EME Collector Description and Company Experience

A. Overview

Installing a new collector system has many advantages over a brushless exciter system. The advantages are not just limited to increased operational reliability, but the purchase of a new collector can also significantly reduce outage time.

Since it is a brand new system, all major components are assembled, aligned, balanced, and tested before shipment. This means that the entire collector system can be delivered to site before the unit is taken off-line. Therefore, there is no risk of an outage delay from unknown findings while the brushless exciter is being repaired.

A collector system can also easily be installed in a one week outage, which is much shorter than the time it takes to rewind and refurbish a brushless exciter.

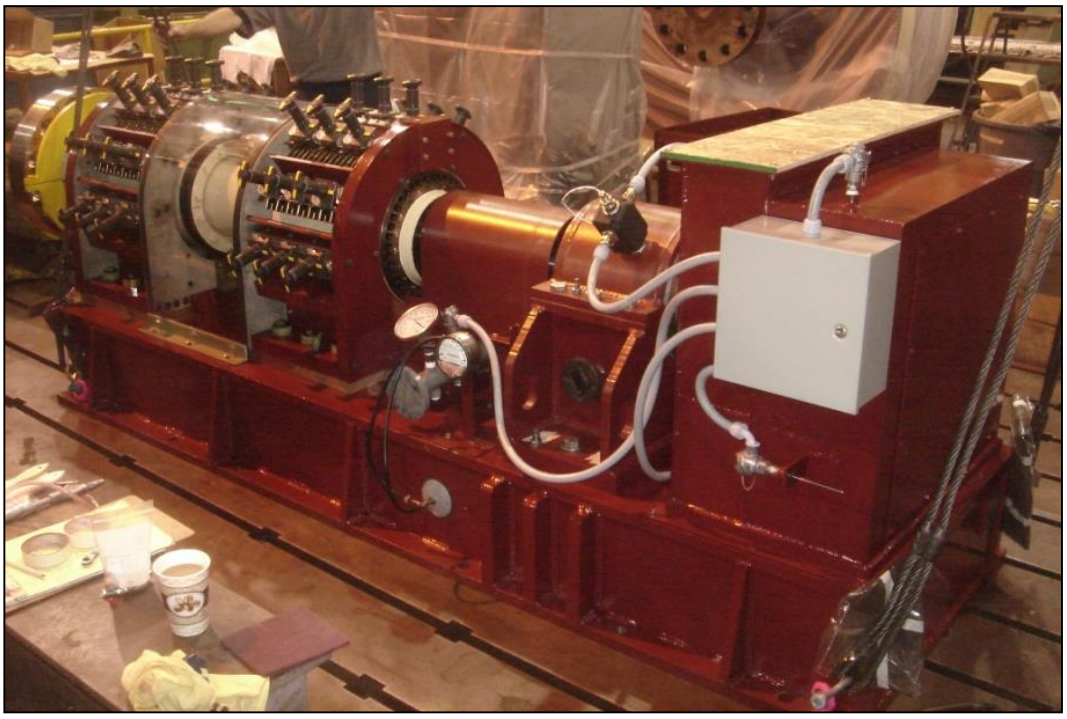
The major operational benefit of a collector system is reliability. Forced outages due to damaged diodes and fuses will no longer be an issue. All power transmission components are stationary and not subject to the high forces associated with rotation. The brushes transmitting the power from the stationary components to the rotating components can be replaced quickly and safely while the unit is still at load.

Technical Description

EME's collectors are designed to directly couple both mechanically and electrically to the generator by means of a solid flanged coupling. The collector assembly provides the electrical connection between the positive and negative polarities of the stationary excitation system and rotating generator rotor. At the center of this interface are the brushes and collector rings. At this interface, the carbon brushes (brush rigging) contact the surface of the hardened steel rings of the collector shaft assembly, which is direct coupled to the generator rotor.

The power collected by the rings is carried to generator rotor through conductors in the center of the shaft. The connection from the rings to the center conductors includes the Radial leads and Flex leads. The Flex leads provide the connection between the collector ring and radial lead. The radial lead is connected into the center conductor.

The designed shipping arrangement consists of the collector rotor, brush rigging, bearing, blower housing, shipping brace, and base. The shaft is supported in this assembly by the bearing at the outboard end and by the shipping brace at the coupling end. At this point, the shaft is completely aligned to the base, bearing pedestal, and brush rigging. During field installation, alignment to the generator is accomplished by only moving the entire collector assembly.



Once assembled, the collector is totally enclosed within a lift off type housing. The housing is a fabricated steel structure. The housing has two critical interfaces, which include the blower housing discharge and the housing end wall adjacent to the generator. The interface with the collector blower housing duct is integral to the collector ventilation, which assures operation within the temperature rating.

B. Shaft Assembly Overview

The shaft assembly collects power from the stationary brushes of the collector rigging and delivers it to the generator field. The collector rings are manufactured from certified high quality alloy steel that that has been heat-treated to yield specific mechanical properties for this application. The rings are assembled onto the shaft over an insulating tube with a suitable shrink fit. The insulation tube is manufactured to G11 properties. The rings include spiral grooving and a polished surface for optimized performance with the brushes. They are cooled by forcing ambient air through axial vent holes.

a. Shaft

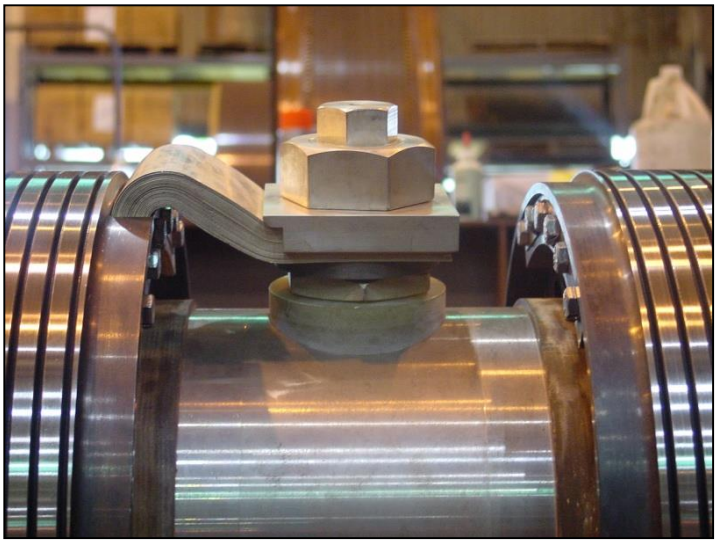
The shaft is of certified high quality alloy steel. The shaft is designed in conjunction with the lateral and torsional characteristics of the entire rotating system such that first bending critical frequencies are sufficiently removed from running speed.

Complete lateral and torsional critical speed studies are performed to ensure that operation near critical speeds does not occur.

b. Coupling

The coupling is a separate high quality forging that is shrunk on and keyed to the collector shaft. The coupling is designed as a form, fit and function duplicate of the original brushless exciter coupling. The collector coupling utilizes the existing brushless exciter coupling bolts and sheer sleeves unless specified otherwise by the customer. For original couplings that utilized shear sleeves, a quantity of four sheer sleeves will be reused with the collector. For the original couplings utilizing a body-bound bolting configuration, only four bolts will be body-bound with new collectors.

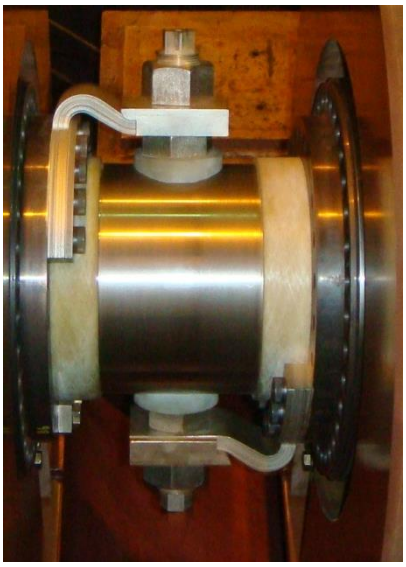
c. Flex Lead Connector



The flex lead connectors are comprised of a stack of copper laminations. They make the connection between the collector rings and radial studs. Each lamination is 100% tin-plated.

d. Radial Stud Connector

The radial stud is of high quality certified copper alloy forging. The radial stud is connected into the center conductor by a special threaded connection. In applications on hydrogen inter-cooled generators, a Chevron seal pack provides a hydrogen gas seal as the radial lead passes through the shaft to the axial lead. The leads are 100% tin-plated and then insulated.

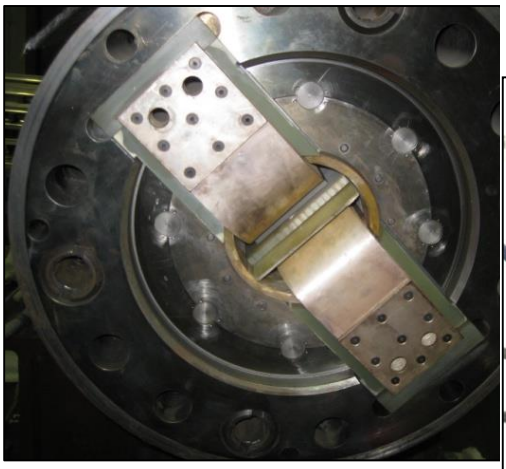


e. Center Conductor

The center conductors are of copper bar. The center conductors bring the power from the collector rings, via the flex leads and radial studs, to the rotor field via the butterfly leads. The center conductors are assembled in a bored hole in the center of the shaft and are insulated with a G11 system.

f. Coupling Leads

The Coupling Leads are comprised of a stack of silver plated copper leafs. The leads span the generator and collector couplings through slots. The leads are functional duplicates of the original brushless exciter leads. Both butterfly and over-the-coupling lead styles can be duplicated.



g. Blower

The blower, which is of centrifugal design using backwards-curved blades, is mounted directly to the collector shaft. It is fabricated of high strength alloy steel and tested by method of magnetic particle inspection after manufacturing and again after independent balancing and overspeed testing.

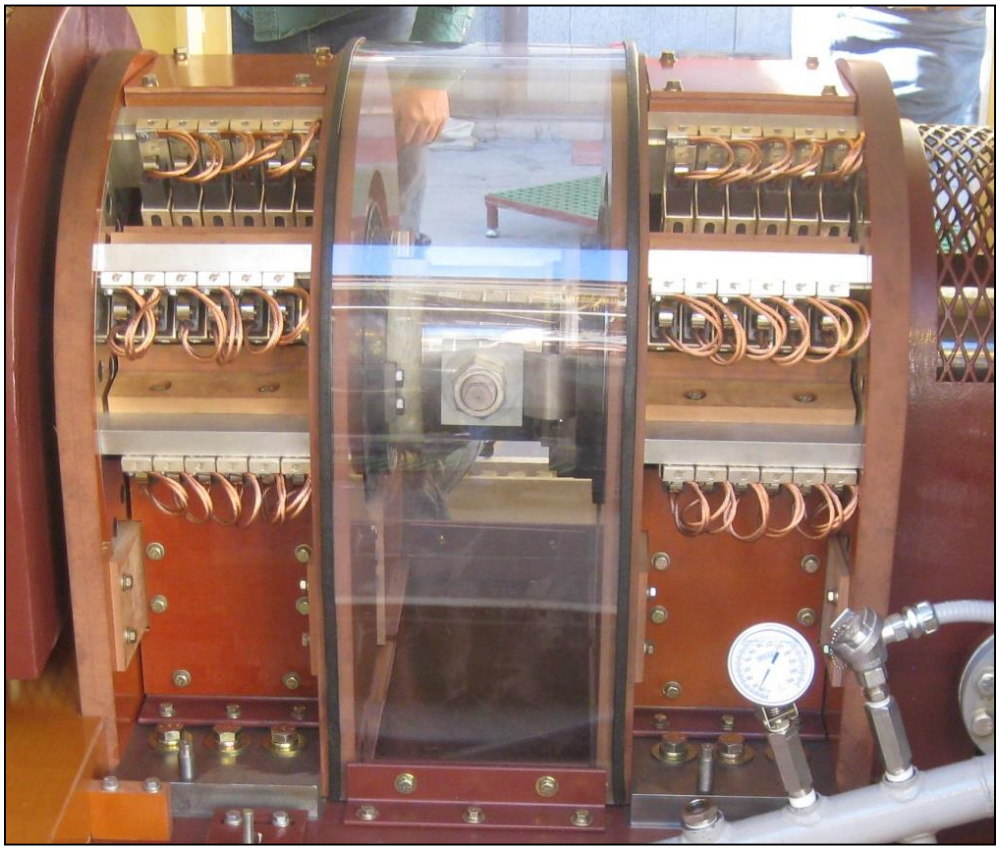
C. Collector Stationary Components

a. Brush Rigging

The brush rigging delivers power from the static source to the collector rings through carbon brushes. The two-brush rigging assemblies (positive and negative polarities) are comprised of steel support arms that span between two insulated end plate assemblies. The support arms carry removable brush magazines to facilitate brush maintenance while the unit is in operation and carrying normal load. The arms are 100% tin plated. The rigging is anchored to the steel base through an electrically insulating anchoring system.

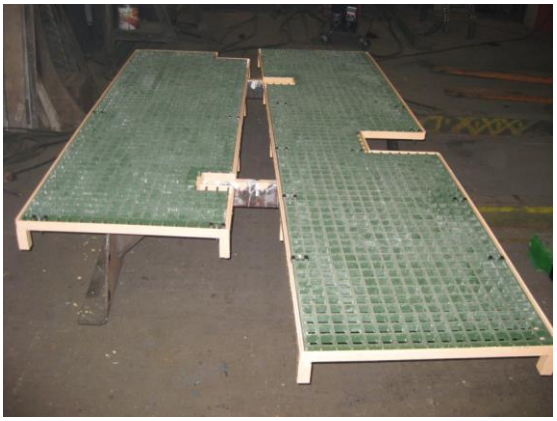
Major features of the collector brush rigging are as follows:

- All electrical pieces are 100% tin-plated. This includes tin plating of the copper end plate rings, copper bus bars, steel brush holder magazine support bars, and steel backing plates.
- The brush rigging ends are split on a vertical plane to facilitate removal and installation of the brush rigging without removing the shaft.
- The end plates and air baffles are constructed from insulated material for safety.
- Tin plated copper rings are recess mounted into the end plates to provide the electrical connection to the bus work. The recess mounting reduces the amount of electrically hot material accessible to the worker changing the brushes and significantly improves safety.



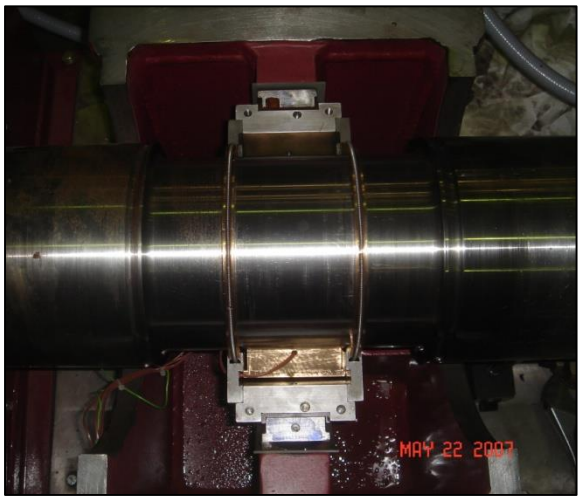
b. Bus Work

The main bus leads make the connection between the DC leads that terminate at the seating plate penetrations and the end plates of the brush rigging. The bus bars are 100% tin plated. Around the bus work, the leads are enclosed in insulated structures. They are further protected from personnel by a fiberglass grated flooring system.



c. Bearing

The bearing is a self-aligning pivoted pad type. There are typically 5 pads (shoes). The bearing assembly consists of steel retaining rings (bearing shell), babbitted bronze shoes, shoe pivots (ball and socket style) and floating brass end seals.



The bearing operates completely flooded with oil. Oil enters the bearing cavity through radial holes in the bottom half of the bearing shell. The flow of oil is controlled by the preset clearance of the floating seal rings and the oil system pressure.

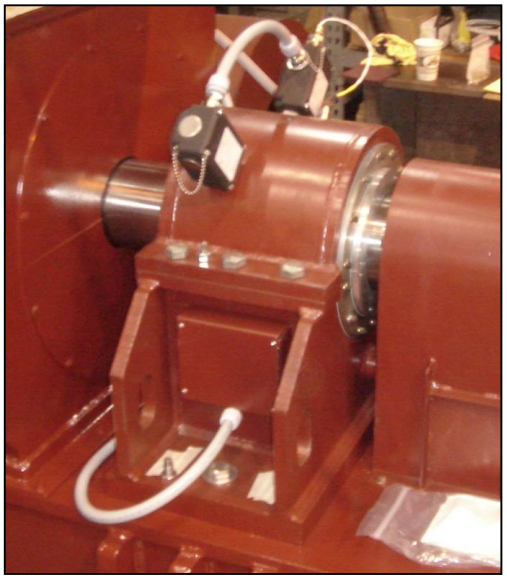
The bearings do not require any field adjustment, including scraping.

Thermocouples are embedded in the base metal of the bearing shoe about .032 inches from the babbitted surface. The thermocouples are connected in the terminal box mounted on the side of the pedestal.

The insulated bearing saddle in combination with an insulated pedestal seat provides double insulation of the bearing. A check wire and ground wire are connected in the terminal box mounted on the side of the pedestal to check the insulation.

d. Bearing Pedestal

The pedestal is fabricated from steel plate. The inboard and outboard faces of the pedestal are machined square with the base and are bored concentric with the bearing seat. Labyrinth style seals are mounted to these faces.



e. Bedplate

The collector base is fabricated from steel plate arranged to obtain maximum rigidity for the mass of material used. The bearing pedestal, collector rigging, blower housing and shipping brace are aligned bolted, and doweled to the base prior to shipping. The base, itself, will be bolted and doweled to the existing foundation sole plate as a part of the field installation and alignment and supports the above components. Additionally, it acts as an air duct for cooling medium.

f. Housing

The collector is enclosed in a lift off type housing of fabricated steel. The primary functions of the housing are as follows:

- Provide an environmentally controlled atmosphere for the equipment.
- Provide an interface for the collector's ventilation system.
- Provide access to the collector for brush maintenance and equipment inspection.
- Noise abatement.
- Provide human safety by isolating the operating equipment.

Features included in the housing construction are as follows

1. The housing is constructed with fabricated steel outer skin lined with 1-inch thick foam sound abatement material with a steel inner skin.
2. 60" x 80" sliding doors spanning the length of both brush riggings for access to the collector on either side.
3. 24" x 24" x ¼" thick tempered glass windows for viewing inside the housing located on the doors.
4. Internal lighting with external switches and electrical outlets.
5. Lift-off interface with the housing end wall. The end wall is located around the generator coupling. The housing end wall provides a seal to the coupling and the housing penetrations for the bearing oil feed and drain lines.
6. Lift off interface with the collector ventilation system.

g. Standard Instrumentation

The collector is equipped with several instrumentation devices for visual inspection and interface with customers automated control systems. These systems can include the following:

- Dual mounted Bently Nevada proximity probes and proximiters
- Embedded bearing shoe thermocouple; two embedded in each of the two bottom shoes.
- Inlet and outlet air temperature RTDs.
- Oil drain temperature gauge and thermocouple.

EME Collector Experience

Reliant Energy, Coolwater Generating Station, Unit #ST30 – 1,275 amps. 250volts

This collector was manufactured under subcontract to GE Industrial Systems. EME was responsible for the design, manufacture, and assembly of all components, with exception to the bedplate and bearing housing which were reused from the brushless exciter.

The Coolwater collector was shipped in December of 2003. No incidents have ever been reported to EME.

PGE Boardman – 5,600 amps, 525 volts

This collector was manufactured under subcontract to ALSTOM Power. This design reused the existing bedplate and housing after retrofitting them to the current design. EME was responsible for all rotating components, the brush rigging, bearing, and bearing housing.

This collector went into service in July of 2004. The unit operated without incident until November of 2005 at which time a problem was noted on one of the radial leads. This problem was found when the unit was shut down for other reasons. ElectroMechanical Engineering Associates, Inc. (EME) was able to supply a new lead and repair the unit in 5 days. The unit is currently in service and operating without restrictions. EME currently has a solid working relationship with PGE and has performed multiple projects as a direct contractor for them this year alone.

Constellation Power, Wagner Unit #4 – 3,200 amps, 500 volts

This collector was produced directly for Constellation Power. EME was responsible for the design, manufacture, and assembly of all of the components. This collector was purchased as a back-up to the existing collector and has not seen service. Its assembly was completed in August 2004. Based upon EME's recommendation, it was put into long term storage in September of 2004.

RWE Power International, Cowes Generating Plant – 815 amps

This collector was manufactured under subcontract to National Electric Coil (NEC). This design was significantly different from the other designs because it was located between the turbine and generator and had to transmit torque.

EME designed, manufactured, and assembled all components and it was shipped in February of 2005 and was put into service. In 2006, there was a problem with migration of silver conducting grease that resulted in low megger readings. The unit was disassembled, cleaned, and put back into service without the conducting grease and operates without restrictions. EME no longer uses any greases components on threaded connections in its current design.

Xcel A S King – 7200 amps, 525 volts

This collector was manufactured under subcontract to ABB. It was started in October of 2005. For this project, EME designed and built all rotating and stationary components.

This unit did immediately encounter problems with spiral vibration upon start-up. This is a phenomenon wherein the vibration vector rotates around the unbalance vector and thus appears to have almost sinusoidal amplitude over time. Initially the maximum amplitude exceeded acceptable limits.

The problem was determined to have been cause by improperly connected brush shunts that impeded the movement of the brushes within the brush holders. Xcel personnel connected the shunts. After correcting the shunt connection, the collector went into service with vibration levels within Class A ISO standards. It has operated without incident or any restrictions since November 1, 2005.

Mirant Morgantown – 6800 amps, 525 volts

This collector was manufactured directly for Mirant Morgantown Station and was put into service in June 2007. The unit has operated without any incidents since that time. In addition to the design and manufacturing of all of the components, this unit was also installed by EME.

MidAmerican Energy Louisa – 7200 amps, 525 volts

For this collector, EME was a sub-contractor to ALSTOM Power.

EME's responsibilities included everything but the construction of the shaft and collector rings. Additionally, EME was on-site as a technical field advisor for the collector's installation. The unit was installed in November 2007. During its initial operation, the unit experienced spiral vibration caused by a near-running speed resonance of Alstom's collector shaft. This was corrected by ALSTOM Power. All components manufactured by EME have operated as designed since installation.

Additionally, due to a plant incident which caused OSHA to have strict regulations for the plant, EME was contracted to build a new housing. The new design details of that housing are now incorporated into EME's standard housing package.

Grand River Dam Authority – 5000 amps, 500 volts

This collector was manufactured under subcontract to ALSTOM Power. EME was responsible for the design and manufacture of all components except the collector rotor, bearing, and bearing pedestal.

This unit was recently installed in May 2010 and no incidents have been reported.

NV Energy, North Valmy Generating Plant, Unit #1 – 3521 amps, 425 volts

This collector was manufactured under subcontract to Eaton Electrical Services & Systems. EME designed, manufactured, assembled, and installed all components and. It is currently operating.

NV Energy, Reed Gardner Generating Plant –

This collector is currently being manufactured under subcontract to Eaton Electrical Services & Systems. This is scheduled for installation in late spring/early summer of 2012.