AMERICAN NATIONAL STANDARD

Procurement Standard for

Gas Turbine Auxiliary Equipment

ANSI B133.3 - 1981

SECRETARIAT

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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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 apply to open cycle, closed cycle, and semi-closed cycle gas turbines with conventional combustion systems for industrial, marine, and electric power applications. 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 aeropropulsion 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 B133.3 standard presents and describes features of several auxiliary systems of a gas turbine power plant. The user should include a consideration of these when developing his specification. The intent is to assist in the selection of a gas turbine and its systems that will provide satisfactory performance, availability, and reliability.

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, New York, 10017.

American National Standard B133.3 was approved by American National Standards Committee B133. Final approval by the American National Standards Institute was granted on April 3, 1981.

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PROCUREMENT STANDARDS FOR GAS TURBINES

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AMERICAN NATIONAL STANDARD

PROCUREMENT STANDARD FOR GAS TURBINE AUXILIARY EQUIPMENT

1. SCOPE

1.1 The purpose of this Standard is to provide guidance to facilitate the preparation of gas turbine procurement specifications. It is intended for use with gas turbines for industrial, marine, and electric power applications.

1.2 This section covers auxiliary systems such as lubrication, cooling, fuel (but not its control), atomizing, starting, heating-ventilating, fire protection, cleaning, inlet, exhaust, enclosures, couplings, gears, piping, mounting, painting, and water and steam injection.

2. GENERAL

2.1 Many combinations of auxiliary systems and variations are expected. This standard specifies minimums as well as outlining many options that require decisions by the user and the manufacturer. The application of the gas turbine, its expected operating mode, and its environment affect the combinations. Application standards such as ANSI B133.16 should help with this decision process.

2.2 The gas turbine, the load equipment, the several auxiliary systems, the control systems, and other necessary equipment shall be arranged in a logical, functional manner. Such arrangement shall consider equipment and station operation, equipment maintenance, installed cost, operating and maintenance cost, and appearance.

2.3 Consumables such as lubricants, antifreeze, etc., shall be furnished by the user unless furnished by mutual agreement between the parties involved.

3. LUBRICATION SYSTEM

3.1 General

The lubrication system(s) encompasses the storage, pressurization, cooling-heating, conditioning, and circulation of the lubricant used by the gas turbine, the load equipment, and the auxiliary equipment, as necessary. It may also supply the fluid to the hydraulic control system as needed.

3.1.1 Equipment. Equipment includes: reservoir, pumps, cooler(s), filter(s), pressure regulator, instrumentation, heater(s), piping, and vapor extractor.

3.2 Design

The lubrication system shall follow as a minimum ASME Standard No. 120.

3.2.1 Gas turbines using sleeve type bearings (rather than rolling element bearings) shall also follow the requirements of 3.3 and 3.4.

3.3 Peak Load Service

As a minimum, the following shall be supplied.

3.3.1 Pumps. A minimum of two pumps driven from two independent and different power sources shall be furnished.

3.3.1.1 Pump Drives. Examples of these pump drive combinations are as follows:

Main	Emergency
Shaft	DC Motor
AC Motor	DC Motor
AC Motor	Steam Turbine
Steam Turbine	DC Motor

3.3.1.2 Pump Controls. The emergency pump shall automatically start upon failure of the main pump or reduction in pressure due to other malfunctions. An accumulator should be supplied in the system when pressure maintenance under transient conditions (e.g., while the emergency pump is accelerating to full speed) is required.

3.3.2 Coolers. Either a single shell and tube cooler or a direct oil-to-air cooler or equivalent shall be supplied.

3.3.3 Filter. A single full flow filter shall be supplied. Filter bypasses shall not be used.

3.3.4 Vapor Extractor. On those turbines where partial vacuum is required in the bearing housings, a vapor extractor shall be supplied. The vapor extractor could be a motor driven device or an eductor.

3.4 Base Load Service

For user specified base load service, some additional redundancy shall be furnished.

3.4.1 Pumps. A minimum of three pumps driven from two independent and different power sources shall be furnished (except as determined by agreement between user and manufacturer).

3.4.1.1 Pump Drives. Examples of these pump drive combinations are as follows:

Main	Auxiliary	Emergency
Shaft	AC Motor	DC Motor
Shaft	AC Motor	Steam Turbine
AC Motor	Steam Turbine	DC Motor
Steam Turbine	AC Motor	DC Motor
AC Motor	AC Motor	DC Motor

3.4.1.2 Pump Controls. The auxiliary pump shall be furnished with automatic controls which shall cut in to provide lubricant pressure and maintain safe gas turbine operation while the auxiliary pump is accelerating to full speed.

3.4.2 Coolers

(a) For shell and tube coolers using raw water as a coolant, dual coolers should be provided and piping in parallel using a continuous flow oil transfer valve (except as determined by agreement between user and manufacturer). Each cooler shall be sized for the total cooling load.

(b) For shell and tube cooler in a closed cooling water system, a single cooler should be provided unless the user chooses the dual cooler similar to (a).

(c) For direct oil-to-air cooler, a single cooler should be provided.

3.4.3 Filters. Dual filters with a continuous flow transfer valve shall be furnished (except as determined by agreement between user and manufacturer). This applies to all primary filters in the lubricant and hydraulic control circuits. A single lubricant flow transfer valve may be used for the cooler and filter.

3.4.4 Vapor Extractor. See 3.3.4.

3.4.5 Transfer Valve. When dual coolers or dual filters are specified, multiport transfer valves shall be provided. The transfer valve must be designed such that flow shall not be interrupted during the transfer. A means should be provided to fill and vent the unused cooler or filter prior to transferring.

4. FUEL SYSTEMS

4.1 General

This section covers liquid and gaseous fuels and their associated systems used in the gas turbine. Included are the handling, treating, and forwarding of the fuel from storage to the gas turbine connection and the filtering, pumping, and metering to the gas turbine nozzles. The component parts of these systems are herein described.

4.2 Liquid Fuel Systems

Several subsystems operate together to make a total liquid fuel system for the gas turbine plant. These include unloading, storage, treatment, forwarding, and main turbine pump subsystems.

The main pump subsystem shall be furnished by the manufacturer. The forwarding system should be an option available from the manufacturer by agreement with the user. The remaining subsystems may be supplied by the manufacturer upon mutual agreement with the user.

4.2.1 Unloading Subsystem. The unloading subsystem handles the fuel from its unloading point, such as barge, tank car, or tank truck, to the storage tank. The equipment may include: unloading pump, strainers, filters, piping, and valving. For heavy fuels unloading, heating may be needed.

4.2.2 Storage Subsystem. Tankage in quantities suitable for the gas turbine plant size, usage, and the fuel to be used is required. The tanks should be equipped with appropriate inlets, outlets, vents, and sloping or cone bottoms with water drains. For heavy fuels, tank insulation and tank heaters may be required. Refer to ANSI B133.7.

4.2.3 Treatment Subsystem. Some fuels are contaminated in handling from the refinery to the site storage, and some fuels (heavy fuels) have unacceptable metal content. The extent of the treatment subsystem is dependent upon the types of fuel involved and the contaminants to be encountered. When required, subsystem types include cleaning, desalting, and inhibiting subsystems. Requirements for the treatment subsystem shall be determined by agreement between user and manufacturer.

4.2.4 Forwarding Subsystem. The fuel must be delivered to the gas turbine at a pressure and temperature which will permit proper functioning of the turbine fuel system. This forwarding system includes forwarding pump(s), heater(s) (when required), pressure regulating valves, and other necessary valves. It may also contain an automatic fuel stop valve activated by the gas turbine control and trip system.

4.2.5 Main Turbine Pump Subsystem. The main turbine pump subsystem encompasses the main fuel pump, the flow distribution system, the fuel control, the fuel stop valve, the final filtration stage, and the fuel piping.

4.2.6 Pumps. The services of pumps are unloading, forwarding, and main fuel oil pumps. Pumps should be of reliable industrial quality, containing materials suitable for continuous duty liquid fuel operation. The seals should be mechanical type, and arranged for easy access to facilitate maintenance.

4.2.6.1 Unloading. Unloading pumps used to unload barges, tank cars, trucks, etc., may be either centrifugal or positive displacement type with AC motor drive. Unloading pumps are not normally supplied by the manufacturer.

4.2.6.2 Forwarding. Forwarding pump(s) used to transfer fuel between storage tanks and gas turbine may be either centrifugal or positive displacement type with AC motor drive. These options can be purchased from the manufacturer.

When the forwarding pump(s) is employed in user specified base load service, redundant forwarding pumps with automatic switching from the primary to the backup shall be provided. For "black starts," a DC motor driven forwarding pump(s) is optional.

Separate forwarding pump(s) shall be provided for each fuel in dual liquid fuel systems.

4.2.6.3 Main. The main fuel pump is used to pressurize liquid fuel to the required level for injection into the gas turbine. The main fuel pump shall be compatible with the specified fuels. The pump may be either shaft or AC motor driven.

4.2.7 Filters. Filter(s) or strainer(s) are to be installed at the locations and under the circumstances described.

Coarse screen(s) or strainer(s) shall be provided on the suction lines of forwarding and unloading pumps.

A main full flow fine micron filter shall be provided on the main fuel pump suction line.

Twin main full flow filters with a continuous flow transfer valve should be provided for user specified base load service or heavy fuel service (except as determined by agreement between user and manufacturer). Filter bypass valves are not to be used. Centrifuges may be alternatives to the main filter.

Additional high pressure filters should be provided to protect gas turbine components such as fuel distributors and fuel nozzles.

4.2.8 Valves. The types of valves to be supplied are block, control, and stop valves. Other special purpose valves are also defined. Relief and check valves required for the proper operation and protection of the system are to be provided.

4.2.8.1 Block. Hand-operated block valves of plug, ball, or butterfly design are to be installed to bypass or isolate tanks, pumps, heaters, or any other equipment requiring periodic maintenance during operation.

4.2.8.2 Stop. Two means for quick stopping fuel flow shall be provided for each gas turbine. These devices are to respond to normal or emergency shutdown control signals. Fire-actuated stop valves at storage facilities are to be supplied where the local codes or specific circumstances dictate. When they are required, it is the responsibility of the user to so advise the manufacturer at the proposal stage and interlock these valves with the gas turbine fuel control system.

4.2.8.3 Control. Control valve(s) shall be used to regulate the flow of fuel to the turbine as a function of various control parameters. The valve(s) may control fuel flow directly or via bypass system. The valve actuators should be electric, pneumatic; or hydraulic and may interface with an electrical control signal in accordance with the manufacturer's standard.

4.2.8.4 Drain. All liquid fuel fired gas turbines shall contain drain valves. These valves shall be located at low points in the gas turbine where fuel can accumulate (and are also known as "false start drains").

NOTE: Certain low pressure points in the gas turbine may only require open drain piping in lieu of valves.

4.2.8.5 Heavy Fuel Circulate. On units which operate on heavy fuel, a circulation valve(s) is to be provided to continuously circulate heavy fuel in piping which always contains this type of fuel. Consideration should be given to purge in the event of a trip on heavy fuel.

4.2.8.6 Three-Way Selector. On units which will operate on heavy fuel, automatic three-way selector valves are to be provided when it is required to start and stop the gas turbine on light fuels.

4.2.8.7 Blowdown/Vent. Valves should be supplied for the purpose of venting air from fuel at high points. Manual valves are permitted for intermittent or maintenance type periods.

4.2.9 Fuel Distributor. A fuel distribution system is to be located between the main fuel pump and the gas turbine fuel nozzles (multi-nozzle versions).

4.2.10 Fuel Heaters/Tracing. Heaters and heat tracing are required for handling, treating and burning heavy fuel. These may also be required for light fuels in many locations.

4.2.10.1 Tank Heaters. All heavy fuel storage tanks should contain adequate heating to prevent solidifying and enhance pumpability of the fuel oil. Steam heating or electrical heating is usable, and should be specified by the user.

4.2.10.2 Inline Heaters. Inline heaters are frequently required for treatment or for injection into the gas turbine. Steam heaters are preferred for heavy fuels, but the alternates of electric heating or oil fired heaters may be used by agreement between user and manufacturer.

For gas turbines in base load service on heavy fuel, means should be provided to maintain availability in the event of heater failure. This can be accomplished by automatic transfer to light fuel or by redundancy in fuel heaters.

4.2.10.3 Heat Tracing. Piping used to transport heavy fuel should, for the most part, be heat traced and insulated. The heat tracing should be designed to maintain the required temperature at the specific points in the system. Either electrical or steam tracing is permitted in the handling and forwarding sections of the system. Normally, the details of these latter systems are resolved by agreement between user and manufacturer.

4.3 Gaseous Fuel System

Several components operate together for the gas fuel system. The manufacturer shall specify the gas conditions, which usually include pressure and temperature. The manufacturer shall further specify that the gas is dry and free of liquid fuels and that corrosive impurities are within acceptable limits. The user shall specify the heating value and physical properties of the gas.

4.3.1 Pressure Regulation Station. A pressure regulated supply of gas is required to meet the needs of the specific turbine. The pressure regulation station, therefore, shall include the pressure regulating valve, manual gas shutoff valve, and necessary controls for pressure regulation.

4.3.2 Fuel Control Station. It is the function of the fuel control station to control gas fuel from control system signals. Included in this function is fuel-on and shut-off, fuel for firing, fuel for acceleration, and fuel for the operating range. The hardware includes combinations of stop, regulating, and control valves; sensors, instrumentation, and actuators.

The total gas system shall be equipped with automatic vent valves actuated on shutdown so that pressurized gas is not trapped between valves.

The inlet to this system shall be equipped with an inlet strainer.

4.3.3 Fuel Distribution. The gas fuel shall be piped from the control valve in a manner to provide uniform distribution of the fuel to the combustion system.

4.3.4 Fuel Supply. To insure dryness and freedom from liquid hydrocarbons, scrubbers and knockout drums or superheaters may be required.

If the gas is not available at the required pressure from the supply pipe, a gas compressor will be necessary.

The user needs to specify the gas properties such as:

(a) Heating value
(b) Range of heating value
(c) Constituents that are potentially corrosive, such as:
 (1) Hydrogen sulfide
 (2) Sulfur dioxide and sulfur trioxide
 (3) Total sulfur
 (4) Alkali metals, sodium, potassium, and lithium

4.3.5 Special Gases. Process gas and high Btu gas require special consideration to insure that they maintain their gaseous state. Heat tracing is most likely required.

4.3.6 Supply. The manufacturer normally furnishes the fuel control station (4.3.2) and the fuel distribution (4.3.3). The user furnishes the fuel supply (4.3.4) and the pressure regulating station (4.3.1). These can change by agreement between user and manufacturer.

5. ATOMIZING AIR SYSTEMS

5.1 General

Some manufacturers employ atomizing air systems for starting and/or running to assist combustion when fired with liquid fuel. This system is normally composed of a compressor, some type of control valving, and an air supply manifold. Larger packaged boost compressors may also require precooling and/or aftercooling since temperatures from 400° to 700°F (204 to 371°C) may be encountered in these systems. In all cases when this system is provided, the manufacturer is responsible for confirming that the system will produce the desired results.

5.2 Equipment

When atomizing air systems are incorporated into certain manufacturer's designs, the following equipment is normally supplied:

5.2.1 Compressors. Depending on the fuel/air nozzle flow and pressure requirements, either positive displacement or centrifugal compressors can be used to provide atomizing air. The compressors may be single or multi-staged, but must be selected on the basis of intermittent or continuous duty; units designed for intermittent operation normally cannot run continuously. Seals and clearances should be designed to minimize leakage and temperature rise; materials should be compatible with the operating temperatures. Compressors may be driven from the gas turbine or by AC motor.

NOTE: The manufacturer should define whether the compressor is required for starting and/or running, and should specify the horsepower absorbed.

5.2.2 Receivers. Sometimes to minimize the size of starting atomizing air compressors, air receiving storage tanks are employed. These receiver tanks are acceptable as long as they are built and tested per ANSI/ASME BPV-VIII-1. An adequate automatic condensate removal system connected to the tank drain connection must also be provided. The tank must be protected by means of a relief valve and a control to maintain the storage pressure at safe operating levels. The receiver/compressor combination must be designed to provide the required atomizing air flow and pressure as stated by the manufacturer.

5.2.3 Precoolers/Aftercoolers. The atomizing air coolers (when applicable) should be shell and tube or air-to-air, and conform to 7. The materials of construction should be corrosion resistant.

5.2.4 Control Valves. Control valves shall be furnished as necessary for the proper operation of the system.

5.2.5 Manifold. In order to properly distribute the atomizing air to all combustion nozzles, a fabricated piping manifold shall be provided. The manifold shall be sized to properly distribute air flow to the fuel nozzles. Short flexible connectors, suitable for the maximum operating temperatures, are permitted between the manifold and the nozzles. The manifold material shall also be suitable for the operating temperatures and should be corrosion resistant. The manifold shall be constructed with adequate connections for ease of nozzle disassembly and other gas turbine maintenance.

5.2.6 Filters. Filters or separators shall be furnished as necessary for controlling the particulate contamination level required for the proper operation of the system and the fuel nozzles.

6. STARTING SYSTEM

6.1 Types of Starting Equipment

Different types of starting equipment may be available:

(a) Electric Motors
(b) Diesel Engines
(c) Direct Air Injection
(d) Air Motor
(e) Hydraulic Motor
(f) Expander Turbine driven with air, steam, fuel gas, or other gas

The choice of starting equipment should be requested by the user and be agreeable to the manufacturer.

6.2 Service Conditions and Sizing

The starting unit shall be suitable for the acceleration of the gas turbine and the driven equipment, if a single shaft gas turbine and for extended operation at purge, compressor cleaning, and warmup speeds as appropriate. If the starting unit is not suitable for operation up to the gas turbine trip speed, it shall automatically disengage and shut down below the starting unit trip speed. In any event, it shall be selected to accelerate the system to gas turbine self-sustaining speed or beyond within an acceptable time interval. For single shaft gas turbines, the starting system shall be sized to include the load equipment, whether generators or mechanical drive equipment.

For most multiple shaft gas turbines, the starter will be sized by the gas turbine requirements.

6.3 Turning Equipment

If the gas turbine design requires rotation of the shaft prior to startup and/or following shutdown, the starting system shall include a turning mechanism. It may also be used for breakaway in the normal starting sequence.

6.4 Control and Instrumentation

Starting system control shall be provided in the gas turbine startup sequence.

All instruments, relays, etc., shall be in manufacturer's furnished panels and be conveniently and accessibly located.

6.5 Diesel Engine Starting (if applicable)

The starting diesel engine may be two or four stroke, forced lubrication, air or water cooled.

6.5.1 Engine Equipment. Diesel engines shall be complete with:

(a) Electric start motor with suitable battery and rectifier for continuously charging batteries, or air start motor and air source
(b) Fuel supply system
(c) All control and instrumentation required for safe operation, conveniently and accessibly located
(d) Control and safety devices
(e) Shop mounted wiring and cables
(f) Complete engine cooling equipment
(g) Air intake filter
(h) Necessary piping and electrical accessories
(i) Exhaust silencers

6.5.2 Transmission. One hydraulic torque converter shall be furnished, complete with associated accessories and an auxiliary gear, if required. An automatic disengaging clutch shall disconnect the starting engine when the gas turbine reaches self-sustaining speed.

6.6 Electrical Starting (if applicable)

6.6.1 Motor Equipment. Electric motor shall be complete with:

(a) All control and instrumentation required for safe operation, conveniently and accessibly located
(b) Shop mounted wiring and cables
(c) Provisions for space heaters

6.6.2 Transmission. A hydraulic torque converter shall be furnished, if required, complete with associated accessories and auxiliary gears.

An automatic disengaging clutch shall disconnect the starting motor when the gas turbine reaches self-sustaining speed.

6.7 Starting Turbines (if applicable)

6.7.1 A starting turbine using a source of steam, compressed air, or compressed gas shall be supplied. (The steam or compressed fluid shall be furnished by the user.)

The media shall be determined by agreement between user and manufacturer.

The turbine shall be furnished complete with necessary controls and instrumentation.

6.7.2 Transmission. Necessary gearing and associated accessories shall be furnished.

An automatic disengaging clutch shall disconnect the starting turbine when the gas turbine reaches self-sustaining speed.

6.8 Other types of starting systems may be provided by agreement between user and manufacturer.

7. COOLING SYSTEMS

7.1 General

Various systems associated with a gas turbine power plant require cooling, for example, lube oil, turbine air, generator coolant, etc. The type of cooling system to be supplied is to be determined by agreement between user and manufacturer.

7.1.1 Equipment. Equipment to be included is: heat exchangers, coolant pumps, coolant expansion tanks, and coolant control.

7.2 Heat Exchangers

7.2.1 Shell and Tube Heat Exchangers. Shell and tube heat exchangers shall be designed and constructed in accordance with Mechanical Standards TEMA Class "C" Heat Exchangers. The following design attributes should be applied:

(a) Minimum tube outside diameter should be 0.625 in. with a minimum of 18 BWG wall thickness. (The metric equivalent is about 16 mm diameter and 1.14 mm wall thickness.)

(b) The tube bundle should be removable to make maintenance of heat exchange surfaces easier.

(c) Fouling factors applied to the design should be per TEMA standards or as agreed upon between the manufacturer and user. (The user is predominantly involved in this decision with identifying the type of cooling water when it is other than a closed water system.)

(d) Materials of construction should be per manufacturer's standards or as determined by agreement between user and manufacturer.

7.2.2 Air Cooled Exchanger. Air cooled exchangers take many forms. They usually include an extended surface and a fan to force air circulation over the surface. They are used for air-to-air, air-to-water, or air-to-oil cooling. The following design attributes should be applied:

7.2.2.1 Minimum tube inside diameter should be 0.625 in. to facilitate cleaning of tubes.

7.2.2.2 Header construction must be of either removable end plate or plug type to facilitate cleaning of tubes.

7.2.2.3 Materials of construction shall be per manufacturer's standard or as determined by agreement between user and manufacturer.

7.2.2.4 Fan motors must be suitable for outdoor installation. Motors must be sized to accommodate the maximum horsepower required by the fan, which usually occurs at the coldest ambient temperature.

7.2.2.5 Fans may be adjustable or fixed pitch design.

7.2.2.6 Fan motor, fan, and belt or reduction gear, if used, must be accessible for ease of maintenance.

7.2.2.7 The cooler design should take into consideration the sound level for which the power plant is rated. The fan is usually a significant noise source that can be controlled by design method, which may include silencing.

7.3 Coolant Pump

A coolant pump is generally provided by the manufacturer when he supplies a closed cooling system for one of his functions. In an open cooling system, a coolant pump is generally provided by the user. The following design considerations should apply to either situation.

7.3.1 A centrifugal pump is preferred.

7.3.2 Pump construction and material should be suited for cooling water service.

7.3.3 Pump seals should be of mechanical type and arranged for easy access to facilitate maintenance.

7.3.4 If the pump requires minimum through flow to prevent overheating, then a system must be provided to insure this minimum through flow.

7.3.5 For user specified base load service, a second full size backup pump should be provided, piped, wired, and controlled with automatic startup.

7.4 Coolant Expansion Tank

In a closed coolant system, an expansion tank shall be provided to accommodate the increase in coolant volume with increase in temperature. The tank must be adequately sized, taking into account the temperature extreme and the volume of coolant in the system. The tank should be located on the suction side of the coolant pump.

7.5 Coolant Control

In either an open or closed cooling system, a means must be provided for controlling the coolant flow or temperature as a function of the fluid whose temperature is to be controlled.

For a closed cooling system, the control system shall be supplied by the manufacturer; for an open cooling system, the supplier of the control system shall be as agreed to by the manufacturer and the user.

7.6 Sizing

The cooling systems shall be sized to perform satisfactorily and provide proper cooling at the ambient extremes at the site. Weather data is a source for the ambient extremes, but the user and the manufacturer should mutually agree upon the extremes for design.

For systems using liquid coolants supplied by the user, the temperature extremes shall be determined by agreement between user and manufacturer.

7.6.1 Antifreeze. Cooling systems using water may require antifreeze as dictated by the ambients involved. The antifreeze shall be supplied by the user. Those systems requiring antifreeze shall be designed for use of the required concentration on a year-round basis.

7.7 Assembly

Cooling systems furnished by the manufacturer preferably should be factory assembled in modules on structural bases for ease of installation.

8. HEATING-VENTILATION SYSTEMS

8.1 General

Heating, ventilation, and air conditioning systems are utilized to maintain acceptable environment within the gas turbine power plant enclosures.

8.2 Design Parameters

Requirements for these systems are determined by the following plant operating conditions:

(a) Ambient temperature conditions

(b) Material and construction of plant enclosures

(c) Required temperature levels within power plant enclosures

(d) Internal heat sources from operating equipment, lighting, and personnel

(e) Required cleanliness of power plant enclosures for operating equipment and personnel in relation to the site conditions

(f) Locations of heating, ventilation, and air conditioning equipment to prevent recirculation, the spread of airborne contaminants and hazardous substances, and noise.

8.3 Machinery Enclosure Requirements

The several groupings of equipment such as gas turbine, accessory package, etc., are enclosed for various reasons. Appropriate heating, ventilation, and/or air conditioning are provided for the equipment during operation and for readiness to operate. The ventilation shall minimize the accumulation of hazardous atmospheres. Ventilation fans and enclosure openings for ventilation will be acoustically treated as necessary to satisfy the requirements of ANSI B133.8. Ventilation openings will be equipped with necessary closures interlocked with the fire protection system so that extinguishing agent concentrations can be maintained (9.2).

For applications at user-identified locations of high dirt concentrations or sand storm conditions, filtered pressurizing ventilation systems may be furnished by mutual agreement. The user is responsible for advising the manufacturer during the proposal stage that he may use fuel with a flash point below 110°F (43°C), and that explosion proofing is required.

Heating, ventilation, and air conditioning systems will be automatically controlled to maintain the proper conditions for the machinery.

8.4 Control Enclosures

Heating and air conditioning systems may be required to maintain an acceptable temperature level within the enclosure(s) for plant control equipment and operating personnel.

8.5 Hazardous Areas

Because of the combustible nature of some of the materials handled in the gas turbine power plant, special design considerations are necessary.

8.5.1 Liquid Fuels. Leakage of fuels with low flash points below 110°F (43°C) have the potential for forming combustible mixtures.

For gas turbines handling such liquid fuels, all of the electrical equipment in the involved areas shall be explosion-proof per NFPA 70, Class I, Division 2, Group D. Requirements applied to electrical wiring and equipment in Class I locations are defined by NFPA 70, Article 501.

The ventilation of areas exposed to low flash point fuels shall be arranged to minimize accumulation of heavy vapors in low spots of the enclosures.

8.5.2 Gas Fuels. Gas fuel system areas with leakage potential, such as those containing control, regulation, and instrumentation devices, shall be explosion-proof per NFPA 70, Class I, Division 2, Group D. Requirements for these areas are defined by Article 501. Gas detector alarms may be furnished by mutual agreement.

The ventilation of the areas exposed to the gas fuels shall be arranged to minimize the accumulation of the gases. When the gases are heavier than air, the low spots need special consideration.

8.5.3 Batteries. Gases are emitted from batteries, and their enclosures shall be arranged to allow free or forced ventilation of these gases to the atmosphere. Ventilation must provide sufficient diffusion to prevent the accumulation of a explosive mixture.

9. FIRE PROTECTION SYSTEMS

9.1 General

Fire protection should be furnished in those areas of potential risk of lubricating oil, fuel, and electrical equipment fires. Normally these areas include the accessory compartments and the gas turbine compartments. Driven equipment compartments such as a generator package may require fire protection as determined by mutual agreement.

9.2 Requirements

The design of the fire protection system shall be in accordance with the following standards:

(a) Carbon Dioxide Extinguishing Systems – NFPA 12

(b) Halogenated Extinguishing Agent Systems Halon 1301 – NFPA 12A or Halon 1211 – NFPA 12B

(c) Dry Chemical Extinguishing Systems – NFPA 17

(d) National Electrical Code – NFPA 70

The purpose of the fire protection system shall be to detect the fire, extinguish the fire, and prevent rekindling so as to allow time for effective emergency action by trained personnel. The system must have all necessary safeguards to protect the plant operating personnel. The extinguishing agent shall not be injurious to the gas turbine plant equipment. Compartment enclosures should provide a reasonably well enclosed space in order to minimize the loss of extinguishing medium. Ventilating systems shall be shut down prior to agent discharge. Enclosure ventilation openings shall be equipped with automatic closures.

NOTE: Water deluge systems are not acceptable for the insides of the accessory and gas turbine compartments.

9.2.1 Equipment. As a minimum, this system includes the following hardware:

(a) Temperature sensors appropriately located in the several compartments. A reasonable temperature difference between the sensor and its normal location temperature is required to prevent spurious trips. The sensors should normally not be mounted on the gas turbine or in high vibration areas, except when their function dictates. The sensors may be rate compensated thermal detectors. Also, electrical and control equipment areas may be equipped with combustion product detectors. Optical detectors may be used if deemed adequate for specific requirements by the manufacturer and the user.

(b) High pressure cylinders, spheres, or low pressure refrigerated tank for storage of extinguishing agent.

(c) Piping manifolds and nozzles necessary to distribute the agent during discharge.

(d) Automatic closures for the compartment ventilation openings.

(e) Alarm devices to give positive warning of a fire hazard, a discharge, or pending discharge.

(f) Automatic controls to release the extinguishing agent and trip the gas turbine (with fuel shutoff) upon detection of a fire. These controls shall include a time delay before agent release to permit compartment evacuation. The automatic controls should also initiate an annunciator panel indication and provide electrical contacts for remote signal use.

(g) Manual release controls to perform the same function as the automatic controls.

9.2.2 Extinguishing Gas Supply. The quantity of gas to be in storage is determined by the following:

(a) In the gas turbine compartment the initial extinguishing concentration must be achieved in accordance with NFPA 12, 12A, or 12B, depending on the type and volatility of the fuel involved.

Additional quantities of agent are required to overcome normal leakages and maintain an extinguishing concentration sufficient to prevent rekindling.

(b) In the accessory compartments the initial extinguishing concentration shall be determined by the type and quantity of flammable material involved per NFPA 12, 12A, or 12B.

(c) The number of turbines protected from the same storage and the number of releases desired from the agent storage affects the sizing.

(d) When the gas turbine uses a fire-resistant lubricant (such as the phosphate ester type), the agent used to prevent rekindling can be greatly reduced.

9.2.3 Fuel System. The fuel system shall be interlocked with the fire extinguishing system so that the fuel supply is automatically shut off upon actuation of the fire detection system (4.2.8.2).

9.3 Carbon Dioxide Systems

One gaseous extinguishing agent is carbon dioxide. See NFPA 12.

9.3.1 Concentration for the Turbine Compartments. A CO_2 concentration of 34% shall be provided to extinguish oil fires. For accessory compartments, a CO_2 concentration of 50% shall be provided to extinguish fires in electrical equipment and oil. Refer to NFPA 12.

9.3.1.1 For the gas turbine compartments, combustion area, bearing tunnels, and piping areas, the rate of discharge shall be such that a 34% concentration is attained within one minute after release and a 30% concentration shall be maintained for sufficient time to prevent rekindling.

9.3.1.2 For the accessory compartment, an initial discharge concentration of 50% shall be attained within one minute after release and a 30% concentration shall be maintained for at least ten minutes.

9.4 Halon System

Extinguishing agents Halon 1301 and Halon 1211 may be used. Refer to NFPA 12A and 12B, respectively.

9.4.1 Upon release, an extinguishing concentration of 5% at 70°F (21°C) shall be attained within ten seconds in the compartment where the fire is detected. An extinguishing atmosphere shall be maintained for sufficient time to prevent rekindling. The minimum period to maintain an extinguishing Halon atmosphere is ten minutes. When gaseous or highly volatile fuel is used, an initial concentration of 8% shall be attained to provide an inert atmosphere.

9.5 Dry Chemical

Optionally a dry chemical extinguishing system may be furnished for nonelectrical equipment areas. Refer to NFPA 17. (Residue of dry chemical extinguishing may be undesirable for electrical equipment.)

9.6 Backup Systems

9.6.1 Other fire fighting equipment may be advisable, and these are normally supplied by the user. These include backup systems such as site fire hydrants, fire hoses, and portable extinguishers.

10. CLEANING SYSTEM

Due to the varying site locations and types of fuels burned, the compressor and turbine are subject to fouling which results in power reduction. The purpose of the cleaning systems is to introduce a cleaning agent into the gas turbine to remove the buildup on the blades and restore power. A cleaning agent normally will not remove all of the buildup on the blades, and eventually hand cleaning of the blading may be required.

10.1 Compressor Cleaning

Two methods of cleaning the compressor, the wet or the dry method, are accomplished by introducing the cleaning agent into the compressor inlet. Equipment to implement either method can be provided by agreement between user and manufacturer.

10.2 Turbine Cleaning

Certain types of fuels burned in a gas turbine leave deposits on the turbine blades. The nature of these deposits is such that a major portion can be removed by washing with water or other agents. Due to the inaccessibility of turbine blades, a predesigned cleaning system is required. By mutual agreement between the user and manufacturer, the required system(s) will be identified and furnished.

10.3 Washing System

When furnished, this system may include the pump, valves, controls, and piping necessary to transfer the water from the supply to the appropriate injection points on the gas turbine and to drain the effluent from the gas turbine. The hardware shall be corrosion resistant and suitable for this service. Water flow, pressure, and water quality are to be established by the manufacturer.

10.4 Dry System

When furnished, this system injects dry cleaning agents into the gas turbine for deposit removal during operation. The hardware includes a hopper, injector system, controls and necessary piping. The cleaning agent will be specified by the manufacturer.

10.5 Special Considerations

Care should be used in the system design and the operating sequence to prevent the introduction of water and cleaning agents into portions of the gas turbine where they are not wanted (for example, the lubrication system).

11. INLET SYSTEM

11.1 General

The inlet system conveys the ambient air to the gas turbine compressor inlet. This system may include a silencer and may control the ingress of foreign material. It is important that this system provide a uniformly distributed flow to the compressor.

11.2 Equipment

As a minimum, the following equipment is included: ducting, silencer, and the necessary supports and expansion joints.

11.2.1 Optional Equipment. When specified by the user, equipment in addition to that specified in the preceding paragraph would be furnished such as trash screens, inlet filters, evaporate coolers, anti-icing systems, etc.

11.2.2 Supply Option. The manufacturer will normally supply the inlet system. When the manufacturer does not furnish system components, the user should submit the designs to the gas turbine manufacturer for review and comment.

11.2.3 Marine Applications. Due to the severe environment of marine applications, special considerations are normally entailed. Refer to ANSI B133.16.

11.3 Design

The manufacturer should state the inlet system total pressure drop and the operating conditions for this drop.

11.3.1 Loads. The inlet system will be designed to meet the wind, snow, and seismic loads of the current edition of the Uniform Building Code.

The system design shall minimize the accumulation of water from rain or melting snow and ice.

11.3.2 Fasteners. The inlet system design will minimize the need for bolts, nuts, or other connectors which can become loose and be carried in the air system. Any such fasteners used will be welded or otherwise suitably locked so that they will not loosen and be carried into the compressor.

11.3.3 Materials

11.3.3.1 Normal Environment. Low carbon steel duct walls shall be suitably primed to resist corrosion. It is recommended practice that, as a minimum, any thin gage sheet or perforated sheet in the airstream be made of low alloy, corrosion resistant steel, galvanized or otherwise, suitably protected against corrosion.

11.3.3.2 Corrosive Environment. When warranted by the site conditions, extra corrosion protection should be requested by the user. Consideration shall be given to special corrosion-resistant paints, galvanizing, or the use of stainless steel as dictated by the site environment and by agreement between user and manufacturer.

11.3.4 Screens. Inlet systems not equipped with inlet filtration may have a coarse metal entrance screen to prevent debris or birds from entering the inlet. An additional screen may be furnished and mounted downstream of the silencer. The furnishing of screens will be by agreement between user and manufacturer.

11.3.5 Silencers. Many forms of silencers may be used such as parallel baffles, lined ducts, etc. Refer to ANSI B133.8.

11.3.5.1 Attenuation. The silencer, duct, and total inlet system shall control the inlet noise consistent with the overall noise limitation specified in ANSI B133.8.

11.3.5.2 Construction. The silencers shall be designed to minimize loss of the lining and packing material into the airstream.

11.3.6 Ducting. In keeping with the total design pressure losses, the duct system shall be arranged for low air velocity with a minimum number of changes in direction and a minimum of transitions consistent with the air conveyance, conditioning, and silencing functions.

11.3.6.1 Walls. Duct walls shall be sufficiently rigid to avoid vibration problems.

11.3.6.2 Supports. When the inlet system is supported by anything but the foundation, the supports shall be furnished with the inlet system.

These supports shall carry the static loads plus dynamic loads, such as wind and flow stream reactions.

The support system shall allow for necessary relative growths between the ducts and other components and the structure.

The ducting and supports shall be designed to remain in place when sections near the gas turbine are removed for access or maintenance.

11.3.6.3 Manways. Manways shall be provided to allow final cleaning and inspection of the entire duct system before operation, and access for maintenance.

11.3.6.4 Maintenance. Removal of a minimum of the inlet system should be required for access to the gas turbine or other equipment during maintenance.

11.3.7 Expansion Joint. Expansion joints shall be provided to accommodate the relative movement of the inlet system components and the gas turbine. They may have an internal liner to prevent undue flutter, joint deterioration, or pressure drop. The joints should be covered with sound absorbing material as required to meet noise level specifications.

11.3.8 Filters. For base load service or under adverse conditions, the user should specify the use of inlet filters.

11.3.8.1 Types. The inlet filter type may be media, inertial, or a combination of both. Media filters may be either renewable or cleanable.

11.3.8.2 Site Conditions. The user will specify site contaminants and conditions influencing filter selection. (The gas turbine manufacturer can assist by providing a site survey if specified by the user.)

11.3.8.3 Filter Equipment. Included with the filter are the media and filter elements; the casing forming the filter chamber and media support; a coarse metal entrance screen or weather louvers; ladders and platforms for inservice inspection or changing of filter media; automatic relief or implosion doors to prevent starving of gas turbine inlet; and a differential pressure alarm.

11.3.9 Evaporative Coolers. Coolers may be either spray type or media type. When coolers are to be supplied, the type must be specified.

Included with the cooler is the media or spray system; the casing forming the cooler chamber and the media or spray support; the water distribution and collection systems; the control system, the support system (if other than the concrete foundation); and ladders and platforms for inservice inspection and maintenance.

11.3.9.1 Cooler Parameters. As a minimum, the following parameters shall be mutually agreed upon:

(a) **Effectiveness.** The normal range of effectiveness is 60%-90%. It is defined as:

$$\text{Effectiveness} = \frac{T1DB - T2DB}{T1DB - T1WB}$$

T1DB = dry bulb temperature at entrance of cooler

T1WB = wet bulb temperature at entrance of cooler

T2DB = dry bulb temperature at the cooler discharge

(b) **Pressure Drop.** The pressure drop due to the addition of the evaporative cooler must be mutually agreed upon and its effect on gas turbine performance taken into account.

11.3.9.2 Water Quality. The manufacturer must define water quality requirements and recommended blowdown procedure for satisfactory operation of the evaporative cooler and gas turbine.

11.3.9.3 Water Carry-Over. A moisture separator or some inherent feature of the design must be used to limit liquid carryover into the airstream.

11.3.9.4 Corrosion Protection. Choice of materials and finishes must be adequate for corrosion protection.

11.3.10 Icing Alarm and Anti-Icing. Although inlet icing is relatively rare, in certain locations it may be a significant risk. Site conditions may dictate either an icing alarm or an anti-icing system. This shall be determined by agreement between user and manufacturer.

11.3.10.1 Icing Alarm. The function of the icing alarm is to provide warning of inlet icing so that the gas turbine can be shut down before icing damage can occur. Shutdown can be automatic or operator initiated as agreed upon between the user and manufacturer. Icing sensor characteristics shall be chosen to provide adequate warning time and minimize false alarms.

11.3.10.2 Anti-Icing. The function of the anti-icing system is to provide sufficient heating of the inlet system or inlet air so that ice formation in the inlet system is precluded, thus allowing gas turbine operation when icing conditions are present. This system may be automatically or manually initiated. Since several techniques can be used to accomplish anti-icing, the design concept and its effect on unit operation and performance must be agreed upon between the user and manufacturer.

12. EXHAUST SYSTEM

12.1 General

The exhaust system conveys exhaust gases through the silencers and directs them up into the atmosphere for dispersion or into heat recovery equipment. If sufficient sound attenuation is achieved by the heat recovery equipment, exhaust silencers may be omitted from the ducting.

12.1.1 Equipment. As a minimum, the following equipment is normally included: ducting, silencers, expansion joints, and structural supports.

12.1.2 Optional Equipment. When specified by the user, additional equipment will be furnished, such as stack covers, heat recovery equipment, and any related dampers or ducting and lagging, or siding for personnel protection and aesthetics.

12.1.3 Supply Option. The manufacturer will normally supply the exhaust system. When the manufacturer does not furnish system components, the user should submit the design to the manufacturer for review and comment.

12.2 Design

The manufacturer should specify the exhaust system pressure drop and the operating conditions for this drop. When heat recovery equipment is specified, suitable allowance in the design must be made for the additional back pressure forces which will occur. The exhaust system shall be suitable for the induced thermal growth loads. It shall also be designed for wind, snow, and seismic loads called out by the Uniform Building Code. The internal and external walls must be suitable for the dynamic forces generated by the gas stream.

The ducting should contain the minimum number of changes of direction and shall have turning vanes when required. Abrupt changes in cross section should be avoided. The gas stream exit should be sufficiently high with respect to adjacent structures and have sufficient velocity to insure adequate dispersion and eliminate downwash effects.

12.2.1 Fasteners. All fasteners shall have adequate locking means to prevent loosening under vibration. Bolt connections exposed to the exhaust gas stream shall have nuts tack welded to the bolt.

12.2.2 Silencers. Sufficient noise attenuation shall be furnished to be compatible with the overall noise requirement (refer to ANSI B133.8). Silencers shall be designed to minimize loss of sound absorbent material into the gas stream.

12.2.3 Ducting. Ducting walls shall be suitable for the dynamic loads and sufficiently rigid to avoid vibration problems. The material must have adequate strength at design temperature. Fixed points and expansion joints must be located to take up thermal growth in the desired manner without putting excessive loads on the gas turbine. Expansion joints, if used, shall be gastight at rated pressure. Maintenance must be considered in the exhaust ducting design. Removal of a minimum amount of the exhaust ducting should be required for turbine access during maintenance.

12.2.4 Manways. In each duct, sufficient access openings must be provided so that the entire ducting and silencer system can be inspected.

12.2.5 Materials. Materials of construction and their protective coatings shall be corrosion resistant at their operating temperatures.

12.2.6 Drains. Appropriate drains shall be provided for rainwater and wash water, with user connections at convenient locations.

12.2.7 Exhaust System Sampling. Regulations may require an acceptance test in which exhaust gas flow and pollutant concentrations are measured by traversing in the stack of exhaust ducting. Sampling fittings shall be provided in accordance with the requirements specified in ANSI B133.9.

13. ENCLOSURES

13.1 General

Enclosures are provided around specific items or major groupings of equipment, such as the gas turbine proper, the accessory package, etc., to provide weather protection, sound attenuation, a means of containing fire protection agent, and to give a generally pleasing appearance.

13.1.1 Equipment. Sufficient equipment shall be provided to give weather protection, sound attenuation, and containment of fire protection agent, as required. This should include the necessary doors, flashing, seals, heating, ventilation, and interior (normal and emergency) lighting.

13.1.2 Optional Equipment. When specified by the user, additional equipment will be furnished such as a maintenance building, crane, appearance siding, or walls.

13.2 Design

Unless otherwise specified, the enclosures shall be designed to meet the wind, snow, and seismic loads of the current edition of the Uniform Building Code. Any walkways, stairways, handrails, and occupied areas must meet the applicable OSHA requirements.

13.2.1 Access for Maintenance. Sufficient access doors and panels shall be provided to give adequate access for maintenance. All access doors shall be openable and shall have provision for being opened from within if there is room for human occupancy in the space they enclose.

13.2.2 Electric Equipment. Any electrical equipment or wiring supplied shall be in accordance with applicable codes that shall be specified by the user.

13.2.3 Field Erection. As far as practical, enclosures will be shipped, installed with equipment items, or so designed as to minimize field erection.

14. COUPLINGS

14.1 General

Shaft driven devices are interconnected with couplings. These devices may include the load equipment, auxiliary gear, load gear, helper drivers, and accessories. The couplings and guards are usually furnished with the gas turbine. As an option, the load coupling may be furnished by the user.

14.1.1 Types. Several types of couplings are usable but they shall be limited to those of all steel, or better construction. Couplings of the following type may be used.

(a) Solid flanged distance piece.

(b) Flexible. Gear type with continuous circulating lubrication.

(c) Flexible. Gear type with contained lubrication.

(d) Flexible. Diaphragm or flexible plate nonlubricated couplings.

14.2 Design

Couplings and guards shall be designed to take the necessary relative movements of the various casings and shafting of the coupled equipment. These relative movements may be axial or in any radial plane or in combinations of axial and radial planes.

The manufacturer shall specify the-alignment for the components connected with these couplings.

Couplings shall be sized to withstand the rated torques and the transient loads, including electrical fault torques.

14.2.1 Balance. The couplings and spacers shall be dynamically balanced independent of the rotating assemblies to a tolerance suitable for the maximum continuous speed. The coupling halves, spacers, and bolting shall be suitably match-marked or numbered. Bolting may be selected by weight to permit interchange without altering balance.

14.2.2 Access. The couplings and guards shall be arranged so that they can be removed without removal of the rotors of the interconnected equipment. Similarly, they shall not prevent access to adjacent bearings and seals.

14.2.3 Guards. All couplings shall be furnished with complete guards for personnel protection (but not failure protection). The maximum opening in the guard should not exceed 1/2 in. (12.7 mm). Guard designs shall be consistent with OSHA requirements. Guards shall be removable and sufficiently heavy and rigid to prevent bodily contact with the coupling or shaft.

Enclosures for continuously lubricated couplings shall be arranged to permit coupling inspection without removing the feed and drain piping.

14.3 Service

By mutual agreement, continuously lubricated couplings may include dual full flow filters nominally rated 0.5 micron, with pressure indication in the lubricant feed at each coupling.

14.4 Critical Speed Analysis

The gas turbine, its load equipment, and the drive trains must be analyzed for torsional, lateral, and axial criticals. The manufacturer may do this analysis by mutual agreement. However, the necessary information must be made available from all suppliers of equipment in the drive system.

15. GEARS

15.1 General

Any load gear unit coupled directly to the gas turbine may be supplied by the manufacturer by mutual agreement. Auxiliary gearing required for starting the gas turbine or operating shaft driven auxiliaries shall be provided with the gas turbine.

15.2 Load Gearing (if required)

Gears for parallel shaft design may be single reduction or double reduction and double or single helical type. The appropriate AGMA (American Gear Manufacturers Association) service factor, based on maximum gas turbine horsepower and type of driven equipment, shall be applied. Gear quality shall be AGMA 12, minimum. For horizontally offset gears, the mesh shall be such that the pinion loading at the contact point is downward and the gear loading upward. Teeth shall be finished on both sides.

Bearing housings shall be of the horizontally split types. They shall include the bearings necessary to support the gear shafting in a stable manner. The bearings shall have replaceable metal-backed liners or pads. The optimum arrangement of bearing feed grooves and bearing liner split shall be determined by a reaction diagram which accounts for weight, reaction at various loads, and hydrodynamic reaction of the bearings (attitude angle). Bearing lubrication may be provided by the gas turbine lubrication system or a separate source.

The thrust loads generated in and transmitted through the total shaft train (gas turbine, load, gear, couplings, etc.) shall be considered. Appropriate thrust bearings shall be furnished as necessary.

The load gear shall be appropriately coupled to the gas turbine and the driven equipment. A torsional and lateral vibration analysis of the entire drive train shall be performed (14.4). Large overhung weights should be avoided on the load gear.

16. PIPING

16.1 General

Piping systems interconnect the several components of the various systems in appropriate manner (per the piping schematic diagrams) and convey the fluids to their points of use in the gas turbine power plant.

16.2 Construction

The piping should be designed, constructed, and inspected in accordance with ANSI/ASME B31.1.

16.3 Flushing and Cleaning

The lubrication system and liquid fuel system piping shall be flushed and cleaned in accordance with ASME Standard No. LOS-4C1. The flushing and cleaning during installation shall be performed by the party responsible for the installation.

16.4 Supply

Piping that is a part of the gas turbine shall be furnished by the manufacturer. Piping within the several skids (or subassemblies) supplied by the manufacturer shall be included by the manufacturer. Interconnecting piping from the several skids (or subassemblies) to the gas turbine will be furnished by either the user or the manufacturer. Skids with only piping interconnections to and from the gas turbine could logically be furnished by the manufacturer by agreement with the user. In the proposal phase, the manufacturer shall identify the interconnecting piping that he will not normally furnish.

17. MOUNTING

17.1 General

The mounting of the gas turbine and its auxiliary equipment may be divided into several categories, such as major packages, auxiliary skids, equipment mounted within packages or skids, or equipment mounted directly on the foundation.

The manufacturer shall furnish the necessary information, such as dimensions and loading, to define the equipment to foundation interface.

17.2 Loads

The gas turbine power plant equipment is subject to various types of loads: static, dynamic, and thermal. These may be encountered during (1) assembly in the plant, (2) shipment to the field, (3) handling and mounting in the field, and (4) plant operation.

17.2.1 Static Loads. These may be categorized into three areas:

(a) Weight of the object

(b) Static force due to another component's weight or structural member reaction force, and

(c) Static forces due to snow loading. The current edition of the Uniform Building Code shall apply for snow loading unless otherwise specified by the user.

17.2.2 Dynamic Loads. Dynamic loads are varying loads that result from machinery operating forces, wind forces, seismic forces, and shipping and handling forces.

Machinery operating forces are encountered with all equipment during normal operation. These are usually mechanically or fluidically induced vibrations.

Equipment exposed to the weather is subject to cyclical wind loads. The major items are the inlet system, the exhaust system, and the enclosures. These items are addressed in 11, 12, and 13 of this Standard.

Seismic loads are special types of dynamic loads from earthquakes. Design loads normally depend on geographical locations; the Uniform Building Code should be followed in handling these loads.

Shipping and handling forces result from transporting components and assemblies during manufacture and installation. The shipment may be by truck, rail, or ship. The specific loads and related considerations are addressed in ANSI B133.11.

17.2.3 Thermal Loads. The gas turbine plant includes components with many differing operating temperatures. A number of these are interconnected so thermal forces can be transferred during operation and during the transition from nonoperating to operating conditions.

17.3 Design

The gas turbine power plant and its components and subassemblies shall be designed to accept these static, dynamic, and thermal loads without failure or operational problems resulting.

Attachment of the various components and subassemblies by such elements as bolting, clamping, welding, rabbeting, and centerline guiding shall be designed for these several loads. Included with these attachments shall be provisions for adjustment of alignment between interconnected components and subassemblies.

17.3.1 Foundations. The foundation interface and mounting is within the scope of ANSI B133.11.

17.3.2 Vibration Isolation Mounting. Isolation mounts should be used for the effective mounting of two types of auxiliary components:

(a) Vibration inducing auxiliaries (such as an auxiliary compressor) of sufficient impulse producing capacity, located in an area where the proper operation of adjacent equipment may be impaired by such impulses.

(b) Vibration responding components whose operation or performance will be affected by the undamped transmission of induced vibrations produced by other nearby components.

The particular type of isolation mounting may vary from simple pad damping materials to encapsulated spring type mounts. Selection of a particular mounting system will depend upon the frequency and magnitude of the vibrations involved.

17.3.3 Maintenance and Accessibility. Rotating equipment should be located and mounted for ease of maintenance. Motors, couplings, etc., requiring periodic lubrication and maintenance should be accessible. Where equipment replacements may be required, mountings should be accessible for fastener removal, and adjacent equipment arranged to permit lifting or removing the subject component. Removable panels, doors, and partitions should be provided, where necessary, to enhance maintenance.

It is the manufacturer's responsibility to consider maintainability in the design of packages. Welding is a permanent fastening method and should be employed only where component removal is unnecessary.

17.3.4 Interface. Interconnections of subassemblies will transmit major static, dynamic, and thermal loads. The location of these subassemblies may have a significant effect on these loads.

When subassemblies and interconnections are furnished by the manufacturer, the design considerations for the load interfaces shall be the manufacturer's responsibility. However, when there is a split in the furnishing of the subassemblies, load limits shall be specified by the manufacturer. Furthermore, when there is a split in the furnishing of subassemblies and interconnections, an understanding of interface responsibilities should be agreed upon in the proposal phase.

18. PAINTING

18.1 General

External surfaces of ferrous material which are not fitted or working surfaces shall be painted for appearance and corrosion protection that will last a reasonable period of time. Surfaces of equipment made of corrosion resistant materials, such as stainless steel and galvanized steel, are exempt from painting requirements.

18.2 Preparation for Painting

The surface preparations shall be in conformance with the Surface Preparation Specifications of the Steel Structures Painting Council.

18.3 Coating

The paint systems shall be compatible with the operating temperatures and the expected exposures of fuels, lubricants, and the ambient.

18.3.1 Normal Surfaces. Several painting systems will be necessary to satisfy the surface requirements of temperature and other environmental conditions. The paint system and its application shall be specified by the manufacturer.

18.3.2 Lubricant Wetted Surfaces. Internal lubricant wetted surfaces such as tanks, bearing casings, gear cases, etc., shall be painted with a lubricant-resistant finish unless otherwise specified. It shall be one that can stand continuous immersion and washing with lubricant. After these surfaces have been washed with the lubricant, repainting is not recommended.

18.3.3 Field Painting. The finish painting will be done in the field after completion of installation. This is usually the responsibility of the user, but it can be done by agreement between user and manufacturer.

19. WATER AND STEAM INJECTION SYSTEMS

19.1 General

At times, water or steam injection is used to reduce or control emission levels in the gas turbine exhaust. Criteria to determine the need for such an emission control system and the applicable regulatory bodies and standards are found in ANSI B133.9.

19.2 Water Injection System

When this system is needed, the manufacturer shall specify the quantity of water required, the chemical quality of the water to be used, and the necessary supply conditions.

The manufacturer should specify the as-necessary size, flow, pressure, and temperature requirements to be met by the user at the gas turbine skid connections.

19.2.1 Equipment. A water injection system may include a water supply, a water treatment system, pumps, strainer-filters, piping, valves, flow distribution system, controls, and monitoring and recording systems. A skid, made up of pumps, piping, valves, distribution system, controls, and monitoring and recording systems that complies with specified regulations and standards should be available from the manufacturer. All equipment shall be compatible with the water. Freeze protection shall be designed into the system. The controls and injection system shall minimize the likelihood of flameout from water injection.

19.3 Steam Injection System

When this system is needed for emissions control, the manufacturer shall specify the quantity required, the chemical quality, and the necessary supply conditions.

19.3.1 Equipment. This system requires a source of steam of the specified conditions plus appropriate piping, valves, distribution, controls, monitoring, and recording. The manufacturer should offer a system, when required, that includes distribution system, on-base piping, valves, controls, and monitoring and recording systems.

19.4 Power Augmentation

Steam injection has been used for power augmentation. This system can be used by mutual agreement between the user and manufacturer. This Standard does not address details of such a system.

APPENDIX

REFERENCES

Documents referenced in the text of this Standard and publishers from which they may be obtained are listed below.

AGMA Classification – Manual 390.02

American Gear Manufacturers Association
1901 N. Fort Myer Drive
Arlington, Virginia 22209

ANSI/ASME BPV-VIII-1

ASME Boiler and Pressure Vessel Code, Section VIII–Division 1, Pressure Vessels

ANSI/ASME B31.1

An American National Standard Code for Pressure Piping: Power Piping

ANSI B133.7

Gas Turbine Fuels

ANSI B133.8

Gas Turbine Installation Sound Emissions

ANSI B133.9

Procurement Standard for Gas Turbine Environmental Requirements and Responsibilities

ANSI B133.11

Procurement Standard for Gas Turbine Preparation for Shipping and Installation

ANSI B133.16

Procurement Standard for Gas Turbine Marine Applications

ASME Standard No. LOS-4C1

ASTM-ASME Recommended Practices for Flushing and Cleaning of Gas Turbine Generator Lubricating Oil Systems

ASME Standard No. 120

ASTM-ASME-NEMA Recommended Practices for the Design of Gas Turbine Generator Lubricating Oil Systems

American Society of Mechanical Engineers
345 E. 47th Street
New York, New York 10017

Uniform Building Code

International Conference of Building Officials
5360 Workman Mill Road
Whittier, California 90601

NFPA 12 Carbon Dioxide Extinguishing Systems

NFPA 12A Halogenated Extinguishing Agent Systems Halon 1301

NFPA 12B Halogenated Extinguishing Agent Systems Halon 1211

NFPA 17 Dry Chemical Extinguishing Systems

NFPA 70 National Electrical Code

National Fire Protection Association
470 Atlantic Avenue
Boston, Massachusetts 02110

OSHA requirements

OSHA
200 Constitution Avenue, NW
Washington, DC 20210

Surface Preparation Specifications

Steel Structures Painting Council
4400 Fifth Avenue
Pittsburgh, Pennsylvania 15213

Standard of Tubular Exchanger Manufacturers Association

Tubular Exchanger Manufacturers Association
707 Westchester Avenue
White Plains, New York 10604