

KINGDOM OF CAMBODIA

Nation, Religion and King

ELECTRIC POWER TECHNICAL STANDARDS

Specific Requirements for Thermal Power Generating Facilities

Specific Requirements for Thermal Power Generating Facilities

Final revised draft in EAC

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CHAPTER 1

Introduction

Article 1 Definitions

In this Specific Requirements of Electric Power Technical Standards, unless the context otherwise requires, the following terms shall have the meanings assigned to each term:

1. EAC

“EAC” is the acronym for the Electricity Authority of Cambodia.

2. Electrical Line

“Electrical Line” means the part of electric power facilities used to transmit or supply electricity, which connects power stations, substations, switching stations and user’s sites, and includes lines and associated protective devices and switchgears.

3. Electric Power Facility

“Electric Power Facility” means generating facilities, substations, switching stations, electrical lines, and dispatching centers, including equipment, buildings, dam, waterways, fuel storage yards, ash disposal areas, etc.

4. Electrical Equipment

“Electrical Equipment” means electrically-charged facilities.

5. GREPTS

“GREPTS” is the acronym for the General Requirements of Electric Power Technical Standards of the Kingdom of Cambodia.

6. IEC

“IEC” is the acronym for the International Electrotechnical Commission.

7. ISO

“ISO” is acronym of International Organization for Standardization.

8. Licensee

“Licensee” means an electric power service provider who has been issued a license by the EAC.

9. SREPTS

“SREPTS” is the acronym for the Specific Requirements of Electric Power Technical Standards of the Kingdom of Cambodia.

10. The Technical Standards

“The Technical Standards” means The Electric Power Technical Standards in the Kingdom of Cambodia.

Article 2 Purpose

This Specific Requirements of Electric Power Technical Standards for Thermal Power Generating Facilities prescribes the basic requirements necessary to regulate the existing and the planned thermal power generating facilities in the Kingdom of Cambodia. The requirements in this standard document are mainly for facility security and safety operation of the most important parts for thermal generating facilities.

Article 3 Area of Application

All thermal power generating facilities in the Kingdom of Cambodia shall be in accordance with the requirements prescribed in this Technical Standard.

All persons including licensees, consultants, contractors and consumers who are related to the study, design, construction and operation of thermal power generating facilities shall follow this Specific Requirements of Electric Power Technical Standards for Thermal Power Generating Facilities.

Article 4 Applicable Standards

Thermal Power Generating Facilities planned to construct and operate in the Kingdom of Cambodia shall be as per the provision of this Technical Standards. In case a matter is not stipulated in the Technical Standards, IEC Standards shall be applied. If it is not covered in the IEC standards, ISO Standards shall be applied. If it

is not covered in the ISO Standards, internationally recognized standards shall be applied, subject to the approval by MIME.

Article 5 Facilities regulated in this Specific Requirements

A thermal power plant consists of three main components, a turbine/engine, a generator and a substation. This Specific Requirements provides the requirements to regulate the generating facilities such as turbine/engine and its accessories, and the generator including control systems, except the substation.

The requirements for the substation shall be in accordance with the Specific Requirements of Electric Power Technical Standards for Transmission and Distribution.

Thermal power generating facilities regulated in this Specific Requirements of Electric Power Technical Standards for Thermal Power Generating Facilities are following:

- 1- Steam Turbine Generating Facility
- 2- Gas Turbine Generating Facility
- 3- Internal Combustion Engine
- 4-Generator

CHAPTER 2

Requirements for all types of Thermal Generating Facility

Article 6 Prevention of Electric Power Disasters from the Facility

The facilities shall be installed in such a manner that does not cause electric shock, fire and other accidents.

The electric power facilities shall be installed with proper measures to protect operators from touching their moving parts, hot parts and other dangerous parts, and to prevent them from falling accidentally.

Article 7 Safety of Third Persons

Appropriate measures shall be taken to prevent third persons from entering compounds containing a power plant. These measures shall include:

- a. External fences or walls separated outside from inside compound. The height of external fences or walls shall not be lower than 1,800 mm. Boundary clearance from the fences or the walls to the electrical equipment shall not be less than the values described in the following table:

Table 1 - Boundary Clearance from Walls or Fences to Electrical Equipment

Nominal voltage [kV]	A : Height of a wall or a fence [mm]	Boundary clearance [mm]	
		B : Wall	C : Fence
(22)	not less than 1,800	not less than 2,100	not less than 2,600
115	not less than 1,800	not less than 2,100	not less than 2,600
230	not less than 1,800	not less than 2,900	not less than 3,400

- b. Signs to alert third persons to danger to be installed at the entrances/exits. Moreover, where necessary, signs shall also be displayed on walls and fences.
- c. Locking devices or other appropriate devices to be installed at the entrances / exits.

Article 8 Requirements related to the Fuel

- 1 Requirements related to Fuel Handling
 - a. Fuel handling shall be in accordance with the related laws.
 - b. Maintenance and safety checks of fuel facilities shall be implemented every day.
 - c. A responsible person for fuel facilities shall be designated.

- d. The responsible person shall receive education and training regarding fuel handling every year.

2 Requirements related to Fuel Storage

- a. Fuel storage tanks and fuel storage yards shall be in accordance with the related laws.
- b. An appropriate vessel shall be used for the storage tank.
- c. The storage yard shall be kept clean and appropriate signs shall be indicated in front of the storage tank.
- d. Necessary fire extinguishers or fire fighting systems shall be installed around the fuel storage area.

3 Requirements related to Fuel Transportation

- a. Specifications of fuel transportation facilities or vehicles shall be in accordance with the related laws.
- b. Working areas for fuel unloading shall be kept clean and appropriate lighting systems shall be installed around the working area.
- c. Working procedures for fuel transportation shall be prepared and be followed by the persons concerned.

Article 9 Requirements related to the Handling of Chemical Materials

Handling of chemical materials at power plants shall follow the provisions of environment law and regulations of the Kingdom of Cambodia.

Taking the characteristics of chemical materials to be used into consideration, appropriate measures against those chemical materials shall be implemented and tools to protect against potential danger shall be installed.

Article 10 Requirements related to the Natural Disasters

Proper measures shall be taken to prevent failures of electric power facilities from anticipated natural disasters such as floods, lightning, earthquakes and strong winds

Article 11 Requirements related to the Operation of Generating Facilities with Power System

When any generating facility has a serious fault, this facility shall be disconnected from the power system so that the effect of the fault on the system can be minimized and the system could be operated continuously.

When a power system fault occurs in a system connected to a generating facility, the generating facility shall be immediately disconnected from the system, so that the generator runs continuously with no-load while waiting for the recovery of the system from fault. The next action shall be in accordance with procedures of Grid Code and/or Distribution Code of the system.

Article 12 Requirements related to the Environment

1 Compliance with Environmental Standards

To prevent environmental pollution, the electric power facilities shall be constructed in accordance with the environmental laws and regulations of the Kingdom of Cambodia.

2 Prohibition of Installation of Electrical Machines or Equipment Containing Polychlorinated Biphenyls (PCBs)

- a. The installation of new electrical equipment using insulating oil that contains greater than 0.005 percent (50ppm) polychlorinated biphenyls (PCBs) shall be prohibited.
- b. The use of existing electrical equipment using material containing PCBs, if it was installed before the Specific Requirements of Electric Power Technical Standards came into force, and effective and sufficient measures shall be taken in order to prevent the material containing PCBs from escaping from the oil container, shall be permitted.
- c. Once removed from the electric equipment, the material containing PCBs greater than 0.005 percent (50ppm) PCBs shall not be reinstalled in another electrical facility and shall be safely scrapped as noxious industrial wastes.

Article 13 The Life of Electrical Power Facilities

Electrical power facilities shall be durable for long term usage with efficient and stable operation.

Article 14 Requirements related to the Design of Electrical Power Facilities

With regard to the design of electrical power facilities, selection of the materials, assembling and installation of the equipment, suitable safety factors against foreseeable stresses, such as thermal stress, mechanical stress and insulation strength shall be considered.

1. Insulation Co-ordination

Taking everything into consideration technically, economically and operationally, the insulation strength of electrical equipment in the power plant shall be coordinated with the insulation of electrical equipment in substations, transmission lines and distribution lines so that it may be in the most rational conditions.

2. Dielectric Strength of Electrical Circuits

The dielectric strength of electrical circuits in the power plant shall be examined by dielectric strength test, insulation resistance measurement and so on, to ensure that their performance corresponds to their nominal voltage.

Moreover, before starting operation, the dielectric strength shall be confirmed by charging nominal-voltage to the circuit continuously for 10 minutes.

However, if the nominal voltage of the electrical circuit is low-voltage, it can be tested by insulation resistance measurement or leakage current measurement. In case of the leakage measurement, it is sufficient to keep 1mA or less.

3. Mechanical Strength of Electrical Equipment against Short-circuit Current

All electrical equipment to be installed in the power plant shall be able to withstand the mechanical shock caused by short-circuit current.

4. Thermal Strength of Electrical Equipment

Electrical equipment to be installed in the power plant shall be able to withstand the heat generated by electrical equipment in normal operations.

5. Prevention of Damage of Pressure Tanks

Gas insulated equipment placed in the power plant shall be designed as following in order to avoid any risk of damage:

- a. Materials and structure of the parts receiving pressure shall be able to withstand the maximum operating pressure and shall also be safe.
- b. Parts receiving pressure shall be corrosion-resistant.
- c. Insulation gas shall not be inflammable, corrosive or hazardous.
- d. Tanks shall withstand the gas pressure rising during fault continuous time at internal failure of gas insulated equipment.

Article 15 Requirements related to the Technical Document of Electrical Power Facilities

To secure long term operation, each facility shall have its drawings, installation records, technical manuals, instruction manuals and operation records necessary for its proper maintenance works. These documents shall be safekept well.

Article 16 Requirements related to the Grounding

Grounding or other appropriate measures shall be provided for electrical equipment of thermal generating facilities to prevent electric shock, danger to human beings, fire, and other trouble to objects.

Grounding for electrical equipment shall be installed to ensure that current can safely and securely flow to the ground. This grounding shall be in accordance with the types, the method and the resistance value of grounding of each equipment provided in the Specific Requirements of Technical Standard for Transmission and Distribution.

CHAPTER 3

Requirements for Steam Turbine Generating Facility

Article 17 Steam Turbine Generating Facility

A steam turbine generating facility is a facility which generates electrical power from the rotation of steam turbine which rotates by the power of pressurized steam spouted out from the boiler. Two main components of the steam turbine generating facility are the boiler and the steam turbine.

A boiler is a closed vessel in which water is heated under pressure. Then the steam from the boiler is used for turbine rotation and preheating feed water.

A steam turbine is a mechanical device that can extract thermal energy from pressurized steam, which is supplied from a boiler, and converts it into useful mechanical work to rotate the turbine. The steam turbine consists of a rotor supported on bearings and enclosed in a cylindrical casing. The rotor is turned by steam, which expands through nozzles and spouts out at a high speed against the moving blades to turn the impellers.

3.1- PART 1: Boiler

Article 18 Requirements for Materials of Boiler and its Accessories

Vessels and tubes of the boiler, independent superheater and steam storage vessel and its accessories, and the parts which are subject to an internal pressure higher than 0MPa (hereinafter, referred to as pressure parts) shall be made of materials having sufficient mechanical strength and chemical stability under the maximum working pressure and temperature.

“Sufficient mechanical strength” shall mean having good weldability, tensile strength, ductility, toughness, hardness and other mechanical properties.

“Sufficient chemical stability” shall mean having character like good corrosion resistance, good heating resistance and other chemical properties.

Article 19 Requirements for Structure of Boiler and its Accessories

1-Safety margins against the maximum stress

Structure of pressure parts of the vessels and tubes of the boiler shall have adequate safety margins against the maximum stress under maximum working pressure or temperature condition. In this case, to prevent the danger the stress shall keep the level not exceeding the allowable stress of the material. The allowable tensile stress for each material shall be determined in accordance with its material temperature condition.

To ensure adequate safety margins against the maximum stress, the structure of pressure parts of the boiler and its accessories shall be able to withstand a water pressure test with a water pressure 1.5 times as high as their respective maximum allowable working pressures without the occurrence of leakage.

The design pressure of economizers shall be not less than the maximum working pressure of the economizer determined based on the maximum working pressure of the feed pump.

2. Prevention against Overheat

To prevent overheat of the water tubes in the furnace the following conditions shall be provided:

- a. Boiler water shall be sufficiently circulated to the water tubes.
- b. Boiler water shall be sufficiently purified. For this, proper measures such as a water softener, a demineralizer, etc. shall be provided.

3. Protections against Flame

In case part of the boiler drum and tube heater are so constructed that they are exposed to flames or high temperature gas, proper thermal protection, such as installation of a heat resisting tube material and/or installation of a heat protection, or other suitable means shall be provided.

4. Considerations for Structural Strength

Where the effects of additional stresses such as spot concentration stress, repeated loads and thermal stress are significant, suitable measurements such as increasing thickness shall be taken if necessary.

Article 20 Safety Valve for Vessels and Tubes of the Boiler

Vessels and tubes of the boiler which may be subjected to overpressure shall be equipped with safety valves in order to release the pressure. In case of overpressure such as when the steam pressure of the boiler goes up beyond regulation limits, safety valves shall be operated to release the pressure in order to prevent danger.

The safety valves for the boiler and its accessories shall have the following conditions:

- a. The safety valves shall be installed in position that can be easily inspected.
- b. At least, one safety valve shall be installed on the drum and one on the super-heater outlet.
- c. The total capacity of the safety valves shall be not smaller than the maximum designed steam capacity of the boiler.
- d. At least one set pressure of the safety valves shall be not higher than the maximum allowable pressure of any parts of the boiler (including superheaters and reheaters).
- e. The safety valves shall be spring loaded safety valves or safety valves with a spring loaded pilot valve.

Article 21 Feed Water System of Boiler

A feed water system is the system of equipment for feeding water to a boiler. The requirements for the feed water system for boiler are the following:

- The feed water system shall be able to prevent thermal damage to the boiler during the maximum evaporating condition.
- In order to prevent the thermal damage to the boiler caused by the feed water system's trouble, the feed water system of the boiler shall be equipped with two or more means of water supply equipment.
- The feed water system shall be able to independently supply a quantity of water not less than the maximum designed steaming capacity of the boiler at any time and independently.

Article 22 Water Feeding and Steam Outpouring of Boiler

Water feeding and steam outpouring of boiler shall be required as follows:

- The steam outlet of the boiler shall be able to shut off the steam;
- The feed water inlet of the boiler shall be able to automatically and firmly shut off;
- A circulation boiler shall be equipped with a drain-off device which protects deposit and regulates the water level.

Article 23 Monitoring the Running Condition of Boiler and Safety and Alarm System

The boiler and its accessories shall be equipped with the systems to monitor the running condition and the alarm systems to prevent from the damage to the boiler and its accessories. The monitoring and alarm systems as described above shall be equipped with devices as defining below:

1. For monitoring Circulation Boilers:
 - a. Water level indicator in the boiler drum
 - b. Pressure indicator in the boiler drum
 - c. Temperature indicator at superheater and reheater outlet steam
2. For monitoring Once-through Boilers
 - a. Pressure indicator at superheater outlet steam
 - b. Temperature indicator at superheater and reheater outlet steam
3. For Safety and Alarm

The boiler shall be fitted with safety devices, which are capable of shutting off automatically the fuel supply to all burners, and alarm devices which are capable to alarm when:

 - a. The flame vanishes
 - b. The water level falls (for circulation boiler drums)
 - c. The combustion air supply stops

4. For monitoring Boiler Water

The boilers shall be provided with means such as a water analyzer or other suitable devices to supervise and control the quality of the feed water and boiler water.

* All above monitoring devices shall be installed in position that allows easy observation.

3.2- PART 2: Steam Turbine

Article 24 Requirements for Materials of Steam Turbine and its Accessories

Cylinders, vessels and tubes of the steam turbine and its accessories, and the pressure parts shall be made of materials having sufficient mechanical strength such as good weldability, tensile strength, ductility, toughness, hardness, and other mechanical properties and chemical stability such as having character like corrosion resistance, abrasion resistance and other chemical properties under the maximum working pressure and temperature.

Article 25 Mechanical Strength of Structure of Steam Turbine and its Accessories

Structure of steam turbines shall have sufficient mechanical strength such as having good weldability, tensile strength, ductility, toughness, hardness and other mechanical properties, even when they are operated at the speed, that the steam turbine reaches when the emergency governor is actuated. "Speed that the steam turbine reaches when the emergency governor is actuated" shall include not only the actuated point of the emergency governor but also the accelerated speed from the actuated point.

Structure of steam turbines shall have sufficient mechanical strength against the maximum amplitude value of vibration produced on the major bearings and shafts. "Maximum amplitude value of vibration" shall mean the maximum vibration reached during turbine operation including turbine start and stop operation.

The pressure parts and its accessories of the steam turbine shall have a sufficient safety margin against the maximum stress under the maximum working pressure and shall not exceed the allowable stress of the material.

A steam turbine and its accessories which are likely to be subjected to overpressure shall be equipped with an overpressure protection device in order to release the pressure.

Article 26 Bearings of Steam Turbine

Bearings of steam turbines shall be constructed to be able to stably support the load during operation and without the occurrence of abnormal wear and deformation and overheat. To prevent the bearings from “its abnormal wear and deformation and overheat” the following measures shall be provided:

- a. Steam turbines shall be equipped with main lubricating oil feed pumps, auxiliary oil pumps and an emergency oil pump.
- b. Quantity of lubricating oil for steam turbines shall be sufficient in all times.
- c. Auxiliary oil pumps shall start automatically when the main oil pump out-put pressure becomes abnormally low
- d. An emergency oil pump or manual operation auxiliary oil pumps, which are installed for safety stop of the main turbine when the main and/or auxiliary oil pumps have broken down.
- e. The lubricating oil tank shall have necessary lubricating oil for the turbine.
- f. Devices to clean lubricating oil shall be equipped
- g. Device to control temperature of lubricating oil shall be equipped.

Article 27 Governance of Turbine Speed

1-Speed Governor

A steam turbine shall be equipped with a system capable to adjust automatically the steam entering the steam turbine in accordance with the actual speed of the turbine in order to prevent its speed and output from fluctuating continuously even in case of a change in load condition. This system is called speed governor. The speed governor consists of a speed monitoring device used for monitoring the actual speed of steam turbine and then providing the order to a steam adjusting valve to adjust the quantity of steam flow entering the steam turbine for the purpose to maintain speed of the turbine at the constant level. This speed governor shall regulate the turbine speed not to reach the tripping speed even if the rated turbine output is shut down instantaneously.

2-Emergency Speed Governor

In addition to a speed governor, a main turbine shall be equipped with an independent emergency speed governor in order to prevent the speed from being increased abnormally. The emergency speed governor shall be activated to interrupt the flow of steam to the turbine when the speed of turbine reaches the tripping speed. The tripping speed of the turbine shall be at 110% ($\pm 1\%$) of the rated speed.

3-Normal Speed, Over Speed and Critical Speed of Turbine

Normal Speed of a steam turbine is the operational speed of the turbine when it normally loaded and when the governor is in normal operation. The turbine shall be capable to operate at normal speed without any restrictions upon the time and output. This normal speed shall be in between 98 to 101% of the rated speed of the turbine. The normal speed of the turbine shall not be the speed remarkably less or more than the rated speed.

Over-speed is the speed over than the normal speed which could do harm to the turbine.

Critical speed of a turbine is the speed which creates the resonance on the turbine. To avoid the damage of the turbine caused by this resonance, the critical speed of the turbine combined with the generator on the same shaft shall not be in the speed between the minimum speed controlled by the governor and the maximum available speed of emergency stop device. However, it will be exempted if it will be arranged to have enough countermeasure against the vibration at critical speed during operation of the turbine.

“Speed between the minimum speed controlled by the governor and the maximum available speed of the emergency governor” is the speed can be operated by the steam turbine.

4-Limits of Turbine Speed

A turbine shall be capable to maintain the speed within the following limits:

- a. Momentary variations shall be not more than 10% of the maximum rated speed when the rated output of the generator is suddenly thrown off;
- b. At all loads in a range between no load and the rated load, the permanent speed variation shall be within $\pm 5\%$ of the maximum rated speed.

5- Protection against Over-speed

- a. All main and auxiliary turbines (in case of turbine-driven boiler feed pumps) shall be equipped with over-speed protective devices to prevent the turbine speed from being exceeded by more than 10% of the normal speed of turbine.
- b. In addition to the over-speed protective device, the main steam turbine shall be equipped with a device capable to control the speed of the unloaded turbine without activating the over-speed protective device into action.

Article 28 Requirements to Alarm and to Stop the Turbine in Emergency Case

In order to avoid the occurrence of damage from abnormal conditions (emergency case) during steam turbine operation, the steam turbine shall be equipped with two systems: 1-protection system and 2-alarm system.

1- Emergency Protection System or Tripping System

In order to avoid the occurrence of damage from abnormal conditions, a main turbine shall be equipped with a protection system which is capable to automatically shut off the steam supply to the turbine (automatic emergency stop device) in the following cases:

- a. Low lubricating oil pressure
- b. High exhaust steam pressure
- c. Low condenser vacuum
- d. Over-speed
- e. Emergency stop button is locally or remotely operated.

In addition to the automatic emergency stop device, the protection system shall have also a manual emergency stop device.

When the above emergency stop device is actuated, the emergency stop alarm shall be energized.

2- Emergency Alarm System

The steam turbine shall be provided with alarm systems which give visual and audible alarm in the event of abnormal conditions before steam shut off devices are activated. The abnormal conditions of steam turbine operation can be indicated by the level of vibrations of the steam turbine.

When the maximum double amplitude value of vibrations of the major bearings or the shaft close to it is detected to be beyond the allowable level during the turbine operation, the steam turbine operation is considered as in abnormal condition.

The steam turbine shall be equipped with an alarm system, which gives an alarm when the maximum double amplitude of vibrations of the major bearing or the shaft close to it exceeds the value shown in the table below:

Table2 Allowable Level of Maximum Double Amplitude of Vibrations

Measurement point	Rated speed	Allowable level of the maximum double amplitude of vibrations	
		In case of speed less than rated speed	In case of speed not less than rated speed
Bearing pedestal	3000 rpm	0.075 mm	0.062 mm
	1500 rpm	0.105 mm	0.087 mm
Shaft	3000 rpm	0.15 mm	0.125 mm
	1500 rpm	0.21 mm	0.175 mm

3. Reviewing of Emergency Protection and Alarm System

For insuring the safety of steam turbine operation, before commercial operation of steam turbines, Licensee shall submit to EAC for reviewing the following documents related to emergency protection and alarm system:

- a. Turbine protection system diagram
- b. Explanation sheet for alarming and tripping set-points figure

Article 29 Monitoring the Condition of Turbine Operation

A steam turbine and its accessories shall be equipped with systems necessary to monitor the operating condition and necessary alarm system to prevent any damages to the steam turbine and its accessories during the operation.

Monitoring and alarm systems of steam turbines shall be capable to monitor the following data:

- a. Rotational speed of the turbine
- b. Main steam temperature and pressure (before main stop valve position)
- c. Reheated steam temperature and pressure (before reheat stop valve position)
- d. Steam turbine exhaust steam pressure
- e. Lubricating oil inlet pressure of steam turbine bearings
- f. Lubricating oil outlet temperature of steam turbine bearings or bearing metal temperature
- g. Steam flow control valve position
- h. Steam turbine vibration amplitude (with automatic recorder - media record is acceptable.)

Article 30 Reviewing the Safety of Steam Turbine and its Accessories

To ensure the safety of steam turbine operation, Licensees who plan to install a steam turbine in the Kingdom of Cambodia shall submit the drawings and data related to the steam turbine on the items as follows to EAC for reviewing the adoption of the requirements in this standard:

- a. Turbine casings
- b. Turbine rotors
- c. Critical speed of turbine rotor
- d. Technical data for strength calculations specified above
- e. Material specifications of principal components
- f. Assembly drawings
- g. Control system diagram
- h. Drawings and data which are deemed necessary by the Government

CHAPTER 4

Requirements for Gas Turbine Generating Facility

Article 31 Gas Turbine Generating Facility

A gas turbine generating facility is a facility which generates electrical power from the rotation of the gas turbine which rotates by the power of the flow of combustion gas spouted out from the combustor. In the combustor, fuel is mixed with air and ignited, this combustion increases the temperature, velocity and volume of the gas which expands through nozzles and spouts out at a high speed against the moving blades to turn the impellers.

Main components of the gas turbine which are regulated by the requirements in this chapter are the following:

- Turbine itself
- Bearings
- Governor
- Emergency stop and alarm device
- Overpressure protection device
- Monitoring and alarm system

Article 32 Requirements for Materials of Gas Turbine and its Accessories

Principal components of gas turbines which are subject to an internal pressure higher than 0MPa shall be made of materials having enough mechanical strength such as having good weldability, tensile strength, ductility, toughness, hardness and other mechanical properties and chemical stability such as good corrosion resistance, good heating resistance and other chemical properties under the maximum working pressure and temperature.

These principal components of gas turbines are following:

- a. Rotors, stationary blades and moving blades of turbines
- b. Rotors, stationary blades and moving blades of compressors
- c. Turbines and compressor casings
- d. Combustion chambers
- e. Turbine output shafts
- f. Connecting bolts for main components of turbines
- g. Shaft coupling and bolts
- h. Pipes, valves and fittings attached to turbines

The principal components of gas turbines excluding bolts, pipes, valves and fittings shall have been subjected to the non-destructive tests.

The materials used in high temperature parts shall possess properties suitable for the design performance and service life against corrossions, thermal stresses, creeps and relaxations.

In case where the base material coated with corrosion-resistant surfacing, the coating material shall be firmly attached to the base material and shall not impair the strength of the base material.

The mechanical strength of all materials of gas turbines shall be confirmed to be sufficient through strength calculation or other methods.

Article 33 Mechanical Strength of Structure of Gas Turbine and its Accessories

Structure of gas turbines shall have sufficient mechanical strength such as having good weldability, tensile strength, ductility, toughness, hardness and other mechanical properties even when it is operated at the speed that the gas turbine reaches when the emergency speed governor is actuated. Even if the rotational speed of the gas turbine exceeds the rated rotational speed for any reasons and an emergency speed governor is actuated, the turbine shall not be damaged.

Structure of gas turbines shall have sufficient mechanical strength against the maximum amplitude value of vibration produced on the major bearings and shaft. "Maximum amplitude value of vibration" shall mean the maximum vibration reached during turbine operation including turbine start and stop operation.

The pressure parts and their accessories of the steam turbine shall have a sufficient safety margin against the maximum stress under maximum working pressure and temperature. In this case, the stress shall not exceed the allowable stress of the material. To ensure the sufficient safety margin again the maximum stress, the structure of pressure parts of the gas turbine and its accessories shall be able to withstand a water pressure test with a water pressure 1.5 times as high as their respective maximum allowable working pressures without leakage.

Gas turbine and its accessories which are likely to be subjected to overpressure shall be equipped with an overpressure protection device in order to release the pressure.

Article 34 Bearings of Gas Turbine

Bearings of gas turbines shall be constructed to be able to stably support the load during operation and without the occurrence of abnormal wear and deformation, and overheat. To prevent the “abnormal wear and deformation and overheat” of bearings, the gas turbine shall be equipped with the following lubricating oil feed pumps to provide the satisfactory lubricating oil to the bearings:

a. Main lubricating oil feed pumps

While the turbine is operating, the main lubricating oil feed pumps shall be operated to provide a satisfactory lubricating oil to the bearing of the gas turbine.

b. Auxiliary oil pumps

Auxiliary oil pumps shall automatically start when the main oil pump out-put pressure becomes abnormally low

However, if a gas turbine is equipped with a device to automatically shut off the inflow of fuel and safety stop when the outlet pressure of a main oil pump decreases, it is not required to equip an auxiliary oil pump.

c. Emergency oil pump

An emergency oil pump or manual operation auxiliary oil pumps shall be installed for safety stop of the main turbine when main and/or auxiliary oil pumps have broken down.

Article 35 Governance of Turbine Speed

1- Speed Governor

A gas turbine shall be equipped with a device capable to automatically adjust the flow of fuel entering the gas turbine in order to prevent its speed and output from fluctuating continuously even in case of a change in load condition. The device to automatically adjust the flow of fuel entering into the gas turbine automatically is called Speed Governor. This Speed Governor shall have an ability to hold the turbine speed after the interruption of the rated load below the speed at which the emergency governor is actuated.

Even the gas turbines without direct fuel burning shall be equipped with a device to control the maximum rotational speed.

2- Normal Speed, Over-Speed and Critical Speed of Gas Turbine

Normal Speed of a gas turbine is the operational speed of the turbine when it normally loaded and when the governor is in normal operation. The turbine shall be capable to operate at normal speed without any restrictions upon the time and output. This Normal Speed shall be in between 98 to 101% of the rated speed of the turbine. The normal speed of the turbine shall not be the speed remarkably less or more than the rated speed.

Over-speed is the speed over than the normal speed which could do harm to the turbine.

Critical speed of a turbine is the speed which creates the resonance on the turbine. To avoid the damage of the turbine caused by this resonance, the critical speed of the turbine combined with the generator on the same shaft shall not be in the speed between the minimum speed of governor and the maximum available speed of emergency stop device. However, it will be exempted if it will be arranged to have enough countermeasure against the vibration at critical speed during operation of the turbine.

“Speed between the minimum speed of governor and the maximum available speed of emergency stop device” is the speed can be operated by the steam turbine.

“The minimum speed of governor” shall mean the following;

- a. The minimum speed in speed variation when the turbine is not combined with a generator or a rotor.
- b. The minimum speed of grid frequency when the turbine is combined with a generator or a rotor.

Article 36 Emergency Alarm and Stop Devices

In order to avoid the occurrence of damage from over-speed and abnormal conditions (emergency case) during operation, the gas turbine shall be equipped with two devices: 1-Emergency Stop Device and 2- Emergency Alarm Device.

1- Emergency Stop Device

In order to avoid the occurrence of damage from over-speed or other abnormal conditions during gas turbine operation, the gas turbine shall be equipped with a device which automatically interrupts the inflow of fuel or gas called Automatic Emergency Stop Device. In addition to the Automatic Emergency Stop Device, the gas turbine shall be also equipped with a manual emergency stop device. When the above emergency stop device is actuated, the emergency stop alarm shall be activated.

In case of over-speeds or speeds exceeded the rated speed of the gas turbine, the automatic emergency stop device shall be actuated to stop the turbine when the speed reaches the tripping speed. The tripping speed of the turbine shall be at 110% ($\pm 1\%$) of the rated speed.

“Other abnormal conditions” are the following cases:

- a. The case where an internal failure occurs in a generator.
- b. The case where the gas temperature significantly increases.
- c. The case where the lubricating oil temperature significantly increases.
- d. The case where the lubricating oil pressure significantly decreases.

2- Emergency Alarm Device

A gas turbine shall be equipped with a device that functions to provide an alarm when the amplitude value of vibrations is detected to be beyond the allowable level during the gas turbine operation.

Article 37 Monitoring and Alarm Systems

A gas turbine and its accessories shall be equipped with systems necessary to monitor the operating condition and alarm system to prevent any damages of the gas turbine and its accessories during the operation.

Monitoring systems of gas turbines shall be capable to monitor the following data:

- a. Rotational speed of the turbine (Gas turbine tachometer)
- b. Outlet pressure of an air compressor of gas turbine
- c. Gas temperature at the inlet of a gas turbine (The calculation method to determine the inlet temperature of gas based on the measured outlet temperature of the gas is applicable.)
- d. Lubricating oil inlet pressure of gas turbine bearings
- e. Lubricating oil outlet temperature of gas turbine bearings or bearing metal temperature

Alarm systems of gas turbines shall provide an alarm when the following situations occur:

- a. Temperature of inlet or outlet gas of gas turbine is high
- b. Lubricating oil pressure is low (shall alarm before the function of the emergency stopping device.)
- c. Fuel oil supply pressure is low.

Article 38 Reviewing the Safety of Gas Turbine

To ensure the safety of gas turbine operation, Licensees who plans to install gas turbine in The Kingdom of Cambodia shall submit the drawings and data related to the gas turbine on the items as follows to EAC for reviewing the adoption of safety requirements in this standard:

- a. Combustion chambers
- b. Piping arrangements fitted to turbines (including fuel, lubricating oil and cooling water system)
- c. Particulars (type of turbine, power and rotation speed of turbine, gas pressure and temperatures at turbine inlet and outlet, ambient condition, service fuel and lubricating oil)
- d. Material specifications of principal components
- e. General arrangement
- f. Control system diagram
- g. Calculation sheets for vibration of turbine blades

Article 39 Requirements for Gas-Turbine Combined Cycle and its Accessories

Gas turbine combined cycle plants and their accessories shall be designed, manufactured, constructed and operated in accordance with the requirements in this chapter and chapter 3.

CHAPTER 5

Requirements for Internal Combustion Engine

Article 40 Internal Combustion Engine

A generating facility by an internal combustion engine is a facility where the generator is rotated by the internal combustion engine to generate the electric power. The internal combustion engine is a engine in which the fuel is mixed with air and burnt in confined space called a combustion chamber. The combustion of mixed fuel and air in the combustion chamber creates gases of high temperature and pressure which moves the moving parts of the engine such as pistons, rotors.

Main components of the internal combustion engine which are regulated by the requirements in this chapter are the following:

- Engine itself
- Bearings
- Governor
- Emergency stop and alarm device
- Overpressure protection device
- Monitoring and alarm system

Article 41 Requirements for Materials of Internal Combustion Engine

Cylinders, vessels and tubes of the internal combustion engine and its accessories and the pressure parts shall be made of the materials which have sufficient mechanical strength such as having good weldability, tensile strength, ductility, toughness, hardness and other mechanical properties and chemical stability such as good corrosion resistance, good heating resistance, and other chemical properties under the maximum working pressure and temperature.

The scope of properties of materials shall be chosen according to the specific conditions of use.

Article 42 Mechanical Strength of Structure of Internal Combustion Engine

Structure of an internal combustion engine shall have sufficient mechanical strength such as having good weldability, tensile strength, ductility, toughness, hardness and other mechanical properties even when it is operated at the speed that the engine reaches when the emergency speed governor is actuated. Even if the rotational speed of the engine exceeds the rated rotational speed for any reasons and the emergency speed governor is activated, the machine shall not be damaged.

Pressure parts and their accessories of the internal combustion shall have a sufficient safety margin against the maximum stress under the maximum working pressure and temperature. In this case, the stress shall not exceed the allowable stress of the material.

To provide “sufficient safety margins” to the pressure parts and their accessories, the following conditions shall be fulfilled:

- a. Combustion chamber and pipes of the ancillary equipment for internal combustion engines shall meet the requirement of good weldability, tensile strength, ductility, toughness, hardness and other properties.
- b. Internal combustion engines and ancillary equipment shall meet the requirement of corrosion resistance and abrasion resistance, if it's necessary.
- c. The pressure parts of internal combustion engines and their accessories shall be able to withstand a water pressure test using a water pressure 1.5 times their respective maximum allowable working pressures without leakage.
- d. However, the water pressure test is not required for;
 - (i) Internal combustion engine's casing which has the result of a water pressure test that was conducted under the same structure and same material conditions.
 - (ii) Internal combustion engines, the strength of which has been proven theoretically by calculation to have the mechanical strength to resist a water-pressure of 1.5 times of the maximum allowable pressure.

Article 43 Bearings of Internal Combustion Engine

Bearings of the internal combustion engine shall be structurally able to stably support the load during operation and without the occurrence of abnormal wear, deformation and overheat.

For the bearings with lubricating oil system to prevent the abnormal wear and deformation and overheat of bearings the following conditions shall be provided:

- a. The main lubricating oil pump shall be capable to feed sufficient lubricating oil to the engine during normal conditions
- b. The lubricating oil tank shall be capable to store the quantity of lubricating oil required for the engine.
- c. Devices capable to clean the lubricating oil (An oil filter which has the capacity to clean the lubricating oil can be one of them.) shall be equipped.
- d. Devices capable to regulate the temperature of the lubricating oil (An oil cooler for controlling the oil temperature, which may be automatic or manual, can be one of them.) shall be equipped.

Bearings without lubricating oil system shall also be regarded as satisfactory if their technical mechanism is proved to be sufficient for the required level of safety.

Article 44 Governance of Internal Combustion Engine Speed

An internal combustion engine shall be equipped with a device to automatically adjust the fuel entering the engine in order to prevent its speed and output from fluctuating continuously even in case of a change in load condition. This device is called a speed governor. Speed governors shall be capable of preventing the rotational speed and output of the engine from hunting in case of any changes. The maximum rotational speed shall be controlled in the range lower than the speed at which the emergency speed governor is actuated, even when the rated load is cut off.

Article 45 Emergency Stop and Alarm Devices

In order to avoid the occurrence of damage from over-speed or other abnormal conditions during the engine operation, the internal combustion engine shall be equipped with an automatic emergency stop device, a manual emergency stop device and emergency alarm device. Emergency stop device automatically interrupts the inflow of fuel. When the above emergency stop device is actuated, the emergency stop alarm shall be activated. "Over-speed" in this article is the state which an internal combustion engine speed exceeds its rated rotational speed. "Other abnormal conditions" in this article is the state with an excessive rise of the cooling water temperature, the accidental stoppage of the cooling water feed and so on.

All internal combustion engines except those with a rated output less than 3000kW shall be equipped with an emergency governor which is actuated to stop the engine at a speed higher than engine rated speed but not higher than 1.16 times of this rated speed.

All internal combustion engines except those with a rated output less than 3000kW shall be equipped with a device which stops the fuel flow automatically in case the cooling water temperature rises abnormally or the cooling water feeding stops.

Article 46 Overpressure Protection Devices

An engine and its accessories which are likely to be subjected to overpressure shall be equipped with an overpressure protection device in order to release the pressure such as relief valve which shall have a sufficient capacity for preventing overpressure, and shall activate at a pressure lower than the maximum pressure.

“An engine and its accessories are likely to be subjected to overpressure” means the following parts:

- a. Cylinders with a diameter of more than 230mm and the maximum allowable pressure of more than 3.4 MPa (excluding gas fuel engines).
- b. Sealed crankcases in the cylinders with a diameter of more than 250mm.

Article 47 Monitoring and Alarm Systems

An engine shall be equipped with systems necessary to monitor the operating condition and systems necessary to provide an alarm to prevent damages to the engine and its accessories during the operation.

Monitoring systems of internal combustion engines shall be capable to monitor the following data:

- a. The rotation speed of the internal combustion engine
- b. The temperature of the cooling water at the outlet of the internal combustion engine
- c. The pressure of the lubricating oil at the inlet of the internal combustion engine
- d. The temperature of the lubricating oil at the outlet of the internal combustion engine

CHAPTER 6

Requirements for Generators

Article 48 Protection of Generators

Thermal power generators shall be equipped with a protection device against any over-current accident.

The thermal power generators shall be also equipped with devices to automatically cut off the generator from the electrical line when:

- a. Over-current occurs.
- b. Internal failures, such as grounding or short-circuit of stator windings, of the generator with a capacity of 3000kVA or more occurs.
- c. The thrust bearings of the turbine with a rated capacity of 3000kW or more are significantly worn down and there is a significant rise in the temperature of the bearings.

Article 49 Electrical Equipment

Electrical equipment installed in thermal power plants shall be designed and constructed so that it structurally allows easy operation, inspection, overhauls and repairs.

Article 50 Cables in Thermal Power Plants

Cables used in thermal power plants shall be installed so that the original properties of non-flammability are not impaired.

In case cables are installed in such hazardous areas that there is a risk of fire or explosion in the event of an electrical fault, proper protections against such risks shall be provided.

Cables and wires shall be installed and supported so that they will not be damaged by any mechanical stress.

Article 51 Installation of Hydrogen Cooling Type Generators

The hydrogen cooling system is usually adopted in a large capacity generator. Such generators are filled with hydrogen to cool all windings of generator. Because hydrogen explodes if it is mixed with air, the following measures against the explosion shall be taken for the generator with the hydrogen cooling system:

1. The generator shall be structurally constructed so that the hydrogen will not leak to the outside and the air will not go into the inside.
2. The structure of the generator shall have sufficient mechanical strength (explosion-proof construction) to withstand pressure generated by hydrogen explosion.
3. The generator shall be equipped with an alarm device to be activated when purity of hydrogen decreases to 85% or less. Moreover, the device shall raise an alarm when pressure and/or temperature of the hydrogen change remarkably.
4. Tubes and valves filled with hydrogen shall have the structure to prevent hydrogen leakage. The tubes shall be a copper pipe or a seamless steel pipe.
5. When the hydrogen leaks from the shaft seal part of the generator, the gas leakage shall be stopped and the gas shall be safely discharged outside.

Article 52 Control Systems

The control system for generators shall have the integrated interlocking system to properly and safely control the generator.

Annunciators shall be provided for detection of abnormal operating conditions and shall be equipped with emergency trip functions necessary to assure equipment integrity and overall plant safety. The annunciator and trip functions shall be implemented through each independent device.

The control system shall have a function to start up and shut down the generator. The thermal power plant including the generator shall be started up and shut down manually from the control panel and automatically through the individual sequence programs.

CHAPTER 7

Transitional Provisions

Article 53 Transitional Provisions for Small and Medium Licensees

Requirements in this chapter are the minimum requirements and temporarily applicable to generation facilities of small and medium licensees when their generation facilities are in the transitional stage taking into consideration present level of existing generation facilities in Cambodia. Therefore these requirements will be cancelled in the future by Ministry of Industry, Mines and Energy when the generation facilities of Licensees in Cambodia passed the transitional stage.

“Small licensee” means the licensees with an installed capacity of less than 500 kW

“Medium licensee” means the licensees with an installed capacity from 500kW up to 3000kW.

The minimum requirements to temporary apply to generation facilities of small and medium licensees are described in the following articles in this chapter.

Article 54 Prevention of Electric Power Disasters

For prevention of electric power disasters, all power generating facilities of small and medium licensees which are in the transitional stage at present shall be at least in accordance with the following minimum requirements:

- A generator circuit breaker shall be equipped to each generator.
- A bare conductor is allowed only when it is installed inside of the panel or box.
- A naked knife-switch is allowed only when it is installed inside of the panel or box.
- Each cable shall have the cable number attached.
- Electrical facilities shall be grounded appropriately.
- All power cables and control cables shall be installed inside the cable tray or conduit pipe in the facility area.

Article 55 Safety of Third Persons

For prevention of danger to third persons, all power generating facilities of small and medium licensees which are in the transitional stage at present shall be at least in accordance with the following minimum requirements:

- Fences and/or walls shall be installed around the generating facilities to prevent third persons' accidents.
- The entrances/exits of above fences or walls needs appropriate key lock systems.
- "Keep out" signs shall be indicated at the entrance of generating facilities.
- Generating facility area shall be kept clean.
- All rotating and working parts shall be covered and protected from workers' accidents.
- Any belt drive power transmission systems shall be not approvable.

Article 56 Safety Measures for Fuel and Chemical Materials

For safety in using fuel and chemical materials, all power generating facilities of small and medium licensees which are in the transitional stage at present shall be provided with the following measures:

- Fire fighting systems and/or extinguishers shall be equipped near the fuel storage area.
- Fuel tanks shall be equipped at least 1 (one) meter away from electrical facilities.
- Fuel tanks shall be equipped solidly and combustible materials shall not be left within 1 (one) meter.
- Exhaust gas shall be discharged at least 2(two) meters high outside of the building.
- Exhaust pipes and/or hot parts of engines shall be protected.

Article 57 Environmental Protection

-Noise of generating facilities shall be prevented in residential areas. (Refer to related laws).

Table 3 Countermeasures for Preventing Noise of Generating Facilities

Operation case	Countermeasures
Interval operations (except night time)	-----
24 hours operation (including night time)	Generation facilities shall be enclosed by walls or installed in a specific building.

- Waste oil shall not be discharged directly to the ground in order to prevent soil pollution and protecting well water.

Article 58 Requirements for Operation

1-Monitoring Devices

Generators and generating facilities shall be equipped with the following monitoring devices:

- a. Generator volt meter
- b. Generator ammeter
- c. Generator frequency meter
- d. Energy meter (kWh)
- e. Generator out put (kW) meter
- g. Fuel tank level (or fuel flow meter)
- h. Engine oil pressure meter
- i. Engine oil temperature meter (if any)
- j. Cooling water temperature (if any)

2- Record Requirements and Maintenance of Generating Facilities

- Daily operational data, such as generated energy (kWh), Voltage, frequency, operation time and all instrument data, shall be recorded.
- Considering the operational period, overhaul of the engines shall be scheduled and implemented.
- Maintenance records including replacement parts and checking points shall be established.

3- Report Requirement

The following reports shall be submitted to EAC and copied to MIME every year:

- a. Operation records
- b. Maintenance records
- c. Trouble records

If any trouble or accidents in relation to the generating facilities occurs, the licensee shall report to EAC without delay.

Article 59 Safety and Technical Training

“Small and Medium Licensee” and/or technical staff who operate and maintain their facilities shall pass a training school program or course recognized by MIME or EAC. The technical training shall be provided to refresh their memory within three years or less.