AMERICAN NATIONAL STANDARD

Procurement Standard for

Gas Turbine Electrical Equipment

ANSI B133.5 - 1978

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

United Engineering Center 345 East 47th Street New York, N.Y. 10017

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FOREWORD

The purpose of the B133 standards is to provide criteria for the preparation of gas turbine procurement specifications. These standards will also be useful for response to such specifications.

The B133 standards provide essential information for the procurement of gas turbine power plants. They appy to open-cycle, closed-cycle, and semi-closed cycle gas turbines with conventional combustion systems for industrial, marine, and electric power applications. All auxiliaries needed for proper operation are covered. Not included are gas turbines applied to earth moving machines, agricultural and industrial-type tractors, automobiles, trucks, buses and aero-propulsion units.

For gas turbines using unconventional or special heat sources (such as: chemical processes, nuclear reactors, or furnaces for supercharged boilers), these standards may be used as a basis; but appropriate modifications may be necessary.

The intent of the B133 standards is to cover the normal requirements of the majority of applications, recognizing that economic trade-offs and reliability implications may differ in some applications. The user may desire to add, delete or modify the requirements in this standard to meet his specific needs, and he has the option of doing so in his own procurement specification.

The B133.5 standard applies mostly to gas turbine stations used for power generation. Appropriate sections however, can be used where applicable for mechanical drive turbine stations. The size of station considered in the B133.5 standard includes all electric utility size units but not small power supplies of a semi-portable nature.

Suggestions for improvement of this standard will be welcome. They should be sent to The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.

American National Standard B133.5 was approved by the B133 Standards Committee and final approval by the American National Standards Institute was granted on November 21, 1978.

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Procurement Standards For Gas Turbines

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AMERICAN NATIONAL STANDARD

PROCUREMENT STANDARD FOR GAS TURBINE ELECTRICAL EQUIPMENT

1. GENERAL

The aim of this standard is to provide guidelines and criteria for specifying electrical equipment, other than controls, which may be supplied with a gas turbine. Much of the electrical equipment will apply only to larger generator drive installations, but where applicable this standard can be used for other gas turbine drives.

Electrical equipment described here, in almost all cases, is covered by standards, guidelines, or recommended practices documented elsewhere. This standard is intended to supplement those references and point out the specific areas of interest for a gas turbine application. The individual items in the Table of Contents will in general have an overall standard referenced in the first paragraph. For a few of the individual items, no other standard is referenced for the entire subject, but where applicable a standard is referenced for a subitem. Definitions of terms can be obtained from ANSI Standard C42.100, "IEEE Standard Dictionary of Electrical & Electronics Terms." A user is advised to employ this and other more detailed standards to improve his specification for a gas turbine installation. In addition, regulatory requirements such as OSHA and local codes should be considered in completing the final specification.

Gas turbine electrical equipment covered by this standard is divided into four major areas. These are:

B133.5.1–Main Power System

B133.5.2–Auxiliary Power System

B133.5.3–Direct Current System

B133.5.4–Relaying

The main power system includes all electrical equipment from the generator neutral grounding connection up to the main power transformer or bus but not including a main transformer or bus.

The auxiliary power system is the gas turbine station ac supply and includes all equipment necessary to provide such station power as well as motors utilizing electrical power.

The dc system includes the battery and charger only.

Relaying is confined to electric system protective relaying that is used for protection of the gas turbine station itself.

2. MAIN POWER SYSTEM

2.1 Generator

The generator connected to the gas turbine drive shaft should be in accordance with applicable requirements of ANSI C50.10, C50.12, C50.13, and C50.14. Special features and accessories for a particular application or expected usage should be included in the final specification.

Design

Gas turbine generators may be either air or hydrogen cooled depending on the application, expected usage, and atmosphere of the site.

In accordance with ANSI C50.14, the generator output, at rated power factor, should be equal to or greater than that of the gas turbine for the base and peak operating modes and over the ambient temperature range specified.

Audible noise from the generator should be compatible with gas turbine sound emission requirements.

The cyclic nature of the gas turbine generator peaking application should be recognized in the design of the stator and rotor to minimize the effect of metal fatigue and insulation abrasion caused by winding movement in the slots and many thermal cycles. This is distinct from base load applications where there are fewer starts but much more time at rated load.

Air Cooled Features

A weatherproof enclosure should house the generator unless the design is for outdoor service.

Appropriate inlet air filtration with pressure gauges to indicate when maintenance is required should be included.

If required to meet plant sound emission requirements, silencers should be provided for inlet and discharge air ducts.

The generator should be provided with space heaters for shutdown periods.

Low temperature applications may require the use of heated air. High temperature applications may require inlet air cooling.

Temperature detectors should be included for stator winding and cooling air temperatures.

Hydrogen Cooled Features

The generator casing should be constructed to withstand an internal hydrogen explosion and limit damage to the enclosed parts.

Provision should be made for monitoring and maintaining hydrogen pressure and purity, and for CO_2 purge when hydrogen pressure or purity are outside acceptable limits.

A suitable hydrogen sealing system should be provided to minimize the loss of hydrogen during both running and shutdown conditions.

Temperature detectors should be included for the stator winding. In addition, cold gas and hot gas temperature detectors are desirable for each hydrogen cooler.

Additional Instrumentation

Instrumentation or provision for instrumentation to determine excessive vibration levels should be included and the use of bearing metal or oil temperature display or protection is encouraged.

2.2 Excitation System

The gas turbine power plant excitation system should be described in terms defined by IEEE Standard 421, "IEEE Standard Criteria and Definitions for Excitation System for Synchronous Machines." Those features considered a minimum will be described here as well as certain options desired in some gas turbine power plants.

The excitation system is considered to include all exciters or main field power supplies, field breakers or means of removing generator field current, regulators, controls, limiters, etc., that provide the power to the field of the generator and control the output voltage of the generator. The following paragraphs describe the minimum features to be considered.

Exciter

The exciter may contain either rotating or static components and must be suitably matched to the generator field requirements for the full range of generator operation. Depending on power system requirements the exciter output may be reversible or not.

Regulators

The excitation system should have two means of controlling the generator output voltage. One method would be by a continuously acting regulator and the other a manual control or additional regulator. Each means of controlling the generator output should be suitable for the various starting modes described in B133.4, Paragraph 2.2.1.

The steady state load regulation should be no more than ±0.5% with a drift of no more than ±0.75% over the ambient temperature range. Regulation requirements for special applications may be more or less stringent than these. Adjustment of generator voltage should be possible over a range compatible with power system requirements for minimum and maximum operating voltage.

In some applications, the gas turbine power plant excitation system should not control generator voltage as its primary controlled variable but instead control power factor or generator var output. For these applications all excitation system requirements would remain the same as described except for the primary regulator controlled variable.

Limiters, Signal Modifiers and Compensators

Over-excitation and under-excitation limiting may be included where desired for operating and protection philosophies. When employed, these should be compatible with plant operation and other excitation system functions. Limiters may sense either generator field or power system quantities in order to perform the desired protection functions which include:

a. Protection of generator field against overheating

b. Protection of generator from heating due to under-excitation

c. Protection of power system from under-excitation

Signal modifiers may be included to affect the primary voltage regulating function of the excitation system for purposes of improving performance with the power system. For example, a power system stabilizer or volts per hertz regulator may be included if so indicated, plus any other signal modifiers that would improve total excitation systems performance in special applications.

Compensation may be included for division of reactive current among generators typically within ±5% if the impedance from the generator to the paralleling point is less than approximately 6%. Compensation for line drop to better regulate a voltage other than at the generator terminals may be required by the application. In any case, when compensators are employed, the regulated generator terminal voltage is allowed to change outside the specified band due to action of the compensator in modifying the signal sensed by the excitation system regulator.

System Response

The excitation system voltage response ratio as defined in the reference should be a minimum of 0.5 unless power system requirements dictating higher values are desired or a high initial response system is needed.

Excitation system ceiling voltage, if defined at all, should be consistent with system response, and for systems having a response ratio of 0.5 the ceiling voltage would be a minimum of 120% of nominal exciter output voltage.

Generator Field Power Removal

The excitation system should include the means to rapidly remove power from the generator field in the event of protective system action. The means may include ac or dc circuit interrupting devices with discharge resistors (dc only), or static components controlled to produce the desired action.

Fault Current Support

The excitation system should include the means to provide generator fault current for faults external to the generator for a period sufficient to allow the fault protective system (system relaying) to operate.

2.3 Bus Connections

The main power system bus connections are those connections from the generator terminals to the generator circuit breaker main power transformer, or station bus. They may be cable or buswork, overhead or underground, enclosed or open, but should have the following characteristics.

Main buses and conductors should be capable of carrying the maximum load continuously with a temperature rise not exceeding specified values.

Bolted bar joints should receive particular attention to avoid hot spots by plating or similar treatment to insure a good connection.

Insulators and supports should be braced to prevent displacement due to stresses incident to short circuits.

Terminals should be adequately spaced for attaching bus housings or a suitable area shall be provided for cable terminations for the generator main leads. Flexible connections should be provided where required for vibration, expansions and differential settlement.

2.4 Circuit Breaker

This item covers general requirements for a circuit breaker controlling the output of a gas turbine generating plant. The circuit breaker may be connected to either the generator output terminals or to the high voltage winding of a unit-connected generator transformer. Circuit breakers associated with purchaser's substation or switchyard are not included in this standard.

The circuit breaker should conform to requirements specified in ANSI C37.12 covering ratings, performance, tests, insulation structure, operating mechanism, secondary and control devices, and structural details. If the generator circuit breaker is housed in switchgear, this equipment should be in accordance with Section 12 of the reference.

The maximum voltage rating as well as continuous, momentary and interrupting current ratings should conform to ANSI C37.04, C37.04a and C37.06.

For a plant with a variable output based on ambient temperature, the breaker continuous current rating should be based on maximum expected generator output current at the proper ambient and site elevation. Current carrying capability at other ambients, as determined by Section 4.4.3.2 of ANSI

C37.010, should be equal to or greater than maximum expected generator output current capability over the specified range of ambient temperatures. Current carrying capability above 40°C ambient generally determines the circuit breaker continuous current rating.

The interrupting rating should be specified or system characteristics should be provided to permit selection of a circuit breaker with capabilities suitable for the application.

The circuit breaker should be suitable for synchronizing service and be capable of withstanding out-of-phase voltage across the open contacts when operated in this manner.

Design

The mechanical and physical characteristics of the insulation system should be adequate for the duty imposed by circuit breaker operation, including strains from lead connections and variations in ambient temperature. Materials used in the insulation system should be of a type that would not support combustion, produce toxic gases or absorb moisture. Insulating materials in oil circuit breakers should not be adversely affected by the oil nor should they cause significant oil deterioration.

Design of the operating mechanisms and associated control devices should conform to the requirements for power circuit breaker control per ANSI C37.11. The operating mechanism should be designed to assure proper operation of the circuit breaker when the applied control voltage is within the range specified in Table 8 of ANSI C37.06.

2.5 Surge Protection

Generator surge protection consisting of one (1) lightning arrestor and capacitors connected between each line terminal and station ground should be provided in accordance with ANSI C62.2 Section 4.22.

Lightning arrestors and capacitors should be located as close as possible to the generator line terminals. If it is necessary to separate the arrestors and capacitors, the capacitors should be located nearest to the generator.

A solid connection to station ground is required from the generator frame (two points), the grounded end of the neutral impedance and the surge protective devices.

Unit Connected Generators

In the case of the generator(s) connected to the system through a step-up transformer, it is recommended that surge protection be installed at the generator line terminals. Some unit-connected generators may not require surge protection if the generator surge impedance is sufficiently low; however, these cases should be carefully analyzed on an individual basis to establish conclusively that the machine and transformer characteristic will limit a severe surge wave front to a level and duration which will not cause damage to the machine.

In most installations, unit-connected generators are high impedance grounded. Lightning arrestor and capacitor ratings should be determined consistent with the grounding method utilized.

Generator neutral surge protection is not required except in the case of wye-wye transformer connections. When wye-wye transformers are used, neutral surge protection should be provided as per section 6.2 for an ungrounded neutral.

Generators connected Directly to Overhead Lines

This arrangement included connection through resistors, regulators or any other arrangement utilizing a continuous metallic connection between the generator and an overhead line.

When the generator neutral is ungrounded, and in most cases where it is reactance grounded, surge protection is required for the generator neutral. Such protection should consist of a station type or rotating machine type arrestor having a rating that affords protection to generator windings for maximum expected overvoltage conditions, taking into consideration generator voltage rating and method of grounding.

Generators connected to a Plant Medium Voltage Bus

With a few exceptions, lightning arrestors should be installed at the generator line terminals regardless of the method used (cable or bus) for connection of the generator to the bus.

A high value of series impedance of the transformer exposing the generator to a line surge may permit omission of the lightning arrestors.

Capacitors should be installed at the generator line terminals to reduce the rate of rise of the surge.

2.6 Neutral Grounding

Application Factors

The major factors which should be considered in generator neutral grounding methods are:

1. **Protective Relaying.** The magnitude of line-to-ground faults are controlled to a degree by the grounding device in the generator neutral. A low impedance ground is desired where selective relaying is needed for several generators bused at generator voltage. Generators not bused together may have a range of ground impedances depending on the type of relaying protection desired.

2. **Mechanical Stress.** Grounding should meet the limitation of winding stress in wye-connected generators, as specified in ANSI Standard C50.13.

3. **Limitation of Transient Overvoltages.** The neutral grounding system should be designed to limit the magnitude of transient voltages below arrestor sparkover voltage.

4. **Limitation of Damage at Fault Point.** Fault damage can be minimized by limiting the neutral current during ground faults.

Types

The generator neutral is usually grounded through a reactor, resistor, or distribution transformer. In selecting the method of neutral grounding to be applied to a specific installation, consideration should be given to the amount of ground fault current which is allowed to flow. High fault current is generally associated with neutral reactor grounding. Low fault currents are usually associated with distribution transformer grounding. An AIEE Application Guide No. 954 entitled, "Application Guide for the Grounding of Synchronous Generator Systems," could be used for a detailed review of a specific application.

2.7 Instrument Transformers

Sufficient potential and current transformers should be furnished for protective relaying and instrumentation to promote the safe and efficient operation of the gas turbine unit(s). The basic standard in this area is ANSI C57.13.

Potential Transformers

In general:

Burden and Accuracy Classifications should be suitably selected for the intended service.

Transformer insulation should be consistent with the insulation of the system to which it is connected.

Secondary faults not causing sufficient primary current should be protected by secondary circuit fuses.

For generator application, if combined regulator and instrumentation burden produces a ratio error greater than 0.3%, or if switching of regulator burden produces a change of potential transformer secondary voltage in excess of 0.3%, two sets of potential transformers are recommended.

Potential transformers are necessary on each side of the synchronizing circuit breaker(s).

Generator Side

a. Potential transformers for metering, instrumentation, protective relaying, and synchronization

b. Potential transformers as required for the generator voltage regulator

Line Side

a. Potential transformers for instrumentation, synchronization and possible protective relaying or metering

b. Potential transformers may be used for grounding the bus under special circumstances

Primaries of potential transformers should be protected with current limiting fuses with required interrupting rating. Current limiting resistors may be used if duty exceeds available fuse capability.

Auxiliary metering may require additional sets of potential transformers.

Current Transformers

In general:

Burden and Accuracy Classifications should be suitably selected for the intended service.

Transformer insulation should be consistent with the insulation of the system to which it is connected.

For generator application several sets of three current transformers should be provided on the generator neutral leads for service as follows:

One set of current transformers assigned exclusively for generator differential relaying but may be shared by the generator and main transformer differential relays.

One set of current transformers may be provided for main transformer differential relaying and arranged to overlap all generator CT's and thus provide redundant differential protection of the generator. (Line side CT's providing the protection overlap are also feasible.)

If physically possible the third set of current transformers should be provided for metering, instrumentation and nondifferential protective relaying. (A fourth set is possible if protective relaying functions are separated from metering and instrumentation.)

Sets of CT'S (depending on the number of sets provided on the generator neutral leads) should be provided on the generator line leads located on the generator bushings (if so equipped) or in the generator switchgear for service as follows:

One set of CT's are required to complete the generator differential protective zone.

One or more CT's should be provided for the generator voltage regulator.

If it is not possible to provide a third or fourth set of CT's on the generator neutral leads for metering, instrumentation and relaying, the CT's for this service may be located on the generator line side.

Current transformers of the required accuracy class, burden capability, turns ratio and voltage class, may be provided where desired for the following:

a. Generator differential relay auxiliary bus tap

b. Generator auxiliary bus overload

c. Wye-connected auxiliary and large motor transformer neutrals

d. Auxiliary transformer and large motor transformer overload

e. Auxiliary system metering

2.8 Disconnect Switches

This item covers general requirements for high voltage air disconnect switches which may be associated with a gas turbine generating plant. The switches may be used for isolation of a generator circuit breaker or as disconnects for an auxiliary feeder.

Switches should conform to ANSI Standards C37.30, C37.32 and C37.34, with respect to preferred ratings, service conditions, definitions, tests, manufacturing specifications and application.

Ratings

Switches for isolation of a circuit breaker should be rated in accordance with Table 1 of ANSI C37.32 based on the maximum voltage, continuous current and momentary current requirements of the system and the associated circuit breaker. Auxiliary feeder disconnect switches should be rated on the basis of system voltage, maximum momentary current, and auxiliary feed requirements, i.e., auxiliary transformer rating.

The switches should be suitable for operation at their specified ratings within the proper ambient temperature range, and site elevation.

Disconnect switches should be designed to limit the observable temperature rise of any part of the switch to the values listed in Table 3 of ANSI C37.30. At other than rated ambient the allowable maximum temperature from this table should apply.

The allowable continuous current capability of other than rated ambient temperature should be determined per paragraph 4.5.1 of ANSI C37.50. The capability should match that of the associated equipment over the specified range of ambient temperature. Correction for site elevation, above 3300 ft, should be per Table 1 of ANSI C37.50.

Design

Disconnect switches are recommended for isolation of oil circuit breakers when such are necessary to generator breaker service on larger machines where air circuit breaker ratings are inadequate. Disconnect switches are not usual for isolation of generator air circuit breakers when this type of breaker may be racked out of its switchgear cubicle to give visual confirmation of isolation.

Disconnect switches for oil circuit breaker isolation should be group (gang) operated with a manual operating mechanism. Necessary interlocking may be included to prevent operation when breaker is closed.

Open outdoor disconnect switches for auxiliary feeders may be hook-stick operated if ferroresonance is not possible. Enclosed switches may be group (gang) operated with necessary interlocking to prevent improper operation.

Switch operating mechanisms should be designed to insure that the switch can be fully closed and latched, or fully opened without requiring undue force such as a handle extension or an extra person.

Power operating mechanisms (motor-driven, hydraulic, pneumatic) should not be specified except in special circumstances where remote operation is required. When supplied, they should include necessary limit switches, position indicator, interlocks and provisions for manual operation.

3. AUXILIARY POWER SYSTEM

3.1 Transformers

This item covers transformers for supplying power to gas turbine plant auxiliaries. Oil immersed transformers should not be installed indoors.

All requirements, definitions, and tests should be in accordance with ANSI Standards C57.12.00, C57.12.10, C57.12.80a and C57.12.90.

Design and Accessories

The transformer should have a standard KVA rating and voltage rating based on auxiliary power requirements of the gas turbine plant, including any customer-supplied equipment when specified.

Oil-immersed transformers should be equipped with the following accessories:

1. Tap changer for de-energized operation
2. Liquid level indicator
3. Liquid temperature indicator
4. Pressure-vacuum gauge
5. Drain and filter gauge
6. Nameplate
7. Ground pads
8. Lifting, moving and jacking facilities

Additional equipment and accessories may be specified as follows to meet special requirements:

1. Disconnect switch for high voltage side with interlock and terminal chamber
2. Throat connection on high voltage and/or low voltage side
3. Alarm contacts on temperature and liquid level indicators
4. Current transformers on high voltage and/or low voltage side and neutral if grounded wye connection is used
5. Fans and controls for forced-air cooling to increase rating (750 KVA and above)
6. Sudden pressure relay for indication of transformer faults
7. Cover mounted bushings with lightning arrestors on high voltage side
8. Gas detector relay

A transformer for supplying an electric motor-driven starting device requires special consideration. The KVA and voltage rating should be based on expected duty cycle and primary system characteristics. Recommendations should be provided by the gas turbine manufacturer, since it is common practice to operate the motor above its continuous rating during the starting cycle.

3.2 Motor Controls

Motor controls, when furnished with a gas turbine unit, normally provide for the protection and control of power plant motors and other remote electrical loads at voltages of 600 volts or less. Higher voltage motors and loads are sometimes controlled by special high voltage motor controls. In general, the basic reference is ANSI C19.7.

A motor control center consists of motor or other circuit interrupting devices, controlling and circuit protective devices, bus-work and accessories mounted on metal frames with all electrical connections completely enclosed inside sheet metal housings.

All equipment in the control center above 150 V shall be 600 volt class (120 V or less may be 300 V class) and shall withstand any three-phase short circuit up to the short circuit KVA specified without thermal or mechanical injury.

Most control centers should be designed with sufficient attention to access for field terminations and maintenance so that space is available to perform these tasks. Maintenance aids such as lights, convenience receptacles, terminal board locations, bus access, etc., may be included where ncessary.

Each circuit breaker or starter should be installed in a separate compartment.

Screens, barriers, etc., should be provided to prevent access by small animals that could cause equipment faults.

Circuit interrupting devices should be of sufficient capacity to handle the fault duty without damage to the equipment.

Motor control devices should not malfunction when supplied by bus voltages within the operating range of the plant.

Protection against single phase operation should be considered.

3.3 Switchgear

Switchgear, if included with the gas turbine plant, consists of circuit breakers, buses, and accessories, mounted on metal frames, with all electrical connections completely enclosed within sheet metal housings. The consolidated form of ANSI C37.20 provides the basic reference.

Switchgear may be used for all motor and plant loads, for higher than 600 V loads, or for selected high reliability loads at any voltage. Switchgear may also be used to house the generator circuit breaker and accessories (see section 5).

Many aspects of construction, ratings, service condition, and application are discussed in ANSI C37.20. In the gas turbine application particular attention must be paid to switchgear suitable for possibly frequent starts, unattended operation, and unusual atmospheres.

Main current carrying parts, insulators, supports and housings should have sufficient strength to withstand, without incurring damage, the effect of any momentary current resulting from a three-phase, line-to-line, or line-to-ground short circuit. The current shall be the rms value, including the direct current component, during the maximum cycle.

The switchgear may house protective relaying, instrument transformers, surge protection, neutral grounding, and other equipment associated with the bus and feeder circuits.

Sufficient space for termination should be provided especially in the case of potheads and stress cones.

3.4 Grounding

An equipment grounding system should be provided to interconnect and ground (normally) non-current-carrying conducive parts. This grounding system should be in accordance with recommended practices of IEEE Standard 142, "IEEE Standard Grounding of Industrial and Commercial Power Systems," which emphasizes the following:

"1) to assure freedom from dangerous electric shock and voltage exposure to persons in the area.

"2) to provide adequate current-carrying capability, both in magnitude and duration, to accept the ground-fault current permitted by the overcurrent protection system without creating a fire or explosive hazard to building or contents."

Equipment grounding paths closest to the power conductors (i.e., conduits and raceways) should be sized to carry essentially the entire time-current duty permitted by the overcurrent protective device without thermal or mechanical distress. This may involve an internal grounding conductor to share the return fault current duty with the conduit or raceway if the conduit or raceway does not have a sufficiently low ground impedance to carry the anticipated maximum fault current.

The equipment grounding network should maintain a sufficiently low grounding network impedance to accommodate full magnitude of ground fault current without producing voltages dangerous to personnel. In addition, connections from equipment to the ground grid should be numerous so that a loss of one would not result in a hazardous condition.

3.5 Motors

Basic motor standards are ANSI C51.1 and C52.1.

The nameplate rating of the motors should be suitable to meet the load requirements of the driven equipment at maximum capability. In general, motors should have sufficient capacity to operate without replacement over the life of the turbine and without restricting load. Starting motors may be operated beyond their nameplate rating for short periods of time.

Insulation of windings on all open drip-proof, weather-protected and splash-proof motors exposed to the surrounding atmosphere should be of such character and treated so that the winding will successfully withstand the conditions existent in gas turbine plants where there are atmospheres containing heat, moisture, oils and possible chemicals. The insulation shall be built up and impregnated so that it will remain flexible or pliable.

Shaft and bearing housings shall be constructed so that the lubricant will not leak along the shaft or be thrown into the windings.

Sufficient access holes and clearance around motors is needed to provide proper maintenance.

3.6 Wiring

Wiring in the gas turbine plant covers only those conductors that connect together panels, assemblies, or separately mounted devices. The internal wiring of these equipments and devices is considered outside the scope of this document. Flame retardant wiring should be supplied on all equipment where practical. Particular care must be exercised over placement of wire near high temperature or potentially high temperature parts of the turbine, and wire ducts, conduits, etc., should be mounted in vibration-free areas.

Control wiring should be at least #14 gauge copper, except where large size conductors are needed for current-carrying and voltage drop requirements. Insulation should be sufficient to a working voltage of at least 600 V. Wiring for instrumentation such as thermocouples should be appropriate for the use.

Cable and raceway applications should follow the scope of Section 13 of IEEE 422, "Guide for the Design and Installation of Cable Systems in Power Generating Stations." Cable trays and multi-conductor cables with plugs may be used for interconnections and between assemblies. Plug connectors should be of a type that do not loosen under expected vibration, are accessible and of the proper voltage rating.

Terminal boards used for purpose of interconnection of assemblies should have extra terminals if possible. No more than two wires per terminal should be connected unless long studs are supplied specifically for this purpose.

Circuits for 460 V or higher and for 120 V or lower should have separate terminal boards so that power and control circuits can be readily identified for safety and maintenance.

All wiring shall be continous from terminal to terminal. Separation by voltage level should be provided to minimize electrical noise and hazard as required. Shielding or twisted pairs should be provided where required.

4. DC SYSTEM

4.1 Battery

This section contains the general requirements for storage batteries furnished with a gas turbine. Definitions applying to lead storage batteries are contained in standard documents referenced below.

Batteries should be connected across a regular constant voltage charger. Battery loads will consist of control circuits, emergency lighting, emergency auxiliary equipment, and other essential loads.

Capacity

The batteries should be of sufficient capacity so that in the event battery chargers are inoperative, or ac auxiliary power is unavailable, the batteries will permit operation of all dc auxiliaries required for a safe shutdown without damage. There should be sufficient capacity for safe shutdown after a specified number of unsuccessful starts.

Battery sizing should consider the size, sequence and duration of loads to be carried, and derating factors for operating temperature. In addition, sizing should allow for degradation of battery capacity in service. Note that ANSI Standard N41.15, "IEEE Recommended Practice for Maintenance, Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations," in Section 6 calls for battery replacement if capacity tests indicate capacity is below 80% of the manufacturer's rating.

Battery Type

Selection of battery type should be made from those which are known to offer satisfactory characteristics with long life. Consideration should be given to the following types: lead-antimony, lead-calcium, and nickel-cadmium as listed and described in IEEE Standard 466, "IEEE Recommended Practice for Emergency and Standby Power Systems," Table 14.

Batteries should be designed to operate on a floating basis at the float voltage recommended by the manufacturer, and receive equalizing charges as recommended.

Battery voltage in service should be within the range of 105 to 140 volts to supply protective relays and control circuit devices that are accessible to an operator even though device voltage minimums may be lower. Additional, higher voltage batteries should be furnished if required to meet auxiliary loads economically.

Definitions of plates to identify various lead-acid cell constructions are given in NEMA Standards Publication No. 1B-1, "Definitions for Lead-Acid Industrial Storage Batteries."

Batteries as furnished on site should have an initial charge.

Location of Battery

The installation should provide mechanical protection, environmental conditions and maintenance features in accordance with IEEE Standard 484, "IEEE Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations," Section 4, "Installation Design Criteria," as applicable.

4.2 Battery Charger

This section contains the general requirements for storage battery chargers to be furnished with a gas turbine.

Definitions of terms applying to battery chargers are contained in NEMA Standards Publication No. PV5, "Consistent Potential-Type Electric Utility Battery Chargers."

The charger(s) should function to maintain a charge on the associated battery(ies) and to supply the load requirement of the dc system.

Performance

The battery charger should satisfactorily maintain a charge on the battery and within the limits of its rating should supply the normal load requirements of the dc system with or without the battery connected to the system. The charger should be capable of supplying the plant dc load plus charging current to a discharged battery to restore full charge within a reasonable time.

The charger floating and equalizing voltage ratings should be in accordance with the recommendations of the battery manufacturer for the type and number of cells employed.

The charger should consistently maintain the battery voltage within satisfactory limits from zero to the charger's current limit simultaneously with input voltage variations expected in the plant.

"Float" and "Equalize" (if required) voltage levels should be continuously (no taps) adjustable to at least ±4% from nominal values.

The charger should be designed for ungrounded operation to allow a ground detection system to be provided which will alarm in the event of a battery circuit ground.

The charger should employ automatic current limiting control and the unit should be fully self-protecting and capable of continuously carrying the load to the present current limit without damage.

Output ripple and voltage spikes should be limited as necessary with the battery connected so as to minimize electrical noise levels that may cause equipment malfunction or damage.

Accessories

The charger should be equipped with an ac input circuit interrupting device, a dc output circuit interrupting device, and dc output ammeter and volmeter.

5. PROTECTIVE RELAYING

This section contains the general requirements for electrical protective relays furnished with a gas turbine driven generator station. These are confined to larger units used primarily for utility power generation. Internal protection of the gas turbine and its mechanical accessories are considered part of the control section B133.4.

Terminology and classification pertaining to the protective relays are contained in ANSI Standard C37.90, "IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus," Section 4, "Definitions" and Section 5, "Classification of Relays, Relay Systems, and Related Terminology."

Protection

Protective relays should be furnished so that in the event a fault occurs affecting the unit, an alarm will be given if continued operation is permissible, or that unit will be automatically taken off the line if necessary. Action is suggested for the following conditions:

Generator Differential Faults
Generator Overcurrent
Generator Ground Faults
Generator Motoring
Generator Negative Sequence
Generator Loss of Excitation
Auxiliary Bus and/or Main Bus Undervoltage
Generator Field Ground

Additional protection may be required for specific installations. Main transformer protection may be included with the gas turbine even if the main transformer is not.

Lockout relays should be furnished to trip and hold equipment out of service for those fault conditions where restarting or reenergizing the unit without verifying that the fault has been remedied would present a hazard.

Backup Protection

Backup protection is advisable for generator and transformer faults. Consideration should be given to backup protection for other faults where the failure of one device might leave the unit in service exposed to damage.

Design Requirements

The relays should be suitable for operation in conformance with ANSI Standard C37.90, Section 6, "Service Conditions." They should be located and installed so as to avoid conditions that Section 6 lists under "Unusual Service Conditions."

Standard voltage and current ratings for relays should conform to ANSI Standard C37.90, Section 7, "Ratings.'

The relays shall operate within the limits of temperature rise for coils given in ANSI Standard C37.90, Section 8, "Heating."

The relays should pass dielectric tests in accordance with ANSI Standard C37.90, Section 9, "Dielectric Tests." In addition, static relays should be capable of passing surge withstand capability tests as described in ANSI Standard C37.90a, "IEEE Guide for Surge Withstand Capability Tests."

Test switches or test jacks should be provided for isolation and test for relay current circuits, potential circuits and tripping circuits.

Current test and isolating devices should be arranged to short circuit current transformer secondary circuits when the switch or device is opened.

Where possible, protective relays furnished should include an operation indicator or an alarm should be provided.

Consideration should be given to supervising the coil circuit of each lockout relay to assure proper operation.

AMERICAN NATIONAL STANDARDS FOR GAS TURBINES

The ASME Publications Catalog shows a complete list of all Standards published by the Society.

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