nickel Cadmuim type)的電壓則是 1.2V , 在 24V 的系統中,是由 20 個鹼性電池所組成.

電池的模式可分為入水式 (Vent type) 和密封式(Seal type) 兩種.

入水式 (Vent type) 因化學作用而產生大量氫氣, 引致電池液的水份減少, 固需要定期補充蒸餾水.

密封式在設計上, 已改善了電池因化學作用而減少水份的問題, 所以不需要定期補充水份, 這種電池可免保養的 (Maintenance free).

基於消防條例列明, 大廈的後備發電機組需裝配鹼性電池 (Nickel Cadmuim type).

電球 ALTERNATOR

2.1.1. 交流發電機之基本原理

磁鐵的兩端有南北兩極，在空氣中有很多無形的磁力線〔magnetic line of force〕使兩極連接起來。在圖 2.1 中，我們可以看到磁力線從北極出發，經過空氣，然後回到南極去。由於兩極的磁力線是最多最集中的，兩極的磁場是最強。

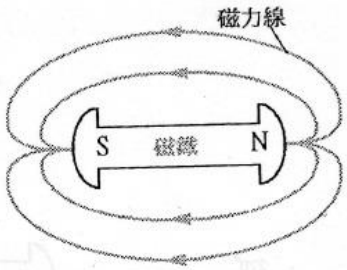


圖 2.1.

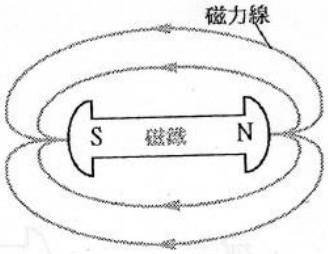


圖 2.1.

假若我們把一根導線推近磁鐵，導線便切斷磁力線〔見圖 2.2〕。當導線與磁力線發生交切的一刻，導線產生了一個瞬間感應電壓〔電動勢〕。

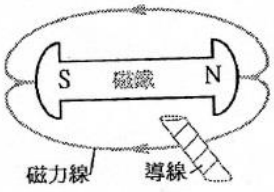
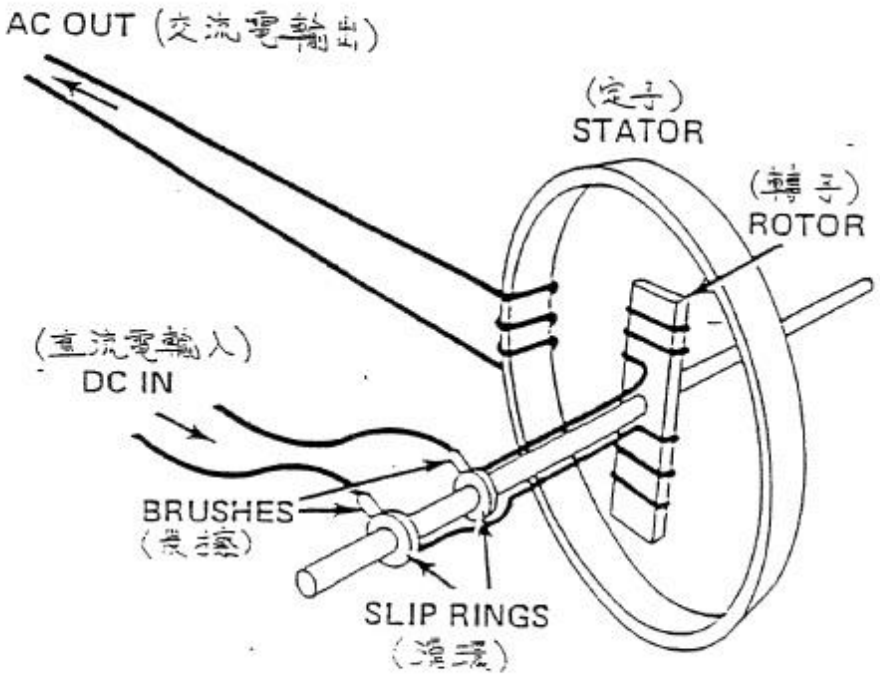


圖 2..2

當磁石在不停地自轉時，導線〔線圈〕與無形的磁力線不斷地交切，導線連續地產生感應電壓；這就是發電的基本原理。

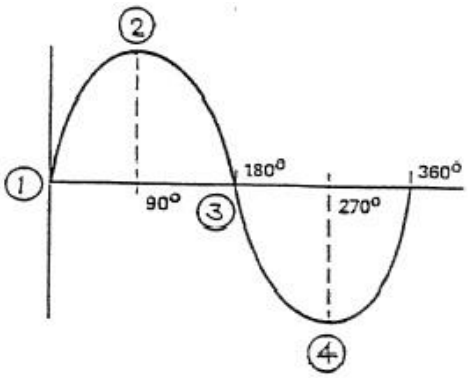
磁電效應



圖甲一：旋轉式磁場交流發電機簡略圖解

旋轉式磁場發電機的操作原理

在一組旋轉式磁場發電機，直流電源通過滑環輸電至轉子的線圈上；轉子即時產生強力的磁場。因爲定子核心是採用電磁物料造成，所以磁場產生磁力線通過定子核心。而定子上的線圈切割著定核心上的磁力線，因此電壓會即時產生。轉子每旋轉一圈，定子線圈會產一個原整的交流正弦波(AC SINE WAVE)。交流電輸出的強弱，要視乎直流電的輸入量；而交流電輸出的頻率，則視乎轉子的轉速。



圖甲二：單相交流正弦波

單相交流電壓的產生過程

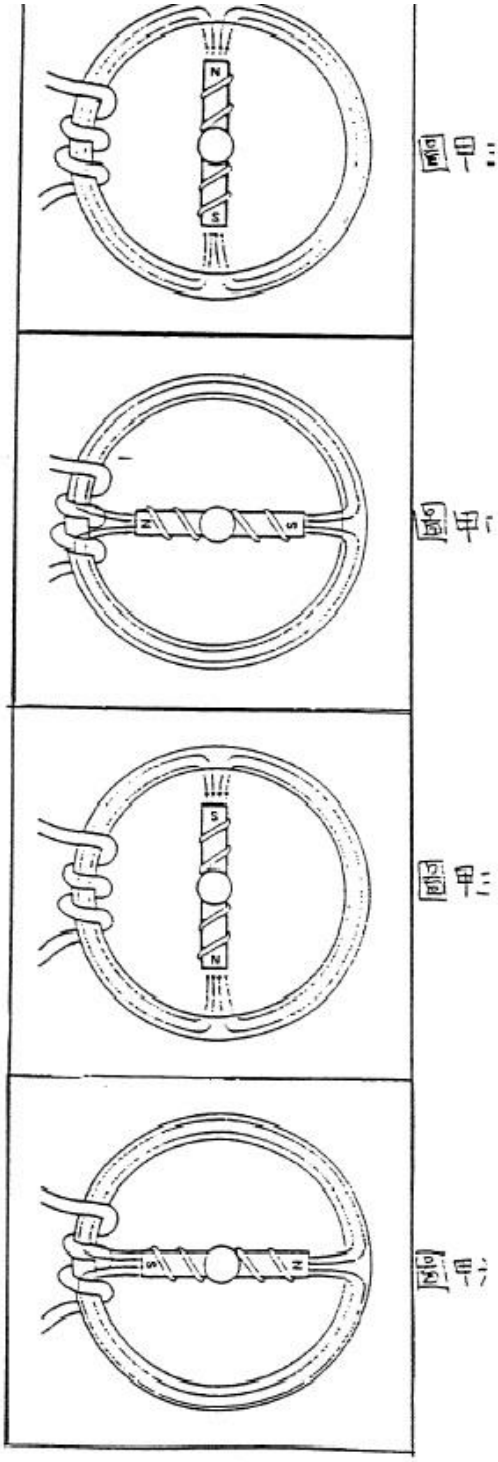
在上頁圖解已清楚說明電壓是通過電磁場和磁力線在定子和轉子切割而通過定子上線圈感應而產生。

看附圖甲三，電壓感應量最低。所以電壓值在圖甲二顯示在位置①。

看附圖甲四，當北磁極轉 90° 到定子上的線圈位置，電壓值會達到最高點(最強電壓輸出)。即圖甲二的位置②。

看附圖甲五，當轉子轉 180° 到定子上的底部時，磁力線在定子線圈上切割程度減至最低，而感應電壓會減低至零。即圖甲二的位置③。

看附圖甲六，當轉子轉多一個 90° ，其南磁極會對正定子上的線圈。感應電壓會增加回最高點，但顯示在相反方向，即圖甲二的位置④。



圖甲三

圖甲四

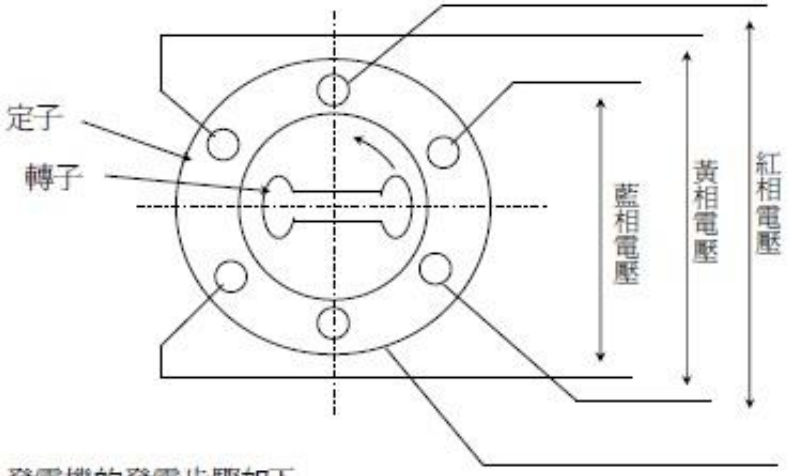
圖甲五

圖甲六

緊急發電機（E03）

緊急發電機的操作

緊急發電機包括定子和轉子兩部分,即



發電機的發電步驟如下

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緊急發電機（E03）

緊急發電機的構造

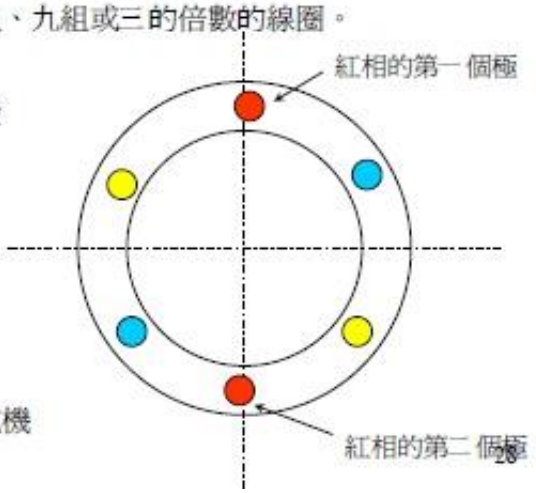
1. 定子

定子是在發電機的外殼內部設置一些坑槽，坑槽內藏有線圈，這些線圈就叫定子線圈。

在三相發電機內，設有三組、六組、九組或三的倍數的線圈。

內藏三組線圈的，就叫兩極發電機。內藏六組線圈的，就叫四極發電機。如此類推。

兩極發電機的線圈分佈



兩極發電機

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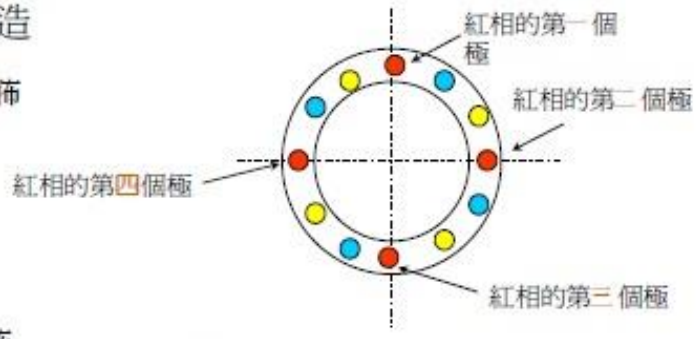
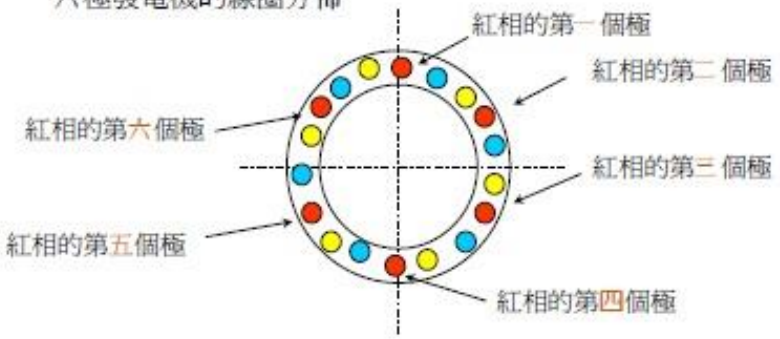
緊急發電機（E03）

緊急發電機的構造

四極發電機的線圈分佈



六極發電機的線圈分佈



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緊急發電機（E03）

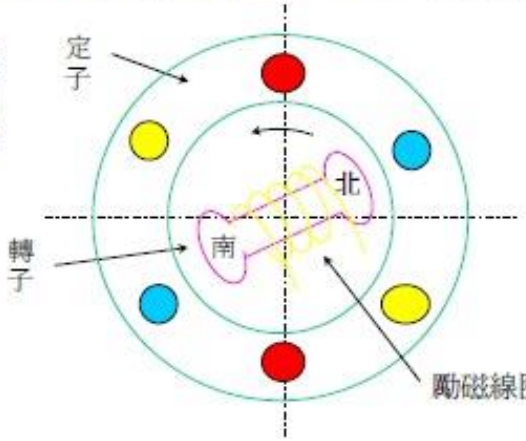
緊急發電機的構造

2. 轉子

轉子是設在發電機中心，一個和承軸同心的圓筒，圓筒上設置了一些坑槽，坑槽內藏有一組線圈，這一組線圈就叫轉子線圈或勵磁線圈。

勵磁線圈接駁到直流電源，當使用發電機時，直流電通過勵磁線圈使轉子變成一磁電磁石。

當轉子變成一磁電磁石，並由柴油引擎帶動轉動，就可以在定子線圈上感應電流和電壓。



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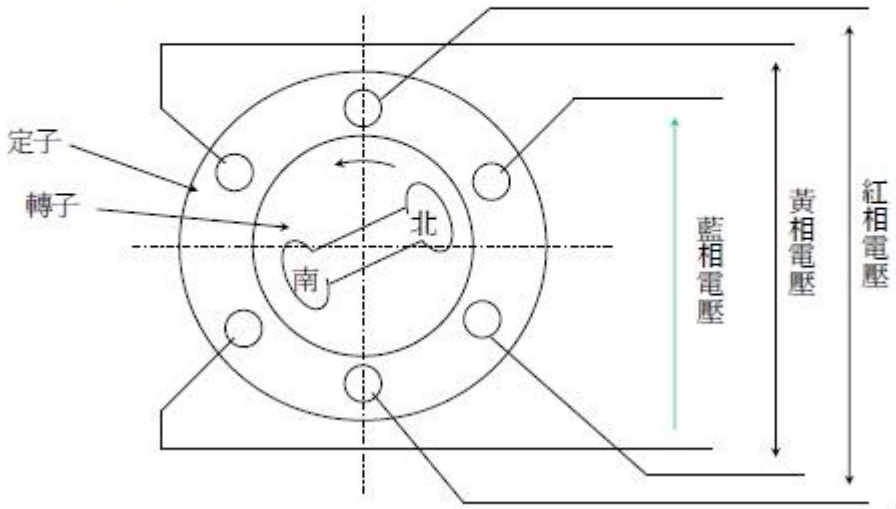
緊急發電機（E03）

緊急發電機的操作

轉子的北極轉到藍相，使藍相產生電壓



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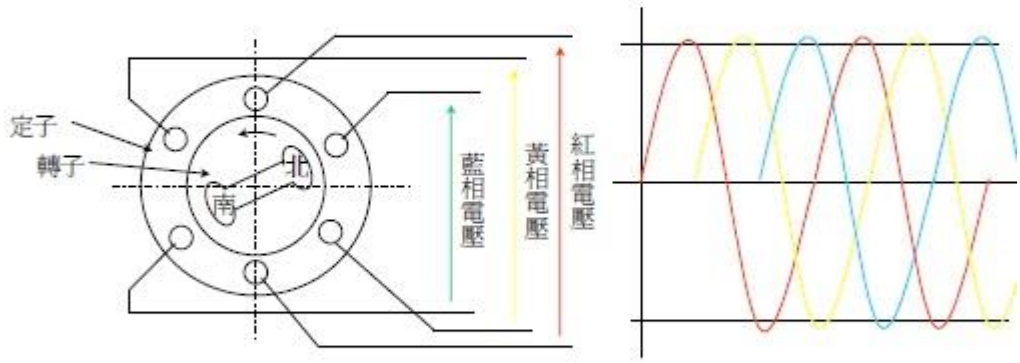
緊急發電機（E03）

緊急發電機的操作



當三相線圈一起運作時，就能產生三相電壓。

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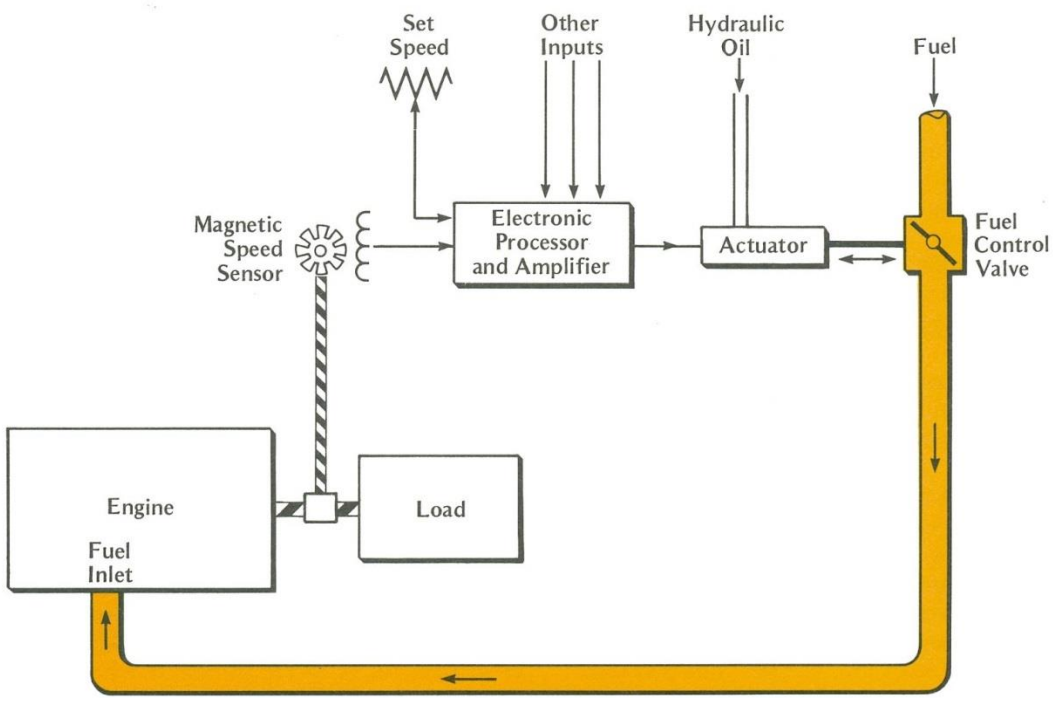
Silencer

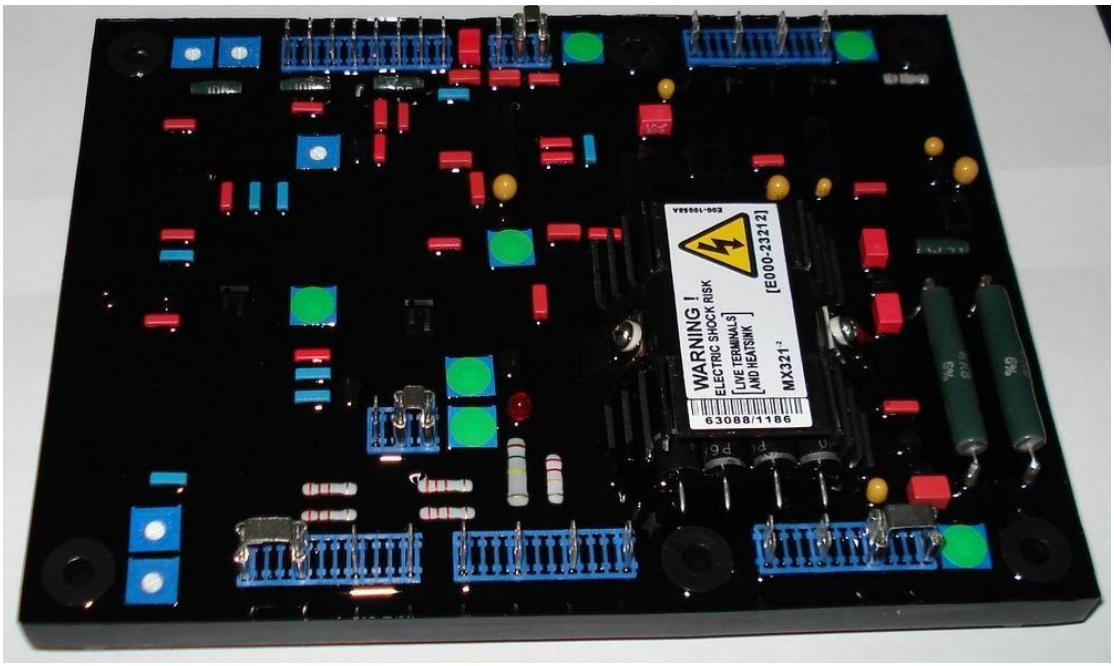
Speed Governor

SPEED SENSOR

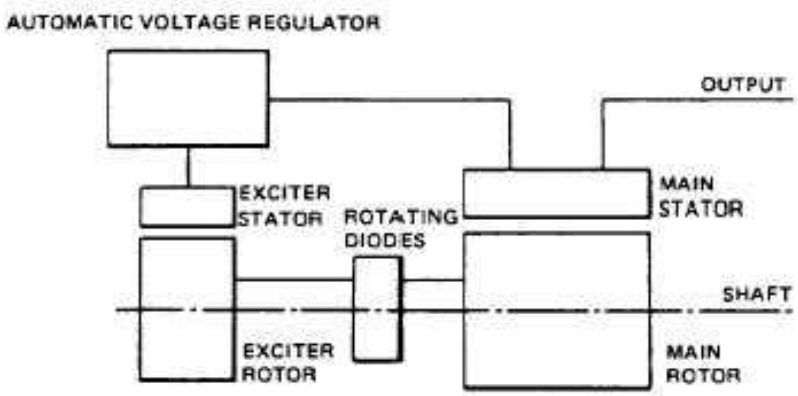


Speed sensor sense the magnetic pick up in the generator for the rotary speed, then adjust the fuel control valve to modify the fuel insert to motor, as the result to control the speed.

Exciter and voltage regulator



Automatic-voltage regulator (AVR) 自動穩壓器，原理是感應發電機的電壓輸出和預先調節的標準電壓作對比，從而控制勵磁定子的電磁場. 令發機電可在波動的負荷中，電壓得以保持.



Part C: Routine Maintenance

- 發電機房的清潔及設施
    1. 房間地下的清潔及積水
    2. 冷卻進風喉的入口，冷卻風扇及出風口可有異物阻擋
    3. 接地系統有沒有鬆脫
    4. 發電機的避震彈簧

- 柴油油路
    - 檢查及記錄油路有否滲漏
        1. 柴油油泵，油喉駁口
        2. 柴油濾清器
        3. 柴油缸的排油位
        4. 柴油油量

- 引擎的潤滑系統
    - 檢查及記錄油路有否滲漏
        1. 引擎的油喉接駁
        2. 潤滑油的濾清器
        3. 拉出油尺以檢查是否足夠

- 起動電池系統
    1. 電池水是否足夠
    2. 使用電池比重計量度池水酸鹼度比重
    3. 量度電池輸出電壓　（要先關上充電器）
    4. 起動馬達的電線有否鬆脫

- 冷卻系統
    1. 引擎冷卻水箱有否滲漏
    2. 冷卻水是否足夠
    3. 用酸鹼度測試紙檢查冷卻水酸鹼度　(P.H. 7.5-9)
    4. 風扇皮帶有否破損
    5. 隔熱防護罩有否破損

- 空氣系統
    1. 檢查及清潔空氣濾清器
    2. 打開排氣消音器底的排水閥

Part D: Testing

測試前:

1. 掛消防牌
2. 必須配戴護耳罩
3. 隔離消防裝備及關閉升降機
4. 檢查發電機

測驗中:

1. 關上給緊急供電的總開關
2. 觀察發電機有否自動起動
3. 觀察自動轉換制 (Change-over) 的運作情況
4. 觀察及記錄下列儀表
    1. 機油壓力錶
    2. 轉速錶
    3. 充電電流錶
    4. 水溫錶
    5. 機油溫度錶
    6. 輸出電壓, 電流, 頻率
5. 冷卻風扇及皮帶轆於運作時聲響是否正常
6. 有否任何滲漏

測試完成:

還原之前上述步驟