

Instruction Manual

Installation
Operation
Maintenance

Two Bearing KAMAG Generator
with Outboard Exciter

Publication
350-04002-00 (September 1981)



Safety Summary

WARNING

This equipment contains high speed (1800 RPM) rotating parts and develops lethal voltage (480 VAC or higher). Stop generator set before removing protective covers for the purpose of making electrical connections, installation, adjustments, inspection, troubleshooting, testing, repair, or parts replacement. Install protective covers before starting the generator set. Failure to observe this precaution can result in serious injury or electrocution.

WARNING

Where meters or test instruments are used for purpose of troubleshooting and testing, it is recommended the test equipment be placed external to the generator and the generator set be stopped while making or removing meter and instrument connections. Be sure protective covers are installed before running unit. Failure to observe this precaution can result in serious injury or electrocution.

WARNING

Do not lift complete generator set by means of lifting eye on generator. Disregarding these instructions may result in serious injury or equipment damage.

WARNING

Do not lift or pry on generator fan. Failure to observe this precaution can result in serious injury and equipment damage.

WARNING

Make certain that sufficient clearance exists between fan and stationary parts and make certain fan and fan hub bolts are torqued. Failure to observe this precaution can result in serious injury and equipment damage.

WARNING

When circuit breakers are not included with the generator, the terminals on the ends of the stator lead wires are not insulated. These terminals must be insulated before generator set is operated. Failure to observe this precaution can result in serious injury and equipment damage.

CAUTION

Do not push on rotating rectifier or exciter winding. Failure to observe this precaution can result in equipment damage.

Table of Contents

Section 1

General Information, Principles of Operation and Mechanical Construction

GENERAL	1-1
PRINCIPLES OF OPERATION	1-1
MECHANICAL CONSTRUCTION	1-1
Generator Frame and Stator	1-1
Generator Frame Cover	1-1
Generator Rotor Assembly	1-1
A. Shaft	
B. Generator Field Poles	
C. Air Circulating Fan	
D. Bearings	
Exciter Rotor	1-2
A. Exciter Armature	
B. Rectifier	
Exciter Field Assembly	1-3
Endbells	1-3
Terminal Box	1-3

Section 2

Receiving Inspection Handling Instructions and Storage

RECEIVING YOUR KAMAG GENERATOR	2-1
WINDING INSPECTION	2-1
UNPACKING	2-1
STORAGE	2-1

Section 3

Mounting and Aligning Generator Set

HANDLING	3-1
BASES AND BED PLATES	3-1
A. Belted Generator Sets	
B. Flexible Coupled Generator Sets	
EXCITER ALIGNMENT AND BEARING ENDCLEARANCE	3-1
Checking Bearing Endclearance	3-1
SELECTION OF DRIVES FOR TWO-BEARING GENERATOR	3-2
BELT DRIVES	3-2
A. V-Belt	
B. Synchronous Belts	
FLEXIBLE COUPLINGS	3-3
Aligning Flexible Couplings	3-3
A. Checking Parallel (Shaft Offset) Alignment	
B. Checking Angular Alignment	

Section 4

Electrical Connections

GENERAL	4-1
A. Three-Phase Wye Connected Generator	
B. Three-Phase Delta Connected Generator	
C. Single Phase Three Wire	
D. Single Phase Two Wire	
E. Generator Frame Ground	
F. Exciter Field Lead Wires	
G. Voltage Regulator	

Table of Contents (Cont.)

GENERAL	4-1
H. Voltage Regulator Fuse	
I. Voltage Shutdown Switch	
J. Field Circuit Breaker	
K. Automatic/Manual Voltage Control	
L. Space Heaters	

Section 5 Operation

PRE-START INSPECTION	5-1
FIELD FLASHING	5-1
VOLTAGE ADJUSTMENTS	5-2
VOLTAGE RANGE ADJUST	5-2
STABILITY ADJUSTMENT	5-2
STARTING UP THE GENERATOR FOR SINGLE UNIT OPERATION	5-2

Section 6 Preventive Maintenance

INSPECTION	6-1
CLEANING	6-1

Section 7 Troubleshooting

GENERAL	7-1
TROUBLESHOOTING PROCEDURE	7-1
A. No Voltage	
B. Low Voltage	
C. High Voltage	
D. Voltage Fluctuating	

Section 8 Generator Tests

MEASURING EXCITER FIELD EXCITATION	8-1
TESTING EXCITER ROTATING RECTIFIER DIODES	8-1
TESTING ZENER DIODE SURGE SUPPRESSOR	8-2
MEASURING WINDING RESISTANCE	8-2
A. Measuring Exciter Field Winding Resistance	
B. Measuring Generator Field Winding Resistance	
C. Measuring Exciter Armature Winding Resistance	
D. Generator Stator Winding Resistance	
MEASURING WINDING INSULATION RESISTANCE	8-3
A. Measuring Generator Stator Winding Insulation Resistance	
B. Measuring Generator Field Winding Insulation Resistance	
C. Measuring Exciter Field Winding Insulation Resistance	
D. Measuring Exciter Armature Winding Insulation Resistance	

Section 9 Drying Windings and Removing and Installing Parts

DRYING GENERATOR	9-1
A. Heated Enclosure	
B. Forced Air	
C. Oven	
REMOVING AND INSTALLING EXCITER ROTOR	9-1
A. Removing Exciter Rotor	
B. Installing Exciter Rotor	
REMOVING AND INSTALLING TERMINAL BOX AND OUTBOARD ENDBELL	9-2
A. Removing Terminal Box and Outboard Endbell	
B. Installing Terminal Box and Outboard Endbell	
REMOVING AND INSTALLING DRIVE ENDBELL	9-2
A. Removing Drive Endbell	
B. Installing Drive Endbell	
REMOVING AND INSTALLING BEARING	9-4
REMOVING AND INSTALLING GENERATOR FAN	9-5
A. Removing Fan	
B. Installing Fan	
REMOVING AND INSTALLING GENERATOR ROTOR	9-5
A. Removing Rotor	
B. Installing Rotor	

Section 10 Tables and Figures

GENERAL	10-1
Table 1 Generator Voltage Standard Kamag Generators	10-1
Table 2 Minimum Air Gap for Kato Brushless Exciter	10-1
Table 3 Recommended Torque SAE 5 Steel and SAE 8 Steel Cap Screws	10-2
Figure 1 Two Bearing Kamag Generator with Outboard Exciter	10-3
Figure 2 Exciter Rotor Installation	10-4
Figure 3 Rotating Rectifier	10-4
Figure 4 Coupling — Parallel Alignment	10-5
Figure 5 Coupling — Angular Alignment	10-5
Figure 6 Twelve Wire Generator Stator Lead Wire Connection Diagram	10-6
Figure 7 Exciter and Generator Field Interconnection	10-7
Figure 8 Field Excitation Measurement Meter Connection Diagram	10-7

SECTION 1

GENERAL INFORMATION, PRINCIPLES OF OPERATION AND MECHANICAL CONSTRUCTION

GENERAL

KAMAG AC generators are brushless 4-pole machines producing 60 Hz power at 1800 rpm or 50 Hz power at 1500 rpm. The generators are of the revolving field type, having rotating field poles called the rotor and a stationary armature called the stator. All standard units are broad voltage range machines that have twelve lead wires brought out from the stator coil groups. This feature permits connection of the stator winding in either three-phase wye, three-phase delta, or single-phase configuration. Table 1 lists the voltages that can be obtained from the output of KAMAG generators.

Two bearing generators have a rotor shaft that extends beyond the driven end of the generator for mounting sheaves or a flexible drive coupling.

Drawings and tables are contained in Section 10 in this manual.

The major parts comprising the KAMAG generator are shown on Figure 1. Figure 7 is an electrical schematic of the generator field and exciter. The twelve stator lead wires and respective stator coil groups are shown on Figure 6.

PRINCIPLES OF OPERATION

Ac generators require direct current flowing through the field winding to set up the magnetic flux which generates ac power in the stator winding. An exciter, which is a small ac generator with rectified output, provides this direct current. While the generator armature is stationary and the field rotates, the exciter field is stationary and the armature and rectifier rotate.

The exciter itself requires direct current for excitation. This excitation may be provided by any dc power supply that provides the proper excitation. However, in order to keep the generator output voltage relatively constant, the dc excitation must be automatically regulated by means of a voltage regulator.

The voltage regulator provides regulated dc excitation. This device measures the generator voltage and compares the measured voltage with a pre-set voltage established by adjustment of a voltage adjust potentiometer or rheostat. It then uses the result of the comparative process to automatically control the excitation supplied to the exciter field winding. This action in turn regulates the excitation applied to the generator field winding, which controls the magnetic flux and thereby the ac power generated by the generator stator winding.

The voltage regulator requires electrical power for operation of its circuitry. Usually a portion of the power generated by the generator is used to power the voltage regulator.

MECHANICAL CONSTRUCTION

The major parts comprising the KAMAG generator are shown in Figure 1 and described in the paragraphs that follow.

Generator Frame and Stator

Rectangular steel bars welded to endrings provide rigid support for the stator, the generator endbell, and the adapter. Weldments rigidly secure the stator to the frame bars.

The stator core is composed of a stack of thin, notched electrical steel laminations assembled under pressure and welded to the frame bars. The semi-closed notched slots are Class F insulated; random wound coils are firmly wedged in the insulated slots. The stator coils in KAMAG generators are connected in three-phase groups with twelve lead wires that terminate within the terminal box. Stator wire connections are insulated and the entire stator is then impregnated with thermo-setting 100 percent solid bonding epoxy and baked under a controlled cycle. This process minimizes voids and ensures high dielectric strength and excellent moisture resistance.

Generator Frame Cover

A removable sheet metal cover encloses the generator frame.

Generator Rotor Assembly

A precision machined steel shaft, the four-pole rotating field, the exciter armature and the rotating rectifier comprise the rotor assembly. Also mounted on the shaft and provided with a replacement rotor are the drive hub and the generator bearing. A two-section fan mounts on the rotor at the adapter end of the generator.

The rotor is dynamically balanced at the factory. Rotor balance is attained by mounting weights on rings located at the front and back of the field poles.

A. Shaft

The rotor shaft includes a keyway and key at the drive end for mounting the drive sheaves or flexible coupling, a keyway and key for mounting the rotor field core, and a keyway and key for mounting the exciter armature and rotating rectifier.

B. Generator Field Poles

The four poles which carry the field windings are comprised of a stack of one-piece electrical steel laminations press-fitted together using a hydraulic press. Copper rods of the amortisseur winding are pressed into circular holes through the pole head portion of the core structure and welded to copper end plates that form the front and back section of the assembled field core structure. The field core structure is pressed on the shaft using a high pressure hydraulic press and keyed, forming a rigid rotating element. Round steel studs are pressed into each pole head for attachment of rotor balance rings at the front and back section of the field assembly.

Heavily insulated series-connected field coils are wound about the four poles. A support block made of insulating material provides coil support at the bottom and top of the field coil. Two lead wires are brought out to the rotating rectifier.

A thermo-setting epoxy is applied to the completed generator field assembly and the field assembly is baked under a controlled cycle to ensure high dielectric strength and mechanical strength.

C. Air Circulating Fan

The fan consists of two half-sections that clamp together and are held securely in place on the shaft by two steel bolts. The fan mounts at the drive end of the generator between the drive hub and the generator field poles.

Ambient air is drawn into the outboard end of the generator, and passes over the exciter, across the outside of the generator stator windings and stator laminations, and through the air gap between the generator stator and field poles. This circulation of air removes heat from the windings and laminations. The cooling fan exhausts the heated air from the generator.

D. Bearings

Two bearing KAMAG generators have duty-selected shielded ball bearings that are factory packed with lubricating grease. A machined housing at the center of the endbell located at the exciter end of the machine supports the outer race of the outboard bearing. The machined bearing housing at the center of the adapter at the driven end of the generator supports the bearing located at the driven end of the generator. Bearing inner races are interference fit onto bearing journals machined on the generator shaft.

Exciter Rotor

The exciter rotor consists of the exciter armature wound with a three-phase winding and a full-wave rotating rectifier. Three-lead wires, one from each phase of the exciter armature winding, connect to the rectifier diodes as shown on Figure 7. The direct current from the rotating rectifier is conducted to the generator field through lead wires.

Two bolts mount the rectifier assembly to the exciter armature core structure. The entire exciter rotor unit slides over the generator shaft and is held in place by a rectangular key located in the shaft keyway and a retaining bolt and washer at the outboard end of the shaft as shown on Figure 2.

A. Exciter Armature

The exciter armature core structure is comprised of a stack of thin, notched, one-piece laminations held assembled under pressure and kept compressed and aligned by steel rivets through the stack of laminations. The semi-closed slots are insulated with Class F insulation, and the coils of the three-phase exciter armature winding are then securely wedged in the slots. The entire exciter armature is completely impregnated with thermo-setting epoxy and baked under a controlled cycle. Three lead wires, one from each phase of the exciter armature winding, connect to the rotating rectifier as shown on Figure 7.

B. Rectifier

The exciter armature three-phase ac output is applied to a full-wave rectifier comprised of a positive heat sink, a negative heat sink, a molded insulating plate, a metal plate, three forward polarity diodes, three reverse polarity diodes, a forward polarity zener diode, and a reverse polarity zener diode. The heat sinks are molded onto the insulating plate. The three forward polarity diodes and the forward polarity zener diodes mount on the positive heat sink, while the three reverse polarity diodes and the reverse polarity

zener diode mount on the negative heat sink. A generator field lead wire attaches to the positive heat sink while the second generator field lead attaches to the negative heat sink. This rectifier output circuit provides excitation to the series-connected generator field winding. Three wires, one from each phase of the exciter armature winding, attach to the diodes as shown in Figure 7. The complete rectifier assembly is held in place on the exciter armature by two bolts.

Exciter Field Assembly

The exciter field core structure is comprised of a stack of thin, notched electrical steel laminations that are held axially and tangentially aligned by a weldment across the stack of laminations. The steel laminations are of the type that retain residual magnetism. This residual magnetism produces a magnetic field which, when the generator is started, induces current in the exciter armature, providing the generator field with sufficient dc excitation for generator voltage build-up.

The slots in the exciter field core structure are insulated with Class F insulation and the coils are then firmly wedged in the slots. The coils are series connected; lead wires are brought out for connection to the voltage regulator dc output. The entire exciter field assembly is completely impregnated with thermo-setting epoxy and baked under a controlled cycle. Bolts that pass through holes in the exciter field core structure and thread into tapped holes in the bosses located on the generator endbell provide rigid mounting and ensure concentric alignment.

Endbells

Cast iron endbells enclose the outboard and driven ends of the generator. Precision machined matching pilot and recess on the endbell and generator frame endring ensure concentric alignment with the generator frame. The endbells are rigidly secured to the frame by bolts that pass through holes in the endbell and thread into tapped holes in the frame endring. A machined bearing housing at the center of the endbell supports the outer race of the generator bearing. The outboard endbell includes bosses with tapped holes which provide mounting for the exciter field assembly.

Terminal Box

KAMAG generators include a large terminal box with ample room inside for the voltage regulator, most circuit breakers, and other options. The twelve generator stator lead wires and the exciter field leads terminate within the terminal box. The terminal box mounts on the outboard end of the generator.

SECTION 2 RECEIVING, INSPECTION, HANDLING INSTRUCTIONS AND STORAGE

RECEIVING YOUR KAMAG GENERATOR

Upon receipt of the generator it is recommended that it be carefully examined to determine if any shipping damage has occurred before accepting the shipment from the transportation company.

Generators received during freezing weather should be slowly warmed to prevent condensation of moisture on the windings.

WINDING INSPECTION

Winding inspection prior to operating the generator is recommended. If moisture is observed or condensation of moisture on the windings is suspected, a test of the stator winding insulation resistance should be made. If the result is less than the minimum value, the generator should be dried out.

Insulation resistance of the stator winding in the KAMAG generator should not be less than 1.48 megohms when calculated by the formula that follows.

$$\text{Minimum Winding Insulation Resistance in Megohms} = \frac{\text{Rated Voltage of Generator}}{1000} + 1$$

UNPACKING

Unpack the generator carefully. Make certain that foreign material such as crating nails and packing material does not enter the generator. Read all instruction cards and keep all instructions, drawings, and test cards with the generator as this information will be required by personnel when installing, operating, and servicing the equipment.

When lifting your KAMAG generator, attach an overhead crane to the lifting eye(s) located on the generator frame. Apply lifting force in a vertical direction if possible. Make certain that crane, lifting cables, and other hardware used is of sufficient strength to safely lift the weight of the generator. Generator weight may be determined by referring to the weight given on the shipment bill of lading.

WARNING

Do not lift complete generator set by means of lifting eye(s) on generator. Disregarding these instructions may result in serious injury or equipment damage.

WARNING

Do not apply any lifting force to generator fan for lifting or turning generator rotor. Failure to observe this instruction may result in serious injury or equipment damage.

STORAGE

When the generator will not be installed immediately it is recommended that it be stored in a clean, dry area which is not subject to rapid changes in temperature and humidity.

When storage will be for a period of six months or longer it is recommended the unit be wrapped with a thin water proof protective covering, and that a moisture absorbing agent such as bags of silica gel be placed within the covering.

SECTION 3 MOUNTING AND ALIGNING GENERATOR SET

HANDLING

A lifting eye is provided on top of the generator frame. The generator may be moved into position on the generator set base by means of an overhead hoist. Apply lifting force in vertical direction. Avoid applying angular force on the lifting eye.

WARNING

Lift vertically only. Angular force increases tension in hoist cable and applies shear force on lifting eye. Excessive angular force can result in breakage of cable or lifting eye which could cause serious injury and equipment damage.

After the generator and prime mover have been mounted on a single base, any further transporting or handling of the entire assembly must be made by using the lifting fixture provided on the base.

WARNING

Do not use generator lifting eye to lift entire generator set comprised of generator base and prime mover. Failure to observe this warning can result in serious injury and equipment damage.

BASES AND BED PLATES

A. Belted Generator Sets

Belt driven generator and its prime mover may be solidly mounted on a single base, separate bases, bed plates, or mounted directly on a level foundation.

In applications where vibration isolators are required, both the generator and its prime mover must be mounted on a single base of rigid construction with vibration isolators installed between the base and foundation.

B. Flexible Coupled Generator Sets

Where application requires that the generator and prime mover shafts be coupled with flexible couplings, both the generator and its prime mover must be mounted on a single base. Vibration isolators may be installed between the base and foundation.

Bases selected for flexible coupled operation must not twist or bend during mounting or operation of the generator set because maintaining alignment of the flexible coupling is important for maximum coupling life, maximum bearing life and minimizing vibration.

EXCITER ALIGNMENT AND BEARING ENDCLEARANCE

The generator is provided with factory lubricated shielded anti-friction ball bearings. Excessive thrust load will shorten bearing life and increase noise and vibration. In order to avoid thrust loading of the bearing, clearance should exist between the bearing and machined end of the bearing housing. Before coupling the generator to the prime mover, check to make certain bearing endclearance is correct. In applications where generator is driven through flexible coupling, care should be taken to make sure generator shaft is not pulled out of alignment while coupling and aligning the generator set.

Excessive axial misalignment of the exciter can result in lower than normal generator field excitation. This can result in excessive exciter field current under all loads from no-load to full load and lower than normal generator voltage when operating with load applied. Exciter alignment should be checked before coupling the generator to the prime mover and again after the generator has been coupled and aligned.

The rotor in KAMAG two bearing generators should have unrestrained axial travel from 1/16 inch to 3/32

inch. Each bearing in the two bearing KAMAG generator should have 1/32 inch to 3/64 inch endclearance. Check may be made by measuring length of shaft at driven end of generator as follows:

1. Pull rotor forward (towards drive end) until it stops. Front bearing will now have zero endclearance.
2. Measure length of shaft that extends beyond drive endbell.
3. Push rotor back until it stops. Rear bearing will now have zero endclearance.
4. Again measure length of shaft that extends beyond drive endbell.
5. Compute total rotor travel. Shaft length measured during step 2 minus shaft length measured during step 4 equals total rotor travel.
6. Compute one-half total rotor travel.
7. Pull rotor forward the distance determined during step 6. Rotor should be centered and each bearing should have correct endclearance.
8. Measure and record length of shaft that protrudes beyond drive endbell. This measurement should be used to determine that rotor has remained aligned during coupling and alignment of the generator set and also after generator set has been operated.
9. Check to make certain exciter is satisfactorily aligned. Axial misalignment between the exciter field core and exciter armature core should not exceed 0.125 inch.
10. After generator set is mounted, coupled, and aligned, check exciter alignment and verify that the length of shaft that extends beyond drive endbell is the same as that measured during step 8.

SELECTION OF DRIVES FOR TWO-BEARING GENERATOR

Satisfactory generator operation will depend upon intelligent selection of drive couplings. In general, solid couplings are not recommended except when the generator and prime mover frames are directly connected. Belt drives should not be used when belt speed exceeds 5000 feet per minute.

BELT DRIVES

Proper alignment and tightness of belt drives is essential. Improper alignment and belt tightness will increase belt wear as well as bearing load and vibration. Select belt drive in accordance with belt manufacturer's specifications. Make certain generator and prime mover are rigidly mounted. In general, belt drives are not recommended when belt speed exceeds 5000 feet per minute.

A. V-BELT

Use only matched belt sets and avoid minimum pitch sheaves and belts. Follow the manufacturer's specifications of NEMA limits for sheave pitch.

Make certain the shaft axis of the prime mover and generator are parallel. Belts must enter and leave sheaves with no side bending. Tighten just enough to prevent slippage at full load. Never grease or use belt dressing on belts.

B. SYNCHRONOUS BELTS

Synchronous belts have evenly spaced teeth on the bottom surface that mesh with grooves on the pulleys. In general, installation of synchronous belts will be the same as for flat belts. The following precautions should be taken when installing a synchronous belt drive.

1. Belts should be installed with snug fit, neither too tight nor too loose. High initial tension is not necessary but when torque is unusually high, a loose belt may "jump grooves". If the belt jumps the grooves the tension should be increased gradually until satisfactory operation is attained.
2. Be sure that shafts are parallel and pulleys are in alignment. On a long center drive, because of the tendency of the belt to run against the flange, it is sometimes advisable to offset the driven pulley to compensate.
3. On a long center drive, it is imperative that belt sag is not enough to permit teeth on the slack side to engage the teeth at the tight side.
4. It is important that both prime mover and generator are mounted rigidly to prevent variation in belt tension.
5. Although belt tension requires little attention after initial installation, provision should be made for some center distance adjustment for ease in installing and removing belt. Do not force belt over flange of pulley.

FLEXIBLE COUPLINGS

In applications where these types are used instead of belt drives, the generator and prime mover must be solidly mounted on a rigid base and shafts must be carefully aligned. Prior to installing the coupling half-sections the generator and prime mover shafts should be adjusted to a position that provides bearing end clearance; they should be carefully maintained at that position while mounting and coupling the units. When mounting the units and installing coupling half-sections, be sure to maintain clearance between shaft ends and check the generator exciter axial alignment. Where base mounts solidly to foundation, care should be taken to ensure foundation is level because mounting base to an uneven foundation could twist or bend base and cause coupling misalignment.

In application where vibration isolators are installed between the base and foundation, care should be taken to make certain base will support the weight and torsional load without bending or twisting.

ALIGNING FLEXIBLE COUPLINGS

Where flexible coupling drives are used, the generator and prime mover shaft centers must be in line. This is done by checking parallel or shaft offset alignment and angular alignment. Recommended method is given in the procedures that follow.

To correct alignment, shims may be installed between the generator mounting feet and the base and the prime mover mounting feet and the base. Alignment should be checked while mounting and coupling the generator set, then checked again after the generator set has been completely coupled and mounted on the base and the base has been installed on the foundation. Parallel and angular alignment tests may be done consecutively using one dial indicator, or simultaneously when two dial indicators are used.

A. Checking Parallel (Shaft Offset) Alignment

1. Mount dial indicator as shown in Figure 4. Where sufficient space exists, dial indicator may be mounted as shown in Figure 4(a). In applications where coupling halves are close together or when coupling is slightly out-of-round and not concentric with respect to the shaft centerline, fabricate rigid brackets and install brackets and dial indicator as shown in Figure 4(b).
2. Turn shafts simultaneously through one complete revolution observing dial indicator as shafts are turned.
3. Shafts should not be offset more than .002 inch total indicator reading (T.I.R.).
4. If offset is more than .002 inch T.I.R., install shims under generator or prime mover mounting feet, secure mounting bolts and again test alignment.
5. Repeat steps 2 through 4 until shaft offset is .002 inch or less.
6. Retest parallel (shaft offset) and angular alignment after coupling has been completely assembled, generator set mounting bolts have been tightened, and base has been secured to foundation. Mount dial indicator (or when used, "L" brackets) on outer surface of coupling hubs or on the shafts.
7. If T.I.R. exceeds .002 inch, check to make certain generator set base is level and has not twisted or bent. One or more of the following steps may be necessary:
 - a. Level foundation.
 - b. Place shim between base and foundation.
 - c. Strengthen base.

B. Checking Angular Alignment

1. Mount dial indicator as shown in Figure 5. Where sufficient space exists, dial indicator may be mounted as shown in Figure 5(a). In applications where coupling halves are close together or coupling face run-out exists, fabricate rigid brackets and install brackets and dial indicator as shown in Figure 5(b).
2. Turn shafts simultaneously through one complete revolution, observing dial indicator as shafts are turned.
3. Total indicator reading (T.I.R.) should not exceed .001 inch per inch of radius from shaft center.
4. Correct excessive angular misalignment either by turning the generator or prime mover on the base until shafts are aligned, or by installing shims between mounting pads and the base.
5. Repeat steps 2 through 4 until satisfactory angular alignment is attained.

6. Retest angular and parallel alignment after coupling has been completely assembled, generator set mounting bolts have been tightened, and base has been secured to foundation. Measure by installing dial indicator across outside of coupling or, where "L" brackets are used, mount brackets on shafts as close to the coupling as possible.
7. If excessive shaft offset or angular misalignment exists, check to make certain base has not bent or twisted. One of the following may be necessary.
 - a. Level foundation.
 - b. Place shim between base and foundation.
 - c. Strengthen base.

SECTION 4 ELECTRICAL CONNECTIONS

GENERAL

KAMAG generators have twelve stator lead wires that terminate within the terminal box. The two lead wires from the exciter field winding also terminate within the terminal box.

The generator may be connected three-phase series wye, three-phase parallel wye, three-phase series delta, three-phase parallel delta or single phase. The units may be operated 60 Hertz, 1800 rpm or 50 Hertz, 1500 rpm. The voltage regulating system voltage control rheostat permits adjustment of generator output voltage. Voltage generated when stator lead wires are connected in one of the configurations described above is listed in Table 1. Select the hookup that will provide the appropriate voltage. Be sure to connect the generator stator, load lines and voltage regulator as shown in the wiring diagram provided with the generator. Observe the general precautions that follow.

A. Three-Phase Wye Connected Generator

For a 4-wire system the neutral line may be brought out to the load distribution system. Where electrical code requires system ground, be sure the neutral leg is electrically connected to ground stud or ground wire.

B. Three-Phase Delta Connected Generator

Where generator is connected 3-wire delta, the stator connection neutral should not be connected to the ground stud and load lines do not contain a neutral line. The load conductors (phase A, B, and C) should not be grounded.

C. Single Phase Three Wire

Neutral (N) and two load conductors (L1 and L2) are contained in the load distribution system. Where electrical code requires system ground, neutral leg may be grounded.

D. Single Phase Two Wire

Two load conductors connect to the load distribution system. In single phase two wire 200-240 VAC applications where generator neutral is grounded, the two load conductors must not be grounded.

E. Generator Frame Ground

Generator frame should be connected to an earth ground in accordance with electrical code. Ground wire must be connected to the generator ground stud located above the left mounting foot.

F. Exciter Field Lead Wires

Exciter field lead wires F+ and F- connect to the voltage regulator output terminals F+ and F-. Be sure to maintain polarity. **THIS CIRCUIT MUST NOT BE EITHER GROUNDED OR OPENED WHILE GENERATOR IS RUNNING.**

G. Voltage Regulator

Refer to the voltage regulator instruction manual and the wiring diagram provided with the generator set. Make certain all internal and external connections are correct before operating the generator set.

CAUTION

Incorrect electrical connection of the voltage regulator can result in immediate equipment damage.

H. Voltage Regulator Fuse

This fuse protects the voltage regulator circuitry.

In applications where the generator set does not include a field circuit breaker it is recommended that a 1 1/2 ampere normal blow fuse be used in the voltage regulator. This is to protect the KAMAG generator against excessive voltage due to loss of sensing and excessive field forcing.

I. Voltage Shutdown Switch (Engine Idle Switch)

Where this accessory is provided, connect as described in the voltage regulator instruction manual and generator set wiring diagram.

J. Field Circuit Breaker

Where this accessory is provided, connect as described in the voltage regulator instruction manual and the generator set wiring diagram.

K. Automatic/Manual Voltage Control

Where this accessory is provided, connect as described in the voltage regulator instruction manual and the generator set wiring diagram.

L. Space Heaters

Where this accessory is provided, connect as described on the generator set wiring diagram.

SECTION 5 OPERATION

PRE-START INSPECTION

Before operating the generator for the first time, the following checks are recommended.

WARNING

When circuit breakers are not included with the generator, the terminals on the ends of the stator lead wires are not insulated. These terminals must be insulated before generator set is operated. Failure to observe this precaution can result in serious injury and equipment damage.

1. Make certain generator set base is level. Check to make sure bolts that mount the generator and prime mover onto the base are tight. Refer to procedure given in Section 3.
2. On belted generator set, make certain drive sheaves are aligned and belts do not have excessive slack. Where variable sheaves are used, check to make certain sheaves are adjusted to provide correct rpm. Check rpm with tachometer during initial startup of the unit.
3. On flexible coupled generator set, make sure coupling is aligned and generator bearings have end clearance. Refer to procedure given in Section 3.
4. Check to make sure fan bolts are tight and space exists between the fan and stator windings. Check to make sure exciter retaining bolt is tight.
5. Check all wiring against the proper connection diagrams and make sure all connections are properly insulated.
6. Inspect to make sure all packing materials and shipping support blocking has been removed. Remove loose cloths and tools.
7. Install covers and guards.

FIELD FLASHING

The generator relies on residual voltage to start the generator action which in turn generates the rated voltage. If the generator fails to generate voltage after it has come up to rated speed, it may be necessary to flash the exciter field. Field flashing must be done while the generator is at a standstill as described in the procedure that follows.

1. Stop the engine and open the output circuit breaker.

CAUTION

Be sure to maintain polarity (+) to (F+) and (-) to (F-).

2. Connect the negative lead (-) from a common 12 volt storage battery onto exciter field lead F-.
3. Connect the positive lead (+) from the battery onto exciter field lead F+. Only a few seconds flashing should be necessary.
4. Remove battery and connect exciter field leads onto voltage regulator terminals F+ and F-. Be sure to maintain correct polarity.
5. Start generator and check for satisfactory voltage build up.

VOLTAGE ADJUSTMENTS

A means for adjusting the voltage is incorporated in the regulator. For details refer to the voltage regulator instruction manual applicable for this unit.

VOLTAGE RANGE ADJUST

This control is incorporated in most voltage regulators. For details refer to the voltage regulator instruction manual applicable for this unit.

STARTING UP THE GENERATOR FOR SINGLE UNIT OPERATION

The following procedures should be followed for starting up the generator set.

1. The generator output must be disconnected from the load. Be sure the main circuit breaker is open.
2. If fuses have been removed, install the fuses.
3. Where generator set is equipped with field circuit breaker, set breaker to ON.
4. Where generator set is equipped with voltage shutdown switch, set switch to RUN position.
5. Where generator set is equipped with Automatic/Manual control, set switch to AUTO position.
6. Where space heaters have been supplied with the generator set, turn off the heater before operating the generator.
7. Where generator sets are equipped for parallel operation and include UNIT/PARALLEL switches, set switch to UNIT position whenever generator is operated singly.
8. Start generator set and bring to rated speed. Adjust voltage to required value by means of the voltage adjust rheostat.
9. Close the main circuit breaker and apply load.
10. Before stopping the generator set, remove the load by tripping the main circuit breaker.

SECTION 6 PREVENTIVE MAINTENANCE

INSPECTION

To ensure peak performance and maximum service life, the generator must be kept in good condition. This can best be ensured by periodic inspection of the unit and immediate repair of minor problems. The preventive maintenance inspection schedule that follows is enclosed as a guide for establishing a preventive maintenance program.

A. Daily or Whenever Generator is Operated

1. Before starting generator be sure air inlet and air exhaust screens are not clogged.
2. On belt driven generator application, check drive belts for wear and correct tension.
3. While generator is running be sure voltage is correct and not oscillating.
4. While generator is running observe any unusual noise or vibration.

B. Once Every Six Months

1. Remove terminal box cover and inspect wiring for signs of damaged insulation and loose or corroded connections. Repair damaged wiring; clean and tighten connections.
2. Inspect control devices for accumulation of dust, moisture or other foreign material. Clean using nylon bristle brush or compressed air at pressure between 25 PSI and 50 PSI.
3. Inspect to make certain that bolts which mount the voltage regulator, circuit breakers, meters, etc. have not loosened. Tighten as necessary.
4. Remove or loosen cover that surrounds generator frame. Inspect inside of generator frame. Inspect inside of generator for signs of damaged winding insulation and excessive dirt or moisture. Inspect to make certain bolts are tight.
5. Check to make sure generator set base is level. Check to make certain generator and its prime mover are solidly mounted on base.
6. On belted generator set applications, check belts for general condition and proper tightness (see Section 3).
7. On flexible coupled generator set applications, check coupling alignment (see Section 3). Where coupling is grease lubricated, lubricate coupling in accordance with the coupling manufacturer's instructions.

CLEANING

A. Controls

Clean using nylon bristle brush or compressed air at pressure between 25 PSI and 50 PSI.

B. Generator

Wipe exterior of generator and air intake and exhaust with cloth or nylon bristle brush. Clean loose dust or other abrasive material from generator interior using compressed air at pressure between 25 PSI and 50 PSI.

SECTION 7 TROUBLESHOOTING

GENERAL

Loose, corroded, or broken connections and wiring errors are often the cause of generator malfunction. Before assuming problem is within the generator or voltage regulator, check condition of wiring and terminal connections and verify wiring according to wiring diagrams provided with the generator set.

TROUBLESHOOTING PROCEDURE

The troubleshooting information that follows is divided by symptoms. They are: no voltage, low voltage, high voltage, and voltage fluctuating.

Observe the safety precautions in the Safety Summary at the front of this manual before operating, testing or making repairs to this equipment.

A. No Voltage

1. Shut down the generator set.
2. Remove terminal box cover and check generator leads and interwiring to the voltage regulator for loose or broken connections.
3. Check regulator fuses with ohmmeter. If defective, replace.
4. Start up generator. Measure ac voltage at input power terminals on the voltage regulator. The voltmeter reading should exceed 7 vac. If it does not, field flashing is required. Refer to field flashing procedure in Section 5 of this manual.
5. Where voltage reading before or after field flashing exceeds 7 vac but output voltage fails to build-up, shut down the generator set. Then proceed as described to either step 6 or steps 7 and 8 that follow.
6. Connect meters as shown in Figure 8. Then start generator set and measure exciter field excitation as described in Section 8.
7. Shut down the generator set. Disconnect voltage regulator by removing the voltage regulator fuse. Where regulator does not include fuse, disconnect voltage regulator by removing the connections to the regulator input power terminals. Insulate terminal lugs on wires to prevent grounding during test described in step 8 that follows.
8. Disconnect wires F+ and F- from regulator output terminals F+ and F-. Connect a common 12 volt storage battery to wires F+ and F-, keeping the polarity the same. Start up the generator set. While the generator is operating at a rated speed, read the voltage output of the generator measured by a voltmeter. If the reading is one-half or greater of the rated output when there is no load on the generator, the problem is in the voltage regulator. If the voltage remains near zero, the voltage regulator is good, and the problem is most likely within the exciter or generator. Shut down the generator. Reconnect the voltage regulator and proceed to step 9.
9. Remove cover located on end of terminal box. Examine the rectifier diodes for loose or broken connections. Proceed to step 10.
10. Test the generator exciter rotating rectifier diodes as described in the procedure contained in Section 8. Refer to Figures 3 and 7. Install diodes as described in Section 9 and then reconnect generator field leads.
11. Test zener diode surge suppressor as described in Section 8. Reverse polarity zener diode is located on the exciter rectifier negative heat sink, while the rectifier positive heat sink mounts a forward polarity zener diode. Part location and electrical connections are shown on Figures 3 and 7. Install and torque zener diode 15 inch-lbs. Connect zener diodes together and connect generator field leads (see Figure 3). If above test indicates zener diodes were good, proceed to step 12.
12. Check windings for continuity as described in the winding resistance test procedure contained in Section 8. If opens or shorts are found in the exciter stator or exciter armature, replace the necessary component. If the condition is found in the generator stator or the generator rotor field winding, major repair or generator replacement is probably required.
13. Connect wiring in accordance with wiring diagram(s) provided with the generator set.

B. Low Voltage

1. Test using auxiliary voltmeter connected at generator load leads.
2. Shut down the generator set.
3. Remove cover located at end of terminal box. Check main generator leads and wiring to the voltage regulator for correct connection. Make certain that connections are tight and not corroded.
4. Start up the generator set. Verify correct speed (1800 rpm for 60 hertz and 1500 rpm for 50 hertz).
5. Be sure the voltage adjust rheostat is adjusted as necessary to increase generator voltage.
6. Adjust the voltage range potentiometer clockwise to increase generator voltage.
7. Where voltage is normal with no-load applied but drops with load applied, make certain load does not exceed nameplate capacity. Verify using clamp-on ammeter on the generator load lines. Current in any line must not exceed nameplate amps.
8. Shut down the generator set and open the output circuit breaker.
9. Check wiring to the voltage regulator sensing and input power terminals. Where voltage regulator has multi-tap sensing transformer, make certain connections to the transformer are correct. Where voltage regulator has different internal connections for 60 hertz and 50 hertz operation, verify connections are correct. Where voltage regulator is of the series boost saturable transformer type, verify that boost winding is connected correctly. Refer to the voltage regulator instructions and the wiring diagrams provided with the generator set. Where connections are found to be correct, proceed as follows.
10. Continue by testing either field excitation as described in step 11 or test using battery as described in steps 12 through 14.
11. Connect meters as shown in Figure 8. Then start generator set and measure exciter field excitation as described in Section 8.
12. Disconnect the voltage regulator by removing wires at the regulator input power terminals and the regulator output terminals F+ and F-. Tape ends of input power wires to prevent accidental ground or short during the test described in step 11.
13. Connect a common 12 volt storage battery to exciter field lead wires F+ and F-, keeping the polarity the same. Start up the generator set. While the generator is running at rated speed, read the voltage output. If the reading is one-half or greater when there is no-load on the generator, the problem is in the voltage regulator. If the reading remains near zero, the problem is most likely within the exciter or generator.
14. Shut down the generator set. Remove battery and reconnect voltage regulator determined to be in good condition. If preceding test indicated that the problem was within the exciter or generator, test as described in the steps that follow.
15. Remove the cover located on end of terminal box. Examine the rotating rectifier diodes for loose or broken connections. If connections are good, proceed to step 16.
16. Test rotating rectifier diodes using an ohmmeter as described in Section 8. If one reading is high and the other is low, the diode is good. A shorted diode will have very low resistance in both forward and reverse polarity while an open circuited diode will exhibit high resistance in both forward and reverse polarity. Install good or replacement diodes as described in Section 9. Connect generator field leads.
17. Test zener diode surge suppressors as described in the procedure contained in Section 8. Install, torque, and wire zener diode surge suppressors as described in Section 9. Reconnect generator field leads. If test indicated zener diodes were good, proceed to step 18.
18. Check windings for continuity as described in the winding resistance test procedures contained in this manual. If opens or shorts are found in the exciter stator or exciter armature, replace the necessary component. If the condition is found in the generator stator or rotor, major repair or generator replacement is probably required.

C. High Voltage

1. Verify by testing with an auxiliary voltmeter at the generator load lines.
2. Be sure the voltage adjust rheostat is adjusted as necessary to reduce voltage.
3. Adjust the voltage range potentiometer in the voltage regulator counter-clockwise to reduce voltage.
4. Shut down the generator set and open the generator output circuit breaker.
5. Remove terminal box cover and check generator set wiring for correct connection.

6. Check wiring to the voltage regulator sensing and input power terminals for correct connection. Check voltage regulator sensing transformer for correct connection. Where voltage regulator includes different internal connections for 50 Hertz or 60 Hertz, verify that connections are correct. Where voltage regulator is of the type that has boost transformer or winding, verify that connections are correct. Refer to the wiring diagrams provided with the generator set and the voltage regulator instructions.

D. Voltage Fluctuating

1. Verify generator voltmeter performance using auxiliary voltmeter at generator lines.
2. Verify with a tachometer to ensure stable speed.
3. Where generator is providing power to SCR type load, transient voltage spikes during SCR switching can cause voltage to fluctuate. If this is the case, set stability adjust for slower regulator response.
4. Adjust voltage regulator stability control potentiometer as described in the voltage regulator instruction manual. Test with no load applied and again with load applied.
5. Shut down generator set and open generator output circuit breaker. Remove the terminal box cover and check all wiring for loose connections.
6. Where wiring is found to be correct and in good condition, proceed to either step 7 or steps 8 and 9.
7. Connect meters as shown on Figure 8 and measure exciter field excitation as described in Section 8.
8. Shut down generator set and remove cover located on end of terminal box. Proceed to step 9.
9. Disconnect the voltage regulator by removing the connections to the regulator input power terminals. Tape lugged ends on wires to prevent ground or short during test. Remove F+ and F- exciter field lead wires from the F+ and F- terminals on the voltage regulators. Connect a common 12 volt storage battery onto exciter field leads F+ and F- keeping the polarity the same. Start up the generator set. While generator is operating at rated speed, read the voltage output on a voltmeter. Following this procedure, if the voltage is one-half or greater of rated output and does not fluctuate when there is no load on the generator, the problem is within the voltage regulator. Consult the voltage regulator instruction manual for further information.

SECTION 8 GENERATOR TESTS

MEASURING EXCITER FIELD EXCITATION

Exciter field excitation can be measured using a dc voltmeter and dc ammeter connected in the circuit between the voltage regulator dc output and exciter field as shown in Figure 8. The meters must be capable of measuring full load excitation. This will vary according to the size of the generator and can be determined from the test card attached to the generator or by contacting Kato Engineering/Reliance Electric, Mankato, Minnesota. Be sure to provide the generator serial number when requesting information.

Procedure

Observe the safety precautions in the Safety Summary at the front of this manual before operating, testing or making repairs to this equipment.

1. Connect dc voltmeter and dc ammeter as shown in Figure 8.
2. Start unit and run at rated speed.
3. Measure no-load excitation. The following abnormal conditions could occur.
 - a. Generator Output Voltage Low, with Normal or Higher than Normal Excitation**
If this condition occurs, the problem is within the generator or exciter. Test the rotating rectifier diodes and winding resistance.
 - b. Generator Voltage Low and Excitation Low**
If this condition occurs, the problem is within the voltage regulator or the wiring to the voltage regulator.
 - c. No Generator Voltage and No Excitation**
If this condition occurs, flash exciter field to restore residual magnetism as described in the procedure given in Section 5 in this manual.
4. Measure excitation with full load applied. The following abnormal conditions could occur.
 - a. Generator Voltage Low and Full-Load Excitation Normal or Higher Than Normal**
If this condition occurs, verify that speed is not low. Make certain load does not exceed rated full load current given on the generator nameplate.
 - b. Generator Voltage Low and Full Load Excitation Low.**
If this condition occurs, problem is within the voltage regulator.

TESTING EXCITER ROTATING RECTIFIER DIODES

Observe the safety precautions in the Safety Summary at the front of this manual before operating, testing or making repairs to this equipment.

Stop generator set. Remove cover located on end of terminal box. Test as described in the procedure that follows using ohmmeter or three-volt test light.

NOTE: Where three-volt test light is used: bulb should light when connected in low resistance circuit and should not light when connected in high resistance circuit.

1. Unsolder wire connected to diode, then remove diode from heat sink (see Figure 3).
2. Measure resistance across diode. Reverse meter probes and again measure resistance.
A good diode will have low resistance in the normal direction of current flow and high resistance to reverse current. High resistance both forward and reverse indicates diode has become open and should be replaced. Where light is used, failure of bulb to illuminate in both forward and reverse tests indicates an open diode.
Very low resistance both forward and reverse indicates a shorted diode.
Where light is used, diode is shorted when light illuminates during both forward and reverse polarity test.
3. Install diode. Torque 15 inch-pounds. Where original diode is replaced, make sure replacement diode is of the same rating and polarity.

4. Solder wire onto diode (see Figures 3 and 7).
5. Repeat steps 1 through 4 until each diode has been tested.

TESTING ZENER DIODE SURGE SUPPRESSOR

Observe the safety precautions in the Safety Summary at the front of this manual before operating, testing or making repairs to this equipment.

Stop generator set. Remove cover located on end of terminal box. Using an ohmmeter, measure zener diode forward polarity and reverse polarity resistance as described in the procedure that follows.

1. Unsolder wire that connects the zener diode located on the negative heat sink to the zener diode located on the positive heat sink. Then remove zener diode (see Figures 2 and 3).
2. Measure resistance across zener diode. Reverse meter probes; again measure resistance. Zener diode in good condition should have very high resistance, near infinity (∞) in one direction and resistance in the range of 1.25 to 3.0 megohms in the opposite direction.
Very low resistance in both forward and reverse polarity indicates zener diode is short circuited and should be replaced while infinity resistance both forward and reverse indicates zener diode is open circuited and should be replaced.
3. Install zener diode. Torque 15 inch-pounds. Where original zener diode is replaced, make sure replacement zener diode is of the same rating and polarity (see Figures 3 and 7).
4. Test second zener diode as given in steps 1 through 3.
5. Carefully solder wire connecting zener diodes together (see Figures 3 and 7).

MEASURING WINDING RESISTANCE

Observe the safety precautions in the Safety Summary at the front of this manual before operating, testing or making repairs to this equipment.

Resistance test of winding may be made to determine whether winding has become open circuited. Resistance measured across a winding that has become open circuited will be very high (near infinity). In the case of shorted turns, resistance will generally be lower than normal. Where shorted turns are suspected, additional test using growler is recommended. Short to ground may be determined by testing winding insulation resistance using a hand cranked 500 VDC megger.

Resistance of winding will vary in proportion to the winding temperature. Where winding temperature is either higher or lower than 25°C (77°F), the formula that follows should be used to compute resistance.

$$\text{Resistance at } 25^{\circ} \text{ C} = \text{Measured Resistance} \times \frac{234.5 + 25}{234.5 + \text{Winding temp. in } ^{\circ} \text{C}}$$

A. Measuring Exciter Field Winding Resistance

Test as follows:

1. Stop generator set and remove cover located on end of terminal box.
2. Remove exciter field leads F+ and F- from the F+ and F- terminals on the voltage regulator.
3. Connect ohmmeter onto exciter field leads F+ and F- and measure exciter field winding resistance.
4. Where winding temperature is either high or lower than 25° C, compute resistance as given in the formula contained in preceding topic "Measuring Winding Resistance."
5. Before starting generator set be sure to connect field leads onto voltage regulator terminals F+ and F-. Maintain correct polarity (F+ to F+ and F- to F-).

B. Measuring Generator Field Winding Resistance

Test as follows:

1. Stop generator set and remove cover located on end of terminal box.
2. Remove generator field leads from the exciter rotating rectifier heat sink (+) and (-) terminals.
3. Connect test instrument such as Wheatstone bridge or Kelvin bridge onto generator field leads and measure generator field winding resistance.
4. Where winding temperature is either higher or lower than 25°, compute resistance as given in the formula contained preceding topic "Measuring Winding Resistance."
5. Before starting generator set, be sure to connect generator field leads onto the rotating rectifier heat sinks. Maintain correct polarity (positive to + and negative to -).

C. Measuring Exciter Armature Winding Resistance

This test requires removing the exciter armature lead wires from the exciter rotating rectifier diodes (refer to Figures 2 and 3).

Test as follows:

1. Stop generator set and remove cover located on end of terminal box.
2. Observe which of the exciter rotating rectifier diodes each of the three exciter armature leads connect to. Then unsolder any two of the three exciter armature lead wires.
3. Measure exciter armature phase-to-phase resistance using test instrument such as Kelvin bridge connected between exciter armature phase 1 lead wire and phase 2 lead wire. Repeat measuring from phase 1 to 3 and again phase 2 to 3.
4. Phase to phase resistances should be quite similar. Where winding temperature was either higher or lower than 25° C, compute resistance as given in formula contained in preceding topic entitled "Measuring Winding Resistance."
5. Before starting generator set be sure to solder leads onto the exciter rotating rectifier diodes (refer to Figures 3 and 7).

D. Generator Stator Winding Resistance

The stator has twelve lead wires brought out from the coil groups permitting connection of the generator stator winding series wye, parallel wye, series delta, parallel delta, or single phase. It is recommended that when testing winding resistance the stator be connected three-phase series wye by connecting the stator leads as shown in Figure 6.

Test as follows:

1. Stop generator set and remove cover located on end of terminal box.
2. Disconnect the twelve generator stator leads numbered 1 through 12 from outgoing load lines, and the leads to voltage regulator, current transformers, and meters.
3. Connect stator leads in series wye configuration as shown in Figure 6 (a).
4. Measure resistance Phase 1 to 2 using a Kelvin bridge. Then measure Phase 1 to 3 and Phase 2 to 3. Phase to phase resistances should be quite similar. Where winding temperature was either higher or lower than 25° C, compute resistance as given in formula contained in preceding topic entitled "Measuring Winding Resistance".
5. Connect generator wiring as shown on the wiring diagram provided with the generator set.

MEASURING WINDING INSULATION RESISTANCE

Observe the safety precautions in the Safety Summary at the front of this manual before operating, testing or making repairs to this equipment.

The insulation resistance will slowly decrease over the normal life of the generator. Test will indicate abnormal decrease in insulation resistance. Where insulation resistance test is to be made, use a 500 VDC hand cranked megger.

A. Measuring Generator Stator Winding Insulation Resistance

1. Stop generator set and remove cover located on end of terminal box.
2. Disconnect wiring from the twelve generator stator lead wires.
3. Connect stator leads in series wye configuration as shown on Figure 6 (a). Be sure to remove neutral lead from ground connection.
4. Connect megger ground lead to generator frame.
5. Connect megger lead onto phase 1 stator lead wire number 1. Make certain no connections other than the megger ground lead are touching the generator frame or other metal parts.
6. Test stator winding insulation resistance. Resistance should not be less than 1.48 megohm. If insulation resistance is lower than minimum value given above, determine cause of low insulation resistance. If due to wet windings, dry out the generator as described in Section 9 in this manual.

7. Before operating generator, connect wiring as shown on the wiring diagram supplied with the generator set. Install covers.

B. Measuring Generator Field Winding Insulation Resistance

Use 500 VDC hand cranked megger.

Test as follows:

1. Stop generator set and remove cover located on end of terminal box.
2. Disconnect the generator field leads from the (+) and (-) terminals located on the exciter rotating rectifier assembly heat sinks.
3. Connect megger ground lead onto either the generator shaft, fan, or drive hub.
4. Connect megger test lead onto either of the generator field lead wires. Make certain non-insulated lugs on field leads are not touching any generator parts.
5. Measure generator field winding insulation resistance. If the generator field winding insulation resistance is less than one megohm, determine cause of abnormally low insulation resistance. If due to wet windings, dry out generator as described in Section 9 in this manual.
6. Before operating the generator set, connect generator field leads onto exciter rotating rectifier heat sink (+) and (-) terminals (See Figure 3). Install covers.

C. Measuring Exciter Field Winding Insulation Resistance

Test using 500 VDC hand cranked megger as follows:

1. Stop generator set and remove cover located on end of terminal box.
2. Disconnect exciter field leads F+ and F- from the voltage regulator terminals F+ and F-.
3. Connect megger ground lead to the generator frame.
4. Connect megger test lead onto either exciter field lead F+ or exciter field lead F-. Make certain non-insulated ends on leads F- and F+ do not touch any metal parts.
5. Measure exciter field winding insulation resistance. If insulation resistance is less than one megohm, determine cause of abnormally low insulation resistance. If due to wet winding, dry out generator as described in Section 9 in this manual.
6. Before operating generator set, connect F+ lead wire onto voltage regulator terminal F+ and lead wire F- onto voltage regulator terminal F-. Install covers.

D. Measuring Exciter Armature Winding Insulation Resistance

Test using 500 VDC megger as follows:

1. Stop generator set and remove cover located on end of terminal box.
2. Using soldering gun, disconnect the three exciter armature lead wires from the exciter rotating rectifier assembly (see Figures 3 and 7).
3. Insulate non-insulated ends on two of the lead wires to prevent grounding during test.
4. Connect megger test lead onto the remaining exciter armature lead wire. Make certain non-insulated connection does not touch any metal part during test.
5. Connect megger ground lead onto either the generator shaft, fan, or drive hub.
6. Measure exciter armature winding insulation resistance. If insulation resistance is less than one megohm, determine cause of abnormally low insulation resistance.
7. Before operating generator set, solder exciter lead wires onto the exciter rotating rectifier assembly (see Figures 3 and 7).

SECTION 9 DRYING WINDINGS AND REMOVING AND INSTALLING PARTS

DRYING GENERATOR

An excessive accumulation of moisture on the generator windings can reduce the winding insulation resistance. The recommended stator winding insulation resistance test procedure and the minimum allowable insulation resistance is described in Section 8 in this manual.

Where moisture is present and test indicates insulation resistance does not exceed the minimum standard, thoroughly dry out the generator before operating the machine. The following are recommended drying methods.

A. Heat Enclosure

Remove the generator cover. Enclose the generator and insert heating units such as space heaters, lamps, or coils of steam pipe to raise the temperature. Leave a hole at the top of the enclosure to permit the escape of moisture. Temperature within the enclosure should not exceed 93 degrees C or 200 degrees F. The voltage regulator and any electronic components must be removed from the generator when using this method.

B. Forced Air

A portable forced air heater can be used to direct heat into the exciter end of the generator through openings in the endbell. Heat at point of entry should not exceed 93 degrees C or 200 degrees F.

C. Oven

Place the machine in a thermostat controlled oven and bake it at a temperature not to exceed 93 degrees C or 200 degrees F. The voltage regulator and any electronic component accessories must be removed from the generator when using this method.

REMOVING AND INSTALLING EXCITER ROTOR

The exciter rotor, Figure 2, consists of the exciter armature and the full-wave rotating rectifier assembly. The assembly mounts on an extension of the generator shaft that protrudes beyond the generator endbell. The exciter rotor assembly is held in place on the shaft by a rectangular key on the shaft and a bolt and washer on the end of the shaft. The inside surface on the exciter armature core is pushed against a raised shoulder on the generator shaft. The exciter has a small air gap with respect to that of the generator. For this reason the exciter rotor should be removed while transporting, assembling, or disassembling the generator and while coupling the generator to the prime mover.

A. Removing the Exciter Rotor

1. Remove cover located on end of generator terminal box.
2. Disconnect the generator field leads from the rotating rectifier (+) and (-) terminals.
3. Remove exciter retaining bolt from end of generator shaft.

NOTE: If exciter rotor cannot easily be removed by hand, a 1/4-20 bolt can be threaded into the tapped hole next to the exciter rotor. This action will push the exciter rotor off the shaft.

CAUTION

Do not pull on or strike the exciter armature windings.

4. Pull exciter rotor assembly off generator shaft. Pull rectangular key out of the keyway in shaft and keep it with the exciter rotor assembly.

B. Installing Exciter Rotor

1. Install rectangular key in keyway located in generator shaft.
2. Align keyway in the exciter armature core with the key and push exciter rotor onto shaft. **DO NOT PUSH OR STRIKE WINDING OR RECTIFIER. MAKE SURE INSIDE EDGE ON ARMATURE CORE IS AGAINST RAISED SHOULDER ON SHAFT.**
3. Install exciter retaining bolt on end of shaft. Torque 1/2 inch bolt to 60 foot-pounds.

4. Check exciter air gap. Air gap should not be less than that listed in Table 4. Check to make certain exciter armature core and the exciter field core are axially aligned.
5. Connect generator field leads onto rotating rectifier (+) and (-) terminals (refer to Figure 7).
6. Install cover on terminal box.

REMOVING AND INSTALLING TERMINAL BOX AND OUTBOARD ENDBELL

These parts must be removed to service or replace the bearing located at the exciter end of the generator. Be sure to follow the handling precautions described in Section 2 in this manual. Parts are shown on Figures 1 and 2.

A. Removing the Terminal Box and Outboard Endbell

1. Remove the side covers and the louvered end cover from the terminal box.
2. Disconnect incoming electrical cables and conduit. Disconnect stator leads.
3. Disconnect electrical wiring from voltage regulator and other controls mounted within the terminal box.
4. Remove the exciter rotor, comprised of the exciter armature and rotating rectifier assembly. Follow the steps given in procedure titled "Removing the Exciter Rotor."
5. Remove fiber wire retaining ring.
6. Remove parts that mount onto the back plate of the terminal box and the endbell.
7. Remove cover that surrounds the generator frame.
8. Place rotor support blocking in the generator air gap.
9. Remove bolts that mount the terminal box and the endbell onto the generator frame.
10. Remove terminal box.
11. On larger generators, attach hoist onto endbell. Take up slack but do not lift generator.
12. Pry endbell loose from pilot recess located in the frame endring.
13. Pull endbell straight back to position where bearing outer race is out of the bearing housing at the center of the endbell.
14. Remove endbell.
15. Some units may have circular fiber spacers located in the bearing housing section of the endbell. If this is the case, be sure to install spacers when reinstalling endbell.
16. Inspect and clean rust and dirt from the mounting face on endbell and the bearing housing. Remove any metal burrs.
17. Wipe a thin coat of grease in the bearing housing section of the endbell.

B. Installing Terminal Box and Outboard Endbell

During this procedure be sure to follow the handling precautions described in Section 2 in this manual. Refer to Figure 1 and the wiring diagram provided with the generator set.

1. Where generator was provided with circular spacers in the bearing housing section of the endbell, install the spacers.
2. Inspect to make certain bearing and mounting face on endbell is free of rust, dirt, and metal burrs.
3. Wipe thin coat of grease in bearing housing section in endbell.
4. Lift endbell into alignment with the bearing and carefully push bearing housing section on endbell over the outer race of the bearing.
5. Place endbell over end of shaft and turn endbell to position where lead wire hole in endbell aligns with lead wires. Pull stator leads through opening in the endbell. Make certain generator field leads are along wireway on shaft.
6. Push endbell bearing housing over the bearing outer race.
7. Mount terminal box and endbell onto the generator frame using hex head bolts and washers. Watch to make certain endbell fits evenly into pilot recess, and sequentially tighten bolts. Torque bolts according to recommended torque for SAE 5 cap screws given in Table 3.
8. Remove rotor support blocking from generator.
9. Install fiber wire retaining ring.
10. Install the exciter rotor as described in procedure titled "Installing Exciter Rotor."
11. Mount voltage regulator and controls.

12. Connect electrical wiring according to appropriate wiring diagram.
13. Before operating generator set, check to make certain unit is connected correctly and terminals are tight and insulated.
14. Remove tools and shop cloths.
15. Install covers and guards.

REMOVING AND INSTALLING DRIVE ENDBELL

The drive endbell encloses the driven end of the generator and also functions as the housing around the generator fan. This part must be removed to service or replace the bearing located at the driven end of the generator.

A. Removing Drive Endbell

1. On belt driven applications, remove drive belts and sheaves before removing endbell. Where generator is driven through flexible coupling, remove coupling and remove generator from the base before removing the drive endbell.
2. Loosen or remove cover that surrounds generator frame.
3. Place rotor support blocking in generator air gap.
4. Remove dripproof cover and screen from around endbell.
5. Remove bolts that mount the drive endbell onto the generator frame.
6. Pry endbell loose from pilot recess located in the frame endring.
7. Pull endbell straight back to position where bearing outer race is out of the bearing housing at the center of the endbell.
8. Remove endbell.
9. Remove air baffle located between the endbell and frame endring.
10. Some units may have circular fiber spacers located in the bearing housing section of the endbell. If this is the case, be sure to install spacers when reinstalling endbell.
11. Inspect and clean rust and dirt from the mounting face on endbell and the bearing housing. Remove any metal burrs.
12. Wipe a thin coat of grease in the bearing housing section of the endbell.

B. Installing Drive Endbell

During this procedure be sure to follow the handling precautions described in Section 2 in this manual. Refer to Figure 1 and the wiring diagram provided with the generator set.

1. Where generator was provided with circular spacers in the bearing housing section of the endbell, install the spacers.
2. Inspect to make certain bearing housing and mounting face on endbell is free of rust, dirt, and metal burrs.
3. Wipe thin coat of grease in bearing housing section in endbell.
4. Install air baffle.
5. Lift endbell into alignment with bearing and carefully push endbell over bearing.
6. Turn air baffle and endbell to position where bolt holes align with tapped holes in frame endring.
7. Sequentially tighten bolts that mount endbell onto the frame endring. Make certain endbell fits evenly into the pilot recess located in frame endring. Torque bolts. Refer to recommended torque for SAE 5 cap screws given in Table 3.
8. Remove support blocking from the generator air gap.
9. Remove tools and shop cloths.
10. Install generator covers.
11. Mount and align generator. Refer to procedures given in Section 3.

REMOVING AND INSTALLING BEARING

If the bearing(s) need to be removed for any reason, always install a new bearing. Remove and install bearing according to the general procedure that follows. Be sure to follow the handling precautions described in Section 2 in this manual.

1. Remove appropriate endbell.
 - a. To replace drive bearing first remove drive endbell according to "Removing and Installing Drive Endbell" procedure.
 - b. To replace outboard bearing, first remove exciter rotor, terminal box and endbell as described in "Removing and Installing Exciter Rotor" and "Removing and Installing Terminal Box and Outboard Endbell" procedures.
2. Remove bearing with suitable puller.
3. Apply a thin coat of clean lubricating oil or anti-seize lubricant to the pressure fit on the rotor shaft.
4. Heat the new bearing in an oven to a maximum temperature of 225°F.

CAUTION

Under no circumstances should pressure be applied to the outer race of the bearing, as permanent bearing damage could result.

CAUTION

Before installing bearing located at exciter end of generator, make sure generator field leads are in place in the wireway machined along generator shaft.

CAUTION

When handling heated bearing, wear protective clothing and gloves.

NOTE: The bearing should slide on the shaft and be seated without excessive force. If the bearing binds on the shaft before being fully seated, a piece of tubing slightly larger than the shaft diameter can be placed over the shaft and the bearing can be slid in place by tapping lightly on end of tubing with a soft mallet. Care must be taken to ensure pressure is applied to the inner race only.

5. Wearing protective gloves, start bearing evenly onto machined bearing journal section of the generator shaft.
6. Before bearing is allowed to cool, push bearing into place on shaft using a metal or fiber pipe with I.D. larger than the shaft. When properly installed, the bearing inner race will be against the step on the shaft.
7. Allow bearing to cool.
8. Install endbell. Refer to appropriate procedure.
 - a. Where drive bearing was replaced follow "Installing Drive Endbell" procedure.
 - b. Where outboard bearing was replaced follow "Installing Terminal Box and Outboard Endbell" procedure.
9. Where outboard bearing was replaced, install exciter rotor as given in the "Installing Exciter Rotor" procedure.
10. Remove rotor support blocking from generator air gap.
11. Where drive end bearing was replaced, mount, couple, and align generator as given in Section 3.
12. Remove tools and shop cloths.
13. Install covers.

REMOVING AND INSTALLING GENERATOR FAN

The fan consists of two half-sections bolted together. Access to the fan bolts is attained by removing the screen and dripproof shield that surrounds the drive endbell. In general, it will be necessary to remove the fan or loosen the fan bolts only when one of the following repair procedures is required:

1. Maintenance on fan blades or hub.
2. Removal of generator rotor through exciter end of generator.
3. Installation of original fan on a replacement rotor.

A. Removing Fan

NOTE: Do not remove fan or loosen fan blades unless it is absolutely necessary. Refer to preceding description.

1. Remove covers that surround generator frame and drive endbell.
2. Measure and record one or both of the following dimensions before loosening fan bolts.
 - a. Measure from the fan blades to the air baffle.
 - b. Measure from the fan hub to the drive bearing.

NOTE: When installing fan, position the fan on the shaft according to distance measured during step 2.

3. Place support blocking in generator air gap, remove coupling and remove drive endbell as given in "Removing and Installing Drive Endbell" instructions.
4. Loosen fan bolts and remove fan.

B. Installing Fan

1. Position fan on generator shaft at distance measured during step 2 of preceding "Removing Fan" instructions.
2. Torque fan bolts according to recommended torque fan SAE 5 cap screws.

REMOVING AND INSTALLING GENERATOR ROTOR

Rotor removal requires removal of the following parts:

1. Exciter rotor
2. Outboard endbell and terminal box
3. Drive endbell
4. Drive coupling or on belted generator sets the drive sheaves and belts

NOTE: On flexible coupled generator sets, unless there is sufficient space for removing the rotor through the outboard end of the generator, it will be necessary to remove the generator from the base.

Where rotor will be removed from drive end, the generator fan should be left in place on the rotor. Rotor removal through the outboard or exciter end requires the fan to be removed from the shaft before attempting to slide the rotor out of the stator.

A. Removing Rotor

Determine direction rotor will be removed from stator. Refer to preceding note and items 1 through 4.

1. Remove required parts according to the appropriate instructions given in preceding parts of Section 9.
2. Where rotor will be removed from drive end of generator, obtain a burr free metal pipe that is as long as the generator stator and has an I.D. slightly larger than the shaft. Slide the pipe over the portion of the generator shaft that mounts the exciter rotor.
3. Where rotor will be removed from exciter end of generator, obtain a burr free metal pipe that is as long as the generator stator and has an I.D. slightly larger than the shaft. Slide the pipe over the driven end of the generator shaft.

4. Follow either step a or b.
 - a. Install portable jack under the pipe and another under the shaft at the opposite end.
 - b. Wrap cable around the pipe and attach to an overhead hoist. Wrap a cable about the generator shaft at the opposite end of generator and attach cable to another hoist.

CAUTION

While removing and installing rotor, visually check to make certain that windings do not strike or rub against parts in the generator.

5. Carefully lift both ends of generator rotor to position where air gap exists around entire O.D. of rotor core structure.
6. Move rotor out of stator by moving the jacks or hoists. Visually check to make certain that air gap is maintained and windings do not strike or rub against other parts of the generator.
7. Place rotor on support blocks.

B. Installing Rotor

1. Lift rotor into alignment with the stator.
2. Install pipe through stator and onto end of rotor shaft. See steps 2 and 3 of preceding "Removing Rotor" instructions.
3. Attach cables and hoists or use jacks as described in step 4 of "Removing Rotor" procedure.
4. Carefully move rotor into stator watching to make sure air gap is maintained and windings do not strike or rub on generator parts.
5. Install rotor support blocks in air gap.
6. Lower rotor onto rotor support blocking. Then remove cables and hoists or jacks.
7. If fan was removed, install fan.
8. Install drive endbell as described in "Installing Drive Endbell" procedure.
9. Install outboard endbell and terminal box as described in "Installing Terminal Box and Outboard Endbell" procedure.
10. Measure to make certain fan is correct distance from air baffle. Refer to "Installing Fan" procedure. Torque fan bolts in accordance with recommended torque for SAE 5 cap screws given in Table 3.
11. Install exciter rotor as given in the "Installing Exciter Rotor" procedure.
12. Remove support blocking from generator air gap.
13. Turn generator rotor slowly by hand. Visually check to make certain rotating parts do not rub on stationary parts.
14. Mount, couple and align generator. Refer to procedures given in Section 3.
15. Remove tools and shop cloths.
16. Connect electrical wiring.
17. Install covers.

SECTION 10 FIGURES AND TABLES

GENERAL

The drawings, electrical schematics, and tables contained in this section are included to aid in the installation and maintenance of this equipment. The overall electrical connection diagram supplied with the generator set should be followed when connecting the stator lead wires, voltage regulator, and any other operating controls provided with this unit.

**Table 1
Generator Voltage - Standard Kamag Generators**

Connection (See Note)	Voltage Range (By Adjustment of voltage control rheostat)	
	50 Hertz	60 Hertz
3 Phase series wye (Phase-to-Phase)	340 to 400	408 to 490
3 Phase parallel wye (Phase-to-Phase)	170 to 200	204 to 245
3 Phase series delta (Phase-to-Phase)	196 to 230	236 to 283
Single Phase 3 wire (Line-to-Line)	196-230	236 to 283

NOTE: Phase-to-neutral voltage for 3-phase wye connections are 58% of line-to-line voltages listed. Line-to-neutral voltage for 3 wire single phase is one-half the line-to-line voltage listed.

**Table 2
Minimum Air Gap for Kato Brushless Exciter**

Exciter Rotor (Armature) Diameter (in inches)	Minimum Air Gap (in inches)
5 3/4	0.014
9 7/8	0.014
12 1/2	0.018
16 1/4	0.035

Table 3
Recommended Torque SAE 5 Steel and SAE 8 Steel Cap Screws

Shank Diameter (in inches)	Recommended Torque (in foot pounds)	
	A.S.T.M. A449 S.A.E. 5 Steel	S.A.E. 8 Steel
1/4	9	13
5/16	18	28
3/8	31	46
7/16	50	75
1/2	75	115
9/16	110	165
5/8	150	225
3/4	250	370
7/8	378	591
1	583	893
1 1/8	782	1410
1 1/4	1097	1964
1 3/8	1461	2633
1 1/2	1748	3150

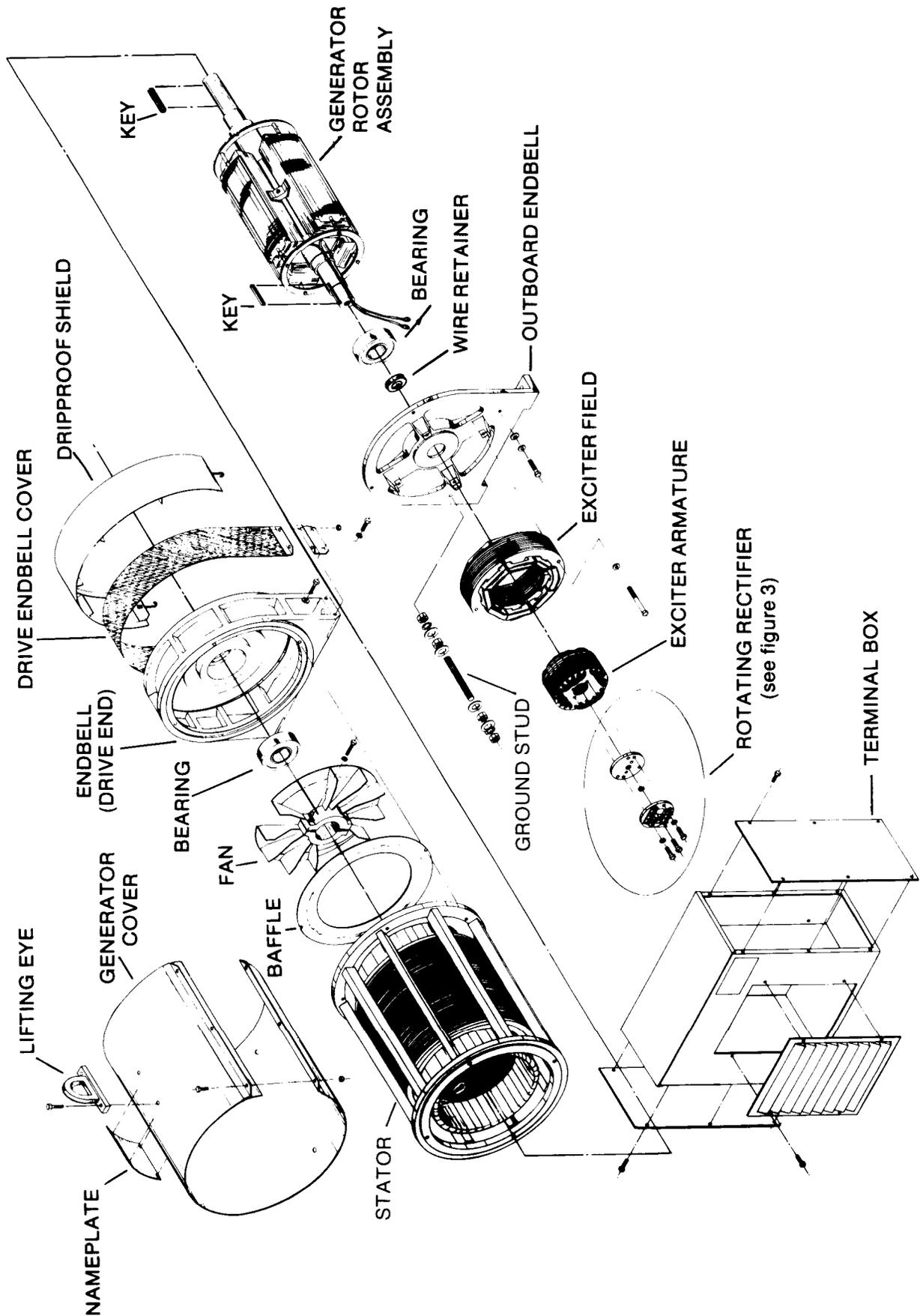


Figure 1 Two Bearing Kamag Generator with Outboard Exciter

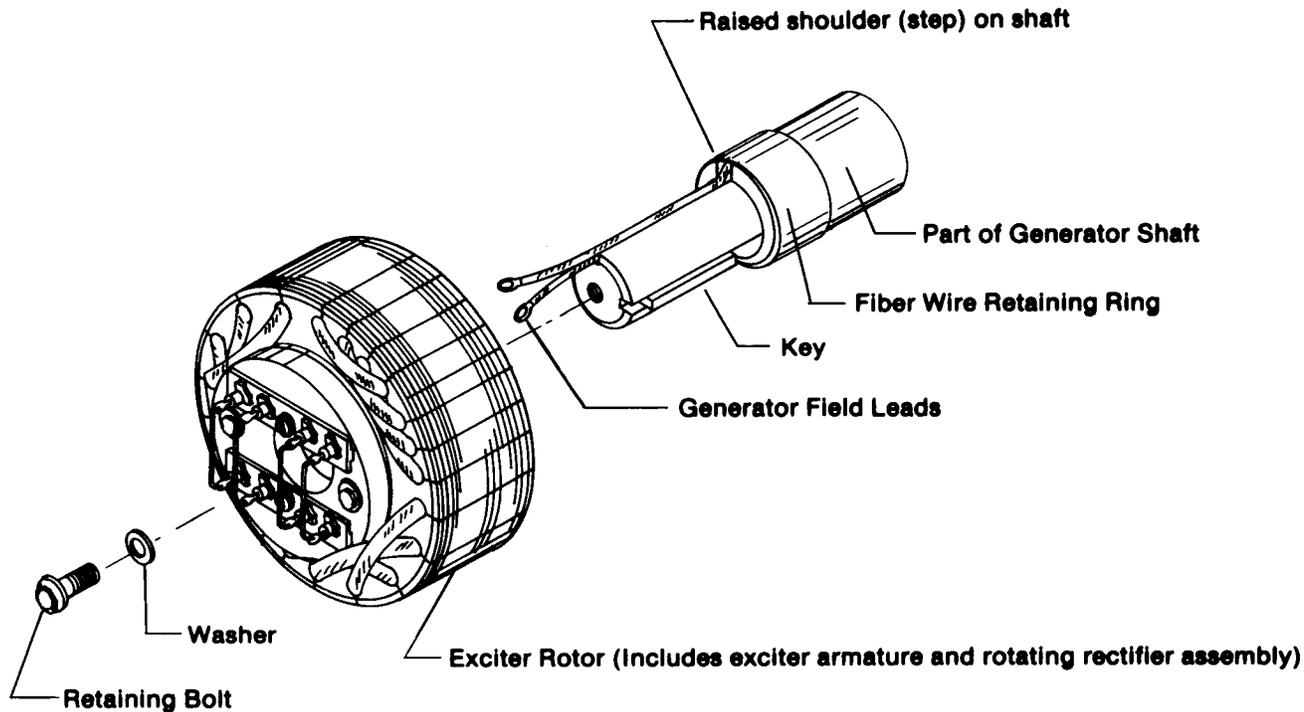


Figure 2 Exciter Rotor Installation

NOTE: Exciter and Generator Field Interwiring is shown on Figure 7.

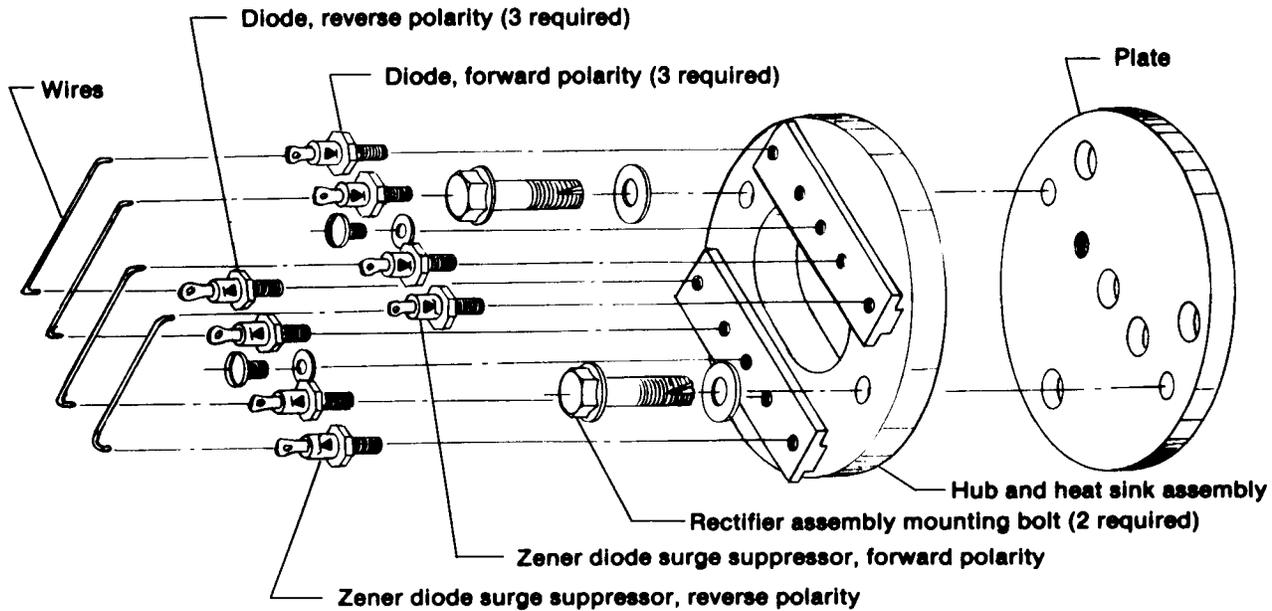
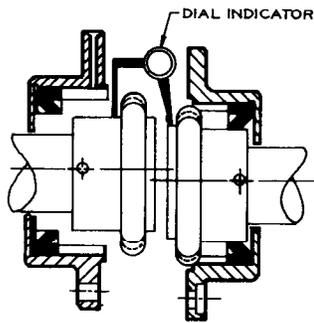
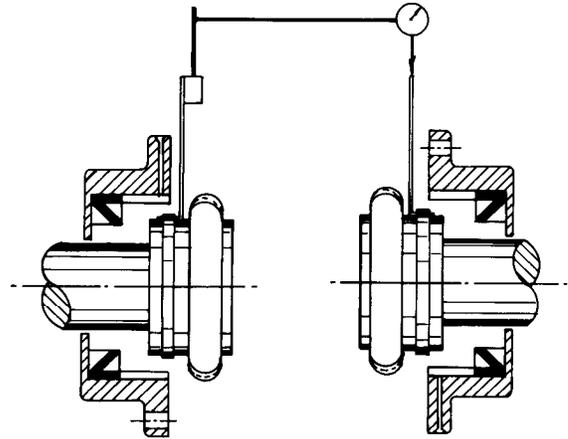


Figure 3 Rotating Rectifier

NOTE: Shaft offset should not exceed .002 inch.



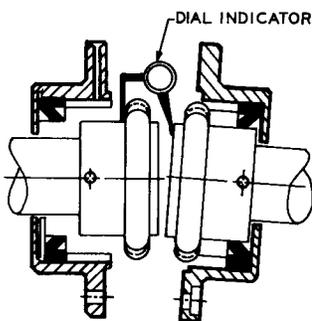
a. Testing shaft offset (parallel) alignment using dial indicator on coupling hub O.D.



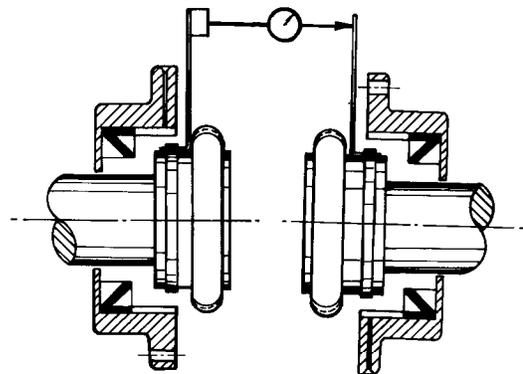
b. Testing shaft offset (parallel) alignment using brackets and dial indicator.

Figure 4 Testing Shaft Offset (Parallel) Alignment of Flexible-Coupled Generator

NOTE: T.I.R. should not exceed .001 inch multiplied by r , where r equals distance in inches from shaft center to dial indicator finger

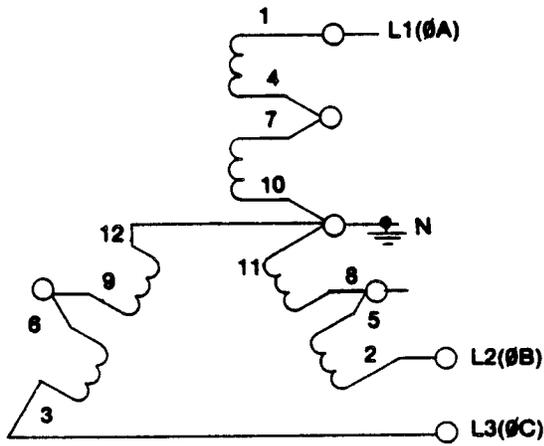


a. Testing angular alignment using dial indicator against coupling face.

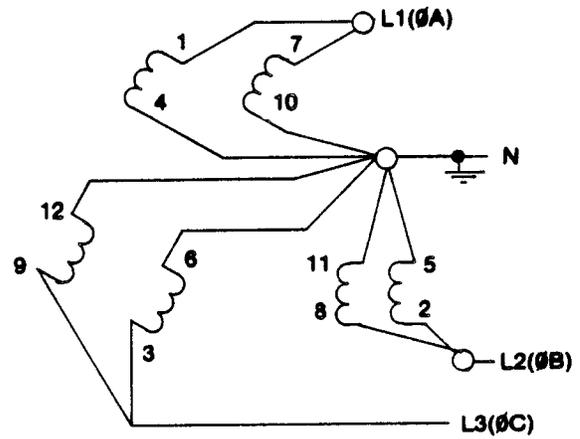


b. Testing angular alignment using brackets and dial indicator.

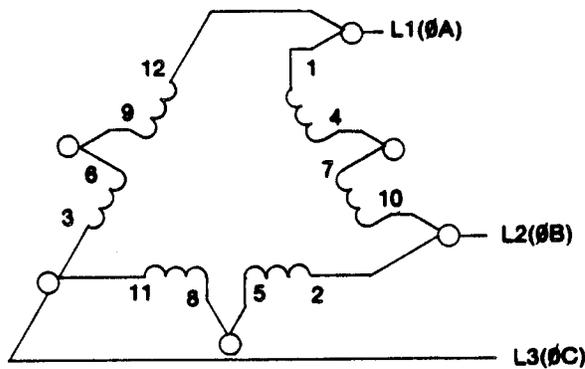
Figure 5 Testing Angular Alignment of Flexible-Coupled Generator



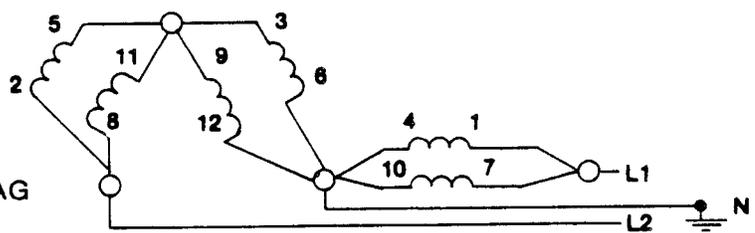
a. 3-Phase series wye



b. 3-Phase parallel wye



c. 3-Phase series delta



d. Single-phase, 3 wire

NOTE: Voltage Range for standard KAMAG generators listed in Table 1 in this manual.

Figure 6 Twelve Wire Generator Stator Lead Wire Connection Diagram

CAUTION

This drawing does not show interconnection for voltage regulator and other controls that could be provided with the generator set. Be sure to follow the wiring diagram provided with the generator set when making electrical connections.

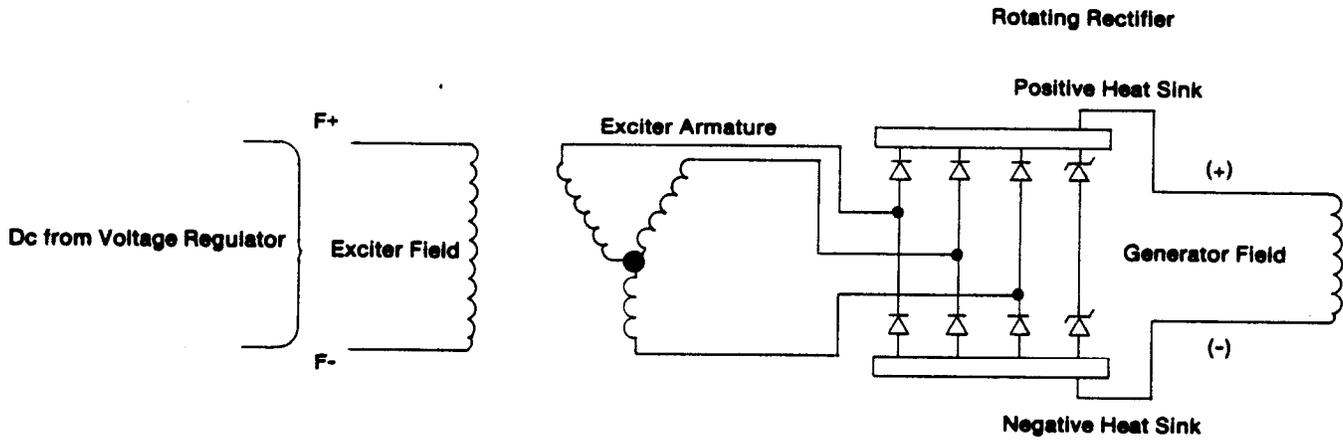
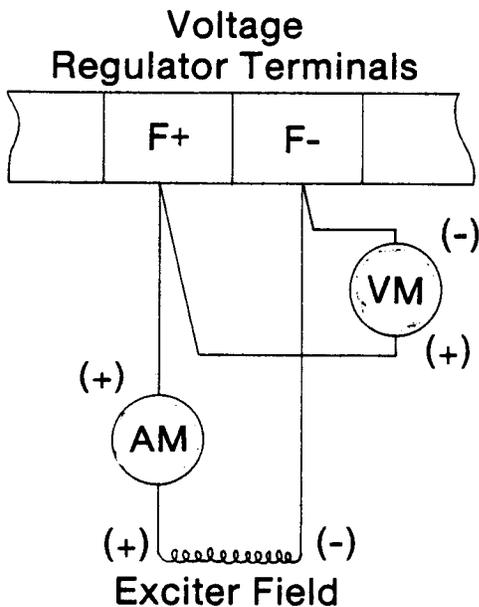


Figure 7 Exciter and Generator Field Interconnection

NOTE: Three forward polarity diodes and one forward polarity zener diode surge suppressor mounted on positive heat sink.
 Three reverse polarity diodes and one reverse polarity zener diode surge suppressor mounted on negative heat sink.



NOTE: Use dc voltmeter and dc ammeter with scale equal to or more than the one-minute field forcing capacity given in the voltage instruction manual.

Figure 8 Field Excitation Measurement Meter Connection Diagram

WARRANTY

Kato Engineering warrants that its products will perform as specified in bonafide quotations or Kato publications, providing such products are properly installed, properly cared for, and properly operated under normal environmental conditions.

Standard products manufactured by Kato Engineering are warranted to be free from defects in workmanship and material for a period of one year in operation or 18 months from date of shipment, and any products which are defective in workmanship or material will be repaired or replaced at the option of Kato Engineering. Final determination as to whether a product is actually defective rests with Kato Engineering. The obligation of Kato Engineering hereunder shall be limited solely to repair and replacement at its factory, of products that fall within the foregoing limitations and shall be conditioned upon receipt by Kato Engineering of written notice within the warranty period of any alleged defects or deficiency. No products shall be returned to Kato Engineering without its prior consent. In no case will Kato Engineering accept shipping charges incurred either through return of defective items to its factory or return of repaired or replacement items to the user. Kato Engineering cannot assume responsibility or accept invoices for unauthorized repairs to its components even though defective. In the case of components, parts or units purchased by Kato Engineering the obligation of Kato Engineering shall not exceed the settlement that it is able to obtain from the supplier thereof.

The life of the products of Kato Engineering depends to a large extent upon the type of usage. Kato Engineering makes no warranty as to period of service nor as to fitness of its products for specific applications by the buyer. In no event will Kato Engineering be liable for consequential or incidental damages or any expense incurred by the Buyer due to use or sale of products sold by Kato Engineering.

The foregoing warranty is exclusive and in lieu of all other warranties expressed or implied, including but not limited to any warranty of merchantability or of fitness for a particular purpose.

This Warranty does not apply to experimental or developmental products.

P.O. Box 47 / Mankato, Minnesota 56001 / (507)625-4011 TLX: 29-0786 / 1-83

KATO ENGINEERING 
RELIANCE ELECTRIC



Kato Engineering Support

The brand you trust, the power you depend on. Include the serial number and model number for your machine in the email subject line.

Field Service

KatoService@mail.nidec.com

Parts

KatoParts@mail.nidec.com

Remanufacturing

KatoRemanufacturing@mail.nidec.com

Warranty/Quality Assurance

KatoWarranty@mail.nidec.com