MCM ENGINEERING, INC.

AUTHORIZED DISTRIBUTOR

Aircraft Ground Power Motor-Generators

Kato Engineering™

EMERSON™
Industrial Automation

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Contents

Advantages of Ground Power Motor-Generators over Solid State Solutions

KATO™ motor-generator (MG) sets offer many advantages over solid-state units:

- **Long Life:** The mean time before failure (MTBF) for a motor-generator is in excess of 100,000 hours (with a 100,000 L10h bearing life). This is four times the average MTBF of a solid state converter.
- **Low Maintenance Cost:** KATO offers a horizontal, single-shaft design, which means that there are no couplings, gears or belts to wear out. KATO exciters are brushless; there are no commutators or brushes to replace.
- **Low Harmonics:** Harmonics can be a contributing factor in nuisance tripping of circuit breakers, transformer failures and incidental damage to electronic components. MGs have a smooth sine wave generated by the mechanical construction of the generator resulting in negligible harmonic distortion.
- **Dual Exciters:** KATO MGs have dual exciters, one for the motor and another for the generator. This allows the equipment to operate at unity or even a leading power factor. The results are lower energy costs through the reduction of power factor demand charges and lower input current.
- **Transient Spike Protection:** MGs provide isolated protection for the aircraft from 60Hz transient power spikes. The physical construction of the motor generator makes it impossible for a transient to go through the equipment. While most aircraft come equipped with internal protective measures, some airlines do not purchase this option. A transient spike can cause significant damage to an aircraft's electrical circuits.
- **High Overload Capability:** MGs are better suited to take short-term overload situations (300% of nominal amps for 3 seconds). Overload conditions, while not common, can occur when aircraft hydraulic motors or ovens operate.
- **Environmental Conditions:** MGs are more robust and are able to operate in more severe conditions than solid state converters. The windings of KATO motor generators are vacuum-pressure impregnated for maximum protection.
- **Proven Technology:** KATO MGs are built with the latest technology and are backed by 85 years of experience in building rotary motor generators.

Features

- **NEMA Type 1 enclosure:** Factory-installed on top of M-G set; wiring between controls and M-G is also factory-installed
- **Series-Parallel motor starter:** Connects the motor windings in series for start and acceleration, then re-connects to parallel for operation. Includes high-repeatability, manually-re-settable electronic overload relays and positive mechanical interlock between series- and parallel- connection contactors.
- **Motor Field Failure and OSP protection:** Monitors motor line current and trips if motor field current is lost or an out-of-step condition (loss of synchronism) is detected. Requires manual reset at the device.
- **Motor-line ammeter:** Digital type display; standard is single phase inside control panel with motor field adjust.
- **Motor field adjust control:** Sets the level of motor field voltage, which determines the operating power-factor of the motor. This is normally a one-time adjustment and is not accessible from outside the enclosure.
- **Running time meter:** Elapsed-time meter records operating time to 100,000 hours. Non-resettable type.
- **Emergency-stop pushbutton:** Trips generator circuit breaker, opens output contactor, and stops motor. Button latches in position until manually reset.
- **Automatic voltage regulator:** Kato K65-12B connected for 3-phase sensing.
- **Voltage adjust rheostat:** Allows the operator to set the generator voltage to any value between + and -10% of rated voltage.
- **Generator output contactor:** Contactor controlled by "open" and "close" interface, connects 400 Hz power to the load.
- **Output circuit breaker with shunt trip:** Circuit breaker is manually operated, also opens via the shunt-trip coil on all monitored failures and when "Emergency Stop" is pressed. Operating handle located at front of control cubicle.

- **300% short-circuit current capability:** In event of a short-circuit in the 400 Hz system, provides 300% current for up to 10 seconds for fault clearing.
- **Generator overload protection:** Electronic-type, high repeatability overload relay. Normally set for manual reset, but it can be changed to auto reset in the field.
- **Generator overvoltage protection:** When voltage exceeds OV sensor setting, trips generator circuit breaker and opens output contactor, plus removes generator excitation. Automatically resets when voltage returns to normal.
- **Generator under voltage protection:** When voltage drops below the UV sensor setting, trips generator circuit breaker and opens output contactor; resets automatically when voltage returns to normal.
- **Under/Over excitation protection:** High Speed, Patent Pending generator over/under excitation protection algorithm employed via MFC2000™ Multi-Function Digital Controller
- **Generator under frequency protection:** When frequency drops below the UF sensor setting, trips generator circuit breaker and opens output contactor; resets automatically when voltage returns to normal.

- **Reverse power protection:** If the reverse power sensor detects power flow from the 400 Hz system to the generator, opens the generator output contactor. (Paralleling units only)
- **Low-voltage control power transformer:** Provides 110 to 120 volt power for all control functions. Includes fuses required for UL-508 listing.
- **Power supply:** Provides 24 volt DC for various devices and for all indicators. (Paralleling Units Only)
- **EMI suppression:** To meet the requirements of the US FCC, Part 18 of CFR Title 47.
- **Summary failure alarm signal:** Form "C" contacts for summary failure alarm.
- **Remote control provisions:** Terminals provided for connection of remote start/stop, contactor on/off, and open-to-trip emergency stop. Also form "C" contacts for summary failure alarm. (Non-paralleling units only)
- **Ethernet/IP communications standard:** All systems shipped with Ethernet Switch and available ports as standard offering.
- **Remote Control Provisions:** Terminals provided for connection of remote start/stop, contactor on/off, and open-to-trip emergency stop. Also form "C" contacts for summary failure alarm. (Non-paralleling units only)
- **Programmable Logic Controller (PLC):** Provides all control logic required to operate the M-G normally as well as in even of a monitored failure. Controls the sequence of events during synchronizing and paralleling operations. Provides the high-demand start and low-demand stop logic.

- **MFC2000™ Multi-Function Digital Controller:**
  - RMS metering of all generator output voltages and currents
  - Measures kW, kVA, kVAR, P.F. for metering and protection
  - RMS metering of bus voltage
  - Provides motor pole alignment control between MG sets during paralleling
  - Provides high speed synchronization control of the generators during paralleling
  - Provides for adjustable, high speed generator/motor protection

- **Touch Screen HMI providing:**
  - Start/Stop control: Provides local control for starting and stopping the M-G set.
  - Generator connect/disconnect control: When operating the "manual" mode, the "Connect" interface initiates the synchronizing operation, which is completed when the generator output contactor closes. In the "manual" mode, the "Disconnect" control opens the contactor. (Paralleling units only)
  - Load demand controls: Includes the parallel request and disconnect request timers and the high load demand start and low load demand stop controls. These determine the 400 Hz load level at which start and stop signals occur and the delay before they are passed on the next M-G in the system. (Paralleling units only)
  - Automatic/manual mode control: Determines whether the start/stop and connect/disconnect interface or the 400 Hz load level controls the M-G sets in the system. (Paralleling units only)
  - Master/Slave sequence control: Determines whether this M-G runs independently of others in the system or is controlled by the 400 Hz system load demand. (Paralleling units only)
  - Indicators: Generator On, Generator on-bus, Generator Online, Paralleling or Active, Motor Pole Synchronizing, Motor On, Motor Starting, Motor Coasting, Fault Indicator, Master & Slave, Contactor Closed,
  - Access to all metering data: All metering data is RMS with better than 0.5% max. error
  - Access to fault data: All faults are logged and time stamped in the HMI for ease of troubleshooting

- Access to metering data of neighboring MG sets connected to the same network/system: Provides centralized indication of M-G set(s) voltage, and as well as total bus load.
- Access to MFC2000™ protection and control settings: (At Technician Security Level)
- Graphical data trending (At Technician Security Level)
- Instant local access to documentation (At Technician Security Level): User's Manual, Electrical Schematics, Mechanical Drawings, Connection Diagrams, Technical Assistance Contact Information.

Options

- **Audible Alarm:** Provides audible indication of monitored failures at the M-G. Includes alarm-silence control.
- **UL Listed:** UL-508 Industrial Control listing.
- **EMI suppression** to Mil 461C, Class C2 UM04, part 9 (or equivalent latest revision) on panel but not tested.
- **Sound Attenuation Enclosures**
- **Trailer Mounted**
- **Weather-proof enclosures** with forklift and crane lift provisions.
- **Coastal insulation protection (CIP) system:** This system includes an asphalt epoxy application and curing process on the exciters. Once cured, asphalt epoxy is very difficult to remove even by sanding and machining making this material appropriate protection material for coastal and for more rigorous environmental applications.

Trailer mount

Weatherproof enclosures

Common Specifications

STANDARD MOTOR-GENERATOR SETS
60/400 Hz for Airfield Ground Power

1.0 GENERAL

1.1 Scope of Work

This specification describes and defines the construction and performance requirements for a motor-generator set (M-G) used to convert 60 Hz to 400 Hz power to supply ground power to aircraft. Converter shall be a complete package including controls and safeties.

1.2 Reference

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only:

ISO 281-1990 :Bearing dynamic load ratings and rating life.

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE).
IEEE 115 1995 Test Procedures for Synchronous Machines.

FEDERAL COMMUNICATION COMMISSION (FCC).
FCC, PART 18, CFR TITLE 47, Radio Frequency Interference Suppression.

MILITARY STANDARDS.
MIL-STD-704 (Rev. E) (Notice 7) Aircraft Electric Power Characteristics.
MIL-STD-705 (Rev. C) Generator Sets, Engine Driven, Methods of Tests and Instructions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA).
NEMA 250 , TYPE 1 Enclosures for electrical equipment.
NEMA MG 1 1998 (Rev. 1) Motors and Generators.

ISO 9001 Quality management systems

This specification covers all standard models of this series. An appendix follows containing tabulated specifications for each model of M-G set covered by this specification. This appendix will be hereinafter referred to as TABLE.

1.3 Quality Assurance

A. The system supplier shall be a company that specializes in 400 Hz system design and that has been in business a minimum of 8 years. Supplier shall submit proof of prior experience in the design and application of 400 Hz systems and specified equipment. Manufacturer of the M-G set shall have a quality program certified to ISO 9001. Motor generators shall be manufactured by Kato Engineering and supplied by MCM Engineering.

B. Factory Testing (to be performed prior to shipping)

1. Motor Generator

a. Advance notice of testing and witness testing shall be by arrangement at time of purchase.

b. The motor generators shall be tested in accordance with Kato standard test procedure (based on MIL-STD-705 and IEEE Std 115) to verify the following parameters:

1) Insulation Resistance and Dielectric Strength
2) Winding Resistance
3) Voltage Transients and Recovery Time
4) Voltage Regulation
5) Short Circuit Current (steady state)
6) Efficiency (at full load and rated power factor)
7) Voltage Adjustment Range
8) Vibration measurement

Other tests may be available by prior arrangement at extra cost.

c. The acceptance criteria for the motor generators shall be the test results of standard tests plus any optional tests as agreed. A functional test shall be performed on the control panel and M-G together to verify proper operation of motor-generator controls and metering devices. Units which include paralleling provisions shall be tested in parallel. Paralleling tests may be simulated if only one unit is available for test.

d. Motor generator shall conform to NEMA MG-1 to the extent applicable.

1.5 Environmental Conditions

A. The MG set shall be capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degrading of operating characteristics:

1. Operating ambient temperature -10°C to 40°C.
2. Non-operating and storage ambient temperature from -20°C to 55°C.
3. Relative humidity 0-95% for temperatures stated in (1), not including condensation from temperature change.
4. Altitudes ranging from 0-1000 m (0-3300 feet).

B. Motor Generator Room Conditions: All equipment shown for indoor installation shall be suitable for continuous operation in a ventilated room where ambient temperature is between $+10^0$ C to $+40^0$ C.

2.0 PRODUCT

1.1 Motor Generator

2.1.1 General Description

A. The motor-generator sets shall consist of a single shaft rotor motor-generator assembly for 60 to 400 Hz conversion, with unit mounted controls and on a steel base. A voltage regulator shall be provided with standard controls, protective devices necessary for paralleling (if applicable) and control. The M-G set shall have open dripproof construction, and the control panel shall be enclosed in accordance with NEMA 250, Type 1. The frame and enclosure shall be vermin proof. The motor-generator set and control panel shall be painted ANSI 61 gray.

1. The three phase, 1200 RPM synchronous motor, with a 60 Hz rated input shall be adjustable to maintain unity power factor at full load and operate on a constant excitation regardless of load and with adequate horsepower to drive the generator at 120 percent of rated load.

2. The three phase, 1200 RPM synchronous generator with 400 Hz output will have a minimum full load capacity as specified in TABLE at 0.8 lagging power factor.

1.1.2 CAPABILITY AND PERFORMANCE REQUIREMENTS

A. Overload Capability: Satisfactory operating time is based on not more than one overload in 24 consecutive hours of operation.

Percent of Full Load	Satisfactory Operating Time
125 percent	5 minutes
110 percent	2 hours

B. Efficiency: The efficiency of the M-G set including control panel shall be according to the value specified in TABLE at 100 percent rated load and rated power factor, measured as ratio of input power to output power.

C. Short Circuit: When a three-phase symmetrical short circuit is applied to the generator, the generator shall be capable of sustaining at least 300 percent of rated current for not less than 10 seconds duration (with output circuit breaker disabled). Output circuit breaker shall be set to trip in less than 10 seconds at 300% rated current.

D. Radio Frequency Interference: The Motor-Generator and controls shall be designed to suppress generated radio noise to the limits required by FCC Part 18, CFR Title 47 for Radio Navigation and Radio Communication.

E. Frequency Characteristics Input/Output: The Motor-Generator shall provide 400 Hz output at 60 Hz input. The limits with input at a constant 60 Hz ± 0.5% shall be:

1. Frequency regulation shall not exceed plus or minus 0.5% steady-state.
2. Deviation change rate shall not exceed values shown in Figure "7" of MIL-STD-704E.
3. Transient limits shall not exceed values shown in Figure "5" of MIL-STD-704E upon sudden application or removal of ½ load at rated power factor.
4. Frequency modulation shall not exceed 0.5 percent.

F. Voltage Characteristics: Initial voltage buildup shall be completely automatic. The output voltage shall be capable of being adjusted over a minimum range of plus or minus 10 percent from the rated voltage.

1. The steady-state limits shall be:

a. Voltage regulation shall not exceed plus or minus 0.5 % from no load to full load.
b. Drift shall not exceed plus or minus 0.5 percent over a 24-hour interval for an ambient temperature range of 10° C to 40° C.
c. Voltage modulation shall not exceed 0.5 percent.

2. Transient Limits:

The voltage deviation and recovery time with step load change shall not exceed the values given in TABLE at rated power factor. Transient voltage and recovery on step load application to 95% of nominal voltage and step load removal to 105% of nominal voltage.

4. Line-to-Neutral Phase-Voltage Unbalance:

a. With a balanced load shall not exceed one percent between individual line voltages.
b. With an unbalanced load of one-third rated current on one phase and no load on the other two phases, shall not exceed 4 percent measured according to MIL-STD-705 Part 620.1/620.2, defined as difference between maximum and minimum voltage divided by nominal voltage.

G. Waveform Characteristics:

1. With a balanced linear load:

a. The total RMS voltage harmonics shall not exceed 3 percent of the fundamental voltage, measured line-to-line and line-to-neutral.

b. The maximum single RMS line-to-neutral harmonic voltage shall not exceed 2 percent of the fundamental voltage.

2. With unbalanced load of one-third rated current on one phase and no load on the other two phases, total RMS harmonic shall not exceed 4 percent line-to-neutral. The deviation factor shall not exceed 0.1 per NEMA MG-1.

2.1.3 MOTOR-GENERATOR SET FABRICATION

A. General Configuration: The motor-generator shall be a single shaft unit with individual exciters for the motor and the generator, an automatic voltage regulator system, necessary devices (where applicable as shown in TABLE) for automatic paralleling and control. All components shall be mounted on a common rigid steel base with the rotor assembly statically and dynamically balanced so as not to exceed a 0.001" double amplitude indicator reading. The noise level shall not exceed 95 decibels at a distance of 3 feet from the front of the set and at approximately one-half the set height

B. Bearing Requirements: The bearings shall have a minimum calculated 100,000 hours of L-10 life as defined by ISO 281, when lubricated according to the schedule and with the type of grease specified in the operating manual. The bearings shall be equipped with grease fittings extended to the outer surface of the MG Set. Greasing of the bearings shall not require a shutdown of the motor-generator set. It shall be possible to replace either bearing without removing the rotor from the stator.

C. Synchronous Machine: The motor-generator shall be a brushless type, self ventilated, of drip-proof construction with windings which are impervious to oil, solvents, moisture, mild acids and alkalis. All terminals are to be identified on the wiring diagrams. For units with paralleling provision (see TABLE), the motor and generator poles shall be prealigned to allow the motor pole alignment detector to automatically align the two motors for parallel operation without mechanically moving either the generator or motor stator.

D. Insulation: The insulation of the motor and generator stators and fields shall be Class F or better, 100% vacuum pressure impregnated. The temperature rise will not be greater than 105° C above a 40° C ambient temperature. Asbestos insulation is prohibited. All materials are to be non-organic to prevent the support of fungus growth.

E. Exciter System: The exciter system shall be a brushless synchronous system utilizing two separate exciters, each with shaft mounted, three-phase, silicon-diode bridge assemblies to supply the motor and generator fields.

G. Dimensions: The size and weight of the motor-generator complete with unit-mounted controls shall be per the TABLE.

2.1.4 CONTROL CABINET

A. Control Cabinet: All controls, indications, protective devices, paralleling system and instruments shall be located within the control cabinet. All wiring must have ample service loops and be protected from abrasion. Wiring and wiring harnesses are to be secured at least every six inches. All terminals are to be identified and shown on the wiring diagrams.

C. Input Motor Controller: The synchronous motor shall be started and stopped by means of a reduced-current motor controller equipped with overload protection. The motor starting current shall be limited to the value given in the TABLE. The field windings and rectifier assembly shall be protected against damage due to surges during starting or pulling out-of-step.

D. Output Disconnect: The 400 Hz output shall be controlled by an electro-mechanical contactor. Circuit breaker disconnect of the 400 Hz power shall be provided. The control circuit shall be protected by fuses in accordance with industry standards.

1.1.5 PROTECTIVE CONTROLS

A. Protective Controls: Relays, instrument transformers and circuitry on the generator's 400 Hz output necessary to provide protective control shall be provided. Protection to meet short circuit and overload requirement shall be provided. Protective circuits require operation of a reset to allow output disconnect closing after a protective device opens the disconnect.

B. Overvoltage: Shall protect by tripping the output circuit breaker for sustained overvoltage of 15 % above the nominal voltage or more, using a relay having an inverse-time characteristic.

C. Undervoltage: If the voltage decreases to below 90 % of the nominal voltage for longer then 1 second, relaying will trip the output circuit breaker.

D. Under-frequency: Shall protect by tripping input/output devices for under-frequency in excess of 5 percent of the rated output frequency (400 Hz).

2.1.6 OPERATOR CONTROLS
All controls shall be heavy-duty industrial-type devices.

A. Manually Operated Controls:
1. Set Control: Provide "start" and "stop" touch points to operate the motor controller.
2. Provide "open" and "close" pushbuttons to operate the contactor which connects the generator to the 400 Hz load.
3. Emergency Stop: Include an emergency stop/power-off pushbutton which is readily accessible and guarded to prevent accidental operation. Operation of this pushbutton shall immediately open the circuit between the generator and the 400 Hz load terminals, plus disconnect the motor from the 60 Hz power source. Include provisions to extend this function to a customer-supplied open-to-trip contact.
4. Include a touch point which must be actuated to restore normal operation after a monitored failure has occurred. Pressing this button shall not cause an attempt to restore normal operation until the failure has been corrected.
5. 400 Hz circuit breaker: The operating handle for the generator circuit breaker shall be accessible from outside the enclosure.
6. Voltage adjust: A readily accessible control which provides for setting the regulated generator voltage over the range of + and – 10 % of rated shall be provided.
7. If an input circuit breaker is specified, the operating handle for the breaker shall be accessible from outside the enclosure.
8. If audible alarm is specified, an "alarm silence" button shall be provided. Pressing this button shall silence the alarm and illuminate the "alarm silenced" indicator. Clearing of the fault which initiated the alarm shall return the alarm to the original state.

B. Data Indication: Provide the following data indication and controls on the control panel. Metering accurate to two percent of the full-scale value. The characters displayed on digital meters shall have a minimum overall height of 0.66 inches and provide a three-figure readout for values of less than 100.
1. Digital generator voltmeter with a selector switch having three phase-to-phase positions and one "off" position, or digital display showing all three phases.
2. Generator ammeter displaying the full-load current value on the upper one-third of the scale and with a selector switch having three "phase" positions and one "off" position, or digital display showing all three phases.
3. Running-time meter displaying up to 99,999 hours total unit operating time.
4. Motor line ammeter to indicate the current in at least one phase of the motor.

C. Other Visual Indication: Indicators shall be denoted on the touch screen HMI to display the following:
1. Motor on: Provide a green indicator which is illuminated when the motor controller is energized.
2. Generator on: Provide a green indicator which is illuminated when the generator is at normal voltage.
3. 400 Hz contactor closed: Provide a green indicator which is illuminated only when the generator-to-400 Hz load contactor is closed.
4. Motor failure: Provide a red indicator which is illuminated when the field supply to the synchronous motor fails or the motor is overloaded.
5. Overvoltage: Provide a red indicator which is illuminated when the generator voltage exceeds the limits determined by the overvoltage protective relay.
6. Undervoltage: Provide a red indicator which is illuminated when the generator voltage falls below the limits determined by the undervoltage protective relay.

7. Underfrequency: Provide a red indicator which is illuminated when the generator frequency falls below the limits determined by the underfrequency protective relay.
8. Generator overload: Provide a red indicator which is illuminated when the generator current exceeds the limit set by the generator overload sensing relay.
9. If an audible alarm is specified, provide a red "alarm silenced" indicator.

2.1.7 Automatic Paralleling (applies only to units shown in TABLE to have paralleling function).

A. Paralleling Control: Paralleling shall be automatic for normal operation, with manual controls provided for backup operation. A pole alignment detector shall automatically align the rotor poles to permit shifting of the unit's phase angle, as necessary, to parallel and share loads equally with the other motor-generator sets on the system. The motor-generator sets shall be equipped with necessary switchgear and switchboards to allow closing of the output contactor only when that motor-generator set's voltage and phase angle matches bus voltage. Each set shall include indication of synchronizing and paralleling status.

B. Automatic Paralleling Operation: Shall provide for unmanned control to start up, load share, load shed and shutdown units as necessary to meet load demand. Manual means for alternating the units to equalize lead machine selection and unit running times between units shall be provided. A selector switch shall be provided at each M-G to determine whether it is started and stopped in response to the load-demand signals or run continuously. Units selected as "slave" shall be started in sequence after the master unit reaches a predetermined percent of load. The control logic shall provide a means of bypassing any motor-generator set in which a fault has occurred or for which routine maintenance is required. The automatic paralleling operation shall function as follows:

1. When the 400 Hz load reaches a preset level (adjustable from 50 to 100% of the master's maximum rating, as measured at the 400 Hz load terminals of the continuously-operating unit or units), the first slave will be ready to start, but will be prevented by a time delay relay (adjustable from 1 to 10 minutes). If the load remains above the set point for longer than the time delay period, the first slave unit will start and be automatically paralleled with the main bus. After phase alignment has been achieved between the main bus and the unit being paralleled, the main output contactor of the slave generator will close and the motor-generators will share the total load. When these motor-generators reach the preset rating, the same sequence will bring the next slave motor-generator on line.
2. Automatic cross-current compensation sensing and control circuitry shall be provided to insure that load sharing within 5% of the unit rating will be maintained from no-load to full load output rating of the combined motor-generators.
3. To prevent "short Cycling", once a machine is started, it shall be controlled to run for a minimum period of time (adjustable from 5 to 60 minutes) regardless of load.
4. When the 400 Hz load shared by the motor-generators decreases to a preset level (adjustable from 5 to 50%) of the combined output of the connected motor-generators as sensed at the main output bus, the slaves shall be switched off in reverse sequence.
5. In event of a failure of a "slave" unit, shutdown of the problem motor-generator set shall automatically bring the next available motor-generator set "on-line".

C. Manual Paralleling: Manual control of all functions which are required for automatic paralleling shall be provided.

D. Paralleling Circuitry Malfunction: The output disconnect shall automatically open upon failure of that set to properly parallel or share load with any other set in a parallel group. The following protective devices shall be provided for this purpose:
1. Reverse Power: Shall protect by tripping/opening the output devices when reverse power exceeds 10 percent of the motor-generator rating.
2. Over/Under Excitation: Shall protect by tripping/opening the output devices for excitation above or below the level required to achieve reactive load sharing within the range of 25 percent of the unit rating.

E. Other indicators related to parallel operation shall include: Automatic mode, manual mode, master unit, slave unit, generator output circuit breaker closed, ready to parallel, paralleling in process, over-excitation failure, under-excitation failure, reverse power failure, and unsuccessful parallel attempt.

2.1.8 Other

A. Terminal Blocks: Suitable clearly and permanently labeled terminal blocks which are readily accessible shall be provided in each separately mounted unit for the interconnecting wiring and for the power supply and load connections.

B. Lifting Provisions: Two forklift openings meeting NEMA MG-1 requirements shall be provided on each side of the base.

C. Remote Indication Provisions: Terminals shall be provided for user's connection to a voltage-free normally-open contact rated 120 V, 1 A, for remote summary alarm indication.

APPENDIX
TABLE of specifications for individual models.

GENERATOR						
Voltage	**200-208**	**200-208**	**575**	**575**	**575**	**575**
Rated kW	**75**	**144**	**144**	**250**	**320**	**400**
Rated kVA	**93.75**	**180**	**180**	**312**	**400**	**400**
Rated PF	0.8	0.8	0.8	0.8	0.8	1.0
Transient:						
0-50 % Load	-9.0%	- 8.0%	- 8.0%	- 7.0%	- 12.5%	- 8.3%
Sec to 95%	0.150	0.150	0.150	0.260	0.260	0.1.50
0-100 % Load	-18.0%	- 16.0%	- 16.0%	- 14.0%	- 22.5%	- 15%
Sec to 95%	0.150	0.150	0.150	0.320	0.320	0.15
50-0 % Load	11.0%	10.0%	10.0%	8.0%	13.5%	9%
Sec to 105%	0.160	0.160	0.160	0.260	0.260	0.160
100-0% Load	22.0%	20.0%	20.0%	16.0 %	28.0%	28.0%
Sec to 105%	0.160	0.160	0.160	0.320	0.320	0.320
MOTOR						
Voltage	480	480	480	480	480	480
HP at Gen FL	125	210	210	360	470	560
Amps at FL	116	205	205	355	445	550
Inrush Amps	185	390	390	750	850	900
SKVA/HP (ser)	1.3	1.5	1.5	1.6	1.5	1.3
CODE Letter	A	A	A	A	A	A
M-G SET						
Efficiency						
2/4 Load	80.6%	82.3%	82.3%	82.0%	84.0%	85.2
4/4 Load	81.2%	84.5%	84.5%	86.0%	87.0%	89.0
Paralleling	No	No	No	Yes	Yes	Yes

93.75 kVA (75 kW), 200-280 V, 60 - 400 Hz

Without paralleling

MOTOR-GENERATOR SET

Speed: 1200 RPM

Efficiency (@ rated PF):
- @ 2/4 load: 80.6%
- @ 4/4 load: 81.2%

Duty Cycle: Continuous

Overload: 110%, 2/24 hours

Temperature: 95°C rise/40°C ambient

Insulation: Class F

Excitation: Brushless synchronous

Construction: Open drip-proof enclosure for rotating part. Common frame single-shaft two-bearing horizontal construction for low vibration and ease of maintenance. Stator built with silicon electrical steel laminations. Coils are film-insulated copper wire vacuum-pressure impregnated with a Class F insulation system. Rotor is laminated steel with field winding of insulated copper wire, impregnated with 100% solids resin. Bearings are re-greasable anti-friction with grease fittings accessible while running.

MOTOR

Type: Synchronous

Poles: 6

Frequency: 60 Hz

Phase: 3

Connection: Wye

Voltage: 480 V

Power Factor: 1.0 nominal

NEMA Code: "A" in S-P start

HP @ Gen FL: 125

Amps @ FL: 116

Inrush Amps: 185

SkVA/HP (ser): 1.3

Starts/hour: 2 (1 cold/1 hot per NEMA MG-1 21.13.1)

GENERATOR

Type: Synchronous

Poles: 40

Frequency: 400 Hz

Phase: 3

Connection: Wye

Power Factor: 0.8

Voltage Balance: 1% with balanced load (MIL-STD-705), 4% with 33% unbalanced current

Waveform: 3% max. T.H.D., 2% max. individual harmonic w.r.t. fundamental, linear load

Transient:

0-50% load: -9.0%
Sec to 95%: 0.150

0-100% load: -18.0%
Sec to 95%: 0.150

50-0% load: 11.0%
Sec to 105%: 0.160

100-0% load: 22.0%
Sec to 105%: 0.160

CONTROLS

Enclosure: NEMA 1 steel mounted on top of the M-G set. Cable entry is through the top.

Key functions and features (all features):

Motor starter, 3 phase, reduced current, with overload relay with START/STOP

Output Disconnect Contactor

Input and Output Circuit Breaker

Generator protection:
- Overload
- Underfrequency
- Undervoltage
- Overvoltage

Paralleling Controls (selected models)

PLC control

Touch screen with capability of 250 individual alarms with easy instrumentation access.

OPTIONS

Ethernet communication provisions for remove monitoring access

Space Heaters

Audible Alarm

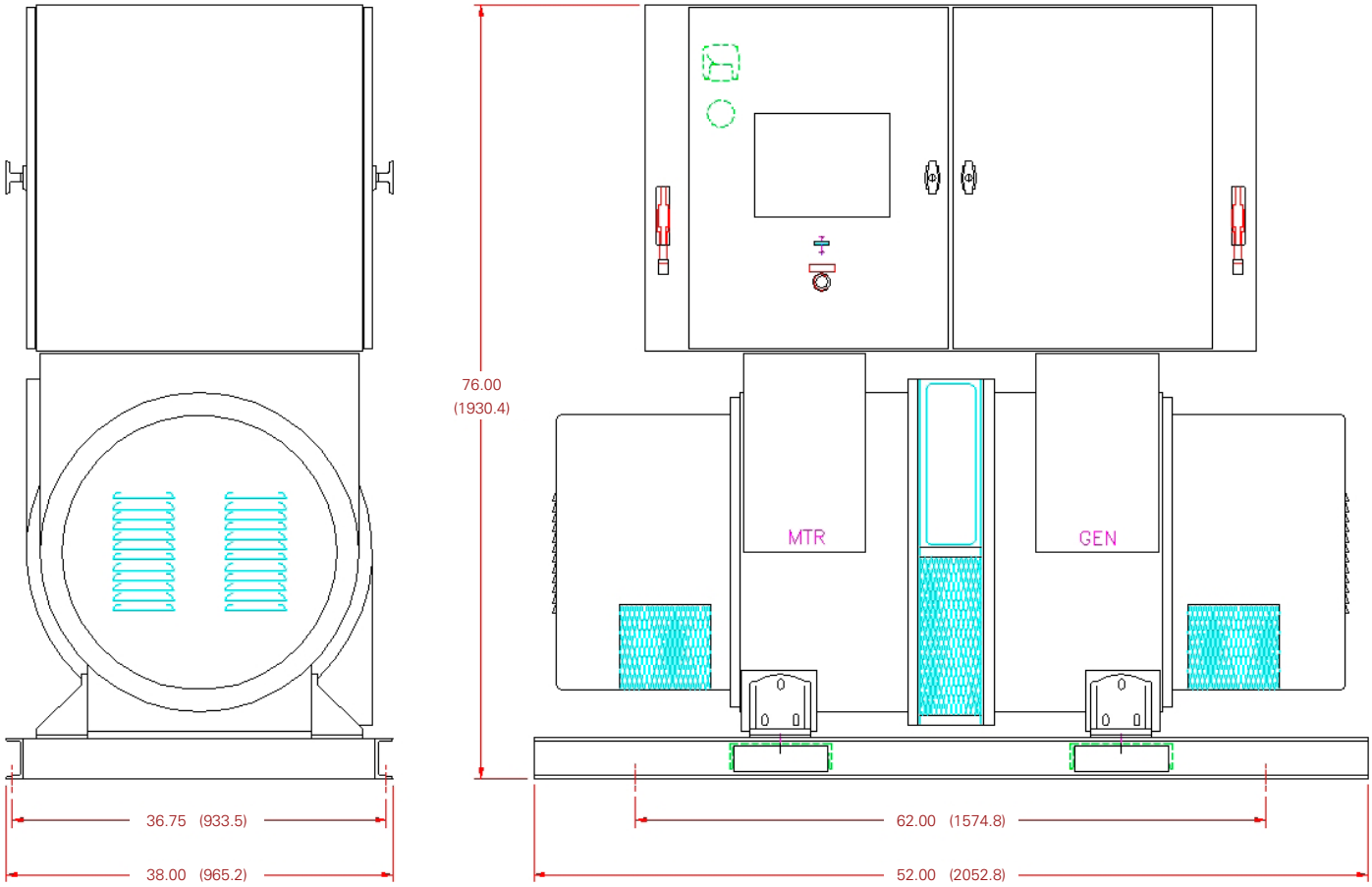
UL 508 on Control Panel
EMI suppression (to MIL 461)

Weather-proof Enclosure

Trailer Mount

Coastal Insulation Protection System (CIP)

DIMENSIONS



180 kVA (144 kW), 200-208 V, 60 - 400 Hz

Without paralleling

MOTOR-GENERATOR SET

Speed: 1200 RPM

Efficiency (@ rated PF):
- @ 2/4 load: 82.3%
- @ 4/4 load: 84.5%

Duty Cycle: Continuous

Overload: 110%, 2/24 hours

Temperature: 95°C rise/40°C ambient

Insulation: Class F

Excitation: Brushless synchronous

Construction: Open drip-proof enclosure for rotating part. Common frame single-shaft two-bearing horizontal construction for low vibration and ease of maintenance. Stator built with silicon electrical steel laminations. Coils are film-insulated copper wire vacuum-pressure impregnated with a Class F insulation system. Rotor is laminated steel with field winding of insulated copper wire, impregnated with 100% solids resin. Bearings are re-greasable anti-friction with grease fittings accessible while running.

MOTOR

Type: Synchronous

Poles: 6

Frequency: 60 Hz

Phase: 3

Connection: Wye

Voltage: 480 V

Power Factor: 1.0 nominal

NEMA Code: "A" in S-P start

HP @ Gen FL: 210

Amps @ FL: 205

Inrush Amps: 390

SkVA/HP (ser): 1.5

Starts/hour: 2 (1 cold/1 hot per NEMA MG-1 21.13.1)

GENERATOR

Type: Synchronous

Poles: 40

Frequency: 400 Hz

Phase: 3

Connection: Wye

Power Factor: 0.8

Voltage Balance: 1% with balanced load (MIL-STD-705), 4% with 33% unbalanced current

Waveform: 3% max. T.H.D., 2% max. individual harmonic w.r.t. fundamental, linear load

Transient:

0-50% load: -8.0%
Sec to 95%: 0.150

0-100% load: -16.0%
Sec to 95%: 0.150

50-0% load: 10.0%
Sec to 105%: 0.160

100-0% load: 20%
Sec to 105%: 0.160

CONTROLS

Enclosure: NEMA 1 steel mounted on top of the M-G set. Cable entry is through the top.

Key functions and features (all features):

Motor starter, 3 phase, reduced current, with overload relay with START/STOP

Output disconnect contactor

Input and output circuit Breaker

Generator protection:
- Overload
- Underfrequency
- Undervoltage
- Overvoltage

Paralleling controls (selected models)

PLC control

Touch screen with capability of 250 individual alarms with easy instrumentation access.

OPTIONS

Ethernet communication provisions for remove monitoring access

Space heaters

Audible alarm

UL 508 on control Panel

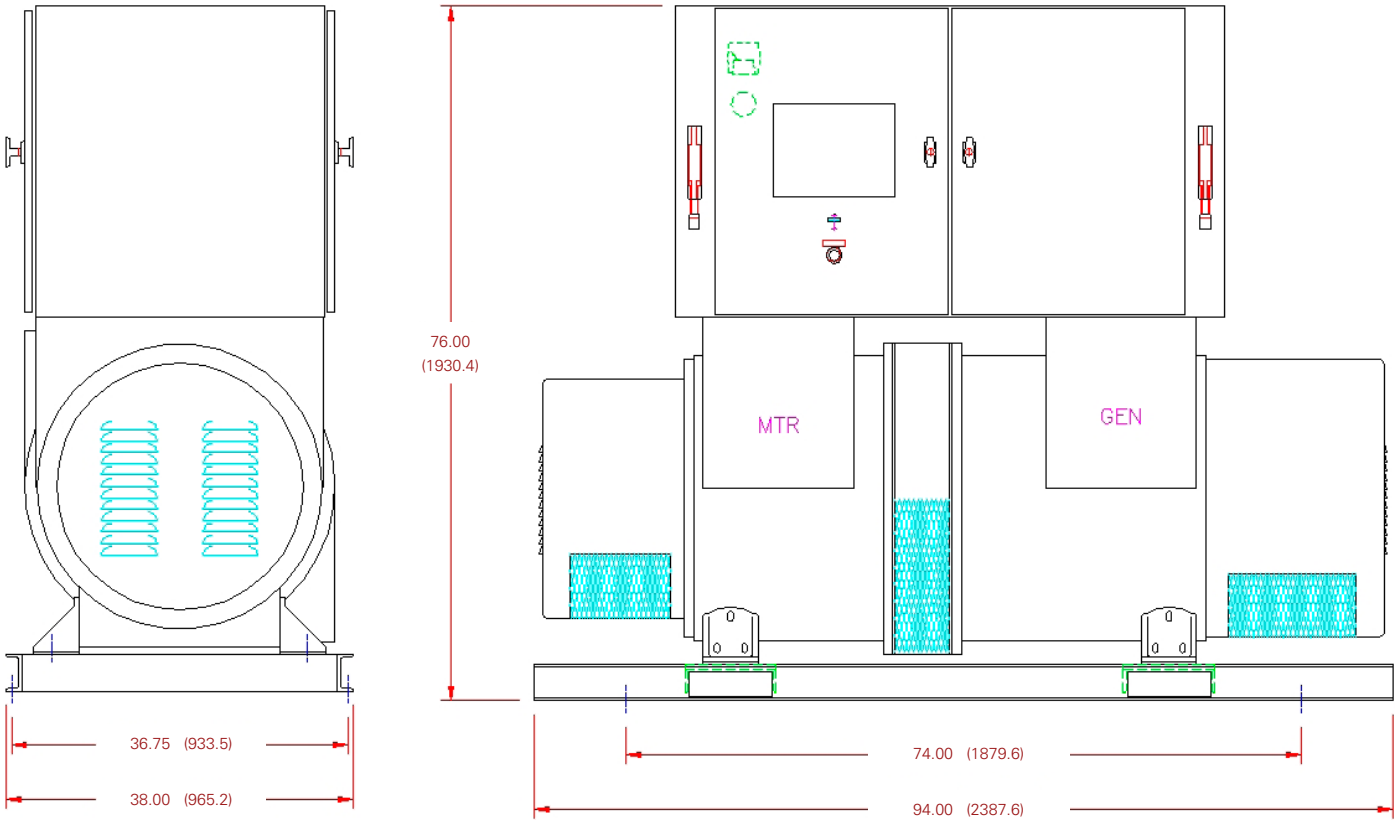
EMI suppression (to MIL 461)

Weather-proof Enclosure

Trailer Mount

Coastal Insulation Protection System (CIP)

DIMENSIONS



180 kVA (144 kW), 575 V, 60 - 400 Hz

Without paralleling

MOTOR-GENERATOR SET

Speed: 1200 RPM

Efficiency (@ rated PF):
- @ 2/4 load: 82.3%
- @ 4/4 load: 84.5%

Duty Cycle: Continuous

Overload: 110%, 2/24 hours

Temperature: 95°C rise/40°C ambient

Insulation: Class F

Excitation: Brushless synchronous

Construction: Open drip-proof enclosure for rotating part. Common frame single-shaft two-bearing horizontal construction for low vibration and ease of maintenance. Stator built with silicon electrical steel laminations. Coils are film-insulated copper wire vacuum-pressure impregnated with a Class F insulation system. Rotor is laminated steel with field winding of insulated copper wire, impregnated with 100% solids resin. Bearings are re-greasable anti-friction with grease fittings accessible while running.

MOTOR

Type: Synchronous

Poles: 6

Frequency: 60 Hz

Phase: 3

Connection: Wye

Voltage: 480 V

Power Factor: 1.0 nominal

NEMA Code: "A" in S-P start

HP @ Gen FL: 210

Amps @ FL: 205

Inrush Amps: 390

SkVA/HP (ser): 1.5

Starts/hour: 2 (1 cold/1 hot per NEMA MG-1 21.13.1)

GENERATOR

Type: Synchronous

Poles: 40

Frequency: 400 Hz

Phase: 3

Connection: Wye

Power Factor: 0.8

Voltage Balance: 1% with balanced load (MIL-STD-705), 4% with 33% unbalanced current

Waveform: 3% max. T.H.D., 2% max. individual harmonic w.r.t. fundamental, linear load

Transient:

0-50% load: -8.0%
Sec to 95%: 0.150

0-100% load: -16.0%
Sec to 95%: 0.150

50-0% load: 10.0%
Sec to 105%: 0.160

100-0% load: 20%
Sec to 105%: 0.160

CONTROLS

Enclosure: NEMA 1 steel mounted on top of the M-G set. Cable entry is through the top.

Key functions and features (all features):

Motor starter, 3 phase, reduced current, with overload relay with START/STOP

Output disconnect contactor

Input and output circuit Breaker

Generator protection:
Overload
Underfrequency
Undervoltage
Overvoltage

Paralleling controls (selected models)

PLC control

Touch screen with capability of 250 individual alarms with easy instrumentation access.

OPTIONS

Ethernet communication provisions for remove monitoring access

Space heaters

Audible alarm

UL 508 on control Panel

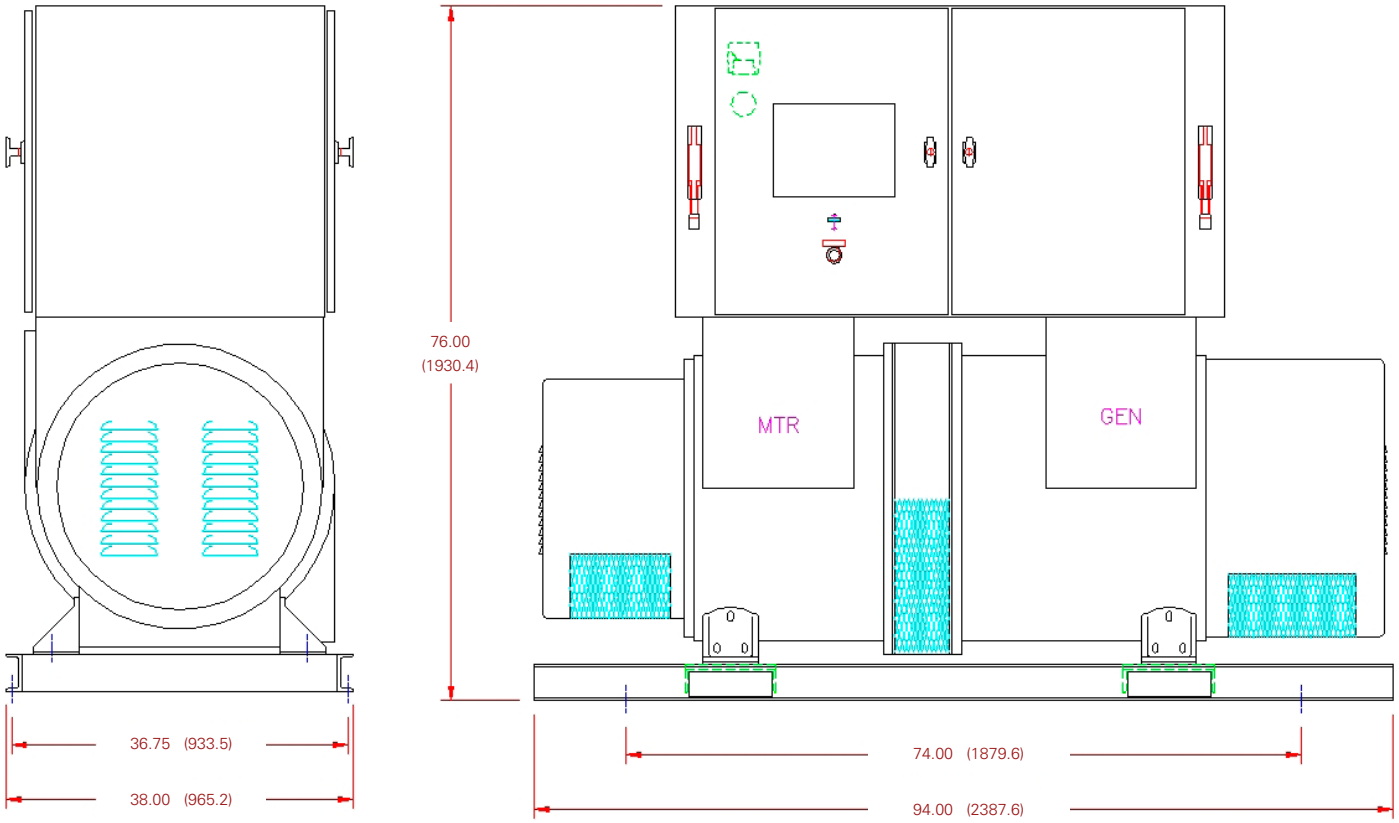
EMI suppression (to MIL 461)

Weather-proof Enclosure

Trailer Mount

Coastal Insulation Protection System (CIP)

DIMENSIONS



312 kVA (250 kW), 575 V, 60 - 400 Hz

With paralleling

MOTOR-GENERATOR SET

Speed: 1200 RPM

Efficiency (@ rated PF):
- @ 2/4 load: 82.0%
- @ 4/4 load: 86.0%

Duty Cycle: Continuous

Overload: 110%, 2/24 hours

Temperature: 95°C rise/40°C ambient

Insulation: Class F

Excitation: Brushless synchronous

Construction: Open drip-proof enclosure for rotating part. Common frame single-shaft two-bearing horizontal construction for low vibration and ease of maintenance. Stator built with silicon electrical steel laminations. Coils are film-insulated copper wire vacuum-pressure impregnated with a Class F insulation system. Rotor is laminated steel with field winding of insulated copper wire, impregnated with 100% solids resin. Bearings are re-greasable anti-friction with grease fittings accessible while running.

MOTOR

Type: Synchronous

Poles: 6

Frequency: 60 Hz

Phase: 3

Connection: Wye

Voltage: 480 V

Power Factor: 1.0 nominal

NEMA Code: "A" in S-P start

HP @ Gen FL: 360

Amps @ FL: 355

Inrush Amps: 750

SkVA/HP (ser): 1.6

Starts/hour: 2 (1 cold/1 hot per NEMA MG-1 21.13.1)

GENERATOR

Type: Synchronous

Poles: 40

Frequency: 400 Hz

Phase: 3

Connection: Wye

Power Factor: 0.8

Voltage Balance: 1% with balanced load (MIL-STD-705), 4% with 33% unbalanced current

Waveform: 3% max. T.H.D., 2% max. individual harmonic w.r.t. fundamental, linear load

Transient:

0-50% load: -7.0%
Sec to 95%: 0.260

0-100% load: -14.0%
Sec to 95%: 0.320

50-0% load: 8.0%
Sec to 105%: 0.260

100-0% load: 16%
Sec to 105%: 0.320

CONTROLS

Enclosure: NEMA 1 steel mounted on top of the M-G set. Cable entry is through the top.

Key functions and features (all features):

Motor starter, 3 phase, reduced current, with overload relay with START/STOP

Output disconnect contactor

Input and output circuit Breaker

Generator protection:
Overload
Underfrequency
Undervoltage
Overvoltage

Paralleling controls (selected models)

PLC control

Touch screen with capability of 250 individual alarms with easy instrumentation access.

OPTIONS

Ethernet communication provisions for remove monitoring access

Space heaters

Audible alarm

UL 508 on control Panel

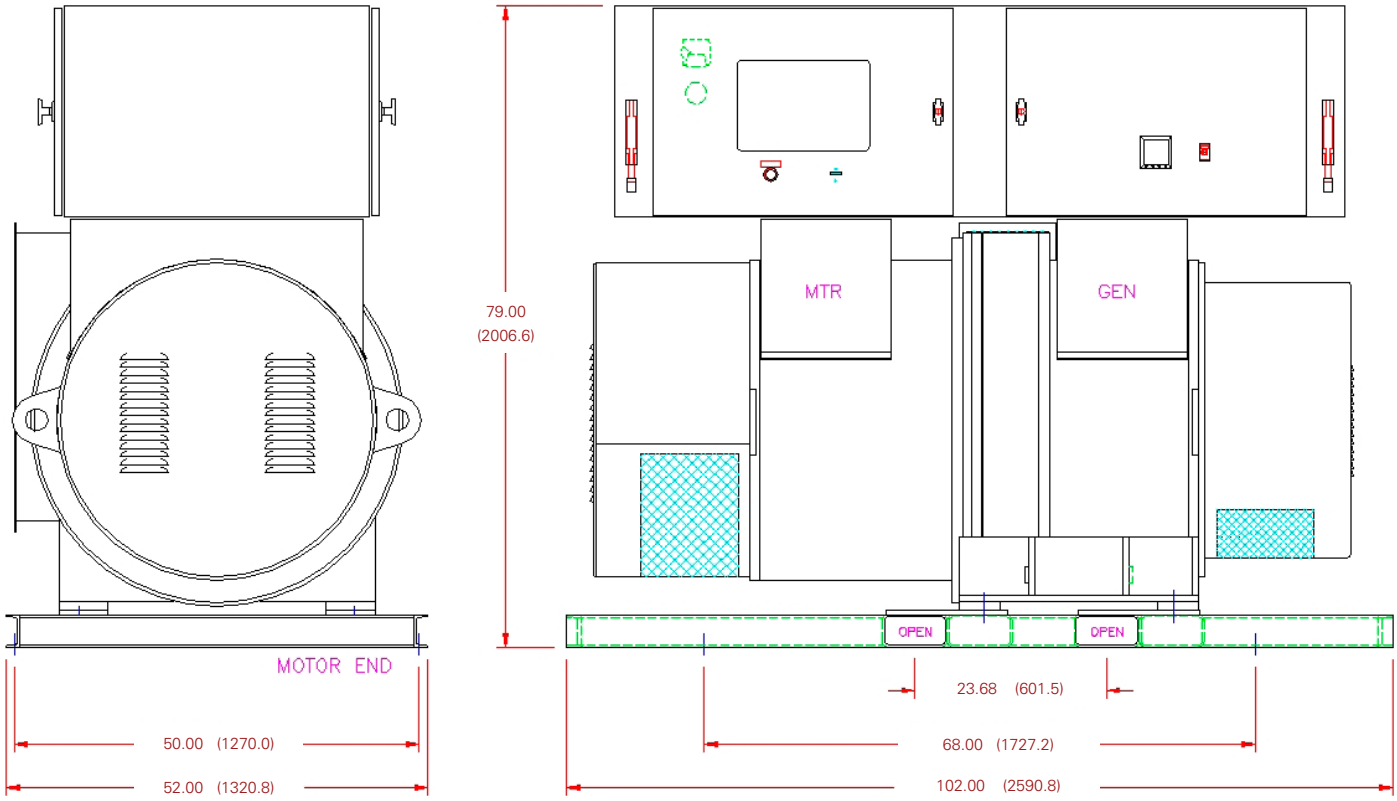
EMI suppression (to MIL 461)

Weather-proof Enclosure

Trailer Mount

Coastal Insulation Protection System (CIP)

DIMENSIONS



650-259-9100
www.mcmeng.com
sales@mcmeng.com

312 kVA (250 kW), 575 V, 50 - 400 Hz

With paralleling

MOTOR-GENERATOR SET

Speed: 1500 RPM

Efficiency (@ rated PF):
- @ 2/4 load: 83.2%
- @ 4/4 load: 87.6%

Duty Cycle: Continuous

Overload: 110%, 2/24 hours

Temperature: 95°C rise/40°C ambient

Insulation: Class F

Excitation: Brushless synchronous

Construction: Open drip-proof enclosure for rotating part. Common frame single-shaft two-bearing horizontal construction for low vibration and ease of maintenance. Stator built with silicon electrical steel laminations. Coils are film-insulated copper wire vacuum-pressure impregnated with a Class F insulation system. Rotor is laminated steel with field winding of insulated copper wire, impregnated with 100% solids resin. Bearings are re-greasable anti-friction with grease fittings accessible while running.

MOTOR

Type: Synchronous

Poles: 4

Frequency: 50 Hz

Phase: 3

Connection: Wye

Voltage: 380 - 416 V

Power Factor: 1.0 nominal

NEMA Code: "A" in S-P start

HP @ Gen FL: 375

Amps @ FL: 420

Inrush Amps: 800

SkVA/HP (ser): 1.5

Starts/hour: 2 (1 cold/1 hot per NEMA MG-1 21.13.1)

GENERATOR

Type: Synchronous

Poles: 32

Frequency: 400 Hz

Phase: 3

Connection: Wye

Power Factor: 0.8

Voltage Balance: 1% with balanced load (MIL-STD-705), 4% with 33% unbalanced current (L - N)

Waveform: 3% max. T.H.D., 2% max. individual harmonic w.r.t. fundamental, linear load

Transient:

0-50% load: -7.5%
Sec to 95%: 0.150

0-100% load: -15.0%
Sec to 95%: 0.150

50-0% load: 8.0%
Sec to 105%: 0.160

100-0% load: 16.5%
Sec to 105%: 0.160

CONTROLS

Enclosure: NEMA 1 steel mounted on top of the M-G set. Cable entry is through the top.

Key functions and features (all features):

Motor starter, 3 phase, reduced current, with overload relay with START/STOP

Output disconnect contactor

Input and output circuit Breaker

Generator protection:
Overload
Underfrequency
Undervoltage
Overvoltage

Paralleling controls (selected models)

PLC control

Touch screen with capability of 250 individual alarms with easy instrumentation access.

OPTIONS

Ethernet communication provisions for remove monitoring access

Space heaters

Audible alarm

UL 508 on control Panel

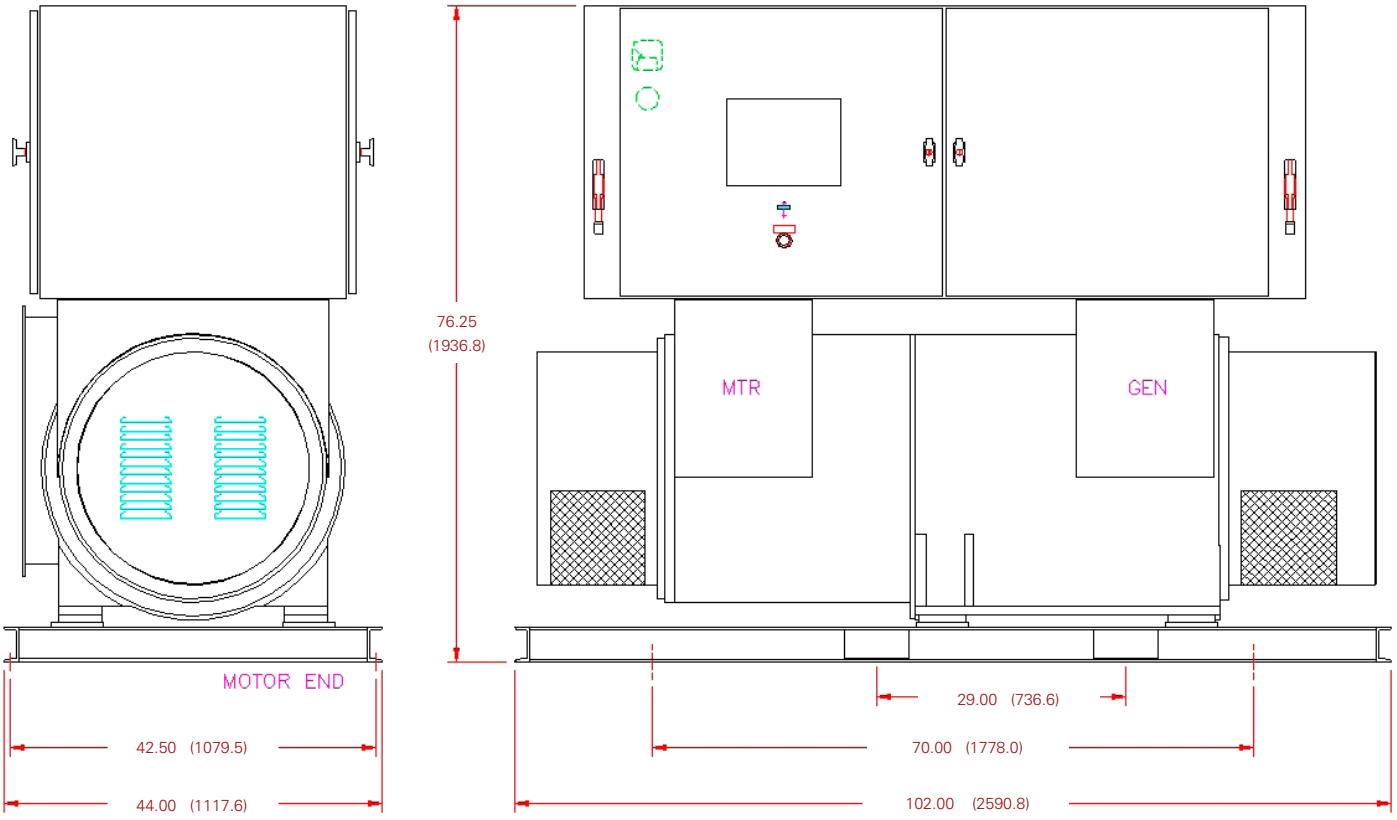
EMI suppression (to MIL 461)

Weather-proof Enclosure

Trailer Mount

Coastal Insulation Protection System (CIP)

DIMENSIONS



400 kVA (320 kW), 575 V, 60 - 400 Hz

With paralleling

MOTOR-GENERATOR SET

Speed: 1200 RPM

Efficiency (@ rated PF):
- @ 2/4 load: 84.0%
- @ 4/4 load: 87.0%

Duty Cycle: Continuous

Overload: 110%, 2/24 hours

Temperature: 95°C rise/40°C ambient

Insulation: Class F

Excitation: Brushless synchronous

Construction: Open drip-proof enclosure for rotating part. Common frame single-shaft two-bearing horizontal construction for low vibration and ease of maintenance. Stator built with silicon electrical steel laminations. Coils are film-insulated copper wire vacuum-pressure impregnated with a Class F insulation system. Rotor is laminated steel with field winding of insulated copper wire, impregnated with 100% solids resin. Bearings are re-greasable anti-friction with grease fittings accessible while running.

MOTOR

Type: Synchronous

Poles: 6

Frequency: 60 Hz

Phase: 3

Connection: Wye

Voltage: 480 V

Power Factor: 1.0 nominal

NEMA Code: "A" in S-P start

HP @ Gen FL: 470

Amps @ FL: 445

Inrush Amps: 850

SkVA/HP (ser): 1.5

Starts/hour: 2 (1 cold/1 hot per NEMA MG-1 21.13.1)

GENERATOR

Type: Synchronous

Poles: 40

Frequency: 400 Hz

Phase: 3

Connection: Wye

Power Factor: 0.8

Voltage Balance: 1% with balanced load (MIL-STD-705), 4% with 33% unbalanced current

Waveform: 3% max. T.H.D., 2% max. individual harmonic w.r.t. fundamental, linear load

Transient:

0-50% load: -12.5%
Sec to 95%: 0.260

0-100% load: -22.5%
Sec to 95%: 0.320

50-0% load: 13.5%
Sec to 105%: 0.260

100-0% load: 28.0%
Sec to 105%: 0.320

CONTROLS

Enclosure: NEMA 1 steel mounted on top of the M-G set. Cable entry is through the top.

Key functions and features (all features):

Motor starter, 3 phase, reduced current, with overload relay with START/STOP

Output disconnect contactor

Input and output circuit Breaker

Generator protection:
Overload
Underfrequency
Undervoltage
Overvoltage

Paralleling controls (selected models)

PLC control

Touch screen with capability of 250 individual alarms with easy instrumentation access.

OPTIONS

Ethernet communication provisions for remove monitoring access

Space heaters

Audible alarm

UL 508 on control Panel

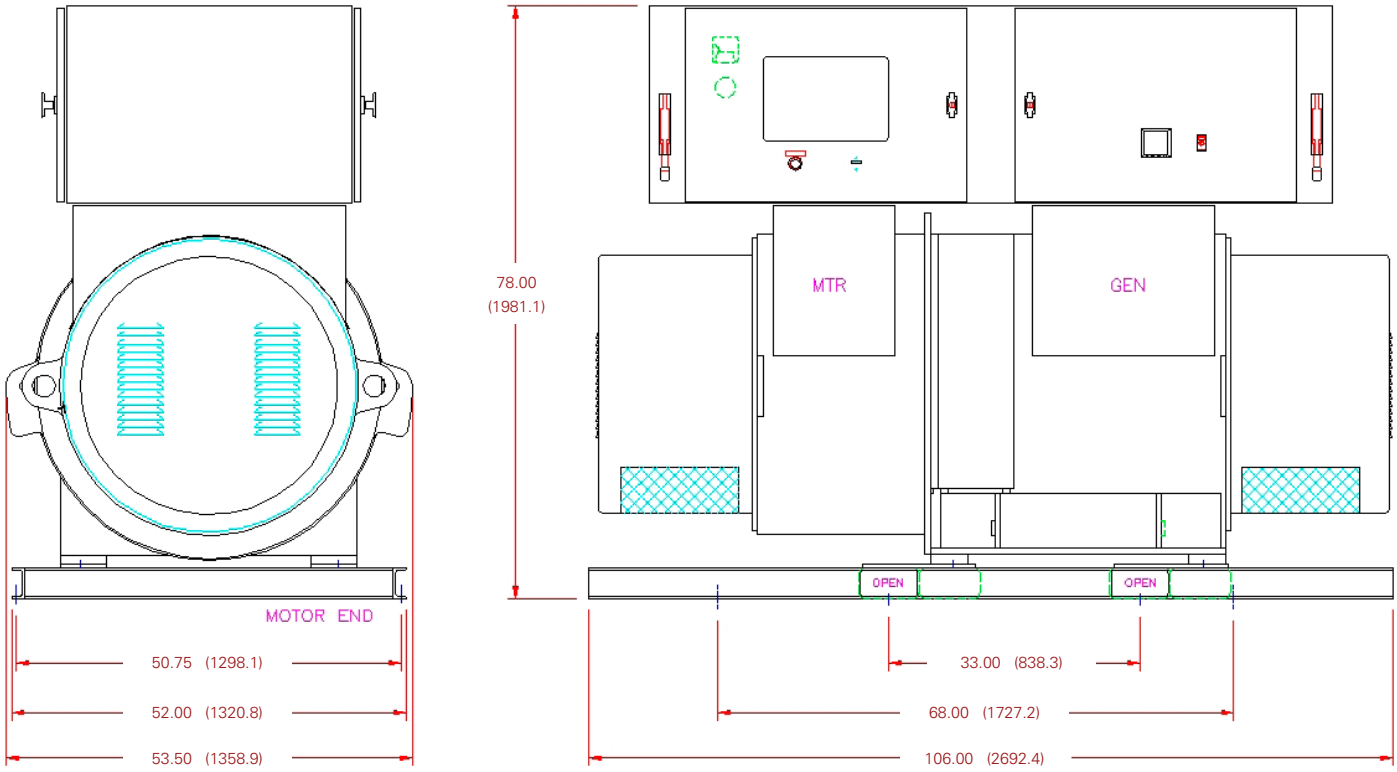
EMI suppression (to MIL 461)

Weather-proof Enclosure

Trailer Mount

Coastal Insulation Protection System (CIP)

DIMENSIONS



400 kVA (400 kW), 575 V, 60 - 400 Hz

With paralleling

MOTOR-GENERATOR SET

Speed: 1200 RPM

Efficiency (@ rated PF):
- @ 2/4 load: 85.1%
- @ 4/4 load: 89.5%

Duty Cycle: Continuous

Overload: 110%, 2/24 hours

Temperature: 105°C rise/40°C ambient

Insulation: Class F

Excitation: Brushless synchronous

Construction: Open drip-proof enclosure for rotating part. Common frame single-shaft two-bearing horizontal construction for low vibration and ease of maintenance. Stator built with silicon electrical steel laminations. Coils are film-insulated copper wire vacuum-pressure impregnated with a Class F insulation system. Rotor is laminated steel with field winding of insulated copper wire, impregnated with 100% solids resin. Bearings are re-greasable anti-friction with grease fittings accessible while running.

MOTOR

Type: Synchronous

Poles: 6

Frequency: 60 Hz

Phase: 3

Connection: Wye

Voltage: 480 V

Power Factor: 1.0 nominal

NEMA Code: "A" in S-P start

HP @ Gen FL: 560

Amps @ FL: 540

Inrush Amps: 800

SkVA/HP (ser): 1.2

Starts/hour: 2 (1 cold/1 hot per NEMA MG-1 21.13.1)

GENERATOR

Type: Synchronous

Poles: 40

Frequency: 400 Hz

Phase: 3

Connection: Wye

Power Factor: 1.0

Voltage Balance: 1% with balanced load (MIL-STD-705), 4% with 33% unbalanced current

Waveform: 3% max. T.H.D., 2% max. individual harmonic w.r.t. fundamental, linear load

Transient:

0-50% load: 5.0%
Sec to 95%: 0.150

0-100% load: 9.8%
Sec to 95%: 0.150

50-0% load: 6.1%
Sec to 105%: 0.160

100-0% load: 13.2%
Sec to 105%: 0.160

CONTROLS

Enclosure: NEMA 1 steel mounted on top of the M-G set. Cable entry is through the top.

Key functions and features (all features):

Motor starter, 3 phase, reduced current, with overload relay with START/STOP

Output disconnect contactor

Input and output circuit Breaker

Generator protection:
Overload
Underfrequency
Undervoltage
Overvoltage

Paralleling controls (selected models)

PLC control

Touch screen with capability of 250 individual alarms with easy instrumentation access.

OPTIONS

Ethernet communication provisions for remove monitoring access

Space heaters

Audible alarm

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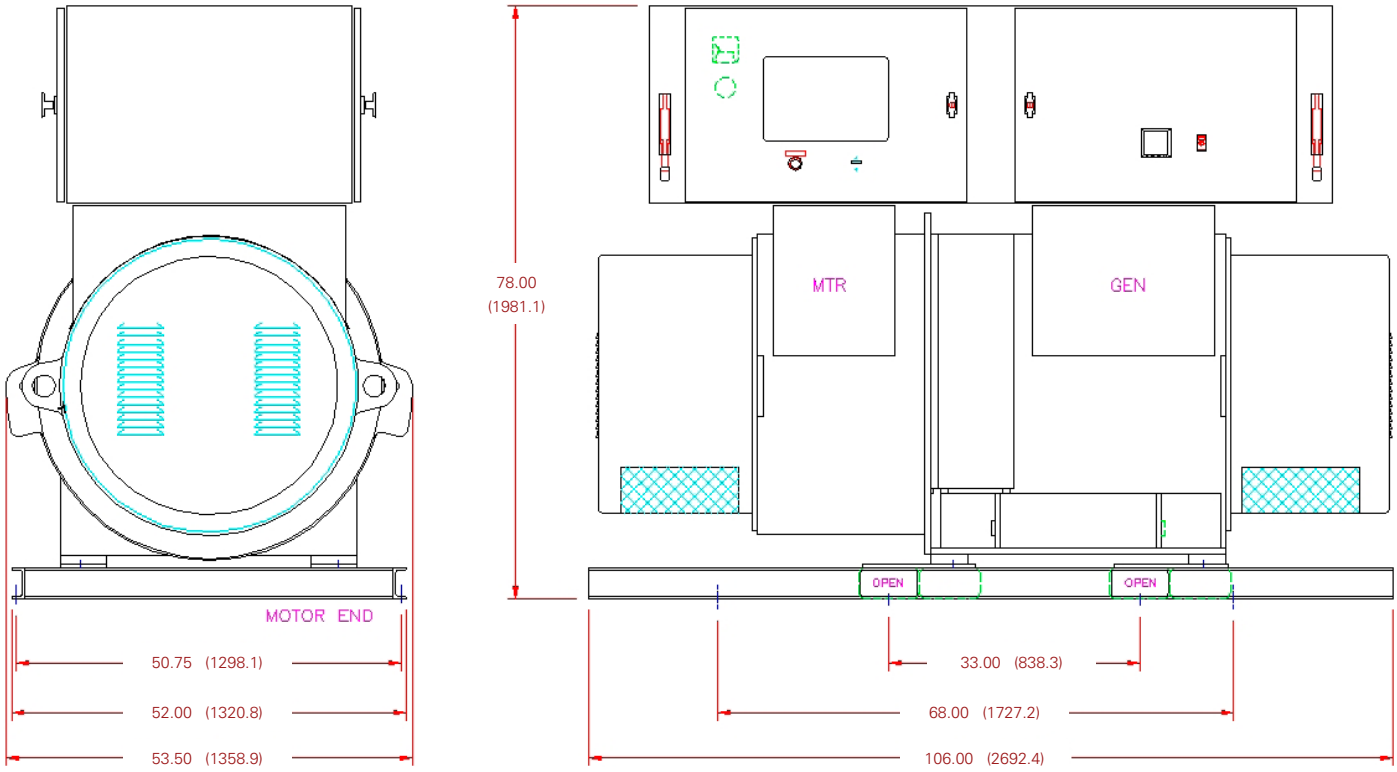

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