

## Your Reliable Guide for Power Solutions

To fulfill our commitment to be the leading supplier in the power generation industry, the Buckeye Power Sales team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our **Information Sheets** are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

### Guide to 600V Generator Set Applications in North America

#### 1.0 Introduction

This information sheet discusses the two main applications for generator sets that use of 600 volts in North America. Each application is vastly different and there should be no confusion in supply, to avoid potentially catastrophic results.

***This information sheets discusses the differences in the two applications and which generator to select. The principal applications for 600 volt are Canadian grid input and US & Canadian Oil & Gas equipment.***

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Typical US & Canadian Electric Distribution Systems (Note the 600 V connections)

| Description                                    | L -N VAC | L-L VAC | Countries  |
|------------------------------------------------|----------|---------|------------|
| 1-phase, 2-wire 120V with neutral              | 120      | -       | US         |
| 1-phase, 2-wire 208V with (No neutral)         | -        | 208     | US         |
| 1-phase, 2-wire 240V with (No neutral)         | -        | 240     | US         |
| 1-phase, 3-wire 208V with (No neutral)         | 120      | 240     | US         |
| 3-phase, 3-wire 480V with (No neutral)         | -        | 480     | US         |
| 3-phase, 3-wire 600V with (No neutral)         | -        | 600     | US; Canada |
| 3-phase, 4-wire 208Y/120 V                     | 120      | 208     | US         |
| 3-phase, 4-wire 480Y/277 V                     | 277      | 480     | US         |
| 3-phase, 4-wire 600Y/347 V                     | 347      | 600     | US; Canada |
| 3-phase, 4-wire Delta 120/206/240 V Wild Phase | 120; 208 | 240     | US         |
| 3-phase, 4-wire Delta 120/206/240 V Wild Phase | 240; 415 | 480     | US         |

Typical 600V Oil Field Application Generator Set



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## 2.0 Canadian 600V Application:

Frequently in Canada the three-phase voltage distribution feed into a commercial building is 600 volt. Higher transmission voltages result in a lower current and reduced losses over long distances. Canadian utility companies chose 600 V as a common feed into commercial buildings and stepped down to the lower voltage through transformers.

**Standby Generator Set** - In Canada the principal generator 600V application is for stationary standby or emergency sets to provide electrical power in the case of utility failure, or when the utility supply falls outside predetermined voltage and/or frequency limits.

**Prime Power Generator Set** - There are also some applications where prime power is necessary such as remote locations away from the utility and load sharing to reduce high utility tariffs during peak demand periods. Some mobile or rental generator sets (without a voltage selector switch and normally above 100kW output), employ dedicated 600 volt three-phase alternators. Many customers prefer to connect the emergency power source before any building transformers but after (on the load side) the utility metering equipment.

**600 V Windings** - Most alternator manufacturers have brushless generators wound to give a dedicated 600 V output. However, unlike the traditional brushless alternator there is not the same winding arrangement enabling lower connected voltages of 110 to 240V and 380 to 415V.

**Commercial Building Input Volts** - Most modern buildings in Canada are equipped to receive a 600 volt input from the utility provider. Equipment such as air conditioning units (over 5 tons), larger exhaust fans, electric heaters and some lighting will utilize 600 volt. The buildings will have transformers installed to reduce the 600 volt feed to standard outlets and lighting at 208 volt. The transformers are installed close to the main service entrance, to reduce the 600 volt incoming feed to 480 and 208 volts three-phase as well as single-phase voltages.

## 3.0 North American Oil Field Rig Power 600V Application:

Electric powered drilling rigs mostly have diesel generator sets for their power supply. There are three types of electric rigs. There are three categories of electric powered rigs:

1. DC rigs - DC power supplied directly to the DC electric motor drives (driving drawworks, rotary tables, mud pumps and other systems). These DC rigs were commonplace back in the 1960's. Many of the older DC rigs are being converted to AC.
2. SCR electric rigs introduced in the 1970's used Silicon Controlled Rectifiers (SCR) to convert generator AC power to DC power. The AC generators are dedicated 600 volt, three-phase 60 Hz machines. The SCRs rectify the voltage to 800V DC which is ideal for the motors. Transformers convert 600V to 480V to power other auxiliary equipment on the site.
3. Variable Frequency Drive (VFD) rigs are the newest kind of rig utilizing variable rpm 600V AC motors that have the advantage of more power out of the same sized equipment and greater control.  
VFD rigs. The same engine/generator used for SCR rigs will suit VFD system perfectly. VFD applications generate at 600 to 690V. A portion is transformed for 480 volt loads like hotel and non-variable speed loads. The majority of the power is rectified to 800V DC and is made available to a VFD control system for variable speed 750 and 1500 hp AC motors. VFD's use front end diode technology, smoothing the conversion from AC to DC, removes much of the stress that older SCR systems placed on the generator and creates load characteristics similar to a large UPS load. Harmonics however remain a concern so the same type of alternator as for SCR rigs is needed.

## 4.0 Drilling Rig Load Effects on Generators:

Generators powering rigs have to be sized and specified to manage the following load conditions:

**Power Factor (PF)** - Operating DC motors at varying speeds causes the Power Factor (PF) to fluctuate. Drawworks transition from 0.2 PF to 1.0 PF every hoisting cycle and Mud Pumps at low strokes result in a low PF. Therefore the AC generator is oversized to 0.6 or 0.7 PF with a higher kVA rating to provide more generator ampere capacity. In addition to over sizing the alternator, it must be wound to provide additional mechanical bracing of the generator windings to resist the forces caused by the current surges from operation of the SCR controllers. The design limit for the generator winding rise is also lowered to compensate for the additional heating caused by the SCR load. It is not uncommon for the generator to be rated for 60 to 70°C winding temperature rise at 40°C ambient per NEMA MG - 1, compared to maximum 150°C rise accepted in most standby generator sets applications.

**Voltage Drop** - When a load is applied to or removed from a generator set, the engine speed, voltage and frequency are changed temporarily from its steady state condition – called transient response. The degree of voltage dip (generally called overshoot) depends on the active (kW) and reactive (kVAR) changes. The voltage regulator setting and the total capacity and dynamic characteristics of the generator set, as well as the electrical inertia of other loads in the system. The larger the acceptable voltage dip, the smaller the generator set can be. Typical permissible voltage dip for oil field applications is 25 to 30%, whereas a sensitive application like a hospital might be only 2%.

**Duty Cycle** - The real duty cycle for such generators is often 8,000 hours a year. Unless precautions as described above are taken in over sizing the generators, the life, durability and reliability, will be greatly affected with constant field problems.

Never confuse or incorrectly supply generators for these two vastly different 600 volt applications.



**Columbus, OH**  
6850 Commerce Court Drive  
P.O. Box 489  
Blacklick OH 43004-0489  
(614) 861-6000  
(800) 523-3587  
(614) 861-2291 fax

**Cincinnati, OH**  
7782 Service Center Drive  
West Chester, OH 45069  
(513) 755-2323  
(800) 368-7422  
(513) 755-4515 fax

**Cleveland, OH**  
8465 Tower Drive  
P.O. Box 394  
Twinsburg, OH 44087-0394  
(330) 425-9165  
(800) 966-2825  
(330) 487-0229 fax

**Indianapolis, IN**  
1229 Indy Place  
Indianapolis, IN 46214  
(317) 271-9661  
(800) 632-0339  
(317) 271-0242 fax

