



# Kato Engineering

Generators • Motor-Generator Sets • Controls



Leroy Somer North America

# Prime, standby, conditioning More Power to You!

*Founded in 1926, Kato Engineering has a long tradition of design and manufacturing excellence and innovation:*

- *Kato was an early user of vacuum-pressure impregnation for coil protection.*
- *Kato was a pioneer in the use of split bearings on rotor shafts.*
- *Kato was an early user of permanent magnet and brushless excitation.*

**K**ato Engineering (Kato) offers a complete line of precision-engineered, high quality ac generators, motor-generator sets and controls for prime, standby, and peak shaving power generation.

Kato generators supply power to tap the world's resources; oil, gas, coal, copper, iron ore and lumber are all extracted from the earth with the help of Kato generators. Kato furnishes the power to keep the world moving. Ships, freighters, locomotives, aircraft and mass transit systems all use Kato equipment. Any place where dependable, controllable electrical power is needed: hospitals, computer centers and telecommunication stations all rely on Kato generators to supply clean power.

The ruggedly-constructed Kato generators survive the harshest environments, and the Kato name has become synonymous with dependable power generation worldwide.



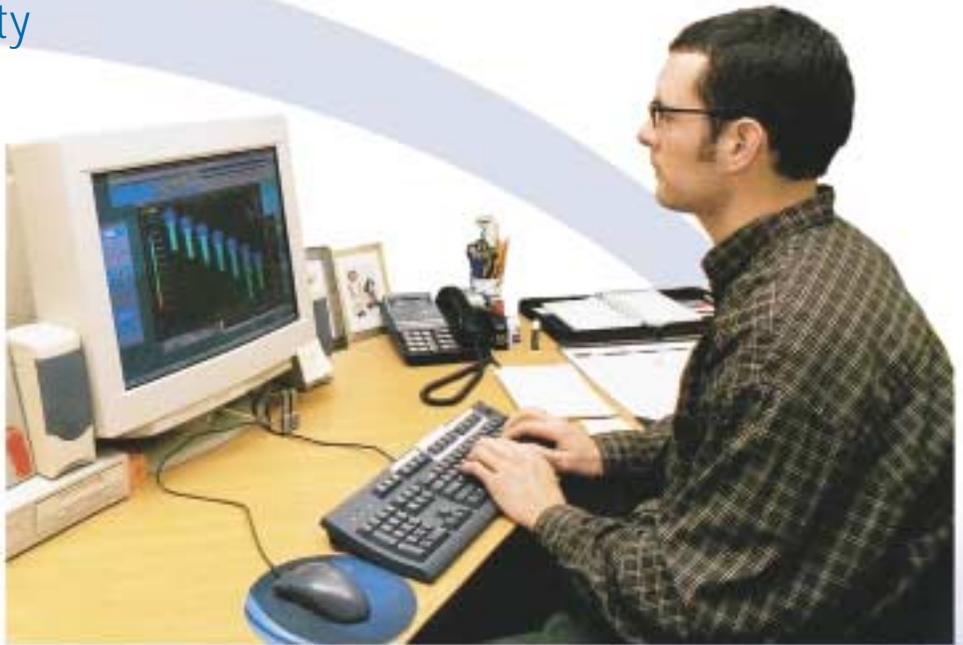
In 1995 Kato Engineering achieved certification to ISO 9001, a quality program that is recognized world wide.



## Superior design and manufacturing capability

Kato Engineering has a superior staff of professionals to support research & development, design, manufacturing and service activities. And, as a subsidiary of Emerson, Kato has a broad network of human resources, technical knowledge and manufacturing capacity available to augment our North Mankato, MN manufacturing facility. All of these assets allow us to use the latest technology to provide a reliable product with a competitive price.

From manufacturing existing designs to developing new, cutting-edge technology, from providing technical information before the sale to design, construction, startup and service, we are ready to meet the world's critical power needs.



Finite element analysis is an integral part of Kato Engineering's development and design programs.



# Rotors & Stators

*Precision-designed and skillfully manufactured stators and rotors are paramount to generator performance and life.*

## Rotors

**Rotor poles** are punched or fabricated from high-strength steel. The pole shape is designed to withstand mechanical stresses caused by rotational forces and prime mover pulsations. The pole contour is optimized to generate low harmonics in the voltage waveform.

**Field coils** are machine wound on the poles with high temperature insulated copper wires. The coil end and interpolar region are blocked to prevent coil movement and distortion. Depending upon the application, damper bars are inserted into the pole face and brazed or welded at each end to complete the damper/amortisseur winding. The purpose of the damper windings is to reduce the generator harmonics and absorb torque pulsations caused by the prime mover or an unbalanced load distribution. The damper windings also reduce system oscillations caused during parallel operation. The complete rotor is either vacuum-pressure impregnated before the shaft is pressed or wet wound.

**The shaft** is precision machined from rolled or forged steel. The bearing surfaces meet stringent tolerance requirements for runout and concentricity. The rotor is dynamically balanced to meet specifications.

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For long and smooth operation, rotors are precisely made with the highest quality components.

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From the laminations to the frames to the windings, stators are precisely designed and constructed for peak performance and a long operating life.

# Stators

**Frames:** Sophisticated design software and over 75 years of experience ensure that the generator frame is made with strength and support where needed instead of just adding useless size and weight. Stator frames are welded with heavy rings and bar steel. The frame is reinforced with welding plates between bars or with a heavy wrapper. Heavy gauge steel is formed and fastened to the frame to provide an ample airflow path. The endrings are precisely machined to support the bearing brackets.

**Cores:** Stator cores are built from high-grade electrical steel laminations. Each lamination is core plated on both sides to minimize core loss and heating. Slots in the cores are skewed to minimize harmonic voltages.

**Random-wound windings:** Random windings are used for selected applications under 1000 volts and for high-frequency generators. The windings are made with the highest quality round copper wire, which has a heavy film coating rated at 200° C.

**Form-wound windings:** Insulating tapes are precisely layered using state of the art equipment to ensure maximum insulation properties and optimum fit in the coil slot, eliminating discharges that would shorten the generator's operating life. In the stator, coil end windings are braced and supported with surge ropes to withstand short-circuit fault conditions.

**Vacuum-pressure impregnation:** Entire stator assemblies are immersed into liquid thermosetting epoxy resin insulation and vacuum-pressure impregnated. The vacuum exhausts air, moisture and other vapors from the windings and permits complete penetration of the epoxy resins, filling voids and creating a rigid mass with optimum dielectric strength.



# Bearings & Adaptation

*Because bearings and adaptation are based upon various factors, including load carrying capacity, speed and type of prime mover, Kato Engineering offers several options.*

## Ball bearing

The most popular and universally used bearing. Being permanently lubricated or equipped with grease fittings, it is suitable for low, medium or high speeds and single or two-bearing generators. The ball bearing is lowest in cost.

## Spherical roller bearing

Capable of heavy thrust and radial loads, it has the additional feature of being self aligning. It is suitable for both single and two-bearing machines.

## Cylindrical roller bearing

Excellent for heavy radial loads and radial shock, such as railway generators. The cylindrical bearing is also suitable for low and medium speeds. It is used on two-bearing machines only.

## Split roller bearing

Used on large generators of low and medium speed up to 1800 RPM. It is self aligning and can be replaced without moving the generators endbracket or shaft, a feature desirable when the generator is driven by an engine on each end. Because it is self aligning, this bearing is suitable for single or two-bearing machines.

## Sleeve bearing

Has a long life and the ability to run at higher speeds and loads. It is also capable of high radial shock. Because it is split, it can be easily removed without disturbing the shaft and endbracket. It is self aligning and can be used on single and two-bearing generators. It may be self lubricated or pressure lubricated depending upon the application.

## Oil cooling

With pressure-lubricated systems, an external oil cooling system can be provided to lower oil temperature.

## Prime mover connections

Single-bearing units may have either SAE flexible disk type couplings or forged flanged shafts for direct connection to engine flywheels. Generators with two bearings have shaft extensions that are suitable for direct coupling to prime movers. Close-coupled SAE housing adapters are also available with both single and two-bearing designs.

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Sleeve bearings can be easily disassembled.



# Excitation & Regulation

## Voltage regulation

Kato Engineering offers several voltage regulators for various applications. Our standard K65-12B (used for 65 Vdc field requirements) & K125-10B (used for 125 Vdc field requirements) models are encapsulated for weather protection. Their solid state analog design is UL recognized. They have the following specifications:

### Sensing

100 to 120 V +/-10% with standard 10K ohm control, 1 phase or 3 phase, 50/60 or 400 Hz; 1 VA maximum burden per terminal

### Paralleling

1 A or 5 A for 6% droop maximum; 10 VA maximum burden; isolated for use in either reactive droop or cross-current method

### Regulation accuracy

+/- 0.5% maximum over full range of generator loading and +/- 5% frequency variation

### Under frequency

#### protection breakpoints

Adjustable 45 to 65 Hz (50/60 Hz regulators only)

### Regulator response

Less than 4 milliseconds

## Field excitation

Fast voltage response time to generator load changes with short time constant is provided with the Kato brushless excitation systems. This allows the voltage regulator to react to changes in field excitation requirements. Three-phase high-frequency revolving armature excitation current is full wave rectified through six silicon type rectifiers mounted in heat sinks and positioned in the air stream for maximum heat dissipation. Diode PIV rating is at least twice the peak operating voltage normally required.

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Kato's solid state, encapsulated voltage regulator

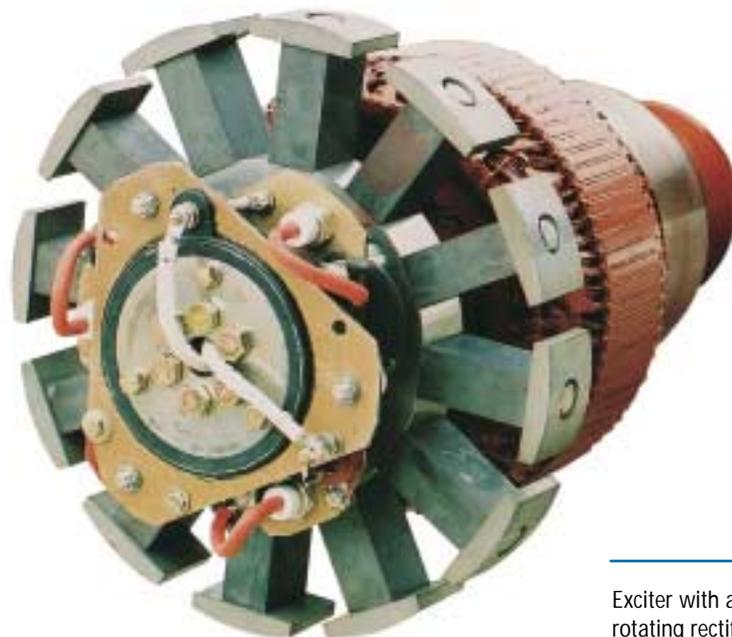


## PMG

A separate permanent magnet rotating exciter can be supplied in addition to the brushless exciter as an option.

- Reduces the effects of both conducted and radiated electromagnetic interference (EMI). With an EMI filter, the PMG and a Kato voltage regulator will meet the emissions requirements of Mil-Std-461C, Part 9, Class C2
- Enhances manual voltage control regulation as the PMG provides a more stable power source to the manual control

- Provides full exciter power, regardless of alternator voltage, for motor starting and is a separate voltage source for use external to the generator set, such as a tachometer and relay options
- Provides an economical and simple means of reliable, responsive and stable input power to the voltage regulator
- Supplies continuous power to the exciter through the voltage regulator to maintain up to 300% short-circuit current from the alternator during a fault condition



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Exciter with a PMG and rotating rectifier

# Features & Options

## Standard features

Kato's standard generators have the following features:

- Open drip-proof and guarded enclosure that conforms to IP21, IP22 or IP23
- Kato three-phase voltage regulator with single turn voltage adjust
- Brushless exciter
- Drawings, including dimensional and electrical connection
- Operation and maintenance manuals with replacement parts list, available as a hardcopy or in various electronic formats



Generator with a standard IP22 enclosure

## Optional features

The Kato Design and Manufacturing teams also have the capability to provide many other options to meet exact customer requirements:

- Stator temperature detectors (two per phase): embedded RTDs and thermocouples; surface-mounted thermistors
- Bearing RTDs
- Space heaters
- Lightning arrestors and surge capacitors



- Redundant diodes
- Rotor and stator monitoring



- Special enclosures and protection; IP55 outlet box, air filters
- Proximity probes
- Sound attenuation
- Permanent magnet exciter (PMG)

## Certifications & standards

Kato Engineering equipment is manufactured in accordance with NEMA MG-1 and IEEE Std 115. In addition, we can comply with many other certifications and standards:

### Certifications

ABS  
BASEEFA (ATEX)  
DNV  
Bureau Veritas  
Lloyds  
CSA  
NKK  
USCG 259  
VDE  
UL

### Standards

NEMA MG-1  
IEEE 115  
ANSI C50.12  
BS 4999  
CSA C22.2NO.100  
Australian AS 1359  
IEC 34  
API-546  
ISO 9001  
Mil-Std-705

# Testing

Before manufacturing, Kato Engineering tests its designs using sophisticated analysis software. During manufacturing we monitor critical processes and test or inspect components before they move to the next step. Kato's final test facility includes two seismic test bases and precise control and data acquisition systems.

## Standard tests

Generators are subjected to the following standard commercial tests in accordance with IEEE Std 115, NEMA MG-1, or Mil-Std 705 standards (Testing to IEC 60034, marine classification societies or other applicable specifications is available upon request):

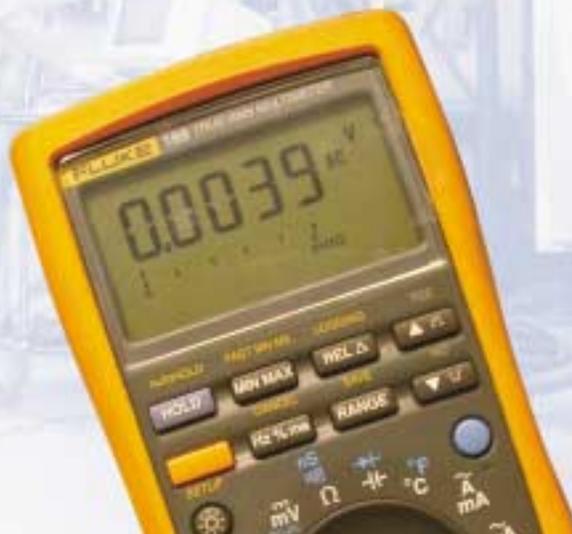
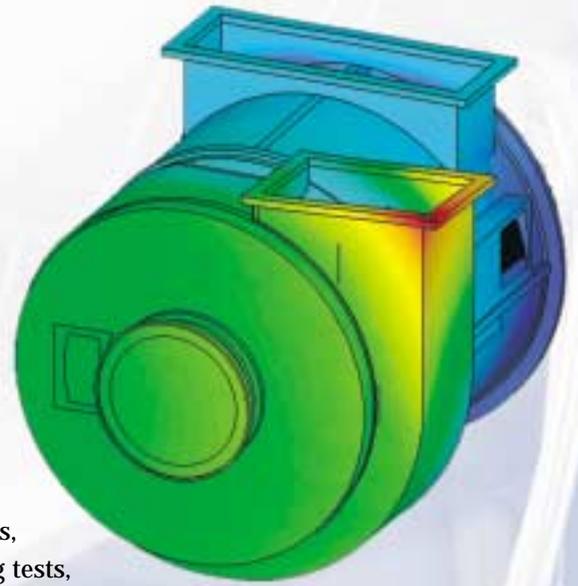
- Resistance on all windings (cold)
- Insulation resistance on all windings
- High potential on all windings
- Open-circuit saturation curve
- Voltage and current balance on windings
- Phase sequence
- Mechanical balance (vibration)
- Circulating current (when applicable)
- Three-phase build-up short-circuit (conducted if the generator has a PMG or SBO)
- Voltage transient at rated kVA (voltage regulation, stability, and response)
- Regulator range (voltage adjust) test (if a regulator is provided)
- Tests on optional components (e.g., RTDs, space heaters)

## Special tests

In addition to the standard tests, Kato can perform the following tests, which are usually done on the first unit of a new design or on special designs:

- Open-circuit saturation with slip rings
- Synchronous impedance curve (short-circuit saturation)
- Zero power factor saturation curve
- Summation of losses (efficiency tests)
- Reactances and time constants
- Overspeed
- Voltage waveform (harmonic analysis)
- Voltage modulation tests
- Temperature rise test
- Polarization index (stator)
- Water-immersion and spray tests

Witness testing and test reports are also available.



# Platform AC Generators

*Kato Engineering's platform ac generator line includes custom-designed generators and modular generators for particular applications.*

Simple but with advanced designs, Kato platform generators offer high reliability and easy access for maintenance. Used for a variety of applications and engine or turbine driven, they have the following specifications:

**Power Rating:** 500 - 3000 kW (low voltage), 500 kW - 15 MW (medium voltage), 750 kW - 15 MW (high voltage)

**Voltage:** up to 600 V (low voltage), 601 - 6000 V (medium voltage), 6001 - 15,000 V (high voltage)

**Power factor:** 0.8 standard (other PFs available upon request)

**Frequency:** 60 Hz or 50 Hz, three phase (six-phase optional)

**Speed @ 50/60 Hz:** 1500/1800 RPM, 1000/1200 RPM, 750/900 RPM, 600/720 RPM

**Efficiency:** 88% to 97% based on power rating, operating speed and voltage. All Kato generators have a high grade of electrical steel to yield low core losses and provide high efficiencies. Depending upon kW rating, premium steel may be used, resulting in even higher efficiencies. Efficiency data for specific models will be furnished upon request.

**Temperature rise:** For continuous duty applications, generators are typically 80° C, 105° C or 125° C rise by resistance per NEMA MG-1. Standby ratings are either 105° C, 130° C or 150° C rise per NEMA MG-1. Rise is based on an ambient temperature of 40° C.

**Insulation:** All windings are of Class F or Class H insulation using vacuum-pressure impregnation (VPI) cycle. Various types of epoxies are used depending on the functional requirements of individual components.

**Overload:** Typical allowable overloads are 50% for 5 minutes and 10% for 2 hours during 6 hours of operation. Short-circuit capability is at least 15 seconds at 300%.

**Voltage balance:** With balanced loads, the voltage is held within 1.0% between phases.

**Waveform:** Generators are specifically designed to minimize harmonic distortion. Typical waveform characteristics are as follows:

- Deviation factor is less than 5%
- Crest factor: 1.3 - 1.5
- Harmonic content: any single harmonic is less than 3% and the total harmonic is less than 4%
- Telephone influence factor (TIF): meets or exceeds NEMA MG-1-22.43 standards
- Telephone harmonic factor (THF): meets or exceeds IEC 60034-1, B.9.2 requirements

*Please refer to the previous sections for standard and optional features. Other options are available upon request.*



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Engine-driven low-voltage generator



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High-voltage generator for turbine application

# Packaged Generators

*This new Kato Engineering line is a group of commercial and industrial quality generators that can meet the broadest range of standby or prime power requirements. Competitively priced, they have the shortest build cycle time in the industry.*

## Ratings

125° C/40° C ambient temperature rise, continuous duty, Class H

<u>kW range</u>	<u>Voltage</u>	<u>RPM</u>	<u>Hertz</u>
210 to 2750	480	1800	60
150 to 2200	400	1500	50
1000 to 2750	4160	1800	60
800 to 2200	3300	1500	50
250 to 2100	480	1200	60
200 to 1775	400	1000	50
505 to 2100	4160	1200	60
400 to 1775	3300	1000	50

## Standard features

Random-wound stators: multiple dips and bakes with Class H polyester varnish and epoxy overcoat

Form-wound stators: vacuum-pressure impregnation with Class H polyester

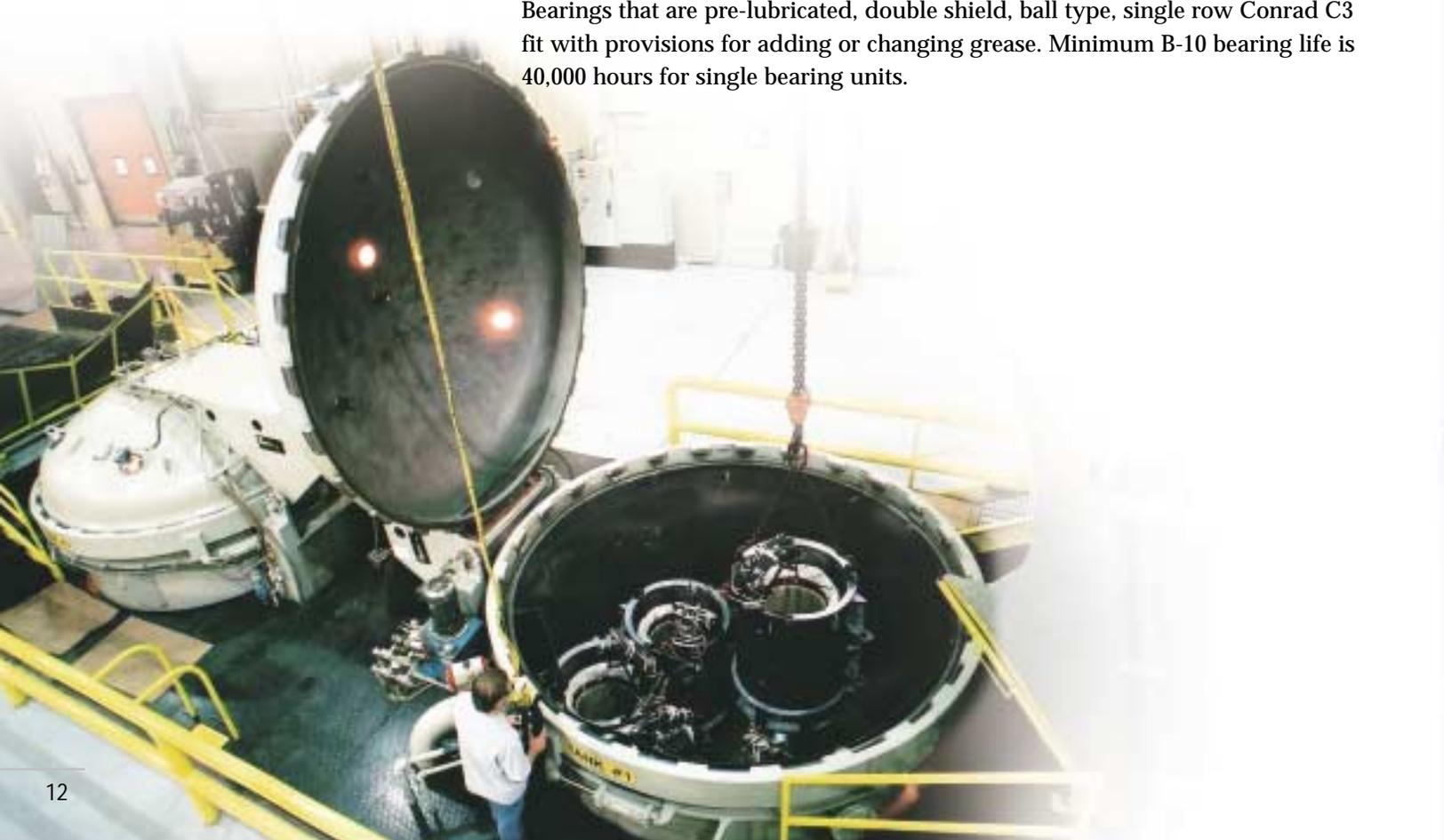
Rotors: Class H epoxy brushed wet on each layer during winding

Enclosure: fully guarded per NEMA MG-1-25.4

Solid-state fully encapsulated voltage regulator and a permanent magnet generator

Cast iron end brackets and a fabricated steel frame

Bearings that are pre-lubricated, double shield, ball type, single row Conrad C3 fit with provisions for adding or changing grease. Minimum B-10 bearing life is 40,000 hours for single bearing units.



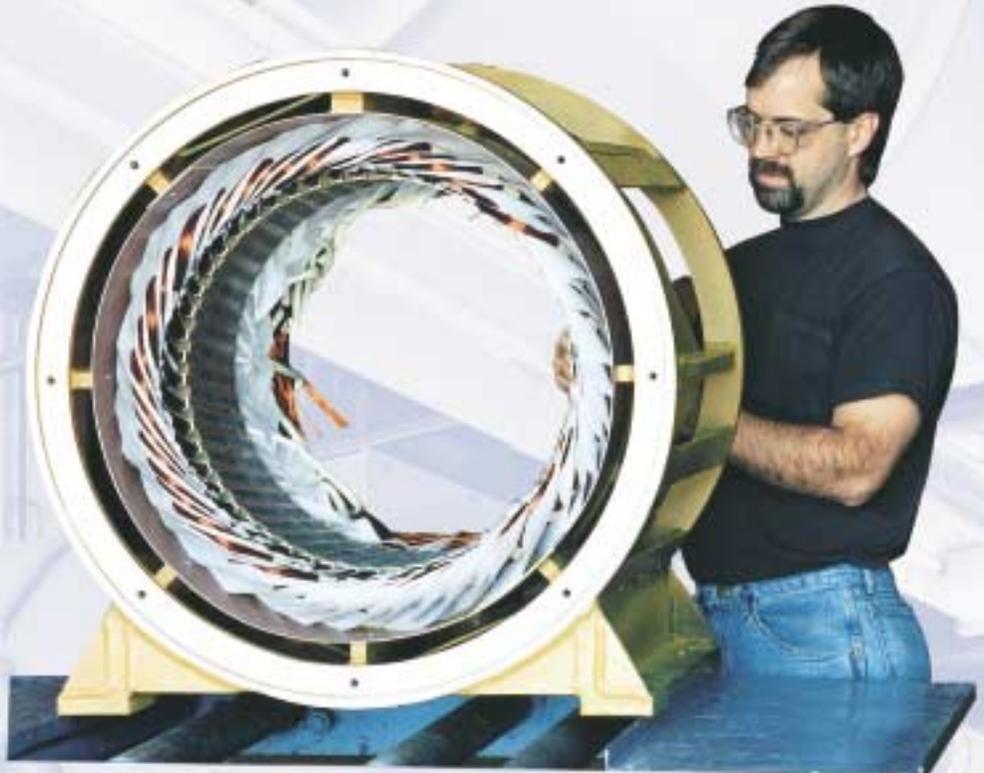
### Conformity

The new line of Kato generators conforms to the applicable parts of IEEE, NEMA, IEC and ISO standards. The generators have CSA listing and are suitable for submission as a component of UL 2200 certification.

Marine generators may be certified to American Bureau of Shipping, Lloyds Register of Shipping, Bureau Veritas, DNV, RINA and others.

### Quality Standards

The new Kato line of generators is manufactured in a plant that is certified to the new quality standards, TS-16949, which includes ISO 9001. This was the first generator manufacturing plant to achieve this certification.



Random-wound stators are standard on Kato's packaged generator line on models below 600 V.

### Options

- Digital voltage regulator with VAR/PF control
- Reactive droop paralleling
- Cross-current compensation paralleling
- EMI filter
- Manual voltage control
- Stator or bearing temperature detectors
- Space heaters
- Class F stator epoxy
- IP22 or IP23 protection



Packaged generator

# Traction Alternators

*Built smaller and lighter, Kato's traction alternators help reduce vehicle payload. But rugged construction and superior insulation ensure they can handle bumpy, grimy conditions as well as the thermal cycling caused by the constant acceleration and deceleration mine haul trucks and locomotives must endure.*

For every application, Kato Engineering's design objectives for traction alternators are to be both mechanically and electrically compatible. The mechanical design ensures structural integrity, minimum vibration, maximum bearing life, a proper fit and accessibility for service. Electrically, the design must ensure the required power is available for the specified load requirements.

## Locomotive applications

For new or rebuilt 1500 to 3000 hp, 700 to 1250 Vdc and up to 4800 Idc locomotives used in switchyard and short road-haul applications.

A typical locomotive package consists of a traction alternator and a dual auxiliary alternator. The dual auxiliary alternator includes two components:

- A 188 kVA, 1.83 V/Hz 2400 or 1800 RPM companion for ac loads, such as electric air compressor, radiator cooling fans and cab accessories
- An 18 kW ac rectified to dc 74-volt battery charger.

Different configurations of these locomotive packages are available depending on the application.



## Off-highway truck applications

For ac drive mine trucks in the 260 to 400-ton range.

Driven by Detroit Diesel 4000 series 16V-4000 or 20V-4000 engines or Cummins QSK60 and QSK78 series engines in the 2700 hp to 3600 hp range, they have the following specifications:

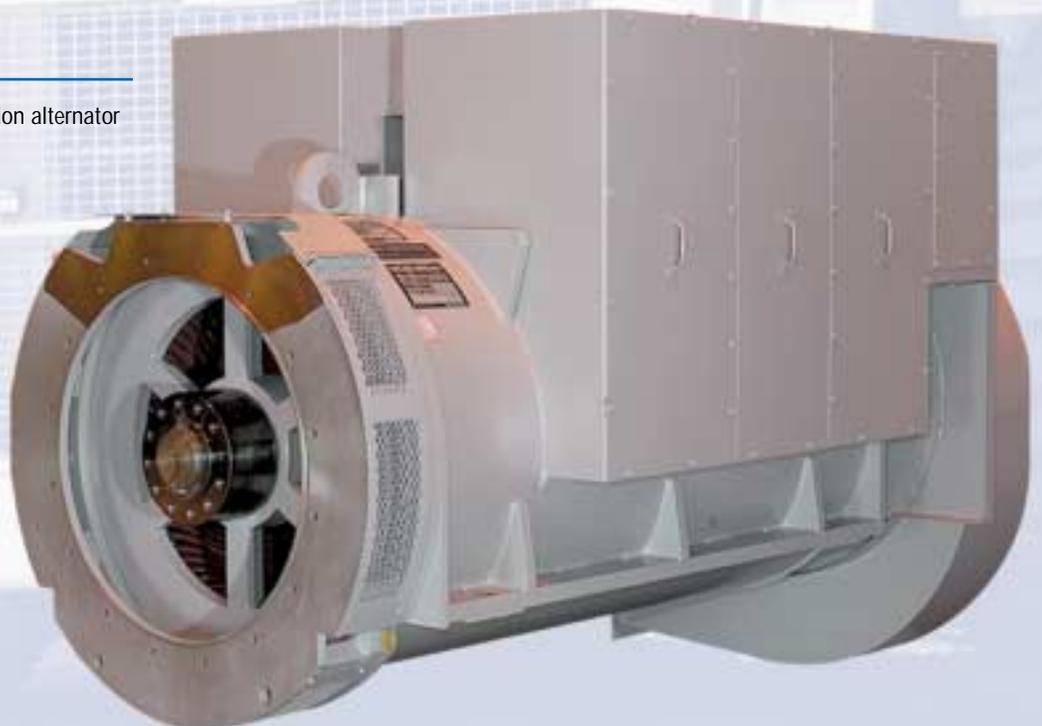
Vac: 1500 to 2000  
kVA: 1800 to 2700  
Frequency: 120 Hz  
RPM: 1800 nominal

Kato Engineering has almost 30 years of experience in supplying traction power for mine-haul trucks. These trucks are used in some of the harshest environments all over the globe.

Off-highway truck traction alternator



Locomotive traction alternator



# Motor-Generator Sets & High-Frequency Generators

*Precision applications around the world, including laboratory testing, aircraft ground support, line conditioning on ships and shore power depend on the superiority of Kato motor-generator sets and high-frequency generators.*

## Motor-generator sets

Motor-generator (MG) sets provide line conditioning and load isolation for computers and other sophisticated electrical systems. They can also perform frequency conversion. Long life, minimum maintenance costs, low harmonics, high overload capacities and many other features make motor-generator sets a clear choice over solid-state systems.

With input of 50 or 60 Hz, output frequencies of 50, 60, or 400 Hz are available as standard. For custom designed systems, fixed frequency outputs from 25 Hz to 1200 Hz may be selected, or we can provide continuously variable frequency using a VFD on the motor. Power capacities range from 10 kVA to 20,000 kVA and up, depending upon system requirements.

Typically, Kato furnishes a factory-programmed PLC control panel to provide a complete power conversion or isolation system. The panel is usually unit-mounted but can also be free-standing or wall-mounted. The panel will include the motor starter, output circuit breaker, metering, protective relaying, a voltage regulator and any other required components. Manual and automatic paralleling are also available.

Motor-generator set with a unit-mounted panel



400-Hz generator for aircraft ground support

# High-frequency generators

Kato Engineering offers a complete line of high frequency (400 Hz) generators. These units provide economical power for grounded aircraft's navigational equipment, ground power and military support products.

Phase: 3

Power factor: 0.8

Voltage range: 115/200, 120/208, 240/416, 277/480

<u>Pole</u>	<u>RPM</u>	<u>kVA</u>
26	1846	up to 312.5
24	2000	up to 156
20	2400	up to 156

(Other designs available upon request)

All units are available in a two-bearing design. Typically, units rated 100 kW and lower with 26 or fewer poles can be supplied in a single-bearing design for direct connection to the SAE engine drive arrangements. Bearings are double shielded regreaseable ball type.

Rotor and stator insulation is Class F or Class H with void-free resin. Efficiency is 82% to 94% depending upon kW rating.



Totally-enclosed motor-generator set



When portability is a requirement, Kato motor-generator sets can be trailer mounted.



Paralleling panel for a three motor-generator set system

# Special Cooling & Protection

*In addition to our standard open dripproof enclosure, used where there is an abundance of clean air, Kato Engineering offers a variety of cooling and protection options for gritty, moist or explosive environments.*

## **Totally enclosed air-to-air cooled (CACA/TEAAC)**

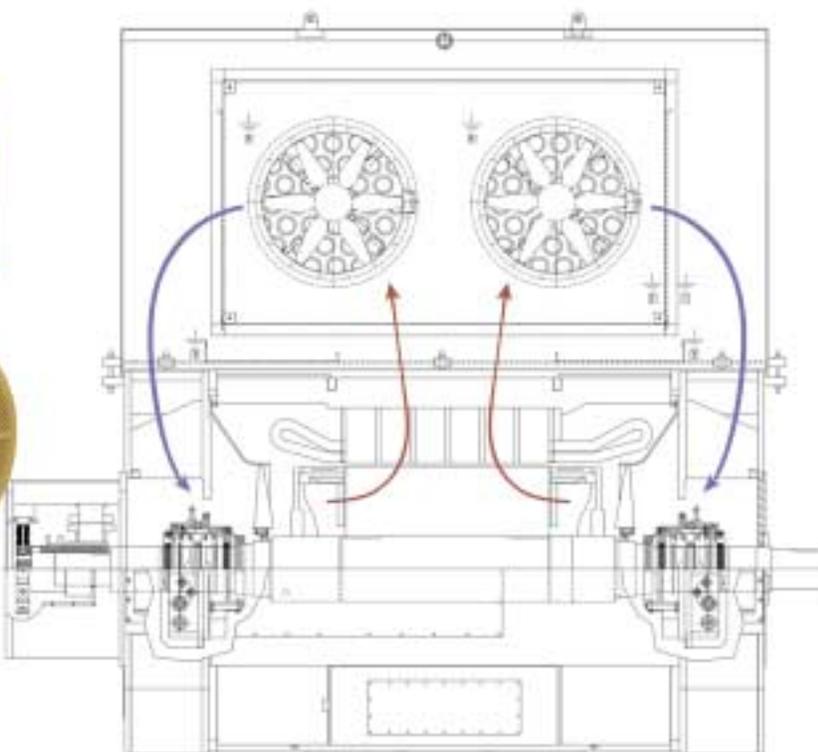
Air-heat exchanger cooled generators are available from 500 kW to 10 MW. CACA generators are typically used in dusty, salt-laden or corrosive environments.

These units are equipped with one or two internal fans to direct the enclosed air up and through an array of stainless steel tubes, which are mounted on top of the generator. Air from a second external fan is directed through an outer sheet metal enclosure to cool the tubes, and air is then exhausted on the opposite side of the generator.

## **Totally enclosed air-to-water cooled (CACW/TEWAC)**

Water-heat exchanger cooled units are available from 500 kW to 12 MW. These units are commonly used aboard ship or on off-shore drilling rigs where there is a confined space, harsh environment or flammable atmosphere and where there is an abundance of ocean water for cooling.

The units are equipped with one or two internal fans. Air is forced up and through a large air-to-water radiator within the generator enclosure. Air is continually re-circulated with the heat created from the generator being displaced by cool water from the radiator coils. The radiator consists of an inner tube of 90-10 copper-nickel for corrosion resistance and an optional outer tube to detect water leakage. A separate system to pump a continuous supply of cooling water throughout the radiator must be supplied.



Totally enclosed air-to-air cooled unit (CACA/TEAAC) with shaft-mounted fan and flow diagram for a similar unit with radiator-mounted fans

### Weather-protected II

For generators that must be under an open sky, Kato Engineering offers weather-protected II enclosures, built to NEMA standards.

To prevent moisture entry, air intakes and exits have three 90° changes in direction. Air flow velocity is also kept below 600 feet per minute. A “blow through” allows wind to pass through the unit.

### Air filters

For dusty, gritty applications, Kato Engineering offers air-filtered generators. Filters on these machines remove over 78% of the particles with diameters over 5 microns.

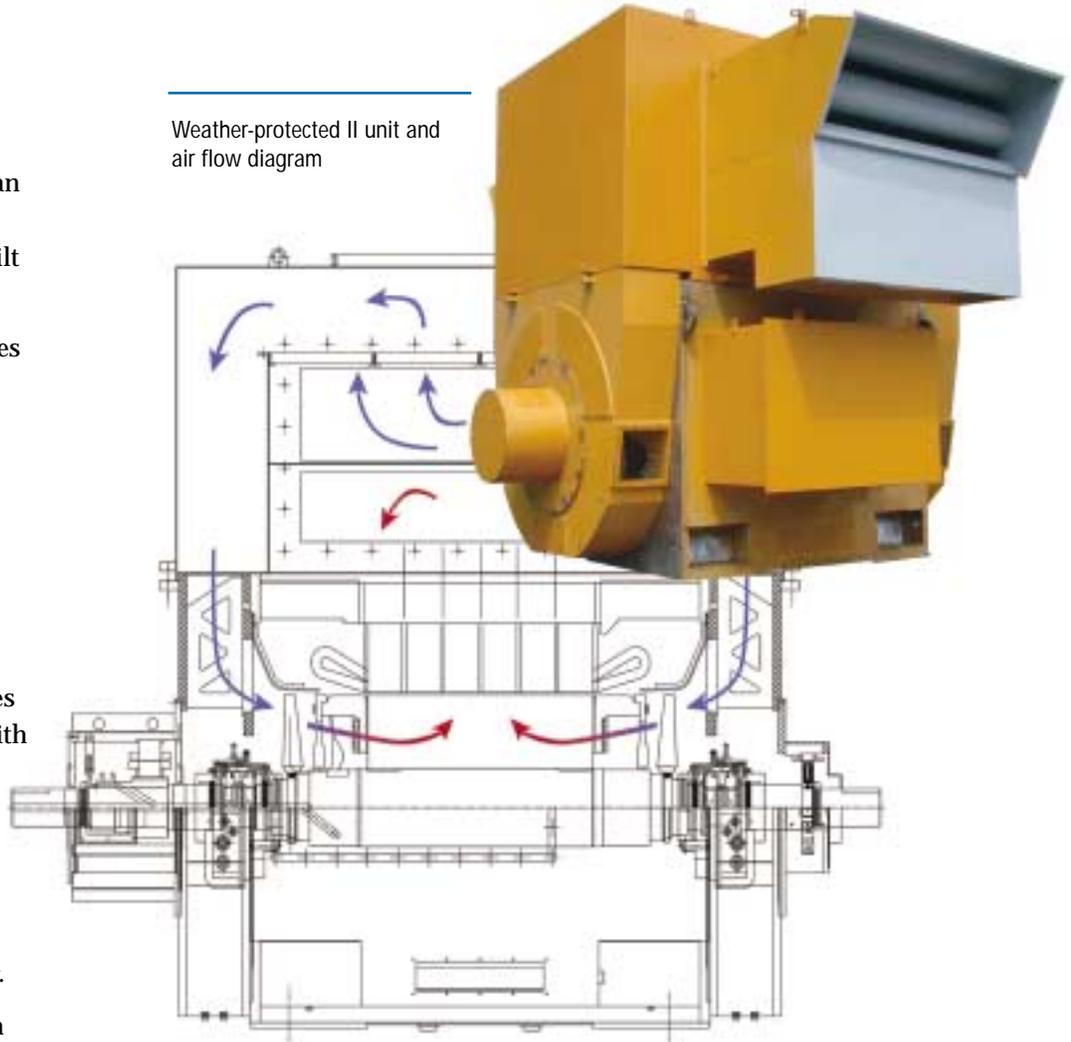
Air filters and mounting frames are made from stainless steel to prevent rusting and corrosion. The filters can be easily removed for cleaning with steam or soapy water.

A differential pressure safety switch is included. If the filter becomes clogged, the switch actuates. The switch can be connected to an alarm, indicator lights or shutdown circuitry.

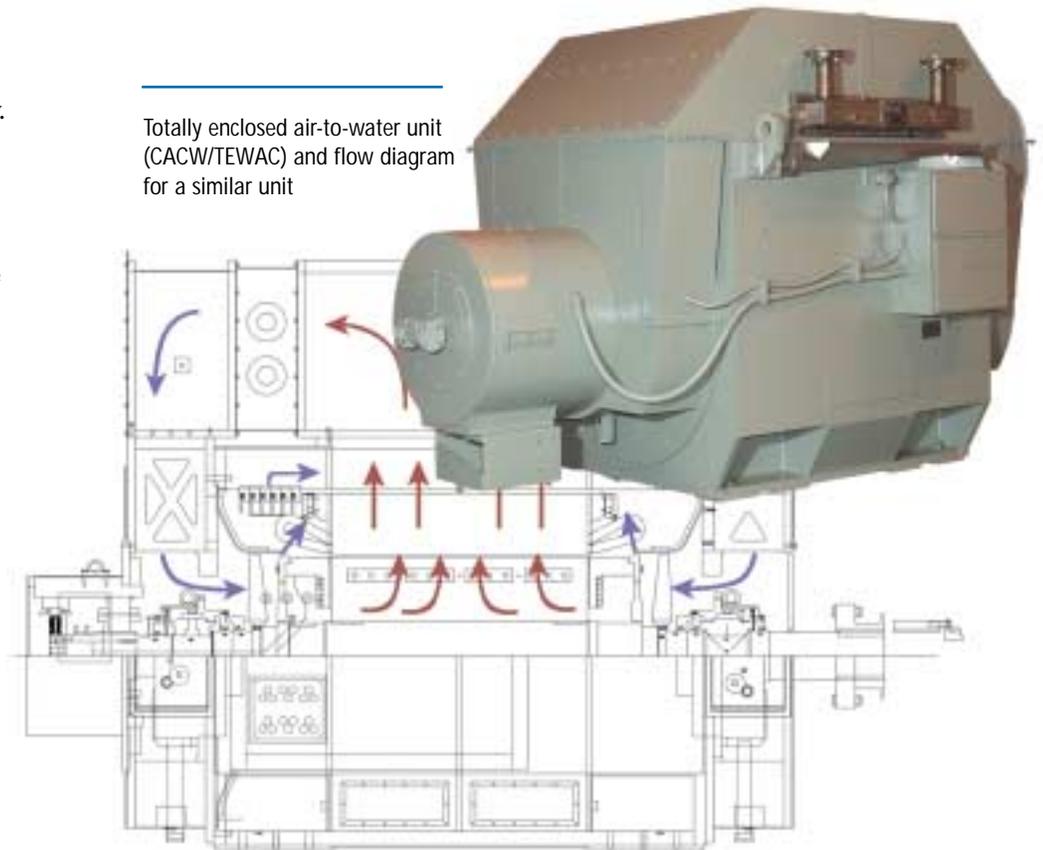
### Sealed windings

Generators with sealed windings can withstand water and salt spray. They are typically used outdoors in marine environments. They withstand water immersion testing per NEMA and API-546.

Weather-protected II unit and air flow diagram



Totally enclosed air-to-water unit (CACW/TEWAC) and flow diagram for a similar unit



# Parts and Service

**W**e at Kato Engineering know how important your power needs are. That is why we have experienced factory field service personnel on call 24 hours a day, every day of the year.

As well as repair and on site rebuilding, we can assist you with installation and startup and perform scheduled maintenance or training. We stock a variety of parts for quick delivery.

We provide technical manuals in electronic and hard-copy formats. These manuals include operation, maintenance and illustrated parts breakdown.

Our knowledgeable and friendly staff is always ready to answer your questions, send a needed component or arrange a site visit anywhere in the world.

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