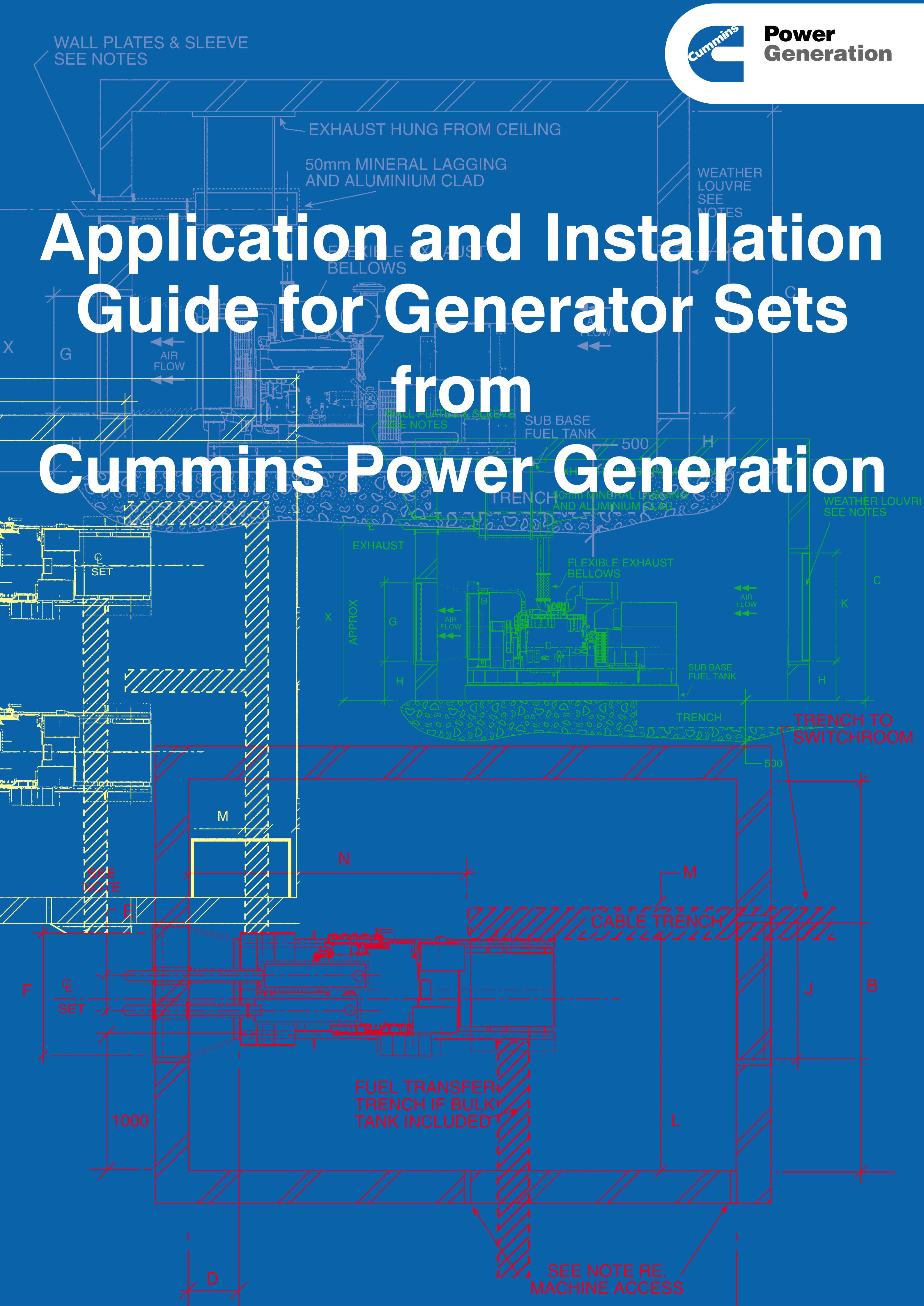
# Application and Installation Guide for Generator Sets from Cummins Power Generation



# INDEX

## Scope

This manual provides an Installation Guide for Cummins Power Generation generator sets. This includes the following information:-

- Room Sizes
- Mounting Recommendations
- Electrical Connections
- Mechanical Connections
- Health and Safety
- General Maintenance
- Silencing
- Technical Data

This manual details typical installations only as it is not possible to give specific details to many variables in an application.

If you should require any further advice or information, please consult:

**Cummins Power Generation Ltd**
Manston Park
Columbus Avenue, Manston
Ramsgate
Kent CT12 5BF, UK
Tel : +44 (0) 1843 255000
Fax : +44 (0) 1843 255902

## Regulations and Bibliography

The authorities listed below may provide informative sources when planning and implementing an installation.

**Electrical Installation**

Electrical Supply Regulations - 1937

“For securing the safety of the public and for ensuring a proper and sufficient supply of electrical energy”

Electricity (Supply) Acts 1882 1936

Her Majesty’s Stationary Office (H.M.S.O)

Distribution units for electricity supplies for construction and building sites.

British Standard (BS) 4363

Regulations for the Electrical Equipment of Buildings.

Institute of Electrical Engineers (1966)

Electrical Installations - General

British Standard Code of Practice CP321

Private Electric Generating Plant CP323

Quality Assessment Schedule QAS/3420.121 relating to BS5750 Part 1 will apply.

ABGSM Publication TM3 (Revised 1985)

“Code of Practice for Designers, Installers and Users of Generating Sets.”

Asbestos (Licensing) Regulations 1983 (SI 1983 No 1649) and Health and Safety at Work series Booklet H5 (R) 19

A Guide to Asbestos (Licensing ) Regulations 1983.

Electricity Council Engineering Recommendations G5/3 and G59.

Factories Act 1961

Health and Safety at Work Act 1974

ISO 4782 - Measurement of Airborne noise emitted by construction equipment for outdoor use - method of checking for compliance.

BS 4142 ISO 1996 - Method of rating industrial noise affecting mixed residential and industrial areas.

**Electrical Equipment**

The Electrical Performance of Rotating Electrical Machinery BS2615

Electrical Protective Systems for A.C Plant BS3950

A useful glossary of British Standards applicable to electrical components is given at the ‘ Sectional List of British Standards Institution.’

IEC 479 Effects of Current Passing through the Human Body

IEE Regulations (15th Edition)

BS 159 1957 - Busbars and Busbar Connections.

BS 162 1661 - Electrical Power Switchgear and Associated Apparatus.

BS 2757 Insulation

BS 4999 - General requirements for Rotating Electrical Machines.

BS 5000 Part 3 1980 - Generators to be driven by reciprocating Internal Combustion Engines.

BS 5424 Part 1 1977 - Contractors.

BS 5486 (IEC 439) - Factory Built assemblies of Low Voltage Switchgear and Control Gear.

**Mechanical Equipment**

BS 1649 - Guards for Shaft Couplings

BS529 - Steel Eye Bolts

EEC Directive 84/536/EEC - Noise from construction equipment - power generators.

BS 476 Part 7 Class 1 - Surface spread of Flame Tests of Materials.

BS 799 Part 5 - Oil Storage Tanks

BS 2869 1970 - Fuel Oils for Oil Engines and Burners for non- marine use.

BS 3926 - Recommendations for the use of maintenance of Engine Coolant Solutions.

BS 4675 Part 1 (ISO 2372) - Mechanical vibration in reciprocating machinery.

BS 4959 - Recommendations for Corrosion and Scale Prevention in Engine Cooling Water Systems.

BS 5117 - Methods of Test for Corrosion Inhibition Performance of Anti-Freeze Solutions.

BS 5514 (ISO 3046) - Specification for Reciprocating Internal Combustion Engines, Part 1 to 6.

**Manufacturing and Design Standards**

The generator and its control system are manufactured under a registered quality control system approved to BS EN ISO 9001 (1994). The following regulations are observed where applicable:

The Health & Safety at work Act 1974.

The Control of Substances Hazardous to Health Act 1974, 1988 & 1989.

IEE Wiring Regulations for Electrical Installations (16th Edition).

The Electricity at Work Regulations 1989.

The Environmental Protection Act 1990.

The Health & Safety at work Regulations 1992.

The EMC Directive 89/336/EEC.

The LV Directive 73/23/EEC.

The Machinery Directive 89/392/EEC.

The generator and its control system has been designed, constructed and tested generally in accordance with the following Standards where applicable:

| | |
|---|---|
| • BS 4999 (IEC 34[1]) | General requirements for rotating electrical machines. |
| • BS 5000 (IEC 34[1]) | Rotating electrical machines of particular types or for particular applications. |
| • BS 5514 (ISO 3046[2]) | Reciprocating internal combustion engines: performance. |
| • BS 7671 (IEC 364[1]) | Requirements for electrical installations. IEE Wiring Regulations (sixteenth edition). |
| • BS 7698 (ISO 8528[2]) | Reciprocating internal combustion engine driven alternating current generating sets. |
| • BS EN 50081 (EN 50081[2]) | Electromagnetic compatibility. Generic emission standard. |
| • BS EN 50082 (EN 50082[2]) | Electromagnetic compatibility. Generic immunity standard. |
| • BS EN 60439 (IEC 439[1]) (EN 60439[2]) | Specification for low-voltage switchgear and control gear assemblies. |
| • BS EN 60947 (IEC 947[1]) (EN 60947[2]) | Specification for low voltage switchgear and control gear. |

**KEY:**

[1] A related, but not equivalent, standard: A BSI publication, the content of which to any extent at all, short of complete identity or technical equivalence, covers subject matters similar to that covered by a corresponding international standard.

[2] An identical standard: A BSI publication identical in every detail with a corresponding international standard.

**Regulations Governing Installations**

Before purchasing a generating set, the advice of the local authority should be obtained with regard to the following requirements:-

Planning permission for the generator building.

Regulations governing the following:-

Storage of fuel

Noise levels

Air pollution levels

Electrical earthing requirements

Failure to comply with the local authorities regulations, may result in the generator not being used. This type of purchase should be installed correctly using the “best” materials and installation guides to ensure the generator set lasts a lifetime.

Specialist advice should be sought concerning any part of the building requirements, installation, commissioning etc. or any references in this manual from Cummins Power Generation Applications Engineering Group.

Data compiled in this manual will be continuously improved and therefore subject to change without notice, all rights are reserved.

## World Electricity Supplies

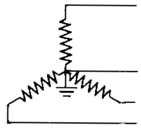
| Country | Frequency (Hz) | Supply Voltage Levels in Common Use (V) |
|---|---|---|
| Abu Dhabi (United Arab Emirates) | 50 | 415/250 |
| Afghanistan | 50; 60 | 380/220; 220 |
| Algeria | 50 | 10 kV; 5.5 kV; 380/220; 220/127 |
| Angola | 50 | 380/220; 220 |
| Antigua | 60 | 400/230; 230 |
| Argentina | 50 | 13.2 kV; 6.88 kV; 390/225; 339/220: 220 |
| Australia | 50 | 22 kV; 11 kV; 6.6 kV; 440/250; 415/240; 240 |
| Austria | 50 | 20 kV; 10 kV; 5 kV; 380/220; 220 |
| Bahamas | 60 | 415/240; 240/120; 208/120; 120 |
| Bahrain | 50: 60 | 11 kV; 400/230: 380/220; 230; 220/110 |
| Bangladesh | 50 | 11 kV; 400/230; 230 |
| Barbados | 50 | 11 kV; 3.3 kV; 230/115; 200/115 |
| Belgium | 50 | 15 kV; 6 kV; 380/220; 2201127, 220 |
| Belize | 60 | 440/220; 220/110 |
| Bermuda | 60 | 4.16/2.4 kV; 240/120; 208/120 |
| Bolivia | 50; 60 | 230/115; 400/230/220/110 |
| Botswana | 50 | 380/220: 220 |
| Brazil | 50; 60 | 13.8 kV; 11.2 kV: 380/220,220/127 |
| Brunei | 50 | 415/230 |
| Bulgaria | 50 | 20 kV; 15 kV; 380/220; 220 |
| Burma | 50 | 11 kV; 6.6 kV; 400/230; 230 |
| Burundi | | |
| Cambodia (Khmer Republic) | 50 | 380/220; 208/120; 120 |
| Cameroon | 50 | 15 kV; 320/220; 220 |
| Canada | 60 | 12.5/7.2 kV; 600/347; 240/120; 208/120; 600; 480; 240 |
| Canary Islands | 50 | 380/220; 230 |
| Cape Verde Islands | 50 | 380/220; 127/220 |
| Cayman Islands | 60 | 480/240; 480/227; 240/120; 208/120 |
| Central African Republic | 50 | 380/220 |
| Chad | 50 | 380/220; 220 |
| China | 50 | 380/220 50Hz |
| Chile | 50 | 380/220; 220 |
| Colombia | 60 | 13.2 kV; 240/120; 120 |
| Costa Rica | 60 | 240/120; 120 |
| Cuba | 60 | 440/220; 220/110 |
| Cyprus | 50 | 11 kV; 415/240; 240 |
| Czechoslovakia | 50 | 22 kV; 15 kV; 6 kV; 3 kV; 380/220; 220 |
| Dahomey | 50 | 15 kV; 380/220; 220 |
| Denmark | 50 | 30 kV; 10 kV; 380/220; 220 |
| Dominica (Windward Islands) | 50 | 400/230 |
| Dominican Republic | 60 | 220/110; 110 |
| Dubai (United Arab Emirates) | 50 | 6.6 kV; 330/220; 220 |
| Ecuador | 60 | 240/120; 208/120; 220/127; 220/110 |
| Egypt (United Arab Republic) | 50 | 11 kV; 6.6 kV; 380/220; 220 |
| Eire (Republic of Ireland) | 50 | 10 kV; 380/220; 220 |
| El Salvador | 60 | 14.4 kV; 2.4 kV; 240/120 |
| Ethiopia | 50 | 380/220; 220 |
| Faeroe Islands (Denmark) | 50 | 380/220 |
| Falkland Islands (UK) | 50 | 415/230; 230 |
| Fiji | 50 | 11 kV; 415/240; 240 |
| Finland | 50 | 660/380; 500; 380/220; 220 |
| France | 50 | 20 kV; 15 kV; 380/220; 380; 220; 127 |
| French Guiana | 50 | 380/220 |
| French Polynesia | 60 | 220; 100 |
| Gabon | 50 | 380/220 |
| Gambia | 50 | 400/230; 230 |
| Germany (BRD) | 50 | 20 kV; 10 kV; 6 kV; 380/220; 220 |
| Germany (DDR) | 50 | 10 kV; 6 kV; 660/380; 380/220; 220/127; 220; 127 |
| Ghana | 50 | 440/250; 250 |
| Gibraltar | 50 | 415/240 |
| Greece | 50 | 22 kV; 20 kV; 15 kV; 6.6 kV; 380/220 |
| Greenland | 50 | 380/220 |
| Grenada (Windward Islands) | 50 | 400/230; 230 |
| Guadeloupe | 50; 60 | 20 kV; 380/220; 220 |
| Guam (Mariana Islands) | 60 | 13.8 kV; 4 kV; 480/277; 480: 240/120; 207/120 |
| Guatemala | 60 | 13.8 kV; 240/120 |
| Guyana | 50 | 220/110 |
| Haiti | 60 | 380/220; 230/115; 230; 220; 115 |
| Honduras | 60 | 220/110; 110 |
| Hong Kong (and Kowloon) | 50 | 11 kV; 346/200; 200 |
| Hungary | 50 | 20 kV; 10 kV; 380/220; 220 |
| Iceland | 50 | 380/220; 220 |
| India | 50; 25 | 22 kV; 11 kV; 440/250; 400/230; 460/230; 230 |
| Indonesia | 50 | 380/220; 2201127 |
| Iran | 50 | 20 kV; 11 kV; 400/231; 380/220; 220 |
| Iraq | 50 | 11 kV; 380/220; 220 |
| Israel | 50 | 22 kV; 12.6 kV; 6.3 kV; 400/230; 230 |
| Italy | 50 | 20 kV; 15 kV; 10 kV; 380/220; 220/127; 220 |
| Ivory Coast | 50 | 380/220; 220 |
| Jamaica | 50 | 4/2.3 kV; 220/110 |
| Japan | 50; 60 | 6.6 kV; 200/100; 22 kV; 6.6 kV; 210/105; 200/100; 100 |
| Jordan | 50 | 380/220; 220 |
| Kenya | 50 | 415/240; 240 |
| Korea Republic (South) | 60 | 200/100; 100 |
| Kuwait | 50 | 415/240; 240 |
| Laos | 50 | 380/220 |
| Lebanon | 50 | 380/220; 190/110; 220;110 |
| Lesotho | 50 | 380/220; 220 |
| Liberia | 60 | 12.5/7.2 kV; 416/240; 240/120; 208/120 |
| Libyan Arab Republic | 50 | 400/230; 220/127; 230;127 |
| Luxembourg | 50 | 20 kV; 15 kV; 380/220; 220 |
| Macao | 50 | 380/220; 220/110 |
| Malagassy Republic (Madagascar) | 50 | 5 kV; 380/220; 220/127 |
| Malawi | 50 | 400/230; 230 |
| Malaysia (West) | 50 | 415/240; 240 |
| Mali | 50 | 380/220; 220/127; 220; 127 |
| Malta | 50 | 415/240 |
| Manila | 60 | 20 kV; 6.24 kV; 3.6 kV; 240/120 |
| Martinique | 50 | 220/127; 127 |
| Mauritania | 50 | 380/220 |
| Mauritius | 50 | 400/230; 230 |
| Mexico | 60 | 13.8 kV; 13.2 kV; 480/277; 220/127; 220/120 |
| Monaco | 50 | 380/220; 220/127; 220; 127 |

## World Electricity Supplies

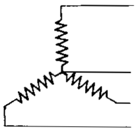
| Country | Frequency (Hz) | Supply Voltage Levels in Common Use (V) |
|---|---|---|
| Montserrat | 60 | 400/230; 230 |
| Morocco | 50 | 380/220; 220/127 |
| Mozambique | 50 | 380/220 |
| Muscat and Oman | 50 | 415/240; 240 |
| Naura | 50 | 415/240 |
| Nepal | 50 | 11 kV; 400/220; 220 |
| Netherlands | 50 | 10 kV; 3 kV; 380/220; 220 |
| Netherlands Antilles | 50; 60 | 380/220; 230/115; 220/127; 208/120 |
| New Caledonia | 50 | 220 |
| New Zealand | 50 | 11 kV; 415/240; 400/230; 440; 240; 230 |
| Nicaragua | 60 | 13.2 kV; 7.6 kV; 240/120 |
| Niger | 50 | 380/220; 220 |
| Nigeria | 50 | 15 kV; 11 kV; 400/230; 380/220; 230; 220 |
| Norway | 50 | 20 kV; 10 kV; 5 kV; 380/220; 230 |
| Pakistan | 50 | 400/230; 230 |
| Panama | 60 | 12 kV; 480/227; 240/120; 208/120 |
| Papua New Guinea | 50 | 22 kV; 11 kV; 415/240; 240 |
| Paraguay | 50 | 440/220; 380/220; 220 |
| Peru | 60 | 10 kV; 6 kV; 225 |
| Philippines | 60 | 13.8 kV; 4.16 kV; 2.4 kV; 220/110 |
| Poland | 50 | 15 kV; 6 kV; 380/220; 220 |
| Portugal | 50 | 15 kV; 5 kV; 380/220; 220 |
| Portuguese Guinea | 50 | 380/220 |
| Puerto Rico | 60 | 8.32 kV; 4.16 kV; 480; 240/120 |
| Qatar | 50 | 415/240; 240 |
| Reunion | 50 | 110/220 |
| Romania | 50 | 20 kV; 10 kV; 6 kV; 380/220; 220 |
| Rwanda | 50 | 15 kV; 6.6 kV; 380/220; 220 |
| Sabah | 50 | 415/240; 240 |
| Sarawak (East Malaysia) | 50 | 4151240; 240 |
| Saudi Arabia | 60 | 380/220; 220/127; 127 |
| Senegal | 50 | 220/127; 127 |
| Seychelles | 50 | 415/240 |
| Sierra Leone | 50 | 11 kV; 400/230; 230 |
| Singapore | 50 | 22 kV; 6.6 kV; 400/230; 230 |
| Somali Republic | 50 | 440/220; 220/110; 230: 220; 110 |
| South Africa | 50; 25 | 11 kV; 6.6 kV; 3.3 kV; 433/250; 400/230; 380/220; 500; 220 |
| Southern Yemen (Aden) | 50 | 400/230 |
| Spain | 50 | 15 kV; 11 kV; 380/220; 220/127; 220; 127 |
| Spanish Sahara | 50 | 380/220; 110; 127 |
| Sri Lanka (Ceylon) | 50 | 11 kV; 400/230; 230 |
| St. Helena | 50 | 11 kV; 415/240 |
| St. Kitts Nevis Anguilla | 50 | 400/230; 230 |
| St. Lucia | 50 | 11 kV; 415/240; 240 |
| Saint Vincent | 50 | 3.3 kV; 400/230; 230 |
| Sudan | 50 | 415/240; 240 |
| Surinam | 50; 60 | 230/115; 220/127; 220/110; 127; 115 |
| Swaziland | 50 | 11 kV; 400/230; 230 |
| Sweden | 50 | 20 kV; 10 kV; 6 kV; 380/220; 220 |
| Switzerland | 50 | 16 kV; 11 kV; 6 kV; 380/220; 220 |
| Syrian Arab Republic | 50 | 380/220; 200/115; 220; 115 |
| Taiwan (Republic of China) | | 60 22.8 kV; 11.4 kV; 380/220; 220/110 |
| Tanzania (Union Republic of) | 50 | 11 kV; 400/230 |
| Thailand | 50 | 380/220; 220 |
| Togo | 50 | 20 kV; 5.5 kV; 380/220; 220 |
| Tonga | 50 | 11 kV; 6.6 kV; 415/240; 240; 210 |
| Trinidad and Tobago | 60 | 12 kV; 400/230; 230/115 |
| Tunisia | 50 | 15 kV; 10 kV; 380/220; 220 |
| Turkey | 50 | 15 kV; 6.3 kV; 380/220; 220 |
| Uganda | 50 | 11 kV; 415/240; 240 |
| United Kingdom | 50 | 22 kV; 11 kV; 6.6 kV; 3.3 kV; 400/230; 380/220; 240; 230; 220 |
| Upper-Yolta | 50 | 380/220; 220 |
| Uruguay | 50 | 15 kV; 6 kV; 220 |
| USA | 60 | 480/277; 208/120; 240/120 |
| USSR | 50 | 380/230; 220/127 and higher voltages |
| Venezuela | 60 | 13.8 kV; 12.47 kV; 4.8 kV; 4.16 kV; 2.4 kV; 240/120; 208/120 |
| Vietnam (Republic of) | 50 | 15 kV; 380/220; 208/120; 220; 120 |
| Virgin Islands (UK) | 60 | 208; 120 |
| Virgin Islands (US) | 60 | 110/220 |
| Western Samoa | 50 | 415/240 |
| Yemen, Democratic (PDR) | 50 | 440/250; 250 |
| Yugoslavia | 50 | 10 kV; 6.6 kV; 380/220; 220 |
| Zaire (Republic of) | 50 | 380/220; 220 |
| Zambia | 50 | 400/230; 230 |
| Zimbabwe | 50 | 11 kV; 390/225; 225 |

*Table 1 World Electricity Supplies*

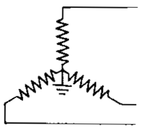
## Supply Voltages



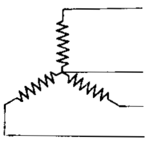
A THREE PHASE STAR: FOUR WIRE: EARTHED NEUTRAL — 50 Hz, 550/320, 440/254, 415/240, 346/200, 390/225, 200/115, 190/110; 50 Hz or 60 Hz, 440/230, 380/220, 220/127, 208/120; 60 Hz only, 460/265, 480/277



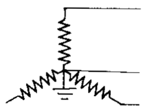
B THREE PHASE STAR: THREE WIRE: — 50 Hz, 380/220; 60 Hz, 220/127, 416/240



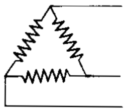
C THREE PHASE STAR: THREE WIRE: EARTHED NEUTRAL POINT — 60Hz, 480/277



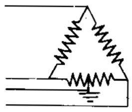
D THREE PHASE STAR: FOUR WIRE: NON EARTHED NEUTRAL: — 50 Hz, 380/220; 60 Hz, 208/120



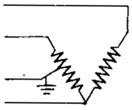
E TWO PHASE STAR: THREE WIRE: EARTHED NEUTRAL: — 50 Hz, 220/127; 380/220, 400/230, 415/240



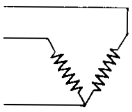
F THREE PHASE DELTA: THREE WIRE: — 50 Hz, 220; 60 Hz, 230,240,480, 575



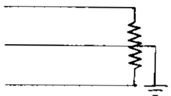
G THREE PHASE DELTA: FOUR WIRE: EARTHED MID POINT OF PHASE: — 50 Hz, 220/110; 440/220; 50/60 Hz, 230/115; 60 Hz, 240/120,240/210, 480/240



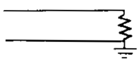
H THREE PHASE OPEN DELTA: FOUR WIRE: EARTHED MID POINT OF PHASE: — 50 Hz, 200/100; 230/115; 60 Hz, 210/105, 220/110, 240/120



J THREE PHASE OPEN DELTA: FOUR WIRE: EARTH JUNCTION OF PHASE: — 50 Hz, 200



K SINGLE PHASE: THREE WIRE: EARTHED MID POINT: — 50 or 60 Hz, 200/100, 220/110; 230/115; 60 Hz, 210/105, 240/120



L SINGLE PHASE: TWO WIRE: EARTHED END OF PHASE: — 50 Hz, 200, 225, 250; 50 or 60 Hz, 100, 110, 115, 120, 127, 220, 230, 240

M SINGLE PHASE: TWO WIRE: EARTHED NEUTRAL: — 60 Hz, 120

| Special delta - One leg centre tapped | | | | | |
|---|---|---|---|---|---|
| A-SAC | C-SAC | B-SAC | A-SAC | C-SAC | B-SAC |
| 90 | 90 | 156 | 185 | 185 | 320 |
| 95 | 95 | 164 | 190 | 190 | 329 |
| 100 | 100 | 173 | 195 | 195 | 338 |
| 104 | 104 | 180 | 200 | 200 | 346 |
| 105 | 105 | 182 | 205 | 205 | 355 |
| 110 | 110 | 190 | 208 | 208 | 359 |
| 115 | 115 | 199 | 210 | 210 | 364 |
| 120 | 120 | 207 | 215 | 215 | 372 |
| 125 | 125 | 216 | 220 | 220 | 381 |
| | | | 225 | 225 | 390 |
| 170 | 170 | 294 | 230 | 230 | 398 |
| 175 | 175 | 294 | | | |
| 180 | 180 | 312 | 250 | 250 | 433 |

| Line Volts A-B B-C C-A | Std. 4 Wire Line to Neutral A-N B-N C-N | Line Volts A-B B-C C-A | Std. 4 Wire Line to Neutral A-N B-N C-N |
|---|---|---|---|
| 180 | 104 | 370 | 213 |
| 190 | 110 | 380 | 220 |
| 200 | 110 | 390 | 225 |
| 208 | 120 | 400 | 230 |
| 210 | 121 | 410 | 237 |
| 220 | 127 | 415 | 240 |
| 230 | 133 | 420 | 248 |
| 240 | 139 | 430 | 252 |
| 250 | 144 | 440 | 254 |
| | | 450 | 260 |
| 340 | 196 | 460 | 266 |
| 350 | 202 | | |
| 360 | 208 | 500 | 288 |

# Equivalents and Formulae

### Equivalents

1 horsepower = 746watts
1 horsepower = 0.746kW
1 horsepower = 33,000ft lb/min

1 kW = 1 000watts
1 kW = 1.3415hp
1 kW = 56.8ft lb/min

ft lb/min
1 horsepower = 550ft lb/sec
1 horsepower = 2546Btu/hr
1 horsepower = 42.4Btu/min

1 kW = 738ft lb/sec
1 kW = 3412Btu/hr

1 Btu = 9340in lb
1 Btu = 778.3ft lb
1 Btu =.0002930kWhr
1 Btu = 1.05506kJ

1ft lb = 0.001284Btu
1 kWhr = 3413Btu

1 Btu/min = 17.57watts
1 Btu/min = 0.0176kW
1 Btu/min = 0.0236hp
1 Btu/hr = 0.293watts

1 ft lb = 1.35582Nm
1 ft lb/sec = 0.001355kW
1 ft lb/sec = 0.001818hp

1 therm = 100,000Btu

12,000Btu = 1 Ton (air conditioning)

### Formulae

**Brake Mean Effective Pressure (BMEP)**

$$\text{BMEP} = \frac{792{,}000 \times \text{BHP}}{\text{rpm} \times \text{cubic inch displacement}} \text{ (for 4-cycle)}$$

**Brake Horsepower (BHP)**

$$\text{BHP} = \frac{\text{BMEP} \times \text{cubic inch displacement} \times \text{rpm}}{792{,}000} \text{ (for 4-cycle)}$$

**Torque**

$$\text{Torque (ft lb)} = \frac{5250 \times \text{BHP}}{\text{rpm}}$$

**Temperature**

$$\text{Temp. (°C)} = \frac{(°F - 32)}{1.8} \qquad °F = (°C \times 1.8) + 32$$

**Power Factor & kVA**

$$PF = \frac{kW}{kVA} \qquad KVA = \frac{kW}{PF}$$

### Formulae for Obtaining kW, kVA, Reactive kVA, BHP and Amperes

To Obtain:

| | Single Phase AC | Three Phase AC | Direct Current |
|---|---|---|---|
| KW = | $\frac{V \times A \times PF}{1000}$ | $\frac{kVA \times PF}{1000}$ | $\frac{V \times A}{1000}$ |
| KVA = | $\frac{V \times A}{1000}$ | $\frac{V \times A \times 1.732}{1000}$ | |
| Reactive kVA = | kVA x 1 - $PF^2$ | kVA x 1 - $PF^2$ | |
| BHP (Output) = | $\frac{V \times A \times \sqrt{\text{Gen. Eff.} \times PF}}{746 \times 1000}$ | $\frac{1.73 \times \sqrt{V \times A \times \text{Eff.} \times PF}}{746 \times 1000}$ | $\frac{V \times A \times \text{Gen. Eff.}}{746 \times 1000}$ |
| BHP (Input) = | $\frac{kW}{746 \times 1000}$ | $\frac{kW}{746 \times 1000}$ | |
| A (when BHP is known) = | $\frac{BHP \times 746 \times 100}{V \times \text{Gen. Eff.} \times PF}$ | $\frac{BHP \times 746 \times 100}{1.73 \times V \times \text{Gen. Eff.} \times PF}$ | $\frac{BHP \times 746 \times 100}{V \times \text{Gen. Eff.}}$ |
| A (when kW is known) = | $\frac{KW \times 1000}{V \times PF}$ | $\frac{kW \times 1000}{V \times PF \times 1.732}$ | $\frac{kW \times 1000}{V}$ |
| A (when KVA is known) = | $\frac{KVA \times 1000}{V}$ | $\frac{KVA \times 1000}{V \times 1.732}$ | |

### Misc.

$$HZ = \frac{\text{No. of poles} \times \text{RPM}}{120} \qquad \frac{\text{No. of poles} \times \text{RPM}}{120}$$

$$HP = \frac{KW}{0.746 \times \text{Gen Efficiency}} \qquad \frac{KW}{0.746 \times \text{Gen Efficiency}}$$

Where;-
kW = Kilowatts
V = Line to Line Voltage
A = Line Current
PF = Power Factor
HZ = Frequency
HP = Horse Power

## Installation Questionnaire for Generating Sets

In order to accurately estimate the materials, technicalities and costing for any installation it is essential that all available data relating to the generator, location and room be itemised and documented before contacting the supplier. This service can alternatively be provided by your local Cummins Distributor.

Project ..........................................................................................
..................................................................................................
Customer (End User) ......................................................................
..................................................................................................
Address of Site ...............................................................................
..................................................................................................
..................................................................................................
..................................................................................................
Consultant .......................................................................................
..................................................................................................
Address ..........................................................................................
..................................................................................................
..................................................................................................
..................................................................................................
Telephone No. ................................................................................
Site Drawing No. ............................................................................
Architect .........................................................................................
..................................................................................................

**GENERATING SET DETAILS**

Model ........................................ kVA ..........................................
p.f. ............................................... kW ............................................
Voltage ....................................... Phases .......................................
Frequency .................................. Engine .......................................
Alternator .................................. Control System .........................
Number ....................................... Size of Room ............................
Position of Set(s) ...........................................................................
indicate on site drawing if possible
Are Control Panels to be Integral ☐ or Free Standing ☐
Position of Free Standing Control Panel ........................................
..................................................................................................
Motor starting YES ☐ NO ☐
UPS Load YES ☐ NO ☐
Operate Lifts YES ☐ NO ☐
Base Fuel Tank YES ☐ NO ☐

**SITE CONDITIONS**

**Brief description of site working conditions including time scale for installation:** ....................................................................
..................................................................................................

Type of Crane ................................................................................
Distance to position of set from roadway? ....................................
Type of Transport ..........................................................................
Police Involvement YES ☐ NO ☐ Road Closure YES ☐ NO ☐

**Access** (obstructions, restrictions, etc.) ...........................................
..................................................................................................
Is set to be positioned
IN BASEMENT ☐ GROUND LEVEL ☐
MID LEVEL ☐ ROOF TOP ☐
Is set to be dismantled YES ☐ NO ☐
ON PLINTHS ☐ R.S.J's ☐ FLOOR ☐

Special Access Requirements: ........................................................
..................................................................................................
Radiator 40°C ☐ 50°C ☐
Is radiator to be Integral ☐ or REMOTE ☐ or OTHER ☐
Position of Remote radiator relative to both plant and control panel ...................................................................................
..................................................................................................

**EXHAUST**

Type of flue to be used: Steel ☐ Twin wall stainless steel ☐
Overall length of exhaust Horiz ................Vert ..............metres/ft.
Number of Bends ..........................................................................
Type of Silencers: Residential ☐ Acoustic ☐ Other ☐
Type of Brackets: Roller ☐ Fixed ☐ Spring ☐
GLC type ☐ Mixed ☐
Pipework to be: Flanged ☐ Butt welded ☐
Residential Silencer to be:
floor mounted ☐ wall mounted ☐ ceiling mounted ☐
Acoustic Silencer to be:
floor mounted ☐ wall mounted ☐ ceiling mounted ☐
Exhaust weathering in: wall ☐ roof ☐
Termination in: tailpipe ☐ cowl ☐
Finish to pipework: red lead ☐ black epoxy paint ☐
Access for erecting pipework:
good ☐ bad ☐ scaffold required ☐
Welding supply available: YES ☐ NO ☐
Type of lagging: rockwool ☐ other ☐
Type of cladding:
22 swg aluminium ☐ stainless steel ☐ other ☐
Length of pipe to be lagged and clad ...............................metres/ft.
Type of silencer to be lagged and clad: Residential ☐ Acoustic ☐

**CABLE**

Type of Load Cables:
PVCSWAPVC ☐ CSP/EPR ☐ Bus bar ☐ LSF ☐
Route length of control cables between plant and panel:
..........................................................................................metres/ft.
Type of control cables:
PVCSWAPVC ☐ PVC ☐ LSF ☐
Route length of control cables between plant and panel:
..........................................................................................metres/ft.
Load and control cable run in:
Trunking ☐ On tray ☐ Clipped ☐
Load and control cables run overhead:
on wall ☐ on floor ☐ in trench ☐
Cable entry to panel: top ☐ bottom ☐ side ☐
Position of LTB: ...........................................................................
Other control cables:
Service ......................................................................... metres/ft
Cable Type .................................................................. metres/ft
Cable Route Length ..................................................... metres/ft

**WATER**

Pipe route length between remote radiator and engine:
.........................................................................................metres/ft

Pipe route length between break tank and radiator:
......................................................................................... metres/ft

Break Tank required: YES ☐ NO ☐

Pipework to be: screwed ☐ welded ☐

Pipework to be: galvanised ☐ steel ☐

---

**FUEL**

Type of bulk tank:
Cylindrical ☐ Rectangular ☐ Double skinned ☐ Bunded ☐

Capacity of bulk tank:.......................................................................

Standard Bosses ☐ Extra Bosses ☐

Position of Bulk Tank in relation to set:.............................................
(height above or below ground etc.)

Access for offloading:.......................................................................

Pipe route length between bulk tank and service tank:
flow ........................................ return ..............................metres/ft

Local Atmosphere ☐ Remote Vent ☐ Route .................... ☐

Pipework: below ground ☐ above ground ☐

Pipework to be jacketed: YES ☐ NO ☐

Pipe: Trace heated☐ Denso ☐

Type of fillpoint required: Cabinet ☐ Valve, cap and chain ☐

Pipe route length between bulk tank and fill point:..............metres/ft

Fill alarm unit and tank float switch required:
YES ☐ NO ☐

Pipework: Thickness ..................Single Skin ☐ Double Skin ☐

If double skin all pipe ☐ or specify .................................................

Pipework support/fixing ....................................................................

Type of bulk tank contents gauge:
Hydrostatic ☐ Electronic ☐ Mechanical ☐

Position of contents gauge: ........................if not in fill point cabinet

Distance from bulk tank:.................................................... metres/ft.

Service tank: free standing ☐ on set ☐

Overspill tank required: YES ☐ NO ☐

If tank free standing, pipe route length to engine:
......................................................................................... metres/ft.

Auto fuel transfer system: YES ☐ NO ☐
Duplex YES ☐ NO ☐

Solenoid valve required: YES ☐ NO ☐

Position: ..........................................................................................

If pump positioned away from tank determine position: ....................
.............................................................................................................

Fire valve required: YES ☐ NO ☐
MERC: YES ☐ NO ☐
MKOB ☐ SQR ☐ BATT PACK ☐

Other alarms required: ....................................................................

Dump valve ☐

---

**ATTENUATION**

Level of noise to be obtained ................................................dB(A)

What distance.................................................................. metres/ft.

Position of inlet splitter: low level ☐ high level ☐

Position of outlet splitter: low level ☐ high level ☐

Number of acoustic doors: ..............................................................
Type: single ☐ double ☐

Antivibration mounts required: YES ☐ NO ☐

Acoustic louvres: YES ☐ NO ☐

Noise survey required: YES ☐ NO ☐

Sound proof enclosure: YES ☐ NO ☐
Container ☐ Drop over ☐ Int fit out ☐
Walk round ☐ Close fit ☐ EEC style ☐

Paint finish ..........................RAL/BS4800 .......................................

---

**DUCTING**

Length of inlet duct: ........................................................ metres/ft.
No. of bends: .........................................................................

Length of outlet duct: ...................................................... metres/ft.
No. of bends: .........................................................................

Inlet duct: floor mounted ☐ wall mounted ☐ off ceiling ☐

Outlet duct: floor mounted ☐ wall mounted ☐ off ceiling ☐

Fire damper in inlet duct: YES ☐ NO ☐

Fire damper in outlet duct: YES ☐ NO ☐

---

**LOUVRES**

Inlet louvre ☐ Outlet louvre ☐

Type: fixed blade ☐ gravity ☐ motorised ☐

Position of louvre inlet: external ☐ internal ☐

Position of louvre outlet: external ☐ internal ☐

Colour finish to louvres: ..................................................................

---

**COMMISSION**

Distance from Genset/Conn............................................. metres/ft.

Load Bank ☐ Resistive ☐ Reactive ☐

Ground level ☐ Roof ☐ Other ☐

Weekend working ☐

Out of normal hours ☐

During normal hours ☐

First fill of lub. oil: YES ☐ NO ☐ ................................litres

First fill of fuel ☐ Quantity ☐ ................................litres

Anti freeze ☐ YES ☐ NO ☐

Maintenance contract required:: YES ☐ NO ☐

Are civil works required: YES ☐ NO ☐

Set Length mm ..................................................................................
Width mm ..................................................................................
Height mm ..................................................................................
Weight Kg ..................................................................................

---

**DRAWINGS**

Plant Room ☐ Builders/Civils ☐ Other ☐

---

COMPILED BY: .................................................................................

DATE: .................................................................................................

## General

In order to start to consider the possible layouts for a site, the following criteria must first be determined:-

The total area available and any restrictions within that area (i.e. buried or overhead services).

Any noise constraints. (i.e. the location of offices or residential property).

The access to the site, initially for delivery and installation purposes, but afterwards for the deliveries of fuel and servicing vehicles, etc.

The ground condition, is it level or sloping?

When installing the equipment within a plant room, consideration must be given to each of the following:-

A forced ventilation system is required for the equipment, which draws sufficient cooling and aspiration air into the room at the back of the alternator and discharges the air from in front of the engine. Dependent upon the layout of the building, it may be necessary to install additional ductwork to achieve the airflow required.

In order to reduce the heat gain within the plant room, all the elements of the exhaust system will need to be fully lagged. Where practical, the silencer and as much of the pipework as possible should be outside the generator room.

The access into the building, initially for the delivery and installation of the equipment, and, afterwards for servicing and maintenance of the equipment.

The plant room should be of sufficient size to accommodate the following items of equipment:

The engine/alternator assembly.

The local fuel tank (if applicable).

The generator control panel including the PCC (if free standing).

The exhaust system (if internally erected).

The air handling system including any sound attenuating equipment that may be required.

The relative height of the base for the bulk tanks should also be taken into consideration to determine the type of fuel transfer system that is to be utilised. The sizes for the bulk fuel storage tank(s) are dependent on the duration of the storage that is required.

Where possible the equipment should be positioned in a manner such that "cross overs" of the ancillary services, (fuel, water and electrical power/controls) do not occur.

Due consideration should be given to the direction of the noise sensitive areas so that elements generating noise can be positioned to restrict any potential problem.(i.e. exhaust outlets).

## Modular Installation

In terms of the external appearance the "drop-over" enclosure system is virtually identical to a containerised system. The principle difference between the two systems is that in the containerised arrangement the generator is mounted on the floor of the module, whereas in the "dropover" arrangement, the generator locates directly on the concrete plinth and the enclosure drops over onto the plinth.

To maintain the advantage of the reduction in site work, it is essential to give careful consideration to the positioning of the set to optimise the space and to minimise the lengths of any inter-connections.

## Off-loading and Positioning the Equipment

Prior to the commencement of the off-loading, using the specific site and equipment drawings, the positions for each of the principle items of equipment should be carefully marked out on the plinth/plant room floor.

The order in which various items of equipment are to be positioned should be determined to ensure that double lifting is avoided as far as possible.

The appropriate size and type of crane should be considered bearing in mind the site conditions and lifting radius. All the necessary lifting chains, spreader beams, strops etc., should be used to off-load and position the equipment.

Note : Special foundations are unnecessary. A level and sufficiently strong concrete floor is adequate.

## Introduction

The responsibility for the design of the foundation (including seismic considerations) should be placed with a civil or structural engineer specialising in this type of work.

Major functions of a foundation are to:

Support the total weight of the generating set.

Isolate generator set vibration from surrounding structures.

To support the structural design, the civil engineer will need the following details:-

the plant's operating temperatures (heat transfer from machines to mass could lead to undesirable tensile stresses).

the overall dimensions of the proposed foundation mass.

the mounting and fixing arrangements of the generator bedframe.

## Concrete Foundations

The foundation will require at least seven days between pouring the concrete and mounting the generating set to cure. It is also essential that the foundation should be level, preferably within ± 0.5° of any horizontal plane and should rest on undisturbed soil.

The following formula may be used to calculate the minimum foundation depth :

$$t = \frac{k}{d \times w \times l}$$

t = thickness of foundation in m

k = net weight of set in kg

d = density of concrete (take 2403 kg/m$^2$)

w = width of foundation in (m)

l = length of foundation in (m)

The foundation strength may still vary depending on the **safe bearing capacity** of supporting materials and the **soil bearing load** of the installation site, therefore reinforced gauge steel wire mesh or reinforcing bars or equivalent may be required to be used.

## Foundations

**Main Block Materials**

1 Part Portland Cement

2 Parts clean sharp sand

4 Parts washed ballast (3/4")

**Grouting Mixture**

1 Part Portland Cement

2 Parts clean sharp sand

When the water is added, the consistency of the mixture should be such that it can be easily poured.

Should a suitable concrete base already exist or it is not convenient to use rag-bolts, then rawl-bolts or similar type of fixing bolt may be used. This obviates the necessity of preparing foundation bolt holes as already described. However, care should be taken that the correct size of masonry drill is used.

## Modularised System/Enclosed-Silenced Generators

In the design of the layout for this type of system the same constraints and guidance for the foundation should be observed, however, as the generator set and enclosure will be located directly onto the plinth, more care is required in its casting to ensure that it is flat and level with a "power float" type finish.

When the generator compartment is in the form of a dropover enclosure, it will be necessary to provide a weatherproofing sealing system in the form of angle section laid on an impervious strip seal. This will also act as a bund to retain fuel, water or oil spillage.

## Vibration Isolation

Each generator is built as a single module with the engine and alternator coupled together through a coupling chamber with resilient mountings to form one unit of immense strength and rigidity. This provides both accuracy of alignment between the engine and alternator and damping of engine vibration. Thus heavy concrete foundations normally used to absorb engine vibration are not necessary and all the generator requires is a level concrete floor that will take the distributed weight of the unit.

## Foundation

The generator can be placed directly on a level, concrete floor, but where a permanent installation is intended, it is recommended that the unit is placed on two raised longitudinal plinths. This allows for easy access for maintenance and also allows a drip tray to be placed under the sump to meet fire regulation. Plinths should raise the plant 100 to 125mm above floor level, the actual height depending on the type of plant. The plinths are normally cast in concrete but RSJ's or timber can be used. If either of these two materials are used the bearers should be bolted down with parobolts.

If in any doubt consult a Civil Engineer.

### Bolting Down

Parobolts should also be used for anchoring the concrete plinths when necessary.

Caution: Ensure that the concrete is completely set and hardened before positioning the plant and tightening holding down bolts.

### Levelling

A poor foundation may result in unnecessary vibration of the plant.

## Connections

All piping and electrical connections should be flexible to prevent damage by movement of the plant. Fuel and water lines, exhaust pipes and conduit can transmit vibrations at long distances.

*300 kVA standard generator with base fuel tank in typical plant room.*

## Generator installations with acoustic treatment to achieve 85dBA at 1 metre

Note:- The layout drawings provided are intended as a guide and to form the basis of the installation design, but before the room design is finalised please ensure you have a "project specific" generator general arrangement drawing. Certain ambient temperatures or specific site requirements can affect the finalised generator build, layout configuration and room dimensions.

### Room size allowance

The dimensions as indicated A & B allow for good maintenance/escape access around the generator. Ideally you should allow a minimum distance of 1 metre from any wall, tank or panel within the room.

### Machine access

It is important to remember that the generator has to be moved into the constructed generator room, therefore the personnel access door has to be of a sufficient size to allow access alternatively the inlet/outlet attenuator aperture should be extended to the finished floor level, with the bottom uplift section built when the generator is in the room.

### Inlet and outlet attenuators with weather louvres

The inlet and outlet attenuators should be installed within a wooden frame and are based on 100mm. airways with 200mm. acoustic modules. The attenuators should be fitted with weather louvres with a minimum 50% free area, good airflow profile and afford low restriction airflow access. The noise level of 85dB(A) at 1m will comply with minimum EEC Regulations. To achieve lower levels attenuator size can more than double in length.

The weather louvres should have bird/vermin mesh screens fitted on the inside, but these screens must not impede the free flow of cooling and aspiration air.

The outlet attenuator should be connected to the radiator ducting flange with a heat and oil resistant flexible connection.

### Exhaust systems

The exhaust systems shown on the layout drawings are supported from the ceiling. Should the building construction be such that the roof supports were unable to support the exhaust system, a floor standing steel exhaust stand will be needed. Exhaust pipes should terminate at least 2.3m above floor level to make it reasonably safe for anyone passing or accidentally touching.

It is recommended that stainless steel bellows be fitted to the engine exhaust manifold followed by rigid pipework to the silencer.

The dimension "E" as indicated on the layout diagrams is based upon using standard manufacturers silencers to achieve 85dBA at 1m, please ensure that the intended silencers to be used can be positioned as indicated as this dimension affects the builders works such as apertures to the walls for the exhaust outlet.

The exhaust run as indicated exits via the side wall through a wall sleeve, packed with a heat resistant medium and closed to the weather with wall plates.

Should the generator room, internally or externally, be constructed with plastic coated profiled steel sheet cladding, it is important to ensure that the wall sections at the exhaust outlet are isolated from the high exhaust pipe temperature and sealed by a specialist cladder. The same applies for any exhaust going through or near any timber or plastic guttering.

It is good installation practice for the exhaust system within the generator room to be insulated with a minimum of 50mm. of high density, high temperature mineral insulation covered by an aluminium overclad.

This reduces the possibility of operator burn injury and reduces the heat being radiated to the operating generator room.

### Cable systems

The layout drawings assumes that the change-over switch-gear is external to the generator room and located in the power distribution room. Specific project requirements can affect this layout.

The power output cables from the generator output breaker to the distribution panel must be of a flexible construction:-

EPR/CSP (6381TQ)
PCP (H07RNF)

Should the cable route length from the generator to the distribution room be extensive the flexible cables can be terminated to a load terminal close box to the generator and then extended to the distribution room with armoured multi-core cables. (See typical load terminal box layout).

The flexible power cables as installed should be laid up in trefoil, placed on support trays/ladder rack in the trench with the recommended inter-spacing and segregated from the system control cables.

The cables should be correctly supported and rated for the installation/ambient conditions.

The flexible single core power cables when entering any panel must pass through a non ferrous gland plate.

**Change-over panels.**

Should the change-over panel be positioned within the generator room due note must be made of the floor/wall space that must be made available.

For change-over cubicles up to 1000Amp. rating the wall mounting panel of maximum depth 420mm. can be mounted directly above the cable trench in the side access area without causing too many problems.

For change-over cubicles from 1600Amp. and above, a floor standing panel is used which needs additional space to be allocated. Refer to Page D11 for dimensions.

The room dimensions need to be increased in the area of the cable duct/change-over panel to allow space and man access around cubicles with the following dimensions. A minimum of 800mm. for rear access should be allowed.

The cable trench in the area of the change-over cubicle needs to be increased in size to allow for the mains, load and generator cable access requirement.

**Generator Sets.**

All generators shown include 8 hour base fuel tanks. Free standing tanks can be provided but additional room space will be required.

Canvas ducting between the radiator and ductwork or attenuator should be a minimum of 300mm.

Air inlet should be at the rear of the alternator to allow adequate circulation.

**Doors.**

Doors should always open outwards. This not only makes for a better door seal when the set/s are running but allows for a quick exit/panic button or handle to get out. Make allowance for the generator to be moved into the room by using double doors at the attenuator space.

## Generator installations WITHOUT acoustic treatment.

Note: Handy rule of thumb for INTAKE louvres. Use 1.5 x radiator area.

All the previous notes regarding "generator installations with acoustic treatment" equally apply to installations without acoustic attenuators with the exception of paragraph 3 relating to the Inlet and Outlet louvres.

**Inlet and outlet louvres.**

The inlet and outlet weather louvres should be installed within a wooden frame with a minimum 50% free area, good airflow profile and low restriction airflow access.

The weather louvres should have bird/vermin mesh screens fitted on the inside, but must not impede the free flow of cooling and aspiration air.

The outlet weather louvre should be connected to the radiator ducting flange with a heat and oil resistant flexible connection.

**When a radiator is mounted on the end of the plant main frame, position the set so that the radiator is as close to the outlet vent as possible, otherwise recirculation of hot air can take place. The recommended maximum distance away from the outlet vent is 150mm without air ducting.**

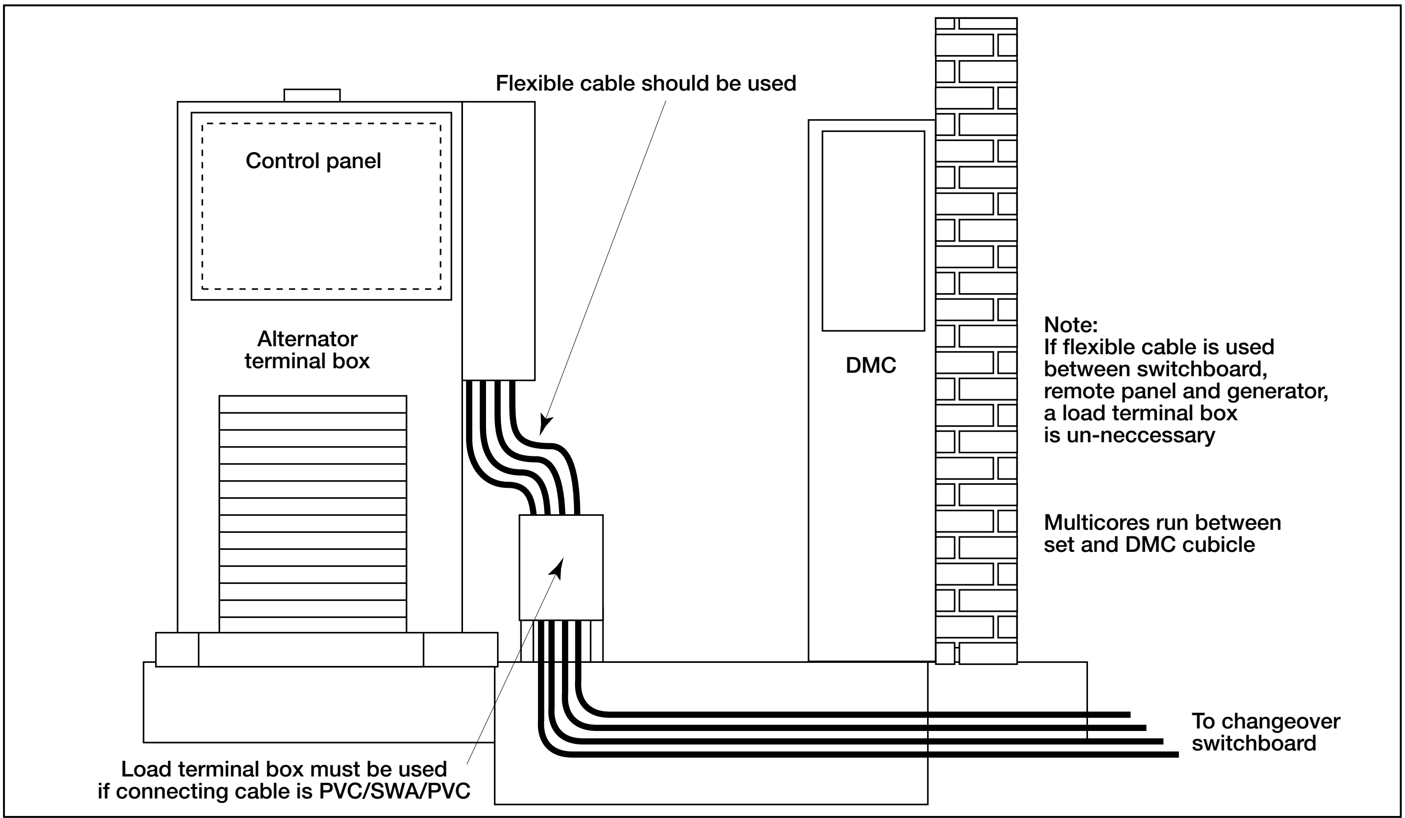



*Fig. B1 Cable Connections*

**CUMMINS ENGINE POWERED 37 kVA - 511 kVA GENERATING SETS WITHOUT ACOUSTIC TREATMENT.**

## SINGLE SETS.

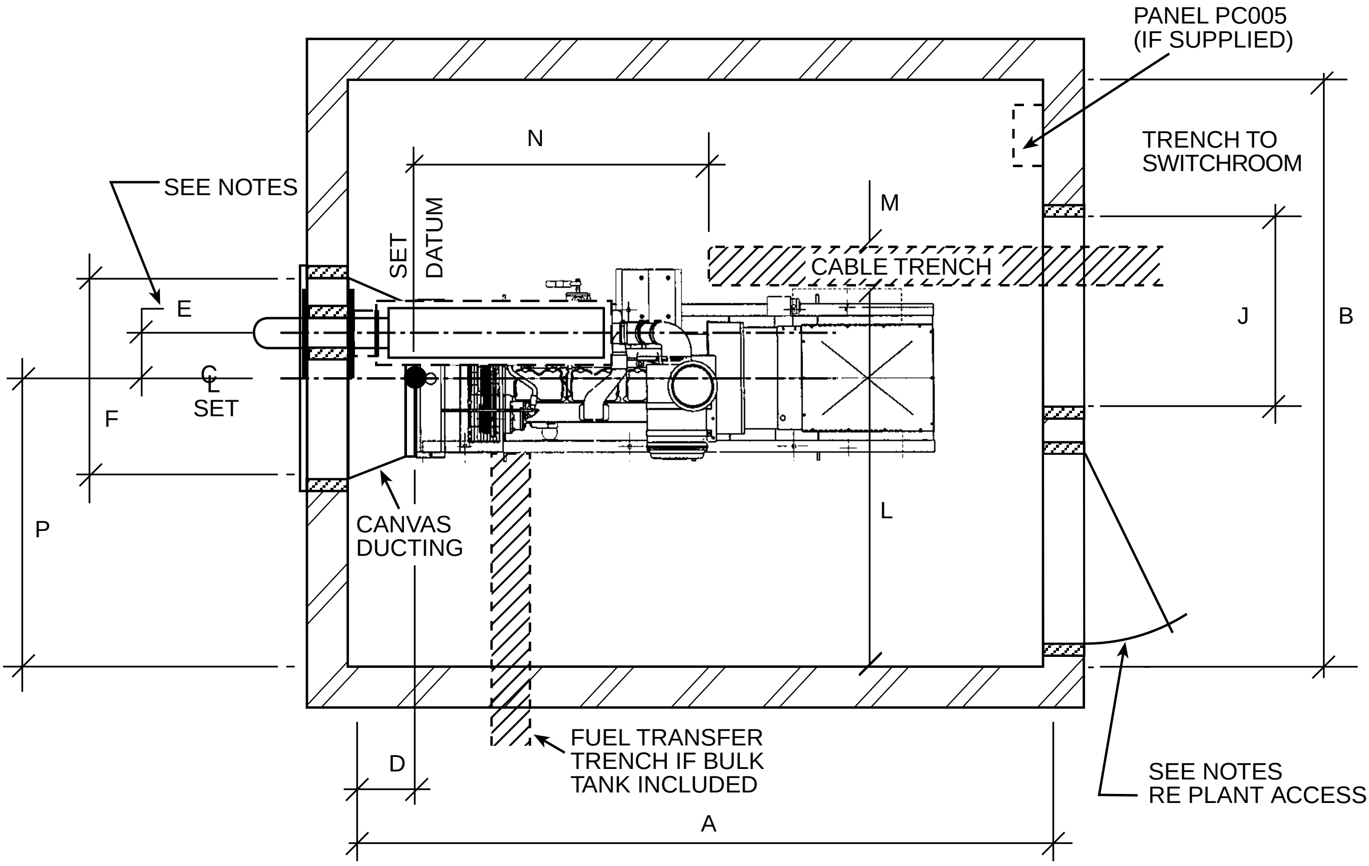
| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions | | | Set back | Set C/L position | Exhaust | | Outlet Louvre | | Uplift | Inlet Louvre | | Cable trench position | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Length A | width B | height C | D | P | Offset E | Height X | F | G | H | J | K | L | M | N |
| 32.5 | B3.3G1 | 26 DGGC | CP30-5 | 3100 | 3000 | 2600 | 400 | 1500 | 159 | 2300 | 650 | 700 | 650 | 750 | 800 | 420 | 400 | 1165 |
| 50 | B3.3G2 | 40 DGHC | CP50-5 | 3100 | 3000 | 2600 | 400 | 1500 | 275 | 2300 | 750 | 800 | 650 | 900 | 900 | 420 | 400 | 1165 |
| | | | | | | | | | | | | | | | | | | |
| 38 | 4B3.9G | 30 DGBC | CP40-5 | 3100 | 3000 | 2600 | 400 | 1500 | 141 | 2300 | 650 | 750 | 600 | 750 | 850 | 520 | 400 | 1325 |
| 52 | 4BT3.9G1 | 42 DGCA | CP50-5 | 3200 | 3000 | 2600 | 400 | 1500 | 194 | 2300 | 650 | 750 | 600 | 750 | 850 | 520 | 400 | 1325 |
| 64 | 4BT3.9G2 | 51 DGCB | CP60-5 | 3200 | 3000 | 2600 | 400 | 1500 | 194 | 2300 | 650 | 750 | 600 | 750 | 850 | 520 | 400 | 1325 |
| 70 | 4BTA3.9G1 | 56 DGCC | CP70-5 | 3250 | 3000 | 2600 | 400 | 1500 | 194 | 2300 | 650 | 750 | 600 | 750 | 850 | 520 | 400 | 1410 |
| | | | | | | | | | | | | | | | | | | |
| 96 | 6BT5.9G2 | 77 DGDB | CP90-5 | 3500 | 3000 | 2600 | 400 | 1500 | 168 | 2300 | 700 | 860 | 540 | 800 | 800 | 520 | 400 | 1630 |
| 106 | 6BT5.9G2 | 85 DGDF | CP100-5 | 3500 | 3000 | 2600 | 400 | 1500 | 168 | 2300 | 700 | 860 | 540 | 800 | 800 | 520 | 400 | 1630 |
| | | | | | | | | | | | | | | | | | | |
| 129 | 6CT8.3G2 | 103 DGEA | CP125-5 | 3850 | 3000 | 2700 | 400 | 1500 | 255 | 2300 | 850 | 1025 | 600 | 1000 | 1150 | 520 | 400 | 1910 |
| 153 | 6CTA8.3G | 122 DGFA | CP150-5 | 3850 | 3000 | 2700 | 400 | 1500 | 255 | 2300 | 850 | 1025 | 600 | 1000 | 1150 | 520 | 400 | 1910 |
| 185 | 6CTA8.3G | 148 DGFB | CP180-5 | 3850 | 3000 | 2700 | 400 | 1500 | 255 | 2300 | 850 | 1025 | 600 | 1000 | 1150 | 520 | 400 | 2070 |
| 200 | 6CTAA8.3G | 163 DGFC | CP200-5 | 3950 | 3000 | 2700 | 400 | 1500 | 255 | 2300 | 850 | 1025 | 600 | 1000 | 1150 | 520 | 400 | 2070 |
| | | | | | | | | | | | | | | | | | | |
| 233 | LTA10G2 | 186 DFAB | CP200-5 | 4850 | 3250 | 2800 | 500 | 1625 | 361 | 2300 | 1000 | 1075 | 520 | 1150 | 1250 | 625 | 400 | 2285 |
| 252 | LTA10G3 | 202 DFAC | CP250-5 | 4850 | 3250 | 2800 | 500 | 1625 | 361 | 2300 | 1000 | 1075 | 520 | 1150 | 1250 | 625 | 400 | 2285 |
| | | | | | | | | | | | | | | | | | | |
| 315 | NT855G6 | 252 DFBH | CP300-5 | 4850 | 3200 | 2700 | 500 | 1600 | 284 | 2300 | 1000 | 1300 | 700 | 1250 | 1400 | 625 | 400 | 2525 |
| 350 | NTA855G4 | 280 DFCC | CP350-5 | 4850 | 3200 | 2700 | 500 | 1600 | 284 | 2300 | 1000 | 1300 | 700 | 1250 | 1400 | 625 | 400 | 2525 |
| 431* | NTA855G6 | 340 DFCE | CS450-5 | 4850 | 3200 | 2700 | 500 | 1600 | 284 | 2300 | 1000 | 1300 | 700 | 1250 | 1400 | 625 | 400 | 2630 |
| | | | | | | | | | | | | | | | | | | |
| 431 | KTA19G3 | 345 DFEC | CP400-5 | 5275 | 3400 | 3000 | 500 | 1700 | 320 | 2500 | 1400 | 1450 | 700 | 1600 | 1675 | 775 | 400 | 2815 |
| 450 | KTA19G3 | 360 DFEL | CP450-5 | 5275 | 3400 | 3000 | 500 | 1700 | 320 | 2500 | 1400 | 1450 | 700 | 1600 | 1675 | 775 | 400 | 2815 |
| 511 | KTA19G4 | 409 DFED | CP500-5 | 5275 | 3400 | 3000 | 500 | 1700 | 320 | 2500 | 1400 | 1450 | 700 | 1600 | 1675 | 775 | 400 | 2815 |

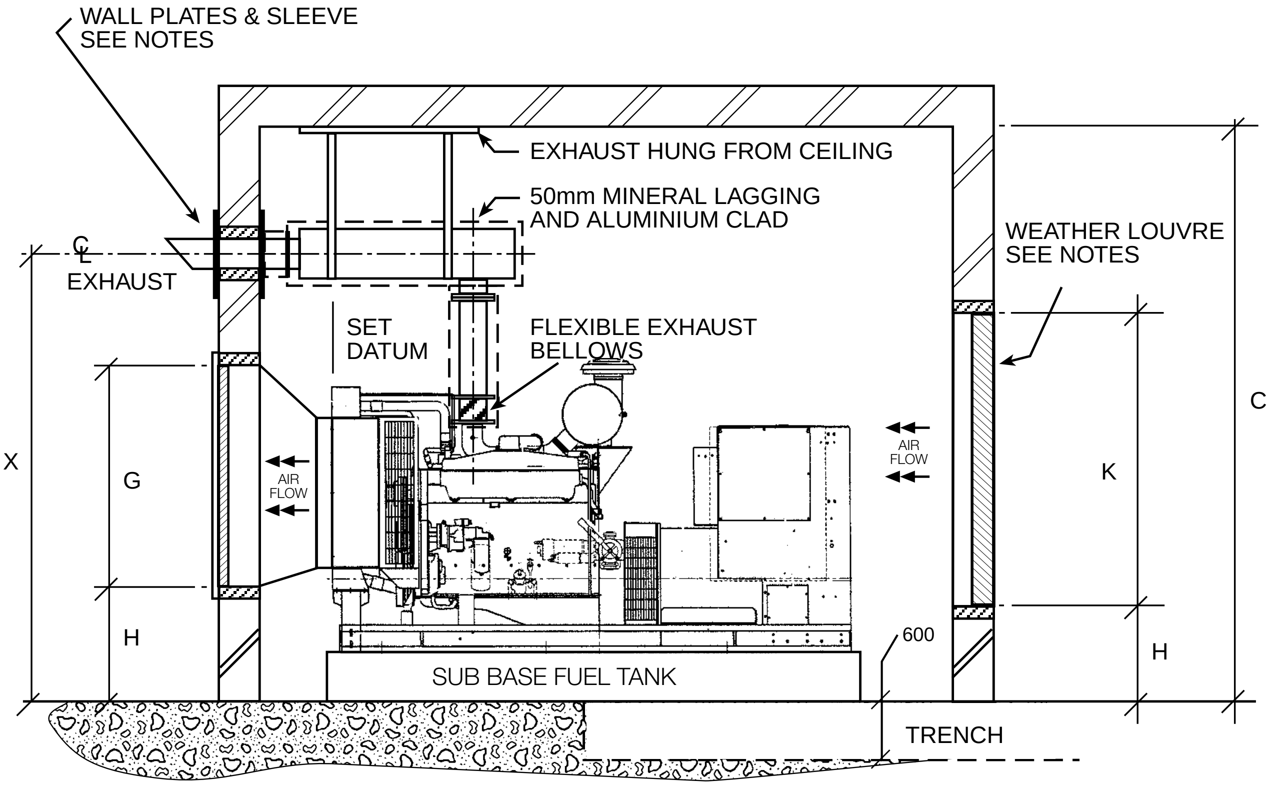
**Before finalising the generator room layout please ensure you read the guidance notes.**

*Standby rating only.

## Cummins Generating Sets 30 kVA - 511 kVA

Generator 100m layout without Acoustic Treatment



# RECOMMENDED ROOM SIZES

### CUMMINS ENGINE POWERED 37 kVA – 511 kVA GENERATING SETS **WITH ACOUSTIC TREATMENT. SINGLE SETS.**

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | length A | width B | height C | Set back D | Set C/L position P | Exhaust offset E | Exhaust height X | Attenuator Dimensions | | | uplift H | Cable trench position. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | F | Y | G | | L | M | N |
| 32.5 | B3.3G1 | 26 DGGC | CP30-5 | 4900 | 3000 | 2700 | 400 | 1500 | 159 | 2300 | 900 | 900 | 1000 | 400 | 420 | 400 | 1165 |
| 50 | B3.3G2 | 40 DGHC | CP50-5 | 4900 | 3000 | 2700 | 400 | 1500 | 275 | 2300 | 900 | 900 | 1000 | 400 | 420 | 400 | 1165 |
| | | | | | | | | | | | | | | | | | |
| 38 | 4B3.9G | 30 DGBC | CP40-5 | 4920 | 3000 | 2700 | 400 | 1500 | 168 | 2300 | 900 | 900 | 1000 | 400 | 520 | 400 | 1325 |
| 52 | 4BT3.9G1 | 42 DGCA | CP50-5 | 5000 | 3000 | 2700 | 400 | 1500 | 221 | 2300 | 900 | 900 | 1000 | 400 | 520 | 400 | 1325 |
| 64 | 4BT3.9G2 | 51 DGCB | CP60-5 | 5000 | 3000 | 2700 | 400 | 1500 | 221 | 2300 | 900 | 900 | 1000 | 400 | 520 | 400 | 1325 |
| 70 | 4BTA3.9G1 | 56 DGCC | CP70-5 | 5000 | 3000 | 2700 | 400 | 1500 | 221 | 2300 | 900 | 900 | 1000 | 400 | 520 | 400 | 1410 |
| | | | | | | | | | | | | | | | | | |
| 96 | 6BT5.9G2 | 77 DGDB | CP90-5 | 5600 | 3000 | 2700 | 400 | 1500 | 208 | 2300 | 900 | 1200 | 1000 | 400 | 520 | 400 | 1630 |
| 106 | 6BT5.9G2 | 85 DGDF | CP100-5 | 5600 | 3000 | 2700 | 400 | 1500 | 208 | 2300 | 900 | 1200 | 1000 | 400 | 520 | 400 | 1630 |
| | | | | | | | | | | | | | | | | | |
| 129 | 6CT8.3G2 | 103 DGEA | CP125-5 | 6300 | 3000 | 2800 | 400 | 1500 | 320 | 2300 | 900 | 1200 | 1200 | 400 | 520 | 400 | 1910 |
| 153 | 6CTA8.3G | 122 DGFA | CP150-5 | 6300 | 3000 | 2800 | 400 | 1500 | 320 | 2300 | 900 | 1200 | 1200 | 400 | 520 | 400 | 1910 |
| 185 | 6CTA8.3G | 148 DGFB | CP180-5 | 6300 | 3000 | 2800 | 400 | 1500 | 320 | 2300 | 900 | 1200 | 1200 | 400 | 520 | 400 | 2070 |
| 200 | 6CTAA8.3G | 163 DGFC | CP200-5 | 6450 | 3000 | 2800 | 400 | 1500 | 320 | 2300 | 1200 | 1200 | 1200 | 400 | 520 | 400 | 2070 |
| | | | | | | | | | | | | | | | | | |
| 233 | LTA10G2 | 186 DFAB | CP200-5 | 7100 | 3250 | 2900 | 500 | 1625 | 426 | 2400 | 1200 | 1200 | 1200 | 300 | 625 | 400 | 2285 |
| 252 | LTA10G3 | 202 DFAC | CP250-5 | 7100 | 3250 | 2900 | 500 | 1625 | 426 | 2400 | 1200 | 1200 | 1200 | 300 | 625 | 400 | 2285 |
| | | | | | | | | | | | | | | | | | |
| 315 | NT855G6 | 252 DFBH | CP300-5 | 7240 | 3200 | 3000 | 500 | 1600 | 362 | 2500 | 1200 | 1200 | 1600 | 400 | 625 | 400 | 2525 |
| 350 | NTA855G4 | 280 DFCC | CP350-5 | 7240 | 3200 | 3000 | 500 | 1600 | 362 | 2500 | 1200 | 1200 | 1600 | 400 | 625 | 400 | 2525 |
| 431* | NTA855G6 | 340 DFCE | CS450-5 | 7360 | 3200 | 3200 | 500 | 1600 | 362 | 2700 | 1500 | 1200 | 1800 | 400 | 625 | 400 | 2630 |
| | | | | | | | | | | | | | | | | | |
| 431 | KTA19G3 | 345 DFEC | CP400-5 | 7775 | 3400 | 3250 | 500 | 1700 | 420 | 2750 | 1500 | 1200 | 1850 | 400 | 775 | 400 | 2815 |
| 450 | KTA19G3 | 360 DFEL | CP450-5 | 7775 | 3400 | 3250 | 500 | 1700 | 420 | 2750 | 1500 | 1200 | 1850 | 400 | 775 | 400 | 2815 |
| 511 | KTA19G4 | 409 DFED | CP500-5 | 7775 | 3400 | 3250 | 500 | 1700 | 420 | 2750 | 1500 | 1200 | 1850 | 400 | 775 | 400 | 2815 |

**Before finalising the generator room layout please ensure you read the guidance notes.**

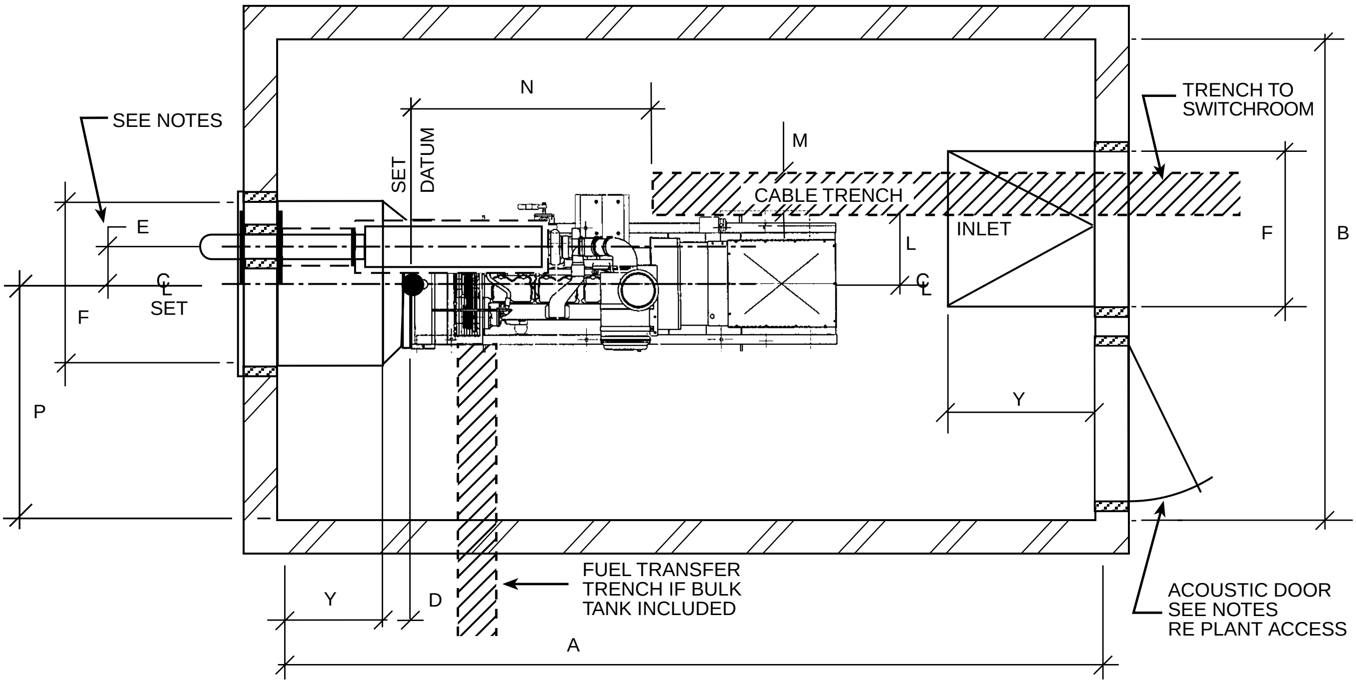
**The attenuator dimensions indicated are based on 100mm. airways and 200mm acoustic modules.**

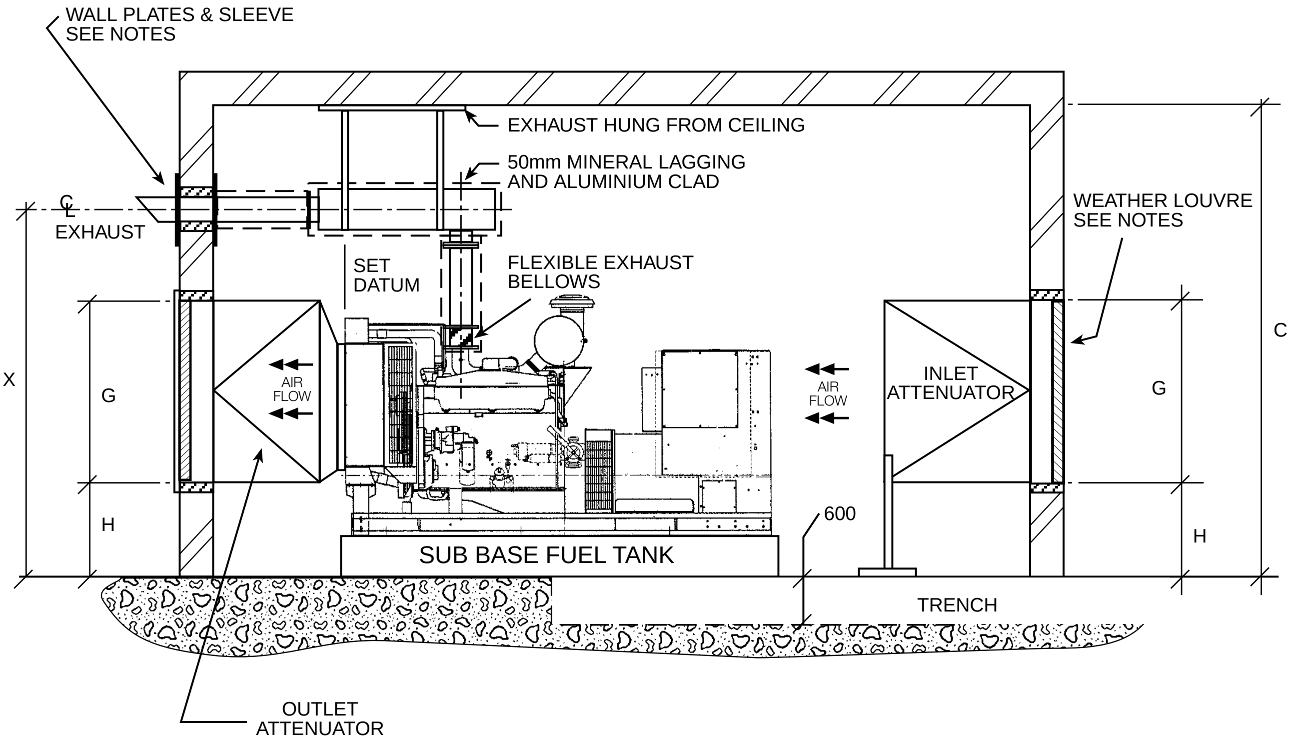
**In free field conditions we would expect this treatment to achieve 85dBA at 1 metre.**

*Standby rating only.

## Cummins Generating Sets 30 kVA - 511 kVA

Generator room layout with Acoustic Treatment to achieve 85dB(A) @ 1 metre



# RECOMMENDED ROOM SIZES

**CUMMINS ENGINE POWERED 575 kVA – 2000 kVA GENERATING SETS WITHOUT ACOUSTIC TREATMENT.**

## SINGLE SETS.

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions Length A | width B | height C | Set back D | Set C/L position P | Exhaust Offset E | Height X | Outlet Louvre F | G | Uplift H | Inlet Louvre J | K | Cable trench position L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 5300 | 3450 | 3200 | 400 | 1725 | 300 | 2700 | 1500 | 1800 | 600 | 1800 | 2000 | 775 | 500 | 3150 |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 5300 | 3450 | 3200 | 400 | 1725 | 300 | 2700 | 1500 | 1800 | 600 | 1800 | 2000 | 775 | 500 | 3150 |
| | | | | | | | | | | | | | | | | | | |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 5960 | 3640 | 3400 | 500 | 1820 | 300 | 2950 | 1500 | 1850 | 600 | 1850 | 2000 | 920 | 500 | 3575 |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 5960 | 3640 | 3400 | 500 | 1820 | 300 | 2950 | 1500 | 1850 | 600 | 1850 | 2000 | 920 | 500 | 3575 |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 5960 | 3640 | 3400 | 500 | 1820 | 300 | 2950 | 1500 | 1850 | 600 | 1850 | 2000 | 920 | 500 | 1665 |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 6050 | 3640 | 3500 | 500 | 1820 | 350 | 3000 | 1800 | 2150 | 600 | 2200 | 2350 | 920 | 600 | 3825 |
| | | | | | | | | | | | | | | | | | | |
| 936 | KTA38G3 | 748 DFJC | CP900 -5 | 6050 | 3800 | 3400 | 500 | 1900 | 350 | 3000 | 1800 | 2150 | 600 | 2200 | 2350 | 920 | 500 | 3655 |
| 1019 | KTA38G5 | 815 DFJD | CP100-5 | 6050 | 3800 | 3500 | 500 | 1900 | 350 | 3000 | 1800 | 2150 | 600 | 2200 | 2350 | 920 | 600 | 3655 |
| | | | | | | | | | | | | | | | | | | |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 6800 | 3800 | 3500 | 500 | 1900 | 350 | 3000 | 2100 | 2150 | 600 | 2200 | 2350 | 920 | 600 | 4375 |
| 1405 | KTA50G8 | 1125 DFLE | CP1400-5 | 7500 | 4000 | 3500 | 500 | 2000 | 350 | 3000 | 2100 | 2150 | 600 | 2300 | 2600 | 920 | 600 | 5000 |
| | | | | | | | | | | | | | | | | | | |
| 1688 | QSK60G3 | 1350 DQKB | CP1700-5 | 7850 | 4500 | 4400 | 600 | 2250 | 693 | 3720 | 2750 | 3000 | 525 | 3300 | 3300 | | 600 | |
| 1875* | QSK60G3 | 1500 DQKC | CP1875-5 | 7850 | 4500 | 4400 | 600 | 2250 | 693 | 3720 | 2750 | 3000 | 525 | 3300 | 3300 | | 600 | |

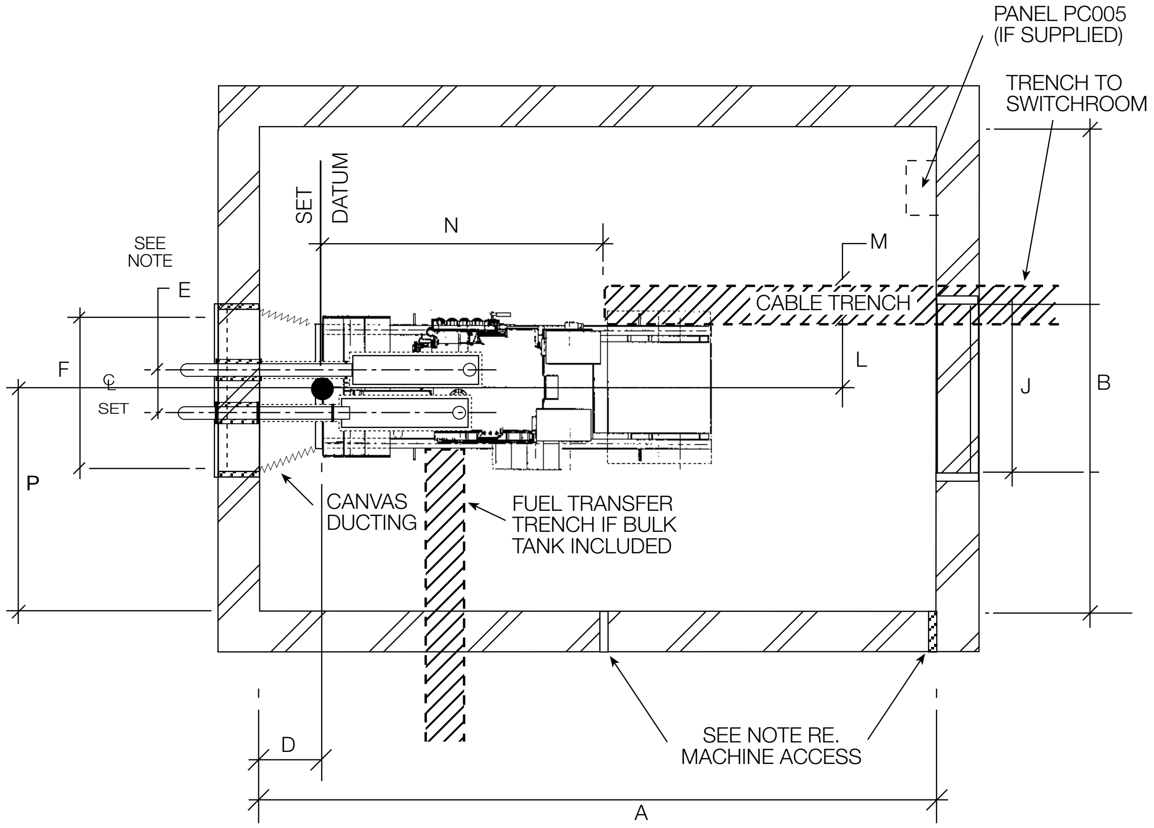
**Before finalising the generator room layout design please ensure you read the guidance notes.**

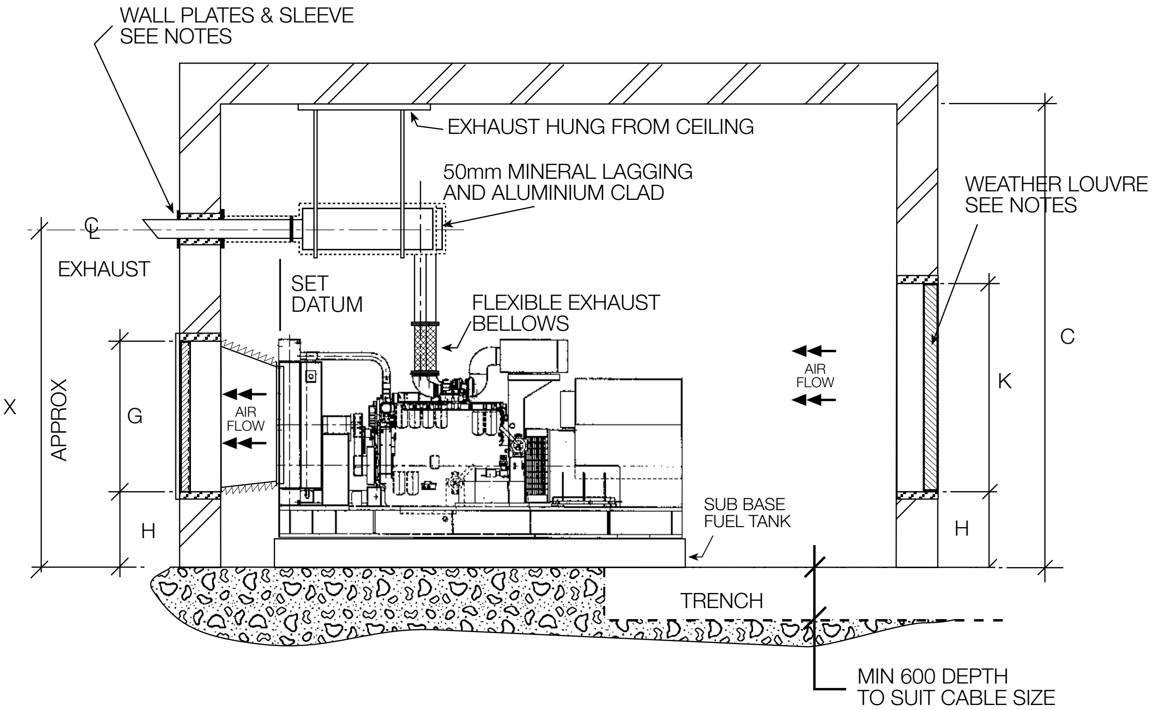
*Note: Prime rating now extends up to 2000 kVA.

*Model CP625-5 (640kVA) in a typical hot climate installation.*

## Cummins Generating Sets 575 - 2000 kVA

Generator room layout without Acoustic Treatment



# RECOMMENDED ROOM SIZES

**CUMMINS ENGINE POWERED 575 kVA – 2000 kVA GENERATING SETS WITH ACOUSTIC TREATMENT. SINGLE SETS.**

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions | | | Set back D | Set C/L position P | Exhaust offset E | Exhaust height X | Attenuator Dimensions | | | uplift H | Cable trench position. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | length A | width B | height C | | | | | F | Y | G | | L | M | N |
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 8400 | 3450 | 3450 | 400 | 1725 | 400 | 2950 | 1500 | 1500 | 2000 | 400 | 775 | 500 | 5150 |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 8400 | 3450 | 3450 | 400 | 1725 | 400 | 2950 | 1500 | 1500 | 2000 | 400 | 775 | 500 | 5150 |
| | | | | | | | | | | | | | | | | | |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 8400 | 3640 | 3700 | 500 | 1820 | 400 | 3150 | 2400 | 1200 | 2400 | 400 | 920 | 500 | 5100 |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 8400 | 3640 | 3700 | 500 | 1820 | 400 | 3150 | 2400 | 1200 | 2400 | 400 | 920 | 500 | 5100 |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 8400 | 3640 | 3700 | 500 | 1820 | 400 | 3150 | 2400 | 1200 | 2400 | 400 | 920 | 500 | 5100 |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 8450 | 3640 | 3800 | 500 | 1820 | 450 | 3150 | 2700 | 1200 | 2400 | 200 | 920 | 500 | 5100 |
| | | | | | | | | | | | | | | | | | |
| 936 | KTA38G3 | 748 DFJC | CP900-5 | 9500 | 3800 | 3800 | 500 | 1900 | 450 | 3100 | 1950 | 1800 | 2200 | 200 | 920 | 500 | 3655 |
| 1019 | KTA38G5 | 815 DFJD | CP1000-5 | 9500 | 3800 | 3800 | 500 | 1900 | 450 | 3100 | 1950 | 1800 | 2200 | 200 | 920 | 600 | 3655 |
| | | | | | | | | | | | | | | | | | |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 10360 | 3800 | 3800 | 500 | 1900 | 450 | 3100 | 1950 | 1800 | 2200 | 200 | 920 | 600 | 4375 |
| 1405 | KTA50G8 | 1125 DFLE | CP1400-5 | 11700 | 4000 | 4500 | 500 | 2000 | 500 | 3500 | 2450 | 2100 | 2600 | 200 | 920 | 600 | 5000 |
| | | | | | | | | | | | | | | | | | |
| 1688 | QSK60G3 | 1350 DQKB | CP1700-5 | 12650 | 4500 | 4500 | 600 | 2250 | 693 | 3720 | 2800 | 2400 | 2600 | 525 | | 600 | |
| 1875* | QSK60G3 | 1500 DQKC | CP1875-5 | 12650 | 4500 | 4500 | 600 | 2250 | 693 | 3720 | 2800 | 2400 | 2600 | 525 | | 600 | |

**Before finalising the generator room layout design please ensure you read the guidance notes.**

**The attenuator dimensions indicated are based on 100mm airways and 200mm acoustic modules.**

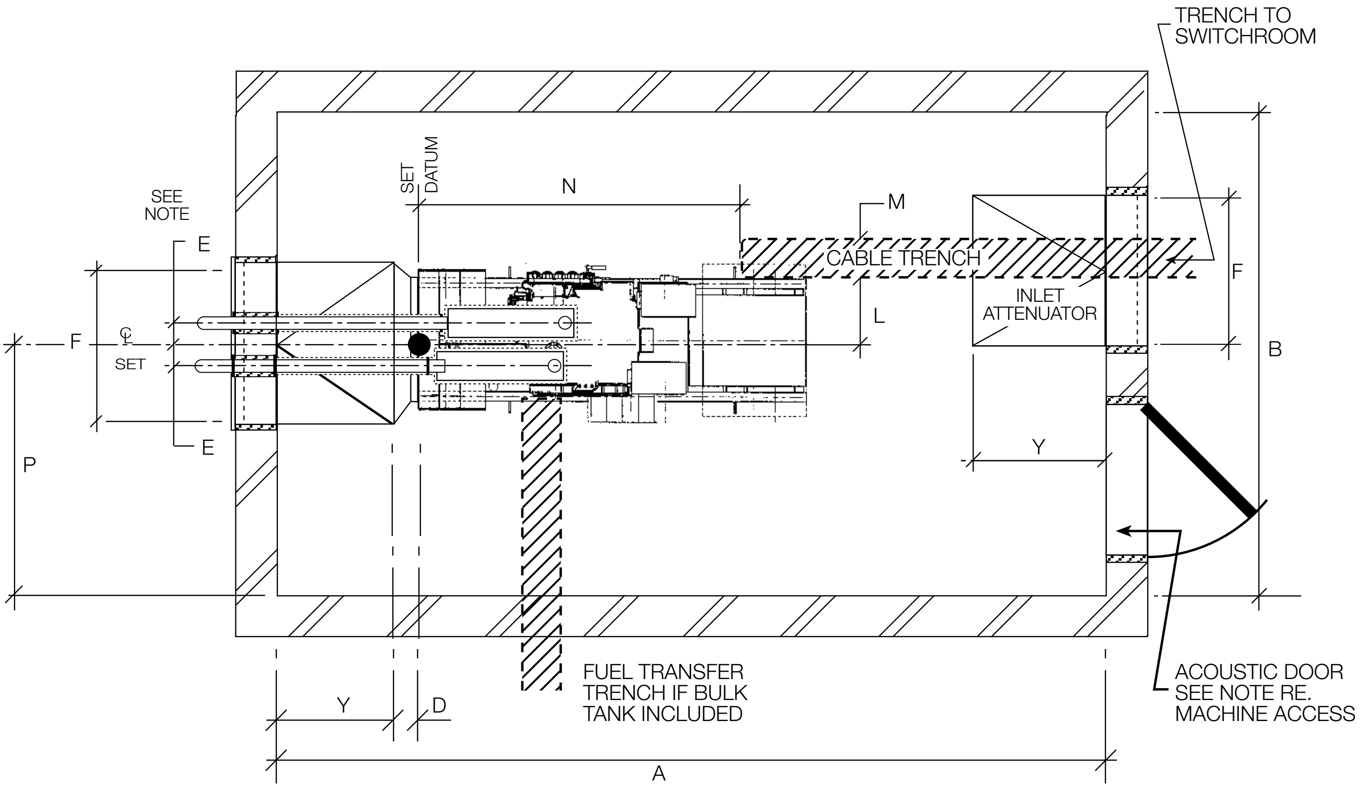
**In free field conditions we would expect this treatment to achieve 85dBA at 1 metre.**

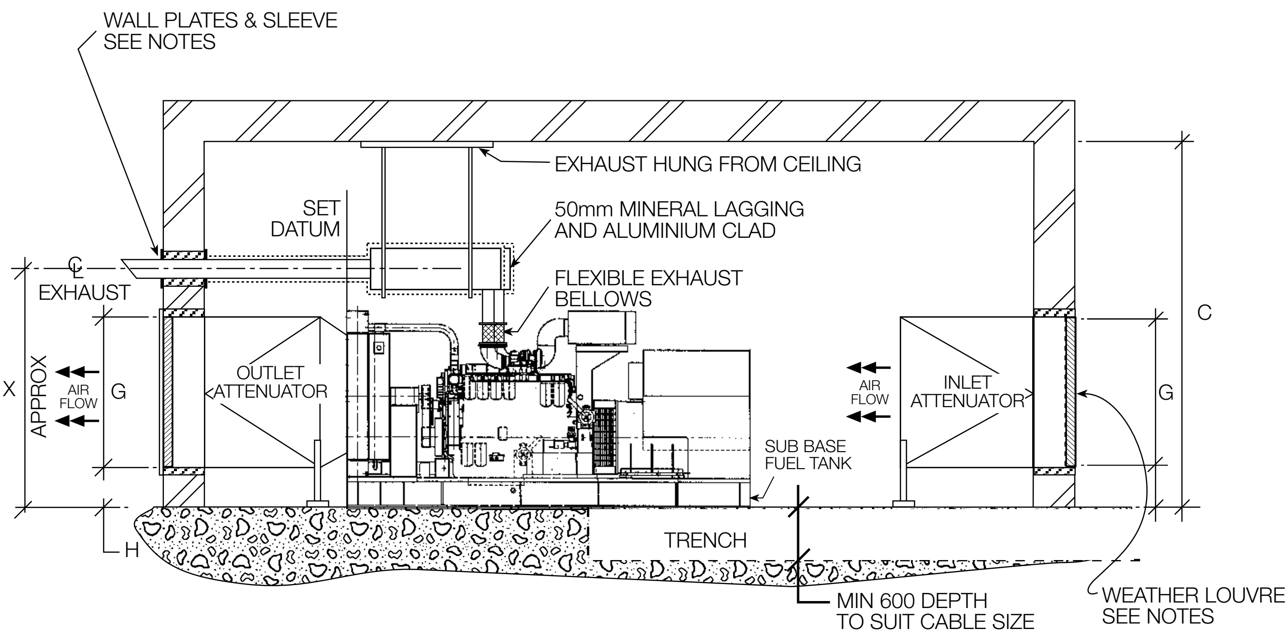
*Note: Prime rating now extends up to 2000 kVA.

*Good example of purpose made building to house two 1000 kVA generators with sound attenuators extending to the outside.*

## Cummins Generator Sets 575 - 2000 kVA

Generator room layout **with Acoustic Treatment** to Achieve 85dBA @ 1 metre



**ROOM WITH TWO GENERATORS INSTALLED.**

**CUMMINS ENGINE POWERED 233 kVA - 511 kVA GENERATING SETS WITHOUT ACOUSTIC TREATMENT.**

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions | | | Positions | | | Exhaust | | OUTLET LOUVRE | | uplift | INLET LOUVRE | | Cable trench position. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | length A | width B | height C | apart Z | back D | set C/L P | Offset E | Height X | F | G | H | J | K | L | M | N |
| 233 | LTA10G2 | 186 DFAB | CP200-5 | 4850 | 6300 | 2800 | 2250 | 500 | 2425 | 361 | 2300 | 1000 | 1075 | 520 | 1150 | 1250 | 625 | 400 | 2285 |
| 252 | LTA10G3 | 202 DFAC | CP250-5 | 4850 | 6300 | 2800 | 2250 | 500 | 2425 | 361 | 2300 | 1000 | 1075 | 520 | 1150 | 1250 | 625 | 400 | 2285 |
| | | | | | | | | | | | | | | | | | | | |
| 315 | NT855G6 | 252 DFBH | CP300-5 | 4850 | 6200 | 2700 | 2200 | 500 | 2425 | 284 | 2300 | 1000 | 1300 | 700 | 1250 | 1400 | 625 | 400 | 2525 |
| 350 | NTA855G4 | 280 DFCC | CP350-5 | 4850 | 6200 | 2700 | 2200 | 500 | 2425 | 284 | 2300 | 1000 | 1300 | 700 | 1250 | 1400 | 625 | 400 | 2525 |
| 431* | NTA855G6 | 340 DFCE | CS450-5 | 4850 | 6200 | 2700 | 2200 | 500 | 2425 | 284 | 2300 | 1000 | 1300 | 700 | 1250 | 1400 | 625 | 400 | 2630 |
| | | | | | | | | | | | | | | | | | | | |
| 431 | KTA19G3 | 345 DFEC | CP400-5 | 5275 | 6600 | 3000 | 2400 | 400 | 2500 | 320 | 2500 | 1400 | 1450 | 700 | 1600 | 1675 | 775 | 400 | 2815 |
| 450 | KTA19G3 | 360 DFEL | CP450-5 | 5275 | 6600 | 3000 | 2400 | 400 | 2500 | 320 | 2500 | 1400 | 1450 | 700 | 1600 | 1675 | 775 | 400 | 2815 |
| 511 | KTA19G4 | 409 DFED | CP500-5 | 5275 | 6600 | 3000 | 2400 | 400 | 2500 | 320 | 2500 | 1400 | 1450 | 700 | 1600 | 1675 | 775 | 400 | 2815 |

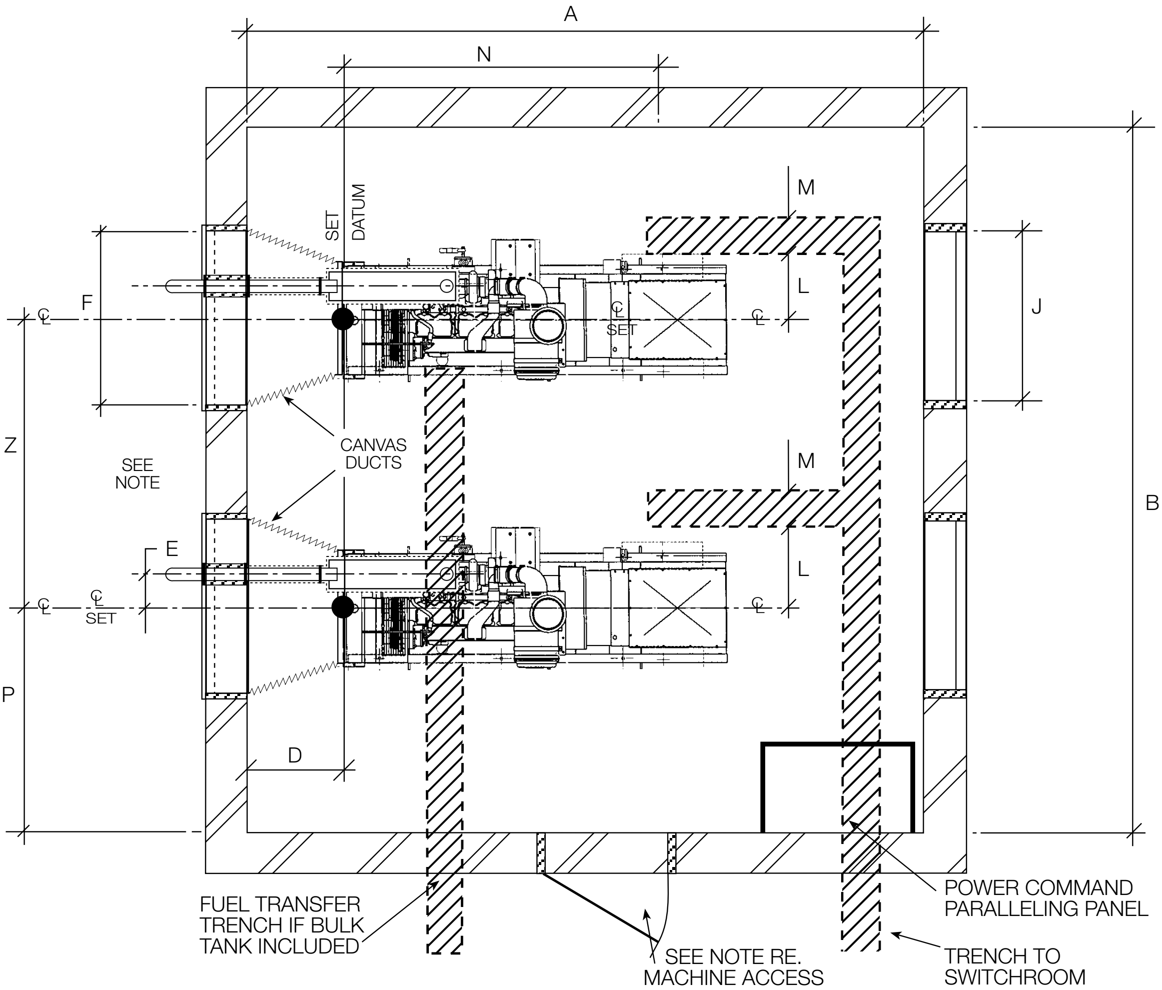
**Before finalising the generator room layout please ensure you read the guidance notes.**

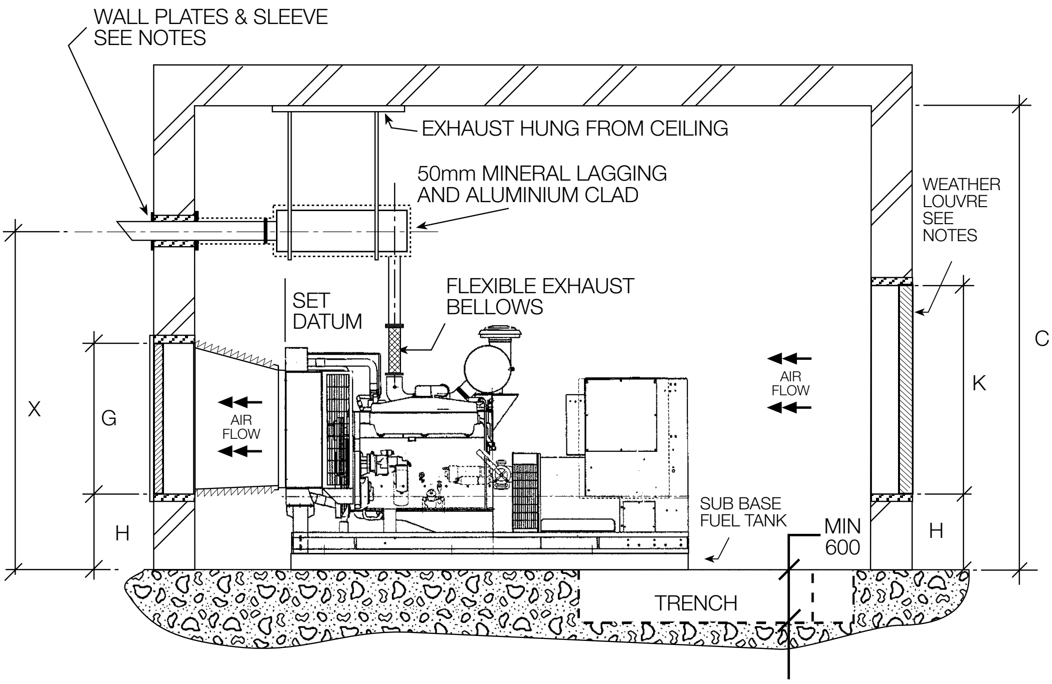
*Standby rating only.

*Twin CP1000-5 sets (1000kVA) with QST30 G4 engines, PCC control and DMC autosync cubicle in a typical installation.*

## Cummins Generating Sets 233 - 511 kVA

2 Set installation without Acoustic Treatment



# RECOMMENDED ROOM SIZES

**ROOM WITH TWO GENERATORS INSTALLED.**

**CUMMINS ENGINE POWERED 233 kVA – 511 kVA GENERATING SETS WITH ACOUSTIC TREATMENT.**

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions length A | width B | height C | Positions Apart Z | back D | Set C/L P | Exhaust Offset E | Height X | Attenuator Dimensions F | Y | G | uplift H | Cable trench position. L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 233 | LTA10G2 | 186 DFAB | CP200-5 | 7700 | 6300 | 2900 | 2250 | 500 | 2425 | 426 | 2400 | 1200 | 1500 | 1200 | 300 | 625 | 400 | 2285 |
| 252 | LTA10G3 | 202 DFAC | CP250-5 | 7700 | 6300 | 2900 | 2250 | 500 | 2425 | 426 | 2400 | 1200 | 1500 | 1200 | 300 | 625 | 400 | 2285 |
| | | | | | | | | | | | | | | | | | | |
| 315 | NT855G6 | 252 DFBH | CP300-5 | 7840 | 6200 | 3000 | 2200 | 500 | 2425 | 362 | 2500 | 1200 | 1500 | 1600 | 400 | 625 | 400 | 2525 |
| 350 | NTA855G4 | 280 DFCC | CP350-5 | 7840 | 6200 | 3000 | 2200 | 500 | 2425 | 362 | 2500 | 1200 | 1500 | 1600 | 400 | 625 | 400 | 2525 |
| 431* | NTA855G6 | 340 DFCE | CS450-5 | 7960 | 6200 | 3200 | 2200 | 500 | 2425 | 362 | 2700 | 1500 | 1500 | 1800 | 400 | 625 | 400 | 2630 |
| | | | | | | | | | | | | | | | | | | |
| 431 | KTA19G3 | 345 DFEC | CP400-5 | 8375 | 6600 | 3250 | 2400 | 400 | 2500 | 420 | 2750 | 1500 | 1500 | 1850 | 400 | 775 | 400 | 2815 |
| 450 | KTA19G3 | 360 DFEL | CP450-5 | 8375 | 6600 | 3250 | 2400 | 400 | 2500 | 420 | 2750 | 1500 | 1500 | 1850 | 400 | 775 | 400 | 2815 |
| 511 | KTA19G4 | 409 DFED | CP500-5 | 8375 | 6600 | 3250 | 2400 | 400 | 2500 | 420 | 2750 | 1500 | 1500 | 1850 | 400 | 775 | 400 | 2815 |

**Before finalising the generator room layout please ensure you read the guidance notes.**

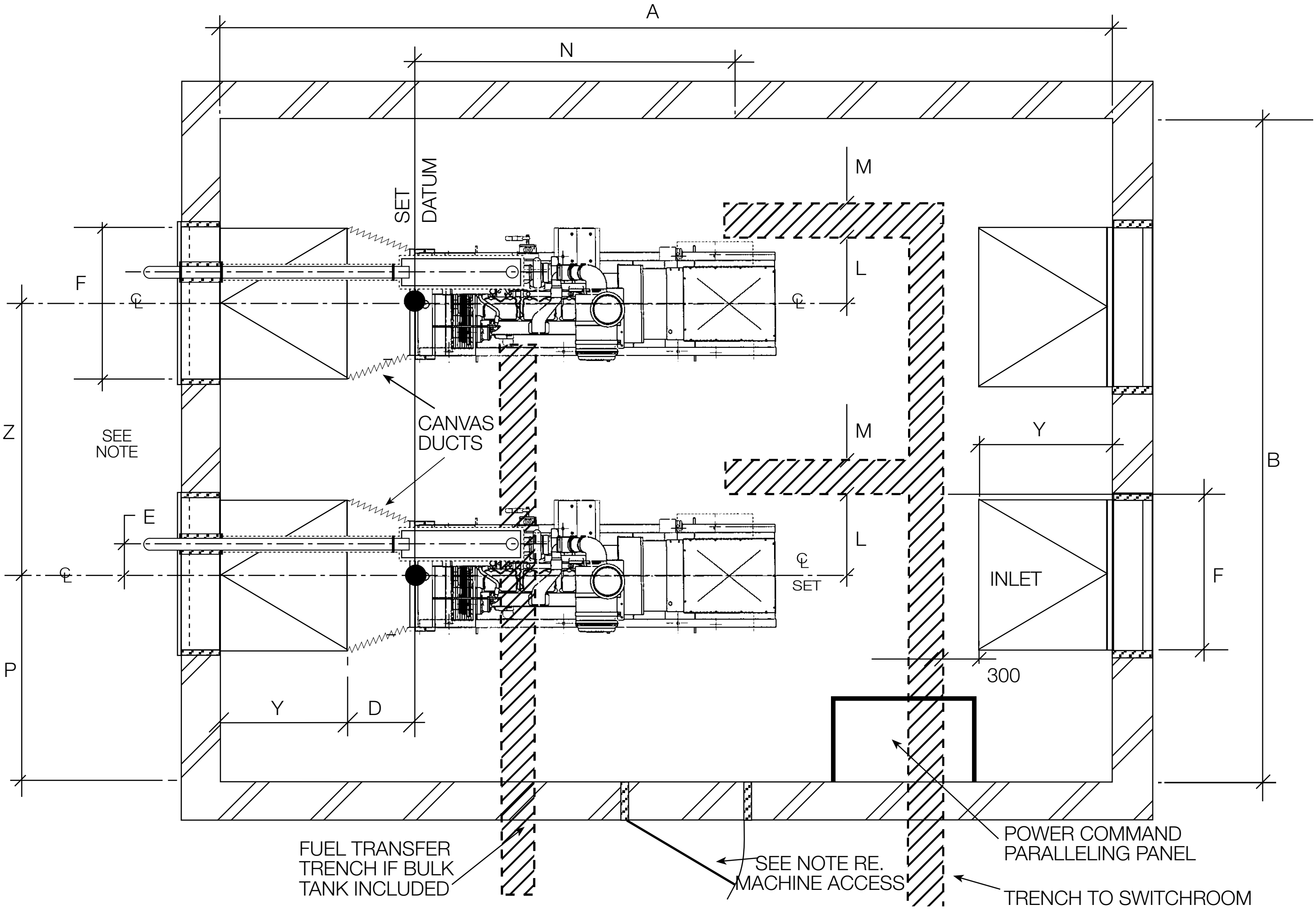
**The attenuator dimensions indicated are based on 100mm. airways and 200mm acoustic modules.**

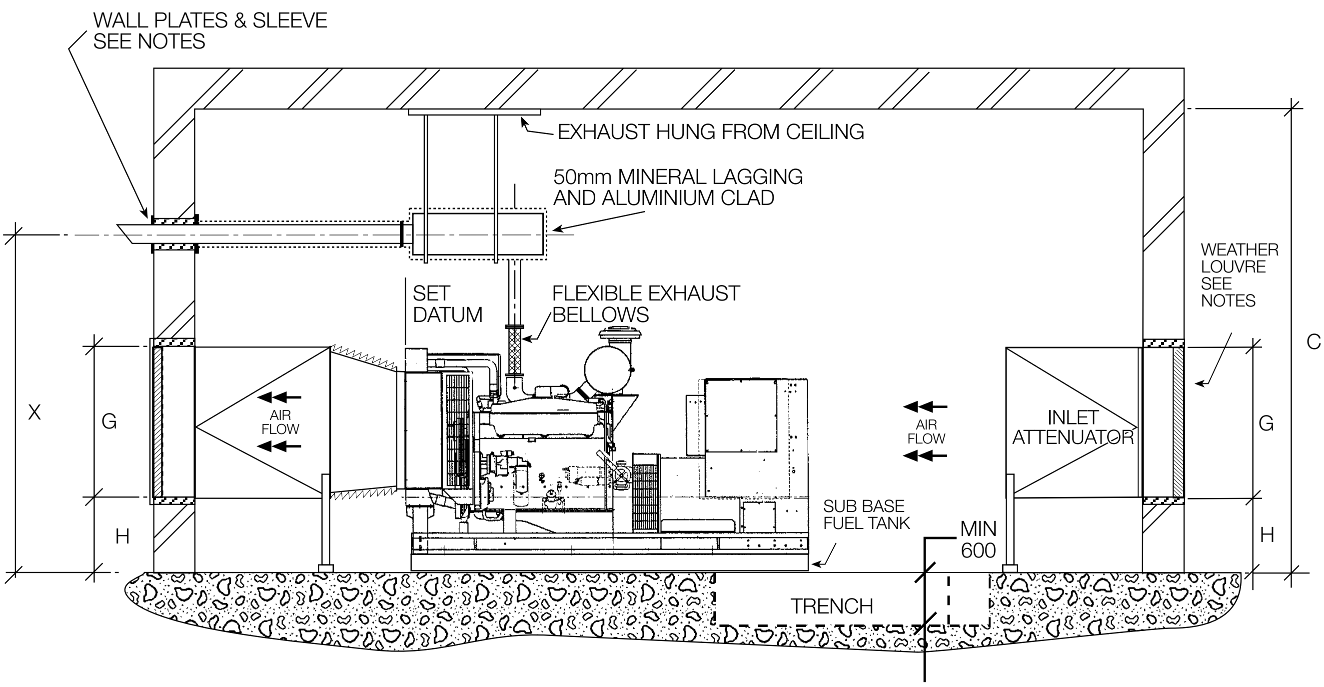
**In free field conditions we would expect this treatment to achieve 85dBA at 1 metre.**

*Standby rating only.

## Cummins Generating Sets 233 - 511 kVA

Room layout for 2 Set installation with Acoustic Treatment to Achieve 85dBA @ 1 metre



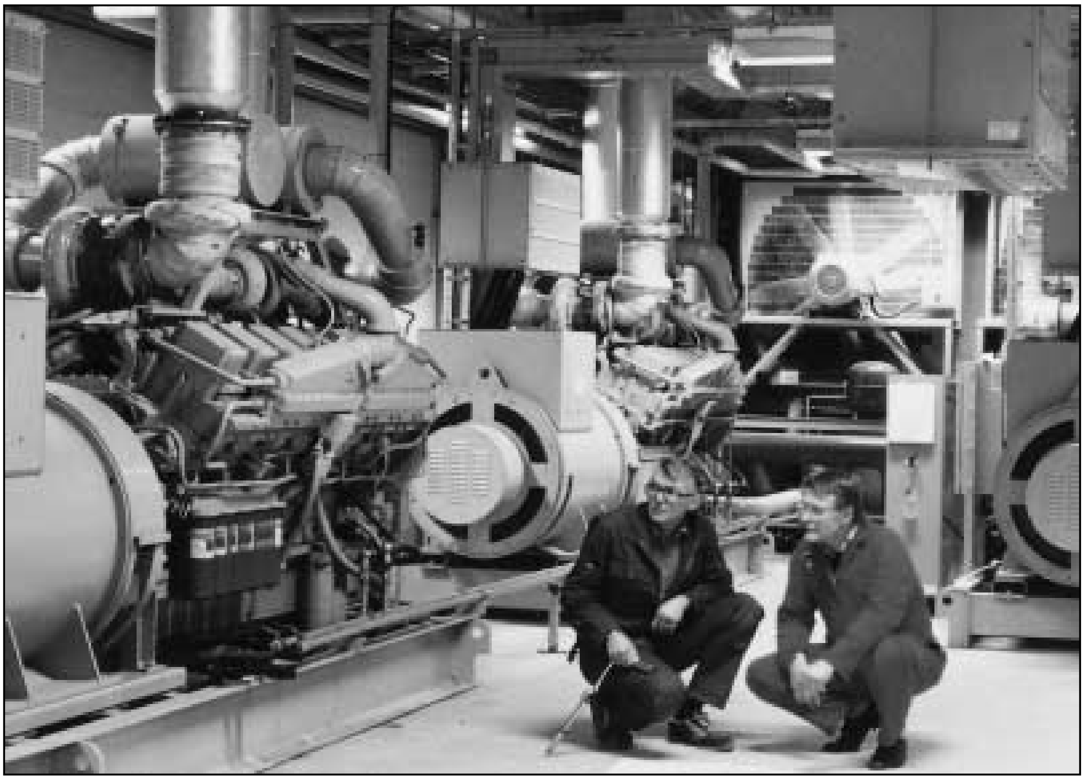
**ROOM WITH TWO GENERATORS INSTALLED.**

**CUMMINS ENGINE POWERED 575 kVA - 2000 kVA GENERATING SETS WITHOUT ACOUSTIC TREATMENT.**

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions length A | width B | height C | Positions apart Z | back D | set C/L P | Exhaust Offset E | Height X | OUTLET LOUVRE F | G | uplift H | INLET LOUVRE J | K | Cable trench position. L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 5300 | 6700 | 3200 | 2450 | 400 | 2575 | 300 | 2700 | 1500 | 1800 | 600 | 1800 | 2000 | 775 | 500 | 3500 |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 5300 | 6700 | 3200 | 2450 | 400 | 2575 | 300 | 2700 | 1500 | 1800 | 600 | 1800 | 2000 | 775 | 500 | 3500 |
| | | | | | | | | | | | | | | | | | | | |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 5960 | 7080 | 3400 | 2640 | 500 | 2620 | 300 | 2950 | 1500 | 1850 | 600 | 1850 | 2000 | 920 | 500 | 3900 |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 5960 | 7080 | 3400 | 2640 | 500 | 2620 | 300 | 2950 | 1500 | 1850 | 600 | 1850 | 2000 | 920 | 500 | 3900 |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 5960 | 7080 | 3400 | 2640 | 500 | 2620 | 300 | 2950 | 1500 | 1850 | 600 | 1850 | 2000 | 920 | 500 | 3900 |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 6050 | 7080 | 3500 | 2640 | 500 | 2620 | 350 | 3000 | 1800 | 2150 | 600 | 2200 | 2350 | 920 | 600 | 4200 |
| | | | | | | | | | | | | | | | | | | | |
| 936 | KTA38G3 | 748 DFJC | CP900-5 | 6050 | 7400 | 3500 | 2800 | 500 | 2700 | 350 | 3000 | 1800 | 2150 | 600 | 2200 | 2350 | 920 | 500 | 3655 |
| 1019 | KTA38G5 | 815 DFJD | CP1000-5 | 6200 | 7400 | 3500 | 2800 | 500 | 2700 | 350 | 3000 | 1800 | 2150 | 600 | 2200 | 2350 | 920 | 600 | 3655 |
| | | | | | | | | | | | | | | | | | | | |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 6800 | 7400 | 3500 | 2800 | 500 | 2700 | 350 | 3000 | 1800 | 2150 | 600 | 2200 | 2350 | 920 | 600 | 5000 |
| 1405 | KTA50G8 | 1125 DFLE | CP1400-5 | 7500 | 7800 | 3500 | 3000 | 600 | 2800 | 350 | 3000 | 2100 | 2150 | 600 | 2300 | 2600 | 920 | 600 | 5700 |
| | | | | | | | | | | | | | | | | | | | |
| 1688 | QSK60G3 | 1350 DQKB | CP1700-5 | 7850 | 8800 | 4400 | 3500 | 600 | 3050 | 693 | 3720 | 2750 | 3000 | 525 | 3300 | 3300 | 645 | 600 | 4805 |
| 1875* | QSK60G3 | 1500 DQKC | CP1875-5 | 7850 | 8800 | 4400 | 3500 | 600 | 3050 | 693 | 3720 | 2750 | 3000 | 525 | 3300 | 3300 | 645 | 600 | 4805 |

**Before finalising the generator room layout design please ensure you read the guidance notes.**

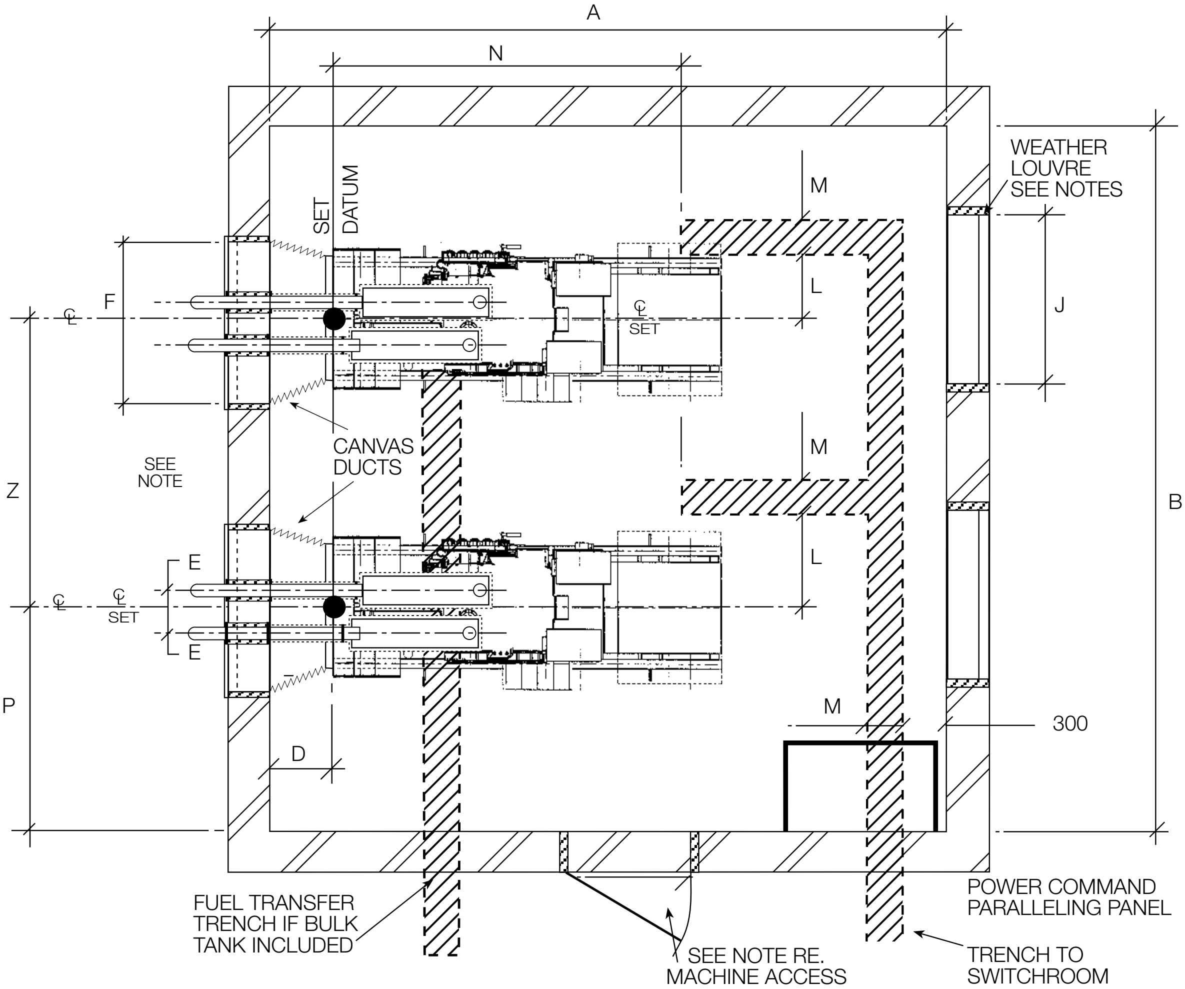
*Note: Prime rating now extends up to 2000 kVA.

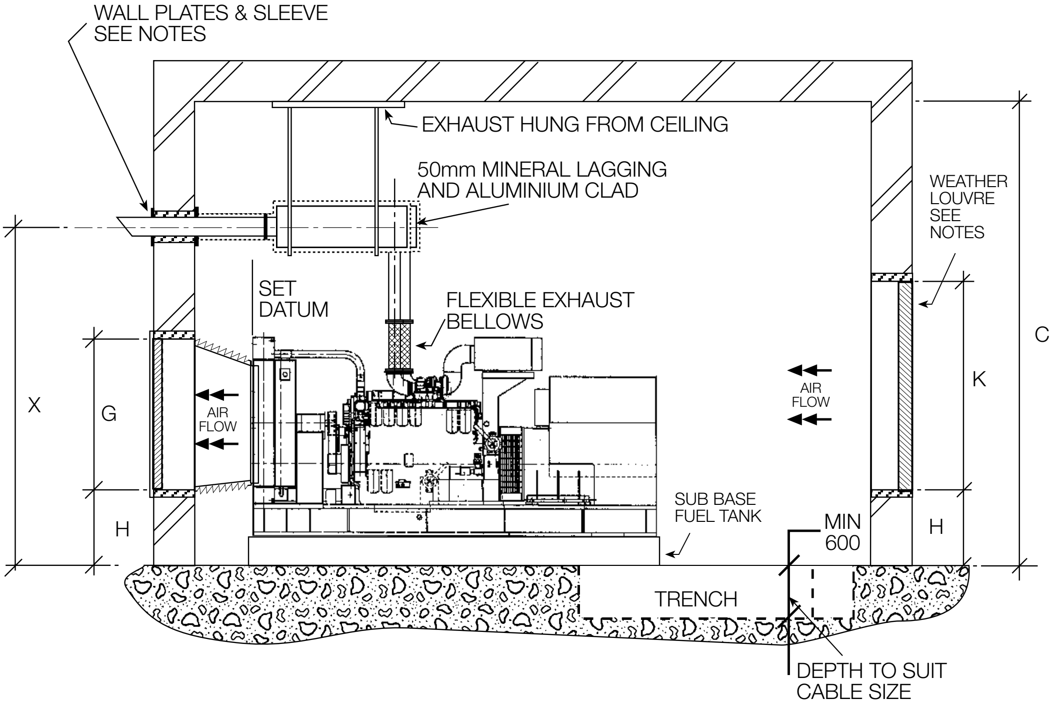


*Three 1250 kVA standby sets with Cummins KTA50G engines provide backup to 150 computer centres in Norway.*

## Cummins Generating Sets 575 - 2000 kVA

Room layout for 2 Set installation **without** Acoustic Treatment



**ROOM WITH TWO GENERATORS INSTALLED.**

**CUMMINS ENGINE POWERED 575 kVA – 2000 kVA GENERATING SETS WITH ACOUSTIC TREATMENT.**

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions | | | Positions | | | Exhaust | | Attenuator Dimensions | | | uplift H | Cable trench position. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Length A | width B | height C | apart Z | back D | set C/L P | Offset E | height X | F | Y | G | | L | M | N |
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 9000 | 6700 | 3450 | 2450 | 400 | 2575 | 400 | 2950 | 1500 | 1800 | 2000 | 400 | 775 | 500 | 3500 |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 9000 | 6700 | 3450 | 2450 | 400 | 2575 | 400 | 2950 | 1500 | 1800 | 2000 | 400 | 775 | 500 | 3500 |
| | | | | | | | | | | | | | | | | | | |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 9000 | 7080 | 3700 | 2640 | 500 | 2620 | 400 | 3150 | 2400 | 1500 | 2400 | 400 | 920 | 500 | 3900 |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 9000 | 7080 | 3700 | 2640 | 500 | 2620 | 400 | 3150 | 2400 | 1500 | 2400 | 400 | 920 | 500 | 3900 |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 9000 | 7080 | 3700 | 2640 | 500 | 2620 | 400 | 3150 | 2400 | 1500 | 2400 | 400 | 920 | 500 | 3900 |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 9050 | 7080 | 3800 | 2640 | 500 | 2620 | 450 | 3150 | 2700 | 1500 | 2400 | 200 | 920 | 500 | 4200 |
| | | | | | | | | | | | | | | | | | | |
| 936 | KTA38G3 | 748 DFJC | CP900-5 | 10100 | 7400 | 3800 | 2800 | 500 | 2700 | 450 | 3100 | 1950 | 2100 | 2200 | 200 | 920 | 500 | 3655 |
| 1016 | KTA38G5 | 815 DFJD | CP1000-5 | 10100 | 7400 | 3800 | 2800 | 500 | 2700 | 500 | 3100 | 1950 | 2100 | 2200 | 200 | 920 | 600 | 3655 |
| | | | | | | | | | | | | | | | | | | |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 10960 | 7400 | 3800 | 2800 | 500 | 2700 | 450 | 3100 | 1950 | 2100 | 2200 | 200 | 920 | 600 | 5000 |
| 1405 | KTA50G8 | 1125 DFLE | CP1400-5 | 12300 | 7800 | 4500 | 3000 | 600 | 2800 | 500 | 3500 | 2450 | 2400 | 2600 | 200 | 920 | 600 | 5700 |
| | | | | | | | | | | | | | | | | | | |
| 1688 | QSK60G3 | 1350 DQKB | CP1700-5 | 12650 | 8800 | 4500 | 3500 | 600 | 3050 | 693 | 3720 | 2800 | 2400 | 2600 | 525 | 645 | 600 | 4805 |
| 1875* | QSK60G3 | 1500 DQKC | CP1875-5 | 12650 | 8800 | 4500 | 3500 | 600 | 3050 | 693 | 3720 | 2800 | 2400 | 2600 | 525 | 645 | 600 | 4805 |

**Before finalising the generator room layout design please ensure you read the guidance notes.**

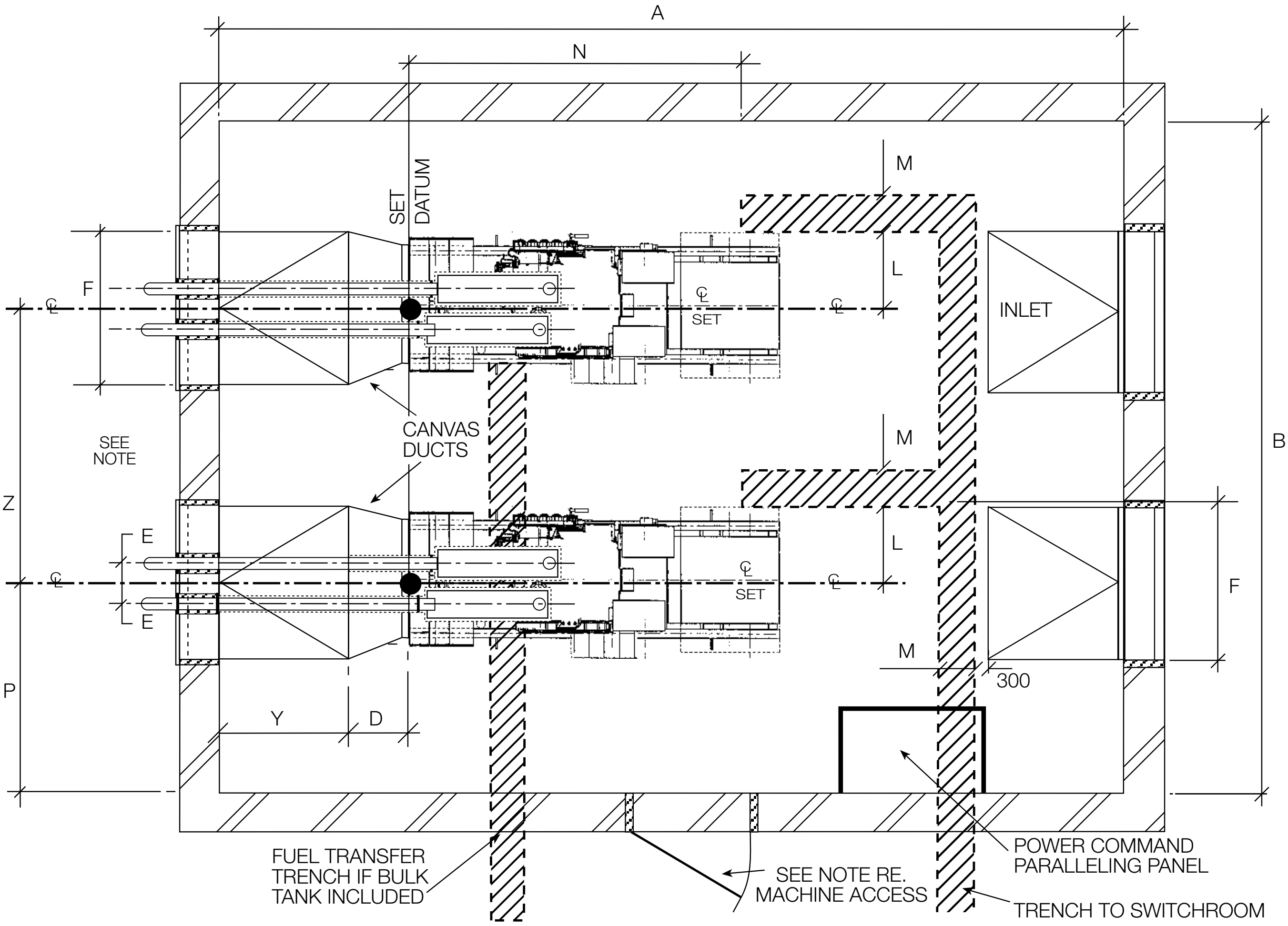
**The attenuator dimensions indicated are based on 100mm airways and 200mm acoustic modules.**

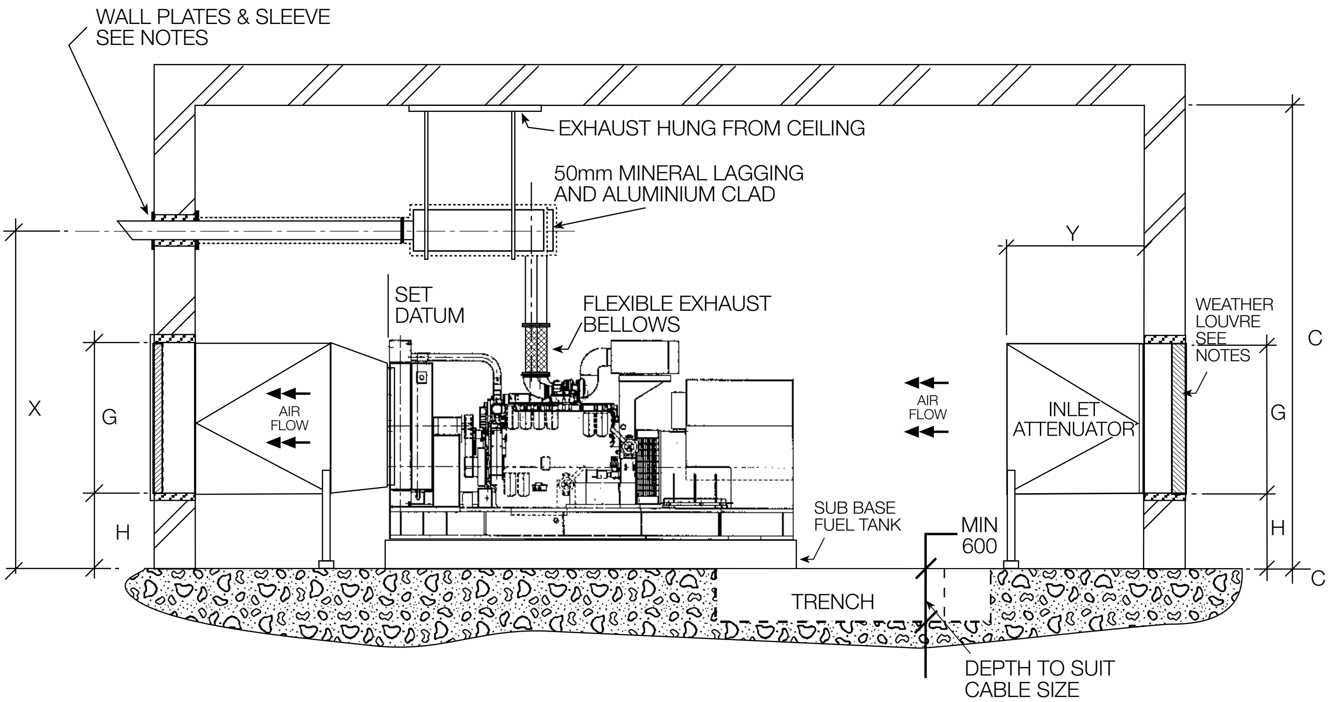
**In free field conditions we would expect this treatment to achieve 85dBA at 1 metre.**

*Note: Prime rating now extends up to 2000 kVA.

## Cummins Generating Sets 575 - 2000 kVA

Room layout for 2 Set installation with Acoustic Treatment



**ROOM WITH THREE GENERATORS INSTALLED.**

**CUMMINS ENGINE POWERED 575 kVA – 2000 kVA GENERATING SETS WITH ACOUSTIC TREATMENT.**

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions | | | Positions | | | Exhaust | | Attenuator Dimensions | | | uplift | Cable trench position. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | length A | width B | height C | Apart Z | back D | set C/L P | Offset E | Height X | F | Y | G | H | L | M | N |
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 9300 | 9150 | 3450 | 2450 | 400 | 2575 | 400 | 2950 | 1500 | 1950 | 2000 | 400 | 775 | 500 | 3500 |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 9300 | 9150 | 3450 | 2450 | 400 | 2575 | 400 | 2950 | 1500 | 1950 | 2000 | 400 | 775 | 500 | 3500 |
| | | | | | | | | | | | | | | | | | | |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 9300 | 9720 | 3700 | 2640 | 400 | 2620 | 400 | 3150 | 2400 | 1650 | 2400 | 400 | 920 | 500 | 3900 |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 9300 | 9720 | 3700 | 2640 | 400 | 2620 | 400 | 3150 | 2400 | 1650 | 2400 | 400 | 920 | 500 | 3900 |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 9300 | 9720 | 3700 | 2640 | 400 | 2620 | 400 | 3150 | 2400 | 1650 | 2400 | 400 | 920 | 500 | 3900 |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 9350 | 9720 | 3800 | 2640 | 450 | 2620 | 450 | 3150 | 2700 | 1650 | 2400 | 200 | 920 | 500 | 4200 |
| | | | | | | | | | | | | | | | | | | |
| 936 | KTA38G3 | 748 DFJC | CP700-5 | 10400 | 10200 | 3800 | 2800 | 450 | 2700 | 450 | 3100 | 1950 | 2000 | 2200 | 200 | 920 | 500 | 3655 |
| 1016 | KTA38G3 | 815 DFJD | CP1000-5 | 10400 | 10200 | 3800 | 2800 | 500 | 2700 | 450 | 3100 | 1950 | 2000 | 2200 | 200 | 920 | 600 | 3655 |
| | | | | | | | | | | | | | | | | | | |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 11260 | 10200 | 3800 | 2800 | 450 | 2700 | 450 | 3100 | 1950 | 2250 | 2200 | 200 | 920 | 600 | 5000 |
| 1405 | KTA50G8 | 1125 DFLE | CP1400-5 | 12600 | 10800 | 4500 | 3000 | 500 | 2800 | 500 | 3500 | 2450 | 2550 | 2600 | 200 | 920 | 600 | 5700 |
| | | | | | | | | | | | | | | | | | | |
| 1688 | QSK60G3 | 1300 DQKB | CP1700-5 | 12650 | 12300 | 4500 | 3500 | 600 | 3050 | 693 | 3720 | 2800 | 2400 | 2600 | 525 | 645 | 600 | 4805 |
| 1875* | QSK60G3 | 1500 DQKC | CP1875-5 | 12650 | 12300 | 4500 | 3500 | 600 | 3050 | 693 | 3720 | 2800 | 2400 | 2600 | 525 | 645 | 600 | 4805 |

**Before finalising the generator room layout design please ensure you read the guidance notes.**

**The attenuator dimensions indicated are based on 100mm airways and 200mm acoustic modules.**

**In free field conditions we would expect this treatment to achieve 85dBA at 1 metre.**

*Note: Prime rating now extends up to 2000 kVA.

**ROOM WITH FOUR GENERATORS INSTALLED.**

**CUMMINS ENGINE POWERED 575 kVA – 2000 kVA GENERATING SETS WITH ACOUSTIC TREATMENT.**

| Prime Rating KVA | Type of ENGINE | 2000 Model | 1999 Model | Room dimensions | | | Positions | | | Exhaust | | Attenuator Dimensions | | | uplift | Cable trench position. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | length A | width B | height C | Apart Z | back D | set C/L P | Offset E | Height X | F | Y | G | H | L | M | N |
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 9600 | 11600 | 3450 | 2450 | 400 | 2575 | 400 | 2950 | 1500 | 2100 | 2000 | 400 | 775 | 500 | 3500 |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 9600 | 11600 | 3450 | 2450 | 400 | 2575 | 400 | 2950 | 1500 | 2100 | 2000 | 400 | 775 | 500 | 3500 |
| | | | | | | | | | | | | | | | | | | |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 9600 | 12360 | 3700 | 2640 | 500 | 2620 | 400 | 3150 | 2400 | 1800 | 2400 | 400 | 920 | 500 | 3900 |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 9600 | 12360 | 3700 | 2640 | 500 | 2620 | 400 | 3150 | 2400 | 1800 | 2400 | 400 | 920 | 500 | 3900 |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 9600 | 12360 | 3700 | 2640 | 500 | 2620 | 400 | 3150 | 2400 | 1800 | 2400 | 400 | 920 | 500 | 3900 |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 9650 | 12360 | 3800 | 2640 | 500 | 2620 | 450 | 3150 | 2700 | 1800 | 2400 | 200 | 920 | 500 | 4200 |
| | | | | | | | | | | | | | | | | | | |
| 936 | KTA38G3 | 748 DFJC | CP900-5 | 10400 | 13000 | 3800 | 2800 | 500 | 2700 | 450 | 3100 | 1950 | 2000 | 2200 | 200 | 920 | 500 | 3655 |
| 1016 | KTA38G3 | 815 DFJD | CP1000-5 | 10400 | 13000 | 3800 | 2800 | 500 | 2700 | 450 | 3100 | 1950 | 2000 | 2200 | 200 | 920 | 600 | 3655 |
| | | | | | | | | | | | | | | | | | | |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 11560 | 13000 | 3800 | 2800 | 500 | 2700 | 450 | 3100 | 1950 | 2400 | 2200 | 200 | 920 | 600 | 5000 |
| 1405 | KTA50G8 | 1125 DFLE | CP1400-5 | 12900 | 13800 | 4500 | 3000 | 600 | 2800 | 500 | 3500 | 2450 | 2700 | 2600 | 200 | 920 | 600 | 5700 |
| | | | | | | | | | | | | | | | | | | |
| 1688 | QSK60G3 | 1300 DQKB | CP1700-5 | 12650 | 15800 | 4500 | 3500 | 600 | 3050 | 693 | 3720 | 2800 | 2400 | 2600 | 525 | 645 | 600 | 4805 |
| 1875* | QSK60G3 | 1500 DQKC | CP1875-5 | 12650 | 15800 | 4500 | 3500 | 600 | 3050 | 693 | 3720 | 2800 | 2400 | 2600 | 525 | 645 | 600 | 4805 |

**Before finalising the generator room layout design please ensure you read the guidance notes.**

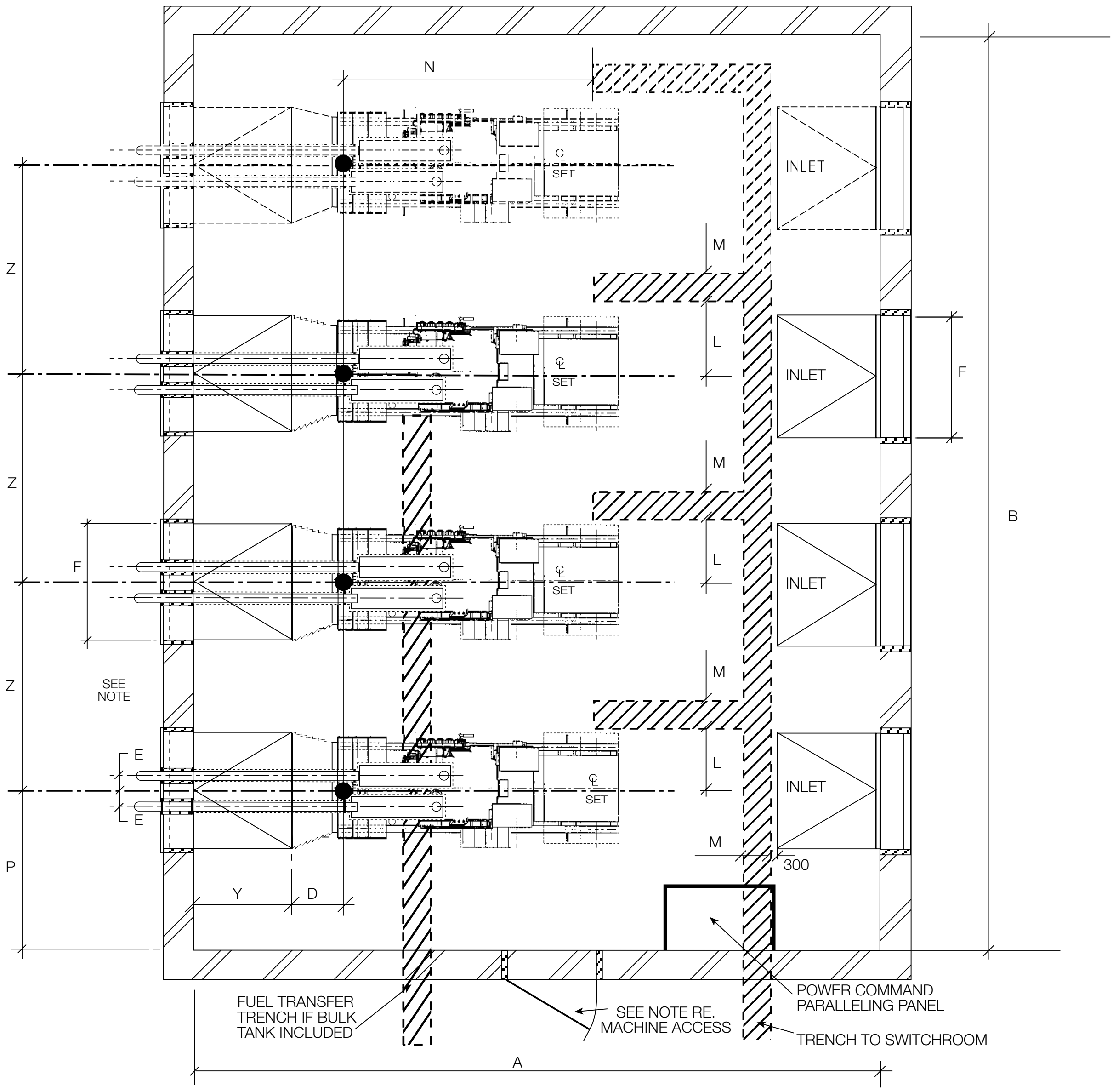
**The attenuator dimensions indicated are based on 100mm airways and 200mm acoustic modules.**

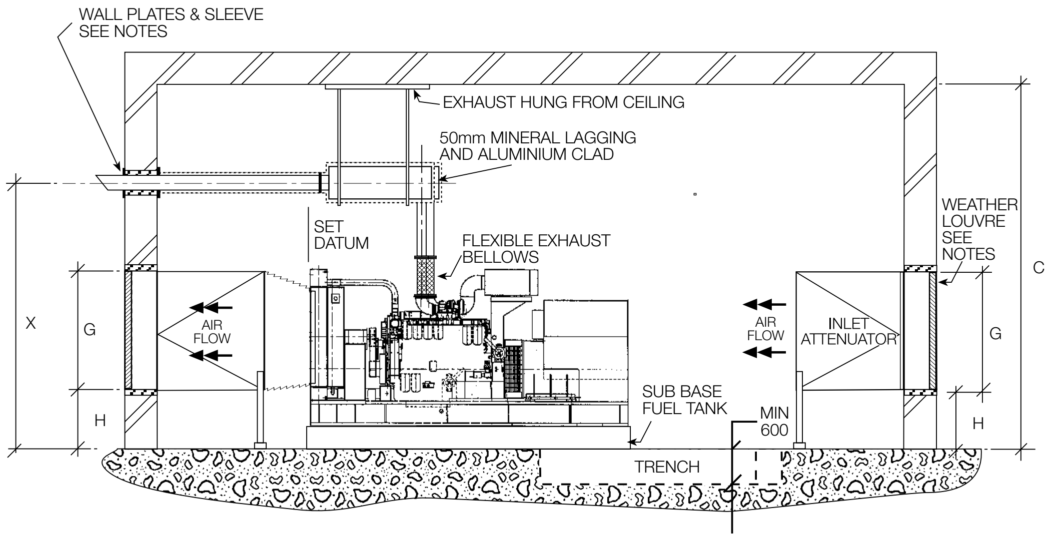
**In free field conditions we would expect this treatment to achieve 85dBA at 1 metre.**

*Note: Prime rating now extends up to 2000 kVA.

## Cummins Generating Sets 575 - 2000 kVA (up to 4.5 MW installation)

Room layout for Multiple Set installation **with Acoustic Treatment** to Achieve 85dBA @ 1 metre



## Multiple Gen Set Installations

*4 x 800 kVA Gen Sets in a ground level room installation with simple but effective exhaust run.*

*Four 1500 kVA sets with KTA50 engines running on base load operation in Saudi Arabia.*

## Enclosed and Roof Mounted Generating Sets

Where internal Ground Floor or Basement space is unavailable, either an adjacent outside location can be used or, providing the structure is sufficiently strong enough or can be strengthened, the flat roof area of a building can be used. Roof installations have become widely used in many towns and cities where space is of a premium. Packaged and soundproofed individual units up to 2MW each have been successfully accommodated in this manner over the last few years in many countries.

**Recommendations for Roof Top and High Level Installations**

Only consider when there is no ground or basement level room available or/and when the cost of high level installation – including structural work – is cheaper than normal installations.

**Benefits**

No air flow problems

No expensive ductwork

No lengthy exhaust runs

No problems with exhaust fume emissions

No noise problem

No space limitation problems

**Disadvantages**

Roof structure may have to be strengthened

Large crane required

Possible road closure

Planning permission required

Longer cable runs

Limited fuel storage

*Unusual roof top (15 storeys high) installation for three 1500 kVA sets demands re-assembly of sets using rails and specially built A frame for transport and lifting.*

**Roof structure**

The structure of the roof area must be suitable for an installation. The strength of the flooring structure is vital. Should the floor be found unsuitable the problem can often be overcome by installing a floating floor of structural steel platforms across the building's main columns.

**Vibrations**

Transmitted vibration through the building can be drastically reduced by:

(a) Having built-in anti-vibration units within the design of the generating set. This eliminates up to 75-80% of transmitted engine vibrations.

(b) Installing additional vibration dampers between the generating set chassis and the roof. This combination eliminates up to 98% of the vibration.

(c) With generators over 1MW it may also be desirable to include a concrete slab base which in turn is resiliently mounted to eliminate vibration through the building.

While all these methods have been used on various buildings within the UK the majority have been found quite satisfactorily with the normal built-in anti-vibration system as described in item (a) and in other cases a combination of any two of the methods described has proved more than adequate.

*Where possible a packaged set, 300 kVA as shown in picture, on a base frame provides a faster installation. Silenced enclosure drops over unit. Note prepared steel structure support base.*

### Noise

It is recommended that all generating sets installed at roof level have soundproof enclosures fitted or are installed in rooms with full inlet and outlet sound attenuators and twin residential silencers. Heavy duty soundproof enclosures can reduce noise levels by 15 to 30dB(A) and limited only by budget or local noise regulations. A sound level of 75dB(A) at 1 metre is a substantial reduction and equal to a normal office environment.

### Accessibility

The final roof location for the generator must take into account access and cranage requirements. For example, a 100 ton mobile crane with a 30m (100ft.) radius will only lift approximately 5 tons. Lifting vertically is no problem but positioning a large generator 30 or 40 metres from the building's edge will place a heavy stress on the crane's jib. The lifting capacity is therefore limited by the required reach or radius. To illustrate, in order to lift a 1.3MW set weighing 22 tons onto an eight storey roof and place it 14 metres from the edge, it was found necessary to use a 250 ton crane.

In many cases because of the weight and radius problem coupled with ground and street accessibility, it is necessary to dismantle the generating set – sometimes into five or six loads – engine, alternator, chassis, control cubicle, soundproof enclosure and radiator.

Although this procedure may take a little longer in terms of crane hire, dismantling and re-assembling, the smaller crane size will cost less and overall the total installation price is unlikely to be greatly changed.

It is possible to use a Helicopter, although there will be weight and flying limitations, and this can be very cost effective if all the restrictions can be overcome. At least 2 tons can be lifted and although this invariably means dismantling the generator the cost of a helicopter will only be a fifth of the cost of an equivalent sized crane.

In order to use a helicopter, it must have a 'safe' dropping area to fly over if it has to carry the equipment any distance. Alternatively, it has to be able to lift from a 'free and safe' area in order to land equipment on a roof. The helicopter hire company will advise you and seek flying permission from the Aviation Authorities or the whole job can be left to the generating set manufacturer.

### Colour and Planning Permission

As you will almost certainly be changing the shape of the skyline, Planning Permission will have to be sought. Many area authorities stipulate that existing skylines cannot be altered, whilst others specify that soundproof enclosures must blend with the skyline.

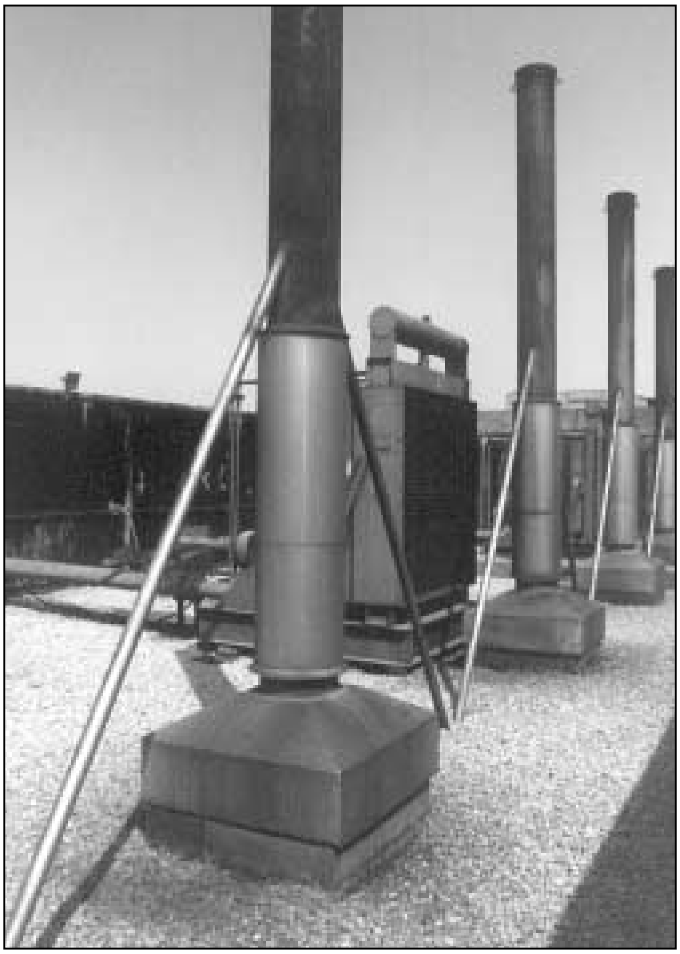
For this reason, many enclosures are specified as 'Sky Blue'. The interpretation for colour ranges from Light Grey to Dark Blue. It is wise, therefore, to seek guidance from the local planning authorities in this respect.

It is the Client's or Agent's responsibility to acquire Planning Permission.

### Fuel Supply

A very limited amount of fuel storage is permitted at roof level. Weight and Fire considerations are paramount. In general, a 'day tank' for each set is permitted but even this may be limited to 450 litres (100 gallons) by some Local Planning and Fire Authorities. It is essential to obtain full approval from the Authorities for the fuel system.

Your bulk fuel storage will be at ground level and subject to the Fire Regulations governing all safety aspects. Fuel will be pumped up to the day service tank – which will normally have a high and low float level regulator fitted to control the pump motor. It is essential that the day tank has adequately sized overflow pipework – certainly equal to the supply pipe size if not larger – which returns to the bulk fuel tank.



*Roof mounted remote radiators for four 1000 kVA sets and extended exhaust tail pipes where space and air flow is restricted.*

### Exhaust and Air Flows

Few problems are likely to be encountered with either exhaust or air flows at roof top levels and this is a major advantage with this type of location. If the roof level is below adjoining buildings, the direction of the exhaust system should be carefully sited – and prevailing winds taken into consideration. A vertical stack with a weathercap is occasionally recommended if offices with open windows are in close proximity.

Air flow inlet areas should be kept clear of any obstructions likely to restrict the air intake passage. Air outlet is unlikely to cause any problems but again prevailing winds should be considered as gale force winds blowing straight into the air outlet may cause restriction. As a solution use angled outlet louvres to overcome this problem.

### Cabling

Probably the most expensive item as a result of roof top installation. It is recommended that the control cubicle containing the changeover contractors be located as close to the building's incoming public power supply as possible. This will limit one of your main power cable runs to the minimum.

Control cables will still have to be run up to the roof level but these are small core cables. It is recommended that the generator's control system, sensing and instrumentation, be retained in close proximity to the installed generator. Output cable from the generator should use existing service ducting where possible.

### Police

Invariably, the use of heavy vehicles and large cranes will mean road closures, particularly in densely populated urban areas. Notifying the Police well in advance is recommended and their co-operation encouraged. In busy city areas, traffic diversions are essential – it also means delivery and installation is only possible at weekends.

*Two roof mounted super-silenced 1000 KVA sets with extended attenuators for a superstore provide a clean installation.*

## Recommended room sizes for Natural Gas Generating Sets 1400 to 2000 kVA

**Power station with silencing treatment and designed for tropical climates and prime/continuous operation.**

**Main features, with soundproofing**

This power plant room is designed for temperate climates or hot climate countries. Enhanced for sound attenuation the residual noise level is 50 dBA @ 50 metres.

Maintenance areas are provided around the generator sets, providing the ability to repair each generator set individually without breakout noise.

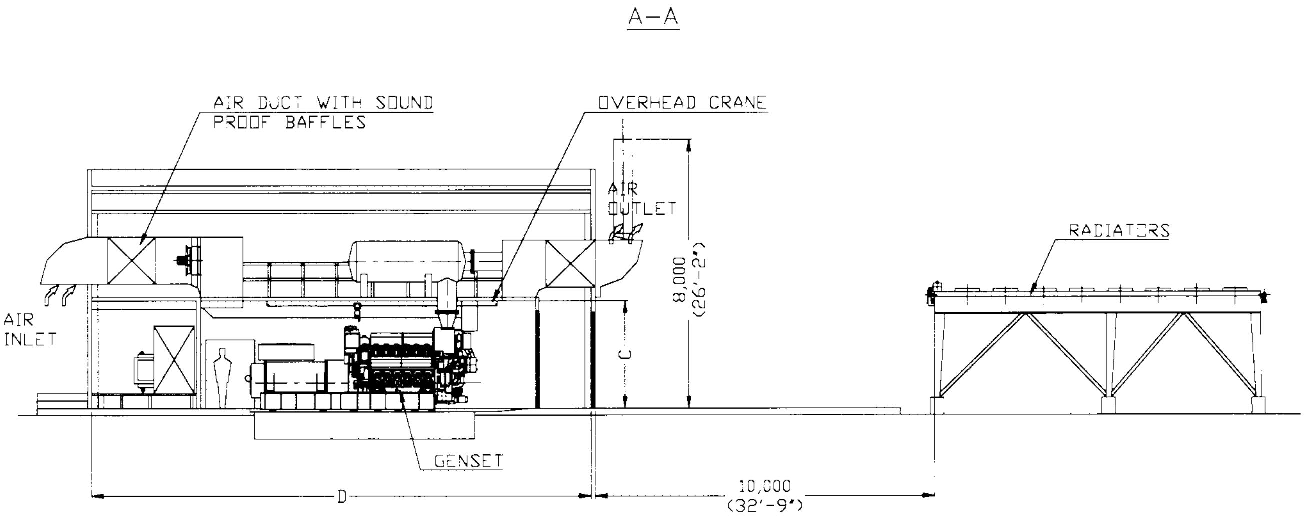
The external structure of the building may be made of steel with insulating material or of concrete.

Sufficiently large maintenance doors should be provided to allow generator set removal from the building.

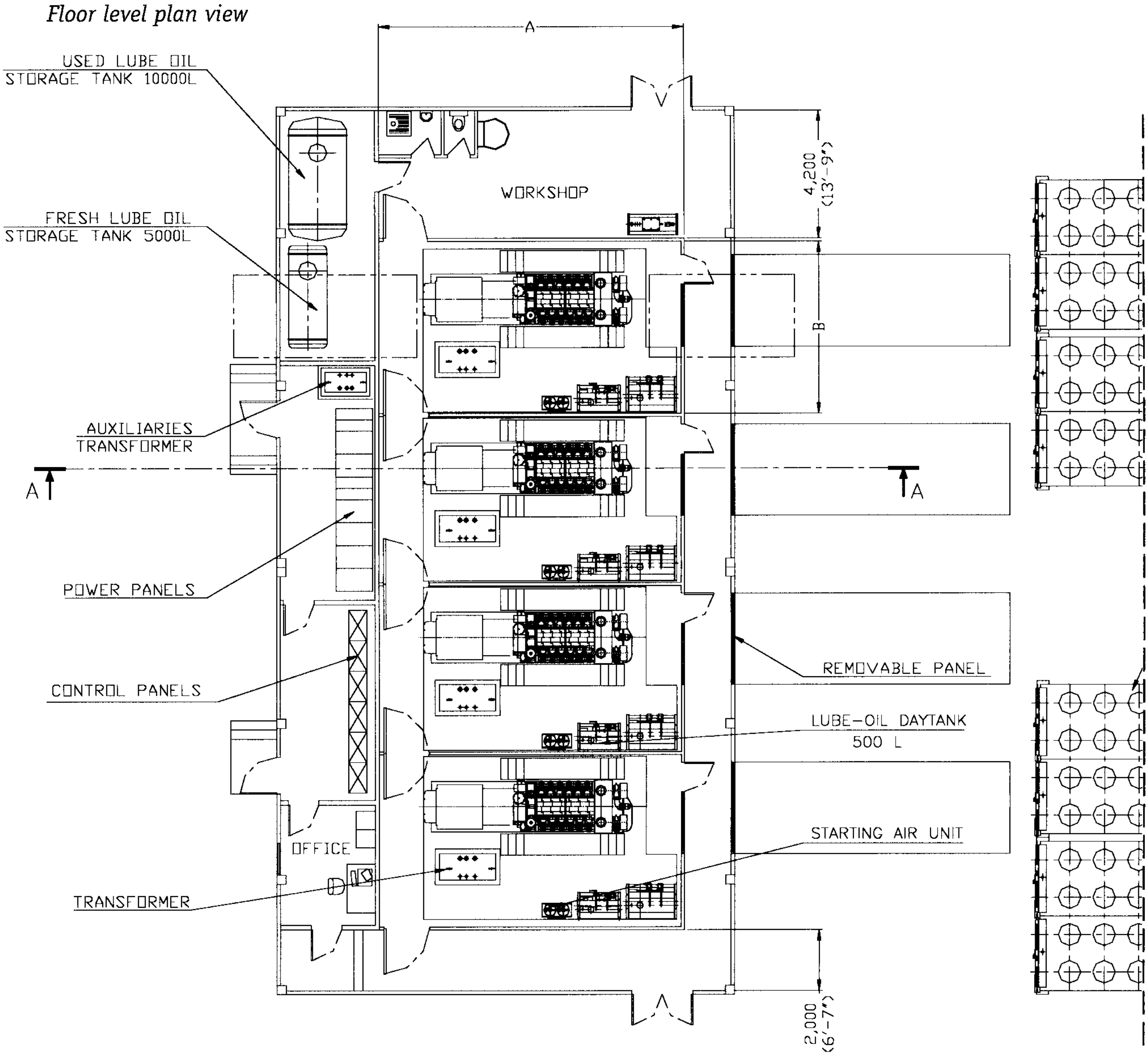
Combustion air is taken into the generator set room from outside by a fan through a sound trap. The air outlet is soundproofed and the exhaust line is equipped with two high efficiency residential silencers.

Power cables may be routed in trenches or on overhead cable trays.

| Prime Rating kVA (kW) 50Hz 1500 rpm | Gen Set | Engine | Set Room A | Set Room B | Height C | O/Length D | Prime Rating kVA (kW) 60Hz 1200 rpm | Set Sizes (approx) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Length (m) | Width | Height | Weight (tons) |
| 1625 (1300) | CQVF | QSV81G Vee 16 cyl | 10.0m (33') | 5.7m (18.7') | 3.4m (11') | 14.5m (47.6') | 1375 (1100) | 5.95 | 1.72 | 2.35 | 19.0 |
| 1875 (1500) | CQVG | QSV91G Vee 18 cyl | 10.0m (33') | 5.7m (18.7') | 3.4m (11') | 14.5m (47.6') | 1500 (1200) | 6.20 | 1.72 | 2.35 | 21.0 |



*Floor level plan view*



## Large Containerised Power Plants

### General

Containerised power plants are designed to be EASILY AND QUICKLY DELIVERED ALL OVER THE WORLD, AND INSTALLED IN A VERY SHORT TIME. THE LOW SOUND LEVEL of a soundproofed container is 85 dB(A) at one metre distance around the container or 75 dB(A) with the supersilenced version.

### Modularity

These large power plants are enclosed in two kinds of containers, one 40ft for the generating set, one 20ft or 40ft, air conditioned, for electrical items. Radiators are delivered separately and installed near the generator container.

Step-up power transformers are situated outdoors. Prepared cables are available for interconnecting mechanical and electrical containers. External cooling piping material is delivered loose. All the external equipment (silencers, radiators, ventilation) is delivered in a separate container.

A workshop container, with air conditioning may be ordered as an option.

### Installation Requirements

Containerised plant is intended to permit quick installation on a paved area. Cables and pipe trenches can be provided for multiple generator sets interconnection. Slab concrete thickness should not vary more than 30 mm over the whole seating area of the generator set container. Horizontal tolerance is 10 mm per metre. Slab strength shall be sufficient to support indicated weights only. There are no significant dynamic forces during operation.

Local scope of supply is mainly the electrical distribution system and/or switchboard.

Operating power supply needs (25 to 50kW per generator set) for preheating and starting, and fresh water delivery for cooling circuit top-up.

Black-start containerised power plant can be provided on request.

### Installation of radiators

Radiators should be installed at ten metres distance from the generator containers, to prevent exhaust gases recirculating through the radiator. If multiple radiators are installed, it is recommended to group them, ensuring that the lateral air inlet section is equal or more than the top surface. This arrangement ensures fresh air can reach the central blowers. If these rules are followed, recirculating hot air from existing radiators will be minimised.

### Exhaust stack

If exhaust lines are grouped into a common stack, each single engine exhaust should be routed separately.

### Civil works

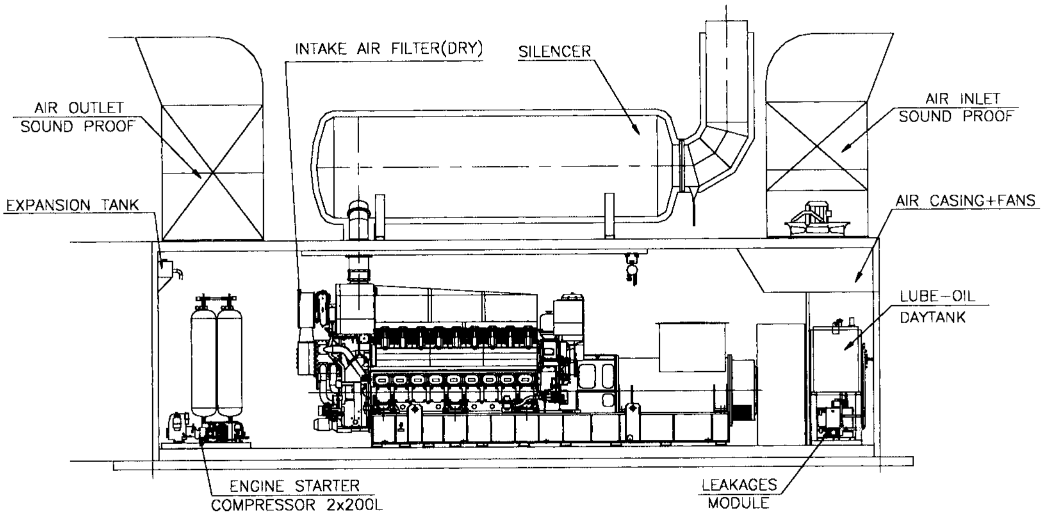
Free areas to be provided between containers, with separate trenches for pipes and for power cables. Control and instrumentation cables may be eventually installed over the pipes, but should never be routed with power cables. Trenches shall be well drained by a large diameter free running pipe.

Concrete slab should be layed on a well drained area. Slab around containers must be able to support the weight of generator sets when removed from container, and the surround must provide a solid base for operating the loading cranes.

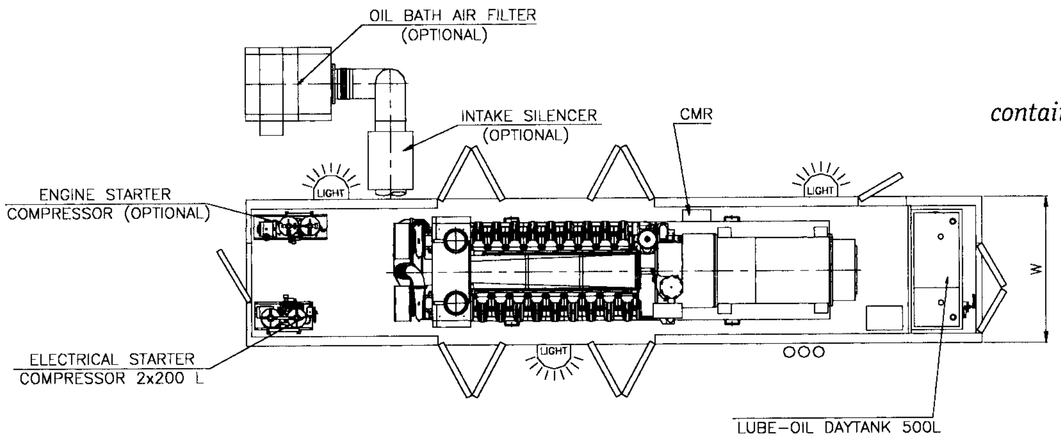
Paved or gravelled area should be layed under radiators, to prevent dust clogging.

## Large Containerised Power Plants

*container sectional view*




*container overview*



## Recommended buildings room sizes for Natural Gas generating sets 1400 to 2000 kVA

**Basic Power Station without sound attenuation treatment**

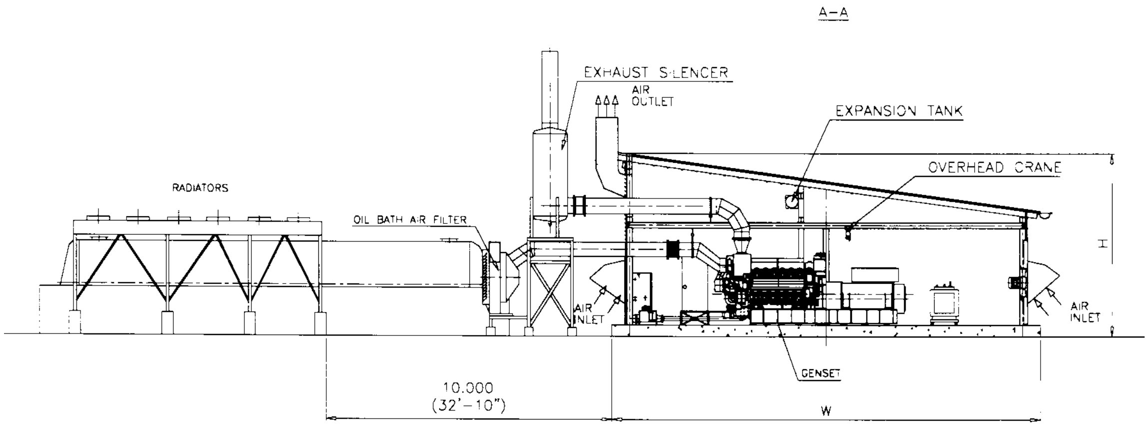
**Main features**

This power plant is designed for cost effective installation, providing fast commissioning and simplified servicing.

The electrical room should be built in masonry to prevent temperature changes and condensation effects. Placed in the middle of the building it will shorten power and control lines. Power cables may be routed in trenches or on overhead cable trays.

Radiators are grouped together to prevent hot air recirculating. It is recommended to place them 10 metres (30 ft) from the power station.

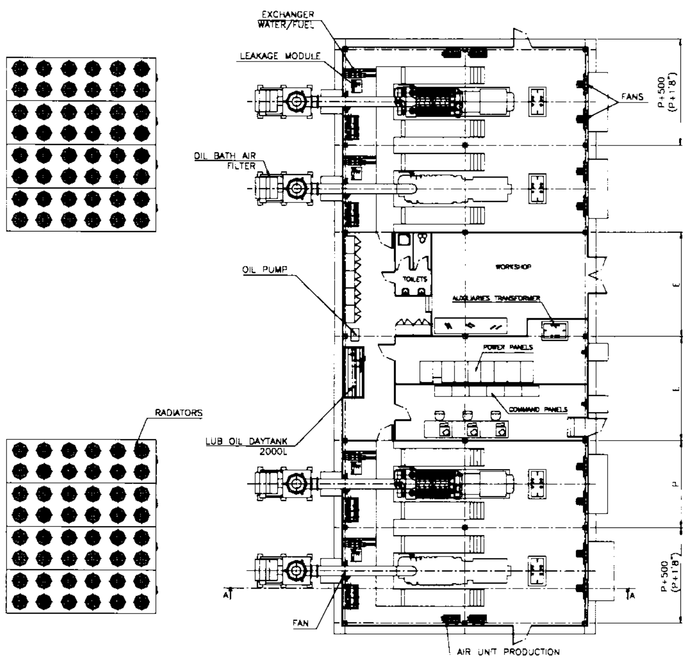
| Prime Ratings kVA (kW) 50Hz 1500 rpm | Gen Set | Engine | W | P | E | H | Number of gensets | Prime Ratings kVA (kW) 60Hz 1200 rpm |
|---|---|---|---|---|---|---|---|---|
| 1625 (1300) | CQVF | QSV81G V16 | 15.0 m | 5.0 m | MV-HV 6.5 m 21 ft | 7.0 m | 2 to 8 | 1375 (1100) |
| 1875 (1500) | CQVG | QSV91G V18 | 49 ft | 16' 5" | LV 7.0 m 23 ft | 23 ft | 2 to 8 | 1500 (1200) |




The whole building is erected on an elevated slab to prevent flooding. The structure of the building is made of steel with a wall filling of corrugated steel or masonry. Fans are installed on the front of the building and push air towards the engine, transformer and generator. Room ventilation may be by natural convection through large inlet and outlet louvres, if ambient temperature is below 35ºC. Air exits are normally on the roof but take care that louvres are not facing main winds.

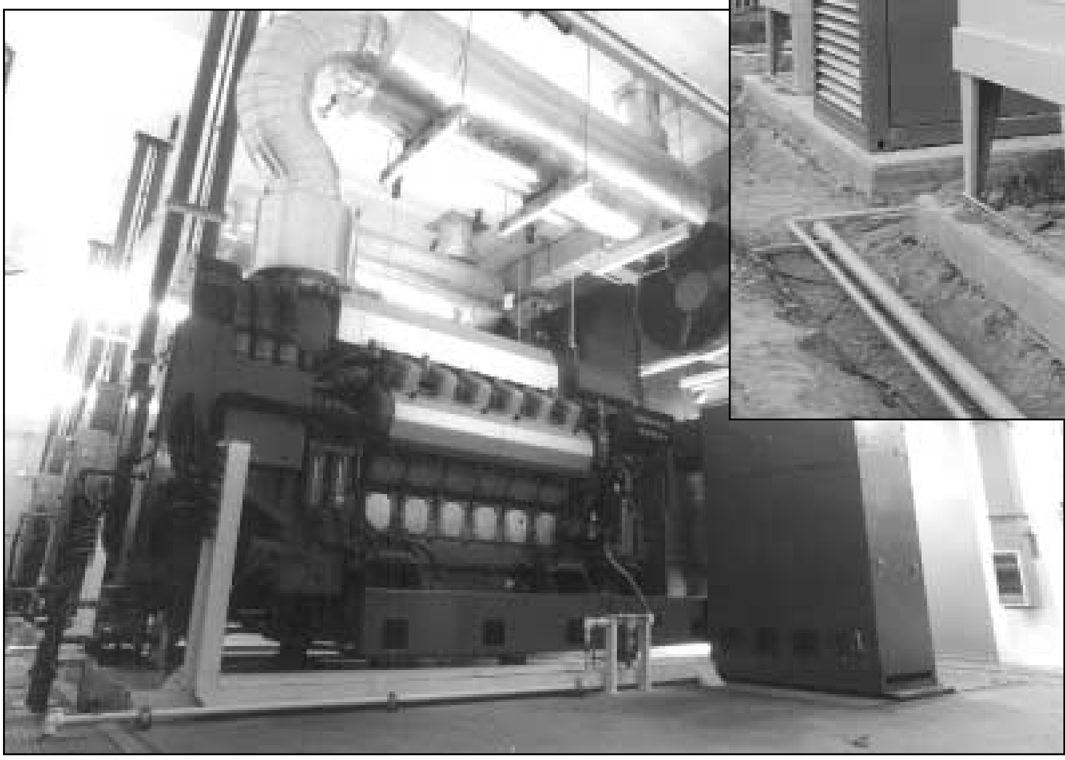
Mechanical auxiliaries are positioned near the front end of the engine to reduce piping runs.

An oil bath air filter, placed outdoors takes in air at a high level to prevent dust and exhaust hot air recirculating.



*Three containerised, 2.2 MW HV sets used for peak lopping duties with horizontal external cooling radiators. Whole installation silenced down to 75dB(A) at 1m and inaudible at around 50ft.*

*6.6 MW installation. Fuel piping and auxiliary cabling runs.*



*Three 2.2MW HV standby sets in specially prepared plant room. Note height required to accommodate large silencers.*

## General

Dependent upon the specific site layout, the fuel can be supplied to the engine either from:-

1. Directly from the sub-base fuel tank located under the generating set.
2. An intermediate daily service tank located within the plant room or generator enclosure, which is automatically refilled from a bulk storage tank; or
3. Directly from the bulk storage tank, provided that the outlet connection from this tank is at least 500mm higher than the base on which the generator is mounted.

Reputable fuel suppliers deliver clean, moisture free oil. Most of the dirt and water in the fuel is introduced through careless handling, dirty storage tanks or lines and poorly fitted tank covers.

The final selection of the fuel system is very much dependent upon the site layout and the relative heights of the generator and the bulk storage facility. The engine is designed to run on light domestic fuel oil to the following specification:-

There are many fuel composition requirements that must be met when purchasing diesel fuel. The following table lists fuel properties and their limits: the more critical definitions follow.

It is very important that the fuel oil purchased for use in any engine be as clean and water-free as possible. Dirt in the fuel can clog injector outlets and ruin the finely machined precision parts in the fuel injection system. Water in the fuel will accelerate corrosion of these parts.

## Fuel Oil Recommendations

The following fuel oil specification is typical. **For a specific engine refer to manufacturers' data sheets for fuel oil details.**

| FUEL OIL PHYSICAL PROPERTIES | RECOMMENDED SPECIFICATIONS | ASTM TEST METHOD |
|---|---|---|
| Viscosity | 1.3 to 5.8 centistrokes (1.3 to 5.8mm per second) at 40°C (104°F) | D445 |
| Cetane Number | 40 Minimum above 0°C (32°F) 45 Minimum below 0°C (32°F) | D613 |
| Sulphur Content | Not to exceed 0.5 mass percent* | D129 or 1552 |
| Active Sulfur | Copper Strip Corrosion not to exceed No. 2 rating after three hours at 50°C (122°F) | D130 |
| Water and Sediment | Not to exceed .05 volume percent | D1796 |
| Carbon Residue (Ramsbottom or Conradson) | Not to exceed 0.35 mass percent on 10 volume percent residuum | D524 or D189 |
| Density | 42 to 30° API gravity at 60°F (0.816 to 0.876 g/cc at 15°C). | D287 |
| Cloud Point | 6°C (10°F) below lowest ambient temperature at which the fuel is expected to operate | D97 |
| Ash | Not to exceed 0.02 mass percent (0.05 mass percent with lubricating oil blending) | D482 |
| Distillation | The distillation curve must be smooth and continuous | D86 |
| Acid Number | Not to exceed 0.1 Mg KOH per 100 ML | D664 |
| Lubricity | 3100 grams or greater scuffing BOCLE test or Wear Scar Diameter (WSD) less than .45mm at 60°C (WSD less than .38mm at 25°C) as measured with the HFRR method. | |

### Diesel Fuel Property Definitions

**Ash** - Mineral residue in fuel. High ash content leads to excessive oxide build up in the cylinder and / or injector.

**Cetane Number** - "Ignitability" of the fuel. The lower the cetane number, the harder it is to start and run the engine. Low cetane fuels ignite later and burn slower. This could lead to explosive detonation by having excessive fuel in the chamber at the time of ignition.

In cold weather or with prolonged low loads, a higher cetane number is desirable.

**Cloud and Pour Points** - The pour point is the temperature at which the fuel will not flow. The cloud point is the temperature at which the wax crystals separate from the fuel. The pour point should be at least 6°C (10°F) below the ambient temperature to allow the fuel to move through the lines. The cloud point must be no more than 6°C (10°F) above the pour point so the wax crystals will not settle out of the fuel and plug the filtration system.

**Distillation** - Temperature at which certain portions of the fuel will evaporate. The distillation point will vary with the grade of fuel used.

**Sulphur** - Amount of sulphur residue in the fuel. The sulphur combines with the moisture formed during combustion to form sulphuric acid.

**Viscosity** - Influences the size of the atomised droplets during injection. Improper viscosity will lead to detonation, power loss and excessive smoke.

Fuels that meet the requirements of ASTM or 2.0 diesel fuels are satisfactory with Cummins fuel systems.

### Use of Jet A Fuel in Diesel Engines

Jet A fuel can be used in diesel engines if it has a 40 cetane minimum. However, due to the lower specific gravity of the fuel, there will be fewer BTU's available per unit injected, and engine output will be lowered. Specifically all Cummins engines using the PT fuel system are Jet A tolerant (most L10, NT, V28 and K range) and the in-line Bosch pumps as used on the C and B series engines are Jet A tolerant. However the Stanadyne rotary pumps used on the B series are only marginally tolerant. Customers should expect to change fuel pumps approx one third the engine rebuild life but will generally be quite suitable for standby or low hour gensets.

## Sub-Base Fuel Tank

All Cummins Power Generation sets can be supplied with or without base fuel tanks. Capacities vary but are designed to provide approximately 8 hours of operation at full load. In practice with a variable load this will be extended. Recommended room layout drawings (Section B) incorporate base fuel tanks on the generators and the room height allows for this feature.

This provides a self contained installation without the addition of external fuel lines, trenches and fuel transfer pumps. Generators with base tanks are delivered fully connected and ready to run.

All base tanks have provision to accept fuel lines from externally mounted bulk fuel tanks or auxiliary free standing fuel tanks installed in the generator room.

Fuel transfer can be manually, electrically or automatically transferred via hand operated pumps or electric motor driven units.

## Without Intermediate Fuel Tank (Fig. C1)

The simplest arrangement would be to supply the engine directly from the bulk storage tank and return the injector spill directly to this tank. A typical arrangement for this is shown in Fig. C1.

The principle limitations of this method are:

In order to gravity feed the engine, the outlet from the bulk storage tank must be a minimum of 600mm above the generator plinth level;

The pressure drop of the spill return pipework must not exceed that detailed in the Engine Data sheet

The supply pipework from the bulk storage tank to the engine must be sized to allow the total volume of fuel required by the engine (consumed fuel plus spill return fuel) to flow under gravity.

## With Intermediate Fuel Tank (Fig. C2)

Where, due to site constraints, it is not possible to supply the engine direct from the bulk tank an intermediate tank can be located within the plant room/generator enclosure which supplies fuel directly to the engine.

This type of system can be further enhanced by the addition of the following optional items of equipment:

1. An automatic duplex fuel transfer pump and primary filter system arranged to start the standby pump should the duty pump fail. The transfer pump(s) must be sized to cater for the total fuel required by the engine, i.e. fuel consumed and the spill return volumes (Fig. C5);
2. A fusible link operated dead weight drop valve designed to cut off the supply of fuel to the intermediate tank and to transmit a signal in the event of fire;
3. A fusible link operated dump valve, arranged to dump the contents of the local tank back into the bulk tank in the event of a fire within the generator enclosure.

The connection details for these additional items of equipment are indicated. See Fig. C2.

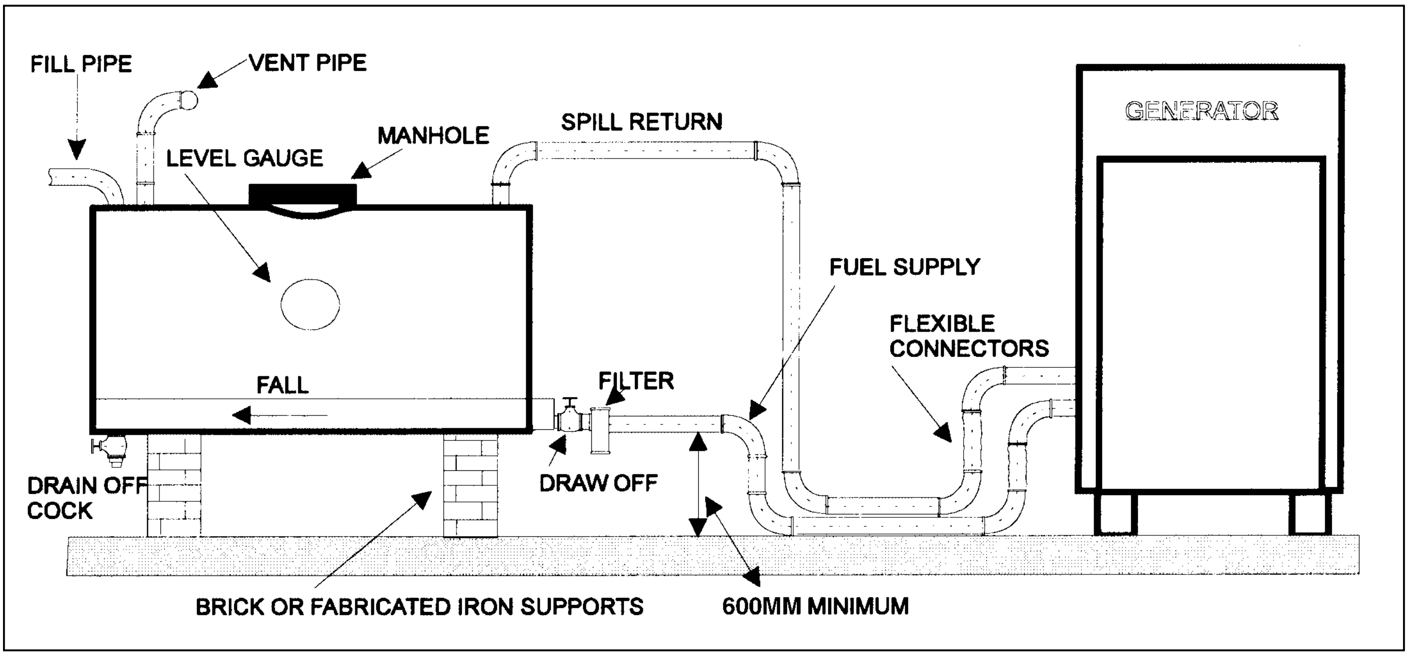



*Fig. C1 Fuel System Without Intermediate Tank*

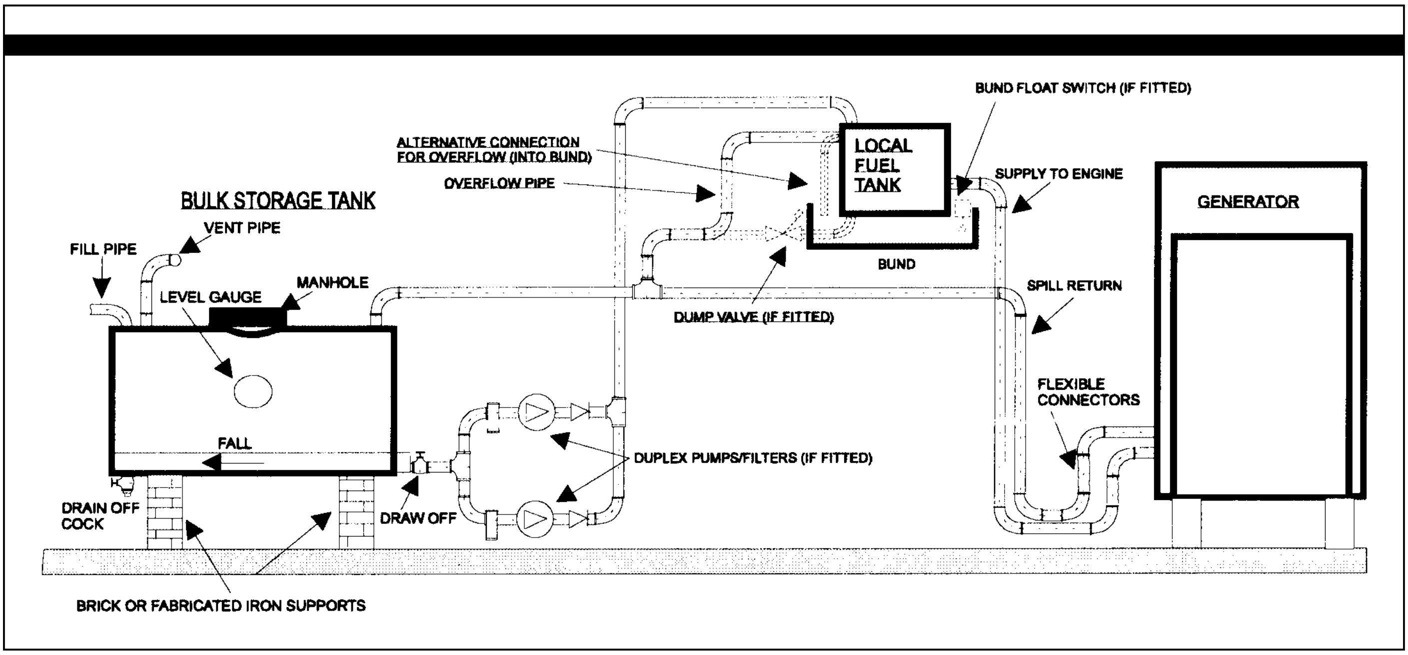
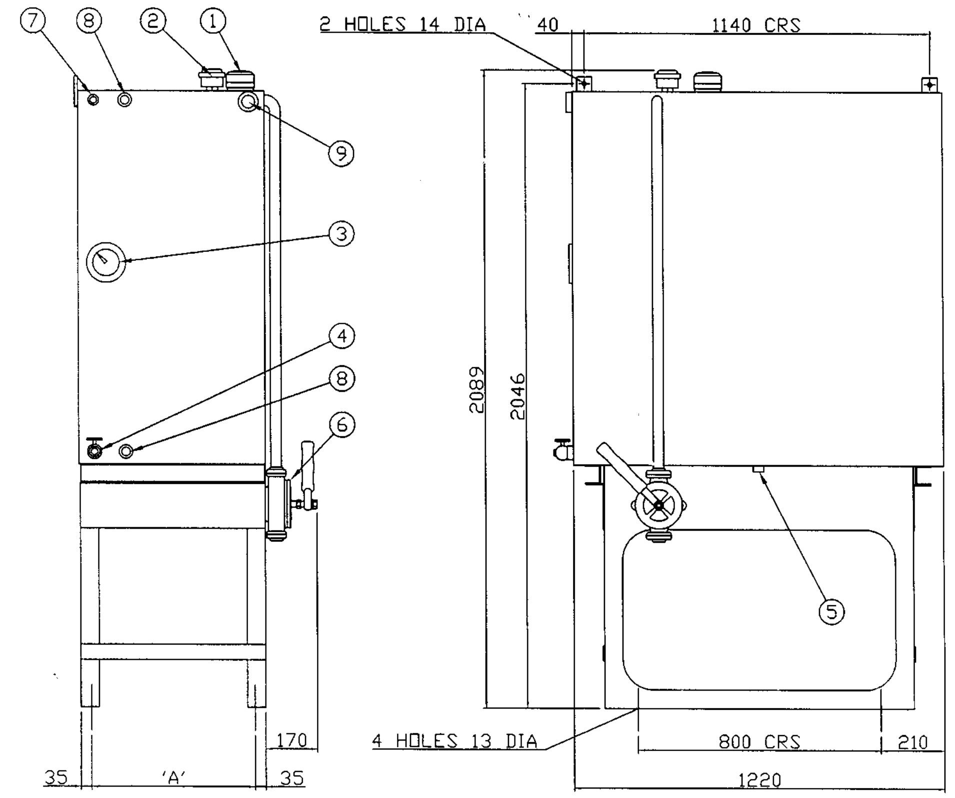



*Fig. C2 Fuel System With Intermediate Tank*

*Example of a free standing 900 Litre fuel tank installed within a bund wall.*

*14000 Litre (3000 gallon) bulk fuel tank with a bund wall. Feeding a 500 kVA super silenced set with sufficient fuel for 6 days full load operation.*




| ITEM | DESCRIPTION | QTY |
|---|---|---|
| 1 | FILLER CAP/BREATHER | 1 |
| 2 | FLOAT SWITCH (OPTIONAL) | 1 |
| 3 | FUEL CONTENTS GAUGE | 1 |
| 4 | ENGINE FEED VALVE 3/4"BSP | 1 |
| 5 | DRAIN PLUG 1/2"BSP | 1 |
| 6 | HAND PUMP (OPTIONAL) | 1 |
| 7 | COLLAR 3/4"BSP | 1 |
| 8 | COLLAR 1"BSP | 2 |
| 9 | COLLAR 1 1/2"BSP | 1 |

| FLOAT SWITCH POSITION | FUEL CAP |
|---|---|
| HIGH LEVEL ALARM | 93% |
| PUMP OFF | 88% |
| PUMP ON | 50% |
| LOW LEVEL ALARM | 25% |
| SHUTDOWN | 6% |

| DESCRIPTION | DIM 'A' |
|---|---|
| 450 LTR. TANK C/W STAND | 232 |
| 900 LTR. TANK C/W STAND | 534 |
| 1350 LTR. TANK C/W STAND | 836 |

| DESCRIPTION | WEIGHT DRY |
|---|---|
| 450 LTR. TANK C/W STAND | 150 Kgs |
| 900 LTR. TANK C/W STAND | 190 Kgs |
| 1350 LTR. TANK C/W STAND | 235 Kgs |
| HAND PUMP | 6 Kgs |

| DESCRIPTION | WEIGHT WET |
|---|---|
| 450 LTR. TANK C/W STAND | 600 Kgs |
| 900 LTR. TANK C/W STAND | 1090 Kgs |
| 1350 LTR. TANK C/W STAND | 1585 Kgs |
| HAND PUMP | 6 Kgs |

*Fig. C3 Fuel Tank and Stand Assembly*

## Daily Service Fuel Tank (Fig. C3)

The capacity of a daily Service Tank can be 450 litres, 900 or 1300 litres and a transfer system arranged to automatically feed from the bulk storage tank electric motor driven pump(s) operating from signals from a level sensing float switch. Interconnecting pipework should be compatible with the duty of the transfer pump.

Fuel tanks should **NOT** be made from galvanised iron as diesel fuel oil reacts against zinc.

The daily service tank should be positioned so that it is easily accessible for filling. In addition to an automatic filling system, provision should be made to fill from barrels by means of a semi-rotary hand pump. The fill connection should suit the method of filling.

**A vent pipe should be extended to the highest point of the fuel system installation. The diameter of the pipe should at least match that of the fill connection. Provision should be made to prevent the ingress of dirt.**

The overflow from the daily service intermediate tank can either be:

1. Piped directly back to the bulk storage tank;
2. Piped into the bund of the intermediate tank with a bund level alarm system arranged to cut off the fuel transfer pump system on detection of a spillage;
3. Piped to overflow into the bunded area.

The feed connection on the tank should not be lower than 600mm above the level on which the engine sits in order to maintain a gravity feed to the engine. It should not be so high as to exceed the maximum pressure head of the engine's fuel lift pump. (See Engine Data Sheets).

The spill return connection should not be higher than the suction lift capability of the engine's fuel pump. (See Engine Data Sheets).

When the intermediate tank is located at a lower level than the bulk storage tank it is essential that a solenoid valve be incorporated into the transfer line.

All final connections to the engine should be in flexible hose to restrict vibration transmission through the pipe.

## Bulk Storage Tanks

The purpose of the fuel-supply system is to store an adequate quantity of fuel to suit the application for which the system is intended. The bulk storage tanks should be sized accordingly.

The filling of the tanks will be by means of a fill connection housed in a suitable lockable cabinet located so as to permit easy access by delivery tanker. This cabinet may also house a contents gauge and an overfill alarm connected to the float switch inserted into a manhole on the tank.

## Bulk Storage Tanks

When used with an intermediate tank an electrically driven fuel transfer pump will be needed. Where possible this pump should be located close to the bulk tank on the grounds that any given size of pump has a greater ability to push fuel than to pull it. It is good practice to install a relief valve to return excess fuel from the discharge to the suction side of the pump.

The storage tank should incorporate the following facilities:

- provision for isolation during cleaning or repair (where multiple tanks are installed);
- a fill connection;
- a vent pipe/breather;
- intermediate tank overflow connection;
- inspection or manhole cover of approx. 18ins. diameter;
- a sludge drain connection at the lowest point;
- a level indicator (if contents are transmitted to the fill point cabinet); or dipstick
- a feed connection at the opposite end to the sludge drain connection;
- strainer and (where necessary) a foot valve.

The tank piers or supports should be arranged so that the tank is tilted some 50 from the horizontal. These supports should be constructed or protected so as to have a standard fire protection of 4 hours and should permit thermal movement. That end of the tank to which the principle pipelines are to be connected should be secured to its supports, the other end should be free to move.

A purpose built bund should be provided for all above ground tanks, constructed in consideration of the following requirements:

- It should be large enough and be structurally sound enough to hold at least 10% more than the contents of the tank;
- The floor should be laid to fall to an impervious un-drained sump
- Walls and floor should be lined with an impervious lining;
- All round access to tank's sides and fittings should be possible;
- A hand or electric pumping system should facilitate the draining of the bund.
- Metalwork should be earthed in accordance with local regulations.

For underground tanks the size of the excavation should be sufficient to allow for easy installation. The pit should be large enough to permit a clear gap of at least 1m between the shell of the tank and the walls before backfilling. The tank's protective coating should not be damaged when the tank is being lowered onto its supports and care should be taken that rocks or other abrasive materials do not damage the tank when backfilling. Underground tanks should be fitted with an extended nozzle of sufficient length to bring the manhole clear of the backfill which should be some 0.6m above the top of the tank.

## Determining Pipe Sizes

Minimum pipe sizes are determined by the size of the inlet to the fuel transfer pump. The pipe inner diameter must be a least as large as the transfer pump inlet. If the piping must carry the fuel over long distances, the pipe size must be increased. An auxiliary transfer pump at the tank outlet may also be needed to avoid high suction pressure within the piping. In all cases, excessive fuel line suction pressures must be avoided. At high suction pressures the fuel will vaporise in the piping and the fuel supply to the engine will be decreased.

When selecting pipe for fuel system installation, the cloud points and pour points of the diesel fuel must be considered. Over normal temperature ranges, this will not be a factor. However, as the fuel cloud and pour point temperatures are approached, the oil will become thicker and the pipe size will have to be increased.

When sizing piping, always remember to account for pressure drop across filters, fittings and restriction valves.

A flex connector must be added to isolate the engine vibration from the fuel piping. If this vibration is not isolated, the piping could rupture and leak. The flexible connector must be as close to the engine transfer pumps as possible.

Any expanse of exposed piping must be properly supported to prevent piping ruptures. Use pipe hangers to isolate vibration from the system.

Exposed fuel piping must never run near heating pipes, furnaces, electrical wiring or exhaust manifolds. It the area around the piping is warm, the fuel lines should be insulated to prevent the fuel and piping from picking up any excess heat.

All pipes should be inspected for leaks and general condition, including cleanliness before installation. Back flush all lines to the tank before start-up to avoid pulling excess dirt into the engine and fuel piping system. After installation, the air should be bled from the fuel system. A petcock should included at some high point in the system to allow air removal.

## GRAVITY FEED FUEL TRANSFER SUPPLY SYSTEM

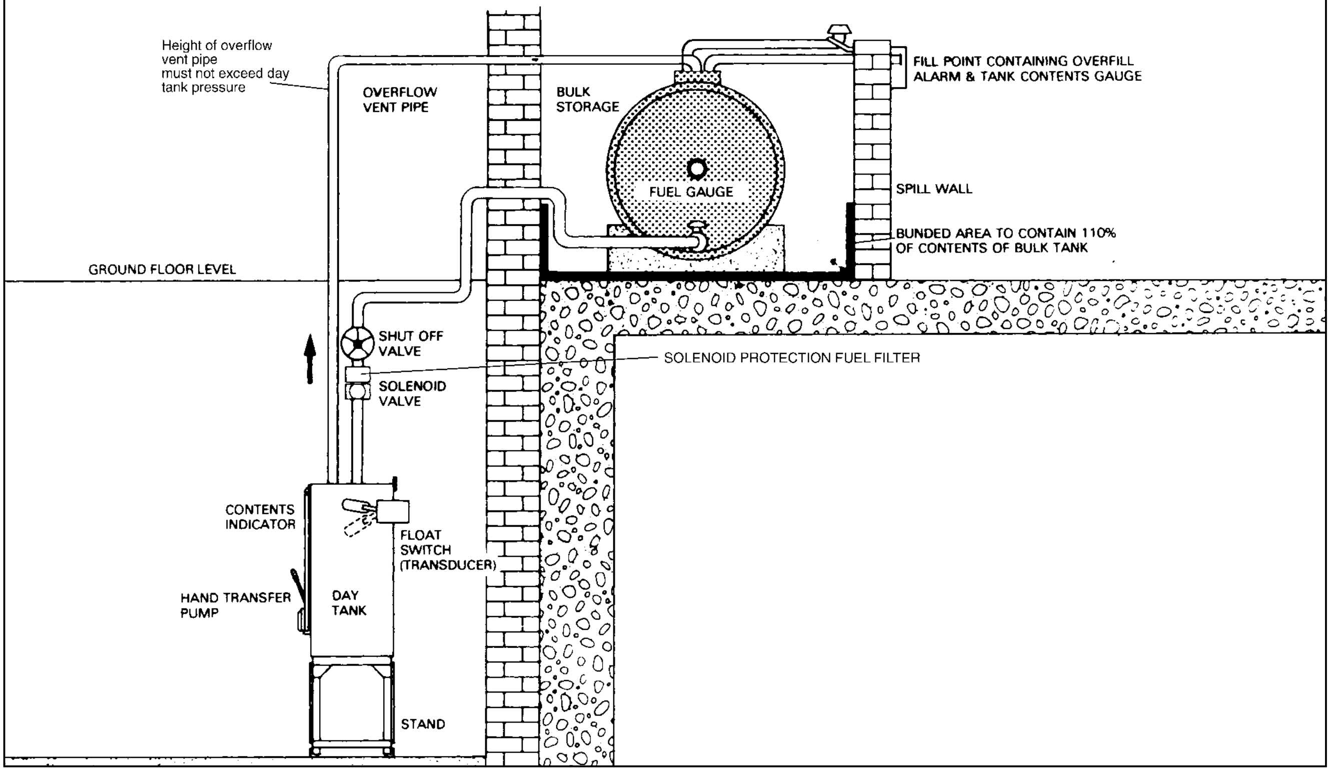



*Fig. C4*

## REMOTE FUEL TRANSFER SYSTEM

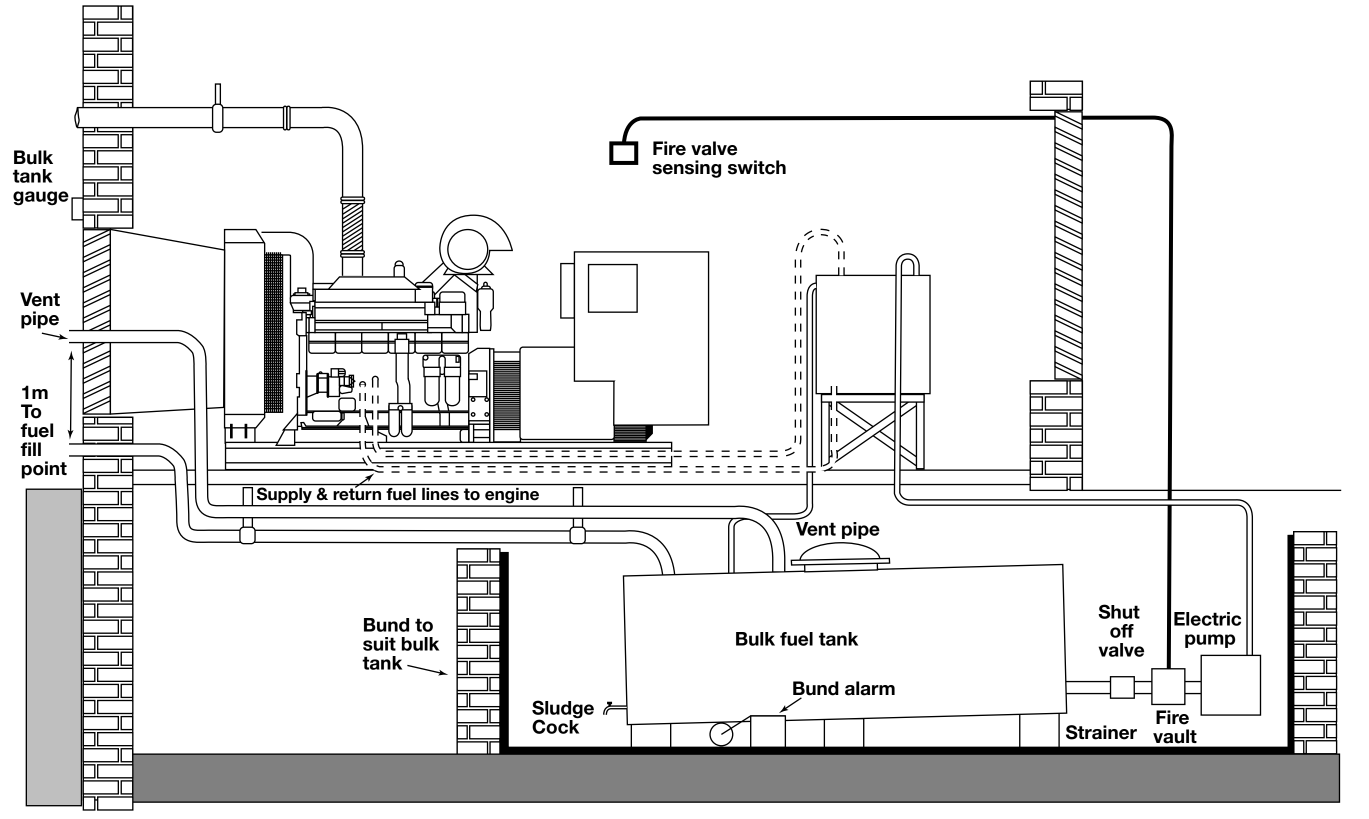



*Fig. C5*

Use plugged tees, not elbows, to make piping bends. This will allow for cleaning by removing the plugs and flushing out the lines. All threaded pipe fittings must be sealed with a suitable paste.

Caution: Do not use tape to seal fuel line pipe fittings. Pieces of tape could shear off and jam in the pump or injectors.

### Fuel Return Lines

Fuel return lines take the hot excess fuel not used in the engine cycle away from the injectors and back to either the fuel storage tank or the day tank. The heat from the excess fuel is dissipated in the tank.

Caution: Never run a fuel return line directly back to the engine fuel supply lines. The fuel will overheat and break down.

**The fuel return lines should always enter the storage or day tank above the highest fuel level expected.** This statement is true for all Cummins Gensets powered by engines with the PT fuel system (L10, NT, V28 and K range). However with sets using the B series, C series or the QST30 series engines drain lines for fuel will cause siphoning back through the supply line and result in hard starting if installed above the fuel level.

The fuel return line should never be less than one pipe size smaller than the fuel supply line.

### Fuel Coolers

Fuel returned to the fuel tank normally collects heat from the engine. In some cases, specifically using QSK45 and QSK60 engined gensets, a fuel cooler will be necessary to be installed within the fuel system.

**TYPICAL DIMENSIONS OF BULK FUEL STORAGE TANKS (CYLINDRICAL TYPE)**

| | DIA. | LENGTH |
|---|---|---|
| 500 GALLONS<br>2273 LITRES | 1372mm<br>4ft 6ins | 1753mm<br>5ft 9ins |
| 1000 GALLONS<br>4546 LITRES | 1372mm<br>4ft 6ins | 3353mm<br>11ft 0ins |
| 2000 GALLONS<br>9092 LITRES | 1981mm<br>6ft 6ins | 3277mm<br>10ft 9ins |
| 3000 GALLONS<br>13638 LITRES | 2134mm<br>7ft 0ins | 4115mm<br>13ft 6ins |
| 4000 GALLONS<br>18184 LITRES | 2438mm<br>8ft 0ins | 4267mm<br>14ft 0ins |
| 5000 GALLONS<br>22730 LITRES | 2286mm<br>7ft 6ins | 5944mm<br>19ft 6ins |
| 6000 GALLONS<br>27276 LITRES | 2744mm<br>9ft 0ins | 5029mm<br>16ft 6ins |

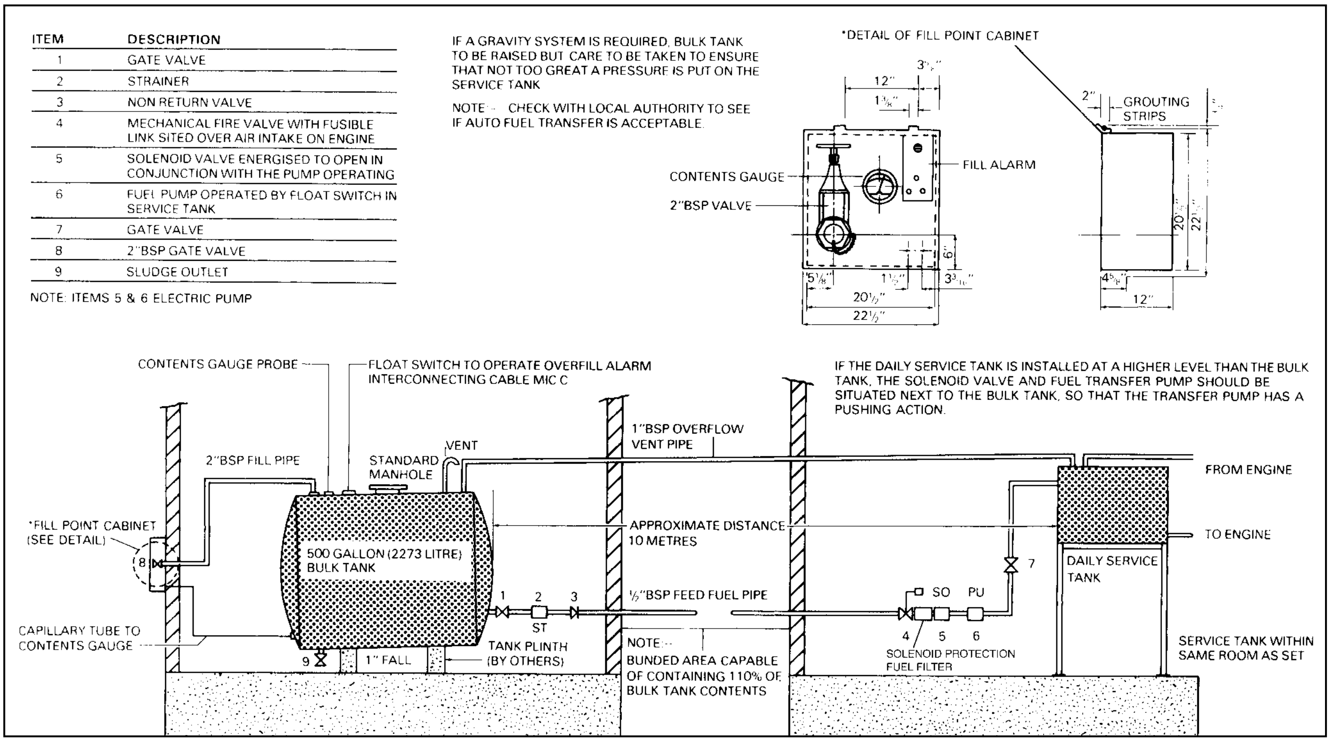



*Fig. C6 Suggested Installation for Bulk and Set Tanks*

## Exhaust System

### Sizing

An exhaust system should be designed to dispel the exhaust gases to atmosphere at the nearest convenient point in an installation. The length of the run and the number of changes in direction should be kept to a minimum to avoid exceeding optimum.

The calculation of the effect on the back pressure is based upon the restriction through the straight lengths of pipe, the bends and the silencers. The smaller the bore of the pipe, the greater its length and the more times it changes its direction, the greater is its resistance to flow. The resistance through the silencer varies according to the level of attenuation it is to achieve.

The formula for this calculation is based upon the following parameters:

F = Exhaust gas flow (Fig. C8)

P = Maximum allowable back pressure

A = Cross sectional area of the pipe

L = Length of straight pipe

B = Number of bends

R = Resistance through the silencer(s)

V = Linear velocity through the silencer

Listed below are pipe nominal bores and their cross sectional areas (A):

| Cross Sectional Area of Exhaust Piping | | | |
|---|---|---|---|
| Inches | sq. $ft^2$ | mm | sq. $m^2$ |
| 3 | 0.049 | 76 | 0.0045 |
| 4 | 0.087 | 102 | 0.008 |
| 6 | 0.196 | 152 | 0.018 |
| 8 | 0.349 | 203 | 0.032 |
| 10 | 0.545 | 254 | 0.050 |
| 12 | 0.785 | 305 | 0.073 |
| 14 | 1.070 | 356 | 0.099 |
| 16 | 1.396 | 406 | 0.129 |

| Engine | Silencer Exhaust Bore | |
|---|---|---|
| | inches | mm |
| B3.3, 4B, 6B | 3 | 76 |
| 6C | 4 | 100 |
| L, N, K19, V28 | 6 | 152 |
| K38, QSK30 | 6x2 | 152 |
| K50 | 8 | 200 |
| QSK45/60 | 12 | 300 |

The back pressure limit for most Cummins engines is 3 ins Hg (76mm Hg) although gensets using the latest designs are down to 2 ins Hg (50mm Hg) based on the maximum exhaust flow stated. If in doubt refer to the technical data sheets, Section G.

The example given in Fig. C8, shows a typical exhaust run complete with bends, straight lengths and silencer details. The pressure loss in each part of the system is dependent upon the average velocity (V) through it. Add together the pressure loss for each part of the system. **Take an estimate of the size of the pipe by starting with the bore of the exhaust flange off the manifold and increasing the size by 1" for each 20ft length or 3 x 90° bends.**

Select the silencers required to achieve the noise attenuation required and determine the linear velocity through each one by dividing the flow (F) in ft/sec by the cross sectional area (A) of the bore of the silencer.

eg: L range engines (250 kVA) silencer bore = 6" (152mm) equal to 0.196 sq.ft

Exhaust Gas Flow @ 1500 rpm prime = 1405 cubic ft/min.

$\frac{1405 \text{ CFM}}{0.196 \text{ ft}^2}$ = 7168 ft/min ÷ 60 = 119 ft/second.

Bore Velocity. Using 119 against the graph Fig. C10 we read off 4 inches Wg (100mm Wg) for silencer resistance.

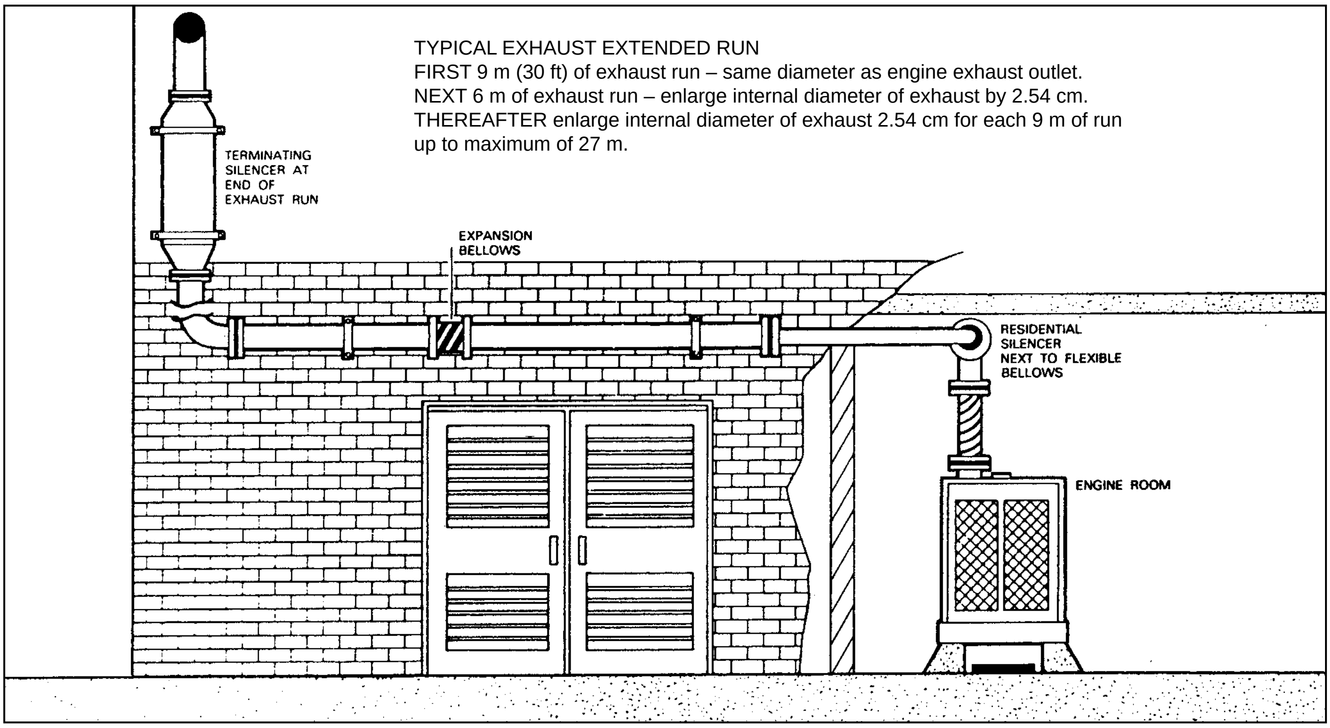



*Fig. C8 Typical Exhaust Run*

| Fig. C7 Exhaust pipeline recommendations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Exhaust outlet size mm (inches) | | Pipe size recommendations* | | | | | | | |
| | | Up to 6m (20ft) | | 6m to 12m (20 to 40ft) | | 12m to 18m (40 to 60ft) | | 18m to 24m (60 to 80ft) | |
| mm | (ins) | mm | (ins) | mm | (ins) | mm | (ins) | mm | (ins) |
| 50 | (2) | 50 | (2) | 63 | (2½) | 76 | (3) | 76 | (3) |
| 76 | (3) | 76 | (3) | 89 | (3½) | 100 | (4) | 100 | (4) |
| 89 | (3½) | 89 | (3½) | 100 | (4) | 100 | (4) | 100 | (4) |
| 100 | (4) | 100 | (4) | 127 | (5) | 127 | (5) | 150 | (6) |
| 127 | (5) | 127 | (5) | 150 | (6) | 150 | (6) | 200 | (8) |
| 150 | (6) | 150 | (6) | 150 | (6) | 200 | (8) | 200 | (8) |
| 200 | (8) | 200 | (8) | 200 | (8) | 254 | (10) | 254 | (10) |
| 254 | (10) | 254 | (10) | 254 | (10) | 305 | (12) | 305 | (12) |

* Note. These sizes are for guidance only. Specification and special silencer applications may affect the actual line sizes.

The following formula can be used to calculate the actual back pressure to the exhaust system for a given length and diameter.

$$P = \frac{L \times S \times Q^2}{5184 \times D^5}$$

L = Pipe length and elbows in feet/metres
Q = Exhaust flow CFM/$m^3$/sec
D = Inside diameter of pipe inches/metres
S = Specific weight of exhaust gas lb./cu.ft./kg/$m^3$
S will vary with the absolute temperature of exhaust gas as follows

$$S = \frac{41}{460 + \text{exhaust temp. °F}} \quad \Big| \quad S = \frac{365}{273 + \text{exhaust temp. °C}}$$

P = Back pressure (p.s.i.). Must not exceed max. allowable back pressure as shown in accompanying table.

**Some useful conversions**

Millimeters to inches – multiply by 0.03937
Inches to centimetres – multiply by 2.54
Metres to feet – multiply by 3.281
Cubic metres to cubic feet – multiply by 35.31
Centigrade to Fahrenheit – multiply by (C x 1.8) + 32
p.s.i. to inches of water (H2O) – divide by 0.0361
Inches of water to mm of water – multiply by 25.4
Metric formula

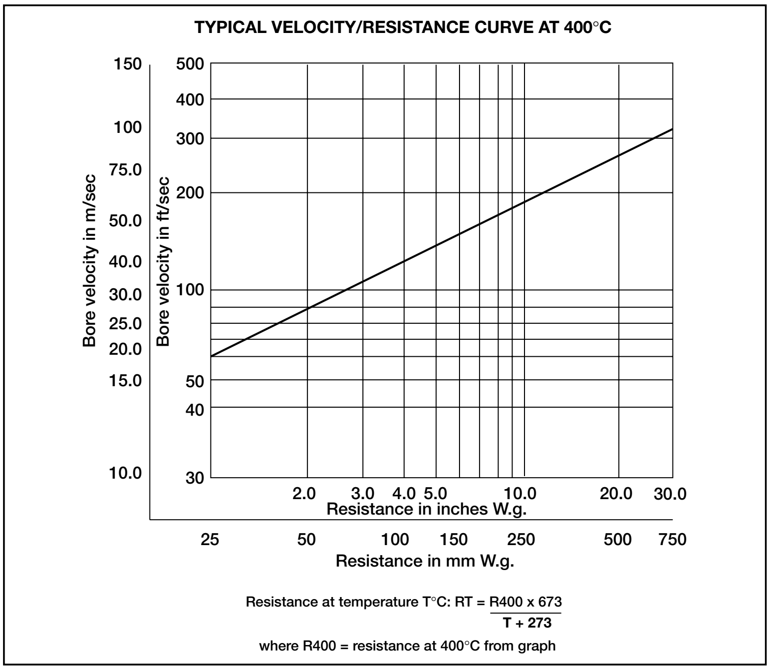
$$P = \frac{L \times S \times Q^2}{77319 \times D^5}$$

| Fig. C9 Exhaust Gas Flows and Temperatures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1500 rpm | | | | 1800 rpm | | | |
| | Prime | | Standby | | Prime | | Standby | |
| Engine | CFM | °F | CFM | °F | CFM | °F | CFM | °F |
| 4B3.9G* | 260 | 1105 | 280 | 1215 | 325 | 1120 | 350 | 1270 |
| 4BT3.9G1 | 290 | 870 | 315 | 935 | 370 | 860 | 395 | 915 |
| 4BT3.9G2 | 335 | 970 | 365 | 1030 | 420 | 950 | 460 | 1010 |
| 4BTA3.9G1 | 377 | 940 | 352 | 890 | 420 | 950 | 460 | 1010 |
| 6BT5.9G2 | 600 | 1070 | 650 | 1130 | 745 | 1010 | 800 | 1060 |
| 6CT8.3G2 | 895 | 970 | 980 | 1040 | 1100 | 951 | 1221 | 1065 |
| 6CTA8.3G | 1090 | 1180 | 1205 | 1210 | 1380 | 1095 | 1515 | 1130 |
| 6CTAA8.3G | 1080 | 1080 | 1272 | 1100 | 1436 | 925 | 1605 | 952 |
| LTA10G2 | 1405 | 955 | 1290 | 935 | 1655 | 905 | 1915 | 920 |
| NT855G6 | 2270 | 1065 | 2450 | 1125 | 2290 | 950 | 2400 | 975 |
| NTA855G4 | 2390 | 975 | 2595 | 1005 | 1866 | 895 | 2030 | 925 |
| NTA855 G6 | 2270 | 1065 | 2450 | 1125 | 2290 | 950 | 2400 | 975 |
| KTA19G3 | 2850 | 975 | 3155 | 990 | 3345 | 880 | 3630 | 915 |
| KTA19G4 | 3039 | 1000 | 3398 | 1604 | 3673 | 898 | 3945 | 939 |
| VTA28G5 | 4210 | 920 | 4340 | 945 | 4635 | 885 | 5040 | 935 |
| QST30G1 | 1995 | 527 | 2170 | 538 | 2620 | 455 | 2908 | 480 |
| QST30G2 | 2216 | 538 | 2526 | 557 | 2794 | 467 | 3118 | 496 |
| QST30G3 | 2430 | 541 | 2720 | 563 | 3000 | 464 | 3290 | 481 |
| QST30G4 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| KTA50G3 | 7900 | 968 | 8500 | 977 | 8400 | 860 | 9100 | 887 |
| KTA50G8 | 8150 | 900 | 9210 | 950 | – | – | – | – |
| KTA50G9 | – | – | – | – | 9600 | 880 | 10650 | 960 |
| QSK60G3 | 9650 | 920 | 10700 | 940 | – | – | – | – |
| QSK60G3 | 10700 | 940 | 11800 | 960 | – | – | – | – |
| QSK60G6 | – | – | – | – | 12400 | 760 | 13400 | 794 |
| QSK60G6 | – | – | – | – | 13765 | 805 | 15150 | 850 |

CFM = Cubic feet per minute

*Refer to page G3 for data on B3.3 engines

*Fig. C10*



**Pressure drop calculations**

Section A - Straight length of pipe.

Section B - 90° bends

Section C - Straight length of pipe, one sixth that of Section A.

Section D - The exhaust gas silencer, the manufacturers data is required to calculate the pressure drop.

Section E - Straight length of pipe, one third that of Section A

Section F - Outlet, total pressure drop of the exhaust system

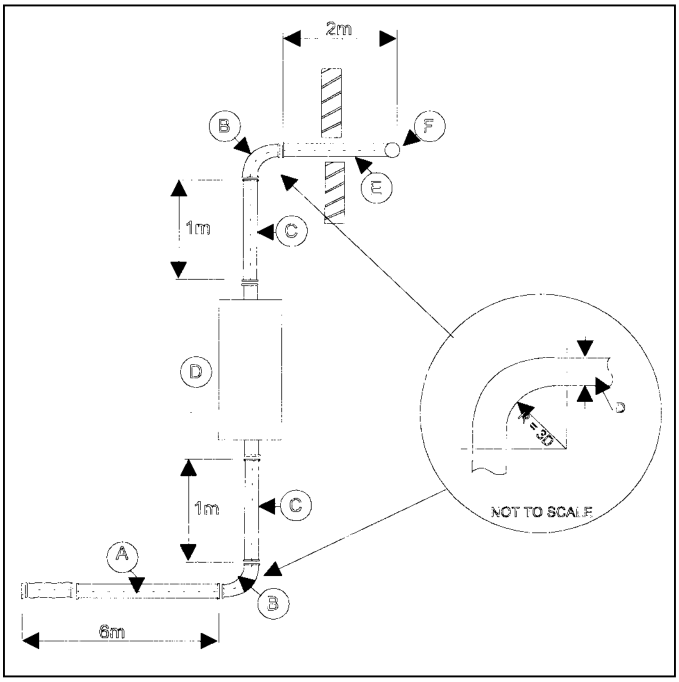



*Fig. C11 Typical Exhaust Run Complete with Bends*

Select the appropriate silencer(s) required to achieve the noise attenuation required and determine the linear velocity through each one by dividing the flow (F) in ft/sec by the cross sectional area of the bore of the silencer.(A)

e.g. F(8500cfm) = 64.98ft/sec 60 x A(2.180 Ft$^2$)

The resistance through the silencer can be determined by reference to the silencer manufacturer's nomograph. (Nelson Burgess BSA range nomograph is shown as Fig. C12). In the event that a reactive and an absorptive silencer is needed to achieve the noise attenuation level, the absorptive silencer would be placed after the reactive one and its resistance should be considered the same as an equivalent bore straight length of pipe.

When added to the resistance through the silencer(s) the total should not exceed the maximum allowable back pressure of the engine. If it does, the procedure should be repeated using an increased bore pipe and/or silencer(s).

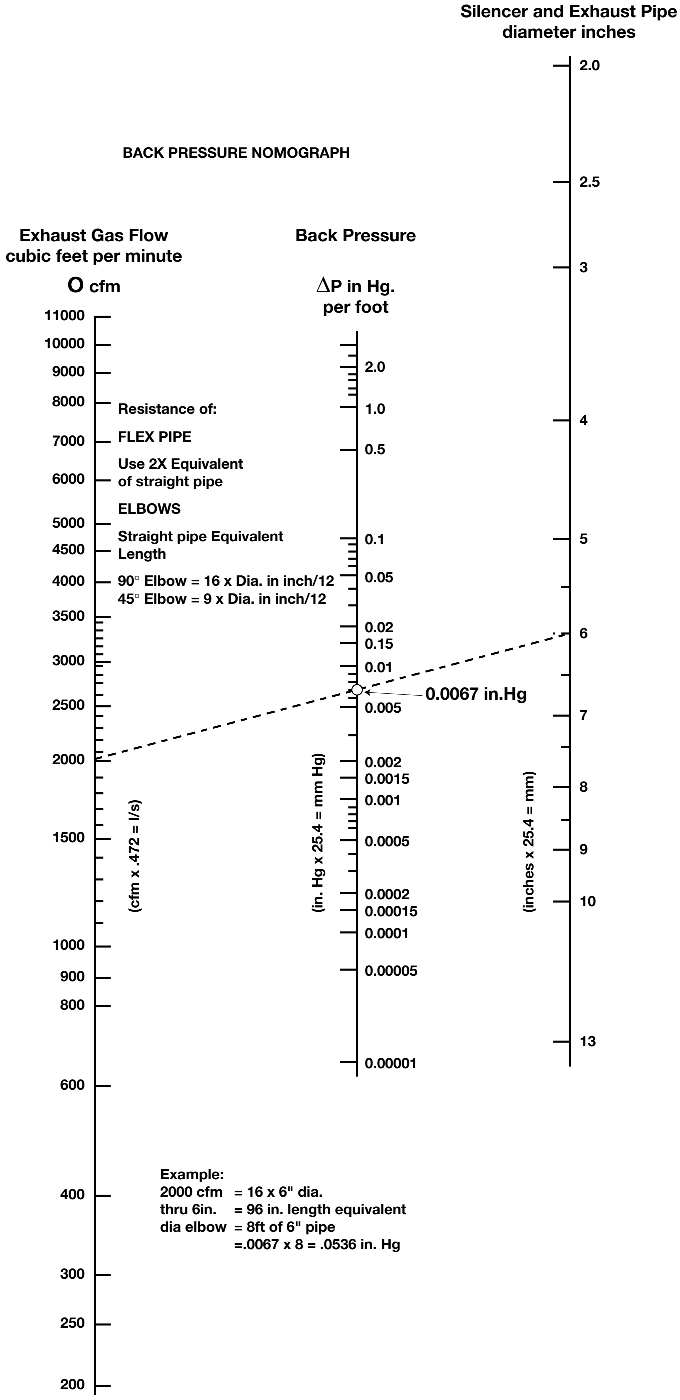



*Fig. C12 Silencer and Straight Line Nomograph*

## Routing

Once the final size and route of the pipework and the silencer have been established, the exhaust route can be determined, taking into account the following factors:

A flexible bellows unit must be fitted on the engine connection to allow the engine to move on its mountings;

If the silencer is to be located within the plant room, due to its physical size and weight it may need to be supported from the floor;

It may be necessary to install expansion joints at each change of direction to compensate for the thermal growth in the pipe during operation;

The inner radius of a 90° bend should be 3 times the diameter of the pipe;

The primary silencer should be mounted as close as possible to the engine;

When installing a long exhaust system, it may be necessary to install a terminal silencer to reduce any regenerated noise that may occur in the pipework after the primary silencer.

The termination point should not be directed at combustible materials/structures, into hazardous atmospheres containing flammable vapours, where there is a danger that the gases will re-enter the plant room through the inlet air vent, or into any opening to other buildings in the locality.

All rigid pipework should be installed in such a manner that the engine's exhaust outlet is not stressed. Pipes should be routed so that they are supported by fixtures to the building fabric or by existing structural steelwork where such methods are acceptable;

## Installation

Due to its overall size and weight, if the silencer is to be located within the plant room consideration should be given during the initial planning stages of the installation as to the exact method of moving this item into the room and then lifting it into final position as it may be necessary for it to be installed before the generator set is moved into position.

To ensure that condensation does not run back into the exhaust manifold, horizontal pipes should slope downwards away from the engine. Provision should be made for extending the condensate drain on the silencer and any other drain points, such as those at the base of vertical pipework, to a readily accessible position for regular draining to take place.

Where the pipe passes through combustible roofs, walls or partitions it should be protected by the use of metal sleeves with closing plates infilled with mineral wool. (See Fig. C13).

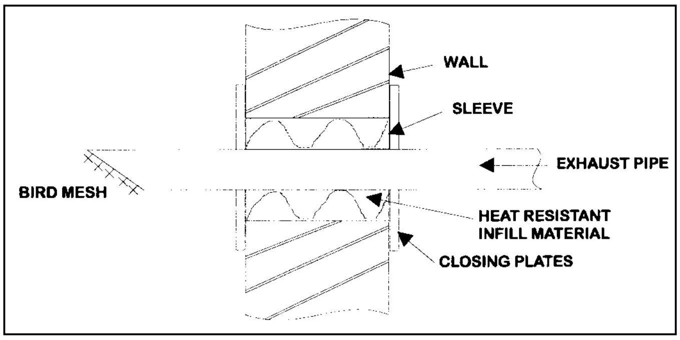



*Fig. C13 Protection by the Use of Metal Sleeves*

Where possible, in order to reduce the heat gain into the plant room, as much of the exhaust system as possible should be located outside of the plant room, with the remaining pipework within the room being fully lagged and clad. However, if due to the specific site constraints it is necessary to install the silencer and additional pipework within the room it should be fully insulated with 50mm of mineral wool and clad with aluminium foil. It may also be necessary to install the silencer inside the plant room to avoid noise break-out from the pipe connecting to the engine side of the silencer.

Care should be taken when insulating at pipe support or guide points so that the thermal growth of the pipe can take place. (See Fig. C14).

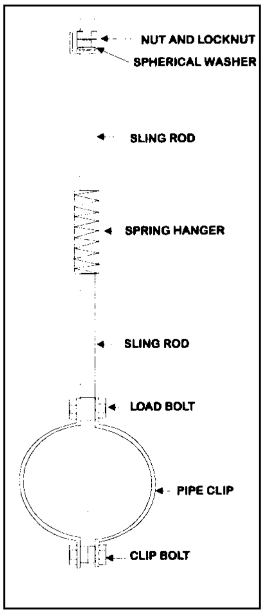



*Fig. C14 Allowing for Thermal Growth*

At the termination point the pipe should be protected against the ingress of rain either by turning into the horizontal plane with a mitred end or by being fitted with a rain cap.

## Exhaust System Design Considerations and Requirements

### Noise Level

The exhaust noise created by the engine must be attenuated sufficiently to satisfy all local regulations and on-site requirements. This can be accomplished with proper silencer selection.

| | |
|---|---|
| – Industrial (or Non-Critical) | 12 to 18 dBA attenuation |
| – Residential | 18 to 25 dBA attenuation |
| – Critical | 25 to 35 dBA attenuation |

### System Restriction

It is important to keep the exhaust back pressure as low as possible. Excessive exhaust back pressure can contribute to poor engine performance and poor durability by negatively affecting combustion efficiency and increasing gas temperatures.

**The back pressure limit on many Cummins generator drive engines is normally 3 in Hg (76mm Hg) but can be down to 2 in Hg (50mm Hg) on the latest engines based on the maximum exhaust gas flow stated on the Engine Data Sheet.** To satisfy this requirement, it is important to minimize piping length, elbow quantities, and silencer restriction, and to maximize piping diameters.

### Exhaust Outlet Location

#### Location Planning

Normally, the discussion for the exhaust outlet location would be included within a discussion of piping design. However, the exhaust outlet location is worthy of a dedicated discussion.

The most convenient exhaust outlet location is not always the best location. The designer must recognize that prevailing winds, building design, property layout, the distance to the property line, and the available exhaust gas velocity are each critical ingredients in selecting the proper outlet location. The gases must not have the opportunity to enter any vital air inlets (windows, doors, ventilation ducts, engine combustion air intakes, engine cooling/ventilation intakes, etc.), and many items must be considered to prevent this.

Every precaution must be taken when selecting the proper exhaust outlet location to prevent exhaust gases from contaminating the air entering vital air inlets. Such vita air inlets include windows, building ventilation systems, engine combustion air intakes, doors, and engine cooling/ventilation intakes.

**Special consideration must be given to prevailing winds, and potential stagnant air pockets near buildings.** These are as important as the mere distance between the exhaust outlet and the vital air inlets.

**The exhaust outlet must be located so as to minimize the effects of stack noise on workers and neighbours and to minimize the potential of carbon particle accumulation on nearby structures and to minimize the effects of noise.**

### Piping Design

All exhaust piping must be well supported by the building or enclosure.

The silencer must never be mounted directly to the exhaust manifold or turbocharger outlet on any engine without supplementary support.

The exhaust outlet must be fitted with a rain cap, bonnet, or otherwise be designed to prevent rainwater and snow from entering the exhaust system.

A condensate trap and drain valve must be fitted as close as practical to the engine to collect any water vapour that might condense from the exhaust gas.

### System Costs

Exhaust systems certainly cost money, but shaving costs on the front end of a project may well cost the end-user a great deal over the life of the unit. A restrictive system will force the engine to run at an unacceptable air to fuel ratio and could lead to temperature related durability problems and smoke complaints.

### System Length

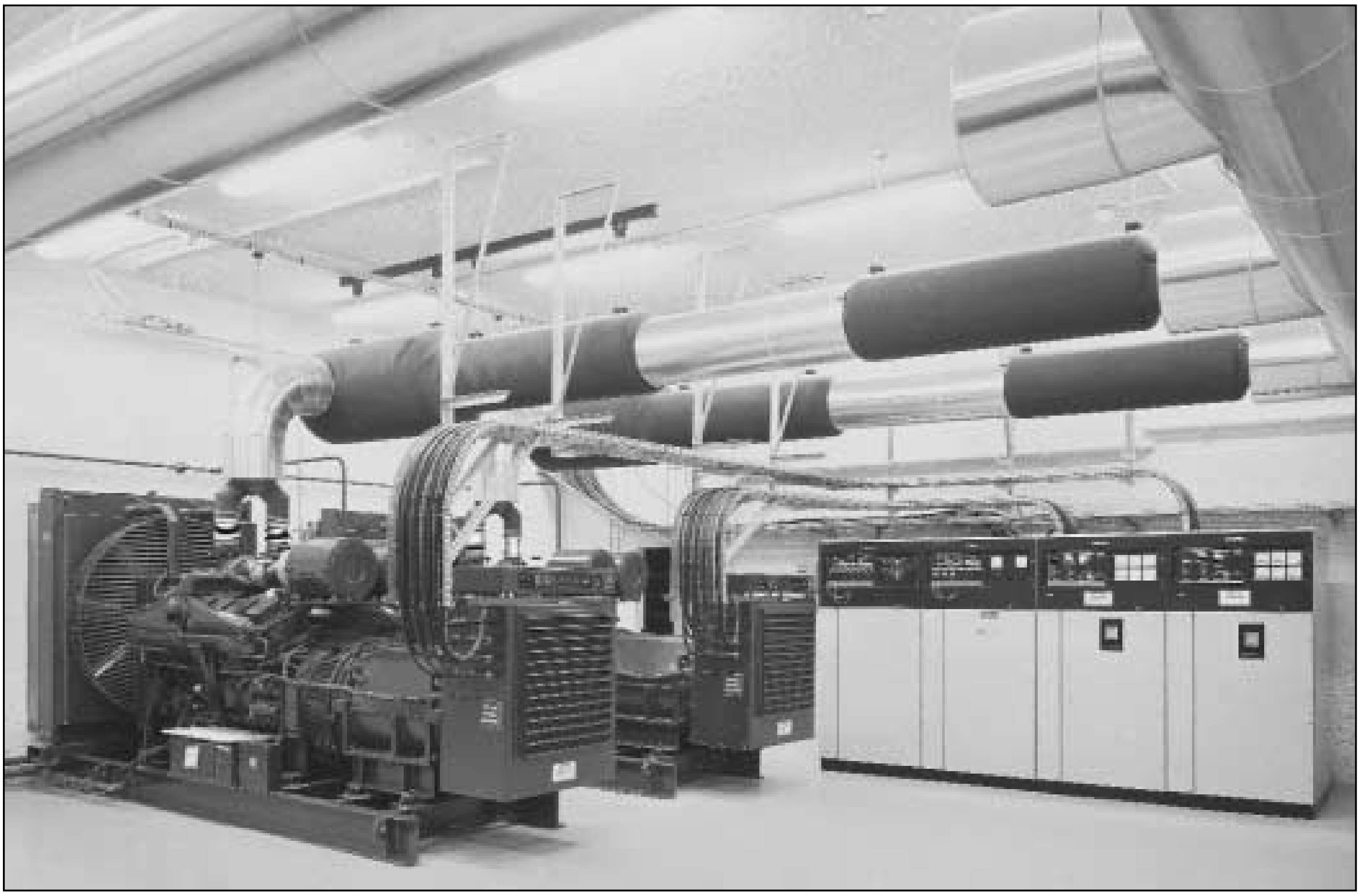
The designer must make every effort to find the shortest practical exhaust piping route between the engine and the properly selected exhaust outlet location. The following list summarises some of the reasons why the system should be as short as possible:

- Minimize system restriction (back pressure).
- Maintain reasonable exhaust gas exit velocities so that gases are easily dispersed (largest possible plume).
- Minimize exhaust gas condensing so that gases are not excessively dense when they exit.

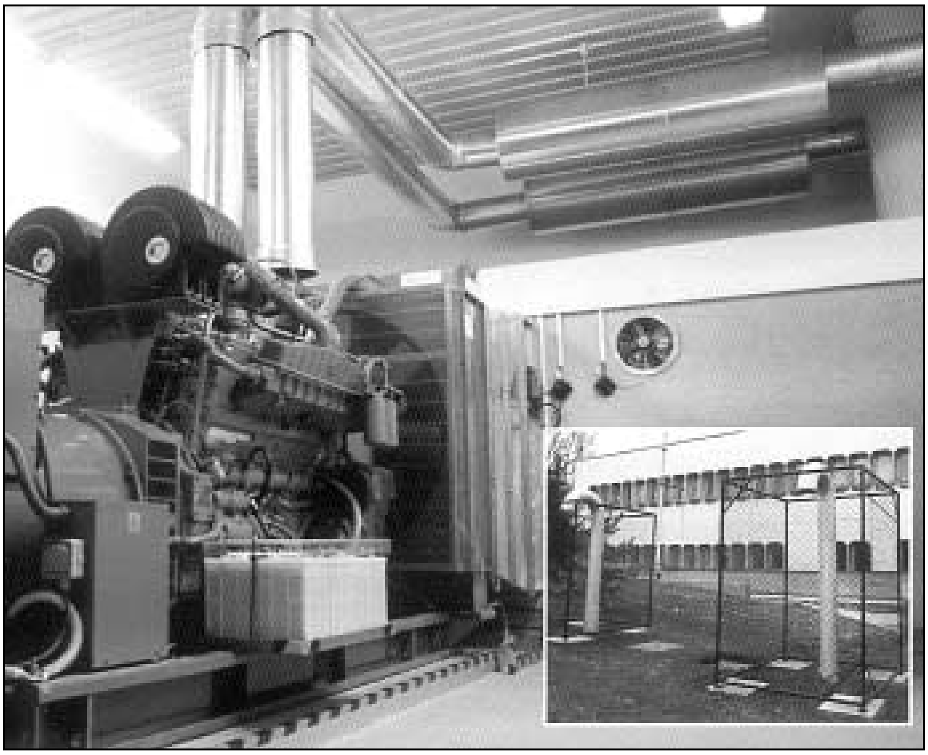
Dense gases exiting at a low velocity contribute to smoke complaints and to poor dispersion.

#### Flexible Connections

The piping system will expand and contract as it heats and cools. It will also be susceptible to the vibration and motion of the engine. For these reasons, a flexible piping connection must be placed between the engine and the piping system. The flexible pipe will minimize the stresses on the engine and the stresses in the piping



*Good example of clean and well lagged exhaust installation run from two 725 kVA twelve cylinder engined powered standby sets.*



*Dual exhaust run, lagged and aluminium foil clad from a Cummins VTA28 twelve cylinder twin turbocharged engine.*
*Set output 640 kVA/50 Hz.*

system. The flexible pipe should be located at or near the engine exhaust outlet (turbo or exhaust manifold).

**Mandatory Accessories**

The exhaust outlet must be fitted with a rain cap, bonnet or otherwise be designed to prevent rainwater and snow from entering the exhaust system. Flapper-type rain caps are effective devices, but they are subject to the effects of corrosion and carbon buildup which can prevent them from operating properly. It is wise to use these only in applications where they can be easily accessed for maintenance.

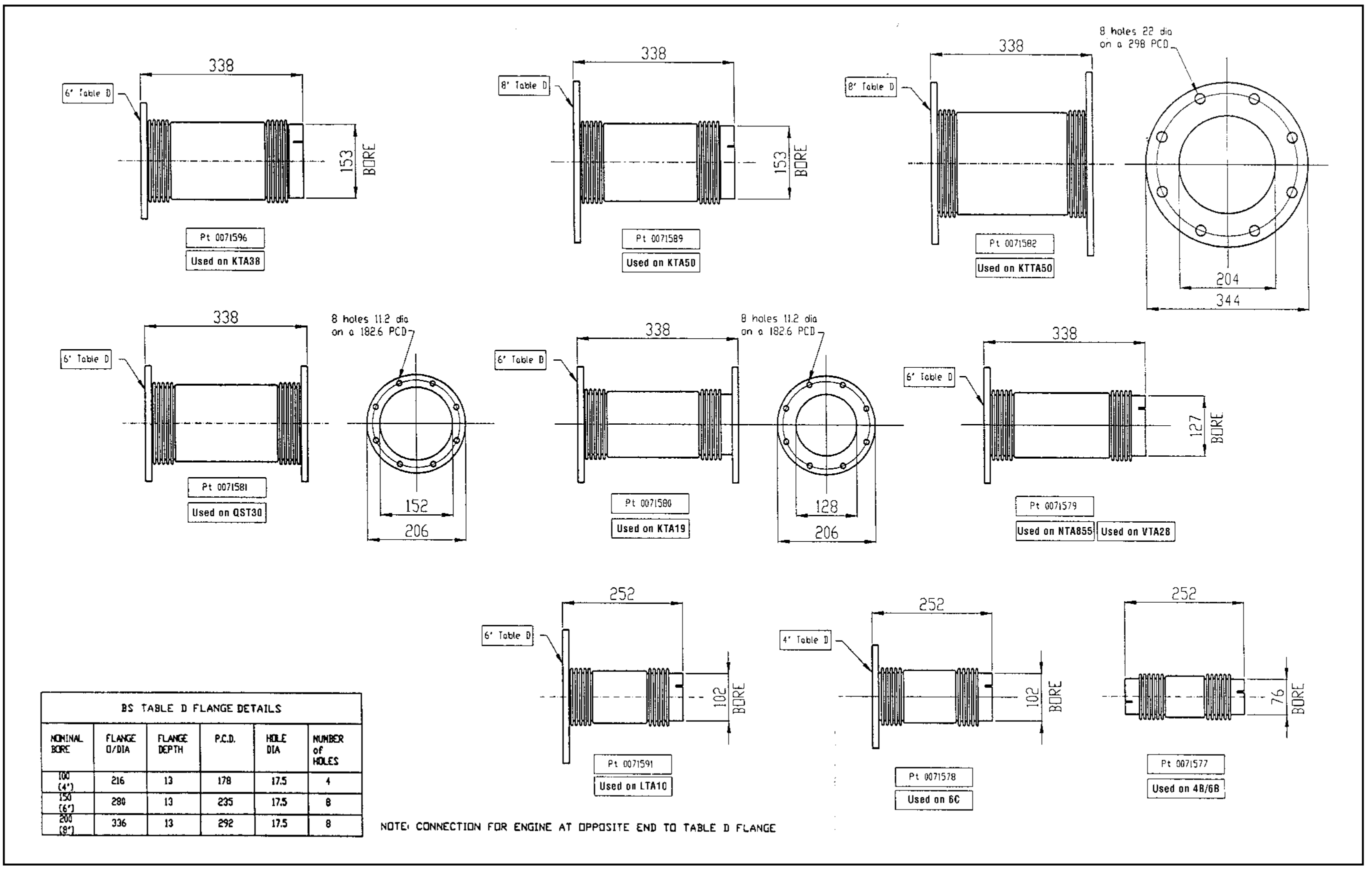
A condensate trap and drain valve must also be fitted as close as practical to the engine to collect any water vapour that might condense from the exhaust gas. Such a device is recommended, but rarely practical for a portable unit.

**Common Systems for Multiple Exhaust Sources**

The practice of manifolding or plumbing engines into a common exhaust system with furnaces, boilers, or other engines is not recommended. Non-running engines are at great risk to suffer damage due to the buildup of carbon and condensation from a running engine or other exhaust source. The turbocharger on a non-running engine can be driven by the exhaust flow from other sources and result in turbocharger bearing damage due to lack of lubrication.

There is no effective way to safely isolate engines from a common piping system. Valves used in the piping to isolate specific branches tend to suffer from carbon buildup and eventually leak or become stuck.

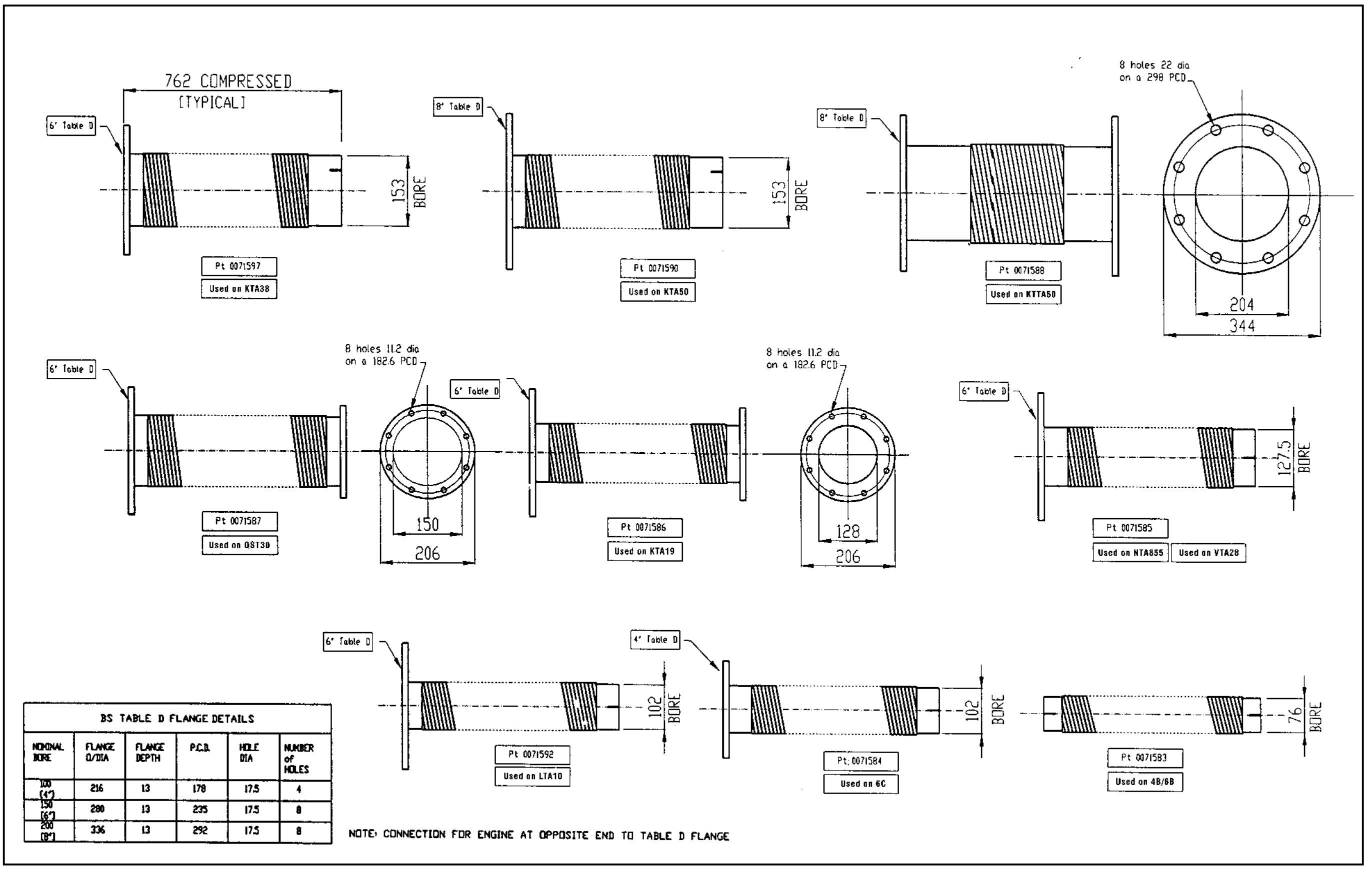
The exhaust gas velocities also tend to suffer in a system like this especially when only a few exhaust sources are operating. The exhaust gases condense and do not disperse well at the outlet. It may be possible to develop a forced air system to push the gases through the common stack to achieve the desired velocity, but this adds complication to the system. Cummins has no experience with such a forced air/blower system.




BS TABLE D FLANGE DETAILS

| NOMINAL BORE | FLANGE O/DIA | FLANGE DEPTH | P.C.D. | HOLE DIA | NUMBER of HOLES |
|---|---|---|---|---|---|
| 100 (4") | 216 | 13 | 178 | 17.5 | 4 |
| 150 (6") | 280 | 13 | 235 | 17.5 | 8 |
| 200 (8") | 336 | 13 | 292 | 17.5 | 8 |

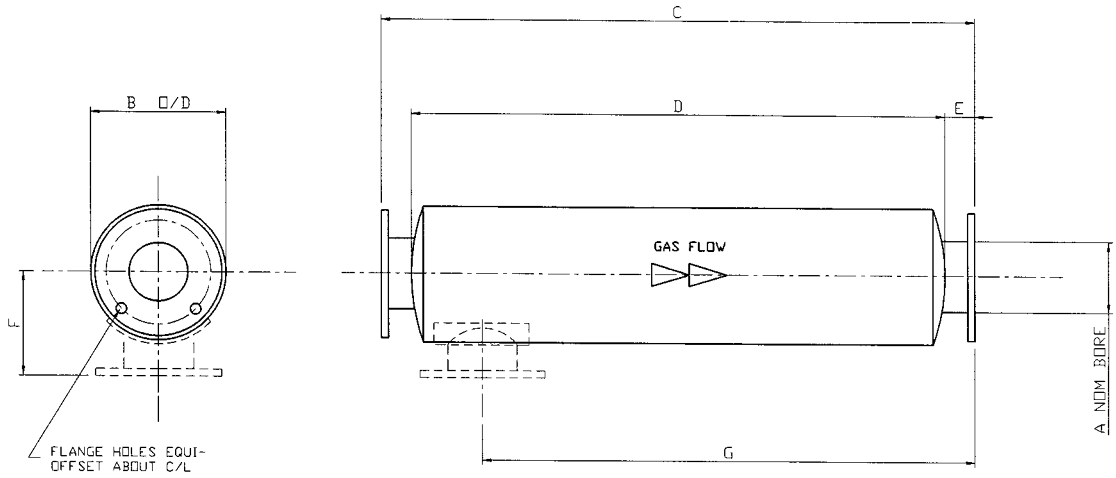
*Standard Exhaust Bellows*




BS TABLE D FLANGE DETAILS

| NOMINAL BORE | FLANGE O/DIA | FLANGE DEPTH | P.C.D. | HOLE DIA | NUMBER of HOLES |
|---|---|---|---|---|---|
| 100 (4") | 216 | 13 | 178 | 17.5 | 4 |
| 150 (6") | 280 | 13 | 235 | 17.5 | 8 |
| 200 (8") | 336 | 13 | 292 | 17.5 | 8 |

*Standard Exhaust Flex*

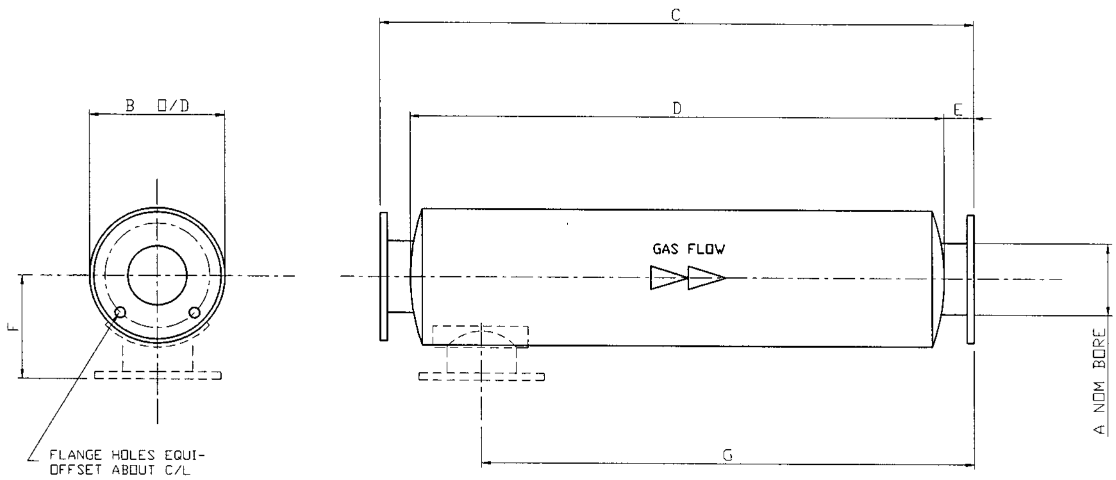



| BS TABLE D FLANGE DETAILS | | | | | |
|---|---|---|---|---|---|
| NOMINAL BORE | FLANGE O/DIA | FLANGE DEPTH | P.C.D. | HOLE DIA | NUMBER of HOLES |
| 100 | 216 | 13 | 178 | 17.5 | 4 |
| 150 | 280 | 13 | 235 | 17.5 | 8 |
| 200 | 336 | 13 | 292 | 17.5 | 8 |

NOTE : 3" BORE SILENCERS HAVE 3" BSP/MALE STUBS INSTEAD OF FLANGES

| Used on | Part No. | Dim A | Dim B | Dim C | Dim D | Dim E | Dim F | Dim G |
|---|---|---|---|---|---|---|---|---|
| 4B,6B | 015322 | 3" | 208 | 780 | 680 | 50 | / | / |
| 4B,6B | 015308 | 3" | 208 | / | 680 | 50 | 155 | 650 |
| 6C | 015323 | 100 | 260 | 900 | 800 | 50 | / | / |
| 6C | 015319 | 100 | 260 | / | 800 | 50 | 180 | 745 |
| L,N,K19,V28,K38,Q30 | 015324 | 150 | 375 | 1250 | 1100 | 75 | / | / |
| L,N,K19,V28,K38,Q30 | 015320 | 150 | 375 | / | 1100 | 75 | 255 | 1050 |
| K50 | 015325 | 200 | 413 | 1550 | 1400 | 75 | / | / |
| K50 | 015321 | 200 | 413 | / | 1400 | 75 | 285 | 1310 |

*GA of Exhaust Silencers (Industrial)*

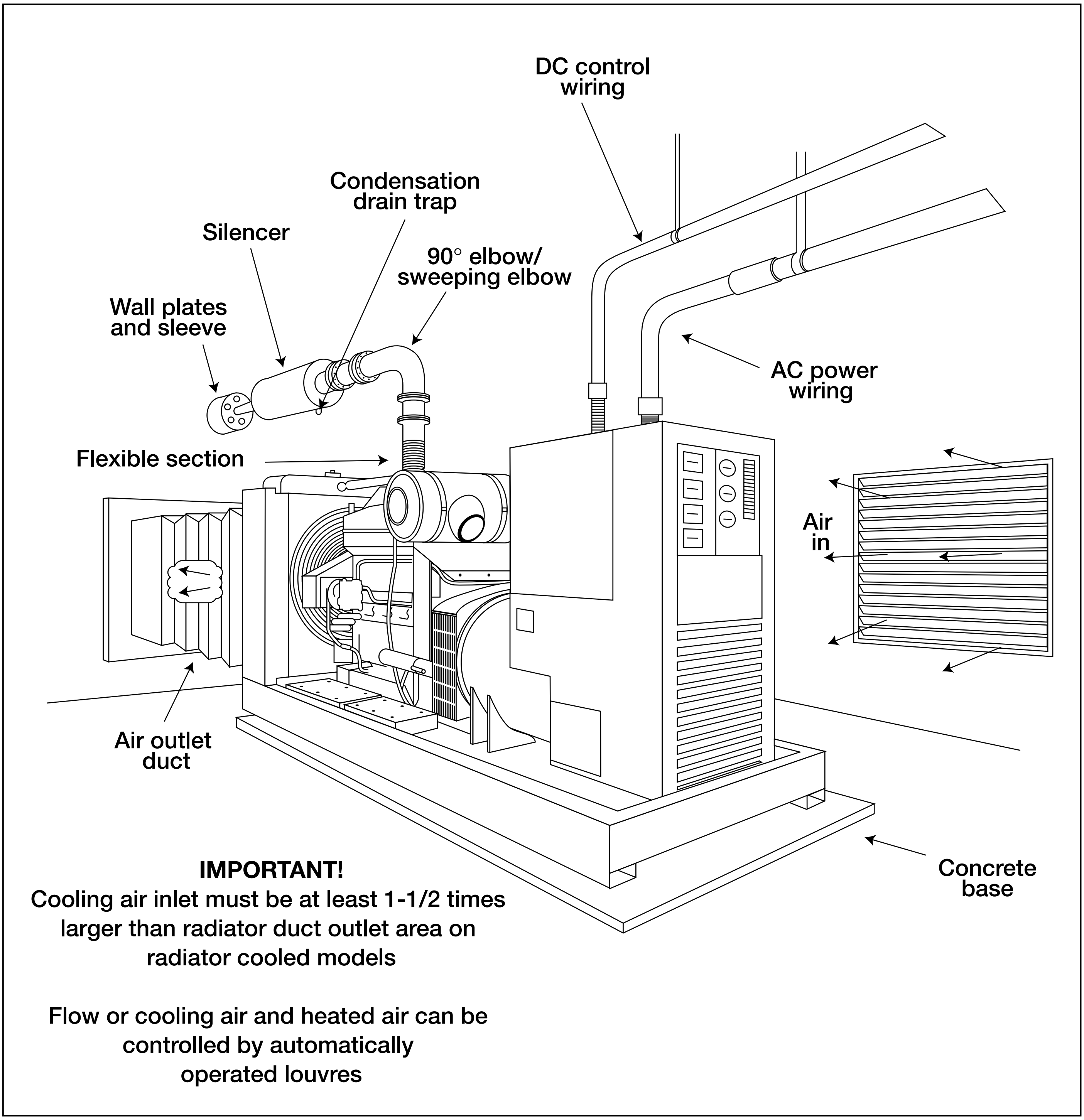



| BS TABLE D FLANGE DETAILS | | | | | |
|---|---|---|---|---|---|
| NOMINAL BORE | FLANGE O/DIA | FLANGE DEPTH | P.C.D. | HOLE DIA | NUMBER of HOLES |
| 100 | 216 | 13 | 178 | 17.5 | 4 |
| 150 | 280 | 13 | 235 | 17.5 | 8 |
| 200 | 336 | 13 | 292 | 17.5 | 8 |

NOTE : 3" BORE SILENCERS HAVE 3" BSP/MALE STUBS INSTEAD OF FLANGES

| Used on | Part No. | Dim A | Dim B | Dim C | Dim D | Dim E | Dim F | Dim G |
|---|---|---|---|---|---|---|---|---|
| 4B / 6B | 015313 | 3" | 260 | 750 | 650 | 50 | / | / |
| 4B / 6B | 015309 | 3" | 260 | / | 650 | 50 | 180 | 590 |
| 6C | 015314 | 100 | 304 | 900 | 800 | 50 | / | / |
| 6C | 015310 | 100 | 304 | / | 800 | 50 | 205 | 712 |
| L,N,K19,V28,K38,Q30 | 015315 | 150 | 413 | 1350 | 1200 | 75 | / | / |
| L,N,K19,V28,K38,Q30 | 015311 | 150 | 413 | / | 1200 | 75 | 285 | 1070 |
| K50 | 015316 | 200 | 567 | 1750 | 1600 | 75 | / | / |
| K50 | 015312 | 200 | 567 | / | 1600 | 75 | 360 | 1400 |

*GA of Exhaust Silencers (Residential)*




*Typical Installation*

## General

Cooling and ventilation of an engine room is very important. Provision must be made for an adequate air flow through the room, to replace the air consumed by the engine, and air pushed out by the cooling radiator fan.

There are various types of cooling systems that can be adopted, the main ones being as follows.

Set mounted radiator.

Remotely positioned radiator.

Heat exchanger cooling.

## IMPORTANT
## Radiator Cooled Sets

**When a radiator is mounted on the end of the plant main frame, position the set so that the radiator is as close to the outlet vent as possible, otherwise recirculation of hot air can take place. The recommended maximum distance away from the outlet vent is 150mm without air ducting.**

If the plant cannot be positioned as above an air duct must be incorporated in the system.

The minimum cross sectional area of the ducting must be the same as the cooling area of the radiator. A canvas duct with mating steel flanges to suit radiator and output louvres is normally adequate for this purpose.

Ducting bends must be well radiused and where long runs are required the ducting must be enlarged to reduce back pressure on the radiator. Sound attenuated ducts require long runs and have to be designed specifically for each building.

The air inlet and outlet apertures in a building are normally louvred or screened with mesh. The free area taken up by the louvring slats or mesh must be taken into consideration when calculating size of aperture.

The large volume of air required by a diesel engine for cooling and combustion is not always appreciated and it is recommended that the total area of incoming air vents should be at least double that of the engine radiator outlet. All vents should be protected against the ingress of rain. In cold climates where sets are employed on standby duty and only run occasionally, the room should be kept warm. Air inlets and radiator outlets should be provided with adjustable louvres that can be closed when the set is not in use. Thermostatically controlled immersion heaters are generally fitted in the engine coolant system on automatic mains failure sets, as standard.

## Dampers

Dampers or louvres protect the genset and equipment room from the outside environment. Their operation of opening and closing should be controlled by operation of the genset.

In cooler climates movable or discharge dampers are used. These dampers allow the air to be recirculated back to the equipment room. This enables the equipment room to be heated while the genset engine is still cold, increasing the engine efficiency.

## Radiator Set Requirements

Radiator set cooling air is drawn past the rear of the set by a pusher fan that blows air through the radiator. Locate the air inlet to the rear of the set. Make the inlet vent opening 1-1/2 to 2 times larger than the radiator area.

Locate the cooling air outlet directly in front of the radiator and as close as possible. The outlet opening must be at least as large as the radiator area. Length and shape of the air outlet duct should offer minimum restriction to airflow.

The radiator has an air discharge duct adapter flange. Attach a canvas or sheet metal duct to the flange and the air outlet opening using screws and nuts so duct can be removed for maintenance purposes. The duct prevents circulation of heated air. Before installing the duct, remove the radiator core guard.

**Standard Radiator Cooling** uses a set mounted radiator and engine pusher fan to cool engine water jacket. Air travels from the generator end of the set, across the engine and out through the radiator. An integral discharge duct adapter flange surrounds the radiator grille.

**Remote Radiator Cooling (Optional)** substitutes a remote mounted radiator and an electrically driven fan for the set mounted components. Removal of the radiator and the fan from the set reduces noise levels without forcing dependence on a continuous cooling water supply. The remote radiator installation must be completely protected against freezing.

**Before filling cooling system, check all hardware for security. This includes hose clamps, capscrews, fittings and connections. Use flexible coolant lines with heat exchanger, standpipe or remote mounted radiator.**

## Ventilation

Ventilation of the generator room is necessary to remove the heat and fumes dissipated by the engine, generator and its accessories and to provide combustion air.

**Factory-mounted Radiator Ventilation**

In this configuration the fan draws air over the set and pushes it through the radiator which has flanges for connecting a duct to the out-of-doors. Consider the following:

- See the Generator Set Data Sheet for the design airflow through the radiator and allowable airflow restriction. **The allowable air flow restriction must not be exceeded.** The static pressure (air flow restriction) should be measured to confirm, before the set is placed in service, that the system is not too restrictive, especially when ventilating air is supplied and discharged through long ducts, restrictive grilles, screens and louvers.
- Note that the inlet duct must handle combustion air flow (see the Set Data sheet) as well as ventilating air flow and must be sized accordingly.
- Louvres and screens over air inlet and outlet openings restrict air flow and vary widely in performance. A louvre assembly with narrow vanes, for example, tends to be more restrictive than one with wide vanes. The effective open area specified by the louvre or screen manufacturer should be used.
- The airflow through the radiator is usually sufficient for generator room ventilation. See the example calculation for a method of determining the air flow required to meet room air temperature rise specifications, if any.
- Because the radiator fan will cause a slight negative pressure in the generator room, it is highly recommended that combustion equipment such as the building heating boilers not be located in the same room as the generator set. If this is unavoidable, it will be necessary to determine whether there will be detrimental effects, such as backdraft, and to provide means (extra large room inlet openings and/or ducts, pressurising fans, etc.) to reduce the negative pressure to acceptable levels.

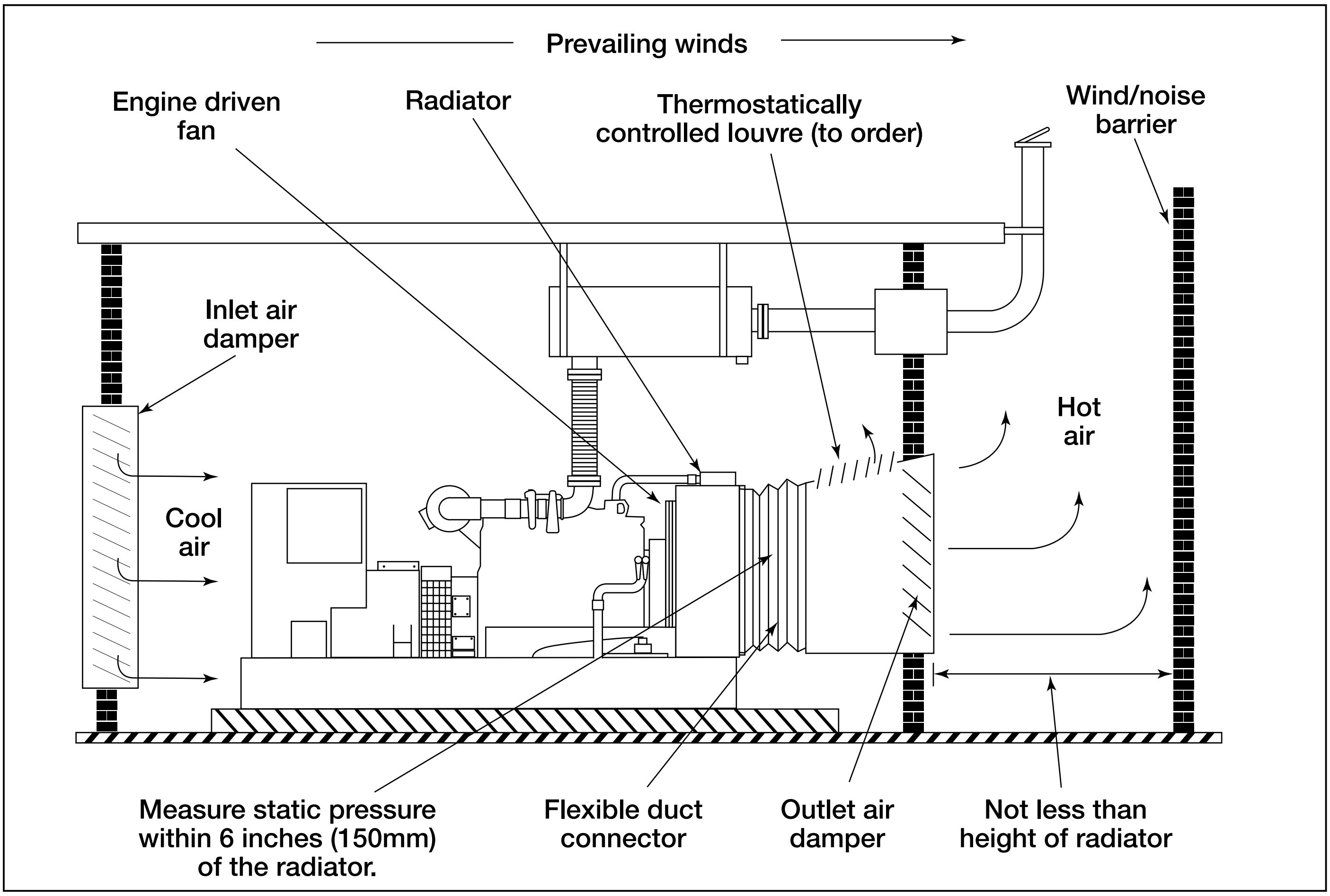



*Fig. C15 Factory-Mounted Radiator Cooling*

- In colder climates, automatic dampers should be used to close off the inlet and outlet air openings to keep the generator room warm when the set is not running. And, a thermostatic damper should be used to recirculate a portion of the radiator discharge air to reduce the volume of cold air that is pulled through the room when the set is running. The inlet and outlet dampers must fully open when the set starts. The recirculating damper should close fully at 16°C (60°F) .
- Other than recirculating radiator discharge air into the generator room in colder climates, all ventilating air must be discharged directly to the out-of-doors. It must not be used to heat any space other than the generator room.
- A flexible duct connector must be provided at the radiator to take up generator set movement and vibration and prevent transmission of noise.
- Ventilating air inlet and discharge openings should be located or shielded to minimize fan noise and the effects of wind on airflow.

Engine room ventilation can be estimated by the following formulas:

$$V\ (\text{cfm}) = \frac{H}{0.070 \times 0.24 \times \Delta T} + \text{Engine Combustion Air}$$

or

$$V\ (\text{m}^3/\text{min}) = \frac{H}{1.099 \times 0.017 \times \Delta T} + \text{Engine Combustion Air}$$

V = Ventilating air (cfm) (m3/min).

H = Heat radiation (Btu/min) (kW).

ΔT = Permissible temperature rise in engine room (°F) (°C).

Density of air at 100°F = 0.070 lb/cu ft (1.099 kg/m3).

Specific heat of air = 0.24 Btu/°F (0.017 kW/°C).

Assuming 38°C (100°F) ambient air temperature.

***Example Ventilating Air Flow Calculation:*** The generator set Specification Sheet indicates that the heat radiated to the room from the generator set (engine and generator) is 4,100 BTU/min (72 kW). The silencer and 10 feet of 5-inch diameter exhaust pipe are also located inside the generator room. Determine the air flow required to limit the air temperature rise to 30°F.

1. Add the heat inputs to the room from all sources. Table 11 indicates that the heat loss from 5-inch exhaust pipe is 132 BTU per min per foot of pipe and 2,500 BTU per min from the silencer. Add the heat inputs to the room as follows:

| | |
|---|---|
| Heat from Generator Set | 4,100 |
| Heat from Exhaust Pipe 10 x 132 | 1,320 |
| Heat from Silencer | 2,500 |
| **TOTAL HEAT TO GENERATOR ROOM (Btu/Min)** | **7,920** |

2. The required air flow is proportional to the total heat input divided by the allowable room air temperature rise:

$$\text{Required Air Flow} = \frac{58 \times \text{Total Heat}\ \left(\frac{\text{Btu}}{\text{Min}}\right)}{\text{Temp Rise}\ (\Delta°\text{F})} = \frac{58 \times 7{,}920}{30} = 15{,}312\ \text{cfm}$$

| PIPE DIAMETER INCHES (mm) | HEAT FROM PIPE BTU/MIN-FOOT (kJ/Min-Metre) | HEAT FROM SILENCERS BTU/MIN (kJ/Min) |
|---|---|---|
| 1.5 (38) | 47 (162) | 297 (313) |
| 2 (51) | 57 (197) | 490 (525) |
| 2.5 (64) | 70 (242) | 785 (828) |
| 3 (76) | 84 (291) | 1,100 (1,160) |
| 3.5 (98) | 96 (332) | 1,408 (1,485) |
| 4 (102) | 108 (374) | 1,767 (1,864) |
| 5 (127) | 132 (457) | 2,500 (2,638) |
| 6 (152) | 156 (540) | 3,550 (3,745) |
| 8 (203) | 200 (692) | 5,467 (5,768) |
| 10 (254) | 249 (862) | 8,500 (8,968) |
| 12 (305) | 293 (1,014) | 10,083 (10,638) |

*Fig. C16 Heat Losses from Uninsulated Exhaust Pipes and Silencers*

**Guide to Heat radiated to room from Engine and Alternator**

| Engine | kW/min @50Hz | kW/min @60Hz |
|---|---|---|
| B3.3G1 | 15.4 | 13.1 |
| B3.3G2 | 15.4 | 21.1 |
| 4B3.9G | 10.8 | 11.4 |
| 4BT3.9G1 | 13.1 | 15 |
| 4BT3.9G2 | 15 | 17 |
| 4BTA3.9G1 | 15.5 | 18 |
| 6BT5.9G2 | 22 | 25 |
| 6CT8.3G2 | 34 | 36 |
| 6CTA8.3G | 35 | 40 |
| 6CTAA8.3G | 36 | N/A |
| LTA10G2 | 41 | 50 |
| LTA10G3/G1 | 46 | 55 |
| NT855G6 | 57 | N/A |
| NTA855G4/G2 | 65 | 72 |
| NTA855G6/G3 | 81 | 76 |
| KTA19G2 | N/A | 85 |
| KTA19G3 | 79 | 95 |
| KTA19G4 | 88 | 99 |
| VTA28G5 | 114 | 133 |
| QST30G1 | 126 | 153 |
| QST30G2 | 137 | 166 |
| QST30G3 | 137 | 152 |
| QST30G4 | 152 | N/A |
| KTA38G4 | N/A | 197 |
| KTA50G3 | 176 | 229 |
| KTA50G8 | 236 | N/A |
| KTA50G9 | N/A | 224 |

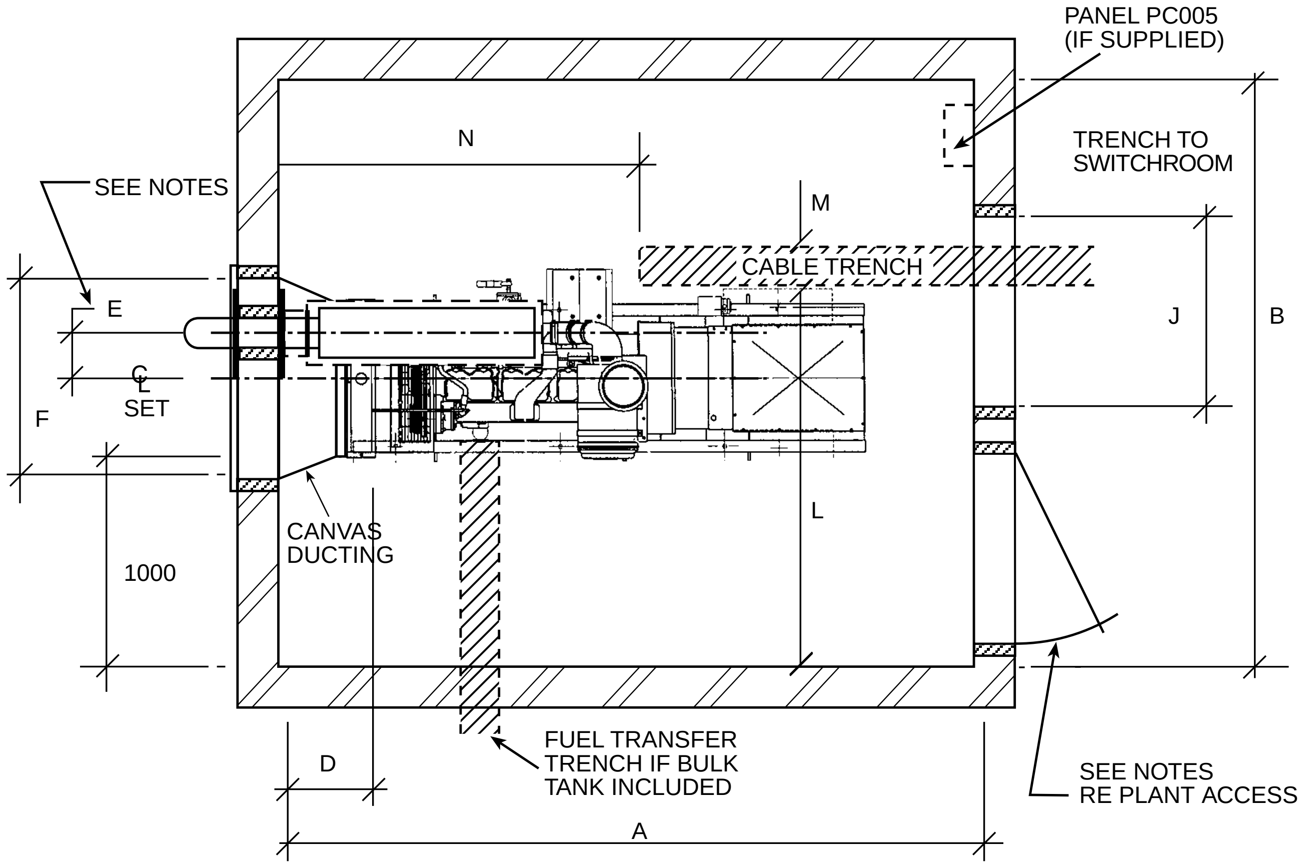
1 kW/min = 56.8 Btu/min

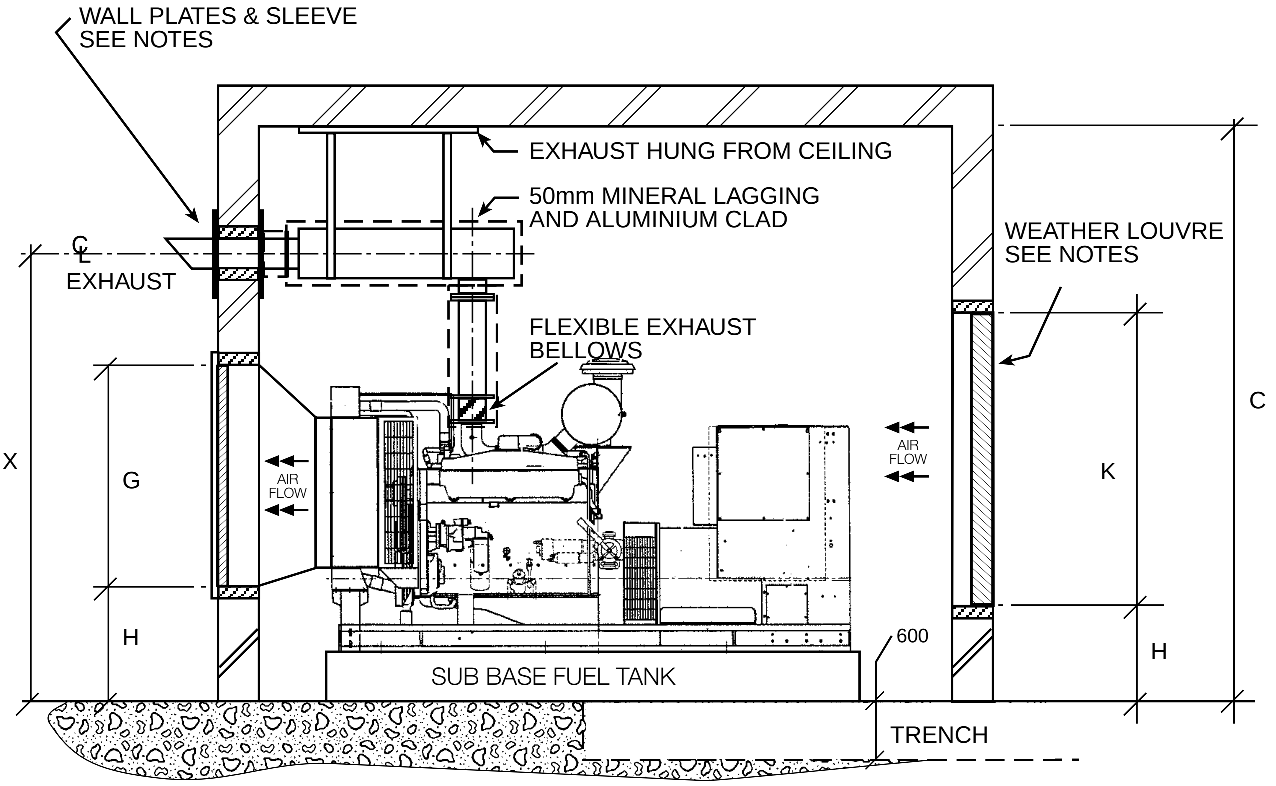
*Fig. C17*

QSK60 – Refer to Tech Data Sheets

## Cummins Generating Sets 37 KVa - 511 KVa – exhaust run and radiator cooling

Generator room layout without Acoustic Treatment (see page B6 for table dimensions)



## Remote Radiator Cooled Systems

Where space in a below ground level installation precludes the use of ducting a number of alternative methods of cooling are available.

Conventional small cooling tower which is reasonably cheap, simple to install and maintain, or a separate radiator system which can be constructed as shown in figure 18. The radiator in this system is separated from the engine and the fan driven by an electric motor.

The radiator with an electric driven fan can be supplied as a totally enclosed unit for outside use, or an open type for installation inside a building

When the radiator is mounted more than 3.0 metres higher than the set, on most engines a break tank and an electric driven water pump is required. The size of the break tank depends on the capacity of the entire cooling system.

Water is circulated from the break tank through the radiator and engine by means of an electrically driven circulating pump.

As the radiator electric fan motor and water circulating pump are powered by the generator, this load requirement must be added to the total set power.

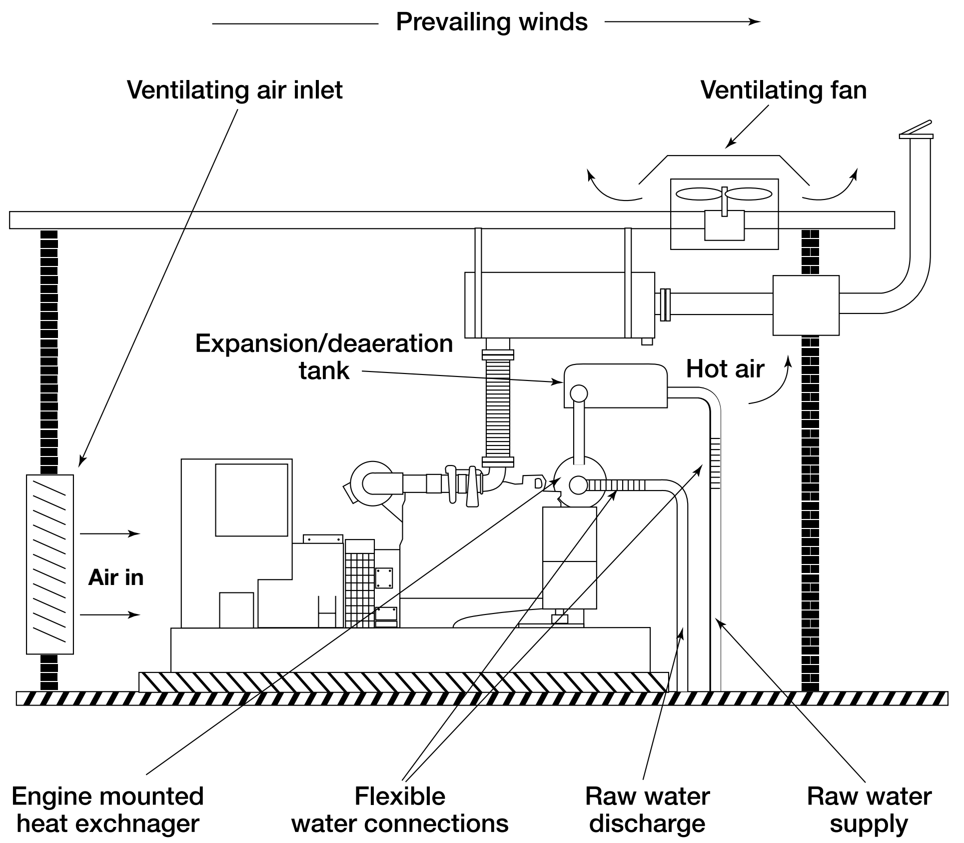
As the water from the radiator will drain into the break tank when the set is at rest, the tank must have sufficient capacity to f ill the entire cooling system when the set is running, and still retain enough coolant for it to circulate efficiently.

**Precautions Required with this System**

The following precautions are required:

1. Against contamination of coolant water by foreign matter.
2. Water becoming oxygenated through turbulence in break tank.
3. Avoidance of air locks in system (pipes should have vent points).
4. Suitable water treatment to engine manufacturers' recommendations.
5. Protect against freezing.
6. Engine runs virtually unpressurised.

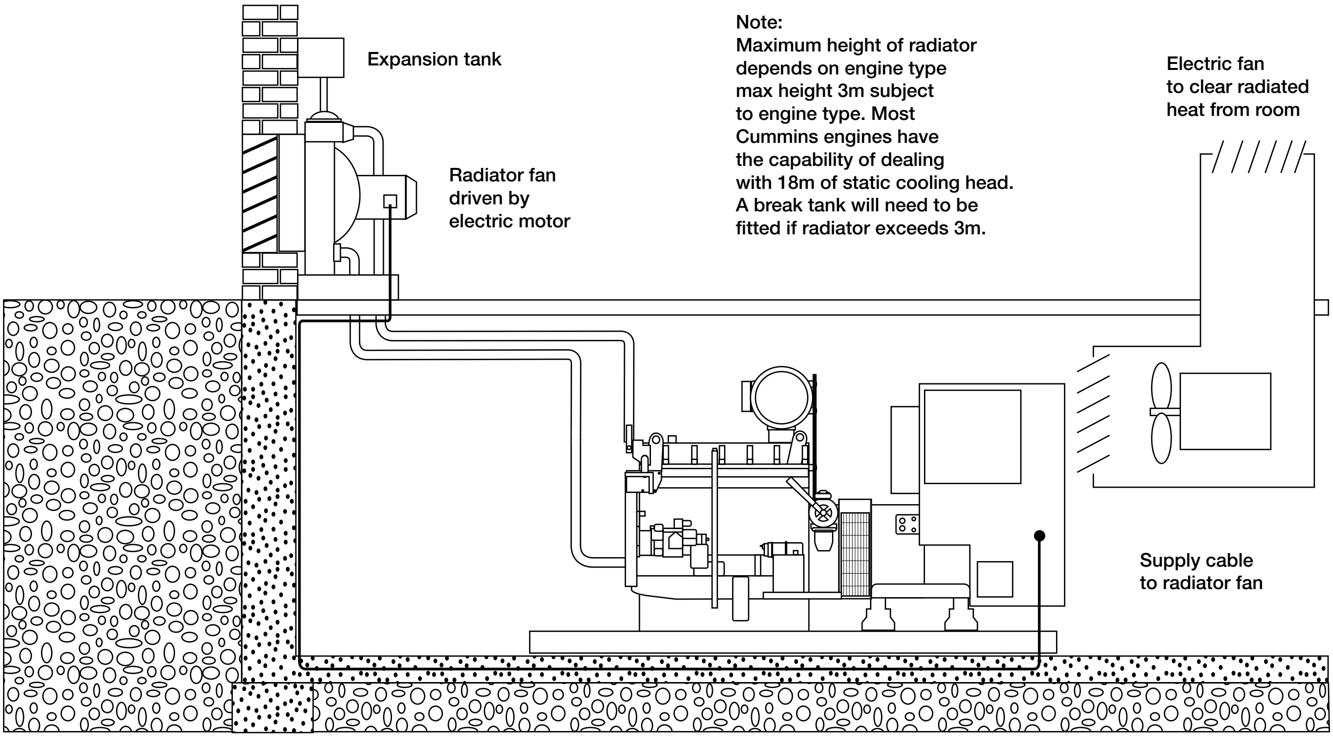
If the radiator is mounted at the same level as the engine and no break tank is required, an expansion tank should be fitted just above the radiator to allow for the expansion of the coolant water.




FACTORY-MOUNTED HEAT EXCHANGER COOLING AND VENTILATION FLOW

*Fig. C17*

REMOTE RADIATOR COOLING




REMOTE RADIATOR COOLING – HIGH LEVEL

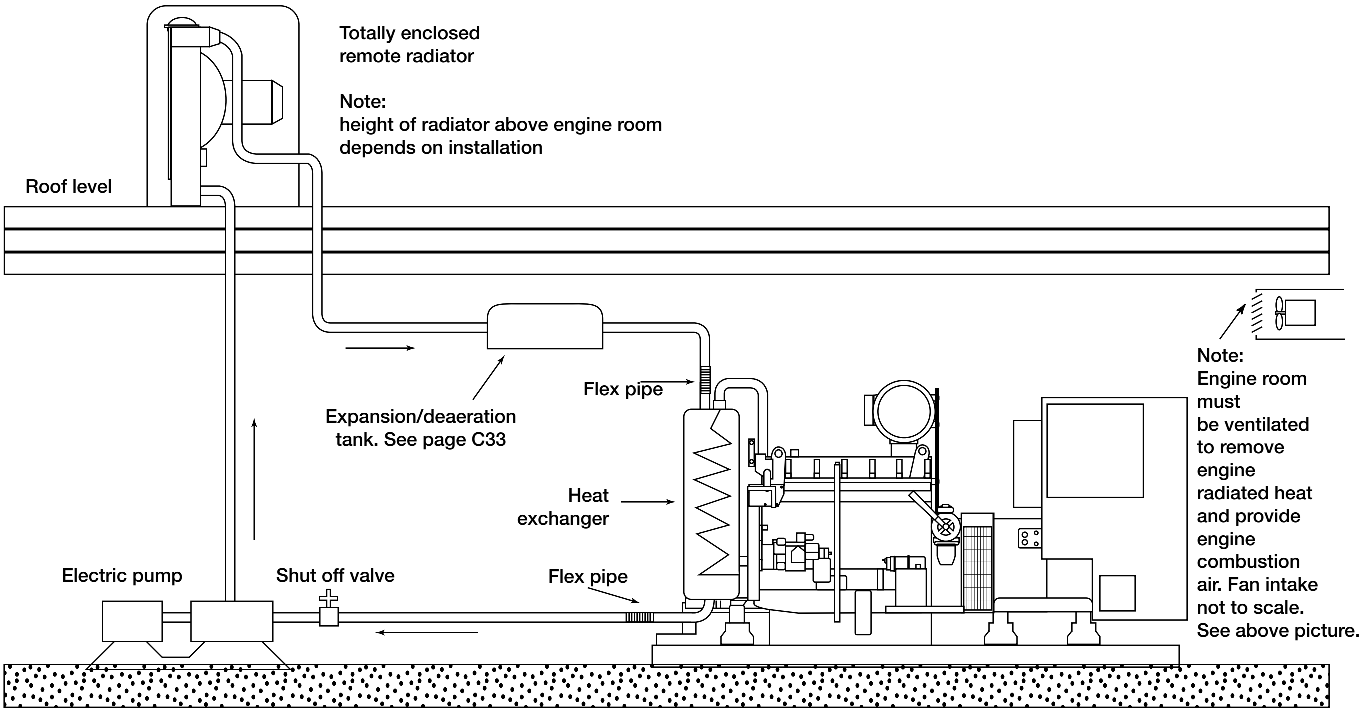
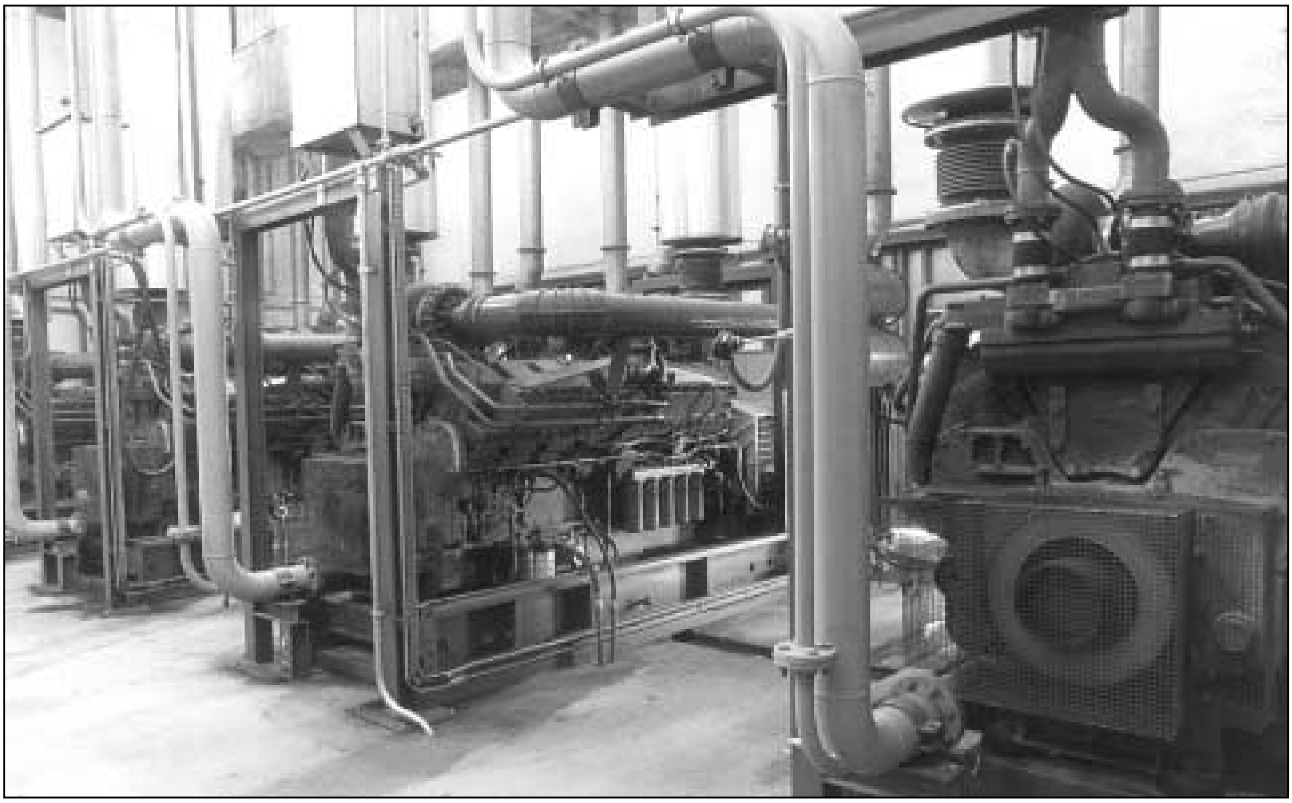



*Fig. C18*



*Four heat exchange cooled KTA50 Powered 1256 kVA sets run continuously for a factory in Spain.*

*Where sets are in basement areas flexible trunking direct to the air intake cleaner ensures a cool supply.*

### Heat Exchanger

In situations where a constant source of cold water is available, such as a reservoir or river, a heat exchanger can be fitted to cool the engine. However, where direct water cooling is used the quality of the water has an important bearing on the life of the engine. Natural water, such as that from rivers, lakes, reservoirs and ponds can carry scale forming impurities so the raw water should be passed through the tubes of the heat exchanger. The raw water is passed through the tubes rather than the engine coolant because the tubes can be cleaned more easily than the outside. It is necessary to establish the composition and quality of the water to ensure correct selection of materials for the tubes.

The heat exchanger should be located within the plant room adjacent to the engine, with a header tank located locally above the height of the engine or heat exchanger. The circulating pump should be located at a low point within the system, as generally the pumps have a greater pushing capacity compared with their lifting ability).

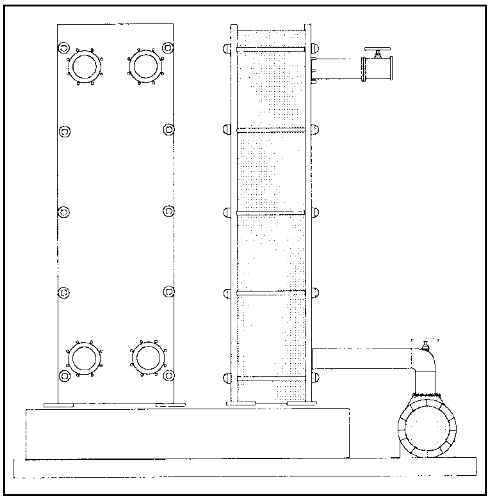


*Fig. C19 Heat Exchanger*

The heat exchanger pipework recommended should be steel, cast iron or neoprene, or in some cases aluminium, copper or galvanised steel. All connections to the engine should be by means of flexible pipes to avoid the transmission of vibration.

When locating the heat exchanger within the plant room area an allowance should be made for the radiated heat from the units when selecting the ventilation fans.

### Cooling Tower

Where, due to site limitations such as high ambient air temperature, it is not practical to cool the engine by means of a standard package, a cooling tower is used in conjunction with a heat exchanger. Under these circumstances the cooling tower, heat exchanger and circulating pump would need to be selected to form a matched system. The pump should provide the required flow rate whilst overcoming the resistance's of the heat exchanger, the cooling tower and interconnecting pipework.

The raw water, after passing through the engine heat exchanger, is pumped to the cooling tower where the heated water is cooled by running over slats into a reservoir. The cooled water is then returned to the engine heat exchanger. To aid the cooling, a motor operated fan, may be required depending on the size of the tower and amount of water to be cooled. For optimum efficiency, the water circulating pump for the cooling tower, should also be mounted within the plant room adjacent to the heat exchanger. The cooling tower should be located in a convenient position outside the plant room.

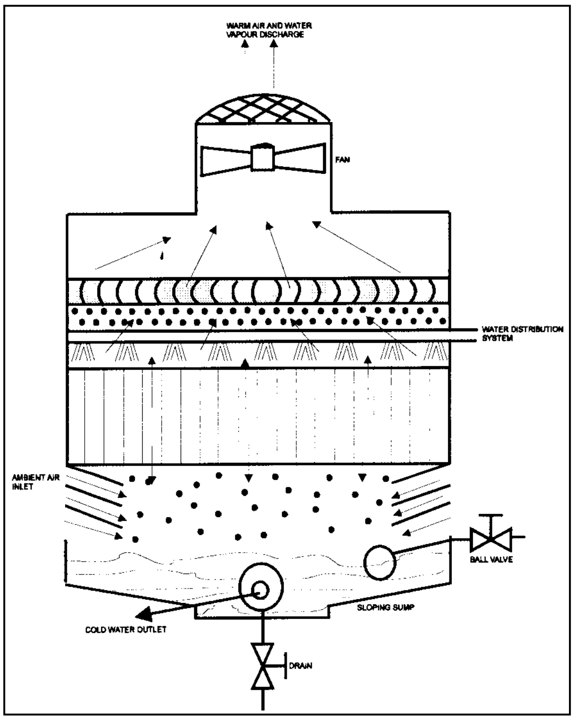
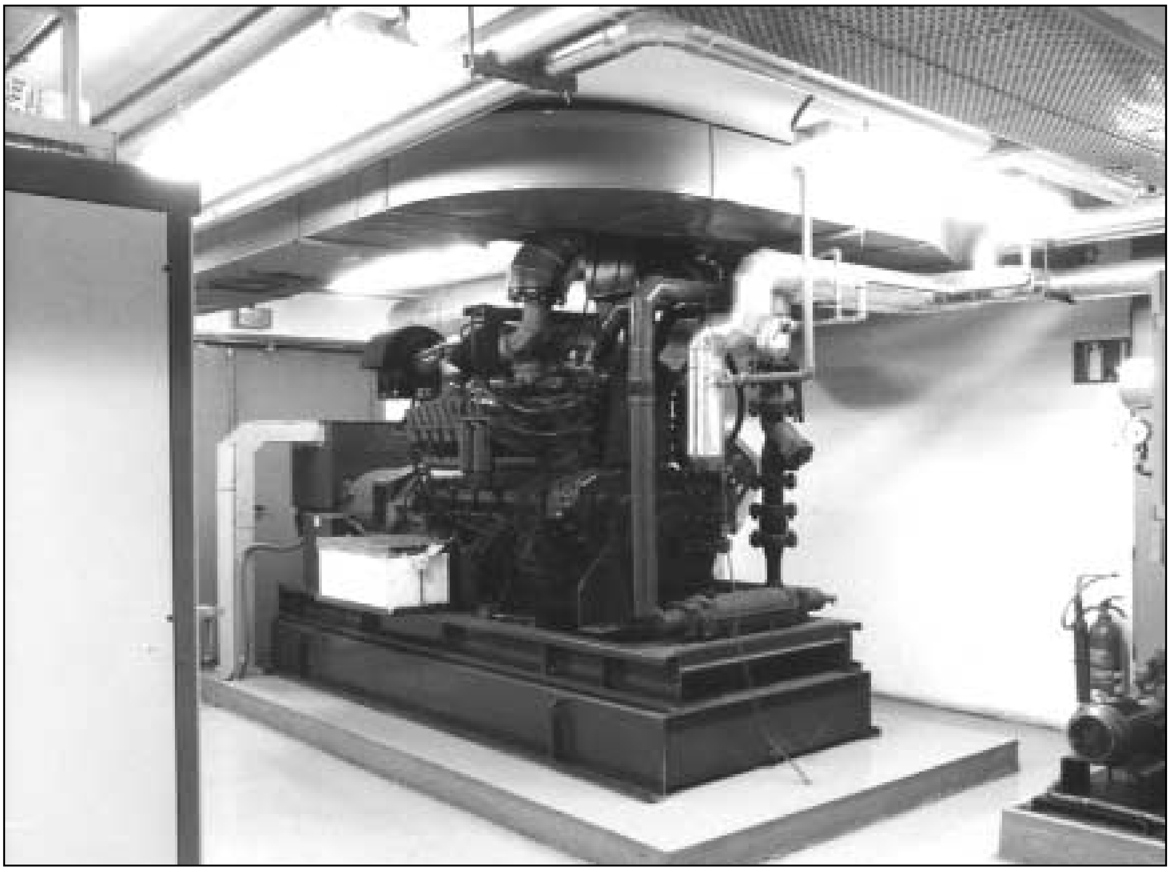
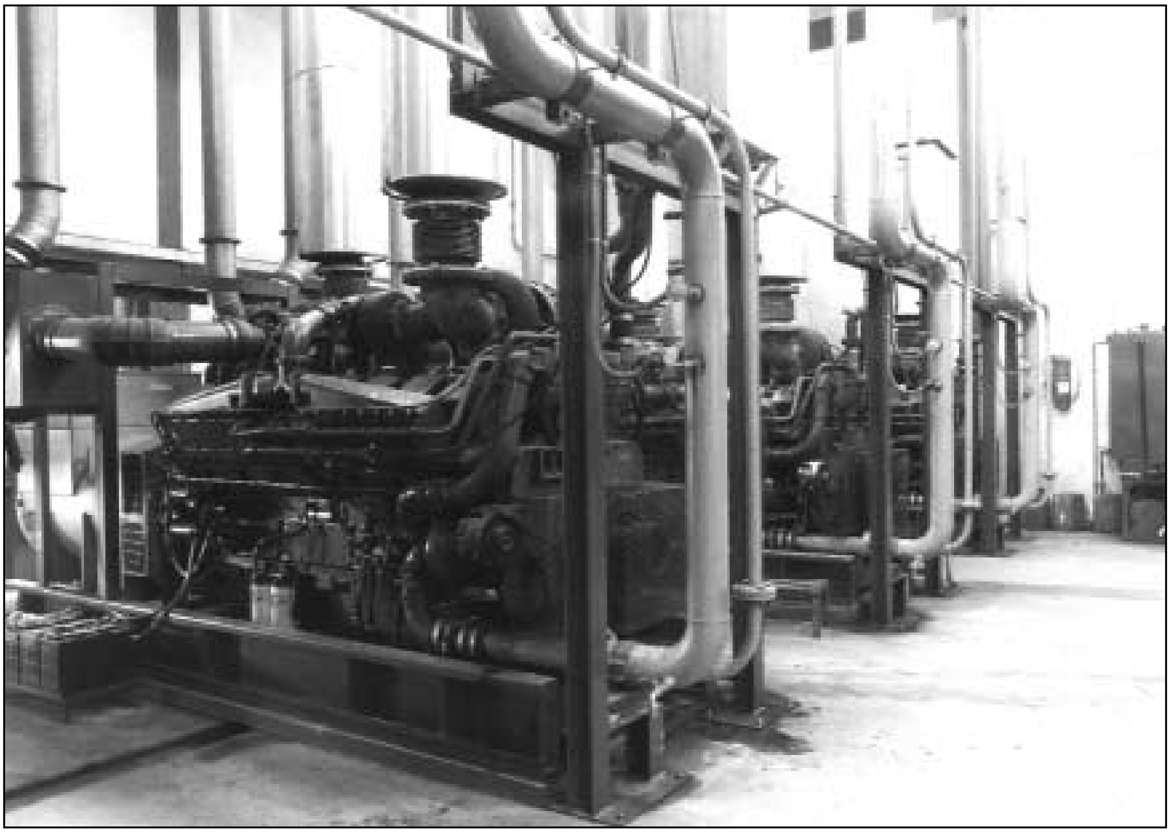



*Fig. C20 Cooling Tower*



*Example of 600 kW Heat Exchanger Cooling Standby Set.*



*Four set (1 MW) Heat Exchange Cooling Installation for Base Load Operation.*

| Typical Friction Losses in Water Pipe (Old pipe) (Flow v Nominal Pipe Diameter) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Flow** | | **Nominal Pipe Diameter** | | | | | | |
| g/min | L/sec | 0.75" (19.05mm) | 1.0" (25.4mm) | 1.25" (31.75mm) | 1.5" (38.1mm) | 2.0" (50.8mm) | 2.5" (63.5mm) | 3.0" (76.2mm) |
| | | **Head Loss in ft/100 ft (m / 100 ft)** | | | | | | |
| 5 | .34 | 10.5 | 3.25 | 0.84 | 0.40 | 0.16 | 0.05 | |
| 10 | .63 | 38.0 | 11.7 | 3.05 | 1.43 | 0.50 | 0.17 | 0.07 |
| 15 | .95 | 80.0 | 25.0 | 6.50 | 3.05 | 1.07 | 0.37 | 0.15 |
| 20 | 1.26 | 136.0 | 42.0 | 11.1 | 5.20 | 1.82 | 0.61 | 0.25 |
| 25 | 1.58 | 4.0" (101.6mm) | 64.0 | 16.6 | 7.85 | 2.73 | 0.92 | 0.38 |
| 30 | 1.9 | 0.13 | 89.0 | 23.0 | 11.0 | 3.84 | 1.29 | 0.54 |
| 35 | 2.21 | 0.17 | 119.0 | 31.2 | 14.7 | 5.10 | 1.72 | 0.71 |
| 40 | 2.52 | 0.22 | 152.0 | 40.0 | 18.8 | 6.60 | 2.20 | 0.91 |
| 45 | 2.84 | 0.28 | 5" (127mm) | 50.0 | 23.2 | 8.20 | 2.76 | 1.16 |
| 50 | 3.15 | 0.34 | 0.11 | 60.0 | 28.4 | 9.90 | 3.32 | 1.38 |
| 60 | 3.79 | 0.47 | 0.16 | 85.0 | 39.6 | 13.9 | 4.65 | 1.92 |
| 70 | 4.42 | 0.63 | 0.21 | 113.0 | 53.0 | 18.4 | 6.20 | 2.57 |
| 75 | 4.73 | 0.72 | 0.24 | 129.0 | 60.0 | 20.9 | 7.05 | 2.93 |
| 80 | 5.05 | 0.81 | 0.27 | 145.0 | 68.0 | 23.7 | 7.90 | 3.28 |
| 90 | 5.68 | 1.00 | 0.34 | 6.0" (152.4mm) | 84.0 | 29.4 | 9.80 | 4.08 |
| 100 | 6.31 | 1.22 | 0.41 | 0.17 | 102.0 | 35.8 | 12.0 | 4.96 |
| 125 | 7.89 | 1.85 | 0.63 | 0.26 | 7.0" (177.8mm) | 54.0 | 17.6 | 7.55 |
| 150 | 9.46 | 2.60 | 0.87 | 0.36 | 0.17 | 76.0 | 25.7 | 10.5 |
| 175 | 11.05 | 3.44 | 1.16 | 0.48 | 0.22 | 8.0" (203.2mm) | 34.0 | 14.1 |
| 200 | 12.62 | 4.40 | 1.48 | 0.61 | 0.28 | 0.15 | 43.1 | 17.8 |
| 225 | 14.20 | 5.45 | 1.85 | 0.77 | 0.35 | 0.19 | 54.3 | 22.3 |
| 250 | 15.77 | 6.70 | 2.25 | 0.94 | 0.43 | 0.24 | 65.5 | 27.1 |
| 275 | 17.35 | 7.95 | 2.70 | 1.10 | 0.51 | 0.27 | 9.0" (228.6mm) | 32.3 |
| 300 | 18.93 | 9.30 | 3.14 | 1.30 | 0.60 | 0.32 | 0.18 | 38.0 |
| 325 | 20.5 | 10.8 | 3.65 | 1.51 | 0.68 | 0.37 | 0.21 | 44.1 |
| 350 | 22.08 | 12.4 | 4.19 | 1.70 | 0.77 | 0.43 | 0.24 | 50.5 |
| 375 | 23.66 | 14.2 | 4.80 | 1.95 | 0.89 | 0.48 | 0.28 | 10.0" (254.0mm) |
| 400 | 25.24 | 16.0 | 5.40 | 2.20 | 1.01 | 0.55 | 0.31 | 0.19 |
| 425 | 26.81 | 17.9 | 6.10 | 2.47 | 1.14 | 0.61 | 0.35 | 0.21 |
| 450 | 28.39 | 19.8 | 6.70 | 2.74 | 1.26 | 0.68 | 0.38 | 0.23 |
| 475 | 29.97 | - | 7.40 | 2.82 | 1.46 | 0.75 | 0.42 | 0.26 |
| 500 | 31.55 | - | 8.10 | 2.90 | 1.54 | 0.82 | 0.46 | 0.28 |
| 750 | 47.32 | - | - | 7.09 | 3.23 | 1.76 | 0.98 | 0.59 |
| 1000 | 63.09 | - | - | 12.0 | 5.59 | 2.97 | 1.67 | 1.23 |
| 1250 | 78.86 | - | - | - | 8.39 | 4.48 | 2.55 | 1.51 |
| 1500 | 94.64 | - | - | - | 11.7 | 6.24 | 3.52 | 2.13 |
| 1750 | 110.41 | - | - | - | - | 7.45 | 4.70 | 2.80 |
| 2000 | 126.18 | - | - | - | - | 10.71 | 6.02 | 3.59 |

*Fig. C21 Typical Friction Losses in Water Pipe*

## Line Velocities

Water velocity guidelines are as follows:

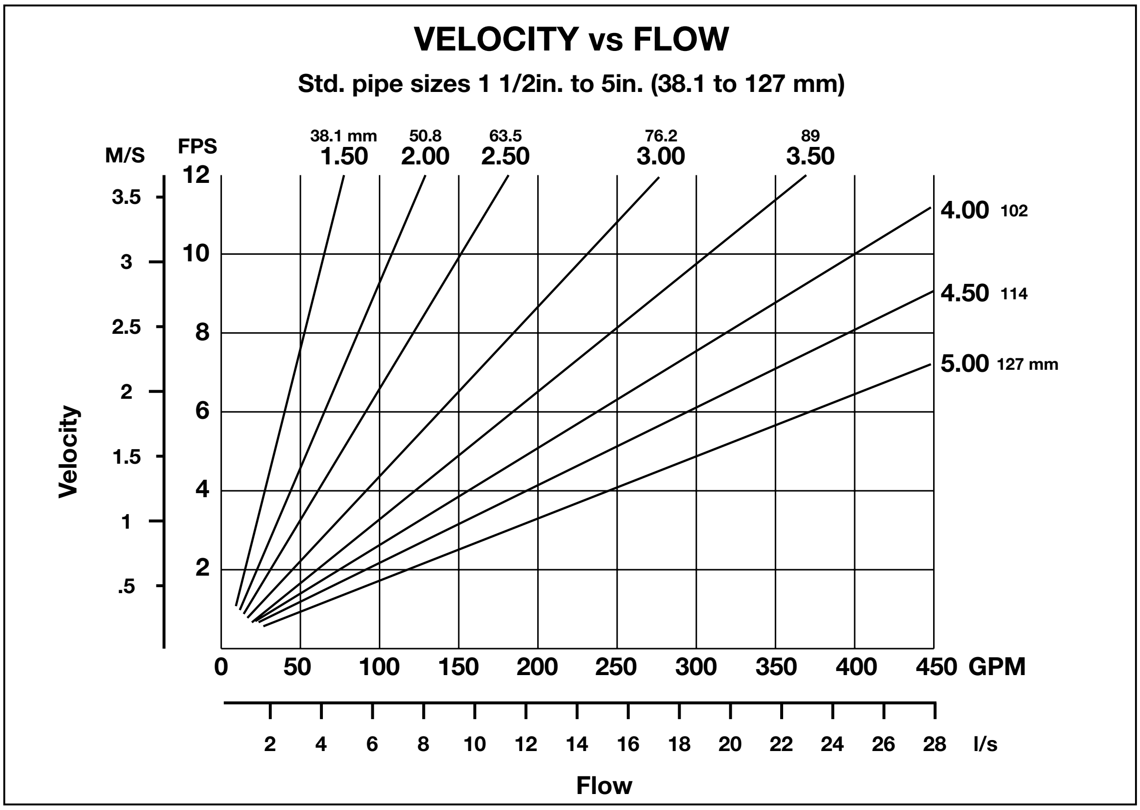
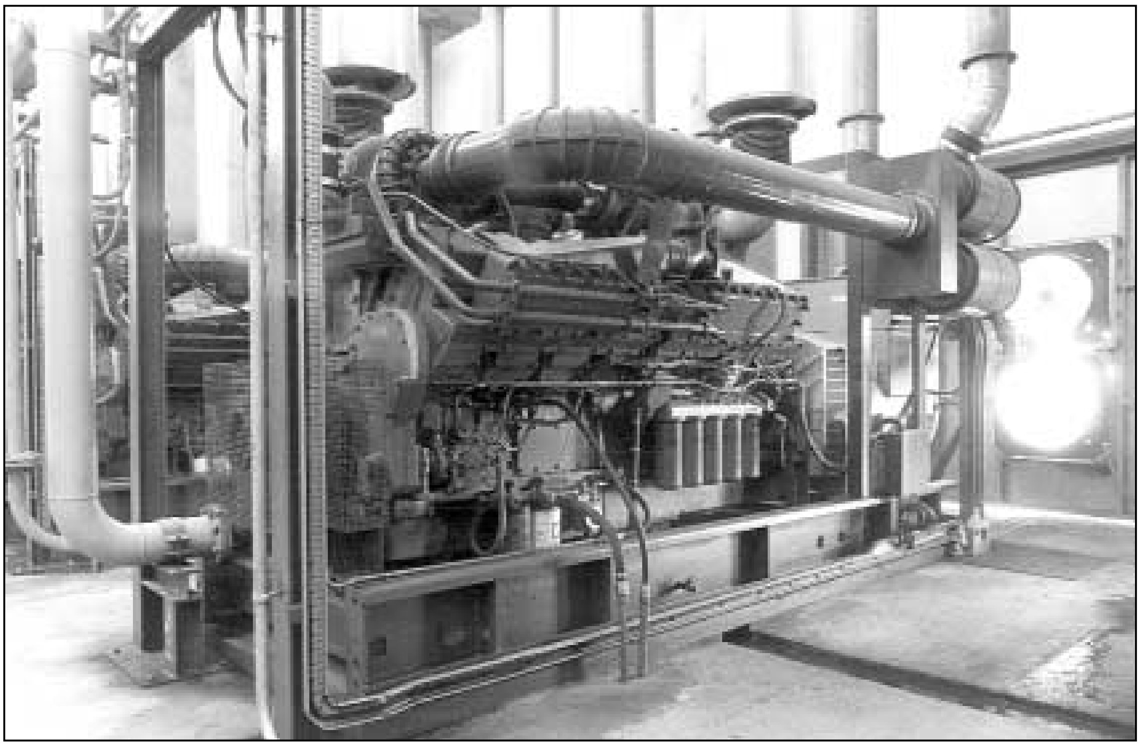



*Fig. C23*



*1250 kVA base power generators with heat transfer system.*

## General

The engine cooling system is subject to rust and cavitation attacks. To minimise the severity of this condition an anti-corrosive agent can be added to totally clean and limpid coolant water.

An antifreeze solution is also required to prevent freezing of the coolant in the cold weather.

## Engine Coolant

Water for coolant should be clean and free from any corrosive chemicals such as chlorides, sulphates and acids. It should be kept slightly alkaline with a pH value in the range 8.5 to 10.5.

Generally, any water which is suitable for drinking can be used, with treatment as described below.

### Protection against corrosion

Supplemental Coolant Additive (Cummins DCA4 or equivalent) is required to protect the cooling system from fouling, solder blooming and general corrosion.

The use of antifreeze is also recommended as DCA4 concentrations are dependent upon the presence of antifreeze. Antifreeze also interacts with DCA4 to provide greater corrosion and cavitation protection.

### Procedure for Treating Coolant

1. Add the required amount of water to a mixing container and dissolve in the required quantity of DCA.

> Caution: Allow the cooling system to cool down before removing the radiator cap. Observe the manufacturer's instructions regarding pressurised cooling systems and take great care when removing the pressure cap.

2. Add the required amount of antifreeze, if used, to the water solution and mix thoroughly.
3. Add the coolant to the cooling system and replace the radiator cap securely.

### Cold Weather Protection

Antifreeze must be added to the coolant where there is any possibility of freezing to protect the engine from damage due to coolant freezing I unfreezing.

A 50% antifreeze / 50% water mixture is recommended because DCA4 concentrations are dependent upon the presence of antifreeze. The dosage of DCA4 must be increased to higher concentration if antifreeze is not added to the coolant. A low-silicate antifreeze is recommended.

## Engine Warming

Where thermostatically controlled immersion heaters operating from the mains supply are fitted in the cooling system these maintain the temperature of the coolant in cold weather.

A heater alone, fitted in the radiator will not be adequate for starting or preventing freezing, so an antifreeze mixture should be used.

The engine charge combustion and aspirated air system components are as follows:

Air Intake filter (all engines)

Turbocharger (most engines)

Exhaust Gas Bellows (all engines)

Exhaust Gas Silencer(s) (all engines)

The main function of the charge air / exhaust gas system is to provide the engine with fresh combustion air of sufficient quality and quantity, and to provide the means of silencing and venting the combustion gases. (See this Section for the Exhaust System). To prevent re-circulation, hot air must be ducted out of the plant room or enclosure directly through a flexible duct and an air outlet louvre. An insufficient air supply will cause carbon deposits on the engine components.

## Air Intake Filter

### Dry Type Air Intake Filter

A dry type air intake filter unit is normally fitted to the engine to prevent the ingress of dirt or dust into the combustion systems.

The intake filter can be supplied loose for mounting on an outside wall of the enclosure or plant room, piped and vented to the air intake system on the engine.

### Air Combustion Flows

Refer to Section G Technical Data for engine air combustion flow figures.

### Heavy Duty Air Intake Filters

In severe locations such as the desert, heavy duty air intake cleaners are required. They consist of one or more pleated paper elements, which are fire resistant and waterproof. The dust and dirt particles in the air are deposited on the paper fibres, gradually building up to a restrictive limit in which the element must be cleaned or replaced.

In other installations with extreme conditions (cement factories, etc.) the highest allowed particle concentrations at turbocharger inlets are as follows:

| | |
|---|---|
| Cement dust | 10mg/$m^3$ |
| Calcium hydroxide | 5mg/$m^3$ |
| Chlorine | 1.5mg/$m^3$ |
| Oxides of sulphur | 20mg/$m^3$ |

## Heat Rejection (Radiated Heat)

Whilst the cooling water system detailed in Section 7 serves to remove a substantial amount of the heat produced by the engine, an additional amount is rejected into the room from the following sources:-

The alternator, in terms of direct radiation from the machine body and from its integral fan cooling system

Radiated heat from the engine assembly.

The sections of the exhaust system within the room, especially unlagged sections of pipework or the silencer.

Details of the level of heat rejected to the ambient by the engine and alternator are given on the specification data sheets or in the project technical specification. Heat rejected from the exhaust pipework and manifolds is taken into consideration for the assessment of the total amount of heat that will be dissipated into the plant room. Typically, 10% of the value given in the engine data sheets as **"heat rejected to exhaust"** will cover the exhaust system provided it is lagged.

The ventilation system should be designed to limit the temperature rise within the plant room between 10 to15°C (18 to 27°F) above the ambient when operating at full load. If the resultant temperature within the plant room exceeds 40°C the aspiration air should be ducted direct from the atmosphere to the engine.

## Cooling Air Flow Calculation

Utilising the total heat rejection value, the cooling air flow required through the plant room can be calculated using the following formula:-

$$\textbf{Air Flow (cfm)} = \frac{\text{Rejected Heat (KW) X 58}}{\text{Air Density (0.07) x Specific heat of air (0.238) x Temp Rise (F°)}}$$

Where:

The total kW of heat rejected is sourced from all equipment within the plant room: the engine; the alternator; the exhaust pipework and silencers etc.

The temperature rise is the maximum rise above ambient permissible within the plant room (can vary between 10 to 15°C (18 to 27°F).

## Ventilation Fans and Louvres

Where cooling radiators are mounted externally ventilation fans are used to remove this volume of air from the plant room. The air inlet and discharge louvres must be sized for this amount plus the aspiration air requirement (if this is being drawn from within the plant room).

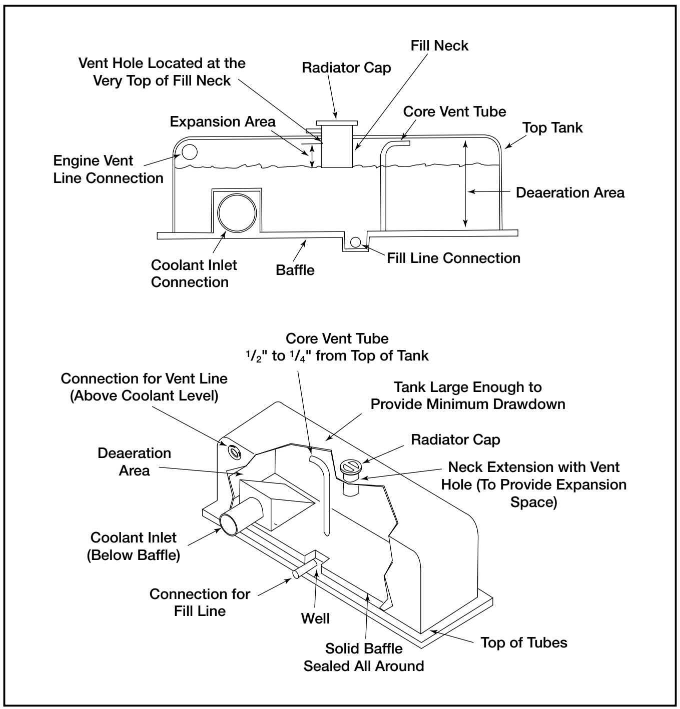
Where the cooling radiator is mounted within the plant room, an aperture should be positioned in an external wall directly in line with the air flow through the radiator. The radiator has a discharge duct adapter in which a canvas flexible duct may be attached, this directs unwanted hot air out of the plant room and prevents re-circulation of the hot air. Re-circulation can also be possible if the inlet and discharge air apertures are too close together.

In some applications it is required to remove the heat losses from the plant room while the generator is at standstill. Inlet and outlet louvres may be motorised to automatically move into the open position when the generator is started, or where the air blast radiator is of the pressure type, the outlet louvres may be gravity operated.

## Expansion/Deaeration Tanks

Figs 17 and 18 illustrate provision for an expansion/ deaeration tank above the heat exchanger. In general there are included with the heat exchanger, alternatively you may need to arrange the fabrication of this tank.

**Components of Expansion/Deaeration Top Tanks**




Cooling system must be designed so that when a cold system is completely filled there is at least a 6% (max 8%) additional capacity to allow for coolant expansion when it is at operating temperature with the correct coolant concentration. This extra volume is obtained by proper location of the FILL NECK. The distance between the underside of the roof of the tank and the bottom of the fill neck is the area in the tank used for expansion of the fluid when it is heated, i.e. at least 6% of the total system volume.

## Electric Starting Systems

Electric starting systems are generally used on all gensets.

Electric starting systems employ a starter motor, flange mounted on the flywheel housing and driving the flywheel through a pinion and "Bendix" type gear arrangement. For larger engines, a twin starter arrangement may be used.

The power source for electric starting systems is a 12 or 24VDC battery system. The starting voltage is determined by engine size, 24VDC being used for larger engines to reduce starting current and hence cable size. Control of starting is via a start solenoid which is controlled by the genset control system.

**Starter Arrangement**

On start up, the "Bendix" gear maintains engagement of the starter motor pinion with the flywheel until the engine reaches self sustaining speed. At that stage a speed sensing device automatically de-energises the start solenoid which removes the supply to the electric starter and starter motor pinion disengages from the flywheel.

**Battery Systems**

**Types of Batteries Used**

Batteries are of two types - lead acid and NiCad. Lead acid batteries are generally used, being the least expensive. NiCad batteries are used where longer life, etc., is required.

**Installing a Battery System**

Batteries are an essential part of any standby generator system and some 90% of all generator failures are due to batteries. It is therefore vital that batteries are stored, commissioned and maintained to the required standards.

On most Cummins Power Generation sets provisions made for lead acid batteries to be fitted on the generator chassis. A battery rack is provided for this purpose. If NiCad batteries are provided the following advice should be followed.

When installing a battery system for an electric starter system consideration should be given to the following:

- Space requirement - for larger gensets the battery system may require a considerable floor area.
- Install the battery system in a clean, well lit, and well ventilated area. If installed in a cubicle, adequate ventilation must be provided. Easy access should be provided for maintenance - for checking electrolyte level, topping up cells, etc.
- If the battery must be placed on the floor it is necessary to use battens, preferably on insulators. This will raise crates or cell bottoms clear of any damp or dust which may accumulate.
- Avoid installing batteries in a hot area. For optimum efficiency it is preferable to operate NiCad batteries within the range 15°C to 25°C. It is essential that filler openings of all cells are readily accessible.
- Place crates or tapered blocks of cells in the correct position for connecting-up as a battery. Fit inter-crate, or inter-block connectors and then the main battery leads. Tighten all nuts firmly with a box spanner. Smear the battery terminals with petroleum jelly to prevent corrosion.
- Battery charging system -
  - This may be a charge alternator which charges the batteries only when the set is running, and / or
  - Mains powered battery charger which will maintain the battery system in a charged condition when the set is not running and is powered from a mains supply.

    Note: a mains powered battery charger must be fed with power from a "maintained supply", not from the set output.
- During the charging of a battery, explosive gases are given off.

| |
|---|
| Caution: Ensure that batteries are charged in a well ventilated area, away from naked flames and sparks. |

| |
|---|
| Caution: When putting a battery into service on a genset, connect the earth lead **LAST;** when removing the battery, disconnect the earth lead **FIRST.** |

| |
|---|
| Caution: Ensure correct polarity when connecting the battery to the genset. Even momentary incorrect connection may cause damage to the electrical system. Connect the positive generator cable FIRST, followed by the negative ground. |

**Starting Aids**

It is customary to maintain coolant temperatures above 40°C min. to promote quick starting on an emergency generating plant. Thermostatically controlled immersion heaters, deriving their supply from the primary source of power, are fitted in the engine cooling system to provide this heating. For severe circumstances it is advisable to include a similar heater for lubricating oil temperatures.

Avoid installing lead acid batteries in the same room as NiCad batteries as these will deteriorate due to gaseous fumes from the lead acid batteries.

Verify all electrical connections are secure and all wiring is complete and inspected. Replace and secure any access panels that may have been removed during installation.

## Battery Connections

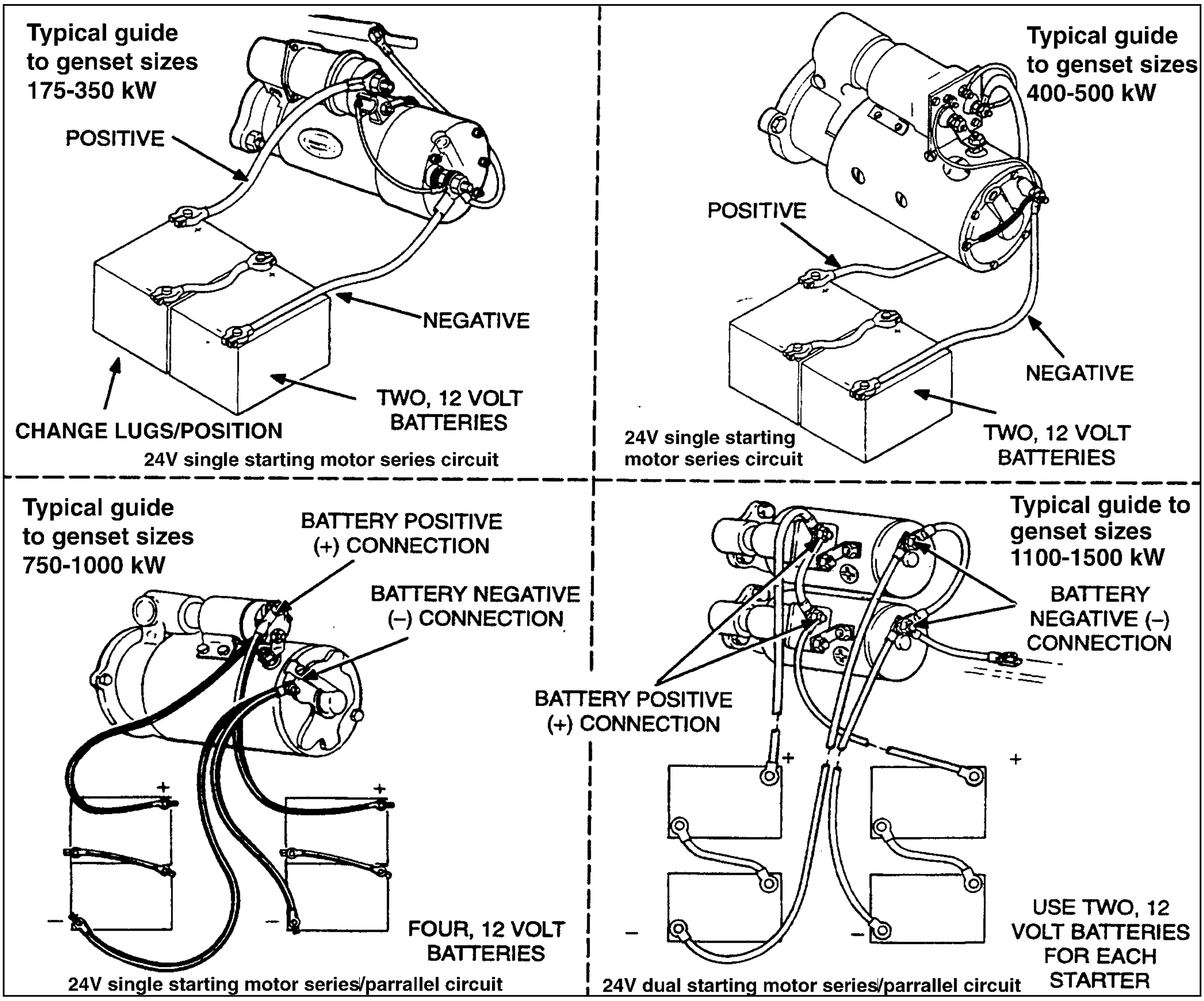
WARNING ***Accidental starting of the generator set can cause severe personal injury or death. Make sure that the Run/Off/Auto switch on the control panel is set to the Off position before connecting the battery cables.***

Sets with LTA10 engines and above require 24 volt battery current, using two or four, 12 volt batteries (see Specification section). Connect the batteries in series (negative post of first battery to the positive post of the second battery) as shown below.

Necessary battery cables and rack are on the unit. Service batteries as necessary. Infrequent use (as in emergency standby service), may allow battery to self-discharge to the point where it cannot start the unit. If installing an automatic transfer switch that has no built-in charge circuit, connect a separate trickle charger. Cummins automatic transfer switches include such a battery charging circuit.

WARNING ***Ignition of explosive battery gases can cause severe personal injury. Always connect battery negative last to prevent arcing.***

WARNING ***Be sure battery area has been well ventilated prior to servicing near it. Lead-acid batteries emit a highly explosive hydrogen gas that can be ignited by arcing, sparking, smoking, etc. Ignition of these gases can cause severe personal injury.***




*175 Through 1500 kW Genset Battery Connections*

Legislation to control environmental noise pollution in sensitive areas exists and must be complied with, but generally it will be the local authority who will determine the requirements. Planning must be sought with the local authority to determine the noise level of the equipment. The requirements for noise control will depend on the environmental conditions and operating time at the proposed location of the generating set and associated equipment.

There are two types of noise to be considered:-

Structure borne noise - emanates from the vibrations created by the generating set and associated connected equipment. Minimise this type of noise by use of anti vibration mounts and flexible connections.

Airborne Noise - emanated from the generating set in particular at the high end of the frequency range.

## Noise Reduction Methods

Reduction of structure borne noise can be achieved by use of anti vibration mountings and flexible hangers and connections. Reductions of airborne noise can be achieved by the use of splitter attenuators, exhaust gas mufflers, acoustic wall and ceiling linings, acoustic inlet and outlet louvres, enclosures and drop over canopies.

In addition the use of slow speed fans within a plant room or an internally mounted heat exchanger with an externally mounted, low noise cooling tower would be advantageous whilst locating them outside the plant room in acoustic housings.

Enclosures can be supplied for installing over a generating set within a plant room to isolate the rest of the building from noise.

The noise level at a given location is a resultant from all sources, once the level is known and the site restrictions are known, the sound attenuation louvre sizes and equipment can be considered and selected as required.

Each engine has a noise spectrum for both mechanical noise coming off the block and for the exhaust noise emitting from the end of the pipe. This information, together with the combustion and cooling air flow requirements and maximum pressure restrictions allowable should be provided to the noise attenuation equipment suppliers to size the splitter attenuators required for the inlet and discharge air apertures and silencers for the exhaust gas.

See Section F Silenced Generators.

## Noise Legislation

Noise Legislation relating to generators working on construction and building sites exists throughout all countries in the EEC or are directives of the EEC.

**Noise Legislation in other Countries**

- France — 85dB(A) at 1m for a generating set on any construction site within 50 metres of a residential area.
- W. Germany — 80dB(A) at 1m for a generating set on any construction site within 50 metres of a residential area.
- Sweden — Swedish standard SEN590111 sets a limit of 85dB(A). This is applied for the purpose of reducing the exposure of employed persons where the level of sound is continuous for eight hours in any one day. Hearing protection must be used when the level exceeds 85dB(A). The equivalent is 90dB(A) in the UK at present.
- U.S.A — The OSHA Safety and Health standard sets the limit of 90dBA for an eight hour exposure, 95dB(A) for four hours and 100dB(A) for two hours.

## Auxiliary AC Supplies

Auxiliary AC supplies must be provided for all auxiliary equipment (e.g., ventilation fans, heaters, pumps, etc.), together with the associated AC distribution panel. A motor control unit (MCC) may be provided where applicable.

## Fire Protection

Diesel fuel can be stored safely above ground in suitable containers. Whilst the flash point is high, it is inflammable and suitable fire fighting equipment should be provided.

Provision for fire fighting equipment should be made in the initial design of the plant room. The storage area should be adjacent to an access door, if possible.

Foam or $CO^2$ should be used for oil fires, i.e. fuel oil, gas, lubricating oils etc.

$CO^2$ or CTC should be used for electrical fires or near bare conductors.

Sand can be used for minor and isolated fires.

Under **NO** circumstances should water be used to control a fire in the plant room.

## Tools

A standard kit of engine tools are supplied with the plant. They should be protected from corrosion and stored in a safe dry place.

## Spares

If spares are supplied with the plant they should be protected against corrosion and stored in a safe dry place.

## Plant Room Lighting & Staging

The plant room should be well illuminated to assist manual operations and maintenance. Natural lighting from windows should give good illumination to critical areas. Double glazing on windows will reduce heat loss and emitted noise.

To provide access to elevated items on larger plants it may be necessary to erect suitable staging which must provide safe access.

## Maintenance Space

All component parts of the installation should have ample space and access around them to assist maintenance.

The control cubicle should have sufficient free space to enable all access doors and panels to be opened and removed.

Space should be left around the plant to give safe and easy access for personnel.

There should be a minimum distance of 1 metre from any wall, tank or panel within the room.

## Generator Control Panel

The generator set is controlled locally by a dedicated Generator Control Panel. This incorporates the control systems, metering and alarm indications and customer connections.

Two forms of control system are currently available; PCL and PowerCommand™ control, described below.

## PCL (Power Control)

PCL is a low cost generator set monitoring, metering and control system which provides local control of the generator set and forms part of the main control panel. This control system provides high reliability and optimum generator set performance.

Two versions of PCL are available:

PCL 001 which provides generator set control with manual start.

PCL 002 which provides generator set control with remote start.

Both units provide generator start / stop and indicate operational status. In the event of a fault, the units will indicate the fault condition(s) and in the case of shutdown faults, e.g., low oil pressure, automatically shut down the engine. Faults are indicated by means of LED's.

PCL 002 may be used with an Automatic Transfer Switch (ATS) Control Unit which senses mains failure, supplies a remote start signal to the generator set control unit and provides breaker control.

An alarm annunciator module, with 6 input channels and 6 corresponding LED's configurable to customer requirements, may be used as a protection expansion unit, an annunciator or a combination of both. Each unit provides two relay outputs. A maximum of two alarm annunciator units modules can be fitted to the generator control panel.

## PowerCommand™ Control (PCC)

PowerCommand™ Control (PCC) is a microprocessor-based generator set monitoring, metering and control system which provides local control of the generator set. This system provides high reliability and optimum generator set performance.

PCC provides an extensive array of integrated standard control and display features, eliminating the need for discrete component devices such as voltage regulator, governor and protective relays. It offers a wide range of standard control and digital features so that custom control configurations are not needed to meet application specifications. Refer to the Cummins Technical Manual.

Two versions of PowerCommand™ are available:

PowerCommand™ Generator Set Control which provides generator set control for single sets.

PowerCommand™ Generator Set Control Paralleling Version which provides generator set control with paralleling for multi set applications.

Major Control features include:

- Digital governing, voltage regulation, synchronising and load sharing control.
- Electronic overcurrent alternator protection.
- Analogue and digital AC output metering.
- Digital alarm and status message display.
- Generator set monitoring status display of all critical engine and alternator functions.
- Starting control including integrated fuel ramping to limit black smoke and frequency overshoot with optimised cold weather starting.
- Easy servicing.
- Communications network capability.

The Power Command Control meets or exceeds the requirements of the following codes and standards:

UL508 - Category NIWT7 for US an Canadian Usage.

ISO 8528-4 - Control Systems for reciprocating engine - driven generator sets. Canadian Standards - 282-M1

14 CSAC22.2, No - M91 for industrial Control Equipment.

NFPA 70 - US National Electrical Code

NFPA 110 - Emergency Power Systems. Meets all requirements for Level 1 systems.

AS3000 SAA Wiring Rules

AS3009 Emergency Power Supplies

AS3010.1 Electrical Supply by Generator Sets.

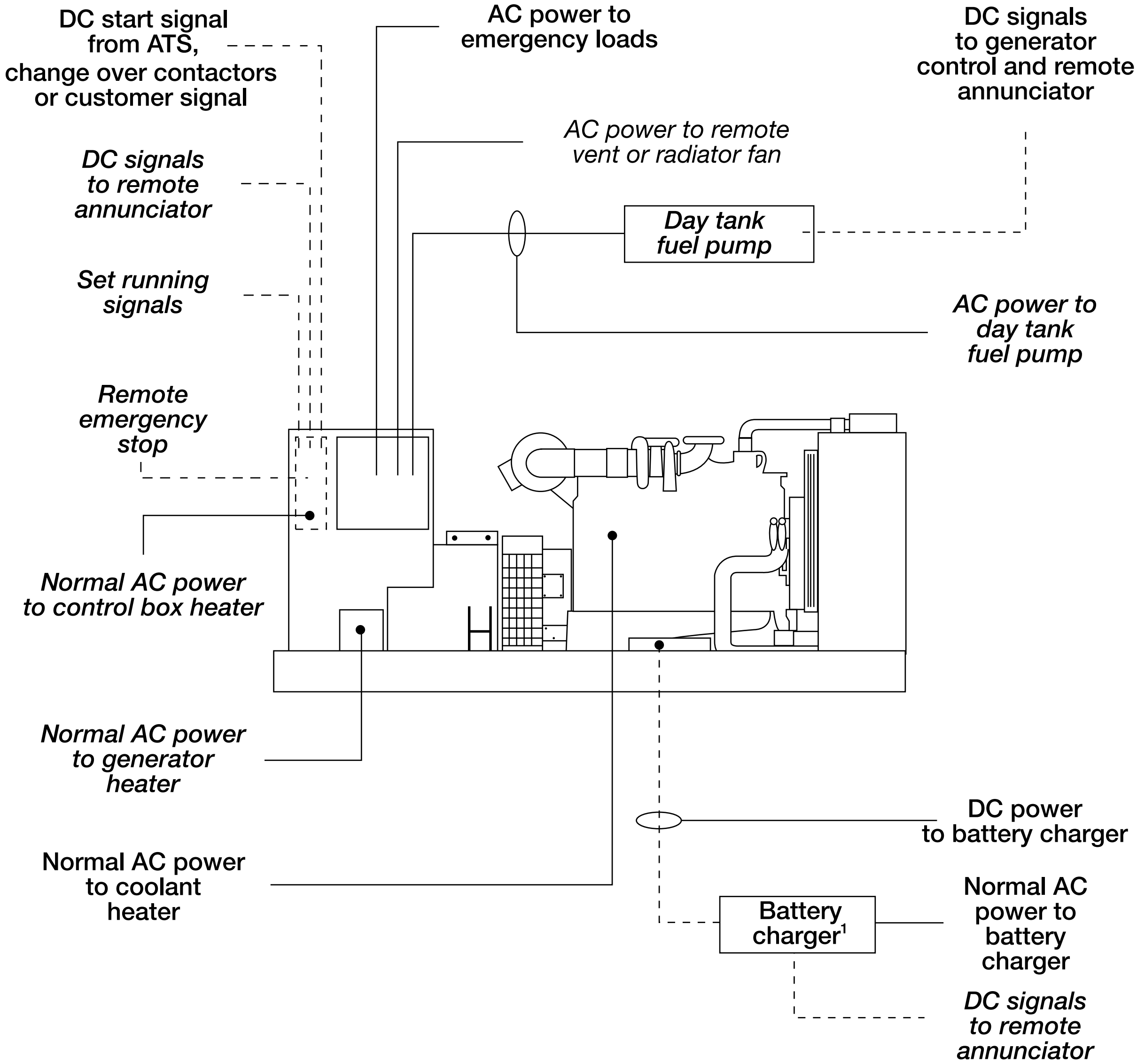
Mil Std 461 Electromagnetic Emission and Susceptibility Requirements.

IEC801.2 Electrostatic Discharge Test

IEC801.3 Radiated Susceptibility

IEC801.4 Electrically Fast Transient

IEC801.5 / IEEE587 Surge Immunity



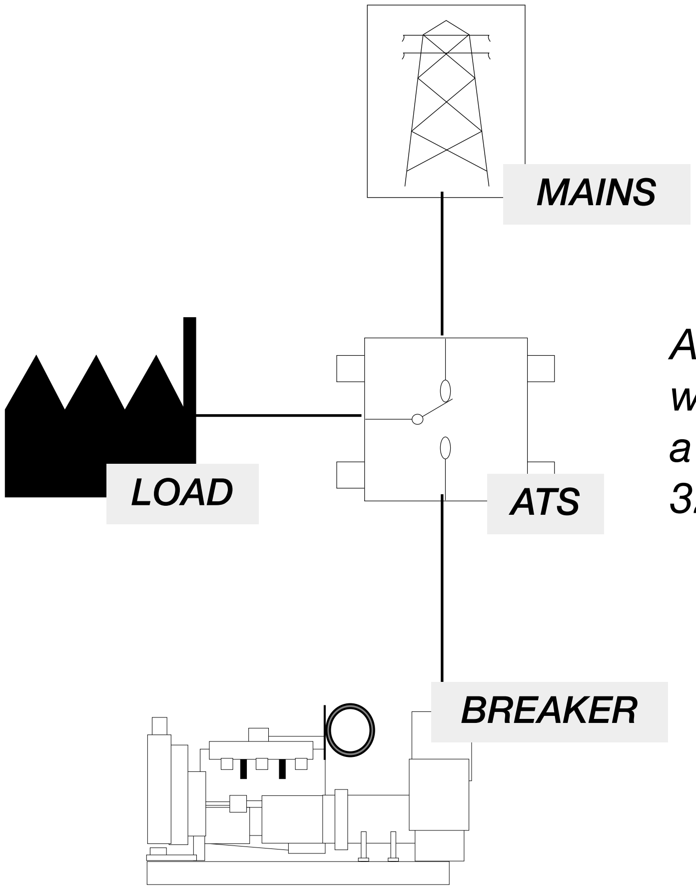

Notes:
1. The items in italics are not always used

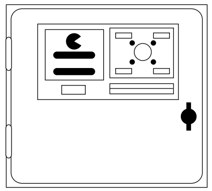
**TYPICAL GENERATOR SET CONTROL AND ACCESSORY WIRING**

*Fig. D1*

# Typical Automatic Mains Fail Application
## *PCL or PCC configuration*

*A single generating set with control system PCL002 or PCC, an automatic transfer switch and a transfer switch controller (the PCL005)*

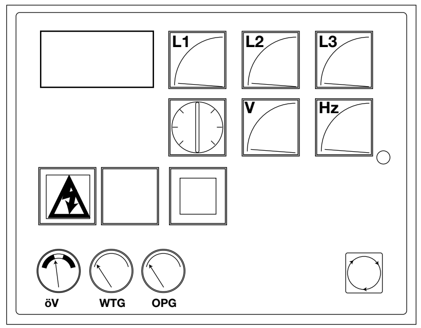


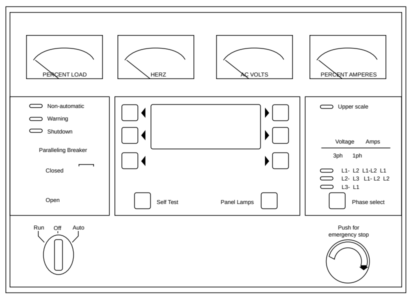
*PCL005*

*Wall mounting PCL005 mains failure control system, providing two wire start output when the mains fails. This incorporates mains fail, mains return and run on timers.*

*Automatic Transfer Switch (ATS) wall mounting up to 1250 A and a free standing from 1600 A to 3200 A.*




*PCL002*




*PCC*

*PCL002 or PCC control system with two wire start input from the mains failure control unit PCL005*

## Parallel Operation

PowerCommand™ Digital Paralleling Systems are available for isolated prime power, emergency standby or interruptible applications utility (mains) paralleling applications. These systems are unique in that they use fully integrated, microprocessor-based control for all system control functions to eliminates the need for separate paralleling control devices such as synchronisers and load sharing controls.

PowerCommand™ Control allows state of the art servicing of the entire paralleling control system integration, monitoring and adjustment of system parameters with a laptop computer.

The PowerCommand™ Control incorporates AmpSentry Protection for paralleling operations. This is a comprehensive power monitoring and control system integral to the PowerCommand™ Control that guards the electrical integrity of the alternator and power system from the effects of overcurrent, short circuit, over/under voltage, under frequency, overload, reverse power, loss of excitation, alternator phase rotation and paralleling circuit breaker failure to close. Current is regulated to 300% for both single phase and 3 phase faults when a short circuit condition is sensed.

If the generating set is operating for an extended period at a potentially damaging current level, an overcurrent alarm will sound to warn the operator of an impending problem before it causes a system failure. If an overcurrent condition persists for the time pre-programmed in the time/current characteristic for the alternator, the PMG excitation system is de-energised, avoiding alternator damage. The overcurrent protection is time delayed in accordance with the alternator thermal capacity. This allows current to flow until secondary fuses or circuit breakers operate, isolate the fault and thus achieve selective co-ordination.

Fixed over/under voltage and under frequency time delayed set points also provide a degree of protection for load equipment. Over/under voltage conditions trigger a shutdown message on the digital display screen and under frequency conditions prompt both warning and shutdown message, depending on the length of time and magnitude of variance below rated frequency.

AmpSentry protection includes an overload signal that can be used in conjunction with transfer switches or master controls to automatically shed load, preventing a potential generating set shutdown. The overload signal is programmable for operation at a specific kW level, on the basis of an under frequency condition, or both. It also includes protection for generating set reverse power, loss of excitation, alternator phase rotation and circuit breaker failure to close. It includes permissive (synchronising check functions for automatic and manual breaker closure operations.


*Seven 900 kVA sets working in parallel for a major soft drinks bottling factory in the Middle East.*

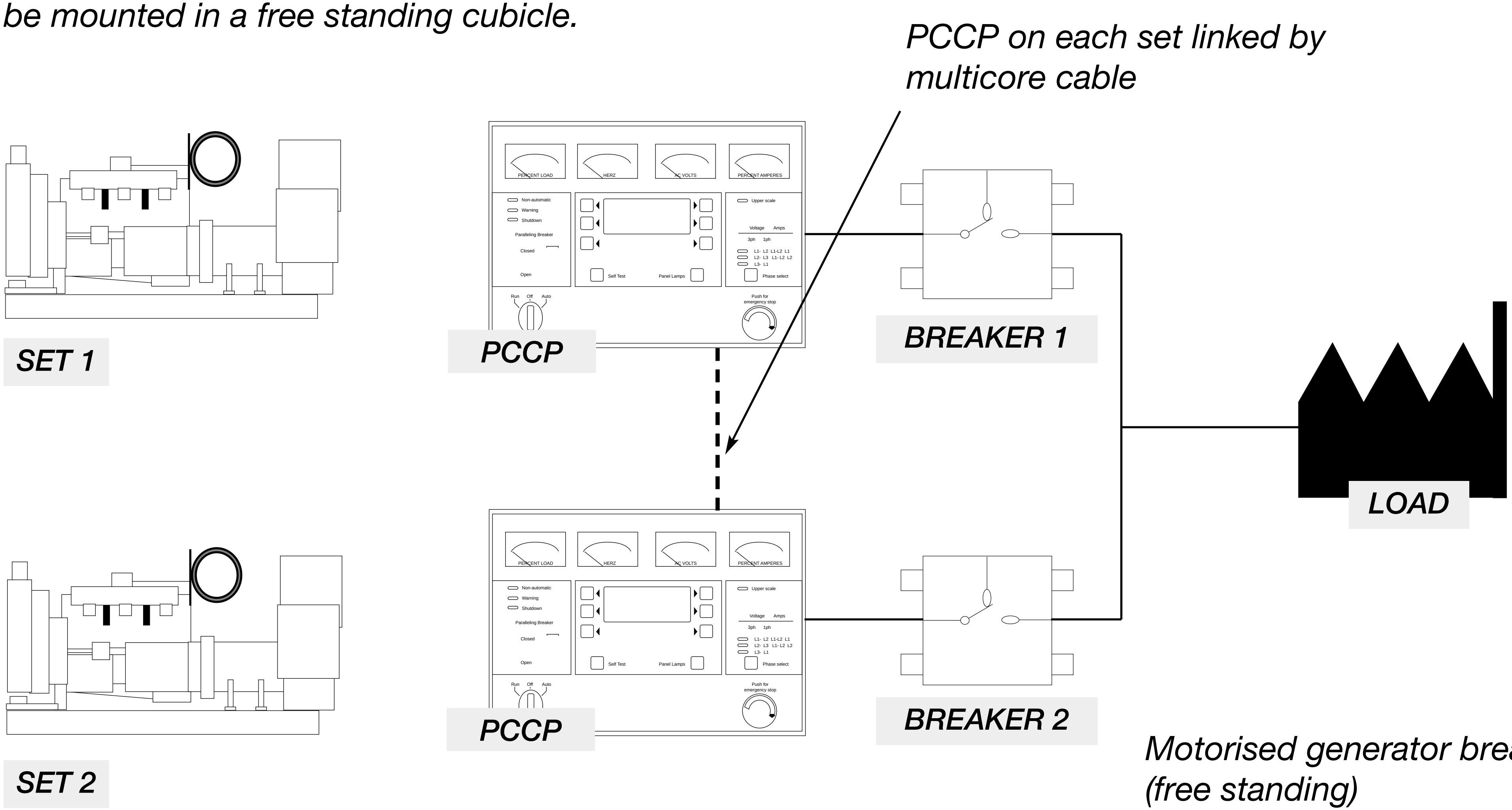
*Twelve 1250 kVA sets working together as construction camp base power using the PCL control system.*

*Thirty-nine 1125 kVA sets with KTA50 engines produce a combined 30MW of site power using PowerCommand Control (PCC) and Digital Master Control Systems when all operating in parallel.*

# Typical Paralleling Application

## *PCC configuration*

*An unlimited number of sets can be paralleled together with PCC(P). Each set must have a PCCP and be no more than 20 metres away from the next set. PCCP requires a motorised breaker. Motorised breakers must be mounted in a free standing cubicle.*

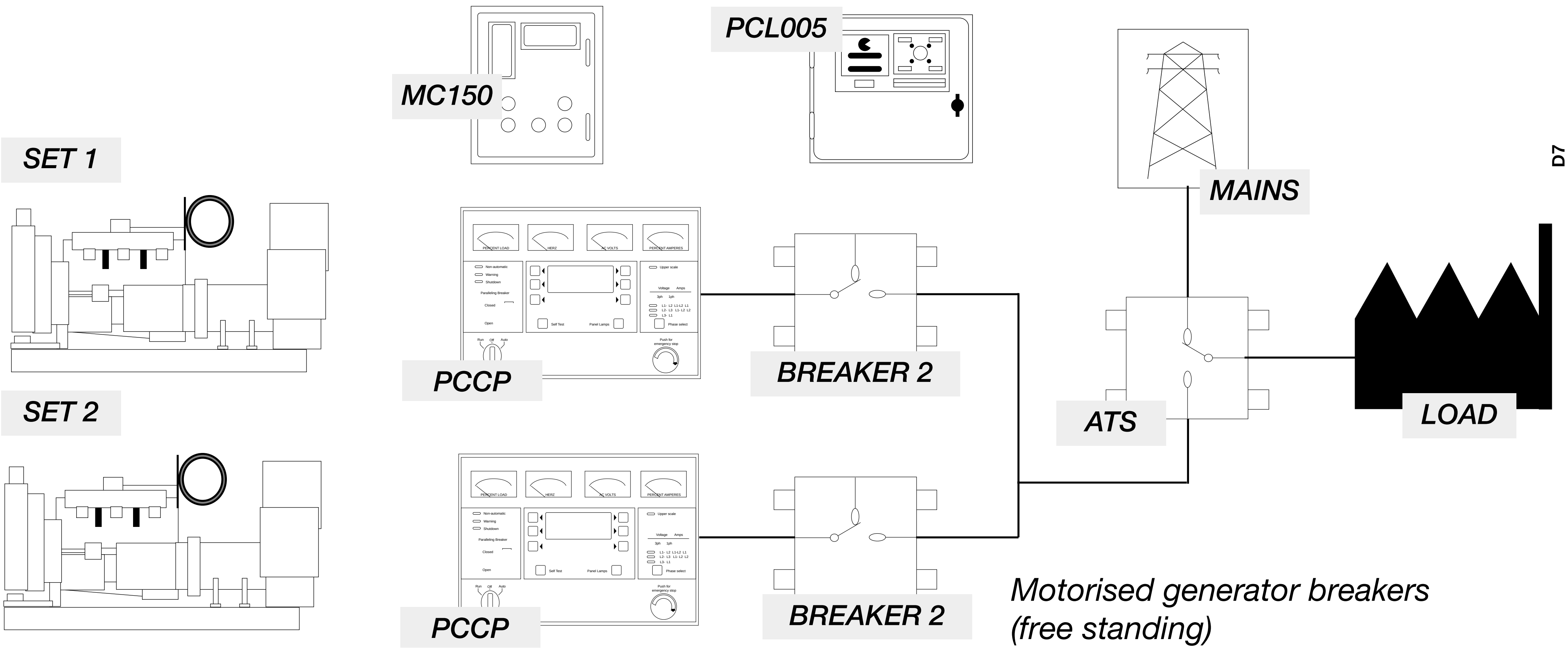


# MC 150 Control Typical Application

*Two set standby application – automatic synchronising*

*Features:*
*Master first start*
*Priority load add & load shed*
*Load demand*
*AMF*

*Once signalled to start (by manual input or remote start signal) the MC150 will: start both sets, sense which reaches rated speed and volts first and switch this set onto the load, the remaining sets are then synchronised to this first set to start. Each set (maximum total of 4) is controlled to take its proportional share of the load.*



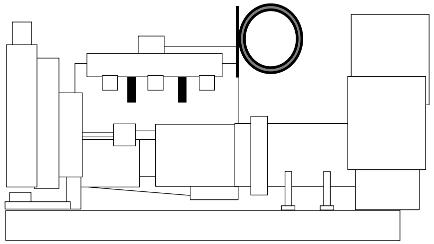
# MC 150 PLTE Control Typical Application

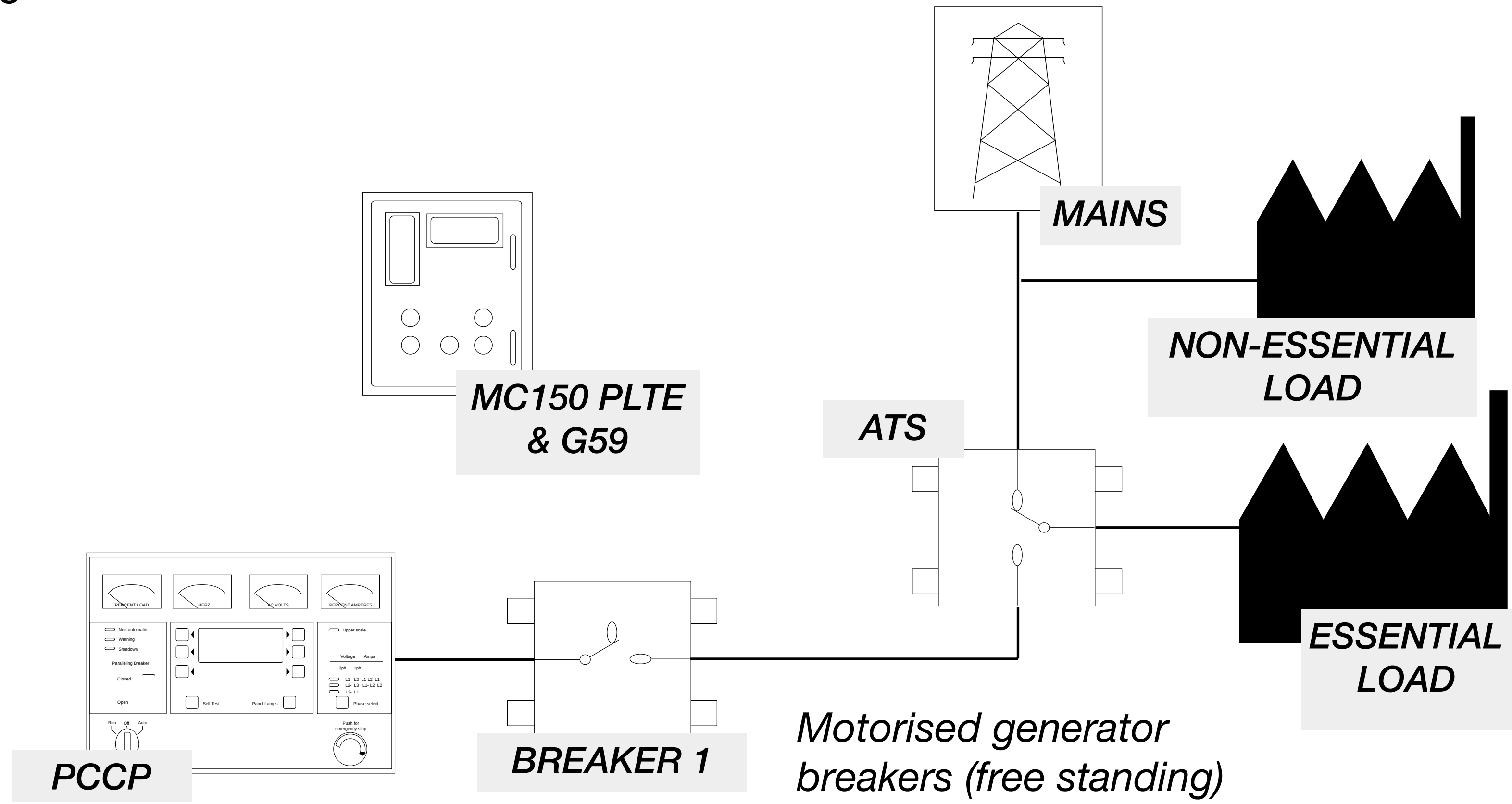
*Single set standby / peak lop application*



*Features:*
*Mains monitoring*
*Essential & non-essential load control*
*Peak lop auto or manual*
*G59 utility protection*
*Max time in parallel warning*
*AMF (integral no PCL005)*
*Load share*
*N-E contactor control*
*On & off load test*
*No break return*
*Volt free signals*

*The MC150 PLTE is a configurable controller designed to operate as an automatic mains failure system with the option of full output or peak-lopping in three modes: – automatic, manual or share.*





## Networking

The PowerCommand™ Control includes a Generator Control Module (GCM) which allows for communications over the PowerCommand™ Network. The Network is suitable for local or remote control and monitoring using PowerCommand™ Network hardware and PowerCommand™ software for Windows". See Fig. 28.

The Network provides complete and consistent control, monitoring and information access, additionally, all alarm events may be programmed to automatically dial out to a user specified telephone number upon alarm occurrence. This provides all the required information, when needed, from unattended sites. All events including alarms, operator activities and system events are recorded and may be printed as reports or saved to disk for archiving purposes.

PowerCommand™ software for windows allows the facility for remote monitoring of the generation sites. A Remote Access, Single Site version of Power Command will be provided for a host monitoring computer. Power Command will provide detailed information on the status of the generating sets and their associated accessories.

The system communicates using an unshielded twisted wire pair which illuminates the need for expensive hardwired, point to point terminations.

## AC Terminal Box

The AC terminal box, which forms part of the GCP (Generator Control Panel), acts as marshalling box between the engine / alternator and the AC auxiliary supplies / control panel monitoring system.

## Alternator Terminal Box

The alternator output terminals are mounted on a flat thick steel saddle welded on the non-drive end of the alternator. The terminals are fully sealed from the airflow and are widely spaced to ensure adequate electrical clearances. A large steel terminal box is mounted on top of the saddle. It provides ample space for customer wiring and gland arrangements and has removable panels for easy access. Contained within the Alternator terminal box is the following instruments and controls:-

- Current Transformers
- Alternator Voltage Regulator
- Electronic Governor
- Power factor controller
- Quadrature Droop kit

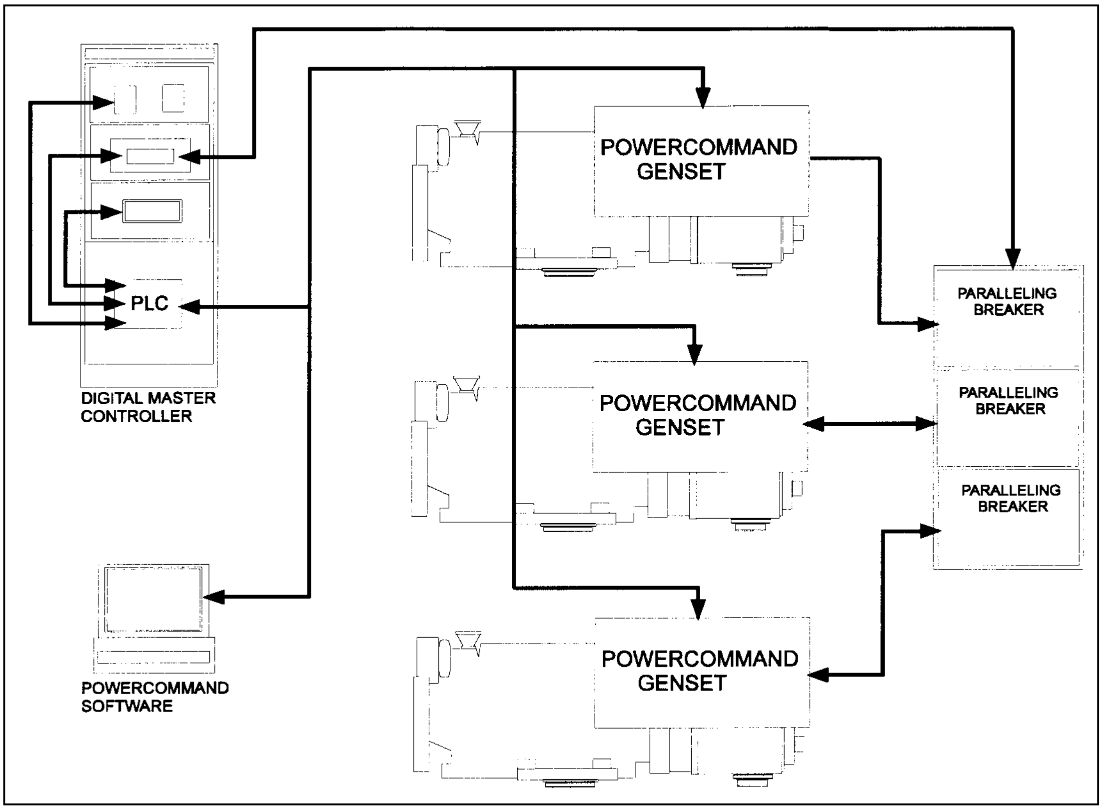



*Fig. D2 PowerCommand™ Network*

## Circuit Breakers

The circuit breakers fitted in the switchgear control panel (if supplied) are manufactured by Merlin Gerin on the low Voltage applications and Yorkshire Switchgear (A Division of Merlin Gerin) on the high Voltage applications. For specific details on the type and specification of the breakers consult Cummins Power Generation.

### Low Voltage System Breakers

The L.V air circuit breakers are compliant with International Standards, they are safe and reliable and have a range of control units which offer multiple functions, accessories and auxiliaries to suit the site requirements. Circuit breakers are operated via a stored energy mechanism for instantaneous opening and closing. The mechanism is charged either manually or electrically as required.

All characteristics for the breaker operation should be collated, so that selection of the required breaker can be made from the Merlin Gerin Manual. The points to be considered are:-

- rated current and voltage
- number of poles required, either three or four depending on the application of the system.
- breaking capacities and protection type

Auxiliaries and accessories

The manufacturer's literature should be consulted for the short circuit curves and technical data before selection of the breaker can take place.

### Medium and High Voltage System Breakers (YSF6)

The YSF6 circuit breakers are compliant with international Standards and designed for a range of voltages up to 24kV and symmetrical breaking fault levels up to 40kA. The insulation and arc control systems are designed and certified for use on 3 phase 50/60Hz systems with earthed neutral. The manufacturer must be consulted if this type of breaker is required to be used on any other application.

Facilities fitted on the YSF6 Circuit Breaker include:-

- Tripping timer, from the application of tripping voltage to final arc extinction in the order of 50m sec.
- SF6 is a gas, Sulphur Hexafluoride, it is colourless, odourless, non-toxic and non-flammable and is artificially synthesised. At high temperatures and when exposed to arcing, the gas transfers heat away from the arc, to cool the arc and lessen the possibilities of re-strikes after current zero, therefore the gas is far more effective than air.
- A spring closing mechanism is fitted that may either be charged by hand or by means of a spring charging motor and the breaker may be tripped by means of a mechanical trip lever or by the trip coil.
- Interlocks are incorporated into the design to prevent potentially dangerous situations or operations, also control levers can be supplied with padlocking facilities.
- A low pressure switch is fitted to detect if the gas pressure falls below a preset level, a relay will operate to signal to alarms and indications and to disconnect the trip and close circuits, or to trip the circuit breaker.
- A cast resin insulation system enables a 125kV impulse level to be incorporated into the unit for current 12kV systems, complete with a monobloc moulding which houses three contact systems and carries the main isolating contacts with insulators, shrouds and busbar receptacles.

The manufacturer's literature should be consulted for the short circuit curves and technical data.

## Contactors

Contactors can be supplied if required, as a source of automatic changeover between the mains supply and the generator output supply. The contactors are fitted in a separate switchgear panel, complete with electrical and mechanical interlocks. They can be supplied as three or four pole depending on the application and neutral earthing of the system with instantaneous overload protection.

The manufacturers' literature should be consulted with regards to the short circuit curves and technical data.

## Busbar Arrangements

Where one or more single busbar system output breaker panels are fitted together, the linking or commoning of the supplies or outputs is achieved by the use of a single busbar system.

Stationary breakers and buswork are housed within a rigid, free standing panel, designed for indoor applications, provided with bolt on covers, barriers and supports. The framework is constructed with a minimum of 12 gauge steel metal. Control components are totally isolated from power carrying components by metal or insulating barriers. All components and surfaces operating in excess of 50 volts are shielded to prevent inadvertent contact.

The current carrying capacity of busbars is determined by the materials conductivity and the operating temperature. In an air insulated system heat is dissipated from the busbars, however the bars are supported on insulating materials and the heat conducted away is very small. This can be additionally reduced by sleeving, painting and laminating.

## CHANGEOVER CONTACTOR CUBICLES

Wall mounted cubicles up to 1000 amperes

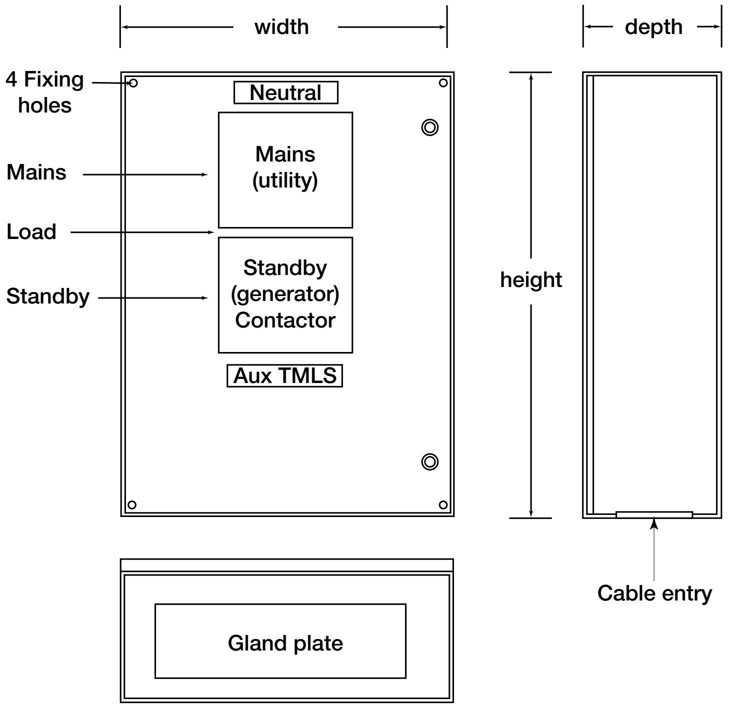
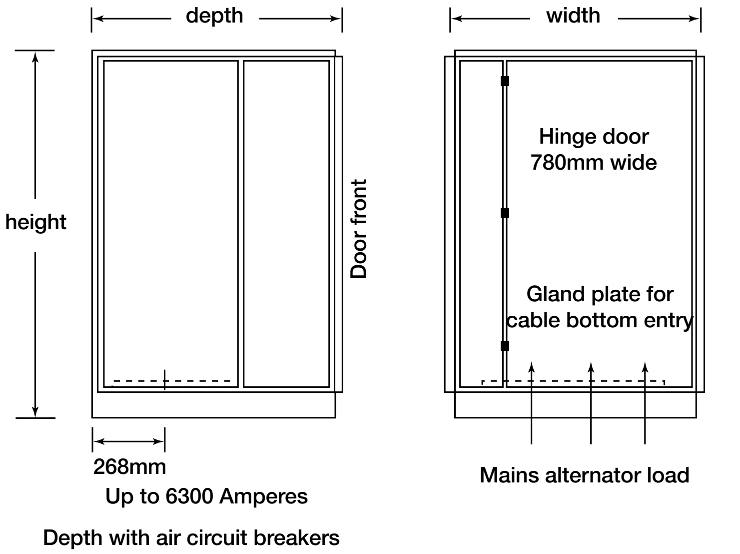



TABLE A

| Contactor rating | | Dimensions (mm) | | |
|---|---|---|---|---|
| | | Width | Height | Depth |
| 40A | 3 pole | 400 | 500 | 210 |
| 40A | 4 pole | 400 | 500 | 210 |
| 60A | 3 pole | 400 | 500 | 210 |
| 60A | 4 pole | 400 | 500 | 210 |
| 80A | 3 pole | 400 | 500 | 210 |
| 80A | 4 pole | 400 | 500 | 210 |
| 125A | 3 pole | 400 | 500 | 210 |
| 125A | 4 pole | 400 | 500 | 210 |
| 200A | 3 pole | 600 | 800 | 300 |
| 200A | 4 pole | 600 | 800 | 300 |
| 270A | 3 pole | 600 | 800 | 300 |
| 270A | 4 pole | 600 | 800 | 300 |
| 350A | 3 pole | 600 | 800 | 300 |
| 350A | 4 pole | 600 | 800 | 300 |
| 500A | 3 pole | 800 | 1000 | 350 |
| 500A | 4 pole | 800 | 1000 | 350 |
| 700A | 3 pole | 800 | 1000 | 350 |
| 700A | 4 pole | 800 | 1000 | 350 |
| 1000A | 3 pole | 800 | 1000 | 350 |
| 1000A | 4 pole | 800 | 1000 | 350 |
| Approx. weight 1000A 85kg. | | | | |

Floor mounted cubicle for changeover contactors up to 6300 Amperes




For use where controls and instruments are mounted on set/panel

TABLE B

Floor standing contactor changeover cubicles up to 6300 amperes

| | | | | |
|---|---|---|---|---|
| 1600A | 3 or 4 pole | 1000 | 1500 | 1050 |
| 2000A | 3 or 4 pole | 1000 | 1500 | 1050 |
| 2500A | 3 or 4 pole | 1000 | 1500 | 1050 |
| 3200A | 3 or 4 pole | 1000 | 1500 | 1050 |
| 4000A | 3 or 4 pole | 1344 | 2000 | 1520 |
| 5000A | 3 or 4 pole | 1344 | 2000 | 1520 |
| 6300A | 3 or 4 pole | 1500 | 2000 | 1520 |

Dimensions and weights are for guidance only. Specifications may change without notice.

The busbar system when fitted, is constructed from silver plated copper bars with bolted joints for all three phases, a full neutral, and a 1/4 x 2 inch ground bus extended through all sections. This system is a typical single busbar system as shown in Fig. 30.

Steady state bus ratings are based on a maximum of 1000amps/square inch current density, sized particularly for the breaker or the combined output of the total generators. In either case the busbars can be selected using the space requirements within the panel and the current capacity required.

Bus bracing levels range from 50kA to 200kA. The fault ratings on the busbars and all data can be found in the manufacturer's literature manual.

## Generator Neutrals

The electrical output of generators is normally in four wire form, with the neutral point of the windings brought out. An out of balance current results where there is practical difficulty in balancing the single phase load across all three phases. This out of balance load flows through the neutral conductor. Current will also flow through the neutral during an earth fault. In common practice, the star point of the machine is connected to the neutral bar, which in turn is earthed. There is a possibility of large harmonic currents circulating in the interconnected neutrals when machines are paralleled. Careful consideration should, therefore, be given to the paralleling of neutrals in any system.

The neutrals of generators of dissimilar construction and differing output and power factor ratings, should therefore, never be interconnected. Switchgear such as neutral earthing contactors should be employed to cater for this, ensuring that only one machine star point is connected to the neutral bar at any one time. It is usual to connect the largest running machine in the system for this duty.

NOTE: machines of similar types, operating loads and power factors, the neutrals can be connected in parallel.

## Auxiliary Supplies Transformer

An auxiliary supply transformer may be required for the interconnection of high voltage equipment. This is mounted external from the complete package. This may be provided by Cummins or others as per the contract requirements.

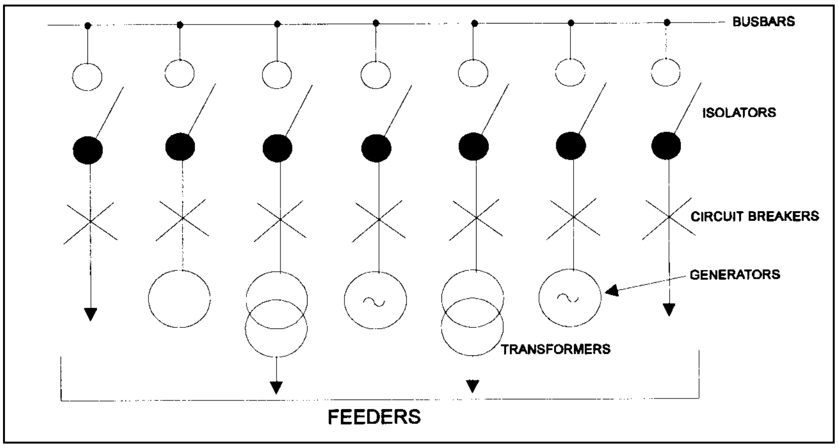



*Fig. D3 Typical Single Busbar System*

## Typical System One-Line Diagram

Figure D4 is a one-line diagram of a typical electrical distribution system that incorporates an emergency generator set.

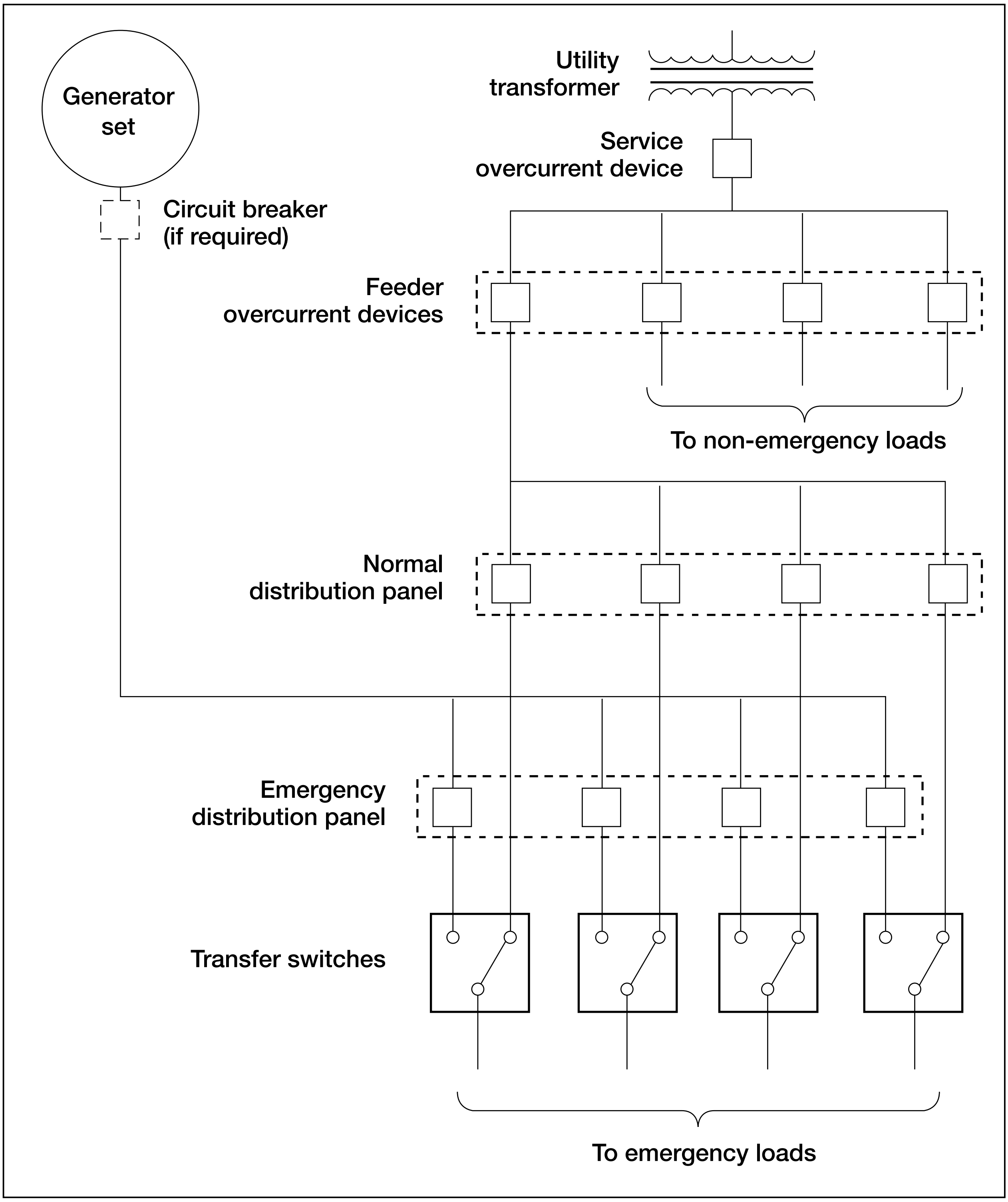



*Figure D4 typical one-line diagram of an electrical distribution system*

## General

The cables in generator installations vary from multicored light current control and communication types to large single core. They are installed in a variety of ways:

- In open runs directly attached to structural surfaces, such as walls beams and columns
- In trenches, open, enclosed or back-filled
- On cable trays
- In underground ducts
- In metallic or plastic conduits and trunking

The cable runs between genset and associated switchgear and control gear require to be as short as possible.

The factors that influences the selection of the conductor size are:

- Temperature
- Continuous, short-term, and cyclic loading requirements.
- The type of protection afforded against overload current.
- The fault level of the system, i.e. the power sources fault capacity
- Voltage drop considerations for the installation.

It is good practice to use a flexible cable to connect on to the alternator terminals in order to take out vibration. EPR/CSP or BUTYL cable is recommended for this purpose. If the switchgear panel is located at some distance from the genset it may be more cost effective to install a cable link box adjacent to the set to minimise the length of flexible cable needed. Main connections between the link box and switchgear panel and then to the distribution panel can then be in less expensive armoured cable.

All installations should have an isolator switch between the mains incoming supply and the plant control cubicle incoming terminals to enable maintenance to be carried out on the plant.

*Flexible cable entry into control module and cable tray arrangement for side entry.*

## Cable Ratings

Cables must be chosen so that their current carrying capacity (related to the cross sectional area) is not less than the full load current they are required to carry. The continuous current rating of a cable is dependent upon the way heat is generated. Installation conditions have, therefore, to be taken into account when determining the size of the cable to be used. More often than not, the limiting factor in low voltage installations is the cable voltage drop.

The current carrying capacity of a cable is influenced by:-

- Conductor material - copper or aluminium.
- Insulation material.
- The nature of its protective finishes - bedding, armouring or sheathing.
- The installation ambient temperature.
- The method of installation - be it, in open air, in trenches, buried, grouped with cables of other circuits.

Low voltage installations come within the scope of IEE Regulations. They must comply with the requirements of Regulation 522. This means using the methods for determining the cross sectional areas of cable conductors to comply with Regulation 522-1.

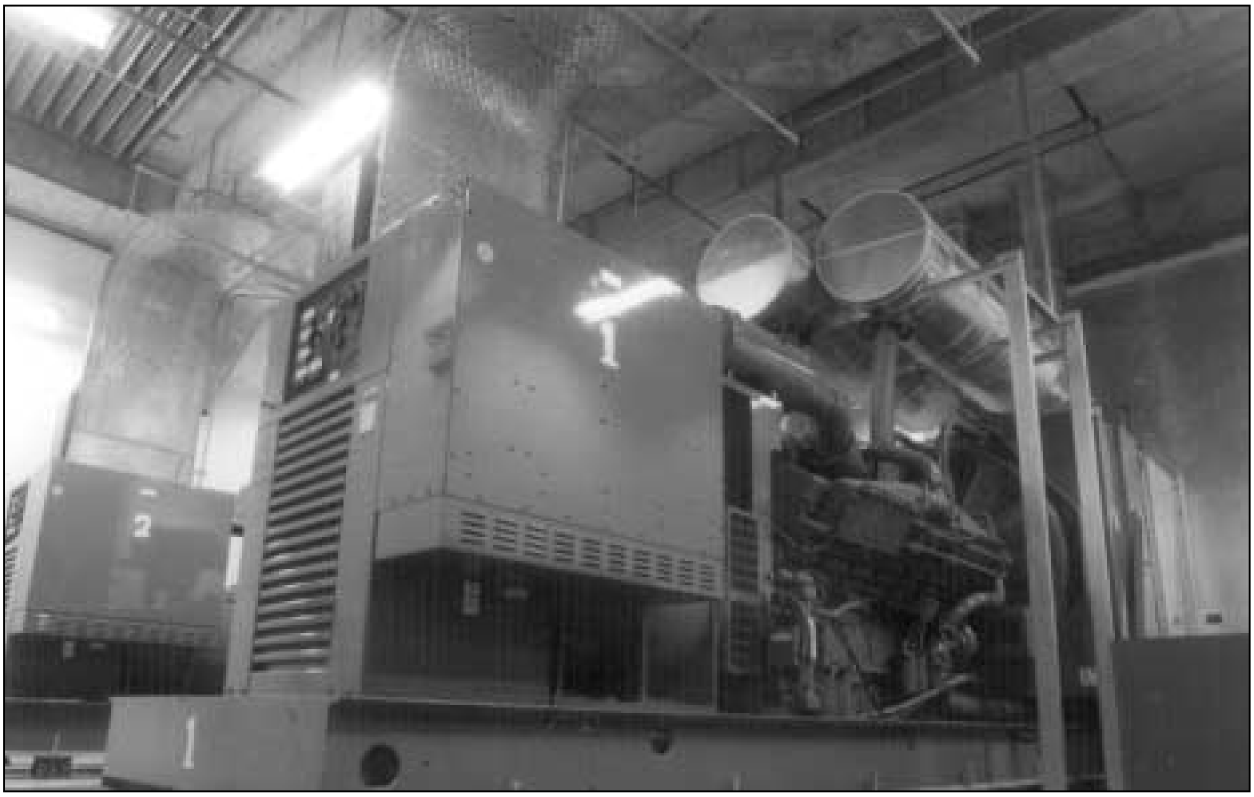
Digital connections - The type/gauge wire to use for these connections are:

- Less than 305m (1000ft), use 20 gauge stranded copper wire.
- to 305 to 610m (2000ft), use 18 gauge stranded copper wire.

To obtain the on-site rating of the cable, the correction factors cover variations in ambient air and ground temperatures, depth of laying, soil thermal resistivity, and cable grouping. It is then possible to determine the actual rating for the cables installed in free air, in ducts, in trunking and conduit, and in open, enclosed and back-filled trenches.

Appendix 9 of the IEE Regulations in particular will provide valuable guidance on calculation methods.


*Top cable entry and overhead cable tray run between sets (1000 kVA sets).*



*Neat cable top entry into control module using perforated steel cable tray and ceiling supports.*

*Top cable entry. Control panels provide choice of top or bottom entry. LH or RH mounted.*

## Methods of Installing Cables

**Conduit**

- Screwed conduit of the welded type to BS 4568 should be used.
- Surface conduits should be supported and fixed by means of distance saddles spaced and located within 300mm of bends or fittings.
- Runs must be earthed.
- The conduit system should be completely erected before cables are drawn in.
- A space factor of at least 40% should be provided.
- The inner radii of bends should never be less than 2.5 times the outer diameter of the conduit..
- Conduit systems should be designed so that they can be sealed against the entry of dust and water. Nevertheless, ventilation outlets should be provided at the highest and lowest points in each section of the system. These will permit the free circulation of air and provide drainage outlets for any condensation that may have accumulated in the runs.
- To maintain the fire resistance of walls, ceilings and floors, any opening made in them should be made good with materials to restore the fire integrity of the particular building element.

**Trunking**

- Steel trunking must comply with BS 4678
- Fittings must be used to ensure that bend radii are adequate.
- As with steel conduit, steel trunking may be used as a protective conductor provided it satisfies the IEE Wiring Regulations, it may not be used as a combined protective and neutral (pen) conductor.
- A space factor of at least 45% should be provided.
- Supports should be spaced at distances and ends should not overhang a fixing by more than 300mm.
- Trunking should not be installed with covers on the underside. Covers should be solidly fixed in passage through walls, floors and ceilings.
- On vertical runs internal heat barriers should be provided to prevent air at the topmost part of the run attaining excessively high temperatures.

*Cable installation into PCC module with Digital Master Control (DMC) cubicle and wall mounted changeover contactor box adjacent to set.*

### Segregation of Circuits

Segregation of cables of different circuits will prevent electrical and physical contact. Three circuits are defined in the Regulations. They are:

- 1 LV circuits (other than for fire alarm or emergency lightning circuits) fed from the main supply system.
- 2 Extra low voltage or telecommunication circuits fed from a safety source (e.g. telephones, address and data transmissions systems).
- 3 Fire alarm or emergency lighting circuits.

Where it is intended to install type 1 cables in the same enclosure as telecommunication system which may be connected to lines provided by a public telecommunications system authority, the approval of that authority is necessary. Cables used to connect the battery chargers of self contained luminaries to mains supply circuits are not deemed to be emergency lighting circuits.

### Cable Trays

The most common method for installing cables is by clipping them to perforated trays. The trays should be galvanised or protected with rust preventing finishes applied before erection. Cleats or clips should be of galvanised steel or brass.

Cables should be laid in a flat formation. The maximum spacing for clips and cleats should be 450mm.

Tray supports should be spaced adequately, usually about 1200mm.

Steel supports and trays should be of sufficient strength and size to accommodate the future addition of approximately 25% more cables than those originally planned.

*Digital Master Control Cubicle (DMC) installed with a water companies Switchboard Suite. Access to the DMC is all front entry.*

### Trenches

Trenches within plant rooms and generator halls should be of the enclosed type with concrete slab or steel chequer plate covers. (See Fig. D5).

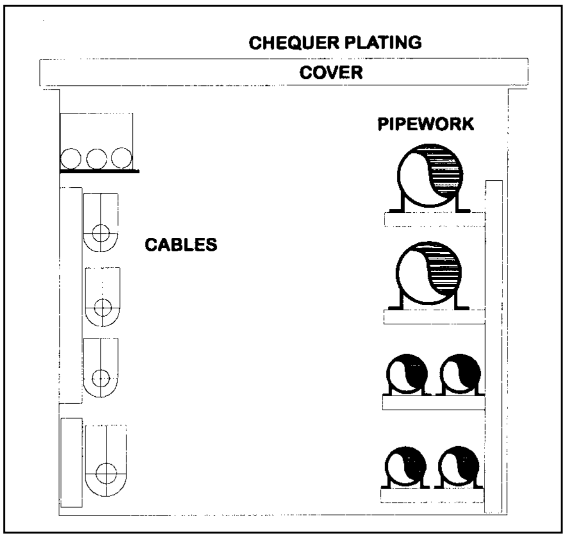



*Fig. D5 Trench Construction*

Trench bends should be contoured to accommodate the minimum bending radius for the largest cable installed.

Trenches should be kept as straight as possible. The bottoms should be smoothly contoured and arranged to fall away from the engine plinths so that water and oil spillages do not accumulate within the trenches but are drained away to a common catchment pit.

Trenches external to the building are often back-filled which should be consolidated before the cable is installed. This ensures that there is no further ground settlement. Back filling should be made in even layers.

### Laid Direct in Ground

Where armoured and sheathed cables are run external to the buildings and laid direct in the ground, they should be laid on a 75mm deep bedding medium.

Every cable in the layer should be protected by interlocking cable tiles (to BS2484).

The separation distances between HV and LV cables in trenches or laid direct in the ground should be between 160mm and 400mm, depending on the space available.

Cables passing under roads, pavements, or building structures should be drawn through ducts and must be of a type incorporating a sheath and/or armour which is resistant to any mechanical damage likely to be caused during drawing-in. The ducts should be laid on a firm, consolidated base. The ends of the ducts should always be sealed by plugs until the cables are installed.

No more than one cable should occupy a ductway, providing a number of spare ways for future cables (say 25% more than those initially required).

### Cable Termination

The termination of any power cable should be designed to meet the following requirements:-

- Electrically connect the insulated cable conductor(s) to electrical equipment
- Physically protect and support the end of cable conductor, insulation, shielding system, and the sheath or armour of the cable
- Effectively control electrical stresses to give the dielectric strength required for the insulation level of the cable system.

It is only necessary on LV systems to apply tape from the lower portion of the terminal lug down onto the conductors extruded insulation. The tape should be compatible with the cable insulation. An alternative method is to use heat shrinkable sleeves and lug boots. Where cables are connected direct to busbars which are likely to be operating at higher temperatures than the cable conductors, high temperature insulation in sleeve or tape form is used.

Screened MV cables must be terminated at a sufficient distance back from the conductor(s) to give the creepage distance required between conductor and shield.

It is recommended that heat shrink termination kits is used on 11kV XLPE cables. These incorporate stress control, non-tracking and weatherproof tubes, cable gloves and termination boots.

### Glands

Polymeric cables should be terminated using mechanical type compression glands to BS6121. The material of the gland must be compatible with the cable armour. Where the glands terminate in non-metallic gland plates they must be fitted with earth tags. Where glands are to be screwed into aluminium or zinc base alloy plates, use cadmium plated glands.

The gland must be capable of withstanding the fault current during the time required for the cable protective device to operate. Where a circuit breaker is used the fault clearance time could be near one second.

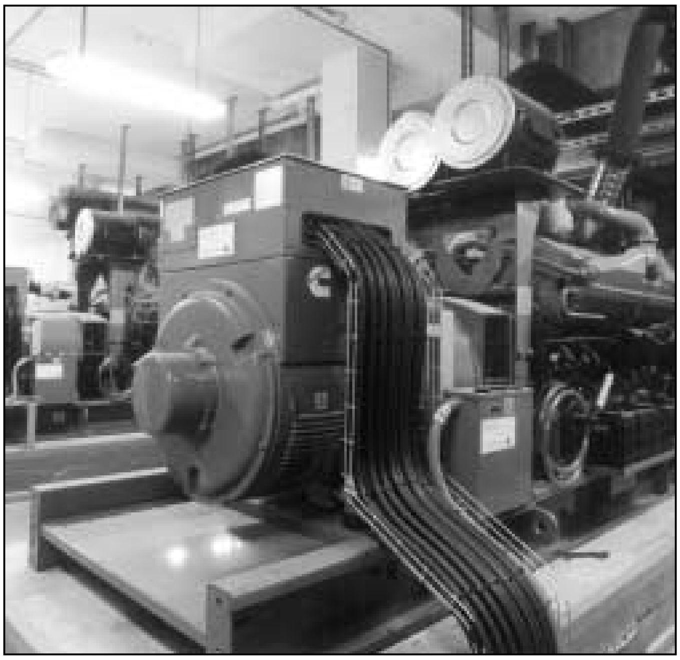
It is good practice to fit PVC or neoprene shrouds over armoured cable glands, particularly in outdoor applications.

### Connections to Terminals

Power cable conductors are usually terminated in compression type cable lugs using a hydraulic tool. The hexagonal joint appears to be the most popular crimp shape for conductors over 25mm$^2$. Insulated crimped lugs are used on the stranded conductors of small power and control cables. Soldered lugs and shell type washer terminations are now seldom specified.

### Cable Tails

Cable tails from the gland to the terminals of the equipment should be sufficient length to prevent the development of tension within them. Allowance should be made for the movement of cables connected to the terminal boxes of any plant mounted on vibration isolators. In these circumstances, and where connections to the main switchboard are in single core armoured cable, or in multicore, unarmoured cable, it is usual to terminate in a free standing terminal box mounted as close as possible to the plant. Flexible connections, e.g. in single-core, PVC insulated or PVC/XLPE insulated and PVC sheathed cables, are then used between this floor mounting box and the plant terminals. The connections should be generously looped.



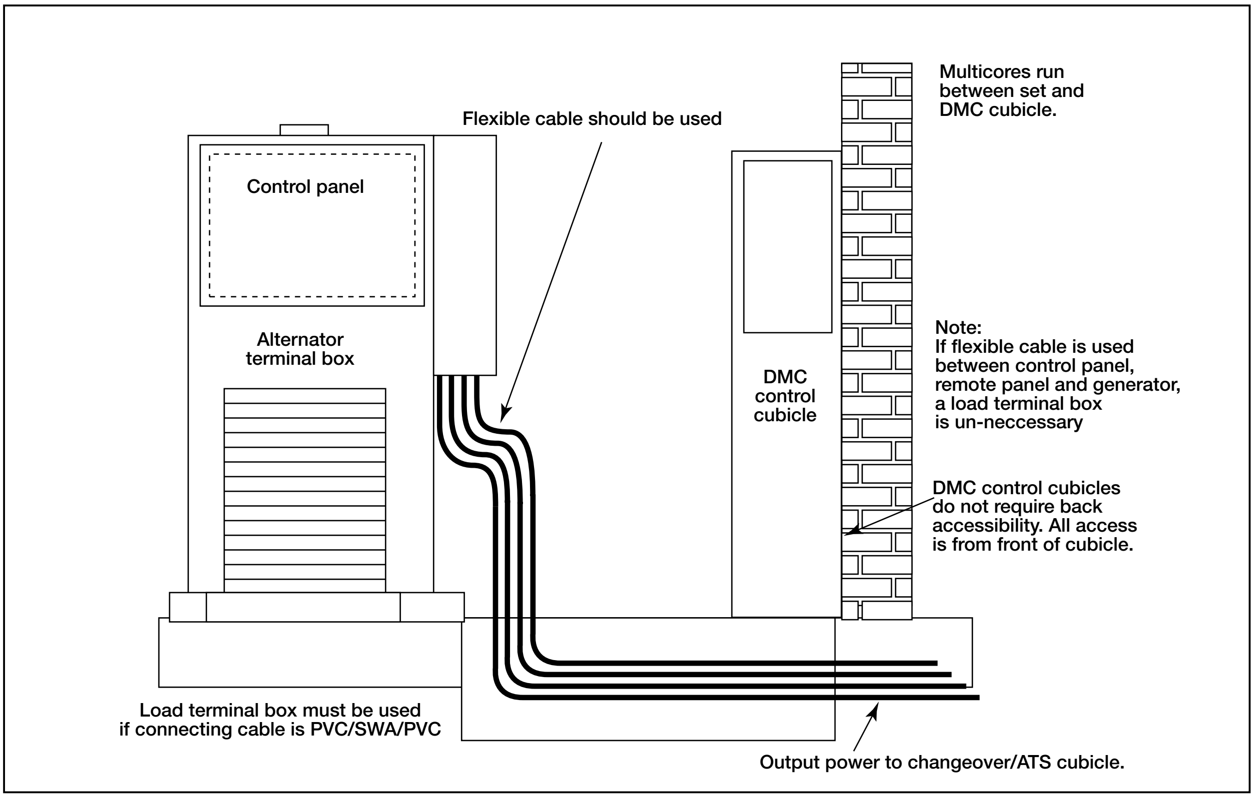



*Fig. D6 Cable Connections – Cable Tails*

The generating set and all associated equipment, control and switchgear panels must be earthed before the set is put into operation. Earthing provides a reference for system voltages to:

- Avoiding floating voltages
- Prevents insulation stress
- Allows single earth faults to be detected
- Prevents touch voltages on adjacent components

Provision is made on the set and within the panels for connection of an earth continuity conductor. It is the responsibility of the installers to ensure that the system is correctly earthed with references to IEE Wiring Regulations in countries where these apply, or to the local wiring regulations where they do not.

There are a number of different earthing systems:-

## Solid Earthing

The system is earthed with a direct connection via an earth electrode with no intentional impedance to earth. This method is used and required by the electrical code on all low voltage systems, 600 volts and below with a grounded earth electrode. This earthing system is made up of the following;-

### Earth Electrode

The earth electrode is one or more copper clad steel rods driven into the ground. (neither water or gas mains used separately or together are acceptable as an earth electrode.) It must have a low resistance to earth to prevent a dangerous voltage appearing between any points which a person could reach simultaneously and be capable of carrying a large current.

### Earth Lead

The earth lead is a copper conductor of sufficient cross sectional area, connecting the earth terminal to the earth electrode. The size of the conductor may be obtained from the IEE Wiring Regulations. The point of connection of the earthing lead to the earth rod(s) should be protected from accidental damage, but also must be accessible for inspection.

### Earth Terminal

The earth terminal is situated adjacent to the generator circuit breaker to which all earth continuity conductors are connected or terminated. The earth continuity conductor bonds all non current carrying metalwork, metallic conduit, enclosures and generator frame etc. in the installation and customer premises, plant room to the earth terminal. The conductor shall be connected to the customers earth terminal, which will be effectively earthed to an earth electrode.

### Earth Rods

The number of rods that are required to form a satisfactory earth electrode is dependent upon the ground resistance. The earth loop resistance (of which the electrode is part) must be low enough that in the event of an earth fault occurring, sufficient current will flow to operate the protection devices (fuses or circuit breakers). The fault path value may be found by using the formula in the IEE Wiring Regulations.

## Impedance (Resistance or Reactance) Grounding

An earthing fault limiting resistor is permanently installed in the path of the neutral point of the generator phases to the earth electrode. Used on three phase three wire systems where continuity of power with one ground fault is required. Systems 600 volts and below.

### Unearthed

No internal connection is made between the AC generator system and earth. Used on three phase, three wire systems where continuity of power with one ground fault is required. Used on systems of 600 volts and below.

## Protections

### Unrestricted Earth Fault.

A single Current Transformer is fitted in the neutral earth link, protection is by a simple current sensing relay, which will respond to any current flowing in the earth path, it protects the whole system. The advantages of unrestricted earth fault are:

- It provides protection for all earth faults on the generator, switchgear and system.
- It provides a good level of personnel protection throughout the system.

### Restricted Earth Fault.

Current transformers are fitted in all phases and neutral of the system. Protection is by a simple current sensing relay, which again, will respond to any current flowing in the earth path, it operates only within a protection zone. The zone being limited to the generator and the position of the neutral relative to the current transformers. It does not discriminate with downstream protection. The advantages of restricted earth fault protection are:

- It is not affected by faults outside the protection zone
- It will provide protection discrimination.
- There is less risk of nuisance tripping.
- The protection relay can be set to low levels, reducing damage to the alternator or cables in the event of a fault.
- The protection relay can be set for instantaneous operation. reducing the possibility of touch voltages.

**Differential Protection.**

Current transformers are fitted in all three phases of the equipment and the switchgear equipment. Under fault free conditions, equal currents are induced in the line-end and the neutral-end current transformers. No current flows in the sensing relay, however, under a fault condition it will respond instantaneously to any current flowing in the earth path. The location of the earth link is not important as the whole system is protected. The advantages of differential protection are:

- The relay is very sensitive.
- Both line-to-line and line-to-earth faults are sensed.
- The zone protection eliminates discriminative problems.
- The ability to annunciate which phase(s) have faulted.

## Earthing

Earthing or Grounding a conductor means the connection of the conductor to the earth (the earth is a conductor of electricity). The purpose of this is:

- **TO DECREASE HAZARD TO HUMAN LIFE**
- **TO STABILIZE THE VOLTAGE OF THE SYSTEM WITH RESPECT TO EARTH**
- **TO ENSURE THAT THE VOLTAGE BETWEEN ANY PHASE AND EARTH DOES NOT NORMALLY EXCEED THE PHASE VOLTAGE OF THE SYSTEM**
- **TO REFERENCE THE NEUTRAL POINT SO THAT ITS POTENTIAL DOES NOT FLUCTUATE**
- **TO ALLOW A MEANS OF IMPLEMENTING PROTECTION OF FAULT CURRENT BETWEEN ANY PHASE AND EARTH.**

## Earthing of Low Voltage Single Generating Sets

It is usual for Low Voltage systems (LV) (below 600V), to have their neutral conductor connected directly to earth. This is done between the neutral point of the alternator and the alternator frame (or sometimes in the control panel or switchboard), with a physical linking cable or copper bar. The alternator frame should in turn be earthed into the soil through **BONDING CONDUCTORS** via the main building earth, in accordance with local legislation. In practice, the resistance of the path between neutral and earth should be less than 1Ω in good soil, and less than 5Ω in highly resistive soil. (Absolute maximum 20Ω.)

The neutral to earth connection can be monitored to detect current flowing between earth and neutral. Current will only flow between these two conductors in the case of a short between one of the phases and earth. A direct sustained short via earth represents a near infinite load for the alternator and will result in burning out of the windings.

## Earthing of Low Voltage Multiple Generating Sets

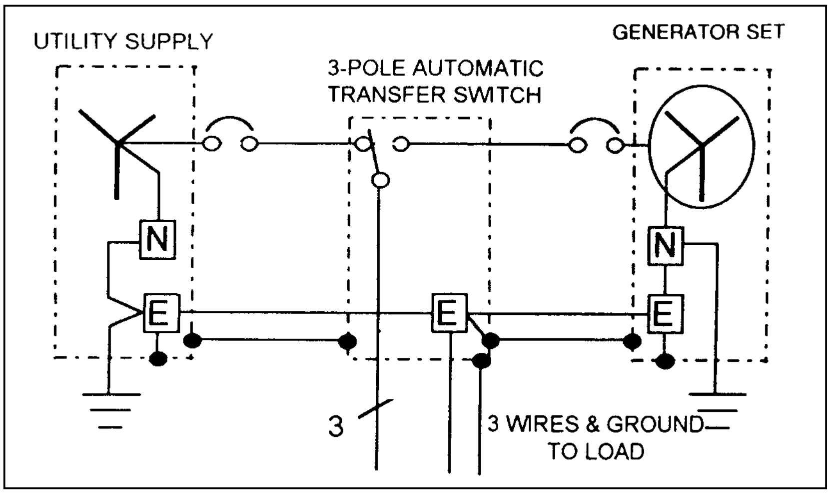
Earthing arrangements for multiple generating set systems should always be in accordance with alternator manufacturers recommendations and the local legislation. Always refer to the system designer.

## Earthing of High Voltage Generating Sets

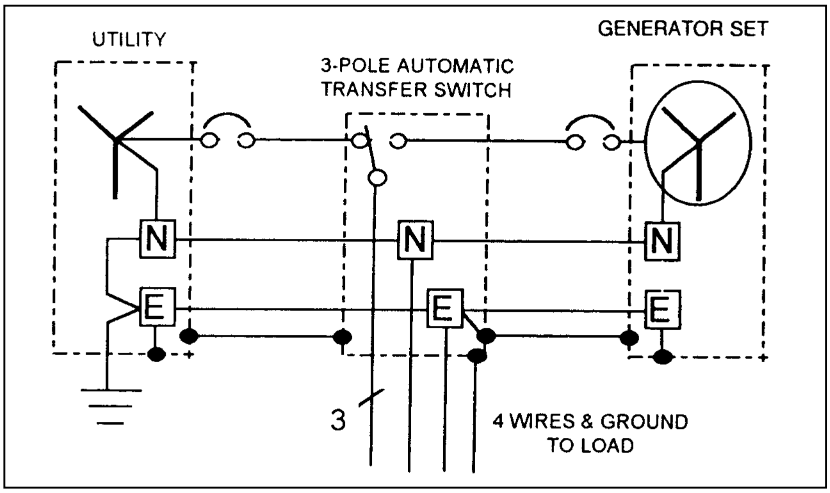
In the case of high voltage systems, the fault current which will flow as a result of one phase being shorted to earth would be many times higher than that of a low voltage system. In order to limit this current to a level which is convenient for detection of CTs and discrimination, a resistance is often placed between neutral and earth in HV systems. Specification and installation of HV systems should always be referred to the designer.

## Typical Earthing Arrangements

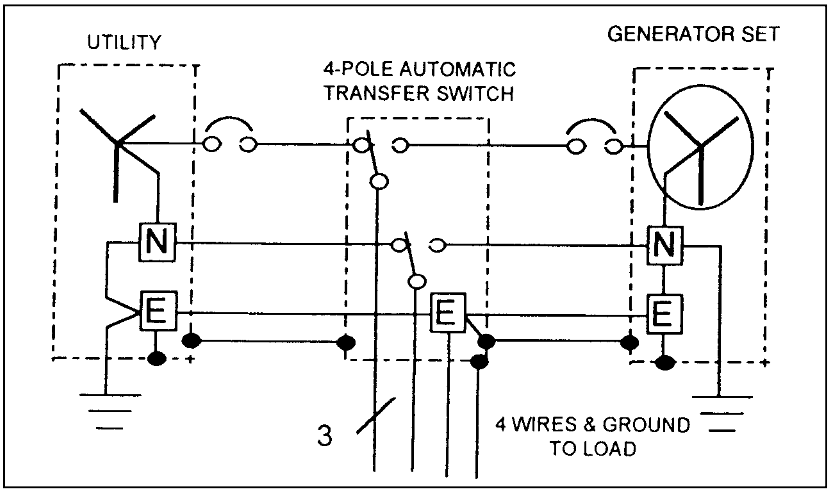
Standby generating set earthing with 3 and 4 pole ATS. N denotes NEUTRAL, E denotes EARTH.




3 phase
3 wire
connection




3 phase
4 wire
connection
3 pole switched
(PME typical)




3 phase
4 wire
connection
4 pole switched

## Earth Fault Protection Schemes

Earth fault protection schemes for generator systems are designed to protect the alternator. Earth fault protection is sometimes referred to in general terms when discussing operator safety and protection schemes. Unless otherwise stated **EARTH FAULT PROTECTION IS FOR MACHINE PROTECTION UNLESS OTHERWISE STATED.** Always investigate whether protection for operators is required.

Earth fault protection schemes for generating sets fall into the following two main categories.

**Restricted**

Restricted earth fault protection concerns only one **ZONE OF PROTECTION**. Restricted earth fault protection should be used on generating set systems to confine the trip in the event of an earth fault to the generating set system **ZONE OF PROTECTION** and not its load. In this way, it is possible to set up more systems which discriminate between the earth faults of the load.

**Unrestricted**

Unrestricted earth fault protection concerns all connected load all the way down the supply line. The **ZONE OF PROTECTION** will in effect be all of the loads connected to the generating set and the set itself. For operator safety 30mA unrestricted protection is used. That is, when 30mA is detected in the earth path, the protection operates.

## Earthing Checklist

- **LV SOLID EARTH.**
- **CONNECTION POINT FOR EARTH.**
- **EARTH LEAKAGE PROTECTION SCHEME REQUIRED.**
- **HV OR MULTIPLE GENERATING SET INSTALLATION – REFER TO DESIGNER.**

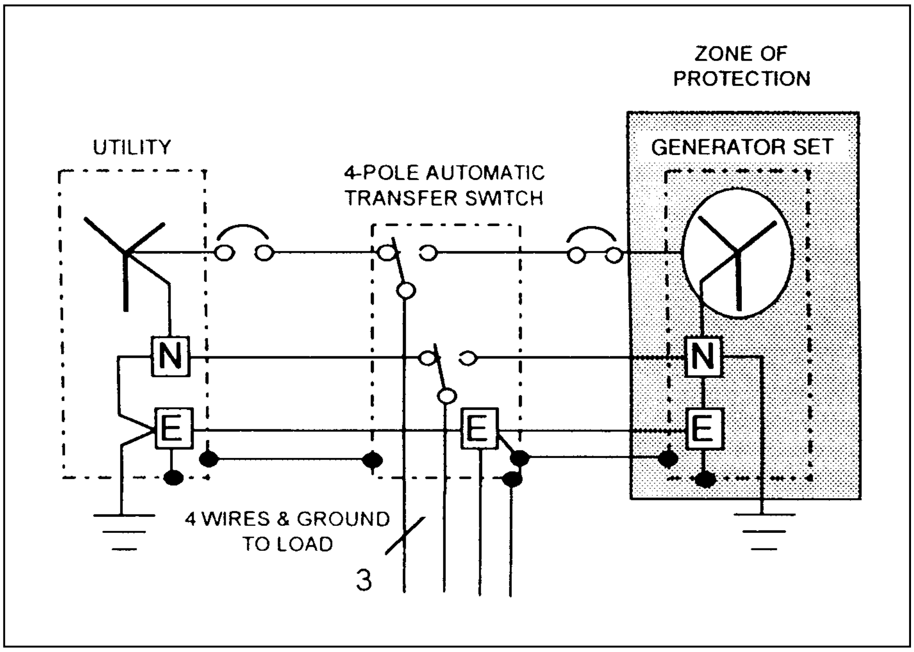



*Fig. D6*

## Earthing or Grounding

An effective earth system is one that ensures at all times an immediate discharge of electrical energy without danger to the lives or health of personnel operating within the installation.

Good connections to earth should have:

- **A LOW ELECTRICAL RESISTANCE TO THE PATH OF LIGHTNING OR FAULT CURRENTS GOOD CORROSION RESISTANCE.**
- **ABILITY TO CARRY HIGH CURRENT REPEATEDLY.**
- **THE ABILITY TO PERFORM THE LISTED FUNCTIONS FOR THE LIFE OF THE INSTALLATION WITHOUT DEGRADATION.**

The earth conductor of a generating set system and all subsidiary earth connections should be sized in accordance with local safety legislation. The IEE Regulations should be used in the absence of specific local legislation.

## System Earthing

This term is used to describe the way in which the generator set system is connected to earth.

Installations either have their neutral connected to earth, or operate with an unearthed neutral in marine cases.

Diesel electric generators for use on land should be intentionally earthed via solid conductor link or resistance in the case of HV sets.

## Equipment Earthing

This term is used to describe the connection of the enclosures of electrical equipment to earth for safety reasons. In such context, the enclosure of a piece of equipment acts as a **PROTECTIVE CONDUCTOR**. Protective conductors in an installation connect together any of the following:

exposed conductive parts which are not live, but could become live in fault conditions,

conductors which do not form part of the electrical system, but which are liable to introduce a potential through magnetic and capacitive coupling, the main earth terminal,

earth electrodes,

earth point of the supply source.

**BONDING CONDUCTORS** act to ensure that a dangerous potential difference cannot exist between the earthed metalwork of the installation and other conductive parts of other services, such as water and gas pipes. Bonding in this way ensures that circuit protection devices will operate in the instance of contact between live conductors and other metalwork. This minimizes the risk of electric shock.

## Lightning Protection

The purpose of lightning protection is to reduce destructive effect of a lightning strike on the installation by conducting the lightning discharge directly to earth. Lightning protection is detailed in BS 6651.

### Air Termination Networks

This is intended to intercept the lightning strike. Current recommendations call for horizontal conductors over the roof of an installation which is never more than 5M away from the roof at any point.

### Down Conductors

This conducts the lightning discharge from the air termination network to the earth point. The conductor should take the most direct route. The conductors should be symmetrically spaced around a building. Loops should be avoided. Each down conductor should have its own earth connection point.

### Bonding to Prevent Side Flashing

Side flashing from a down conductor will occur when a lightening discharge finds an alternative low impedance path to earth via other metalwork near to a down conductor. Where isolation by distance is not possible, then a bond between the metalwork and the system should be fitted.

### Earth Termination Networks

The effectiveness of the termination of the down conductor into the earth is largely dependent on the resistivity of the soil at that point. The resistivity of soil is affected by:

**Physical Composition**

Ash coke and carbon content increase conductivity.

**Moisture Content**

Moisture between 5 and 40% is typically found, increased moisture increases conductivity. (Sandy soils have poor conductivity.)

**Chemical Composition**

There are additives which can be put into the soil to increase its electrolytic properties and increase conductivity.

**Temperature and Depth**

Warmer soil conducts better, and the deeper the soil level, the lower its resistance. The traditional earth rod is about 2.4M. At this depth, the resistivity decreases.

A circuit breaker is an electro-mechanical switch which can be connected in series with the alternator output. The breaker is a type of automatic switching mechanism. Under normal circumstances, it passes current and is said to be closed. It automatically “opens” or “trips” and breaks the circuit when excess current over a preset level flows. The **RATING** of a breaker is the thermal full load capacity of the breaker which it can pass continuously. The essential purpose of a generator circuit breaker is to:

**PROTECT THE ALTERNATOR AGAINST EXCESSIVE CURRENT BEING DRAWN WHICH WOULD EVENTUALLY OVERHEAT THE INSULATION AND SHORTEN THE LIFE OF THE MACHINE.**

Excessive current would flow as a result of either:

**PHASE TO NEUTRAL SHORT CIRCUIT**

or

**PHASE TO PHASE SHORT CIRCUIT**

A circuit breaker should ensure that current levels detailed in the damage curves for the alternator do not flow for longer than the times specified in the damage curves.

Circuit breakers are classified by their trip rating and number of poles.

Breakers provide one trip system per phase and an option for a neutral conductor trip, all are mechanically interlocked, i.e.

- **3 POLE** – all three phases
- **4 POLE** – all three phases and neutral.

In addition, a main line breaker serves the following purposes:

- **DIFFERENTIATE BETWEEN SUSTAINED AND TEMPORARY SHORT CIRCUIT CONDITIONS, TRIP IN THE PRESENCE OF A SUSTAINED FAULT AND NOT TRIP IN THE PRESENCE OF A TEMPORARY FAULT, WHICH CAN BE CLEARED BY THE DOWNSTREAM DEVICES.**
- **PROTECT THE ALTERNATOR FEEDER CABLES IN THE EVENT OF EXCESSIVE CURRENT FLOW.**
- **PROVIDE A MEANS OF ISOLATING THE ALTERNATOR FROM EXTERNAL EQUIPMENT (BY AUTOMATIC AND MANUAL MEANS).**

When generators are connected in parallel, breakers are essential for isolating one running generating set from another which may not be running. Without the ability to isolate the set which is not running, the running set would motor the non-running set. This would result in damage to the engine, and/or alternator on that set.

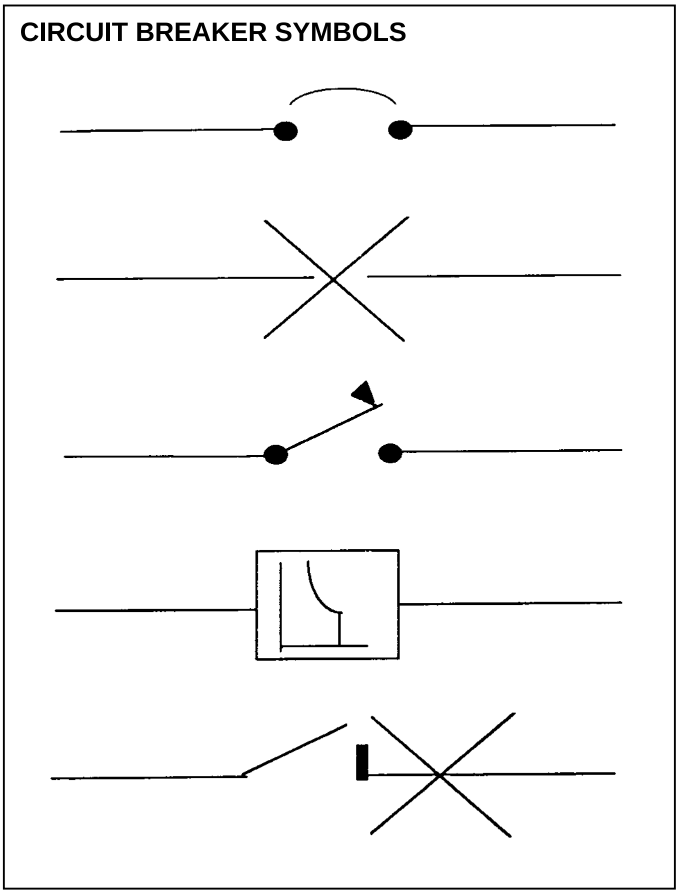



*Fig. D7 In practice, many different symbols are used to represent a circuit breaker by different manufacturers.*

## Fault Clearance Time

This is the time taken for the protective device, the breaker, to disconnect the generator set from the load in the presence of a fault. Different levels of fault current require different disconnection times. For example, an alternator can sustain an overload current of 120% for far longer than it can sustain 300%, without degradation to its insulation.

Local legislation dictates the required maximum clearance time of protective devices under short circuit or earth fault conditions. In practice this is dependent on:

- **THE EARTH LOOP IMPEDANCE OF THE INSTALLATION**
  This is determined by calculation of the resistance of all conductors in the system, or by measurement.
- **THE SENSITIVITY OF THE PROTECTION DEVICE**
  Magnetic trips found in MCCBs can be adjusted to within a tolerance of 20%, while solid state breakers can be adjusted to within 1%.

## Circuit Breaker Action

The action of breaking a current flow between two contacts of a circuit breaker causes the air between the contacts to ionize and conduct, the result being an arc across the contacts.

Contact arcing is undesirable, several methods of increasing the resistance, and therefore dissipating arcs, are employed in circuit breakers. Increasing the resistance of the medium between the contacts is the prime method of arc reduction used. This breaker medium is also used loosely by breaker manufacturers to classify breaker types.

The term **FRAME** used in relation to breakers is used to describe the physical size of the mechanical housing used to contain the circuit breaking mechanism.

- **ACB – Air Circuit Breaker**
  Air is used as the arc interrupt medium, ACBs are loosely divided into:

  **MCCB – Moulded Case Circuit Breakers**
  These are light duty, sealed, and relatively inexpensive breakers. Current technology provides MCCBs for operation up to 600V and between 100 to 2500A. Note Miniature Circuit Breakers MCBs are available from 2-100A as single phase units. These are for use in distribution systems, MCBs are very light duty units for down-line load protection, where fuses might also be used.

  **Metal Frame Air Circuit Breakers**
  These are a heavy duty open frame and heavier duty type of ACB, being used up to 15kV and over 800 to 3200A. Often, these breakers incorporate a **SOLID STATE** overload trip in place of thermal and magnetic trips. **SOLID STATE** trips have the following features:

  - **IMPROVED AND REPEATABLE ACCURACY**
  - **ADJUSTABLE, NARROW BAND PREDICTABLE ACCURACY**
  - **WIDE CURRENT ADJUSTMENT**
- **Oil Circuit Breakers**
  Oil filled breakers have now largely been superseded by advances in VCBs. Oil is used as the interrupt medium. The oil has to be changed at periodic intervals and presents a danger in certain installations.
- **VCB – Vacuum Circuit Breakers**
  The insulation properties of a vacuum make it an excellent arc quencher for HV applications.
- **SF6 – Sulphur Hexafluoride Breakers**
  When pressurized, SF6 is an excellent insulator and braking medium for HV applications.

NB: SF6 has toxin by-products.

## Moulded Case Circuit Breaker (MCCB)

MCCBs are in common use for protecting generating sets, they are available is sizes of 100A to 2500A. The moulded case of the circuit breaker is sealed and maintenance free. The MCCB is designed to be an inexpensive protection device and as such is not intended for repeatedly interrupting fault current (20000 to 50000 changeover cycles). As fault current only flows as the exception and not the normal in a generating set application, MCCBs are acceptable for use on the most common generating set applications up to approximately 1000A, above which ACBs are more often used.

## MCCB Action

MCCBs detect and clear faults by thermal and magnetic trip action.

- **Magnetic Action**

  **Purpose**
  The magnetic tripping element’s characteristic is to give an instantaneous trip in the case of an extreme short circuit, which would damage the alternator.

  **Construction**
  The magnetic tripping element is a type of electromagnetic solenoid operating from the breaker current.

**Trip Time**
There is **NO INTENDED** time delay in this trip, though the physical breaking action takes about 16ms.

**Adjustment**
Adjustment is provided on the instantaneous trip level, the range of adjustment varies according to the manufacturer, but 2-5 times trip rating is possible for a ‘G’ trip, 4-10 times for a ‘D’ trip.

- **Thermal Action**

**Purpose**
The thermal tripping element’s characteristic is to give inverse time delayed tripping action in the case of long-term over current which, if allowed to continue, would damage the alternator.

**Construction**
The thermal trip is a bi-metallic strip, arranged to deform with the heating effects of long-term over current.

**Trip Time**
The trip time is not instantaneous, it is proportional to the time and level of current flowing over the breaker rating.

**Adjustment**
Thermal trips are calibrated by the manufacturers of the breaker, a 40%-100% adjustment range is typically provided. Thermal trips are often provided as interchangeable modules which will fit a range of physically different frame sizes.

In addition, MCCBs are designed to incorporate the following features:

- **Manual Trip Action**

**Purpose**
To provide a means of manually isolating the alternator supply. Used in testing the generator set and as a crude switch in some basic applications.

**Construction**
A toggle is provided which is normally arranged to protrude from the breaker housing. This can be operated like a switch to open the breaker. However, should the toggle be physically held closed in the presence of over current, the breaker will still trip.

**Trip Time**
Regardless of the speed of manual operation, the trip is arranged to always switch in a fixed time period, i.e. that of the instantaneous magnetic trip.

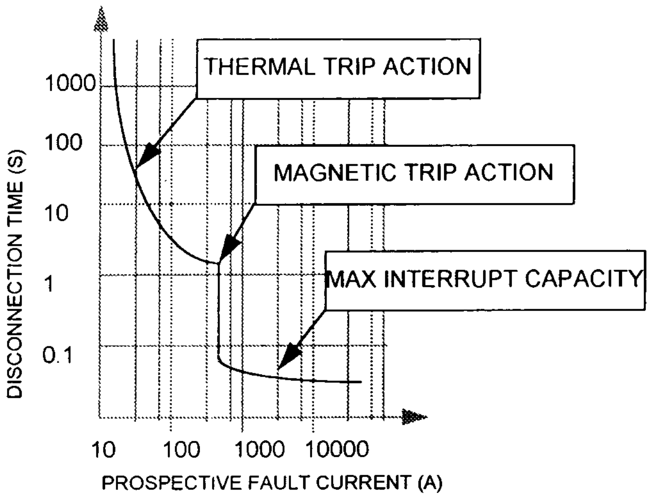



*Fig. D8 MCCB THERMAL AND MAGNETIC TRIP PROFILE*

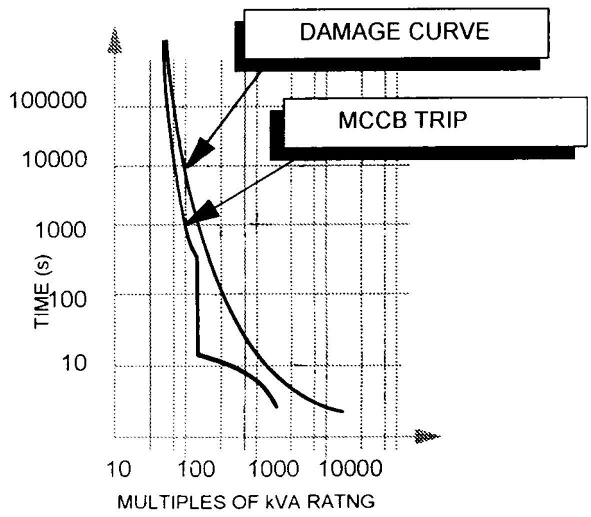



*Fig. D9 MCCB TRIP PROFILE AND THE ALTERNATOR DAMAGE CURVE*

- **Motor Operated Breaker For Paralleling**

  **Purpose**

  A motor assembly (typically DC) is provided by the breaker manufacturer. This motor assembly fits neatly onto the breaker assembly. It provides a means of opening and closing the breaker from a switched motor breaker supply under controlled conditions (unlike the shunt trip, which is provided to open the breaker in the case of a fault). The motor breaker supply may be switched through paralleling equipment, the motor breaker is an essential feature of any automatic paralleling system.

  **Construction**

  Motors for MCCBs fit either to the front or side of the breaker. The complete unit is larger than a single MCCB and housings designed for manual MCCBs often require modification or alternative hood arrangement to house a motor MCCB.

## Breaker Capacity

Most standard specification generating sets are supplied with a breaker as part of the package. In these circumstances, the breaker will suit the majority of generator set applications and will usually be sized around the standby rating.

When selecting a breaker, the following should be considered:

### Steady Current Carrying Capacity

This is the continuous current which the breaker will carry during steady state conditions. For example, while the generator is running at full load.

### Breaking Capacity

This is the maximum current rating which the breaker is able to operate. For example, this would be in the order of 40 times the rated carrying capacity (the level at which the magnetic trip will operate). The breaking capacity required should be calculated from the worst case three phase fault current of the load circuit.

### Ambient Temperature

Breakers are usually rated for 40°C before derate. As the tripping action relies on thermal action it is extremely important to consider the ambient environment and the effect of the enclosure on breaker operating temperature.

### Continuous Operation

The breaker should carry its full load rating indefinitely.

### Full Load Current

Full load current or FLC can be calculated for a given system from:

$$FLC = \frac{1000(\text{POWER in kW})}{1.73 \times \text{PHASE VOLTAGE} \times \text{POWER FACTOR}}$$

or

$$FLC = \frac{1000(\text{POWER in kVA})}{1.73 \times \text{PHASE VOLTAGE}}$$

## MCCB Physical Size, Mounting and Connection

Circuit breakers increase in physical size with the increased current carrying and tripping capacity. With current technology, MCCBs are available up to 1000A and can be mounted onto the alternator conduit box. This is done for reasons of economy. Vibration rarely causes a problem, however towards 630A, it is common to find the breaker separately mounted from the alternator for added vibration isolation.

Above 1000A the breaker would be of the traditional ACB type, larger and heavier than an MCCB. This type of breaker would be mounted in a free-standing cubicle.

As the current carrying capacity of the breaker increases, so does the load cable diameter. It is common practice to double up on load cables, that is use two per phase, instead of using one large, and often very expensive area on the breaker terminal required for the load cable lugs to be fitted. In addition, the glanding and channeling arrangement for the load cable will increase as the number of load cables are increased.

It is useful to obtain some idea of customer load cable arrangements, as this will figure in deciding upon the most appropriate position for the set breaker.

The use of steel wire armoured cables will necessitate the use of an interposing link box between a set mounted breaker and the armoured load cable. Armoured load cable is rigid and should be installed into a trench or into fixed channeling. This type of cable should be terminated close to the generator set and flexible cables used to connect to a breaker which is vibration isolated from the bed of the set. Failure to use this arrangement for steel wire armoured cable will almost certainly result in the disturbance of the cable mountings on the generating set with eventual damage to the load cable and possible fire.

## Switchgear Certification in Accordance with the LVD

The European (EEC) Low Voltage Directive (LVD) has been in force since 1973. In the UK, this is implemented by BS 5486, which calls for switch gear to be tested to its declared rating. The Association of Short Circuit Testing Authorities (**ASTA**), is one of the four bodies in the UK authorized to assess compliance with the LVD. Its objectives are:

- The coordination of the type testing of electrical power transmission and distribution equipment.
- The issuing of certificates based on the satisfactory performance of type tests under the direction of independent ASTA observers.

Other bodies with this authorization in Europe include:

N.V. tot Keuring Van Electrotechnische Materialen (**KEMA**) in Holland.

Gesellschaft fur Elektrische Hochleistungsprufungen (**PHELA**) in Germany.

Centro Elletrotechnico Sperimentale Italiano (**CESI**) in Italy.

Ensemble des Stations Dessais a Grand Puissanse Francaises (**ESEF**) in France.

## Power Switching Standards

| Standards | Content |
|---|---|
| BSEN 60947 | Part 1 – general rules<br>Part 2 – circuit breakers<br>Part 3 – switches, disconnectors<br>Part 4 – contractors and motor starters<br>Part 5 – control devices and switching elements;automatic control components |
| IEC 158-1 2nd edn. 1970<br>Part 158-1A (1975) | Low voltage control equipment, including contactors |
| UTE.NFC 63-110 (April 1970) | Low voltage industrial equipment, including contactors |
| VDE-0100 (May 1973) | Specification for the construction of high current installations where the nominal voltage <1000V |
| VDE-0105 (August 1964) | Specification for high current installations |
| VDE-0110 (November 1972) | Specification for leakage paths and distances in air |
| VDE-0113 (December 1973) | Din 57113. Specification of electrical equipment for machine tools where the nominal voltage <1000V |
| VDE-0660/1 (August 1969) | Specification for switches where the nominal voltage <1000V for AC and <3000V for DC |
| BS 5425 1977 | Contactors for voltages <1000V AC and <1200V DC |
| CEI Publ. 252 | Contactors for voltages <1000V AC and <1200V DC |
| NEN 10-158-1 | Low voltage control equipment |
| SEN 280/600 (1974) | Low voltage control equipment |
| IEC 408 (or BS 5419) | Defines duty categories for power switching devices AC22 switching of mixed resistive and inductive loads including moderate overloads<br>AC22 switching of motor or other high inductive loads |
| IEC 947 | Defines electrical characteristics of power breakers and is adhered to by breaker manufacturers |
| BS 5486 part 1 | Low voltage switchgear and control gear assemblies |

## Breaker Enclosures

Breaker enclosures are provided to protect live terminals from the touch of operators, to contain electrical arcs and in some outdoor applications, to protect from the effect of the environment.

The housing of a breaker for generating set protection is normally either set-mounted, wall-mounted or free-standing. The wall-mounted and free-standing types require interconnection cable between alternator and breaker, which will be physically further away than the set-mounted devices. This physical distance should be kept as short as possible (less than 3m) and the interconnecting cables should be rated with the breaker capacity in mind.

The affect of the enclosed on the breaker rating should be carefully considered. The thermal tripping capacity of a breaker must be derated with increase in ambient temperature. It therefore follows that the better the sealing of a breaker enclosure, and hence the worse the ventilation, then the more the breaker will require derating.

This derate should be incorporated into the generator set design. However when operating at full load capacity in high ambient temperatures (above 40$^0$C), it is important to consider the effect of the increased ambient to avoid nuisance tripping of the breaker.

The degree of protection provided by a breaker enclosure is classified by the Index of Protection (IP) as outlined by BS 5420 (IEC144).

As a general guide, IP33 is a standard specification for indoor breaker enclosures, this offers protection:

- against the ingress of foreign bodies up to 2.5mm diameter
- against contact by the fingers with internal parts
- against vertically falling water droplets.

As a general guide, IP55 is an enhanced specification for indoor breaker enclosures, this offers increased protection:

- against deposits of dust which would prevent normal operation
- against contact by the fingers with internal parts
- against jets of water from any direction.

## Discrimination and Coordination

In electrical distribution systems with one large feeder (a generator set) feeding multiply branches, it is important to insure that a single fault on one small load of a few amps on one branch, does not cause the whole system to shut down. Particularly in stand-by generating set systems, where critical loads must be maintained, the breakers and fuse systems must be arranged to isolate a faulty load and allow the rest of the circuit to operate undisturbed.

The term **DISCRIMINATION** (or selective tripping) applied to electrical systems is used to describe a system with graded protective devices which operate to isolate only the faulted load from the rest of the circuit.

The term **CO-ORDINATION** applied to electrical systems is used to describe the arrangement of discriminative tripping devices.

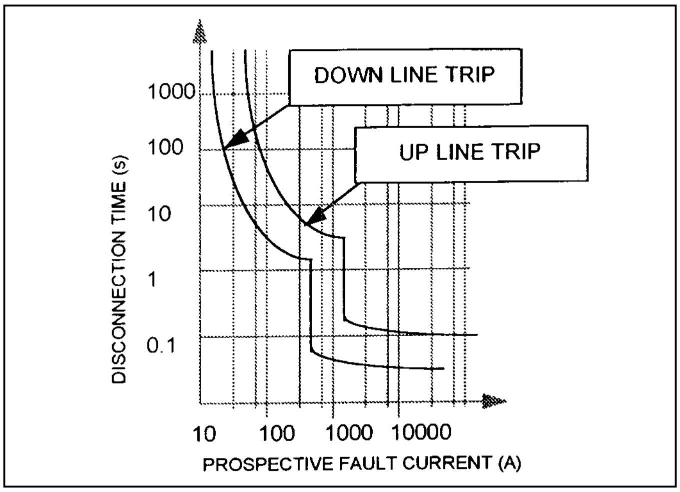



*Fig. D10*

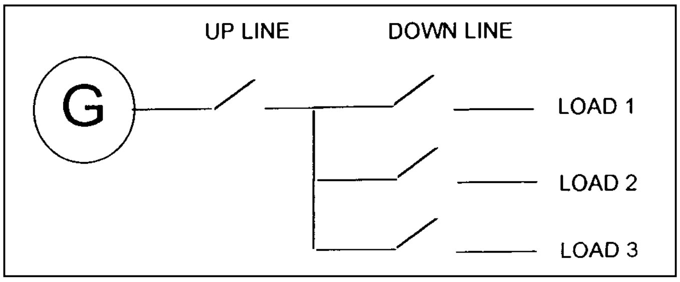



*Fig. D11*

## Breaker Checklist

- **LOAD FAULT CURRENT VERSUS BREAKER CONTINUOUS LOAD CURRENT RATING**
- **FAULT CLEARANCE TIME**
- **DERATE FOR TEMPERATURE**
- **SPECIFY NUMBER OF POLES**
- **SET-MOUNTED OR FREE-STANDING ENCLOSURE**
- **IP RATING OF ENCLOSURE**
- **NUMBER OF CUSTOMER LOAD CABLES PER PHASE AND CABLE LUG SIZE**
- **STEEL WIRE ARMOUR CABLE TERMINATION ARRANGEMENTS**
- **GLANDING AREA REQUIRED FOR CUSTOMER LOAD CABLES**
- **BENDING RADIUS OF CUSTOMER LOAD CABLES ONTO BREAKER**

## Automatic Transfer Switch (ATS)

The term **ATS** or **AUTOMATIC MAINS FAILURE PANEL** is usually associated with the switching arrangements for mains fail emergency standby generating set systems. The purpose of an automatic transfer switch is to:

- **MONITOR THE UTILITY SUPPLY FOR FAILURE**
- **TRANSFER THE LOAD TO AND FROM THE UTILITY SUPPLY TO THE STAND-BY SYSTEM IN A CONTROLLED MANNER**

The ATS contains a power switch element and a control element. The control element is sometimes part of the generator set control or some centralized control system in larger installations.

The ATS is usually housed in a separate cubicle wall-mounted or free-standing. The ATS may be located in the main switching facility of a large installation, whereas the generator may have its own dedicated building. It is most desirable to site the ATS near to the load, thereby minimising the length of cable run from each power source to the load.

## Automatic Transfer Switch Control System

In some European specifications, the transfer switch controls can be located on the generating set, others and in particular those influenced by the US, will have a degree of intelligence (timers) built into the transfer switch. The transfer switch control system is responsible for the following three control sequences.

### Mains Fail

In order to detect the failure of the utility supply the control system must compare the utility supply voltage with a preset minimum level, then a timer is started. The timer introduces a delay of about 5 seconds before the transfer switch will start the generating set. The purpose of this **MAINS FAIL TIMER** is to ensure that short duration dips in the utility supply voltage will not cause the generator to start unnecessarily. As a result of the mains fail timer expiring, the controller signals the generator to start. The generator starter motor is often controlled from the ATS. This will engage and rest the starter motor for regular periods until the engine turning conditions are detected. (Alternator voltage, speed sensed at the flywheel.) If the engine does not start after a pre-determined number of attempts, then a fail to start alarm is indicated.

Once the engine is up to rated speed and volts the load breaker is closed.

### Mains Return

Once the generator is running and supplying the load acting as emergency standby, the utility supply may be reinstated. There may, though, be several cases of the utility supply being established momentarily and then failing again. The **MAINS RETURN TIMER** takes care of this effect by starting every time the mains is established and resetting should the mains drop off again. The mains return timer is usually around 3 to 5 minutes, the mains must therefore be healthy for this period before the transfer switch opens.

### Run On

After the transfer switch has re-connected the load onto the mains, the generator set is **RUN ON** for a cooling down period before it is signalled to stop by the transfer switch. Should the mains fail again during this **RUN ON** period, then the transfer switch will immediately switch in the generator set output.

In addition, it is common to site the engine exercising timer in with the ATS control system in automatic mains failure stand-by systems.

### Exercise Timer

This will automatically start the generator set at regular periodic intervals, the transfer switch is not operated over from the utility supply position.

It is important to be clear on the most suitable position for the transfer switch controls in any application. This may be dictated to a large extent by the features of the particular genset/ATS controls used.

However, always be sure where controls are required in the ATS, that there is a suitable local supply for these controls. In cases where the generating set is located near to the ATS and the generating set batteries are available, then supply voltage is not an issue.

In cases where the ATS is to be located remotely, some distance (more than 20 metres) from a generating set, then it is not recommended to run long lengths of supply cable to the ATS, as the volt drop in these cables can lead to non-start problems. A relay scheme will assist in these cases.

In particular, for remote ATS type systems, it may be tempting to position battery charges inside the transfer switch panel, or next to it. This is not recommended, as the battery charging current in this situation will be faced with the resistance of the cable between the charger and the batteries and will consequently not see true battery terminal voltage.

In summary, the approach of controlling the transfer switch from the generator set is a more flexible and hence favourable scheme for general ATS/generator control.

## ATS Standards

ATS for use in Europe should meet any local legislation and the international standards IEC-947-4 AC1, IEC-158-1, VDE0106, BS 4794. As standard products, they are usually available in approved ratings from 30A to 4000A below 600V.

For use in North America, ATS should be UL approved. ATS are listed in Underwriters Laboratory Standard UL1008. UlL approval adds to the cost of the ATS and is not necessary for the sale of an ATS in Europe.

## ATS Power Switch Element

Transfer switches are available as three or four poles switching mechanisms (linear switches) and changeover contactor pairs. They employ similar techniques to current breaking as circuit breakers. Many ATS systems under 1250A are comprised of two contactors mechanically and electrically interlocked. Above 1250A, it becomes economic to incorporate the circuit breaker element into the generator contractor and these are now widely available as a package at 1250 Amps plus.

## Sizing an ATS

To correctly detail the transfer switch requirement for a particular application, it is necessary to consider each of the following features of an ATS.

**Voltage**

The operating voltage of the circuit must be greater than the circuit voltage.

**Frequency**

The operating frequency of the ATS must be equal to the operating frequency of the circuit.

**Number of Phases**

In general, transfer switches are available as three phase units.

**Number of Cables Per Phase**

Each phase may comprise of more than one cable to carry total load. It is important to ensure that there is adequate termination on the transfer switch for the number of cables used to carry the load. For example, there may be two cables per phase onto the switching mechanism. The width of the termination lug and the diameter of terminating bolt need to be known in order to determine the cable termination arrangements. Most manufacturers offer a range of termination kits which can be retro fitted onto a standard terminal arrangement. Always follow manufacturer’s and legal recommendations for cable termination. There are minimum safe distances between exposed conductors.

**Type of Load**

Special consideration must be given to switching motor loads. For example:

- **MOTORS**
- **HIGH INERTIA LOADS**
- **CENTRIFUGAL PUMPS**
- **CHILLERS**

Due to the voltage decay characteristics of inductors when experiencing a sudden change to the current flow, the voltage across motor terminals will take time to fall. For this reason, it is necessary to incorporate a delay into the transfer action of the ATS when live switching motors. This is usually provided as a timer in the ATS control, which is normally set to instantaneous transfer with no motor loads.

**Available Fault Current**

The worst case three phase fault current for the given load must not destroy the transfer switch before the over current or ground fault protection systems have operated.

**Number of Switched Poles**

Ground fault protection of electrical systems that have more than one power source, i.e. a load is fed by either a utility or engine generator set, requires special consideration. A problem may occur in that the neutral conductor of the engine generator set is generally required to be grounded at its location, thus creating multiple neutral-to-ground connections. Unless the system is properly designed, multiple neutral-to-ground connections may cause improper sensing of the ground fault currents and nuisance tripping of the circuit breaker. One approach is to use a four pole ATS in which the neutral conductor is switched to provide isolation in the event of a ground fault.

**Cable Entry**

As the rating increases, the routing of cable becomes increasingly more awkward. It is important to specify the correct cable entry point into the ATS enclosure for the type of cable, its angle of entry to, and connection point within, the enclosure.

**Temperature**

The continuous rating of an ATS will be quoted up to $40^0$C approximately, above this a derate must be applied to the maximum current carrying capacity.

## ATS Checklist

- **VOLTAGE**
- **FREQUENCY**
- **NUMBER OF PHASES**
- **NUMBER OF CUSTOMER LOAD CABLES PER PHASE**
- **LOCATION OF ATS MAINS FAIL DETECTION AND CONTROL TIMERS**
- **SUPPLY VOLTAGE FOR ATS CONTROL**
- **INDUCTIVE LOAD SWITCHING – TRANSITION TIMERS**
- **LOAD FAULT CURRENT VERSUS CONTINUOUS ATS/CONTACTOR PAIR CURRENT RATING**
- **NUMBER OF SWITCHED POLES**
- **DERATE FOR TEMPERATURE**
- **IP RATING OF ENCLOSURE**
- **NUMBER OF CUSTOMER LOAD CABLES PER PHASE AND CABLE LUG SIZE**
- **STEEL WIRE ARMOUR CABLE TERMINATION ARRANGEMENTS**
- **GLANDING AREA REQUIRED FOR CUSTOMER LOAD CABLES**
- **BENDING RADIUS OF CUSTOMER LOAD CABLES ONTO BREAKER**

Safety should be the primary concern of the facility design engineer and all personnel engaged on installation and commissioning. Safety involves two aspects:

1) Safe operation of the generator itself (and its accessories).
2) Reliable operation of the system.

Reliable operation of the system is related to safety because equipment affecting life and health, such as life support equipment in hospitals, emergency egress lighting, building ventilators, elevators and fire pumps, may depend on the generator set.

## Fire Protection

The design, selection and installation of fire protection systems require the following considerations:

- The fire protection system must comply with the requirements of **National Standards** and of the authority having jurisdiction; who may be the building inspector, fire marshal or insurance carrier.
- Typically, the generator room will be required to have a one hour fire resistance rating if the generator set will be in at level 1 application. Generator room construction will have to have a two hour fire resistance rating.
- The generator room shall **NOT** be used for storage purposes.
- Generator rooms shall not be classified as hazardous locations **(as defined by the NEC)** solely by reason of the engine fuel.
- The authority will usually classify the engine as a heat appliance when use is for only brief, infrequent periods, even though the flue gas temperature may exceed 1000°F (538°C).
- The authority may specify the quantity, type and sizes of approved portable fire extinguishers required for the generator room.
- A manual emergency stop station outside the generator room or enclosure or remote from the generator set in an outside enclosure would facilitate shutting down the generator set in the event of a fire or another type of emergency.
- The authority may have more stringent restrictions on the amount of fuel that can be stored inside the building than published in national standard.
- Fuel tank construction, location, installation, venting, piping, and inspection inside buildings and above the lowest storey or basement should comply in accordance with National Standards.
- The generator set shall be exercised periodically as recommended under at least 30% load until it reaches stable operating temperatures and run under nearly full load at least once a year to prevent fuel from accumulating in the exhaust system.

Many national, state and local codes incorporate standards which are periodically updated, requiring continual review. Compliance with the applicable codes is the responsibility of the facility design engineer.

**General**

- Do **NOT** fill fuel tanks when the engine is running, unless tanks are located outside the generator room.
- Do **NOT** permit any flame, cigarette, pilot light, spark, arcing equipment, or other ignition source near the generating set or fuel tank.
- Fuel lines must be adequately secured and free of leaks. Fuel connection at the engine should be made with an approved flexible line. Do **NOT** use copper piping on flexible lines as copper will become brittle if continuously vibrated or repeatedly bent.
- Be sure all fuel supplies have a positive shut-off valve.

## Exhaust Gases

- Be sure the exhaust system will properly dispel discharged gases away from enclosed or sheltered areas and areas where individuals are likely to congregate. Visually and audibly inspect the exhaust for leaks as per the maintenance schedule. Ensure that exhaust manifolds are secured and not warped.
- **NEVER** connect the exhaust systems of two or more engines.
- **NEVER** discharge engine exhaust into a brick, tile or cement block chimney, or a similar structure. Exhaust pulsations could cause severe structural damage.
- Do **NOT** use exhaust gases to heat a compartment.
- Be sure that the unit is well ventilated.
- Shield or insulate exhaust pipes if there is a danger of personal contact or when routed through walls or near other combustible materials.
- **ENSURE** that there is independent support for the exhaust system. No strain should be imposed on the engine exhaust manifolds. Which is especially important on a turbocharged engine. Stress on a turbocharger could distort the housing, leading to failure.

## Annunciation

Codes may require different levels of annunciation for critical life safety and all other emergency standby applications.

## Moving Parts

- Tighten supports and clamps and keep guards in position over fans drive belts etc. Make sure that fasteners on the set are secure.
- Keep hands, clothing and jewellery away from moving parts.
- If adjustment must be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

## Hazardous Voltages

Electrical power generating, transmission and distribution systems will be required to comply with the applicable statutory regulations and approved codes of practice of the particular country of installation.

**Statutory Regulations (UK)**

These include:

- Electricity Supply Regulations 1988; security of the safety of the public and ensuring a proper and sufficient supply of electrical energy.
- Electricity at Work Regulations 1989, Statutory Instrument 1989 No 635; these came into force on the 1st April 1990 and apply to all work places - not only factories and sub-stations.
- Health and Safety at Work, etc. Act 1974; imposing requirements for safety (including electrical) in all employment situations; and the control of certain emissions to the atmosphere.
- The Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972; this and the following regulation cover premises where fire risk is of an unusual character and requires special consideration.
- The Petroleum Consolidation Act 1928.
- The Construction (General provisions) Regulations 1961; apply to the construction sites and contain regulations relating to precautions to be taken with contact with overhead lines and underground cables; may also apply to temporary installations under particular local authority and insurance company requirements.

The administrative or legislative authority for Electricity Supply Regulations is the secretary of State for Energy; in every other case stated above it is the Health and Safety Commission.

Some regulations are sufficiently detailed as to set down just what has to be done for compliance. They may or may not include direct reference to Codes of Practice. Where they do, such codes have the same legal force as the Regulations themselves. Other generally accepted codes of good practice, which are not directly referenced, are not legally enforceable.

With any legislation there is always a need for guidance on the application of regulations. The following publications are recommended reading. They are obtainable from **HMSO (Her Majesty's Stationery Office).**

- Explanatory notes on the Electricity Supply Regulations 1988.
- Memorandum of Guidance on the Electricity at Work Regulations 1989, HSE booklet HS(R)25.
- In the context of the Petroleum Consolidation Act 1928, the Home Office Model Code of Principles of Construction and Licensing Conditions Part 1.
- Note: Local authorities are empowered to grant licences for the storage of petroleum spirit on premises with their jurisdiction. The conditions for Licence may vary from one authority to another.

Where it is proposed to install a protective multiple earthing system it is mandatory, in the UK, that approval is obtained from the Secretary of State for Energy. Government authorisation is now largely delegated to area electricity boards.

Before a generating station or transmission line is erected, prior approval of the local planning authority must be obtained. This is a requirement of the Town and Country Planning Acts in the UK.

**Codes of Practice**

Approved Codes of Practice are usually generated by the Health and Safety Commissions, possibly in conjunction with industrial committees or with the British Standards Institution. Codes of Practice otherwise published by BSI or professional or trade bodies are classified as non approved codes. The BSI codes of Practice are supplemented by detailed specifications covering application and design of equipment, material and manufacturing standards.

Of the Codes and Standards prepared by professional institutions and trade associations perhaps the most important in our context, are the IEE Regulations for Electrical Installations. Whilst they may not be legally enforceable they represent the best practice in electrical safety. Indeed, failure to the fundamental requirements contained in Part 1 of the Regulations could not lead to a an Electricity Supply Authority withholding a supply of energy to the installation.

**Overseas Regulations**

It is necessary to ascertain what regulations apply when designing an overseas installation. For example, in those locations where American practice is observed, safety codes are inevitably those prepared by the National Fire Protection Association. (NFPA). The BSI's Technical Help to Exporters (THE) service should be consulted for guidance on other territories.

Control wire installation must be carried out with care to avoid touching un-insulated live parts, especially inside the control panel box which can result in severe personal injury or death.

Improper wiring can cause fire or electrocution, resulting in severe personal injury or death and property or equipment damage.

For personal protection, stand on a dry wooden platform or rubber insulating mat, make sure clothing and shoes are dry, remove jewellery from hands and use tools with insulated handles.

- Do **NOT** leave cables trailing on the engine room floor.
- Do **NOT** use the same trunking for electric cables and fuel or water lines
- Do **NOT** run AC and DC cables in the same looms or trunking
- **ALWAYS** ensure that bonding and equipment earthing are correctly done. All metallic parts that could become energised under abnormal conditions must be properly earthed.
- **ALWAYS** disconnect the batteries and battery charger when servicing or carrying out maintenance, particularly on equipment arranged for automatic mains failure operation. **ALWAYS** disconnect a battery charger from its AC source before disconnecting the battery cables. Otherwise, disconnecting the cables can result in voltage spikes high enough to damage the DC control circuit of the set. Accidental starting of the generator set while working on it can cause severe personal injury or death.
- Do **NOT** tamper with interlocks.
- **ALWAYS** follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician.
- Do **NOT** connect the generator set directly to any building electrical system.
- Hazardous voltages can flow from the generator set utility line. This creates a potential for electrocution or property damage. Connect only through an approved isolation switch or an approved paralleling device.

**High voltage** sets work differently to low voltage ones. Special equipment and training is required to work around high voltage equipment. Operation and maintenance must be done only by persons trained and qualified to work on such devices. Improper use or procedures may well result in personal injury or death.

- Do **NOT** work on energised equipment. Unauthorised personnel must not be permitted near energised equipment. Due to the nature of high voltage electrical equipment induced voltage remains after the equipment is disconnected from the power source. Equipment should be de-energised and safely earthed.

**Water**

Water or moisture inside a generator increases the possibility of "flashing" and electrical shock, which can cause equipment damage and severe personal injury or death. Do not use a generator which is not dry inside and out.

## Coolants and Fuel

The coolant heater must not be operated while the cooling system is empty or when the engine is running or damage to the heater will occur.

Coolant under pressure have a higher boiling point than water.

- Do **NOT** open a radiator, heat exchanger or header tank pressure cap while the engine is running. Allow the generator set to cool and bleed the system pressure first.

Never use galvanised or copper fuel lines, fittings or fuel tanks. Condensation in the tanks and lines combines with the sulphur in the fuel to produce sulphuric acid. The molecular structure of the copper or galvanised lines or tanks reacts with the acid and contaminates the fuel.

Generating plants are used in three main duties:

1) **Primary or Base Load Duty**
2) **Peak Lopping Operation**
3) **Standby to Utility mode**

## Load Characteristics

An overall assessment of load characteristics is necessary therefore the nature and characteristics of loads must be established, supported by analysed data. Installed equipment should be listed and duty cycles known.

The proposed method of plant operation should be known so that the load factor can be assessed and the demand deduced.

Where loads of different power factor are being considered, the active and reactive powers should be segregated, and then added separately. More accurate predictions can be made by applying diversity factors on both the reactive and active power.

The mode of operation of any motors requires to be established.

Generating capacity must be sufficient to meet peak power demand, even if the peak only occurs for a few hours once a year. Future load expansion should not be ignored, as there may well be a rise in energy requirements.

The timing of power plant additions must be carefully planned and expedited and extra capacity should be deferred until the need arises. Designs must be flexible enough to allow for planned expansion with the minimum of disruption to existing plant. It is usual to provide, at the outset, 10 to 20% margin of capacity over and above that required by the annual peak demand.

**'Safe Generating Capacity' (SGC)**

The SGC (safe generating capacity) = (installed capacity of station) - (capacity of largest machine) - (a further margin of 15% of the remaining installed generating plant). The SGC caters for system demand.

The latter margin allows for the site derating due to high ambient temperatures and low atmospheric pressures.

A typical **5MW** station with 5 x 1MW sets would have an SGC of:

(5) - (1) - (4 x 0.15) = 3.4MW

**Definitions**

**Peak load** is the maximum load or maximum demand during the period specified.

**Utilisation factor** the ratio of peak load to the plant capacity.

**Average load** is the average height of the load curve, given by;

$$\frac{\text{the total energy over a period}}{\text{the total hours in the period.}}$$

**Capacity factor** is the ratio of the average load to the plants total capacity. It is the measure of the actual energy supplied.

**Load factor** the measure of the plants utilisation, or the ratio of the energy units actually supplied in a given period.

The more usual way of expressing the load factor is to use the consumer's maximum demand (in kW or kVA) multiplied by the length of period in hours. The annual load factor (ALF) would then be given by:

$$\text{ALF(\%)} = \frac{\text{units* used in the period x 100}}{\text{Maximum Demand (MD) x 8760}}$$

(*the units would be in kWh, if the MD is in kW)

It is very unusual that individual consumers' MD's will coincide at any one time. The maximum demand on the plant will always be less than the sum of the MD's of the individual consumers.

The type and rating of generating plant must be dependent on the nature and size of the load it is required to serve.

- The element which require close tolerance parameters (computers and telecommunications)
- The element likely to change the load demand of the set or affecting transient performance, such as;
- step change loads or motor starting.
- non-linear loads.
- cyclically varying loads.
- regenerative loads.

## Motor Starting

**To accurately calculate the size of your generating set when the load consists of a number of electric motors, varying in size, possibly with different forms of starting methods plus a variety of resistive loads it is necessary to be very accurate to avoid undersizing your machine. For this reason Cummins Power Generation have developed a software programme called GENSIZE III to assist and considerably speed up the calculations necessary. If this programme does not accompany this manual, please apply to your local distributor or direct to the factory in Manston, Ramsgate, Kent, U.K.**

The effect of motors starting and start sequence should be determined in conjunction with the running loads so that the least size of genset can be selected to match the load profile. In certain circumstances, it may be more prudent to consider the miss-matching of engine and alternator to find the optimum solution.

### Sizing

It should be noted that the largest motor may not necessarily have the largest impact on load, the impact being determined by the starting method.

The various normal starting methods, with their general starting characteristics, are as follows:-

| | | |
|---|---|---|
| a) | Direct on line | 7 x flc, 0.35 pf |
| b) | Star Delta | 2.5 flc, 0.4 pf |
| c) | Auto transformer | 4 x flc (75% tap), 0.4 pf |
| d) | Electronic Soft start | 3 x flc, 0.35 pf |
| e) | Inverter Drive | 1.25 flc, 0.8 pf |
| | | (flc = full load current) |

Particular care must be taken to ensure that:

1. **engines can develop sufficient kilowatts.**
2. **alternators can develop sufficient kVA.**
3. **frequency and voltage drops can be maintained within acceptable limits when the various loads are introduced.**

It is recommended that the client, or his consultant, be contacted to discuss the load profile, particularly in cases where worst case loading (i.e. the most onerous impact load starting with all other loads connected) provides a less economical solution in terms of capital cost of equipment. A better solution may be achievable by re-arranging the profile.

- To size the generating sets once the optimum sequence of operation has been determined, refer to the GenSize 3.0 programme (available free on request).

### Voltage Dip

Voltage dip is largely independent of the load already carried by the generator, particularly if this is a mixed passive load, but any motors running on the system at the time will experience a speed change, which will cause them to draw more current. This increased load current, when added to the starting current of the starting motors causes the voltage dip to exceed its expected value.

The magnitude of the voltage dip at the generators terminals, following load switching, is a direct function of the subtransient and transient reactances of the machine.

Dip, $\Delta V = X'du\ (X'du + C)$

Where X'du is the per unit unsaturated transient reactance and C is the ratio:

$$C = \frac{\text{generator rating (kVA or current)}}{\text{impact load (kVA or current)}}$$

### Limiting Voltage Dip

The voltage dip on a machine can be limited in a number of ways:

1. Where a number of motors constitute a major part of the load, it may be feasible to limit the starting sequences of the motors minimising the impact load.
2. The motors with the largest load should be run up first.
3. A generator of low transient reactance may be used, this can be achieved by using a larger frame size machine.

## Power Factor Correction

When the load current and voltages are out of phase due to the load not being purely resistive, defined as lagging and leading loads, no single angle can be used to derive the power factor.

The methods used for power factor correction are:

1) Synchronous motors (driving pumps, fans, compressors, etc. with their working power factor adjusted, through excitation control, to give operation at unity or leading power factor. The motors will only contribute to power factor correction whilst they are running.
2) Synchronous condensers, which are effectively synchronous motors used solely for power factor correction and voltage regulation.

### Capacitors

By individual correction using capacitors directly connected to the supply terminals of individual, low power factor items of plant.

By using manually controlled capacitors, located at key points within the plant, and switched in when the appropriate sections of plant are in operation.

Automatically controlled capacitors switched in and out of circuit by contactors as the load varies.

Power factor correction capacitors operate at almost zero power factor leading and are used to correct the overall lagging power factor of a complete installation to a value near to unity power factor but still lagging.

## Unusual Loads

### Non-linear Loads

The use of solid state power devices such as thyristers and triacs are major sources of harmonic distortion in supply networks. The non linear load currents that characterise such equipment may well be within acceptable limits, where the power source is a low impedance public utility supply, but if a converter is used in the installation the non linear loads will be more significant and less predictable. The harmonic currents generated will depend upon the type of converter used, whereas the resulting voltage harmonics will relate to the property supply network.

To suppress harmonic distortion the following methods can be used;

**Filter banks:** their design requires considerations of the load duty cycle and knowledge of the impedances, to avoid them acting as sinks for harmonics generated elsewhere.

- Grouping the converters to form a single unit.
- Phase shifting; with the use of special rectifier transformers which alter the phasing of the secondary winding or the angle at which the harmonics are produced.
- Reduction of the supply system impedance: by increasing the frame size of the alternator or using a specially designed low-reactance machine.

### Fluorescent Lights

At ‘switch on’, fluorescent lights produce high transient terminal voltages, as a purely capacitive load is present without any appreciable level of active load. The power factor correction capacitors of fluorescent lamp installations can have the effect of imposing high transient stresses on the rotating diodes of the brushless alternator. A non inductive and matched resistance in parallel with the main field offers a solution to the problem.

### Lifts and Cranes

Mechanical energy may be fed back to the power source in the form of electrical energy when braking lifts and cranes. This energy may be absorbed by the other equipment operating, but the surplus power will cause the generator to act as a motor, tending to drive its prime mover. The generator speed will increase and the governor will reduce its fuel supply. The reverse power must be totally absorbed by the mechanical losses and the generators electrical losses. However the generator is capable of absorbing limited regenerative power so if regenerated load is connected to the generator, the total of the other load elements should be equal to the regenerated power. It may also be necessary to connect a continuously rated resistive load to absorb the regenerated power, such as load banks.

### Capacitive Loads

As the capacitive load increases, there is a tendency to over excite the generator, unless the main field current can be reversed by the action of the machines excitation control system. This is not possible with an ordinary brushless alternator. The effect of capacitive loads, produces a high terminal voltage, limited by the magnetic saturation of the machine. The terminal voltage is determined by the intersection of an impedance line with the open-circuit magnetisation characteristic of the generator. There must be a limit to the amount of capacitance that can be switched onto the generator if voltage stability is to be maintained. A non inductive and matched resistance in parallel with the main field resolves this problem as such loads will tend to increase the main and excitor field currents and oppose the self exciting effects of the capacitive load element.

The limitation on capacitive load level or the lowest particle working level should be 0.75 p.u.

## Unbalanced Loads

Unbalanced currents are caused by faults other than those involving all three phases. Faults are usually cleared by circuit protection, any failure of the remote protection to operate or related circuit breakers to trip would result in the fault circuit remaining connected to the generator. Action should be taken to trip the generator breaker if the unbalanced condition persists or if the level of the negative phase sequence current rises. The alternator manufacturer’s literature should be consulted for the level settings of the fault circuits.

## Suggested Maintenance Schedule

Check Sheet – Emergency standby generators

| | | | 10 hrs/ Weekly | 100 hrs/ Monthly | 200 hrs/ Yearly |
|---|---|---|---|---|---|
| 1 Engine | 1.1 | Check lubricating oil level | x | | |
| | 1.2 | Change lubricating oil | | | x |
| | 1.3 | Check fuel tank level | x | | |
| | 1.4 | Check water coolant level | x | | |
| | 1.5 | Check anti-freeze content in cooling system and change DCA filter | | 6 monthly | x |
| | 1.6 | Check vee belt tension | | | x |
| | 1.7 | Clean air filter or if oil bath type check level | | | x |
| | 1.8 | Check all fuel, exhaust, air piping for leaks | | | x |
| | 1.9 | Drain sediment from fuel tank | | x | |
| | 1.10 | Check fuel tank breather | | x | |
| 2 Engine Electrics | 2.1 | Check electrolyte level in battery | x | | |
| | 2.2 | Check state of charge with hydrometer | | x | |
| | 2.3 | Clean cable terminations on battery and regrease | | | x |
| | 2.4 | Check fuel solenoid is operating correctly | | x | |
| | 2.5 | Check auxiliary terminal box connections | x | | |
| 3 Generator | 3.1 | Clean apertures and internally with a dry air supply | | x | |
| | 3.2 | Grease bearings (if required) | | | x |
| | 3.3 | Check ventilation areas for obstructions | x | | |
| 4 Switchgear | 4.1 | Check functioning of all relays | | | x |
| | 4.2 | Check functioning of all switches (including engine) | | | x |
| | 4.3 | Check that contacts of circuit breakers and contactors are clean | | | x |
| | 4.4 | Check condition and rating of fuses and tripping devices | | | x |
| 5 General | 5.1 | Check and tighten all nuts and bolts (as required) | | | x |
| | 5.2 | Check condition of anti-vibration mountings (if fitted) | | | x |
| 6 Complete Set | 6.1 | Run set for one hour minimum preferably on 50 per cent load | x | | |
| | | Check and Note:<br>1 Approximate starting time<br>2 That all engine instruments are functioning<br>3 That all switchgear meters are functioning<br>4 All lamps are operating correctly<br>5 All switches are functioning | | | |
| | 6.2 | Clean complete set and exterior of panel and remove dust | | | x |
| 7 | 7.1 | Have generating set inspected by manufacturer | | | x |

## Regular Maintenance

Most owners of standby sets ensure that they are completely and regularly maintained. There are, however, other operators who ignore maintenance and when there is a power shutdown, the set does not always start. In most of these instances, faulty starting and control systems are blamed, but over the years, the real villain is neglect of regular preventive maintenance. This neglect can be expensive and can endanger life.

**Preventive maintenance** is the easiest and most inexpensive form of maintenance since it permits staff to carry out the work at convenient times. It starts with a well prepared schedule. This should be established according to the duties expected of the generating set, since while most sets are only used for short periods, “in anger”, there are others used for load shedding, which have higher working periods.

### Regular checking

Generally, a standby set should be checked weekly and run for a short period, preferably on load, to exercise both the engine/alternator and its control panel. All information and readings should be logged. The suggested schedule check sheet may be used as a guide to establish a maintenance programme to fit any specific operation. It is assumed that the set has been commissioned and that the initial running in instructions have been carried out by a properly trained maintenance Dept, who should supplement these with any other particular operation that may be listed in the generating sets engine manual. The time between checks could vary depending upon site conditions, e.g. high dust laden atmosphere, which the maintenance schedule should take into account.

At some installations, there may be no properly trained maintenance staff to carry out this work in which case it is advisable to enter into a regular maintenance contract with the supplier.

**A maintenance contract** can take the form of a simple signed agreement between the owners of the generating set and the set manufacturer or its representative. The owner being referred to as the “user”, the manufacturer as “The contractor”. It would be expected that the maintenance contract would include clauses covering:

1. That the user only utilises experienced and trained operators.
2. An agreed time between visits.
3. Exact details of work to be carried out.
4. The contractor to replace any parts recommended by the user not covered by the guarantee or maintenance schedule within a reasonable period of time.
5. The contractor to undertake arrangements for major engine overhauls that may be needed from time to time.
6. An agreed period for work laid down in the maintenance schedule (it is usual to add the cost of parts used during the execution of the schedule).
7. The user to provide all necessary facilities to enable the contractor to carry out the execution of the schedule during normal workday hours.
8. Indemnification of the contractor against loss or damage to property or injury to personnel arising directly or indirectly in the performance of the service.
9. Notice of termination of the contract by either party. To avoid any contention that may arise as a result of any misunderstanding or obligation it is advisable to have a formal, legalised agreement drawn up.

**The basic maintenance schedule** normally covers the following services:

(a) Check condition of air cleaners, fuel oil filter elements and lubricating oil filter elements, change if necessary.

(b) Check coolant level, leaks, anti-freeze strength and DCA content where applicable.

(c) Check lubricating oil level and leaks and top up or change if necessary.

(d) Check fuel oil levels and leaks.

(e) Check fuel injectors (visual only).

(f) Check fan belt condition and tension correct if necessary.

(g) Check starter battery condition, voltage and specific gravity of electrolyte and level.

(h) Check alternator brushes if applicable, replace as necessary.

(i) Check condition of switchboard lamps, fuses, meter, contactors and other switches.

(j) Check output of battery charger if applicable.

(k) Check for loose electrical and mechanical connections, tighten as necessary.

(l) Check regulation of alternator voltage and frequency.

(m) Simulate “mains failure” operation if applicable.

(n) Submit report to customer on condition and state of plant. the most common cause of an engine failing to start is badly charged batteries. Since most installations incorporate lead-acid batteries, care has to be taken as to their method of charging.

## Batteries

Invariably batteries are either under-charged or over-charged, the latter being more common and causing a deterioration in the battery's life.

It is essential that special attention is given to batteries to ensure that they are always in a near fully charged condition at possible and regular readings are taken of their specific gravity. The misuse of battery chargers is normally found to be the cause of over-charging.

**Nickel-cadmium batteries** do not suffer with this problem and therefore require less maintenance, but of course they do cost considerably more than an equivalent lead-acid battery.

Nicads must have a condition discharge-recharge, recommend this twice per year.

It is not generally appreciated by the user of a diesel generating set that during the starting cycle of an engine the voltage of the battery drops to its lowest value and the current drawn is at its highest level directly the starting switch is operated.

Immediately the motor turns or "breaks away" the current falls off with the voltage rising. It is at the initial critical moment of operating the starting switch that essential components such as fuel cut off solenoids and relays are required to operate. Although some manufacturers arrange their circuits to avoid this situation, by slightly delaying the operation of the starter motor, there are many sets where these two operations are carried out simultaneously. It is therefore absolutely vital that the battery is in peak condition.

### Light Loads

A fault that occurs quite frequently even when maintenance is carried out regularly, is the engine injectors fouling due to excessive light load running. As will be seen from the typical maintenance schedule, a figure of 50 per cent loading is mentioned. The load factor should be considered as a minimum and a full load factor would be more desirable, followed by 110 per cent load for a short period.

With this load factor it does ensure that the engine does not suffer from injectors being "clogged with carbon deposits due to unburnt fuel. Also, running on a light load could in time dilute the engine lubricating oil. Obviously there are many causes of a set failing to start or failing to provide volts when started, preventive or planned maintenance is not a panacea for malfunctioning, but it will go a long way to avoid the non-starting of the set when it is most needed.

## Enclosed Soundproof Generating Sets

The choice of reducing sound levels on generating sets falls into a number of categories.

**Standard Sheet Metal Weather Protection** – For use outdoors, small reduction on mechanical noise, but radiator noise is unaffected. Exhaust noise can be considerably reduced.

**Enclosing the Generator in a Specially Designed Sound Proof Canopy** with air inlet and outlet sound attenuators – for use outdoors.

Standard soundproof enclosures will give a reduction between 15 and 30 dBA. A further reduction can be achieved by increasing the density of the barrier and increasing the length of air inlet and outlet attenuator on specially designed enclosures for specific duties.

**Installing the Generating Set in a Normal Brick Room** with air inlet and outlet sound attenuators and acoustic doors. High reverberant noise level within the plant room but effective reduction of the noise levels to outside.

**Installing the Generating Set in a Room Lined with Sound Absorbing Material** and with air inlet and outlet sound attenuators.

Noise inside plant room reduced and considerable reduction on noise level to outside.

**Installing an Enclosed Generating Set in a Room.**

The set is enclosed in a specially designed sound proof canopy with integral air inlet and outlet sound attenuators.

Low noise levels inside and outside of room.

**Other Means of Reducing Noise.**

The use of remote radiators (to spread the noise over selected areas) and the use of cooling towers, although in both cases the generating set noise, even without the radiator will be relatively high.

## Definitions:

**Weatherprotected**

Sheetmetal enclosure with side doors for accessibility and silencers mounted on roof. Small amount of soundproofing but lowest cost weather protection.

**Silenced**

Noise level 85dba @ 1 metre distance from enclosure x 1 metre high. This is the average noise level recorded at 8 points around the enclosure with the genset operating at 75% prime rating. Meets EEC Regulations.

**Super Silenced**

Noise level 75dba @ 1 metre distance from enclosure x 1 metre high. This is the average noise level recorded at 8 points around the enclosure with the genset operating at 75% prime rating.

**Self Contained and Close Fit**

Standard Genset housed within a soundproof enclosure with an under-frame incorporating a lifting facility enabling a single unit lift. A daily service fuel tank is also housed within the enclose.

The enclosure sizes are kept to a minimum. Service and maintenance is carried out through a number of access doors. The genset controls are accessed from outside the unit.

**ISO Container**

In 6m (20 ft), 9m (30 ft) and 12m (40 ft) sizes. Silenced, supersilenced or unsilenced. Self contained with walkround facilities.

**Drop Over**

This arrangement requires the genset to be placed on a prepared concrete slab first. The soundproof enclosure is then placed over the genset. The enclosure is provided with a suitable lifting facility. Finally, the radiator duct and exhaust system must be connected.

**Walk Round**

The enclosure sizes increase to provide space around the genset within the enclosure to carry out service/ maintenance and operate the set.

## Description

Silencing and weather protection of generating sets is accomplished in a wide variety of applications with a range of enclosures.

## Weatherprotected

Where sound levels are not critical, the “totally enclosed” style, weatherprotected enclosure, suitable for site operation, mobile work and emergency duties, can be provided. Designed for generating Sets from 35kVA to 500kVA, these enclosures fit on to a skid style bedframe to form a compact unit providing accessibility to fuel, oil and water servicing points for maintenance and operation.

Each enclosure has wide hinged side doors providing 70% service accessibility to the engine, alternator and control system. Each door is lockable. These enclosures allow generating Sets to be run with all doors closed. Silencers are mounted internally.

A base fuel tank is normally incorporated in the chassis of the generating Set, complete with a low level fuel filter, splash-guard, twist release cap, retaining chain and internal filter.


*Fig. F1 A typical drop over Acoustic Enclosure for a 1000 kVA generator.*

## Silenced and Supersilenced (Fig. F2)

Acoustic enclosures are designed to reduce noise emitted from a generating Set. A range of types provide noise reductions from 15dB(A) to 30dB(A) and above.

Air inlet and outlet air flow is through attenuator splitters positioned at the front and rear end of the enclosure.

Each enclosure has wide, hinged and lockable doors each side providing excellent accessibility to all servicing points.

Residential silencers are installed internally. Internal pipework is lagged with a heat and sound resistant material.

All enclosures have four lifting points to allow the installation and removal of the acoustic body. Where specified, additional lifting lugs are welded to the base for lifting of both the enclosure and generating Set. All units are totally self contained with base fuel tanks, batteries, exhaust system and control panel.

## Containerised Style (Fig. F3)

For packaged and portable style generating Sets, “container” style, acoustic sound-proofed enclosures can be provided. These are available for all sizes of generating Sets from 35kVA to 2000kVA. Generating Sets up to 1200kVA can be accommodated within standard ISO 6m (20 ft) containers.

Air inlet and discharge flows are through external sound attenuators positioned at each end of the container and constructed in splitter or baffle form to achieve effective noise absorption with minimum air resistance. Each sound attenuator incorporates fixed blade weather louvres and bird guards.

The exhaust system employs residential silencers mounted on the roof with pipework lagged inside the container.

All containers incorporate personnel access doors, generally with one single door on each side. These have a peripheral compression seal and are fitted with either a heavy-duty single-point handle and fastener or an espagnolette fastener. An internal panic release mechanism is fitted and all doors are lockable.

Four-point lifting is provided.

A cable gland plate is fitted on the output side.

Containerised power plant complying to EEC and other noise directives are produced for generating Sets up to 2000kVA.

## Drop Over and Walk-around Style Enclosures

Walk-around style enclosures are designed for installations where a silenced generating Set and acoustic enclosure will take the place of a brick-built plant room (see Fig. F1).

Full-height doors are provided at each side of the enclosure to permit personnel to enter and walk inside the facility for maintenance and operating purposes. Chromium plated slam locks are provided on each lockable door, with panic buttons on the inside to release the door-locking mechanism.

The generating Set is silenced by an acoustic enclosure built to the customers specification generally meeting 75dB(1) @ 1 m or better. A prepared concrete platform with a smooth surface is necessary to accommodate the generating Set initially, normally a ‘packaged’ unit with its own base fuel tank, prior to the acoustic enclosure being ‘dropped over’. Allowance for cable runs and, if necessary, fuel pipes from a bulk tank must be made into the concrete slab. The underside of the enclosures bodywork should be provided with a suitable sealant before installation to ensure a totally airtight bonding. Check which side of the set fuel lines and cables originate from.

## Installation of Enclosed / Silenced Sets

**Positioning**

Select a position for the enclosured generator which is as close as possible to the load to be supplied, ensuring that the following conditions are met:

The ground must be dry, level and firm enough to support the weight of the enclosure without any sinking with time.

The positioning of the enclosured generator should be such that generator exhaust and cooling air flows do not create a nuisance, or potential source of danger to personnel, or buildings etc.

There must be adequate access for installation and commissioning of the generator. Also allowance must be made for maintenance including:

- Inspection of door seals and door hinges, door handles, locks, and internal panic-release mechanisms for correct operation.
- Inspection of air inlet and outlet ventilation grilles for clogging by debris, and obstruction by objects.
- Inspection of exhaust system for leaks and damage, and that no materials or debris can come into contact with the hot exhaust system.
- Inspection of exhaust pipe exit for obstruction.
- Inspection of external surfaces for damage periodically, with periodic cleaning where required.

**Preparing for Installation**

Prepare for installation as follows:

- Position the enclosure in the required place.
- Open the canopy doors and carry out the full installation procedure as described in the Generator manual.
- Carry out generator commissioning as described in the Control System manual.

### Caution:

Plugs / wiring of adequate current, voltage and insulation rating must be used.

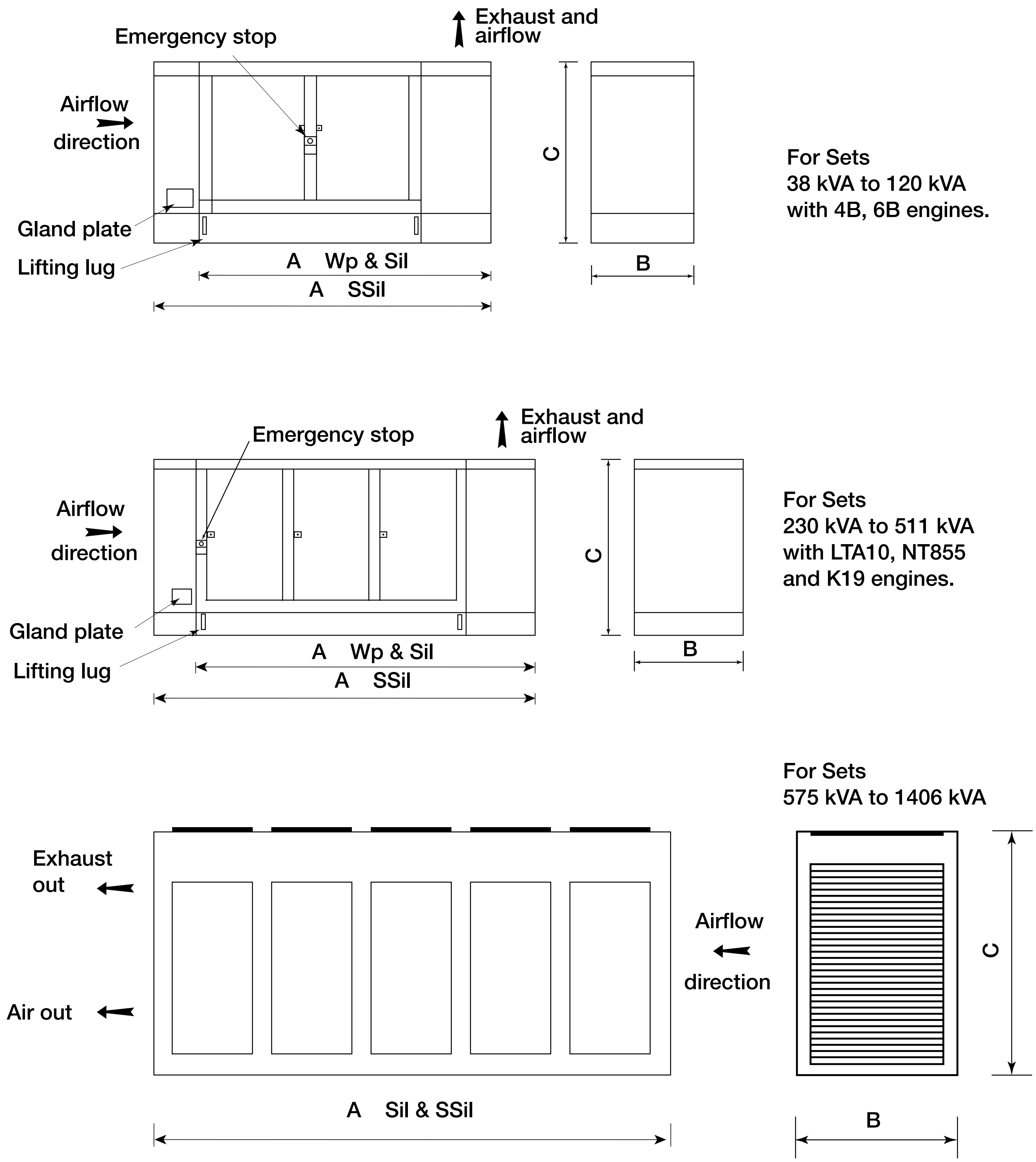
### Caution:

All non-current carrying metalwork associated with the equipment must be bonded to a suitable earth connection.


*Fig. F2 Packaged Super silenced 100kVA Generator*


*Fig. F3 Super silenced 1000kVA ISO style containerised unit*

*Example of containerised style silenced enclosure for generators up to 2000 kVA*




Note: All dimensions and weights are intended as an approximate guide only. Always ask for certified drawings once a project proceeds.

Wp = weather protected
Sil = silenced 85dBC(A) @ 1m
SSil = supersilenced 75dB (A) @ 1m

*Fig. F4*

### Weather protected Generating Sets — Type WP

| Rating Prime KVA | Engine | 2000 Model | 1999 Model | Length A mm | width B mm | height C mm | Weight (Dry) |
|---|---|---|---|---|---|---|---|
| 38 | 4B3.9G | 30 DGBC | CP40-5 | 2850 | 1050 | 1725 | 1200 |
| 52 | 4BT3.9G1 | 42 DGCA | CP50-5 | 2850 | 1050 | 1725 | 1500 |
| 64 | 4BT3.9G2 | 51 DGCB | CP60-5 | 2850 | 1050 | 1725 | 1550 |
| 70 | 4BTA3.9G1 | 56 DGCC | CP70-5 | 2850 | 1050 | 1725 | 1580 |
| 96 | 6BT5.9G2 | 77 DGDB | CP90-5 | 2850 | 1050 | 1725 | 2000 |
| 106 | 6BT5.9G2 | 85 DGDF | CP100-5 | 2850 | 1050 | 1725 | 2000 |
| 129 | 6CT8.3G2 | 103 DGEA | CP125-5 | 3423 | 1050 | 1825 | 2685 |
| 153 | 6CTA8.3G | 122 DGFA | CP150-5 | 3423 | 1050 | 1825 | 2785 |
| 185 | 6CTA8.3G | 148 DGFB | CP180-5 | 3423 | 1050 | 1825 | 2865 |
| 233 | LTA10G2 | 186 DFAB | CP200-5 | 4350 | 1400 | 2200 | 3960 |
| 252 | LTA10G3 | 202 DFAC | CP250-5 | 4350 | 1400 | 2200 | 3970 |
| 313 | NT855G6 | 250 DFBF | CS300-5 | 4350 | 1400 | 2200 | 5010 |
| 315 | NT855G6 | 252 DFBH | CP300-5 | 4350 | 1400 | 2200 | 5140 |
| 350 | NTA855G4 | 280 DFCC | CP350-5 | 4350 | 1400 | 2200 | 5185 |
| 425 | NTA855G6 | 340 DFCE | CS400-5 | 4350 | 1400 | 2200 | 5318 |
| 431 | KTA19G3 | 345 DFEC | CP400-5 | 5126 | 2451 | 3020 | 8016 |
| 450 | KTA19G3 | 360 DFEL | CP450-5 | 5126 | 2451 | 3020 | 8120 |
| 511 | KTA19G4 | 409 DFED | CP500-5 | 5126 | 2451 | 3020 | 8156 |
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 6072 | 2451 | 3020 | 9635 |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 6072 | 2451 | 3020 | 10010 |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 6072 | 2451 | 3020 | 11102 |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 6072 | 2451 | 3020 | 11252 |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 6072 | 2451 | 3020 | 11772 |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 6072 | 2451 | 3020 | 12047 |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 7062 | 2451 | 3020 | 16798 |
| 1406 | KTA50G8 | 1125 DFLE | CP1400-5 | 7062 | 2451 | 3020 | 18195 |

### Silenced Generating Sets 85dB(A) @ 1 m — Type Sil

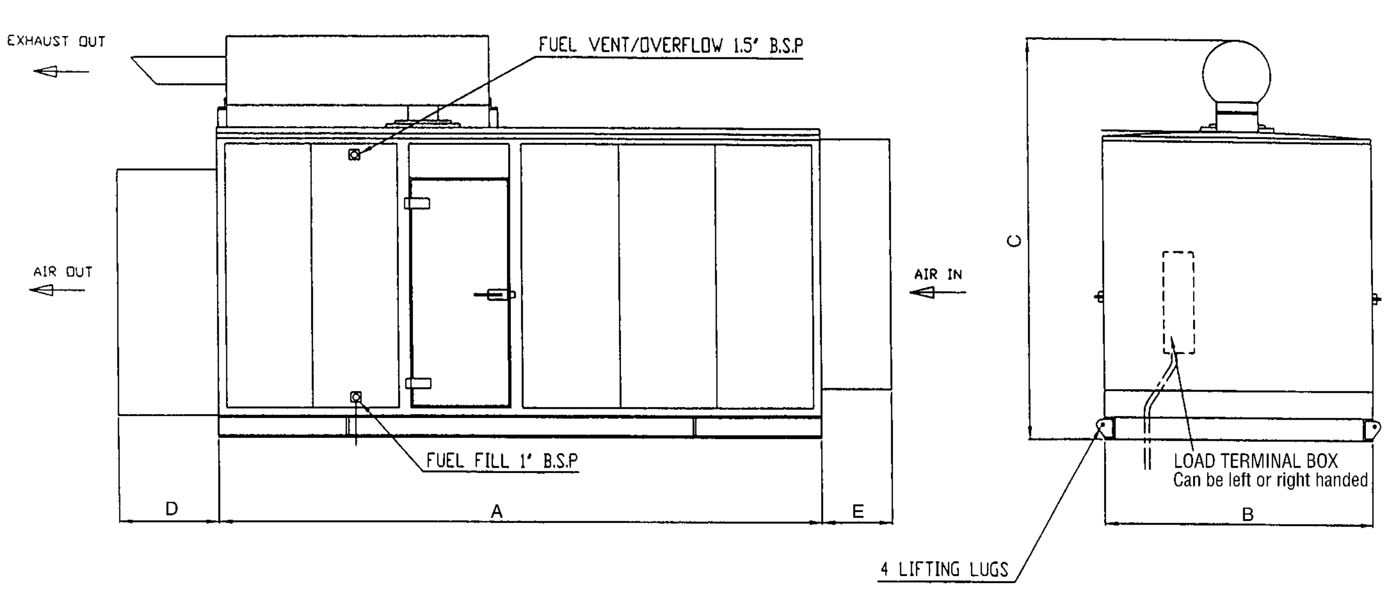
| Rating Prime KVA | Engine | 2000 Model | 1999 Model | Length A mm | width B mm | height C mm | Weight (Dry) | Style |
|---|---|---|---|---|---|---|---|---|
| 38 | 4B3.9G | 30 DGBC | CP40-5 | 2850 | 1050 | 1725 | 1210 | CF |
| 52 | 4BT3.9G1 | 42 DGCA | CP50-5 | 2850 | 1050 | 1725 | 1510 | CF |
| 64 | 4BT3.9G2 | 51 DGCB | CP60-5 | 2850 | 1050 | 1725 | 1560 | CF |
| 70 | 4BTA3.9G1 | 56 DGCC | CP70-5 | 2850 | 1050 | 1725 | 1590 | CF |
| 96 | 6BT5.9G2 | 77 DGDB | CP90-5 | 2850 | 1050 | 1725 | 2010 | CF |
| 106 | 6BT5.9G2 | 85 DGDF | CP100-5 | 2850 | 1050 | 1725 | 2010 | CF |
| 129 | 6CT8.3G2 | 103 DGEA | CP125-5 | 3523 | 1050 | 1825 | 2700 | CF |
| 153 | 6CTA8.3G | 122 DGFA | CP150-5 | 3523 | 1050 | 1825 | 2800 | CF |
| 185 | 6CTA8.3G | 148 DGFB | CP180-5 | 3523 | 1050 | 1825 | 2880 | CF |
| 233 | LTA10G2 | 186 DFAB | CP200-5 | 4350 | 1400 | 2200 | 3980 | CF |
| 252 | LTA10G3 | 202 DFAC | CP250-5 | 4350 | 1400 | 2200 | 3990 | CF |
| 313 | NT855G6 | 250 DFBF | CS300-5 | 4350 | 1400 | 2200 | 5030 | CF |
| 315 | NT855G6 | 252 DFBH | CP300-5 | 4350 | 1400 | 2200 | 5160 | CF |
| 350 | NTA855G4 | 280 DFCC | CP350-5 | 4350 | 1400 | 2200 | 5205 | CF |
| 425 | NTA855G6 | 340 DFCE | CS400-5 | 4350 | 1400 | 2200 | 5338 | CF |
| 431 | KTA19G3 | 345 DFEC | CP400-5 | 7062 | 2451 | 3020 | 9716 | WR |
| 450 | KTA19G3 | 360 DFEL | CP450-5 | 7062 | 2451 | 3020 | 9820 | WR |
| 511 | KTA19G4 | 409 DFED | CP500-5 | 7062 | 2451 | 3020 | 9856 | WR |
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 8052 | 2451 | 3020 | 11635 | WR |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 8052 | 2451 | 3020 | 12010 | WR |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 9137 | 2451 | 3020 | 15602 | WR |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 9137 | 2451 | 3020 | 15752 | WR |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 9137 | 2451 | 3020 | 16202 | WR |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 9137 | 2451 | 3020 | 16547 | WR |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 10127 | 2451 | 3020 | 21198 | WR |
| 1406 | KTA50G8 | 1125 DFLE | CP1400-5 | 10127 | 2451 | 3020 | 22595 | WR |

### Supersilenced Generating Sets 75dB(A) @ 1 m — Type SSil

| Rating Prime KVA | Engine | 2000 Model | 1999 Model | Length A mm | width B mm | height C mm | Weight (Dry) | Style |
|---|---|---|---|---|---|---|---|---|
| 38 | 4B3.9G | 30 DGBC | CP40-5 | 2850 | 1050 | 1725 | 1330 | CF |
| 52 | 4BT3.9G1 | 42 DGCA | CP50-5 | 2850 | 1050 | 1725 | 1661 | CF |
| 64 | 4BT3.9G2 | 51 DGCB | CP60-5 | 2850 | 1050 | 1725 | 1710 | CF |
| 70 | 4BTA3.9G1 | 56 DGCC | CP70-5 | 2850 | 1050 | 1725 | 1740 | CF |
| 96 | 6BT5.9G2 | 77 DGDB | CP90-5 | 3400 | 1050 | 1725 | 2201 | CF |
| 106 | 6BT5.9G2 | 85 DGDF | CP100-5 | 3400 | 1050 | 1725 | 2201 | CF |
| 129 | 6CT8.3G2 | 103 DGEA | CCP125-5 | 3923 | 1050 | 1825 | 2970 | CF |
| 153 | 6CTA8.3G | 122 DGFA | CP150-5 | 3923 | 1050 | 1825 | 3080 | CF |
| 185 | 6CTA8.3G | 148 DGFB | CP180-5 | 3923 | 1050 | 1825 | 3168 | CF |
| 233 | LTA10G2 | 186 DFAB | CP200-5 | 4900 | 1400 | 2200 | 4378 | CF |
| 252 | LTA10G3 | 202 DFAC | CP250-5 | 4900 | 1400 | 2200 | 4389 | CF |
| 313 | NT855G6 | 250 DFBF | CS300-5 | 4900 | 1400 | 2200 | 5533 | CF |
| 315 | NT855G6 | 252 DFBH | CP300-5 | 4900 | 1400 | 2200 | 5670 | CF |
| 350 | NTA855G4 | 280 DFCC | CP350-5 | 4900 | 1400 | 2200 | 5725 | CF |
| 425 | NTA855G6 | 340 DFCE | CS400-5 | 4900 | 1400 | 2200 | 5872 | CF |
| 431 | KTA19G3 | 345 DFEC | CP400-5 | 8052 | 2451 | 3020 | 104716 | WR |
| 450 | KTA19G3 | 360 DFEL | CP450-5 | 8052 | 2451 | 3020 | 10820 | WR |
| 511 | KTA19G4 | 409 DFED | CP500-5 | 8052 | 2451 | 3020 | 10856 | WR |
| 575 | VTA28G5 | 460 DFGA | CP575-5 | 9137 | 2451 | 3020 | 14235 | WR |
| 640 | VTA28G5 | 512 DFGB | CP625-5 | 9137 | 2451 | 3020 | 14610 | WR |
| 725 | QST30G1 | 580 DFHA | CP700-5 | 11120 | 2451 | 3020 | 16302 | WR |
| 800 | QST30G2 | 640 DFHB | CP800-5 | 11120 | 2451 | 3020 | 16452 | WR |
| 939 | QST30G3 | 751 DFHC | CP900-5 | 11120 | 2451 | 3020 | 16902 | WR |
| 1000 | QST30G4 | 800 DFHD | CP1000-5 | 11120 | 2451 | 3020 | 17247 | WR |
| 1256 | KTA50G3 | 1005 DFLC | CP1250-5 | 12200 | 2451 | 3020 | 22298 | WR |
| 1406 | KTA50G8 | 1125 DFLE | CP1400-5 | 12200 | 2451 | 3020 | 23695 | WR |

Note 1. Weight: For complete set and enclosure (dry).
2. Styles: CF – self contained close fit. WR – self contained ISO style walk round.
3. All dimensions and weights are for guidance only. Ask for certified drawings on specific projects.

## Silenced Generating sets with DROP OVER ENCLOSURES. 85 dB(A) @ 1m

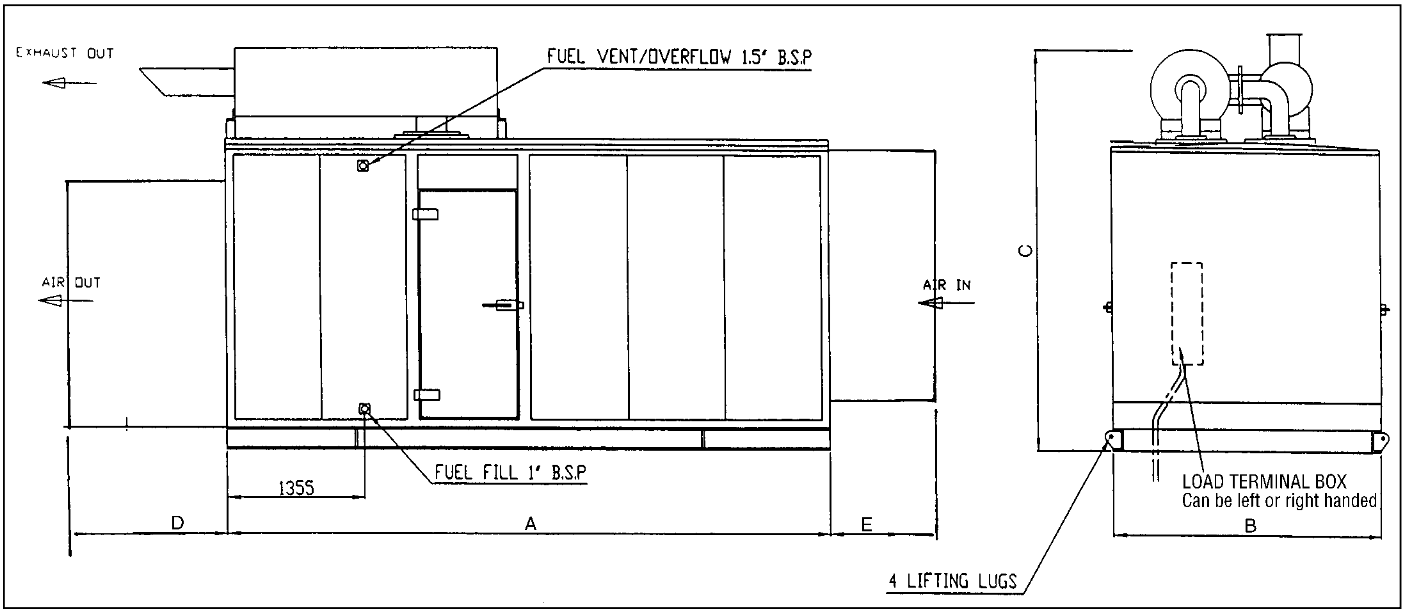



***Approximate acoustic enclosure dimensions for 85 dBA at 1 metre, drop-over, walk-round design***

*Note: Height includes for generator sets fitted with base mounted fuel tanks and enclosures with roof mounted exhaust silencer systems. Attenuator lengths to be added to enclosure for **total** overall length*

| Prime kVA | Standby kVA | 2000 Model Pime | 1999 Model Prime | 2000 Model Standby | 1999 Model Standby | Cummins Engine Model | Enclosure Dimensions (mm) Length A | Width B | Height C | Attenuator Length (mm) Discharge D | Inlet E | Enclosure Weight (Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | 119 | 85 DGDF | CP100-5 | 95 DGDF | CS125-5 | 6BT5.9G2 | 4400 | 2200 | 3000 | 1200 | 900 | 1300 |
| 129 | 145 | 103 DGEA | CP125-5T | 116 DGEA | CS150-5 | 6CT8.3G2 | 4400 | 2200 | 3000 | 1200 | 900 | 1300 |
| 153 | 170 | 122 DGFA | CP150-5 | 136 DGFA | CS170-5 | 6CTA8.3G | 4400 | 2200 | 3000 | 1200 | 900 | 1300 |
| 185 | 204 | 148 DGFB | CP180-5 | 163 DGFB | CS200-5 | 6CTA8.3G | 4400 | 2200 | 3000 | 1200 | 900 | 1300 |
| 233 | 259 | 186 DFAB | CP200-5 | 207 DFAB | CS250-5 | LTA10G2 | 5200 | 2200 | 3000 | 1200 | 900 | 1600 |
| 204 | – | 163 DGFC | CP200-5T | – | – | 6CTAA8.3G | 5200 | 2200 | 3000 | 1200 | 900 | 1600 |
| 252 | 279 | 202 DFAC | CP250-5 | 223 DFAC | CS280-5 | LTA10G3 | 5200 | 2200 | 3000 | 1200 | 900 | 1600 |
| – | 313 | – | – | 250 DFBF | CS300-5 | NT855G6 | 5200 | 2200 | 3400 | 1200 | 900 | 1900 |
| 315 | 350 | 252 DFBH | CP300-5 | 280 DFBH | S350-5 | NT855G6 | 5200 | 2200 | 3400 | 1200 | 900 | 1900 |
| 350 | 390 | 280 DFCC | CP350-5 | 312 DFCC | CS400-5 | NTA855G4 | 5200 | 2200 | 3400 | 1200 | 900 | 1900 |
| – | 425 | – | – | 340 DFCE | CS450-5 | NTA855G6 | 5200 | 2200 | 3400 | 1200 | 900 | 1900 |
| 431 | – | 345 DFEC | CP400-5 | – | – | KTA19G3 | 5700 | 2400 | 3400 | 1500 | 1200 | 3200 |
| 450 | 500 | 360 DFEL | CP450-5 | 400 DFEL | CS500-5 | KTA19G3 | 5700 | 2400 | 3400 | 1500 | 1200 | 3200 |
| 511 | 576 | 409 DFED | CP500-5 | 461 DFED | CS575-5 | KTA19G4 | 5700 | 2400 | 3400 | 1500 | 1200 | 3200 |
| 575 | 636 | 460 DFGA | CP575-5 | 509 DFGA | CS625-5 | VTA28G5 | 5700 | 2400 | 3500 | 1500 | 1200 | 3200 |
| 640 | 706 | 512 DFGB | CP625-5 | 565 DFGB | CS700-5 | VTA28G5 | 5700 | 2400 | 3500 | 1500 | 1200 | 3200 |
| 725 | 800 | 580 DFHA | CP700-5 | 640 DFHA | CS800-5 | QST30G1 | 6400 | 2800 | 4100 | 1500 | 1200 | 4100 |
| 800 | 891 | 640 DFHB | CP800-5 | 713 DFHB | CS900-5 | QST30G2 | 6400 | 2800 | 4100 | 1500 | 1200 | 4100 |
| 939 | 1041 | 751 DFHC | CP900-5 | 833 DFHC | CS1000-5 | QST30G3 | 6400 | 2800 | 4100 | 1500 | 1200 | 4100 |
| 1000 | 1110 | 800 DFHD | CP1000-5 | 888 DFHD | CS1100-5 | QST30G4 | 6400 | 2800 | 4100 | 1500 | 1200 | 5300 |
| 1256 | 1400 | 1005 DFLC | CP1250-5 | 1120 DFLC | CS1400-5 | KTA50G3 | 7700 | 3000 | 4600 | 1500 | 1200 | 5300 |
| 1406 | 1675 | 1125 DFLE | CP1400-5 | 1340 DFLE | CS1675-5 | KTA50G8 | 7700 | 3000 | 4600 | 1800 | 1500 | 5900 |

## Silenced Generating sets with DROP OVER ENCLOSURES. 75dB(A) @ 1m




***Approximate acoustic enclosure dimensions for 75 dBA at 1 metre, drop-over, walk-round design***

*Note: Height includes for generator sets fitted with base mounted fuel tanks and enclosures with roof mounted exhaust silencer systems. Attenuator lengths to be added to enclosure for **total** overall length*

| Prime kVA | Standby kVA | 2000 Model Prime | 1999 Model Prime | 2000 Model Standby | 1999 Model Standby | Cummins Engine Model | Enclosure Dimensions (mm) Length A | Enclosure Dimensions (mm) Width B | Enclosure Dimensions (mm) Height C | Attenuator Length (mm) Discharge D | Attenuator Length (mm) Inlet E | Enclosure Weight (Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | 119 | 85 DGDF | CP100-5 | 95 DGDF | CS125-5 | 6BT5.9G2 | 4400 | 2200 | 3000 | 1800 | 1500 | 1500 |
| 129 | 145 | 103 DGEA | CP125-5T | 116 DGEA | CS150-5 | 6CT8.3G2 | 4400 | 2200 | 3000 | 1800 | 1500 | 1500 |
| 153 | 170 | 122 DGFA | CP150-5 | 136 DGFA | CS170-5 | 6CTA8.3G | 4400 | 2200 | 3000 | 1800 | 1500 | 1500 |
| 185 | 204 | 148 DGFB | CP180-5 | 163 DGFB | CS200-5 | 6CTA8.3G | 4400 | 2200 | 3000 | 1800 | 1500 | 1500 |
| 233 | 259 | 186 DFAB | CP200-5 | 207 DFAB | CS250-5 | LTA10G2 | 5200 | 2200 | 3000 | 1800 | 1500 | 1800 |
| 204 | – | 163 DGFC | CP200-5T | – | – | 6CTAA8.3G | 5200 | 2200 | 3000 | 1800 | 1500 | 1800 |
| 252 | 279 | 202 DFAC | CP250-5 | 223 DFAC | CS280-5 | LTA10G3 | 5200 | 2200 | 3000 | 1800 | 1500 | 1800 |
| – | 313 | – | – | 250 DFBF | CS300-5 | NT855G6 | 5200 | 2200 | 3400 | 1800 | 1500 | 2400 |
| 315 | 350 | 252 DFBH | CP300-5 | 280 DFBH | CS350-5 | NT855G6 | 5200 | 2200 | 3400 | 1800 | 1500 | 2400 |
| 350 | 390 | 280 DFCC | CP350-5 | 312 DFCC | CS400-5 | NTA855G4 | 5200 | 2200 | 3400 | 1800 | 1500 | 2400 |
| – | 425 | – | – | 340 DFCE | CS450-5 | NTA855G6 | 5200 | 2200 | 3400 | 1800 | 1500 | 2400 |
| 431 | – | 345 DFEC | CP400-5 | – | – | KTA19G3 | 5700 | 2400 | 3400 | 2100 | 1800 | 4000 |
| 450 | 500 | 360 DFEL | CP450-5 | 400 DFEL | CS500-5 | KTA19G3 | 5700 | 2400 | 3400 | 2100 | 1800 | 4000 |
| 511 | 576 | 409 DFED | CP500-5 | 461 DFED | CS575-5 | KTA19G4 | 5700 | 2400 | 3400 | 2100 | 1800 | 4000 |
| 575 | 636 | 460 DFGA | CP575-5 | 509 DFGA | CS625-5 | VTA28G5 | 5700 | 2400 | 3500 | 2100 | 1800 | 4000 |
| 640 | 706 | 512 DFGB | CP625-5 | 565 DFGB | CS700-5 | VTA28G5 | 5700 | 2400 | 3500 | 2100 | 1800 | 4000 |
| 725 | 800 | 580 DFHA | CP700-5 | 640 DFHA | CS800-5 | QST30G1 | 6400 | 2800 | 4100 | 2100 | 1800 | 5200 |
| 800 | 891 | 640 DFHB | CP800-5 | 713 DFHB | CS900-5 | QST30G2 | 6400 | 2800 | 4100 | 2100 | 1800 | 5200 |
| 939 | 1041 | 751 DFHC | CP900-5 | 833 DFHC | CS1000-5 | QST30G3 | 6400 | 2800 | 4100 | 2100 | 1800 | 5200 |
| 1000 | 1110 | 800 DFHD | CP1000-5 | 888 DFHD | CS1100-5 | QST30G4 | 6400 | 2800 | 4100 | 2100 | 1800 | 5200 |
| 1256 | 1400 | 1005 DFLC | CP1250-5 | 1120 DFLC | CS1400-5 | KTA50G3 | 7700 | 3000 | 4600 | 2100 | 1800 | 6700 |
| 1406 | 1675 | 1125 DFLE | CP1400-5 | 1340 DFLE | CS1675-5 | KTA50G8 | 7700 | 3000 | 4600 | 2400 | 2100 | 7200 |

## Main Sources of Noise

Generator noise falls into three main categories -

- airborne noise from the engine itself
(typically 100-110 dBA at 1 m)

- engine exhaust noise
(typically 120-130 dBA at 1 m, unsilenced)

- radiator fan noise (where applicable)
(typically 100-105 dBA at 1 m)

Although the alternator itself is also a noise source, levels are typically 15-20 dBA below engine noise levels, and are thus normally not significant.

Where set mounted or local motor driven radiators are involved it is important to recognise the significance of the radiator fan as a noise source. This is particularly the case now that ‘high duct allowance’ radiator fans are increasingly used to reduce the size and cost of ventilation/attenuation systems.

Whilst looking at noise levels, it is worth noting that noise is not particularly sensitive to the size of the generator set - for the output range of 100-2000 kVA, for example, typically airborne engine noise levels may only vary by up to 15 dB (i.e. 100-115 dBA).

## Noise + Ventilation

The main problem with generator noise control is not the noise control per se, but the **combination** of noise control and ventilation requirements.

Diesel generator sets radiate significant amounts of heat and whether directly radiator cooled, remote radiator, or heat exchanger cooled - significant air quantities are required for cooling (e.g. 15-20m$^3$/s for a 1000 kVA set). This, when compared with noise control requirements, involves significant space for the equipment involved - and space is invariably at a premium.

## Standards/Spec. Levels

Such National / European Community standards specific to generator sets as exist or are envisaged relate more to noise exposure from a health and safety aspect than to ‘comfort’ levels. Whilst for most sets this involves some degree of noise control (typically around 85 dBA at 1m), ‘comfort’ levels associated with the surrounding environment into which the generator is to be introduced generally result in more stringent noise levels. In many cases theses levels are stipulated by Local Authority Environmental Health Departments as part of the planning conditions, and relate to Environmental Legislation (the Environmental Protection Act etc..)

These levels will often relate to existing background noise levels in the area /(e.g. at nearby residences, offices, hospitals etc..). Whilst some relaxation may be tolerated due to the standby nature of most generators, this would typically only be +5 dBA on levels specified for continuous running plant.

Some account will be taken, however, of likely times of operation (i.e. night-time levels will generally have to be significantly lower than daytime levels).

Noise levels are still most common expressed in ‘dBA’ requirements. The ‘A’ weighting essentially relates to the response of the human ear (i.e. less sensitive to low frequency noise). Environmental noise is often expressed in time weighted averaged (e.g. Lgo, Leq), but for test purposes a generator would effectively be taken as continuous running.

Sometimes noise levels are specified in ‘NC’ or ‘NR’ terms. These relate to standard curves (See Table 1) which must not be exceeded in any particular octave band (unlike the ‘dBA’ figure, which is an overall level).

**As a rough guide**, dBA can be related to NC/NR levels using the following relationship:

NC/NR +5 $\overset{-\Omega-}{=}$ dB(A)

E.G. NR40 $\overset{-\Omega-}{=}$ 45 dBA

**It is important** when relating to specified levels that the **distance/position** at which that level applies is clarified (see below).

EC Directive 84/536 which specifically applies to the generator sets used on construction sites is widely used as a base standard for noise levels in the absence of overriding environmental requirements. The specification uses sound **power** level rather than **pressure** level as a unit (the intention being that the measure is independent of the environment in which the plant is used - a common analogy is that a 2kW electric fire will not tell you the temperature a space will reach unless you know the details about that space).

Currently (for sets above 2 kVA) the figure is 100 dBA sound **power** level, which **broadly** relates to 83-85 dBA @1M sound **pressure** level (depending on the physical size of the set). However, the Directive is currently under review, and it is anticipated that these levels will drop by 3 dB.

*Drop over super silenced enclosure for 2 x 1000 kVA standby generators.*

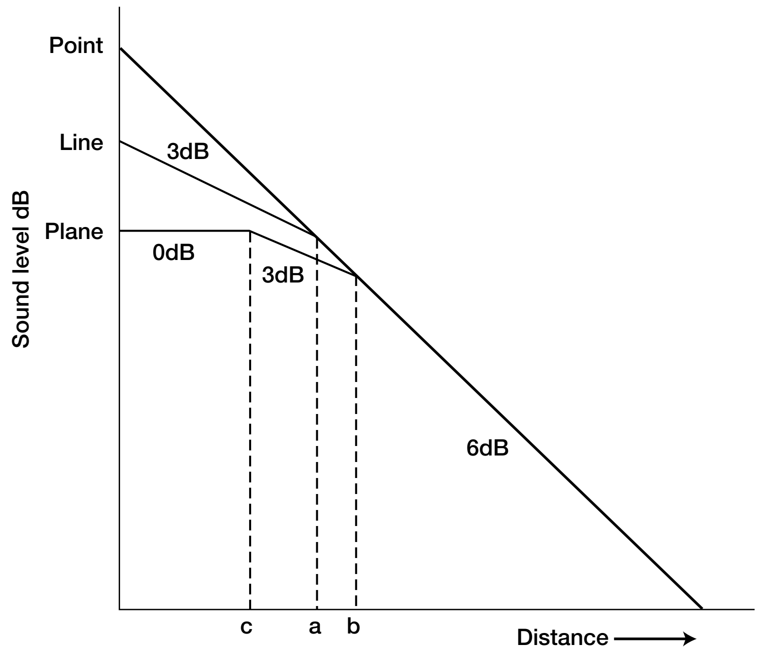
**Table 1**

| NR LEVELS<br>OCTAVE BAND CENTRE FREQUENCY (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K |
| NR100 | 125 | 119 | 105 | 102 | 100 | 98 | 96 | 95 |
| NR 95 | 111 | 105 | 100 | 97 | 95 | 93 | 91 | 90 |
| NR 90 | 107 | 100 | 96 | 92 | 90 | 88 | 86 | 85 |
| NR 85 | 103 | 96 | 91 | 87 | 85 | 83 | 81 | 80 |
| NR 80 | 99 | 91 | 86 | 82 | 80 | 78 | 76 | 74 |
| NR 75 | 95 | 87 | 82 | 78 | 75 | 73 | 71 | 69 |
| NR 70 | 91 | 83 | 77 | 73 | 70 | 68 | 66 | 64 |
| NR 65 | 87 | 78 | 72 | 68 | 65 | 62 | 61 | 59 |
| NR 60 | 83 | 74 | 68 | 63 | 60 | 57 | 55 | 54 |
| NR 55 | 79 | 70 | 63 | 58 | 55 | 52 | 50 | 49 |
| NR 50 | 75 | 65 | 59 | 53 | 50 | 47 | 45 | 43 |
| NR 45 | 71 | 61 | 54 | 48 | 45 | 42 | 40 | 38 |
| NR 40 | 67 | 57 | 49 | 44 | 40 | 37 | 35 | 33 |
| NR 35 | 63 | 52 | 45 | 39 | 35 | 32 | 30 | 28 |
| NR 30 | 59 | 48 | 40 | 34 | 30 | 27 | 25 | 23 |
| NR 25 | 55 | 44 | 35 | 29 | 25 | 22 | 20 | 18 |
| NR 20 | 51 | 39 | 31 | 24 | 20 | 17 | 14 | 13 |
| NR 15 | 47 | 35 | 26 | 19 | 15 | 12 | 9 | 7 |
| NR 10 | 43 | 31 | 21 | 15 | 10 | 7 | 4 | 2 |

| NR LEVELS<br>OCTAVE BAND CENTRE FREQUENCY (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K |
| NC 70 | 83 | 79 | 75 | 72 | 71 | 70 | 69 | 68 |
| NC 65 | 80 | 75 | 71 | 68 | 66 | 64 | 63 | 62 |
| NC 60 | 77 | 71 | 67 | 63 | 61 | 59 | 58 | 57 |
| NC 55 | 74 | 67 | 62 | 58 | 56 | 54 | 53 | 52 |
| NC 50 | 71 | 64 | 58 | 54 | 51 | 49 | 48 | 47 |
| NC 45 | 67 | 60 | 54 | 49 | 46 | 44 | 43 | 42 |
| NC 40 | 64 | 57 | 50 | 45 | 41 | 39 | 38 | 37 |
| NC 35 | 60 | 52 | 45 | 40 | 36 | 34 | 33 | 32 |
| NC 30 | 57 | 48 | 41 | 35 | 31 | 29 | 28 | 27 |
| NC 25 | 54 | 44 | 37 | 31 | 27 | 24 | 22 | 21 |
| NC 20 | 51 | 40 | 33 | 26 | 22 | 19 | 17 | 16 |
| NC 15 | 47 | 38 | 29 | 22 | 17 | 14 | 12 | 11 |

**Table 2** shows the typical ambient levels for both day time and night time in central London, suburban and country conditions.

| Group | Location | Noise Climate dB(A) 08.00-18.00h | Noise Climate dB(A) 01.00-06.00h |
|---|---|---|---|
| A | Arterial roads with many heavy vehicles and buses (kerbside). | 80-68 | 68-50 |
| B | i) Major roads with heavy traffic and buses.<br>ii) Side roads within 15-20m of a road in group A or B(I) | 75-63 | 61-48 |
| C | i) Main residential roads<br>ii) Side roads within 20-50m of heavy traffic routes<br>iii) Courtyards of blocks of flats screened from direct view of heavy traffic. | 70-60 | 54-44 |
| D | Residential roads with local traffic only. | 65-57 | 52-44 |
| E | i) Minor roads<br>ii) Gardens of houses with traffic routes more than 100m distant | 60-52 | 48-43 |
| F | Parks courtyards and gardens in residential areas well away from traffic routes | 55-50 | 46-41 |
| G | Places of few local noises and only very distant traffic noise | 50-47 | 43-40 |




Attenuation with distance from various sources
The slope represents 0.3 and 6dB per doubling of distance

## Noise Legislation in Other Countries

France - 85 dBA at 1 metre for any construction site within 50 metres of a residential area.

Germany - 80 dBA at 1 metre for a generating set on any construction site within 50 meters of a residential area.

Sweden - Swedish standard SEN 590111 sets a limit of 85 dBA. This is applied for the purpose of reducing the exposure of employed persons where the level of sound is continuous for eight hours in any one day. Hearing protection must be used when the level exceeds 85 dBA.

USA - The OSHA Safety and Health standards sets a limit of 90 dBA for an eight hour exposure, 95 dBA for four hours and 100 dBA for two hours.

## Typical Noise 'Climates'

Where a noise level is not specified, but it is felt that some attenuation may be required, an assessment of a desirable level can be made by relating to the prevailing background noise (this is broadly what current UK environmental legislation does). It is important to recognise that background noise would **not** generally include noise 'peaks' from (e.g.) passing traffic, trains or planes. More distant (e.g. motorway) traffic noise may be relevant if it effectively represents a more continuous type of noise. Table 2 indicates some typical ambient noise levels, and also shows the variation between daytime and night-time.

As a **rough guide** (in the absence of other specified levels) **standby** generator noise should equal or be up to 5 dBA less than the background noise at the **most likely noise sensitive points**. Note that peak lopping, CHP, landfill gas and other 'non-standby' sets will generally need designing to a lower level dependant on times of operation.

## Relating the Specification Level to Generator Noise

Having been given or estimated a spec. level it is important - as stated earlier - to establish **where** these level(s) apply - at what distance(s) and position(s) in relation to the generator set. If there is a choice in the siting of the set this can have a significant effect on the attenuation required. If, for example, the level applies at a particular boundary then siting the generator remotely from that boundary will allow distance attenuation to assist in establishing a more realistically achievable noise level at the set position.

Similarly, the effect on any building(s)/topography on site between the generator position and spec. point should be considered. The resultant 'screening' attenuation can be valuable in assisting to achieve the spec. level required.

It is important that such factors are taken into account when specifying generator noise levels - often the latter are presented in terms of a level at 1 m from the set/package/plant-room **without** allowing for 'natural' attenuation. The resultant spec. level - apart from being unrealistic - can often be very costly (if it is not impossible) to achieve.

In most situations the main 'natural' attenuation available is that due to distance (as the sound waves radiate further from the source the radiating area increases and so sound pressure level reduces). Whilst the commonly used formula for distance attenuation is "6 dB drop with doubling of distance" this **must be used with caution**. This is because the formula relates to radiation from a point source. At closer distances a generator set (whether enclosed or via plant room louvres) effectively represents a plane source. Nearer a **plane** source the reduction from attenuation due to distance is **considerably less** than for a point source. (See figure 3)

The following corrections should be used as an **approximate guide** for attenuation due to distance.

**Up to 10m** 1 dB per meter
(i.e. 5m = -5 dB, 10m = -10 dB etc.)

**Above 10m**, apply 6 dB per doubling of distance,
i.e. 20m = -16 dB, 40m = -22 dB etc..

The following table summarises the attenuation due to distance:

| Distance (m) | Attenuation (dB) |
|---|---|
| 1 | -1 |
| 3 | -3 |
| 5 | -5 |
| 7 | -7 |
| 10 | -10 |
| 15 | -13 |
| 20 | -16 |
| 30 | -19 |
| 40 | -22 |
| 50 | -23 |
| 100 | -29 |

Also see Page F12.

# Application Notes

## Outdoor locations, acoustically enclosed

In this situation the acoustic enclosure performs two main functions - providing a secure weatherproof housing for the generator, and the required level of attenuation.

The enclosure and its ancillaries can take various forms, but all contain a number of key features:

- The enclosure itself. Typically a one piece ‘drop over’ style unit with access doors as appropriate or a self contained package unit.
- The attenuated ventilation system, comprising inlet and outlet louvres/attenuators, with dampers/gravity flap units as required.
- The exhaust silencing system.

It is important that the generator set itself is isolated from the enclosure components, to minimise vibration transmission. This is achieved using anti-vibration mounts under the set itself, a flexible connector between the radiator and discharge attenuator, and a flexible bellow in the exhaust system (plus flexible links in fuel lines etc.).

Fig. F5 shows a fairly typical layout. Although this shows the enclosure/set sitting on a concrete plinth, in many situations ‘packaged’ units are supplied - for example when the unit sits on I section steel joists or on raised concrete piers. For these applications the enclosure has a separate steel base, or the set is supplied in a ‘containerised’ unit.

### Noise Levels

For arrangements such as this noise levels of 70-85 dBA at 1m are readily achievable for most sets. Lower levels down to 60/65 dBA at 1m can be achieved but require special attention to the ventilation attenuation and exhaust systems. With regard to the latter, noise radiating from the casings of external silencers can be problematical for lower noise levels, requiring them to be located inside the enclosure, and thermally lagged to control radiated heat.

It should also be noted that - at lower noise levels - regenerated noise at weather louvres can cause high frequency problems.

### Very Low Noise

Fig. F6 shows one arrangement for an enclosure to meet lower noise specs. This arrangement can also be used where ‘cleaner lines’ are required for aesthetic reasons - the conventional ‘3 box’ arrangement of an enclosure with external attenuators and roof mounted exhausts is not always acceptable to architects and planners.

This particular example also shows an acoustically treated steel base - the ‘package’ approach previously referred to.

60 dBA at 1 m generally represents the lowest practically achievable level for the ‘single enclosure’ approach. If a lower level is required (and they are often asked for !) and it **is** required at 1 m, then the ‘extreme’ treatment of a ‘double’ (inner and outer) enclosure - with two stage attenuation and elaborate exhaust systems - is required. It is important to recognise that not only is the cost of such treatment very significant, but that the increased space (and weight) involved can make it impractical.

## Indoor plant-room locations

Although the main principles of acoustic enclosure design and layout broadly apply to plant-room situations, the latter often have particular design difficulties brought about by building layout and space constraints.

A fairly typical situation is that of the generator(s) located below ground level in an urban office complex (Fig. F7).

If we consider ventilation aspects first, as these are often problematical in their own right (without the complication of noise control), particularly on multiple set installations.

### Ventilation

Ventilation paths can be somewhat restricted (due to limited shaft areas available to/from ground level), and an added complication is that frequently only one outside wall/well is available. This can cause problems in terms of getting an acceptable airflow pattern across the set (i.e. avoiding ‘dead’ spots at the alternator end) and - more particularly - in terms of possible recirculation of hot air between the air discharge and air inlet. This leads to overheating (and eventual shutdown) of the generator set, and needs controlling using barriers in/around ventilation spaces.

These problems are exacerbated with the introduction of noise control. Such ventilation paths invariably terminate at street level, where relatively severe noise constraints will apply (55-60 dBA at pavement level is a typical requirement).

### Attenuators

To achieve the high degree of attenuation required along what is unlikely to be a ‘straight through’ type ventilation path often means that conventional ‘cased’ attenuator units cannot be used. One proven approach is to construct acoustic plenum chambers from acoustic panels, creating the attenuators therein using acoustic splitter elements (Fig. F8).

Noise via the ventilation system is often the most difficult problem to solve, but it is by no means the only consideration. Noise breakout to adjacent areas via the plant-room walls/ceiling slab can also be a problem. Whilst the attenuation achieved through standard wall/slab constructions is normally appreciable, it must be remembered that internal noise levels for (say) office areas are considerably lower than might be required at the external louvres.

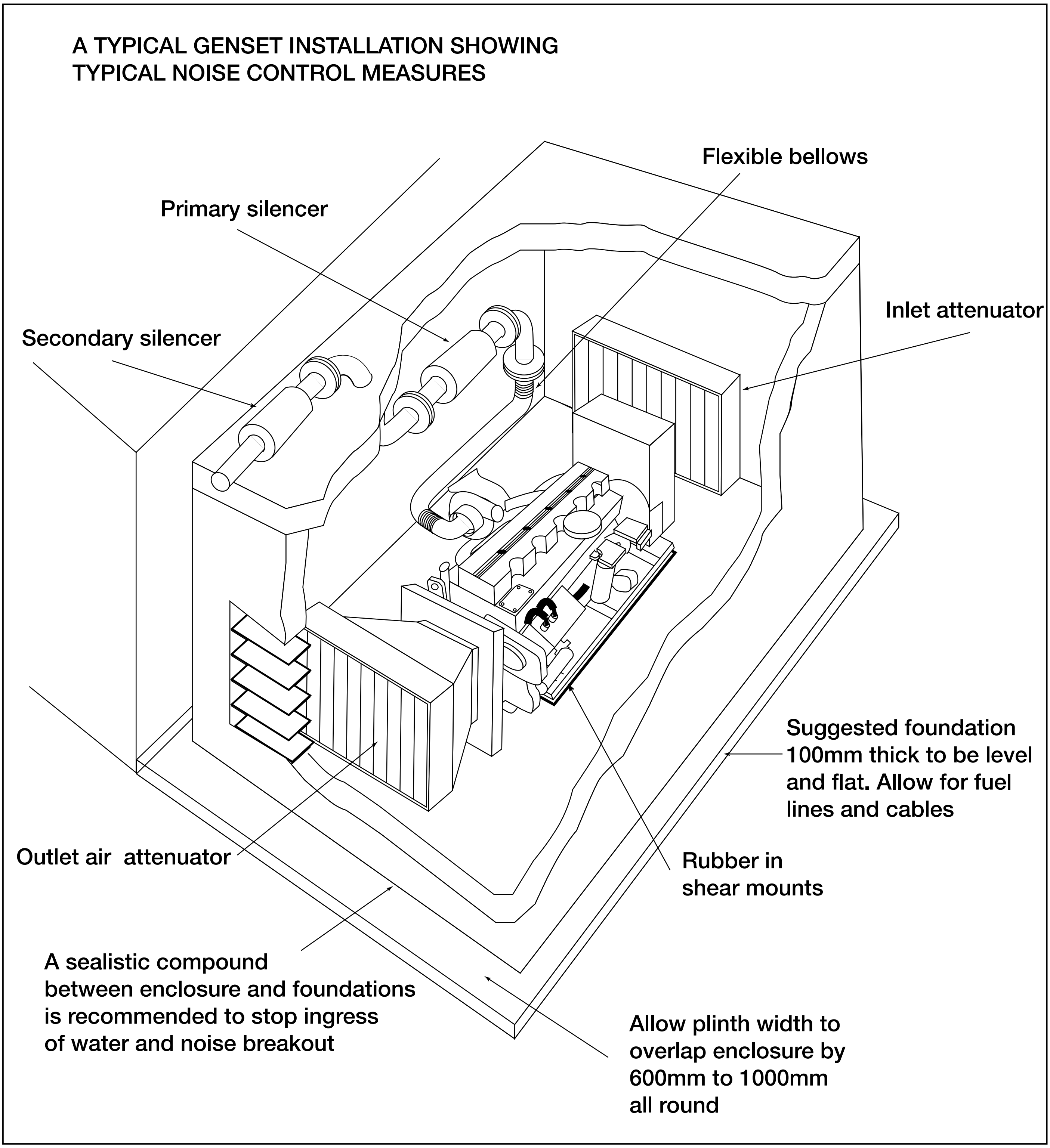

A TYPICAL GENSET INSTALLATION SHOWING
TYPICAL NOISE CONTROL MEASURES
Flexible bellows
Primary silencer
Inlet attenuator
Secondary silencer
Suggested foundation
100mm thick to be level
and flat. Allow for fuel
lines and cables
Outlet air attenuator
Rubber in
shear mounts
A sealistic compound
between enclosure and foundations
is recommended to stop ingress
of water and noise breakout
Allow plinth width to
overlap enclosure by
600mm to 1000mm
all round

*Fig. F5*

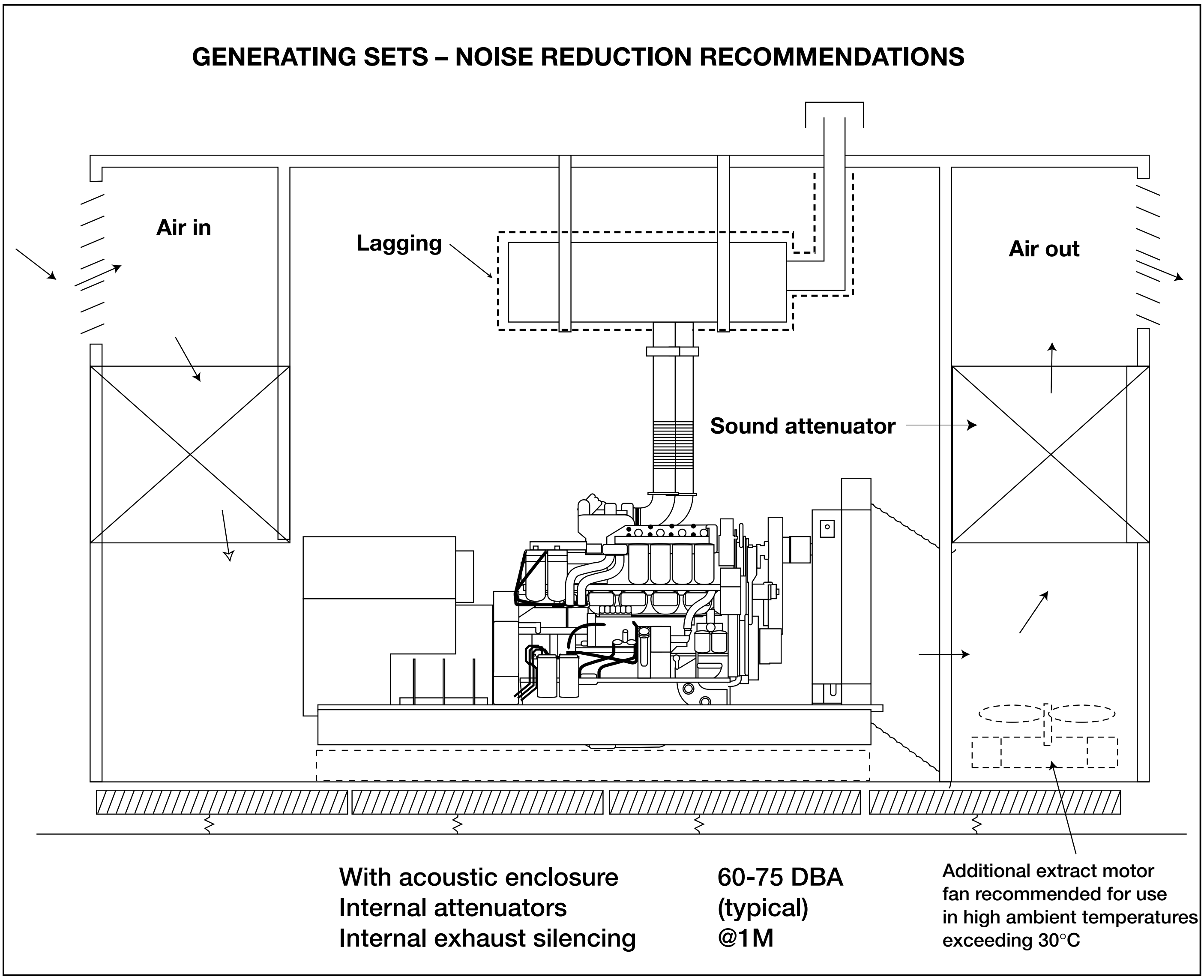



*Fig. F6 Arrangement to meet low noise specifications.*

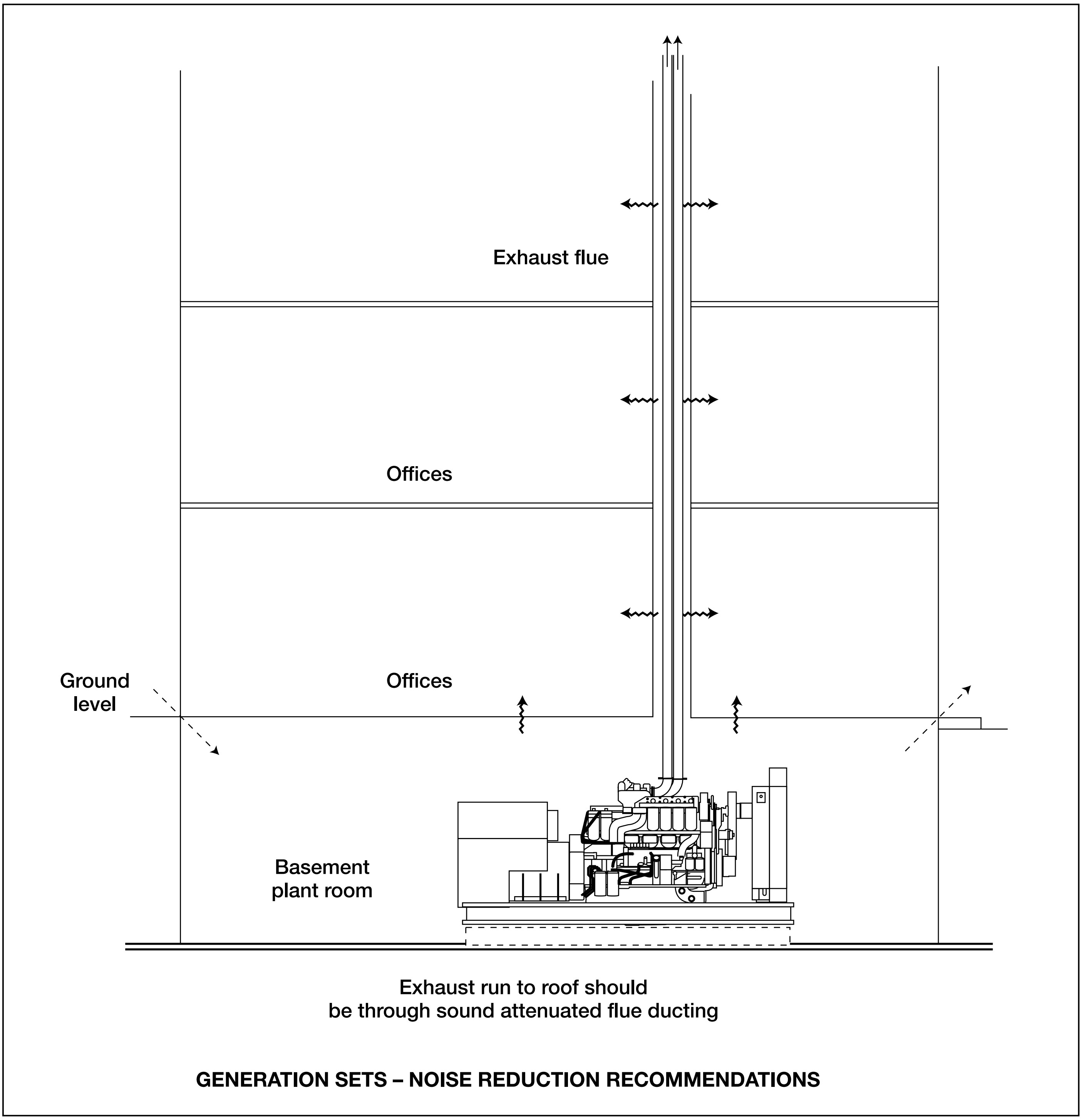



*Fig. F7 Generator located below ground level.*

*Sound attenuators inside a plant room for two 1256kVA CP1250-5 sets*

*1000kVA Super Silenced (75dBA@1m) automatic standby set for major hypermarket chain warehouse*

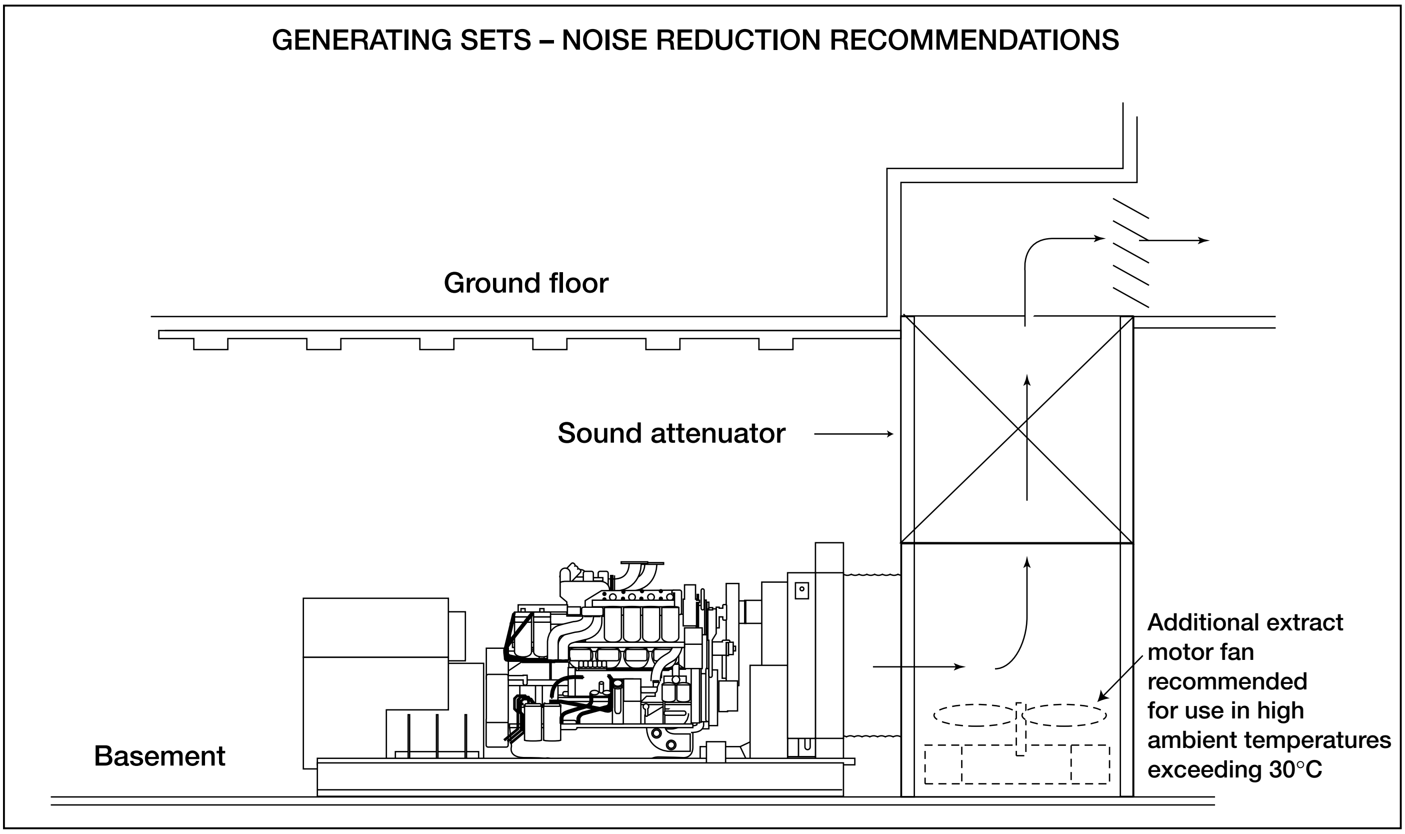



*Fig. F8 Acoustic plenum chamber silencing.*

## Plant-room locations (cont.)

Thus with a plant-room noise level of (say) 105 dBA, and typical reductions through walls of 25-35 dBA, and through a ceiling slab of 30-40 dBA, resultant levels in adjacent areas would be 70-80 dBA (the other side of the walls) and 65-75 dBA (above the slab). Whilst areas to either side of the generator room may well be non-critical (e.g. if they are other plant-rooms), areas above are usually office/reception areas, where maximum tolerable levels are likely to be 45-55 dBA.

**Room Treatment**

To significantly improve noise breakout levels - either involves fitting an indoor style acoustic enclosure around the set (space/access problems often preclude this) or adding acoustic panel wall/ceilings to the room. It is important to recognise that such treatments are different to simple absorptive lining treatments. These latter, which are applied direct onto the surfaces involved, simply introduce areas of adsorption into the area , reducing the reverberant noise level in the plant-room.

Whilst this reduction (typically about 5 dBA) in **internal** plant-room noise level will also manifest itself as a reduction in noise breaking through to adjacent areas, such treatments do not significantly improve the sound insulation of the wall/slab treated.

By using secondary acoustic panel treatments **spaced off the wall/slab concerned** the noise breakout level can be reduced by 10-15 dBA. On acoustic ceilings it is important to minimise rigid fixings to the slab, using spring hangers where possible.

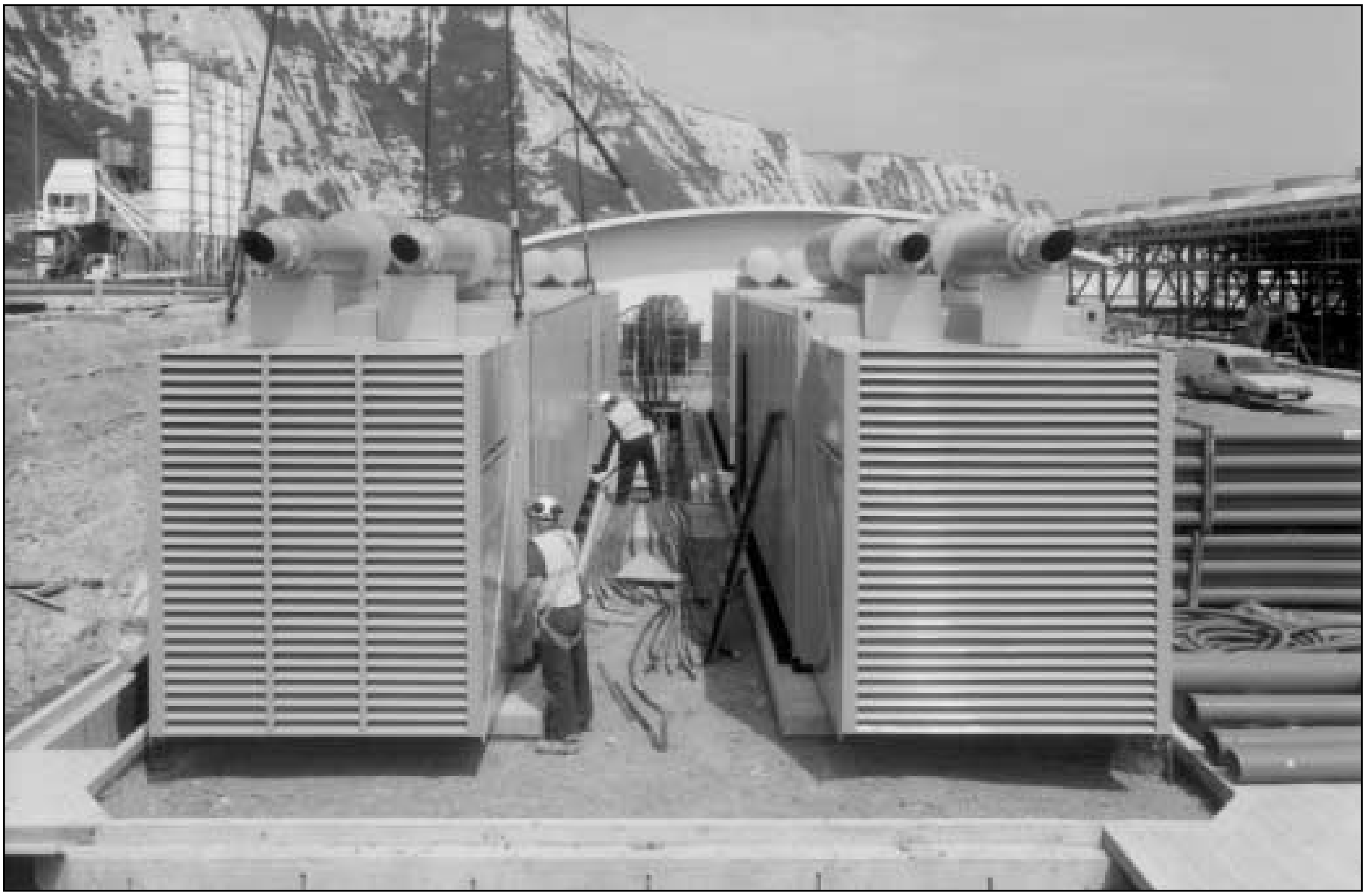
**Plant-Room Doors**

One final (but critical) point concerning noise breakout from the generator plant-room is that any access doors should generally be of the acoustic type (of appropriate performance), and consideration must be given to noise breakout via pipe/cable penetrations - particularly trenches which often pass under dividing wall lines.

**Exhaust system**

Turning now to the exhaust system - this is often overlooked somewhat on the basis this is frequently piped via a flue to roof level, and so assumed that ‘residential’ grade silencing is adequate. Whilst this may be acceptable in many cases, consideration should be given to noise from the flue itself (Fig. F7). Even with primary silencing carried out in the generator room, residual noise levels inside the exhaust riser are still relatively high (possibly 90-100 dBA), and if the riser shaft is constructed from lighter weight materials, or has access doors/panels then noise breakout to low noise level offices can be a problem. In terms of noise at the exhaust termination, this should obviously relate to spec. levels at (say) surrounding buildings - or noise breaking back into the building served. For particularly low levels regenerated noise caused by the relatively high pipe velocities can be a problem.

*Two 1000kVA silenced standby sets with 'drop over' enclosures at roof top level eliminate many problems but create others*



*Four 1250kVA automatic starting, auto sync sets in specially adapted containers reduce noise levels down to 75dB(A)@1m Photo: Courtesy of EuroTunnel - Transmanche link*


*6m (20ft) silenced module forms part of an 18m (60ft) installation containing a 2000kVA standby generator*

*Modular construction cuts time factor down significantly on site.*

*Completed installation with roof mounted radiators and exhaust system.*

*Large containerised generators for isolated locations provide a convenient package for transportation and fast installation.*

## Roof top locations

Not all generators are located in basements, however, and mention should be made of units in higher level - or rooftop - plant-rooms . The main additional problem here is noise breakout through the floor slab to areas below (which are generally noise sensitive). This can be controlled by full floating floors, although these are often problematical with large heavy items such as generator sets.

A more practical approach is to have the generator set on plinths (using suitable high performance anti-vibration mountings) with an ‘infill’ acoustic floor for the intermediate spaces.

Table 8 summarises plant-room treatments for a range of external noise levels.

## Table 8

DIESEL GENERATOR INSTALLATIONS - PLANT ROOM.
ELEMENTS RELATIVE TO NOISE LEVELS (GUIDANCE ONLY)

| Noise Level | Louvres/Attenuators | Doors | Walls | Exhaust | Comments |
|---|---|---|---|---|---|
| 85-90 | Acoustic Louvres | Solid Core Timber | Blockwork | Single Residential | |
| 75-80 | Attenuators | Acoustic (Standard) | Cavity Blockwork (plastered/sealed) | Residential + Secondary or high performance | |
| 65-70 | Attenuators | Acoustic (Heavy Duty) | Cavity Blockwork (plastered/sealed) | 2 residential + secondary or high performance + secondary | |
| 55-60 | Attenuators, possibly with acoustic louvres or lined bend(s). Attenuators may need panelwork casings. | Acoustic inner + outer | Cavity Blockwork + acoustic lining | 4 Silencer System | Internal Enclosure - possible option. Air generated noise at louvres needs consideration |
| 55 or less | Untypical and often impractical. Requires special consideration. | | | | |

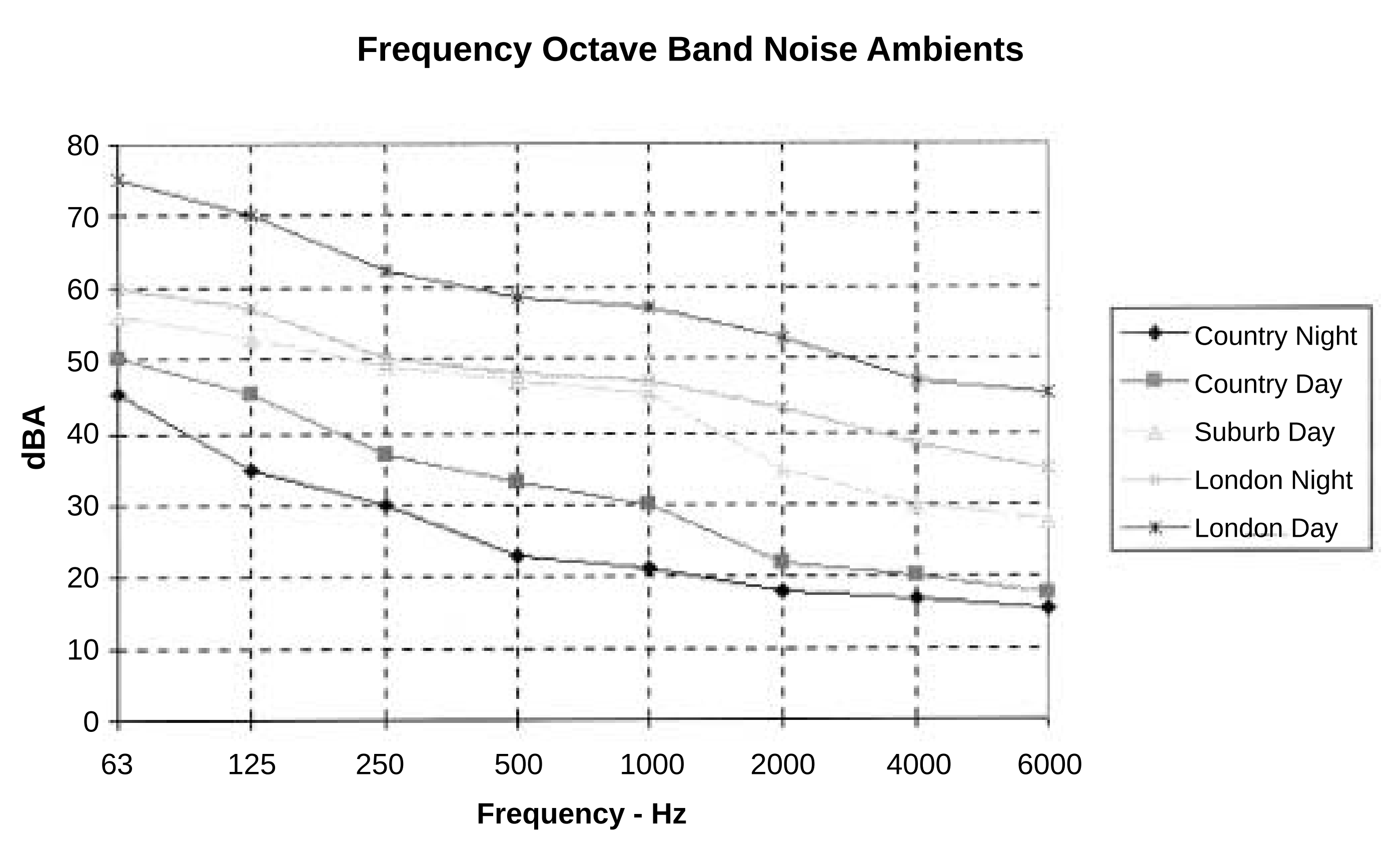



*Fig. F9 Frequency Octave Band Noise Ambients*

## Units of Sound Measurement

Sound power level (environmental noise) = dB(A) / 1pw

Sound pressure level (at operators ear) = dB(A)

The 'regulated' levels of sound are unlikely to be adequate for standby generators located near to sensitive environments such as hospitals, offices, public places and residential districts.

## Measurement of Sound - Decibels

Pressure Measurement

Each crest of a sound wave arriving at the ear causes the eardrum to flex inward. A powerful wave with high crests will cause more eardrum flexure than a weaker wave and so the brain perceives one sound as being more loud than another.

The diaphragm of a microphone behaves exactly the same way as the eardrum when struck by a sound wave. A microphone, augmented by amplifiers, rectifiers and a measuring instrument can thus measure the sound pressures of different sound waves and therefore determine the intensity of the sound.

Measurements have shown that a barely audible sound has an intensity of one picowatt (one million-millionth of a watt) per square meter, whereas a jet engine at a range of 25 meters delivers 100 w/m2. The roar of the jet engine is thus 1014 times more intense!

## Logarithmic Decibel Scale

Absolute values of sound pressure and sound intensity can only be expressed in long and cumbersome numbers. The use of a logarithmic scale makes it much easier to express the levels in convenient terms. The unit of measurement on this scale is called the 'bel' after Alexander Graham Bell. In practice, for the sake of being able to work with whole numbers, it is customary to multiply values in bels by 10 and to express the values in decibels (dB).

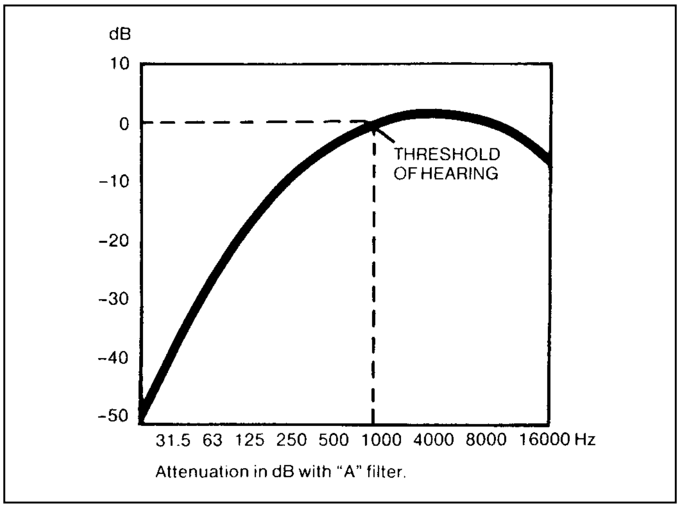



*Fig. F10 Attenuation in dB with 'A' Filter*

## Logarithmic Decibel Scale (cont.)

The decibel rating of a given sound indicates the level of sound pressure or intensity at which it lies. The threshold of hearing (Fig. F10) at a frequency of 1000 Hz gives the starting point of 0 dB, and the threshold of pain is reached somewhere between 120 and 130 dB.

But we have to be careful with decibels, logarithmic numbers cannot be added together in the same way as ordinary numbers. Thus a rise of 3 dB corresponds to a doubling of sound intensity, while a rise of 10 dB from a given level means that the sound intensity becomes 10 times higher than before.

## Frequency Filter

Although two sound waves with different frequencies may have the same sound pressure, we do not necessarily hear them as loud. This is because the ear is most sensitive in the 2000 to 4000 (2 - 4 kHz) range, while lower frequencies in particular are not picked up as well. Allowances are made for this non-uniform sensitivity when noise levels are measured. Most sound level meters therefore have built in filters. They imitate the ear by attenuating the lower frequencies thereby obtaining physiologically realistic noise level readings.

There are several different types of frequency filter, but the most widely used one is the ‘A’ filter. This is standard equipment when measuring traffic noise, for example. Readings obtained with such meters are expressed in dB(A), the letter in brackets indicating the filter type used.

## Octave Band Analysis

A measurement of true loudness requires, not only single reading of a noise-level meter, but at least eight single readings of the sound level, each reading being an indication of the noise power in part of the frequency range encompassed by the noise. Some simple arithmetical manipulation of the eight values obtained then gives the true loudness, a figure that would agree with the subjective reactions of a panel of listeners.

Most common noises consist of a mixture of separate frequencies and are not just a single frequency. A measurement of the distribution of the sound energy can be given by a sound level meter, preceded by suitable electronic circuits that separate the total frequency band into eight separate sections and allows the noise energy in each section to be separately determined. These are the eight readings known as octave band analysis. See Figs. F9 and F11.

Hz Frequency bands (full width) Octave

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 75 | 150 | 300 | 800 | 1200 | 2400 | 4800 |
| 75 | 150 | 300 | 600 | 1200 | 2400 | 4800 | 9600 |

Typical Octave on Centre Frequency

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K |

*Fig. F11*

## How loud is ‘too loud’

It is accepted that the ‘upper threshold’ of sensitivity to noises varies from person to person: variations of ±20 dB have been noted. The composition of noises in terms of frequency is another variable factor, and the effects of different parts of the noise spectrum on human physiology are well documented. The predominant frequencies in a noise are of fundamental importance when selecting the means of controlling noise.

Normal industrial acoustic-measurements systems incorporate a weighting which balances out sound in terms of human response at different frequencies. Of the three principal weighting networks (A,B and C), A equates so well with the subjective response of average people that many noise problems are assessed in terms of the A-weighted decibel, denoted dB(A).

## Specifying sound - Decibels and noise ratings

Decibels

Sound levels in decibels should be defined by one of the three principal frequency filters, namely A, B or C. For example, most sound levels, if intended to relate directly to human hearing should be defined in dB(A) terms.

But dB(A) figures by themselves are valueless until applied to a distance, for example 83 dB(A) at 1 metre.

This is essentially the ‘average’ value of decibel readings at specific frequencies taken across an octave of eight frequency bands, say from 63 to 8000 Hz (see Figs. F11 and F12).

**Examples of noise levels of generating sets on full load**

Unsilenced 200 kW generating set

| Frequency Hz | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | dBA |
|---|---|---|---|---|---|---|---|---|---|
| @ 1m from radiator & exhaust | | 88 | 89 | 98 | 94 | 91 | 90 | 98 | 105 |
| @ 1m from side | | 78 | 92 | 92 | 93 | 96 | 89 | 92 | 105 |

200 kW generating set in Silencing Enclosure

| Frequency Hz | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | dBA |
|---|---|---|---|---|---|---|---|---|---|
| @ 1m from radiator & exhaust | | 83 | 87 | 71 | 65 | 61 | 58 | 60 | 84 |
| @ 1m from side | | 72 | 75 | 67 | 63 | 61 | 55 | 55 | 76 |
| @ 7m from radiator & exhaust | | 77 | 73 | 66 | 62 | 56 | 52 | 57 | 76 |
| @ 7m from side | | 68 | 67 | 66 | 59 | 56 | 52 | 49 | 72 |

*Fig. F12*

## Noise Rating (NR terms)

A further and lesser used system to define the noise level for a generating set is the NR (Noise Rating) method as illustrated in Figure F13.

In this case the specification could call for an NR40 rating at 30 metres for example. The NR ratings are an arbitrary scale and are used as a guide to the ‘annoyance’ factor that a certain level of noise will create in the minds of those exposed to the irritation.

Scales for dB(A) levels and the eight frequency levels (as in Fig. F11) are the accepted international standards for noise measurement. The NR ratings on the RH side of the diagram, however, are ‘values of annoyance’. The accompanying table gives an indication of possible results using this method.

Sound of equal loudness but of different frequency do not produce equal degrees of irritation, high frequency noises being much more ‘annoying per decibel’ than an equal lower frequency noise. Instruments do not take this into account but as Figure 13 shows, graphical illustration does.

Each curve is a contour of ‘equal annoyance’, indicating the sound intensity required at each frequency to produce the value of annoyance mark at the right hand side of the curve.

To test, readings of sound intensity, in each of the eight octave bands, can be taken by a sound level meter preceded by an octave filter and plotted on the curve sheet. The points should then be joined together by straight lines. The resultant plot gives this noise a ‘Noise Rating’, the rating being taken at that point of the curve immediately above the highest plotted rating.

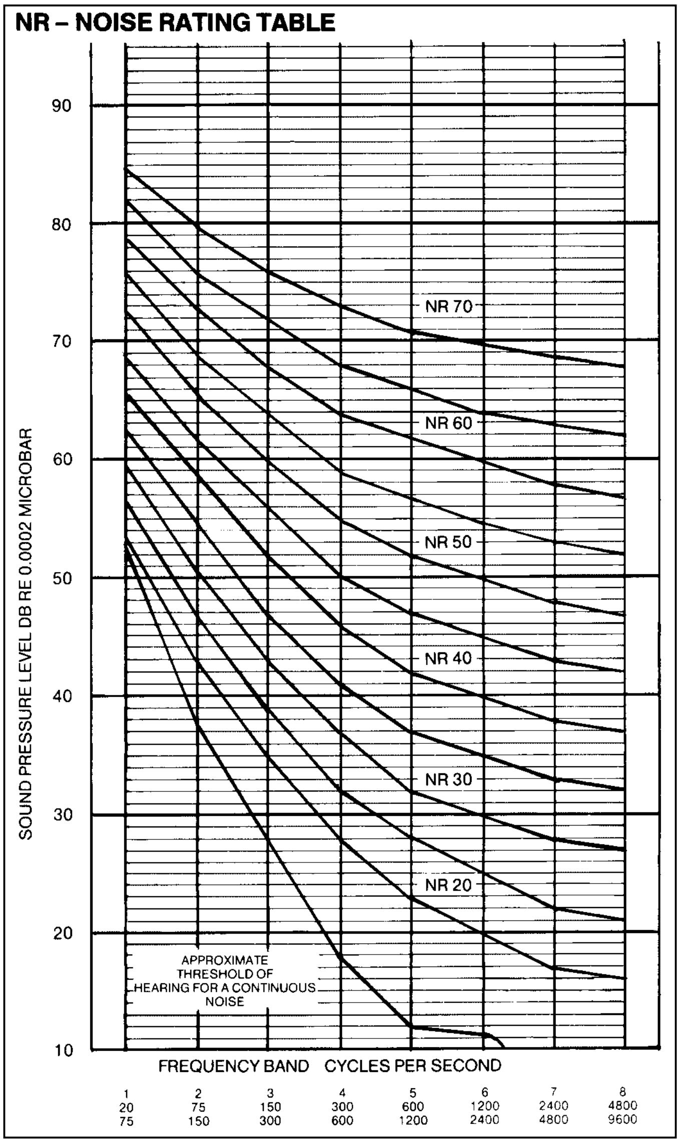



*Fig. F13*

For anyone to specify noise levels below - say NR40 - it is necessary for them to specify the distance away from the generating set that the readings are taken. For instance, a generator 30 m away will probably comply, but not 15m away. As an approximate guide to "noise annoyance" levels, the following NR ratings are indicated and apply to Figure F13.

| | |
|---|---|
| NR40 and below | - No observed reaction |
| NR40 to NR50 | - Few complaints |
| NR45 to NR55 | - Main sector for complaints |
| NR50 to NR60 | - Legal action possibly threatened |
| NR65 and above | - Action taken |

By comparison with actual environments (Figure F15) illustrates NR ratings against specific locations.

*Fig. F14*

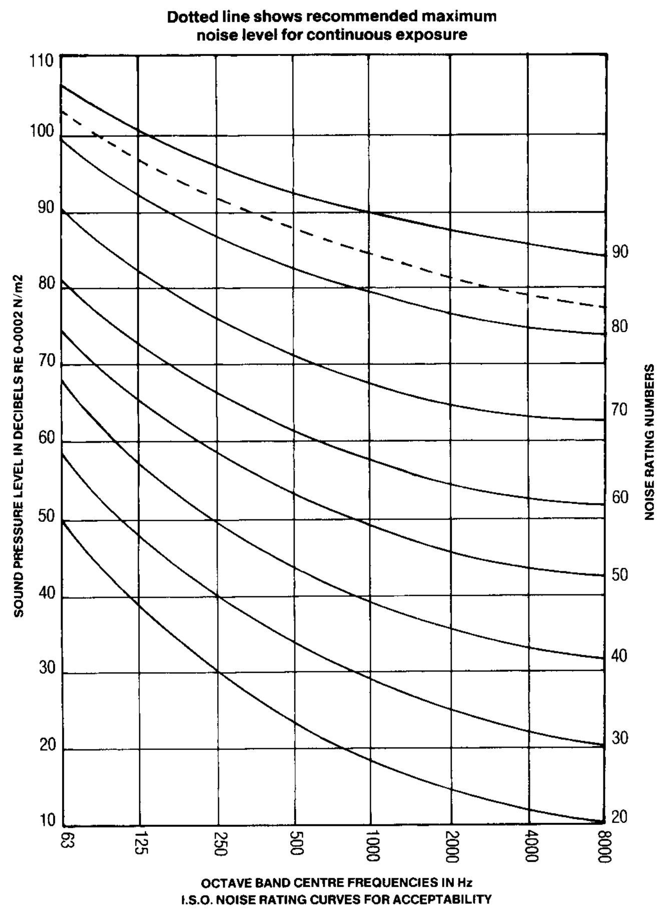



Fig. F15 NR - Noise Rating Table

| Noise Rating Number | Type of Room |
|---|---|
| 15 | Broadcasting Studio |
| 20 | Concert Hall or Theatre |
| 25 | Bedroom, large conference room, classroom, TV studio |
| 30 | Living room, small conference room, hospital, church library |
| 40-50 | Private office, gymnasium, restaurants |
| 50-55 | General office |
| 65-75 | Workshops |

Table. F16 Decibel Rating - (dB) - Environments

| **Decibels** | **dB** |
|---|---|
| Threshold of hearing at 1kHz | 0 |
| Studio for sound pictures | 20 |
| Residence - no children | 40 |
| Conversation | 60 |
| Heavy Traffic | 80 |
| Underground train | 100 |
| Close to pneumatic drill | 120 |
| Gas turbine engine at 30m (damage to ears) | 140 |
| Rocket engine at 30m (panting of stomach) | 160 |
| | |
| 110dB in vicinity of airports | |
| Logarithmic scale of measurement | |
| Sound of 1 watt at 0.3m distance | = Intensity of $10^4$ (painful to ears) |
| Each step of 10 decibels | = Increase of intensity of 10 times |
| Therefore 20 dB | = 100 times the minimum |
| Therefore 30 dB | = 1000 times the minimum |

## Sound Reduction - The choice

The choice of reducing sound levels on generating sets falls into a number of categories.

- Standard sheet metal weather protection - for use outdoors, small reduction on mechanical noise, but radiator noise is unaffected. Exhaust noise can be considerably reduced.
- Enclosing the generator in a specially designed sound proof canopy with air inlet and outlet sound attenuators - for use outdoors.
- Standard soundproof enclosures will give a reduction between 12 and 30 dBA. A further reduction can be achieved by increasing the density of the barrier and increasing the length of air inlet and outlet attenuator on specially designed enclosures for specific duties.
- Installing the generating set in a normal brick room with air inlet and outlet sound attenuators and acoustic doors. High reverberant noise level within the plant room but effective reduction of the noise levels to outside.
- Installing the generating set in a room lined with sound absorbing material and with air inlet and outlet sound attenuators.

Noise inside plant room reduced and considerable reduction on noise level to outside.

- Installing an enclosed generating set in a room. The set is enclosed in a specially designed sound proof canopy with integral air inlet and outlet sound attenuators.

Low noise levels inside and outside of room.

- Other means of reducing noise. These remote radiators (to spread the noise over selected areas) and the use of cooling towers, although in both cases the generating set noise, even without the radiator will be relatively high.

The noise level of an unsilenced or silenced generating set as heard by the listener depends on the following factors

i) The level of the noise at its source

ii) The level of ambient background noise

iii) The hearing ability of the listener

iv) The distance of the listener from the source of the noise

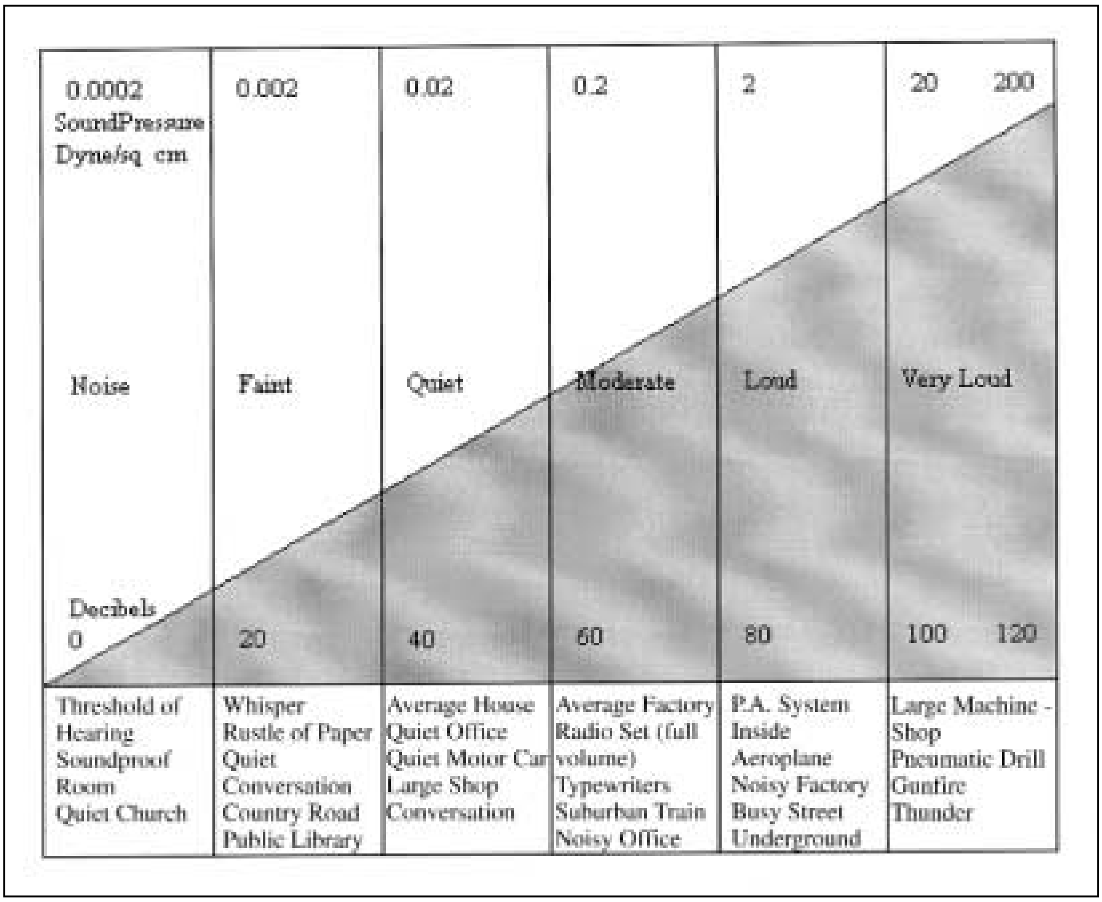



*Fig. F17 Sound Intensity Examples*

## Acoustically Treated Enclosures for Cummins Generating Sets

## Attenuation

The standard enclosures are designed to give a noise reduction of 15 to 30 dB(A) and relate to the two standards of silencing produced by Cummins Power Generation ie: (see Fig F18)

Silenced sets - 85dB(A)@1m

Supersilenced sets - 75dB(A)@1m

**General Specification - Package Units**

In noise critical installations, the addition of acoustic enclosure over the generating set will normally reduce the mechanical noise to an acceptable level. See page F6 and F7 for dimensions and weights.

The enclosures are pre assembled on a channel support. The exhaust silencer(s) will be mounted within the enclosure. The primary silencer is normally lagged with insulation to reduce the radiated heat. The exhaust is discharged to atmosphere through a tuned tail pipe in the direction of the cooling air flow. A flexible exhaust section is incorporated between the engine outlet and the silencer to isolate the enclosure from vibration. The generating plant is fully protected against the weather by the enclosure. Hand pumps are recommended on the plant for filling the fuel tank and draining the engine lubricating oil and, on large plant, for filling the radiator water cooling system. Doors are provided in the enclosure to gain access to the plant for routine maintenance and operating controls, but for major overhauls, the enclosure may be lifted clear.

**Specification - Drop Over Enclosures**

Require a concrete pad for generator and enclosure. Generator is positioned and silenced enclosure ‘dropped over’, leaving only the exhaust system to be connected and cables run in to the load terminal box. Exhaust silencers are generally roof mounted.

The enclosures can also be supplied for assembling over a generating plant inside an engine room to isolate the rest of the building from noise. With this type of installation, additional exhaust piping and cooling air ducting may be required. The enclosures can be used equally well for mobile generating plant, and in these cases the trailer should be suitably uprated to allow for the additional weight involved.

| Examples of Noise Level | dB |
|---|---|
| Very noisy factory, Thunder | 110 |
| Unsilenced pneumatic drill | 100 |
| Underground train | 90 |
| Construction site, Busy street | 80 |
| Normal office, Restaurant | 70 |
| Conversation @ 1m | 60 |
| Quiet office | 50 |
| Quiet park | 40 |
| Residential suburban night | 30 |
| Quiet garden at night | 20 |
| Quiet church | 10 |
| | 0 |

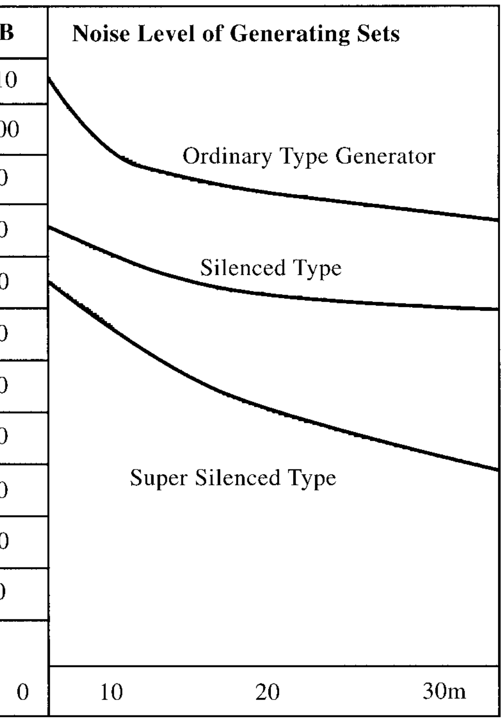



*Fig F18*

## Sound Reduction - Site Conditions

As noise is highly modified by its surroundings, it is essential to know the ultimate location of the generating plant. This usually falls into separate categories: Installed in a plant room or external to a building in the open. The following questions need to be answered:

1) What is the existing noise and vibration climate of the site?
2) What is the maximum noise level allowable in the surrounding area?
3) Is the predetermined noise level realistic?
4) If an existing plant room, what is the insulating and isolating performance of the building?
5) Is there sufficient ventilation for the plant?
6) What is the permissible floor loading of the site?

## Existing Noise on Site (See Table 2 page F12 and Fig. F17 page F28)

It is always advisable to measure the existing background noise level before installation of the equipment, as it is pointless to attempt to attempt to reduce the noise levels below those already existing. There are, however, exceptions to this in certain parts of the country, where there is an obvious attempt by local authorities to reduce the overall noise pollution. Although many existing sites are extremely noisy during working hours, they may be extremely quite at night-time and this should be borne in mind, particularly if the standby plant may be required to run outside normal hours.

## Maximum Noise Level

Correction for the type of district in the neighbourhood of the measuring position.

| | |
|---|---|
| 1) Rural residential. | -5dBA |
| 2) Suburban, little road traffic. | 0 |
| 3) Urban residential. | +5bBA |
| 4) Predominantly residential urban but some light industry or main roads | +10dBA |
| 5) General industrial (between 4 and 6) | +15dBA |
| 6) Predominantly industrial area with few dwellings | +20dBA |

Correction of time of day

Weekdays only

| | |
|---|---|
| 08.00 - 18.00 | +5dBA |
| 22.0 - 17.00 | -5dBA |
| Other times | 0 |

If it is known that the noise will occur only during the winter months, +5dBA is added to the base criterion.

## Realistic pre-determined Noise Levels

As previously pointed out, there is little point in attenuating noise to ridiculously low levels. In certain cases (TV and radio studios, hospitals etc.), very low noise levels are required but these are generally well specified.

In the main, noise levels of 60 dBA are usually acceptable for residential areas and to attempt to reduce the noise levels below this figure is costly and can add considerably to the size of an installation (a 40 dBA outlet attenuator can exceed 2m in length)

## Insulating and Isolating Properties of Plant room materials.

We should first consider the terms used:

Sound Insulation

This is the reduction in sound energy achieved by a structure separating a noise source from a quiet area. Sound insulation term is only used when a reduction of airborne sound is involved and implies a net reduction in sound when it is transmitted by walls etc. connecting two rooms.

Sound Isolation

A term used for the transmission originating at impacting or vibrating sources, i.e. water hammer in pipework, slammed doors, vibrational excitation originating at machinery. The ability of a partition to resist impact noise is dependant on the character of the surface receiving the energy. The effectiveness of a partition to act as an insulator is determined by the following parameters:

1) Weight
2) Stiffness
3) Homogeneity and uniformity
4) Discontinuity and isolation

The following list gives some idea of the average Sound Reduction index for typical building materials (see also Figures 19,20,22,23 and 24)

| | |
|---|---|
| **Doors** | |
| Hollow door with 3mm wood panels | 15dB |
| 42mm solid wood, normally hung | 20dB |
| **Glass** | |
| 3mm | 26dB |
| 6mm | 30dB |
| 12mm | 33dB |
| Double glazed units with two 6mm panels and 12mm gap | 40dB |
| **Plaster** | |
| 50mm | 35dB |
| Plastered breeze block | 40dB |

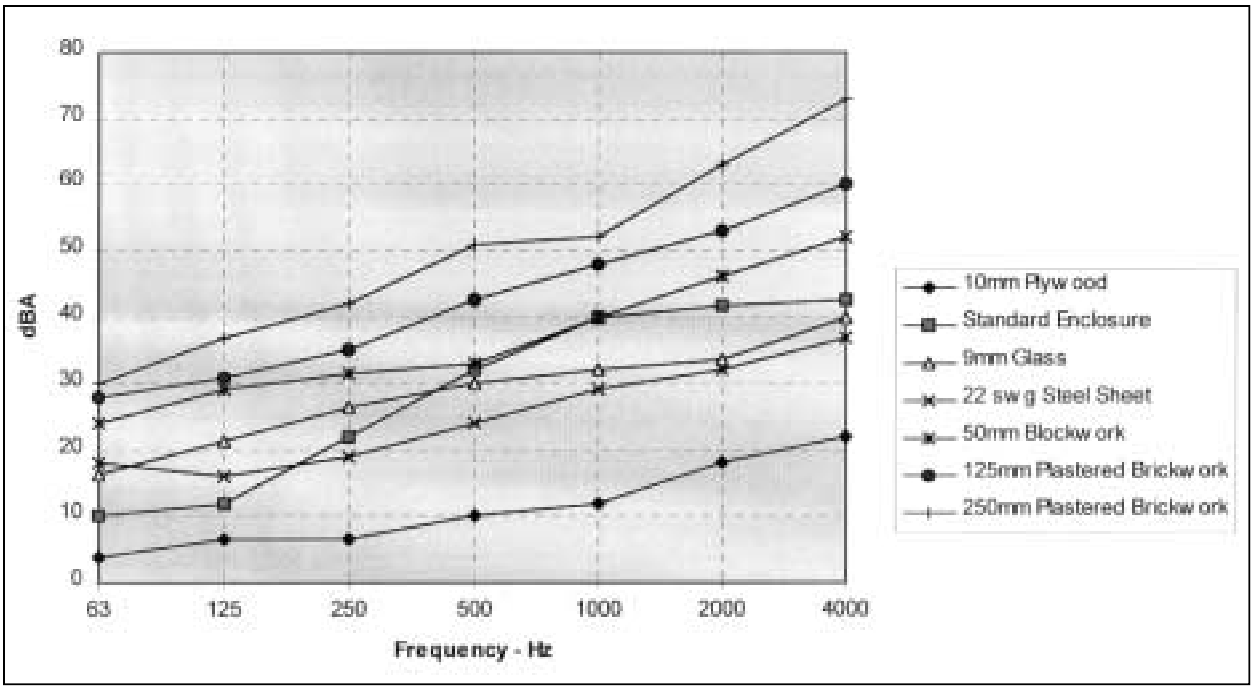



*Fig F19*

Brickwork

| | |
|---|---|
| 100mm unfinished breeze block | 20dB |
| 110mm brick | 45dB |
| 220mm brick | 45dB |
| 350mm brick | 50dB |
| 450mm brick | 55dB |

The Sound Reduction Index can be arrived at by the following formula:

$R_{mean} = 20 + 14.5 \log_{10} W$ dB

Where W is the superficial weight in $lb/ft^2$

## Plant Ventilation

An important factor in specifying noise control equipment for diesel generating plant is the need for adequate provision of air into and out of the plant room or enclosure. As the larger plant (800kW) require a combustion air volume of around 3200 c.f.m. and a radiator throughput of 40 000 c.f.m., this can entail using quite large attenuators if the pressure drop is to be kept to reasonable figures.

Certain locations may require the air to be ducted in from the outside and allow for this in the site survey.

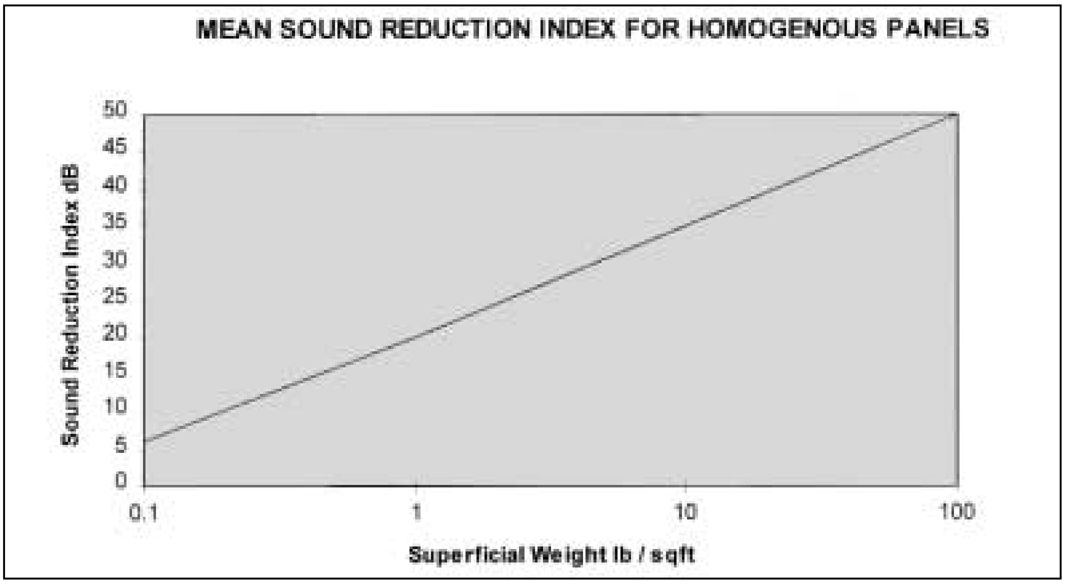



*Fig F20*

## 6. Floor Loading

The acoustic mass law relates the superficial weight of a partition to its transmission loss. In general, for every doubling of the weight , there is an increase in insulation of about 5dB.

As most acoustic partitions have a weight of approximately 41kg/sq.m.(10 lb/ft$^2$,) it can be seen that the overall weight of an enclosure can be quite large, i.e. an 2.4m (8 ft) wide by 4.6m (15 ft) long enclosure for a 300 kW generator can weigh 4 tons. If you add to this the weight of the plant it is easy to see that there will be a considerable floor loading at the site.

There are many factors which can modify the sound level on site - either increasing or decreasing the sound pressure level. Amongst these factors are :

Absorption of sound energy in the atmosphere (See Fig. F21)

Diffraction due to atmospheric gradients of temperature and wind speed.

Reflections from buildings.

The directivity of the noise.

The addition of one or more sets in a generator room.

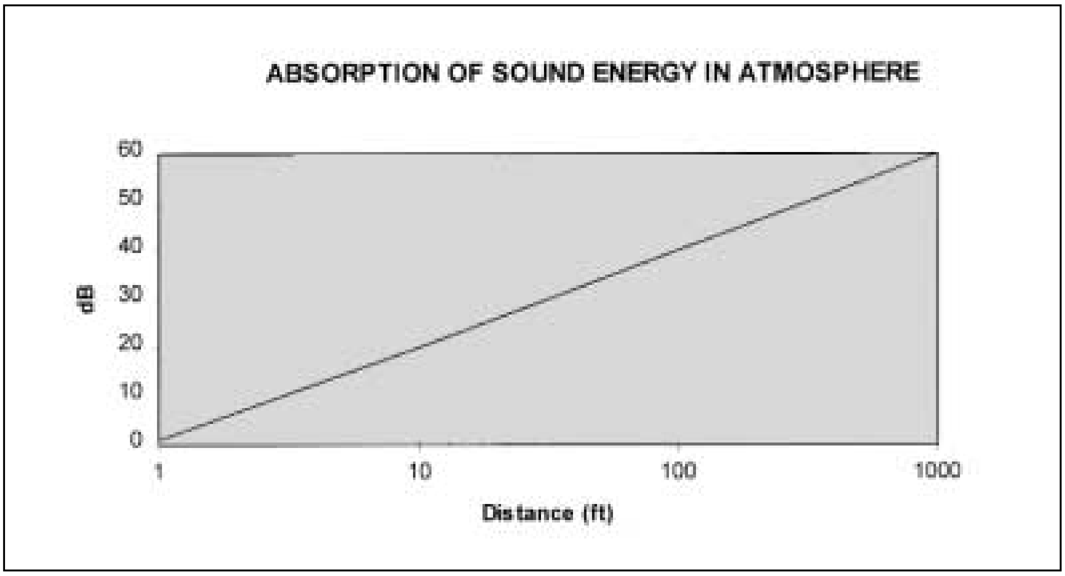



*Fig F21*

## Installation of a Closed Set

For the most effective reduction in noise levels, it is recommended that the installation be isolated and as far away from working, office and residential quarters as possible. This may prove impractical on occasions and does mean increased costs for cable and fuel pipe runs.

Control cubicles can be located inside the enclosure mounted on the set and for manual electric start versions, this is recommended. For automatic mains failure system, the changeover contactors or ATS units should be located as near to the incoming mains as possible to avoid unnecessary cable runs. Protected gullies in the plinth are necessary for the output cables.

Sets can be provided with integral fuel tanks or from an externally mounted day tank with an automatic fuel transfer system from the bulk tank, which is recommended for the permanent installation. Allowance must be made for fuel lines to run to and from the engine through the concrete plinth. Also check which side of the engine these emerge from.

Ensure that the air inlet and outlet flows are not obstructed, as any restrictions of air flows may lead to overheating, loss of output and even shutdown.

**Average Sound Reduction Indices For Typical Partitions**

| | | | | |
|---|---|---|---|---|
| dB | | | | dB |
| 10 | | | | 10 |
| | _____1mm Plywood_____ | | | |
| | | _20 SWG Plain Aluminium_ | | |
| | _____6mm Plywood_____ | | | |
| 20 | _____9mm Plywood_____ | | | 20 |
| | ____22mm Whitewood____ | | | |
| | ____19mm Chipboard____ | ___22 SWG Sheet Steel____ | ___3mm Glass___________ | |
| 30 | ____50mm Mahogany____ | ___16 SWG Sheet Steel____ | ___6mm Glass___________ | 30 |
| | ____Gypsum Wallboard____ | ___9mm Asbestos faced___ 18 SWG Sheet Steel | ___12mm Glass__________ | |
| | __19mm Plasterboard____ Plaster Both Sides | __Corrugated Aluminium__ | | |
| 40 | ___4 x 12mm Gypsum___ Wallboard | | __50mm Reinforced concrete | 40 |
| | | | ___125mm Plain Brick_____ | |
| | | | _100mm Reinforced concrete | |
| 50 | | | ___300mm Plain Brick_____ | 50 |
| | | | ___50mm x 200mm____ blockwork with 100mm gap in between | |
| 60 | | | | 60 |

*Figure F22*

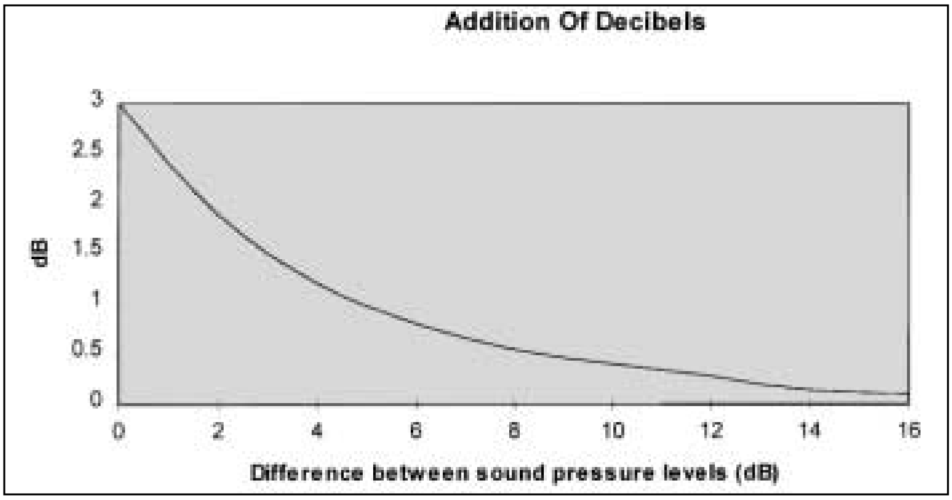



*Figure F23*

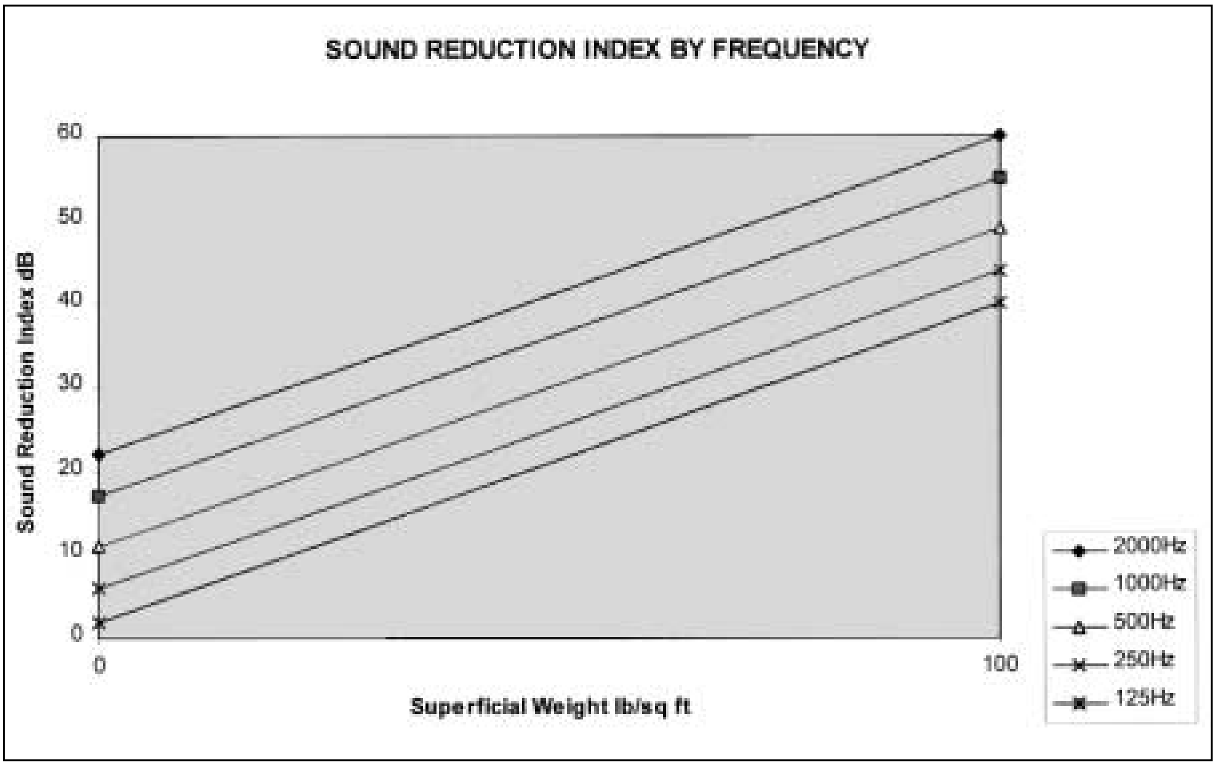



*Figure F24*

*ISO container (9m) 30ft unit contains 600kVA emergency generator. Silenced to 75dB(A) at 1m*

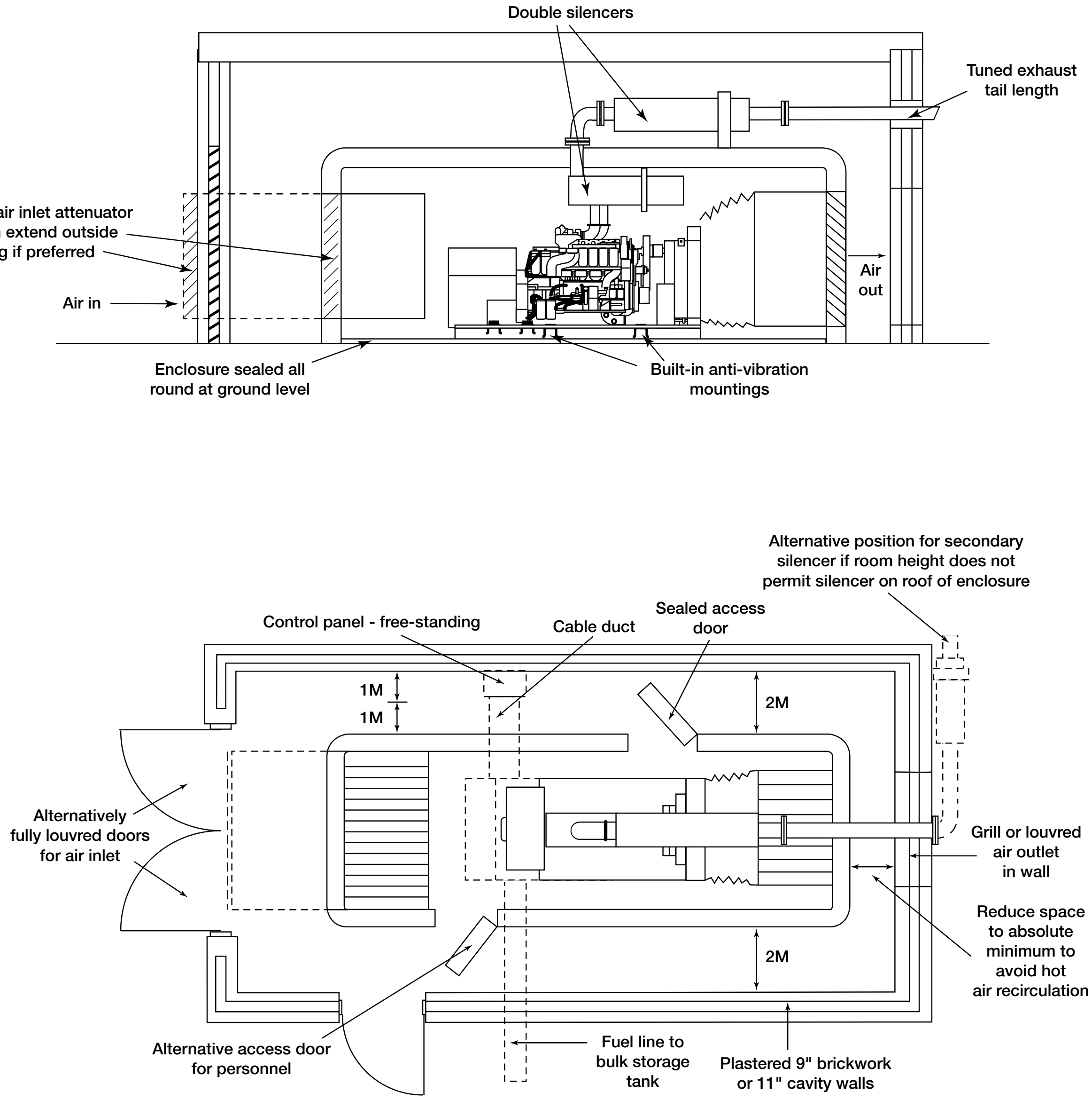
*Drop over supersilenced enclosure for a 3700kVA Prime Power set sits on specially prepared concrete base*

## Installation of a Silenced Enclosed Set inside a Building

For extremely critical locations, where little or no noise can be tolerated, and the cost of the installation is secondary, the use of a soundproof enclosure over a generating set and all enclosed in a well built double capacity brick room is the most effective means. The soundproof enclosure is dismantled, transported into the room in sections and rebuilt in situ, as most installations of this type are in existing buildings.

Air inlet and outlet attenuators are part of the enclosure and it is only necessary to provide normal louvred apertures in the walls for air flow requirements, unless additional sound attenuators in the louvres are specifically required. This type of installation has an additional advantage - from the operator's point of view - of also being extremely quiet "within" the room as well as outside.

Height and space may prove a problem - especially if the site is a converted room in an existing building and, in these cases, the air attenuators can be positioned separately from the enclosure. The secondary silencer can be extended to an outside wall.




INSTALLATION OF A SILENCED ENCLOSED SET INSIDE A BUILDING

*Fig F25*

# 50 Hz Ratings Diesel Powered Generating Sets 26 kW - 1760 kW

***New nomenclature for Year 2000 superceeds 1999 models**

| Prime Rating | | *2000 Model Prime | 1999 Model Prime | Standby Model | | 2000 Model Standby | Cummins 1999 Model Standby | Engine Model |
|---|---|---|---|---|---|---|---|---|
| kVA | kW | | | kVA | kW | | | |
| 32 | 26 | 26 DGGC | CP30-5T | 37 | 30 | 30 DGGC | CS40-5T | B3.3G1 |
| 50 | 40 | 40 DGHC | CP50-5T | 55 | 44 | 44 DGHC | CS60-5T | B3.3G2 |
| 38 | 30 | 30 DGBC | CP40-5 | 41 | 33 | 33 DGBC | CS40-5 | 4B3.9G |
| 52 | 42 | 42 DGCA | CP50-5 | 59 | 47 | 47 DGCA | CS60-5 | 4BT3.9G1 |
| 64 | 51 | 51 DGCB | CP60-5 | 70 | 56 | 56 DGCB | CS70-5 | 4BT3.9G2 |
| 70 | 56 | 56 DGCC | CP70-5 | 78 | 62 | 62 DGCC | CS80-5 | 4BTA3.9G1 |
| 96 | 77 | 77 DGDB | CP90-5 | 106 | 85 | 85 DGDB | CS100-5 | 6BT5.9G2 |
| 106 | 85 | 85 DGDB | CP100-5 | 119 | 95 | 95 DGDB | CS125-5 | 6BT5.9G2 |
| 129 | 103 | 103 DGEA | CP125-5T | 145 | 116 | 116 DGEA | CS150-5 | 6CT8.3G2 |
| 153 | 122 | 122 DGFA | CP150-5T | 170 | 136 | 136 DGFA | CS170-5 | 6CTA8.3G2 |
| 185 | 148 | 148 DGFB | CP180-5T | 204 | 163 | 163 DGFB | CS200-5 | 6CTA8.3G2 |
| 204 | 163 | 163 DGFC | CP200-5T | NA | NA | NA | NA | 6CTAA8.3G1 |
| 233 | 186 | 186 DFAB | CP200-5 | 259 | 207 | 207 DFAB | CS250-5 | LTA10G2 |
| 252 | 202 | 202 DFAC | CP250-5 | 279 | 223 | 223 DFAC | CS280-5 | LTA10G3 |
| NA | NA | NA | NA | 313 | 250 | 250 DFBF | CS300-5 | NT855G6 |
| 315 | 252 | 252 DFBF | CP300-5 | 350 | 280 | 280 DFBF | CS350-5 | NT855G6 |
| 350 | 280 | 280 DFCC | CP350-5 | 390 | 312 | 312 DFCC | CS400-5 | NTA855G4 |
| NA | NA | NA | NA | 425 | 340 | 340 DFCE | CS450-5 | NTA855G6 |
| 431 | 345 | 345 DFEC | CP400-5 | NA | NA | NA | NA | KTA19G3 |
| 450 | 360 | 360 DFEC | CP450-5 | 500 | 400 | 400 DFEC | CS500-5 | KTA19G3 |
| 511 | 409 | 409 DFED | CP500-5 | 576 | 461 | 461 DFED | CS575-5 | KTA19G4 |
| 575 | 460 | 460 DFGA | CP575-5 | 636 | 509 | 509 DFGA | CS625-5 | VTA28G5 |
| 640 | 512 | 512 DFGB | CP625-5 | 706 | 565 | 565 DFGB | CS700-5 | VTA28G5 |
| 725 | 580 | 580 DFHA | CP700-5(T) | 800 | 640 | 640 DFHA | CS800-5 | QST30G1(6) |
| 800 | 640 | 640 DFHB | CP800-5(T) | 891 | 713 | 713 DFHB | CS900-5 | QST30G2(7) |
| 939 | 751 | 751 DFHC | CP900-5(T) | 1041 | 833 | 833 DFHC | CS1000-5 | QST30G3(8) |
| 1000 | 800 | 800 DFHD | CP1000-5 | 1110 | 888 | 888 DFHD | CS1100-5 | QST30G4 |
| 936 | 748 | 748 DFJC | CP900-5 | 1040 | 832 | 832 DFJC | CS1000-5 | KTA38G3 |
| 1019 | 815 | 815 DFJD | CP1000-5 | 1132 | 906 | 906 DFJD | CS1100-5 | KTA38G5 |
| 1256 | 1005 | 1005 DFLC | CP1250-5(T1/2) | 1400 | 1120 | 1120 DFLC | CS1400-5 | KTA50G3(6/7) |
| 1406 | 1125 | 1125 DFLE | CP1400-5 | 1675 | 1340 | 1340 DFLE | CS1675-5 | KTA50G8 |
| 1688 | 1350 | 1350 DQKB | CP1700-5 | 1875 | 1500 | 1500 DQKB | CS1900-5 | QSK60G3 |
| 1875 | 1500 | 1500 DQKC | CP1875-5 | 2063 | 1650 | 1650 DQKC | CS2000-5 | QSK60G3 |
| 2000 | 1600 | 1600 DQKD | CP2000-5 | 2200 | 1760 | 1760 DQKD | CS2200-5 | QSK60G4 |

**Rating Conditions:**

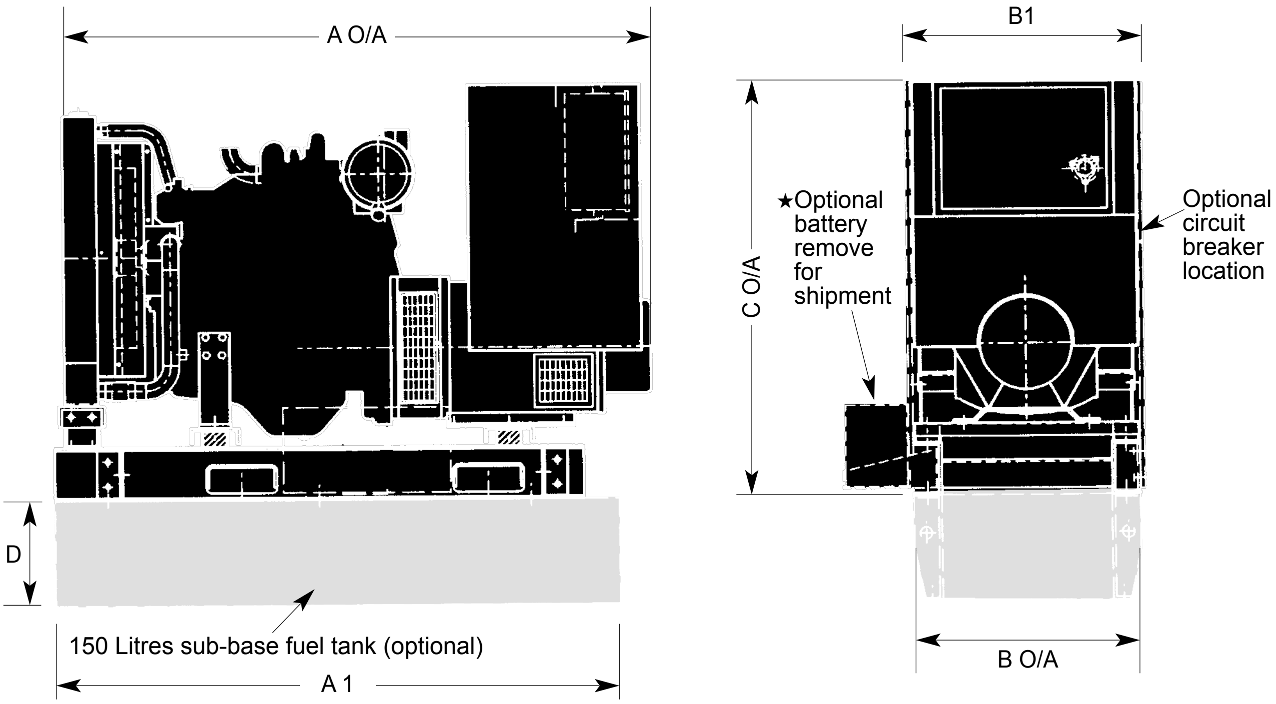
All ratings at 40°C (104°F) ambient temperature.

Ratings: Prime (Unlimited Running Time), applicable for supplying power in lieu of commercially-purchased power.

Prime power is available at a variable load for an unlimited number of hours. A 10% overload capacity is available. Nominally rated. All in accordance with ISO 8528, ISO 3046, AS 2789, DIN 6271 and BS 5514.

Standby: Applicable for supplying emergency power for the duration of normal power interruption. No sustained overload capability is available for this rating. Nominally rated. In accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.

## B3 Series Engines

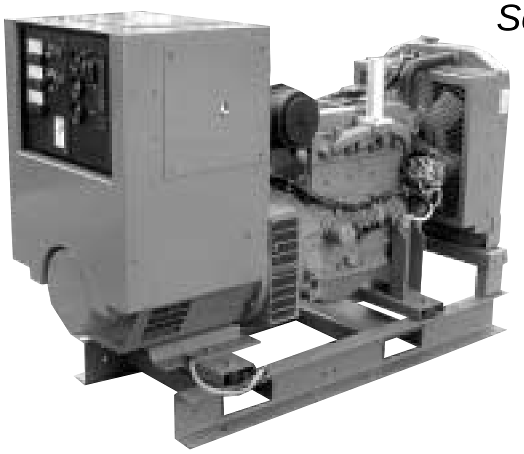



| New Model | Old Model | Engine | Length A mm | A1 mm | Width B mm | B1 mm | Height C mm | D mm | Set weight kg wet | Set weight kg dry | Sub base Tank. Dry Weight kg | Sub base Tank. Wet Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 DGGC | CP30 | B3.3G1 | 1667 | 1600 | 645 | 635 | 1183 | 300 | 835 | 819 | 150 | 299 |
| 40 DGHC | CP50 | B3.3G2 | 1760 | 1600 | 645 | 635 | 1183 | 300 | 890 | 871 | 150 | 299 |

NOTE 1:
★ Dry and Wet weights of sets do NOT include fuel tank or contents.

Set weights are **without** sub-base tank. Dimensions and weights are for **guidance** only.
Sub-base tank weights are for single skin tanks.
Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# TECHNICAL DATA



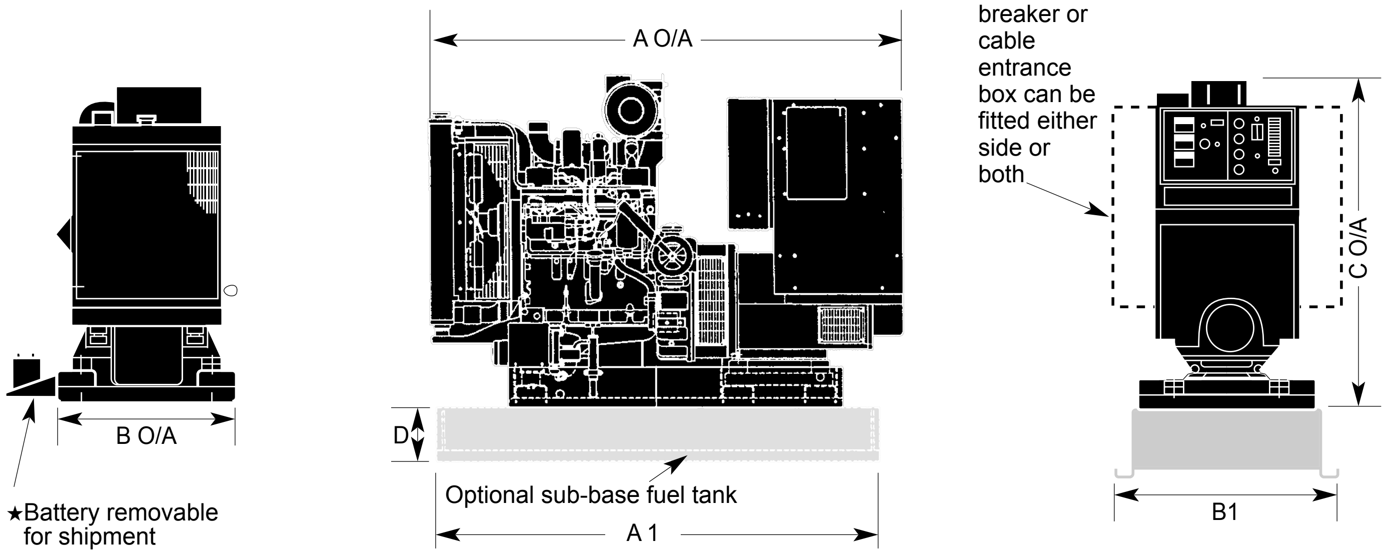
## 26 kW - 45 kW 50 Hz
## B3 Series Engines

### Generating Sets – 50 Hz

| | | |
|---|---|---|
| Set output | 380-440 V 50 Hz | 380-440 V 50 Hz |
| Prime at 40°C ambient | 26 kWe 32.5 kVA | 40 kWe 50 kVA |
| 1999 Set Model (Prime) | CP30-5T | CP50-5T |
| New Model (Prime) | 26 DGGC | 49 DGHC |
| Standby at 40°C ambient | 30 kWe 37.5 kVA | 44 kWe 55 kVA |
| 1999 Set Model (Standby) | CS40-5T | CS60-5T |
| New Model (Standby) | 30 DGGC | 44 DGHC |
| Engine Make | Cummins | Cummins |
| Model | B3.3G1 | B3.3G2 |
| Cylinders | Four | Four |
| Engine build | In-line | In-line |
| Governor/Class | Mechanical | Mechanical |
| Aspiration and cooling | Natural aspiration | Turbocharged |
| Bore and stroke | 95 mm x 115 mm | 95 mm x 115 mm |
| Compression ratio | 18.2:1 | 17.0:1 |
| Cubic capacity | 3.26 Litres | 3.26 Litres |
| Starting/Min °C | Unaided/–4°C | Unaided/–4°C |
| Battery capacity | 126 A/hr | 126 A/hr |
| Nett Engine output – Prime | 31 kWm | 45 kWm |
| Nett at flywheel – Standby | 34 kWm | 49 kWm |
| Maximum load acceptance – single step | 100% | 100% |
| Speed | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±1.5% | ±1.5% |
| Alternator insulation class | H | H |
| Single load step to NFPA110 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 7.8 l/hr | 11.86 l/hr |
| Fuel consumption (Standby) 100% load | 9 l/hr | 13.6 l/hr |
| Lubrication oil capacity | 8 Litres | 8 Litres |
| Base fuel tank capacity – open set | 150 Litres | 150 Litres |
| Coolant capacity – radiator and engine | 11.5 Litres | 14 Litres |
| Exhaust temp – full load prime | 450°C | 475°C |
| Exhaust gas flow – full load prime | 445 $m^3$/hr | 445 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air flow – radiator @ 12mm restriction* | 6582 $m^3$/hr | 4872 $m^3$/hr |
| Air intake – engine | 125.7 $m^3$/hr | 176.7 $m^3$/hr |
| Minimum air opening to room | 0.63 sq m | 0.63 sq m |
| Minimum discharge opening | 0.47 sq m | 0.47 sq m |
| Pusher fan head (duct allowance) | 12 mm Wg | 12 mm Wg |
| Total heat radiated to ambient | 15.4 kW | 15.4 kW |
| Engine derating – altitude | 0.7% per 100 m above 1000 m | 0.9% per 100 m above 1000 m |
| Engine derating – temperature | 1% per 10°C above 40°C | 4.5% per 10°C above 40°C |

In accordance with ISO 8528, ISO 3046.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature reference.
*Subject to factory verification.

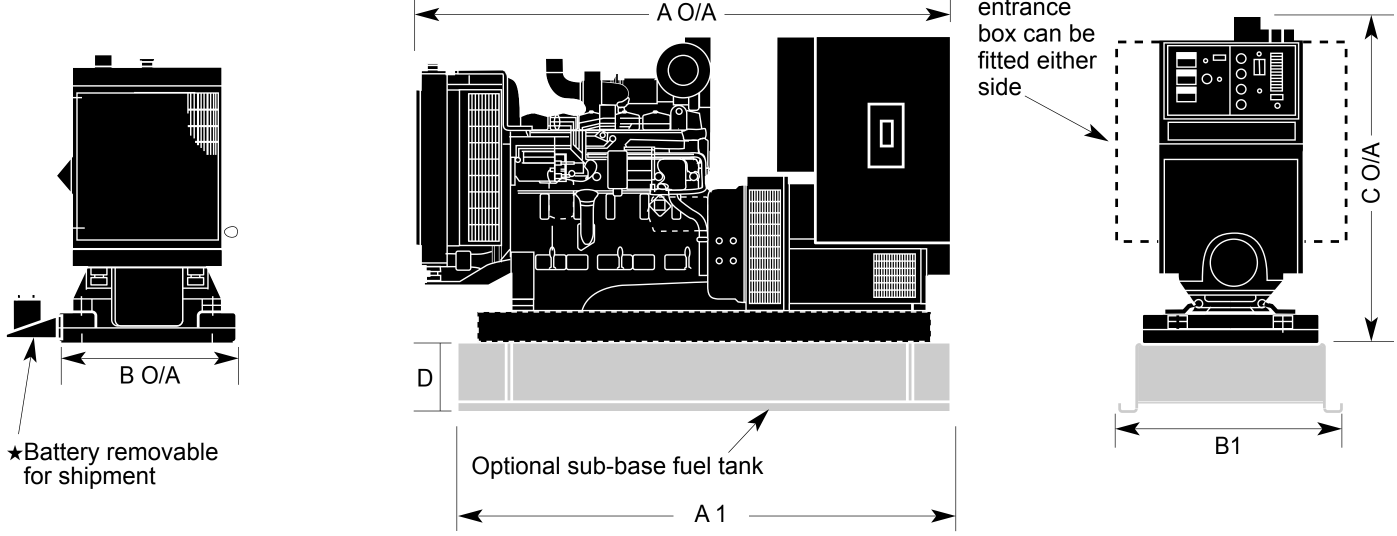
## 4B Series Engines




| New Model | Old Model | Engine | Length A mm | A1 mm | Width B1 mm | B mm | Height C mm | D mm | Set weight kg wet | Set weight kg dry | Sub base Tank. Dry Weight kg | Sub base Tank. Wet Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 DGBC | CP40-5 | 4B3.9G | 1720 | 1675 | 840 | 675 | 1345 | 200 | 800 | 772 | 150 | 310 |
| 42 DGCA | CP50-5 | 4BT3.9G1 | 1810 | 1675 | 840 | 675 | 1245 | 200 | 850 | 822 | 150 | 310 |
| 51 DGCB | CP60-5 | 4BT3.9G2 | 1810 | 1675 | 840 | 675 | 1245 | 200 | 920 | 892 | 150 | 310 |
| 56 DGCC | CP70-5 | 4BTA3.9G1 | 1846 | 1675 | 840 | 675 | 1245 | 200 | 975 | 932 | 150 | 310 |

NOTE 1: ★ Battery/tray extends out 260 mm from side when fitted. ★ Dry and Wet weights of sets do NOT include fuel tank or contents.

## 6B Series Engines



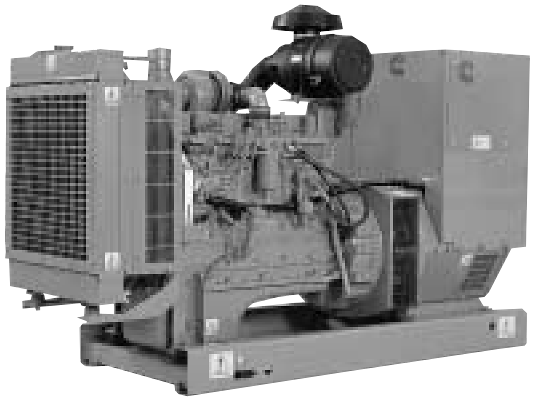

| New Model | Old Model | Engine | Length A mm | A1 mm | Width B1 mm | B mm | Height C mm | D mm | Set weight kg wet | Set weight kg dry | Sub base Tank. Dry Weight kg | Sub base Tank. Wet Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77 DGDB | CP90-5 | 6BT5.9G2 | 2087 | 1675 | 840 | 675 | 1337 | 200 | 1175 | 1138 | 150 | 310 |
| 85 DGDB | CP100-5 | 6BT5.9G2 | 2162 | 1675 | 840 | 675 | 1337 | 200 | 1175 | 1138 | 150 | 310 |

NOTE 1: ★ Battery tray extends out 260 mm from side – when fitted. ★ Dry and Wet weights of sets do NOT include fuel tank or contents.

Set weights are **without** sub-base tank. Dimensions and weights are for **guidance** only. Do not use for installation design.
Ask for certified drawings on your specific application. Specifications may change without notice.

# TECHNICAL DATA

## 30 kW - 62 kW 50 Hz
## 4B Series Engines

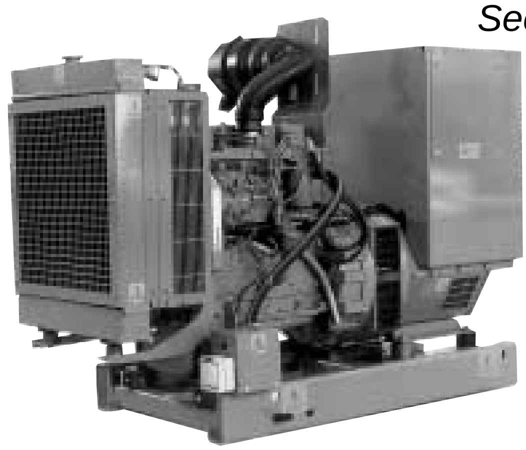


### Generating Sets – 50 Hz

| | | | | |
|---|---|---|---|---|
| Set output | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz |
| Prime at 40°C ambient | 30 kWe 38 kVA | 42 kWe 52 kVA | 51 kWe 64 kVA | 56 kWe 70 kVA |
| 1999 Set Model (Prime) | CP40-5 | CP50-5 | CP60-5 | CP70-5 |
| New Model (Prime) | 30 DGBC | 42 DGCA | 51 DGCB | 56 DGCC |
| Standby at 40°C ambient | 33 kWe 41 kVA | 47 kWe 59 kVA | 56 kWe 70 kVA | 62 kWe 78 kVA |
| 1999 Set Model (Standby) | CS40-5 | CS60-5 | CS70-5 | CS80-5 |
| New Model (Standby) | 33 DGBC | 47 DGCA | 56 DGCB | 62 DGCC |
| Engine Make | Cummins | Cummins | Cummins | Cummins |
| Model | 4B3.9G | 4BT3.9G1 | 4BT3.9G2 | 4BTA3.9G1 |
| Cylinders | Four | Four | Four | Four |
| Engine build | In-line | In-line | In-line | In-line |
| Governor/Class | Mechanical | Mechanical | Mechanical | Mechanical |
| Aspiration and cooling | Natural aspiration | Turbocharged | Turbocharged | Turbocharged |
| Bore and stroke | 102 mm x 120 mm | 102 mm x 120 mm | 102 mm x 120 mm | 102 mm x 120 mm |
| Compression ratio | 17.3:1 | 16.5:1 | 16.5:1 | 16.5:1 |
| Cubic capacity | 3.92 Litres | 3.92 Litres | 3.92 Litres | 3.92 Litres |
| Starting/Min °C | Unaided/–12°C | Unaided/–12°C | Unaided/–12°C | Unaided/–12°C |
| Battery capacity | 165 A/hr | 165 A/hr | 165 A/hr | 165 A/hr |
| Nett Engine output – Prime | 34 kWm | 48 kWm | 57 kWm | 64 kWm |
| Nett at flywheel – Standby | 38 kWm | 53 kWm | 63 kWm | 71 kWm |
| Maximum load acceptance – single step | 33 kWe | 36 kWe | 40 kWe | 40 kWe |
| Speed | 1500 rpm | 1500 rpm | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% | ±1.0% | ±1.0% |
| Alternator insulation class | H | H | H | H |
| Single load step to NFPA110 | 100% | 100% | 100% | 100% |
| Fuel consumption (Prime) 100% load | 9.7 l/hr | 12.76 l/hr | 15.37 l/hr | 15.0 l/hr |
| Fuel consumption (Standby) 100% load | 10.6 l/hr | 13.89 l/hr | 16.88 l/hr | 17.0 l/hr |
| Lubrication oil capacity | 9.5 Litres | 9.5 Litres | 9.5 Litres | 9.5 Litres |
| Base fuel tank capacity – open set | 195 Litres | 195 Litres | 195 Litres | 195 Litres |
| Coolant capacity – radiator and engine | 19 Litres | 19 Litres | 19 Litres | 20 Litres |
| Exhaust temp – full load prime | 596°C | 466°C | 521°C | 475°C |
| Exhaust gas flow – full load prime | 432 $m^3$/hr | 493 $m^3$/hr | 569 $m^3$/hr | 598 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg | 76 mm Hg | 76 mm Hg |
| Air flow – radiator* | 2.26 $m^3$/s | 2.26 $m^3$/s | 2.26 $m^3$/s | 2.27 $m^3$/s |
| Air intake – engine | 144 $m^3$/hr | 187 $m^3$/hr | 205 $m^3$/hr | 248 $m^3$/hr |
| Minimum air opening to room | 0.7 sq m | 0.7 sq m | 0.7 sq m | 0.7 sq m |
| Minimum discharge opening | 0.5 sq m | 0.5 sq m | 0.5 sq m | 0.5 sq m |
| Pusher fan head (duct allowance)* | 10 mm Wg* | 10 mm Wg* | 10 mm Wg* | 10 mm Wg* |
| Total heat radiated to ambient | 10.8 kW | 13.1 kW | 15 kW | 15.5 kW |
| Engine derating – altitude | 3% per 300 m above 150 m | 4% per 300 m above 610 m | 4% per 300 m above 150 m | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

In accordance with ISO 8528, ISO 3046.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature reference.
*Subject to factory verification.

# TECHNICAL DATA



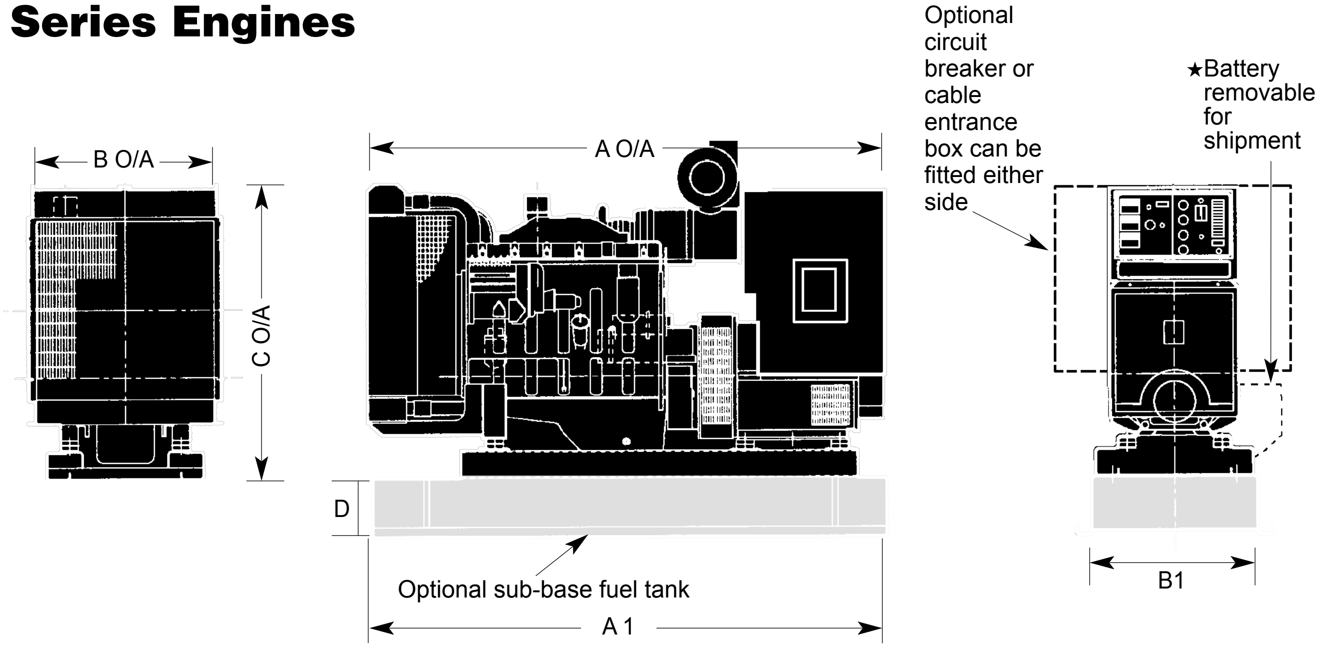
## 77 kW - 95 kW 50 Hz
## 6B Series Engines

### Generating Sets – 50 Hz

| | | |
|---|---|---|
| Set output | 380-415 V 50 Hz | 380-415 V 50 Hz |
| Prime at 40°C ambient | 77 kWe 96 kVA | 85 kWe 106 kVA |
| 1999 Set Model (Prime) | CP90-5 | CP100-5 |
| New Model (Prime) | 77 DGDB | 85 DGDB |
| Standby at 40°C ambient | 85 kWe 106 kVA | 95 kWe 119 kVA |
| 1999 Set Model (Standby) | CS100-5 | CS125-5 |
| New Model (Standby) | 85 DGDB | 95 DGDB |
| Engine Make | Cummins | Cummins |
| Model | 6BT5.9G2 | 6BT5.9G2 |
| Cylinders | Six | Six |
| Engine build | In-line | In-line |
| Governor/Class | Mechanical | Mechanical |
| Aspiration and cooling | Turbocharged | Turbocharged |
| Bore and stroke | 102 mm x 120 mm | 102 mm x 120 mm |
| Compression ratio | 17.5:1 | 17.5:1 |
| Cubic capacity | 5.88 Litres | 5.88 Litres |
| Starting/Min °C | Unaided/–12°C | Unaided/–12°C |
| Battery capacity | 165 A/hr | 165 A/hr |
| Nett Engine output – Prime | 93 kWm | 93 kWm |
| Nett at flywheel – Standby | 103 kWm | 103 kWm |
| Maximum load acceptance – single step | 65 kWe | 65 kWe |
| Speed | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% |
| Alternator insulation class | H | H |
| Single load step to NFPAII0 para 5.13.2.6 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 22.0 l/hr | 24.07 l/hr |
| Fuel consumption (Standby) 100% load | 24.3 l/hr | 26.87 l/hr |
| Lubrication oil capacity | 14.3 Litres | 14.3 Litres |
| Base fuel tank capacity – open set | 200 Litres | 200 Litres |
| Coolant capacity – radiator and engine | 25.1 Litres | 25.1 Litres |
| Exhaust temp – full load prime | 577°C | 577°C |
| Exhaust gas flow – full load prime | 1020 $m^3$/hr | 1020 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air flow – radiator* | 1.5 $m^3$/s | 1.5 $m^3$/s |
| Air intake – engine | 338 $m^3$/hr | 338 $m^3$/hr |
| Minimum air opening to room | 0.7 sq m | 0.7 sq m |
| Minimum discharge opening | 0.5 sq m | 0.5 sq m |
| Pusher fan head (duct allowance) | 10 mm Wg* | 10 mm Wg* |
| Total heat radiated to ambient (Engine) | 22 kW | 22 kW |
| Engine derating – altitude | 4% per 300 m above 150 m | 4% per 300 m above 150 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature reference.
*Subject to factory verification.

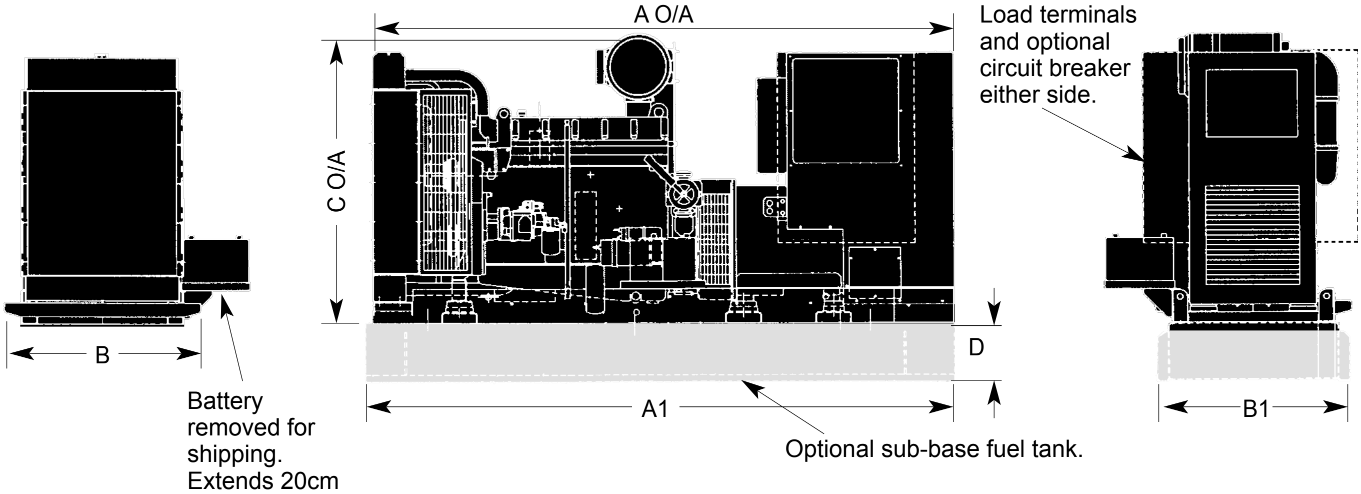
## 6C Series Engines




| New Model | Old Model | Engine | Length A mm | A1 mm | Width B1 mm | B mm | Height C mm | D mm | Set weight kg wet | Set weight kg dry | Sub base Tank. Dry Weight kg | Sub base Tank. Wet Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 103 DGEA | CP125-5 | 6CT8.3G2 | 2332 | 2200 | 840 | 831 | 1412 | 250 | 1500 | 1448 | 210 | 490 |
| 122 DGFA | CP150-5 | 6CTA8.3G | 2339 | 2200 | 840 | 831 | 1412 | 250 | 1650 | 1594 | 210 | 490 |
| 148 DGFB | CP180-5 | 6CTA8.3G | 2429 | 2200 | 840 | 831 | 1412 | 250 | 1760 | 1704 | 210 | 490 |
| 163 DGFC | CP200-5 | 6CTAA8.3G | 2555 | 2200 | 840 | 1070 | 1426 | 250 | 1800 | 1744 | 210 | 490 |

NOTE 1:
★ Battery tray extends out 260 mm from side – when fitted. ★ Dry and Wet weights of sets do NOT include fuel tank or contents.

## LTA10 Series Engines

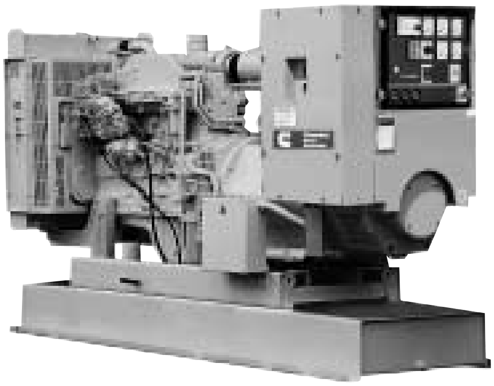



| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank (dry) Weight kg | Tank (wet) Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 186 DFAB | LTA10G2 | CP200-5 | 2980 | 3338 | 1048 | 1050 | 1644 | 300 | 2230 | 2300 | 445 | 1085 |
| 202 DFAC | LTA10G3 | CP250-5 | 2980 | 3338 | 1048 | 1050 | 1644 | 300 | 2230 | 2300 | 445 | 1085 |

Set weights are **without** sub-base tank.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# TECHNICAL DATA

## 103 kW - 163 kW 50 Hz
## 6C Series Engines



### Generating Sets – 50 Hz

| | | | | |
|---|---|---|---|---|
| Set output | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz |
| Prime at 40°C ambient | 103 kWe 129 kVA | 122 kWe 153 kVA | 148 kWe 185 kVA | 163 kWe 204 kVA |
| 1999 Set Model (Prime) | CP125-5 | CP150-5 | CP180-5 | CP200-5 |
| New Model (Prime) | 103 DGEA | 122 DGFA | 148 DGFB | 163 DGFC |
| Standby at 40°C ambient | 116 kWe 145 kVA | 136 kWe 170 kVA | 163 kWe 204 kVA | N/A |
| 1999 Set Model (Standby) | CS150-5 | CS170.5 | CS200-5 | N/A |
| New Model (Standby) | 116 DGEA | 136 DGFA | 163 DGFB | N/A |
| Engine Make | Cummins | Cummins | Cummins | Cummins |
| Model | 6CT8.3G2 | 6CTA8.3G | 6CTA8.3G | 6CTAA8.3G |
| Cylinders | Six | Six | Six | Six |
| Engine build | In-line | In-line | In-line | In-line |
| Governor/Class | Mechanical | Mechanical | Mechanical | Mechanical |
| Aspiration and cooling | Turbocharged | Turbo Aftercharged | Turbo Aftercharged | Turbo Aftercharged/ Charge Air Cooled |
| Bore and stroke | 114 mm x 135 mm | 114 mm x 135 mm | 114 mm x 135 mm | 114 mm x 135 mm |
| Compression ratio | 16.8 | 16.5:1 | 16.5:1 | 16.8:1 |
| Cubic capacity | 8.3 Litres | 8.3 Litres | 8.3 Litres | 8.3 Litres |
| Starting/Min °C | Unaided/–12°C | Unaided/–12°C | Unaided/–12°C | Unaided/–12°C |
| Battery capacity | 165 A/hr | 165 A/hr | 165 A/hr | 165 A/hr |
| Nett Engine output – Prime | 122 kWm | 159 kWm | 159 kWm | 183 kWm |
| Nett at flywheel – Standby | 135 kWm | 176 kWm | 176 kWm | 203 kWm |
| Maximum load acceptance – single step | 87 kWe | 100 kWe | 100 kWe | 131 kWe |
| Speed | 1500 rpm | 1500 rpm | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% | ±1.0% | ±1.0% |
| Alternator insulation class | H | H | H | H |
| Single load step to NFPAII0 | 100% | 100% | 100% | 100% |
| Fuel consumption (Prime) 100% load | 30 l/hr | 33 l/hr | 40 l/hr | 44.5 l/hr |
| Fuel consumption (Standby) 100% load | 34 l/hr | 36.6 l/hr | 44 l/hr | 49.9 l/hr |
| Lubrication oil capacity | 23.8 Litres | 23.8 Litres | 23.8 Litres | 23.8 Litres |
| Base fuel tank capacity – open set | 330 Litres | 330 Litres | 330 Litres | 330 Litres |
| Coolant capacity – radiator and engine | 26 Litres | 28 Litres | 28 Litres | 26 Litres |
| Exhaust temp – full load prime | 521°C | 627°C | 638°C | 583°C |
| Exhaust gas flow – full load prime | 1522 $m^3$/hr | 1716 $m^3$/hr | 1850.4 $m^3$/hr | 1955 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg | 76 mm Hg | 75mm Hg |
| Air flow – radiator* | 3.5 $m^3$/s | 3.1 $m^3$/s | 3.1 $m^3$/s | 3.6 $m^3$/s |
| Air intake – engine | 568 $m^3$/hr | 546 $m^3$/hr | 586.8 $m^3$/hr | 676 $m^3$/hr |
| Minimum air opening to room | 0.9 sq m | 0.9 sq m | 0.9 sq m | 0.9 sq m |
| Minimum discharge opening | 0.6 sq m | 0.6 sq m | 0.6 sq m | 0.6 sq m |
| Pusher fan head (duct allowance)* | 10 mm Wg* | 10 mm Wg* | 10 mm Wg* | 13 mm Wg* |
| Total heat radiated to ambient (Engine) | 27 kW | 34 kW | 35 kW | 36 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m | 4% per 300 m above 1000 m |
| Engine derating – temperature | 1% per 5°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 1.5% per 1°C above 30°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature reference (with exception of Model CP200-5 which is 30°C).
*Subject to factory verification.

# TECHNICAL DATA

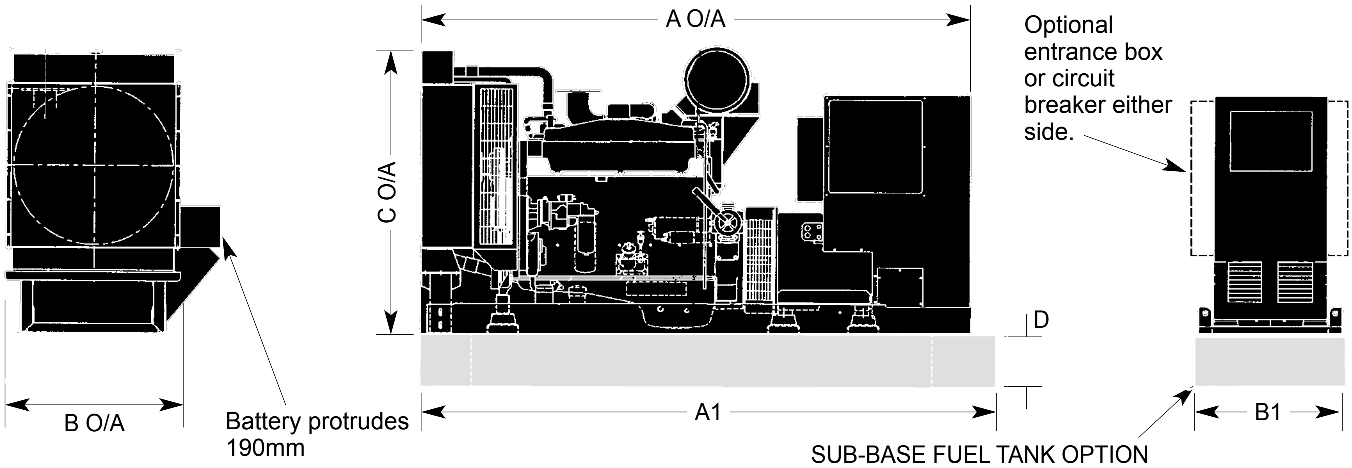
## 186 kW - 223 kW 50 Hz
## LTA10 Series Engines

### Generating Sets – 50 Hz

| | | |
|---|---|---|
| Set output | 380-415 V 50 Hz | 380-415 V 50 Hz |
| Prime at 40°C ambient | 186 kWe 233 kVA | 202 kWe 253 kVA |
| 1999 Set Model (Prime) | CP200-5 | CP250-5 |
| New Model (Prime) | 186 DFAB | 202 DFAC |
| Standby at 40°C ambient | 207 kWe 259 kVA | 223 kWe 279 kVA |
| 1999 Set Model (Standby) | CS250-5 | CS280-5 |
| New Model (Standby) | 207 DFAB | 223 DFAC |
| Engine Make | Cummins | Cummins |
| Model | LTA10G2 | LTA10G3 |
| Cylinders | Six | Six |
| Engine build | In-line | In-line |
| Governor/Class | Electronic/A1 | Electronic/A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 125 mm x 136 mm | 125 mm x 136 mm |
| Compression ratio | 16.0:1 | 16.0:1 |
| Cubic capacity | 10 Litres | 10 Litres |
| Starting/Min °C | Unaided/–1°C | Unaided/–1°C |
| Battery capacity | 127 A/hr | 127 A/hr |
| Engine output – Prime | 203 kWm | 218 kWm |
| Nett at flywheel – Standby | 225 kWm | 240 kWm |
| Maximum load acceptance – single step | 120 kWe | 120 kWe |
| Speed | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% |
| Alternator insulation class | H | H |
| Single load step to NFPAII0 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 48.4 l/hr | 51.1 l/hr |
| Fuel consumption (Standby) 100% load | 53.4 l/hr | 55.6 l/hr |
| Lubrication oil capacity | 36 Litres | 36 Litres |
| Base fuel tank capacity – open set | 675 Litres | 675 Litres |
| Coolant capacity – radiator and engine | 53 Litres | 53 Litres |
| Exhaust temp – full load prime | 502°C | 510°C |
| Exhaust gas flow – full load prime | 2192 $m^3$/hr | 2329.2 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air flow – radiator (40°C) ambient* | 5.6 $m^3$/s | 4.5 $m^3$/s |
| Pusher fan head (duct allowance) 40°C* | 13 mm Wg | 13 mm Wg |
| Air intake – engine | 817 $m^3$/hr | 848 $m^3$/hr |
| Air flow – radiator (50°C)* | 5.0 $m^3$/s | 3.8 $m^3$/s |
| Pusher fan head (duct allowance) 40°C and 50°C* | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient | 41 kW | 46 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

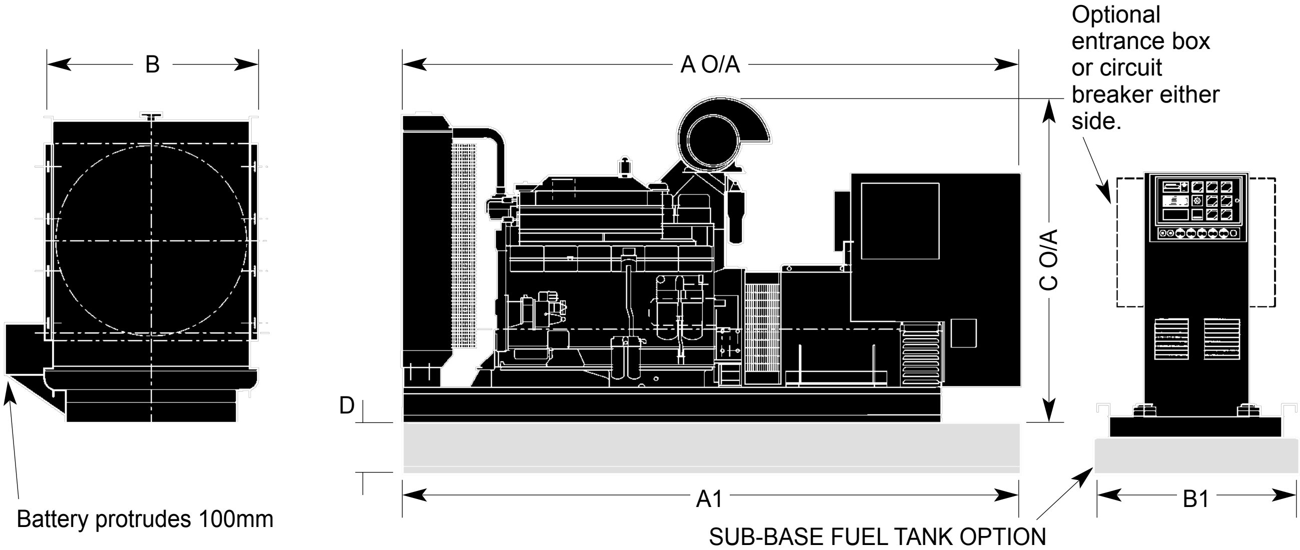
In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) reference.

## NT855 Series Engines




| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 250 DFBF | NT855G6 | CS300-5 | 3196 | 3338 | 990 | 1048 | 1777 | 300 | 2983 | 3100 | 445 | 1085 |
| 252 DFBF | NT855G6 | CP300-5 | 3286 | 3338 | 990 | 1048 | 1777 | 300 | 3133 | 3230 | 445 | 1085 |
| 280 DFCC | NTA855G4 | CP350-5 | 3286 | 3338 | 990 | 1048 | 1777 | 300 | 3178 | 3275 | 445 | 1085 |
| 340 DFCE | NTA855G6 | CS450-5 | 3304 | 3338 | 990 | 1048 | 1777 | 300 | 3291 | 3388 | 445 | 1085 |

## K19 Series Engines




| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 345 DFEC | KTA19G3 | CP400-5 | 3490 | 3875 | 1266 | 1350 | 1830 | 300 | 4136 | 4270 | 580 | 1580 |
| 360 DFEC | KTA19G3 | CP450-5 | 3490 | 3875 | 1266 | 1350 | 1830 | 300 | 4136 | 4270 | 580 | 1580 |
| 409 DFED | KTA19G4 | CP450-5 | 3490 | 3875 | 1266 | 1350 | 1830 | 300 | 4276 | 4410 | 580 | 1580 |

Set weights are **without** sub-base tank.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# TECHNICAL DATA

## 250 kW - 340 kW 50 Hz NT855 Series Engines

### Generating Sets – 50 Hz

| Set output | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz |
|---|---|---|---|---|
| Prime at 40°C ambient | – | 252 kWe 315 kVA | 280 kWe 350 kVA | – |
| 1999 Set Model (Prime) | – | CP300-5 | CP350-5 | – |
| New Model (Prime) | – | 252 DFBF | 280 DFCC | – |
| Standby at 40°C ambient | 250 kWe 313 kVA | 280 kWe 350 kVA | 312 kWe 390 kVA | 340 kWe 425 kVA |
| 1999 Set Model (Standby) | CS300-5 | CS350-5 | CS400-5 | CS450-5 |
| New Model (Standby) | 250 DFBF | 280 DFBF | 312 DFCC | 340 DFCE |
| Engine Make | Cummins | Cummins | Cummins | Cummins |
| Model | NT855G6 | NT855G6 | NTA855G4 | NTA855G6 |
| Cylinders | Six | Six | Six | Six |
| Engine build | In-line | In-line | In-line | In-line |
| Governor/Class | Electronic/A1 | Electronic/A1 | Electronic/A1 | Electronic/A1 |
| Aspiration and cooling | Turbocharged | Turbocharged | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 140 mm x 152 mm | 140 mm x 152 mm | 140 mm x 152 mm | 140 mm x 152 mm |
| Compression ratio | 14.0:1 | 14.0:1 | 14.0:1 | 14.0:1 |
| Cubic capacity | 14 Litres | 14 Litres | 14 Litres | 14 Litres |
| Starting/Min °C | Unaided/4°C | Unaided/4°C | Unaided/–7°C | Unaided/–7°C |
| Battery capacity | 127 A/hr | 127 A/hr | 127 A/hr | 127 A/hr |
| Nett Engine output – Prime | 272 kWm | 272 kWm | 309 kWm | – |
| Nett at flywheel – Standby | 302 kWm | 302 kWm | 342 kWm | 361 kWm |
| Maximum load acceptance single step | 172 kWe | 172 kWe | 175 kWe | 175 kWe |
| Speed | 1500 rpm | 1500 rpm | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% | ±1.0% | ±1.0% |
| Alternator insulation class | H | H | H | H |
| Single load step to NFPAII0 | 100% | 100% | 100% | 100% |
| Fuel consumption (Prime) 100% load | 60 l/hr | 69 l/hr | 76 l/hr | – |
| Fuel consumption (Standby) 100% load | 67 l/hr | 76 l/hr | 84 l/hr | 91 l/hr |
| Lubrication oil capacity | 38.6 Litres | 38.6 Litres | 38.6 Litres | 38.6 Litres |
| Base fuel tank capacity – open set | 800 Litres | 800 Litres | 800 Litres | 800 Litres |
| Coolant capacity – radiator and engine | 63.9 Litres | 63.9 Litres | 69.8 Litres | 69.8 Litres |
| Exhaust temp – full load prime | 574°C | 574°C | 524°C | 487°C |
| Exhaust gas flow – full load prime | 3855.6 $m^3$/hr | 3855.6 $m^3$/hr | 4060.8 $m^3$/hr | 4723 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg | 76 mm Hg | 76 mm Hg |
| Air flow – radiator (40°C) | 7.6 $m^3$/s | 7.6 $m^3$/s | 6.4 $m^3$/s | 7.6 $m^3$/s |
| Pusher fan head (duct allowance) 40°C | 13 mm Wg | 13 mm Wg | 13 mm Wg | 13 mm Wg |
| Air intake – engine | 1299.6 $m^3$/hr | 1299 $m^3$/hr | 1468.8 $m^3$/hr | 1854 $m^3$/hr |
| Air flow – radiator (50°C) | 7.6 $m^3$/s | 7.6 $m^3$/s | 8.3 $m^3$/s | 8.3 $m^3$/s |
| Pusher fan head (duct allowance) 50°C | 13 mm Wg | 13 mm Wg | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient | 57 kW | 57 kW | 65 kW | 81 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.

# TECHNICAL DATA

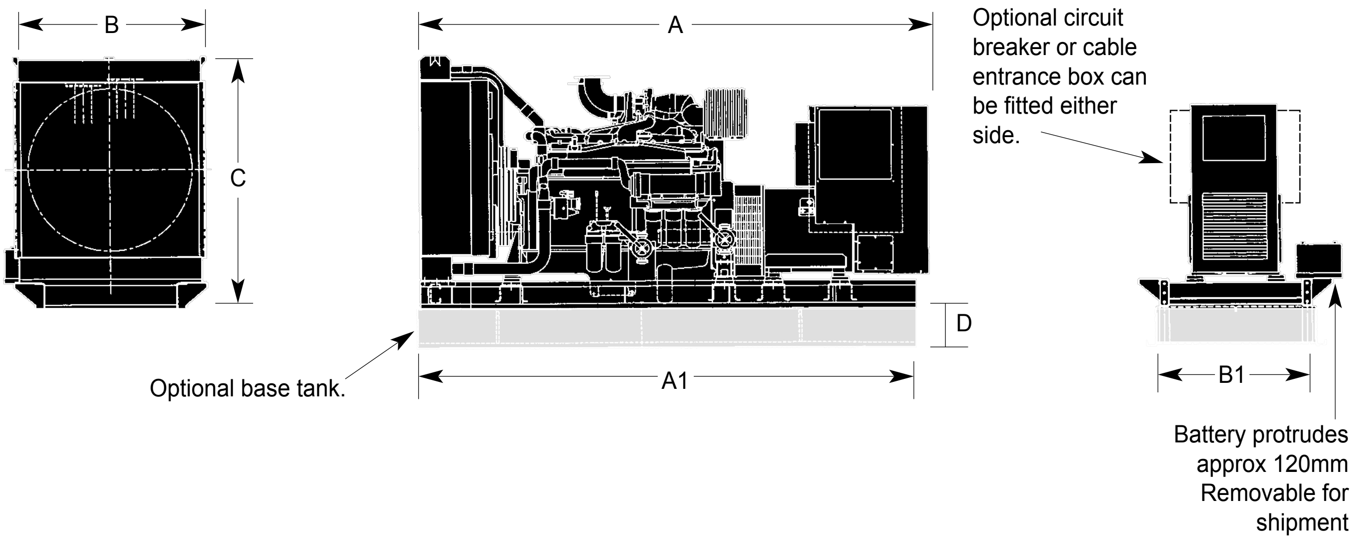
## 345 kW - 461 kW 50 Hz
## K19 Series Engines

### Generating Sets – 50 Hz

| | | | |
|---|---|---|---|
| Set output | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz |
| Prime at 40°C ambient | 345 kWe 431 kVA | 360 kWe 450 kVA | 409 kWe 511 kVA |
| 1999 Set Model (Prime) | CP400-5 | CP450-5 | CP500-5 |
| New Model (Prime) | 345 DFEC | 360 DFEC | 409 DFED |
| Standby at 40°C ambient | – | 400 kWe 500 kVA | 461 kWe 576 kVA |
| 1999 Set Model (Standby) | – | CS500-5 | CS575-5 |
| New Model (Standby) | – | 400 DFEC | 461 DFED |
| Engine Make | Cummins | Cummins | Cummins |
| Model | KTA19G3 | KTA19G3 | KTA19G4 |
| Cylinders | Six | Six | Six |
| Engine build | In-line | In-line | In-line |
| Governor/Class | Electronic/A1 | Electronic/A1 | Electronic/A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 159 mm x 159 mm | 159 mm x 159 mm | 159 mm x 159 mm |
| Compression ratio | 13.9:1 | 13.9:1 | 13.9:1 |
| Cubic capacity | 18.9 Litres | 18.9 Litres | 18.9 Litres |
| Starting/Min °C | Unaided/7°C | Unaided/7°C | Unaided/0°C |
| Battery capacity | 190 A/hr | 190 A/hr | 190 A/hr |
| Nett Engine output – Prime | 384 kWm | 384 kWm | 429 kWm |
| Nett at flywheel – Standby | NA | 429 kWm | 485 kWm |
| Maximum load acceptance single step | 250 kWe | 250 kWe | 250 kWe |
| Speed | 1500 rpm | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% | ±1.0% |
| Alternator insulation class | H | H | H |
| Single load step to NFPAII0 | 100% | 100% | 100% |
| Fuel consumption (Prime) 100% load | 91 l/hr | 97 l/hr | 107 l/hr |
| Fuel consumption (Standby) 100% load | 100 l/hr | 107 l/hr | 121 l/hr |
| Lubrication oil capacity | 50 Litres | 50 Litres | 50 Litres |
| Base fuel tank capacity – open set | 1200 Litres | 1200 Litres | 1200 Litres |
| Coolant capacity – radiator and engine | 91 Litres | 91 Litres | 91 Litres |
| Exhaust temp – full load prime | 524°C | 524°C | 538°C |
| Exhaust gas flow – full load prime | 4842 $m^3$/hr | 4842 $m^3$/hr | 5162 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg | 76 mm Hg |
| Air flow – radiator (40°C ambient) | 13.7 $m^3$/s | 13.7 $m^3$/s | 13.7 $m^3$/s |
| Pusher fan head (duct allowance) 40°C | 13 mm Wg | 13 mm Wg | 13 mm Wg |
| Air intake – engine | 1749 $m^3$/hr | 1749.6 $m^3$/hr | 1912 $m^3$/hr |
| Air flow – radiator (50°C) | 11.5 $m^3$/s | 11.5 $m^3$/s | 11.5 $m^3$/s |
| Pusher fan head (duct allownace) 50°C | 13 mm Wg | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient | 78 kW | 79 kW | 88 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m | 4% per 300 m above 2280 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

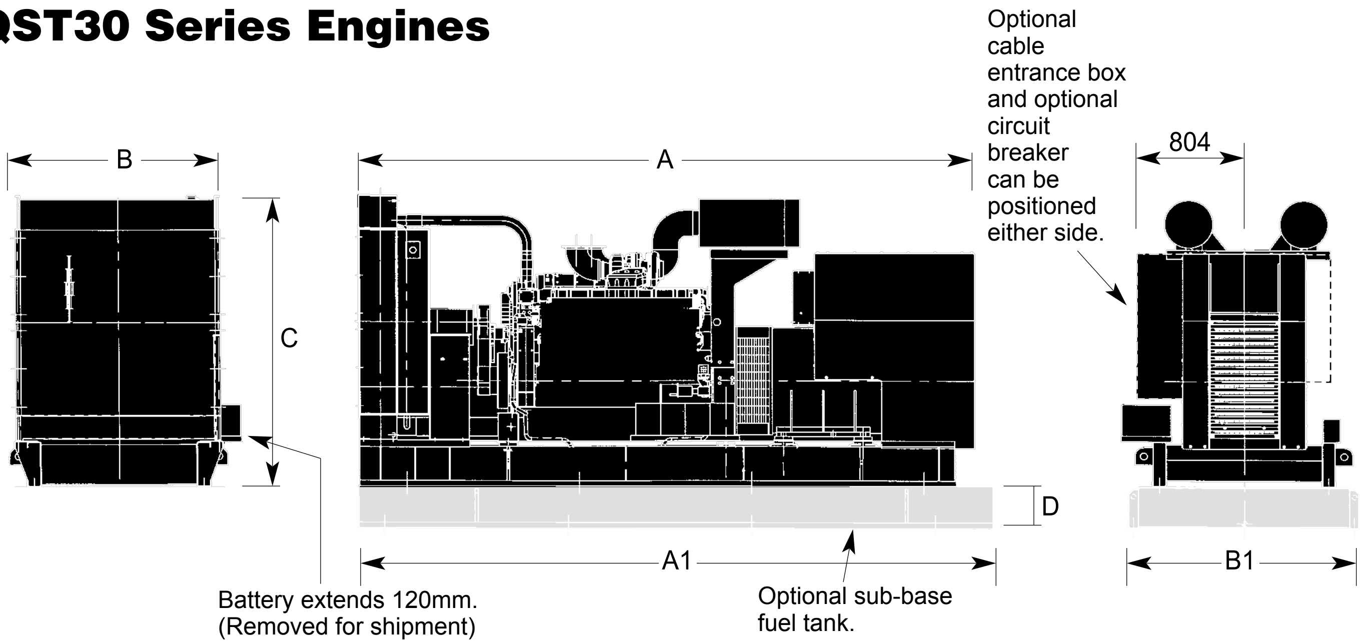
In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.

## VTA28 Series Engines




| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B1 | B | C | D | | | | |
| 460 DFGA | VTA28G5 | CP575-5 | 3825 | 3875 | 1350 | 1423 | 1942 | 300 | 5355 | 5665 | 580 | 1580 |
| 512 DFGB | VTA28G5 | CP625-5 | 3900 | 3875 | 1350 | 1423 | 1942 | 300 | 5730 | 6040 | 580 | 1580 |

## QST30 Series Engines




| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 580 DFHA | QST30G1 | CP700-5 | 4297 | 4460 | 1442 | 1640 | 2092 | 300 | 6552 | 6850 | 850 | 2210 |
| 640 DFHB | QST30G2 | CP800-5 | 4297 | 4460 | 1442 | 1640 | 2092 | 300 | 6702 | 7000 | 850 | 2210 |
| 751 DFHC | QST30G3 | CP900-5 | 4297 | 4460 | 1442 | 1640 | 2092 | 300 | 7152 | 7450 | 850 | 2210 |
| 800 DFHD | QST30G4 | CP1000-5 | 4547 | 4460 | 1722 | 1640 | 2332 | 300 | 7712 | 8000 | 850 | 2210 |

Set weights are **without** sub-base tank.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# TECHNICAL DATA

## 458 kW - 565 kW 50 Hz VTA28 Series Engines

### Generating Sets – 50 Hz

| | | |
|---|---|---|
| Set output | 380-440 V 50 Hz | 380-440 V 50 Hz |
| Prime at 40°C ambient | 460 kWe 575 kVA | 512 kWe 640 kVA |
| 1999 Set Model (Prime) | CP575-5 | CP625-5 |
| New Model (Prime) | 460 DFGA | 512 DFGB |
| Standby at 40°C ambient | 509 kWe 636 kVA | 565 kWe 706 kVA |
| 1999 Set Model (Standby) | CS625-5 | CS700-5 |
| New Model (Standby) | 509 DFGA | 565 DFGB |
| Engine Make | Cummins | Cummins |
| Model | VTA28G5 | VTA28G5 |
| Cylinders | Twelve | Twelve |
| Engine build | Vee | Vee |
| Governor / Class | Electronic / A1 | Electronic / A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 140 mm x 152 mm | 140 mm x 152 mm |
| Compression ratio | 13.0:1 | 13.0:1 |
| Cubic capacity | 28 Litres | 28 Litres |
| Starting / Min °C | Unaided / 4°C | Unaided / 4°C |
| Battery capacity | 254 A/hr | 254 A/hr |
| Nett Engine output – Prime | 548 kWm | 548 kWm |
| Nett at flywheel – Standby | 604 kWm | 604 kWm |
| Maximum load acceptance – single step | 340 kWe | 340 kWe |
| Speed | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% |
| Alternator insulation class | H | H |
| Single load step to NFPAIIO | 100% | 100% |
| Fuel consumption (Prime) 100% load | 124 l/hr | 140 l/hr |
| Fuel consumption (Standby) 100% load | 137 l/hr | 154 l/hr |
| Lubrication oil capacity | 83 Litres | 83 Litres |
| Base fuel tank capacity – open set | 1200 Litres | 1200 Litres |
| Coolant capacity – radiator and engine | 166 Litres | 166 Litres |
| Exhaust temp – full load prime | 493°C | 493°C |
| Exhaust gas flow – full load prime | 7153 $m^3$/hr | 7153.2 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air flow – radiator (40°C ambient) | *13.7 $m^3$/s | *13.7 $m^3$/s |
| Pusher fan head (duct allowance) 40°C | *19 mm Wg | *19 mm Wg |
| Air intake – engine | 2976.6 $m^3$/hr | 2976.6 $m^3$/hr |
| Air flow – radiator (50°C) | *13.1 $m^3$/s | *13.1 $m^3$/s |
| Pusher fan head (duct allowance) 50°C | *19 mm Wg | *19 mm Wg |
| Total heat radiated to ambient | 112 kW | 114 kW |
| Engine derating – altitude | 4% per 300 m above 1220 m | 4% per 300 m above 1220 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
*Subject to factory verification.

# TECHNICAL DATA

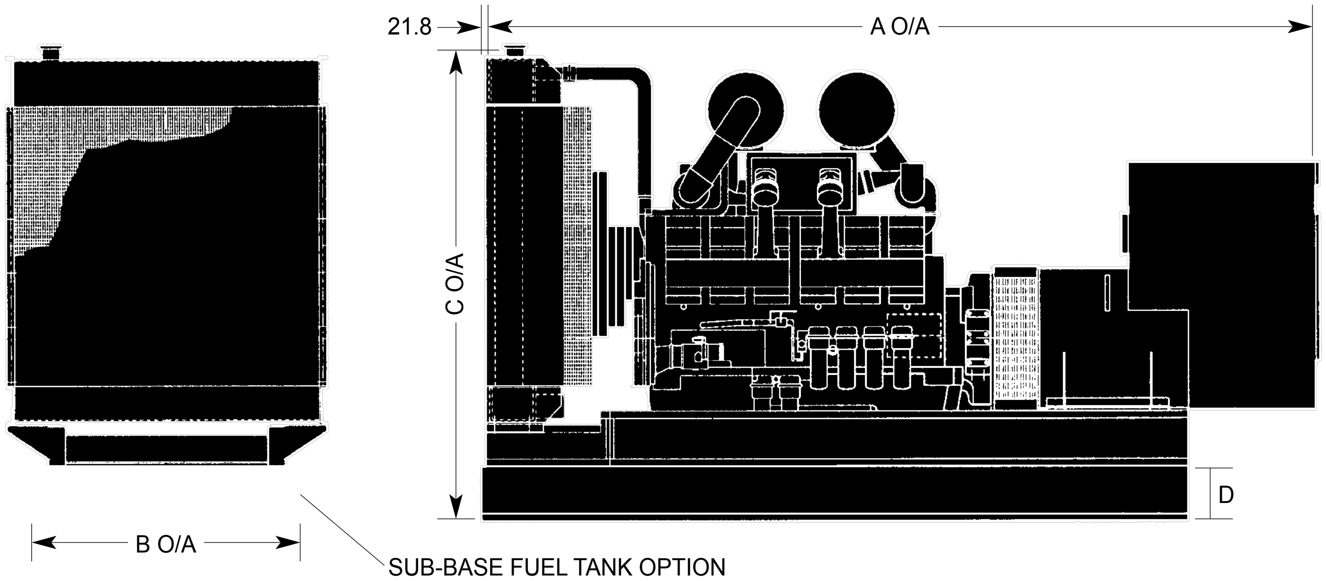
## 580 kW - 888 kW 50 Hz QST30 Series Engines

### Generating Sets – 50 Hz

| | | | | |
|---|---|---|---|---|
| Set output | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz | 380-440 V 50 Hz |
| Prime at 40°C ambient | 580 kWe 725 kVA | 640 kWe 800 kVA | 751 kWe 939 kVA | 800 kWe 1000 kVA |
| 1999 Set Model (Prime) | CP700-5 | CP800-5 | CP900-5 | CP1000-5 |
| New Model (Prime) | 580 DFHA | 640 DFHB | 751 DFHC | 800 DFHD |
| Standby at 40°C ambient | 640 kWe 800 kVA | 713 kWe 891 kVA | 833 kWe 1041 kVA | 888 kWe 1110 kVA |
| 1999 Set Model (Standby) | CS800-5 | CS900-5 | CS1000-5 | CS1100-5 |
| New Model (Standby) | 640 DFHA | 713 DFHB | 833 DFHC | 888 DFHD |
| Engine Make | Cummins | Cummins | Cummins | Cummins |
| Model | QST30G1 | QST30G2 | QST30G3 | QST30G4 |
| Cylinders | Twelve | Twelve | Twelve | Twelve |
| Engine build | Vee | Vee | Vee | Vee |
| Governor/Class | Electronic/A1 | Electronic/A1 | Electronic/A1 | Electronic/A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 140 mm x 165 mm | 140 mm x 165 mm | 140 mm x 165 mm | 140 mm x 165 mm |
| Compression ratio | 14:1 | 14:1 | 14:1 | 14:1 |
| Cubic capacity | 30.48 Litres | 30.48 Litres | 30.48 Litres | 30.48 Litres |
| Starting/Min °C | Unaided/1°C | Unaided/1°C | Unaided/7°C | Unaided/7°C |
| Battery capacity | 254 A/hr | 254 A/hr | 254 A/hr | 254 A/hr |
| Engine output – Prime | 634 kWm | 697 kWm | 806 kWm | 880 kWm |
| Engine output – Standby | 701 kWm | 768 kWm | 895 kWm | 970 kWm |
| Maximum load acceptance – single step | 570 kWe | 570 kWe | 583 kWe | 622 kWe |
| Speed | 1500 rpm | 1500 rpm | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±0.5% | ±0.5% | ±0.5% | ±0.5% |
| Alternator insulation class | H | H | H | H |
| Single load step to NFPAII0 | 100% | 100% | 100% | 100% |
| Fuel consumption (Prime) 100% load | 153 l/hr | 168 l/hr | 184 l/hr | 202 l/hr |
| Fuel consumption (Standby) 100% load | 169 l/hr | 187 l/hr | 204 l/hr | 224 l/hr |
| Lubrication oil capacity | 154 Litres | 154 Litres | 154 Litres | 154 Litres |
| Base fuel tank capacity – open set | 1700 Litres | 1700 Litres | 1700 Litres | 1700 Litres |
| Coolant capacity – radiator and engine (40°C) | 169 Litres | 169 Litres | 169 Litres | 302 Litres |
| Coolant capacity – radiator and engine (50°C) | 175 Litres | 175 Litres | 175 Litres | 342 Litres |
| Exhaust temp – full load prime | 527°C | 538°C | 541°C | 565°C |
| Exhaust gas flow – full load prime | 7182 $m^3$/hr | 7977 $m^3$/hr | 8748 $m^3$/hr | 10728 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg | 76 mm Hg | 51 mm Hg |
| Air flow – radiator (40°C ambient)* | 15.5 $m^3$/s | 15.5 $m^3$/s | 15.5 $m^3$/s | 18 $m^3$/s |
| Pusher fan head (duct allowance) 40°C* | 13 mm Wg | 13 mm Wg | *13 mm Wg | *13 mm Wg |
| Air intake – engine | 2544 $m^3$/hr | 2794 $m^3$/hr | 3114 $m^3$/hr | 3402 $m^3$/hr |
| Air flow – radiator (50°C ambient)* | 17.6 $m^3$/s | 17.6 $m^3$/s | 18.1 $m^3$/s | 24.8 $m^3$/s |
| Pusher fan head (duct allowance) 50°C* | 13 mm Wg | 13 mm Wg | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient | 126 kW | 137 kW | 137 kW | 152 kW |
| Engine derating – altitude | 4% per 300 m above 1524 m | 4% per 300 m above 1524 m | 4% per 300 m above 1000 m | 5% per 300 m above 1000 m |
| Engine derating – temperature | 2% per 11°C above 40°C (52°C below 305 m) | 2% per 11°C above 40°C (52°C below 305 m) | 2% per 11°C above 40°C | 4% per 5°C above 50°C† |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature.
*Subject to factory verification.
†No temperature derating is applicable to any of these generator sets with a Class H alternator up to 50°C. For Class F alternators refer to factory.

## KTA38 Series Engines



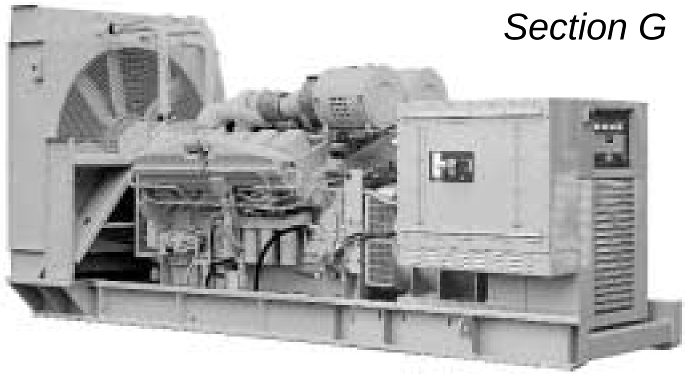

| New Model | Engine | Old Model | Dimensions and Weights (cm/kg) | | | | 50 Hz Weight kg | Tank capacity Litres | Tank Weight kg (dry) |
|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | | | |
| 748 DFJC | KTA38G3 | CP900-5 | 457 | 179 | 254 | 30 | 7640 | 1700 | 800 |
| 815 DFJD | KTA38G5 | CP1000-5 | 457 | 179 | 254 | 30 | 7640 | 1700 | 800 |

| Floor mounted circuit breaker and load terminal cubicle (for use above 1250 amps) | | | |
|---|---|---|---|
| Capacity amps | Width mm | Depth mm | Height mm |
| 1600 | 1000 | 1050 | 1500 |
| 2000 | 1000 | 1050 | 1500 |
| 2500 | 1000 | 1050 | 1500 |
| 3200 | 1000 | 1050 | 1500 |

Weights are dry **without** sub-base tank. Add 250 kg when PowerCommand panel is fitted.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# TECHNICAL DATA





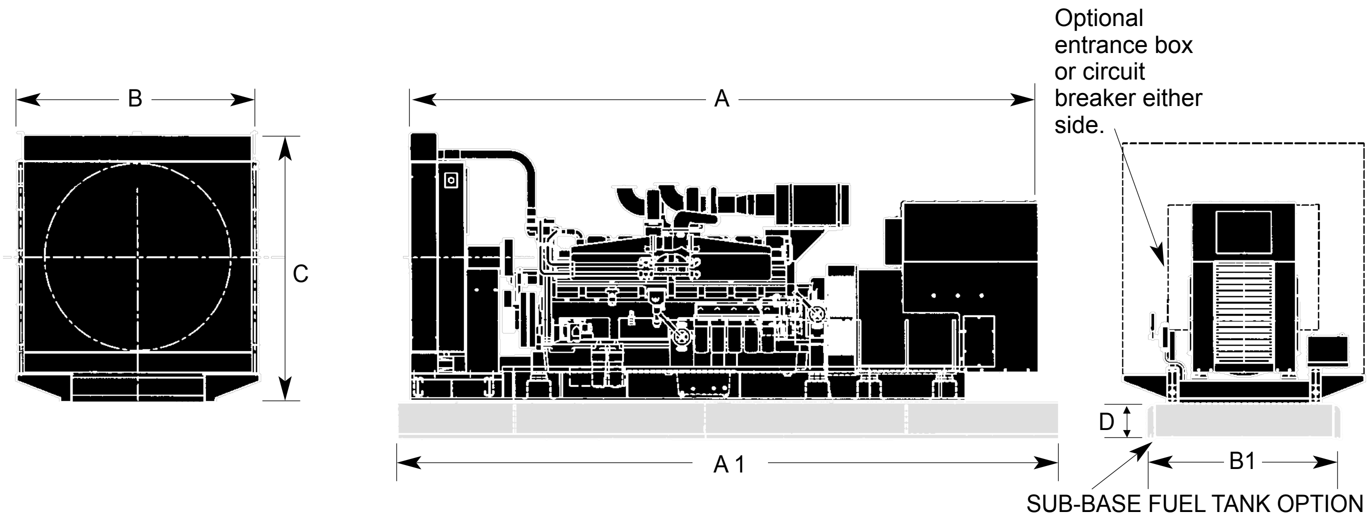
## 748 kW - 906 kW 50 Hz KTA38 Series Engines

### Generating Sets – 50 Hz

| | | |
|---|---|---|
| Set output | 380-415 V 50 Hz | 380-415 V 50 Hz |
| Prime at 40°C ambient | 748 kWe 936 kVA | 815 kWe 1019 kVA |
| 1999 Set Model (Prime) | CP900-5 | CP1000-5 |
| New Model (Prime) | 748 DFJC | 815 DFJD |
| Standby at 40°C ambient | 832 kWe 1040 kVA | 906 kWe 1132 kVA |
| 1999 Set Model (Standby) | CS1000-5 | CS1100-5 |
| New Model (Standby) | 832 DFJC | 906 DFJD |
| Engine Make | Cummins | Cummins |
| Model | KTA38G3 | KTA38G5 |
| Cylinders | Twelve | Twelve |
| Engine build | Vee | Vee |
| Governor / Class | Electronic / A1 | Electronic / A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 159 mm x 159 mm | 159 mm x 159 mm |
| Compression ratio | 13.9:1 | 13.9:1 |
| Cubic capacity | 37.8 Litres | 37.8 Litres |
| Starting / Min °C | Unaided | Unaided / 7°C |
| Battery capacity | 254 A/hr | 254 A/hr |
| Nett Engine output – Prime | 786 kWm | 860 kWm |
| Nett at flywheel – Standby | 875 kWm | 950 kWm |
| Maximum load acceptance single step (cold) | 500 kWe | 451 kWe |
| Speed | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±0.5% | ±0.5% |
| Alternator insulation class | H | H |
| Single load step to NFPAII0 para 5.13.2.6 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 194 l/hr | 209 l/hr |
| Fuel consumption (Standby) 100% load | 215 l/hr | 228 l/hr |
| Lubrication oil capacity | 135 Litres | 135 Litres |
| Base fuel tank capacity – open set | 1700 Litres | 1700 Litres |
| Coolant capacity – radiator and engine | 290 Litres | 290 Litres |
| Exhaust temp – full load prime | 507°C | 499°C |
| Exhaust gas flow – full load prime | 9932 $m^3$/hr | 10983 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air flow – radiator (40°C ambient) | 13.8 $m^3$/s | 15 $m^3$/s |
| Pusher fan head (duct allowance) 40°C | 13 mm Wg | 13 mm Wg |
| Air intake – engine | 3603 $m^3$/hr | 4104 $m^3$/hr |
| Air flow – radiator (50°C ambient) | 13.8 $m^3$/s | 22.3 $m^3$/s |
| Pusher fan head (duct allowance) 50°C | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient | 164 kW | 163 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C |
| Weight wet with tank | 9740 kg | 10130 kg |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Note: Sets with PowerCommand control system fitted add 250 kg to weight.

## KTA50 Series Engines



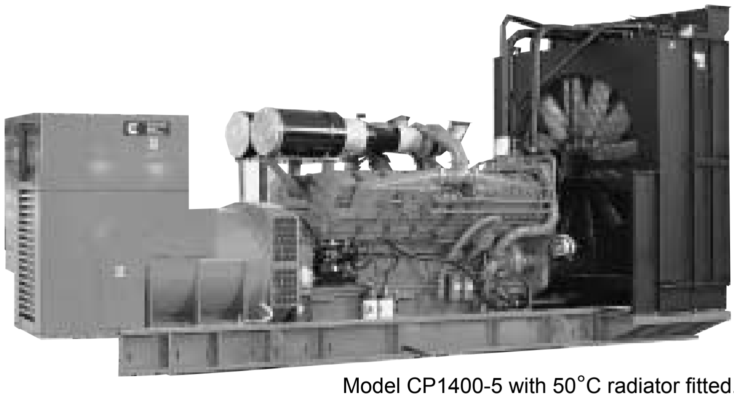

| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (wet) | Tank Weight kg (dry) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B1 | B | C | D | | | | |
| 1005 DFLC | KTA50G3 | CP1250-5 | 5290 | 5690 | 1640 | 1785 | 2241 | 300 | 9743 | 10300 | 2755 | 1075 |
| 1125 DFLE | KTA50G8 | CP1400-5 | 5866 | 5690 | 1640 | 2033 | 2333 | 300 | 11140 | 11700 | 2755 | 1075 |
| 1125 DFLE | *KTA50G8 | CP1400-5 | 5880 | 5690 | 1640 | 2033 | 2771 | 300 | 11540 | 12100 | 2755 | 1075 |

*With 50°C ambient radiator

| Floor mounted circuit breaker and load terminal cubicle (for use above 2000 amps) | | | |
|---|---|---|---|
| Capacity amps | Width mm | Depth mm | Height mm |
| 1600 | 1000 | 1050 | 1500 |
| 2000 | 1000 | 1050 | 1500 |
| 2500 | 1000 | 1050 | 1500 |

Set weights are **without** sub-base tank.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# 1005 kW - 1340 kW 50 Hz KTA50 Series Engines



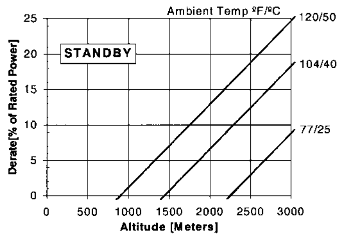
Model CP1400-5 with 50°C radiator fitted.

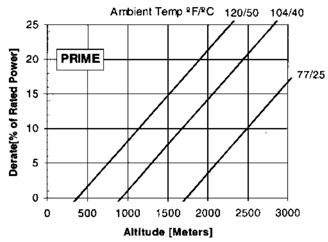
## Generating Sets – 50 Hz

| | | |
|---|---|---|
| Set output | 380-440 V 50 Hz | 380-440 V 50 Hz |
| Prime at 40°C ambient | 1005 kWe 1256 kVA | 1125 kWe 1406 kVA |
| 1999 Set Model (Prime) | CP1250-5 | CP1400-5 |
| New Model (Prime) | 1005 DFLC | 1125 DFLE |
| Standby at 40°C ambient | 1120 kWe 1400 kVA | 1340 kWe 1675 kVA |
| 1999 Set Model (Standby) | CS1400-5 | CS1675-5 |
| New Model (Standby) | 1120 DFLC | 1340 DFLE |
| Engine Make | Cummins | Cummins |
| Model | KTA50G3 | KTA50G8 |
| Cylinders | Sixteen | Sixteen |
| Engine build | 60° Vee | Vee |
| Governor / Class | Electronic / A1 | Electronic / A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 159 mm x 159 mm | 159 mm x 159 mm |
| Compression ratio | 13.9:1 | 14.9:1 |
| Cubic capacity | 50.3 Litres | 50.3 Litres |
| Starting / Min °C | Unaided / 7°C | Unaided / 7°C |
| Battery capacity | 254 A/hr | 254 A/hr |
| Nett Engine output – Prime | 1076 kWm | 1168 kWm |
| Nett at flywheel – Standby | 1206 kWm | 1397 kWm |
| Maximum load acceptance – single step (cold) | 640 kWe | 900 kWe |
| Speed | 1500 rpm | 1500 rpm |
| Alternator voltage regulation | ±0.5% | ±0.5% |
| Alternator insulation class | H | H |
| Single load step to NFPAIIO | 100% | 100% |
| Fuel consumption (Prime) 100% load | 254 l/hr | 289 l/hr |
| Fuel consumption (Standby) 100% load | 282 l/hr | 345 l/hr |
| Lubrication oil capacity | 177 Litres | 204 Litres |
| Base fuel tank capacity – open set | 2000 Litres | 2000 Litres |
| Coolant capacity – radiator and engine | 351 Litres | 400 Litres |
| Exhaust temp – full load prime | 518°C | 482°C |
| Exhaust gas flow – full load prime | 13590 $m^3$/hr | 13842 $m^3$/hr |
| Exhaust gas back pressure max (standby) | 51 mm Hg | 51 mm Hg |
| Air flow – radiator (40°C ambient)† | 21.6 $m^3$/s | 21.7 $m^3$/s |
| Pusher fan head (duct allowance) 40°C† | 13 mm Wg | 13 mm Wg |
| Air intake – engine (prime) | 5166 $m^3$/hr | 5400 $m^3$/hr |
| Air flow – radiator (50°C ambient)† | 27.1 $m^3$/s | 28.4 $m^3$/s |
| Pusher fan head (duct allowance) 50°C† | 13 mm Wg | 15 mm Wg |
| Total heat radiated to ambient | 176 kW | 210 kW |
| Engine derating – altitude | Refer to derate curves | Refer to derate curves |
| Engine derating – temperature | Refer to derate curves | Refer to derate curves |

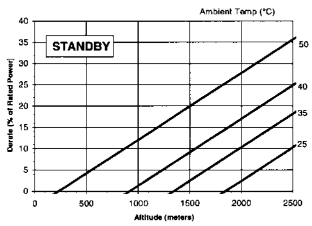
In accordance with ISO 8528, ISO 3046.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
†Subject to factory verification.

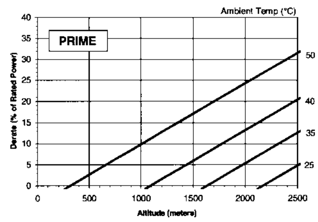
### KTA50-G3 Derate Curves @ 1500 rpm



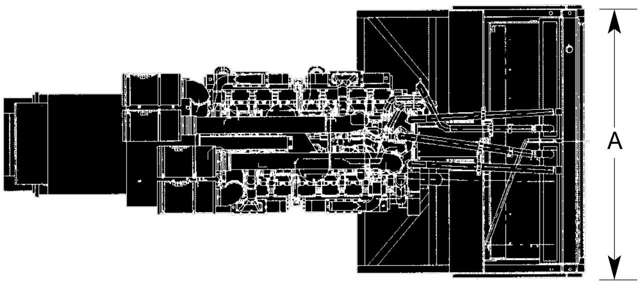

### KTA50-G8 Derate Curves @ 1500 rpm

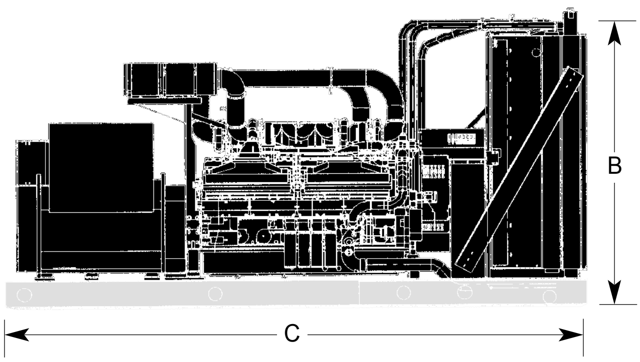



For sustained operation above 50°C ambient, refer to factory.

## QSK60 Series



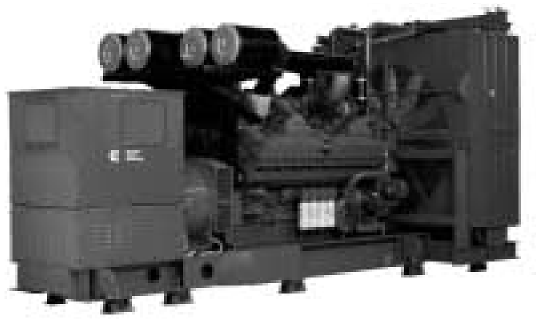

| Model | Dim "A" | | Dim "B" | | Dim "C" | | Dry Weight* | |
|---|---|---|---|---|---|---|---|---|
| 1350 DQKB | 98.2 in | 2494 mm | 119.8 in | 3043 mm | 239.7 in | 6090 mm | 34260 lb | 15540 kg |
| 1500 DQKC | 98.2 in | 2494 mm | 119.8 in | 3043 mm | 239.7 in | 6090 mm | 34701 lb | 15740 kg |

*Weight given is with standard low voltage alternator.

| Floor mounted circuit breaker and load terminal cubicle (for use above 2000 amps) | | | |
|---|---|---|---|
| Capacity amps | Width mm | Depth mm | Height mm |
| 1600 | 1000 | 1050 | 1500 |
| 2000 | 1000 | 1050 | 1500 |
| 2500 | 1000 | 1050 | 1500 |

Set weights are **without** sub-base tank.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# 1350 kW - 1650 kW 50 Hz QSK60 Series Engines



## Generating Sets – 50 Hz

| | Standby | Prime | Standby | Prime |
|---|---|---|---|---|
| Ratings kW (kVA) | 1500 (1875) | 1350 (1688) | 1650 (2063) | 1500 (1875) |
| Model | 1500 DQKB | 1350 DQKB | 1650 DQKC | 1500 DQKC |
| Engine Model | QSK60-G3 | QSK60-G3 | QSK60-G3 | QSK60-G3 |
| Aspiration | Turbocharged and Aftercooled | Turbocharged and Aftercooled | Turbocharged and Aftercooled | Turbocharged and Aftercooled |
| Gross Engine Power Output | 1,615 kWm | 1,453 kWm | 1,790 kWm | 1,615 kWm |
| BMEP | 2,158 kPa | 1,944 kPa | 2,386 kPa | 2,159 kPa |
| Bore | 159 mm | 159 mm | 159 mm | 159 mm |
| Stroke | 190 mm | 190 mm | 190 mm | 190 mm |
| Piston Speed | 9.5 m/s | 9.5 m/s | 9.5 m/s | 9.5 m/s |
| Compression Ratio | 14.5:1 | 14.5:1 | 14.5:1 | 14.5:1 |
| Lube Oil Capacity | 280 Litres | 280 Litres | 280 Litres | 280 Litres |
| Overspeed Limit | 1,850 ± 50 rpm | 1,850 ± 50 rpm | 1,850 ± 50 rpm | 1,850 ± 50 rpm |
| Regenerative Power | 146 kW | 146 kW | 146 kW | 146 kW |
| Fuel Consumption Load | 1/4 1/2 3/4 Full | 1/4 1/2 3/4 Full | 1/4 1/2 3/4 Full | 1/4 1/2 3/4 Full |
| Fuel Consumption L/hr | 111 187 266 356 | 102.9 171 243 320 | 115 203 298 402 | 106 185 268 360 |
| Maximum Fuel Flow | 1,893 L/hr | 1,893 L/hr | 1,893 L/hr | 1,893 L/hr |
| Maximum Inlet Restriction | 120 mm Hg | 120 mm Hg | 120 mm Hg | 120 mm Hg |
| Maximum Return Restriction | 229 mm Hg | 229 mm Hg | 229 mm Hg | 229 mm Hg |
| Maximum Fuel Inlet Temperature | 70°C | 70°C | 70°C | 70°C |
| Maximum Fuel Return Temperature | 113°C | 113°C | 113°C | 113°C |
| Fan Load | 32 kW | 32 kW | 32 kW | 32 kW |
| Coolant Capacity (with radiator) | 492 Litres | 492 Litres | 492 Litres | 492 Litres |
| Coolant Flow Rate (engine jacket) | 1,438 L/Min | 1,438 L/Min | 1,438 L/Min | 1,438 L/Min |
| Coolant Flow Rate (aftercooler) | 426 L/Min | 426 L/Min | 426 L/Min | 426 L/Min |
| Heat Rejection to Eng Jacket Coolant | 27.3 MJ/Min | 23.4 MJ/Min | 33.0 MJ/Min | 27.3 MJ/Min |
| Heat Rejection to Aftercooler Coolant | 21.9 MJ/Min | 19.0 MJ/Min | 25.3 MJ/Min | 21.9 MJ/Min |
| Heat Rejection to Fuel | 2.1 MJ/Min | 2.1 MJ/Min | 2.1 MJ/Min | 2.1 MJ/Min |
| Heat Radiated to Room | 15.6 MJ/Min | 13.9 MJ/Min | 17.2 MJ/Min | 15.6 MJ/Min |
| Max Coolant Friction Head (JW) | 69 kPa | 69 kPa | 69 kPa | 69 kPa |
| Max Coolant Friction Head (aftercooler) | 35 kPa | 35 kPa | 35 kPa | 35 kPa |
| Maximum Coolant Static Head | 18.3 m | 18.3 m | 18.3 m | 18.3 m |
| Heat Ex. Max Raw Water Flow (JW/AC) | 1,363 L/Min | 1,363 L/Min | 1,363 L/Min | 1,363 L/Min |
| Heat Ex. Max Raw Water Press (JW/AC/Fuel) | 1,034 kPa | 1,034 kPa | 1,034 kPa | 1,034 kPa |
| Heat Ex. Max Raw Water Flow (Fuel) | 144 L/Min | 144 L/Min | 144 L/Min | 144 L/Min |
| Max Top Tank Temp (engine jacket) | 104°C | 100°C | 104°C | 100°C |
| Max Inlet Temp (aftercooler) | 61°C | 61°C | 66°C | 66°C |
| Combustion Air | 125 $m^3$/min | 113 $m^3$/min | 139 $m^3$/min | 125 $m^3$/min |
| Maximum Air Cleaner Restriction | 6.2 kPa | 6.2 kPa | 6.2 kPa | 6.2 kPa |
| Alternator Cooling Air | 246 $m^3$/min | 246 $m^3$/min | 246 $m^3$/min | 246 $m^3$/min |
| Radiator Cooling Air | 1,752 $m^3$/min | 1,752 $m^3$/min | 1,439 $m^3$/min | 1,439 $m^3$/min |
| Minimum Air Opening to Room | 8.4 $m^2$ | 8.4 $m^2$ | 8.4 $m^2$ | 8.4 $m^2$ |
| Minimum Discharge Opening | 5.7 $m^2$ | 5.7 $m^2$ | 5.7 $m^2$ | 5.7 $m^2$ |
| Max Static Restriction | 125 Pa | 125 Pa | 125 Pa | 125 Pa |
| Gas Flow (Full Load) | 303 $m^3$/min | 273 $m^3$/min | 334 $m^3$/min | 303 $m^3$/min |
| Gas Temperature | 505°C | 493°C | 515°C | 505°C |
| Maximum Back Pressure** | 6.8 kPa | 6.8 kPa | 6.8 kPa | 6.8 kPa |
| Unit Dry Weight (with oil)** | 15,875 kgs | 15,875 kgs | 15,875 kgs | 15,875 kgs |
| Derating Factors | Engine power available up to 6070 ft (1850 m) at ambient temperatures up to 40°C (104°F). Above 6070 ft (1850 m) derate at 3.5% per 1000 ft (305 m), and 8% per 11°C (4% per 10°F) above 40°C (104°F). | | Engine power available up to 3280 ft (1000 m) at ambient temperatures up to 40°C (104°F). Above 3280 ft (1000 m) derate at 3.5% per 1000 ft (305 m), and 8% per 11°C (4% per 10°F) above 40°C (104°F). | |

** Approximate only. Actual weight dependent upon options slected.

# 60 Hz Ratings Diesel Powered Generating Sets 32 kW - 2000 kW

| Prime Rating | | 2000 Model Prime | 1999 Model Prime | Standby Model | | 2000 Model Standby | 1999 Model Standby | Cummins Engine Model |
|---|---|---|---|---|---|---|---|---|
| kVA | kW | | | kVA | kW | | | |
| 40 | 32 | 32 DGGC | CP40-6 | 43 | 35 | 35 DGGC | CS40-6 | B3.3G1 |
| 57 | 46 | 46 DGHC | CP60-6 | 63 | 52 | 52 DGHC | CS60-6 | B3.3G2 |
| 44 | 36 | 36 DGBC | CP40-6 | 50 | 40 | 40 DGBC | CS50-6 | 4B3.9G |
| 60 | 48 | 48 DGCA | CP60-6 | 64 | 51 | 51 DGCA | CS60-6 | 4BT3.9G1 |
| 73 | 59 | 59 DGCB | CP70-6 | 81 | 65 | 65 DGCB | CS80-6 | 4BT3.9G2 |
| 83 | 66 | 66 DGCC | CP80-6 | 89 | 72 | 72 DGCC | CS90-6 | 4BTA3.9G2 |
| 95 | 76 | 76 DGDA | CP100-6 | 106 | 85 | 85 DGDA | CS100-6 | 6BT5.9G1 |
| 119 | 95 | 95 DGDB | CP125-6 | 131 | 105 | 105 DGDB | CS125-6 | 6BT5.9G2 |
| 153 | 122 | 122 DGEA | CP160-6 | 167 | 133 | 133 DGEA | CS170-6 | 6CT8.3G2 |
| 210 | 168 | 168 DGFB | CP200-6 | 228 | 182 | 182 DGFB | CS200-6 | 6CTA8.3G2 |
| 254 | 203 | 203 DFAB | CP250-6 | 250 | 200 | 200 DFAB | CS250-6 | LTA10G2 |
| 286 | 229 | 229 DFAC | CP300-6 | 315 | 252 | 252 DFAC | CS300-6 | LTA10G1 |
| 351 | 281 | 281 DFCB | CP350-6 | 390 | 312 | 312 DFCB | CS400-6 | NTA855G2 |
| 402 | 322 | 322 DFCC | CP400-6 | 437 | 350 | 350 DFCC | CS450-6 | NTA855G3 |
| 439 | 351 | 351 DFEB | CP450-6 | 500 | 400 | 400 DFEB | CS500-6 | KTA19G2 |
| 504 | 403 | 403 DFEC | CP500-6 | 562 | 450 | 450 DFEC | CS550-6 | KTA19G3 |
| 561 | 449 | 449 DFED | CP550-6 | 626 | 501 | 501 DFED | CS625-6 | KTA19G4 |
| 681 | 545 | 545 DFGB | CP700-6 | 754 | 603 | 603 DFGB | CS750-6 | VTA28G5 |
| 862 | 690 | 690 DFHA | CP850-6 | 950 | 760 | 760 DFHA | CS950-6 | QST30G1 |
| 920 | 736 | 736 DFHB | CP900-6 | 1012 | 810 | 810 DFHB | CS1000-6 | QST30G2 |
| 1044 | 835 | 835 DFHC | CP1000-6 | 1156 | 925 | 925 DFHC | CS1100-6 | QST30G3 |
| 1160 | 928 | 928 DFJD | CP1100-6 | 1276 | 1020 | 1020 DFJD | CS1250-6 | KTA38G4 |
| 1400 | 1120 | 1120 DFLC | CP1400-6 | 1587 | 1270 | 1270 DFLC | CS1600-6 | KTA50G3 |
| 1608 | 1286 | 1286 DFLE | CP1600-6 | 1931 | 1545 | 1545 DFLE | CS1900-6 | KTA50G9 |
| 2000 | 1600 | 1600 DQKB | CP2000-6 | 2188 | 1750 | 1750 DQKB | CS2200-6 | QSK60G6 |
| 2250 | 1800 | 1800 DQKC | CP2250-6 | 2500 | 2000 | 2000 DQKC | CS2500-6 | QSK60G6 |

**Rating Conditions:**

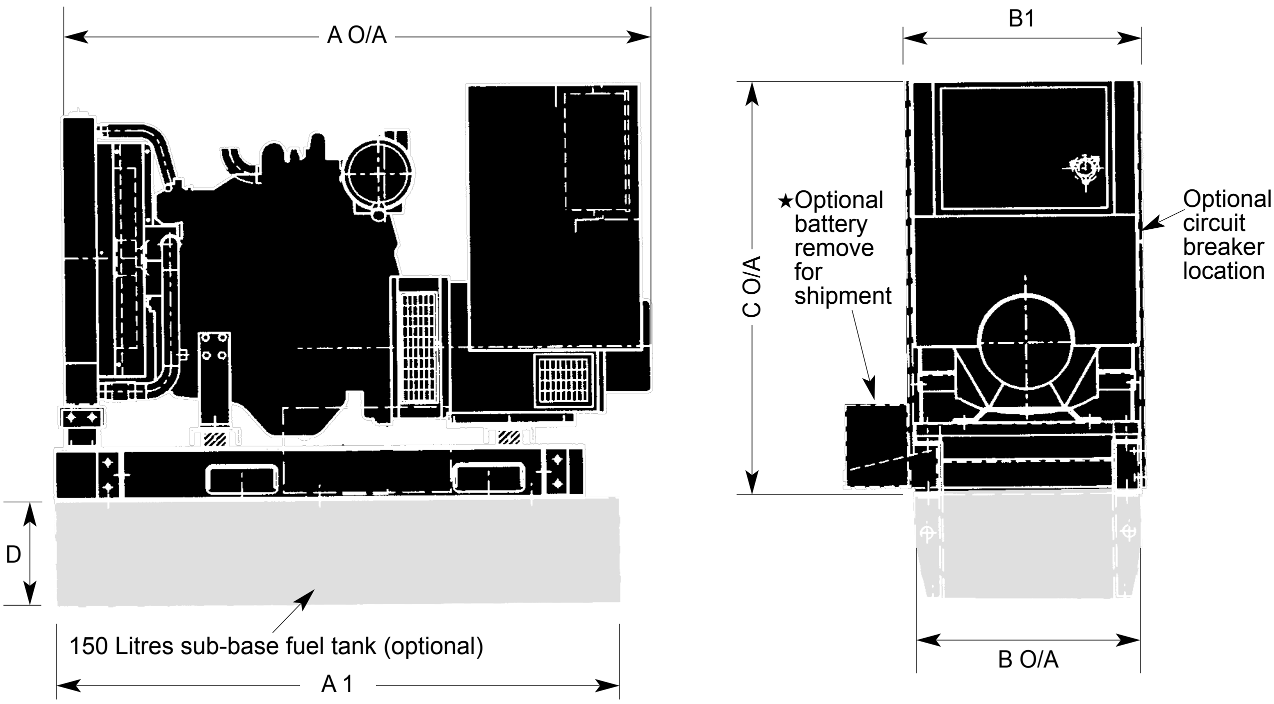
All ratings at 40°C (104°F) ambient temperature with a 50°C (122°F) radiator.

Ratings: Prime (Unlimited Running Time), applicable for supplying power in lieu of commercially-purchased power.

Prime power is available at a variable load for an unlimited number of hours. A 10% overload capacity is available. Nominally rated. All in accordance with ISO 8528, ISO 3046, AS 2789, DIN 6271 and BS 5514.

Standby: Applicable for supplying emergency power for the duration of normal power interruption. No sustained overload capability is available for this rating. Nominally rated. In accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.

## B3 Series Engines

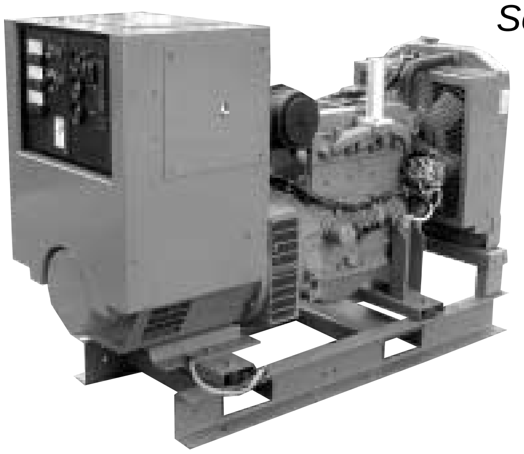



| New Model | Old Model | Engine | Length A mm | A1 mm | Width B mm | B1 mm | Height C mm | D mm | Set weight kg wet | Set weight kg dry | Sub base Tank. Dry Weight kg | Sub base Tank. Wet Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 DGGC | CP40-6 | B3.3G1 | 1667 | 1600 | 645 | 671 | 1175 | 300 | 832 | 813 | 185 | 310 |
| 46 DGHC | CP60-6 | B3.3G2 | 1667 | 1600 | 645 | 671 | 1175 | 300 | 841 | 820 | 185 | 310 |

NOTE 1:
★ Dry and Wet weights of sets do NOT include fuel tank or contents.

Set weights are **without** sub-base tank. Dimensions and weights are for **guidance** only.
Sub-base tank weights are for single skin tanks.
Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# TECHNICAL DATA



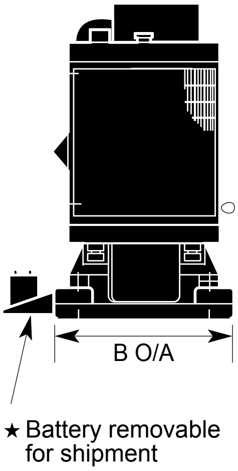
## 32 kW - 52 kW 60 Hz B3 Series Engines

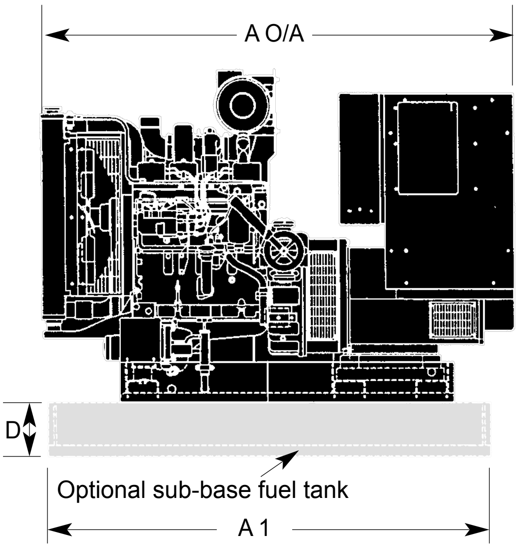
### Generating Sets – 60 Hz

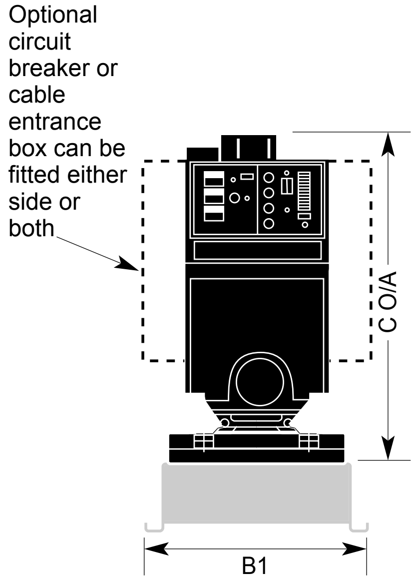
| | | |
|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 32 kWe 40 kVA | 46 kWe 57 kVA |
| 1999 Set Model (Prime) | CP40-6 | CP60-6 |
| New Model (Prime) | 32 DGGC | 46 DGHC |
| Standby at 40°C ambient | 35 kWe 43 kVA | 52 kWe 63 kVA |
| 1999 Set Model (Standby) | CS40-6 | CS60-6 |
| New Model (Standby) | 35 DGGC | 52 DGHC |
| Engine Make | Cummins | Cummins |
| Model | B3.3G1 | B3.3G2 |
| Cylinders | Four | Four |
| Engine build | In-line | In-line |
| Governor/Class | Mechanical/G2 | Mechanical/G2 |
| Aspiration | Natural aspiration | Turbocharged |
| Bore and stroke | 95 mm x 115 mm | 95 mm x 115 mm |
| Compression ratio | 8.2 | 17 |
| Cubic capacity | 3.26 Litres | 3.26 Litres |
| Starting/Min °C | Unaided/–4°C | Unaided/–4°C |
| Battery capacity | 126 A/hr | 126 A/hr |
| Nett Engine output @ flywheel @ Prime | 36.6 kWm | 52.7 kWm |
| Nett at Engine output @ flywheel @ Standby | 40.3 kWm | 59.3 kWm |
| Maximum load acceptance @ single step | 100% | 100% |
| Speed | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±1.5% | ±1.5% |
| Alternator insulation class | H | H |
| Single load step to NFPA110 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 8.7 l/hr | 13.3 l/hr |
| Fuel consumption (Standby) 100% load | 9.8 l/hr | 14.8 l/hr |
| Lubrication oil capacity | 8 Litres | 8 Litres |
| Base fuel tank capacity – open set | 150 Litres | 150 Litres |
| Coolant capacity – radiator and engine | 11.5 Litres | 14 Litres |
| Exhaust temp @ full load standby | 460°C | 510°C |
| Exhaust gas flow @ full load standby | 424 $m^3$/hr | 608 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air flow – radiator @ 0mm back pressure | 8430 $m^3$/hr | 5866 $m^3$/hr |
| Air intake – engine | 144 $m^3$/hr | 231 $m^3$/hr |
| Minimum air opening to room* | 0.48 sq m | 0.63 sq m |
| Minimum discharge opening* | 0.36 sq m | 0.47 sq m |
| Pusher fan head (duct allowance) | 12 mm Wg | 12 mm Wg |
| Total heat radiated to ambient | 13.1 kW | 21.1 kW |
| Engine derating for altitude | 0.7% per 100 m above 1000 m | 0.9% per 100 m above 1000 m |
| Engine derating for temperature | 1% per 10°C above 40°C | 4.5% per 10°C above 40°C |

In accordance with ISO 8528, ISO 3046.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature and 1000m altitude reference.
*Subject to 6mm Wg each, inlet and outlet restriction.

## 4B Series Engines



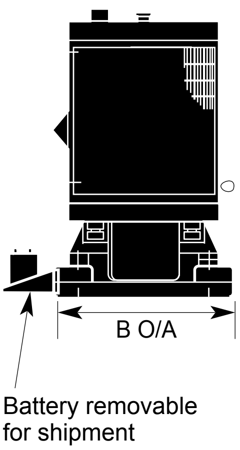



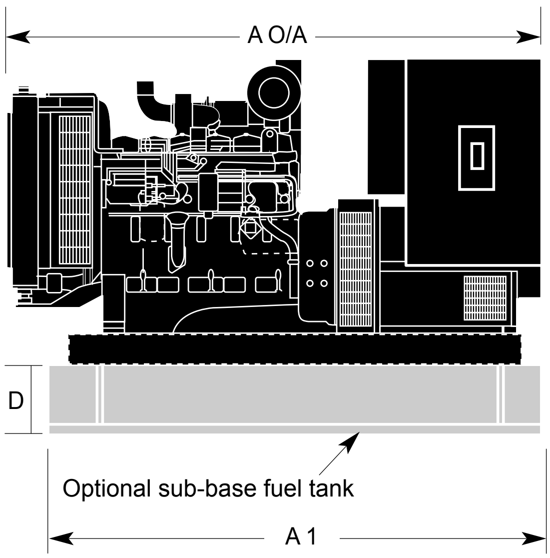



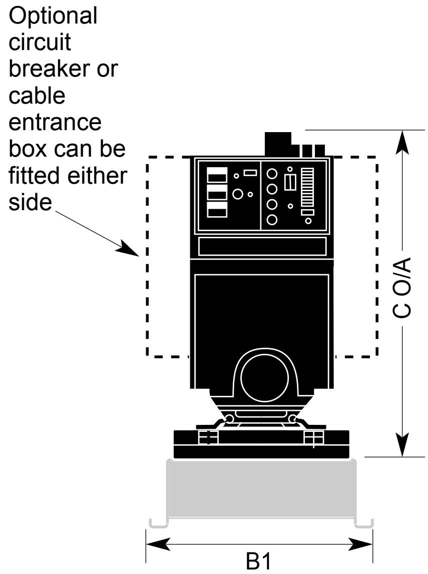

| New Model | Old Model | Engine | Length A mm | A1 mm | Width B1 mm | B mm | Height C mm | D mm | Set weight kg wet | Set weight kg dry | Sub base Tank. Dry Weight kg | Sub base Tank. Wet Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 DGBC | CP40-6 | 4B3.9G | 1720 | 1675 | 840 | 675 | 1345 | 200 | 800 | 772 | 150 | 310 |
| 48 DGCA | CP60-6 | 4BT3.9G1 | 1810 | 1675 | 840 | 675 | 1245 | 200 | 870 | 842 | 150 | 310 |
| 59 DGCB | CP70-6 | 4BT3.9G2 | 1810 | 1675 | 840 | 675 | 1245 | 200 | 920 | 892 | 150 | 310 |
| 66 DGCC | CP80-6 | 4BTA3.9G2 | 1847 | 1675 | 840 | 675 | 1377 | 200 | 975 | 938 | 150 | 310 |

NOTE 1: ★ Battery/tray extends out 260 mm from side when fitted. ★ Dry and Wet weights of sets do NOT include fuel tank or contents.

## 6B Series Engines



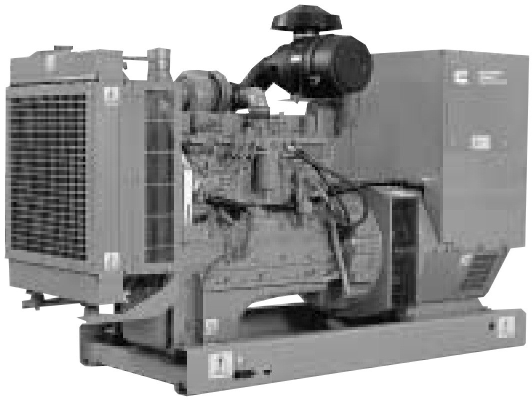




| New Model | Old Model | Engine | Length A mm | A1 mm | Width B1 mm | B mm | Height C mm | D mm | Set weight kg wet | Set weight kg dry | Sub base Tank. Dry Weight kg | Sub base Tank. Wet Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 76 DGDA | CP100-6 | 6BT5.9G1 | 2087 | 1675 | 840 | 675 | 1337 | 200 | 1100 | 1060 | 150 | 310 |
| 95 DGDB | CP125-6 | 6BT5.9G2 | 2162 | 1675 | 840 | 675 | 1337 | 200 | 1175 | 1131 | 150 | 310 |

NOTE 1: ★ Battery tray extends out 260 mm from side – when fitted. ★ Dry and Wet weights of sets do NOT include fuel tank or contents.

Weights are **without** sub-base tank. Dimensions and weights are for **guidance** only. Do not use for installation design.
Ask for certified drawings on your specific application. Specifications may change without notice.

# TECHNICAL DATA



## 36 kW - 72 kW 60 Hz
## 4B Series Engines

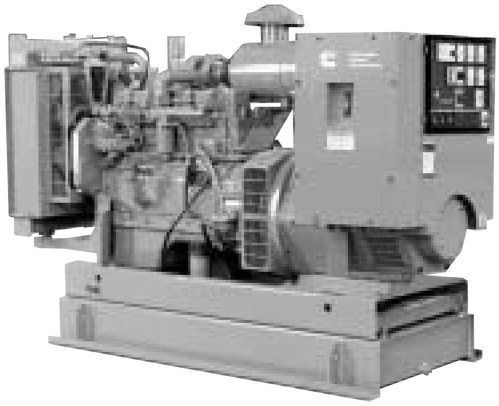
### Generating Sets – 60 Hz

| | | | | |
|---|---|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 36 kWe 44 kVA | 48 kWe 60 kVA | 59 kWe 73 kVA | 66 kWe 83 kVA |
| 1999 Set Model (Prime) | CP40-6 | CP60-6 | CP70-6 | CP80-6 |
| New Model (Prime) | 36 DGBC | 48 DGCA | 59 DGCB | 66 DGCC |
| Standby at 40°C ambient | 40 kWe 50 kVA | 51 kWe 64 kVA | 65 kWe 81 kVA | 72 kWe 89 kVA |
| 1999 Set Model (Standby) | CS50-6 | CS60-6 | CS80-6 | CS90-6 |
| New Model (Standby) | 40 DGBC | 51 DGCA | 65 DGCB | 72 DGCC |
| Engine Make | Cummins | Cummins | Cummins | Cummins |
| Model | 4B3.9G | 4BT3.9G1 | 4BT3.9G2 | 4BTA3.9G2 |
| Cylinders | Four | Four | Four | Four |
| Engine build | In-line | In-line | In-line | In-line |
| Governor/Class | Mechanical | Mechanical | Mechanical | Mechanical |
| Aspiration and cooling | Natural aspiration | Turbocharged | Turbocharged | Turbocharged |
| Bore and stroke | 102 mm x 120 mm | 102 mm x 120 mm | 102 mm x 120 mm | 102 mm x 120 mm |
| Compression ratio | 17.3:1 | 16.5:1 | 16.5:1 | 16.5:1 |
| Cubic capacity | 3.92 Litres | 3.92 Litres | 3.92 Litres | 3.92 Litres |
| Starting/Min °C | Unaided/–12°C | Unaided/–12°C | Unaided/–12°C | Unaided/–12°C |
| Battery capacity | 165 A/hr | 165 A/hr | 165 A/hr | 165 A/hr |
| Nett Engine output – Prime | 40 kWm | 54 kWm | 65 kWm | 73 kWm |
| Nett at flywheel – Standby | 46 kWm | 60 kWm | 72 kWm | 80 kWm |
| Speed | 1800 rpm | 1800 rpm | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% | ±1.0% | ±1.0% |
| Alternator insulation class | H | H | H | H |
| Single load step to NFPAII0 para 5.13.2.6 | 100% | 100% | 100% | 100% |
| Fuel consumption (Prime) 100% load | 12.8 l/hr | 14.99 l/hr | 17.6 l/hr | 18.0 l/hr |
| Fuel consumption (Standby) 100% load | 14.5 l/hr | 16.43 l/hr | 19.5 l/hr | 20.0 l/hr |
| Lubrication oil capacity | 9.5 Litres | 9.5 Litres | 9.5 Litres | 9.5 Litres |
| Base fuel tank capacity – open set | 197 Litres | 197 Litres | 197 Litres | 197 Litres |
| Coolant capacity – radiator and engine | 21 Litres* | 21 Litres* | 21 Litres* | 21 Litres* |
| Exhaust temp – full load prime | 604°C | 463°C | 510°C | 461°C |
| Exhaust gas flow – full load prime | 550 $m^3$/hr | 630 $m^3$/hr | 713 $m^3$/hr | 810 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg | 76 mm Hg | 76 mm Hg |
| Air flow – radiator | 2.9 $m^3$/s | 2.9 $m^3$/s | 2.9 $m^3$/s | 2.27 $m^3$/s |
| Air intake – engine | 180 $m^3$/hr | 237 $m^3$/hr | 252 $m^3$/hr | 349 $m^3$/hr |
| Minimum air opening to room | 0.7 sq m | 0.7 sq m | 0.7 sq m | 0.7 sq m |
| Minimum discharge opening | 0.5 sq m | 0.5 sq m | 0.5 sq m | 0.5 sq m |
| Pusher fan head (duct allowance) | 10 mm Wg* | 10 mm Wg* | 10 mm Wg* | 10 mm Wg* |
| Total heat radiated to ambient | 11.4 kW | 15 kW | 17 kW | 18 kW |
| Engine derating – altitude | 3% per 300 m above 150 m | 4% per 300 m above 1525 m | 4% per 300 m above 1220 m | 4% per 300 m above 1220 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature reference.
*Subject to factory verification.

# TECHNICAL DATA

## 76 kW - 105 kW 60 Hz
## 6B Series Engines

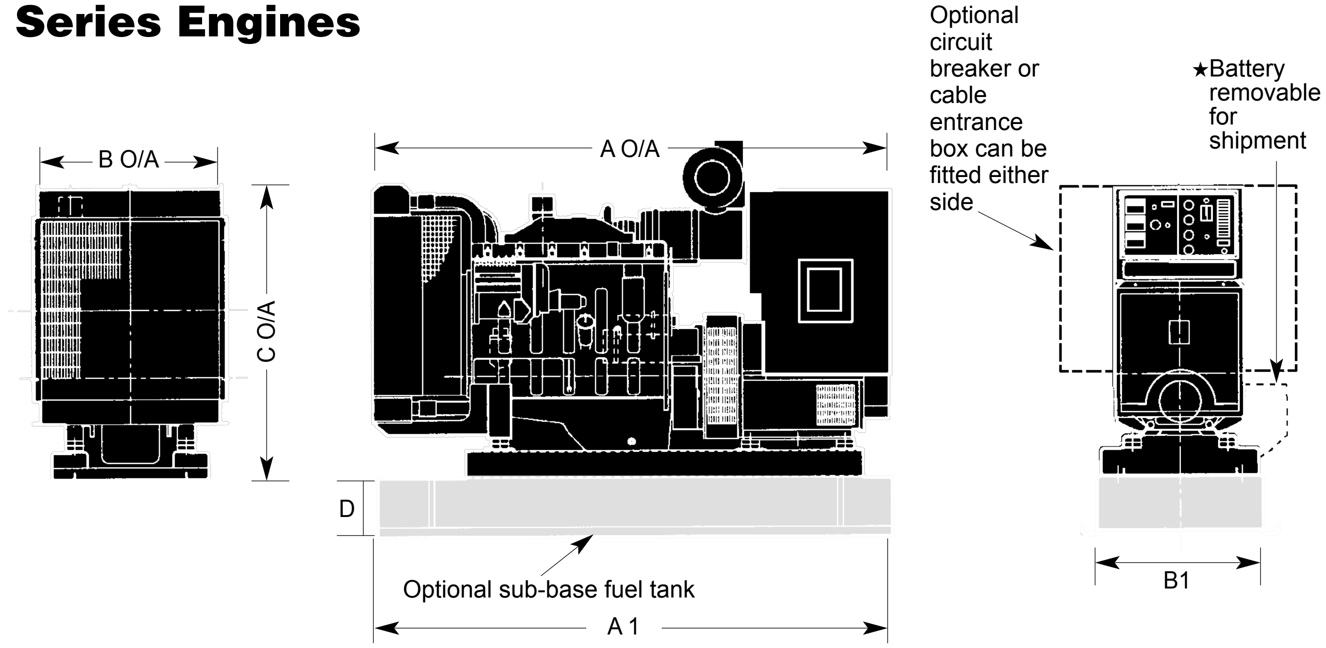


### Generating Sets – 60 Hz

| | | |
|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 76 kWe 95 kVA | 95 kWe 119 kVA |
| 1999 Set Model (Prime) | CP100-6 | CP125-6 |
| New Model (Prime) | 76 DGDA | 95 DGDB |
| Standby at 40°C ambient | 85 kWe 106 kVA | 105 kWe 131 kVA |
| 1999 Set Model (Standby) | CS100-6 | CS125-6 |
| New Model (Standby) | 85 DGDA | 105 DGDB |
| Engine Make | Cummins | Cummins |
| Model | 6BT5.9G1 | 6BT5.9G2 |
| Cylinders | Six | Six |
| Engine build | In-line | In-line |
| Governor/Class | Mechanical | Mechanical |
| Aspiration and cooling | Turbocharged | Turbocharged |
| Bore and stroke | 102 mm x 120 mm | 102 mm x 120 mm |
| Compression ratio | 17.5:1 | 17.5:1 |
| Cubic capacity | 5.88 Litres | 5.88 Litres |
| Starting/Min °C | Unaided/–12°C | Unaided/–12°C |
| Battery capacity | 165 A/hr | 165 A/hr |
| Nett Engine output – Prime | 83 kWm | 106 kWm |
| Nett at flywheel – Standby | 95 kWm | 118 kWm |
| Speed | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% |
| Alternator insulation class | H | H |
| Single load step to NFPAII0 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 23.4 l/hr | 27.1 l/hr |
| Fuel consumption (Standby) 100% load | 25.7 l/hr | 29.8 l/hr |
| Lubrication oil capacity | 14.3 Litres | 14.3 Litres |
| Base fuel tank capacity – open set | 200 Litres | 200 Litres |
| Coolant capacity – radiator and engine | 22.4 Litres | 23.3 Litres |
| Exhaust temp – full load prime | 482°C | 543°C |
| Exhaust gas flow – full load prime | 1036 $m^3$/hr | 1267 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air flow – radiator | 2.5 $m^3$/s* | 2.3 $m^3$/s* |
| Air intake – engine | 392 $m^3$/hr | 443 $m^3$/hr |
| Minimum air opening to room | 0.7 sq m | 0.7 sq m |
| Minimum discharge opening | 0.5 sq m | 0.5 sq m |
| Pusher fan head (duct allowance) | 10 mm Wg* | 10 mm Wg* |
| Total heat radiated to ambient (Engine) | 22 kW | 25 kW |
| Engine derating – altitude | 4% per 300 m above 2285 m | 4% per 300 m above 2285 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature reference.
*Subject to factory verification.

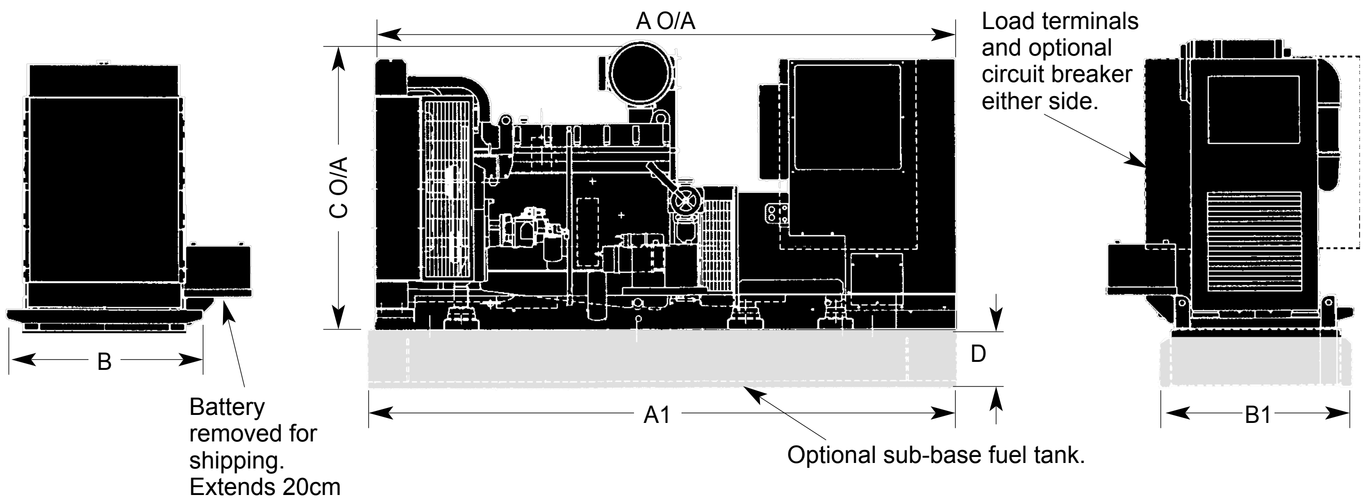
## 6C Series Engines




| New Model | Old Model | Engine | Length A mm | A1 mm | Width B1 mm | B mm | Height C mm | D mm | Set weight kg wet | Set weight kg dry | Sub base Tank. Dry Weight kg | Sub base Tank. Wet Weight kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 122 DGEA | CP150-6 | 6CT8.3G2 | 2332 | 2200 | 840 | 831 | 1412 | 250 | 1550 | 1498 | 210 | 490 |
| 168 DGFB | CP200-6 | 6CTA8.3G2 | 2389 | 2200 | 840 | 831 | 1412 | 250 | 1760 | 1704 | 210 | 490 |

NOTE 1:
★ Battery tray extends out 260 mm from side – when fitted. ★ Dry and Wet weights of sets do NOT include fuel tank or contents.

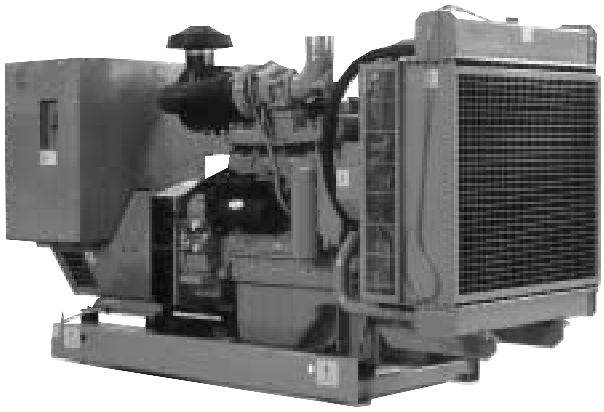
## LTA10 Series Engines




| New | | Old | Dimensions and Weights (mm/kg) | | | | | | Set Weight | Set Weight | Tank (dry) | Tank (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | Engine | Model | A | A1 | B | B1 | C | D | kg Dry | kg Wet | Weight kg | Weight kg |
| 203 DFAB | LTA10G2 | CP250-6 | 2980 | 3338 | 1048 | 1050 | 1644 | 300 | 2230 | 2300 | 445 | 1085 |
| 229 DFAC | LTA10G1 | CP300-6 | 2980 | 3338 | 1048 | 1050 | 1644 | 300 | 2332 | 2380 | 445 | 1085 |

Set weights are **without** sub-base tank.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# TECHNICAL DATA



## 122 kW - 182 kW 60 Hz
## 6C Series Engines

### Generating Sets – 60 Hz

| | | |
|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 122 kWe 153 kVA | 168 kWe 210 kVA |
| 1999 Set Model (Prime) | CP150-6 | CP200-6 |
| New Model (Prime) | 122 DGEA | 168 DGFB |
| Standby at 40°C ambient | 133 kWe 167 kVA | 182 kWe 228 kVA |
| 1999 Set Model (Standby) | CS170-6 | CS200-6 |
| New Model (Standby) | 133 DGEA | 182 DGFB |
| Engine Make | Cummins | Cummins |
| Model | 6CT8.3G2 | 6CTA8.3G2 |
| Cylinders | Six | Six |
| Engine build | In-line | In-line |
| Governor/Class | Mechanical | Mechanical |
| Aspiration and cooling | Turbocharged | Turbo Aftercharged |
| Bore and stroke | 114 mm x 135 mm | 114 mm x 135 mm |
| Compression ratio | 16.8:1 | 16.5:1 |
| Cubic capacity | 8.3 Litres | 8.3 Litres |
| Starting/Min °C | Unaided/–12°C | Unaided/–12°C |
| Battery capacity | 165 A/hr | 165 A/hr |
| Nett Engine output – Prime | 132 kWm | 180 kWm |
| Nett at flywheel – Standby | 146 kWm | 199 kWm |
| Speed | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% |
| Alternator insulation class | H | H |
| Single load step to NFPAII0 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 37 l/hr | 46 l/hr |
| Fuel consumption (Standby) 100% load | 41 l/hr | 51 l/hr |
| Lubrication oil capacity | 23.8 Litres | 23.8 Litres |
| Base fuel tank capacity – open set | 330 Litres | 330 Litres |
| Coolant capacity – radiator and engine | 26 Litres | 28 Litres |
| Exhaust temp – full load prime | 511°C | 591°C |
| Exhaust gas flow – full load prime | 1872 $m^3$/hr | 2343 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air flow – radiator* | 4.4 $m^3$/s | 3.9 $m^3$/s |
| Air intake – engine | 752 $m^3$/hr | 781 $m^3$/hr |
| Minimum air opening to room | 0.9 sq m | 0.9 sq m |
| Minimum discharge opening | 0.6 sq m | 0.6 sq m |
| Pusher fan head (duct allowance)* | 13 mm Wg* | 13 mm Wg* |
| Total heat radiated to ambient (Engine) | 36 kW | 40 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 5°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature reference.
*Subject to factory verification.

# TECHNICAL DATA

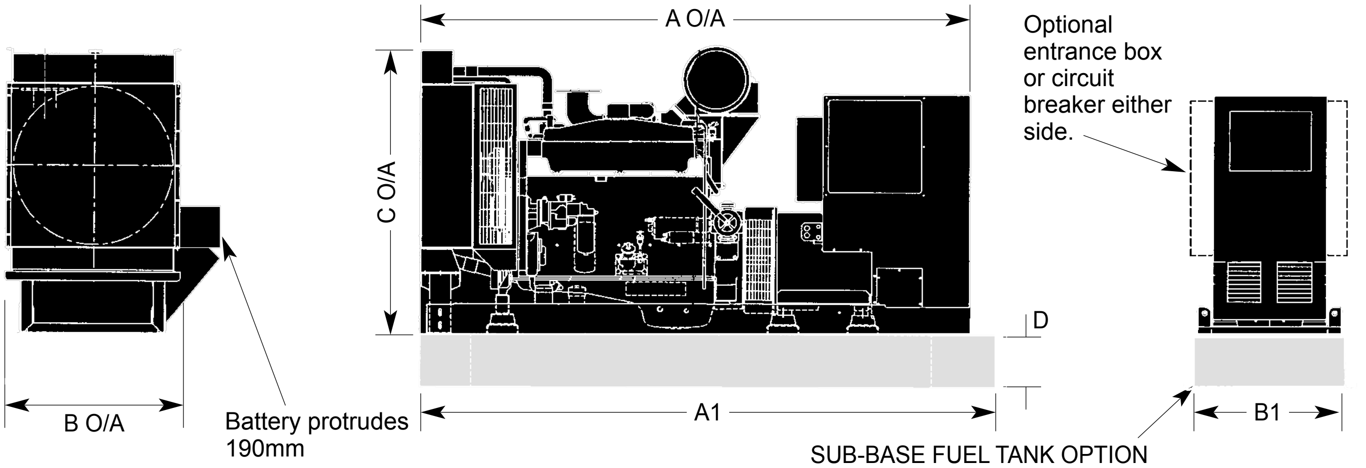
## 203 kW - 252 kW 60 Hz
## LTA10 Series Engines

### Generating Sets – 60 Hz

| | | |
|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 203 kWe 254 kVA | 229 kWe 286 kVA |
| 1999 Set Model (Prime) | CP250-6 | CP300-6 |
| New Model (Prime) | 203 DFAB | 229 DFAC |
| Standby at 40°C ambient | 200 kWe 250 kVA | 252 kWe 315 kVA |
| 1999 Set Model (Standby) | CS250-6 | CS300-6 |
| New Model (Standby) | 200 DFAB | 252 DFAC |
| Engine Make | Cummins | Cummins |
| Model | LTA10G2 | LTA10G1 |
| Cylinders | Six | Six |
| Engine build | In-line | In-line |
| Governor/Class | Electronic/A1 | Electronic/A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 125 mm x 136 mm | 125 mm x 136 mm |
| Compression ratio | 16.0:1 | 16.0:1 |
| Cubic capacity | 10 Litres | 10 Litres |
| Starting/Min °C | Unaided/–1°C | Unaided/–1°C |
| Battery capacity | 2 x 127 A/hr | 2 x 127 A/hr |
| Nett Engine output – Prime | 220 kWm | 246 kWm |
| Nett at flywheel – Standby | 246 kWm | 272 kWm |
| Speed | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% |
| Alternator insulation class | H | H |
| Single load step to NFPAII0 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 56.4 l/hr | 59 l/hr |
| Fuel consumption (Standby) 100% load | 63.2 l/hr | 64.7 l/hr |
| Lubrication oil capacity | 36 Litres | 36 Litres |
| Base fuel tank capacity – open set | 675 Litres | 675 Litres |
| Coolant capacity – radiator and engine | 61.8 Litres | 61.8 Litres |
| Exhaust temp – full load prime | 485°C | 504°C |
| Exhaust gas flow – full load prime | 2812 $m^3$/hr | 2794 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air intake – engine | 1069 $m^3$/hr | 1037 $m^3$/hr |
| Air flow – radiator (50°C) | 6.5 $m^3$/s | 6.5 $m^3$/s |
| Pusher fan head (duct allowance) 50°C | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient | 50 kW | 55 kW |
| Engine derating – altitude | 4% per 300 m above 1220 m | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

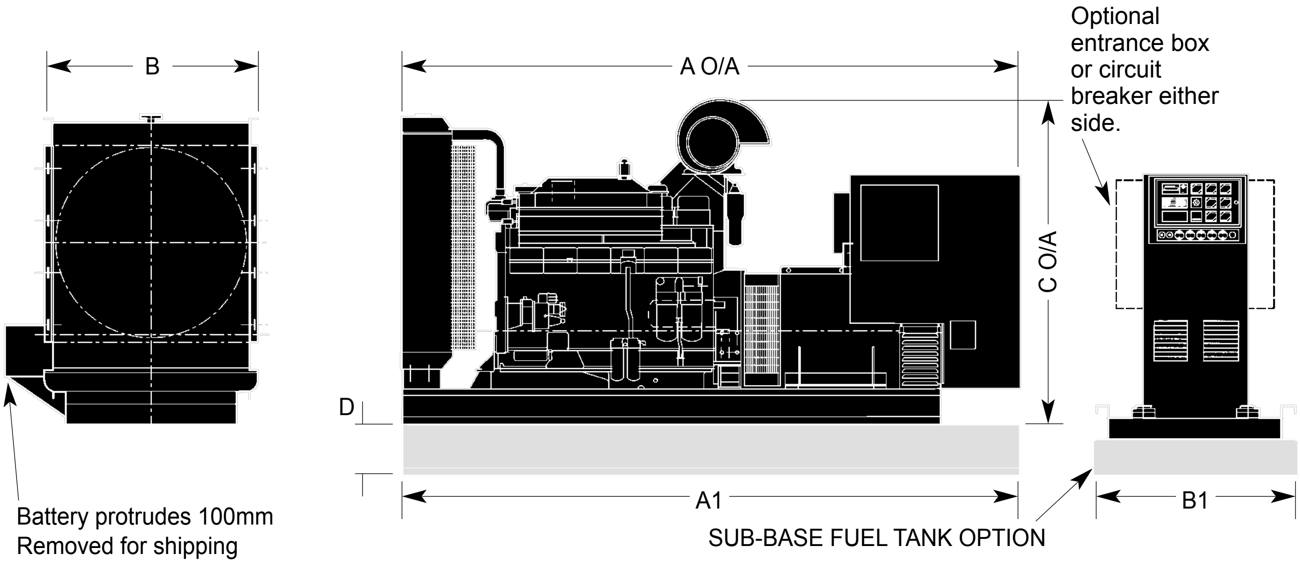
In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.

## NT855 Series Engines




| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 281 DFCB | NTA855G2 | CP350-6 | 3286 | 3338 | 990 | 1048 | 1117 | 300 | 3178 | 3275 | 445 | 1085 |
| 322 DFCC | NTA855G3 | CP400-6 | 3304 | 3338 | 990 | 1048 | 1117 | 300 | 3293 | 3390 | 445 | 1085 |

## K19 Series Engines

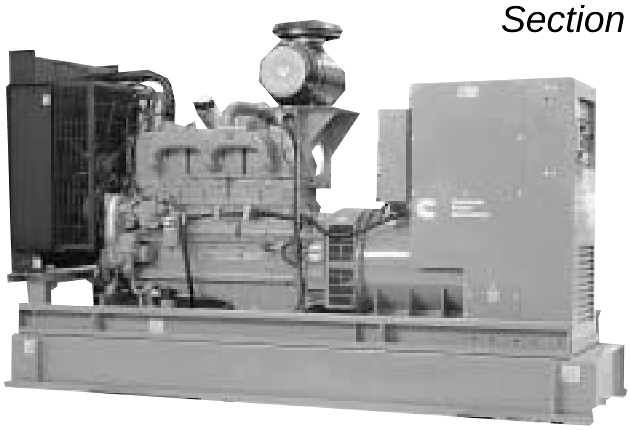



| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 351 DFEB | KTA19G2 | CP450-6 | 3490 | 3875 | 1266 | 1350 | 1830 | 300 | 4136 | 4270 | 580 | 1580 |
| 403 DFEC | KTA19G3 | CP500-6 | 3490 | 3875 | 1266 | 1350 | 1830 | 300 | 4276 | 4410 | 580 | 1580 |
| 449 DFED | KTA19G4 | CP550-6 | 3490 | 3875 | 1266 | 1350 | 1830 | 300 | 4276 | 4410 | 580 | 1580 |

Set weights are **without** sub-base tank.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

# TECHNICAL DATA

## 281 kW - 350 kW 60 Hz
## NT855 Series Engines



### Generating Sets – 60 Hz

| | | |
|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 281 kWe 351 kVA | 322 kWe 402 kVA |
| 1999 Set Model (Prime) | CP350-6 | CP400-6 |
| New Model (Prime) | 281 DFCB | 322 DFCC |
| Standby at 40°C ambient | 312 kWe 390 kVA | 350 kWe 437 kVA |
| 1999 Set Model (Standby) | CS400-6 | CS450-6 |
| New Model (Standby) | 312 DFCB | 350 DFCC |
| Engine Make | Cummins | Cummins |
| Model | NTA855G2 | NTA855G3 |
| Cylinders | Six | Six |
| Engine build | In-line | In-line |
| Governor/Class | Electronic/A1 | Electronic/A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 140 mm x 152 mm | 140 mm x 152 mm |
| Compression ratio | 14.0:1 | 14.0:1 |
| Cubic capacity | 14 Litres | 14 Litres |
| Starting/Min °C | Unaided/–7°C | Unaided/–7°C |
| Battery capacity | 127 A/hr | 127 A/hr |
| Nett Engine output – Prime | 299 kWm | 344 kWm |
| Nett at flywheel – Standby | 333 kWm | 385 kWm |
| Speed | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% |
| Alternator insulation class | H | H |
| Single load step to NFPAII0 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 79 l/hr | 87 l/hr |
| Fuel consumption (Standby) 100% load | 89 l/hr | 96 l/hr |
| Lubrication oil capacity | 38.6 Litres | 38.6 Litres |
| Base fuel tank capacity – open set | 800 Litres | 800 Litres |
| Coolant capacity – radiator and engine | 79.8 Litres | 84.8 Litres |
| Exhaust temp – full load prime | 466°C | 521°C |
| Exhaust gas flow – full load prime | 4136 $m^3$/hr | 4734 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg |
| Air intake – engine | 1613 $m^3$/hr | 1717 $m^3$/hr |
| Air flow – radiator (50°C) | 9.7 $m^3$/s | 9.2 $m^3$/s |
| Pusher fan head (duct allowance) 50°C | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient | 72 kW | 76 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.

# TECHNICAL DATA

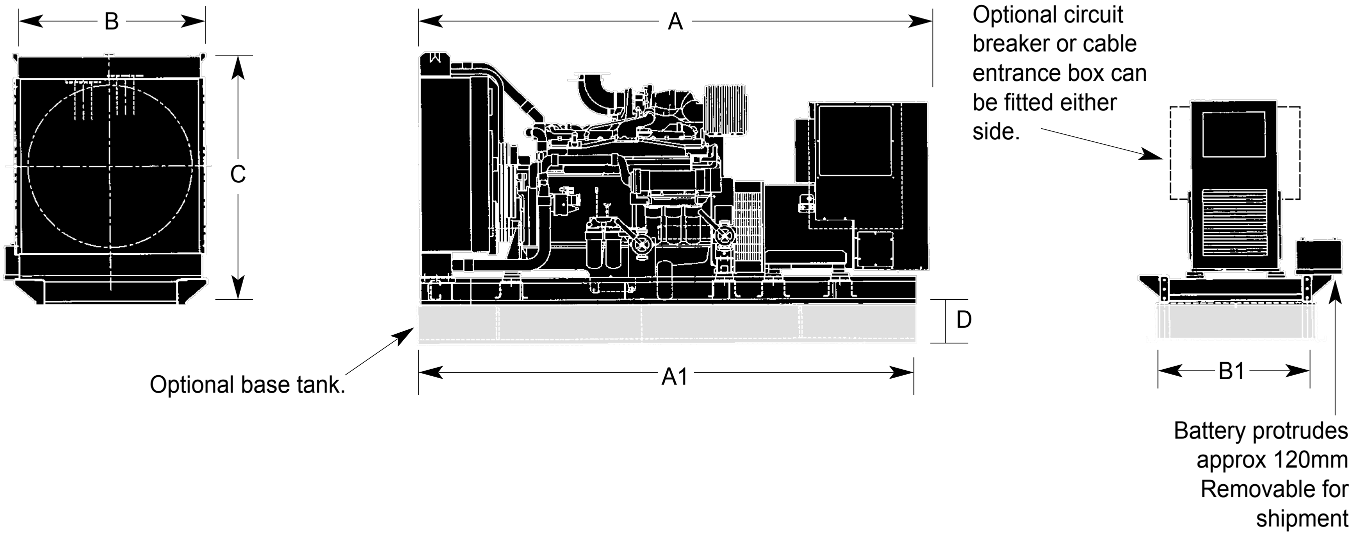
## 351 kW - 453 kW 60 Hz
## K19 Series Engines

### Generating Sets – 60 Hz

| | | | |
|---|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 351 kWe 439 kVA | 403 kWe 504 kVA | 449 kWe 561 kVA |
| 1999 Set Model (Prime) | CP450-6 | CP500-6 | CP550-6 |
| New Model (Prime) | 351 DFEB | 403 DFEC | 449 DFED |
| Standby at 40°C ambient | 400 kWe 500 kVA | 450 kWe 562 kVA | 501 kWe 626 kVA |
| 1999 Set Model (Standby) | CS500-6 | CS550-6 | CS625-6 |
| New Model (Standby) | 400 DFEB | 450 DFEC | 501 DFED |
| Engine Make | Cummins | Cummins | Cummins |
| Model | KTA19G2 | KTA19G3 | KTA19G4 |
| Cylinders | Six | Six | Six |
| Engine build | In-line | In-line | In-line |
| Governor/Class | Electronic/A1 | Electronic/A1 | Electronic/A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 159 mm x 159 mm | 159 mm x 159 mm | 159 mm x 159 mm |
| Compression ratio | 13.9:1 | 13.9:1 | 13.9:1 |
| Cubic capacity | 18.9 Litres | 18.9 Litres | 18.9 Litres |
| Starting/Min °C | Unaided/7°C | Unaided/7°C | Unaided/0°C |
| Battery capacity | 190 A/hr | 190 A/hr | 190 A/hr |
| Nett Engine output – Prime | 373 kWm | 429 kWm | 473 kWm |
| Nett at flywheel – Standby | 429 kWm | 477 kWm | 529 kWm |
| Speed | 1800 rpm | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±1.0% | ±1.0% | ±1.0% |
| Alternator insulation class | H | H | H |
| Single load step to NFPAII0 | 100% | 100% | 100% |
| Fuel consumption (Prime) 100% load | 98 l/hr | 111 l/hr | 120 l/hr |
| Fuel consumption (Standby) 100% load | 113 l/hr | 122 l/hr | 133 l/hr |
| Lubrication oil capacity | 50 Litres | 50 Litres | 50 Litres |
| Base fuel tank capacity – open set | 1200 Litres | 1200 Litres | 1200 Litres |
| Coolant capacity – radiator and engine | 105 Litres | 105 Litres | 105 Litres |
| Exhaust temp – full load prime | 493°C | 471°C | 481°C |
| Exhaust gas flow – full load prime | 5554 $m^3$/hr | 5684 $m^3$/hr | 6242 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg | 76 mm Hg |
| Air intake – engine | 2092 $m^3$/hr | 2199 $m^3$/hr | 2473 $m^3$/hr |
| Air flow – radiator (50°C)* | 11.3 $m^3$/s | 14.8 $m^3$/s | 14.8 $m^3$/s |
| Pusher fan head (duct allowance) 50°C* | 13 mm Wg | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient | 85 kW | 95 kW | 99 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C | 2% per 11°C above 40°C | 2% per 11°C above 40°C |

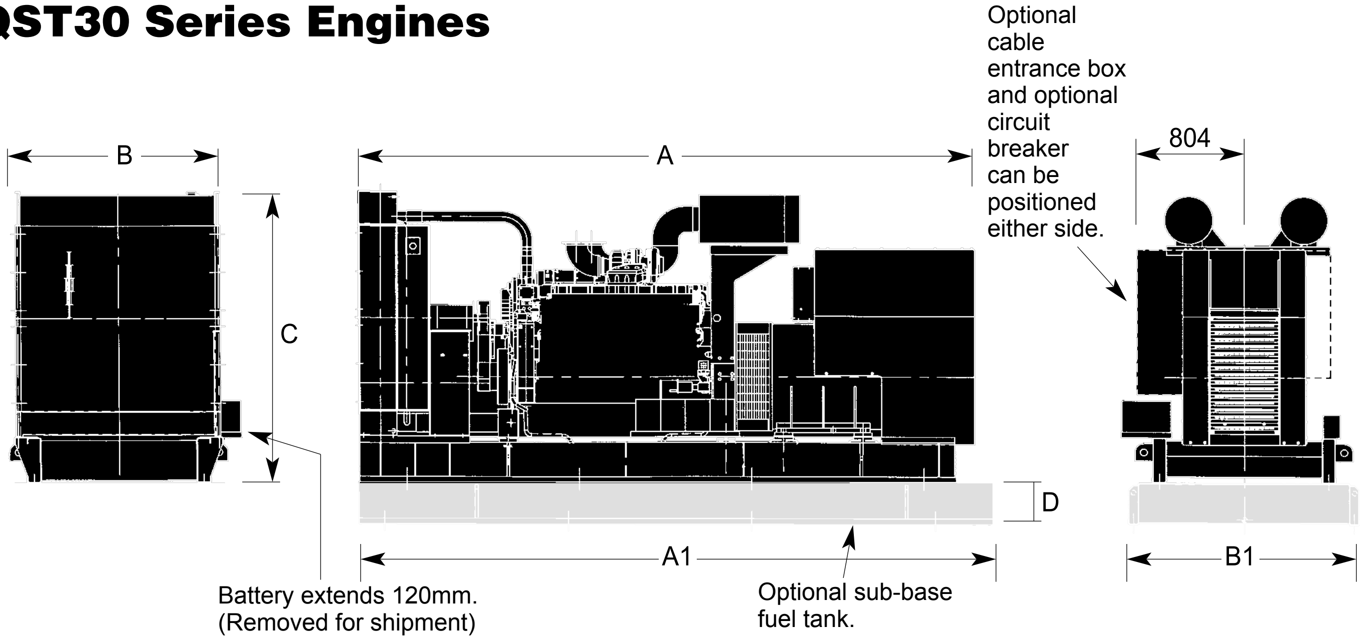
In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
*Subject to factory verification.

## VTA28 Series Engines




| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B1 | B | C | D | | | | |
| 545 DFGB | VTA28G5 | CP700-6 | 4047 | 4092 | 1350 | 1423 | 1987 | 300 | 5730 | 6040 | 610 | 1670 |

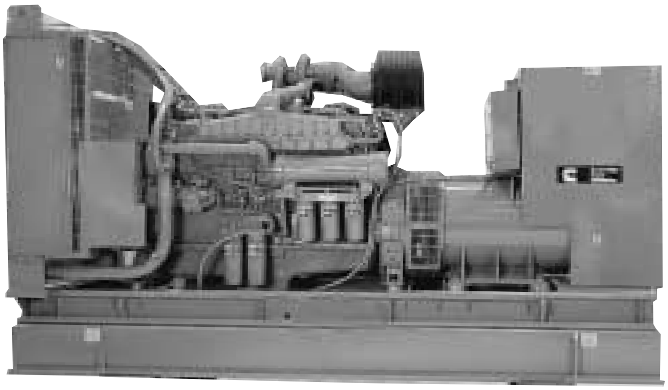
## QST30 Series Engines




| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 690 DFHA | QST30G1 | CP850-6 | 4297 | 4460 | 1442 | 1640 | 2092 | 300 | 6702 | 7000 | 850 | 2210 |
| 736 DFHB | QST30G2 | CP900-6 | 4297 | 4460 | 1442 | 1640 | 2092 | 300 | 6852 | 7150 | 850 | 2210 |
| 835 DFHC | QST30G3 | CP1000-6 | 4391 | 4460 | 1442 | 1640 | 2092 | 300 | 7152 | 7450 | 850 | 2210 |

Set weights are **without** sub-base tank.Dimensions and weights are for **guidance** only. Do not use for installation design.
Ask for certified drawings on your specific application. Specifications may change without notice.

# TECHNICAL DATA



## 545 kW - 603 kW 60 Hz VTA28 Series Engines

### Generating Sets – 60 Hz

| | |
|---|---|
| Set output | 220-480 V 60 Hz |
| Prime at 40°C ambient | 545 kWe 681 kVA |
| 1999 Set Model (Prime) | CP700-6 |
| New Model (Prime) | 545 DFGB |
| Standby at 40°C ambient | 603 kWe 754 kVA |
| 1999 Set Model (Standby) | CS750-6 |
| New Model (Standby) | 603 DFGB |
| Engine Make | Cummins |
| Model | VTA28G5 |
| Cylinders | Twelve |
| Engine build | Vee |
| Governor / Class | Electronic / A1 |
| Aspiration and cooling | Turbo Aftercooled |
| Bore and stroke | 140 mm x 152 mm |
| Compression ratio | 13.0:1 |
| Cubic capacity | 28 Litres |
| Starting / Min °C | Unaided / 4°C |
| Battery capacity | 254 A/hr |
| Nett Engine output – Prime | 576 kWm |
| Nett at flywheel – Standby | 639 kWm |
| Speed | 1800 rpm |
| Alternator voltage regulation | ±1.0% |
| Alternator insulation class | H |
| Single load step to NFPAIIO para.5.13.2.6 | 100% |
| Fuel consumption (Prime) 100% load | 154 l/hr |
| Fuel consumption (Standby) 100% load | 173 l/hr |
| Lubrication oil capacity | 83 Litres |
| Base fuel tank capacity – open set | 1325 Litres |
| Coolant capacity – radiator and engine | 207 Litres |
| Exhaust temp – full load prime | 474°C |
| Exhaust gas flow – full load prime | 7877 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg |
| Air intake – engine | 3510 $m^3$/hr |
| Air flow – radiator (50°C)* | 19.4 $m^3$/s |
| Pusher fan head (duct allowance) 50°C* | 13 mm Wg |
| Total heat radiated to ambient | 133 kW |
| Engine derating – altitude | 4% per 300 m<br>above 1220 m |
| Engine derating – temperature | 2% per 11°C<br>above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
*Subject to factory verification.

# TECHNICAL DATA

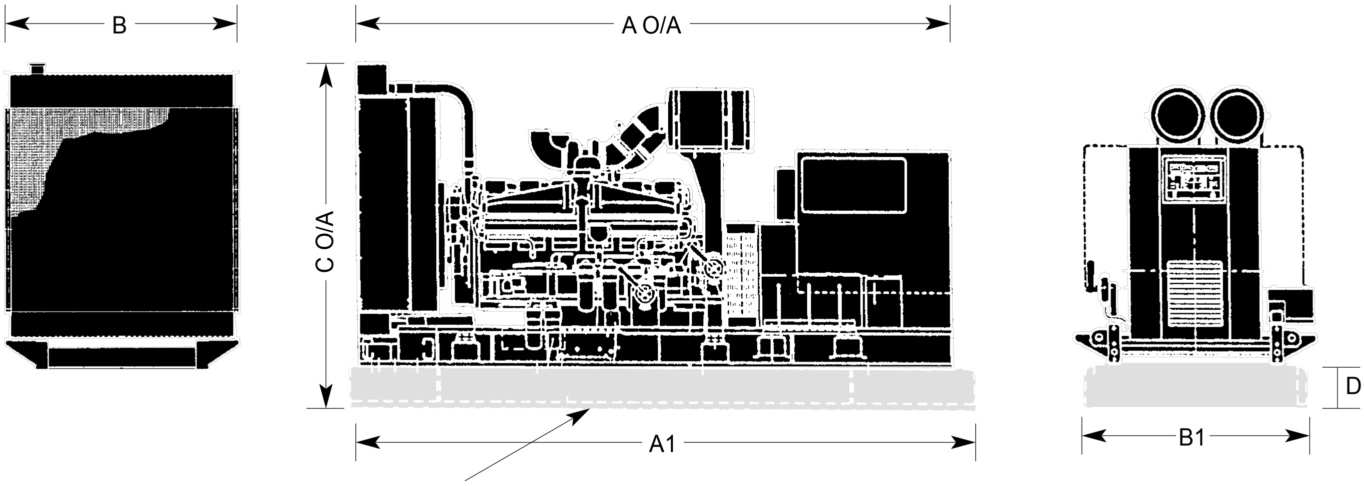
## 690 kW - 925 kW 60 Hz QST30 Series Engines

### Generating Sets – 60 Hz

| | | | |
|---|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 690 kWe 862 kVA | 736 kWe 920 kVA | 835 kWe 1044 kVA |
| 1999 Set Model (Prime) | CP850-6 | CP900-6 | CP1000-6 |
| New Model (Prime) | 690 DFHA | 736 DFHB | 835 DFHC |
| Standby at 40°C ambient | 760 kWe 950 kVA | 810 kWe 1012 kVA | 925 kWe 1156 kVA |
| 1999 Set Model (Standby) | CS950-6 | CS1000-6 | CS1100-6 |
| New Model (Standby) | 760 DFHA | 810 DFHB | 925 DFHC |
| Engine Make | Cummins | Cummins | Cummins |
| Model | QST30G1 | QST30G2 | QST30G3 |
| Cylinders | Twelve | Twelve | Twelve |
| Engine build | Vee | Vee | Vee |
| Governor/Class | Electronic/A1 | Electronic/A1 | Electronic/A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 140 mm x 165 mm | 140 mm x 165 mm | 140 mm x 165 mm |
| Compression ratio | 14:1 | 14:1 | 14:1 |
| Cubic capacity | 30.48 Litres | 30.48 Litres | 30.48 Litres |
| Starting/Min °C | Unaided/1°C | Unaided/1°C | Unaided/7°C |
| Battery capacity | 254 A/hr | 254 A/hr | 254 A/hr |
| Nett Engine output – Prime | 718 kWm | 759 kWm | 910 kWm |
| Nett Engine output – Standby | 796 kWm | 844 kWm | 1007 kWm |
| Speed | 1800 rpm | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±0.5% | ±0.5% | ±0.5% |
| Alternator insulation class | H | H | H |
| Single load step to NFPAII0 | 100% | 100% | 100% |
| Fuel consumption (Prime) 100% load | 186 l/hr | 197 l/hr | 207 l/hr |
| Fuel consumption (Standby) 100% load | 207 l/hr | 219 l/hr | 228 l/hr |
| Lubrication oil capacity | 154 Litres | 154 Litres | 154 Litres |
| Base fuel tank capacity – open set | 1700 Litres | 1700 Litres | 1700 Litres |
| Coolant capacity – radiator and engine | 168 Litres | 168 Litres | 168 Litres |
| Exhaust temp – full load prime | 455°C | 467°C | 464°C |
| Exhaust gas flow – full load prime | 9432 $m^3$/hr | 10058 $m^3$/hr | 10800 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg | 76 mm Hg | 76 mm Hg |
| Air intake – engine | 3679 $m^3$/hr | 3859 $m^3$/hr | 4284 $m^3$/hr |
| Air flow 40°C ambient* | 19.1 $m^3$/s | 19.1 $m^3$/s | TBA |
| Air flow – radiator (50°C ambient)* | 21.9 $m^3$/s | 21.9 $m^3$/s | 21.9 $m^3$/s |
| Pusher fan head (duct allowance) 50°C* | 13 mm Wg | 13 mm Wg | 13 mm Wg |
| Total heat radiated to ambient (prime) | 153 kW | 166 kW | 152 kW |
| Engine derating – altitude | 4% per 300 m above 1524 m | 4% per 300 m above 1524 m | 4% per 300 m above 1000 m |
| Engine derating – temperature | 2% per 11°C above 40°C (52°C below 305 m) | 2% per 11°C above 40°C (52°C below 305 m) | 2% per 11°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
Prime and standby ratings are outputs at 40°C (104°F) ambient temperature.
*Subject to factory verification.

## KTA38 Series Engines

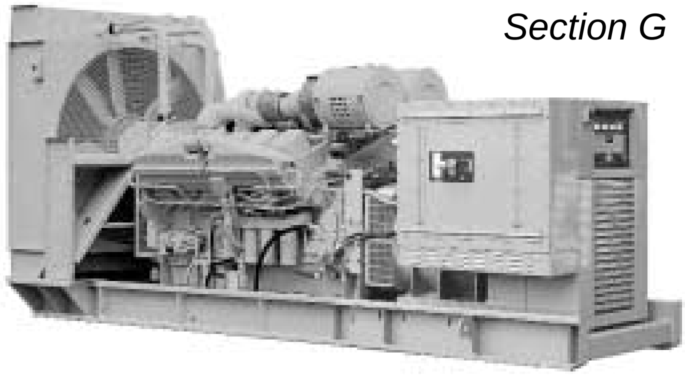



| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 928 DFJD | KTA38G4 | CP1100-6 | 4470 | 4600 | 1785 | 1640 | 2229 | 300 | 8527 | 8600 | 850 | 2210 |

| Floor mounted circuit breaker and load terminal cubicle (for use above 1250 amps) | | | |
|---|---|---|---|
| Capacity amps | Width mm | Depth mm | Height mm |
| 1600 | 1000 | 1050 | 1500 |
| 2000 | 1000 | 1050 | 1500 |
| 2500 | 1000 | 1050 | 1500 |
| 3200 | 1000 | 1050 | 1500 |

Set weights are **without** sub-base tank.Dimensions and weights are for **guidance** only. Do not use for installation design.
Ask for certified drawings on your specific application. Specifications may change without notice.

# TECHNICAL DATA



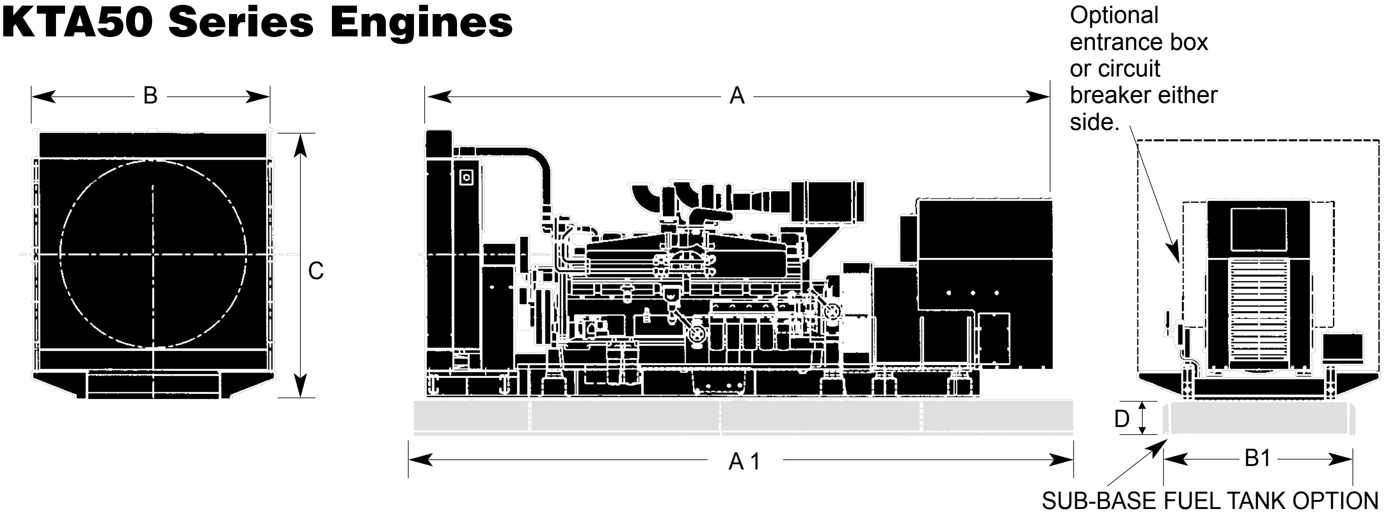
## 928 kW - 1020 kW 60 Hz KTA38 Series Engines

### Generating Sets – 60 Hz

| | |
|---|---|
| Set output | 220-480 V 60 Hz |
| Prime at 40°C ambient | 928 kWe 1160 kVA |
| 1999 Set Model (Prime) | CP1100-6 |
| New Model (Prime) | 928 DFJD |
| Standby at 40°C ambient | 1020 kWe 1276 kVA |
| 1999 Set Model (Standby) | CS1250-6 |
| New Model (Standby) | 1020 DFJD |
| Engine Make | Cummins |
| Model | KTA38G4 |
| Cylinders | Twelve |
| Engine build | Vee |
| Governor / Class | Electronic / A1 |
| Aspiration and cooling | Turbo Aftercooled |
| Bore and stroke | 159 mm x 159 mm |
| Compression ratio | 13.9:1 |
| Cubic capacity | 37.8 Litres |
| Starting / Min °C | Unaided / 7°C |
| Battery capacity | 254 A/hr |
| Nett Engine output – Prime | 973 kWm |
| Nett at flywheel – Standby | 1078 kWm |
| Speed | 1800 rpm |
| Alternator voltage regulation | ±0.5% |
| Alternator insulation class | H |
| Single load step to NFPAII0 para 5.13.2.6 | 100% |
| Fuel consumption (Prime) 100% load | 245 l/hr |
| Fuel consumption (Standby) 100% load | 271 l/hr |
| Lubrication oil capacity | 135 Litres |
| Base fuel tank capacity – open set | 1700 Litres |
| Coolant capacity – radiator and engine | 307 Litres |
| Exhaust temp – full load prime | 499°C |
| Exhaust gas flow – full load prime | 13107 $m^3$/hr |
| Exhaust gas back pressure max | 76 mm Hg |
| Air intake – engine (Prime) | 4892 $m^3$/hr |
| Air flow – radiator (50°C ambient)* | 28.5 $m^3$/s |
| Pusher fan head (duct allowance) 50°C* | 13 mm Wg |
| Total heat radiated to ambient | 197 kW |
| Engine derating – altitude | 4% per 300 m above 1525 m |
| Engine derating – temperature | 2% per 11°C above 40°C |

In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
*Subject to factory verification.

## KTA50 Series Engines



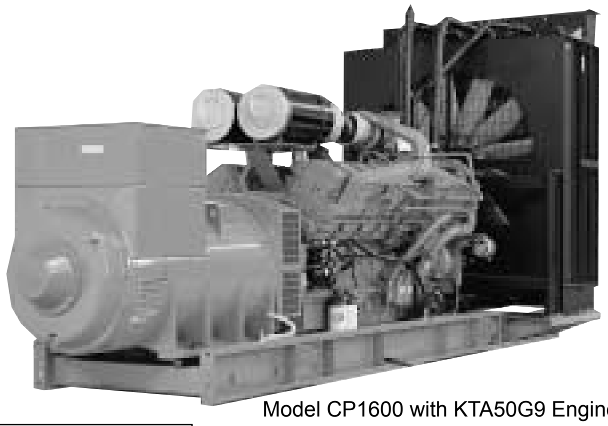

| New Model | Engine | Old Model | Dimensions and Weights (mm/kg) | | | | | | Set Weight kg Dry | Set Weight kg Wet | Tank Weight kg (dry) | Tank Weight kg (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | A1 | B | B1 | C | D | | | | |
| 1120 DFLC | KTA50G3 | CP1400-6 | 5290 | 5690 | 1785 | 1640 | 2244 | 300 | 9743 | 10300 | 2755 | 1075 |
| 1286 DFLE | KTA50G9 | CP1600-6 | 5866 | 5690 | 2033 | 1640 | 2333 | 300 | 11540 | 12100 | 2755 | 1075 |

| Floor mounted circuit breaker and load terminal cubicle (for use above 2000 amps) | | | |
|---|---|---|---|
| Capacity amps | Width mm | Depth mm | Height mm |
| 1600 | 1000 | 1050 | 1500 |
| 2000 | 1000 | 1050 | 1500 |
| 2500 | 1000 | 1050 | 1500 |

Set weights are **without** sub-base tank. Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application. Specifications may change without notice.

# TECHNICAL DATA

## 1120 kW - 1545 kW 60 Hz
## KTA50 Series Engines



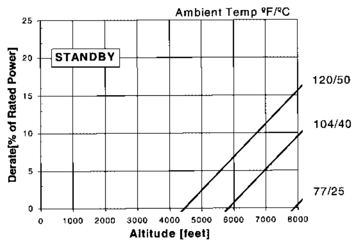
Model CP1600 with KTA50G9 Engine

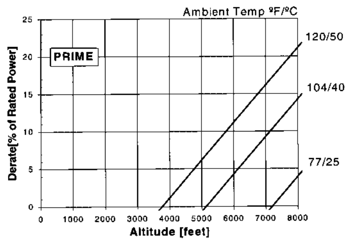
### Generating Sets – 60 Hz

| | | |
|---|---|---|
| Set output | 220-480 V 60 Hz | 220-480 V 60 Hz |
| Prime at 40°C ambient | 1120 kWe 1400 kVA | 1286 kWe 1608 kVA |
| 1999 Set Model (Prime) | CP1400-6 | CP1600-6 |
| New Model (Prime) | 1120 DFLC | 1286 DFLE |
| Standby at 40°C ambient | 1270 kWe 1587 kVA | 1545 kWe 1931 kVA |
| 1999 Set Model (Standby) | CS1600-6 | CS1900-6 |
| New Model (Standby) | 1270 DFLC | 1545 DFLE |
| Engine Make | Cummins | Cummins |
| Model | KTA50G3 | KTA50G9 |
| Cylinders | Sixteen | Sixteen |
| Engine build | 60° Vee | 60° Vee |
| Governor / Class | Electronic / A1 | Electronic / A1 |
| Aspiration and cooling | Turbo Aftercooled | Turbo Aftercooled |
| Bore and stroke | 159 mm x 159 mm | 159 mm x 159 mm |
| Compression ratio | 13.9:1 | 13.9:1 |
| Cubic capacity | 50.3 Litres | 50.3 Litres |
| Starting / Min °C | Unaided / 7°C | Unaided / 7°C |
| Battery capacity | 254 A/hr | 254 A/hr |
| Nett Engine output – Prime | 1172 kWm | 1370 kWm |
| Nett at flywheel – Standby | 1332 kWm | 1609 kWm |
| Speed | 1800 rpm | 1800 rpm |
| Alternator voltage regulation | ±0.5% | ±0.5% |
| Alternator insulation class | H | H |
| Single load step to NFPAIIO para.5.13.2.6 | 100% | 100% |
| Fuel consumption (Prime) 100% load | 291 l/hr | 330 l/hr |
| Fuel consumption (Standby) 100% load | 330 l/hr | 392 l/hr |
| Lubrication oil capacity | 177 Litres | 204 Litres |
| Base fuel tank capacity – open set | 2000 Litres | 2000 Litres |
| Coolant capacity – radiator and engine | 351 Litres | 521 Litres* |
| Exhaust temp – full load prime | 460°C | 471°C |
| Exhaust gas flow – full load prime | 14270 $m^3$/hr | 16308 $m^3$/hr |
| Exhaust gas back pressure max | 51 mm Hg | 51 mm Hg |
| Air flow – radiator (50°C ambient)* | 33.7 $m^3$/s | 28.2 $m^3$/s |
| Pusher fan head (duct allowance) 50°C* | 13 mm Wg | 13 mm Wg* |
| Air intake – engine | 6285 $m^3$/hr | 6948 $m^3$/hr |
| Total heat radiated to ambient | 229 kW | 186 kW |
| Engine derating – altitude | up to 1550 m (5500 ft) prime and 1760 m (5800 ft) standby @ 40°C without derating. Above these limits refer to graphs | up to 1000 m (3300 ft) prime or standby @ 40°C without derating. Above these limits refer to graphs |
| Engine derating – temperature | | |

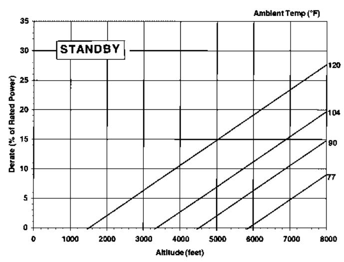
In accordance with ISO 8528, BS5514.
Prime: Continuous running at variable load for unlimited periods with 10% overload available for 1 hour in any 12 hour period.
Standby: Continuous running at variable load for duration of an emergency.
*Subject to factory verification.

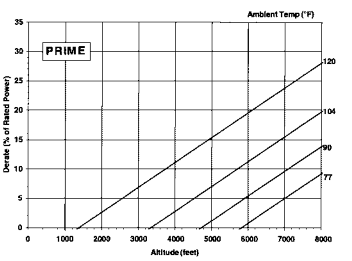
KTA50G3



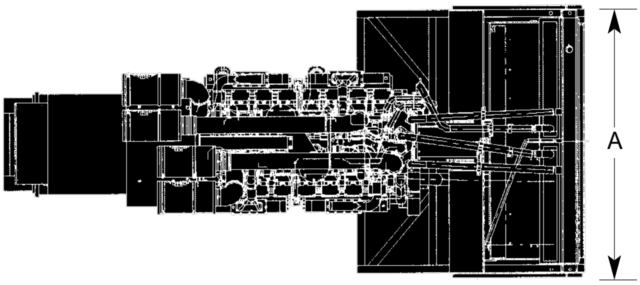



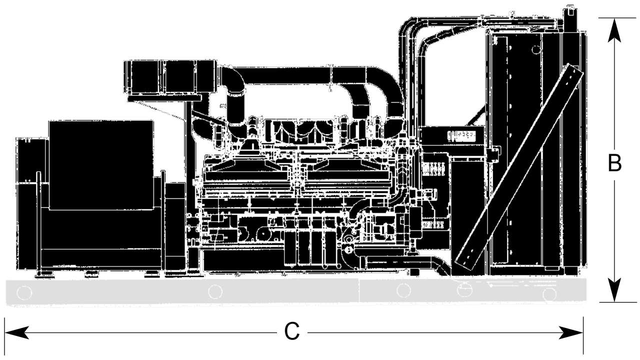

KTA50G9



## QSK60 Series



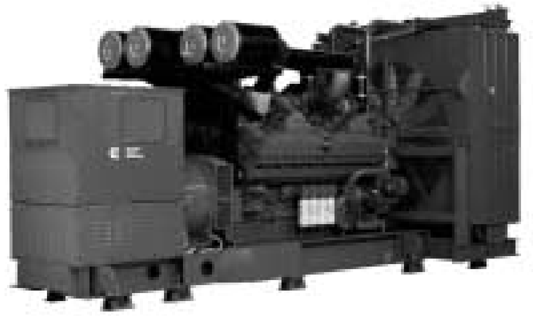

| Model | Dim "A" | | Dim "B" | | Dim "C" | | Dry Weight* | |
|---|---|---|---|---|---|---|---|---|
| 1600 DQKB | 98.2 in | 2494 mm | 119.8 in | 3043 mm | 239.7 in | 6090 mm | 34260 lb | 15540 kg |
| 1800 DQKC | 98.2 in | 2494 mm | 119.8 in | 3043 mm | 239.7 in | 6090 mm | 34701 lb | 15740 kg |

*Weight given is with standard low voltage alternator.

| Floor mounted circuit breaker and load terminal cubicle (for use above 2000 amps) | | | |
|---|---|---|---|
| Capacity amps | Width mm | Depth mm | Height mm |
| 1600 | 1000 | 1050 | 1500 |
| 2000 | 1000 | 1050 | 1500 |
| 2500 | 1000 | 1050 | 1500 |

Set weights are **without** sub-base tank.
Dimensions and weights are for **guidance** only. Do not use for installation design. Ask for certified drawings on your specific application.
Specifications may change without notice.

## 1600 kW - 2000 kW 60 Hz QSK60 Series Engines



### Generating Sets – 60 Hz

| | Standby | Prime | Standby | Prime |
|---|---|---|---|---|
| Ratings kW (kVA) | 1750 (2188) | 1600 (2000) | 2000 (2500) | 1800 (2250) |
| Model | 1750 DQKB | 1600 DQKB | 2000 DQKC | 1800 DQKC |
| Engine Model | QSK60G6 | QSK60G6 | QSK60G6 | QSK60G6 |
| Aspiration | Turbocharged and Aftercooled | Turbocharged and Aftercooled | Turbocharged and Aftercooled | Turbocharged and Aftercooled |
| Gross Engine Power Output | 1,907 kWm | 1,733 kWm | 2,180 kWm | 1,950 kWm |
| BMEP | 2,117 kPa | 1,917 kPa | 2,420 kPa | 2,159 kPa |
| Bore | 159 mm | 159 mm | 159 mm | 159 mm |
| Stroke | 190 mm | 190 mm | 190 mm | 190 mm |
| Piston Speed | 11.4 m/s | 11.4 m/s | 11.4 m/s | 11.4 m/s |
| Compression Ratio | 14.5:1 | 14.5:1 | 14.5:1 | 14.5:1 |
| Lube Oil Capacity | 280 Litres | 280 Litres | 280 Litres | 280 Litres |
| Overspeed Limit | 2,100 ± 50 rpm | 2,100 ± 50 rpm | 2,100 ± 50 rpm | 2,100 ± 50 rpm |
| Regenerative Power | 207 kW | 207 kW | 207 kW | 207 kW |
| Fuel Consumption Load | 1/4 1/2 3/4 Full | 1/4 1/2 3/4 Full | 1/4 1/2 3/4 Full | 1/4 1/2 3/4 Full |
| Fuel Consumption L/hr | 146 243 339 436 | 144 228 314 403 | 161 269 389 517 | 148 247 350 460 |
| Maximum Fuel Flow | 2,309 L/hr | 2,309 L/hr | 2,309 L/hr | 2,309 L/hr |
| Maximum Inlet Restriction | 120 mm Hg | 120 mm Hg | 102 mm Hg | 102 mm Hg |
| Maximum Return Restriction | 229 mm Hg | 229 mm Hg | 229 mm Hg | 229 mm Hg |
| Maximum Fuel Inlet Temperature | 70°C | 70°C | 71°C | 71°C |
| Maximum Fuel Return Temperature | 113°C | 113°C | 113°C | 113°C |
| Fan Load | 50 kW | 50 kW | 50 kW | 50 kW |
| Coolant Capacity (with radiator) | 378.5 Litres | 378.5 Litres | 454 Litres | 454 Litres |
| Coolant Flow Rate (engine jacket) | 1,932 L/Min | 1,932 L/Min | 1,817 L/Min | 1,817 L/Min |
| Coolant Flow Rate (aftercooler) | 510 L/Min | 510 L/Min | 502 L/Min | 502 L/Min |
| Heat Rejection to Eng Jacket Coolant | 36.4 MJ/Min | 34.0 MJ/Min | 40.6 MJ/Min | 37.4 MJ/Min |
| Heat Rejection to Aftercooler Coolant | 28.8 MJ/Min | 26.2 MJ/Min | 37.6 MJ/Min | 31.0 MJ/Min |
| Heat Rejection to Fuel | 3.2 MJ/Min | 3.2 MJ/Min | 3.2 MJ/Min | 3.2 MJ/Min |
| Heat Radiated to Room | 19.0 MJ/Min | 15.9 MJ/Min | 23.3 MJ/Min | 19.5 MJ/Min |
| Max Coolant Friction Head (JW) | 69 kPa | 69 kPa | 69 kPa | 69 kPa |
| Max Coolant Friction Head (aftercooler) | 35 kPa | 35 kPa | 48.3 kPa | 48.3 kPa |
| Maximum Coolant Static Head | 18.3 m | 18.3 m | 18.3 m | 18.3 m |
| Heat Ex. Max Raw Water Flow (JW/AC) | 1,363 L/Min | 1,363 L/Min | 1,363 L/Min | 1,363 L/Min |
| Heat Ex. Max Raw Water Press (JW/AC/Fuel) | 1,034 kPa | 1,034 kPa | 1,034 kPa | 1,034 kPa |
| Heat Ex. Max Raw Water Flow (Fuel) | 144 L/Min | 144 L/Min | 144 L/Min | 144 L/Min |
| Max Top Tank Temp (engine jacket) | 104°C | 100°C | 104°C | 100°C |
| Max Inlet Temp (aftercooler) | 65°C | 65°C | 65°C | 65°C |
| Combustion Air | 151 $m^3$/min | 144 $m^3$/min | 172 $m^3$/min | 161 $m^3$/min |
| Maximum Air Cleaner Restriction | 6.2 kPa | 6.2 kPa | 6.2 kPa | 6.2 kPa |
| Alternator Cooling Air | 290 $m^3$/min | 290 $m^3$/min | 290 $m^3$/min | 290 $m^3$/min |
| Radiator Cooling Air | 1,869 $m^3$/min | 1,869 $m^3$/min | 1,726 $m^3$/min | 1,726 $m^3$/min |
| Minimum Air Opening to Room | 8.4 $m^2$ | 8.4 $m^2$ | 8.4 $m^2$ | 8.4 $m^2$ |
| Minimum Discharge Opening | 5.7 $m^2$ | 5.7 $m^2$ | 5.7 $m^2$ | 5.7 $m^2$ |
| Max Static Restriction | 125 Pa | 125 Pa | 125 Pa | 125 Pa |
| Gas Flow (Full Load) | 380 $m^3$/min | 352 $m^3$/min | 429 $m^3$/min | 390 $m^3$/min |
| Gas Temperature | 423°C | 404°C | 455°C | 430°C |
| Maximum Back Pressure** | 6.8 kPa | 6.8 kPa | 6.8 kPa | 6.8 kPa |
| Unit Dry Weight (with oil)** | 15,875 kgs | 15,875 kgs | 15,875 kgs | 15,875 kgs |
| Derating Factors | Engine power available up to 6300 ft (1920 m) at ambient temperatures up to 40°C (104°F). Above 6300 ft (1920 m) derate at 4.6% per 1000 ft (305 m), and 4% per 11°C (2% per 10°F) above 40°C (104°F). | | Engine power available up to 2300 ft (700 m) at ambient temperatures up to 104°F (40°C). Above 2300 ft (700 m) derate at 3.5% per 1000 ft (305 m), and 4% per 11°C (2% per 10°F) above 40°C (104°F) up to 5000 ft. | |

** Approximate only. Actual weight dependent upon options slected.

## FORMULA FOR DETERMINING AMPS, HORSEPOWER, KILOWATTS AND kVA

| | | | ALTERNATING CURRENT | | |
|---|---|---|---|---|---|
| | | DIRECT CURRENT | SINGLE PHASE 2 WIRE | TWO PHASE 4 WIRE | THREE PHASE 4 WIRE |
| TO FIND | Amps when H.P. is known | $\frac{H.P. \times 746}{E \times Eff}$ | $\frac{H.P. \times 746}{E \times Eff \times PF}$ | $\frac{H.P. \times 746}{2 \times E \times Eff \times PF}$ | $\frac{H.P. \times 746}{1.73 \times E \times Eff \times PF}$ |
| | Amps when kW is known | $\frac{kW \times 1000}{E}$ | $\frac{kW \times 1000}{E \times PF}$ | $\frac{kW \times 1000}{2 \times E \times PF}$ | $\frac{kW \times 1000}{1.73 \times E \times PF}$ |
| | Amps when kVA is known | | $\frac{kVA \times 1000}{E}$ | $\frac{kVA \times 1000}{2 \times E}$ | $\frac{kVA \times 1000}{1.73 \times E}$ |
| | Kilowatts | $\frac{I \times E}{1000}$ | $\frac{I \times E \times PF}{1000}$ | $\frac{I \times 2 \times E \times PF}{1000}$ | $\frac{I \times 1.73 \times E \times PF}{1000}$ |
| | kVA | | $\frac{I \times E}{1000}$ | $\frac{I \times E \times 2}{1000}$ | $\frac{I \times E \times 1.73}{1000}$ |
| | Horse Power | $\frac{I \times E \times Eff}{746}$ | $\frac{I \times E \times Eff \times PF}{746}$ | $\frac{I \times E \times 2 \times Eff \times PF}{746}$ | $\frac{I \times E \times 1.73 \times Eff \times PF}{746}$ |

I = Amps
E = Line Volts
Eff = per Unit Efficiency
kW = Kilowatts
PF = Power Factor
kVA = Kilo-Volt-Amps
H.P. = Horse Power

NOTE:
Efficiency varies between about 86% for 25kVA to 93% for 1000kVA. Generally the larger the alternator, the greater its efficiency. The power factor for normal purposes should be taken as 0.85.

## CONVERSION TABLES

### CENTIMETRES — INCHES

| cm | | INCHES | cm | | INCHES |
|---|---|---|---|---|---|
| 2.54 | 1 | 0.3937 | 129.54 | 51 | 20.0787 |
| 5.08 | 2 | 0.7874 | 132.08 | 52 | 20.4724 |
| 7.62 | 3 | 1.1811 | 134.62 | 53 | 20.8661 |
| 10.16 | 4 | 1.5748 | 137.16 | 54 | 21.2598 |
| 12.70 | 5 | 1.9685 | 139.70 | 55 | 21.6535 |
| 15.24 | 6 | 2.3622 | 142.24 | 56 | 22.0472 |
| 17.78 | 7 | 2.7559 | 144.78 | 57 | 22.4409 |
| 20.32 | 8 | 3.1496 | 147.32 | 58 | 22.8346 |
| 22.86 | 9 | 3.5433 | 149.86 | 59 | 23.2283 |
| 25.40 | 10 | 3.9370 | 152.40 | 60 | 23.6220 |
| 27.94 | 11 | 4.3307 | 154.94 | 61 | 24.0157 |
| 30.48 | 12 | 4.7244 | 157.48 | 62 | 24.4094 |
| 33.02 | 13 | 5.1181 | 160.02 | 63 | 24.8031 |
| 35.56 | 14 | 5.5118 | 162.56 | 64 | 25.1969 |
| 38.10 | 15 | 5.9055 | 165.10 | 65 | 25.5906 |
| 40.64 | 16 | 6.2992 | 167.64 | 66 | 25.9843 |
| 43.18 | 17 | 6.6929 | 170.18 | 67 | 26.3780 |
| 45.72 | 18 | 7.0866 | 172.72 | 68 | 26.7717 |
| 48.26 | 19 | 7.4803 | 175.26 | 69 | 27.1654 |
| 50.80 | 20 | 7.8740 | 177.80 | 70 | 27.5591 |
| 53.34 | 21 | 8.2677 | 180.34 | 71 | 27.9528 |
| 55.88 | 22 | 8.6614 | 182.88 | 72 | 28.3465 |
| 58.42 | 23 | 9.0551 | 185.42 | 73 | 28.7402 |
| 60.96 | 24 | 9.4488 | 187.96 | 74 | 29.1339 |
| 63.50 | 25 | 9.8425 | 190.50 | 75 | 29.5276 |
| 66.04 | 26 | 10.2362 | 193.04 | 76 | 29.9213 |
| 68.58 | 27 | 10.6299 | 195.58 | 77 | 30.3150 |
| 71.12 | 28 | 11.0236 | 198.12 | 78 | 30.7087 |
| 73.66 | 29 | 11.4173 | 200.66 | 79 | 31.1024 |
| 76.20 | 30 | 11.8110 | 203.20 | 80 | 31.4961 |
| 78.74 | 31 | 12.2047 | 205.74 | 81 | 31.8898 |
| 81.28 | 32 | 12.5984 | 208.28 | 82 | 32.2835 |
| 83.82 | 33 | 12.9921 | 210.82 | 83 | 32.6772 |
| 86.36 | 34 | 13.3858 | 213.36 | 84 | 33.0709 |
| 88.90 | 35 | 13.7795 | 215.90 | 85 | 33.4646 |
| 91.44 | 36 | 14.1732 | 218.44 | 86 | 33.8583 |
| 93.98 | 37 | 14.5669 | 220.98 | 87 | 34.2520 |
| 96.52 | 38 | 14.9606 | 223.52 | 88 | 34.6457 |
| 99.06 | 39 | 15.3543 | 226.06 | 89 | 35.0394 |
| 102.60 | 40 | 15.7480 | 228.60 | 90 | 35.4331 |
| 104.14 | 41 | 16.1417 | 231.14 | 91 | 35.8268 |
| 106.68 | 42 | 16.5354 | 233.68 | 92 | 36.2205 |
| 109.22 | 43 | 16.9291 | 236.22 | 93 | 36.6142 |
| 111.76 | 44 | 17.3228 | 238.76 | 94 | 37.0079 |
| 114.30 | 45 | 17.7165 | 241.30 | 95 | 37.4016 |
| 116.84 | 46 | 18.1102 | 243.84 | 96 | 37.7953 |
| 119.38 | 47 | 18.5039 | 246.38 | 97 | 38.1890 |
| 121.92 | 48 | 18.8976 | 248.92 | 98 | 38.5827 |
| 124.46 | 49 | 19.2913 | 251.46 | 99 | 38.9764 |
| 127.00 | 50 | 19.6850 | 254.00 | 100 | 39.3701 |

### METRES — FEET

| METRES | | FEET | METRES | | FEET |
|---|---|---|---|---|---|
| 0.3048 | 1 | 3.28084 | 15.5448 | 51 | 167.323 |
| 0.6096 | 2 | 6.562 | 15.8496 | 52 | 170.604 |
| 0.9144 | 3 | 9.843 | 16.1544 | 53 | 173.884 |
| 1.2192 | 4 | 13.123 | 16.4592 | 54 | 177.165 |
| 1.5240 | 5 | 16.404 | 16.7640 | 55 | 180.446 |
| 1.8288 | 6 | 19.685 | 17.0688 | 56 | 183.727 |
| 2.1336 | 7 | 22.966 | 17.3736 | 57 | 187.008 |
| 2.4384 | 8 | 26.247 | 17.6784 | 58 | 190.289 |
| 2.7432 | 9 | 29.528 | 17.9832 | 59 | 193.570 |
| 3.0480 | 10 | 32.808 | 18.2880 | 60 | 196.850 |
| 3.3528 | 11 | 36.089 | 18.5928 | 61 | 200.131 |
| 3.6576 | 12 | 39.370 | 18.8976 | 62 | 203.412 |
| 3.9624 | 13 | 42.651 | 19.2024 | 63 | 206.693 |
| 4.2672 | 14 | 45.932 | 19.5072 | 64 | 209.974 |
| 4.5720 | 15 | 49.213 | 19.8120 | 65 | 213.255 |
| 4.8768 | 16 | 52.493 | 20.1168 | 66 | 216.535 |
| 5.1816 | 17 | 55.774 | 20.4216 | 67 | 219.816 |
| 5.4864 | 18 | 59.055 | 20.7264 | 68 | 223.097 |
| 5.7912 | 19 | 62.336 | 21.0312 | 69 | 226.378 |
| 6.0960 | 20 | 65.617 | 21.3360 | 70 | 229.659 |
| 6.4408 | 21 | 68.898 | 21.6408 | 71 | 232.940 |
| 6.7056 | 22 | 72.178 | 21.9456 | 72 | 236.220 |
| 7.0104 | 23 | 75.459 | 22.2504 | 73 | 239.501 |
| 7.3152 | 24 | 78.740 | 22.5552 | 74 | 242.782 |
| 7.6200 | 25 | 82.021 | 22.8600 | 75 | 246.063 |
| 7.9248 | 26 | 85.302 | 23.1648 | 76 | 249.344 |
| 8.2296 | 27 | 88.583 | 23.4696 | 77 | 252.625 |
| 8.5344 | 28 | 91.863 | 23.7744 | 78 | 255.906 |
| 8.8392 | 29 | 95.144 | 24.0792 | 79 | 259.186 |
| 9.1440 | 30 | 98.425 | 24.3840 | 80 | 262.467 |
| 9.4488 | 31 | 101.706 | 24.6888 | 81 | 265.748 |
| 9.7536 | 32 | 104.987 | 24.9936 | 82 | 269.029 |
| 10.0584 | 33 | 108.268 | 25.2984 | 83 | 272.310 |
| 10.3632 | 34 | 111.549 | 25.6032 | 84 | 275.591 |
| 10.6680 | 35 | 114.829 | 25.9080 | 85 | 278.871 |
| 10.9728 | 36 | 118.110 | 26.2128 | 86 | 282.152 |
| 11.2776 | 37 | 121.391 | 26.5176 | 87 | 285.433 |
| 11.5824 | 38 | 124.672 | 26.8224 | 88 | 288.714 |
| 11.8872 | 39 | 127.953 | 27.1272 | 89 | 291.995 |
| 12.1920 | 40 | 131.234 | 27.4320 | 90 | 295.276 |
| 12.4968 | 41 | 134.514 | 27.7368 | 91 | 298.556 |
| 12.8016 | 42 | 137.795 | 28.0416 | 92 | 301.837 |
| 13.1064 | 43 | 141.076 | 28.3464 | 93 | 305.118 |
| 13.4112 | 44 | 144.357 | 28.6512 | 94 | 308.399 |
| 13.7160 | 45 | 147.638 | 28.9560 | 95 | 311.680 |
| 14.0208 | 46 | 150.919 | 29.2608 | 96 | 314.961 |
| 14.3256 | 47 | 154.199 | 29.5656 | 97 | 318.241 |
| 14.6304 | 48 | 157.480 | 29.8704 | 98 | 321.522 |
| 14.9352 | 49 | 160.761 | 30.1752 | 99 | 324.803 |
| 15.2400 | 50 | 164.042 | 30.4800 | 100 | 328.084 |

### SQ. CENTIMETRES — SQ. INCHES

| cm° | | INCHES° | cm° | | INCHES° |
|---|---|---|---|---|---|
| 6.452 | 1 | 0.155 | 329.032 | 51 | 7.905 |
| 12.903 | 2 | 0.310 | 335.483 | 52 | 8.060 |
| 19.355 | 3 | 0.465 | 341.935 | 53 | 8.215 |
| 25.806 | 4 | 0.620 | 348.386 | 54 | 8.370 |
| 32.258 | 5 | 0.775 | 354.838 | 55 | 8.525 |
| 38.710 | 6 | 0.930 | 361.290 | 56 | 8.680 |
| 45.161 | 7 | 1.085 | 367.741 | 57 | 8.835 |
| 51.613 | 8 | 1.240 | 374.193 | 58 | 8.990 |
| 58.064 | 9 | 1.395 | 380.644 | 59 | 9.145 |
| 64.516 | 10 | 1.550 | 387.096 | 60 | 9.300 |
| 70.968 | 11 | 1.705 | 393.548 | 61 | 9.455 |
| 77.419 | 12 | 1.860 | 399.999 | 62 | 9.610 |
| 83.871 | 13 | 2.015 | 406.451 | 63 | 9.765 |
| 90.322 | 14 | 2.170 | 412.902 | 64 | 9.920 |
| 96.774 | 15 | 2.325 | 419.354 | 65 | 10.075 |
| 103.226 | 16 | 2.480 | 425.806 | 66 | 10.230 |
| 109.677 | 17 | 2.635 | 432.257 | 67 | 10.385 |
| 116.129 | 18 | 2.790 | 438.709 | 68 | 10.540 |
| 122.580 | 19 | 2.945 | 445.160 | 69 | 10.695 |
| 129.032 | 20 | 3.100 | 451.612 | 70 | 10.850 |
| 135.484 | 21 | 3.255 | 458.064 | 71 | 11.005 |
| 141.935 | 22 | 3.410 | 464.515 | 72 | 11.160 |
| 148.387 | 23 | 3.565 | 470.967 | 73 | 11.315 |
| 154.838 | 24 | 3.720 | 477.418 | 74 | 11.470 |
| 161.290 | 25 | 3.875 | 483.878 | 75 | 11.625 |
| 167.742 | 26 | 4.030 | 490.322 | 76 | 11.780 |
| 174.193 | 27 | 4.185 | 496.773 | 77 | 11.935 |
| 180.645 | 28 | 4.340 | 503.225 | 78 | 12.090 |
| 187.096 | 29 | 4.495 | 509.676 | 79 | 12.245 |
| 193.548 | 30 | 4.650 | 516.128 | 80 | 12.400 |
| 200.000 | 31 | 4.805 | 522.579 | 81 | 12.555 |
| 206.451 | 32 | 4.960 | 529.031 | 82 | 12.710 |
| 212.903 | 33 | 5.115 | 535.483 | 83 | 12.865 |
| 219.354 | 34 | 5.270 | 541.934 | 84 | 13.020 |
| 225.806 | 35 | 5.425 | 548.386 | 85 | 13.175 |
| 232.258 | 36 | 5.580 | 554.838 | 86 | 13.330 |
| 238.709 | 37 | 5.735 | 561.289 | 87 | 13.485 |
| 245.161 | 38 | 5.890 | 567.741 | 88 | 13.640 |
| 251.612 | 39 | 6.045 | 574.192 | 89 | 13.795 |
| 258.064 | 40 | 6.200 | 580.644 | 90 | 13.950 |
| 264.516 | 41 | 6.355 | 587.096 | 91 | 14.105 |
| 270.967 | 42 | 6.510 | 593.547 | 92 | 14.260 |
| 277.419 | 43 | 6.665 | 599.999 | 93 | 14.415 |
| 283.870 | 44 | 6.820 | 606.450 | 94 | 14.570 |
| 290.322 | 45 | 6.975 | 612.902 | 95 | 14.725 |
| 296.774 | 46 | 7.130 | 619.354 | 96 | 14.880 |
| 303.225 | 47 | 7.285 | 625.805 | 97 | 15.035 |
| 309.677 | 48 | 7.440 | 632.257 | 98 | 15.190 |
| 316.128 | 49 | 7.595 | 638.708 | 99 | 15.345 |
| 322.580 | 50 | 7.750 | 645.160 | 100 | 15.500 |

| TO CONVERT | INTO | MULTIPLY BY |
|---|---|---|
| Acres | Hectares (10,000 sq.m) | 0.4047 |
| Acres | Square feet | 43560 |
| Acres | Square metres | 4047 |
| Acres | Square miles | 0.001562 |
| Ampere turns | Gilberts | 1.257 |
| Atmospheres | Inches of water at 4°C | 406.8 |
| Atmospheres | Inches of mercury at 0°C | 29.92 |
| Atmospheres | Kilograms/sq.m. | 10330 |
| Atmospheres | Newtons/sq.m. | 101,320 |
| Atmospheres | Pounds/sq.inch | 14.7 |
| BTU | Joules | 1054.8 |
| Centigrade | Fahrenheit | (C×1.8)+32° |
| Centimetres | Feet | 0.03281 |
| Centimetres | Inches | 0.3937 |
| Centimetres | Metres | 0.01 |
| Circular mils. | Sq. centimetres | 5.067÷1000000 |
| Circular mils. | Sq. inches | 0.785÷1000000 |
| Cubic centimetres | Cubic feet | 35.31÷1000000 |
| Cubic centimetres | Cubic inches | 0.06102 |
| Cubic centimetres | Cubic metres | 1÷1000000 |
| Cubic feet | Cubic centimetres | 28320 |
| Cubic feet | Cubic inches | 1728 |
| Cubic feet | Cubic metres | 0.02832 |
| Cubic feet | Litres | 28.32 |
| Cubic feet/minute | Cubic metres/hour | 1.698 |
| Cubic feet/minute | Litres/second | 0.4717 |
| Cubic inches | Cubic centimetres | 16.387 |
| Cubic inches | Cubic feet | 0.5787÷1000 |
| Cubic inches | Cubic metres | 0.0164÷1000 |
| Cubic metres | Cubic centimetres | 1000000 |
| Cubic metres | Cubic feet | 35.31 |
| Cubic metres | Cubic inches | 61020 |
| Cubic metres | Cubic yards | 1.308 |
| Cubic yards | Cubic metres | 0.7646 |
| Degrees (angle) | Radians | 0.01745 |
| Dynes | Pounds (force) | 2.248÷1000000 |
| Dynes | Poundals (force) | 72.33÷1000000 |
| Dynes | Newtons | 10÷1000000 |
| Dynes/sq.cm. | Newtons/square metre | 0.1 |
| Dynes/sq.cm. | Pounds/square foot (force) | 0.00209 |
| Ergs | Foot-pounds (force) | 0.0737÷1000000 |
| Ergs | Joules | 0.10÷1000000 |
| Ergs/second | Foot-pounds/second | 0.0737÷1000000 |
| Ergs/second | Watts | 0.10÷1000000 |
| Ergs/second-sq.cm. | Foot-pounds/second-sq.ft. | 68.47÷1000000 |
| Ergs/second-sq.cm. | Watta/square metre | 1÷1000 |
| Fahrenheit | Centigrade | (F—32)×0.555 |
| Fathoms | Feet | 6 |
| Feet | Centimetres | 30.48 |
| Feet | Metres | 0.3048 |
| Feet/minute | Metres/second | 0.00508 |
| Feet of water at 4°C | Inches of mercury at 0°C | 0.8826 |
| Feet of water at 4°C | Kilograms/sq.m. | 304.8 |
| Feet of water at 4°C | Newtons/sq.m. | 2989 |
| Feet of water at 4°C | Pounds/sq.ft. | 62.43 |
| Feet of water at 4°C | Pounds/sq.inch | 0.4335 |
| Foot pounds | Kilogram-metres | 0.1383 |
| Gallons (Imperial) | Cubic metres | 0.003785 |
| Gallons (Imperial) | Gallons (US) | 1.201 |
| Gallons (Imperial) | Litres | 4.545 |
| Gauss | Lines/sq.inch | 6.452 |
| Gauss | Webers/sq.metre | 0.0001 |
| Gilberts | Ampere turns | 0.7958 |
| Grams | Dynes | 980.7 |
| Grams | Ounces (weight) | 0.03527 |
| Grams | Pounds (weight) | 0.002205 |
| Grams/sq.cm. | Pounds/square foot | 2.0481 |
| H.P. | Foot-pounds/minute | 33000 |
| H.P. | Kilowatts | 0.746 |
| H.P. | Kilograms-calories/minute | 10.69 |
| Inches | Centimetres | 2.54 |
| Inches | Metres | 0.0254 |
| Inches of water at 4°C | Kilograms/square metre | 25.4 |
| Inches of water at 4°C | Pounds/square foot | 5.202 |
| Joules | Foot-pounds | 0.7376 |
| Joules | Ergs | 10×1000000 |
| Kilogram-calories | Kilogram-metres | 426.9 |
| Kilograms | Grams | 1000 |
| Kilograms | Pounds (weight) | 2.2046 |
| Kilograms | Slugs | 0.06852 |
| Kilograms/sq.m. | Grams/sq.cm. | 0.1 |
| Kilograms/sq.m. | Pounds/sq.inch (weight) | 0.001422 |
| Kilograms/sq.m. | Pounds/sq.foot (weight) | 0.2048 |
| Kilogram/cubic metre | Pounds/cubic inch (weight) | 0.036÷1000 |
| Kilogram/cubic metre | Pounds/cubic foot (weight) | 0.06243 |
| Kilowatthours | Joules | 3.6÷1000000 |
| Kilowatthours | Kilogram-metres | 367100 |
| Litres | Cubic centimetres | 1000 |
| Litres | Cubic feet | 0.03532 |
| Litres | Cubic inches | 61.03 |
| Litres | Cubic metres | 0.001 |
| Litres | Gallons (Imperial) | 0.2199 |
| Litres | Pints | 1.759 |
| Metres | Centimetres | 100 |
| Metres | Inches | 39.37 |
| Metres | Feet | 3.281 |
| Metres | Yards | 1.0936 |
| Micro-bars (dynes/sq.cm.) | Newton/sq. metre | 0.1 |
| Micro-bars | Pounds/sq.foot | 0.00209 |
| Micro-bars | Pounds/sq.inch | 0.0145÷1000 |
| Miles (nautical) | Feet | 6080 |
| Miles (statute) | Feet | 5280 |
| Miles | Kilometres | 1.6093 |
| Miles/hour | Feet/minute | 88 |
| Miles/hour | Kilometres/hour | 1.6093 |
| Miles/hour | Metres/second | 0.44704 |
| Millimetres | Inches | 0.03937 |
| Mm water gauge 4°C | Inches water gauge 4°C | 0.03937 |
| Mm water gauge 4°C | Newtons/square metre | 9.807 |
| Mm water gauge 4°C | Pascals | 9.807 |
| Newtons | Dynes | 100000 |
| Newtons | Kilograms | 0.1020 |
| Newtons | Pounds | 0.2248 |
| Newtons/sq.m. | Dynes/sq.cm. | 10 |
| Newtons/sq.m. | Pounds/sq.foot (force) | 0.020884 |
| Newtons/sq.m. | Pounds/sq.inch | 0.000145 |
| Pounds (weight) | Grams | 453.6 |
| Pounds | Kilograms | 0.4536 |
| Pounds (force) | Newtons | 4.448 |
| Pounds | Slugs | 0.03108 |
| Pounds of water | Cubic feet | 0.01602 |
| Pounds of water | Gallons | 0.0997 |
| Pounds/cubic feet. (weight) | Kilogram/cubic metre | 16.02 |
| Pounds/cubic inch | Pounds/cubic foot | 1728 |
| Pounds/sq.ft. | Grams/square cm. | 0.4882 |
| Pounds/sq.ft. | Kilograms/sq.metre | 4.882 |
| Pounds/sq.ft. (force) | Newtons/square metre | 47.85 |
| Pounds/sq.ft. | Pounds/sq.inch (force) | 0.006944 |
| Pounds/sq.inch (weight) | Kilograms/square metre | 703.1 |
| Pound/sq.inch (force) | Newtons/square metre | 6894 |
| Pounds/sq.inch (force) | Pounds/sq.ft. (force) | 144 |
| Poundals (force) | Dynes | 13830 |
| Poundals | Pounds (force) | 0.031 |
| Poundals | Newtons | 0.1382 |
| Rayls | Mks rayls | 10 |
| Slugs | Kilograms | 14.594 |
| Slugs | Pounds (weight) | 32.174 |
| Slugs/sq.ft. | Kilogram/sq.m. | 157.2 |
| Square centimetres | Square inches | 0.1550 |
| Square feet | Square inches | 144 |
| Square feet | Square metres | 0.0929 |
| Square feet | Square yards | 9 |
| Square metres | Square feet | 10.764 |
| Square metres | Square inches | 1550 |
| Square metres | Square yards | 1.196 |
| Square miles | Acres | 640 |
| Square miles | Square kilometres | 2.590 |
| Tons (2240) | Tonnes (1000 Kg.) | 1.016 |
| Water gauge (inches) | Newtons/sq.m. | 249 |
| Water gauge (mm.) | Newtons/sq.m. | 9.807 |
| Watts | Ergs/second | 10×1000000 |
| Watts | Foot-pounds/minute | 44.26 |
| Watts | Horsepower | 0.001341 |
| Watts | Kilogram-calories/minute | 0.01433 |
| Watts/sq.m. | Watts/sq.cm. | 0.1÷1000 |
| Webers/sq.m. | Gauss | 10×1000 |

## FULL LOAD CURRENT OF THREE PHASE SETS

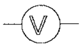
| | | STANDARD THREE PHASE VOLTAGES @ 0.8p.f. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | AMPS | | | | | | | |
| VOLTAGE | 550/ | 440/ 254 | 415/ 240 | 400/ 230 | 380/ 220 | 346/ 200 | 220/ 127 | 208/ 120 | 190/ 110 |
| kVA @ 0.8 P.F. 1 | 1.0 | 1.3 | 1.3 | 1.4 | 1.5 | 1.6 | 2.6 | 2.8 | 3.0 |
| 2 | 2.1 | 2.6 | 2.7 | 2.8 | 3.0 | 3.3 | 5.2 | 5.6 | 6.0 |
| 3 | 3.1 | 3.9 | 4.1 | 4.3 | 4.5 | 5.0 | 7.8 | 8.4 | 9.1 |
| 4 | 4.2 | 5.3 | 5.5 | 5.7 | 6.0 | 6.7 | 10.5 | 11.0 | 12.1 |
| 5 | 5.2 | 6.6 | 6.9 | 7.2 | 7.6 | 8.3 | 14.0 | 14.0 | 15.1 |
| 6 | 6.3 | 7.9 | 8.3 | 8.6 | 9.1 | 10.0 | 15.8 | 16.7 | 18.2 |
| 7 | 7.3 | 9.2 | 9.7 | 10.1 | 10.6 | 11.7 | 18.4 | 19.5 | 21.2 |
| 8 | 8.4 | 10.5 | 11.1 | 11.6 | 12.1 | 13.3 | 21 | 22.3 | 24.3 |
| 9 | 9.4 | 11.8 | 12.5 | 13 | 13.6 | 15.2 | 23.6 | 25 | 27.4 |
| 10 | 10.5 | 13 | 13.9 | 14 | 15 | 16.7 | 26 | 28 | 30 |
| 15 | 16 | 20 | 20.8 | 21 | 22.7 | 25.0 | 39 | 42 | 45 |
| 20 | 21 | 26 | 27.8 | 29 | 30 | 33.4 | 52 | 55 | 60 |
| 25 | 26 | 33 | 34.7 | 36 | 38 | 41.7 | 66 | 69 | 76 |
| 30 | 32 | 39 | 41.7 | 43 | 45 | 50.0 | 78 | 83 | 91 |
| 35 | 37 | 46 | 49 | 50 | 53 | 58.5 | 92 | 98 | 106 |
| 40 | 42 | 53 | 55 | 57 | 60 | 66.8 | 105 | 111 | 122 |
| 45 | 47 | 59 | 62 | 65 | 68 | 75.2 | 118 | 124 | 137 |
| 50 | 52 | 66 | 69 | 72 | 76 | 83.5 | 131 | 138 | 152 |
| 55 | 58 | 72 | 76 | 79 | 83 | 91.8 | 144 | 152 | 167 |
| 60 | 63 | 79 | 83 | 86 | 91 | 100 | 157 | 166 | 183 |
| 65 | 68 | 85 | 90 | 93 | 98 | 108 | 170 | 180 | 198 |
| 70 | 73 | 92 | 97 | 101 | 106 | 116 | 184 | 194 | 213 |
| 75 | 79 | 98 | 104 | 108 | 114 | 125 | 197 | 208 | 228 |
| 80 | 84 | 105 | 111 | 115 | 121 | 133.6 | 210 | 222 | 243 |
| 85 | 89 | 112 | 118 | 123 | 129 | 141 | 223 | 236 | 258 |
| 90 | 95 | 118 | 125 | 130 | 136 | 150 | 236 | 250 | 274 |
| 95 | 100 | 125 | 132 | 137 | 144 | 158 | 250 | 264 | 289 |
| 100 | 105 | 131 | 139 | 144 | 152 | 167.0 | 262 | 278 | 304 |
| 105 | 110 | 138 | 146 | 152 | 159 | 175 | 276 | 292 | 319 |
| 110 | 116 | 144 | 153 | 159 | 167 | 184 | 288 | 305 | 334 |
| 115 | 121 | 151 | 159 | 166 | 175 | 192 | 302 | 319 | 350 |
| 120 | 126 | 158 | 166 | 173 | 182 | 200 | 315 | 333 | 364 |
| 125 | 131 | 164 | 174 | 181 | 190 | 208 | 328 | 347 | 380 |
| 130 | 136 | 171 | 180 | 188 | 197 | 217 | 341 | 361 | 395 |
| 135 | 142 | 177 | 187 | 195 | 205 | 225 | 355 | 375 | 410 |
| 140 | 147 | 184 | 194 | 202 | 212 | 233 | 367 | 389 | 425 |
| 145 | 152 | 190 | 201 | 209 | 220 | 242 | 380 | 403 | 441 |
| 150 | 157 | 197 | 208 | 217 | 228 | 250 | 394 | 416 | 456 |
| 155 | 163 | 203 | 215 | 224 | 235 | 258 | 407 | 430 | 471 |
| 160 | 168 | 210 | 222 | 231 | 243 | 266 | 420 | 444 | 487 |
| 165 | 173 | 217 | 229 | 238 | 250 | 275 | 433 | 458 | 502 |
| 170 | 179 | 223 | 236 | 246 | 258 | 283 | 446 | 472 | 516 |
| 175 | 184 | 230 | 243 | 253 | 266 | 291 | 459 | 486 | 531 |
| 180 | 189 | 236 | 250 | 260 | 273 | 300 | 472 | 500 | 547 |
| 185 | 195 | 243 | 257 | 267 | 281 | 308 | 486 | 514 | 562 |
| 190 | 200 | 250 | 264 | 274 | 289 | 316 | 500 | 528 | 578 |
| 195 | 205 | 256 | 271 | 281 | 296 | 324 | 512 | 542 | 593 |
| 200 | 210 | 263 | 278 | 289 | 304 | 334 | 525 | 555 | 608 |
| 205 | 215 | 269 | 285 | 296 | 310 | 342 | 538 | 569 | 623 |
| 210 | 221 | 275 | 292 | 303 | 319 | 350 | 551 | 583 | 638 |
| 215 | 226 | 282 | 299 | 311 | 327 | 359 | 565 | 597 | 654 |
| 220 | 231 | 289 | 306 | 318 | 335 | 367 | 577 | 611 | 668 |
| 225 | 236 | 296 | 313 | 325 | 342 | 375 | 590 | 625 | 684 |
| 230 | 242 | 302 | 319 | 332 | 350 | 384 | 604 | 638 | 700 |
| 235 | 247 | 308 | 326 | 339 | 359 | 392 | 616 | 652 | 715 |
| 240 | 252 | 315 | 333 | 347 | 365 | 400 | 630 | 666 | 730 |
| 245 | 259 | 322 | 340 | 354 | 372 | 409 | 643 | 680 | 745 |
| 250 | 263 | 328 | 347 | 361 | 379 | 493 | 656 | 694 | 760 |
| 300 | 315 | 394 | 417 | 434 | 456 | 501 | 787 | 833 | 912 |
| 400 | 420 | 525 | 556 | 578 | 608 | 668 | 1050 | 1110 | 1215 |
| 500 | 525 | 656 | 695 | 722 | 760 | 835 | 1312 | 1389 | 1520 |
| 600 | 630 | 787 | 834 | 866 | 912 | 1002 | 1575 | 1665 | 1823 |
| 700 | 735 | 919 | 974 | 1010 | 1064 | 1169 | 1837 | 1943 | 2127 |
| 750 | 787 | 984 | 1043 | 1083 | 1140 | 1252 | 1968 | 2082 | 2279 |

## FULL LOAD CURRENT OF SINGLE PHASE SETS

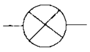
| VOLTAGE | | 240 | 220 | 200 | 120 | 110 | 100 |
|---|---|---|---|---|---|---|---|
| | | STANDARD SINGLE PHASE VOLTAGE AMPS | | | | | |
| kVA @ 0.8 P.F. | 5 | 21 | 23 | 25 | 42 | 45 | 50 |
| | 10 | 42 | 45 | 50 | 84 | 91 | 100 |
| | 15 | 63 | 68 | 75 | 125 | 136 | 150 |
| | 20 | 83 | 91 | 100 | 166 | 182 | 200 |
| | 25 | 104 | 114 | 125 | 208 | 227 | 250 |
| | 30 | 125 | 136 | 150 | 250 | 272 | 300 |
| | 35 | 146 | 159 | 175 | 292 | 318 | 350 |
| | 40 | 167 | 182 | 200 | 334 | 364 | 400 |
| | 45 | 188 | 205 | 225 | 375 | 409 | 450 |
| | 50 | 208 | 227 | 250 | 417 | 454 | 500 |
| | 55 | 229 | 250 | 275 | 458 | 500 | 550 |
| | 60 | 250 | 273 | 300 | 500 | 546 | 600 |
| | 65 | 271 | 295 | 325 | 542 | 591 | 650 |
| | 70 | 292 | 318 | 350 | 584 | 636 | 700 |
| | 75 | 313 | 341 | 375 | 625 | 682 | 750 |
| | 80 | 333 | 364 | 400 | 666 | 727 | 800 |
| | 85 | 354 | 386 | 425 | 709 | 772 | 850 |
| | 90 | 375 | 409 | 450 | 750 | 818 | 900 |
| | 95 | 396 | 432 | 475 | 792 | 864 | 950 |
| | 100 | 417 | 455 | 500 | 834 | 909 | 1000 |
| | 105 | 438 | 477 | 525 | 875 | 954 | 1050 |
| | 110 | 458 | 500 | 550 | 916 | 1000 | 1100 |
| | 115 | 479 | 523 | 575 | 958 | 1046 | 1150 |
| | 120 | 500 | 546 | 600 | 1000 | 1091 | 1200 |
| | 130 | 542 | 591 | 650 | 1083 | 1182 | 1300 |
| | 135 | 563 | 614 | 675 | 1125 | 1227 | 1350 |
| | 140 | 583 | 636 | 700 | 1166 | 1272 | 1400 |
| | 145 | 604 | 659 | 725 | 1209 | 1318 | 1450 |
| | 150 | 625 | 682 | 750 | 1250 | 1364 | 1500 |
| | 155 | 646 | 704 | 775 | 1292 | 1409 | 1550 |
| | 160 | 667 | 727 | 800 | 1334 | 1454 | 1600 |
| | 165 | 688 | 750 | 825 | 1375 | 1500 | 1650 |
| | 170 | 708 | 773 | 850 | 1417 | 1545 | 1700 |
| | 175 | 729 | 795 | 875 | 1458 | 1590 | 1750 |
| | 180 | 750 | 818 | 900 | 1500 | 1636 | 1800 |
| | 185 | 771 | 841 | 925 | 1542 | 1682 | 1850 |
| | 190 | 791 | 864 | 950 | 1583 | 1728 | 1900 |
| | 195 | 812 | 886 | 975 | 1625 | 1772 | 1950 |
| | 200 | 833 | 909 | 1000 | 1666 | 1818 | 2000 |
| | 205 | 854 | 931 | 1025 | 1708 | 1863 | 2050 |
| | 210 | 875 | 954 | 1050 | 1750 | 1909 | 2100 |
| | 215 | 896 | 977 | 1075 | 1791 | 1954 | 2150 |
| | 220 | 917 | 1000 | 1100 | 1833 | 2000 | 2200 |
| | 225 | 937 | 1023 | 1125 | 1875 | 2046 | 2250 |
| | 230 | 958 | 1045 | 1150 | 1917 | 2091 | 2300 |
| | 235 | 979 | 1068 | 1175 | 1958 | 2136 | 2350 |
| | 240 | 1000 | 1091 | 1200 | 2000 | 2181 | 2400 |
| | 245 | 1021 | 1114 | 1225 | 2042 | 2227 | 2450 |
| | 250 | 1042 | 1136 | 1250 | 2082 | 2272 | 2500 |

| WEIGHTS OF LIQUIDS | | | |
|---|---|---|---|
| **Liquid** | **lb/Imp Gallon** | **Kg per Litre** | **Specific Gravity** |
| Water | 10.00 | 1.00 | 1.000 |
| Lube Oil | 9.00 | 0.90 | 0.916 |
| Diesel Fuel | 8.50 | 0.85 | 0.855 |
| Kerosene | 8.00 | 0.80 | 0.8000 |

| Foundations – BEARING LOAD CAPABILITY | | | |
|---|---|---|---|
| **Material** | **Kg/Sq cm** | **PSI** | **KPA** |
| Rock, Hardpan | 4.92 | 70 | 482 |
| Hard clay, Gravel and Course Sand | 3.93 | 56 | 386 |
| Loose Medium Sand and Medium Clay | 1.96 | 28 | 193 |
| Loose Fine Sand | 0.98 | 14 | 96.4 |
| Soft Clay | 0 to 0.98 | 0 to 14 | 0 to 96.4 |




VOLTMETER
A- AMMETER
HZ - FREQUENCY METER
SYN - SYNCHROSCOPE
KW - KILOWATT METER
PF - POWER FACTOR METER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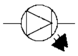
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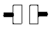
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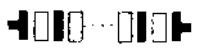
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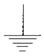
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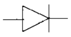
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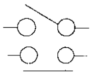
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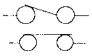
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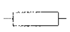
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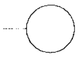
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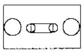
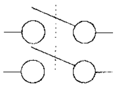
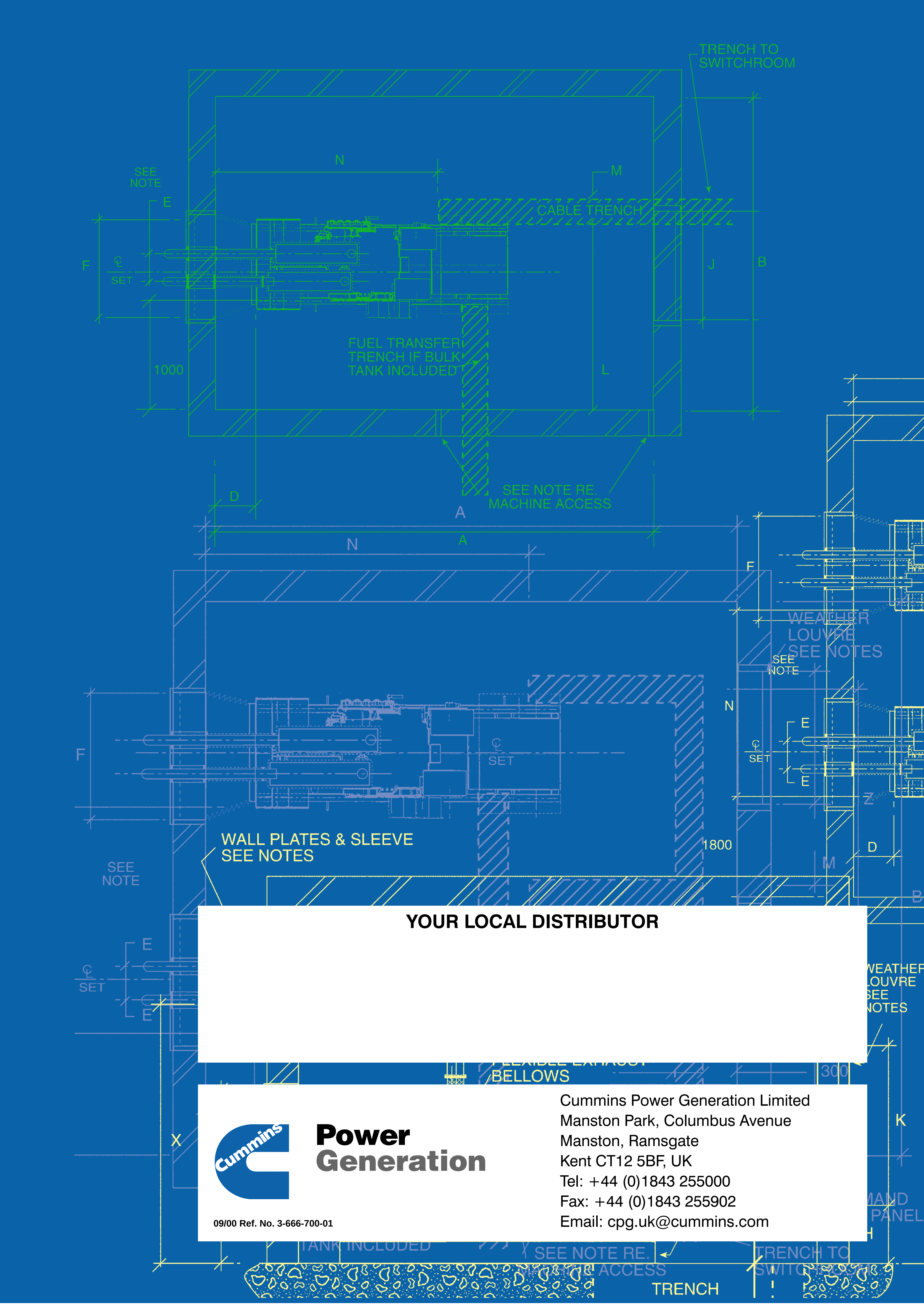

LINK OR FUSE

MOTOR


ISOLATOR

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**Power Generation**

Cummins Power Generation Limited
Manston Park, Columbus Avenue
Manston, Ramsgate
Kent CT12 5BF, UK
Tel: +44 (0)1843 255000
Fax: +44 (0)1843 255902
Email: cpg.uk@cummins.com

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