SOCIALIST REPUBLIC OF VIETNAM
Ministry of Industry and Trade (MOIT)

Guideline for Technical Regulation Volume 5

Inspection of Power System Facilities

Final Draft

June 2013

Japan International Cooperation Agency

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IL
CR(2)
13-095

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Abbreviation

Abbreviation	Description
AC	Alternating current
AFC	Automatic Frequency Control
AFR	Automatic Frequency Regulator
AH	Air Heater
ALR	Automatic Load Regulator
ANSI	American National Standards Institute
APC	Automatic Plant Control
API	American Petroleum Institute
AQR	Automatic Reactive-power Regulator
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AVR	Automatic Voltage Regulator
AVT	All Volatile Treatment
BCP	Boiler Circulation Pump
BFG	Blast Furnace Gas
BFP	Boiler Feed water Pump
BFPM	Boiler Feed water Pump – Motor drive
BFPT	Boiler Feed water Pump – Turbine drive
BTG	Boiler-Turbine-Generator
CB	Circuit Breaker
C/C	Control Center
CIE	International Commission on Illumination
COG	Coke Oven Gas
CPTR	Computer
CRV	Combined Re-heat Valve
cSt	Centistoke
CT	Current transformer
CV	Control Valve
CVCF	Constant Voltage Constant Frequency
CWT	Combined Water Treatment
DC	Direct current
DSS	Daily Start and Stop
ECR	Economical Continuous Rating
EHC	Electro Hydraulic Control System
EIGA	European Industrial Gases Association
EOH	Equivalent Operating Hours
EP	Electric Precipitator
FA	Full Arc
FCB	Fast Cut Back
FCV	Flow Control Valve

Abbreviation	Description
FDF	Forced Draft Fam
GGH	Gas Gas Heater
GMF	Gas Mixing Fan
GRF	Gas Re-circulating Fan
HEPA	High Efficiency Particulate Air
HGI	Hardgrove Index
HID	High intensity discharge
HRSG	Heat Recovery Steam Generator
ICV	Intercept Valve
IDF	Induced Draft Fan
IEC	International Electrotechnical Commission
IGV	Inlet Guide Vane
ISO	International Organization for Standardization
JEC	Japanese Electrotechnical Committee
JIS	Japanese Industrial Standards
LED	Light Emitting Diode
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LS	Line switch
MARD	Ministry of Agriculture and Rural Development
M/C	Metal Clad Switchgear
MFT	Main (Master) Fuel trip
MHC	Mechanical Hydraulic Control
MSV	Main Stop Valve
OSHA	Occupational Safety and Health Administration
PA	Partial Arc
PAF	Primary Air Fan
PB	Push Button
P/C	Power Center
PCB	Polychlorinated Biphenyl
PCV	Presser Control Valve
PDCA	Plan Do Check Act
PMG	permanent-magnet generator
POP	Persistent Organic Pollutant
PSS	Power System Stabilizer
RH	Re-heater
RSV	Re-heat Stop Valve
SAH	Steaming Air Heater
SH	Super Heater
TCVN	Tieu Chuan Viet Nam
UGR	Unified Glare Rating

Abbreviation	Description
UPS	Uninterrupted Power Source
USA	United States of America
VDT	Visual Display Terminal
VT	Voltage transformer
WL	White Lump
WSS	Weekly Start and Stop

Part 1
General

Article 1. Purpose

The purpose of Technical Regulation Vol.4 “Operation and Maintenance of Power Plants and Grid” is as described in Article 1 of Vol.4 covering the network facilities, hydropower plants and thermal power plants.

Technical Regulation Vol.4 was prepared aiming at securing public safety, environmental protection and reliability of the network and power plant facilities and relevant equipment by stipulating the technical requirements in operation and maintenance of such facilities.

Article 2. Scope of application

Technical Regulation Vol.4 is applied to the power generating plants located in Vietnam and connected to the Vietnamese grids as well as applied to the network facilities located in Vietnam subject to the conditions stipulated below:

1. Network facilities

The network facilities of which voltage is equal to or less than 1000 V are exempted from application of Technical Regulation Vol.4.

2. Hydro Power plant

Technical Regulation Vol.4 shall be applied to all of the hydropower plants in Vietnam connected to the national grid regardless of their capacity in principal. In this regard, only small scaled hydropower plants constructed in remote areas for local power supply through isolated local power grid which is not connected to the national power grid are exempted from the application of Technical Regulation Vol.4.

3. Thermal Power plants

Regarding the thermal power plants, most of the oil fired, gas fired and coal fired plants are connected to national power grid through transmission lines with capacity equal to or over 110kV, which is defined as “National Power Transmission Network” in Article 3 of Technical Regulation Vol.4. Such plants are required to comply with the requirements in Technical Regulation Vol.4.

On the other hand, small scale thermal plants such as diesel power plants constructed for local power supply through isolated power grid which are not connected to the national power grid or some small to medium scale thermal power plants which are connected to the national power grid through the transmission lines with capacity less than 110kV are exempted from application of Technical Regulation Vol.4.

Article 3. Definitions

As stipulated in the Technical Regulation Vol.4.

Part 2
Organization and System for Operation

Chapter 1   Organizational Structure and Duties

Article 4.   Power system

Paragraph 10 in Article 3 of the Electricity Law defines that "National Power System" is the system of power generators, power transmission lines, and auxiliary devices which are interconnected one with another and are singly controlled throughout the country.

All components of the National Power System, except the facilities which are exempted from application according to stipulations in Article 2, shall comply with the requirements stipulated in Technical Regulation Vol.4.

Article 5.   Functions of individual units in power system

1. Stipulations in Electricity Law related to stable and reliable power supply

The following articles of the Electricity Law must be referred to for complying with the requirement in Paragraph 1 of Article 5 in Technical Regulation Vol.4.

Article 14 "Electricity savings in power generation" of the Electricity Law:

- *"Power generation units shall be responsible for selecting advanced generation technology with high efficiency, and implement optimal operation mode on power generation equipment in order to save fuel and other energy resource for power generation, contributing to assurance of national energy security."*

Article 15 "Electricity savings in power transmission and distribution" of the Electricity Law:

"Power transmission lines and stations network must satisfy the advanced techno-economical standards and specification, it shall be operated in optimal mode with the aim at meeting requirement on stable, safe, uninterrupted electricity supply and minimizing power losses."

Article 27 "Electricity supply interruption and shedding" of the Electricity Law:

1. *In case the interruption or shedding of electricity supplied to consumers is not urgent, otherwise stipulated in item 6, Article 23 of this Law, the electricity selling party must notify the electricity purchasing party, at least five days in advance the time of interruption or shedding by notifying in three successive days through mass media or other forms.*
2. *In case the interruption or shedding of electricity supplied to consumers is urgent due to force majeure, which are uncontrollable by selling party and may seriously jeopardize the security of human and equipment, or due to the shortage of power generation threatening power system security, then the power generation, transmission and distribution units shall be permitted to stop or shed the level of power supply to the purchasing party to handle, and within 24-hour period, the selling party must notify the purchasing one the reason and the anticipated schedule to recover electricity supply.*

3. *In case the electricity unit interrupts or sheds the level of electricity supply against the regulations on power supply interruption and shedding, penalties stipulated by Law of administration violation shall be applied and any damage shall be compensated to the purchasing party as stipulated by the regulations of law of the agreements.*

4. *In case the electricity purchasing party fails to comply with provisions stipulated in sub-item a, b and item 2, Article 46, sub-item b, c, item 2, Article 47 of this Law, the selling party shall have right to interrupt electricity supply to the purchasing party.*

2. Stipulations in Electricity Law and other regulations relating to quality of power supply

The following articles of the Electricity Law must be referred to for complying with the requirement in Paragraph 2 of Article 5 in Technical Regulation Vol.4.

Article 26 "Guarantee of electric power quality" of the Electricity Law:

1. *Power generation, transmission and distributions units shall ensure the voltage, current frequency are in line with Vietnamese standards, ensure the capacity, electricity energy and electricity supplying period pursuant to signed agreement. In case of failure to meet the criteria on voltage, current frequency, capacity and electricity energy and electricity supplying period as signed agreement, causing losses to the purchasing party, the selling party has to compensate for the purchasing one as prescribed by the regulations of law on the agreements.*

2. *The purchasing party shall be responsible for guarantee of electrical equipment to operate safely without causing faults to the power system and affecting voltage quality of power grid."*

The following article of Decree No.: 105/2005/ND-CP "Decree on detailed regulations and guidelines on implementation of the electricity Law" (August 17, 2005) must be referred to for complying with the requirement in Paragraph 2 of Article 5 in Technical Regulation Vol.4.

Article 9 Electric power quality

1. *The electricity sellers must ensure the electric power quality to be supplied to the electricity buyers in line with the following criteria:*
   a) *With regards to the voltage: in normal condition, permissible voltage deviation is in the range of ± 5% against nominal voltage of power network, and is identified at the locations equipped with electricity meters or other places agreed upon by the two parties. As for unstable power network after recovery from the fault, permissible voltage deviation is in the range of +5% to -10%.*
   b) *About the power frequency: in normal condition, permissible frequency deviation is in the range of ±0.2 Hz against the rated frequency of 50Hz. In case where fault, permissible frequency deviation is ±0.5Hz.*

2. *The electricity buyers who use electricity for production, doing business and services with* P_{max} *from 80 kW or transformer of from 100 kVA upwards shall take responsibility:*
   a) *To inform load behavior of and point out the technical specifications of electrical equipment to the electricity sellers:*

b) To ensure cos$\varphi \geq 0.85$ at the location equipped with electricity meters in conditions that the power system ensures the electric power quality as prescribed in Clause 1 of this Article;

c) To install reactive power compensation equipment in case where cos$\varphi < 0.85$ to increase the cos$\varphi \geq 0.85$, or to buy more reactive power in power system from the electricity sellers.

3. In case where the electricity buyers are capable of generating reactive power to the power system, the two parties can negotiate the reactive power to be purchased and sold in agreements.
Ministry of Industry shall assume the prime responsibility for, and coordinate with Ministry of Finance in guiding the reactive power purchase and sale prescribed in this Article.

4. The electricity sellers and buyers can make negotiation on electric power quality different from the criteria mentioned at Point a and b, Clause 1 of this Article.

3. Complete the load dispatching chart

(1) The load dispatching center must prepare the electric power supply plan for daily operation as well as short term (weekly), midterm (monthly to seasonal) and long term (annual) operation based on information of electric power facilities in the national power system and their status of operation and maintenance.

(2) Furthermore, operation manual must be prepared for the method of restoration of power facilities as well as restoration of power supply by electric power accommodation, etc. after a trouble or accident in all electric power system.

4. Follow the regulations on environmental protection.

All of the power system must comply with the stipulations for environmental protection and conservation in the relevant laws and regulations issued by Ministry of Natural Resource and Environment (MONRE) and other competent authorities.

Regulations and standards on environmental protection are shown as follows ;

Table 5-1 Regulations and standards on environmental protection

Number	Issued	Title
QCVN 01	2009/BYT	National regulation on quality of drinking water
QCVN 02	2009/BYT	National regulation on quality of domestic water
QCVN 05	2009	National technical regulation on ambient air quality
QCVN 06	2009	National technical regulation on hazardous substances in ambient air
QCVN 08	2008	National regulation on surface water
QCVN 14	2008/BTNMT	National regulation on sewage
QCVN 22	2009	National technical regulation on emission of thermal power industry
QCVN 24	2009/BTNMT	National technical regulation on industrial wastewater
TCVN 3985	1999	Acoustics. Allowable noise levels at workplace

Number	Issued	Title
TCVN 4923	1989	Protection against noise. Means and method. Classification
TCVN 5067	1995	Air quality. Weight method for determination of suspended dusts content
TCVN 5126	1990	Vibration. Permissible values at workplaces
TCVN 5136	1990	Noise. Methods of measurement. General requirements
TCVN 5937	1995	Air Quality Standard of Vietnam
TCVN 5938	1995	Air quality-Maximum allowable concentration of hazardous substances in ambient air.
TCVN 5939	1995	Air quality-Industrial emission standards-Inorganic substances and dusts
TCVN 5942	1995	Water quality. Surface water quality standard
TCVN 5943	1995	Water quality. Coastal water quality standard
TCVN 5944	1995	Water quality. Ground water quality standard
TCVN 5945	2010	Industrial waste water. Discharge standards
TCVN 5949	1998	Acoustics. Noise in public and residential areas Maximum permitted noise level
TCVN 5971	1995	Ambient air. Determination of the mass concentration of sulfur dioxide. Tetrachloromercurate (TCM)/pararosaniline method
TCVN 5972	1995	Ambient air. Determination of the mass concentration of carbon monoxide. Gas chromatographic method
TCVN 5976	1995	Stationary source emission. Determination of the mass concentration of sulfur dioxide. Performance characteristics of automated measuring methods
TCVN 5977	2009	Stationary source emissions. Manual determination of mass concentration of particulate matter
TCVN 5978	1995	Air quality. Determination of mass concentration of sulphur dioxide in ambient air. Thorin spectrophotometric method
TCVN 6138	1996	Ambient air. Determination of the mass concentration of nitrogen oxides. Chemiluminescence method
TCVN 6152	1996	Ambient air. Determination of the particulate lead content of aerosols collected on filters. Atomic absorption spectrometric method
TCVN 6157	1996	Ambient air. Determination of the mass concentration of ozone. Chemiluminescence method
TCVN 6503-1	1999	Gas turbines. Exhaust gas emission. Part-1 : Measurement and evaluation
TCVN 6503-2	1999	Gas turbines. Exhaust gas emission. Part-2: Automated emission monitoring
TCVN 6627-9	2000	Rotating electrical machines. Part 9: Noise limits
TCVN 6663-13	2000	Water quality. Sampling. Part 13: Guidance on the sampling of water, wastewater and related sludge
TCVN 6705	2009	Normal solid wastes. Classification

Number	Issued	Title
TCVN 6706	2009	Hazardous wastes. Classification
TCVN 6750	2000	Stationary source emissions. Determination of mass concentration of sulfur dioxide. Ion chromatography method
TCVN 6964-2	2008	Mechanical vibration and shock. Evaluation of human exposure to whole-body vibration. Part 2: Vibration in buildings (1 Hz to 80 Hz)
TCVN 6696	2009	Solid wastes. Sanitary landfill. General requirements to the environmental
TCVN 7171		Air quality. Determination of ozone in ambient air. Ultraviolet photometric method
TCVN 7172	2002	Stationary source emissions. Determination of the mass concentration of nitrogen oxides. Naphthylethylenediamine photometric method
TCVN 7725	2007	Ambient air. Determination of carbon monoxide. Non-dispersive infrared spectrometric method
TCVN 7726	2007	Ambient air. Determination of sulfur dioxide. Ultraviolet fluorescence method
TCVN 7878-1	2008	Acoustics. Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedures
TCVN 7878-2	2010	Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of environmental noise levels
TCVN 8018	2008	Acoustics. Noise control design procedures for open plant

Note: 1) BYT means: Ministry of Health

2) BTNMT means: MONRE

Article 6. Obligations of individual units in power system

In order to satisfy the power supply on its responsibility, it is important for each individual unit in power system to understand the role in the electric power system. For that purpose, it is required to satisfy the following major contents.

1. A power producer must understand completely the role and features of each power plant such as peak load supply, middle load supply and base load supply, automatic frequency control (AFC), etc., and must performs power generation based on the requirement of electric power supply.
2. Individual units in power system must respect an employee's labor rules and must observe related regulations related to employees in order to perform proper management and safety control in operation and maintenance of power facilities.

Article 7. Internal responsibilities of individual units in power system

1. Each individual unit in power system must prepare in-house manuals to implement this technical regulation by stipulating methods and procedures for complying with the requirements in the Technical Regulation Vol.4 as well as relevant regulations in order to secure the compliance of

regulations in operation and maintenance of power (regulation observance manual). Furthermore, it is required for each individual unit to contribute to the development of power system and stable power supply for national economy and social life through continuous efforts in research of advanced technologies for improvement of own power facilities in their operation and maintenance.

2. In order to improve the productivity and efficiency of facilities and to lower the operation cost (running cost), it is important to perform maintenance work of facilities effectively and to keep the facilities in sound conditions by continuous efforts for improving the method of maintenance work as well as improving the facilities by repair and replacement. Moreover, each individual unit has to strive for reduction of power consumption for the station service.
3. In order to pursue the possibility of application of the newest technology, it is important to introduce the knowledge of the latest technology and to increase technical level through information collection, education and training of employees and technical research activities.

The following stipulations in Electricity Law must be referred to for implementing Article 7 of Technical Regulation Vol.4:

Electricity Law Article 14 "Electricity savings in power generation":

"Power generation units shall be responsible for selecting advanced generation technology with high efficiency, and implement optimal operation mode on power generation equipment in order to save fuel and other energy resource for power generation, contributing to assurance of national energy security."

Electricity Law Article 15 "Electricity savings in power transmission and distribution":

"Power transmission lines and stations network must satisfy the advanced techno-economical standards and specification, it shall be operated in optimal mode with the aim at meeting requirement on stable, safe, uninterrupted electricity supply and minimizing power losses."

Chapter 2 Acceptance of Equipment and Plants for putting in Operation

Article 8. Operating condition of power works

Framework for acceptance of power plants and network facilities in Vietnam is as follows:

1. Article 21 "Conditions for being granted electricity activity licenses" of Decree No.: 105/2005/ND-CP "Decree on detailed regulations and guidelines on implementation of the electricity Law" (August 17, 2005) stipulate as follows:
   1. *Organizations, individuals engaged in electricity generation must satisfy the following criteria:*
      a) *Possessing technology, equipment, auxiliary, workshop and constructions as approved design for construction, installation then being checked and accepted in accordance with existing technical standards;*

2. *Units engaged in electricity transmission and distribution must satisfy the following criteria:*
    a) *Possessing technology, equipment, auxiliary, workshop and constructions as approved design for construction, installation then being checked and accepted in accordance with existing technical standards, meeting requirements of maintenance, repair and check of transmission lines, transformers, switchgears, reactive power stations in power transmission and distribution network;*

2. Article 29 "General regulations on safety for electrical equipment and electricity works" of Decree No.: 105/2005/ND-CP "Decree on detailed regulations and guidelines on implementation of the Electricity Law" (August 17, 2005) stipulate as follows:

    1. *Electrical equipment design and manufacture, electricity works construction must conform to the sectoral standards, Vietnamese standards or proper international standards which were accepted by Vietnamese competent bodies, and must ensure the requirements on the safety as follows:*
        a) *Electric safety;*
        b) *Construction safety;*
        c) *Safety on consuming primary energy resources (water, coal, petroleum, natural gas and other energy types)*
        d) *Safety on firefighting- and explosion-fighting*
        e) *Ecological safety, industrial safety and hygiene.*
    2. *Electrical equipment and devices, which have just been manufactured or imported must posses quality certificate or sealed with registered labels conform to the standards and regulations of the Law. Such electrical equipment and devices must be enclosed with user manuals covering technical specifications, functions, uses, as well as other warnings to keep the users from electrical faults and accidents.*
    3. *Electricity works can be only put in operation after being testing, commissioning, adjusting and accepting as satisfaction of standards on the safety.*

3. Article 30 "Safety in electricity generation, transmission and distribution" of Decree No.: 105/2005/ND-CP "Decree on detailed regulations and guidelines on implementation of the electricity Law" (August 17, 2005) stipulate as follows:

    1. *Once preparing for investing into construction of any power plant, substation and line, the investor must own full technical designs, construction designs, total and detailed cost estimates, which all have been approved, documents on completion of construction and installation and other technical documents as regulations of Law on construction for handing over to the operating and managing unit.*
    2. *Before putting power plants, substations and lines into commercial operation, investors of such plants, substations and lines must carry out experiments, calibrating each part and all equipment in power generation, transmission system to ensure the conformity to technical standards, approved designs. Dossiers of experiment and calibration must be available in acceptance minutes of each part and entire project.*

   3. *In case where the overhead transmission lines pass the densely populated areas, operation managing unit must not allow the line to bear the load exceed standards and regulations.*

4. Completion Inspection shall be conducted for acceptance of the electrical equipment for operation based on the provisions stipulated in QCVN Vol.5.
5. Decision 1987-No.48 NL-KHKT "Volume and Standards for Test, Acceptance and Hand Over of Electrical Equipment" has been still applied to the completion inspection for acceptance of electrical equipment in Vietnam.

Article 9. Acceptance of operation of power works

1. Article 9 of this regulation (Vol.4) requires the project owner to check and inspect all of the facilities listed in the article for acceptance.
2. Article 29 "General regulations on safety for electrical equipment and electricity works" of Decree No.: 105/2005/ND-CP "Decree on detailed regulations and guidelines on implementation of the electricity Law" (August 17, 2005) stipulate as follows:

   1. *Electrical equipment design and manufacture, electricity works construction must conform to the sectoral standards, Vietnamese standards or proper international standards which accepted by Vietnamese competent bodies, and must ensure the requirements on the safety as follows:*
      - *a) Electric safety;*
      - *b) Construction safety;*
      - *c) Safety on consuming primary energy resources (water, coal, petroleum, natural gas and other energy types)*
      - *d) Safety on firefighting- and explosion-fighting*
      - *e) Ecological safety, industrial safety and hygiene.*

3. The detailed method for checking and inspection must refer to the relevant standards and regulations available in Vietnam.
4. The paragraph 4 of Article 5 of this Guideline must be referred to regarding the regulations on environmental protection.

Article 10. Acceptance procedure

1. Purpose of acceptance test

Purpose of acceptance procedure is to confirm no-abnormality in power equipment by Owner before commercial operation or taking over for whole power equipment installed in the power plant by Contractor.

If the tests and inspections prove that any materials or components are of unsatisfactory quality or dimension, the Owner may be requested to perform any additional tests as may be required.

2. Test procedure
   1) To perform run test for each component and accept each part of the equipment of machine assembly;
   2) To start the primary and secondary equipment of machine assembly;

3) To perform run test for the whole equipment.
4) Existing regulation (For reference)
   a. 11TCN-18-2006: Electrical facilities code – Part 1 – General requirement.
   b. 11TCN-19-2006: Electrical facilities code – Part 2 – Transmission and distribution network.
   c. 11TCN-20-2006: Electrical facilities code – Part 3 – Distribution and Substation.
   d. 11TCN-21-2006 : Electrical facilities code – Part 4 – Protection and Automation.
   e. Decision No. QD 939-2009-EVN Acceptance and supervision of Power substation with rated voltage up to 500kV.
   f. Decision No. QD-908-2008-EVN Acceptance and supervision of overhead line with rated voltage up to 500kV.

Article 11. Acceptance of equipment

Process of acceptance of equipment is as follows:

1. Test by subcommittee of Acceptance Committee
   1) Various tests and running test of each part of equipment
   2) Acceptance of each component of machine assembly and construction works
   3) Checking the readiness of equipment
   4) Running test of whole equipment
2. Acceptance by authorized Acceptance Committee
   1) Review on results of acceptance tests by subcommittee
   2) Acceptance to operate equipment and construction works
3. Point to be checked at acceptance of equipment
   1) Deviation of actual performance of each equipment from the required performance described in design specifications.
   2) Deviation of actual construction works from the requirements described in design specifications and design drawings.
4. Reference documents:
   1) TCVN 5639-1991: Acceptance for installed equipment. General rule.

Article 12. Acceptance of component

Process of acceptance component is as follows:

1. Test and check by Acceptance Committee
   1) Assembling work of equipment
   2) Trial run of each component of machine assembly
   3) Checking implementation of the following regulations and standards:
      - Regulations on construction
      - Regulations on testing the steam

- Technical safety standards
- Explosion prevention and fire prevention standards
- Electric equipment standards
- Manufacturers' instructions
- Instruction for assembling of equipment
- Other legal document

2. Acceptance by authorized Acceptance Committee
   1) Acceptance of each part of machine assembly
3. Point to be checked at acceptance of component
   1) Deviation of actual performance of component from the required performance described in design specifications.

Article 13. Acceptance for completion

Process of acceptance for completion is as follows:

1. Acceptance by State level Acceptance Committee
   1) Running test of the whole equipment
   2) Fixing all detected defects
   3) Acceptance of equipment, dwelling houses, construction works relating to equipment
   4) Making report of acceptance
2. Regulation by Competent Authority level Acceptance Committee
   1) Regulating temporary operating period of equipment
   2) Complete all necessary experiments
   3) Adjusting and Completing the equipment
   4) Ensuring operation of equipment according to the design specifications
   5) Acceptance of equipment
3. Particular Application for the first batch of manufacturing
   1) Regulating running test period based on combination of completing, adjusting and running test of equipment
   2) Acceptance of equipment
4. Point to be checked at acceptance for completion
   1) Deviation of actual performance of whole equipment from the required performance described in design specifications.

Article 14. Handover of documents

At the acceptance of the equipment and plant, handing over of various documents must be conducted from various units in charge to the plant operation unit al least as follows:

1. From design unit, assembling unit and constructing unit:
   1) Latest designing documents which have been modified during construction, 2) assembling and adjusting period including drawings, presentation documents, processes documents, executing documents and monitoring log of designing unit
   2) Acceptance reports of components
   3) Acceptance reports of underground works
   4) Manufacturer's documents including processes, drawings, diagrams and other documents related with equipment
2. From testing unit
   1) Test reports of automatic firefighting equipments
   2) Test reports of surge arresters
3. From calibration unit
   1) Reports of measurements
   2) Reports of calibrations
   3) Reports of principle diagrams test
   4) Test reports of safety systems
   5) Test reports of air ventilating systems
4. From testing and checking unit.
   1) Testing and initial checking reports of the metal conduits
   2) Testing and initial checking reports of main parts of generator

In addition, Article 17 of this Guideline must be referred to.

Chapter 3 Personnel Preparation

Article 15. General requirements for personnel preparation

Personal preparation is required to be carried out for electric industry related enterprises and agencies to arrange management and working staff properly for operation of power plant and power grid facilities. The required processes for personal preparation are as follows:

1. Education and experience requirements

Article 21 "Conditions for being granted electricity activity licenses" of Decree No.: 105/2005/ND-CP "Decree on detailed regulations and guidelines on implementation of the electricity Law" (August 17, 2005) stipulate as follows:

> *1. Organizations, individuals engaged in electricity generation must satisfy the following criteria:*
>
> *a) Possessing technology, equipment, auxiliary, workshop and constructions as approved design for construction, installation then being checked and accepted in accordance with existing technical standards;*

b) *Technical and production managers must have university degrees specialized in power sector or concerned qualification and worked at least five (05) years in power generation field.*

c) *The staffs that directly operate power generation must be trained and checked on operating procedures and safe procedures.*

2. *Units engaged in electricity transmission and distribution must satisfy the following criteria:*

a) *Possessing technology, equipment, auxiliary, workshop and constructions as approved design for construction, installation then being checked and accepted in accordance with existing technical standards, meeting requirements of maintenance, repair and check of transmission lines, transformers, switchgears, reactive power stations in power transmission and distribution network;*

b) *Technical managers must have university degrees specialized in power sector or concerned qualification and worked at least five (05) years in power transmission and distribution field;*

2. Organizing and Auditing personal preparation

Leaders of electric companies, enterprises and agencies belong to electric industry must organize and audit regularly the personnel preparation.

In the above connection, rules or programs of personal preparation and staff training are required to be set up particularly for each power unit of power industry because the specific requirements of each power unit are different. These rules must meet the following basic criteria:

- Health condition must be suitable for profession and checked periodically.
- Staff must have basic knowledges and/or experiences which are satisfactory with working requirements of assigned position.
- For staff of a specific position, it is required to have additional specific training and qualification of quality after the training.

Article 16. Knowledge test for personnel

Article 5.1.8 to Article 5.1.11 and Article 8.1 to Article 8.4 of QCVN 01 (2008) must be referred to regarding requirements of boiler tester. This regulation stipulates the requirements for health, training, checking, testing, certification, qualifications for the job titles related to boiler and pressure vessel, specifically the job titles of operating, repairing of boiler and pressure vessel, pressure welders. Staffs have been tested and certificated with occupational qualification and safety card in accordance with new job titles which are tasked with the operation and maintenance of boilers and pressure equipment.

Chapter 4 Plan for Repair of Equipment, Plant and Construction

Article 17. Keeping of necessary documents

Regarding the provisions of this article, reference shall be made to the documents listed in Article 50 of Part 4 for hydropower plant, Article 100 of Part 5 for thermal power plant and Article 249 of Part 6 for network facilities.

Article 18. Provision of related standards

Operation units of power plant and network facilities must prepare all of the standards and regulations related to inspection, repair, maintenance and operation of their facilities at least one set at each unit.

The documents to be prepared are, but not limited to, the following:

1. Hydro power

Number	Issued	Title
TCVN1615-75	1975	Descriptor on Electric Diagram. Switchgear Equipments
TCVN1987-1994	1994	Three phase asynchronous squirrel cage electrical motors from 0,55 to 90kW
TCVN1988-77	1977	Electrical equipment for voltages up to 1000V. Enclosures. Degrees of protection.
TCVN2331-78	1978	Electrical rotary machines Determination of moment of inertia of rotary part. Test methods.
TCVN2280-78	1978	Three phase asynchronous electrical motors from 100W and higher power. Test methods.
TCVN2283-78	1978	Transformers for welding. General requirements.
TCVN3623-81	1981	Switching devices for voltages up to 1000V. General requirements.
TCVN3662-81	1981	Metal-enclosed switchgear and control gear for voltages up to 10kV inclusive. Technical requirements
TCVN3682-81	1981	Rotating electrical machines. Types. Terms and Definitions
TCVN3684-81	1981	Electrical equipment. Common concepts. Terms and Definitions
TCVN3685-81	1981	Cables wires and cords. Terms and Definitions
TCVN3689-82	1982	Electrical switch device. Common concepts. Terms and Definitions
TCVN3725-82	1982	Electrical apparatus for voltages up to 1000V. Test methods.
TCVN 3787-83	1983	Electrical relays. Terms and Definitions
TCVN 3788-83	1983	Overhead line hardware. Basic concepts. Terms and Definitions
TCVN 3816-83	1983	Electrical small motors for general industrial application. General requirements.
TCVN 4160-90	1990	Electromagnetic Stators for voltages uo to 1000V. General requirements.
TCVN 4255:2008 (IEC 60529:2001)	2008	Degrees of protection provided by enclosures (IP Code)
TCVN 4306-86	1986	Electrical articles for tropical applications. General technical specifications
TCVN 4697-89	1989	Transformers nomenclature of quality indices
TCVN 4911:89 (ST SEV 1118-78)	1989	Low – voltage electromagnetic contactors. Assembly sizes
TCVN 4912-89	1989	Electrical apparatus for voltages up to 1000V. Requirements for assembling sizes
TCVN 5064:1994	1994	Bare wires for overhead power lines

Number	Issued	Title
TCVN 5064:1994 / SD1: 1995)	1994	Bare wires for overhead power lines
TCVN 5169:1993	1993	Porcelain through insulators of voltages of 6 to 35kV. Technical requirements
TCVN 5582:1991	1991	Cables, wires and cords. Determination of mechanical characteristics of insulation and covering
TCVN 5768:1993	1993	Switches for voltages above 1000V
TCVN 5844:1994	1994	Power electric cables with voltage up to 35kV. General technical requirements
TCVN 5926-3:2007 (IEC 60529:2001)	2007	Low – voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications)
TCVN 5935-1995 (IEC 502-1983)	1995	Extruded solid dielectric insulated power cables for rated voltages from 1kV up to 30kV
TCVN 5936-1:1995 (IEC 540:1982)	1995	Test methods for insulations and sheaths of electric cables and cords (Elastomeric and thermoplastic compounds
TCVN 6099-1:2007 (IEC 60060-1:1989)	2007	High-voltage test techniques. Part 1: general definition and test requirements
TCVN 6099-2:2007 (IEC 60060-2:1994)	2007	High-voltage test techniques. Part 2: measuring systems
TCVN 6099-3:2007 (IEC 60060-3:2006)	2007	High-voltage test techniques. Part 3: definitions and requirements for on-site testing
TCVN 6306-1:2006 (IEC 60076-1:2000)	2006	Power transformers. Part 1: general
TCVN 6306-2:2006 (IEC 60076-2:1993)	2006	Power transformers. Part 2: temperature rise
TCVN 6306-3:2006 (IEC 60076-3:2000)	2006	Power transformers. Part 3: insulation levels, dielectric tests, and external clearances in air
TCVN 6306-5:2006 (IEC 60076-5:2006)	2006	Power transformers. Part 5: ability to withstand short circuit
TCVN 6306-11:2009 (IEC 60076-11:2004)	2009	Power transformers. Part 11: dry-type transformers
TCVN 6434-1:2008 (IEC 60898-1:2003)	2008	Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: circuit-breakers for a.c. operation
TCVN 6447:1998	1998	Electric cables – XLPE insulated – Aerial bundled for working voltages up to 0,6/1kV
TCVN 6592-1:2001 **(IEC 60947-1:1999)**	2001	Low – voltage switchgear and controlgear – Part 1: general rules
TCVN 6592-2:2000 **(IEC 947-2:1995)**	2000	Low – voltage switchgear and controlgear – Part 2: circuit-breakers

Number	Issued	Title
TCVN 6592-4-1:2001 **(IEC 6592-4-1:1990)**	2001	Low – voltage switchgear and controlgear – Part 4: Contactors and motor-starters. Section one: electromechanical contactors and motor-starters
TCVN 6610-1:2007 **(IEC 60227-1:1998)**	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 1: General requirements.
TCVN 6610-2:2007 **(IEC 60227-2:2003)**	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 2: Test methods.
TCVN 6610-3:2007 **(IEC 227-3:1997)**	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 3: Non-sheathed cables for fixed wiring
TCVN 6610-4:2007 **(IEC 227-4:1992)**	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 4: sheathed cables for fixed wiring
TCVN 6610-5:2007 **(IEC 60227-5:2003)**	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 5: flexible cables (cords)
TCVN 6610-6:2000 **(IEC 227-6:1985)**	2000	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 6: lift cables and cables for flexible connections
TCVN 6613-1:2000 **(IEC 332-1:1993)**	2000	Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cables
TCVN 6614-1-2:2008 **(IEC60811-1-2:1985)**	2008	Common test methods for insulating and sheathing materials of electric cables and optical cables – Part 1-2: methods for general application – thermal ageing methods
TCVN 6615-1:2000 **(IEC 1058-1:1996)**	2000	Switches for appliances – Part 1: General requirements.
TCVN 6627-1:2008 **(IEC 60034-1:2004)**	2008	Rotating electrical machines – Part 1: Rating and performance
TCVN 6627-2:2001 **(IEC 34-2:1972)**	2001	Rotating electrical machines – Part 2: methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)
TCVN 6627-2A:2001 **(IEC 34-2A:1974)**	2001	Rotating electrical machines – Part 2: methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles) measurement of losses by the calorimetric method
TCVN 6627-3:2000 **(IEC 34-3:1988)**	2000	Rotating electrical machines – Part 3: Specific requirements for turbine-type synchronous machines
TCVN 6627-5:2008 **(IEC 60034-5:2000)**	2008	Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating Electrical machines (IP code) – Classification
TCVN 6627-7:2008 **(IEC 60034-7:2001)**	2008	Rotating electrical machines – Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM code)

Number	Issued	Title
TCVN 6627-8:2000 **(IEC 34-8:1972)**	2000	Rotating electrical machines – Part 8: Terminal markings and direction of rotation of rotating machines
TCVN 6627-9:2000 **(IEC 34-9:1990)**	2000	Rotating electrical machines – Part 9: noise limits
TCVN 6627-11:2008 **(IEC 60034-11:2004)**	2008	Rotating electrical machines – Part 11: Thermal protection
TCVN 6627-14:2008 **(IEC 60034-14:2003)**	2008	Rotating electrical machines – Part 14: mechanical vibration of certain machines with shaft heights 56mm and higher-measurement, evaluation and limits of vibration severity
TCVN 7540-1:2005	2005	High efficiency three-phase asynchronous squirrel cage Electrical motors – Part 1: minimum energy performance
TCVN 7540-2:2005	2005	High efficiency three-phase asynchronous squirrel cage Electrical motors – Part 2: methods for determination of energy performance
TCVN 7697-1:2007 **(IEC 60044-1:2003)**	2007	Instrument transformers – Part 1: current transformers
TCVN 7697-2:2007 **(IEC 60044-2:2003)**	2007	Instrument transformers – Part 2: Inductive voltage transformers
TCVN 7883-8:2008 **(IEC 60255-8:1990)**	2008	Electrical relays – Part 8: thermal electrical relays
TCVN 7994-1:2009 **(IEC 60439-1:2004)**	2009	Low – voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies
TCVN 7995:2009 **(IEC 60038:2002):**	2009	Standard voltages
TCVN 7997:2009	2009	Power cables buried ground – installation method
TCVN 7998-1:2009 **(IEC 60383-1:1993)**	2009	Insulators for overhead lines with a nominal voltage above 1000V – Part 1: ceramic or glass insulator units for a.c. systems – Definitions, test methods and acceptance criteria
TCVN 7998-2:2009 **(IEC 60383-2:1993)**	2009	Insulators for overhead lines with a nominal voltage above 1000V – Part 2: insulator strings and insulator sets for a.c. systems – Definitions, test methods and acceptance criteria
TCVN 7999-1:2009 **(IEC 60282-1:2005)**	2009	High – voltage fuses – Part 1: current-limiting fuses
TCVN 7999-2:2009 **(IEC 60282-2:2008)**	2009	High–voltage fuses – Part 2: expulsion fuses
National Codes for Electrical Facilities	2006	General Requirements
National Codes for Electrical Facilities	2006	Transmission Power System
National Codes for Electrical Facilities	2006	Distribution Equipments and Electrical Substation Facilities
National Codes for Electrical Facilities	2006	Protection and Automation
National Codes for Electrical Technics	2008	Electrical Facilities Calibration

Number	Issued	Title
National Codes for Electrical Technics	2008	Operating and Maintenance of Power System Facilities
National Codes for Electrical Technics	2008	Installation Power Network
National Codes for Electrical Technics	2008	National Technical regulation on Electric Safety

2. Thermal power

(1) Mechanical

Number	Issued	Title
TCVN3949	1984	Coal for pulverized coal burning boilers in power stations. Specifications
TCVN4395	1986	Non-destructive testing. Radiographic testing of welded joints in metallic materials using X and gamma-rays
TCVN5400	1991	Welded joints. General requirements of sampling for mechanical test
TCVN5401	1991	Welded joints. Bending test method
TCVN5401	2010	Destructive tests on welds in metallic materials. Bend tests
TCVN5402	1991	Welded joints. Blow-bending test method
TCVN5402	2010	Destructive tests on welds in metallic materials. Impact test. Test specimen location, notch orientation and examination
TCVN6008	2010	Pressure equipment. Welded. Technical requirements and testing methods
TCVN6154	1996	Pressure vessels. Safety engineering requirements of design, construction, manufacture. Testing methods
TCVN6155	1996	Pressure vessels. Safety engineering requirements of erection, use, repair
TCVN6156	1996	Pressure vessels. Safety engineering requirements of erection, use, repair. Testing method
TCVN6159	1996	Pipe lines for vapor and hot water. Test methods
TCVN6290	1997	Gas cylinders. Cylinders for permanent gases. Inspection at time of filling
TCVN 7704	2007	Boilers. Technical requirement of design, construction, manufacture, installation, operation, maintenance

(2) Electrical

Number	Issued	Title
TCVN 1615	1975	Graphical symbols to be used electrical diagrams. Switching equipments

Number	Issued	Title
TCVN 1978	1994	Three-phase asynchronous squirrel cage motors of powers from 0,55 to 90 kW
TCVN 3662	1981	Metal- enclosed switchgear and control gear for voltages up to 10 kV inclusive. Specifications
TCVN 3715	1982	Enclosed transformer stations of powers up to 1000 kVA for voltages up to 20 kV inclusive. General specifications
TCVN 3725	1982	Electrical apparatus for voltages up to 1000 V. Test methods
TCVN 4696	1989	Low-voltage electrical equipments. Requirements for the electrical insulation
TCVN 4757	1989	Synchronous three-phase generators of powers above 110 kW. General specifications
TCVN 4758	1989	Synchronous generators of powers up to 110 kW. General specifications
TCVN 4762	1989	Power cables. Nominal voltages
TCVN 5169	1993	Porcelain through insulators for voltages from 10 (6) to 35 kV. Technical requirements
TCVN 5170	1990	Porcelain through insulators for voltages up to 35 kV. Acceptance rules and test methods
TCVN 5427	1991	Power transformers. Top-changing devices. Specifications
TCVN 5428	1991	Power transformers. Methods of measuring partial discharge intensiveness during AC voltage testing
TCVN 5429	1991	Power transformers and reactors. Requirements for electric insulation strength
TCVN 5430	1991	Power transformers. Test methods of inside electric insulation strength by switching impulse
TCVN 5431	1991	Oil power transformers for general purpose. Permissible loads
TCVN 5432	1991	Power transformers. Test methods of electric strength of insulation by A.C voltages at industrial frequency
TCVN 5433	1991	Power transformers. Methods of short-circuit testing
TCVN 5434	1991	Power transformers. Test method of heating
TCVN 5435	1991	Power transformers. Methods for measuring dielectric parameters of insulation
TCVN 5844	1994	Power electric cables with voltages up to 35kV. General technical requirements
TCVN 5928	1995	Current transformers
TCVN 6036-3-1	1997	Power transformers. Part 3/1: Insulation levels and dielectric tests. External clearances in air
TCVN 6097	1996	Voltage transformers
TCVN 6306-1	2001	Power transformers. Part 1: General
TCVN 6306-2	2006	Power transformers. Part 2: Temperature rise

Number	Issued	Title
TCVN 6306-3	2006	Power transformers. Part 3: Insulation levels and dielectric tests and external clearances in air
TCVN 6306-4	1997	Power transformers. Part 3: Insulation levels and dielectric tests
TCVN 6306-5	2006	Power transformers. Part 5: Ability to withstand short circuit
TCVN 6306-11	2009	Power transformers. Part 11: Dry-type transformers
TCVN 6592-1	2001	Low-voltage switchinggear and controlgear. Part 1: General rules
TCVN 6627-1	2008	Rotating electrical machines. Part 1: Rating and performance
TCVN 6627-11	2008	Rotating electrical machines. Part 11: Thermal protection
TCVN 6627-14	2008	Rotating electrical machines. Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher. Measurement, evaluation and limits of vibration severity
TCVN 6627-2	2001	Rotating electrical machines. Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)
TCVN 6627-2A	2001	Rotating electrical machines. Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles). Measurement of losses by the calorimetric method
TCVN 6627-3	2000	Rotating electrical machines – Part 3: Specific requirements for turbine-type synchronous machines
TCVN 6627-5	2008	Rotating electrical machines. Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code). Classification
TCVN 6627-7	2008	Rotating electrical machines. Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM Code)
TCVN 6627-8	2000	Rotating electrical machines. Part 8: Terminal markings and direction of rotation of rotating machines
TCVN 6627-9	2000	Rotating electrical machines. Part 9: Noise limits
TCVN 7697-1	2007	Instrument transformers. Part 1: Current transformers
TCVN 7697-2	2007	Instrument transformers. Part 2 : Inductive voltage transformers
TCVN 7994-1	2009	Low-voltage switchgear and controlgear assemblies. Part 1: Requirements for type-tested and partially type-tested assemblies
TCVN 7995	2009	Standard voltages
TCVN 8091-2	2007	Paper-insulated metal-sheathed cabled for rated voltages up to 18/30 kV (with copper or aluminium conductors and excluding gas-pressure and oil-filled cables). Part 2: General and construction requirements
TCVN 6592-1	2009	Low-voltage switchgear and controlgear. Part 1: General rules

Number	Issued	Title
TCVN 6627-2-1	2010	Rotating electrical machines. Part 2-1:Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
TCVN 6627-3	2010	Rotating electrical machines. Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines
TCVN 6627-8	2010	Rotating electrical machines. Part 8: Terminal markings and direction of rotation

3. Network

Number	Issued	Title
TCVN 1615-75	1975	Graphical symbols to be used electrical schemes. Switchgear (devices)
TCVN 1987:1994	1994	Three phase asynchronous squirrel cage electrical motors from 0,55 to 90kW
TCVN 1988-77	1977	Electrical equiment for voltages up to 1000V. Enclosures. Degrees of protection.
TCVN 2331-78	1978	Electrical rotary machines Determination of moment of inertia of rotary part. Test methods.
TCVN 2280-78	1978	Three phase asynchronous electrical motors from 100W and higher power. Test methods.
TCVN 3623-81	1981	Switching devices for voltages up to 1000V. General requirements.
TCVN 3662-81	1981	Metal-enclosed switchgear and controlgear for voltages up to 10kV inclusive. Technical requirements
TCVN 3682-81	1981	Rotating electrical machines. Types. Terms and Definitions
TCVN 3684-81	1981	Electrical requiment. Common concepts. Terms and Definitions
TCVN 3685-81	1981	Cables wires and cords. Terms and Definitions
TCVN 3689-81	1981	Electrical switch decsice. Common concepts. Terms and Definitions
TCVN 3725-82	1982	Electrical apparetus for voltages up to 1000V. Test methods.
TCVN 3787-83	1983	Electrical relays. Terms and Definitions
TCVN 3788-83	1983	Overhead line hardnare. Basic concepts. Terms and Definitions
TCVN 3816-83	1983	Electrical small motors for general inductrial application. General requirements.
TCVN 4160-90	1990	Electromagnetic Staters for voltages uo to 1000V. General requirements.
TCVN 4255:2008 (IEC 60529:2001)	2008	Degrees of protection provided by enclosures (IP Code)
TCVN 4306-86	1986	Electrical articles for tropical applications. General technical specifications

Number	Issued	Title
TCVN 4697-89	1989	Transformers nomenclature of quality indices
TCVN 4911-89 (ST SEV 1118-78)	1989	Low – voltage electromagnetic contactors. Assembly sizes
TCVN 4912-89	1989	Electrical apparatus for voltages up to 1000V. Requirements for assembling sizes
TCVN 5064:1994	1994	Bare wires for overhead power lines
TCVN5064:1994 /SĐ 1:1995	1994	Bare wires for overhead power lines
TCVN 5169:1993	1993	Procelain through insulattors of voltages of 6 to 35kV. Technical requirements
TCVN 5582:1991	1991	Cables, wires and cords. Determination of mechanical characteristics of insulation and covering
TCVN 5768:1993	1993	Switches for voltages above 1000V
TCVN 5844:1994	1994	Power electric cables with voltage up to 35kV. General technical requirements
TCVN 5926-3:2007 (IEC 60269-3:1987)	2007	Low – voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications)
TCVN 5935-1995 (IEC 502-1983)	1995	Extruded solid dielectric insulated power cables for rated voltages from 1kV up to 30kV
TCVN 5936:1995 (IEC 540-1982)	1995	Test methods for insulations and sheaths of electric cables and cords (Elastomeric and thermoplastic compounds)
TCVN 6099-1:2007 (IEC 60060-1:1989)	2007	High-voltage test techniques. Part 1: general definition and test requirements
TCVN 6099-2:2007 (IEC 60060-2:1994)	2007	High-voltage test techniques. Part 2: measuring systems
TCVN 6099-3:2007 (IEC 60060-3:2006)	2007	High-voltage test techniques. Part 3: definitions and requirements for on-site testing
TCVN 6306-1:2006 (IEC 60076-1:2000)	2006	Power transformers. Part 1: general
TCVN 6306-2:2006 (IEC 60076-2:1993)	2006	Power transformers. Part 2: temperature rise
TCVN 6306-3:2006 (IEC 60076-3:2000)	2006	Power transformers. Part 3: insulation levels, dielectric tests and external clearances in air
TCVN 6306-5:2006 (IEC 60076-5:2006)	2006	Power transformers. Part 5: ability to withstand short circuit
TCVN 6306-11:2009 (IEC 60076-11:2004)	2009	Power transformers. Part 11: dry -type transformers
TCVN 6434-1:2008 (IEC 60898-1:2003)	2008	Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: circuit-breakers for a.c.oeration

Number	Issued	Title
TCVN 6447:1998	1998	Electric cables – XLPE insulated – Aerial bundled for working voltages up to 0,6/1kV
TCVN 6592-1:2001 (IEC 60947-1:1999)	2001	Low – voltage switchgear and controlgear – Part 1: general rules
TCVN 6592-2:2000 (IEC 947-2:1995)	2000	Low – voltage switchgear and controlgear – Part 2: circuit-breakers
TCVN 6592-4-1:2001 (IEC 6592-4-1:1990)	2001	Low – voltage switchgear and controlgear – Part 4: Contactors and motor-starters.Section one: electromechanical contactors and motor-starters
TCVN 6610-1:2007 (IEC 60227-1:1998)	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 1: General requirements.
TCVN 6610-2:2007 (IEC 60227-2:2003)	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 2: Test methods.
TCVN 6610-3:2007 (IEC 227-3:1997)	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 3: Non-sheathed cables for fixed wiring
TCVN 6610-4:2007 (IEC 227-4:1992)	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 4: sheathed cables for fixed wiring
TCVN 6610-5:2007 (IEC 60227-5:2003)	2007	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 5: flexible cables (cords)
TCVN 6610-6:2000 (IEC 227-6:1985)	2000	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V - Part 6: lift cables and cables for flexible connections
TCVN 6613-1:2000 (IEC 332-1:1993)	2000	Tests on electric cables under fire conditions - Part 1: Test on a single vertical insulated wire or cables
TCVN 6614-1-2:2008 (IEC 60811-1-2:1985)	2008	Common test methods for insulating and sheathing materials of electric cables and optical cables - Part 1-2: methods for general application – thermal ageing methods
TCVN 6615-1:2000 (IEC 1058-1:1996)	2000	Switches for appliances – Part 1: General requirements.
TCVN 6627-1:2008 (IEC 60034-1:2004)	2008	Rotating electrical machines – Part 1: Rating
TCVN 6627-2:2001 (IEC 34-2:1972)	2001	Rotating electrical machines – Part 2: methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)
TCVN 6627-2A:2001 (IEC 34-2A:1974)	2001	Rotating electrical machines – Part 2: methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles) measurement of losses by the calorimectric method

Number	Issued	Title
TCVN 6627-3:2000 (IEC 34-3:1988)	2000	Rotating electrical machines – Part 3: Speccific requirements for turbine-type synchronous machines
TCVN 6627-5:2008 (IEC 60034-5:2000)	2008	Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating Electrical machines (IP code) – Classification
TCVN 6627-7:2008 (IEC 60034-7:2001)	2008	Rotating electrical machines – Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM code)
TCVN 6627-8:2000 (IEC 34-8:1972)	2000	Rotating electrical machines – Part 8: Terminal markings and direction of rotation of rotating machines
TCVN 6627-9:2000 (IEC 34-9:1990)	2000	Rotating electrical machines – Part 9: noise limits
TCVN 6627-11:2008 (IEC 60034-11:2004)	2008	Rotating electrical machines – Part 11: Thermal protection
TCVN 6627-14:2008 (IEC 60034-14:2003)	2008	Rotating electrical machines – Part 14: mechanical vibration of certain machines with shaft heights 56mm and higher- measurement, evaluation and limits of vibration severity
TCVN 7540-1: 2005	2005	High efficiency three-phase asynchronous squirrel cage Electrical motors – Part 1: minimum energy performance
TCVN 7540-2:2005	2005	High efficiency three-phase asynchronous squirrel cage Electrical motors – Part 2: methods for determination of energy performance
TCVN 7697-1:2007 (IEC 60044-1:2003)	2007	Instrument transformers – Part 1: current transformers
TCVN 7697-2:2007 (IEC 600044-2:2003)	2007	Instrument transformers – Part 2: Inductive voltage transformers
TCVN 7883-8:2008 (IEC 60255-8:1990)	2008	Electrical relays – Part 8: thermal electrical relays
TCVN 7994-1:2009 (IEC 60439-1:2004)	2009	Low – voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies
TCVN 7995:2009 (IEC 60038:2002):	2009	Standard voltages
TCVN 7997:2009	2009	Power cables buried ground – installation method
TCVN 7998-1:2009 (IEC 60383-1:1993)	2009	Insulators for overhead lines with a nominal voltage above 1000V – Part 1: ceramic or glass insulator units for a.c.systems – Definitions, test methods and acceptance criteria
TCVN 7998-2:2009 (IEC 60383-2:1993)	2009	Insulators for overhead lines with a nominal voltage above 1000V – Part 2: insulator strings and insulator sets for a.c.systems – Definitions, test methods and acceptance criteria
TCVN 7999-1:2009 (IEC 60282-1:2005)	2009	High – voltage fuses – Part 1: current-limitting fuses

Number	Issued	Title
TCVN 7999-2:2009 (IEC 60282-2:2008)	2009	High–voltage fuses – Part 2: expulsion fuses
QCVN 01:2008/BCT	2008	National technical regulation on electric safety
TCVN 7589-21:2007 (IEC 62053-21:2003)	2007	Electricity metering equipment (a.c). Particular requirement. Part 21: Static watt-hour meters for active energy (class 1 and 2)
TCVN 2330-78	1978	Solid electrical insulating materials. Determination of electric strength at industrial frequencies and alternating voltages.

4. Related foreign standards

(1) List of Major Foreign Standards

ISO : International Organization of Standardization

IEC : International Electro-technical Commission

ITU : International Telecommunication Union

EN : European Standards

ETSI : European Telecommunications Standards Institute

ANSI: American National Standards Institute,

AS: Australian Standards,

DIN: Deutschs Institute fur Normung,

BS: British Standard,

CSA: Canadian Standards Association,

DS: Dansk Standsrdiseringsrad,

NEN: Nenderlanddse Norm,

NF: Norme Francaise,

NZS: New Zialand Standard,

PS: Philippine Standards,

UNI: Unificatione Italiano,

UNE : Una Norma Espanola,

SNV: Schweizerische Normen - Vereinigung,

JIS: Japanese Industrial Standard

GB: Guojia Biaozhum

ACI: American Concrete Institute,

AWS: American Welding Society,

AISI: American Iron and Steel Institute,

EIA: Electronic Industries Alliance,

NFPA: National Fire Protection Association,

VDI: Verein Deutscher Ingenieure,

UL : , Underwriters Laboratories, (America)

VDE:	Verband Deutscher Electrotechnicker,
NEMA:	National Electrical Manufacturers Association**,**
ASME:	American Society of Mechanical Engineers,
ASTM:	American Society for Testing and Materials,
IEEE:	Institute of Electrical and Elecronics Engineers,
NEMA:	National Electrical Manufacturers Association**,**
JEC:	Standard of The Japanese Electrotechnical Committee,
JEM:	The Japan Electrical Manufacturers' Association,
ESC:	Japan Electrotechnical Standard and Codes Committee
ETRA:	Electric Technology Research Association,
JEAC:	Japan Electric Association Code,
JEAG:	Japan Electric Association Guide,

(2) Structure of Technical Standard System

The major foreign standards among the ones listed above will be categorized into the two (2) groups which are "Material" and "Performance / Inspection" as follows:.

1) Group of Materials Standards

ISO, EN, DIN, GB, AISI, ASTM,. JIS., etc.,

2) Group of Performance / Inspection Standards

IEC, ANSI, ASME, AWS, IEEE, NEMA, etc.

Article 19. Attachment of rating plate

1. Sample of Rating Plate

The following is a sample of rating plate for a turbine-generator unit.

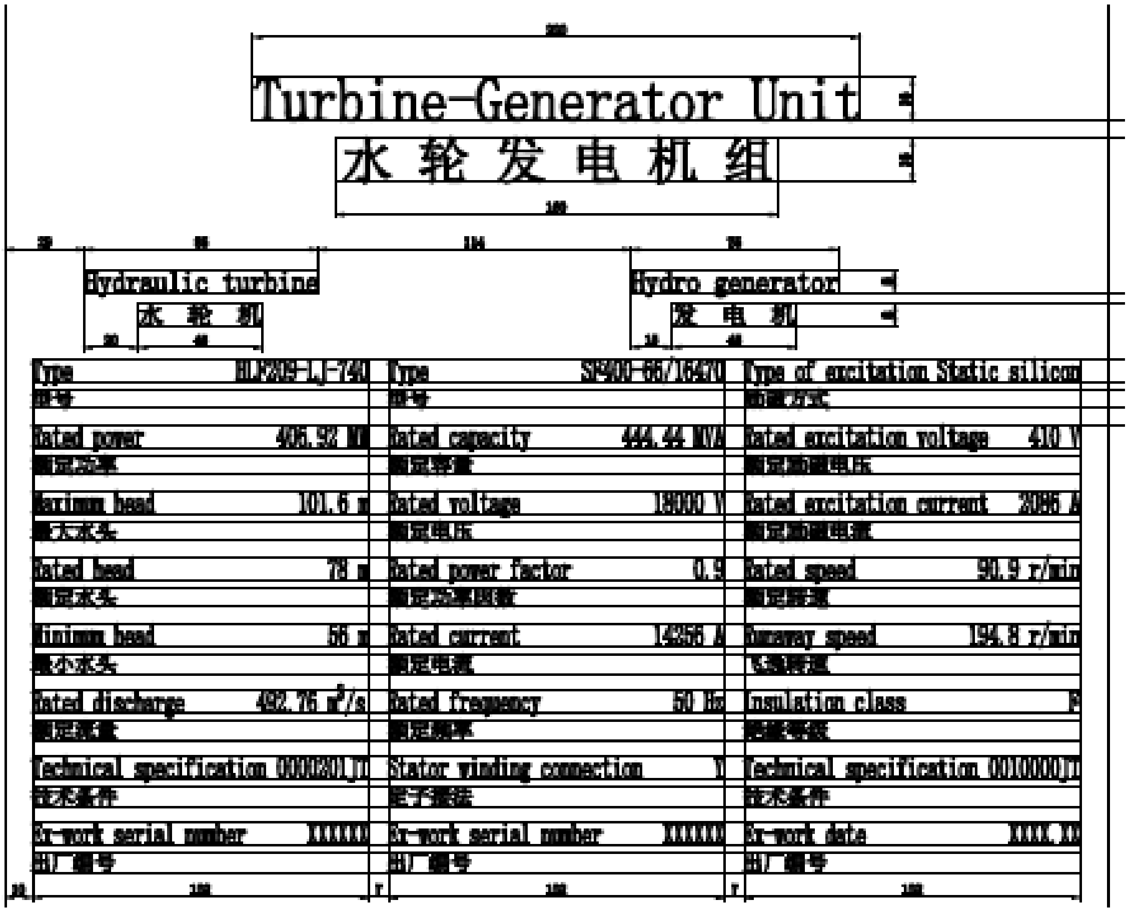


Figure 19-1 Sample of Rating Plate
(Son La HPP: Turbine-Generator Unit)

2. Sample of specifications for Labeling for electrical components

(1) Inscriptions

The labels will show the document reference number and functional name where applicable.

The lettering must be engraved in black in the English language unless otherwise specified in the Technical Specifications.

Label material for major equipment must be stainless steel with black engraving or laminated plastic type with black core and white surface. All outdoor surface mounted labels must be stainless steel or laminated plastic type with black core and white surface.

Electrical devices within the compartment must be labeled with laminated plastic type with black core and white surface. The labels must be placed below the equipment and not on the equipment/devices.

All systems that are assembled in the factory must be delivered to site with the labels attached. Stainless steel / plastic labels must be used to individually identify control and instrument panels, switchboards, motor control centers and junction boxes located outdoors unless otherwise specified in the Work Package Technical Specifications.

(2) Fastening systems

All labels must be securely fixed to the panels self-tapping screws. The use of adhesives is not permitted.

(3) Labeling of electrical main components / feeders

For the main equipment listed below, typical types of labels for electrical main components and its dimensions are shown herein:

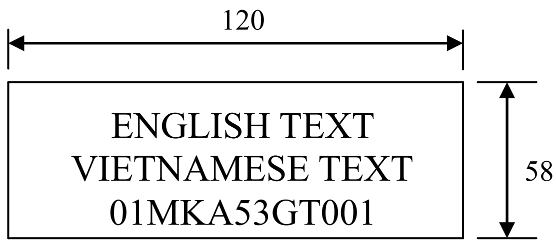
Type A (example)

Plate size:	(w) 105 mm x (h) 37 mm x (t) 1.6 mm
Letter size:	8.0 mm
Letter type:	Arial, normal
Usage:	Panel door

In addition to the external labels the components internal to Control Panels / Switchgears needs to be identified with Name plates as per manufacturer's standard. These plates must be fitted not on the device but below the device so as to identify the component clearly.

Type B (example)

Upper section line 1 :	English text
Upper section line 2 :	Vietnamese text
Lower section:	Power Plant Identification
Plate size:	(w) 120mm x (h) 58mm x (t) 1.6mm
Letter size:	6 mm
Letter type:	Arial



Type C (example)

Upper section :	English text
Lower section:	Power Plant Identification
Plate size:	(w) 200mm x (h) 50mm x (t) 1.6mm

Bigger letter size: 14 mm

Smaller letter size: 12 mm

Letter type: Arial

Module doors

Type D (example)

Upper section line 1 : English text

Upper section line 2 : Vietnamese text

Lower section: Power Plant Identification

Plate size: (w) 297 mm x (h)105 mm x (t)1.6 mm

Bigger letter size: 15 mm

Smaller letter size: 10 mm

Letter type: Arial

3. Label Selection Guideline (Reference)

No.	Description	Label Type
1	Generator terminals and neutral point compartment	A
2	Bus duct	A
3	Generator circuit breaker system	A
4	Transformers	B
5	Emergency diesel generator	A
6	MV Switchgear cubicles	C
7	Control system cubicles	C
8	MCC cubicles	C
9	UPS cubicles	C
10	Generator protection cubicles	C
11	Static excitation and AVR cubicles	D
12	Synchronizing, measuring and metering cubicles	C
13	Fire protection cubicles	C
14	Module doors, General	D
15	Feeders, General	A
16	MCC Feeders, General	A
17		

4. Example of Technical Specifications for reference

(1) Equipment Labeling of Ham Thuan - Da Mi HPP

1) Approved Labels

Approved labels, for example the ASME's label to the pressure vessel, must be attached to equipment where required by the regulating authority having jurisdiction or by the specified governing standard.

2) Nameplates

All Equipment must be suitably identified with nameplates. The name plate and warning label must be in English and/or Vietnamese language.

(a) Nameplates for indicating the name of panel, board, junction box, etc., must be laminated plastic, screw fastened with black lettering on a white field. Minimum letter size to be 4 mm. Nameplates must be fitted in a prominent, readily accessible location.

(b) A permanent corrosion resistant metal nameplate showing the following information must be permanently mounted on each major piece of equipment:

- Equipment designation
- Manufacturer's name and address
- Serial number
- Part number
- Date of Manufacture
- Equipment ratings

3) Warning labels

The warning labels must be provided on or in all electrical equipment where terminals at dangerous voltages (including 400/230V) may be exposed during maintenance. Warning labels must be of plastic laminate with white lettering on a red background.

(2) Equipment’s Labels of Step-up Transformer of Son La HPP

1) General

a) The equipment supplier must provide labels with suitable size and sufficient details to permit rapid and positive identification to be made for operational and maintenance purposes of all pieces of equipment.

b) The identification plates must be protected during erection and especially during painting. New ones must replace damaged or illegible identification plates.

c) The inscription must be printed, punched, or engraved, and must be waterproof and oil-proof.

d) The following data must be shown in accordance with the relevant standards

- Manufacturer's name and address,
- Equipment serial number and date of manufacture,
- Main design data

e) A rating plate complying with the requirements of the appropriate Standard must be provided on each item of the equipment. In addition to the information listed in the appropriate Standard, the rating plate must be marked with the Contract number and other information requested by the Employer’s Representative. The rating plates must be of engraved or stamped stainless steel or brass

2) Functional Plates / Labels

a) Each part appearing under a certain symbol or number in functional diagrams, piping diagrams, in the operation and maintenance instructions, etc., must be equipped with a plate/ label showing the same symbol or umber.

b) Valve labels must include a valve number of the form Faaaaa-bbb, where Faaaaa is the schematic drawing number showing the valve and bbb is the valve number appearing on that drawing. Where relevant, valve labels must also include the notation “NO” or “NC” indicating whether the valve is normally open or normally closed. Fuses and links must be identified by their function, such as voltage, polarity, phase color and fuse link rating.

5. Sample rating plate of 3 phase induction motor

Chapter 10 of IEC 60034-1 shall be referred to regarding items of rating plates for equipment of power facility. Sample rating plate of 3 phase induction motor is shown as follows ;

Table 19-1 Sample rating plate of 3 phase induction motor

<table>
<tr><td>Rated output 15kW</td><td colspan="2">Type FGK</td></tr>
<tr><td>Pole 4</td><td colspan="2"></td></tr>
<tr><td>Rated voltage 440V</td><td colspan="2">Insulation class F</td></tr>
<tr><td>Rated current 25.0A</td><td colspan="2">Rating Continuous</td></tr>
<tr><td>Frequency 60Hz</td><td colspan="2">Coolant temperature degree</td></tr>
<tr><td>Speed 1760 rpm</td><td colspan="2">Performance standard JEC2137</td></tr>
<tr><td rowspan="2">The rated open-circuit voltage between slip-rings

Rated slip-ring current</td><td rowspan="2">Bearing number</td><td>6224</td></tr>
<tr><td>6224</td></tr>
<tr><td></td><td colspan="2">The altitude m</td></tr>
<tr><td>Degree of protection IP54</td><td colspan="2">Year of manufacture 2003-8</td></tr>
<tr><td>Cooling type JC4F</td><td colspan="2"></td></tr>
<tr><td>Serial number M 0111111</td><td colspan="2"></td></tr>
</table>

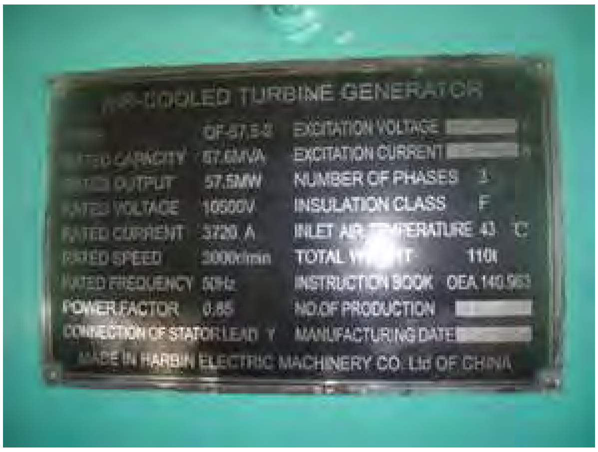


Figure 19- 2 Sample rating plate of generator

Article 20. Numbering of equipment

1. Purpose and application of numbering

(1) The purpose of numbering for all the apparatus, equipment, and facilities which are installed in an electric dispatching center or electric power plant is to make easy the design and construction supervision in the construction stage and the management in the operation and maintenance stage.

The numbering of apparatus, equipment and facilities contributes to the improvement of the certain and speedy transfer of information in the management of equipment by simplification and clear clarification of the related documents, especially preparation of management drawings.

The nomenclatural type for the number of apparatus, equipment and facilities has been almost authorized by each purpose based on the international standards and the number of them is applied with coding of each facility.

(2) Type of piping, i.e., water supply and drainage pipes, pressure oil and drainage pipes, air supply and exhaust pipes, etc. must be expressed with colors and an arrow marks together with numbering in accordance with the purpose of equipment.

Example:

1) The following colors are applied for indicating piping system in general;

- Blue color : Water supply & drainage pipes
- Red color : Pressure oil & drainage pipes
- Brown : Air supply & exhaust pipes

2) The following colors are applied for each phase of conductors installed in an electric power cable, a sealing bus-bar duct, and a transmission line in general;

- "Red, White and Blue" or "Black, White and Red" / "A, B, and C" or "R, S, and T" or "U, V, and W" phases. However, there are "Red, Yellow and Blue" in Vietnam as blow.

Photo 20-1 Sample numbering busduct and control panel

3) An device function number (sequence number) is applied in general to the switching apparatus and control device together with an equipment employment numbering or a marking.

"Regulation on numbering equipment of EVN (Document No.16/2007/QD-BCN, March 28th 2007 Minister: Ministry of Industry)" is described below as a sample:

Chapter VII Numbering equipments in national power system

Article 37. Numbering with voltage level

1. 500 kV level : numbered by 5

2. 220 kV level : numbered by 2

3. 110 kV level: numbered by 1

4. 66 kV level : numbered by 7

5. 35 kV level : numbered by 3

6. 22 kV level : numbered by 4

7. 15 kV level: numbered by 8 (Only with all generator terminal voltage, synchronous machine □15 kV are numbered by 9);

8. 10 kV level: numbered by 9 (Only with all generator terminal voltage, synchronous machine □ 10 kV are numbered by 9);

9 6 kV level: numbered by 6 (with generator terminal voltage, synchronous machine up to 10 kV are numbered by 6);

10. Others voltage level will be self assigned by control dispatch level.

Article 38. Numbering bus-bar

1. The first symbol shall be assigned by letter C.

2. The second symbol show on voltage level, this symbol shall be assigned according to regulations in Article 37 of this documents.

3. The third symbol show on order number of bus bar, particular number 9 show on ring bus-bar.

Example:

- *C12: show on bus bar number 2, voltage level 110 kV;*
- *C21: show on bus bar number 1, voltage level 220 kV;*
- *C29: show on ring bus bar, voltage level 220 kV.*

Article 39. Naming generator, synchronous machine

1. The first letter shall be regulated as follows:

a) With steam thermal power generator: assigned by letter S;

b) With hydro power generator: assigned by letter H;

c) With gas turbine: assigned by letter GT;

d) With the end of gas turbine: assigned by letter ST;

e) With diesel generator: assigned by letter D;

f) With synchronous machine: assigned by letter B;

g) With nuclear power: assigned by letter N;

h) With wind turbine: assigned by letter G;

i) With hydro power storage: assigned by letter P.

2. *The second symbol is order number of generator.*

Example:

- *S1: show on generator number 1 of thermal power plant.*
- *GT2: show on gas turbine number 2.*
- *N1: show on generator number 1 of nuclear power plant.*

Article 40. Naming transformer

1. *The first symbol is regulated as follows:*

a) Two or three winding transformer is assigned by letter T;

b) Auto-transformer is assigned by letter AT;

c) Auxiliary transformer is assigned by letter TD;

d) Exciting transformer is assigned by letter TE;

e) Neutral transformer is assigned by letter TT.

2. *The following letter is order number of transformer. With auxiliary transformer, the following letters are voltage level and order number of transformer.*

Example:

- *T1: show on transformer number 1.*
- *T2: show on transformer number 2.*
- *TD31: show on auxiliary transformer with voltage level is 35 kV.*
- *AT1: show on auto-transformer number 1.*

Article 41. Naming neutral resistor, neutral reactor of transformer

1. *If two first letter are RT show on neutral resistor, KT are show on neutral reactor;*
2. *The third letter are taken on following to the voltage level of multi windings transformer;*
3. *The following letters are taken by name of transformer which RT or KT is connected.*

Example:

- *RT3T1: show on neutral resistor of 35kV winding of transformer named T1.*
- *KT5AT2: show on neutral reactor of 500kV transformer named AT2.*

Article 42. Naming quadrature reactor

1. *The first two letters are KH.*
2. *The third symbol show on voltage level, this symbol shall be assigned according to regulations in Article 37 of this documents.*
3. *The fourth symbol is number 0.*
4. *The fifth symbol is the order number of line that the quadrature reactor is connected.*

Example:

- *KH504: show on 500 kV quadrature reactor connected in line 4.*

Article 43. Naming neutral reactor, neutral resistor of quadrature reactor

1. *If the first two letters are RT show on neutral resistor, KT are show on neutral reactor of quadrature reactor.*
2. *The following symbols are taken on following three latest symbol of quadrature reactor.*

Example:

- *KT504: show on neutral reactor of quadrature reactor KH504.*
- *RT504: show on neutral resistor of quadrature reactor KH504.*

Article 44. Naming Petersen coil

1. *The first two symbols are KI.*
2. *The third symbol show on voltage level, this symbol shall be assigned according to regulations in Article 37 of this documents.*
3. *The following symbols are the order number of cable line or bus bar that the reactor is connected.*

Example:

- *KI212: show on 220 kV petersen coil connected between bus bar number 1 and bus bar number 2.*
- *KI171: show on petersen coil of cable line 171.*

Article 45. Naming reactor

1. *The first symbol is L.*
2. *The following symbols are name of power line.*

Example:

- *L171: show on reactor of 110kV line named 171.*

Article 46. Naming compensating capacitor

1. *The first three symbols: with series capacitor are TBD, with shunt capacitor are TBN.*
2. *The fourth symbol show on voltage level, this symbol shall be assigned according to regulations in Article 37 of this documents.*
3. *The fifth symbol is zero (0).*
4. *The sixth symbol is order number of line that the series capacitor is connected, or is order number of capacitor with shunt capacitor.*

Example:

- *TBD501: show on 500 kV series capacitor connected in line number 1.*
- *TBN302: show on 35 kV shunt capacitor connected in line number 2.*

Article 47. Naming high voltage prevent capacitor

1. *The first symbol is C;*
2. *The following symbols are name of protected equipment. With protected equipment that it's voltage level do not show clearly in it's name, after first symbol is the specific symbol of voltage level and the latest is name of equipment.*

Example:

- *C901: show on high voltage prevent capacitor of circuit breaker named 901.*
- *C9H1: show on high voltage prevent capacitor connected to terminal voltage side of generator named H1.*

Article 48. Naming Voltage transformer

1. *The first symbol is TU;*
2. *The following symbols are name of equipment that the voltage transformer is connected. With protected equipment that it's voltage level do not show clearly in it's name, after first symbol is the specific symbol of voltage level and the latest is name of equipment.*

Example:

- *TU171: show on voltage transformer of 110kV line named 171.*
- *TUC22: show on voltage transformer of 220kV bus bar number 2.*
- *TU5T2: show on voltage transformer on 500kV side of transformer named T2.*

Article 49. Naming current transformer

1. *The first two symbols are TU;*
2. *The following symbols are name of equipment that the voltage transformer is connected. With protected equipment that it's voltage level do not show clearly in it's name, after first symbol is the specific symbol of voltage level and the latest is name of equipment.*

Example:

- *TI171: show on 110kV current transformer of line 171.*
- *TI5AT2: show on 500kV bushing current transformer of auto transformer named AT2.*

Article 50. Naming surge arrester

1. *The first two symbols are CS;*
2. *The following symbols are name of protected equipment. With protected equipment that it's voltage level do not show clearly in it's name, after first symbol is the specific symbol of voltage level and the latest is name of equipment. With surge arrester that is connected to neutral of transformer, voltage level is assigned by zero (0).*

Example:

- *CS1T1: show on surge arrester on 110kV side of transformer named T1.*
- *CS0T1: show on surge arrester connected in neutral of transformer named T1.*
- *CS271: show on surge arrester of line 271.*

Article 51. Naming fuse

1. *The first symbols: with normal fuse are CC, with fuse cut-out are FCO.*
2. *The following symbols are symbol (-) and name of protected equipment.*

Example: CC-TUC31: show on fuse of voltage transformer on busbar named C31.

Article 52. Numbering circuit breaker

1. *The first symbol show on voltage level, this symbol shall be assigned according to regulations in Article 37 of this documents. Only with circuit breaker of capacitor is assigned by T, with reactor the first symbol is K and the second symbol is designated to voltage level.*
2. *The second symbol (three symbol with circuit breaker of capacitor and reactor) is designated to location of circuit breaker and regulated as follows:*

   a) *Circuit breaker of transformer : numbered by 3.*

   b) *Circuit breaker of power line : numbered by 7 and 8 (or from 5 to 8 if connecting diagram is complicate).*

   c) *Circuit breaker of auxiliary transformer : numbered by 4.*

   d) *Terminal circuit breaker of generator : numbered by 0.*

   e) *Circuit breaker of synchronous machine : numbered by 0.*

   f) *Circuit breaker of shunt capacitor : numbered by 0.*

   g) *Circuit breaker of series capacitor : numbered by (or by 9 if connecting diagram is complicate).*

h) *Circuit breaker of reactor : numbered by (or by 9 if connecting diagram is complicate).*

3. *The third symbol (fourth with circuit breaker of reactor or capacitor) show on order number. E.g: 1,2,3...*
4. *With circuit breaker of ring bus bar, two symbols after the first are: 00.*
5. *With communication circuit breaker between two bus bars, two symbols after the first are order numbers of two bus bars.*
6. *With sectionalized bus bar diagram, numbering circuit breakers on even bus bar by even numbers, and by odd numbers with circuit breakers on odd bus bar.*
7. *With polygonal diagram, numbering circuit breakers following to line circuit breakers;*
8. *With 3/2 diagram, 4/3 diagram: circuit breakers can be numbered by following method depend on diagrams:*

   a) *Numbering circuit breakers following to line circuit breakers;*

   b) *Numbering two circuit breakers in centre (do not connect with bus bars) by num ber 5 or number 6.*

   c) *Numbering the third number according to order number of line.*

Example:

- *131: show on 110kV circuit breaker number 1 of transformer.*
- *903: show on terminal generator circuit breaker number 3, voltage level is □10 kV.*
- *K504: show on circuit breaker number 4 of 500 kV reactor.*
- *100: show on 110kV circuit breaker of ring bus bar.*
- *212: show on communication circuit breaker of 220kV bus bars.*

Article 53. Numbering disconnector

1. *The first symbols are name of circuit breaker or name of equipment directly connect to disconnector (with disconnector of voltage transformer, the first symbols are name of voltage transformer, after that is name of equipment that is directly connected to dis-connector), after that is (-) symbol.*
2. *Following symbol is regulated as follows:*

   a) *Order number of bus bar that disconnector is connected with disconnector bus bar;*

   b) *Line disconnector is numbered 7;*

   c) *Disconnector connect to transformer is numbered 3;*

   d) *Disconnector connect to ring bus bar is numbered 9;*

   e) *Earthing disconnector of an equipment is numbered 0 or 9;*

   f) *With sectionalized disconnector is numbered by order number of sectionalized bus bar that is connected.*

   g) *Disconnector connected to neutral resistor or neutral reactor is numbered 0.*

Example:

- *131-3: show on 110 kV disconnector of transformer T1.*
- *K501-1: show on 500 kV disconnector of reactor number 1 connected to bus bar number 1.*

- *TUC22-2: show on 220 kV disconnector of transformer number 2 connected to bus bar number 2.*
- *171-7: show on 110 kV line disconnector of circuit breaker named 171.*
- *272-9: show on disconnector of circuit breaker named 272 that connected to ring bus bar.*
- *275-0: show on earthing disconnector of circuit breaker named 275.*
- *KT101-0: show on disconnector in neutral of 110kV windings of transformer T1 that is connected to reactor named KT101.*

Article 54. Numbering earthing disconnector

1. *First symbols are name of disconnector or direct relating equipment.*
2. *The following symbol is designated to earthing disconnector, and is regulated as follows:*

    a) *Earthing disconnector of line or capacitor is numbered 6;*

    b) *Earthing disconnector of transformer, reactor and voltage transformer is numbered 8;*

    c) *Earthing disconnector of circuit breaker is numbered 5;*

    d) *Earthing disconnector of bus bar is numbered 4;*

    e) *Earthing disconnector in neutral of transformer or reactor is numbered 08.*

Example:

- *271-76: show on earthing disconnector in line named 271.*
- *171-15: show on earthing disconnector of circuit breaker named 171 in disconnector named 171-1.*
- *131-08: show on earthing disconnector in neutral of 110kV wingding of transformer number 1.*

2. Example of numbering system

(1) Sample for Color bands and Arrows

Adhesive tape color banding must be used only for insulated piping, stainless steel pipes and hot galvanized pipes.

Banding is not applied for non-insulated piping. The arrow must be painted onto the no insulated piping surface.

All piping will be labeled by stenciling its designated system name.

Words must be stenciled in black on white background.

Where piping is located above or below the normal line of vision, the lettering must be placed below or above the horizontal centerline of the pipe

Sizes of letters for piping above or below the normal line of vision are as follows in general:

Table 20-1 Size of Letters for Piping

Pipe Sizes	Length of Color Field	Size of Letter
13 mm up to 40 mm	200 mm	13 mm
50 mm to 100 mm	200 mm	19 mm
150 mm	300 mm	32 mm
200 mm larger	600 mm	64 mm

All systems that are assembled in the factory must be delivered to site with the labels affixed.

The color bands and arrow must be indicated on all insulated pipes at the following locations:

- Tank inlets and outlets
- Pumps discharge and suction
- Loading and unloading connection (lorry loading, drum loading, cylinder loading, etc)
- Next to each valve
- Inlets and outlets of underground and pipe trenches
- Upper and lower ends of pipe floor penetration
- Adjacent to changes in direction and branches

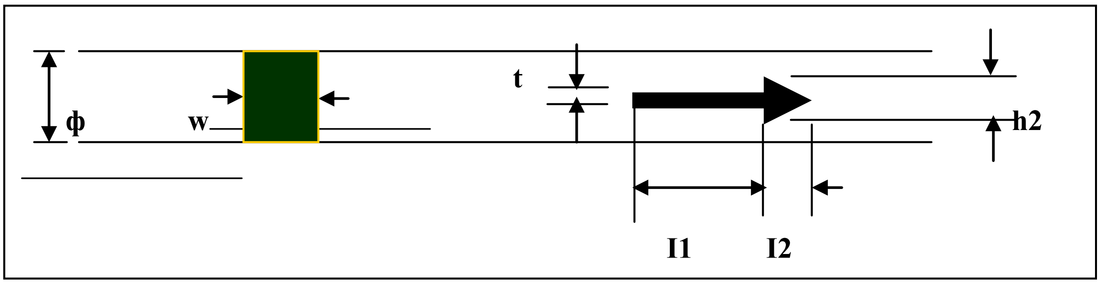
The location of the color banding and arrows for long straight pipes will be at 12 meter intervals in general. For shorter pipe length the distances can be reduced to 6 meter to enable clear identification of the pipes and direction of flow.

The color band and the flow direction will be in accordance with Painting Specification in the Contract.

Color band and arrow tapes must be of durable dimensionally stable, glossy vinyl film with pressure sensitive (self-sticking) adhesive and it must be suitable for outdoor, applicable in tropical environment.

Color of directional arrow for non-insulated piping must be in good contrast to the basic color.

Color band and directional arrow dimensions must be as follows:



(Unit : mm)

ϕ(Pipe Sizes)	h2	t	l1	l2	w
50 mm to 150 mm	40	25	75	35	50
Above 150 mm	60	40	100	50	75

Figure 20-2 Dimensions of Color Band & Directional Arrow

Photo 20-2 Example of Directional Arrow1

(2) Sample for Device Function Numbers

The device function numbers (DFN) will be applied in accordance with IEEE (ANSI), BS, JEM (in Japan), etc., of International standards for each piece of equipment of electric power facility, as Attached **Table 20-2 Comparison of Device Function Numbers** (for Reference)

Table 20-2 Comparison of Device Function Numbers (For Reference)

Function Number	JEM 1091 (2008)	IEEE C37.2 (1970)	BS-3939 (1970)
1	MASTER ELEMENT (MASTER SWITCHING DEVICE)	MASTER ELEMENT	MASTER ELEMENT

Function Number	JEM 1091 (2008)	IEEE C37.2 (1970)	BS-3939 (1970)
2	TIME-DELAY STARTING OR CLOSING RELAY	TIME-DELAY STARTING OR CLOSING RELAY	TIME-DELAY STARTING OR CLOSING RELAY
3	CONTROL SWITHCH	CHECKING OR INTERLOCKING RELAY	CHECKING OR INTERLOCKING RELAY
4	MASTER CONTACTOR OR RELAY	MASTER CONTACTOR	MASTER CONTACTOR
5	STOPPING DEVICE	STOPPING DEVICE	STOPPING DEVICE
6	STARTING CIRCUIT BREAKER CONTACTOR OR RELAY	STARTING CIRCUIT BREAKER	STARTING CIRCUIT BREAKER
7	ANODING SWITCH	ANODE CIRCUIT BREAKER	ANODE CIRCUIT BREAKER
8	CONTROL POWER SWITCH	CONTROL POWER DISCONNECTING DEVICE	CONTROL POWER DISCONNECTING DEVICE
9	REVERSING DEVICE	REVERSING DEVICE	REVERSING DEVICE
10	UNIT SEQUENCE SWITCH	UNIT SEQUENCE SWITCH	UNIT SEQUENCE SWITCH
11	TESTING SWITCH	[RESERVED]	[RESERVED]
12	OVERSPEED DEVICE	OVERSPEED DEVICE	OVERSPEED DEVICE
13	SYNCHRONOUS-SPEED DEVICE	SYNCHRONOUS-SPEED DEVICE	SYNCHRONOUS-SPEED DEVICE
14	UNDERSPEED DEVICE	UNDERSPEED DEVICE	UNDERSPEED DEVICE
15	SPEED OR FREQUENCY MATCHING DEVICE	SPEED OR FREQUENCY MATCHING DEVICE	SPEED OR FREQUENCY MATCHING DEVICE
16	PILOT-WIRE-FAULT PROTECTIVE RELAY	[RESERVED]	[RESERVED]
17	PILOT-WIRE RELAY	SHUNTING OR DISCHARGE SWITCH	SHUNTING OR DISCHARGE SWITCH
18	ACCELERATING OR DECELERATING DEVICE	ACCELERATING OR DECELERATING DEVICE	ACCELERATING OR DECELERATING DEVICE
19	STARTING-TO-RUNNING TRANSITION CONTACTOR OR RELAY	STARTING-TO-RUNNING TRANSITION CONTACTOR	STARTING-TO-RUNNING TRANSITION CONTACTOR
20	VALVE FOR AUXILIARY APPARTUS	ELECTRICALLY OPERATED VALVE	VALVE
21	VALVE FOR MAIN MACHINE	DISTANCE RELAY	DISTANCE RELAY
22	[RESERVED]	EQUALIZER CIRCUIT BREAKER	EQUALIZER CIRCUIT BREAKER
23	TEMPERATURE CONTROL DEVICE (RELAY)	TEMPERATURE CONTROL DEVICE	TEMPERATURE CONTROL DEVICE
24	TAP CHANGING MECHANISM	[RESERVED]	[RESERVED]

Function Number	JEM 1091 (2008)	IEEE C37.2 (1970)	BS-3939 (1970)
25	SYNCHRONIZING OR SYNCHRONISM-CHECK DEVICE	SYNCHRONIZING OR SYNCHRONISM-CHECK DEVICE	SYNCHRONIZING OR SYNCHRONISM-CHECK DEVICE
26	THERMAL RELAY FOR STATIONARY APPARATUS	APPARATUS THERMAL DEVICE	APPARATUS THERMAL DEVICE
27	AC UNDERVOLTAGE RELAY	UNDERVOLTAGE RELAY	UNDERVOLTAGE RELAY
28	ALARM DEVICE	FLAME DETECTOR	FLAME DETECTOR
29	FIRE EXTINGUISHER	ISOLATING CONTACTOR	ISOLATING CONTACTOR
30	ANNUNCIATOR	ANNUNCIATOR RELAY	ANNUNCIATOR RELAY
31	FIELD TRANSFORMER OF FIELD CHANGING BREAKER CONTACTOR OR RELAY	SEPARATE EXCITATION DEVICE	SEPARATE EXCITATION DEVICE
32	DC REVERSE CURRENT RELAY	DIRECTIONAL POWER RELAY	DIRECTIONAL POWER RELAY
33	POSITION SWITCH OR POSITION-DE-TECTING DEVICE	POSITION SWITCH	POSITION SWITCH
34	MOTOR OPERATED SEQUENCE SWITCH	MASTER SEQUENCE DEVICE	MASTER SEQUENCE DEVICE
35	BRUSH-OPERATING OR SLIP RING SHORT-CIRCUITING DEVICE	BRUSH-OPERATING OR SLIP RING SHORT-CIRCUITING DEVICE	BRUSH-OPERATING OR SLIP RING SHORT-CIRCUITING DEVICE
36	POLARITY RELAY	POLARITY OR POLARIZING VOLTAGE DEVICE	POLARITY OR POLARIZING VOLTAGE DEVICE
37	UNDERCURRENT RELAY	UNDERCURRENT OR UNDER POWER RELAY	UNDERCURRENT OR UNDER POWER RELAY
38	BEARING EXCESSIVE TEMPERATURE RELAY	BEARING PROTECTIVE DEVICE	BEARING PROTECTIVE DEVICE
39	[RESERVED]	MECHANICAL CONDITION MONITOR	MECHANICAL CONDITION MONITOR
40	FIELD CURRENT RELAY OR LOSS FIELD RELAY	FIELD RELAY	FIELD RELAY
41	FIELD CIRCUIT BREAKER CONTACTOR OR SWITCH	FIELD CIRCUIT BREAKER	FIELD CIRCUIT BREAKER
42	RUNNING CIRCUIT BREAKER CONTACTOR OR SWITCH	RUNNING CIRCUIT BREAKER	RUNNING CIRCUIT BREAKER
43	MANUAL TRANSFER OR SELECTOR SWITCH	MANUAL TRANSFER OR SELECTOR DEVICE	MANUAL TRANSFER OR SELECTOR DEVICE
44	DISTANCE RELAY	UNIT SEQUENCE STARTING RELAY	UNIT SEQUENCE STARTING RELAY

Function Number	JEM 1091 (2008)	IEEE C37.2 (1970)	BS-3939 (1970)
45	DC OVEROLTAGE RELAY	ATMOSPHERIC CONDITION MONITOR	ATMOSPHERIC CONDITION MONITOR
46	REVERSE-PHASE OR PHASE-BALANCE CURRENT RELAY	REVERSE-PHASE OR PHASE-BALANCE CURRENT RELAY	REVERSE-PHASE OR PHASE-BALANCE CURRENT RELAY
47	OPEN OR REVERSE PHASE VOLTAGE RELAY	PHASE-SEQUENCE VOLTAGE RELAY	PHASE-SEQUENCE VOLTAGE RELAY
48	INCOMPLETE SEQUENCE RELAY	INCOMPLETE SEQUENCE RELAY	INCOMPLETE SEQUENCE RELAY
49	THERMAL RELAY FOR ROTATING MACHINE	MACHINE OR TRANSFORMER THERMAL RELAY	MACHINE OR TRANSFORMER THERMAL RELAY
50	SHORT-CIRCUIT SELECTIVE RELAY OR GROUND SELECTIVE RELAY	INSTANTANEOUS OVERCURRENT OR RATE-OF-RISE RELAY	INSTANTANEOUS OVERCURRENT OR RATE-OF-RISE RELAY
51	AC OVERCURRENT RELAY OR GROUND OVERCURRENT RELAY	AC TIME OVERCURRENT RELAY	AC TIME OVERCURRENT RELAY
52	AC CIRCUIT BREAKER OR CONTACTOR	AC CIRCUIT BREAKER	AC CIRCUIT BREAKER
53	EXCITATION RELAY	EXCITER OR AC GENERATOR RELAY	EXCITER OR AC GENERATOR RELAY
54	HIGH-SPEED DC CIRCUIT BREAKER	[RESERVED]	[RESERVED]
55	AUTOMATIC POWER FACTOR REGULATOR OR POWER FACTOR RELAY	POWER FACTOR RELAY	POWER FACTOR RELAY
56	SLIP-RELAY OR OUT-OF-STEP RELAY	FIELD APPLICATION RELAY	FIELD APPLICATION RELAY
57	AUTOMATIC CURRENT REGULATOR OR CURRENT RELAY	SHORT-CIRCUITING OR GROUNDING DEVICE	SHORT-CIRCUITING OR GROUNDING DEVICE
58	[RESERVED]	RECTIFICATION FAILURE RELAY	RECTIFICATION FAILURE RELAY
59	AC OVERVOLTAGE RELAY	OVERVOLTAGE RELAY	OVERVOLTAGE RELAY
60	AUTOMATIC VOLTAGE BALANCE REGULATOR OR VOLTAGE BALANCE RELAY	VOLTAGE OR CURRENT BALANCE RELAY	VOLTAGE OR CURRENT BALANCE RELAY
61	AUTOMATIC CURRENT BALANCE REGULATOR OR CURRENT BALANCE RELAY	[RESERVED]	[RESERVED]

Function Number	JEM 1091 (2008)	IEEE C37.2 (1970)	BS-3939 (1970)
62	TIME-DELAY STOPPING OR STARTING RELAY	TIME-DELAY STOPPING OR STARTING RELAY	TIME-DELAY STOPPING OR STARTING RELAY
63	PRESSURE RELAY	PRESSURE SWITCH	LIQUID OR GAS PRESSURE OR VACUUM RELAY
64	GROUND OVERVOLTAGE RELAY	GROUND PROTECTIVE RELAY	EARTH-FAULT PROTECTIVE RELAY
65	GOVERNOR	GOVERNOR	GOVERNOR
66	NOTCHING OF FLASHING RELAY	NOTCHING OR JOGGING DEVICE	NOTCHING OR JOGGING DEVICE
67	AC POWER DIRECTIONAL OR AC GROUND DIRECTIONAL RELAY	AC DIRECTIONAL OVERCURRENT RELAY	AC DIRECTIONAL OVERCURRENT RELAY
68	IMPURITY-DETECTING RELAY	BLOCKING RELAY	BLOCKING RELAY
69	FLOW RELAY	PERMISSIVE CONTROL DEVICE	PERMISSIVE CONTROL DEVICE
70	ADJUSTING RHEOSTAT	RHEOSTAT	RHEOSTAT
71	RECTIFIER ELEMEMT PROTECTIVE RELAY OR DEVICE	LEVEL SWITCH	LIQUID OR GAS-LEVEL RELAY
72	DC CIRCUIT BREAKER OR CONTACTOR	DC CIRCUIT BREAKER	DC CIRCUIT BREAKER
73	LOAD RESISTOR CIRCUIT BREAKER OR CONTACTOR	LOAD-RESISTOR CONTACTOR	LOAD-RESISTOR CONTACTOR
74	REGULATING VALVE	ALARM RELAY	ALARM RELAY
75	BREAKING DEVICE	POSITION-CHANGING MECHANISM	POSITION-CHANGING MECHANISM
76	DC OVERCURRENT RELAY	DC OVERCURRENT RELAY	DC OVERCURRENT RELAY
77	LOAD REGULATING DEVICE	PULSE TRANSMITTER	PULSE TRANSMITTER
78	PHASE COMPARISON RELAY OF PILOT PROTECTION	PHASE-ANGLE MEASURING OR OUT-OF-STEP PROTECTIVE RELAY	PHASE-ANGLE MEASURING OR OUT-OF-STEP PROTECTIVE RELAY
79	AC RECLOSING RELAY	AC RECLOSING RELAY	AC RECLOSING RELAY
80	DC UNDERVOLTAGE RELAY	FLOW SWITCH	LIQUID OR GAS FLOW RELAY
81	SPEED GOVERNOR DRIVING DEVICE	FREQUENCY RELAY	FREQUENCY RELAY
82	DC RECLOSING RELAY	DC RECLOSING RELAY	DC RECLOSING RELAY
83	AUTOMATIC SELECTIVE CONTROL OR TRANSFER CONTACTOR OR RELAY	AUTOMATIC SELECTIVE CONTROL OR TRANSFER RELAY	AUTOMATIC SELECTIVE CONTROL OR TRANSFER RELAY

Function Number	JEM 1091 (2008)	IEEE C37.2 (1970)	BS-3939 (1970)
84	VOLTAGE RELAY	OPERATING MECHANISM	OPERATING
85	SIGNAL RELAY	CARRIER OR PILOT-WIRE RECEIVER RELAY	CARRIER OR PILOT-WIRE RECEIVER RELAY
86	LOCKING-OUT RELAY	LOCKING-OUT RELAY	LOCKING-OUT RELAY
87	DIFFERENTIAL CURRENT RELAY	DIFFERENTIAL PROTECTIVE RELAY	DIFFERENTIAL PROTECTIVE RELAY
88	AUXILIARY CONTACTOR OR SWITCH	AUXILIARY MOTOR OR MOTOR GENERATOR	AUXILIARY MOTOR OR MOTOR GENERATOR
89	LINE SWITCH (DISCONNECTING SWITCH)	LINE SWITCH (DISCONNECTING SWITCH)	LINE SWITCH (DISCONNECTING SWITCH)
90	AUTOMATIC VOLTAGE REGULATOR OR REGULATING RELAY	REGULATING DEVICE	REGULATING DEVICE
91	AUTOMATIC POWER REGULATOR OR POWER RELAY	VOLTAGE DIRECTIONAL RELAY	VOLTAGE DIRECTIONAL RELAY
92	DOOR	VOLTAGE AND POWER DIRECTIONAL RELAY	VOLTAGE AND POWER DIRECTIONAL RELAY
93	[RESERVED]	FIELD-CHANGING CONTACTOR	FIELD-CHANGING CONTACTOR
94	TRIP-FREE RELAY	TRIPPING OR TRIP-FREE RELAY	TRIPPING OR TRIP-FREE RELAY
95	AUTOMATIC FREQUENCY REGULATOR OR FREQUENCY RELAY	USED ONLY FOR SPECIFIC APPLICATIONS	USED ONLY FOR SPECIFIC APPLICATIONS
96	INTERNAL FAULT DETECTING DEVICE FOR STATIONARY APPARATUS	Some as above	Some as above
97	RUNNER	Some as above	Some as above
98	CONNECTING DEVICE	Some as above	Some as above
99	AUTOMATIC RECORDING DEVICE	Some as above	Some as above

(3) Objective of numbering system

The objective of numbering system is to identify equipment, installation location and purpose of use.

Sample cable number is shown as follows;.

<Sample cable number : G21M11>

Cable No.	G	21	M	1	1
Item	Classification of sequence diagram symbol	Page of the sequence diagram	Circuit type symbol (Note 1)	Cable circuit number	Unit number

*Note 1 : Circuit type symbol

CT circuit	C
PT circuit	V
Motor circuit	M
Shield for instrumentation and control circuit	Z
Other special circuit compensating lead wire	H
AC circuit other than the above	A
DC circuit other than the above	D

Article 21. Record and Indication of parameter for operation

1. The measured data is displayed in the control panel or CRT (Cathode Ray Tube), in general. Measurement items specified in the Technical Regulation Vol.2 or others must be displayed in the control panel or CRT.
2. In principle, the measured data is recommended to be saved during the required period, because the data is useful for the maintenance and inspection. In many cases, data is saved as electronic data because of easiness for searching and saving. However, period of data storage is limited by the memory capacity; therefore, it is desirable to consider the sampling period in order to save the data during the required period.
3. The data on laws or security (items specified in the technical regulation Vol2 or others) is required to be stored during the existence of facility or organization.

   In this case, data is stored by documents such as the chart recorder and reports of operation and security, in general.

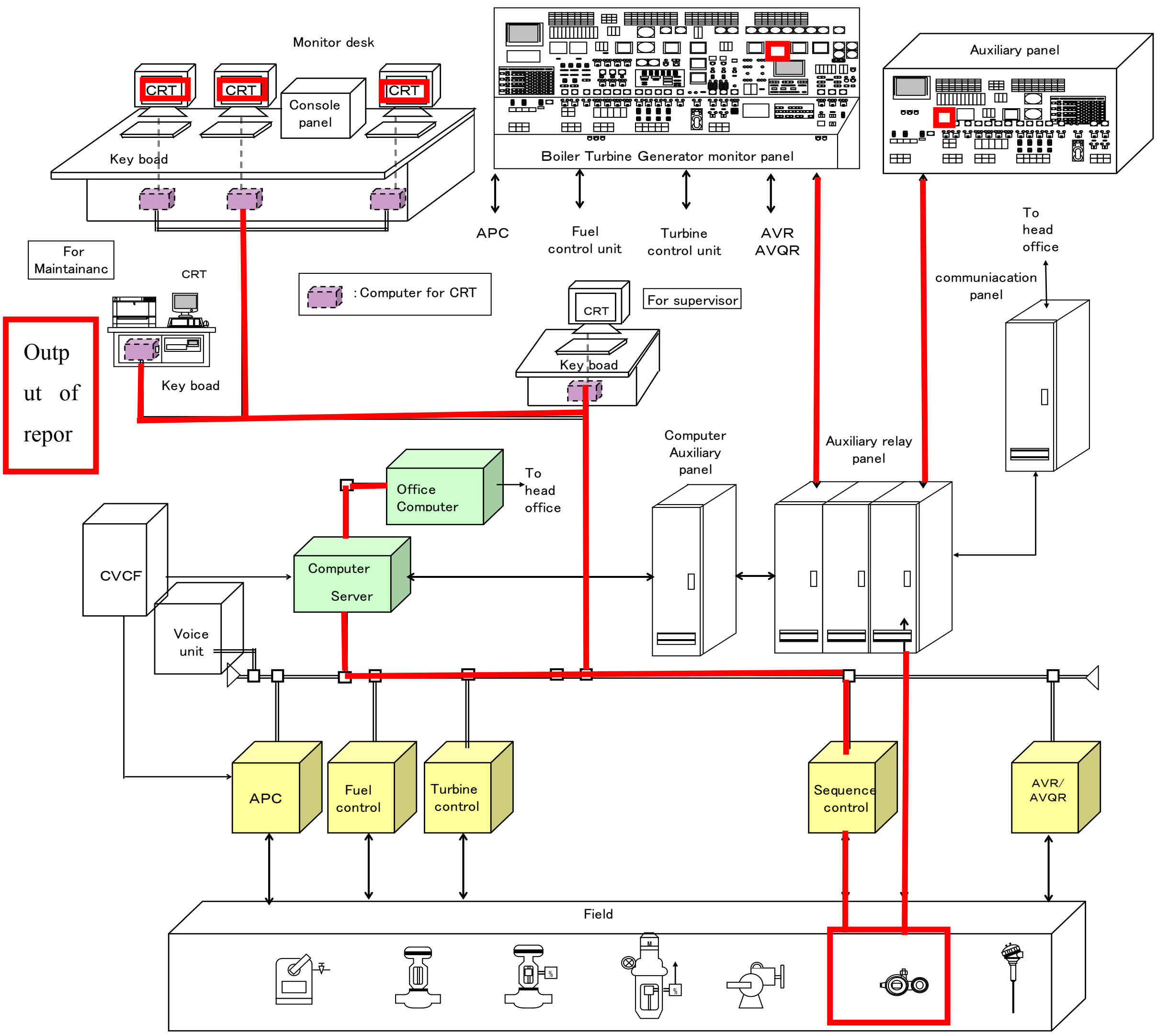


Figure 21-1 Sample of record and indication of parameter for operation

Sample of Record and indication Parameter for Operation

The recording and indication of parameter for operation must be designed for the following data with audible device, if any;

(1) Status signals,

e.g. - Generator circuit breaker (close / open),

- Circuit breaker (close / open),
- Disconnectors (close / open),
- Earthing switches (close / open),
- Position of tap changers for transformer.

(2) Measuring signals,

e.g. - Busbar frequency (Hz),

- Voltage in switchyard and each transmission lines (kV),
- Active and reactive power of each generator (MW / MVar),

- Active and reactive power of the entire power plant (MW / MVar),
- Active and reactive power of each transformer (MW / MVar),
- Active and reactive power of each transmission lines (MW / MVar),
- Current on both side of step-up transformer (A)
- Current on transmission lines (A)

(3) Measurement data,

e.g. - Active and reactive progressive power energy of each unit and the entire plant (kWh / kVarh),

- Active and reactive progressive power energy transmitted on transmission lines (kWh / kVarh),

(4) Control data,

e.g. - Circuit breaker (close / open),

- Disconnector (close / open),
- Generator active & reactive power (increase / decrease / Set point),
- Auxiliary equipment (start / stop

(5) Other important alarms and events as required for the Dispatch Center and approved by National Load Dispatching Center.

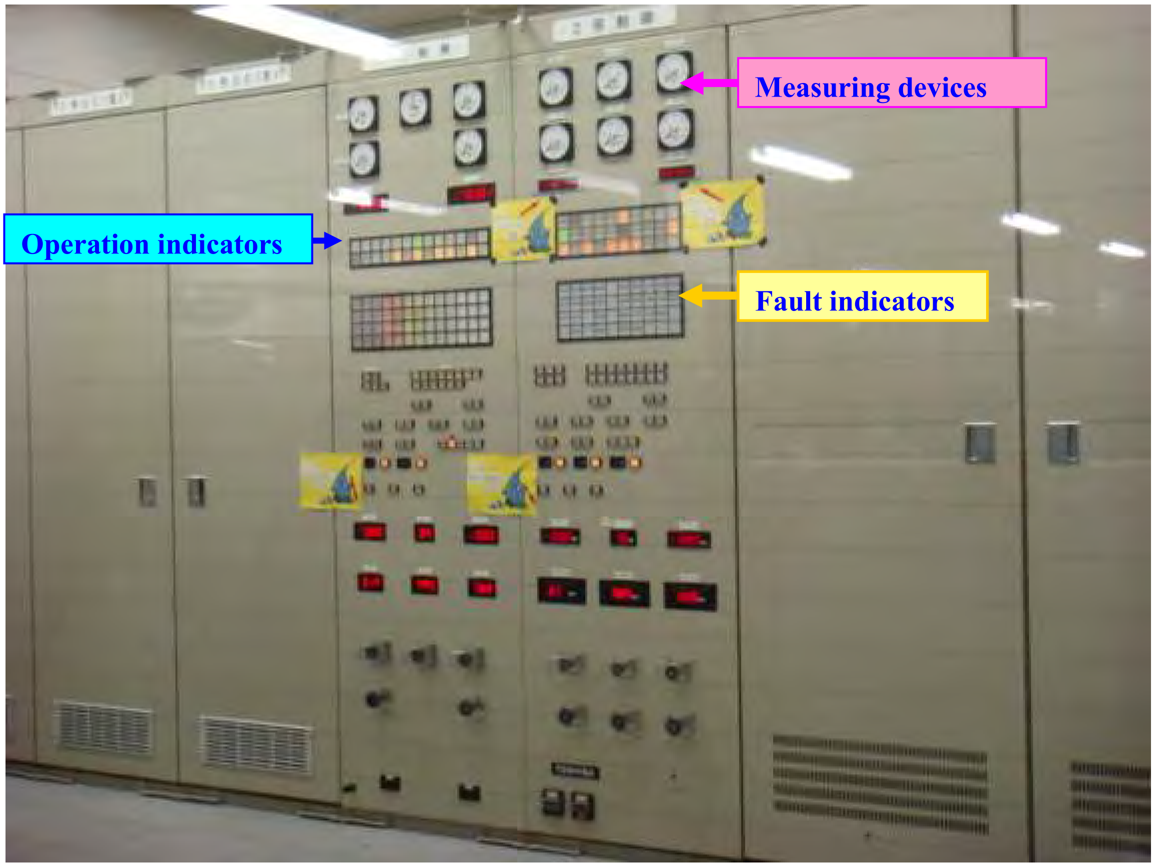


Figure 21-2 Indication of Parameter for Control Boards
(Fault indicator: 30F and Operation indicator: 30S)

(Reference Technical Specification of Control system in Son La HPP)

(Record and indication Parameter only)

- Event Processing

System events are changes-of-state or value that do not require immediate operator acknowledgement, but must be recorded as significant system events or alterations.

These events must cover:

- Operator commands;
- State/condition change of power plant facilities;
- Status changes in the electrical network.

Event messages must be logged in order of occurrence on the event printer.

The event message format must be a single line format similar to the alarm message format. The event message must be presented in a color defined through software maintenance procedures. The default colors must be white.

- Sequence – of – Event Processing

The Distributed Control System (DSC) must collect Sequence-of-Events (SOE) data for certain inputs mainly related to the protection and electrical systems. The SOE data must be time-oriented listing of status change events collected from PLCs. The time difference between events must be resolved within 1.0 millisecond.

The SOE data must be stored in a single contiguous SOE data buffer sized to store 1000 events. Data must be inserted into the buffer in chronological order, re-ordering the buffer when necessary to incorporate data received from other Programmable Logic Controller (PLC)s or RTUs. It must be possible for the system operators to view the contents of the SOE data buffer using a display. The contents of buffer must be logged once each day; when the SOE buffer is approaching capacity; or on demand by the system operator. The display and log must include the database description name, device state, and the date and time (to the nearest millisecond) of each event.

All protection flags, circuit breaker closed contacts and trips, etc, must be configured to be reported in the SOE list.

- Protection Relay Management and Monitoring System

A management and monitoring system for protection relays must be equipped for frequent monitoring of status, management of index setting, analysis of equipment fault, etc. The system must include a management computer, connection devices and other necessary accessories.

System will be designed to ensure that it can get information from all protection equipment about their current status, even when out of operation, about analog and digital values, about changes of operated values of protections, synchronizing private protections with fault-recorder at the plant and remote changing values of protections according to operation mode of the plant. Analysis of fault-process graph wave, analysis of operation situation, time synchronizing all of protection equipment must be carried out by correlative software and checking system by monitor will be carried out by interface port in order to acquire time synchronizing signal.

The system must be able to record all events even when having a violation in working which will be announced to operator.

All data must be collected, preliminarily processed then shown in statistical form, graphs and stored to memory.

Functions of system must be as follow:

- Time synchronizing for all equipment;
- Ensure to change defined values of protection remotely;
- Organize failure analysis;
- Record and process signals, parameters correlative with events and analyze measured data;
- Ensure to show status of plant and measured data;
- Switching, testing and checking of simple functions of protective and logic circuits.

Article 22. Installation of equipment for record

1. Dispatching center

The cases when recorders are required are as follows.

Table 22-1 Outline of control and observation method of load dispatch center system

Function	Item	Remarks
Supervisory	- Status of electrical equipment (such as circuit breaker ON/OFF, generator, etc.) - Power system (national grid) - Power plant (such as hydropower plant and thermal power plant) - Reservoir water level and river flow - Meteorological phenomenon - Electrical fault - Operating condition of electrical equipment	
Control (operation)	- Manual operation - Automatic operation	- Generator of hydropower plant - Switchgear of transmission line and distribution line - Protective relay - Load regulator - Voltage regulator, power factor regulator - Switching of telemetering equipment - Automatic frequency controller - Alarm system of discharge from reservoir

Function	Item	Remarks
Record	- Status of electrical equipment (such as circuit breaker, generator, etc.) - Power flow - Load dispatching - Operation of electrical equipment	Including operation record of this system
Transmission of information	- Operating condition of electrical equipment - Electrical fault - Meteorological phenomenon	
This system management	- Operation of system - Operation of auxiliary equipment of system - Record of this system trouble - Management of record of various load dispatching data - Management of data transmission of system	

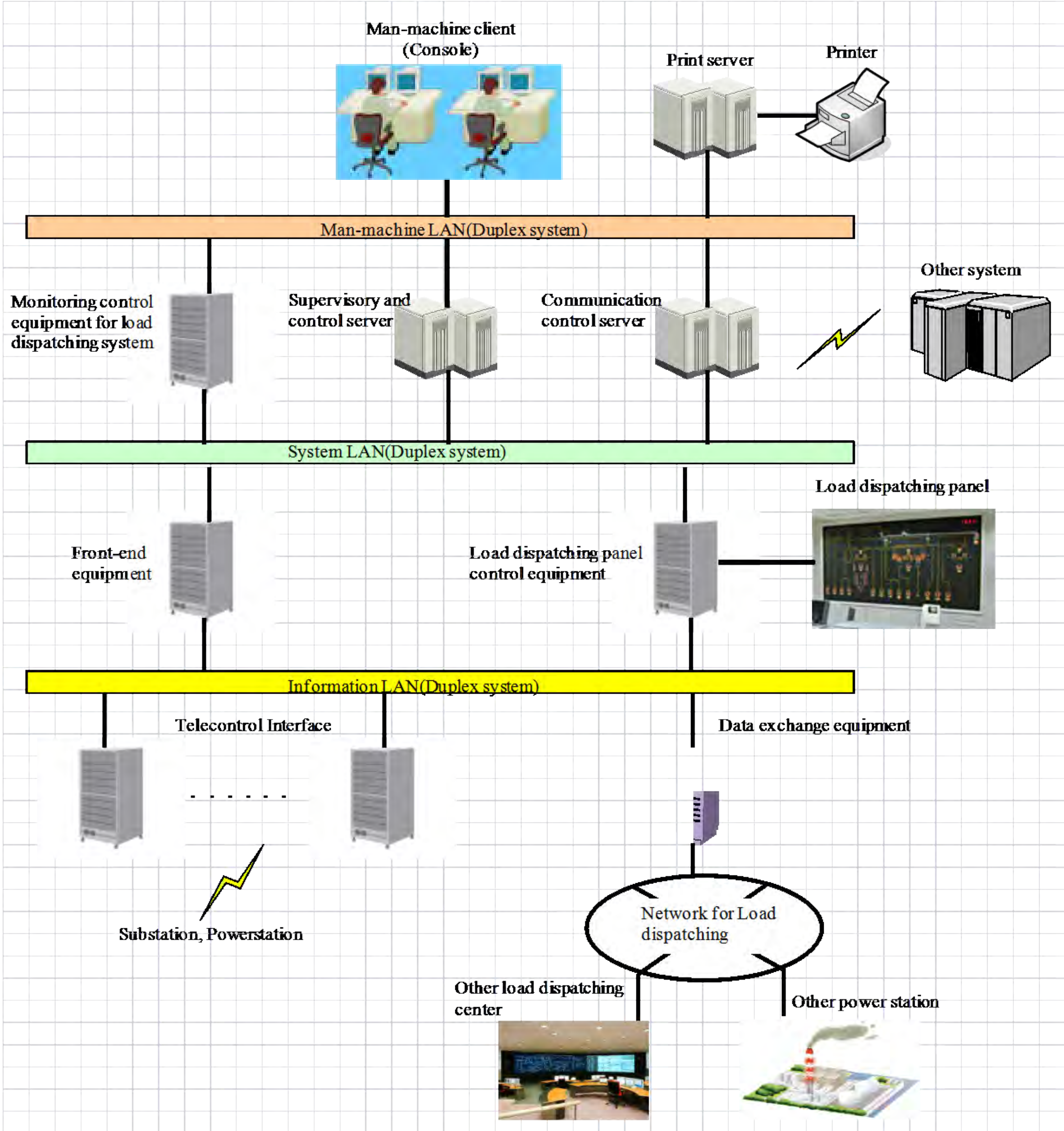


Figure 22-1 System configuration example of Load dispatch center

2. Hydropower plant

The cases when recorders are required are as follows.

(1) This configuration diagram show a general principal diagram for the control, supervision and protection system which is installed a central control room of the hydropower plant. (for example)

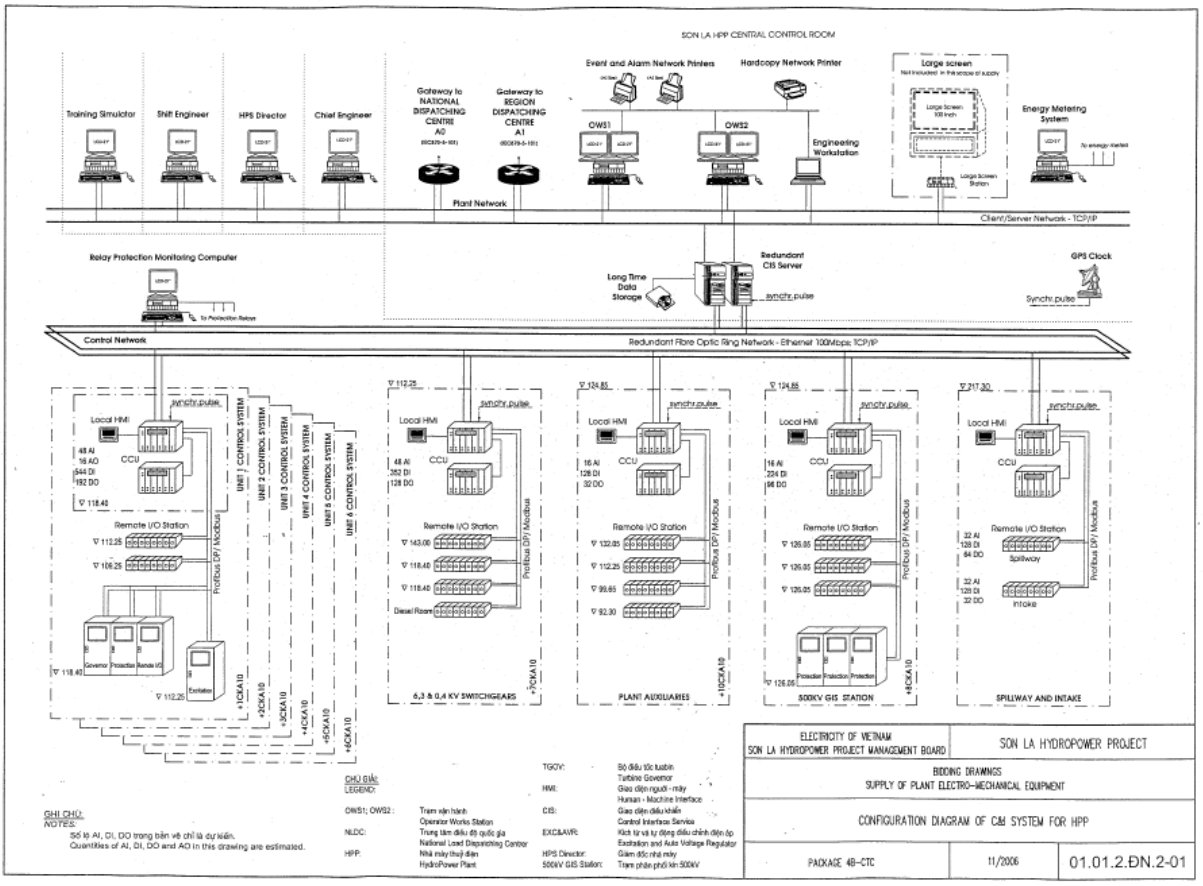


Figure 22-2 Example of installation of equipment with a record (Hydropower plant 1/3)

(2) This figure show an event and alarm of networks and hardcopy of network printers mentioned above on Figure 22-1 (Hydropower plant 1/3).

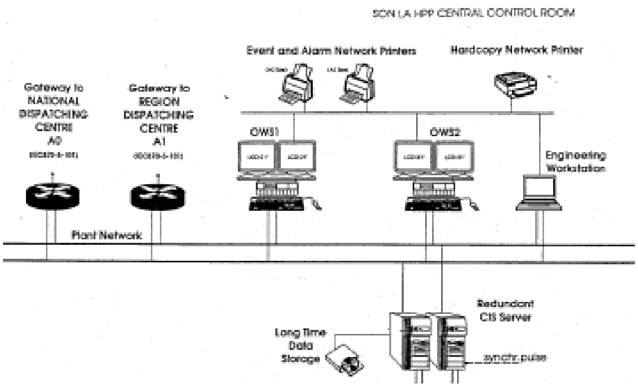


Figure 22-3 Example of installation of equipment for record (Printer) (Hydropower plant 2/3)

(3) This figure shows an on-line monitoring system for unit configuration diagram.

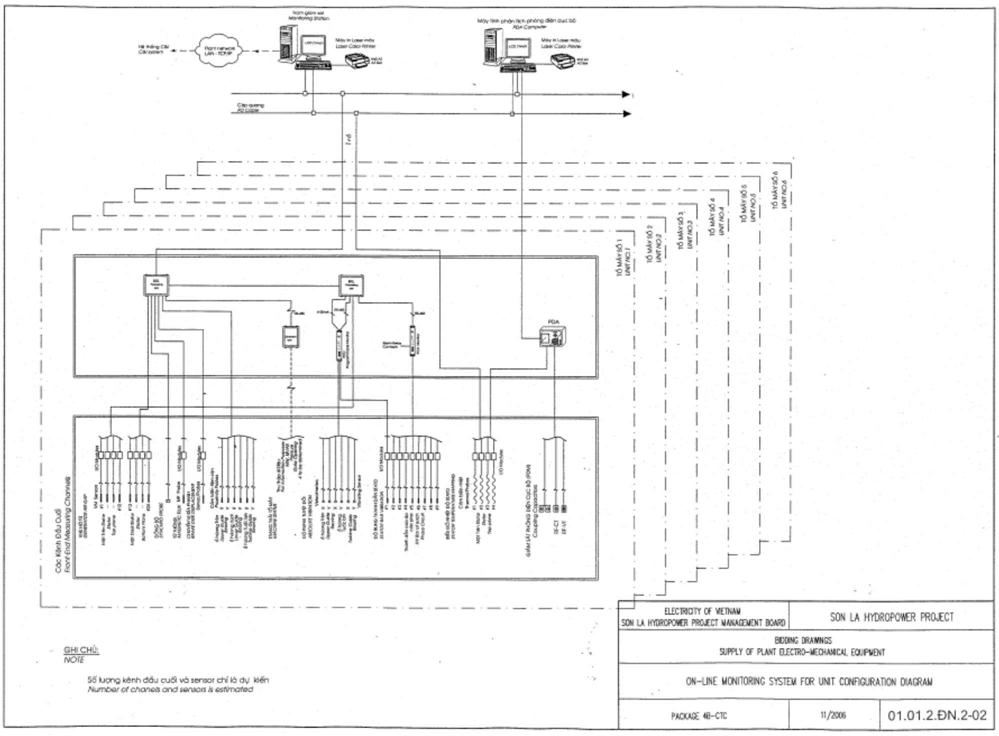


Figure 22-4 Example of installation of equipment for record (Monitoring system) (Hydropower plant 3/3)

3. Thermal Power Plant

The cases when recorders are required are as follows.

(1) Items required by law（QCVN22/2009）

NOX and SO_2（However, dust recorders are not equipped because of accuracy and traceability.）

(2) Items require on security

Items specified in the technical regulation Vol.2（electronic data may be possible ,however, measures to be taken can not be tampered with)

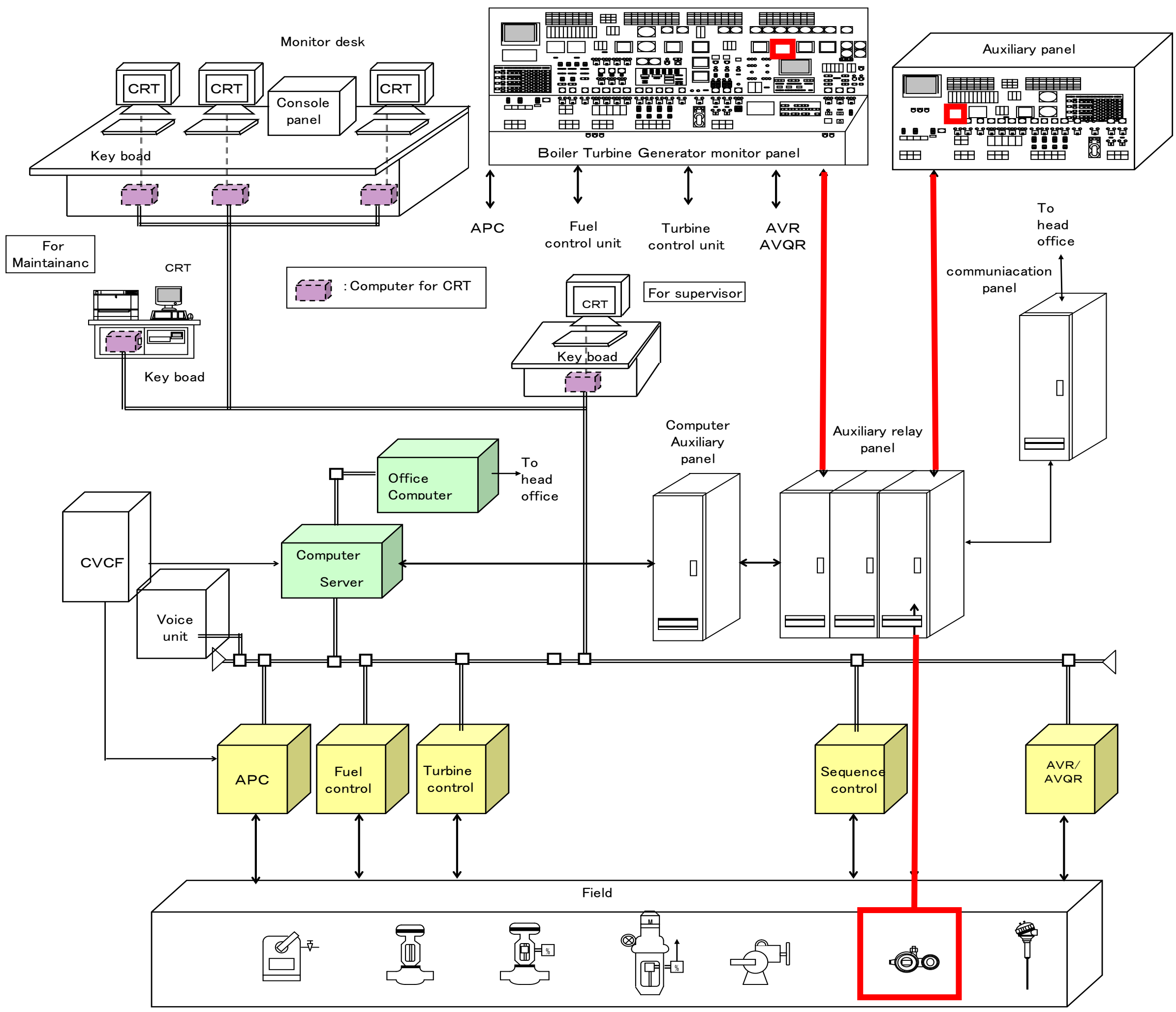


Figure 22-5 Example of installation of equipment for record (Thermal Power Plant)

Chapter 5 Safety Technology

Article 23. Compliance of safety standards

1. Codes and standards (Reference)

(1) The Safety Plates for electrical components must be in compliance with the following codes and standards in the World:

1) ISO 3864: Safety Colors and Safety Signs

2) DIN 4844: Safety Marking

3) DIN 40008: Safety Plates

4) SAE J115 (USA): Safety Signs for Construction and Industrial Equipment

(2) Applicable local regulatory authority's requirements are as follows

1) Decree No.110/2002/NĐ-CP ngày 27/12/2002 For revise, supplying some articles in Decree No.06/NDD-CP dated on January 20, 1995 of Govement regulation detailed articles of Labour law relating to safety labour and industrial hygiene.

2) Decree No. 113/2004/NĐ-CP dated on April 16, 2004 Regulations on deal with violations against Labour law
3) Decree No. 169/2003/NĐ-CP dated on December 24, 2003 Geverment decree for Electrical safety
4) Decree No. 195/CP dated on December 31st, 1994 Government Decree "Decree on detailed regulations and guidelines on implementation of the Labour Law" about working time and rest time.
5) Decree No. 106 /2005/NĐ-CP "Decree on detailed regulations and guidelines on implementation of the Electricity Law" about safeguards of high voltage works.
6) Decision No. 41/2001/QĐ-BCN dated on August 30th ,2001 Decision of Minister of Ministry of Industry about safety of rural electricity network
7) Decision No. 2013/2005/QĐ-BLĐTBXH dated on December 29th, 2005 Regulations on safety technical verification procedure of machine, equipment

(3) Relevant safety regulations and standards are shown as follows in Vietnam;

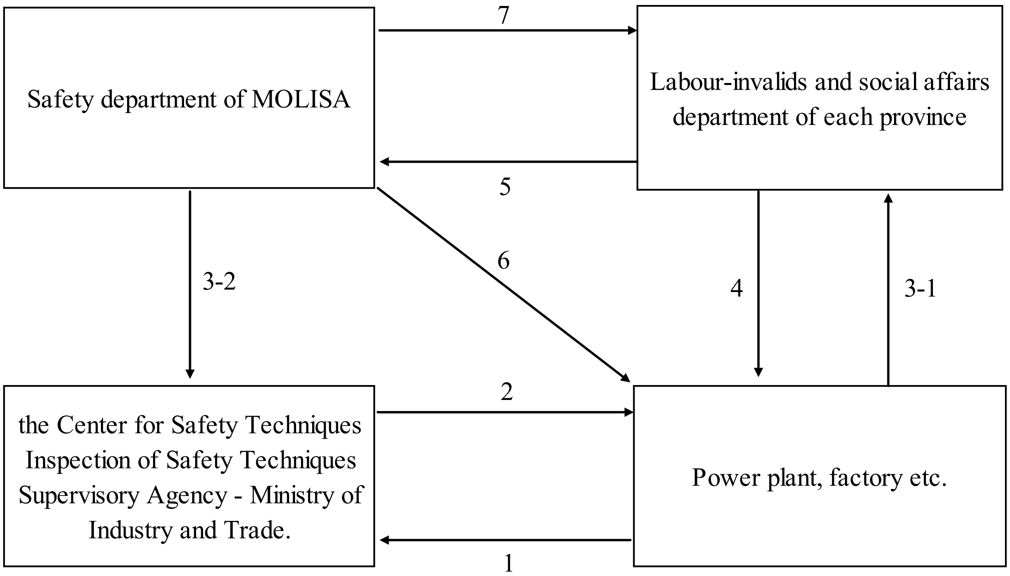
Number	Issued	Title
QCVN 01	2008	National technical regulation on safety work of steam boiler and pressure part
TCVN 3148	1979	Conveyors. General safety requirements
TCVN 6155	1996	Pressure vessels. Safety engineering requirements of erection, use, repair
TCVN 6156	1996	Pressure vessels. Safety engineering requirements of erection, use, repair. Testing method
TCVN 7915-1	2009	Safety devices for protection against excessive pressure. Part-1: Safety valve
TCVN 7915-2	2009	Safety devices for protection against excessive pressure. Part-2: Bursting disc safety devices
TCVN 7915-3	2009	Safety devices for protection against excessive pressure. Part-3: Safety valves and bursting disc safety devices in combination
TCVN 7915-4	2009	Safety devices for protection against excessive pressure. Part-4: Pilot operating safety valve
TCVN 7915-5	2009	Safety devices for protection against excessive pressure. Part-5: Controlled safety pressure relief systems (CSPRS)
TCVN 7915-6	2009	Safety devices for protection against excessive pressure. Part-6: Application, selection and installation of bursting disc safety devices
TCVN 7915-7	2009	Safety devices for protection against excessive pressure. Part-7: Common data

Article 24. Registration of boiler, pressure tank and crane

The following regulations and standards must be referred to regarding this matter.

- Boiler : QCVN 01 (2008) /BLĐTBXH Article 6.1 to Article 6.6
  TCVN 7704 (2007) Article 11.1 to Article 11.5.
- Pressure vessel : TCVN 6156 (1996) Article 3.1 to Article 3.17
- Pressure pipe : TCVN 6159 (1996)
- Crane : TCVN 4244 (2005) Article 4.1to Article 4.3

These regulations and standards stipulate requirements of examination, inspection and testing methods relate to the boiler, pressure vessel, steam and hot water pipes and crane. These devices must be registered and examined in accordance with State regulations. Above equipments are usually examined and inspected by the Center for Safety Techniques Inspection of Safety Techniques Supervisory Agency - Ministry of Industry and Trade. Process flow of registration of boiler and pressure vessel is shown as follows ;



1 : Application for safety investigation

2 : Safety investigation

3-1 : Application for usage

3-2 : Confirmation of result of 2 (safety investigation) when it is rejectable.

4 : Investigation and issuance of certificate

5 : Report of investigation result

6 : Investigation (if necessary)

7 : Confirmation of report (if necessary)

Figure 24-1 Process flow of registration of boiler and pressure vessel

Article 25. Inspection of safety protection system

1. There are safeguards for the entire area of a power plant and for each facility of power plant.
   (1) There are the safeguard for the entire area of power plant, e.g. the automatic surveillance cameras furnished over the entire power plant area, surveillance by infrared rays, a speaker, locking device for entrance, lighting system, etc.

(2) There are safeguards for the facility of power plant, e.g. an interlock system in the sequence diagram and mechanical lock system internally equipped in some power plant facilities, lock system of control board, power supply board, cubicle, and panel, etc., by key or padlock, and a protection system by the control sequence which includes a protection relay.

The lock systems are applied to the power plant facilities related to security of operation such as master control switch for unit operation, switchgear of circuit breaker (CB), disconnecting switch (DS), earthing switch (ES), servomotor of wicket gate, entrance door, CO2 cylinder, control valve for piping, etc.,

2. List of relevant existing regulations

1) Cicular No. 01/2011/TTLT BLDTBXH-BYT Guide to carry out safety and labor hygiene in production unit dated on January 10^{th} 2011 of Ministry of Health and MOLISA.

2) Cicular No. 37/2005/TT-BLĐTBXH-BYT Guide to training on safety and labor hygiene dated on December 29th 2005.

3. Object apparatus (In case of Hydropower station)

1) Intake gate, tailrace gate, outlet gate, dam high-pressure drainage gate (If any)
2) Inlet valve of turbine (if any)
3) Servomotor of turbine wicket gate
4) Switchgear
5) Transformer
6) Fire extinguishing system
7) Emergency power supply unit and uninterruptible control power source unit
8) Power supply unit for emergency lighting
9) Ventilation equipment
10) Control and protective device: Protection of power plant (refer to Article 95)

4. Reference Technical Specification of Step-up Transformer in Son La HPP

Locking Facilities on the access doors

Locking facilities must be provided on the access doors to marshalling operating and terminal boxes or cabinets and cubicles.

All locks and padlocks must be of brass and where fitted to access doors, are to be chromium plated. Where a set of locks is provided under any particular section of plant of apparatus, an additional group master key must be provided

Locks must be designed, constructed and located on the equipment so that they will remain serviceable under the specified climatic conditions, without operation or maintenance for continuous periods of two years and with suitable maintenance must be fit for indefinite service.

The padlocks and keys are to be engraved with suitable identifying code or inscription.

5. Reference Technical Specification of Cameras system in Son La HPP

The camera supervising system is installed on each floor and outside of some locations and the main component are cameras, recorder, central control unit, computer, CRT monitor, etc.,

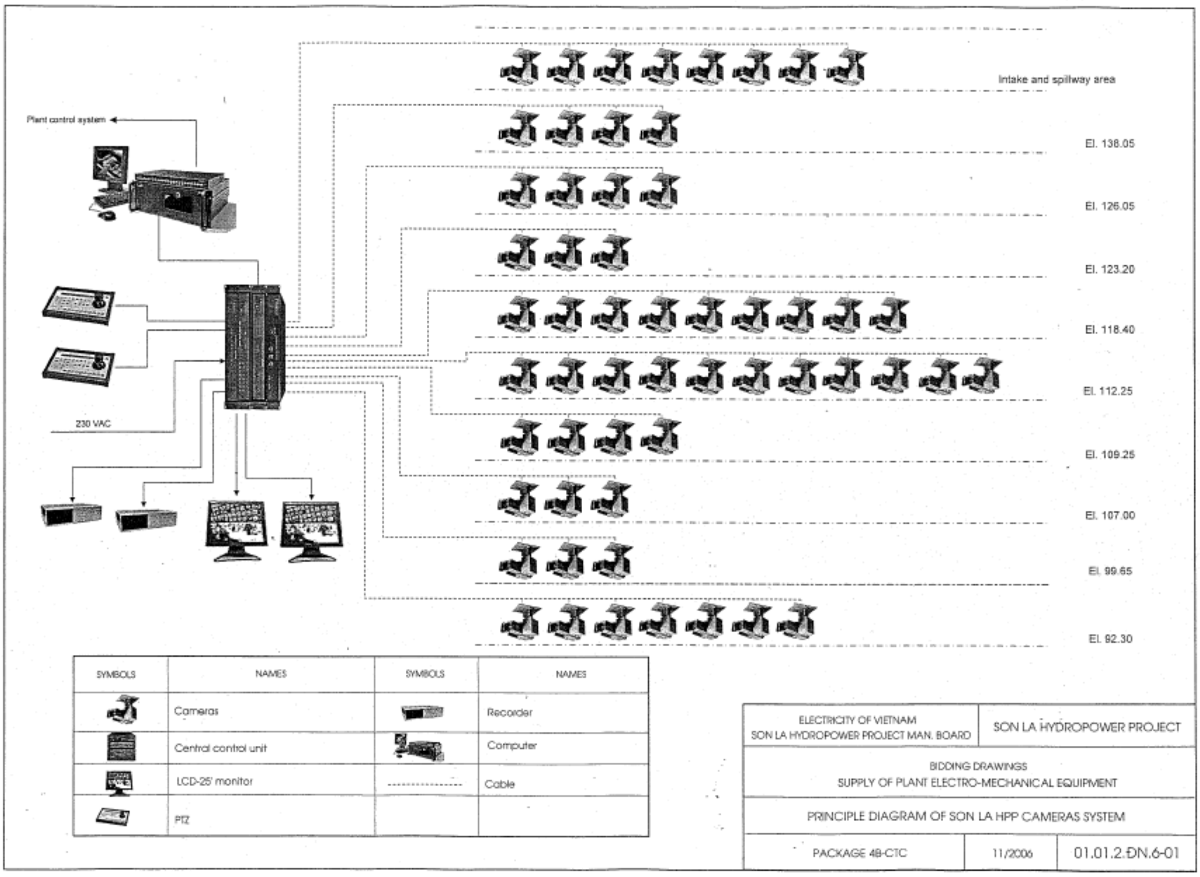


Figure 25-1 Example of installation of equipment for Cameras system

Article 26. Responsibility for safety and hygiene

1. Responsibility of indirect staffs for safety and hygiene

Article 29 "General regulations on safety for electrical equipment and electricity works" of Decree No.: 105/2005/ND-CP "Decree on detailed regulations and guidelines on implementation of the electricity Law" (August 17, 2005) stipulate as follows:

1. Electrical equipment design and manufacture, electricity works construction must conform to the sectoral standards, Vietnamese standards or proper international standards which accepted by Vietnamese competent bodies, and must ensure the requirements on the safety as follows:

a) Electric safety;

b) Construction safety;

c) Safety on consuming primary energy resources (water, coal, petroleum, natural gas and other energy types)

d) Safety on firefighting- and explosion-fighting

e) Ecological safety, industrial safety and hygiene.

In the above connection, indirect staffs who are related to realization of labor safety technical standards and hygiene must be responsible for execution of necessary measures to *prevent occupational accidents and infection in relation to items a) to e) of the above except item b).*

2. *Bearing appropriate responsibility by indirect staffs in charge of safety and hygiene*
   Method of bearing responsibility in case of violating occupational safe and hygienic regulations must be depending on actual cases and must refer to civil law or criminal code in Vietnam.

Article 27. Investigation and report of accident

Occupational incident and accident means any incident or accident occurred on the facilities or workers in a power plant or a network facility during operation, maintenance and any occupational activities except.

Each case of accident or breakdown in equipment operation must be investigated thoroughly and counted in statistics according to "investigation procedure" and "problem and abnormal phenomena listing procedure" of Ministry of Industry and Trade. When investigating, it is required to define the causes of accident and abnormal phenomena, and suggest timely prevention and remedy measures.

When an accident or incident occurred in an unit of power industry, responsible parson must investigate the accident and prepare and send the accident report to Ministry of Industry and Trade and other authorities relevant to the power system operation or Ministry of Labor, War Invalids, & Social Welfare.

The accident report must describe the following information.

1. Report to Ministry of Industry and Trade

   All accidents or incidents must be reported with the following information.

   1) Name of power plant or network facility (e.g. AAA power plant, BBB substation)
   2) Date and time of accident occurrence
   3) Accident status information (detailed description of accident)
   4) Cause of accident (tentative for initial report and investigation result for final report)
   5) Effect to power supply (expected duration or record of power outage and its area)
   6) Measures for solution on effect of accident
   7) Measures for preventing similar accident
   8) Other necessary information

2. Report to other authorities relevant to the power system operation

   Industrial accident which effected power supply must be reported with the following information.

   1) Name of power plant or network facility (e.g. AAA power plant, BBB substation)
   2) Date and time of accident occurrence
   3) Accident status information (brief or detailed description of accident depending on type of accident)
   4) Cause of accident (tentative for initial report and investigation result for final report)
   5) Effect to power supply (expected duration or record of power outage and its area)

6) Measures for solution on effect of accident
7) Measures for preventing similar accident
8) Other necessary information

3. Report to Ministry of Labor, War Invalids, & Social Welfare

   All human accident which caused injury or death of worker must be reported with the following information.

   1) Name of power plant or network facility (e.g. AAA power plant, BBB substation)
   2) Date and time of accident occurrence
   3) Accident status information (detailed description of accident)
   4) Cause of accident (tentative for initial report and investigation result for final report)
   5) Measures for solution on effect of accident
   6) Measures for preventing similar accident
   7) Other necessary information

Article 28. Training of first-aid measure

All personnel who work in installation and repair of power plants and network facilities must be trained with first-aid measures for people who received an electric shock.

It is recommended to organize the training for all the personnel once a year together with other trainings for emergency cases.

- Sample of first-aid measures for people who received an electric shock is shown as follows ;
- Power supply must be shut off or breaker must be turned off .
- Electric cable must be cleared off by using rubber glove etc.
- Breathing and consciousness must be confirmed and an ambulance must be called.
- Cardiopulmonary resuscitation must be conducted in case of cardiopulmonary arrest.

Article 29. Preparation of first-aid dressings

First-aid dressings must be prepared in each workshop, substations, and maintenance offices whose work may involve dangerous and noxious places.

In addition, it is recommended to provide any workers at outdoor working places such as transmission lines with portable first-aid dressings.

Sample of first-aid dressings is shown as follows;

- Automated External Defibrillator
- Disinfectant
- Gauze
- Bandage
- Triangular bandage
- Adhesive tape

- Blood stanching band
- Scissors etc.

Article 30. Outfit for electrical work

All staff must wear pertinent appliances and coveralls when they are in work. The work means those in indoor and outdoor work and maintenance work of substations, work in power plants and in manholes and the like.

In the above regard, any companies or agencies which are in the electric power industry must provide their workers with pertinent appliances and coveralls.

In order to prevent ignition of fuel by static electricity, an outfit for electrical work is required to be anti-electrostatic.

Chapter 6 Fire Prevention Equipment

Article 31. Fire prevention responsibilities in electrical facilities

Layout of power plants and network facilities must fully consider safety in fire prevention.

In the above regard, reference must be made to Article 15 and Article 24 of Law No: 27/2001/QH10 “Law on Fire Prevention and Fighting” dated 29 June 2001:

Article 15.- Designs on fire prevention and fighting, examination and approval thereof

1. *When elaborating planning or projects on the construction or renovation of urban centers, population quarters, exclusive economic zones, industrial parks, export processing zones or hi-tech parks, it is necessary to map out solutions to and designs on fire prevention and fighting, ensuring the following contents:*

   a/ The construction location, arrangement of quarters and blocks;

   b/ The traffic and water supply system;

   c/ The rational arrangement of locations for fire prevention and fighting units at necessary places;

   d/ The estimated funding for fire prevention and fighting project items.

2. *When elaborating projects and designs for construction or renovation of works or change of their use purposes, it is necessary to work out solutions to and designs on fire prevention and fighting, ensuring the following contents:*

   a/ The construction location, safe distances;

   b/ The system of emergency exits;

   c/ The technical system for fire prevention and fighting safety;

   d/ Other requirements on fire prevention and fighting;

   e/ The estimated funding for fire prevention and fighting project items.

3. *Projects and designs prescribed in Clauses 1 and 2 of this Article must be examined and approved in terms of fire prevention and fighting.*

4. *The Government shall prescribe lists of projects that require fire prevention and fighting designs, the design examination and approval as well as the time limit therefor.*

Article 24.- Fire prevention in the production, supply and use of electricity as well as electric equipment and instruments

1. *Power plants, transformer stations and electricity distribution stations must work out measures to take initiative in handling fire incidents.*
2. *When designing, building and installing electric system and equipment, it is necessary to ensure safety standards for fire prevention and fighting.*
3. *Electric equipment and instruments used in the environments facing fire or explosion danger must be those ensuring safety against fire and explosion.*
4. *The electricity-supplying agencies, organizations and individuals shall have to guide measures to ensure fire prevention and fighting safety for electricity consumers.*

The responsible person who bears overall responsibility in safety in fire prevention and fire fighting must be assigned at each unit.

In the above regards, reference shall be made to Article 37 of Law No: 27/2001/QH10 "Law on Fire Prevention and Fighting" dated 29 June 2001:

Article 37.- Fire-fighting commander

1. *In all cases, the persons holding the highest positions in units of the fire prevention and fighting police units, who are present at the fires, shall be the fire-fighting commanders.*

The assigned person must be responsible for arrangement of implementing measures on fire prevention, check of abidance in fire prevention system, availability of automatic fire alarming system and firefighting equipment and methods, and arrangement of practicing firefighting.

Foreman of workshops, head of electricity subsidiaries, substations, technical division, testing division and warehouse are responsible for safety against fire of their own housing and equipment. Initial fire distinguishing facilities must be secured at sufficient and good condition.

Article 32. Implementation of firefighting training

By setting up plans for installing fire prevention equipment and implementing them, relevant regulations on fire prevention must be observed.

Firefighting practice must be organized periodically as regulations.

In the above regards, reference shall be made to Article 46 of Law No: 27/2001/QH10 "Law on Fire Prevention and Fighting" dated 29 June 2001:

Article 46.- Drilling, fostering, directing, inspecting, professionally guiding and mobilizing civil defense force and grassroots fire prevention and fighting force, and the regimes and policies therefore;

1. *The civil defense and grassroots fire prevention and fighting forces shall be drilled and professionally fostered; subject to the direction, inspection and professional guidance by the*

fire prevention and fighting police; and subject to the mobilization by the competent authorities for participation in fire prevention and fighting activities.

2. *The civil defense and grassroots fire prevention and fighting forces shall enjoy regimes and policies during the time of professional drilling and fostering and when directly participating in fire fighting according to the Government's regulations.*

Article 33. Installation of fire prevention equipment

Installation and improvement must be carried out based on the installation plan of fire prevention equipment approved by the relevant authorities.

The fire prevention equipment must be well maintained and be easily recognized. It must be checked periodically or replaced as required.

If automatic firefighting equipment is installed, it must conform to relevant regulations.

In the above regards, reference shall be made to Article 14 of Law No: 27/2001/QH10 "Law on Fire Prevention and Fighting" dated 29 June 2001:

Article 14.- Basic measures for fire prevention

1. *Strictly managing and safely using inflammables, explosives, flame and heat sources, flame- and/or heat-generating equipment and devices as well as substances; meeting fire prevention safety conditions.*
2. *Conducting regular and periodical inspection to detect loopholes and shortcomings in fire prevention and fighting so as to take timely remedies.*

(Reference Technical Specification of Fire Prevention Equipment in Son La HPP)

1. Main component of fire alarm system installed in Son La HPP are as follows;
   - Fire alarm center control unit, fire alarm system control computer, emergency sign lights power supplier with some emergency sign lights, fire alarm sounder amplifier with some electric sounders, ionization smoke detector, photoelectric smoke detector, rate of rise heat detector, manual coll points, etc.,

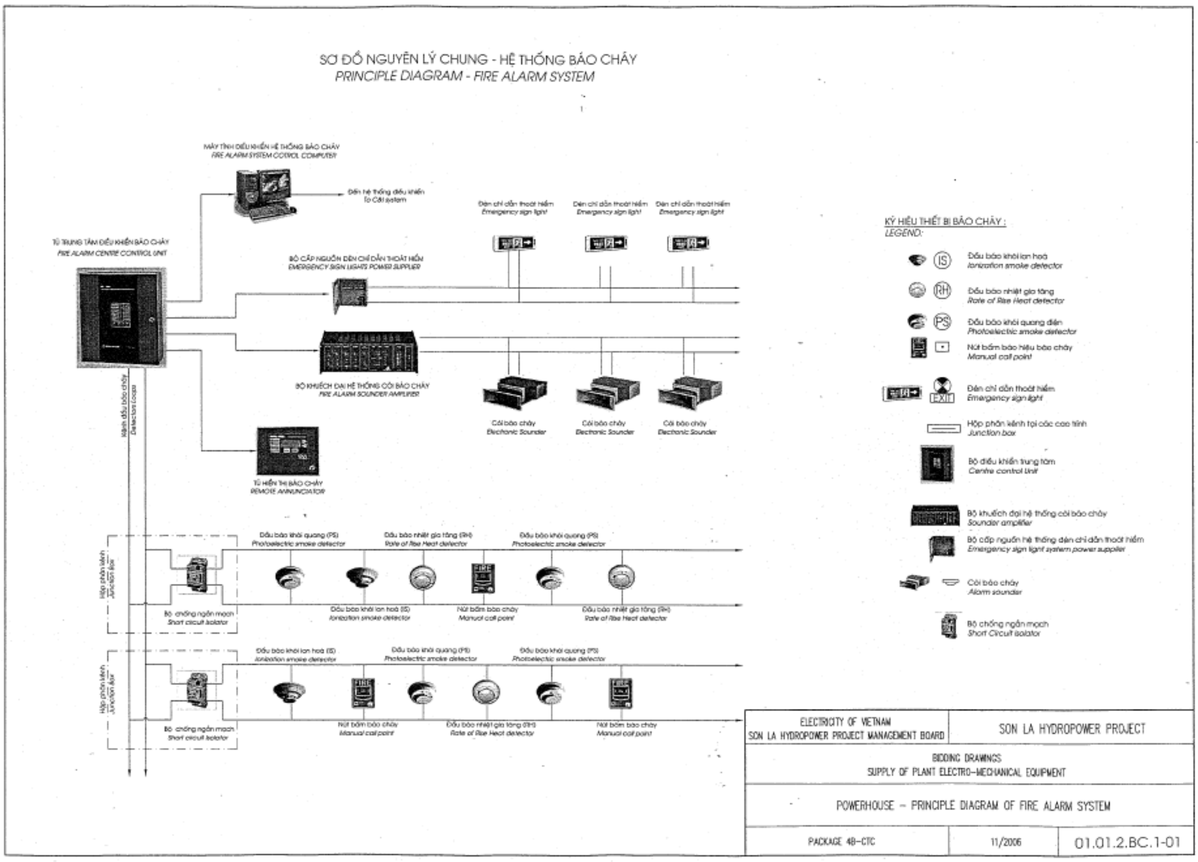


Figure 33-1 Example of Installation of Fire Prevention Equipment

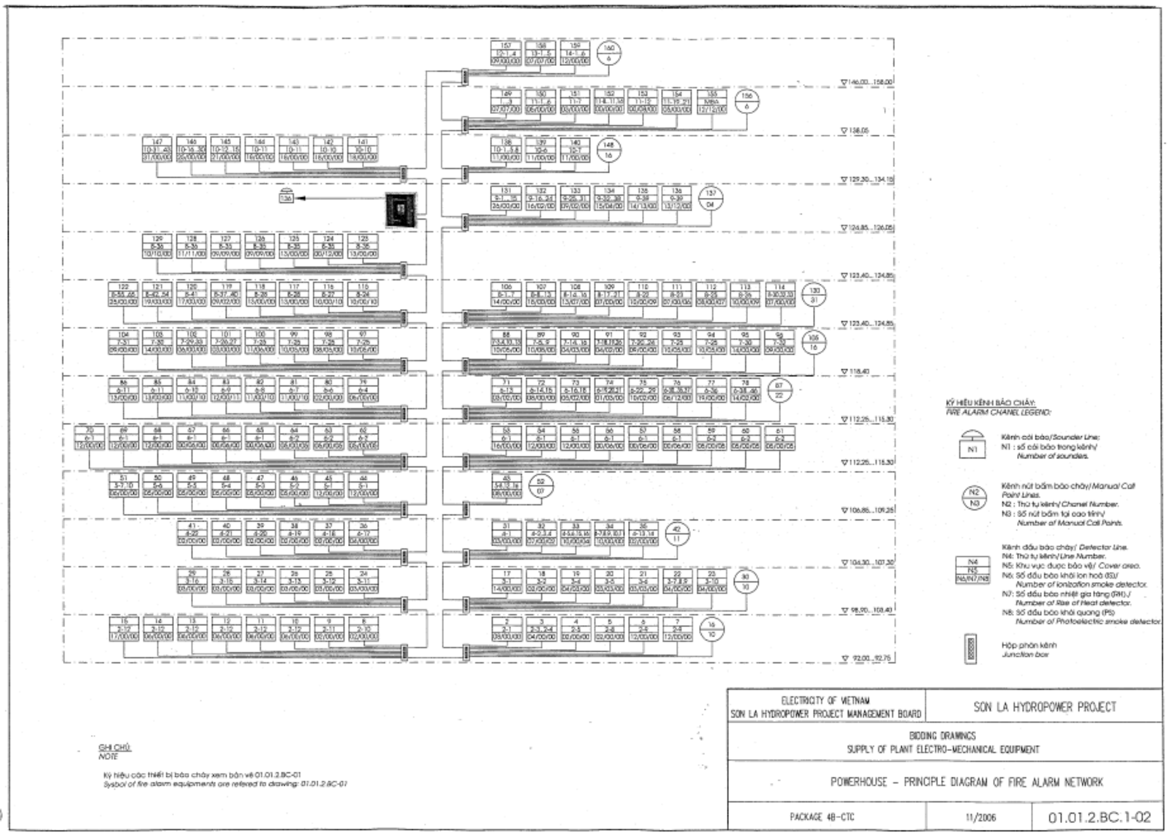


Figure 33-2 Example of Principal Diagram of Fire Alarm Network

Article 34. Compliance with technical standards for operation

To understand correctly and to observe this document are required as mandatory obligation for staff and employees of electric companies, electric supply organizations or power grid operating organizations, local electric companies, power generating companies, power transmission companies, steam system, repair enterprises, moderation centers as well as for related organizations and individuals.

Article 35. Investigation of accident (deleted)

Part 3
Plan, Houses and Power Plants

Chapter 1 Plan

Article 36. Hygienic condition for plan, house and powerhouse plant)

Condition of the following items must be inspected and checked periodically during operation period in order to keep hygienic condition of plan, houses and works for smooth operation of a power plant.

1. Surface and underground drainage system for the whole plan of power plant, substation and relevant facilities;
2. Dust precipitating system and ventilating system;
3. Waste water treatment systems;
4. Water supply system and drainage system;
5. Sources for domestic water, reservoirs and protecting system for water sources;
6. Railways and roads in yards of power plant, substation and relevant facilities;
7. Fences, illumination for parks, other cultural works and public works;
8. Systems for monitoring underground water level.
9. Lighting system of power plant, substation and relevant facilities.

In case that the inconformity with the requirements in relevant environmental regulations are detected in the inspection and checking, necessary measures must be taken immediately to improve the condition.

Article 37. Protection of water route, gas pipeline and cable route

In order to make visible for embedded subjects such as underground water pipes for water supply and wastewater system, embedded gas pipelines and cables, clear and solid display must be provided for such subjects in a systematic manner.

Photo 37-1 Sample of indication pile

Article 38. Water treatment

1. When the wastewater contains pollutant such as oil and chemicals, water treatment system is required before releasing such polluted wastewater into a natural river or reservoir or sea.

   In order to avoid violation against industrial hygiene regulations, it is required to check the quality of wastewater periodically.

   It shall be referred to Article 228 of this Guideline regarding water treatment of thermal power plant.

2. Power house Water Treatment and Drainage System

   1) General arrangement of the water treatment and drainage system for the station is shown on the Figure 38-1 Powerhouse-Waste Water Disposal System in Hydro-power Plant.

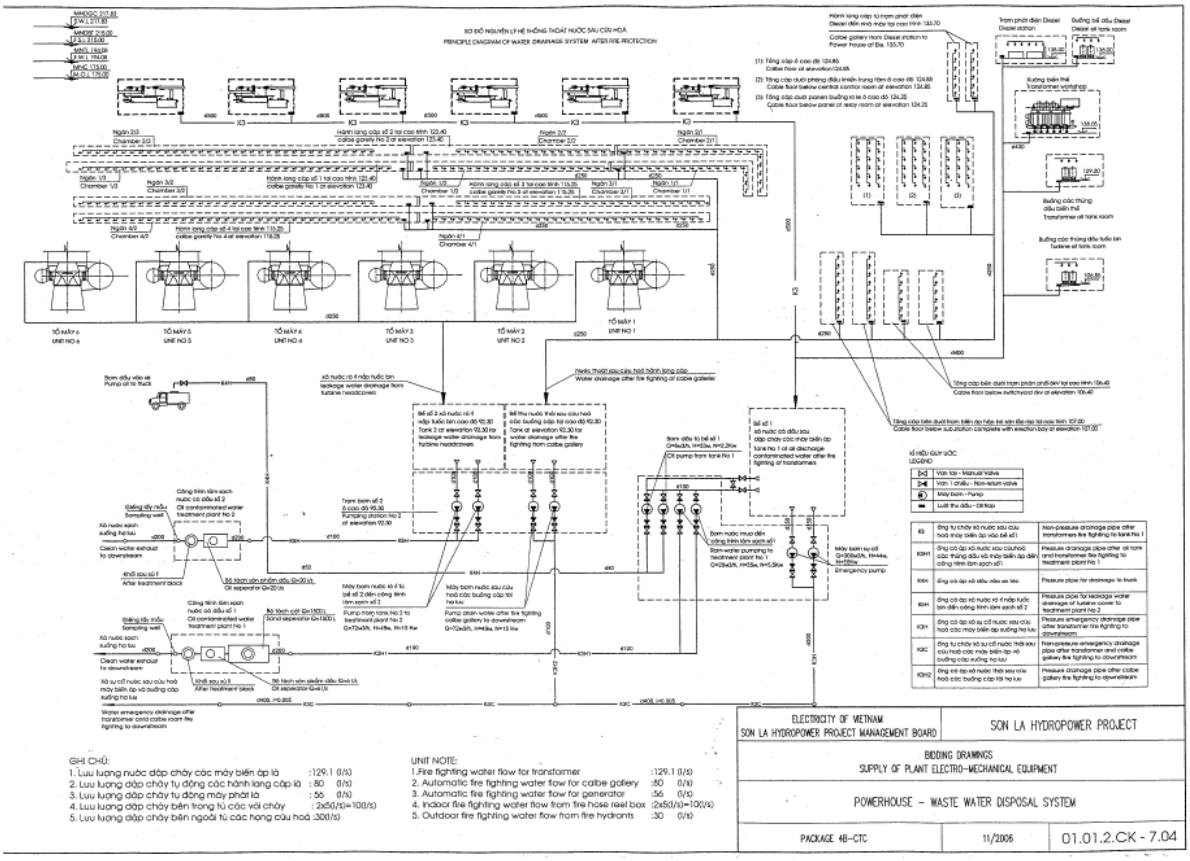


Figure 38-1 Powerhouse-Waste Water Disposal System in Hydro-power Plant

   2) In the absence of any possibility to drain water naturally by gravity from the Powerhouse, there is a vital need to provide a powerful and reliable pumped drainage system.

   3) Water to be pumped from the Station must be classified as followed;

      (1) Seepage water through civil construction works,

      (2) Seepage water from auxiliary mechanical equipment, hydro-mechanical equipment under normal operation in the even of emergency such as through the break of an auxiliary pressure pipe and other drainage sources originating from the process,

      (3) Seepage water through turbine shaft and head cover,

(4) Water source after fire fighting.

4) Except the water seeped through civil construction works and the water in the unit waterway, which are considered as natural sources without oil contamination and to be directly discharged to the river, the other sources of water are potentially oil contaminated and must be treated by separating oil and water before being discharged to the river.

(Refer to Vol.4, Part 4, Chapter 4, Article 91 Oil treatment)

a. QCVN 14:2008/BTNMT – National Technical regulations on domestic waste water

b. QCVN 24:2009/BTNMT National Technical regulations on industrial waste water

c. QCVN 38:2011/BTNMT – National Technical regulations on quality of surface water to protection aquatic lives

d. QCVN 39:2011/BTNMT – National Technical regulations on water quality for irrigated agriculture

e. Decision No. 23/2006/QĐ-BTNMT – Listing hazardous substances

f. Circular No. 47/2011-TT-BTNMT – National Technical regulations on environment

Article 39. Stability of plan

In case that the settlement, landslide and fracture are detected on the plan, proper measures must be carried out to eliminate or mitigate causes of the above-mentioned phenomena in order to prevent the power plant facilities or network facilities from damages.

In order to prevent the plan from settlement, landslide and fracture, routine inspection must be conducted for monitoring of land condition and groundwater level by providing monitoring points at potential locations where such failure in land condition may occur.

Article 40. Railway and road

Railways and relevant works located in the yard and the area under the control of the power plant must be managed and maintained in line with regulations of railways such as Railway Traffic Law (No. 35/2005/QH11). In addition, other relevant regulations shall refer to Article 105 of this Guideline. Management and maintenance of roads in the same area must be also in accordance with the technical regulations and standards of transport and communication sectors such as Road Traffic Law (No. 23/2008/QH12).

In addition, railways and roads must be arranged and maintained to be convenient for maintenance work and for access to adjacent facilities and to secure safety conditions for pedestrians and vehicles.

Chapter 2 Houses, Power Plant, Technical and Hygienic Equipment

Article 41. Principles in maintenance

Power plants and relevant facilities, houses and related structures must be maintained in good condition, and secured for durable, stable and reliable operation of power plants and network facilities as designed.

In addition, they must satisfy occupational safety requirements and industrial hygiene requirements for staffs working at power plants and network facilities.

Article 42. Routine and emergency Inspection of houses, works and equipment

The owner must monitor the condition of houses, works including ancillary facilities and equipment to secure reliable operation of power plants and network facilities, and check them comprehensively to detect damages, deteriorations and potential failure periodically as routine inspection activities in daily maintenance work.

In case that the breakdown or natural hazards such as fire, earthquakes, heavy storm and flood would happen at the area where electrical facilities and equipment are installed, preparation against such hazard must be carefully made and, once such hazard occurred, emergency inspection must be carried out immediately after the incidents in order to detect the damages and take proper measures for securing safety of houses, works and equipment..

Article 43. Check of houses and works on particular ground

In addition to the provision in Article 42, it is necessary to take particular care for the condition of houses and works constructed at new earth-filled area, settlement area and the location where vibration appears frequently during operation by checking carefully and continually.

Article 44. Check of durability of houses and works

When keeping a close watch is required on durability of houses and works, it is necessary to check the condition of following items of house and works:

- Supporting column (crack, deformation, etc.)
- Expansion gaps (width of gap)
- Welded seams (crack, deformation, abrasion, rust, etc.)
- Joints (loosening, etc.)
- Structures of reinforced concrete (crack, deterioration, settlement, etc.)
- Structures and parts affected by active load and heat (damages, deformation, etc.)

It is required for the above items to be checked periodically and continuously to detect the changes in condition or progress of unfavorable phenomena.

Article 45. Countermeasures for fractures and damages

In case that fractures or damages on structures are detected on houses or works, subsequent actions must be selected carefully according to the degree, location and causes of fractures and damages. Excluding the cases that defects are structurally and functionally negligible or, on the contrary, urgent repair works are required immediately, careful successive inspection must be carried out for detected fractures or damages. Depending on the conditions of defects, proper monitoring equipment such as plumb lines, crack gauges, displacement meters, etc. must be installed immediately for accurate monitoring.

A series of investigation activities and countermeasures taken for the defects must be recorded correctly in order to utilize such records for making proper maintenance plan in due considering causes of defects.

Article 46. Check of chimney (deleted)

Article 47. Alteration of facilities

It is prohibited in principle to alter loading condition on facilities by applying additional load such as piercing, arranging heavy machinery and materials, or installing ducts and pipelines, which may damage the stability and safety of facilities.

Overload or alteration must be permitted only on the condition that the safety would be confirmed by design calculation. If alteration of loading condition is needed, such structures must be reinforced properly based on the design calculation.

It is necessary to arrange instruction boards indicating the allowable limit load at visible place on each section of floor surface in order to easily recognize allowable limit-load.

Article 48. Corrosion protection of metal structures

Power plant staff must check metal structure of houses at daily patrol and inspection and must confirm status of it because it is corroded and damaged as time goes by. Points to be checked on daily patrol and inspection of houses are shown as follows;

1. Inspection must be conducted for houses according to procedures developed by each power plant.
2. The following places must be checked mainly because metal structures in these places are easy to corrode.
   1) Places damaged from salt
   2) Blowy places
   3) Humid places
   4) Places damaged from rainwater
3. The following equipments and parts must be checked mainly because these equipments are easy to corrode.
   1) Pipe rack
   2) Bolts and nuts
   3) Welded parts
   4) Joint parts
   5) Painting parts (peeling)
4. Corroded parts must be changed to new parts or corrosion must be removed by grinder and re-painted when finding corrosion on above equipments and parts.

Part 4
Civil Works, Water Sources, and Management of Hydraulic Turbine and Powerhouse

Chapter 1 General Provisions

Article 49. (Article 49) Definitions

<Refer to Technical Regulation Vol.4>.

Article 50. (Article 50) Preparation and preservation of necessary documents

Paragraph 1 of Article 50

This article is based on Chapter III of Decree No.72/2007/ND-CP and aims at preserving records of maintenance, repair, inspection, measurement and hydro-meteorological data so that post-evaluation of hydropower facilities can be conducted to improve quality of maintenance works.

Documents and records to be prepared and preserved would verify the conformity of operation and maintenance activities with the requirements stipulated in the said chapter of the Decree shown below.

Article 10. Regulation of water in reservoir

1. *Dam Owner shall prepare procedures for regulation of water in the reservoir, regulation on water impoundment, water discharge and urgent situation, submit these regulations to the competent organization for approval and organize implementation.*
2. *The regulation of water in the reservoir shall be in compliance with the following:*
   a) *Water level in the reservoir shall not be higher than water level stipulated by the State competent management organization'*
   b) *In case dam is damaged or faulted, water draining off is required in order to lower the water level of the reservoir and avoid slide of the upstream slope of dam;*
   c) *In flood season, the water reservoirs are responsible for flood control, the operation on water filling and flood discharging shall be prioritized for ensuring dam safety, and the flood control and water filling shall be in compliance with the functions of the projects.*

Article 11. Operation of gates of structures

Operation of gates of water intake structures, water outlet structures, flood discharge structures, ship lock are specified as follows:

1. *The dam Owner shall prepare, submit to the competent agency for promulgation, the regulation on rights to command operation and operation procedures for operating gates of each structure (hereinafter referred to as "project operation").*
2. *It is prohibited for the person who has no power to command or force operation of the project.*
3. *The operation of the project not in compliance with the procedures is prohibited; and only responsible person can operate the project.*
4. *There shall be regulation on operation regimes and test operation of gates which are not regularly operated or in the period of non regular operation, including back-up gates.*
5. *The operations as well as test operation of structure gates shall be recorded in the operation record book.*

Article 12. Measurement, monitoring of dam and meteorological- hydrological parameters

1. *For large dams*: the following shall be implemented;*
   a) *After taking over the works of management, the dam Owner shall organize measurement, monitoring or contracting with professional agencies to carry out measurement, gathering meteorological-hydrological data of the catchments of reservoir, progress of seepage through dam body, dam bed and dam abutment, dam displacement, dam cracks, slides in dam foot, foundation and surrounding areas, and the sedimentation in the reservoir.*

   b) *The measurement documents shall be adjusted, analyzed, evaluated and compared with the design and forecast data to find the sudden phenomenon in order to make decision on remedial measures in time and to implement documentation preservation in accordance with the regulation.*

2. *For small dams*: the measurement of water levels and other measurements as specified by the design consulting company.*

Note *: Paragraph 3 and 4 in Article 2 of Decree No.72/2007/ND-CP define large dams and small dams as follows.

3. *The large dam is the dam with height equal or higher than 15 m, calculated from the dam foundation surface to the dam crest or the dam of the reservoir with capacity equal or bigger than 3,000,000 m^3 (three million cubic meters).*

4. *Small dam is the dam with height less than 15 m, calculated from the foundation surface to the dam crest or the dam of the reservoir with capacity less than 3,000,000 m3 (three million cubic meters).*

Article 13. Maintenance of dam

1. *The dam Owner shall specify contents and procedures on maintenance for each structure, components of structure and equipment.*
2. *The maintenance of dam and equipment shall be performed periodically, regularly in compliance with the regulation in order to ensure reliable, safe operation of the structure, for easiness of inspection and finding damages for repairing in time, and for ensuring beauty of the projects.*

Article 14. Inspection of dam

The dam owner shall carry out dam inspection in compliance with the specified contents and regulations as follows:

1. *Regular inspection with analysis, assessment of dam measurement documents, and by measurements on dam and visual inspection.*
2. *Periodical inspection prior to and after annual flood season:*
   a) *Each year, at the time prior to the flood season, it is needed to carry out general inspection, assessment on dam stability; close coordination with Steering Committees on Flood, Typhoon Prevention of ministries, sectors, localities in order to prepare or update, supplement alternatives for protection of dam against floods, typhoons and protection of downstream areas against floods and typhoons.*
   b) *At time after termination of the flood season, it is needed to carry out inspection in order to find out damages (if any); monitoring progress of outstanding problems of dam; drawing experience on protection against flood, typhoons; proposing measures and plans for repairing, overcoming such damages and outstanding problems;*
   c) *The time for inspection prior to the flood season and after flood season are specified as follows:*

- *April and November for provinces in the Northern, Northern Central regions;*
- *April and December for provinces in Highland, Eastern South;*
- *August and January for Central Coastal areas.*

3. *Carry out emergency inspection right after the large floods, earthquakes or sudden damage of dam.*
4. *Detailed inspection, investigation of dam: when dam is heavily damaged, the dam Owner shall organize detailed investigation and survey in order to find out the reason, level and scope of damage; carry out remedial design and carry out measures for prevention, protection and measures for ensuring safety of the dam and downstream areas*

Article 15. Rehabilitation, repairing and upgrading of dams

1. *Restoration, repair and upgrading of dam shall be carried out in the following cases:*
   a) *Dam is heavily damaged and safety is not ensured.*
   b) *Flood discharge structure has not enough flood discharge capacity as specified in the design standards.*
   c) *Change in the design standards which makes dam not satisfactory to the stability conditions in accordance to the new design standards.*
   d) *The regeneration of reservoir banks which affects the dam safety.*
2. *Restoration, repair, upgrading of dam shall be carried out in compliance with the regulation on investment construction management.*

Article 16. Reports of dam safety status

1. *Each year, the dam Owner shall prepare and send report to Ministry of Industry and Trade, Ministry of Agriculture and Rural Development and relating organizations on dam safety in compliance with the existing regulation. The contents of report include:*
   a) *Highest water level in reservoir; maximal flood flow into the reservoir (time of occurrence, peak flood flow, total flood flow, flood discharge process).*
   b) *Measurement results of dam which are adjusted, analyzed and evaluated.*
   c) *Damages of structures and repair, remedial measures.*
   d) *Results of inspection before flood;*
   e) *Other necessary related contents.*
2. *Time for submission of report is specified as follows:*
   a) *Prior to 15th May for provinces in Northern Region, Northern Central, Eastern South areas and Highland.*
   b) *Prior to the 15th September for provinces in the Coastal Central areas.*
3. *The dam Owner shall report to the State competent organizations when the following situations happen:*
   a) *The strange measurement results of seepage, displacement of dam.*
   b) *The dam is heavily damaged or previous damage goes worse.*
   c) *Fault in operation of gates of dam structures during flood season.*
   d) *Heavy rain on the catchments of reservoir when reservoir is full of water.*
   e) *There is doubt of sabotage plan.*

Article 17. Inspection of dam safety

1. *The periodical inspection of dam safety shall be performed for the reservoir with capacity equal or larger than 10,000,000 m^3 (ten million cubic meters), in compliance with the following regulation:*
   a) *Periodical inspection shall be performed in the interval not exceeding 10 years, from the initial water impoundment of the reservoir or from the latest inspection.*
   b) *The inspection work shall be performed by the dam Owner. The dam Owner shall select inspection consultant which has enough capability in compliance with the regulation of the Ministry of Agriculture and Rural Development.*
   c) *The contents of inspection include:*
      - *Assessment of results of dam management works in accordance to the contents specified in the Chapter III of the Decree.*
      - *Checking and analysis of documents of measurement and monitoring of dam;*
      - *Checking and assessment of quality and safety of the dam;*
      - *Checking sedimentation situation of the reservoir;*
      - *Calculation of flood, capacity of flood discharge of reservoir according to present dam design standards and updated meteorological - hydrological data;*
      - *Assessment of works of prevention and protection against flood and typhoon for the project.*
   d) *The inspection results shall be considered and approved by the State competent organization.*
2. *For reservoir with capacity less than 10,000,000 m^3 (ten million cubic meters), every 7 years, the dam Owner shall organize re-calculation of the flood flow into the reservoir, check the capacity of flood discharge of the reservoir in compliance with the present dam design standards and based on the updated meteorological and hydrological data and changes in topography, vegetal cover rate on the catchments area of the reservoir, prepare report and submit report to the State competent organization for consideration and approval.*
3. *The dam Owner shall be responsible for payment to the dam inspection consultants.*

Paragraph 2 of Article 50 Preparation and preservation of necessary documents

1. Purpose

   Article 50 prescribes fundamental items on handling of documents for proper and smooth performance of plant operation. The documents listed in Paragraph 2 of Article 50 provide the Owner with information for maintenance, repair and remodeling of hydropower facilities.

2. Principles of administration

   Important instructions and responses must be recorded in a form of documents to keep process and results of activities. Operation, maintenance and repair record of hydropower facilities must be recorded in a form of documents to leave those records for reference.

   Documents must be unified in a fixed form clarifying contents of each document and to provide with easy access and avoid mistakes.

<u>Paragraph 3 of Article 50 Preparation and preservation of necessary documents</u>

1. Background

Paragraph 3 of Article 50 is based on Article 12 of Decree No. 72/2007/ND-CP.

Monitoring plan must be prepared for each dam so as to satisfy the following requirements stipulated in Article 12 of Decree No. 72/2007/ND-CP.

Article 12. Measurement, monitoring of dam and meteorological- hydrological parameters

1. For large dams:

a) After taking over the works of management, the dam Owner shall organize measurement, monitoring or contracting with professional agencies to carry out measurement, gathering meteorological-hydrological data of the catchments of reservoir, progress of seepage through dam body, dam bed, dam abutment, dam displacement, dam cracks, slides in dam foot, foundation and surrounding areas, the sedimentation in the reservoir.

b) The measurement documents shall be adjusted, analyzed, evaluated, compared with the design and forecast data; finding the sudden phenomenon in order to make decision on remedial measures in time; implementation of documentation preservation in accordance to the regulation.

2. For small dams: the measurement of water levels and other measurements as specified by the design consulting company.

2. Example of monitoring items

Major items to be monitored for dam safety are as follows.

- Water leakage
  - Water leakage from drain holes provided in concrete dams
  - Water leakage from joints provided in concrete dams
  - Water leakage collected in gallery of concrete dams and embankment dams
- Uplift or pore pressure
  - Uplift measured at bedrock and dam body provided in concrete dams
  - Pore pressure measured at impervious zone provided in embankment dams
- Temperature of dam body
- Opening of joint provided in dam body
- Stress and strain in dam body
- Soil pressure in dam embankment
- Deformation of dam body
  - Displacement of targets embedded in dam body
  - Deflection of dam body measured at plumb lines provided in concrete gravity dams
  - Settlement of dam crest in embankment dams
  - Settlement of each zone in embankment dams
- Displacement of bedrock, if faults or weak zone exists in bedrock

3. Monitoring activities

(1) In principle, monitoring equipment must be established in dams with the following conditions and usual monitoring must be implemented depending on the conditions of the safety of the dam body and the progress of sedimentation of the reservoir in order to confirm the safety and proper functioning of a dam body and a reservoir. In Japan, the minimum inspection items to monitor dam safety are specified in Table 50-1.

Table 50-1 Usual monitoring items (example of Japan)

Classification			Monitoring items
Dam type		Height from foundation (m)	
Concrete gravity		Less than 50	Leakage and uplift
		From 50 and up	Leakage, deformation and uplift
Arch		Less than 30	Leakage and deformation
		From 30 and up	Leakage, deformation and uplift
Fill	Homogeneous type	All	Leakage, deformation and seepage line
	Other type	All	Leakage and deformation

(2) In the case that abnormal loads due to events such as earthquake or flood occurs, an emergency inspection must be implemented immediately in order to confirm the safety and proper functioning of the dam. In Japan, the minimum inspection items are specified in Table 50-2.

Table 50-2 Emergency inspection items (example of Japan)

Dam type	Concrete dam	Fill dam	
		Homogeneous type	Other type
Inspection items	Volume of water leakage from dam and abutment, uplift, and deformation	Volume of water leakage from dam and abutment, seepage line, and deformation	Volume of water leakage from dam and abutment, and deformation
	Proper functioning of the discharge facilities		

(3) In principle, it is desirable to establish an inspection gallery in a dam applicable to conditions of the paragraph (1) above in accordance with necessity for inspections and repairs.

4. Monitoring plan

The monitoring plan of a dam is prepared as follows.

(1) Instrumentations

It is desirable that following monitoring equipments shown in Table 50-3 are installed in dams and layout of that the equipment must be prepared in the design stage. If all of that equipment is not established in the dam, monitoring must be conducted as many items as possible. The

Dam owners must consult a design consultant or expert about monitoring items and a layout of instruments considering a scale and situation of a dam, and must get the competent authority's approval.

Table 50-3 Recommended Monitoring items

Classification			Monitoring items
Dam type		Height from foundation (m)	
Concrete gravity		Less than 50	Leakage from drain holes and joints Uplift measured at drain holes and bedrock
Concrete gravity		From 50 and up	Leakage from drain holes and joints Uplift measured at drain holes and bedrock Deformation of dam body, displacement of targets embedded in dam body, deflection of dam body measured at plumb lines, and displacement of bedrock
Arch		Less than 30	Leakage from drain holes and joints Deformation of dam body, displacement of targets embedded in dam body, and displacement of bedrock
Arch		From 30 and up	Leakage from drain holes and joints Uplift measured at drain holes and bedrock Deformation of dam body, displacement of targets embedded in dam body, and displacement of bedrock
Fill	Homogeneous type	All	Leakage collected in gallery or leakage measurement weir Displacement of dam crest and targets embedded in dam body, and displacement of bedrock Seepage line in embankment
Fill	Other type	All	Leakage collected in gallery or leakage measurement weir Displacement of dam crest and targets embedded in dam body, and displacement of bedrock Settlement of dam crest and each zone Pore pressure and soil pressure in dam body

(2) Monitoring stage and frequency

In Japan, frequency of instrumentation is recommended as follows:

A dam monitoring is divided into the following three stages.

1) First stage: From start of impounding to arrival at the full supply level

This is the period to monitor behavior of a dam during initial increase of loads acting on a dam body and it is desirable that monitoring must be continued at least two months after the reservoir water level reaches the full supply level.

2) Second stage: From the end of first stage to the period when behavior of a dam becomes stable

This is the period between the end of the first stage and a point of time when behavior of a dam gets stable. Stable behavior of a dam means that observed data of a dam change in proportion to or in reasonable relation to a change in the reservoir water level. This period must be more than three years for a dam of more than 100m in height or of special design.

3) Third stage: After the end of the second stage

A transition period from the first to the second stage and the second to the third stage must be decided considering observed data of the previous periods. Standard frequency of monitoring is as shown in Table 50-4.

Table 50-4 Standard frequency of monitoring

Dam type		**Concrete**					**Fill**	
		Gravity			**Arch**		**Homogene-ous**	**Zone or surface type**
Item	**Dam height/ Stage**	**<50m**	**≧50m >100m**	**≧100m**	**<30m**	**≧30m**		
Leakage	1st	Once/day						
	2nd	Once/week						
	3rd	Once/month						
Defor-mation*	1st	--	Once/week	Once/day	Once/week	Once/day	Once/week	
	2nd	--	Once/month	Once/week	Once/month	Once/week	Once/month	
	3rd	--	Once/3months	Once/3months	Once/3months	Once/3months	Once/3months	
Uplift**	1st	Once/week			--	Once/week	--	
	2nd	Once/month			--	Once/month	--	
	3rd	Once/3months			--	Once/3months	--	
Seepage line	1st	--					Once/week	--
	2nd	--					Once/month	--
	3rd	--					Once/3months	--

Note *: For a concrete dam except an arch dam of more than 30m in height, observation of deformation may be omitted in the third stage if deformation stays in a constant value. For a fill dam of less than 70m in height, deformation may be observed once per six months in the third stage.

**: For a concrete dam with little leakage and uplift, observation of uplift may be omitted in the third stage.

(3) Monitoring plan by height of dams

Based on the stipulations of Article 2 and Article 12 of Decree No. 72/2007/ND-CP, monitoring plan must be prepared for each dam so as to satisfy the following requirements.

For dams with height equal or higher than 15 m, calculated from the dam foundation surface to the dam crest or the dam of the reservoir with capacity equal or bigger than 3,000,000 m^3, a monitoring plan must be prepared as follows.

1) After taking over the works of management, the dam Owner must organize measurement and monitoring or contracting with professional agencies to carry out measurement, gathering meteorological-hydrological data of the catchments of reservoir, progress of seepage through dam body, dam bed, dam abutment, dam displacement, dam cracks, slides in dam foot, foundation and surrounding areas, the sedimentation in the reservoir.

2) The measurement documents must be adjusted, analyzed, evaluated, compared with the design and forecast data; finding the abnormal phenomenon in order to make decision on remedial measures in time; implementation of documentation preservation in accordance to the regulation.

For dams with height less than 15 m, calculated from the foundation surface to the dam crest or the dam of the reservoir with capacity less than 3,000,000 m^3, the measurement of water levels and other measurements as specified by the design consulting company must be conducted.

(4) Monitoring plan for emergency inspection

In the case that abnormal loads due to events such as earthquake or flood occur, an emergency inspection must be implemented immediately after the event in order to confirm the safety and proper functioning of the dam. The minimum inspection items must be as specified in Table 50-5.

Table 50-5 Emergency inspection items

<table>
<tr><th rowspan="2">Dam type</th><th rowspan="2">Concrete dam</th><th colspan="2">Fill dam</th></tr>
<tr><th>Homogeneous type</th><th>Other type</th></tr>
<tr><td rowspan="2">Inspection items</td><td>Volume of water leakage from dam and abutment, uplift, and deformation</td><td>Volume of water leakage from dam and abutment, seepage line, and deformation</td><td>Volume of water leakage from dam and abutment, and deformation</td></tr>
<tr><td colspan="3">Proper functioning of the discharge facilities</td></tr>
</table>

Chapter 2 Civil Works and Mechanical Equipment for Civil Works

Section 1 Civil Works

Article 51. (Article 51) Taking over

The provisions of Article 51 are interpreted as follows:

1. Purpose

This article stipulates necessary items on taking over of documents from design and construction stage to operation and maintenance stage. Information on design and construction of hydropower facilities must be handed over properly to an organization responsible for operation and maintenance in order to operate and maintain it in a sound condition. The initial periodical inspection must be made to record the initial condition of hydropower facilities in addition to information on design and construction stage. By using the information, the Owner can recognize how conditions of the facilities are changing.

2. Items of taking over

Information of hydropower civil structures in design and construction stages is used for safety and sound operation of a hydropower plant, so taking over of documents from design and construction stage to operation and maintenance stage must be conducted carefully and firmly.

An initial inspection must be conducted to record the initial conditions of all of hydropower civil structures. Details of initial inspections are described in Part 3, Chapter 5 of Vol.5.

Requirements for taking over of technical documents is provided in Article 9 of Decree No. 72/2007/ND-CP. as follows:

Article 9. Technical documentation

1. *When taking over the technical documentation of the construction stage, the dam Owner shall carry out check, review and comparing with the actual situation in order to have sufficient, accurate and clear document dossier; arrangement and preservation of documentation in accordance to the regulation.*
2. *During process of dam management, the dam Owner shall add to the dossier the documents of monitoring, inspections, verification of dam safety, technical documents on overhaul of dam and related administrative decisions.*

Article 52. (Article 52) Principles of operation and maintenance

The provisions of Article 52 are interpreted as follows:

1. Purpose

This article stipulates fundamental items for operation and maintenance of civil works of a hydropower plant.

2. Operation manual for civil works

An operation manual must be so prepared as to fulfill design requirements on safety, stability, durability and sustainability provided in paragraph 1 of this article as follows:

1. *Civil works of hydro power plant (dam, weir, tunnel, channel, penstock, intake, spillway, stilling basin, powerhouse, etc) shall be operated and maintained so as to fulfill the design requirements on safety, stability, durability and sustainability provided in the Technical Regulations.*

An example of an operation manual is as follows.

(1) General

A word “operation” in the guideline for Article 52 is interpreted as an operation of equipment in relation to civil structures and supervision of its operation.

A person in charge of the operation must follow operation manuals and relevant laws, and must confirm a mechanism of equipment, process of the operation and matters to be attended to in the operation before operating the equipment.

A person in charge must operate outlet structures after due understanding of the operation manual.

(2) Operation of dam

1) Spillway

A person in charge of operation of a spillway must pay attention to the following items.

a. A person in charge must confirm a mechanism of a spillway, process of the operation and matters to be attended to in the operation referring to the operation manual of spillway gates and other relevant manuals;

b. A person in charge must watch an ammeter, voltmeter, opening meter and other relevant instruments, and an operating condition of spillway gates to confirm if spillway gates operate in good order;

c. A person in charge must confirm if a power source is turned off and doors of a panel board are locked after the operation is completed; and

d. When spillway gates are operated by remote control, a person in charge must be present at the site at the beginning and the end of gate operation to confirm if gates operate properly, and confirm if there is no water leakage between a gate leaf and bottom and side sills, and sag of steel wire ropes.

2) Outlet (low level outlet)

a. A person in charge of operation of outlet structures must pay attention to the following items.

b. A person in charge must operate outlet equipment with the reservoir water level of less than EL. XX m;

c. A person in charge must watch an ammeter, voltmeter, opening meter and other relevant instruments, and an operating condition of outlet equipment during the operation; and

d. A person in charge must confirm if a power source is turned off and doors of a panel board are locked after the operation is completed.

3) Alarm for discharge

A person in charge of alarm for discharge must pay attention to the following items.

a. A person in charge must confirm if the siren is operated properly before blowing the siren; and

b. A person in charge must confirm if the siren is blown correctly by proper methods such as by applying a system which feedback signals to a control board.

4) Backup power source

A person in charge of a backup power source must pay attention to the following items.

a. Sufficient amount of fuel for a backup power source must be stored;

b. A person in charge must watch a voltmeter, tachometer and other relevant instruments, and an operating condition in starting a backup power source; and

c. A starter must be set in an automatic position.

5) Drainage system in a dam equipped with drain galleries

a. A person in charge of a drainage system in a dam must pay attention to the following items.

b. A drainage pump must be set in an automatic position usually and a trial operation must be conducted once a month in principle; and

c. A person in charge must watch if deposits are collected in a drainage pit, and conditions of a float switch and an electrode.

(3) Operation of waterway

1) Intake

A person in charge of operation of an intake gate must pay attention to the following items.

a. A person in charge must watch an ammeter, voltmeter, opening meter and other relevant instruments, and an operating condition of an intake gate during the operation;

b. A person in charge must open an intake gate after confirming if the water level on both sides of the gate is the same; and

c. A person in charge must confirm if a power source is turned off and doors of a panel board are locked after the operation is completed.

2) Penstock

A person in charge of operation of penstock must pay attention to the following items.

a. A person in charge must keep manholes closed in case of usual operation period;

b. A person in charge must indicate existence of persons in penstock in case of inspection of penstock; and

c. A person in charge must observe conditions of penstock including if there is no water leakage from expansion joints and manholes

3) Draft gate

A person in charge of operation of a draft gate must pay attention to the following items.

a. A person in charge must watch an ammeter, voltmeter, opening meter and other relevant instruments, and an operating condition of a draft gate;

b. A person in charge must open a draft gate after confirming if the water level on both sides of the gate is the same; and

c. A person in charge must confirm if-a power source is turned off and if doors of a panel board are locked after the operation is completed.

4) Outlet

A person in charge of operation of an outlet gate must pay attention to the following items.

a. A person in charge must watch an ammeter, voltmeter, opening meter and other relevant instruments, and an operating condition of an outlet gate;

b. A person in charge must open an outlet gate after confirming if the water level on both sides of the gate is the same; and

c. A person in charge must confirm if a power source is turned off and doors of a panel board are locked after the operation is completed.

3. Prevention of damage on civil works

To prevent serious damages of civil works, the Owner must pay attention to following points.

- Only authorized staff must operate spillway gates
- Change in the reservoir water level, water pressure in waterways and any other designated numerical values.

4. Record of maintenance,

During implementation of maintenance work, equipment conditions and maintenance procedures must be recorded to analyze the cause of problems which occur during operation, if any, by investigating the state of equipment in the past.

Article 53. (Article 53) Prohibition of irregular operation or alteration against design

Irregular operation or alteration of civil works against the design may cause failure of the works. Some examples of irregular operation or alteration of civil works are as follows.

- Reservoir operation out of the range of the designated water level
- Discharge from spillways or bottom outlets out of the range of the designated water level or opening

In case of alteration or remodeling of civil works, design conditions must be compared with those of original design in order to verify the safety and stability of altered or remodeled civil works under the new conditions. The method of verification must be the same with that applied in the original design in principal. However, new verification method may be accepted when new technology is applied in the design alteration or remodeling.

Article 54. (Article 54) Cares for concrete civil works

Typical damages of concrete civil works are as follows.

- Aging of concrete due to weathering by a difference in temperature , ultraviolet rays, or other causes
- Erosion of a spillway chute or any other part which is exposed to high velocity water flow
- Cracking due to earthquake or accidental loading
- Damage of concrete due to chemical reaction including alkali-aggregate-reaction

When damages are detected in concrete civil works, the Owner must consult with an expert specialized in maintenance and repair of concrete structures on solutions.

Article 55. (Article 55) Cares for earth-rock fill works

1. Occurrence of erosion or damages of earth-rock fill works caused by surface flow, seepage, precipitation, plants, animals and lives such as termites etc. may reduce a sectional area of embankment and damage its stability. The Owner must carefully inspect earth-rock fill works in the routine inspection work to prevent occurrence or advance of those phenomena.
2. When a crest and slopes of earth-rock fill works are overgrown with plants and bushes, growth and extension of roots makes aggregate structure of soil and shaking of their trunks and roots by winds loosens embankment and makes space around their base, which damages stability of earth-rock fill works.
3. When erosion or damages are left not repaired, the effective sectional area of earth-rock fill works may reduce and lose stability.

Article 56. (Article 56) Care for seepage line in earth fill works

If seepage line inside earthfill dams and dykes for the designated reservoir water level is higher than that is designed after several years form completion, there is possibility that the drainage system is not working properly or more amount of water than designed infiltrates into embankment and it may lead to piping failure or slope failure of embankment.

Article 57. (Article 57) Cares for drainage system

1. Instruments to measure quantity of seepage or leakage must be so kept that it can always measure discharge accurately. For example, a triangular weir must be free from trash to measure water depth accurately.
2. It is desirable that the seepage water level in an impervious zone of a zone type fill dam or a dam body of a homogeneous type fill dam must be kept as low as possible.
3. If the origin of fine solids in seepage water is earth-filled works or foundation, there is possibility that soil material is solved out of embankment or foundation and it may lead to piping failure of embankment or foundation.

Article 58. (Article 58) Cares for spillway

1. Spillway must be so kept that it can discharge design flood and check flood during the flood season to secure the area surrounding the reservoir and downstream of the dam against flood.
2. Cracks, erosion or any other deterioration which may lead to successive failure of spillway crest and chute must be repaired before the flood season to fulfill the requirements of paragraph 1.
3. Undermining of spillway outlet may spoil not only the function of spillway but also stability of a spillway chute or dam body if spillway is installed on or near the dam body. Spillway outlet must be inspected periodically and severe undermining which may lead to suspension of its use must be repaired before the flood season.

Article 59. (Article 59) Operation of canal

In view of maintenance of safety and stability of a canal, it is desirable to prevent it from being eroded. To avoid erosion of a canal, following issues must be considered.

- Flow velocity: Flow velocity must be so controlled as not to cause cavitation.
- Flow condition: Flow must be kept uniform to avoid occurrence of drift, swirling flow, or any other nonuniform flow which may lead to loss of energy.
- Bottom and side slope: The surface must be finished as uniform as possible to prevent occurrence of swirl flow or cavitation.

In view of maintenance of hydraulic characteristics of a canal, it is desirable to prevent it from accumulation of sediment. To avoid accumulation of sediment in a canal, following issues must be considered.

- Prevention of inflow of sediment: A location of intake must be chosen properly to prevent inflow of water containing sediment. A settling basin or headtank must be so designed that sediment is settled in the basin.

- ➢ Flow velocity: Flow velocity must be so controlled that sediment will not accumulate at the bottom.

Article 60. (Article 60) Water filling and dewatering

1. Purpose

Filling water and dewatering are usually conduced in the following cases.

- ➢ Filling water of reservoir: Completion or partial completion of a dam
- ➢ Dewatering of reservoir: Repair of a dam, intake, spillway, bottom outlet, or any other structures submerged under reservoir water
- ➢ Filling and dewatering of waterways: Initial water filling and periodic inspection of waterways

Rate of water filling and dewatering is so determined that failure of civil works such as excessive water leakage, destruction of structures, landslide in a reservoir area, etc., must not occur.

Especially, the first water filling must be conducted with the greatest care.

2. Process

Water filling and dewatering of waterways must be conducted as follows.

A work plan must be prepared prior to water filling and dewatering as follows;.

(1) Important notices

A work plan must describe a work process, arrangement of staff, number of staff, name of staff and the person responsible for the works, shifts of staff, and any other necessary items.

Water filling and dewatering of waterways must be conducted as follows.

- ➢ Waterway structure must be inspected prior to the water filling.
- ➢ The works must follow the designated process so that water pressure which exceeds the values estimated in design stage may not act on waterways.

(2) Confirmations

The following items must be confirmed in the works.

- ➢ Prior to dewatering
  - Existence of impediments on and around intake gates, tailrace gates and their screens.
  - Open and close operation of gates and valves
  - Existence of spare parts for gates and valves
- ➢ During dewatering
  - Opening of dewatering valves and extent of vibration in valves and penstocks
  - Water level in waterways and change in quantity of water leakage from them
- ➢ Prior to water filling
  - Existence of staff inside waterways and removal of temporary facilities
  - Opening of valves
  - Conditions of watertightness of manholes
  - Open and shut operation of gates and valves
- ➢ During water filling
  - Existence of water leakage from manholes and valves

- Water level in waterways and change in quantity of water leakage from them

Article 61. (Article 61) Prevention from erosion

In principle, civil works must be located on a place free of inundation, a strike of debris avalanche, erosion of foundation, accumulation of sedimentation, or any other effects unfavorable for the works.

However, the above phenomena may affect the civil works if natural conditions surrounding the works change in the operation stage. In that case, proper measures must be considered to mitigate those unfavorable effects.

The following structures are considered as proper measures against erosion.

- Construct a guide wall upstream of the works to prevent river flow from hitting the works; and
- Protect foundation of the works by gabions or concrete to prevent the foundations from being eroded.

Article 62. (Article 62) Condition of penstocks

1. Surroundings
   - Damages of a penstock may occur not only by its own reason, but also it may be caused by surroundings. Conditions of surroundings such as ground condition, inclination and so on must be checked.
2. Vibration
   - Vibration of the penstock must be confirmed during its operation, because it may occur due to change in conditions of the waterway for example sediment deposit inside the tailrace tunnel.
   - If vibration of a penstock occurred, detail investigation must be conducted and the cause of the vibration must be determined to take appropriate countermeasures.
3. Drainage around embedded penstock
   - If the drainage system is installed around an embedded penstock, condition of the drainage system must be checked. However, in many cases, the drainage is difficult to check because it is only exposed very limited part around the exit. Thus it is needed for the condition of drainage system to be deduced based on change in volume of water flow which is observed by means of periodical measurements.
4. Steel penstocks
   - In order to secure safety of steel penstock, the following items must be cared during operation and maintenance.
     - Metal parts of steel penstock must be kept from rust and wear.
     - If water becomes acidified during operation for some reason (pH less than or equal to 4.0), proper countermeasures such as special coatings must be taken for corrosion protection of steel penstocks.
     - Thickness of penstock shell must be checked periodically for aged penstocks.
5. Wooden penstocks
   - In order to secure safety of wooden penstocks, the following items must be cared during operation and maintenance.

- Wooden parts must be kept from rotten.
- It must be prohibited to leave wooden section in dry condition beyond stipulated time in the design.

6. Reinforced plastic penstocks
   - ➢ In order to secure safety of plastic penstocks, the following items must be cared during operation and maintenance.
     - Leakage from joints, which may be a symptom of deterioration of sealing materials at joints, must be checked.
     - If water becomes alkalized during operation due to some reason, chemical durability of plastics must be checked. In case that chemical deterioration is anticipated, proper countermeasures such as installation of protection layer must be designed and carried out.
     - Abrasion of plastics must be checked carefully. If excessive abrasion or erosion of protection layer is detected, proper repair work must be carried out.
     - Stiffness of plastic penstocks must be checked periodically by measuring change of strain during dewatering and water filling of penstocks.
7. Expansion joint
   - ➢ Expansion joint tend to have water leakage because of its structure. Therefore, the condition of leakage from the expansion joint must be checked periodically.
   - ➢ If the water leakage from an expansion joint is confirmed, tightening of the bolts at the joint is needed. If the clearance for tightening is not sufficient, packing must be replaced.
8. Support, Anchor and their Abutment

   (1) Movable support
   - ➢ The check items of a movable support are as follows,
     - Corrosion and deformation at the movable part of the metal support,
     - Lubricant condition of the rotating part,
     - Crack and displacement of the base concrete.

   (2) Anchor block
   - ➢ The check items of an anchor block are as follows,
     - Crack,
     - Deterioration of concrete,
     - Displacement.
   - ➢ Sufficient repair must be implemented if damages are found, and if damages reoccur, adequate investigation must be implemented.
9. Water quality
   - ➢ If water becomes acidified during operation due to some reason, proper countermeasures, such as application of special coatings, must be taken for corrosion protection of steel penstocks.

Article 63. (Article 63) *(deleted)*

Article 64. (Article 64) *(deleted)*

Article 65. (Article 65) *(deleted)*

Article 66. (Article 66) Emergency programs

Regarding Paragraph 1, the rules on fixing emergency cases may include but not limited to the following contents:

1. Tasks of each staff;
2. Emergency contact list;
3. Measures to fix troubles;
4. Emergency Stocks (types, quantity and stockyard);
5. Emergency telecommunications and transportation means;
6. Securing access road etc.

Paragraph 2 is based on Article 23 of Decree No.72/2007/ND-CP.

Article 23. Contents of State management of dam safety

Contents of State management of dam safety include:

1. *Development, promulgation and inspection of implementation of legal standards on management of dam safety, the technical standards, norms on management of dam safety.*
2. *Carrying out check, inspection, supervision on verification of dam safety.*
3. *Making decision on commissioning, taking over of the dam.*
4. *Approval of the rules for water regulation of water in the reservoir, alternative of dam protection, alternative of prevention and protection against flood, typhoon for safety of the dam, alternative of prevention and protection against flood, typhoon for the downstream areas of the dam.*
5. *Making decision on remedial measures, mobilizing manpower, material, facilities for treatment of faults of the dam.*
6. *Granting, withdrawing, extending the license for licensed operation in the protection area of the dam.*
7. *Organizing study, application of technical progress and technologies in construction, management, operation and protection of the dam, prevention and protection against flood, typhoon for downstream areas.*
8. *Organizing propaganda, dissemination of the laws and relating information on dam safety management.*
9. *Carrying out training, building capacity for staffs, employees who are responsible for management, operation, protection of the dam and management of dam safety.*
10. *Organizing international cooperation on the field of management of dam safety.*

Paragraph 3 is based on Article 20 of Decree No.72/2007/ND-CP.

Article 20. Ensuring dam safety in flood seasons

1. *Dams belonged to flood control projects: each year, prior to the flood, raining season, the dam Owner shall prepare or update, supplement the alternative for protection against floods, typhoons, submit the alternative to the State competent organization for approval.*
2. *The contents of the alternative for protection against floods, typhoons shall include:*
   a) *Summary of features, conditions of water reservoir relating to the works for protection against floods, typhoons;*
   b) *Progress of situation and features of rains and floods at the upstream of the reservoir;*
   c) *Assessment of dam quality and equipment operating on the dam;*
   d) *Anticipating the dam unsafe circumstances which could happen and technical solutions for forecast, finding, copping with and warning on flood, typhoon.*
   e) *Preparation works on personnel, materials, back-up materials, equipment, transport means, communication, lighting etc.;*
   f) *List of members of steering committee on prevention and protection against flood, typhoon.*
3. *After the alternative has been approved, the preparatory works shall be performed; materials, tools shall be gathered and protected at the specified points; the technical staffs, rescuing team, rescuing facilities shall be managed in compliance with regulation in order to be ready for operation in when necessary. The Steering Committee on prevention and protection against flood, typhoon shall organize meeting for endorsement of the regulation on working and being on duty.*
4. *Throughout the flood, rainy season, the dam Owner shall maintain communication system in good working conditions and report the situation to the higher level of The Steering Committee on prevention and protection against flood, typhoon and State competent organization, as specified in the Regulation.*

1. Paragraph 4 is based on Article 20 above and Article 22 of Decree No.72/2007/ND-CP.

Article 22. Prevention against floods, inundation for downstream area of dam

1. *In case, water discharge from reservoir makes sudden increase of water level in the river sections in the downstream sides of the flood discharge structure, the dam Owner shall have measures to announce in advance in order to ensure safety for people, ships, boats, and transporting means going through rivers, streams.*
2. *The dam Owner shall prepare the alternative of prevention and protection against flood, typhoon for dam protection for the downstream areas, submit the alternative to the State competent organization, in order to cope with the inundation situation due to urgent water flood discharge or situation of dam break, in order to protect lives of people and mitigate damages of lives and properties of the downstream areas of the dam.*

Article 67. (Article 67) Recheck of safety

This article is prepared to keep civil works in touch with requirements of the latest design regulations.

When the Authority changes a requirement in design conditions, the existing civil works may fail to meet them. In that case, the Owner must consult with the Authority on treatment of the works.

When stability and safety of civil works are rechecked by the revised design conditions, the latest physical properties of the structure and its foundation obtained by proper investigations must be used for analyses, and not those in the design stage.

Section 2 Check of Civil Works' Condition

Article 68. (Article 68) Routine inspection and emergency inspection

1. Purpose

Article 68 stipulates requirements of routine and emergency inspections.

2. Routine inspection

A routine inspection is divided into an inspection of the external appearance of civil works and appurtenant mechanical equipment to confirm if they are in a sound condition and to prepare a repair plan for reference.

3. Emergency inspection

An emergency inspection must be conducted in the following situation.

- At earthquake events
  In case a seismometer installed at the bottom of a dam recorded seismic acceleration of more than “AA” gals at an earthquake event.
  Definite acceleration “AA” gals must be prepared at each power plant as the criteria for execution of emergency inspection for each major civil works.
- At torrential rain or flood
  In case it rained more than BB mm per day at a dam or inflow to a reservoir exceeds CC m^3/s.
  Definite rainfall “BB” mm and inflow “CC” m^3/s must be prepared as the criteria for execution of emergency inspection for each civil works for each dam and reservoir.
- Others
  In case civil works is damaged by any other phenomena, an emergency inspection must be conducted.

Article 69. (Article 69) Revision of monitoring program

This article stipulates that a monitoring program must be revised according to conditions and capacity of measuring devices as follows:

1. A monitoring program must be revised when it is difficult or inappropriate to continue monitoring under the same conditions with present methods or at present locations. Some examples are shown as follows.
   - When measurement cannot be continued in the original condition as measuring devices are buried due to progress of sediment, or damaged by earthquake or any other natural disasters.
   - When measuring devices are lost from the original location due to landslide, flood, change in topography or any other reasons
   - When measuring devices are out of order or get too old to replace them with the same ones of same specifications
   - When there is an event which affected some monitoring data due to change in conditions of civil works.

2. Monitoring is not mere accumulating measurement data but it is important to analyze the observed data in view of variation in order to detect the changes in the conditions of civil works.
3. Measuring instruments must be calibrated periodically to maintain their accuracy by the supplier of measuring devices or competent authority. Frequency of calibration must be decided in consultation with their manufacturers.

Article 70. (Article 70) Investigation of monitoring data

Paragraph 1 of Article 70

This paragraph lists major monitoring items of civil works to see if they are in sound conditions.

1. Purpose

In general, monitoring of dams is conducted during construction and operation for the following purposes.

- Construction supervision
- Study on problems of structural analyses and design method of dams
- Safety control

In general, it is judged that a dam is safe as long as values of monitoring data do not exceed those measured in the initial impoundment except in case of an earthquake. So it is practical to judge safety of a dam by comparing monitoring data with those measured at the normal high water level in the initial impoundment stage or near the normal high water level in normal operation stage rather than comparing them with design values.

In addition, in case of a fill dam, settlement of a dam body continues after completion of embankment, so safety of a dam must be judged not only by comparing monitoring data with those measured at the normal high water level in the initial impoundment stage or near the normal high water level but also by observing tendency in changes of settlement or deformation and also changes in seepage water level of an impervious zone in case of a zone type fill dam or seepage water level of the dam body in case of a homogeneous type fill dam.

Investigation of major monitoring items is shown in the following sections.

2. Displacement

Generally in concrete dams, displacement of a dam body fluctuates constantly according to fluctuation of air temperature, and water temperature and water level of a reservoir. A seasonal change affects displacement of a dam body more than a change in the reservoir water level in the order of a concrete gravity dam, arch gravity dam and arch dam.

Displacement according to a change in air and reservoir water temperature is not considered in design, so it is necessary to exclude an influence of a change in temperature from measurement records of displacement of a dam body by a graphical solution or a multiple regression analysis.

3. Water leakage

In many cases, serious dam breach accidents have occurred in the initial impoundment stage. According to case studies on a dam breach, in case that a dam breach is caused by defects of bedrock, a large amount of water leakage is observed around the bedrock where destruction starts.

Empirically, it is judged that water leakage may not affect dam safety if quantity of water leakage decreases with passing time or constant.

Water leakage is divided into the following three types.

(1) Water leakage from a reservoir to downstream of a dam by seepage through bedrock or through embankment in case of fill dams;

(2) Water leakage from a reservoir to downstream of a dam through joints and cracks of a concrete dam body or a surface diaphragm of surface diaphragm type fill dams; and

(3) Water leakage from foundations surrounding a dam.

For safety control of dams, water leakage of type (1) must be watched, especially that from a fault zone or other weak zones where there is a stratum consisting of fine particles.

In case significant increase in quantity of water leakage through bedrock is observed in the initial impoundment stage, it must be confirmed if water leakage is turbid. In case water leakage is turbid, the place where water springs up must be investigated and proper measures such as additional grouting must be conducted in the periphery of the place of water leakage. In case quantity of water leakage increases and especially turbid water springs up from a weak stratum, the reservoir water level must be lowered and measures must be considered. In case water leakage does not contain silt, mud or other small particles, and the place where water leakage springs up consists of sound rock, conditions of water leakage must be observed with the same reservoir water level as the time when water leakage is found first. In case quantity of water leakage remains constant or decreases, it is judged that a dam is safe against water leakage.

In other cases, quantity of water leakage sometimes increases immediately after a severe earthquake, however, the quantity decreases gradually and returned to its former value in most of the cases.

In case a dam meets with a severe earthquake, the dam is judged to be safe if quantity of water leakage decreases gradually though it increases suddenly just after the earthquake. In case quantity of water leakage just after a severe earthquake increases more than the maximum value observed in the initial impoundment, it is estimated that seepage paths are made in a dam body, dam foundation or bedrock. Under these circumstances, a situation in galleries, and upstream and downstream surface of a dam body must be investigated carefully, and places where quantity of water leakage got more than that before the earthquake must be confirmed, if any.

4. Uplift

In general, it is estimated that sudden increase in uplift is caused by formation of additional seepage paths and it often occurs with sudden increase in quantity of water leakage.

In case increase in uplift and quantity of water leakage occur simultaneously, the same measures as ”3. water leakage” must be considered.

In case only uplift increases and quantity of water leakage does not increase, uplift must be measured at drain holes around the hole(s) where increase of uplift is observed and the extent of high uplift must be investigated.

Paragraph 2 of Article 70 Investigation of monitoring data

In unusual or unexpected cases such as heavy earthquake or even aging of structure is observed, additional monitoring is required to secure the safety of structures. In this regard, this paragraph stipulates that the Owner must observe particular conditions of civil works listed above by surveys and investigations.

The background and approach of surveys and investigations works are described as follows;

- Vibration of civil works;
  Conditions of an intake, outlet, penstock and powerhouse must be observed to check if unusual excessive vibration which may damage their stability and function or cause fatigue fracture occurs.
- Durability and waterproof of concrete;
  Conditions of concrete at concrete dam and other concrete structures must be observed to check if damage or any kind of deterioration which may affect durability and watertightness of concrete such as cracks, alkali aggregate reaction, salt damage, neutralization, etc. occurs.
- Behavior of structures due to thermal stress;
  Conditions of structures at concrete dams and exposed penstocks must be observed to check if an extent of expansion and contraction is within a designed value and if excessive expansion and contraction cause water leakage, damage of supports or any other troubles.
- Corrosion of metal and concrete;
  Conditions of metal and major concrete structures must be observed to check if corrosion which may damage normal functions occurs.
- Conditions of welded seams;
  Conditions of welded seams at gates and exposed penstocks must be observed to check if defects which may damage stability or watertightness occur.

Paragraph 3 of Article 70 Investigation of monitoring data

This paragraph stipulates that the Owner must keep civil works in touch with requirements of the latest circumstances.)

Following changes in working conditions of civil works may severely change working conditions of civil works.

- Operating rules

  Change in reservoir water level: In case the normal high water level is raised, hydrostatic pressure acting on a dam increases. In case available drawdown is expanded due to change in use of reservoir water, change in seepage water level in a fill dam affects its stability.

  Change in reservoir operation rule: In case maximum discharge for power generation is enlarged for expansion of a powerhouse, an increase in drawdown rate becomes severer for stability of a fill dam.

- Natural conditions

  Change in river discharge: In case peak flood discharge increases due to climate change, flood water level may increase and hydrostatic pressure acting on a dam may increase.

  Change in sediment inflow: In case sediment inflow to a reservoir increases due to change in vegetation of the surrounding area, sediment level of a reservoir may rise and sediment pressure acting on a dam body may increase.

When the events including the above which would change the conditions of civil works severely occurred, an additional inspections and surveys are required to observe the change in the conditions and to check and confirm the stability and safety of civil works.

Article 71. (Article 71) Location and geometrical features

Displacement of civil structures are measured by survey works. To measure accurate dimensions of the structure and a long term tendency of change in location and dimensions, it is desirable that the same reference points must be used as long as possible.

- Base marks and mediate ones of civil works such as dams, headworks and powerhouses

  These marks are used as reference points of the structures.
- Location and elevation of anchor blocks of exposed penstocks;

  These data are used to measure displacement of anchor blocks.
- Geometrical features such as length, starting points, terminal points, radius of curves, and location of submerged and embedded equipment for dykes, dams, inlets, canals, and tunnels.

  These features are used to record initial conditions of the structures.

Article 72. (Article 72) Protection of measuring devices

This article stipulates that the Owner must keep measuring instruments in good conditions to conduct the monitoring accurately.

Important measuring instruments and relevant appurtenances must be installed in such a place that may not be damaged by natural hazards, i.e. torrential rain, inundation, debris avalanche, etc. The site of the instruments and relevant appurtenances must be protected by a fence and those doors and covers must be locked to prevent them from artificial obstruction.

Article 73. (Article 73) Board on flood control

Article 73 was prepared based on the requirements in Decree No.72/2007/ND-CP and Circular No.34/2010/TT-BCT. Relevant articles of decrees and circulars are as follows:

<u>Decree No.72/2007/ND-CP:</u>

Article 18. Protection boundary of dam

1. *Dam protection boundary includes dam and surrounding protection area*
2. *The dam Owner shall be responsible for defining, making benchmarks of the boundary of dam protection area in accordance to the Article 25 of the Legislation on Exploitation and Protection of Irrigation Projects; responsible for ensuring safety of dam and dam protection area in compliance with the Article 26 of the Legislation on Exploitation and Protection of Irrigation and other relating stipulations in laws.*
3. *For the reservoir area, the Provincial People Committees shall base on features of the province to issue concrete regulation and implementation of making benchmarks; responsible for management of project protection areas as specified in the Regulation.*

Article 20. Ensuring dam safety in flood seasons

1. *Dams belonged to flood control projects: each year, prior to the flood, raining season, the dam Owner shall prepare or update, supplement the alternative for protection against floods, typhoons, submit the alternative to the State competent organization for approval.*

2. *The contents of the alternative for protection against floods, typhoons shall include:*

   a) *Summary of features, conditions of water reservoir relating to the works for protection against floods, typhoons;*

   b) *Progress of situation and features of rains and floods at the upstream of the reservoir;*

   c) *Assessment of dam quality and equipment operating on the dam;*

   d) *Anticipating the dam unsafe circumstances which could happen and technical solutions for forecast, finding, copping with and warning on flood, typhoon.*

   e) *Preparation works on personnel, materials, back-up materials, equipment, transport means, communication, lighting etc.;*

   f) *List of members of steering committee on prevention and protection against flood, typhoon.*

3. *After the alternative has been approved, the preparatory works shall be performed; materials, tools shall be gathered and protected at the specified points; the technical staffs, rescuing team, rescuing facilities shall be managed in compliance with regulation in order to be ready for operation in when necessary. The Steering Committee on prevention and protection against flood, typhoon shall organize meeting for endorsement of the regulation on working and being on duty.*

4. *Throughout the flood, rainy season, the dam Owner shall maintain communication system in good working conditions and report the situation to the higher level of The Steering Committee on prevention and protection against flood, typhoon and State competent organization, as specified in the Regulation.*

<u>Circular No.34/2010/TT-BCT</u>:

Article 13. Flood protection for downstream areas caused by flood discharge or dam failure

1. Plans preparation a) The dam's owner shall collaborate with local authority in preparing flood protection plan for downstream areas when discharge flood or dam failure occurs, then submit to the Provincial People's Committee for approval; b) The plan shall list out the affected subjects, the influence degree and countermeasures in appropriateness with different flood situations.

2. Dam owner shall announce (by phone or fax) to the local meteorological & hydrological forecasting organization, Local Flood Control Steering Committee in downstream area the following content:

a) The operation of flood discharge gate according to regulations; b) The flood discharge in emergency cases; c) During regulating work performance for flood protection, data of monitoring and measurement times of upstream/downstream water level, flow into reservoir, flow out of spillway, discharge through turbine will be reported; estimating the water surcharge ability of reservoir based on the flow-in forecasting.

3. Dam owner shall install alarm and notice system to notify the upstream / downstream dam's owner, report immediately to the Provincial People's Committee, Local Flood Control Steering Committee for coming dangerous cases caused by dam damage or failure.

Article 14. *Organization of implementation*

1. Department of Safety Engineering and Industrial Environment – MOIT is head organization to carry out the inspection and approval for flood protection plans for dams cases as mentioned in Paragraph 2 of Article 12 of this Circular and inspect national wide the implementation of the regulations on dam safety management of hydropower structures.

2. DOIT takes a lead and collaborates with local competent authorities to inspect the implementation of the regulations on dam safety management of hydropower structures in the province.

Section 3 Mechanical Equipment for Civil Works

Article 74. (Article 74) General requirement

1. Maintenance works

- The purpose of the maintenance work at the hydromechanical equipment is to keep the equipment safe and certain conditions for the long time.
- The checks of the equipment must be implemented periodically as a general rule, but additional checks are conducted as needed for example before/after natural disaster.
- At the maintenance work and/or check, it is necessary to get rid of trashes in order to operate the gates certainly as well as to replace disposables.
- Periodical checks by actual operation are desirable to keep the equipment in good condition.

Article 75. (Article 75) Conditions of gates

1. 1Rust and wear
   - Corrosion at the bottom of the gate may develop rapidly, and corrosion caused by galvanic corrosion may become seriously at the limited part of a gate. Attention must be paid sufficiently to these phenomena at the maintenance.
   - Deterioration of the coating causes corrosion of the base metal. Therefore, condition of the coating must be checked carefully. Also the coating must be checked frequently as much as possible by means of observation, measuring thickness and so on.
   - The typical point at the visual check for coating is whether the following phenomena occurred or not;
     - Blistering
     - Cracking
     - Peeling
     - Chalking
2. Movement of gate
   - At a gate operation, the movement of gate leaf must be stable and an abnormal vibration and an abnormal sound must not occur. In addition, a gate must not be hooked unevenly. If a gate is hooked unevenly, there may be problems in water tightness and resting condition.
3. Positioning of gate
   - In many cases, a gate must be operated for detailed control of the reservoir water level and discharge volume. Therefore, position of the gate must be recognized correctly.
4. Water leakage from gate
   - Seal part of a gate may lose the function because it must endure under friction, pressure, deterioration, deformation and damage caused by intervened trashes. Attention must be paid to the above matter, and a seal rubber must be replaced if it is damaged.
5. Operating condition
   - When a gate is kept at minute opening (crack opening) for a long time, Vibration may occur and seal rubber may be damaged. Attention must be paid to the gate position.

Chapter 3 Management of Water Sources in Powerhouses, Assurance of Meteorology and Hydrology

Section 1 Water Regulation

Article 76. (Article 76) Principle of exploitation of water resources

This article stipulates that the Owner must prepare a plan on water use after due consultation with water users of other economic sectors such as waterway transportation, irrigation, aquaculture, and water supply for life and industry so that a plan on water use of one water user may not damage other water users' benefit.

Article 76 was prepared based on the requirements in Decree No.112/2008/ND-CP. Relevant articles of decrees are as follows:

<u>Decree No.112/2008/ND-CP:</u>

Article 8: Exploitation and use of reservoir's resources and environment

1. The exploitation and use of resources and environment in the protective corridor of reservoir and in reservoir must be based on scheme and plan approved by authorized office, ensuring not to affect the duty of reservoir; keep to technical stipulations of related industries or fields and keep to stipulations of landscape and environment protection; not affecting the technical characteristics of reservoir, and not blocking much water current into reservoir.

2. Precinct people's committee, communal people's where the reservoirs locate are responsible for checking, inspecting the use and exploitation of resources and environment as approved scheme and plan.

3. According to the affecting level to safety, and insurance of implementing reservoir's duty, projects which were built in protective corridor of reservoir must be dismounted, moved or considered for continuous use, but it must obey technical requirements, approved by reservoir's owner in writing and by authorized office according to stipulation of law.

4. The following activities in protective corridor of reservoir and in reservoir (except for the stipulations in section 5 of this Article) can only be implemented when they are approved by the owner in writing and certified by authorized office according to stipulation of law:

a) Building new project;

b) Letting out sewage into water source of reservoir;

c) Exploiting, using water resource of reservoir;

d) Drilling, digging for inspection, geological investigation, exploration, implementation of projects for exploiting underground water, drilling and digging investigation for exploiting minerals; drilling and digging investigation for exploiting construction materials;

đ) Planting long term trees;

e) Activities of tourism, sports, scientific research, business, services;

g) Activities of vehicles (except for two-wheel motors, tri-motors, motorbikes and vehicles for disables);

h) Building warehouses, grounds; stations for cargo or passengers; gathering material, fuel, vehicles;

i) Building breeding facilities, grazing cattle, raising aquatic products;

k) Burying, spilling waste, discarded stuffs;

l) Exploding mines and other activities causing explosion without harm

m) Building underground projects, including oil pipes, electric cables, informatics cable, supplying and drainage water pipes.

5. The following activities are forbidden in reservoir:

a) Building houses, residential living quarter;

b) Building husbandry breeding facilities, building ponds for cultivating aquatic products;

c) Burying, filling up waste, discarded stuffs;

d) Exploding mines and other activities causing harmful explosion.

Article 77. (Article 77) Plan on water use

Article 77 was prepared based on the requirements in Decree No.112/2008/ND-CP. Relevant articles of decrees are as follows:

Decree No.112/2008/ND-CP:

Article 9: Regulating water of reservoir

1. Operating process of reservoir should be established and submitted to authorized office for approval before accumulating water of reservoir, satisfying fully duties of reservoir in priority order, ensuring the safety of project, safety of reservoir's lowlands, general exploit resources and environment of reservoir, maintain minimal water current in the reservoir's lowlands, not causing much change to current at reservoir's lowlands and consider the factor of climate changing; go with operating process of join reservoirs in river valley (if exist) approved by authorized governmental office.

2. The owners of reservoir have duties to supervise, collect information, data of hydrometeorology by their own expense to serve the demand of protection, management, operation, exploitation of reservoir as instruction of governmental managing office for resources and environment and send annual report of implementing result to specialized managing Ministry and related provincial people's committee.

3. Annually, owners of reservoirs are responsible for making plans of regulating water in reservoirs and inform the plan of water regulation to people's committees of different levels where the reservoirs locate and area of reservoir's lowlands to reduce bad effect on production, life of people and environment.

4. The plan of water regulation in reservoir is established based on operating process of reservoir approved by authorized governmental office, demand of maintaining minimal water current, forecast of current changing in the year from hydro meteorological office and the water using demand by sections, local area, economic organizations.

5. In case, offices, related organizations and locality don't agree with the plan of water regulation in reservoir, they can send their petition to owner of reservoir and authorized governmental offices to consider, decide the plan of water regulation in reservoir.

Article 78. (Article 78) Water discharge and storage regime

Article 78 was prepared to let the dam Owner regulate the reservoir water level and discharge water according to the reservoir operation rule prepared after due consultation with other water users.

The first sentence of paragraph 1 allows fluctuation out of the rules in some particular cases but within the limit of the allowable water level for safety based on Chapter III of Decree No.72/2007/ND-CP and aims at keeping the reservoir water level provided that a water level in a reservoir must not be higher than the water level stipulated by the State competent management organization.

Article 10. Regulation of water in reservoir

1. *The regulation of water in the reservoir shall be in compliance with the following:*
    a) *Water level in the reservoir shall not be higher than water level stipulated by the State competent management organization;*

    The paragraph 4 is based on Chapter III of Decree No.72/2007/ND-CP and aims at giving priority to flood control over a reservoir operation of other purposes in the flood season.

Article 10. Regulation of water in reservoir

2. *The regulation of water in the reservoir shall be in compliance with the following:*
    b) *In flood season, the water reservoirs are responsible for flood control, the operation on water filling and flood discharging shall be prioritized for ensuring dam safety, and the flood control and water filling shall be in compliance with the functions of the projects.*

Article 79. (Article 79) Adjustment of hydraulic characteristics of spillway and runoff

Article 79 was prepared to let the dam Owner study, from time to time based on the latest data obtained during the operation stage, how to discharge floods from spillway to minimize damage to the downstream area.

The dam Owner must consider the optimum way to discharge floods from spillway based on hydrological data and hydraulic characteristics of a spillway and revise it continuously using hydrograph of flood and accumulating river discharge data in a manner of the PDCA cycle method.

Here, the hydraulic characteristics of spillway will not change from the design in principal unless a remedial work or replacement of spillway gates is conducted. In the case that a remedial work or replacement is made on the spillway gates structure, it is essential to modify the operation rule and the modified rules must be reported to the competent authority for approval.

The hydraulic characteristics of natural runoff may change from time to time depending on changes in the conditions of river basin. Therefore, it is essential to measure the daily river flow as well as flood flow in order to know the change in characteristics of river runoff and flood hydrographs. Then, the reservoir operation rule and spillway operation rule must be updated so as to fit the changed characteristics of flow resume in order to achieve optimum operation of hydropower plant and reservoir.

Article 80. (Article 80) Operating manuals for spillway

Article 80 was prepared based on the requirements in Circular No.34/2010/TT-BCT. Relevant articles of decrees and circulars are as follows:

Circular No.34/2010/TT-BCT:

Article 10. Hydropower reservoir operation procedure

1. *The procedures are prepared by the dam's owner in compliance with the provisions of Decision No. 285/2006/QD-TTg of the Prime Minister dated December 25, 2006 regarding the power for promulgation and execution of the hydropower reservoir operation procedure, and submitting to competent authority prior to reservoir impounding;*
2. *Competence for approving reservoir operation procedure*
   a. *MOIT approves the procedure of reservoir having capacity of equal or greater than 1,000,000 m3 or for reservoirs located in more than two provinces, except for cases complying with the provisions in Article 12 of Decree 112/2008/ND-CP of the Government dated October 20,2008 regarding the comprehensive protection, management and exploitation of resources and environment of hydropower and hydraulic reservoir;*
   b. *The provincial People's Committee approved the procedures for remaining cases.*
3. *The regulation of water reservoirs shall follow the provisions in the approved procedures.*
4. *Trial test fo*r gates of the structures
   a. *Procedure of dry test for gates is prepared by dam's owner depending on the characteristics of the structures and conduct this test at least once a year before the flood season. Repair works for the gates after dry test shall be finished before the annual flood season;*
   b. *Procedure of wet test for gates is prepared by dam's owner. Depending on hydrological conditions and the characteristics of each structure, the gates wet test can be carried out by beginning of flood season but shall not affect to the downstream area when discharging water through the spillway.*

<u>Decision No: 285/2006/QD-TTg</u>

Article 1. Scope and objects subjected for appliance

1. This *Decision* regulates content of the operation procedures of hydropower reservoirs, competence and responsibilities of organizations, individuals toward the preparation, submission and compliance of reservoir operation procedure.
2. This Decision shall be applied by organizations, and individuals of every sectors who involve in *construction* investment, management and exploitation of hydropower reservoirs, except for cases using small-scale reservoirs for generation of house-hold purpose.

Article 2. Content of the reservoir operation procedures

1. Mission of the hydropower structures.
2. Main *criteria* of the hydropower structures:
   a) *Name and location of the structures;*
   b) *Main criteria of the reservoirs and structures;*
   c) *Criteria of relevant equipment (Number of units, capacity, and specifications of operation equipment).*
3. *Detailed provisions of the reservoir operation procedures:*
   a) *Provisions on flood prevention mission:*
      - *Periods of early flood, main flood and late flood;*

- *Water level of reservoirs in periods of early flood, main flood and late flood;*
- *Performance of reduction of frequent flood and big flood for downstream (implemented for structures with flood reduction mission for downstream);*
- *Handling procedure of valve gate insuring safety operation which shall ensure water level of reservoirs not exceeding designated level of all cases;*
- *Coordination principle between flood reduction and control structures (if any).*

b) *Provisions on power generation mission:*

- *Working regime of hydropower plants in the system;*
- *Requirement of water release volume for the downstream ensuring ecological flow (if any);*
- *Requirement of downstream level fluctuation caused by operation procedure regime of the plants (if any);*
- *Coordination principle of generation mission amongst other sub-missions (if any).*

4. *Responsibilities to organize the reservoir operation:*
   a) *Responsibilities of organizations and individuals issuing orders;*
   b) *Responsibilities of organizations and individuals carrying out those orders;*
   c) *Responsibilities to notify the orders to affected area caused by valve operation;*
   d) *Responsibilities relating to the safety of the structures;*
   e) *Principles in dealing with the accidents when operating the structures;*
   f) *Responsibilities of inspecting the structures and reservoirs before and after flood season;*
   g) *Responsibilities in dealing with damage and faults relating to the structures, and equipment which ensure the safety of exploitation and operation of hydropower structures and reservoirs during flood season.*

Article 3. Competence to approve the reservoir operation procedure

1. *Prime Minister shall approve the operation procedure for specially important reservoirs whose control regimes impact strongly to the safety of dykes and social-economic activities of provinces, cities or neighbouring countries.*
   Industry Ministry shall appraise and submit the mentioned procedures to Prime Minister for review and approval.
2. *Ministry of Industry shall take lead and collaborate with MARD, National Steering Committee of Flood Prevention and relevant local authorities for appraisal and approval of the operation procedure of reservoirs with capacity equal or greater than 1,000,000 cu.m, except for reservoirs stated in Clause 1 of this Article.*
3. *People's Committees of Provinces, Cities shall take lead and collaborate with relevant agencies and Local Steering Committee of Flood Prevention for appraisal and approval of operation procedure of the local reservoirs with capacity lower than 1,000,000 cu.m. This approval Decision shall be sent to Ministry of Industry for consolidation and management.*

Article 4. Organization for execution

1. *Ministry of Industry shall take lead and collaborate with MARD, National Steering Committee of Flood Prevention and relevant local authorities for inspecting the execution of this Decision and the approved operation procedures of reservoirs; solving problems and proposing Prime Minister for amendment and supplementation of the Decision if necessary.*
2. *People's Committees of Provinces and Cities shall disseminate, instruct and inspect the execution of this Decision and the locally-approved operation procedures of reservoirs; solving problems and proposing competent authorities for amendment and supplementation of the Decision if necessary.*
3. *Responsibilities of organizations and individuals who are investors and owners using, exploiting and operating the hydropower structures:*
   a) *Investors of newly constructed structures shall prepare the operation procedures of hydropower reservoirs and submit to the competent level for approval synchronously with the appraisal of basic design;*
   b) *Owners of the operated structures shall prepare the operation procedures of hydropower reservoirs and submit to the competent level for issuance within 03 months since the effective date of this Decision;*
   c) *Owners who use, exploit and operate the hydropower structures shall take liabilities relating to the compliance of the reservoir operation procedures.*
4. *The operation procedures issued before the effective date of this Decision shall be revised and supplemented in compliance with the content of this Decision and relevant regulations.*

Article 81. (Article 81) Spillway operation

Article 81 is related to the requirements in Decree No.72/2007/ND-CP and Decision No: 285/2006/QD-TTg. Relevant articles of the decree and decision are as follows:

Decree No.72/2007/ND-CP:

Article 22. Prevention against floods, inundation for downstream area of dam

1. *In case, water discharge from reservoir makes sudden increase of water level in the river sections in the downstream sides of the flood discharge structure, the dam Owner shall have measures to announce in advance in order to ensure safety for people, ships, boats, and transporting means going through rivers, streams.*
2. *The dam Owner shall prepare the alternative of prevention and protection against flood, typhoon for dam protection for the downstream areas, submit the alternative to the State competent organization, in order to cope with the inundation situation due to urgent water flood discharge or situation of dam break, in order to protect lives of people and mitigate damages of lives and properties of the downstream areas of the dam.*

Decision No: 285/2006/QD-TTg:

Article 2. Content of the reservoir operation procedures

1. *Mission of the hydropower structures.*

2. *Main criteria of the hydropower structures:*
   a) *Name and location of the structures;*
   b) *Main criteria of the reservoirs and structures;*
   c) *Criteria of relevant equipment (Number of units, capacity, and specifications of operation equipment).*
3. *Detailed provisions of the reservoir operation procedures:*
   a) *Provisions on flood prevention mission:*
      - *Periods of early flood, main flood and late flood;*
      - *Water level of reservoirs in periods of early flood, main flood and late flood;*
      - *Performance of reduction of frequent flood and big flood for downstream (implemented for structures with flood reduction mission for downstream);*
      - *Handling procedure of valve gate insuring safety operation which shall ensure water level of reservoirs not exceeding designated level of all cases;*
      - *Coordination principle between flood reduction and control structures (if any).*
   b) *Provisions on power generation mission:*
      - *Working regime of hydropower plants in the system;*
      - *Requirement of water release volume for the downstream ensuring ecological flow (if any);*
      - *Requirement of downstream level fluctuation caused by operation procedure regime of the plants (if any);*
      - *Coordination principle of generation mission amongst other sub-missions (if any).*
4. *Responsibilities to organize the reservoir operation:*
   a) *Responsibilities of organizations and individuals issuing orders;*
   b) *Responsibilities of organizations and individuals carrying out those orders;*
   c) *Responsibilities to notify the orders to affected area caused by valve operation;*
   d) *Responsibilities relating to the safety of the structures;*
   e) *Principles in dealing with the accidents when operating the structures;*
   f) *Responsibilities of inspecting the structures and reservoirs before and after flood season;*
   g) *Responsibilities in dealing with damage and faults relating to the structures, and equipment which ensure the safety of exploitation and operation of hydropower structures and reservoirs during flood season.*

Article 3. Competence to approve the reservoir operation procedure

1. *Prime Minister shall approve the operation procedure for specially important reservoirs whose control regimes impact strongly to the safety of dykes and social-economic activities of provinces, cities or neighbouring countries.*

   Industry Ministry shall appraise and submit the mentioned procedures to Prime Minister for review and approval.
2. *Ministry of Industry shall take lead and collaborate with MARD, National Steering Committee of Flood Prevention and relevant local authorities for appraisal and approval of*

the operation procedure of reservoirs with capacity equal or greater than 1,000,000 cu.m, except for reservoirs stated in Clause 1 of this Article.

3. *People's Committees of Provinces, Cities shall take lead and collaborate with relevant agencies and Local Steering Committee of Flood Prevention for appraisal and approval of operation procedure of the local reservoirs with capacity lower than 1,000,000 cu.m. This approval Decision shall be sent to Ministry of Industry for consolidation and management.*

Article 4. Organization for execution

1. *Ministry of Industry and Trade shall take lead and collaborate with MARD, National Steering Committee of Flood Prevention and relevant local authorities for inspecting the execution of this Decision and the approved operation procedures of reservoirs; solving problems and proposing Prime Minister for amendment and supplementation of the Decision if necessary.*
2. *People's Committees of Provinces and Cities shall disseminate, instruct and inspect the execution of this Decision and the locally-approved operation procedures of reservoirs; solving problems and proposing competent authorities for amendment and supplementation of the Decision if necessary.*
3. *Responsibil*ities of organizations and individuals who are investors and owners using, exploiting and operating the hydropower structures:
   a) *Investors of newly constructed structures shall prepare the operation procedures of hydropower reservoirs and submit to the competent level for approval synchronously with the appraisal of basic design;*
   b) *Owners of the operated structures shall prepare the operation procedures of hydropower reservoirs and submit to the competent level for issuance within 03 months since the effective date of this Decision;*
   c) *Owners who use, exploit and operate the hydropower structures shall take liabilities relating to the compliance of the reservoir operation procedures.*
4. *The operation procedures issued before the effective date of this Decision shall be revised and supplemented in compliance with the content of this Decision and relevant regulations.*

Regarding the paragraph 3 of Article 81 "As for discharge through hydraulic turbines, it is not required to regulate change rate of discharge and to inform related gauging stations and local authorities in advance", the dam Owner does not have to inform the downstream area of discharge by hydropower generation in principle, however, the dam Owner is recommended to consider installation of an alarm system in case sudden fluctuation of discharge through turbine for hydropower generation cause dangerous situation for human life working in the downstream area.

Article 82. (Article 82) Discharge capacity for design flood and check flood

Article 82 was prepared to secure safety margin for discharge capacity of spillway to prevent dam from being breached or overtopped due to flood inflow which exceeds spillway capacity.

In calculating design discharge capacity of a spillway, discharge capacity of other outlet works, fish way, ship lock or other works through which reservoir water flows must not be counted as decrees or circulars related to management of dam safety require.

In calculating the actual maximum discharge of a spillway, discharge capacity of other outlet works, fish way, ship lock or other works through which reservoir water flows must be counted to estimate the whole discharge for record.

The dam Owner must prepare emergency rules to mobilize discharge facilities including a spillway considering occurrence of extreme flood which may exceed design discharge capacity of a spillway and must negotiate about use of those outlet works in case of emergency with related organizations which manage those outlet works at ordinary times.

Article 82-a1. (Article 82-a1) Warning on dam failure

Article 82-a1 was prepared based on the requirements in Decree No.72/2007/ND-CP. Relevant articles of decrees and circulars are as follows:

Decree No.72/2007/ND-CP:

Article 21. Rescue to dam

In case accident happens, which could make unsafe to the dam, the rescue works shall be urgently performed with highest priority and efforts for keeping safety of the projects and minimizing damage.

The People Committees at all levels, within their functions and responsibilities, shall be responsible for organizing rescuing works on the dam and participating in rescuing works for the dams of the other localities in compliance with laws.

In addition, the dam Owner must prepare a suitable type of a warning system in a proper manner and location in cooperation with the People Committees.

Article 82-a2. (Article 82-a2) Measurement of downstream water level

Article 82-a2 was prepared to let the Owner measure the tailrace water level for observation of the head for power generation for proper monitoring of power plant operation.

Measurement of the downstream water level or the tailrace water level is indispensable to observe the head for power generation The Owner must put a measuring device of the downstream water level of a dam or the tailrace water level at a suitable place.

Article 82-a3. (Article 82-a3) Protection of downstream areas from inundation

Article 82-a3 is related to the requirements in Decree No.72/2007/ND-CP and the guideline for this article can be referred to that for Article 81.

Section 2 Environment in Reservoir

Article 83. (Article 83) Sedimentation in reservoir

This article is prepared to know a change in reservoir capacity, quantity of sediment in a reservoir and riverbed level, and to take measures in case a rise in a riverbed level causes damage to the area surrounding a reservoir.

1. Area of survey

The survey area must be entire area of a reservoir impounded by the dam and backwater area.

2. Time of survey

Measurement of sedimentation must be conducted just after the flood season unless otherwise specified.

3. Contents of activities

The following items must be conducted.

- Calculation of sediment volume in a reservoir according to longitudinal or transverse survey
- Calculation of flood water level based on survey of sedimentation in a reservoir
- Investigation of the area affected by rise in flood water level due to progress in sedimentation
- Monitoring on situation of exploitation of sediment deposit in a reservoir
- Investigation and assessment on influence of progress of sedimentation on a reservoir operation rule
- Taking measures against problems such as decrease in effective reservoir capacity, inundation of a backwater area of a reservoir, etc.

4. Report

A report must contain the following items.

- Situation of sedimentation in a reservoir
- Investigation and assessment on influence of progress of sedimentation in a reservoir
- Map of the area inundated by flood
- Plan of a reservoir
- Longitudinal section of a reservoir
- Major cross sections of a reservoir

Article 84. (Article 84) Restriction on use of chemical herbicide

Article 84 was prepared to let the Owner comply with the environmental regulations when he is obliged to use chemical herbicides.

In case it is necessary to weed out undesirable plants from a riverside or around the reservoir, the Owner must use herbicides which comply with environmental regulations so that chemical spraying may not pollute soil or reservoir water.

In case reservoir water is the source of water supply, the Owner must consult with an administrative bureau of a city water and pay close attention to selecting herbicides.

Article 85. (Article 85) Monitoring of reservoir water quality

Article 85 was prepared to let the Owner comply with the environmental regulations by checking reservoir water quality periodically.

The Owner must check water quality of the reservoir following items and intervals which are prescribed in the environmental regulations.

Section 3 Hydro-Meteorological Activities

Article 86. (Article 86) Use of hydro-meteorological data for safe operation

Article 86 was prepared based on the requirements in Decree No.72/2007/ND-CP. Relevant articles of decrees and circulars are as follows:

Decree No.72/2007/ND-CP:

Article 12. Measurement, monitoring of dam and meteorological- hydrological parameters

1. *For large dams:*
   a) *After taking over the works of management, the dam Owner shall organize measurement, monitoring or contracting with professional agencies to carry out measurement, gathering meteorological-hydrological data of the catchments of reservoir, progress of seepage through dam body, dam bed, dam abutment, dam displacement, dam cracks, slides in dam foot, foundation and surrounding areas, the sedimentation in the reservoir.*
   b) *The measurement documents shall be adjusted, analyzed, evaluated, compared with the design and forecast data; finding the sudden phenomenon in order to make decision on remedial measures in time; implementation of documentation preservation in accordance to the regulation.*
2. *For small dams: the measurement of water levels and other measurements as specified by the design consulting company.*

The dam Owner must prepare a standard method of hydro-meteorological surveying following the example of those of the hydro-meteorological agencies and instruct employees in charge of hydro-meteorological surveying who are working at hydropower plants under the control of the dam Owner of the standard method.

An example of a measurement method of river discharge is as follows.

1. Select a suitable place for a gauging station where a rive flow route is stable, and excessive erosion or sedimentation may not occur;
2. Survey the river cross section, and measure river depth and average velocity periodically;
3. Prepare a rating curve indicating the relation between the river water level and river discharge;
4. Install a staff on a river bank so that a person in charge of river discharge measurement can observe the river water level;
5. Observe the river water level at a staff gauge at a fixed time of a day and record river discharge from the rating curve; and
6. Survey the river section periodically and after the flood season or whenever after large flood occurs in order to review and update the rating curve.

The dam Owner must collect hydro-meteorological data from his own gauging stations and from the hydro-meteorological agencies, and analyze them so that hydropower plants under the control of the dam Owner can control hydropower generation more efficiently, and discharge of flood water from dams safely and effectively to minimize damage to the downstream area.

Article 87. (Article 87) Grasp of daily runoff data

Article 87 was prepared to let the Owner manage quantity of water flowing out of a reservoir and record it.

In order to complete the record of reservoir operation and power plant operation, it is necessary to sum-up the records of all of the inflow and outflow items not only through power generation (though turbine) but also through civil works including low level outlet, flushing gate etc. and other facilities including ship lock and fishways. In this regard, it is required for the owners to equip measuring device of water flow or water level gauges for calculation of runoff through spot of inflow and outflow.

An example of recording method of inflow and outflow of a hydropower plant is as follows.

1. Gathering meteorological and hydrological information from related organizations;
2. Listing up all spots of inflow and outflow at a hydropower plant;

Inflow rate is acquired from following methods;

- from change in reservoir water level using a rating curve of reservoir water level and storage capacity;
- from gauging station at upstream of the reservoir installed by the Dam owner, meteorological and hydrological authorities, or any other companies and organizations which observe river discharge;

Outflow rate is acquired from following methods;

- from output of generators and difference of elevation between intake and outlet using an efficiency curve;
- from measuring device of flow rate installed at headrace, penstock, spillway, low level outlet, flushing facilities, ship lock, fishway, or any other devices through which reservoir water is discharged to downstream;

3. Recording daily inflow and outflow thorough each spot;
4. Summing up total inflow and outflow.

Article 88. (Article 88) Survey of operating conditions and criteria

This article stipulates that the Owner must survey meteorological and hydrological data at the point of a hydropower plant and measure environmental conditions of a reservoir.

1. Locations to measure the water level must be fixed at upstream and downstream of weir intake and canal and the water level must be measured with the proper method and at proper interval.
2. Water discharge through civil works such as spillway, bottom outlet, fish way ship lock or other facilities, and hydraulic turbines must be measured with the pooper method and at proper interval.

3. Locations to measure water turbidity and sedimentation must be fixed at proper points of a reservoir, and water turbidity and sedimentation must be measured with the pooper method and at proper interval.
4. Locations to measure water quality for power generation use and discharge from civil works must be fixed at proper points of a hydropower plant, and water quality for power generation use and discharge from civil works must be measured with the pooper method and at proper interval.
5. Locations to measure temperature of water and air must be fixed at proper points of a hydropower plant, and temperature of water and air must be measured with the pooper method and at proper interval.

Article 89. (Article 89) Reliability and accuracy of gauging stations

This article stipulates that the Owner must prove and maintain accuracy of river discharge measurement by himself.

1. Purpose

This article aims at maintenance of accuracy in measurement of runoff by instructing details of measurement methods.

2. Installation of gauging stations

A gauging station must be installed in a place satisfying the following conditions.

- River flow is not too rapid or too slow;
- Watercourse does not move so much;
- River water does not have reverse flow toward upstream or stagnate;
- River water level does not fluctuate by tributaries or distributaries; and
- Existing structures do not affect river flow conditions.

3. Facilities of gauging stations

The following facilities must be installed at gauging stations.

(1) Measuring device of river water level

A measuring device of a river water level must be installed at the place satisfying following conditions.

- A place where river flow or flood does not move or wash away the device; and
- A place where is convenient for measurement.

(2) Self-recording device of river water level

A self-recording device of a river water level must be installed as follows.

- The most suitable device which fits the site conditions must be selected;
- The device must be able to record the maximum and minimum river water level accurately; and
- A staff gauge must be installed near the device to compare records of the device with reading of the staff for checking.

(3) Staff gauge

A staff gauge must be installed as follows.

- A staff gauge must be fixed firmly so that it may not be affected by flowing water or driftage;
- A staff gauge must be marked off in centimeters;
- In case plural staff gauges are installed in stages due to topography of a river section, each staff gauge must be installed in one alignment; and
- The zero point must be installed at the elevation lower than the minimum river water level.

4. Measurement of river flow velocity

River flow velocity must be measured as follows.

- River flow velocity must be measured XX times per month;
- Frequency in measurement of river flow velocity can be reduced in case a river section has not changed in the past YY years; and
- River flow velocity must be measured by a current meter at AA m intervals in a transverse direction of a river and at BB, CC and DD % of the depth at each section.

The criteria of XX, YY, AA, BB, CC and DD must be decided at each gauging station.

5. Calculation of river runoff

River runoff must be calculated as follows.

- River runoff must be calculated by averaging river flow velocity measured at each point;
- A rating curve of river water level and river runoff must be calculated by a least squares method or other appropriate method; and
- A rating curve must be revised whenever topography of a river section changes due to flood or other causes.

6. measurement of river runoff

River runoff must be measured as follows.

- A river water level must be measured YY times at the fixed time per day by reading a staff gauge;
- In case of flood, a river water level must be measured at FF hours intervals and a peak water level must be measured;
- A river water level must be converted into river runoff by a rating curve; and
- In case a self recording device is installed at a gauging station, measurement of a river water level of a flood can be omitted.

Article 90. (Article 90) Notification for violation of regulation on water use

A hydropower plant may accidentally discharge turbid water stored in a reservoir or violate regulations on water usage in an emergency situation. In such case, the Owner must inform the hydro-meteorological agencies and the environmental management agencies immediately of it.

Chapter 4 Hydraulic Turbine / Generator

Article 91. Oil Treatment (Deleted)

(Article 91 is deleted and moved to Article 382-a1 of Chapter 15 "Energy Oil" in Part 6.)

Article 92. Efficient operation

1. The turbine or pump-turbine must be, basically, operated within high-efficiency area in the efficiency curve (hill curve) according to the requirement of relevant situation for power system and hydraulic condition.
2. The power plant is generally operated by some control devices after parallel-in the power system, such as Automatic frequency control (AFC), Joint control (Automatic Load Regulator (ALR) and/or Automatic Reactive Power Regulator (AQR)), Governor free operation, Load limiting control. When they are applied, it is necessary to set them at a high effective position to get optimum power taking account of the relevant situation for power system, hydraulic condition, etc,
3. In case of pumping operation of the pumped storage power plant, a control device is applied confirming the difference between water levels of upper and lower pounds, in order to curry out an optimum pumping operation.

Article 93. Changeable operation mode

1. In case of equipping a remote control and automatic controlling system in the power plant, it is necessary to conduct the tests to confirm the changeable operation mode shown in Table 93-1, -2 and Figure 93-1 as well as a manual control to be controlled by the master switch.
2. The requirements of changeable operation mode for hydraulic power plant must be specified by the Technical Specifications of each power plant as follows, shown in Table 93-1, -2 and Figure 93-1 in general;

Table 93-1 Changeable Operation Mode

Mode / Power plant	Generating mode (G)	Pumping mode (M)	Synchronous Condenser in Generating mode (SG)	Synchronous condenser in Pumping mode (SM)	Line charging mode (CH)
1) Generation only	○	×	×	×	○
2) Generating and Synchronous Condenser	○	×	○	×	○
3) Generating, Pumping and Synchronous Condenser	○	○	○	○	○

Note: 1. Power plant 2) could be changeable both modes between (G) and (SG) vice versa.
2. Power plant 3) could be changeable as following Table 93-1;

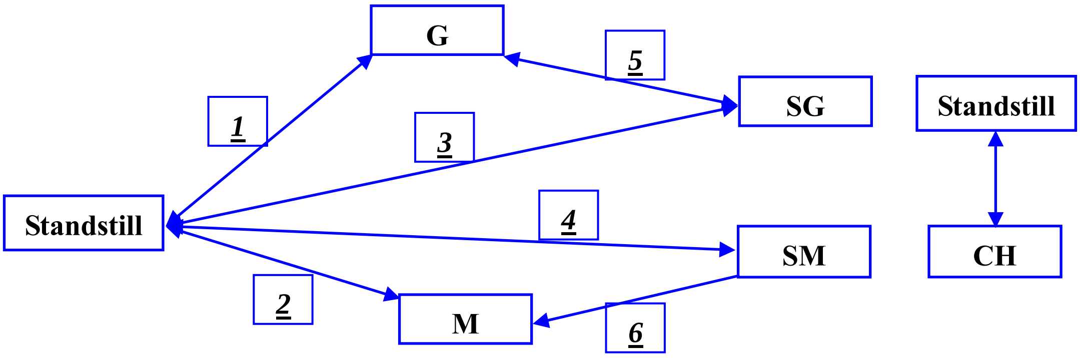


Figure 93-1 Changeable Operation Rule

Table 93-2 Changeable Operation Rule

Rote	Mode	Direction	Mode	Note
1	Standstill	←→	G: Generating mode	
2	Standstill	←→	M: Pumping mode	
3	Standstill	←→	SG: Synchronous Condenser in Generating mode	
4	Standstill	←→	SM: Synchronous Condenser in Pumping mode	
5	G	←→	SG	
6	M	←	SM	
7	Standstill	←→	CH: line charging mode	

Note: SG and SM are applied to a spinning reserve operation.

Article 94. Joint operation

1. The operation of joint control system must be carried out in order to adjust the total station active or reactive powers to the set reference value by the command remotely from the Load Dispatch Center or local control room in the power plant. Based on required active power or required voltage level and availability of the units, the control system must divide the active load or the reactive load between the units to obtain the best station efficiency.
2. The active power joint control system must be applied in order to make a balance for operation time, electric energy and output power of several units installed in the power plant.

Article 95. Protection of power plant

1. The protection of the hydraulic generator must be confirmed to carry out with the tests for all alarm and tripping circuits with interlock circuit of all electromechanical equipment in accordance with sequence diagram.
2. The tests data must be assessed statistically for maintenance & operation data, < e.g.> operating / sequence time with operating value or level for pressure oil or air, pressure oil level, measuring value of electrically, temperature & humidity, etc.,

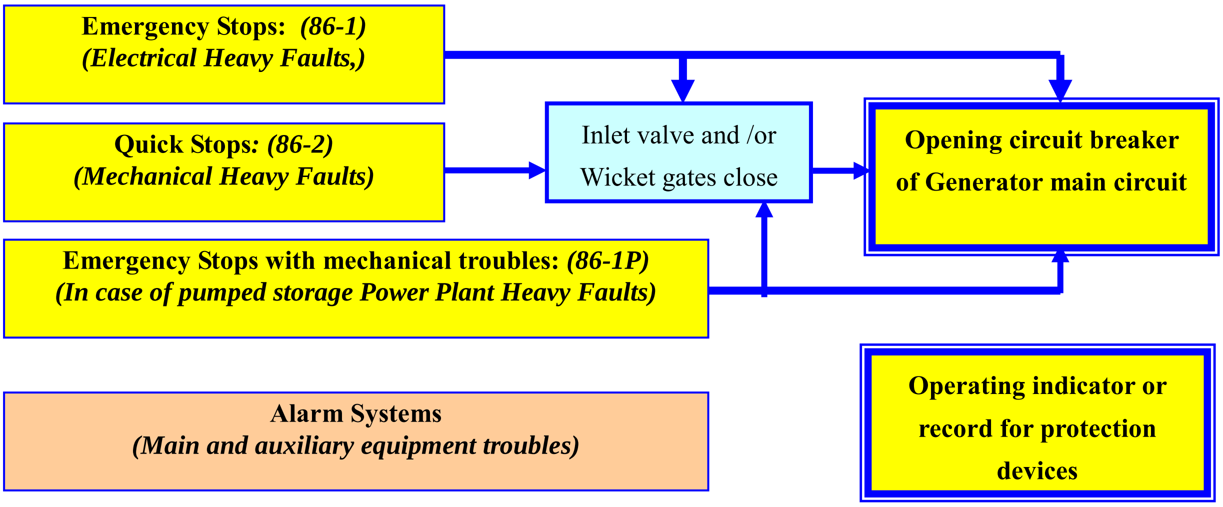


Figure 95-1 Sequence Diagram of Protection System

Article 96. Operation approval

1. The Owner must prepare the checking sheets with inspection/test plan for all equipment/devices before starting working at the site. The checking sheets of the inspection/test must be shown on the previous data with manufacturers' data for each equipment/device.
2. The results of inspection/test must be confirmed by Owner for all equipment/devices carefully, and after that, the Owner must approve to start-up the generator in a cautious manner for every location.

Article 97. Vibration

<Refer to Article 98-a1 of Guideline for Technical Regulation Vol.5.>

Article 98. Runner inspection

1. In case where works need being implemented in runner pit, it is imperative to discharge all water from penstock and/or runner pit through the drainage pipe.
   (1) If an inlet valve to be installed between the penstock and spiral casing of turbine, all water in the penstock and runner pit is not necessary to discharge from penstock in general, i.e. the water in the runner pit must be drained after closing and mechanical & electrical locking the inlet valve and a draft tube gate completely.
   (2) If an inlet valve to be not installed between the penstock and spiral casing of turbine, all water in the penstock and runner pit is necessary to discharge from penstock and runner pit, i.e. all water in the penstock and runner pit must be drained after closing and mechanical & electrical locking the intake gate and a draft tube gate completely.
2. The runner inspection must be carried out to check cavitation corrosion, erosion, crack, etc., together with inspection for the spiral casing, wicket gate with its sealing gaps, draft tube, painting condition of inside, etc., in accordance with an operation & maintenance manuals of each power plant.

3. The repairing cavitation corrosion, erosion, crack, etc., must be curried out by the suitable process, <e.g.> a welding process. However, a suitable repairing period must be decided by the result of the inspection.

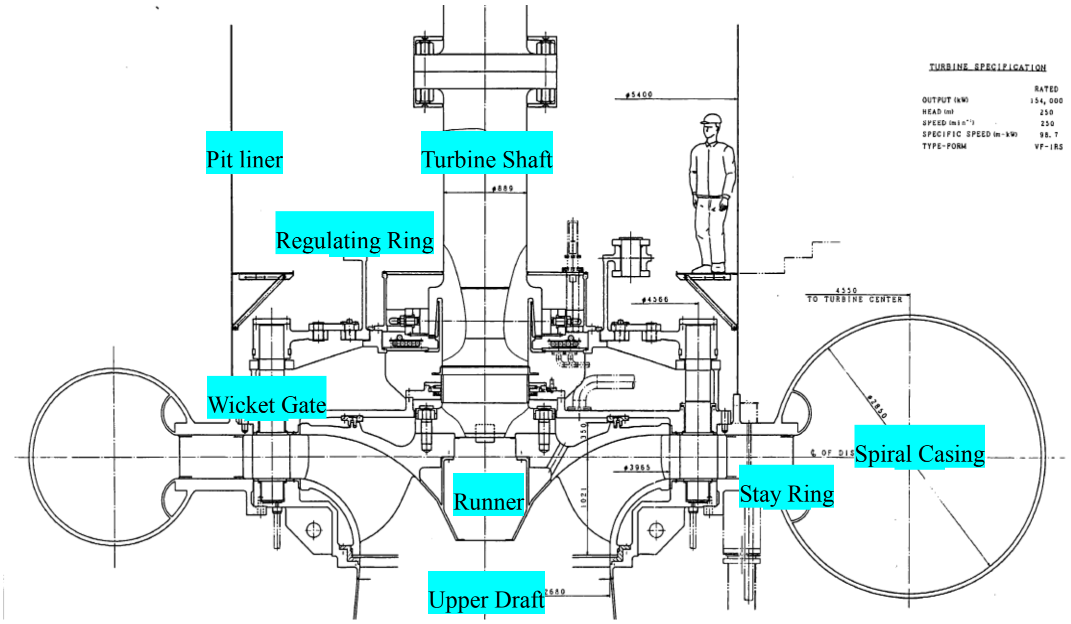


Figure 98-1 Cross-section of Francis Turbine
(An example of Turbine Pit of Hydraulic Power Plant)

Article 99.   Hydraulic pressure inside penstock

1. The designed value of pressure rise ratio (ΔP) of the penstock for the load rejection must be specified in the Technical Specification according to the type of civil design of power plant, as follows;
   (1) In case of long length penstock or high water head for turbine, a pressure rise ratio is small.
   <e.g.> ΔP ≤ 40%, (refer to speed rise ratio of turbine : ΔN ≥ 40%)
   (2) In case of short length penstock or low water head for turbine, a pressure rise ratio is high.
   <e.g.> ΔP ≥ 60%   (refer to speed rise ratio of turbine : ΔN ≤ 15 %)
   <Refer to Item 9, in Article 92 of Guideline for Technical Regulation Vol.5.>
2. Once reducing valve is available, its automatic operation must be in line with the Technical Specifications of equipment and not cause head loss.

Referenced Standards and Regulations

Number	Issued	Title
Decree No.72/2007/ND-CP	2007	Decree on Management of Dam Safety
Decree No.112/2008/ND-CP	2008	Decree on management, protection and general exploitation the resources and environment of hydraulic and irrigational reservoirs
Circular No.34/2010/TT-BCT	2010	Circular regulating on the management of dam safety for hydropower structures
Decision No.285/2006/QD-TTg	2006	Decision on competence to promulgate and organize the operation procedures of hydropower reservoirs

Part 5
Mechanical and Thermo Equipment of Power Plants

Chapter 1 General Provisions

Article 100. Documentation

Following technical materials must be kept and maintained in each thermal power plant by the Owner of facilities. Specific technical materials are shown as follows;

1. Minutes on granting land.
   (1) Minutes (memorandum of agreement) between government and Owner
   (2) Minutes (memorandum of agreement) between municipality and Owner
   (3) Minutes (memorandum of agreement) between land owner and Owner
2. Minutes on set up foundation and profile of boring holes.
   (1) Design documents
   (2) Geological surveys record
   (3) Construction procedures
   (4) Quality management record
   (5) Completion drawings
3. Minutes on check and acceptance of underground works.
   (1) Design documents
   (2) Construction procedures
   (3) Quality management record
   (4) Completion drawings
4. Minutes (or records) on settlement of houses, works and foundations for installing equipment.
   (1) Design documents
   (2) Construction procedures
   (3) Quality management record
   (4) Completion drawings
5. Check-list on testing equipment of fire fighter.
6. Completed work documents with all of the design modifications to change eventually.
   (1) Test records of each equipment
   (2) Completion drawings of each equipment
7. Technical history of houses, works and equipment.
   (1) Construction prehistory, Reason of selection of construction site, basic design policy and general description of construction etc.
   (2) Actual construction schedule, comparison between actual cost and estimated cost and actual quantity consumed for utility (electricity, fuel, chemicals, makeup water etc.)

(3) Site and equipments layout drawings

8. Plan for layout of firefighting equipment and means.
   (1) Plan for layout of each firefighting equipment
   (2) Plan for layout of each power plant equipment
9. Records of each engineering work
10. Results of Completion Inspection and Periodic Inspection for each equipment
11. The overall plan area for signs of housing and location of works, including underground works.
12. Information about the failure of the device.
    (1) Company documents described prehistory of failure, failure reason and countermeasures etc.

Chapter 2 Fuel Transportation and Supply

Article 101. General provisions

Fuel transportation and supply must satisfy the following points:

1. Fuel must be transported to power plant in accordance with following regulations on management and operation of railway and waterway.
   (1) Law on Railway Traffic (No.35/2005/QH11)
   (2) Law on inland waterway navigation (No.23/2004/QH11)
   (3) Decree of the Government detailing and guiding the implementation of a number of articles of the Railway Law (No. 109/2006/ND-CP)
   (4) Decree of the Government detailing the implementation of a number of articles of the Law on inland waterway navigation (No. 21/2005/ND-CP)
   (5) Decision of the Ministry of Transport issued " Provisions on the transport of goods on the national railway (No. 05/2006/QD-BGTVT)
   (6) Decision of the Ministry of Transport issued branch Standard (TCN) " Technical Level of Railway" (No. 34/2007/QD-BGTVT)
   (7) Circular of the Ministry of Transport on Guidelines for urban railway, specialized railway are connected to the national railway (No. 05/2011/TT-BGTVT)
   (8) Circular of Ministry of Transport on management of inland waterway navigation (No. 23/2011/TT-BGTVT)
   (9) Circular of Ministry of Transport on operation of inland port, water ferry (No. 25/2010/TT-BGTVT)
   (10) National Technical Regualation on inland waterway signs (QCVN 39/2011/BGTVT)
   (11) National Technical Standard on technical classification of inland waterway (TCVN 5664/2009)
2. It must be confirmed that fuel receiving volume is correspond with fuel purchase specification by flow meter at unloading equipment of power plant. It must be confirmed that fuel quality

described in specification submitted by transportation company is correspond with fuel purchase specification. It must be referred to Article 103 of this Guideline.

3. Fuel transportation and supply facilities must be maintained properly according to technical regulation and this guideline to keep fuel in good situation as regulations with the lowest loss.
4. Fuel transportation and supply facilities must be maintained properly according to technical regulation and this guideline so that fuel may be supplied to boiler and pulverized coal processing system timely.

Article 102. Specification of fuel

It must be endeavored to procure fuel in which the ingredients differ from design specification very little in order to achieve the design performance and environmental performance. Sample specification of each fuel is shown as follows;

1. Coal

Country	Name	Higher heating value (kcal/kg)	Moisture (%)	Ash (%)	Volatile (%)	Fixed carbon (%)	Total sulfur (%)	Ash melting (^oC)
USA	A coal	6,500	9	9	38.5	46.5	0.55	1.290
	B coal	6,400	10	10	40	47	0.6-1.0	1,480
Australia	C coal	7,240	9.5	9.5	30.5	57.5	0.5	1,490
	D coal	6,750	9.5	14	34	49.5	1.14	1,500
Canada	E coal	6,350	8	10	35	-	0.3	1,250
	F coal	6,050	8	13.5	37	44	0.55	-
Indonesia	G coal	6,801	9.6	3.9	41	43.8	0.35	1,400
	H coal	6,975	11	5.5	38	50.5	0.5	1,600
China	I coal	6,801	8	12	26	-	1.0	1,300
	J coal	6,500	12	10.5	28.5	-	0.35	-

2. Heavy oil

Fuel	Higher heating value (kcal/kg)	Composition (%)				
		C	H	S	Ash	Moisture
A heavy oil	10,890	86.2	13.2	0.6	0.0	0.0
B heavy oil	10,520	85.6	12.2	1.7	0.0	-
C heavy oil	10,460	86.0	11.6	2.3	0.0	0.1

3. Light oil

Fuel	Flash Point (°C)	Pour Point (°C)	Clogging Point (°C)	Cetan index	Kinetic viscosity (30 °C)	Mass of sulfur content (%)
A light oil	≥50	5≥	-	≥50	≥2.7	0.05≥
B light oil	≥50	-7.5≥	-5≥	≥45	≥2.5	
C ligjt oil	≥45	-30≥	-19≥	≥45	≥1.7	

4. Liquefied gas

Fuel	Higher heating value (MJ/m^3)	Elemental analysis (%)						
		CH_4	C_2H_6	C_3H_8	$i\text{-}C_4H_{10}$	$n\text{-}C_4H_{10}$	C_5H_{12}	N_2
Indonesia	44.2	90.45	6.18	2.47	0.45	0.43	0.01	0.01
Australia	45.2	87.51	8.28	3.30	0.39	0.46	0.01	0.05
Qatar	44.2	89.92	6.60	2.25	0.41	0.64	0.00	0.18

5. Gas (Natural gas)

Fuel	Higher heating value ($kcal/m^3$)	Elemental analysis (%)					
		CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	N_2
Alaska	9,500	99.8	0.1	0.0	0.0	0.0	0.1
Indonesia	10,600	89.6	5.7	3.3	1.4	0.0	0.0
Australia	10,600	89.0	7.4	2.5	1.1	0.0	0.0

Article 103. Examination of fuel quality

1. Analysis method of fuel quality

Sample of analysis method of fuel quality is shown as follows;

(1) Coal

It must be conducted analysis of total moisture, heating value, moisture, ash, volatile, fixed carbon, sulfur, nitrogen, hydrogen, carbon, HGI and grain size as coal quality.

1) Total moisture

It must be measured total moisture by using two-stage drying method and referred to JIS M 8820 as reference standard.

2) Heating value

It must be measured heating value by using heat insulation bomb calorimeter, isothermal wall calorimeter, jacket bomb calorimeter and automatic bomb calorimeter and referred to JIS M 8814 as reference standard.

3) Moisture

It must be measured moisture by using air drying loss measurement method, helium airflow drying loss measurement method, nitrogen airflow drying loss measurement method and azeotropic distillation method and referred to JIS M 8812 as reference standard.

4) Ash

It must be measured ash by using electric heating furnace and following equation and referred to JIS M 8812 as reference standard.

Ash (%) = Ash volume (g) / Air dried sample (g) X 100

5) Volatile

It must be measured volatile by using electric heating furnace and following equation and referred to JIS M 8812 as reference standard.

Volatile (%) = Loss on heating (g) / Air dried sample (g) X 100 – Moisture (%)

6) Fixed carbon

It must be measured fixed carbon by above moisture, ash and volatile and following equation.

Fixed carbon (%) = 100 – (Moisture(%) + Ash(%) + Volatile(%))

7) Sulfur

It must be measured sulfur by high temperature combustion method and Eschka method and referred to JIS M 8813 as reference standard.

8) Nitrogen

It must be measured nitrogen by semimicro-Kjeldahl method and referred to JIS M 8813 as reference standard.

9) Carbon and hydrogen

It must be measured carbon and hydrogen by Liebig method and Sheffield high temperature method and referred to JIS M 8813 as reference standard.

(2) Liquid oil

It must be conducted analysis of heating value, density, sulfur and moisture etc. as liquid oil quality.

1) Heating value

It must be measured heating value by using improved Nekken type calorimeter method and referred to JIS K 2279 as reference standard.

2) Density

It must be measured density by using oscillating U-tube method, hydrometer method and capillary pyknometer method and referred to JIS K 2249-1, 2, 3 as reference standard.

3) Sulfur

It must be measured sulfur by using wickbold combustion method, oxidative microcoulometry, quartz-tube combustion method (Air method), energy-dispersive X-ray fluorescence method, general bomb method, ultraviolet fluorescence method and wavelength-dispersive X-ray fluorescence method and referred to JIS K 2541-1 - 9 as reference standard.

4) Moisture

It must be measured moisture by using distillation method and hydride reaction method and referred to JIS K 2275 as reference standard.

5) Nitrogen

It must be measured nitrogen by using macro - Kjeldahl method and micro - Kjeldahl method and referred to JIS K 2609 as reference standard.

6) Kinetic viscosity

It must be measured kinetic viscosity by using glass capillary viscosimeter and referred to JIS K 2283 as reference standard.

(3) Liquefied gas and gas

It must be conducted analysis of composition and total sulfur content as quality of liquefied gas and gas.

1) Composition

It must be measured composition by using gas chromatograph.

2) total sulfur content

It must be measured total sulfur content by barium perchlorate precipitation titration method and absorption dimethylsulfonazo III spectrophotometry and referred to JIS K 2301 as reference standard.

2. Adjustment of operation condition

Moreover, it must be adjusted safety operation condition of combustion facility and appropriate operation condition of environmental facility whenever fuel is changed. Concrete measures are shown as follows;

(1) Boiler

The status of flame, NOx concentration and O_2 concentration at outlet economizer etc. must be confirmed. Combustion status must be adjusted by adjusting air register and wind box damper etc.

(2) Gas turbine

Exhaust gas temperature, deviation of blade path temperature and NOx concentration, O_2 concentration etc. must be confirmed. Combustion status must be adjusted by adjusting fuel flow of main nozzle and pilot nozzle etc.

Article 104. Check and calibration of measuring device

The measuring devices for identification of fuel volume must be checked and calibrated in scheduled approved by the Owner. In addition, these devices must be verified by Directorate for Standards and Quality. Inspection and calibration procedures of volumetric flow meter are shown as follows;

1. Preparation of inspection and calibration
   (1) It must be prepared procedures and tools for inspection and calibration.
   (2) It must be had a meeting with related staff regarding inspection and calibration and informed control room power plant of start of them.
   (3) It must be confirmed that cross line, terminal and alarm adjuster.
   (4) It must be disconnected cable of alarm adjuster if necessary.
   (5) It must be confirmed measuring device name and ID number to be inspected.
   (6) It must be confirmed measuring value of indicator, CPTR and recorder before inspection.
   (7) It must be disconnected cable of detector.
   (8) It must be installed digital multi-meter at outlet of pulse transducer.
2. Inspection and calibration
   (1) It must be inputted square wave signal (0, 25, 50, 75 and 100%) to transducer by signal generator.
   (2) It must be recorded output of transducer by digital multi-meter.
   (3) It must be recorded measuring value of indicator and recorder.
   (4) It must be adjusted measuring value when it is misaligned.
   (5) It must be checked external appearance and cleaned detector and transducer.
3. Recovery work
   (1) It must be conducted recovery work for above inspection and calibration.
   (2) It must be informed control room of power plant of completion of inspection.

Article 105. Fuel transportation by railway

Fuel transportation by railway must be in line with following related regulations.

- Law on Railway of the National Assembly (No. 35/2005/QH11)
- Decree of the Government detailing and guiding the implementation of a number of articles of the Railway Law (No. 109/2006/ND-CP)
- Decision of the Ministry of Transport issued " Provisions on the transport of goods on the national railway" (No. 05/2006/QD-BGTVT)
- Decision of the Ministry of Transport issued branch standard (TCN) " Technical Level of Railway " (No. 34/2007/QD-BGTVT)
- Circular of the Ministry of Transport on guidelines for urban railway, specialized railway are connected to the national railway (No. 05/2011/TT-BGTVT)

Especially, it must be paid attention that above circular (No. 05/2011/TT-BGTVT) and following provisions are stipulated in this circular.

- Principles for specialized railway connecting to the national railway system.
- Procedures for specialized railway connecting to the national railway system.
- Competence and responsibility of the management agency of the State in management for the specialized railway connecting to the national railway system.
- Authorization and obligations of organizations and individuals for proposed specialized railway connecting to the national railway system.
- Referring to following Decision and standard.
- Decision of the Ministry of Transport issued “Provisions on the transport of goods on the national railway” (No. 05/2006/QD-BGTVT)
- Standard of “Technical Level of Railway” (22 TCN 362-07)

The "specialized railway" is defined in the standard 22 TCN 362-07 as "rail transport to serve the needs of organizations and individuals". For example, it means coal railway transportation of coal mines, railway transport fuel for power plants and rail transportation of mineral ore .etc.

Article 106. Railway facilities

The building and equipment for railway station, signal and telecommunication system and train under power plant management must be kept in good condition and repaired complying with the guidelines of railway and referring to following provisions.

1. Building and equipment for railway station
   (1) The building and equipment for railway station must be kept in good condition so that train can operate safely.
   (2) When they are not in above conditions, it must be taken appropriate measures (speed restrictions of train etc.), so that train can operate safely and monitored them with prospect of the failure. Moreover, when detecting failure, it must be repaired quickly.
2. Signal and telecommunication
   (1) The signal and telecommunication system must be kept in good condition so that they can operate correctly.
3. Train
   (1) The train must be kept in good condition so that it can operate correctly.
   (2) It must not be operated trains before confirming that they can be operated safely by organization having authority.

Article 107. Maintenance of fuel facilities

The checking devices, automatic controlling equipment, remote control equipment, protection equipment and interlock of loading equipment, fuel feeding devices of fluid and gas fuel system must be kept in good condition and checked periodically according to this Guideline and Inspection Guideline.

Article 108. Unloading safety

When using tipping device and other equipment, the regulations of railway must be abided for the safety of car and referring to following provisions.

1. It must be operated tipping device and devices safely to prevent accident resulting in injury or death according to unloading procedures (manuals) stipulated by each power plant.
2. It must be confirmed that people outside are not stepped into in unloading area to prevent accident resulting in injury or death.
3. It must be operated tipping device and devices properly to prevent the environmental pollution due to leakage of oil and coal dust dispersion.

Article 109. Operation of coal stock yard facilities

It must be in readiness for safety operation of stacker, reclaimer and belt conveyor and ensured to operate them at rated capacity. It must be removed and cleaned dropped coal powder to eliminate a fire incident.

1. Stacker

Things to keep in mind regarding operation of stacker are shown as follows ;

(1) It must be operated stacker safely to prevent accident resulting in injury or death according to the operation manuals stipulated by each power plant.

(2) It must be paid attention at operating stacker to prevent a fire and the environmental pollution such as coal dust dispersion.

(3) It must be paid attention at climbing to operation seat and climbing out form operation seat because it is high location.

(4) It must be stacked coals evenly at coal stock yard to prevent a fire.

(5) It must be stopped stacker quickly when confirming trouble of stacker and maintained it.

(6) It must be confirmed status of stacker regarding following provisions by daily patrol and inspection.

   1) Hydraulic oil pump (abnormal noise, vibration, status of bearing, leakage of oil etc.)
   2) Pulley and belt of belt conveyor (abnormal noise, vibration, status of bearing, leakage of oil etc.)
   3) Swing device (abnormal noise, vibration, status of bearing, leakage of oil etc.)
   4) Drive unit of traveling (abnormal noise, vibration, status of bearing, leakage of oil etc.)

Photo 109-1 Stacker

2. Reclaimer

Things to keep in mind regarding operation of reclaimer are shown as follows ;

(1) It must be operated reclaimer safely to prevent accident resulting in injury or death according to the operation manuals stipulated by each power plant.

(2) It must be paid attention at operating reclaimer to prevent a fire and the environmental pollution such as coal dust dispersion.

(3) It must be paid attention at climbing to operation seat and climbing out form operation seat because it is high location.

(4) It must be taken coals evenly at coal stock yard to prevent a fire.

(5) It must be stopped reclaimer quickly when confirming trouble of reclaimer and maintained it.

(6) It must be confirmed status of reclaimer regarding following provisions by daily patrol and inspection.

1) Hydraulic oil pump (abnormal noise, vibration, status of bearing, leakage of oil etc.)

2) Pulley and belt of belt conveyor (abnormal noise, vibration, status of bearing, leakage of oil etc.)

3) Swing device (abnormal noise, vibration, status of bearing, leakage of oil etc.)

4) Drive unit of traveling (abnormal noise, vibration, status of bearing, leakage of oil etc.)

Photo 109-2 Reclaimer

3. Belt conveyor

(1) It must be operated belt conveyor safely to prevent accident resulting in injury or death according to the operation manuals stipulated by each power plant.

(2) It must be paid attention regarding following provisions at daily patrol because there is a possibility that a fire is occurred due to friction heat of belt conveyor.
   1) Slip between belt and pulley
   2) Slip between belt and roller
   3) Contact between lopsided belt and conveyor frame
   4) Friction between belt and cleaner
(3) It must be paid attention at operating belt conveyor to prevent a fire and the environmental pollution such as coal dust dispersion.
(4) It must be stopped belt conveyor quickly when confirming trouble of belt conveyor and maintained it.
(5) It must be confirmed status of belt conveyor regarding following provisions by daily patrol and inspection.
   1) Conveyor belt (abnormal noise, deviation, damage etc.)
   2) Pulley (abnormal noise, vibration, status of bearing, leakage of oil, abrasion etc.)
   3) Roller (abnormal noise, vibration, status of bearing, leakage of oil, abrasion etc.)
   4) Drive unit (abnormal noise, vibration, status of bearing, leakage of oil, abrasion etc.)

Photo 109-3 Belt conveyor

Article 110. Crane and coal conveyor safety

It must be prohibited from operating crane (unloader, stacker and reclaimer) and coal conveyor when detecting breakdown of brake, claw, and switch and deviation reducer to keep safety and environment protection. It must be referred to Article 109 regarding operation of stacker, reclaimer and belt conveyor and following provisions regarding operation of unloader.

1. Unloader

Things to keep in mind regarding operation of unloader are shown as follows ;

(1) It must be operated unloader safely to prevent accident resulting in injury or death according to the operation manuals stipulated by each power plant.

(2) It must be paid attention at operating unloader to prevent a fire and the environmental pollution such as coal dust dispersion.

(3) It must be paid attention at climbing to operation seat and climbing out form operation seat because it is high location.

(4) It must be stopped unloader quickly when confirming trouble of unloader and maintained it.

(5) It must be confirmed status of unloader regarding following provisions by daily patrol and inspection.

1) Hydraulic oil pump (abnormal noise, vibration, status of bearing, leakage of oil etc.)

2) Bucket and drive unit

(damage, abnormal noise, vibration, status of bearing, leakage of oil etc.)

3) Pulley and belt of belt conveyor (abnormal noise, vibration, status of bearing, leakage of oil etc.)

4) Swing device (abnormal noise, vibration, status of bearing, leakage of oil etc.)

5) Drive unit of traveling (abnormal noise, vibration, status of bearing, leakage of oil etc.)

Photo 110-1 Unloader

Article 111. Monitoring of temperature of coal stock yard

1. Countermeasures of spontaneous fire at coal stock yard.

It must be monitored temperature of coal carefully because temperature of stacked coals at coal stack yard has the inclination to increase. Therefore, basically it must be taken coals by reclaimer from coal stacked previously at coal stock yard. Moreover, it must be taken following countermeasures of spontaneous fire at coal stock yard.

(1) It must be cooled stacked coals at coal stock yard by water spray.

(2) It must be prevented temperature rise of coals by conducting surface compaction of coal stockpile by bulldozer and restraining inflow of air.

(3) It must be cooled stacked coals at coal stock yard by re-stacking by stacker and reclaimer.

2. Management of temperature of stacked coals at coal stock yard

It must be monitored temperature of stacked coals by using thermo couple every 10 - 20m distance and every 2 - 4m depth from surface of coal stockpile. It must be managed temperature of coal referring to following table. However, it must be managed it according to trend of temperature rise, coal type and past experience etc. because following table is just a reference.

Table 111-1 Management of temperature of stacked coals (sample)

Level	Temperature of coals (deg C)	Countermeasures
Level 1	40 – 50	- It must be shorten monitoring interval if necessary. - It must be monitored carefully confirming temperature rise.
Level 2	50 – 60	- It must be stepped up monitoring of temperature of coals. - It must be taken high temperature coals by reclaimer to coal bunker or re-stacked them. - It must be conducted surface compaction at coal stockpile.
Level 3	60 – 80	- It must be re-stacked high temperature coals immediately. It must be conducted water spray according to the situation.
Level 4	80 over	- It must be re-stacked high temperature coals immediately. It must be cooled them not gaining opposite effect.

It can be confirmed spontaneous fire by following external.

(1) Tar odor

(2) Change of color

(3) White smoke at upper side of coal stockpile


Photo 111-1 Coal stock yard

Article 112. Operation of coal feeding system

It must be operated coal feeding system properly according to following provisions.

1. Operation of belt conveyor and tripper

(1) It must be operated belt conveyor and tripper safely such as announcements in power plant before starting up to prevent accident resulting in injury or death according to operation manuals stipulated by each power plant.

(2) It must be paid attention to environmental pollution due to a fire due by friction heat of belt at operating.

(3) It must be paid attention to environmental pollution due to coal dust dispersion in case of outside belt conveyor.

(4) It must be stopped belt conveyor and tripper quickly when confirming trouble of belt conveyor and tripper and maintained it.

(5) It must be fed coals to coal bunker according to daily coal feeding plan to prevent shortage of coals because it causes stop of power plant.

2. Source investigation of trouble

Coal feeding system is very important and generally redundant at many power plants because trouble of it causes stop of power plant. When confirming trouble of coal feeding system, it must be stopped it promptly, confirmed source of trouble and taken appropriate measures depending on source of trouble. And it must be confirmed that coal feeding system can usually operate properly without trouble. Moreover, when detecting trouble and stopping power plant, it must be taken account of following provisions on operation of power plant.

(1) It must be confirmed that coal feeding system is in whole stopping or one half capacity operation.

(2) It must be confirmed following provisions in case that coal feeding system is in whole stopping

1) How volume coals is in coal bunker

2) How long can power plant operate at rated output by above volume of coals

(3) It must be decreased plant load and operated power plant as long as possible if necessary.

Article 113.

(Nothing)

Article 114. Safety of operation of coal feeding system

It must be confirmed status of coal feeding system regarding following provisions by daily patrol and inspection to detect defects of each equipment promptly and keep stable operation of power plant.

1. Fence system and brake: damage, abrasion, status of corrosion etc.
2. Conveyor belt :

   deviation, abnormal noise, abnormal odor, vibration, damage etc.
3. Pulley :

   abnormal noise, abnormal odor, vibration, status of bearing (heating, leakage of oil), abrasion, status of corrosion etc.
4. Roller :

   abnormal noise, abnormal odor, vibration, status of bearing (heating, leakage of oil), abrasion, status of corrosion etc.

5. Drive unit :

abnormal noise, abnormal odor, vibration, status of bearing (heating, leakage of oil), abrasion, status of valves and piping, status of corrosion etc.

6. Belt cleaner :

abnormal noise, abnormal odor, vibration, abrasion, status of corrosion etc.

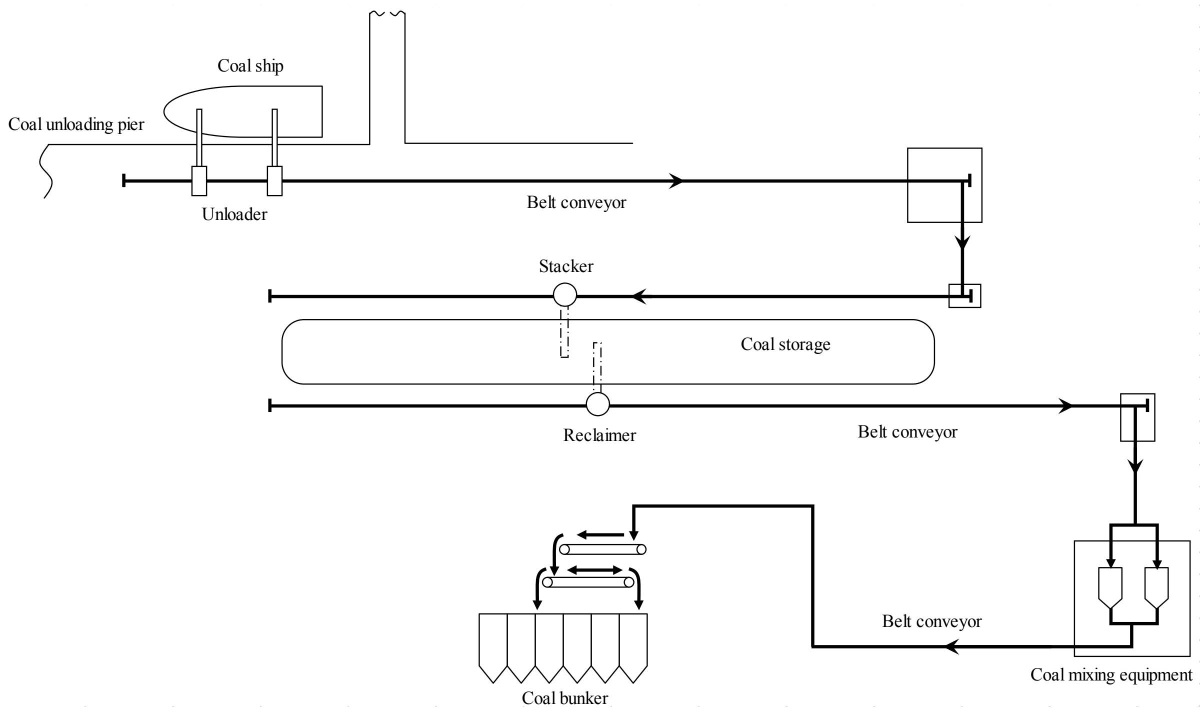


Figure 114-1 Coal feeding system

Article 115. Protection equipment of coal feeding system

1. Outline of explosion of coal dust

It must be removed and cleaned coal dust in rooms of coal feeding system to prevent explosion of coal dust. Explosion of coal dust is caused when following 3 conditions are met.

(1) Coal dust concentration

(2) Oxygen

(3) Source of ignition

Explosion of coal dust is not caused when one condition of above 3 conditions is removed. Therefore, countermeasure of explosion of coal dust is shown as follows;

(1) Prevention of occurrence of coal dust

(2) Removal of coal dust

(3) Removal of source of ignition

1) Maintenance and management of electrical equipment

2) Prevention of spark by hit of metal

Following concrete countermeasures must be adopted in coal feeding system.

(1) Countermeasures for prevention of occurrence of coal dust

1) It must be utilized direct vent type house.

(2) Countermeasures for removal of coal dust

1) It must be utilized dust collector.

(3) Countermeasures for removal of source of ignition

1) It must be adopted electrical equipments of explosion proof type when they are used in atmosphere of coal dust wafting and flammable gas.

2) It must be prevent overload of electrical equipment to avoid overheat of them.

3) It must be confirmed degradation of insulation promptly by measuring insulating resistance periodically.

4) It must be removed metal by magnet separator to prevent spark by hit of metal.

5) It must be prohibited form using fire and smoking near coal feeding system.

2. Confirmation of status of coal dust

It must be confirmed status of coal feeding system taking account of following provisions by daily patrol and maintenance to prevent explosion of coal dust.

(1) It must be confirmed status of dispersion of coal dust at coal feeding system.

(2) It must be confirmed rotary machines such as bearings are not overheated.

(3) It must be confirmed degradation of insulation by measuring insulating resistance periodically.

(4) It must be confirmed electrical equipments of explosion proof type are not damaged.

Article 116. Chute of heavy oil tank

It must be kept in good condition and clean of chutes, hydraulic valves, dampers and filters of heavy oil basins and point to be checked at daily patrol and inspection is shown as follows ;

1. It must be complied procedures developed by each power plant at daily patrol and inspection.
2. It must be confirmed oil leakage as most important item at daily patrol and inspection.
3. It must be paid attention to oil leakage to prevent a fire and environmental pollution when cleaning them.
4. It must be changed operating filter to standby one periodically.

Photo 116-1 Heavy oil tank

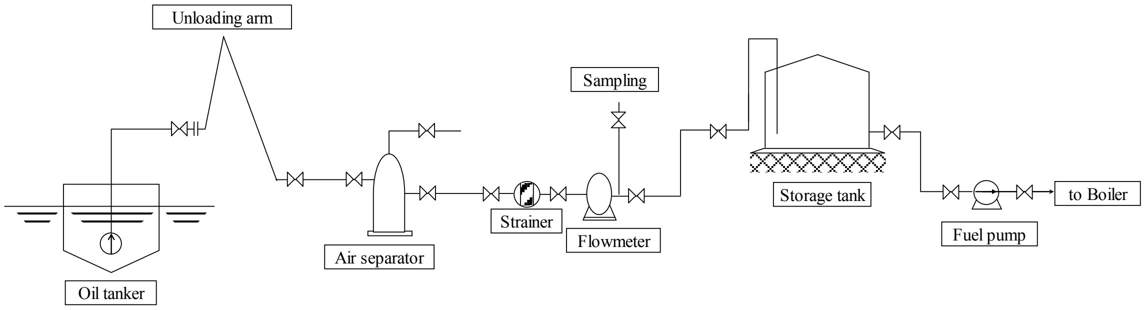


Figure 116-1 Oil unloading and storage system

Article 117. Temperature of heavy oil

It is possible that light oil and low viscosity naphtha is fed to boiler at ambient temperatures and atomized at combustion burner. On the other hand, heavy oil is heated to reasonable temperature for feeding it to boiler because viscosity of heavy oil is high. It can be said that reasonable atomizing viscosity is 20 - 40 cSt. Therefore, heater is installed at power plant to heat heavy oil and they have steam heating type and electric heating type.

It must be prohibited from heating heavy oil more than limiting temperature because there is a possibility that heavy oil is ignited in basins and reservoirs of heavy oil storage. It must be operated heavy oil mixer periodically to heat heavy oil efficiently if it is installed at basins and reservoirs.

Photo 117-1 Temperature gauge

Article 118. Fluid fuel feeding

It must be ensured to supply uninterruptedly the fuel which has been filtered and heated, while satisfying demand of boiler and gas turbine by fluid fuel system. Things to keep in mind at operating fluid fuel system are shown as follows;

1. It must be confirmed following measuring value of fluid fuel system is properly to supply fluid fuel stably.
   (1) Oil pressure for burner and igniter
   (2) Oil temperature (Steam heater, steam heat tracing)
   (3) Differential pressure before and after strainer
   (4) Atomizing air pressure

(5) Atomizing steam pressure

(6) Atomizing steam temperature

(7) Level of oil tank and reservoir

2. It must be paid attention to leakage of oil to prevent fire and environmental pollution.

3. It must be confirmed following provisions before fluid fuel system is started.

(1) It must be fill in oil pump, strainer and piping by oil before pump is started and not be idled oil pump.

(2) It must be operated steam heat tracing after piping is filled in oil.

(3) It must be warmed heavy oil feeding system sufficiently before this system is started.

(4) It must be purged flammable gas in boiler furnace before reigniting when burner is not ignited.

(5) It must be managed fuel oil feeding volume and storage volume of tank and reservoir.

(6) It must be confirmed following provisions for preparation before this system is started up.

1) Heavy oil feeding system

a. It must be confirmed following equipments are turned on.

(a) Heavy oil pump

(b) Warming valve around Heavy oil burner

(c) Heavy oil strainer cleaning equipment

(d) Heavy oil strainer inlet valve

(e) Heavy oil heater temperature control valve

b. It must be confirmed following valves are closed.

(a) Heavy oil leak check valve

(b) Heavy oil shut off valve

(c) Heavy oil burner valve

(d) Atomizing steam valve

(e) Purge valve

c. Bottom heater of heavy oil tank and steam heat tracing are started up.

2) Light oil feeding system

a. It must be confirmed following equipments are turned on.

(a) Light oil pump for igniting

(b) Light oil pump for starting

b. It must be confirmed following valves are closed.

(a) Light oil for igniting

a) Ignite valve

b) Shut off valve

c) Bypass valve (for PCV and flow meter)

(b) Light oil for starting

a) Light oil burner inlet valve
b) Shut off valve
c) Bypass valve (for PCV, FCV and flow meter)
d) Atomizing air inlet valve

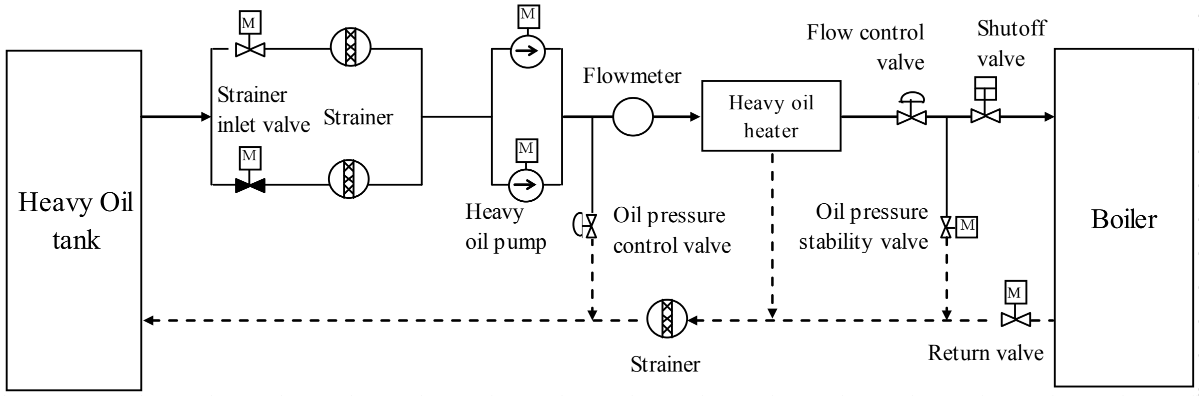


Figure 118-1 Fluid fuel feeding system

Article 119. Operation of oil system

It must be confirmed operation status of oil system such as oil tank, oil reservoir, oil pump, heater, valves, piping and flexible tube etc. carefully according to following provisions by daily patrol and inspection to prevent fire disaster and environmental pollution.

1. It must be confirmed leakage of oil from oil tank, reservoir, pump, heater, valve, piping and flexible tube etc.
2. It must be confirmed fire fighting equipments are installed at stipulated place and external appearance of them are properly.
3. It must be confirmed that flammable materials are not left around oil system.
4. It must be confirmed that measuring value of pressure, temperature and level gauge are appropriate and these gauges are operated normally.
5. It must be confirmed operation status of rotating device such as oil pump, tank mixer etc. according to following provisions.
   (1) Abnormal vibration
   (2) Abnormal noise
   (3) Abnormal temperature rise
6. It must be changed operating strainer to standby one periodically.
7. It must be conducted initial countermeasures promptly to prevent expansion of trouble when detecting oil leakage from oil system. Point to be checked of initial countermeasures are shown as follows ;
   (1) It must be conducted initial countermeasures according to procedures developed by each power plant.

(2) It must be informed control room of power plant of oil leakage promptly when detecting it on daily patrol and inspection.

(3) It must be closed valves installed upstream and downstream of oil leakage place immediately to isolate it after detecting oil leakage place or stopped oil leakage by using setting agent and band (rubber and metal).

(4) It must be prohibited from using fire until oil leakage place is detected. It must be purged oil in piping completely when using fire to maintain leakage place.

(5) It must be called in fire and police station if necessary.

8. It must be conducted operation test for standby start-up light oil pump and heavy oil pump periodically referring to following procedures.

Table 119-1 Sample of operation test procedure of start-up light oil pump

Items		Contents
Preparation	1	It must be conducted operation test according to procedures developed by each power plant.
	2	It must be confirmed all oil burners are extinguished.
	3	It must be confirmed start-up light oil system is normal.
	4	It must be confirmed pressure control valve of start-up light oil is opened completely (full open).
	5	It must be informed control room of power plant of starting operation test.
Operation test	1	It must be started start-up light oil pump by manually.
	2	It must be confirmed vibration, noise, pump outlet pressure and oil leakage etc.
	3	It must be confirmed operation status of pressure control valve of start-up light oil.
	4	It must be informed control room of test result.
	5	It must be stopped start-up light oil pump.
	6	It must be confirmed pressure control valve of start-up light oil is opened completely (full open).
	7	It must be confirmed start-up light oil pump is in automatic mode.

Article 120. Repair of pressure pipe

It must be purged fuel oil immediately and completely to prevent a fire when a long term suspension is planned after halt of the main combustion equipment and using fire for periodic inspection and maintenance work. Point to be checked at purging fuel oil is shown as follows;

1. It must be complied with purging procedure developed by each power plant for the safety of staff and power plant.
2. It must be confirmed fire is not within working area before purging.
3. Typical purging procedure is shown as follows ;

(1) Case1 (Maintenance of leakage place)

1) It must be removed steam heat tracing and heat insulating materials attached piping if it is installed.

2) It must be closed valves installed upstream and downstream of place of oil leakage.

3) It must be discharged remaining oil in piping form blow valve and paid attention to handling of it to prevent a fire.

4) It must be unfastened bolts of flange and unfixed piping to be maintained.

5) It must be cleaned internal face of this piping and removed oil because oil is attached on internal face of piping.

6) It must be maintained leakage place after removing oil in piping completely.

7) It must be fixed maintained piping and opened valves installed upstream and downstream of place of oil leakage after maintaining.

(2) Case2 (Long term suspension)

1) It must be purged oil in piping completely referring to Case1.

4. It must be conducted early extinction and inform control room promptly in case of fire.

Article 121. Safety of fuel oil reservoir

1. Confirmation of oil leakage

A lot of oil is stocked in oil reservoir, it is flammable and has an effect on environment. Therefore, it must be checked oil leakage of each oil reservoir by daily patrol and inspection according to following provisions to prevent a fire and environmental pollution.

(1) It must be confirmed external appearance (damage, rust, painting etc.) of oil reservoirs and oil leakage.

(2) It must be confirmed oil leakage of gland packing and bonnet flange of valve.

(3) It must be operated heavy oil reservoir (tank) mixer periodically to prevent to solidify heavy oil.

2. Confirmation of fire fighting system

It must be installed fire fighting system for oil reservoir based on design technical regulations to extinguish a fire. It must be kept in good condition of this system because this system is important equipment for stable operation of power plant. Point to be checked at daily patrol and inspection of fire fighting system is shown as follows;

(1) It must be confirmed external appearance (damage, rust etc.) of fire fighting system.

(2) It must be confirmed fire fighting system (extinguisher etc.) is installed at stipulated place.

(3) It must be confirmed number of installation of fire fighting system (extinguisher etc.)

(Foam liquid tank)

Photo 121-1 Foam fire extinguishing system

Photo 121-2 Dry chemical extinguishing system

Moreover, it must be conducted fire fighting training by whole power plant periodically because appropriate early extinction prevents spread of the fire. Point to be checked and procedure at this training are shown as follows;

(1) It must be started early extinction and informed control room of power plant when detecting a fire.

(2) It must be informed fire station and established fire fighting team by power plant staff promptly.

(3) It must be clarified role allocation of power plant staff when establishing fire fighting team.

(4) It must be conducted serious fire fighting as soon as possible.

(5) It must be followed directions of leaders of fire fighting team before fire station arrives and followed fire station’s directions after it arrives.

(6) It must be conducted fire fighting training every following sample case.

1) Fire around oil reservoir (tank)

2) Fire at receiving oil from ship or tank lorry

3) Fire around boiler burner

Article 122. Safety of gas supply system

1. When operating gas supply system of power plant, it must be complied with following regulation and standards on the safety in gas system.
   - Decree of the Government on Safety of oil and gas constructions on land (No.13/2011/ND-CP)
   - Liquefied Natural Gas (LNG). Requirements for Production, Storage and Handling (TCVN 8616:2010)
   - Liquefied Petroleum Gas (LPG). Handling Principles, Measurement and Calculation (TCVN 7567:2006)

Article 123. Safety of gas pipeline

It must be confirmed operation of pressure signal from maximum to minimum in gas pipeline of boiler downstream of automatic pressure regulator at intervals decided by the Owner. Inspection and calibration procedures of it are shown as follows;

1. Preparation of inspection and calibration
   (1) It must be prepared procedures and tools for inspection and calibration.
   (2) It must be had a meeting with related staff regarding inspection and calibration and informed control room power plant of start of them.
   (3) It must be confirmed that cross line, terminal and alarm adjuster.
   (4) It must be disconnected cable of alarm adjuster if necessary.
   (5) It must be confirmed measuring device name and ID number to be inspected.
   (6) It must be confirmed measuring value of indicator, CPTR and recorder before inspection.
   (7) It must be closed instrument valve, disconnected coupling and installed inspection devices.
   (8) It must be installed digital multi-meter.
2. Inspection and calibration
   (1) It must be inputted 0, 25, 50, 75 and 100% of input power to measuring device and confirmed output.
   (2) It must be adjusted when output is misaligned.
   (3) It must be conducted zero and span adjustment.
   (4) It must be inputted 0, 25, 50, 75 and 100% of input power to measuring device and confirmed each output after calibration.
   (5) It must be measured power supply voltage of measuring device.
3. Loop test
   (1) It must be informed control room of start of loop test.
   (2) It must be conducted loop test and adjusted when measuring value of indicator, CPTR and recorder is misaligned.
4. Recovery work
   (1) It must be conducted recovery work for above inspection and calibration.
   (2) It must be informed control room of power plant of completion of inspection.

Article 124. Gas charge

When purging as in piping, it must be confirmed following provisions to prevent a fire and explosion.

1. It must be complied with purging procedure developed by each power plant for the safety of staff and power plant.
2. It must be confirmed fire is not within working area before purging.
3. It must be confirmed that all related valves on piping are closed.
4. It must be injected inert gas such as nitrogen in piping from inlet and opened blow valve slightly. It must be adopted inert gas to prevent a fire and explosion.
5. It must be paid attention to open end (vent) of purged gas because LNG is lighter than air and LPG is heavier than air.
6. It must be confirmed oxygen concentration in the gas or residual gas concentration in the air is decreased by measuring instrument. When not confirming it, it must be re-confirmed all related valves on piping are closed because there is a possibility that inert gas is leaked.
7. It must be confirmed oxygen concentration in the gas or residual gas concentration in the air does not exceed 1 % by measuring instrument and completed purging.

Table 124-1 Explosion limit

Gas type	Explosion limit (vol % in air)	
	Lower limit	Upper limit
Methane (CH4)	Approx. 5	Approx.15
Ethane (C2H6)	Approx. 3.2	Approx. 12.5
Propane(C3H8)	Approx. 2.4	Approx. 9.5
LPG	Approx. 1.8	Approx. 9.5

8. It must be conducted early extinction and inform control room promptly if a fire or explosion is occurred.

Article 125. Check of underground gas pipeline

It must be inspected underground gas pipeline in area under management of power plant as scheduled and method decided by the Owner. Gas leakage inspection, inspections for electric protection equipment and corrosion investigations for underground gas pipeline are shown as follows;

1. Gas leakage inspection (during the power plant shutdown)
   (1) Gas pressurization method
      1) It must be prepared gas detector which operates by concentration of lower than 2%.
      2) It must be injected test gas in gas pipeline and held for 12 hours.
      3) It must be excavated ground around weld part and coupling of gas pipeline more than 50cm. It must be paid attention to location (depth) of gas pipeline when excavating.
      4) It must be put gas detector in this hole and confirmed gas leakage.

2. Inspection for electric protection equipment (during the power plant operation)
   (1) It must be informed control room of power plant of start of inspection for electric protection equipment.
   (2) It must be inspected electric protection equipment according to inspection procedure.
   (3) It must be confirmed measuring value of output voltage gauge, output current gauge and corrosion prevention management gauge.
   (4) It must be confirmed that measuring value of corrosion prevention management gauge is within acceptable value.
   (5) It must be confirmed abnormal noise and odor in electric protection equipment.
   (6) It must be confirmed overheat and loose of terminal in electric protection equipment.
   (7) It must be informed control room of completion of inspection.
3. Corrosion investigation
   (1) Measuring of electrical potential of underground pipeline in terms of ground
      1) It is estimated status of corrosion by using high ohm-voltage indicator and reference electrode.
      2) Difference of potential between pipeline and ground is usually 500mV – 600mV. However, there is a possibility that corrosion of pipeline is preceded when difference of potential is plus direction.

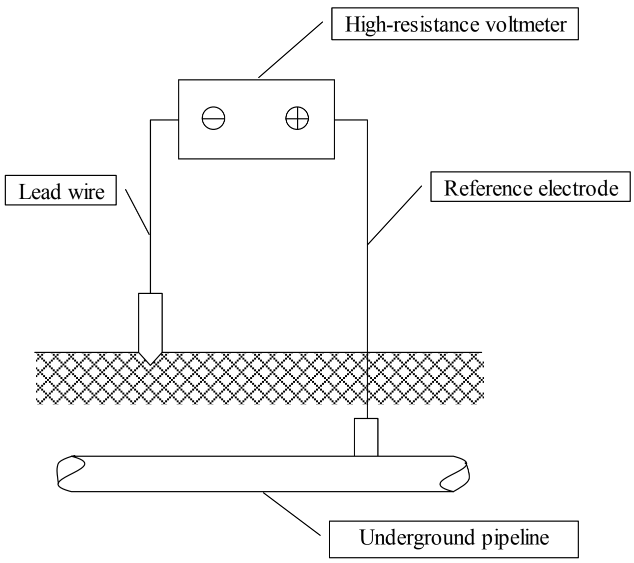


Figure 125-1 Measuring method of electrical potential of underground pipeline in terms of ground

   (2) Measuring of corrosion of underground pipeline
      1) When occurring corrosion, current is generated with corrosion. When corrosion is severe, a lot of current is generated and quantity of current is in proportion as quantity of corrosion. Quantity of current at corroding depends on microcell ohm (current-carrying transformation). Electricity at corroding is direct-current electricity and consists of Ohm's law.

2) Measuring equipment of corrosion of underground pipeline passes direct-current electricity through underground gas pipeline and microcell ohm (current-carrying transformation) is calculated from voltage and current. Microcell ohm (current-carrying transformation) is electric resistance and corrosion is severe when it is lower.

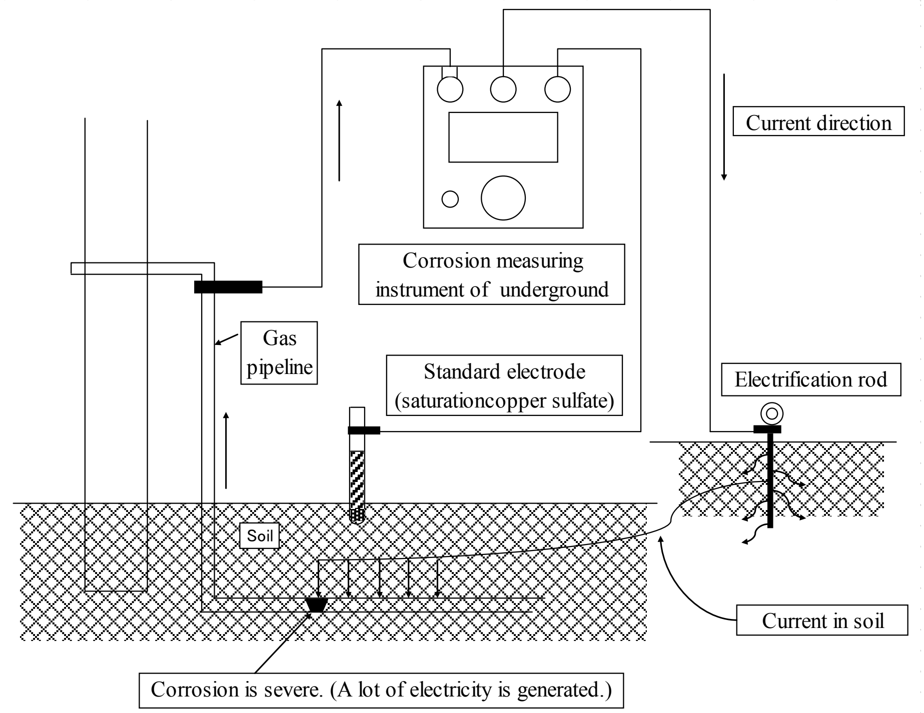


Figure 125-2 Measuring method of corrosion of underground pipeline

(3) Measuring of soil specific resistance

1) It is level of electric resistance of soil. In general, it can be said that soil less than 4,000 ohm has severe corrosive.

Table 125-1 Relation between soil specific resistance and corrosion behavior of soil

Corrosion behavior	Soil specific resistance (ohm cm)				
	F. O. Waters	L. M. Apploc	Y. R. Prrtula	E. R. Shcpord	Komanoff
Severe	0 - 900	0 - 1,000	0 - 500	0 - 500	< 700
Slightly severe	900 - 2,300	1,000 - 5,000	500 - 1,000	500 - 1,000	700 - 2,000
Middle	2,300 – 5,000	5,000 - 10,000	1,000 - 2,000	-	2,000 - 5,000
Poor	5,000-10,000	10,000 - 100,000	2,000 - 10,000	-	> 5,000
Very poor	> 10,000	> 100,000	>10,000	-	-

(4) Measuring of electric potential of oxidation-reduction

1) It is index number of corrosion behavior due to sulfate-reducing bacteria and measured by oxidation-reduction (redox) electrometer.

Table 125-2 Relation between electric potential of oxidation-reduction
and bacteria corrosion

Corrosion behavior	electric potential of oxidation-reduction (mV)
Severe	Less than 100
Middle	100 – 200
Poor	200 – 400
None	More than 400

(5) Measuring of pH

1) It is index number of judging acidic or alkaline and it can sad that corrosion is severe in soil less than pH4.
2) Measuring device is pH meter and litmus paper.

Article 126. Safety of operation in underground structure

It must be used gas analyzer to check gas accumulation in basements, manholes and other underground structure. It must be prohibited from entering into manholes, pits and other underground structure to take air sample because it involves the risk of lack of oxygen. Reaction of human for lack of oxygen is shown as follows;

Table 126-1 Reaction of human for lack of oxygen

Oxygen concentration (%)	Symptom
21	- Normal oxygen concentration
18	- Safety limit - It must be ventilated continuously.
16 - 12	- Increasing of breath and pulse physiology - dropping in concentration power - Headache, buzzing and nauseous
14 – 9	- Stupor - Headache, buzzing - Pallor of the face - Hyposthenia of whole body
10 - 6	- Falling unconscious - Loss of consciousness - Muscle cramp of whole body
Less than 6	- Lie unconscious - Coma, breath-holding - Cardiac arrest, die after 6 minutes

It must be carried out analyzing air in basements of building at basements by safe analyzer, type of explosion prevention. It must be taken out air sample for analyzing in case that such analyzer is not available. And analysis items by analyzer are shown as follows;

1. Oxygen (O_2)
2. Carbon monoxide (CO)
3. Carbon dioxide (CO_2)
4. Methane (CH_4)

It must be prohibited from smoking and using fire when checking basements of building and manholes, pits and other underground structure.

Article 127. Detection of gas leakage

1. Detection of leakage

It is very important to prevent leakage and a fire to ensure security of fuel and combustion equipments. However, it must be monitored status of power plant to detect leakage and a fire promptly and repress them in case of leakage and a fire. It must be installed leak and fire detector at appropriate place to monitor status of power plant steadily. It must be given an alarm by these detectors or operated fire protection and fire fighting system. And it must be operated emergency shut off system of fuel and combustion equipments.

(1) General of gas detector

There is different kind of gas detectors and it must be selected gas detector, precision and sampling method according to installation location, installation condition and target gas aspect etc. Type of gas detector has a combustion type, a semiconductor type and a hot-wire semiconductor type etc. It may be installed more than 2 gas detectors of different basis to enhance the credibility of detecting gas leak.

(2) Type of gas detecting sensor

Major gas detecting sensors are explained as follows;

1) Contact combustion type sensor

It is used in many fields and various purposes. Flammable gas is burned by heated catalyst on platinum wire, its temperature rise is converted to electric resistance variation and output signal is detected by bridge circuit.

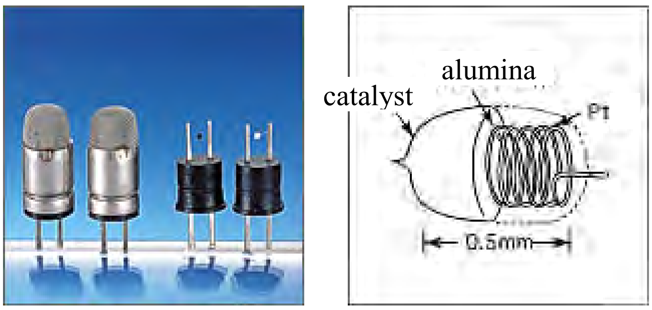


Photo 127-1 Contact combustion type sensor

2) Semiconductor type sensor

It is used at many plants required high precision. Sintered compact (semiconductor) of metal oxide heated by heater, gas molecule is absorbed chemically when it is detected reducing gas (flammable gas), and this sensor utilizes characteristic which its electric resistance is decreased exponentially. This sensor is used as supersensitive alarm device because it is detected high output signal by low concentration gas.

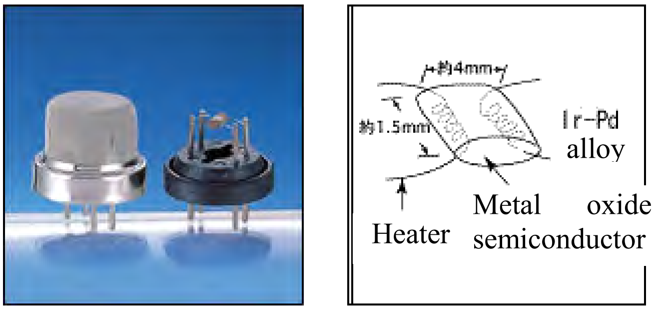


Photo 127-2 Semiconductor type sensor

3) Hot-wire semiconductor type sensor

It has superior characteristic of combustion type and semiconductor type sensor. Structure of this sensor resembles contact combustion type sensor.

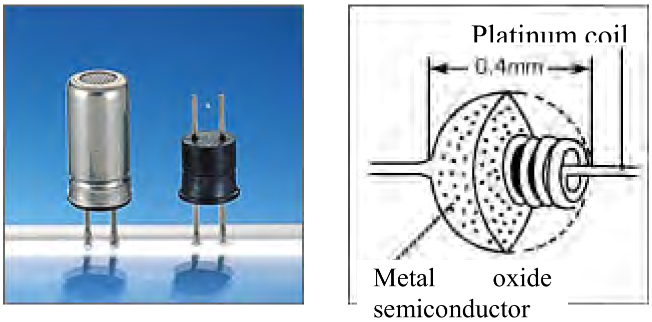


Photo 127-3 Hot-wire semiconductor type sensor

4) Gas heat conduction type sensor

This sensor utilizes deference between conduction deference of standard gas and one of measuring gas. Measuring is contacted detecting part including heated platinum wire coil, its heat is removed by heat conduction of gas, temperature of platinum wire coil is changed and it is resistance variation. This variation is in proportion as gas concentration.

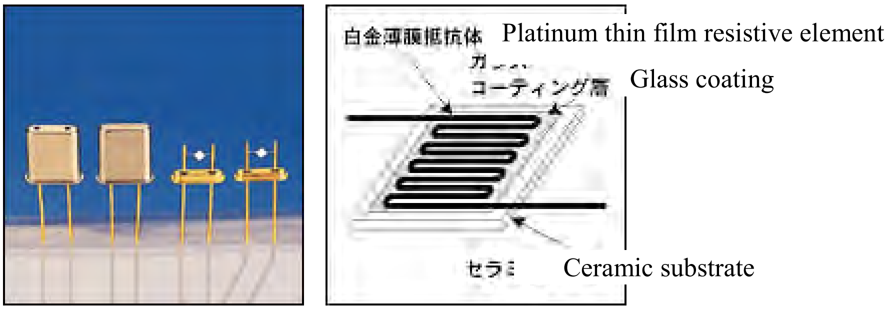


Photo 127-4 Gas heat conduction type sensor

2. Initial countermeasures at detecting gas leakage

It must be conducted initial countermeasures promptly to prevent expansion of trouble when detecting gas leakage. Points to be checked of initial countermeasures are shown as follows;

(1) It must be conducted initial countermeasures according to procedures developed by each power plant.

(2) It must be informed control room of power plant of gas leakage promptly when detecting it by using gas detector etc. on daily patrol and inspection.

(3) It must be closed valves installed upstream and downstream of place of gas leakage immediately to isolate it after detecting place of gas leakage.

(4) It must be prohibited from using fire until gas leakage place is detected. It must be purged gas in piping completely when using fire to maintain leakage place. It must be referred to Article 128 of this guideline.

(5) It must be called in fire and police station if necessary.

Article 128. Investigation of gas leakage

It must be conducted initial countermeasures promptly according to Article 127 of this guideline when detecting gas leakage. After that, it must be maintained gas leakage place taking account of following provisions.

1. It must be maintained gas leakage place according to procedures developed by each power plant.
2. It must be prevented a fire due to ignition of leakage gas absolutely.
3. It must be informed control room power plant of commencement of maintenance.
4. It must be tightened bolts of coupling additionally or exchanged new packing in case of leakage form coupling. It must be sprayed soap water and confirmed bubbles when detecting leakage gas.
5. It must be purged gas in piping in case of leakage from piping and using of welding. In this case, it must be maintained according to following provisions.

   (1) It must be closed valves installed upstream and downstream of place of gas leakage.

   (2) It must be injected inert gas (nitrogen etc.) in piping and exchanged inert gas from gas in piping.

   (3) It must be welded gas leakage place or exchange piping after confirming exchange by inert gas is completed.

   (4) It must be welded according to regulated procedures by certified welder.
6. It must be opened vales installed upstream and downstream of place of gas leakage and inject gas in repaired piping after maintenance, and confirmed gas leakage is stopped absolutely.
7. It must be canceled isolated area after confirming gas leakage is stopped.
8. It must be informed control room power plant of completion of maintenance.

Article 128-a1. Storage tank

1. Daily patrol and inspection

It must be conducted daily patrol and inspection on liquefied gas storage tank taking account of following provisions.

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) It must be confirmed that there is no flammable materials around storage tank.

(3) It must be confirmed level, pressure and temperature of storage tank are within acceptable value.

(4) It must be confirmed defects in gas leakage detector.

(5) It must be confirmed defects in fire fighting equipments (water spray system, fire hydrant system, foam fire extinguishing system, dry chemical extinguishing system etc.)

(6) It must be confirmed external appearance (painting, damage and corrosion etc.) of storage tank.

(7) It must be confirmed defects (crack and damage etc.) in dike.

2. Receiving of liquefied gas

It must be paid attention adequately at receiving liquefied gas to storage tank because it is flammable gas. Point to be checked at receiving it is shown as follows;

(1) Preparation of receiving of liquefied gas

1) It must be conducted receiving of liquefied gas according to receiving procedure developed by each power plant.

2) It must be informed control room of power plant of commencement of receiving.

3) It must be placed off-limits (restricted zone) to prohibit outsider from coming in working area.

(2) Construction of receiving system

1) It must be connected unloading arm and loading arm to tanker.

2) It must be constructed return gas line.

3) It must be constructed liquefied gas line.

4) It must be paid attention to liquefied gas leak adequately when connecting to tanker and constructing above lines.

(3) Receiving of liquefied gas

1) It must be started pump (compressor) installed in tanker to receive liquefied gas.

2) It must be paid attention to liquefied gas leak adequately during receiving it.

3) It must be paid attention to pressure, level and temperature of liquefied storage tank during receiving it.

4) It must be pushed out remaining liquefied gas in receiving line to storage tank by compressor installed in tanker.

(4) Recovery work

1) It must be conducted recovery work of liquefied gas line and return gas line, and disconnected unloading arm and loading arm.

2) It must be canceled off-limits.

3) It must be informed control room of completion of receiving liquefied gas.

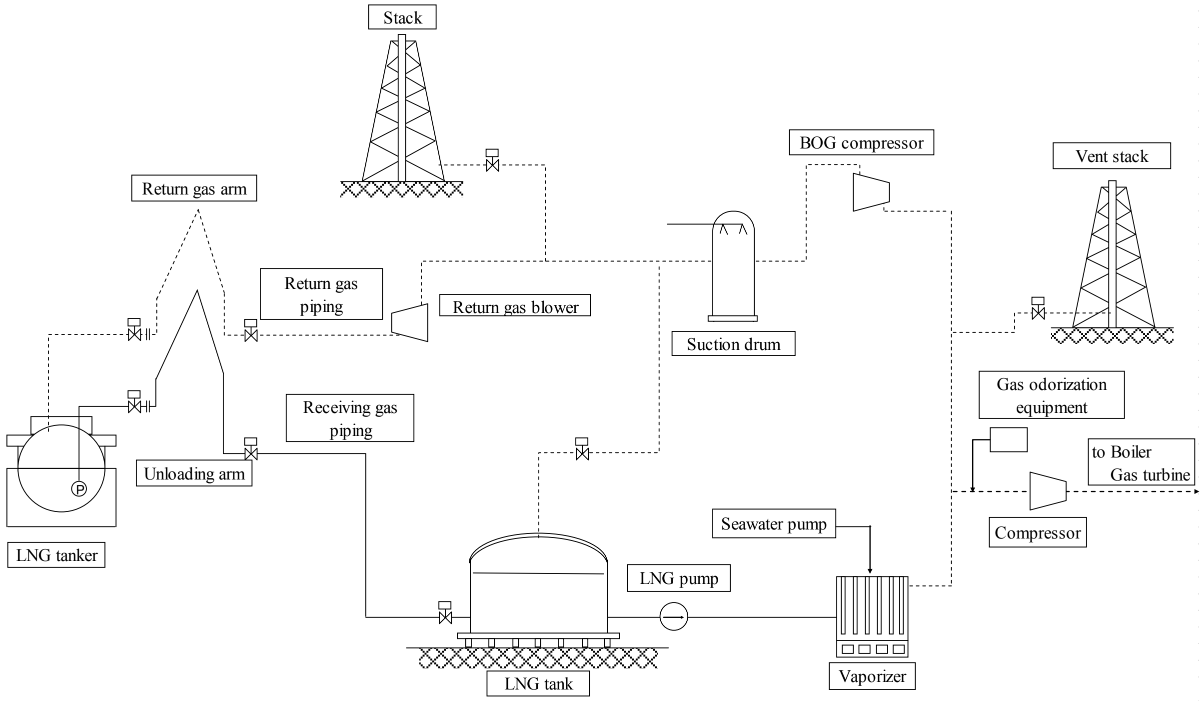
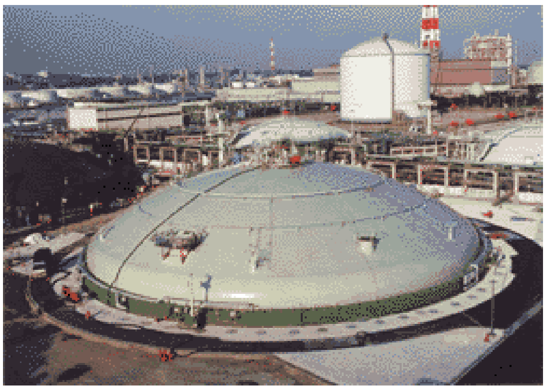


Figure 128-a1-1 LNG receiving terminal

Earth



Under earth

Photo 128-a1-1 LNG storage tank

Article 128-a2. Vaporizer

1. Daily patrol and inspection

It must be conducted daily patrol and inspection on vaporizer of liquefied gas taking account of following provisions.

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) It must be confirmed that there is no flammable materials around vaporizer.

(3) It must be confirmed pressure and temperature of vaporizer are within acceptable value.

(4) It must be confirmed defects in gas leakage detector.

(5) It must be confirmed defects in fire fighting equipments (fire hydrant system etc.).

(6) It must be confirmed defects (damage, corrosion and painting, etc.) in related values and piping of vaporizer.

2. Changeover of vaporizer

It must be shifted from operating vaporizer to standby one periodically. Point to be checked at shifting of it is shown as follows;

(1) Preparation of changeover

1) It must be conducted changeover of vaporizer according to procedures developed by each power plant.

2) It must be informed control room of power plant of commencement of changeover of vaporizer.

3) It must be confirmed status of standby vaporizer (pressure, temperature and level).

4) It must be confirmed related automatic valves are at automatic position.

(2) Changeover

1) It must be operated starting sequence of vaporizer.

2) It must be confirmed gas leakage and operating status of each equipment. It must be stopped changeover immediately when detecting defects in vaporizer.

3) It must be transferred load of vaporizer from operating vaporizer to standby one.

4) It must be operated stopping sequence of vaporizer.

5) It must be operating status (pressure, temperature and level) of started (standby) vaporizer.

6) It must be informed control room of completion of changeover.

Photo 128-a2-1 Vaporizer

Article 128-a3. Compressor

1. Daily patrol and inspection

It must be conducted daily patrol and inspection on liquefied gas compressor taking account of following provisions.

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) It must be confirmed defects in gas leakage detector.

(3) It must be confirmed defects in fire fighting equipments (fire hydrant system etc.).

(4) It must be confirmed compressor body regarding following items.

  1) Inlet and out let gas pressure etc.
  2) Abnormal noise, abnormal odor, vibration and gas leakage
  3) Heating, abnormal noise and oil leakage for bearing
  4) Level, change in color and leakage for lubricant oil
  5) Gas leakage and corrosion of piping
  6) Gas leakage and corrosion of valves
  7) Corrosion and peeling for painting

(5) It must be confirmed lubricant oil and seal oil pump regarding following items.

  1) Outlet lubricant oil pressure and seal oil supply pressure etc.
  2) Abnormal noise, Abnormal odor, vibration and oil leakage
  3) Heating, abnormal noise and oil leakage for bearing
  4) Oil leakage and corrosion of piping
  5) Oil leakage and corrosion of valves
  6) Corrosion and peeling for painting

(6) It must be confirmed cooling water system regarding following items.

  1) Cooling water supply pressure etc.
  2) Cooling water leakage and corrosion of piping
  3) Cooling water leakage and corrosion of valves
  4) Corrosion and peeling for painting

Photo 128-a3-1 Gas compressor

Article 128-a4. Liquefied gas pump

1. Daily patrol and inspection

It must be conducted daily patrol and inspection on liquefied gas pump taking account of following provisions.

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) It must be confirmed defects in gas leakage detector.

(3) It must be confirmed defects in fire fighting equipments (fire hydrant system etc.).

(4) It must be confirmed pump body regarding following items.

1) Out let pressure, vibration, discharge rate o flow and current of motor
2) Abnormal noise, abnormal odor and gas leakage
3) Heating, abnormal noise and oil leakage for bearing
4) Gas leakage and corrosion of piping
5) Gas leakage and corrosion of valves
6) Corrosion and peeling for painting

Photo 128-a4-1 Liquefied gas pump

Article 129. Safety of gas supply in blast furnace and coke-burning boiler

1. Blast Furnace Gas (BFG)

BFG is exhaust gas from blast furnace of steel plant. Its aspect is shown in Table 129-1 and it is composed of carbon monoxide (CO) carbon dioxide (CO_2) and Nitrogen (N_2). In general, diameter of gas piping is large because gas pressure is low. It must be taken appropriate safety countermeasures such as installation of CO gas detector and purge of piping by Nitrogen gas or steam because it is toxic and density of it is slightly heavier than air.

2. Coke Oven Gas (COG)

COG is coal gas which coal is dried by distillation in coke oven. Its aspect is shown in Table 129-1 and it includes many Hydrogen (H2). Heating value of it is relatively high (21,000kJ/Nm3) and density is lighter than air. Gas pressure is low same as BFG and there are times when gas pressure is pressurized by blower. It must be paid attention plugging of piping due to naphthalene, tar and ammonia in COG.

3. Combustion system of BFG and COG

Required gas volume of BFG is large because heating value is low and gas volume BFG and COG is large because gas pressure of them is low. Therefore, these gases are burned by diffusing air and them. In case of BFG and COG are exhaust gas from steel plant and they are used for fuel of boiler, it must be installed U type water seal valve boundary between power plant and steel plant and gas shut off valve for boiler. It must be taken appropriate safety countermeasures such as installation of CO gas detector and vent valve and purge of piping by Nitrogen gas or steam because they includes toxic CO.

Table 129-1 Sample of physical property of BFG & COG

Gas	Aspect				Theoretical air (m3/m3)	Theoretical combustion gas (m^3/m^3)	Maximum CO_2 (%)	Heating value (kJ/Nm3)	
	H2	CO_2	CO	N2				High	Low
BFG	2.7	19.3	23.3	54.7	0.62	1.49	29.2	3,310	3,220
COG	55.2	2.7	8.0	2.6	4.61	5.30	10.9	21,350	18,840

Article 130. Determination characteristics of gas burning

It is important for stable operation of power plant to identify operating characteristics when supplying and burning gas in boiler, industrial emission (Inclusive of SO_2), and sulfur in natural gas (inclusive of mercaptan) in design and regulations of power plant. Main operating characteristics are shown as follows;

1. Operating characteristics

(1) Flame type

In general, flame generated by gas fuel is classified as follows;

1) Classification based on mixed status of gas

a. Premixed flame

Flame is that fuel and air are premixed before burning zone.

b. Diffusion flame

Flame is that fuel and air are mixed in the process of diffusion.

2) Classification based on flow status of gas

a. Laminar flame

Flow before burning zone is laminar, and flame is that mixture and transport are produced by molecular process.

b. Turbulent flame

Flow is turbulent, and flame is that mixture and transport are produced by macroscopic vortex motion of fluid.

3) Classification based on temporal response status

a. Steady state flame

Flame is not changed temporally and depended on space distribution.

b. Unsteady state flame

Flame is changed temporally.

4) Classification based on temporal response status

a. Existence flame

Flame is stayed at same place.

b. Propagation flame

Flame is removed as time go on.

(2) Flammability limit

Mixed gas is burned when mixture ratio of fuel gas and air is within acceptable range. Upper and lower limit of this range is flammability limit and it is indicated by fuel concentration in mixed gas. Lower limit indicates rarefied fuel condition, and upper limit indicates over concentrated fuel condition. Flammability limit is important to make a study on explosion-protection, prevention of back fire and purge of gas piping.

(3) Ignition

After flammable mixed gas of fuel and air is heated and it is approached a temperature, it is broken into a spontaneous flame. It is called ignition temperature and a yardstick for ignition of fuel.

(4) Adiabatic flame temperature

Adiabatic flame temperature is theoretical flame temperature in case that fuel is burned completely under thermal insulation and it is important measure to evaluate generating characteristic of thermal NO.

(5) Oscillatory burning

Oscillatory burning is self-excited oscillation which combines flow fluctuation and burning reaction in combustion chamber by feedback mechanism. It is phenomenon which pressure, flow velocity and flame in combustion chamber are fluctuated. Oscillatory burning tends to take place because burning reaction is sensitive to flow fluctuation in case of gas burning. When oscillatory burning is conducted, vibration noise is generated on specific frequency, combustion efficiency is decreased and related equipments are damaged. Oscillatory burning in boiler is Helmholtz type oscillatory burning and acoustic resonance type oscillatory burning.

(6) Premixed flame

When flammable premixed gas is ignited, flame is produced extremely thin flame and propagated in premixed gas. This flame is reacted chemically immediately, temperature and gas concentration are changed drastically. Burning velocity depends on type, composition, temperature and pressure of premixed gas. Burning velocity of turbulent premixed flame is increased in connection with Reynolds number and is not depended on type of gas.

(7) Turbulent (jet flow) diffusion flame

Fuel and air are jetted out separately and they are burned. Flame is produced at boundary face between fuel and air, fuel and air are supplied to this boundary face by diffusion and flame is kept. Burning velocity depends on diffusion mix velocity.

(8) Stabilization of flame

Flame is stable and not extinguished when fuel flow velocity and air ratio are within proper range. There is a possibility that premixed flame is generated back fire when fuel flow velocity is decreased, generally jet flow diffusion flame is not generated back fire. It is necessary that balance point with mixed gas flow velocity and burning velocity is produced to steady flame. In general, this balance point is base of flame.

2. Exhaust gas composition

It must be paid attention to emission gas from power plant to prevent environmental pollution. It must be referred to Part6 of Vol.2 design technical regulation regarding emission control regulation when identifying industrial emission and sulfur in natural gas in regulation of power plant.

Chapter 3 Pulverized Coal Processing

Article 131. General Provision

Starting mode for coal pulverizer is normal starting mode and starting with remaining coal mode. When boiler is stopped emergency, coal pulverizer emergency is stopped leaving coal in it. This is “remaining coal”. There is a possibility that a fire is occurred in case that coals are left in coal pulverizer for long time. Therefore, it must be paid attention to status of coals carefully. Countermeasures for remaining coal are shown as follows;

1. Countermeasures for remaining coal

(1) Acceptable time for remaining coal (sample)

Acceptable stop time for coal pulverizer with remaining coal (sample) is shown in Table 131-1. It must be referred to actual experience of each power plant and manufacture’s recommendation when it is defined at each power plant.

Table 131-1 Acceptable stop time for coal pulverizer with remaining coal (sample)

Volatile matter content in coal (%)	Acceptable stop time for coal pulverizer with remaining coal (hrs)
Less than 30	24
30 - 50	12
More than 50	6

(2) Concrete countermeasures

It must be following countermeasures within above acceptable time to prevent a fire.

1) Starting with remaining coal of coal pulverizer

Process flow of starting with remaining coal is shown as follows;

a. Preparation before starting

(a) It must be confirming following provisions as preparation before starting with remaining coal.

a) Starting condition of relevant oil burner is formed.

b) Each measuring gauge and recorder is normal.

c) Control air pressure is normal.

d) Following equipments are turned on power and in automatic mode.

- Coal pulverizer
- Coal feeder
- Rotating classifier
- Primary air fan
- Related damper and pumps
- Coal gate etc.

e) Each control source is turned on power. And others

b. Process flow of staring

(a) It must be started starting system of coal pulverizer with remaining coal.

(b) It must be confirmed operation status of following equipments.

a) Lubricant oil pump : Starting

b) Roller pressure pump : Starting

c) Rotating classifier : Starting

d) Igniter : Ignition

e) Hot air damper : Full close

f) Cool air damper : Full open

g) Seal air damper : Open

h) Cut damper : Open

i) Primary air shutoff damper : Open

j) Primary air control damper : Stipulated opening etc.

(c) It must be confirmed following operation condition is met with acceptable value.

a) Primary air flow volume
b) Differential pressure of roller seal
c) Differential pressure of table seal
d) Lubricant oil temperature
e) Inlet lubricant oil pressure of coal pulverizer reduction gears and others

(d) It must be confirmed starting condition of motor of coal pulverizer is formed and it is started.

(e) It must be confirmed coal feeder is started.

(f) It must be confirmed initial stipulated coal feed rate.

(g) It must be confirmed outlet temperature of coal pulverizer is met with acceptable value and initial feeding coal is completed.

(h) It must be confirmed relevant igniters are extinguished.

2) Purging with remaining coal of coal pulverizer

It must be supplied remaining coal to boiler by purging of coal pulverizer. It must be referred to Article 137 of this guideline.

3) Removing from coal pulverizer inside

When coal pulverizer is stopped longer than acceptable stop time shown in Table 131-1, it must be removed remaining coal by hand to prevent a fire. It must be taken appropriate countermeasures of removed coals.

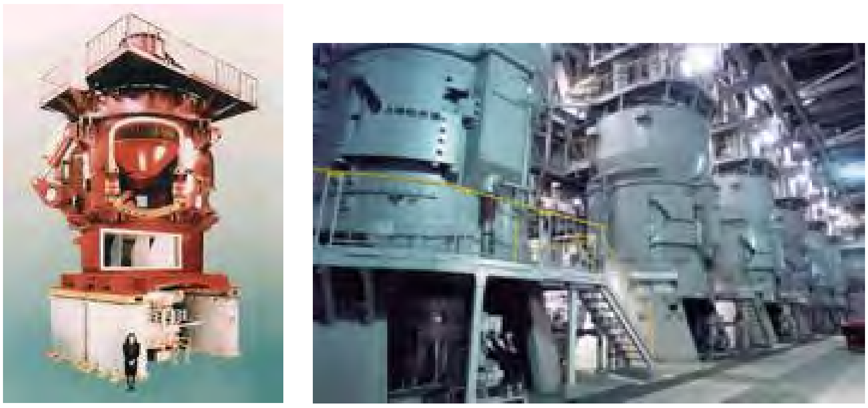


Photo 131-1 Coal pulverizer

Article 132.

(Nothing)

Article 133. Starting up system

When confirming trouble and defects in coal pulverizer, it must be stopped and maintained it immediately to keep stable operation of power plant. It must be confirmed following provisions to operate coal pulverizer system safely before restarting it after stopping it over 72 hours.

1. It must be confirmed following equipments are in good condition.
   (1) Interlock and protection system
      1) Emergency stop
      2) Starting and stopping conditions for loading hydraulic pressure pump of coal pulverizer
      3) Starting and stopping conditions for lubricant oil pump of coal pulverizer
      4) Starting and stopping conditions for coal feeder
      5) Starting and stopping conditions for rotating classifier
      6) Opening and closing conditions for coal gate
      7) Opening and closing conditions for cut damper
   (2) Measuring instruments
      1) Coal pulverizer outlet temperature
      2) Differential pressure in coal pulverizer
      3) Lubricant oil pressure of coal pulverizer
      4) Lubricant oil level of coal pulverizer
      5) Vibration of coal pulverizer
      6) Bearing temperature of each motor
      7) Roller loading hydraulic pressure
      8) Casing metal temperature of coal pulverizer
      9) Differential pressure of roller seal
      10) Differential pressure of table seal And others
   (3) Lubricant oil equipment of each bearing of coal pulverizer and coal feeder
   (4) Cooling water equipment of following equipments
      1) Lubricant oil equipment of each reduction gears
      2) Roller loading hydraulic pressure equipment
      3) Each motor cooler
   (5) Automatic system
   (6) Signaling system
   (7) Remote control system
2. It must be confirmed control air pressure is normal.
3. It must be confirmed there are sufficient quantities coals in coal bunker to operate power plant stably.
4. It must be referred to Article 137 of this guideline regarding purging of coal pulverizer.

Article 134. Check during operation

When operating pulverized coal processing system, it must be checked following items by daily patrol, daily inspection and monitoring from control room;

1. Feeding of fuels for pulverizer

It must be checked feeding of fuels for pulverizer carefully because No flow coal at bunker chute and lack of coal at coal feeder causes emergency trip of coal pulverizer. Countermeasures for no flow coal at bunker chute and lack of coal at coal feeder are shown as follows ;

(1) No flow coal at bunker chute

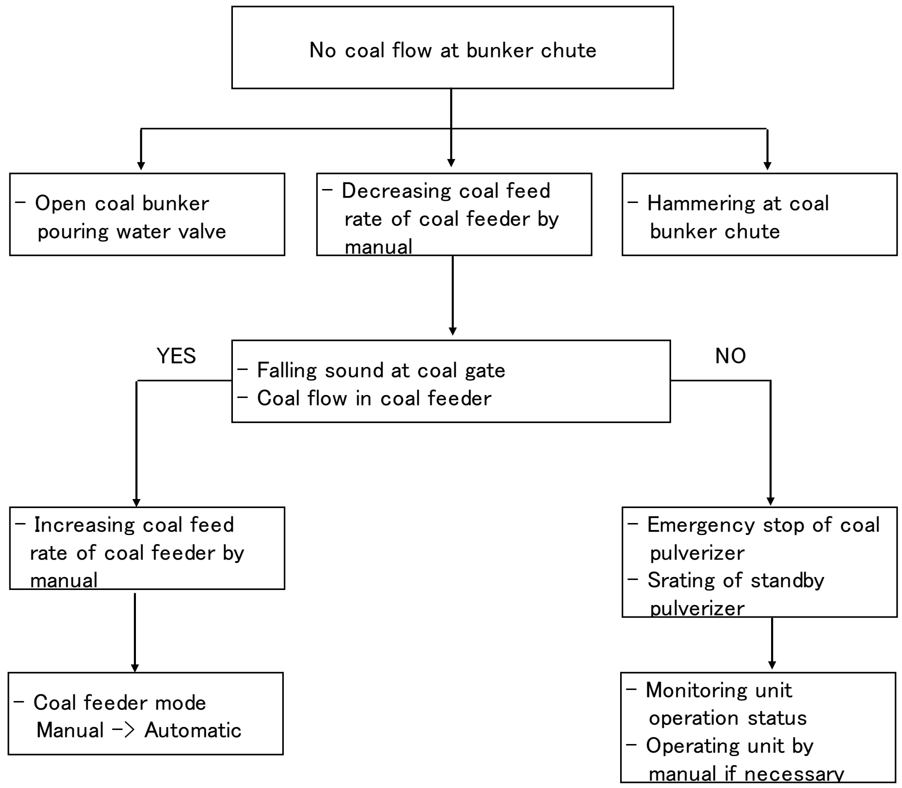


Figure 134-1 Process flow of no flow coal at bunker chute

(2) Lack of coal at coal feeder

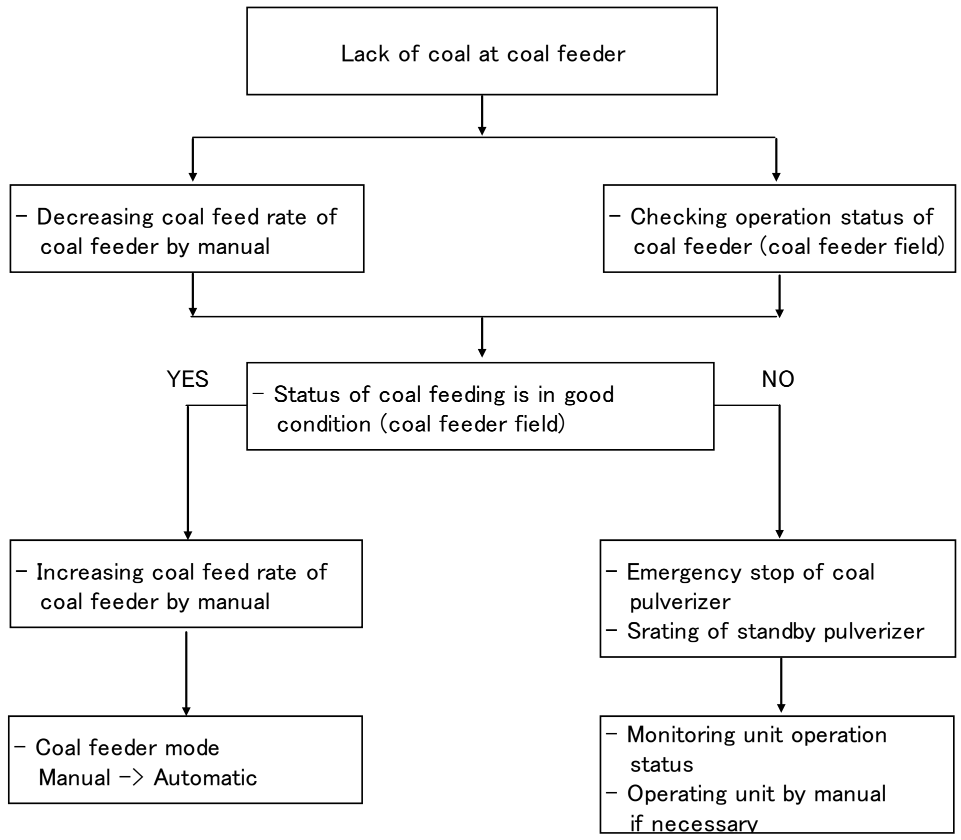


Figure 134-2 Process flow of Lack of coal at coal feeder

2. Amount of raw coal and pulverized coal must not be lower or higher than amount stipulated in regulations of power plant.

Amount of raw coal and pulverized coal are calculated based on output of power plant and heating value etc. When amount of raw coal and pulverized coal are lower or higher than amount stipulated in regulations of power plant, output of power plant is lower or higher than rated output. It must be supplied coal to boiler according to regulations of power plant to operate power plant stably.

3. Temperature of pulverized coal in the system must not be over the stipulated limit

When temperature of pulverized coal in the system is increased, there is a possibility that a fire of coal pulverizer is occurred. Therefore, it must be monitored outlet temperature of coal pulverizer carefully. The reason and countermeasures when outlet temperature of coal pulverizer is high are shown as follows ;

(1) Reason

1) Control failure of cool and hot air damper

2) Rapid decreasing of coal feed rate

3) Failure of temperature switch

(2) Countermeasures

1) Manual adjustment of cool and hot air damper

Adjustment by control drive

2) Confirming of no flow coal at bunker chute and lack of coal at coal feeder

Refer to above paragraph 1 “Feeding of fuels for pulverizer”.

Opening cool air damper manually when coal feed rate is deceased rapidly and outlet temperature of coal pulverizer is increased.

3) Inspection and maintenance of temperature switch

4. Heat insulation and tightness of all parts of equipment. Holes which cause the air and pulverized leakage must be sealed immediately.

It must be checked heat insulation and tightness of all parts of equipment at daily patrol and inspection. When detecting pulverized coal leakage, it must be maintained immediately referring to following items to prevent a fire.

(1) Pulverized coal leakage from coal piping (pin hole)

1) It must be started standby coal pulverizer and stopped one to be maintained.
2) It must be removed piping to be maintained and cleaned pulverized coal in it.
3) It must be welded leakage place and close the hole properly. It must be referred to Article 138 of this guideline regarding welding.
4) It may be used metal repairing materials such as Devcon and Multi Metal etc. instead of welding.
5) It must be installed maintained piping.
6) It must be started maintained coal pulverizer and stopped standby one.

(2) Pulverized coal leakage from flange of coal piping

1) It must be tightened bolts of flange and confirmed that pulverized coal leakage is completed.

5. Clogging of a coal bunker, pulverized coal bunker and mixing bunker

Because clogging of coal bunker, pulverized coal bunker and mixing bunker causes decrease of coal feed rate and makes power plant unstable operation, it must be checked it carefully by daily patrol and inspection and monitoring from control room of power plant. When confirming no flow coal of this bunker, it must be referred to above paragraph 1 “Feeding of fuels for pulverizer”.

Article 135. Adjustment pulverized coal system

Several type of coals are supplied to some coal fired boiler due to cost down, fuel security and burning characteristics etc. . When type of coal is changed, fineness and primary air weight in terms of coal at coal pulverizer outlet. And, it is important to confirm fineness and primary air weight in terms of coal at coal pulverizer outlet regarding operation management of power plant because combustion of boiler, unburnt combustible content in ash and slagging characteristics are changed significantly. Moreover, fineness of pulverized coal is deteriorated as power plant operates. Therefore, it must be conducted sampling of pulverized coal and measuring of fineness periodically.

1. Main process flow for sampling of pulverized coal

(1) Preparation of sampling devices and installation of them

(2) Measuring of flow velocity of pulverized coal (please refer to Photo 135-1.)

(3) Calculation of average of isokinetic sampling flow
(4) Installation of sampling tube
(5) Sampling of pulverized coal
(6) Measuring of fineness and flow volume of pulverized coal (please refer to Photo 135-2)

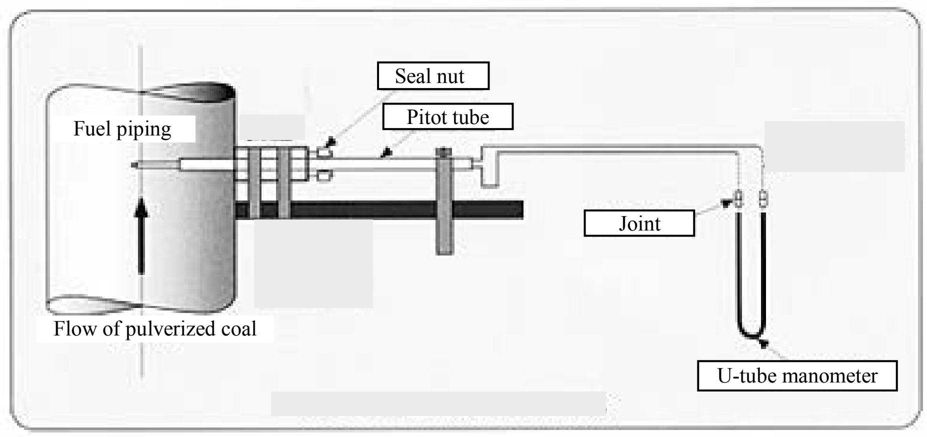


Figure 135-1 Configuration of measuring of flow velocity

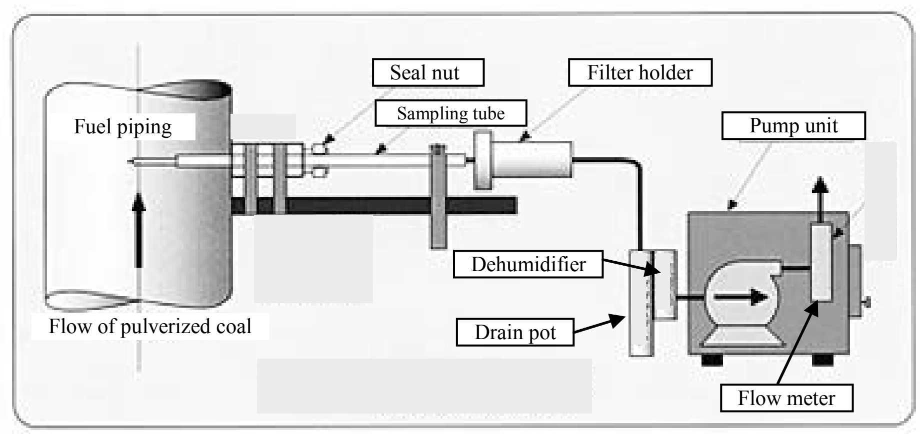


Figure 135-2 Configuration of sampling

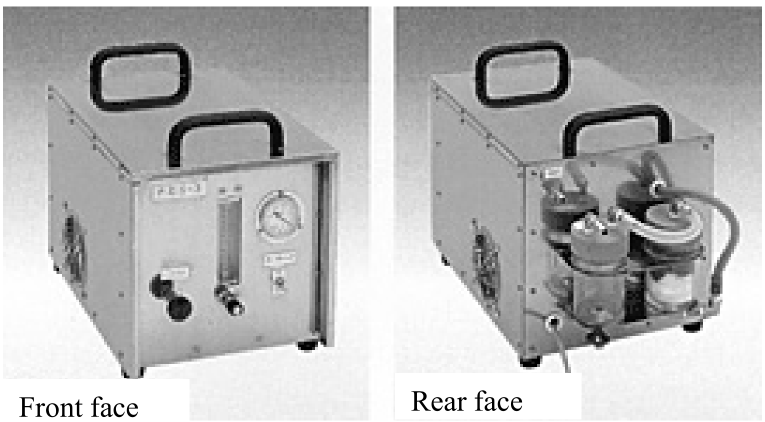


Photo 135-3 Pump unit

Article 136. Pulverized coal processing system with heater

Primary air fan system has Cold Primary Air Fan method and Hot Primary Air Fan method according to temperature of primary air. Please refer to Figure 136-1.

- Cold PAF (Primary Air Fan) method: PAF is installed upstream of AH and supplies cold air.
- Hot PAF (Primary Air Fan) method : PAF is installed downstream of AH and supplies hot air.

Comparison between Cold Primary Air Fan method and Hot Primary Air Fan method is shown as follows;

1. Power consumption

In high load operation with many coal pulverizers operation, Cold PAF method has high efficiency of fan because small numbers of fans supply primary air to all coal pulverizers and small power consumption because it supplies cold air.

On the other hand, in low load operation with few pulverizers operation, Hot PAF method has small power consumption because PAF of stopped coal pulverizer can be stopped.

2. Operational evaluation

When load of coal pulverizer and moisture in coal are changed, inlet air temperature of coal pulverizer is changed. In this case, Hot PAF method is affected by temperature change directly and operating pint of PAF is fluctuated. On the other hand, when inlet air temperature of coal pulverizer is changed, air flow and wind pressure fluctuation to PAF is small and controllability is high.

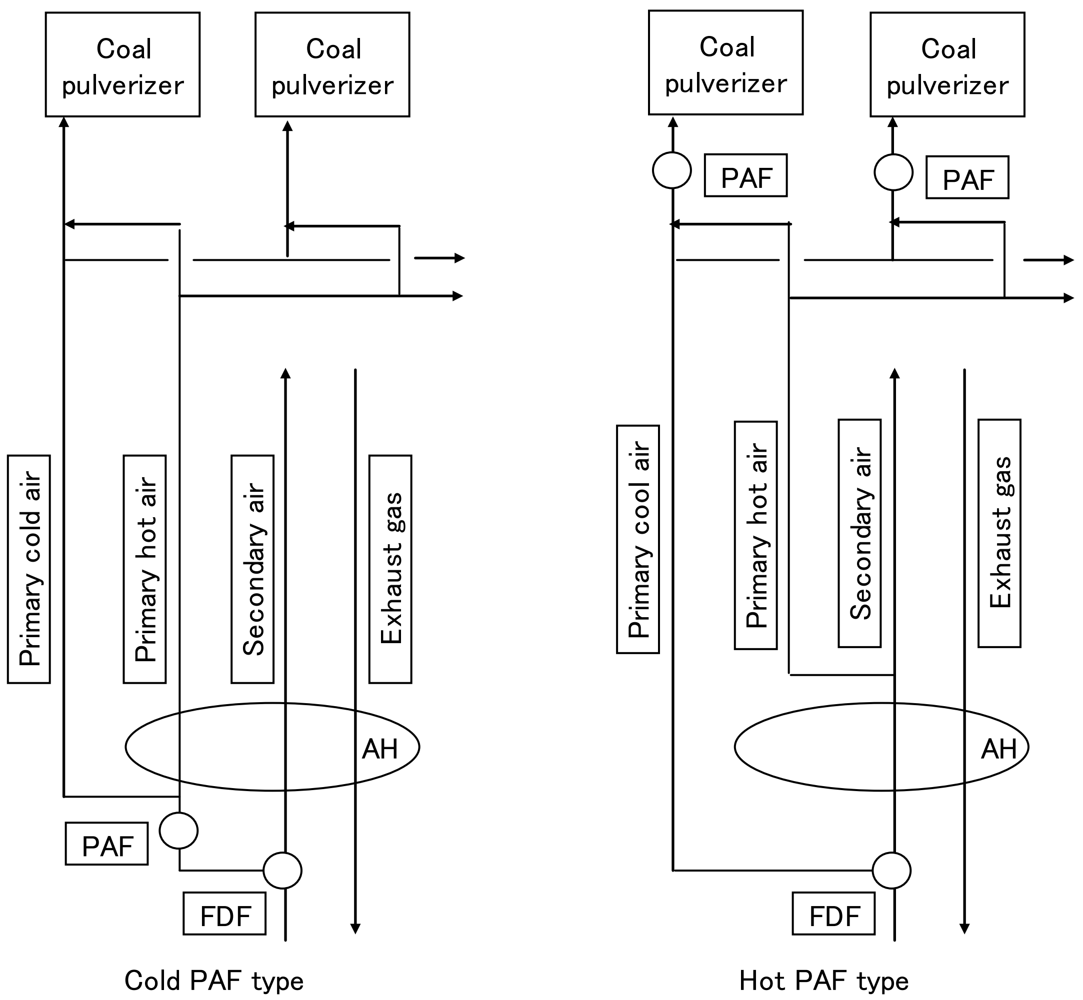


Figure 136-1 PAF system

Article 137. Purge of pulverized coal system

It must be exhausted coal dust from the pulverized coal system when topping system longer than stipulated time and before having boiler overhaul. Purge process of this system is shown as follows;

1. Preparation before purging
   (1) It must be confirming following provisions as preparation before purging.
      1) Starting condition of relevant rotating classifier is formed.
      2) Starting condition of relevant oil burner is formed.
      3) Another coal pulverizer is not under purge.
      4) Some primary air fans are operated.
      5) Seal air pressure of flame detector is normal.
      6) Coal pulverizer system is automatic mode.　And others
2. Process flow of purging
   (1) It must be started purging system of remaining coal.
   (2) It must be confirmed operation status of following equipments.
      1) Lubricant oil pump ： Starting

2) Roller pressure pump : Starting
3) Rotating classifier : Starting
4) Igniter : Ignition
5) Hot air damper : Full close
6) Cool air damper : Full open
7) Seal air damper : Open
8) Cut damper : Open
9) Primary air shutoff damper : Open
10) Primary air control damper : Stipulated opening

(3) It must be confirmed following operation condition is met with acceptable value.
1) Primary air flow volume
2) Differential pressure of roller seal
3) Differential pressure of table seal And others

(4) It must be confirmed starting condition of motor of coal pulverizer is formed and it is started.

(5) It must be confirmed coal feeder is started.

(6) It must be confirmed alarm of lack of coal and coal feeder is stopped after stipulated time.

(7) It must be confirmed motor of coal pulverizer is stopped after stipulated time.

(8) It must be confirmed following equipments are stopped after stipulated time.
1) Roller pressure pump
2) Rotating classifier

(9) It must be following dampers are closed fully after stipulated time.
1) Primary air control damper
2) Primary air shutoff damper
3) Cut damper
4) Seal air damper

(10) It must be confirmed coal bunker pouring water valve is opened for stipulated time and igniters are extinguished.

Article 138. Safety on welding

When welding of pulverized coal processing system, it must be paid attention to following provisions to weld properly and keep safety for power plant staff and stable operation of power plant. Moreover, it must be referred to Part 7 Welding of Vol.2 design guideline regarding further details about welding.

1. It must be conducted preparation and welding according to procedures developed by each power plant.
2. It must be removed inflammable materials around welding place to prevent a fire.
3. It must be cleaned groove face and removed coal, pulverized coal and dust to prevent improper welding.

4. It must be welded by qualified welder which passes stipulated examination.
5. It must be preheated welding place before welding.
6. It must be conducted nondestructive inspection after welding.
7. It must not be welded in case that humidity and/or ambient temperature are higher than stipulated in above procedures.

Chapter 4 Boiler and its Auxiliary

Article 139. General provision

When operating a boiler and its auxiliary, it must be paid attention to the following items:

1. Main equipment and auxiliary facilities operate safely

It must be confirmed following operation status of equipment by daily patrol and inspection.

(1) Boiler safety valve

It must be confirmed steam leakage from valve seat of boiler safety valve.

(2) Main piping related to boiler (Main steam piping, high and low temperature reheat steam piping)

It must be confirmed following defects in main piping.

1) Trouble of hanger
2) Leakage from steam piping
3) Vibration of steam piping

(3) Furnace

It must be confirmed following defects in furnace.

1) Trouble of combustion status (incomplete combustion, black smoke etc.)
2) Trouble of furnace inside

(4) FDF, IDF, GRF and PAF

It must be confirmed following defects in fans and referred to Article 143 of this guideline.

1) Vibration
2) Abnormal noise
3) Air leakage from gland
4) Bearing temperature
5) Oil level and oil leakage

2. To come up to rated steam value, steam and water quality

Rated steam value of each boiler is defined in boiler specification and it must be monitored rated steam value and supply it to steam turbine to operate power plant stably. It must be referred to Article 142 of this guideline regarding steam and water quality.

3. To be in economical operating mode without unstable burning and be identified based on experiments and procedures of manufacturer.

It must be operated power plant stably and economically according to experiments and procedures of manufacturer and. Moreover, it may be made a study on cost down of power plant operation without unstable operation. Sample of cost down method is shown as follows ;

(1) Prolongation of inspection and parts replacement interval

1) Prolongation of inspection interval based on actual performance of power plant, manufacture's recommendation etc.

2) Prolongation of parts replacement interval for them which not have an impact on power plant output.

(2) Usage of inexpensive fuel

1) It must be conducted combustion test and confirm stable combustion when changing fuel.

(3) Reducing of auxiliary power ratio

1) Reducing of operating auxiliary at low power plant output

2) Reducing of unnecessary illumination

(4) Reducing of make-up water

1) Reducing of leakage of closed cooling water

(5) Usage of multipurpose parts

1) Usage of multipurpose parts which not have an impact on power plant output.

(6) Reducing of consumable

1) Chemicals and lubricant oil etc.

4. To maintain demand range that is determined for each type of boiler and fuel.

Following operation condition is different according to type of boiler and fuel. It must be maintained them to operate power plant stably.

(1) Main steam pressure temperature and flow volume

(2) Combustion characteristics

(3) Boiler heat absorption characteristic

(4) Air mass flow

(5) Exhaust gas characteristics and others

Article 140. Cleaning of boiler

1. Purpose of chemical cleaning of boiler

Purpose of chemical cleaning of boiler under construction and commercial operation is shown as follows;

- Removing of foreign objects and scale on inner face of evaporator tube
- Prevention of boiler troubles, keeping stable operation of boiler and of recovery and keeping generating power efficiency

Mill scale (oxide) at manufacturing of boiler tube, oil and fat content at processing and assembling and foreign objects are removed by chemical cleaning under construction. In boiler after commercial operation, impurities coming in boiler are decreased due to installation of condensate demineralizer and highly-developed water treatment. However, scale is adhered to tube inside due to following factors.

- Corrosion of boiler tube
- Corrosion product from feed water system
- Condensation and precipitation of dissolved salt

These causes overheat of boiler tube and corrosion due to concentrated salt, and evagination and burst of boiler tube is caused.

<Before cleaning>

<After cleaning>

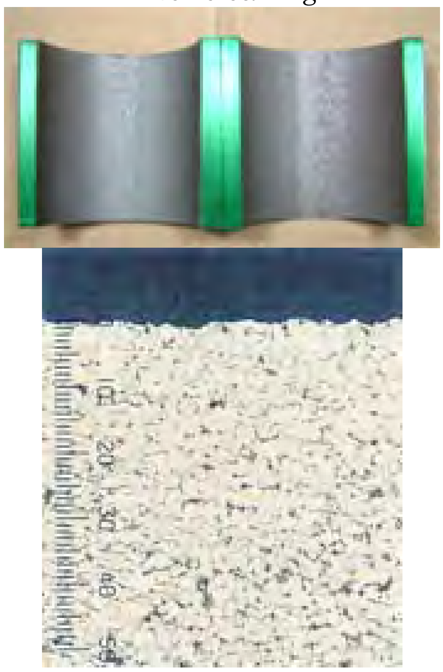


Photo 140-1 Effect of cleaning of boiler

2. Chemical cleaning procedures

 (1) Process flow

 Typical process flow of chemical cleaning is shown as follows;

Table 140-1 Typical process flow of chemical cleaning

	Under construction	After commercial operation		
		Element of copper in scale		
		Copper : large quantity	Copper : small quantity	Copper : nothing
Flushing	Implementation	Implementation	Implementation	Implementation
Ammonia cleaning	-	Implementation	-	-
Defatting cleaning	If necessary	-	-	-
Water cleaning	If necessary	Implementation	-	-
Acid cleaning	Implementation	Implementation	Implementation	Implementation
Water cleaning	Implementation	Implementation	Implementation	Implementation
Neutralization and anticorrosion	Implementation	Implementation	Implementation	Implementation
Final water cleaning	If necessary	If necessary	If necessary	If necessary

1) Under construction

Main purpose of chemical cleaning under construction is to remove mill scale (oxide) oil content and foreign objects. Defatting cleaning is deleted because degreasing agent is added during acid cleaning if necessary.

2) After commercial operation

a. Scale including small quantity of copper

Ammonia cleaning is conducted to melt copper before acid cleaning.

b. Scale including large quantity of copper

Chemical cleaning is started from acid cleaning, ammonia cleaning is not conducted.

(2) Cleaning procedure

1) Flushing

Purpose of flushing is to remove foreign objects and peeled flaked scale. In general, it is continued until foreign objects and coloration in waste water is not checked.

2) Defatting cleaning

Purpose of defatting cleaning is to remove oil and fat content at manufacturing and constructing of boiler. In defatting cleaning, surface-active agent is added to alkaline chemicals, temperature of cleaning is 80 – 90 deg C. It's often the case that surface-active agent is added during acid cleaning because oil and fat content is decreased due to high quality control.

3) Ammonia cleaning

Purpose of ammonia cleaning is to remove copper before acid cleaning in case that quantity of copper in scale is large. Metal scale and copper scale are melted simultaneously by adding chemical admixture in case that quantity of copper in scale is small.

4) Acid cleaning

Purpose of acid cleaning is to remove mill scale (oxide) and rust for newly constructed boiler and scale for scale added during boiler operation for operating boiler. Acid cleaning has following 3 procedures depending on type of chemical agent.

a. Inorganic acid cleaning

Hydrochloric acid is used the most widely, solvent power to scale is strong and it is used at low temperature zone.

b. Organic acid cleaning

Solvent power to scale is weaker than hydrochloric acid and needs high temperature treatment. However, there is not a worry that austenitic stainless steel causes stress corrosion cracking. Therefore, it is safe as boiler cleaning method relatively.

c. Chelate cleaning

Ammonium salt and sodium salt are adopted in chelate cleaning mainly. Same chemical agent is used from melting scale to anti-rust and waste water volume is low.

5) Neutralization and anticorrosion

Neutralization and anticorrosion is conducted to stabilize metal face because surface of boiler tube is energized and tarnishable after chemical cleaning.

Article 141. Check of protection equipment before starting up boilers

It must be confirmed condition of protection equipment and interlock of boiler before being put in operation after it which are repaired or are in long standby (over 72 hours). Sample of alarm test and interlock test is shown as follows;

1. Alarm test

(1) Purpose

It must be confirmed that defect for control system, pressure and temperature etc. related boiler equipment are detected and alarm system is operated normally.

(2) Unit operation status

Under unit operation

Under unit trip

(3) Test procedure and point to be checked (example)

Test item	Test procedure	Point to be checked		
		Set value	Operating value	Indicator
Feed water rate low	a Imitation signal is inputted through input terminal of feed water rate alarm adjuster at boiler converter panel. b Feed water rate is confirmed by recorder (Boiler-Turbine-Generator panel) at alarming.	XX t/h + AA - AA	t/h	Feed water rate low
FDF bearing lubricant oil pressure low	a Valve of bearing lubricant oil pressure switch is closed. b Temporary blow valve is opened and bearing lubricant oil pressure is decreased. c Bearing lubricant oil pressure is confirmed by temporary pressure gauge at alarming.	X.XX Pa + A.AA - A.AA	Pa	FDF abnormal
Steam temperature high of super heater outlet	a Imitation signal is inputted steam temperature adjuster at APC panel. b Steam temperature is confirmed by recorder at alarming.	XX ℃ + AA - AA	℃	Steam temperature high of super heater outlet

(4) Evaluation criteria

It must be confirmed alarms and necessary indications are appeared normally.

2. Interlock test

(1) Furnace purge interlock

1) Purpose

It must be confirmed that furnace purge is operated normally and boiler is ignited after completing furnace purge to prevent furnace explosion at boiler starting.

2) Unit operation status

a. Under boiler stop

b. Under turbine stop

3) Test procedure and point to be checked (example)

Item	Test procedure	Point to be checked
Confirmation of condition of furnace purge	- MFT - Nonuse of igniter - Nonuse of light oil burner - Nonuse of heavy oil burner - Not less than 1 FDF operating - Not less than 1 IDF operating - Heavy oil/light oil transfer valve : light oil side - Stop of all coal pulverizers - 2 GRFs operating - Not less than XX% MCR of air mass flow	- "MFT" : On - Nonuse - Nonuse - Nonuse - "Operating" : On - "Operating" : On - Light oil side - "Stopping" : On - "Operating" : On - Air mass flow : XX% MCR - "Operating permission of furnace purge" : On
Confirmation of start impossibility of furnace purge	- less than XX% MCR of air mass flow - Push "furnace purge" button - Not less than XX% MCR of air mass flow	- "Operating permission of furnace purge" Off - "Operating permission of furnace purge" Off - "Operating permission of furnace purge" On - Air mass flow : XX% MCR
Starting of furnace purge	- Push "furnace purge" button - Opening of all air registers - Opening of all inlet dampers of wind boxes - Opening of all gas distributing dampers	- "Operating" : on - Set opening - Set opening - Full opening
Confirmation of leak check of ignition light oil system	- Light oil pump is started by pushing "starting of ignition light oil system" button. When pressure before light oil shut off valve is not less than stipulated value, ignition light oil shut off valve is opened. When ignition light oil pressure is not less than stipulated value, ignition light oil shut off valve is closed. - When ignition light oil pressure is not less than XX pa for A minutes, leak check of ignition light oil system is completed.	- Light oil pump : Operating - Ignition light oil shut off valve : Open - Ignition light oil shut off valve : Close - Pressure : XX pa - Pressure of igniter header : XX pa XX minutes after leak check

Item	Test procedure	Point to be checked
Confirmation of leak check of light oil system	- Light oil leak check valve is opened after pushing "Operating of light oil system" button. When light oil pressure is less than stipulated value, light oil leak check valve is closed. - When light oil pressure is not less than XX pa for A minutes, leak check of light oil system is completed.	- Light oil leak check valve : Open - Light oil leak check valve : Close - Pressure : XX pa - Pressure of burner header : XX pa XX minutes after leak check
Confirmation of completion of furnace purge	- Furnace purge is completed in XX minutes after leak check is finished.	- Completion of furnace purge : On - Time of purge : XX minutes
Confirmation of ignition impossibility of igniter (before MFT reset)	- No.X ignition of igniter - No.X ignition of igniter - No.X ignition of igniter	- Impossibility of ignition - Impossibility of ignition - Impossibility of ignition
Confirmation of MFT reset	- After furnace purge, ignition light oil system leak check and light oil system leak check are completed, imitation signal of light oil feed rate is increased not less than XX t/h and MFT reset is confirmed.	- Feed water feed rate : XX t/h - MFT : Off - Completion of ignition light oil system starting : On - Completion of light oil system starting : On

4) Evaluation criteria

It must be confirmed each equipment is operated and alarms and necessary indications are appeared normally.

(2) MFT interlock

1) Purpose

It must be confirmed that boiler interlock (MFT) is operated normally due to trouble having an effect on boiler combustion and interlock of each boiler related equipment is operated normally due to MFT. It must be confirmed that alarms and necessary indications are appeared normally.

2) Unit operation status

a. Under boiler stop

b. Under turbine stop

3) Test procedure and point to be checked (example)

<MFT due to loss of all flame>

a. Test procedure

Light oil burner, heavy oil burner and pulverized coal burner are extinguished sequentially, MFT is operated by extinguishing last burner.

b. Status confirmation

Point to be checked	Confirmation procedure			
	Before test	Check	After test	Check
No.X - IDF	Operation		Operation	
No.X – FDF	Operation		Operation	
No.X – PAF	Operation		Stop	
No.X – GRF	Operation		Operation	
No.X – IDF blade	Auto %		Auto %	
No.X – FDF blade	Auto %		Auto %	
No.X – PAF blade	Auto %		Auto %	
No.X – IDF outlet damper	Full open		Full open	
No.X – FDF outlet damper	Full open		Full open	
No.X – PAF outlet damper	Full open		Full close	
No.X – GRF outlet damper	Full open		Full open	
XX stage air register	Open		Full open	
XX stage air register	Open		Full open	
No.X – light oil pump	Operation		Stop	
No.X – heavy oil pump	Operation		Stop	
Light oil shut off valve	Full open		Full close	
Heavy oil shut off valve	Full open		Full close	
Igniter shut off valve	Full open		Full close	
XX stage light oil burner	On		Off	
XX stage heavy oil burner	On		Off	
XX stage igniter	On		Off	
M-BFP	Operation		Stop	
No.X – BFPT	Reset		Stop	
No.X – BFPT booster pump	Operation		Stop	
No.X – super heater spray control valve	Auto %		Auto %	
Reheater spray control valve	Auto %		Auto %	
Reheater spray shut off valve	Full open		Full close	

Point to be checked	Confirmation procedure			
	Before test	Check	After test	Check
No.X – Reheater spray valve	Full open		Full close	
De-SOx bypass damper	Full close		Full open	
No.X – De-NOx ammonia shut off valve	Full open		Full close	
No.X – coal pulverizer	Operation		Stop	
No.X – coal feeder	Operation		Stop	
No.X – coal pulverizer outlet damper	Full open		Full close	
No.X – coal pulverizer primary air damper	Auto %		Auto %	
No.X – coal pulverizer hot air damper	%		%	
No.X – coal pulverizer cold air damper	%		%	
No.X – coal pulverizer inlet air shut off damper	Full open		Full close	
No.X – coal pulverizer seal air fan	Operation		Stop	
No.X – primary air heater outlet gas damper	Auto %		Auto %	
No.X – primary air heater inlet gas damper	Full open		Full close	
No.X – coal pulverizer cold air damper	Full open		Full close	

c. Alarm confirmation

Alarm items	Place	Check
No.X – De-NOx equipment trip	Boiler-Turbine-Generator panel	
No.X – De-SOx equipment trip	Boiler-Turbine-Generator panel	
De-SOx bypass damper open	Boiler-Turbine-Generator panel	
No.X – PAF trip	Boiler-Turbine-Generator panel	
Heavy oil pump trip	Boiler-Turbine-Generator panel	
Light oil pump trip	Boiler-Turbine-Generator panel	
MFT	Boiler-Turbine-Generator panel	
All fuel loss trip	Boiler-Turbine-Generator panel	
Burner abnormal	Boiler-Turbine-Generator panel	
M-BFP trip	Boiler-Turbine-Generator panel	
No.X – BFPT trip	Boiler-Turbine-Generator panel	
Light oil pump C/C trip	Boiler-Turbine-Generator panel	

4) Evaluation criteria

It must be confirmed each equipment is operated and alarms and necessary indications are appeared normally according to interlock.

Article 142. Boiler feed water

It must be controlled water quality management properly to prevent scale and corrosion due to impurities in feed water system and keep high efficiency operation of equipments. There are 2 equipments for managing water quality. Make up water treatment system is to produce purified water supplying to boiler, water conditioning system is to condition boiler feed water. Standard of water quality management is defined based on boiler type (circulation boiler or once-through boiler) and boiler characteristics etc. Sample of water quality management standard are shown as follows;

1. Make up water treatment system

Make up water treatment system has following equipments.

(1) Clarifier (filter and coagulation sedimentation equipment) : It is to remove insoluble matter.

(2) Demineralizer : It is to remove soluble matter in feed water using ion exchange resin etc.

2. Water conditioning system

Purpose of water conditioning system is to manage of water quality of boiler and turbine system and prevent corrosion and scale etc. It is to sample feed water and monitor pH, dissolved oxygen, electric conductivity and total iron etc. continuously and control chemical dosing volume to comply with water quality management standard.

Table 142-1 Sample of water quality management standard

Sample	Item	Unit	Circulation boiler	Once-through boiler
Make up water	electric conductivity (25°C)	μS/cm	≦1	≦1
	Silica	$\mu gSiO_2/\ell$	≦15	≦ 10
Feed water	pH (25°C)	-	9.2 - 9.6	9.3 - 9.6
	electric conductivity (25°C)	μS/cm	≦0.3	≦0.25
	dissolved oxygen	$\mu gO/\ell$	≦7	≦7
	Iron	$\mu gFe/\ell$	≦ 20	≦10
	Copper	$\mu gCu/\ell$	≦5	≦2
	Hydrazine	$\mu gN_2H_4/\ell$	10≦	10≦
	Silica	$\mu gSiO_2/\ell$	≦20	≦20

Sample	Item	Unit	Circulation boiler	Once-through boiler
Boiler water (Water in drum)	pH (25°C)	-	8.5 - 9.8	-
	electric conductivity (25°C)	μS/cm	≦60	-
	phosphoric acid ion	$mgPO_4/\ell$	0.1 - 3	-
	Silica	$\mu gSiO_2/\ell$	≦200	-
	chloride ion	$mgCl/\ell$	≦2	-

3. CWT (Combined Water Treatment)

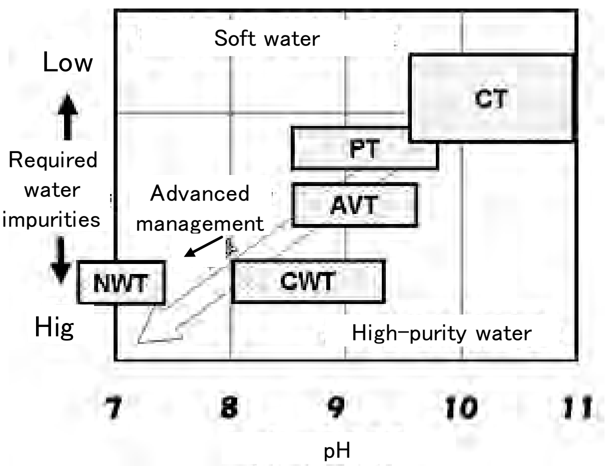
(1) General

Water treatment of super critical boiler and ultra super critical boiler changes AVT to CWT. Fe3O4 (magnetite) is generated in feed water during operation of AVT and there is a possibility that scale is attached in equipments or evaporator. Therefore, CWT is adopted as countermeasure in terms of above troubles. CWT dissolves a small amount of oxygen in high-purity water (purified water) and injects oxygen as oxidant. This treatment method is adopted in Germany, Russia and Japan etc.

(2) Policy of CWT

CWT keeps the condition

This method changes iron component in feed water from bivalent to trivalent of low solubility by oxygen and controls water quality management. At present, dissolved oxygen is unfavorable component as corrosive substance. Therefore, concentration of dissolved oxygen keeps low as much as possible and corrosion is prevented by controlling pH.



CT : Caustic Treatment
PT : Phosphate Treatment
AVT : All Volatile Treatment
CWT : Combined Water Treatment
NWT : Neutral Water Treatment

Figure 142-1 Classification of water treatment

(3) Effects of CWT

Effects of CWT are shown as follows;

1) Reducing chemical cleaning by slowdown of scale growth rate.

2) Reducing resistant of feed water flow in boiler by preventing generation of waved scale.
3) Improvement of environmental protection by reducing quantity consumed of ammonia.
4) Reducing attachment of scale in equipments.
5) Reducing Flow-accelerated corrosion

CWT reduces pressure loss of boiler by preventing waved scale compared to AVT (please refer to Figure 142-2).

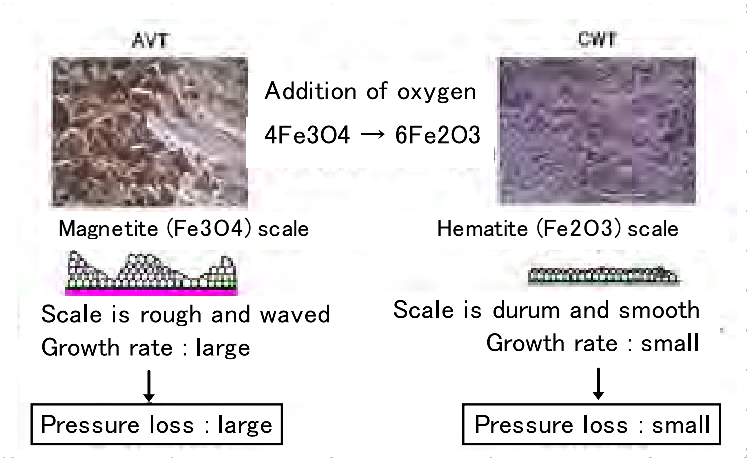


Figure 142-2 Status of scale (Schematic view)

In addition, economic effect of CWT is shown as follows;

1) Extension of interval of boiler chemical cleaning
2) Reducing power consumption of feed water pump by decreasing pressure loss of boiler
3) Reducing quantity consumed of ammonia and hydrazine
4) Reducing regeneration chemicals of condensate demineralizer

Article 143. Operation of fan

It must be conducted furnace purge of boiler to exhaust unburned gas and prevent explosion by operating forced draft fan and induced draft fan at starting up and stopping boiler. It must be referred to paragraph 2 of Article 141 of this guideline regarding furnace purge at starting. Main process flow of furnace purge at stopping of boiler is shown as follows;

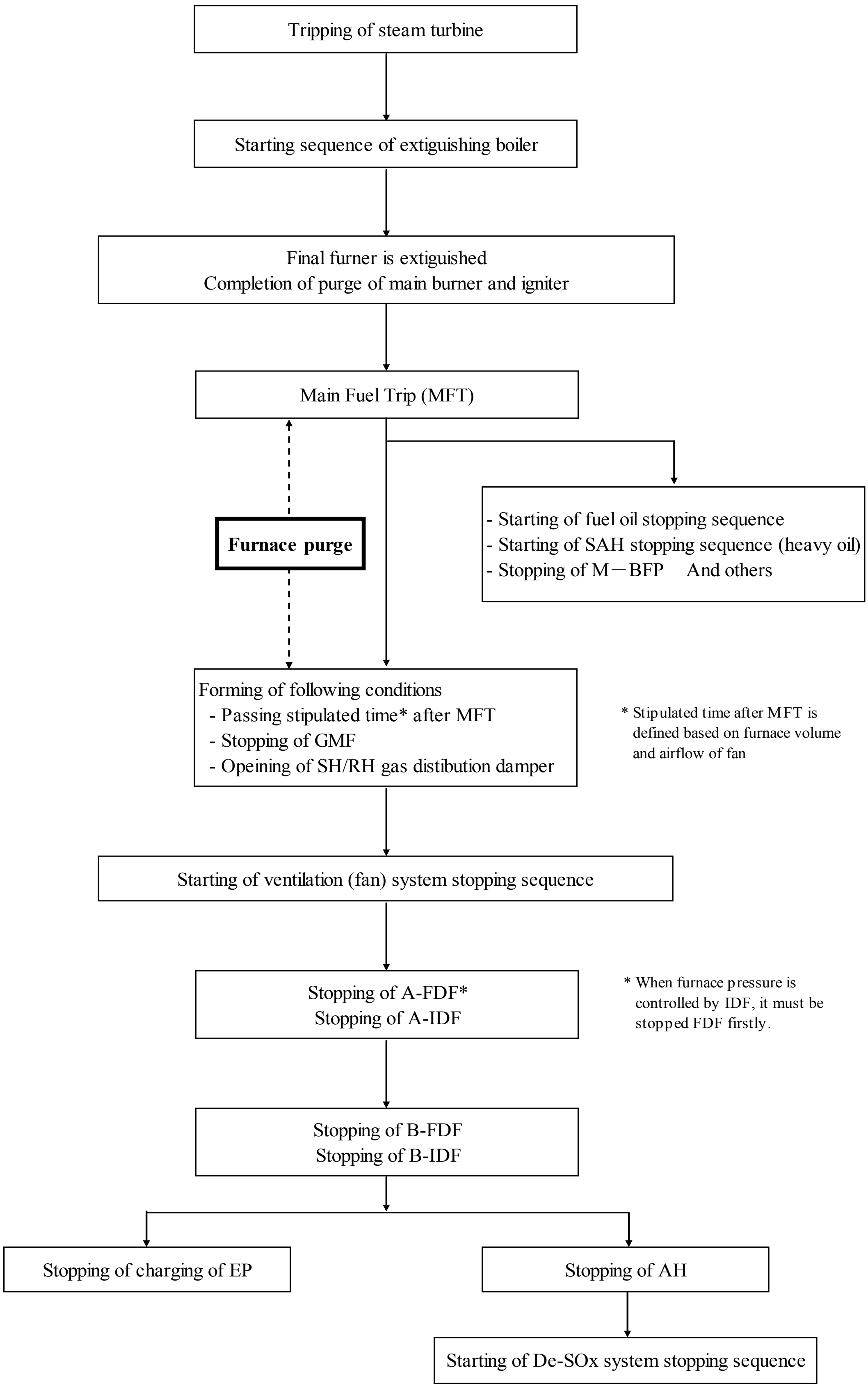


Figure 143-1 Main process flow of furnace purge

Article 144. Water level on steam drum at start up

1. Monitoring of water level in steam drum

It must be started feed water system before boiler ignition and filled feed water at appropriate water level in drum type boiler at boiler water filling. It must be fed water slightly higher than standard height of water level gauge, blown water level gauge and confirmed water level. In this case, it must be opened drain valve of water level gauge. If it is blown in large quantity, foreign objects in water level gauge are removed. It must be kept water level slightly higher than regular water level in forced circulation boiler to prevent water level from falling below visible range when starting BCP.

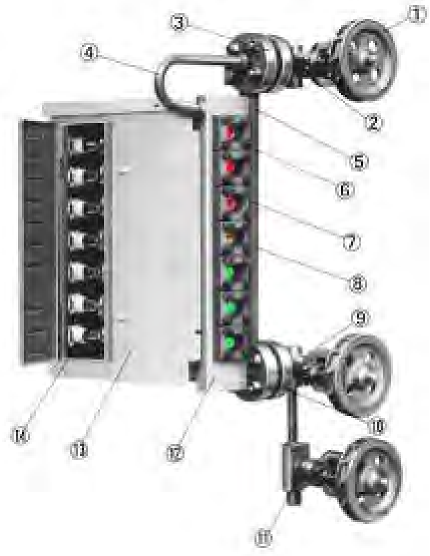


Figure 144-1 Water level

2. Trouble (Falling of drum water level)

When falling drum water level at boiler operation, it causes serious trouble. Therefore, it must be monitored drum water level carefully. It must be conducted daily patrol and inspection on water level gauge. When not confirming drum water level due to lack of feed water or human error by power plant staff, it must be stopped boiler urgently. Point to be checked in this case is shown as follows;

(1) It must be shut off fuel and quenched boiler urgently.

(2) When confirming that it is possible to feed water and there is no damage on pressure part, it must be decreased feed water gradually by manual and not be increased feed water. Because it prevents pressure part from cooling rapidly by rising drum water level. It must be closed feed water control valve when rising water level which can be conducted re-ignition.

(3) When confirming damage on pressure part, it must be opened drain valve of super heater outlet header and decreased steam pressure gradually. It must be decreased air flow to prevent boiler from cooling rapidly.

(4) It must be investigated root cause of falling drum water level.

(5) It must not be blown feed water until temperature of furnace is cooled sufficiently.

(6) It must be inspected leakage or deformation in pressure part due to overheat.

(7) It must be conducted hydraulic pressure test of boiler before re-starting it.

Article 145. Regulation about start-up

1. Confirmation of starting mode

Required unit starting time is determined according to status of boiler and steam turbine. Unit starting mode is determined based on steam turbine 1st stage metal temperature and required overall unit starting time is calculated by adding required each event (preparation of unit starting, clean up, boiler ignition etc.) time. Planned time of synchronization is determined as basic point and planned time of boiler ignition, steam turbine starting and full load (output) etc. is determined according to above required time. Moreover, boiler starting mode is determined based on water separator inner face metal temperature etc., is used for starting fuel program and starting bypass valve control.

Table 145-1 Sample of turbine starting mode

Itmes		Unit	Very hot (Stop time : 2 hours)	Hot (Stop time : 8 hours)	Warm 2 (Stop time : 32 hours)	Warm 1 (Stop time : 56 hours)	Cold (Stop time : 150 hours)
1st stage metal temparature		℃	460 ～	390 ～460	340 ～390	230 ～340	～230
Planned value at starting	Main steam pressure	MPa	8.5	8.5	8.5	8.5	8.5
	Main steam temperature	℃	510	470	410	410	400
	Reheat steam temperature	℃	505	480	377	289	200
	1st stage steam temparature	℃	438	391	315	315	301
	1st stage metal temparature	℃	494	453	368	326	216
	Mismatch temparature	℃	-56	-62	-53	-11	+85
Steam turbine incresing speed rate		rpm/min	300	300	150	150	100
Low speed heat soak time		min	0	0	0	0	20
High speed heat soak time		min	0	0	0	0	55
Initial output		%	3	3	3	3	3
Holding time of initial output		min	0	0	15	15	60

Table 145-2 Sample of boiler starting mode

Mode (stop time)	**water separator inner face metal temperature (℃)**
Very hot (2 hours)	Not lower than 298
Hot (8 hours)	265～298
Warm 2 (32 hours)	197～265
Warm 1 (56 hours)	170～197
Cold (150 hours)	Not greater than 170

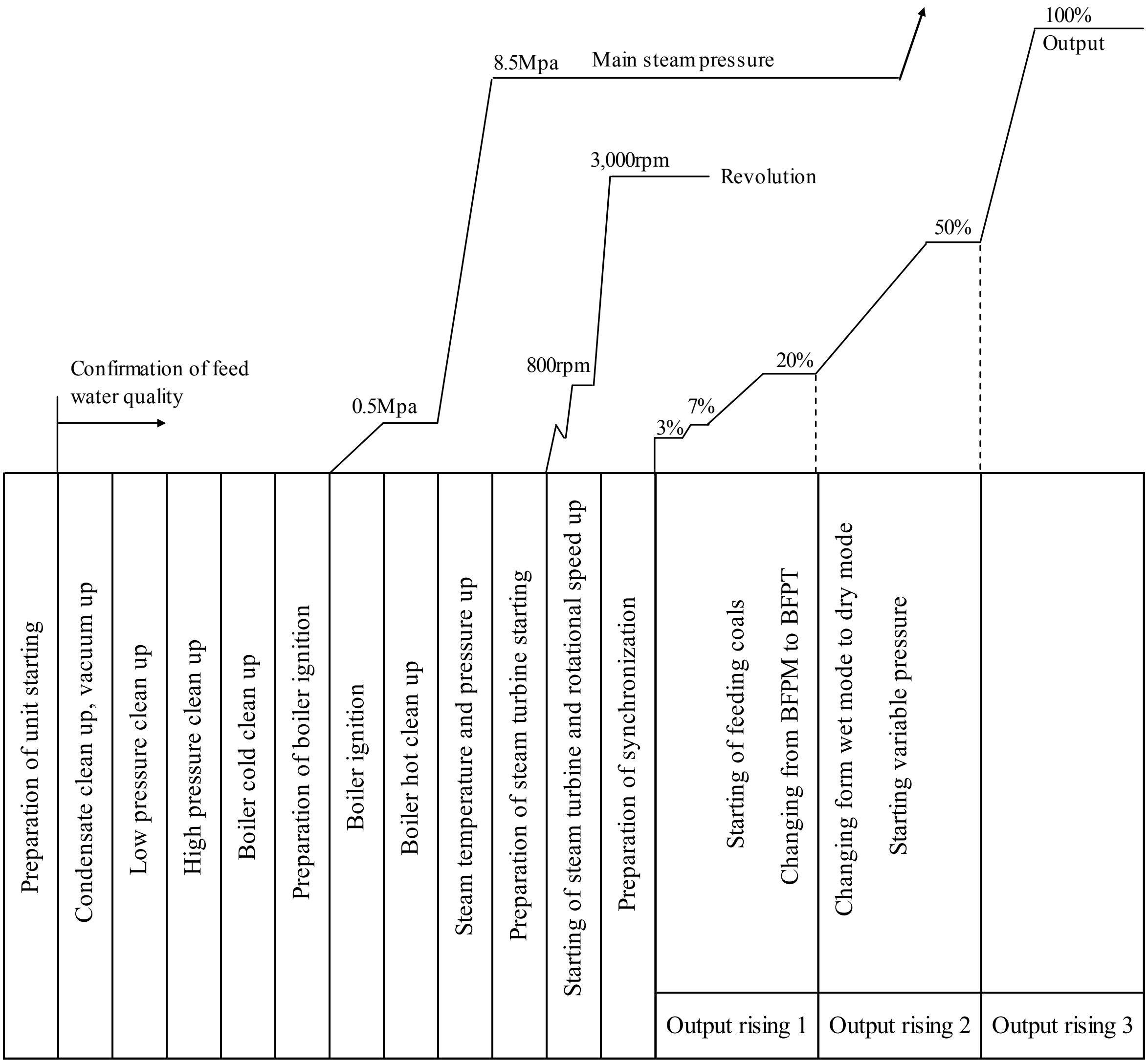


Figure 145-1 Sample of unit starting flow (cold mode)

2. Preparation of unit starting

It must be confirmed following provisions as preparation of unit starting.

(1) Common equipments are operated normally.

(2) Fuel, control and house air and purified water (make-up water) etc. are secured.

(3) Interlock, alarm device and measuring gauge are normal.

3. Pre boiler clean up

In once-through boiler, clean up of impurities (iron etc.) in feed water piping system is conducted to require purified water at unit starting before ignition.

4. Boiler cold clean up

When water quality at pre boiler clean up is met with acceptable value, feed water is supplied to boiler and clean up at normal temperature is conducted.

5. Preparation of boiler ignition

Feed water system is changed form clean up condition to boiler ignition condition. Fan system is started and furnace purge is conducted to prevent furnace explosion. Fuel system for staring (oil or gas) is started and fuel leak check is conducted.

6. Boiler ignition and hot clean up

After boiler ignition, feed water is heated to hot clean up target temperature (sample of furnace outlet water temperature : approx. 150℃). Furnace outlet water temperature is kept to hot clean up target temperature and temperature up of feed water is restarted when water quality is met with acceptable value.

7. Boiler temperature and pressure up

Boiler is heated and pressurized to target steam condition at steam turbine starting based on turbine staring mode. Please refer to Article 147.

Article 146. Checking when start-up

It must be paid attention following provisions regarding steam drum at boiler after boiler ignition.

1. Protection of steam drum (thick metal portion of boiler)

When temperature change of thick metal portion of boiler such as steam drum BCP casing is conducted rapidly, thermal stress is occurred and thick metal is damaged (crack etc.). Therefore, it is defined restricted value of temperature difference between inner and outer face and pace of increase of boiler temperature. Sample of restricted value of temperature difference between inner and outer face and pace of increase of boiler temperature are shown as follows;

(1) Restricted value of temperature difference between inner and outer face
   1) Temperature difference between inner and outer face : 55℃
   2) Temperature difference between upper and lower portion (outer face) : 65℃

(2) Restricted value of pace of increase of boiler temperature
   1) Natural circulation boiler : 45～55℃/hours
   2) Forced circulation boiler : 110℃/hours

2. Keeping of drum water level

It must be kept drum water level to standard level at all times. It must be blown out boiler water timely because water level is raised due to water expansion when starting temperature up from clod boiler. And, it must be kept water level by feeding water because water level is come down gradually when steam is generated and drain blow is increased by drain valve. It must be paid attention to burnout of evaporator tube due to abnormal lowering of drum level. And, it must be paid attention to rapid cooling and influx of drain into steam turbine when drum level is raised. It must be paid attention following provisions when feeding water to boiler.

(1) Damage of economizer tube due to water flow fluctuation and water temperature change

(2) Damage of motor coil due to frequent starting of feed water pump

In general, number of times which can be started continuously regarding large size motor is shown as follows;

(1) Cold : approx. 2 times

(2) Hot : approx. 1 time

Article 147. Connection to main line

It must be connected to main line after the connector is heated, remaining water is discharged, and boiler pressure almost reaches pressure of main line after boiler is started. It is conducted in “temperature and pressure up” step during unit starting. In temperature and pressure up, boiler is heated and pressurized to target steam condition at steam turbine starting based on turbine staring mode. General of temperature and pressure up is shown as follows ;

1. Restricted items at starting

It must be adjusted fuel volume, starting bypass valve and steam drain valve at boiler staring to comply with following provisions and complete temperature and pressure up with target time.

(1) Furnace outlet gas temperature : stipulated temperature (sample : 560℃)

1) Purpose : protecting re-heater from burnout

(2) Fuel flow : stipulated temperature (sample : not greater than 20% of maximum steam flow)

1) Purpose : protecting re-heater from burnout

(3) Temperature up rate : stipulated temperature (sample : not grater than 220℃/hours)

1) Purpose : reducing thermal stress at thick portion of boiler

2) Measuring point : water separator and super heater outlet etc.

2. Adjustment of fuel flow

It must be adjusted steam turbine starting time and main steam temperature according to fuel program based on steam turbine starting mode.

3. Control of feed water flow and water separator drainage tank level

It must be paid attention to fluctuation of water separator drainage tank level and feed water flow due to swelling after boiler ignition.

4. Operation of drain valve and starting bypass valve

It must be determined operation of drain valve and starting bypass valve to conduct warming and discharge of drain of super heater to secure steam flow and be shorten starting time.

5. Completion of temperature and pressure up

After completion of pressure up, it must be exchanged auxiliary steam source from house boiler to main boiler. After main steam temperature is steam turbine steam blow target temperature, temperature and pressure up is completed.

Article 148. Operation mode

When once-through boiler is operated at high load (output), boiler mode is on dry. However, when it is operated at low load, wetness fraction of steam is increased and boiler mode is changed dry to wet. When once-through boiler is operated at minimum load, most of them are on wet mode. Minimum load of unit depends on type of unit, output, performance of auxiliaries etc, general minimum load of unit is 10～40% of rated output. Point to be checked at operating at minimum load is shown as follows;

1. Wetness fraction in turbine exhaust hood

In low load operation of unit, following operation status is appeared.

(1) Reheat steam temperature is decreased.

(2) Wetness fraction in steam turbine hood is increased according to vacuum up of condenser.

It must be operated boiler paying attention to wetness fraction to prevent corrosion of final stage blades of steam turbine.

2. Steam flow

It must be paid attention to following provisions to prevent overheat of super heater and re-heater.

(1) Steam temperature (super heater, re-heater and furnace)

(2) Gas temperature

(3) Tube metal temperature

In once-through boiler, it must be kept feed water not lower than 30% of maximum steam flow to stabilize feed water flow in evaporator tubes of water wall in furnace.

3. Temperature in turbine exhaust hood

In low load operation, when vacuum in condenser is high, temperature of steam turbine hood is decreased and vibration and differential expansion etc. of steam turbine are affected by it. Moreover, it must be operated unit carefully because exhaust temperature of steam turbine is increased in very low load operation (5～10% of rated output).

4. Control of unit

It must be adjusted boiler – steam turbine cooperative control system and boiler automatic control system properly to operate unit stably at low load.

5. Heater drainage control

It must be supplied heater drainage to condenser when pressure in heater is decreased at low load and it is difficult to discharge drainage.

Article 149. Check of temperature

Super heater and re-heater of boiler are damaged due to combustion heat. Therefore, it must be monitored following provisions to maintain allowable steam temperature at each level of super heater and re-heater. Maintaining allowable steam temperature at operating boiler is conductive to stable, long term and economical operation of power plant.

1. Point to be checked to maintain allowable steam temperature of super heater and re-heater

(1) Steam temperature of super heater and re-heater

(2) Metal temperature of super heater and re-heater

(3) Feed water flow volume

(4) Spray flow volume to super heater and re-heater

(5) Furnace heat absorption

2. Sample of damage part and damage cause classification of boiler pressure part

Table 149-1 Sample classification of damage part

Damage part	Rate (%)
Super heater	43
Water tube	33
Re-heater	10
Others	14

Table 149- 2 Sample classification of damage cause

Damage cause	Rate (%)
Fatigue	34
Creep	26
Thinning	19
Others	21

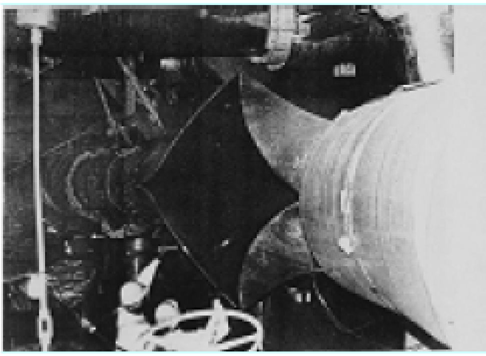



Photo 149-1 Creep damage

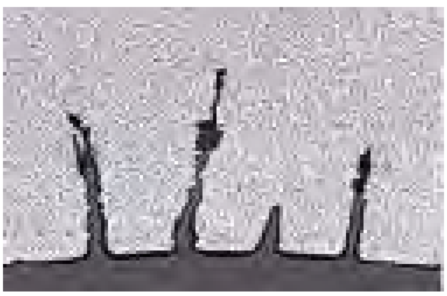



Photo 149-2 Fatigue damage

Relation between boiler damage, root cause, phenomenon and damaged part is shown in Table 149-3.

Table 149-3 Relation between boiler damage, root cause, phenomenon and damaged part

Grouping of defect		Root cause	Phenomenon	Damaged part
Creep		Short time creep	Overheat, evagination	Evaporator, superheater, reheater
		Long time creep	Heating	Evaporator, superheater, reheater
Fatigue		Thermal fatigue	Ligament crack of header inside	Economizer, superheater
			Drain attack	High temperature reheat steam tube
		Fatigue	Crack of tube support	Superheater, reheater, economizer
		Vibration	Crack of header stub	Superheater, reheater
			Crack of dissimilar material joint	Superheater, reheater
	Corrosion fatigue	Corrosion fatigue	Fire crack of tube outside	Superheater, evaporator
	Ouetr corrosion	High temperature corrosion	Tube thinning	Superheater, reheater
		Low temperature corrosion	Tube thinning	Economizer
Corrosion	Inner corrosion	Oxygen corrosion	Pitting corrosion	Evaporator, reheater, economizer
		Alkali corrosion	Pitting corrosion, groove corrosion	Evaporator, economizer
		Hydrogen attack	Brittle fracture of inner face	Evaporator
		Steam oxidation	SUS scale, CrMo scale	Superheater, reheater
Stress corrosion crack		Cl type	Intercrystalline and transgranular crack	Superheater, reheater
		Polythionic acid type	Intercrystalline crack	Superheater, reheater
Abrasion		Ash erosion	Tube thinning	Superheater, reheater, economizer
		Sootblow erosion	Tube thinning	Superheater, reheater, economizer, evaporator
		Clinker erosion	Tube thinning	Evaporator
Others		Liquid metal embrittlement (Cu crack)	Crack of tube inside at welding	Economizer, evaporator
Weld defect				

Article 150. Heating surface

Heating surface of boiler is polluted by ash in fuel, soot and unburnt combustible content in combustion gas, chemical compound with addition agent in fuel and sand in combustion air with time. And, Heat transfer between combustion gas and heating surface is inhibited and boiler heat absorption is deteriorated. Therefore, it must be kept clean of heating surface of boiler by maintaining optimal burning and using cleaning equipment such as soot blower (dust blower) etc. to keep stable and high performance operation. Soot blower sprays steam or air and cleans pollution on heating surface. General of soot blower is shown as follows;

1. Spraying medium

When using steam as spraying medium, it must be paid attention to countermeasures of heat-resistant and drainage. When using air as spraying medium, it must be installed receiver tank to keep air volume of compressor and soot blower.

2. Spraying pressure

Spraying pressure of soot blower is specified according to fuel, gas temperature, boiler operation method etc. and it is adjusted based on design value and actual operation. Sample of spraying pressure is shown in Table 150-1.

Table 150-1 Sample of spraying pressure

Soot blower type	Pressure (MPa)
Long type	0.5～2.0
Rotary type	0.5～1.5
Short type	0.3～0.8

It must be paid attention following table regarding operation of soot blower.

Table 150-2 Point to be checked regarding soot blower and countermeasures

Point to be checked regarding soot blower	Countermeasures
Drain cutting due to spraying drain in steam	Removing drain in steam
Ash erosion due to immixing ash in combustion gas	Adjusting spraying pressure

3. Operation of soot blower

Performance of power plant is decreased due to steam consumption of unnecessary soot blower and heating surface of boiler is adversely affected. Therefore, soot blower system is controlled by following mode (system) to maintain high performance of power plant.

(1) Optimum control mode

Heat absorption of each part of boiler is monitored by soot blower control system and relevant soot blowers are operated when it is confirmed boiler part which heat absorption is decreased.

(2) Sequential mode-1

Operation pattern of soot blower is decided according to coal type and output, operation pattern is selected according to boiler operation status and soot blowers are operated.

Table 150-3 Sample operation pattern of soot blower

Operation pattern	Contents
A pattern	Pattern of burning coals with high fouling
B pattern	Pattern of burning coals with high slagging
C pattern	Pattern of burning coals with high slagging and low output at night

(3) Sequential mode-2

Each group (please refer to Table 150-4) is selected according to boiler operation status soot blowers are operated.

Table 150-4 Sample g rouping of soot blower

Group	Boiler parts
1	Furnace wall
2	Furnace
3	Pendant super heater
4	Re-heater
5	Horizontal super heater
6	Economizer

(4) Manual mode

It is selected and operated simplicial soot blower. This mode is used test etc.

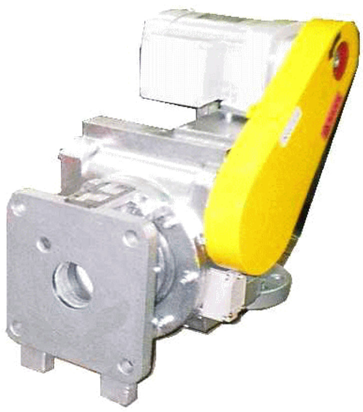


Photo 150-1 Soot blower

Article 151. Technical requirement of fan system

1. Daily patrol and inspection

It must be conducted daily patrol and inspection on FDF and IDF taking account of following provisions.

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) It must be confirmed defects in fire fighting equipments (fire hydrant system etc.).

(3) It must be confirmed compressor body and motor regarding following items.

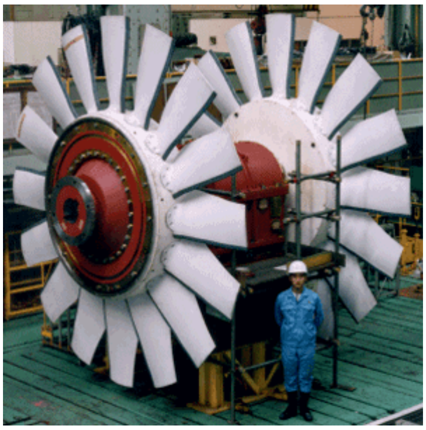
1) Abnormal noise, abnormal odor, vibration and gas leakage
2) Heating, abnormal noise and oil leakage for bearing
3) Level, change in color and leakage for lubricant oil
4) leakage and corrosion of piping
5) leakage and corrosion of valves
6) Corrosion and peeling for painting

(4) It must be confirmed lubricant, control and auxiliary oil pump regarding following items.

1) Outlet lubricant and control oil pressure etc.
2) Differential pressure of pump strainer
3) Abnormal noise, Abnormal odor, vibration and oil leakage
4) Heating, abnormal noise and oil leakage for bearing
5) Oil leakage and corrosion of oil tank
6) Oil leakage and corrosion of piping
7) Oil leakage and corrosion of valves
8) Corrosion and peeling for painting

(5) It must be confirmed oil cooler regarding following items.

1) Abnormal noise, Abnormal odor, vibration and oil leakage
2) Oil leakage and corrosion of piping
3) Oil leakage and corrosion of valves
4) Corrosion and peeling for painting



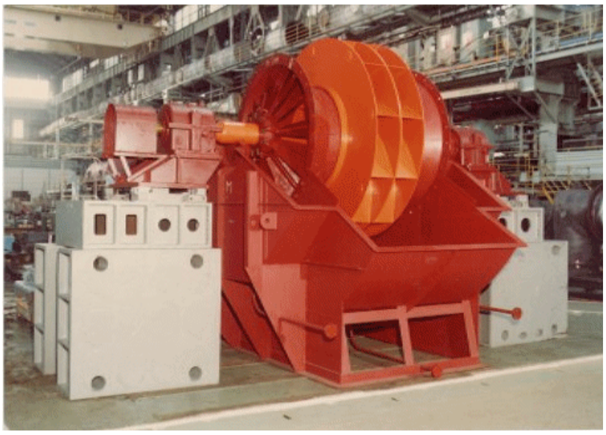


Photo 151-1 FDF and IDF

2. Run back at stopping FDF

When one FDF is emergency stopped, output of power plant is decreased to 50% of rated output rapidly. It is run back system and it must be paid attention to operation status of power plant carefully while run back system is operated. Main process flow of run back system at stopping FDF is shown as follows;

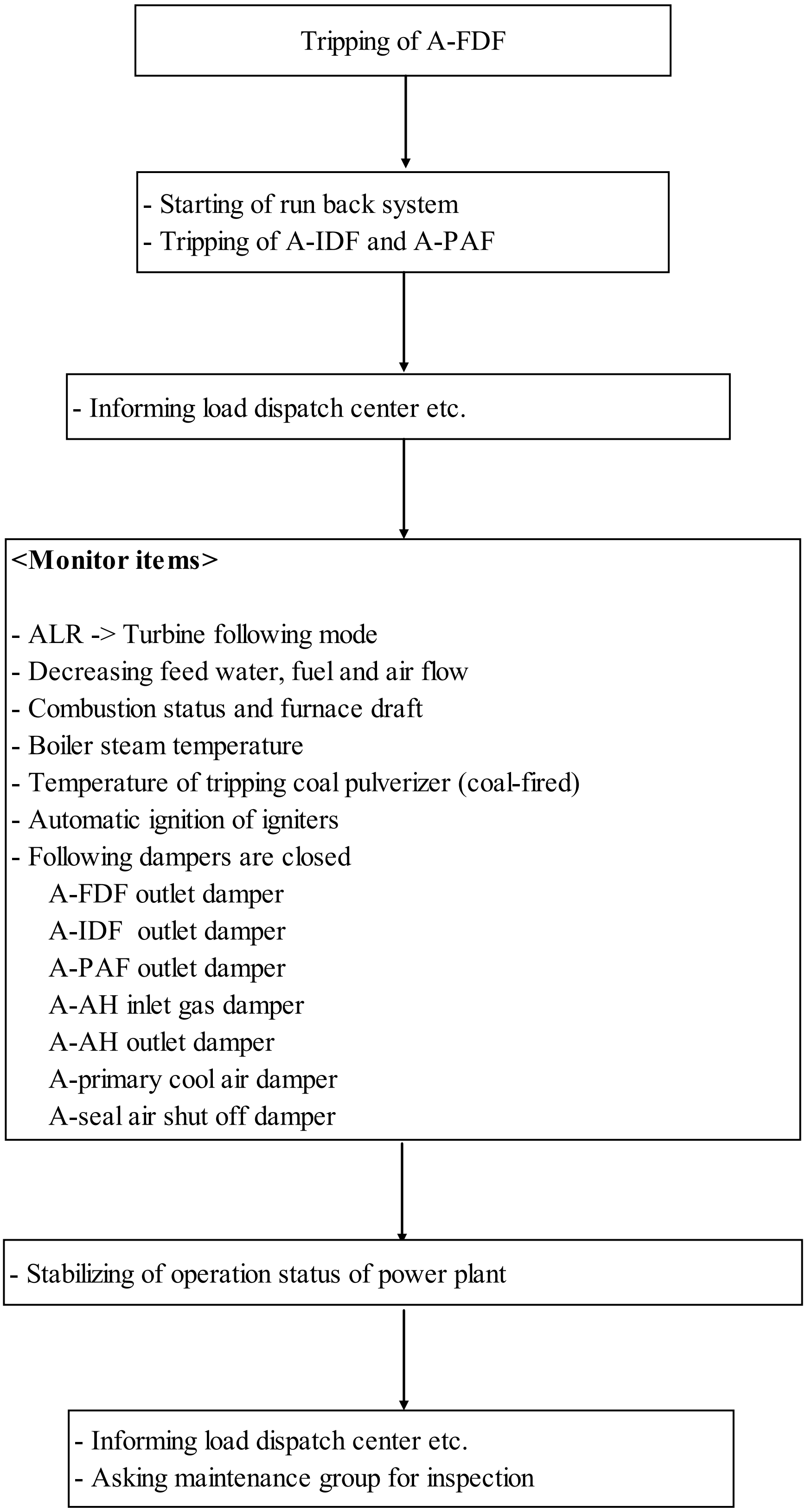


Figure 151-1 Main process flow of run back system at stopping FDF

Article 152. Gas emission

It must be meet gas emission with environmental standard at any mode during boiler operation. Point to be checked at operating and daily patrol and inspection of exhaust gas treatment equipment are shown as follows;

1. De-NOx system

Catalytic reduction of nitric oxide with ammonia as De-NOx system is popular in many power plants because it is not restricted to fuel, boiler type and output. Point to be checked at operating and daily patrol and inspection of catalytic reduction of nitric oxide with ammonia is shown as follows;

(1) Gas temperature

When including SO_3 in gas and injecting ammonia at low output with low gas temperature, NH_4HSO_4 (ammonium hydrogen) is generated due to SO_3, NH_3 and H_2O and it is blocked in catalyst of De-NOx system and performance of De-NOx system is deceased.

$$NH_3 + SO_3 + H_2O \rightarrow NH_4HSO_4$$

When gas temperature is 300 - 350 degree C, NH4HSO4 is resolved. Therefore, it must be kept gas temperature from 300 degree C to 350 degree C.

(2) NH_3/NOx molar ratio

It must be set NH_3/NOx molar ratio to meet target NOx removal efficiency taking account of leak ammonia. When NH_3/NOx molar ratio is increased, NOx removal efficiency is increased. However, leak ammonia is increased and it must be set appropriate NH_3/NOx molar ratio.

(3) Adverse affect to downstream equipments from De-NOx system

SO_3 in gas, leak ammonia and NH_4HSO_4 (ammonium hydrogen) have a great impact on downstream equipments from De-NOx system. SO_3 is at the root of sulfuric acid corrosion under dew point temperature and NH_4HSO_4 is at the root of blockage and corrosion.

(4) Differential pressure of catalyst

When there are many dust in gas, they are accumulated in catalyst, pressure loss of catalyst is increased and performance of De-NOx system is decreased. Therefore, it must be paid attention differential pressure of catalyst.

(5) Deterioration of catalyst

Performance of De-NOx system is decreased due to heat of gas and dust in gas after operating for a long time. Performance of De-NOx system can be kept by increasing NH_3/NOx molar ratio, leak ammonia is increased. Therefore, it must be monitored performance of De-NOx system and leak ammonia.

(6) Daily patrol and inspection

Point to be checked at daily patrol and inspection is shown as follows;

1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

2) It must be confirmed reactor regarding following items.

a. Deferential pressure

b. Gas leak

c. Peeling and defluxion of heat insulating material

3) It must be confirmed ammonia inlet tube regarding following items.

a. Ammonia injection rate

(a) Operation status of flow control valve

(b) Measuring value of ammonia gas pressure gauge

b. Dilution air flow

)(a) Measuring value of dilution air pressure gauge

4) It must be inspected following measuring gauge.

a. NOx gauge

b. O_2 gauge

c. NH_3 gauge   etc.

Photo 152-1 De-NOx equipment

Photo 152-2 Catalyst

2. Electric precipitator

Point to be checked at operating and daily patrol and inspection of is electric precipitator shown as follows;

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) It must be confirmed measuring value regarding following items.

1) Soot and dust concentration

2) O2 concentration at economizer outlet

3) FDF outlet pressure

4) AH inlet and outlet air temperature

5) AH outlet gas temperature

6) AH outlet gas pressure

(3) It must be confirmed hammer device regarding following items.

1) Breakage of shear pin of hammer

2) Operation schedule of hammering system

(4) It must be confirmed charging device regarding following items.

1) Charging voltage

2) Discharge current (abnormal increase or decrease)

3) Spark

(5) It must be confirmed ash handling system regarding following items.

1) Fluctuation of vacuum (ash clogging in ash handling system)

2) Malfunction of ash discharge valve

(6) It must be confirmed ash hopper regarding following items.

1) Hopper temperature (Prevention of corrosion)

2) Ash clogging

Photo 152-3 Electric precipitator

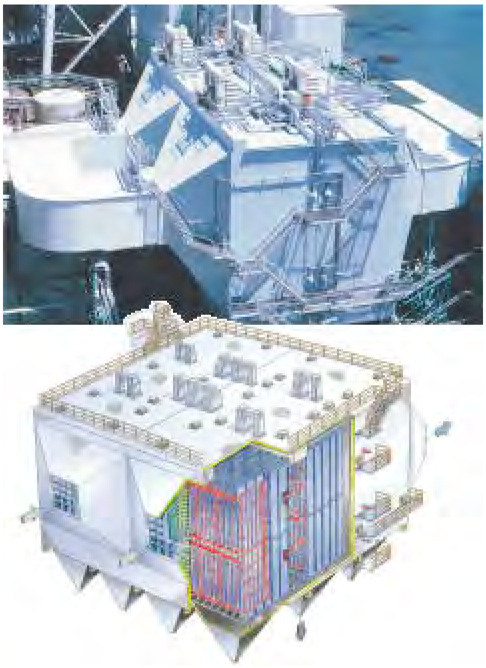


Photo 152-4 Electric precipitator (inner and outer structure)

3. De-SOx system

Point to be checked at operating and daily patrol and inspection of De-SOx system is shown as follows;

(1) Gas cooling and absorption process

1) Exhaust gas flow system

Exhaust gas flow by fans is decreased when pressure loss of exhaust gas increased. Root causes of rise in pressure loss are blockage of mist eliminator and element of gas gas heater (GGH) etc. and, it must be cleaned them if necessary.

2) Desulfurization performance

Parameters impacting on desulfurization performance are pH (limestone concentration) in absorption tower and liquid-gas ratio in absorption tower. When pH in absorption tower is low, desulfurization performance is low and when pH in absorption tower is high desulfurization performance is high and un-reacting limestone concentration is increased. It must be keep most appropriate pH and limestone concentration. In addition, when liquid-gas ratio in absorption tower is decreased due to blockage of spray nozzle and deposition of scale in spray piping, desulfurization performance is decreased.

3) Supply flow rate of limestone slurry

Stable operation of controlling supply flow rate of limestone slurry has impact on pH in absorption tower and desulfurization performance. Thus, it must be confirmed blockage of limestone slurry supply piping and defects in limestone slurry supply pump.

4) Absorption tower inlet exhaust gas temperature

Parts made of plastic and lining made of rubber or resin are installed in absorption tower and heat resistance of them is low. Thus, it must be monitored absorption tower inlet exhaust gas temperature by temperature gauge. It must be stopped De-SOx (desulfurization) fan urgently when absorption tower inlet exhaust gas temperature is not met acceptable value.

5) Liquid level of towers is controlled by liquid level control valve. There is a possibility that pumps and pug mills (mixer) are tripped and De-SOx equipment is tripped when liquid level is very low due to defects in liquid level control valve etc.

(2) Reheat process

In GGH, heat exchange performance is decreased and differential pressure is increased when blockage of element is occurred. In rotary regenerative type GGH, there is a possibility that GGH is stopped due to leak of un-treated exhaust gas. Thus, it must be monitored variation per hour of differential pressure in GGH, exhaust gas temperature and rotor driven equipment etc.

(3) Daily patrol and inspection

1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

2) It must be measuring value regarding following items.

a. SOx concentration

b. Draft loss of De-SOx fan

c. Draft loss of GGH

d. Draft loss of mist eliminator

3) It must be confirmed De-SOx fan regarding following items.

a. Abnormal noise, abnormal odor, vibration and gas leakage

b. Heating, abnormal noise and oil leakage for bearing

c. Level, change in color and leakage for lubricant oil

d. Leakage and corrosion of piping

e. Leakage and corrosion of valves

f. Corrosion and peeling for painting

4) It must be confirmed lubricant and control oil pump of De-SOx fan regarding following items.

a. Outlet lubricant and control oil pressure etc.

b. Abnormal noise, abnormal odor, vibration and oil leakage

c. Heating, abnormal noise and oil leakage for bearing

d. Oil leakage and corrosion of oil tank

e. Oil leakage and corrosion of piping

f. Oil leakage and corrosion of valves

g. Corrosion and peeling for painting

5) It must be confirmed absorber regarding following items.

a. Abnormal noise, abnormal odor, vibration and leakage

b. Leakage and corrosion of piping
c. Leakage and corrosion of valves
d. Corrosion and peeling for painting

6) It must be confirmed circulation pump of De-SOx fan regarding following items.
a. Outlet pressure
b. Abnormal noise, abnormal odor, vibration and oil leakage
c. Heating, abnormal noise and oil leakage for bearing
d. Level, change in color and leakage for lubricant oil
e. Oil leakage and corrosion of piping
f. Oil leakage and corrosion of valves
g. Corrosion and peeling for painting

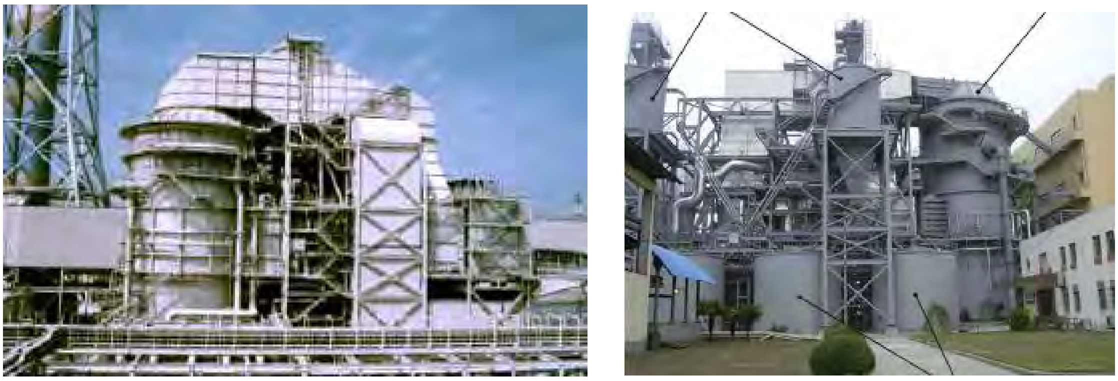


Photo 152-5 De-SOx equipment (Absorber)

Article 153. Operation of heavy oil burner

It must be conducted atomization of oil to increase contact area with air at combusting oil. Burner atomization method is pressure atomization type, medium atomization type and rotary type. In boiler for power plant, pressure atomization type and medium atomization type are adopted universally. Characteristic comparison of burner type is shown as follows;

Table 153-1 Characteristic comparison of burner type

Atomization type	2 fluid atomization		Pressure atomization		
	Internal mixture	**Midterm mixture**	**Return flow (Constant differential pressure)**	**Return flow (Constant supply oil pressure)**	**Straight**
Atomization basis	Oil is mixed with steam (air) and it is atomized by expansive force of steam (air).		Fuel is pressurized and gets turning force. And it is atomized by its centrifugal force.		
Burner inlet pressure (MPa)	0.5 – 1.4	0.5 – 2.1	3.9 - 6.9	3.9 - 6.9	1.0 - 6.9
Injection Characteristic	Atomizing characteristics is constant.	Atomizing characteristics is constant	Atomizing characteristics is constant	Atomizing characteristics is changed by burner load.	Atomizing characteristics is deteriorated when fuel pressure is low.
Fuel property	- Kinetic viscosity : ≦ 50 cSt - It is possible to used shoddy fuel.		- Kinetic viscosity : ≦ 30 cSt - It is not possible to use shoddy fuel.		


External appearance


Oil gun


Spray nozzle

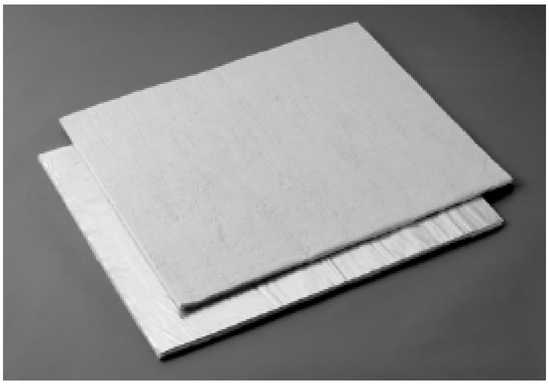
Photo 153-1 Oil burner

Article 154. Thermal insulation

Performance of boiler is decreased due to heat loss of boiler and piping. Therefore, it is important to keep thermal insulation of boiler and piping in good condition for high efficiency operation. Point to be checked on daily patrol and inspection of boiler thermal insulation is shown as follows;

1. It must be confirmed status of thermal insulation of boiler and piping etc. according to procedures developed by each power plant.
2. It must be used portable temperature indicator to confirm abnormal temperature rises of thermal insulation's surface and heat leaks.
3. It must not be touched relevant portion directly to prevent burn injury when confirming abnormal temperature rises of thermal insulation's surface and heat leaks.
4. It must be set restricted zone to prevent access of other power plant staff.
5. It must be informed maintenance group to repair relevant place.

6. In case of outdoor boiler, rain water is infiltrated from damaged outer steel plate and thermal insulation is wetted. After that, rain water is reached to outer face of boiler and piping, and it is possible to corrode boiler and piping under thermal insulation. Therefore, it must be removed thermal insulation and checked status of boiler and piping at periodical inspection if necessary. Non-water absorbing property of thermal insulation is adopted to power plant recently.



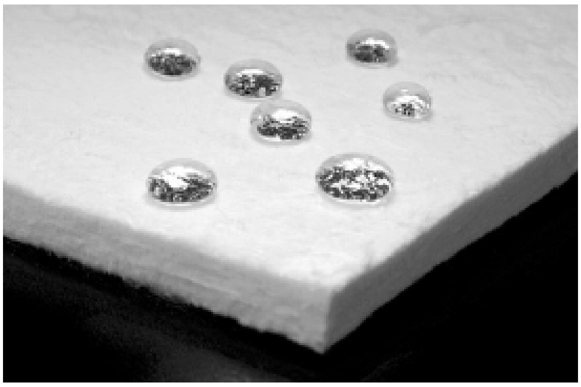


Photo 154-1 Non-water absorbing property of thermal insulation

Table 154-1 Characteristic of insulation material

Type	Thermal insulation	Cold insulation
Working temperature (degree C)	－40 ～ 650	－273 ～ 90
Thickness (mm)	5, 10	5, 10
Density (g/cm3)	0.18	0.13
Thermal conductivity (W/mK)	0(degree C) : 0.020 300(degree C) : 0.035 600(degree C) : 0.089	－150(degree C) : 0.0114 0(degree C) : 0.0138 50(degree C) : 0.0155

Article 155. Commissioning after change of fuel

Operation status of boiler is changed because combustion characteristics are changed by fuel exchange (conversion). Therefore, it must be implemented commissioning of boiler after changing fuel type and confirmed following provisions regarding operation status of boiler.

1. It must be confirmed combustion characteristics of changed fuel. (Please refer to Article 130 of this guideline.)
2. It must be confirmed exhaust gas emission complies with environmental standard in Vietnam.
   (1) NOx concentration
   (2) SOx concentration
   (3) Dust concentration
3. It must be confirmed boiler heat absorption characteristic.
   (1) Furnace heat absorption

   It must be confirmed furnace heat absorption is high or downstream of furnace (super heater and re-heater etc.) of heat absorption is high.

(2) Boiler outlet gas temperature

Temperature up of boiler outlet gas implies that boiler heat absorption is decreased, and it is possible to damage equipments installing at downstream of boiler (after boiler).

4. It must be confirmed ash generation characteristic.

(1) Fly ash

When amount of generating fly ash is increased compared to it before changing fuel, it must be made a study on operation of electric precipitator to comply with environmental standards.

(2) Clinker ash

When amount of generating clinker ash is increased compared to it before changing fuel, it must be made a study on operation of soot blower to keep boiler heat absorption and high thermal efficiency.

5. It must be confirmed operation status of following converted equipments.

(1) Conversion work to coal-fired power plant

1) Added or removed super heater and re-heater etc.

2) Replaced burner

3) Replaced igniter

4) Added coal handling system

5) Converted auxiliary steam system

6) Converted control system

a. Boiler starting and stopping control system

b. Automatic boiler control system

c. Burner control system etc.

(2) Conversion work to LNG-fired power plant

1) Added or removed super heater and re-heater etc.

2) Replaced burner

3) Added burner tilt

4) Replaced igniter

5) Added LNG handling system

a. Vaporizer

b. Compressor etc.

6) Added gas mixing fan

7) Added FDF outlet controlling damper

8) Converted control system

a. Boiler starting and stopping control system

b. Automatic boiler control system

c. Burner control system etc.

Article 156. Wear resistance measures

It must be taken corrosion resistance measures when boiler is put on standby or repaired for a long time. If appropriate corrosion resistance measures are not taken, boiler is corroded and damaged as time go on. Consequently it must be maintained boiler sufficiently and paid this repair work cost when restarting it. Sample of corrosion resistance measures of boiler is shown as follows;

Table 156-1 Sample of corrosion resistance measures of boiler

Equipment		Corrosion resistance measures
Boiler	Economizer – main steam stop valve	- Wet lay up with 1,000ppm of hydrazine
	Re-heater	- Filling with nitrogen gas
Safety valve		- Disassemble and application of anti-rust grease
Combustion equipment	Main fuel piping	- Removing fuel and filling with nitrogen gas
	Pump	- Filling with nitrogen gas in main body - Application of anti-rust grease to bearing and main shaft
	Burner gun	- Application of anti-rust grease
AH (Element)		- Washing by water and application of anti-rust
SAH (Main body)		- Cleaning fin and natural seasoning
Soot blower		- Application of anti-rust grease
Fan	Main body casing	- Natural seasoning
	Bearing metal	- Disassemble and application of anti-rust grease to metal
	Damper	- Application of anti-rust grease to link mechanics
De-NOx equipment (Catalyst)		- Cleaning and natural seasoning
Coal ash handing equipment	Vacuum pump	- Disassemble of bearing and application of anti-rust grease
	Fan	- Disassemble of bearing and application of anti-rust grease
	Ash transport piping	- Inside : Natural seasoning - Outside : Application of anti-rust grease
Valve		- Application of anti-rust grease to valve stem and gland

Article 157. Cooling of steam drum

It must be paid attention to prevention of thermal stress at place where feed water flows through drum. When temperature of drum where feed water flows is low compared to other place, there is a possibility that thermal stress is generated due to direct connection. It must be installed dual structure at drum shell or head connecting feed water piping and decreased thermal stress. Sample of dual structure is shown as follows;

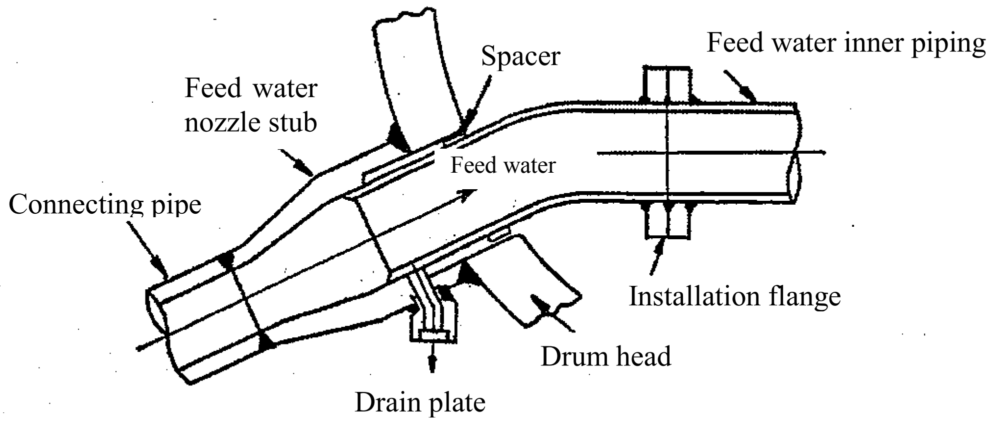


Figure 157-1 Sample of dual structure

Article 158. Water discharge for boiler

It must be carried out water discharge for safety when boiler pressure is equal to ambient pressure and water temperature is not over 80°C after stopping gravity circulation boiler. Water discharge at short and long term stopping is described as follows;

1. Short term stopping

Power plant is prepared for staring rapidly according to request from load dispatch center when stopping term is within 3 days. Thus, it is stopped keeping pressure and temperature in boiler (hot banking). In case that boiler is cooled, boiler is filled with water and boiler blow volume is low.

2. Long term stopping

In general, boiler is in dry lay up with nitrogen. Boiler may be in wet lay up with high concentration hydrazine when stopping term is within 1 month. In case of injecting nitrogen into boiler, boiler blow is conducted injecting nitrogen when temperature of boiler water is from 100 to 150 degree C. Most important item is to keep nitrogen pressure and purity and not to prevent air being mixed into nitrogen. In case of wet lay up, most important item is to keep hydrazine concentration and to take countermeasure of antifreeze. In case of overhaul, boiler is in dry lay up. In this case, boiler blow conducted when temperature of boiler water is from 100 to 150 degree C and it is dried by remaining heat.

Article 159. Monitoring when stopping boiler

Procedures and point to be checked at stopping boiler are shown as follows;

Preparation of stopping power plant

After making up unit stopping schedule, it must be conducted warming of heavy oil and started SAH in case of using heavy oil. Moreover, it must be prepared of staring of house boiler.

1. Output decreasing 1

Out put of power plant is decreased to 50% of rated output. It must be extinguished burner sequentially according to output decreasing.

2. Output decreasing 2

Out put of power plant is decreased to 20% of rated output. It must be ignited oil burner and extinguished coal burner sequentially according to output decreasing, and stopped first BFPT. When output of power plant is 25% of rated output, drain tank level of BCP is increased, BCP is started and boiler mode is changed from dry to wet. After starting BFPM, second BFPT is stopped. After output is 20%, it must be confirmed fuel changeover (coal firing to heavy oil firing) and switching over of auxiliary power system are completed.

3. Output decreasing 3

Out put of power plant is decreased to 5% of rated output. It must be stopped high and low pressure heater and extinguished oil burner sequentially according to output decreasing.

4. Trip of steam turbine and extinction of boiler

After not synchronization, it must be tripped steam turbine. After confirming that auxiliary steam supply source is changed form boiler to house boiler, it must be extinguished all oil burners. After all burners are extinguished and burner purge is conducted, it must be confirmed MFT is conducted and all fuel is shut off. It must be conducted furnace purge after MFT.

5. Boiler hot banking stop

It must be stopped FDF and IDF, closed dampers in air and gas duct and stopped BCP. It must be confirmed drain valves of super heater and main steam and starting bypass valves are closed.

6. Boiler forced cooling stop

After the fuel system is stopped, the duct purge must be conducted during the appropriate time. And the fan and the pump must be stopped after the boiler water temperature is reduced to the temperature indicated from the boiler manufacturer. For an example, after non-synchronization, it must be operated FDF and IDF continuously. It must be started BCP after starting BFPM to keep minimum feed water flow. It must be opened drain valves of main steam and super heater and depressurized boiler pressure. Sample of completion of boiler forced cooling stop is that water separator inlet fluid temperature is not more than 90 degree C. After completion of boiler forced cooling stop, it must be stopped fan and feed water system and broken vacuum in condenser.

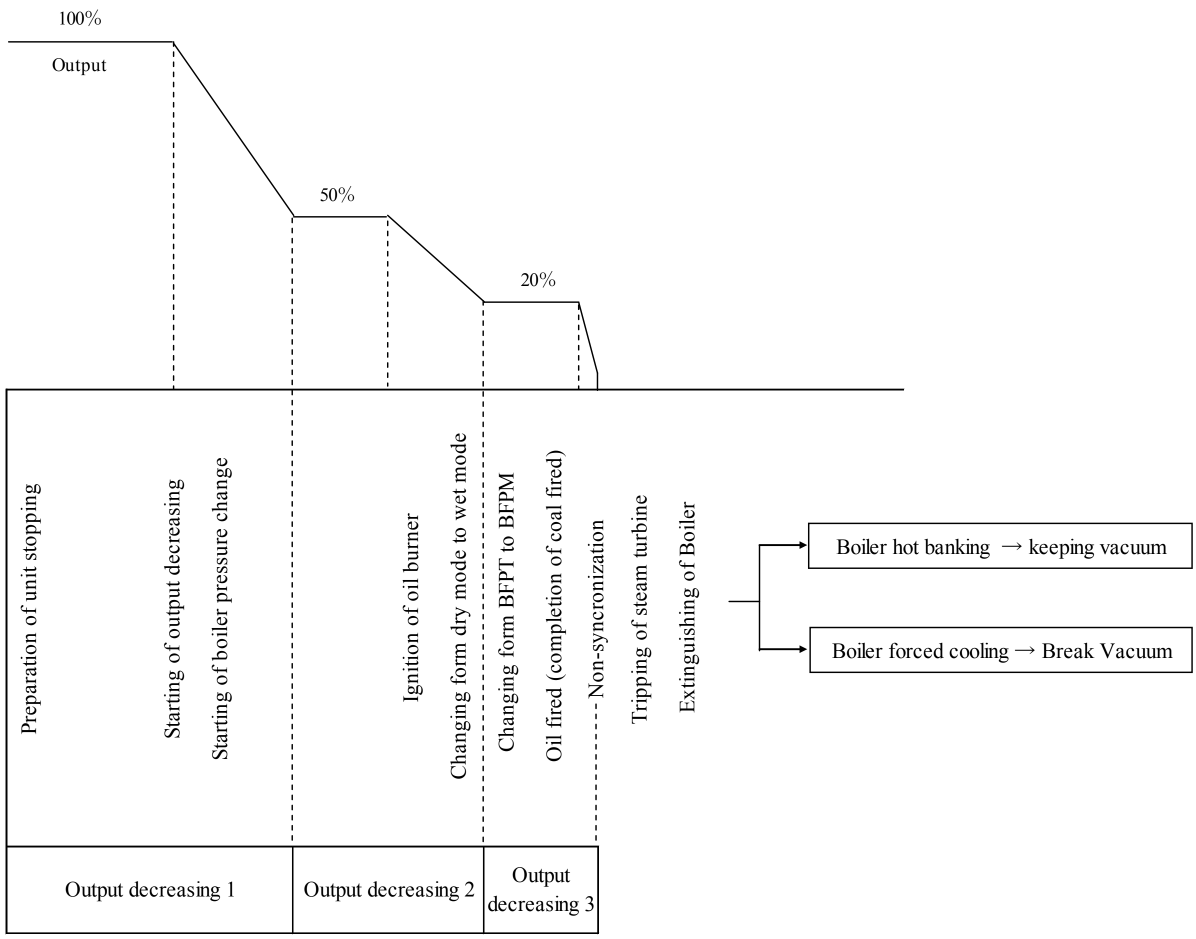


Figure 159-1 Sample of unit stopping flow

Article 160. Emergency stop of boiler

When boiler occurs to be tripping conditions, it must be stopped boiler urgently by MFT to protect boiler, auxiliary equipments and power plant staff. It must be confirmed interlock system is operated certainly at MFT. Moreover, it must not be started boiler until root cause of MFT is confirmed and maintenance is completed. Response after MFT is shown as follows;

1. Point to be checked at MFT
   (1) It must be confirmed fuel shut off, burner, super heater and re-heater shut off valve are closed.
   (2) It must be confirmed all burners are extinguished by furnace monitor screen etc.
   (3) It must be confirmed coal pulverizer hot air dampers are closed.
   (4) It must be confirmed boiler auxiliary equipments are tripped.
   (5) Alarm (It must be confirmed transmitted alarms is normal and irregular alarms are transmitted.)
2. It must be conducted furnace purge over 5 minutes to prevent furnace explosion.

It must be conducted furnace purge by opening dampers and have natural draft (gravity ventilation) when tripping fan system.

3. It must be changed auxiliary steam supply source from tripped boiler to house boiler.

4. It must be purged flammable gas of remaining coal in coal pulverizer to furnace and cooled coal pulverizer inside by flowing minimum air flow from cool air system to prevent spontaneous combustion.
5. It must be confirmed boiler and auxiliary equipments are normal by visual check.
6. It must be re-started boiler after root cause of tripping boiler is confirmed and maintenance is completed.
7. It must be purged remaining oil in burners after igniting igniter.
8. It must be purged remaining coals in coal pulverizer after re-synchronization.
9. It must be confirmed following items when losing all power sources.
   (1) All fuel is shut off.
   (2) AH is operated by air motor and dumpers in air and gas duct are opened.
10. Boiler tripping conditions are shown as follows;
   (1) Water level in steam drum is higher or lower than standard, or all water indicators and signal are broken.

       When power plant staff can not confirm feed water flow, it must be tripped boiler to prevent melting of boiler tubes.

   (2) Water levels in steam drum experience rapid decrease although water is still being fed.

       When power plant staff can not confirm feed water flow, it must be tripped boiler to prevent melting of boiler tubes.

   (3) All boiler feeding pumps are broken.

       It must be tripped boiler because tripping of all boiler feeding pumps causes rapid decreasing of feed water flow and melting of boiler tubes.

   (4) Pressure in steam main piping is over allowable limitation.

       It must be tripped boiler because there is a possibility that boiler tubes are burst.

   (5) Overhaul of the safety valve or other safety devices, repair valve that is not working.

       It must be tripped boiler because there is a possibility that boiler tubes are burst when safety valves or other safety devices are not worked.

   (6) Steam pipelines related to the boiler are broken or cracks, blisters, defective weld in main parts of the boiler (steam drum, collector, steam pipes, water pipe down), in the main steam pipeline, feed water line are occurred.

       It must be tripped boiler because there is a possibility that other pipelines etc. are damaged and feed water flow is decreased rapidly.

   (7) Flame in the combustion chamber is lost.

       It must be tripped boiler because it can be not operated boiler continuously when flame in the combustion chamber is lost. Moreover, it must be re-started boiler after conducting furnace purge.

(8) Adjusted gas or oil pressure reduces the permitted level (Apply for gas or oil fired furnace).

It must be tripped boiler because when boiler combustion is unstable.

(9) At the same time gas and heavy oil pressure (gas mixture) after control valve reduces below the allowable limitation of the plant procedure.

It must be tripped boiler because boiler combustion is unstable.

(10) All induced draft fans and forced draft fans stop, or furnace draft is outside the stipulated range.

It must be tripped boiler because boiler combustion is unstable.

(11) Explosion in combustion chamber, explosion or fire of fuel deposit remained in flue or dust precipitators, incandescence of steel structure of the boiler's body, or other damages threaten operator's life.

(12) Fires threaten operator's life and equipment, remote controlling circuit which can touch boiler's protection circuit.

(13) Remote control, automatic equipment, testers and meters are broken down.

It must be tripped boiler because power plant staffs can not confirmed operation status of boiler.

(14) With gas-fired boilers, apart from above-mentioned requirements, technical standards on safe gas system are violated.

Article 161. Stop of boiler

It must be stopped boiler if the following cases have a large impact on operation of boiler. It must be tripped boiler urgently when boiler is damaged rapidly due to following cases. Point to be checked at MFT is shown in Article 160 of this guideline. Point to be checked at normal boiler stopping is shown in Article 159 of this guideline.

1. Detecting leak-out on heat tube's surface, on steam mains, headers, water feeders as well as flange valves are blown off or leaked out.

It must be stopped boiler because there is a possibility that other tubes etc. are damaged and feed water flow is decreased rapidly.

2. Metal temperature and heating surface is hotter than standard, and after changing operating mode, the temperature does not come up to allowable values.

It must be stopped boiler because there is a possibility that boiler tubes are melted. Reasons why metal temperature and heating surface is hotter than standard are shown as follows ;

(1) Deposition of scale in boiler tube

(2) Decreasing of feed water flow

3. Remote water level indicators are broken.

When power plant staff can not confirm feed water flow, it must be stopped boiler to prevent melting of boiler tubes.

4. Feeding water quality is suddenly bad in comparison with standard.

It must be stopped boiler because there is possible that steam turbine blade and boiler tubes inside are damaged. Reasons why feeding water quality is suddenly bad are shown as follows ;

(1) Condenser tube leak (seawater)

(2) Defects in condensate demineralizer

(3) Defects in chemical dosing equipment etc.

5. Dust precipitators of coal-fired boiler are broken.

It must be stopped boiler because there is a possibility that gas emission form boiler can not meet environmental standard in Vietnam.

6. Some protection equipment, automatic and remote control equipment and indicators, meters are broken.

It must be stopped boiler because power plant staffs can not confirmed operation status of boiler.

Chapter 5 Steam Turbine and its Auxiliary

Article 162. General provision

It must be paid attention to following items when operating steam turbine.

1. Safe operation of main equipment and auxiliaries

It must be paid attention to following provisions to ensure safe operation of main equipment and auxiliaries.

(1) Appropriate operation of main equipment and auxiliaries

1) It must be operated main equipment and auxiliaries according to procedures developed by each power plant.

2) It must be confirmed outlet pressure, temperature and flow etc. of main equipment and auxiliaries meet acceptable value.

3) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

4) It must be maintained main equipment and auxiliaries properly when detecting defects in them.

(2) Prevention of human error

1) It must be operated each equipment according to procedures developed by each power plant.

2) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

3) It must be increased communication between operation group and maintenance group when inspecting of main equipment and auxiliaries.

4) It must be stay in close contact with staff in control room when operating or inspecting of main equipment and auxiliaries at each filed.

5) It must be understood each operation and maintenance work (e.g. opening and closing valve, turning on or off) have impact on operation of power plant.

(3) Management of vibration

It must be paid attention to transition of vibration of normal steam turbine operation and starting and stopping of steam turbine.

Table 162-1 Sample vibration value at alarming and stopping steam turbine

		Rotor (1/100mm) <3,000rpm>	**Bearing (1/100mm) <3,000rpm>**
Stop of steam turbine		25	1.25
Alarm	Over rated speed	12.5	6.2
	Under rated speed	15	7.5
Normal operation	Over rated speed	Not over 7.5	Not over 3.8
	Under rated speed	Not over 12.5	Not over 6.3

(4) Prevention of crack on casing and rotor due to thermal stress

It must be paid attention to thermal stress at staring and stopping of steam turbine as prevention means of crack. Monitoring items regarding thermal stress of steam turbine at starting are shown as follows ;

1) Differential temperature between internal and external metal of main steam stop valve
2) Differential temperature between internal and external metal of control valve
3) Differential temperature between Internal and external metal of 1st stage steam chest and re-heater steam chest
4) Restriction of temperature change rate of high and middle pressure rotor

2. Availability of rated load at heating demand

When steam turbine is operated stably, one of equipments which have an impact on availability of rated load at heating demand is condenser. Countermeasures of keeping and upgrading performance of condenser are shown as follows;

(1) Keeping cleanliness of condenser tube

It must be kept cleanliness of condenser tube by using ball cleaning.

(2) Prevention of plugging of condenser tube

It must be prevented plugging of condenser tube due to shells etc. by operating reversing valve of condenser (backwash).

(3) Anticorrosion of condenser tube

It must be prevented corrosion of condenser tube by condenser cathodic protection equipment.

(4) Reduction of power of circulating water pump

When 2 circulating water pumps are installed, electric power consumption can be decreased by operating 1 pump at low load of power plant. Moreover, electric power consumption can be decreased by using circulating water pump with movable vane (adjustable vane).

Article 163. Turbine control

General description of steam turbine control is shown as follows;

1. Governor setting

Turbine load (valve travel of CV) is set by governor setting during synchronization. Governor setting command is inputted from APC system to EHC system after APC is automatic and steam turbine load is controlled based on boiler-turbine parallel control.

2. Turbine speed control

When there is deviation between actual turbine revolution speed and rated speed, valve travel of CV and ICV is controlled based on its deviation. And, purpose of installing this system is shown as follows;

(1) Over speed of steam turbine is serious trouble which causes damage of rotor and blade due to excessive centrifugal force. Turbine speed control system inhibits over speed of steam turbine and closing CV is given priority all the time.

(2) Turbine speed control system increases and deceases steam turbine load and adjusts steam turbine output according to network load. Governor free operation means that CV is opened and closed slightly by turbine speed control system according to fluctuation of frequency.

3. FA/PA changeover

(1) FA mode

4 CVs are opened evenly form speed up of steam turbine to regulated load (sample: 7% load) to prevent thermal deformation of steam turbine casing.

(2) PA mode

PA mode is changed from FA mode to reduce pressure loss after steam turbine load is gotten to regulated load.

4. Automatic follow-up of load limiter

Load limiter setting is set regulated margin (sample: 5%) above actual load of steam turbine. When frequency of steam turbine (network load) is gone down, actual load is increased regulated margin (sample: 5%) according to turbine speed control system. And, after actual load is gotten to regulated margin, it can be increased at regulated rate of load change (sample: 5%load /min).

5. CV opening (valve travel) control

CV command is changed over current signal and outputted to servo valve by EHC system, it is transformed control hydraulic and CV is controlled. Actual CV opening is detected at liner voltage differential transformer, inputted to EHC system and current signal is amended to bring actual valve opening into line with valve opening command by CV opening control.

6. Power load unbalance

When electric trouble in network is caused, circuit breaker of transmission is opened and over speed of steam turbine is caused. Power load unbalance system detects unbalance between steam turbine load and generator current and confirms that load dump is caused in network. When load dump is caused in network, power load unbalance system detects it rapidly and closes CV and ICV to prevent over speed of steam turbine before turbine speed control system is operated.

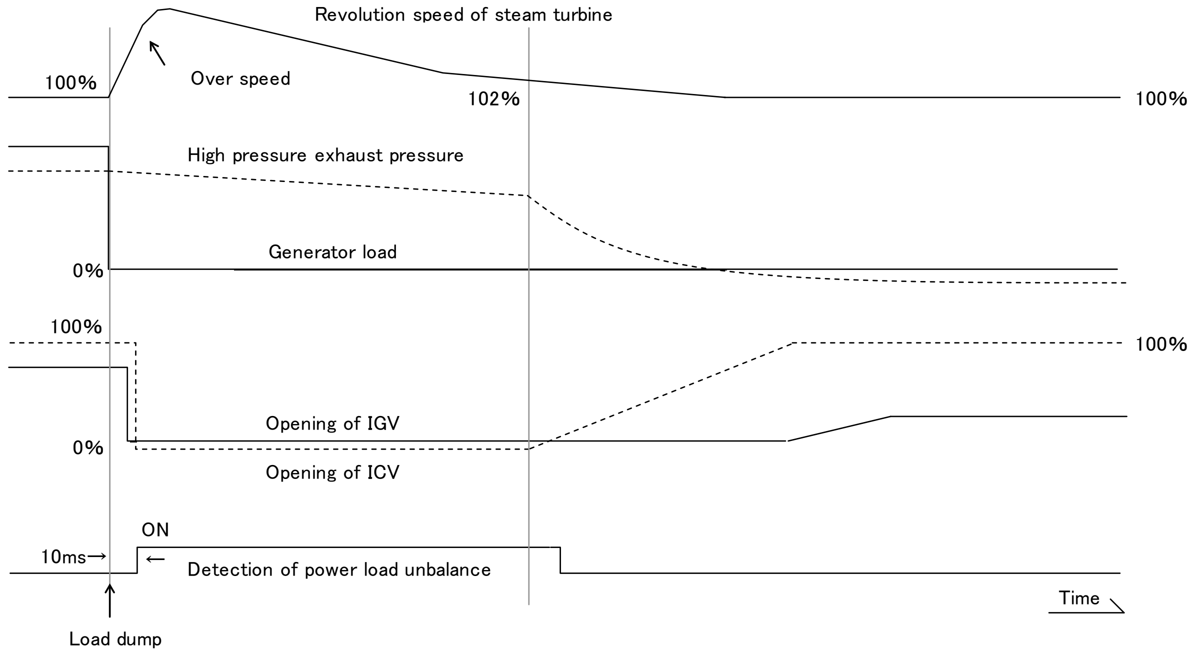


Figure 163-1 Sample behavior of steam turbine at load dump

Article 164. Emergency governor

It must be conducted lock out test and oil trip test regarding emergency governor periodically to stop steam turbine certainly. Procedure of lock out test and oil trip test is shown as follows;

1. Confirmation before test
   (1) Revolution speed of steam turbine (rated revolution speed)
   (2) Indication light of “Master trip test” : lighting
   (3) Indication light of “Release of lock out ” : lighting
   (4) Indication light of “Lock out” : lighting out
   (5) Indication light of “Oil trip ” : lighting out
   (6) Indication light of “Reset ” : lighting
   (7) Indication light of “During reset” : lighting out
2. Test procedure
   (1) It must be pushed PB of “Lock out”.
   (2) It must be confirmed that indication light of “Lock out” is lighted and “Release of lock out” is lighted out.

   It must be confirmed that lock out valve is positioned lock out at steam turbine area.

(3) It must be pushed PB of “Oil trip”.

(4) It must be confirmed that indication light of “Trip” is lighted and “Reset” is lighted out.

It must be confirmed that steam turbine is not tripped.

(5) It must be pushed PB of “Reset” continuously until indication light of “Reset ” is lighted.

(6) It must be confirmed that status following indication light.

1) Indication light of “Reset ” : lighted

2) Indication light of “During reset” : lighted out → lighted → lighted out

3) Indication light of “Trip ” : lighted out

(7) It must be pushed PB of “Release of lock out”.

(8) It must be confirmed that indication light of “Release of lock out” is lighted and “Lock out” is lighted out.

It must be confirmed that lock out valve is positioned release of lock out at steam turbine area.

Article 165. Steam stop valve and regulating valve

1. Main steam stop valve (MSV) and Re-heat stop valve (RSV)

These valves are protect equipment basically, usually opened completely (full open), and closed urgently and steam is shut off when steam turbine has serious defect. Moreover, MSV is added full arc admission decreasing thermal stress in steam turbine with nozzle governing due to high temperature and pressure steam. When steam flow in steam turbine is controlled by MSV such as operation with full arc admission, it is conducted by sub-valve installed in MSV. MSV and RSV is conducted operating test (open-close) periodically to prevent fixing of these valve stem. Strainer is installed before MSV to prevent interfusion of foreign object.

Photo 165-1 Main stop valve

Photo 165-2 Re-heat stop valve

2. Regulating valve (or control valve : CV) and Intercept valve (ICV)

Regulating valve is controlled steam flow in steam turbine and operated with speed governing device. In some small size steam turbines, regulating valve is installed in high pressure casing. In steam turbine over 350MW, it is separated regulating valve from high pressure casing. There is a possibility that steam in re-heat steam piping system is expanded after middle pressure steam turbine and rotary frequency of rotor is increased when load of steam turbine is shut off urgently, governor is operated and regulating valve is closed. Intercept valve is started closing at 101% of rated rotary frequency and closed completely at 105% to shut off steam flow into steam turbine.

Photo 165-3 Control valve

Article 166. Check of valve

It must be conducted operating (open-close) test regarding stop valve and regulating valves of main steam and reheat steam periodically to stop steam turbine certainly. Procedure of operating test is shown as follows. Moreover, it must be referred to Article 167 of this guideline regarding operating test of extraction non-return valve.

1. Preparation before test

No.	Confirmation and operation	Check
1	It must be decreased regulated load of power plant to conduct this test.	
2	It must be confirmed following items. - ALR operation - 65 control (governor control) - Operation status of power plant is stable.	
3	It must be asked maintenance group to witness this test if necessary.	
4	It must be informed load dispatch center of commencement of this test.	

2. MSV operating (open-close) test

No.	Confirmation and operation	Check
1	It must be confirmed relevant staff is distributed at control room and steam turbine field.	
2	It must be confirmed left and right MSV are opened completely.	
3	It must be pushed “Left MSV” button on EHC test panel and held this status.	
4	It must be confirmed following items. - Opening indicator : 0% (full close) - Fluctuation of power plant load and main steam pressure etc. - Operation status of left MSV	
5	It must be quitted hold of “Left MSV” button on EHC test panel.	

No.	Confirmation and operation	Check
6	It must be confirmed following items. - Opening indicator : 100% (full open) - Fluctuation of power plant load and main steam pressure etc. - Operation status of left MSV	
7	It must be confirmed operation status of power plant.	
8	It must be conducted operating test of right MSV according to above procedure.	

3. CV operating (open-close) test

No.	Confirmation and operation	Check
1	It must be operated following item. - AFR : “Usage” → ”Cancel”	
2	It must be pushed “Load limiter Increasing” to upper limit (100%).	
3	It must be confirmed relevant staff is distributed at control room and steam turbine field.	
4	It must be confirmed opening of CV.	
5	It must be pushed “CV-1” button on EHC test panel and held this status.	
6	It must be confirmed CV-1 is closed and other CV are opened.	
7	It must be confirmed following items regarding CV-1. - Opening indicator : 0% (full close) - Fluctuation of power plant load and main steam pressure etc. - Operation status of CV	
8	It must be quitted hold of “CV-1” button on EHC test panel.	
9	It must be confirmed CV-1 is opened and other CV are closed.	
10	It must be confirmed following items. - Opening indicator : recovery of opening of before test - Fluctuation of power plant load and main steam pressure etc. - Operation status of CV	
11	It must be confirmed operation status of power plant.	
12	It must be conducted operating test of other CV according to above procedure.	

4. CRV operating (open-close) test

No.	Confirmation and operation	Check
1	It must be confirmed relevant staff is distributed at control room and steam turbine field.	
2	It must be confirmed left and right CRV are opened completely.	
3	It must be pushed “Left CRV” button on EHC test panel and held this status.	

No.	Confirmation and operation	Check
4	It must be confirmed following items. - Opening indicator : 0% (full close) - Fluctuation of power plant load and main steam pressure etc. - Operation status of left CRV	
5	It must be quitted hold of “Left CRV” button on EHC test panel.	
6	It must be confirmed following items. - Opening indicator : 100% (full open) - Fluctuation of power plant load and main steam pressure etc. - Operation status of left CRV	
7	It must be confirmed operation status of power plant.	
8	It must be conducted operating test of right CRV according to above procedure.	
9	It must be operated following item. - AFR : “Cancel” → “Usage”	
10	It must be informed load dispatch center of completion of this test.	

Article 167. Check of operation of extraction non-return valve

It must be conducted operating (open-close) test regarding extraction non-return valve periodically to stop steam turbine certainly. Procedure of operating test is shown as follows;

1. Preparation before test

No.	Confirmation and operation	Check
1	It must be confirmed operation status of power plant is stable.	
2	It must be confirmed each extraction non-return valve is opened. - Indication WL of “Open ” : lighting (at control room)	

2. Extraction non-return valve operating (open-close) test

No.	Confirmation and operation	Check
1	It must be confirmed relevant staff is distributed at control room and steam turbine field.	
2	It must be confirmed each is opened completely.	
3	It must be pushed each “Extraction non-return valve” button on test panel and held this status.	
4	It must be confirmed relevant extraction non-return valve is closed at control room and extraction non-return valve field.	
5	It must be quitted hold of relevant “Extraction non-return valve” button on test panel.	
6	It must be confirmed relevant extraction non-return valve is opened at control room and extraction non-return valve field.	
7	It must be confirmed operation status of power plant.	

No.	Confirmation and operation	Check
8	It must be conducted operating test of other extraction non-return valve according to above procedure.	

Photo 167-1 Extraction non-return valve

Article 168. Turbine oil feeding system

Steam turbine oil system is to feed lubricant oil to bearings and very important equipment to operate steam turbine stably. This oil system is composed of following equipments.

- Pumps (Main oil pump, auxiliary oil pump, emergency oil pump and turning oil pump)
- Main oil tank
- Oil cooler
- Oil purifier
- Gas extractor (ejector)   etc.

Oil feeding from oil tank is cooled by oil cooler and fed to main oil pump. Main oil pump is connected with steam turbine. Oil temperature going through bearing is increased 10～20 degree C and returned to main oil tank. Auxiliary oil pump are started automatically in case of decreasing of oil pressure and emergency oil pump driven by DC motor is installed in consideration of blackout. It must be ensured following provisions to operate oil feeding system stably.

Photo 168-1 Turbine oil feeding system

1. Reliable operation of turbine in every operating mode

Reliable operation of turbine in every operating mode depends on proper management of each equipment by daily patrol and inspection etc. Point to be checked at daily patrol and inspection of oil feeding system is shown as follows ;

(1) Steam turbine

1) Oil temperature after bearing

2) Oil flow

(2) Main oil tank

1) Oil level

2) Oil leakage

3) Damage and deformation

4) Peeling of painting etc.

(3) Oil cooler

1) Oil temperature

2) Oil leakage

3) Damage and corrosion etc.

(4) Oil purifier

1) Oil leakage

2) Damage and corrosion etc.

(5) Gas extractor

1) Abnormal noise

2) Vibration

3) Damage and corrosion etc.

2. Safe firefighting

It must be conducted fire fighting training by whole power plant periodically because safety firefighting and appropriate early extinction prevents spread of the fire. Point to be checked and procedure at this training in case of a fire at steam turbine oil tank are shown as follows;

(1) It must be started early extinction and informed control room of power plant rapidly when detecting a fire.

(2) It must be informed fire station and established fire fighting team by power plant staff promptly.

(3) It must be followed reader’s directions of fire fighting team before fire station arrives and followed fire station’s directions after it arrives.

(4) It must be clarified role allocation of power plant staff when establishing fire fighting team.

(5) It must be started dry chemical extinguishing system and serious fire fighting as soon as possible.

(6) It must be put on rescue suit if necessary.

(7) It must be prevented outflow expansion of dry chemical and oil.

1) It must be closed rainwater discharge gate

2) It must be stopped waste water pump in steam turbine building.

(8) It must be tripped power plant urgently.

(9) It must be stopped oil pump after rotary frequency of steam turbine is stopped.

(10) It must be repaired damaged parts by maintenance group.

(11) It must be confirmed outflow area of dry chemical and oil and disposed them.

3. Ability to maintain oil quality corresponding to criteria

It must be supplied lubricant oil in conformity to required oil quality to operate steam turbine stably. Because required oil quality is recommended by manufacture, it must be procured oil in conformity to it by power plant. International standard of turbine oil is ASTM D 4304, ISO 8068 and JIS K 2213. In power plant, it must be developed specification of steam turbine lubricant oil including following provisions.

(1) Equipment name

(2) Oil feeding place

(3) Lubricant oil name

(4) Oil volume per one equipment and number of equipment

(5) Total oil volume

(6) Oil feeding procedure

(7) Oil feeding interval

(8) Oil exchange interval

4. Ability to prevent oil leakage into oil cooler (cooling water system)

It must be checked oil cooler by daily patrol and maintenance to prevent oil leakage into oil cooler. It must be referred to paragraph 1 of this article regarding point to be checked at daily patrol and maintenance of oil cooler.

Article 169. Check of backup devices

It must be started auxiliary and emergency oil pumps rapidly and supplied lubricant oil to bearing of steam turbine when main oil pump outlet pressure or bearing oil pressure is decreased. Therefore, it must be conducted automatic starting test of these pumps periodically (sample test interval: once a week). Many emergency oil pumps are driven by DC motor to stop steam turbine steadily when losing AC generator (alternator). There is a possibility that bearing of steam turbine is burnt out at loss of AC generator when pace of increasing of lubricant oil pressure is low and required oil flow is not supplied. Sample procedure of automatic starting test of these pumps is shown as follows;

1. Preparation before test

No.	Confirmation and operation	Check
1	It must be confirmed following items regarding pump. - Power source of pump : turning on - Automatic mode	
2	It must be lubricant oil pressure of steam turbine bearings. - Control room : MPa, Steam turbine field : MPa	
3	It must be informed control room of commencement of automatic starting test.	

2. Automatic starting test

No.	Confirmation and operation	Check
1	It must be confirmed test oil pressure of automatic starting.	
2	It must be closed test valve gradually.	
3	It must be confirmed that pump is started automatically.	
4	It must be confirmed oil pressure of automatic starting and it meets acceptable value.	
5	It must be confirmed transmitted alarms.	
6	It must be opened test valve.	
7	It must be confirmed following items regarding operation status of pump and motor. - Abnormal noise - Vibration etc.	
8	It must be informed control room of operation status of pump and motor.	
9	It must be stopped pump manually and had automatic mode.	

Article 170. Operation of heat exchanger system

It must be ensured following provisions at operating heat exchanger system.

- Reliability of heating exchanger in every operating mode
- Rated feeding water temperature
- To keep rated temperature difference in each heating exchanger

It must be managed heat exchanger system properly by daily patrol and inspection and periodic inspection to meet above provisions. Point to be checked at daily patrol and inspection of heat exchanger system is shown as follows;

- Drain level in heat exchanger system
- Feed water quality
- Opening of drain level control valve

There is a possibility that tube leak is occurred in heat exchanger system when water quality is aggravated and it is serious trouble of power plant. Sample countermeasure of tube leak in low pressure heat exchanger system is shown as follows;

Alarm "No.4 heater water level high"

It must be confirmed following operation status.
- Water levevel of field level gauge
- Control status of No.4 heater water level

Alarm "No.3 and 4 heater water level extreme high"

It must be confirmed following operation status.
- No.4A heater extraction steam inlet valve : Full close
- No.4A heater extraction steam check valve : Full close

Alarm "Low pressure heater drain tank water level high"

It must be requested load dispatch center to decrease power plant load.

It must be decreased power plant load.
(Power plant load is based on manufacture recommendation.)

It must be opened No.4 heater cell drain recovery valve.

It must be changed following item regarding low pressure drain tank water level contorl.
- to low pressure heater → to condenser

It must be opened low pressure heater drain pump outlet blow valve.

It must be operated bypass of No.3 and 4 heater according to following procedure monitoring No.4 heater outlet condensate remperature.
- No.3 extraction sterma inlet valve is closed gradually.
- Low pressure heater drain pump outlet valve is closed gradually.
- Low pressure heater drain pump is stopped.
- No.3 and 4 heater bypass valve is opened gradually.
- No.3 heater condensater inlet valve is closed gradually.
- No.4 heater condensater outlet valve is closed gradually.

It must be closed low pressure heater drain pump outlet blow valve.

Figure 170-1 Sample countermeasure (Bypass of No.3 and 4 heater)

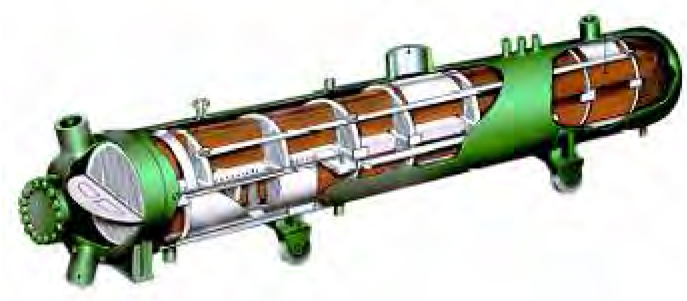
 

Photo 170-1 Heat exchanger system

Article 171. High-pressure heater

When high pressure heater is installed 2 systems (A (No.1) system and B (No.2) system) and one system has a trouble, power plant can be continued operating by bypassing defective heater. High pressure heater is composed of many tubules inside heater and there is a possibility that this tube is occurred tube leak. Sample countermeasure of tube leak in high pressure heat exchanger system is shown as follows;

Alarm "No.6 heater water level high"

It must be confirmed following operation status.
- Water levevel of field level gauge
- Control status of No.6 heater water level

Alarm "No.6 heater water level extreme high"

It must be confirmed that run back system is operated.
- power plant load is decreased to regulated load.
  (Regulated load is based on manufacture recommendation.)

It must be informed load dispatch center of decreasing of power plant load.

It must be confirmed following operation status.
- No.6A heater extraction steam inlet valve : Full close
- No.6A heater extraction steam check valve : Full close

It must be opened No.6A heater cell drain recovery valve.

It must be confirmed that power plant load is decreased and operation status is stable.

It must be stopped high pressure heater A system according to following procedure monitoring differential temperature of feed water and decreasing rate of feed water temperature.
- No.6A, 7A and 8A extraction steam inlet valve is closed completely.
- 6A heater feed water inlet valve and 8A heater feed water outlet valve are closed completely.
- It must be close following valves completely.
  - A high pressure heater vent valve
  - 6A heater drain deaerator inlet valve
  - 6A heater drain condenser inlet valve
  - A high pressure heater drain blow valve
- 8 heater cell blow recovery valve is opened completely.
- 7 heater cell blow recovery valve is opened completery.
- 6 heater cell blow recovery valve is opened completery.
- 6, 7 and 8 cell blow recovery valve are closed completery.

It must be confirmed that operation status of power plant is stable.

Figure 171-1 Sample countermeasure (Stopping of high pressure heater A (No.1) system)

Article 172. Check before starting up

It must be confirmed condition of protection equipment and interlock of steam turbine before starting up turbine (after repair or from shutdown condition). Because it must be stopped steam turbine safely and steadily in case that power plant has serious trouble. Sample of alarm test and interlock test is shown as follows;

1. Alarm test

(1) Purpose

It must be confirmed that defect for control system, pressure and temperature etc. related steam turbine equipment are detected and alarm system is operated normally.

(2) Unit operation status

Under unit operation, under unit trip

(3) Test procedure and point to be checked (example)

Test item	Test procedure	Points to be checked		
		Set value	Operating value	Indicator
Rotor vibration high	1) Interlock switch for rotor vibration high is deselected. 2) Output terminal of turbine revolution monitoring switch in turbine supervisory instrument panel is left open and condition of "turbine revolution more than XXXX rpm" is prepared. 3) Signal cable of rotor vibration detector in turbine supervisory instrument panel is unfixed. 4) Output from test signal generator is connected to above unfixed terminal block 3) and imitation signal is inputted. 5) Vibration value is confirmed through recorder at alarming.	Turbine revolution More than XXX X rpm AA/100 mmp-p + AA/100 - AA/100	mmp-p	Rotor vibration high
Bearing lubricant oil pressure low	1) Valve of bearing lubricant oil pressure switch is closed. 2) Temporary blow valve is opened and bearing lubricant oil pressure is decreased. 3) Bearing lubricant oil pressure is confirmed by temporary pressure gauge at alarming.	X.XX Pa + A.AA - A.AA	Pa	Bearing lubricant oil pressure low
Condenser vacuum low	4) Condenser vacuum pump is stopped at going up vacuum. 5) Vacuum control valve is opened, condenser vacuum is decreased gradually and operating value at alarming is confirmed by vacuum manometer.	XX mmHg + AA - AA	mmHg	Condenser vacuum low

(4) Evaluation criteria

It must be confirmed alarms and necessary indications are appeared normally.

2. Interlock test

(1) Trip due to condenser vacuum low

1) Purpose

It must be confirmed that main steam stop valve and re-heater steam stop valve etc. are operated normally according to steam turbine trip due to condenser vacuum low.

2) Unit operation status

Under steam turbine stopping

3) Test procedure and point to be checked (example)

a. Test procedure

No.- X and No.- Y vacuum low test valve are opened slightly, degree of vacuum of pressure switch inlet is decreased. It must be confirmed that alarm of condenser vacuum low and turbine trip.

b. Status confirmation

Point to be checked		**Confirmation procedure**			
		Before test	**Check**	**After test**	**Check**
Steam turbine		Reset		Trip	
Protection equipment test panel	No.-X	-		Trip	
	No.-Y	-		Trip	
Condenser vacuum				Alarm mmHg	
	No.-X	mmHg		Trip mmHg	
	No.-Y	mmHg		Trip mmHg	
emergency shut off hydraulic pressure		Pa		Pa	
Main steam stop valve		Full open		Full close	
Control valve		%		%	
Reheat steam stop valve		Full open		Full close	
Intercept valve		%		%	
Ventilator valve		Full close		Full open	
BFP steam shut off valve		Full open		Full close	
No.-X – extraction check valve		Full open		Full close	

c. Alarm confirmation

Alarm items	**Place**	**Check**
Condenser vacuum low trip	Boiler-Turbine-Generator panel	
Emergency shut off hydraulic pressure low trip	Boiler-Turbine-Generator panel	
Condenser vacuum low	Boiler-Turbine-Generator panel	
Turbine protection equipment detector operation	Boiler-Turbine-Generator panel	

4) Evaluation criteria

It must be confirmed each equipment and vales etc. are operated and alarms and necessary indications are appeared normally according to interlock.

3. Auxiliaries-related interlock test

1) Purpose

It must be confirmed that automatic start test of turning oil pump, auxiliary oil pump, emergency oil pump and control oil pump.

2) Unit operation status

Under unit operation

3) Test procedure and point to be checked (example)

a. Test procedure

Test item	**Test procedure**	**Point to be checked**		
		Set value	**Operating value**	**Indicator**
Turning oil pump	a This test is conducted under rated rotating speed of steam turbine. b Switch of turning oil pump is set to “Automatic position”. c Test valve of bearing oil pressure low of turbine is opened gradually and turning oil pump is operated automatically. d Test valve is restored, turning oil pump is stopped and switch of it is set to “Automatic position”.	X.XX Pa + A.AA - A.AA	Pa	“Turning oil pump starting automatically ” “Turbine oil pump outlet pressure low ”
Auxiliary oil pump	a Switch of auxiliary oil pump is set to “Automatic position”. b Test valve of bearing oil pressure low of turbine is opened gradually and auxiliary oil pump is operated automatically. c Test valve is restored, auxiliary oil pump is stopped and switch of it is set to “Automatic position”.	X.XX Pa + A.AA - A.AA	Pa	“Auxiliary oil pump starting automatically ” “Turbine oil pump outlet pressure low ”
Emergency oil pump	a Switch of turning oil pump is set to “Lock position” and switch of emergency oil pump is set to “Automatic position”. b Test valve of bearing oil pressure low of turbine is opened gradually and emergency oil pump is operated automatically. c Test valve is restored, emergency oil pump is stopped and switch of it is set to “Automatic position”.	X.XX Pa + A.AA - A.AA	Pa	“Emergency oil pump starting automatically ” “Turbine oil pump outlet pressure low ”

Test item	Test procedure	Point to be checked		
		Set value	Operatin g value	Indicator
Control oil pump	a Switch of control oil pump is set to "Automatic position". b Test valve of oil pressure low is opened gradually, pressure switch for alarm is operated and control oil pump is operated automatically. c Test valve is restored, control oil pump is stopped and switch of it is set to "Automatic position".	X.XX Pa + A.AA - A.AA	Pa	"Control oil pump starting automatically " "Turbine oil pump outlet pressure low "

4) Evaluation criteria

It must be confirmed each equipment is operated and alarms and necessary indications are appeared normally according to interlock.

Article 173. Prohibition of steam turbine start-up

It must be prohibited from starting up steam turbine in case that:

1. Parameters of heat and mechanical condition of turbine exceed limitation;

When steam turbine is during staring and parameters of heat and mechanical condition of turbine exceed limitation, it must be stopped steam turbine. Sample of parameters of heat and mechanical condition is shown as follows;

(1) Vibration (It must be referred to Article 162 of this guideline.)

(2) Over speed

(3) Bearing metal temperature

(4) Lubricant oil supply and return temperature

(5) Lubricant oil pressure

(6) Elongation and differential expansion

(7) Differential temperature between main steam and metal etc.

(It must be referred to paragraph 1 of Article 162 of this guideline.)

2. One of protection equipment for stopping turbine is broken;

It must be stopped steam turbine safely and stably by protection equipment. Therefore, it must not be started steam turbine in case that one of protection equipment for stopping steam turbine is broken. It must be referred to Article 172 of this guideline when conducting operation test of protection equipment of steam turbine. When confirming defects in protection equipment, it must be maintained them completely. And it must be restarted steam turbine after confirming all protection equipments are in good condition.

3. Faults of speed governing system cause turbine's over-speed with main steam and reheat steam.

It must be operated and stopped steam turbine safely and stably by speed governing system. Therefore, it must not be started steam turbine in case that speed governing system has faults. It must be referred to Article 164 of this guideline when conducting operation test of speed governing system of steam turbine. When confirming defects in speed governing system, it must be maintained them completely. And it must be restarted steam turbine after confirming speed governing system is in good condition.

4. One of oil pumps or interlock of oil pump is broken;

It must be operated steam turbine safely and stably by supplying lubricant oil to bearings properly by means of oil pump system. Therefore, it must not be started steam turbine in case that one of oil pumps or interlock of oil pump is broken. It must be referred to Article 172 of this guideline when conducting operation test of oil pump system of steam turbine. When confirming defects in oil pump system, it must be maintained them completely. And it must be restarted steam turbine after confirming oil pump system is in good condition.

5. Oil quality does not come up to standard oil quality for operation, oil temperature is outside the stipulated range;

It must be supplied lubricant oil in conformity to required oil quality to operate steam turbine safely and stably. Therefore, it must be stopped steam turbine when oil quality does not come up to standard oil quality for operation. It must be checked oil quality at periodical inspection and exchanged new oil when oil quality is deteriorated. International standard of turbine oil is ASTM D 4304, ISO 8068 and JIS K 2213 etc. It must be referred to paragraph 3 of Article 168 of this guideline in this matter.

When lubricant oil temperature is outside the stipulated range, performance of oil can not be demonstrated and operation status of steam turbine is unstable by vibration and damage in bearings. Therefore, it must be checked carefully oil temperature at daily patrol and inspection. It must be referred to paragraph 1 of Article 168 of this guideline regarding point to be checked at daily patrol and inspection.

Article 174. Check of turbine bearings, generators

It must be paid attention to vibration value during normal steam turbine operation and starting and stopping of steam turbine because blades and bearings of steam turbine are damaged seriously when vibration value is high. Sample of Vibration value at alarming and stopping steam turbine is shown in Table 173-1.

Table 174-1 Sample vibration value at alarming and stopping steam turbine

		Rotor (1/100mm) <3,000rpm>	**Bearing (1/100mm) <3,000rpm>**
Stop of steam turbine		25	1.25
Alarm	Over rated speed	12.5	6.2
	Under rated speed	15	7.5
Normal operation	Over rated speed	Not over 7.5	Not over 3.8
	Under rated speed	Not over 12.5	Not over 6.3

1. Vibration during rising of rotational frequency

Some steam turbine is passed primary and secondary critical speed. Vibration value of steam turbine at critical speed is high generally and it must be paid attention to it during rising rotational frequency. In some mechanical equipment which load per unit area of bearing is small, oil whip phenomenon is sometimes occurred. This is occurred by self-excited vibration of lubricant oil film of bearing and it is remained even rated rotational frequency. It must be managed bearing oil temperature properly at high velocity revolution zone.

2. Rubbing

There is a possibility that vibration due to rubbing is occurred during rising of rotational frequency. This is a phenomenon which occurred in mechanical equipments after assembling shortly afterward. When high temperature steam is flowed in reheat turbine, casing of reheat turbine is transformed and vibration due to rubbing is occurred. Vibration of low pressure steam turbine due to rubbing is sometimes occurred by changing reheat steam temperature suddenly during low power plant load. This is occurred by deformation due to sudden temperature change of low pressure internal casing. In case of vibration of steam turbine due to rubbing during operation, vibration amplitude is sometimes increased suddenly. In this case, there is a possibility that steam turbine is tripped after confirming alarm and taking countermeasure. Therefore, some power plants adopt interlock in consideration of increasing rate of vibration amplitude.

Article 175. Emergency stop of turbine

When steam turbine is occurred tripping conditions, it must be stopped steam turbine urgently to protect steam turbine, auxiliary equipments and power plant staff. It must be confirmed interlock system is operated certainly. Moreover, it must not be started steam turbine until root cause of tripping is confirmed and maintenance is completed. Point to be checked after tripping steam turbine (MFT) is shown as follows;

1. Point to be checked after tripping steam turbine (MFT)
   (1) It must be confirmed that following valves are closed to prevent over speed of steam turbine.
      1) Main stop valve
      2) Control valve (Regulating valve)
      3) Intercept valve
      4) Reheat steam valve
   (2) It must be confirmed BFPTs are tripped by closing high and low pressure main stop valves.
   (3) It must be confirmed following pumps are started automatically and bearing lubricant oil is supplied because main oil pump can not supply lubricant oil in proportion to deceasing of rotational frequency of steam turbine.
      1) Turning oil pump
      2) Main oil suction pump
   (4) It must be confirmed vibration during decreasing of rotational frequency of steam turbine.
   (5) It must be confirmed following valves are opened to prevent damage of condenser tubes and expansion due to inflow of drain in condenser.

1) Condenser water curtain spray valve
2) Low pressure casing spray valve

(6) It must be confirmed following items in consideration of restarting of steam turbine.
1) Condenser vacuum
2) Gland steam pressure

It must be specified criterion of judgment of vacuum destruction in regulations of power plant.

(7) It must be confirmed condensate re-circulating system is operated to protect gland steam condenser.

(8) It must be confirmed following valves are closed (stopping of extraction steam of high and low pressure heater) to prevent water induction.
1) High and low pressure heater extraction steam inlet valve
2) High and low pressure heater extraction steam check valve

(9) It must be confirmed following turning system is operated at regular intervals after tripping.
1) Main steam turbine turning system
2) BFPT turning system

(10) It must be confirmed transmitted alarms is normal and irregular alarms are transmitted.

(11) It must be confirmed condition of steam turbine and auxiliary equipments are normal by visual check.

(12) It must be re-started steam turbine after root cause of tripping steam turbine is confirmed and maintenance is completed.

Article 176. Stop of turbine

It must be reduced output or stopped steam turbine at the Owner's judgment in consideration of status of the equipment in cases that, (After notice to the National Load Dispatch Center).

1. Stop valve of main steam or reheat steam is stuck

When conducting MSV or RSV operation (open - close) test, there is a possibility that these valves are stuck. Countermeasure in this case is shown as follows;

Left MSV is stuck at MSV operation test

↓

It must be confirmed following operation status of steam turbine.
- Differential temperature between MSV internal metal and outer metal
- Differential temperature between left MSV inlet steam and right MSV

↓

It must be decreased power plant load after informing load dispatch center.

↓

It must be opened following valves.
- Left main steam piping drain valve
- Drain valve before and after left MSV valve

↓

It must be re-conducted MSV operation test.
- Push button of “Left MSV test”
- Quit hold of button of “Left MSV test”

↓

It must be stopped power plant when left MSV is continued sticking.
It must be started stopping of power plant after informing load dispatch center.

Figure 176-1 Countermeasure in case that left MSV is stuck

2. Governing valve for steam coming to turbine is stuck or valve pin is broken

When CV is closed and stuck, operation status of power plant is changed rapidly. Countermeasure in this case is shown as follows ;

No.1 CV is closed and stuck.

↓

It must be confirmed operation status of power plant is changed as follows ;

- Transmitted alarms
  - Deviation of generator power output : Large
  - Deviation of main steam pressure : Large
  - Main steam pressure : Large
- Change of operation status
  - PCV is opened automatically.
  - Generator power output is decreased rapidly.
  - Feed water, fuel and air flow are decreased rapidly.
  - Turbine bypass valve is opened automatically.

↓

It must be stabilized operation status of power plant by “Boiler manual mode” or “Boiler follow mode”.

- Controlling main steam and reheat steam temperature
- Patrol around boiler and steam turbine

↓

It must be discuss with maintenance group and decided countermeasure after confirming operation status of power plant is stable.

Figure 176-2 Countermeasure in case that No.1 CV is stuck

3. Faults in speed governor are occurred (Fluctuation of CV)

When speed governor has a breakdown and operation of CV is fluctuated, operation status of power plant is changed rapidly. Countermeasure in this case is shown as follows ;

No.1 CV is fluctuated.

↓

It must be confirmed operation status of power plant is changed as follows ;

- Transmitted alarms
  - Deviation of main steam pressure : Large
  - Main steam pressure : Large
- Change of operation status
  - Generator power output is fluctuated.
  - PCV is opened automatically.
  - Main steam pressure feed water flow, fuel flow and air flow are decreased rapidly.
  - Main and reheat steam temperature are fluctuated
  - Furnace draft is fluctuated.

↓

It must be stabilized operation status of power plant by “Boiler manual mode”.

↓

Root cause of fluctuation of CV is confirmed by following operation status.

- Opening-closing motion of governor in terms of governor opening command is defective.

↓

It must be changed operation mode from “Boiler manual mode” to “Boiler follow” and controlled generator power output and stabilized operation status of boiler.

Figure 176-3 Countermeasure in case that operation of CV is fluctuated

4. Faults on the auxiliaries, diagram, tubes of boiler and so on occur, and such faults cannot be fixed while turbine is in operation

When tube leak of boiler is conducted, operation status of power plant is changed. Countermeasure in this case is shown as follows;

Tube leak of boiler is conducted

↓

It must be confirmed operation status of power plant is changed as follows ;

- Transmitted alarms
  - Deviation of main steam pressure : Large
  - NOx concentration : High
  - Boiler metal temperature : High
  - Furnace draft : High or Low
- Change of operation status
  - Feed water and fuel flow are increased because main steam pressure is deceased.
  - Boiler metal temperature (water wall) is increased.
  - NOx concentration is increased.
  - Furnace draft is fluctuated.

↓

It must be decreased power plant output after informing load dispatch center.

↓

It must be confirmed root cause of trouble (tube leak) from operation status of boiler.

↓

It must be started stopping of power plant and cooled boiler forcibly after non-synchronization.

Figure 176-4 Co untermeasure in case of boiler tube leak

5. Faults in protection equipment which operates to stop equipment are detected

When there are some faults in protection equipment which operates to stop equipment, there is a possibility that steam turbine is not stopped safely and stably. Therefore, it must be stopped power plant and maintained it immediately.

6. Leakage of oil tubes, main steam pipe, extraction steam pipe, reheat steam pipe, major drain pipe, feed water pipe, header, welded seams or flanges, valves and casing are detected

When detecting above defects, it must be conducted countermeasure in consideration of following provisions and damaged status and maintained damaged place.

(1) Stopping of power plant

(2) Decreasing of power plant output

(3) Bypassing of damaged system

(Damaged system is stopped and bypassed, other system is operated)

Article 177. Stop time of turbine

Steam turbine is rotated through inertia after it is stopped (all main valves are closed) and its rotation is stopped completely at regular intervals. After that time, it must be confirmed steam turbine is started rotating steadily by turning equipment. If not so, steam turbine can not be restarted because there is a possibility that vibration of steam turbine is occurred and bearings and blades are damaged. Therefore, when confirming that steam turbine is not rotated by turning equipment before restarting it, it must be rotated steam turbine by turning equipment until eccentric of steam turbine rotor is met acceptable value. Point to be checked at operating turning equipment is shown as follows;

1. Point to be checked at operating turning equipment
   (1) It must be operated turning oil pump or emergency oil pump to supply lubricant oil to bearings.
   (2) It must be confirmed that bearing oil temperature setting is changed compared to normal operation (steam turbine is operated).
   (3) It must be stopped turning equipment in case of following conditions.
      1) Bearing oil temperature is higher than acceptable value.
      2) Bearing metal temperature is higher than acceptable value.
   (4) It can be stopped turning equipment based on manufacture instruction. However, it must be rotated steam turbine by turning equipment before restarted it.

Article 178. Operation mode of turbine

When operating steam turbine at overload, it must be referred to following sample operation procedure and monitoring items.

1. Sample operation procedure at overload

(1) Preparation

It must be operated following provisions as preparation of overload operation.

1) AFC -> ALR
2) Governor operation mode -> Load limiter operation mode
3) Soot blower operation mode : Automatic -> Manual
4) Rate of change of power plant load is decreased.
5) Upper limit setting of power plant load is increased.

↓

(2) Overload operation

It must be started overload operation according to following provisions.

1) Informing load dispatch center of starting overload operation.
2) Power plant load setting is increased and actual load is got to target load.
3) Confirming that monitoring items are met acceptable value.
   (please refer to paragraph 2 of this article.)

↓

(3) Decreasing of power plant load

It must be started decreasing of power plant load according to following provisions.

1) Informing load dispatch center of decreasing of power plant load.
2) Power plant load setting is decreased and actual load is got to target load.
3) Confirming that monitoring items are met acceptable value.
   (please refer to paragraph 2 of this article.)

↓

(4) Recovery operation

It must be operated following provisions as recovery operation of overload operation.

1) Upper limit setting of power plant load is decreased.
2) Rate of change of power plant load is increased.
3) Governor operation mode -> Load limiter operation mode
4) AFC -> ALR
5) Soot blower operation mode : Automatic -> Manual

Figure 178-1 Sample operation procedure at overload

2. Monitoring items (Watch list) at overload operation

Table 178-1 Monitoring items at overload operation

No.	Items
1	Generator power output
2	Reactive power
3	Main feed water rate
4	Economizer inlet pressure
5	Fuel flow
6	NOx concentration
7	SOx concentration
8	Particulate concentration
9	Deferential temperature between intake water and discharge water
10	Vacuum of condenser
11	Rotational frequency of BFPT
12	Outlet pressure of BFPT
13	Stator coil temperature
14	Rotor coil temperature
15	Traction transformer oil temperature

Article 179. Corrosion protection

It must be taken corrosion resistance measures when boiler is put on long standby. If appropriate corrosion resistance measures are not taken, steam turbine is corroded and damaged as time go on. Consequently it must be maintained steam turbine sufficiently and paid this repair work cost when restarting it. Sample of corrosion resistance measures of steam turbine is shown as follows;

Table 179-1 Sample of corrosion resistance measures of steam turbine

Equipment			Corrosion resistance measures
Steam turbine	Blade and casing		- Natural seasoning
	Rotor and bearing		- Application of anti-rust grease
	Turning equipment		- Application of anti-rust grease
	Governor		- Application of anti-rust grease
Main valve	MSV	Main body	- Wet lay up with hydrazine
		Full arc equipment	- Sealing with vinyl sheet
	CV	Main body	- Natural seasoning
		Drive system	- Application of anti-rust grease
	RSV	Main body	- Filling with nitrogen gas
	ICV	Main body	- Natural seasoning
		Oil cylinder	- Application of anti-rust oil
Lubricant oil system		Tank	- Application of anti-rust oil
		Oil cooler	- Natural seasoning
Condenser		Steam side	- Natural seasoning
		Seawater side	- Natural seasoning
Pump	Feed water pump	Main body	- Wet lay up with hydrazine
		Bearing and speed up gear	- Application of anti-rust grease
	Circulating water pump		- Application of anti-rust grease

Article 180. Cooling water system

1. Cooling water system

Cooling water (seawater) for power plant is utilized at condenser and cooling water heat exchanger to cool steam and closed cooling water. If it is not supplied continuously, power plant can not be operated completely. Therefore, it is very important to operate power plant as well as fuel and air, and it is necessary to operate and maintain cooling water system safely and stably. Point to be checked at daily patrol and inspection of cooling water system is shown as follows;

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) It must be confirmed circulating water pump, rotary screen and seawater booster pump regarding following items.

1) Pump outlet pressure etc.

2) Abnormal noise, abnormal odor, vibration and leakage

3) Heating, abnormal noise and oil leakage for bearing

4) Level, change in color and leakage for lubricant oil

5) Seawater leakage and corrosion of piping
6) Seawater leakage and corrosion of valves
7) Corrosion and peeling for painting

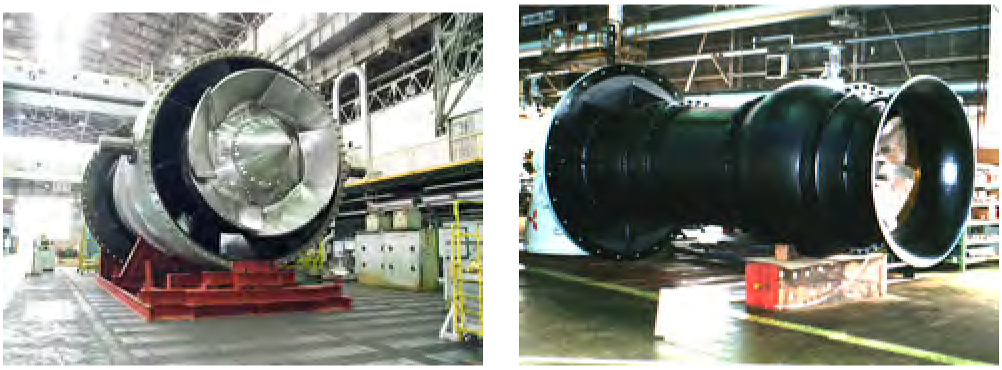


Photo 180-1 Circulating water pump

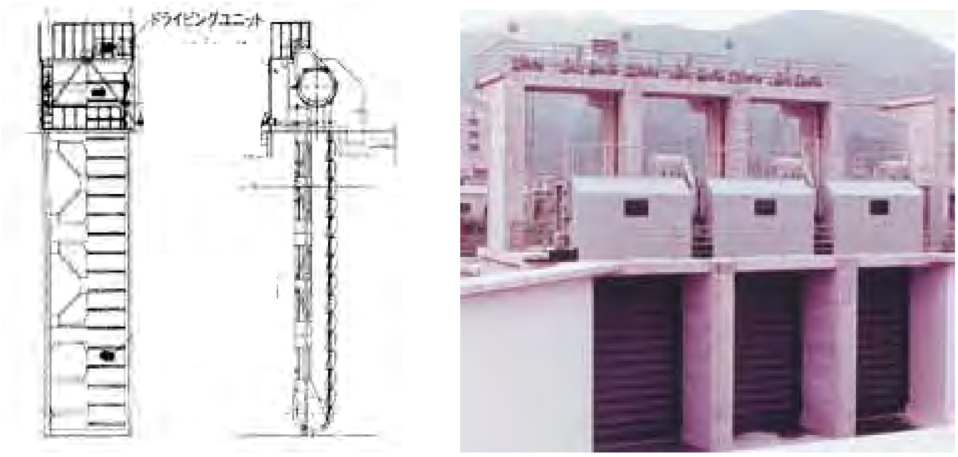


Photo 180-2 Rotary screen

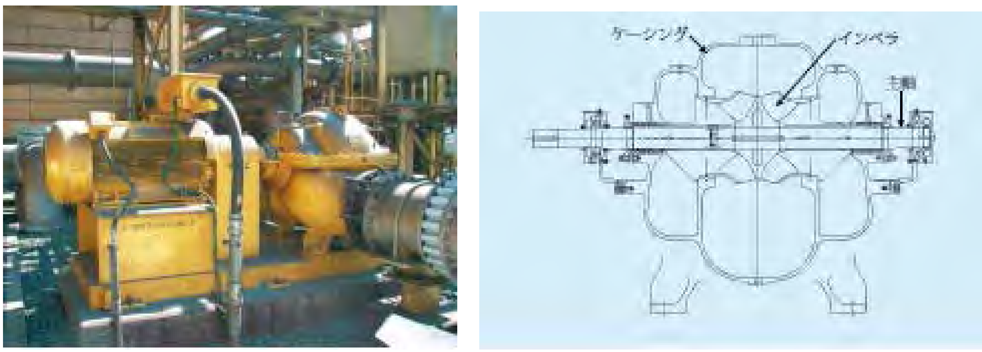


Photo 180-3 Seawater booster pump

(3) It must be confirmed control oil pump of circulating water pump regarding following items.

1) Pump outlet pressure etc.
2) Abnormal noise, abnormal odor, vibration and oil leakage
3) Heating, abnormal noise and oil leakage for bearing
4) Level, change in color and leakage for lubricant oil

5) Oil leakage and corrosion of piping

6) Oil leakage and corrosion of valves

7) Corrosion and peeling for painting

2. Chlorination equipment

Chlorination equipment is utilized to keep in good condition of condenser and circulating tubes at power plant. Chlorination equipment produces sodium hypochlorite by electrolysis of seawater. Marine organism is not attached to condenser and circulating tubes by injecting sodium hypochlorite to cooling (seawater) water intake. Point to be checked of operation and daily patrol and inspection of chlorination equipment is shown as follows;

(1) Point to be checked at operation of chlorination equipment

1) It must be taken electrical safety measure when patrolling and inspecting chlorination equipment because electrolysis vessel is impressed voltage.

2) It must be taken prevention measure of short circuit.

3) It must not be used fire around chlorination equipment because hydrogen is produced by electrolysis of seawater.

4) It must be monitored residual chlorine concentration at cooling water discharge, and stopped chlorination equipment urgently when residual chlorine concentration at cooling water discharge is not met environmental standard.

(2) Point to be checked at daily patrol and inspection of chlorination equipment

1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

2) It must be confirmed seawater pump, electrolysis vessel circulating pump and electrolysis solution feed pump regarding following items.

a. Pump outlet pressure etc.

b. Abnormal noise, abnormal odor, vibration and leakage

c. Heating, abnormal noise and oil leakage for bearing

d. Level, change in color and leakage for lubricant oil

e. Leakage and corrosion of piping

f. Leakage and corrosion of valves

g. Corrosion and peeling for painting

Moreover, ball cleaning equipment and back wash reverse filtration system regarding condenser are utilized.

Article 181. Operation of cooling tower

Point to be checked at daily patrol and inspection of cooling tower is shown as follows;

1. It must be confirmed vacuum of condenser.

If cooling vacuum of condenser is decreased, target cooling efficiency is not achieved.

2. It must be confirmed cooling medium temperature.

If cooling medium temperature is increased, target cooling efficiency is not achieved.

3. It must be confirmed abnormal noise and vibration of fan.
4. It must be confirmed heating, abnormal noise and oil leakage for bearing
5. It must be confirmed leakage and corrosion of piping.
6. It must be confirmed leakage and corrosion of valves.
7. It must be confirmed corrosion and peeling for painting.

Photo 181-1 Cooling tower

Chapter 6 Unit-type of Thermal Power Plants

Article 182. General provision

Operation of unit-type power plant is easier than operation of not unit-type power plant because steam generated by boiler in unit-type power plant is not shared as shown in Figure 182-1. As the result of safe and stable operation of boiler, steam turbine, generator and its auxiliaries, unit-type power plant operation can operate reliably for a long term. It must be referred to Chapter 2, 3, 4 and 5 of this guideline regarding safe and stable operation of boiler, steam turbine, generator and its auxiliaries.

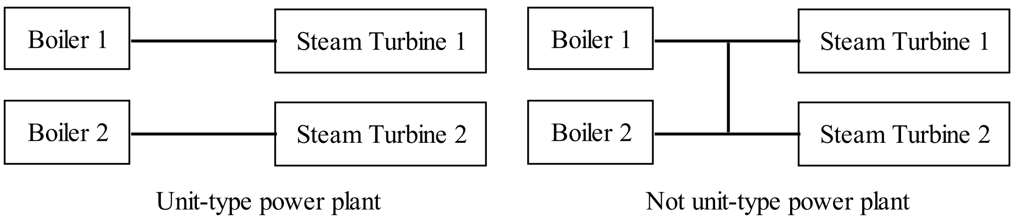


Figure 182-1 Comparison between Unit-type and Not Unit-type power plant

Article 183. Start-up

Prohibitive conditions of starting boiler and steam turbine are same as following conditions. It must be referred to Article 141 and 173 of this guideline regarding prohibitive conditions of starting boiler and steam turbine.

Prohibitive conditions of starting unit-type power plant are shown as follows;

1. Protection equipment to stop unit's equipment is broken
2. Remote control, which acts on adjusting components, and emergency valve are broken
3. When having conditions on prohibiting to start up main equipment and accessories
4. Demineralizer of the unit has not been in readiness yet
5. Bracket and frame of pipe are broken

Article 184. Keeping operation units

When power plant is disconnected to transmission system (network) due to transmission system trouble, power plant is not tripped, continued operating at auxiliary load and re-connected to transmission system after its trouble is settled. This is fast cut back (FCB) operation. Point to be checked at FCB operation is shown as follows;

1. Stable combustion of boiler

When FCB is occurred, it must be decreased output of power plant urgently from operation output to auxiliary load. Number of burner, fuel flow and air flow are controlled properly by FCB system and combustion of boiler is continued stable.

2. Protection of re-heater

It must be paid attention to re-heater metal temperature and fuel flow to prevent burnout of re-heater because steam is not supplied to re-heater at FCB operation.

3. Feed water control

It must be decreased feed water flow to minimum flow rapidly. When 2 feed water pumps are operated, it must be stopped 1 pump. It must be changed steam supply source of BFPT from steam turbine to boiler because extraction steam form steam turbine is not supplied at FCB operation. When extraction steam from boiler is not supplied, it must be stopped BFPT and started BFPM.

4. Main steam pressure

It must be flowed excess main steam to condenser or opened PCV forcibly to prevent sudden rise of main steam pressure.

5. Thermal stress of steam turbine

When boiler is extinguished, steam temperature is decreased significantly, steam in high pressure turbine is wet state and vibration of blade is occurred. Therefore, it must not be extinguished boiler to decrease drop in steam temperature. It must be increased steam temperature during FCB operation because sudden change of steam temperature has an impact on operating life of turbine rotor.

6. Frequency control

When operating FCB system, frequency is increased rapidly due to sharp decline of steam turbine load. Therefore, it must be operated steam turbine at rated frequency to prevent breakage of steam turbine blades due to sympathetic vibration.

Chapter 7 Gas Turbine and its Auxiliary

Article 185. General provision

When operating gas turbine, it must be paid attention to the following items.

- Stable operation of main equipment and auxiliary devices.
- Possibility to operate at rated parameters.
- Without air leakage or fuel, lubricating oil and water leakage.

It must be worked on following provisions to meet above items.

1. Appropriate operation of main equipment and auxiliary devices
   (1) It must be operated each main equipment and auxiliary devices according to procedures developed by each power plant.
   (2) It must be confirmed outlet pressure, temperature and flow etc. of main equipment and auxiliary devices meet acceptable value.
   (3) It must be conducted daily patrol and inspection according to procedures developed by each power plant.
   (4) It must be maintained main equipment and auxiliary devices properly when detecting defects in them.
2. Prevention of human error
   (1) It must be operated main equipment and auxiliary devices according to procedures developed by each power plant.
   (2) It must be conducted daily patrol and inspection according to procedures developed by each power plant.
   (3) It must be increased communication between operation group and maintenance group when inspecting of main equipment and auxiliary devices.
   (4) It must be stay in close contact with staff in control room when operating or inspecting of main equipment and auxiliary devices at each filed.
   (5) It must be understood each operation and maintenance work (e.g. opening and closing valve, turning on or off) have impact on operation of power plant.
3. Management of vibration

It must be paid attention to transition of vibration of normal gas turbine operation and starting and stopping of gas turbine.

Table 185-1 Sample vibration value at alarming and stopping gas turbine

	Rotor (1/100mm) <3,000rpm>	Bearing (1/100mm) <3,000rpm>
Stop of gas turbine	24	13
Alarm	16.5	8.0

4. Management of hot parts

Hot parts of gas turbine are turbine rotor blades and stationary blade and combustor which contacts with high temperature and pressure gas. It is important to manage and maintain hot parts properly to operated gas turbine stably because they are deteriorated and damaged seriously and have a short life span compared to other parts. It must be inspected and maintained hot parts properly at periodical inspection. Point to be checked to manage hot parts at operating gas turbine is shown as follows ;

(1) It must be confirmed that gas temperature of gas turbine outlet at operating meets acceptable value.

(2) It must be confirmed that deviation of blade path temperature meets acceptable value.

(3) It must be managed operating life of hot parts by evaluating EOH (Equivalent Operating Hours). Sample of estimating EOH is shown as follows ;

$$EOH = H + F1 \times (N1 + N2 \times F2 + N3 \times F3 + N4 \times F4)$$

EOH : Equivalent Operating Hours (hours)

H : Actual operating hours (hours)

N1 : Number of actual start, F1 : Conversion factor of EOH

N2 : Number of load dump, F2 : Conversion factor of load dump

N3 : Number of trip, F3 : Conversion factor of trip

N4 : Number of load sudden change, F4 : Conversion factor of load sudden change

Article 186. Regulating system

General description of steam turbine control is shown as follows;

1. Starting control

(1) Fuel control at startup

1) Fuel limit control

When required torque is reduced due to defects in starting equipment and additional fuel is supplied to keep regulated rate of rotational increase, this control system prevents excessive fuel.

2) Temperature control

Gas turbine must be controlled to keep combustion gas temperature (turbine inlet temperature) lower than acceptable value to prevent turbine blade from burnout. Thus, when measured turbine outlet temperature is higher than acceptable value, output of temperature control is reduced, it is selected by priority compared to other control output and fuel flow is limited.

3) Combustion flameout protection control

When rotational torque of starting equipment is excessive large at startup and rate of rotational acceleration is increased, fuel flow is reduced to decrease rate of rotational acceleration. In this case, lower limit of fuel flow is installed to prevent fuel flow less than acceptable value because there is a possibility that flameout is caused due to low fuel flow.

2. Load control

(1) Speed control and load limiter

1) Speed control (Governor free)

This system is conducted proportional control based on deviation between speed set value and measuring value, and load of gas turbine is increased and deceased according to fluctuation of frequency. Speed set value is increased and deceased automatically to match load command from load dispatch center and actual generating power.

2) Load limiter control

This system keeps constant load of gas turbine regardless of fluctuation of frequency and this is recommended operation mode in terms of lifetime of gas turbine because combustion gas temperature is constant.

(2) Restriction of rate of load change

Rate of load change of gas turbine is restricted because thermal stress has an impact on lifetime of gas turbine blade etc. Thus, when load of gas turbine is changed, set value of speed control or load limiter control is changed at constant rate.

(3) Restriction of maximum load

Inlet air mass flow of compressor is changed according to ambient temperature and maximum load of gas turbine is changed. Thus, maximum load of gas turbine is restricted by controlling gas turbine inlet temperature.

3. IGV control

When open cycle gas turbine is operated, IGV is opened completely (full open). On the other hand, in case of combined cycle power plant, efficiency of power plant is improved by increasing exhaust gas temperature to HRSG. In addition, it is effective with reduction of carbon monoxide or volatile organic compound. Thus, opening of IGV is kept a minimum at partial load: IGV is opened according to increase of load at load more than 70% rated.

4. Low NOx combustion control

(1) Fuel control at startup

Pilot fuel and main fuel (main fuel A) are supplied from fuel ignition and rate of 2 fuels is set as revolution speed function (please refer to following table.). This function is regulated based on balance with NOx and combustion stability.

(2) Fuel control during load operation

When gas turbine load is less than load of fuel change over, Pilot and main fuel are supplied from fuel ignition and rate of 2 fuels is set as revolution speed function in common with above. When gas turbine load is at fuel change over, top hat fuel (main fuel B) is started supplying and 3 fuel systems are operated. Fuel ratio after fuel change over is set as load function.

(3) Opening of combustion bypass valve is set to enhance combustion stability at fuel ration above paragraph (1) and (2) and regulated as function of various signal such as power output of generator, opening of IGV and ambient temperature etc.

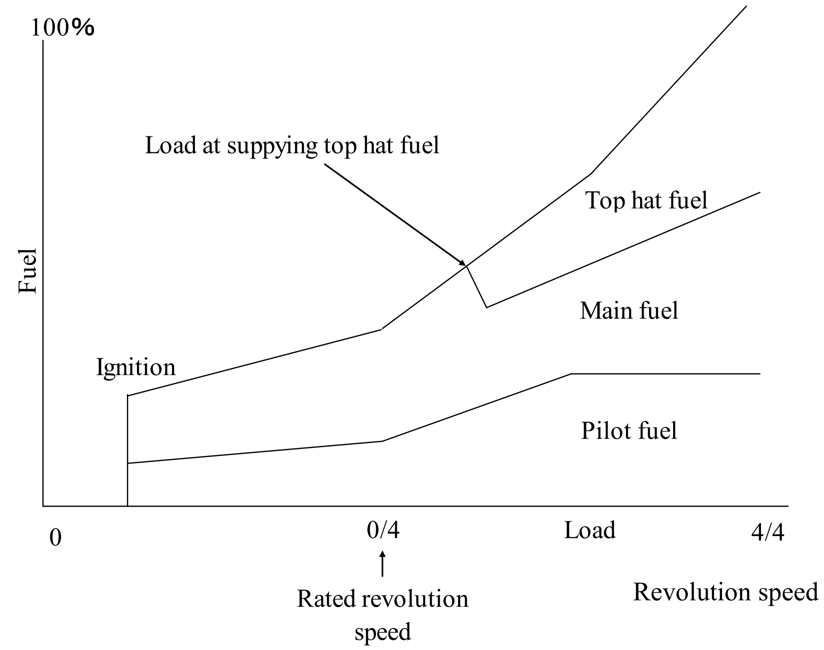


Figure 186-1 Sample of fuel distribution of low NOx combustor

Article 187. Monitoring of temperature rise

Sudden change in gas temperature of gas turbine has an impact on EOH and operating life as described in paragraph 4 of Article 185 of this guideline. Therefore, it must be monitored it carefully during starting-up and operation of gas turbine. Moreover, it must be operated gas turbine and auxiliaries safely and stably not to occur sudden change in gas temperature of gas turbine. It must be referred to paragraph 1, 2 and 3 of Article 185 of this guideline to operate gas turbine and auxiliaries safely and stably.

Article 188. Protection equipment for gas temperature

Protection equipment, which keeps gas temperature from exceeding limitation, must be calibrated for being able to operate at the stipulated temperatures of manufacturer when it's necessary. Therefore, it must be inspected and calibrated thermocouple. Inspection and calibration procedures of thermocouple are shown as follows;

1. Preparation of inspection and calibration

(1) It must be prepared procedures and tools for inspection and calibration.

(2) It must be had a meeting with related staff regarding inspection and calibration and informed control room power plant of start of them.

(3) It must be confirmed that cross line, terminal and alarm adjuster by drawings.

(4) It must be disconnected cable of alarm adjuster if necessary.

(5) It must be confirmed thermocouple name and ID number to be inspected.

(6) It must be confirmed range of thermocouple.

(7) It must be confirmed measuring value of indicator, CPTR and recorder before inspection.

(8) It must be confirmed disconnecting place by drawings.

2. Inspection and calibration

(1) It must be disconnected extension lead wire (compensating lead wire) and measured resistance of thermocouple.

(2) It must be confirmed output value of digital tester.

(3) It must be measured insulation resistance to earth (ground) by insulation resistance tester.

(4) It must be disconnected insulation resistance tester, connected to earth and discharged charging power.

(5) It must be recovered disconnected place.

(6) It must be connected voltage and current generator to junction terminal.

(7) It must be inputted power input (0, 25, 50, 75 and100%) by voltage and current generator.

(8) It must be adjusted measuring value of indicator, CPTR and recorder when it is misaligned.

(9) It must be maintained and exchanged new parts if necessary.

3. Recovery work

(1) It must be conducted recovery work for above inspection and calibration.

(2) It must be informed control room of power plant of completion of inspection.

Photo 188-1 Thermocouple

Article 189. Emergency governor

When rotation speed of gas turbine is increased 10 - 12% against rated speed or reached to stipulate speed by manufacturer, it must be stopped gas turbine urgently by emergency governor. After stopping gas turbine, it must be inspected root cause of rise of rotation speed. If there is defects in emergency governor, it must be calibrated it at manufacture factory. It must be conducted operation test of emergency governor before restarting gas turbine. Procedure of operation test of emergency governor is shown as follows;

1. Operation test
   (1) Preparation before test
      1) It must be conducted automatic start up test for following pumps.
         a. Gas turbine auxiliary pump
         b. Gas turbine emergency oil pump
      2) It must be confirmed status of gas turbine.
         a. Under gas turbine operating (no load and rated rotating speed)
         b. It must be confirmed following items before and after test.

Point to be checked	Before test	After test
Rotating speed	rpm	rpm
Fuel shut off valve	%	%
Fuel flow control valve	%	%
Inlet guide vane	%	%
Compressor bleed valve	Full close	

   (2) Test procedure
      1) It must be pushed test PB and raised gas turbine rotating speed.
      2) It must be confirmed gas turbine rotating speed when emergency governor is operated.
      3) It must be confirmed its rotating speed is within acceptable value.

Item	Acceptable value	Operating value
Rotating speed	Acceptable value : 110 – 120% + 0% / - 1%	rpm %

      4) It must be confirmed related alarms are transmitted.

Alarm item	Alarm transmission	Place
Gas turbine trip	Yes / No	Gas turbine control panel

Article 190. Protection from dust, waste of inlet chamber the gas turbine

Removing dust in air is very important to operate gas turbine stably because gas turbine gets in air. In gas turbine installed at coastal area, particle size distribution of dust in air is from 0.2 to 10 micro meters (μm) and salt content casing high temperature corrosion is included in it. Therefore, it must be taken appropriate measure for prevention of erosion and corrosion of mechanical equipments and stoppage of cooling air flow path in turbine stationary and rotor blade. Sample of measures on minimizing air dust attacking gas turbine inlet are shown as follows;

- Air filter
- Asphalt on the roads
- Spray water
- Plant grass on vacant spaces

There is a possibility that surface of compressor stationary and rotor blade is smudged by dust in air even if above measures are taken. When surface of compressor stationary and rotor blade is smudged, efficiency of compressor is decreased. Therefore, it must be washed and cleaned it by compressor blade cleaning equipment. General of compressor blade cleaning equipment is shown as follows;

- Cleaning method : injecting water (clean water, hot water) or cleaning agent in front of compressor inlet guide vane
- Cleaning time : Online cleaning at operating gas turbine

  It is conducted during load operation of gas turbine and brought certain advantages to operation of gas turbine. However, it is cleaned completely and compressor efficiency is not recovered completely.

  Offline cleaning at stopping gas turbine

  Stopping period of gas turbine is longer because it is conducted after gas turbine is stopped. However, it can be cleaned compressor blades of downstream stage and compressor efficiency can be recovered largely.

Article 191. Air filter

Removing dust in air is very important to operate gas turbine stably because gas turbine gets in air as described above. One of measures for removing dust is air filter. At present, HEPA (High Efficiency Particulate Air) is high performance filter which is used for air-conditioning at clean room in semiconductor and medicinal product factory. General of HEPA filter is shown as follows;

Items	Contents
Performance	- It is removed diameter 0.3 micro meters (μm) of dust almost completely.
Materials	- Glass wool (glass fiber).
Advantage	- Reduction of operation cost and impact on the environment by keeping gas turbine performance - Improvement of reliability of gas turbine by blockading corrosive substance to compressor and turbine. - Omission of cleaning and maintaining compressor blade at periodical inspection. - Unnecessary cleaning of compressor blade and compressor blade cleaning equipment.

Items	Contents
Disadvantage	- High cost (only filter) (Exchange interval is short because collection efficiency is high.) - High Differential pressure (Differential pressure is increased because collection efficiency is high.)

Photo 191-1 Air intake room

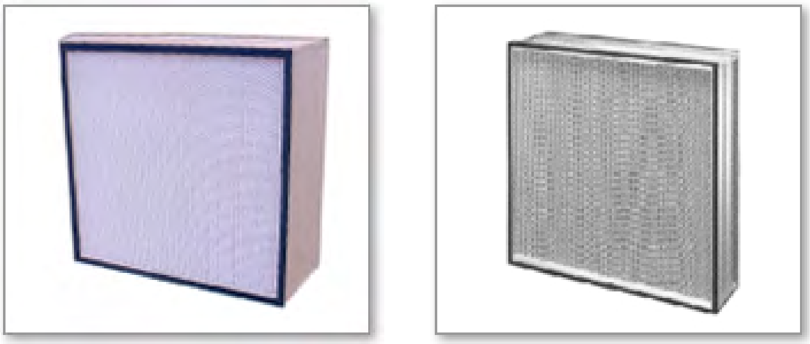


Photo 191-2 HEPA filter

When conducting daily patrol and inspection of air (HEPA) filter, it must be confirmed following provisions.

- Differential pressure of filter
- Defluxion of filter
- Removing of foreign objects (plastic bag and dry leaf etc.)

Article 192. Protection of air filter

When using HEPA filter to gas turbine intake duct, there is a possibility that differential pressure of it is increased rapidly. In this case, it must be stopped gas turbine and cleaned up or replaced filter to decrease differential pressure. However, operation cost of power plant is advanced or revenue from sales of electric power is reduced by stopping gas turbine. Therefore, it must be monitored differential pressure and replaced or cleaned up filter at DSS or WSS. Moreover, it can be cleaned up filter under a low load. However, it must not be entered gas turbine intake duct after air filter when cleaning it.

Article 193. Regulating valve

Stop valve and fuel regulating valve of gas turbine is very important equipments to stop gas turbine safely and stably. When stopping gas turbine, it must be closed stop valve and fuel regulating valve tightly. It must be conducted daily patrol and inspection of them and confirmed that they keep in good condition to operate them stably. General of daily patrol and inspection is shown as follows;

1. General of daily patrol and inspection of stop valve and fuel regulating valve
   (1) Gas leak (gas detector)
   (2) Abnormal noise and vibration
   (3) Damage, corrosion and erosion
   (4) Loose and defluxion of bolt and screw nut

Article 194. Valve on the oil system

It must be ensured safe operation and prevented human error when operating valve on the oil system. Point to be checked of preventing human error is shown as follows;

1. Prevention of human error
   (1) It must be operated each equipment according to procedures developed by each power plant.
   (2) It must be conducted daily patrol and inspection according to procedures developed by each power plant.
   (3) It must be increased communication between operation group and maintenance group when inspecting of main equipment and auxiliaries.
   (4) It must be stay in close contact with staff in control room when operating or inspecting of main equipment and auxiliaries at each filed.
   (5) It must be understood each operation and maintenance work (e.g. opening and closing valve, turning on or off) have impact on operation of power plant.

Article 195. Check before start-up turbine

It must be confirmed condition of protection equipment and interlock of steam turbine before starting up gas turbine after refurbishment or standby of more than 72 hours. Because it must be stopped gas turbine safely and steadily in case that power plant has serious trouble. Sample of alarm test and interlock test is shown as follows;

1. Alarm test
   (1) Purpose

      It must be confirmed that defect for control system, pressure and temperature etc. related gas turbine equipment are detected and alarm system is operated normally.

   (2) Unit operation status

      Under unit operation

      Under unit trip

(3) Test procedure and point to be checked (example)

Test item	Test procedure	Point to be checked		
		Set value	Operating value	Indicator
Rotor vibration high	1) Interlock switch for rotor vibration high is deselected. 2) Output terminal of turbine revolution monitoring switch in turbine supervisory instrument panel is left open and condition of "turbine revolution more than XXXX rpm" is prepared. 3) Signal cable of Rotor vibration detector in turbine supervisory instrument panel is unfixed. 4) Output form test signal generator is connected to above unfixed terminal block 3) and imitation signal is inputted. 5) Vibration value is confirmed through recorder at alarming.	Turbine revolution More than XXX X rpm AA/100 mmp-p + AA/100 - AA/100	mmp-p	Rotor vibration high
Bearing lubricant oil pressure low	1) Valve of bearing lubricant oil pressure switch is closed. 2) Temporary blow valve is opened and bearing lubricant oil pressure is decreased. 3) Bearing lubricant oil pressure is confirmed by temporary pressure gauge at alarming.	X.XX Pa + A.AA - A.AA	Pa	Bearing lubricant oil pressure low

(4) Evaluation criteria

It must be confirmed alarms and necessary indications are appeared normally.

2. Interlock test

(1) Trip due to exhaust gas temperature high

1) Purpose

It must be confirmed that fuel shut off valve and control valve etc. are operated normally according to gas turbine trip due to exhaust gas temperature high.

2) Unit operation status

Under gas turbine stopping

3) Test procedure and points to be checked (example)

a. Test procedure

(a) It must be confirmed lock out rely is reset.

(b) It must be simulated that gas turbine is started.

(c) It must be simulated that generator is synchronized.

(d) It must be simulated that exhaust gas temperature is higher than acceptable value.

(e) It must be confirmed that this system is operated normally according to interlock of gas turbine and following status of system and transmitted alarm are appropriate.

b. Status confirmation

Point to be checked	**Confirmation procedure**			
	Before test	**Check**	**After test**	**Check**
No.X Fuel shut off solenoid valve	Reset		Trip	
No.X Fuel shut off solenoid valve	Reset		Trip	
No.X shut off oil shut off solenoid valve	Reset		Trip	
No.X shut off oil shut off solenoid valve	Reset		Trip	
Fuel shut off valve	-		Full close	
No.X fuel control valve	-		Full close	
No.X fuel control valve	-		Full close	
Generator circuit breaker	-		Shut off	
Field circuit breaker	-		Shut off	

c. Alarm confirmation

Alarm items	**Place**	**Check**
Gas turbine trip	Gas turbine panel	
Trip for Gas turbine exhaust gas temperature high	Gas turbine panel	
Run back for exhaust gas temperature high	Gas turbine panel	

4) Evaluation criteria

It must be confirmed each equipment and vales etc. are operated and alarms and necessary indications are appeared normally according to interlock.

(2) Auxiliaries-related interlock test

1) Purpose

It must be confirmed that automatic start test of auxiliary oil pump and emergency oil pump.

2) Unit operation status

Under unit operation

3) Test procedure and point to be checked (example)

a. Test procedure

Test item	Test procedure	Point to be checked		
		Set value	Operating value	Indicator
Auxiliary oil pump	(a) Switch of auxiliary oil pump is set to "Automatic position". (b) Test valve of bearing oil pressure low of turbine is opened gradually and auxiliary oil pump is operated automatically. (c) Test valve is restored, auxiliary oil pump is stopped and switch of it is set to "Automatic position".	X.XX Pa + A.AA - A.AA	Pa	"Auxiliary oil pump starting automatically" "Gas turbine oil pump outlet pressure low "
Emergency oil pump	(a) Switch of turning oil pump is set to "Lock position" and switch of emergency oil pump is set to "Automatic position". (b) Test valve of bearing oil pressure low of turbine is opened gradually and emergency oil pump is operated automatically. (c) Test valve is restored, emergency oil pump is stopped and switch of it is set to "Automatic position".	X.XX Pa + A.AA - A.AA	Pa	"Emergency oil pump starting automatically" "Gas turbine oil pump outlet pressure low "

4) Evaluation criteria

It must be confirmed each equipment is operated and alarms and necessary indications are appeared normally according to interlock.

Article 196. Prohibition of start up

It must be prohibited from starting up gas turbine in case that:

1. Gas turbine is broken or stopped by any actions of protection equipment, but the cause is not specified and recovered yet;

It must not be restarted gas turbine before confirming the cause and maintaining it. If it is restarted, damage of gas turbine is expanded. When breaking or stopping gas turbine, it must be confirmed the cause, maintained it and restarted it immediately. Sample of investigation procedures of cause is shown as follows;

(1) It must be informed maintenance group of its trouble and discuss with operation and maintenance group.

(2) It must be confirmed time-series operation status concerning trouble before stopping gas turbine. It can be utilized trend graph.

1) Related pressure, temperature and flow volume etc.

2) Related equipments operation

(3) It must be confirmed time-series transmitted alarm.

(4) It must be inspected related equipments (visual check, overhaul etc.).

(5) It must be conducted operation test of related equipments if necessary.

2. Shortcomings of adjusting system, accordingly, gas temperature increases over allowable limitation or turbine speeds up;

This trouble is caused by defect in fuel control system. Fuel control system controls fuel feed rate to gas turbine and is composed of following system.

- Fuel program control system (at starting)
- Revolution speed and load control system
- Exhaust gas temperature control system

When there is some defects in fuel control system, it must be confirmed the cause referring to paragraph 1 of this article.

3. One of oil pumps or their interlock system are broken;

It must be operated gas turbine safely and stably by supplying lubricant oil to bearings properly by means of oil pump system. Therefore, it must not be started gas turbine in case that one of oil pumps or interlock of oil pump is broken. It must be referred to Article 195 of this guideline when conducting operation test of oil pump system of gas turbine. When confirming defects in oil pump system, it must be maintained them completely. And it must be restarted gas turbine after confirming oil pump system is in good condition.

4. Fuel or oil quality does not come up to standard, and fuel pressure (or oil pressure) is lower or higher stipulated limitation;

(1) Fuel

When fuel quality does not meet design condition, combustor can not be burned safely and stably. Therefore, it must be procured appropriate fuel meeting design condition by procurement group (materials group). When fuel pressure is outside the stipulated range, performance of gas turbine can not be demonstrated and operation status of gas turbine is unstable. Therefore, it must be checked fuel quality carefully by procurement group. It must be referred to Article 102 of this guideline regarding fuel quality.

(2) Oil

It must be supplied lubricant oil in conformity to required oil quality to operate gas turbine safely and stably. Therefore, it must be stopped gas turbine when oil quality does not come up to standard oil quality for operation. It must be checked oil quality at periodical inspection and exchanged new oil when oil quality is deteriorated. International standard of turbine oil is ASTM D 4304, ISO 8068 and JIS K 2213 etc. It must be referred to paragraph 3 of Article 168 of this guideline in this matter.

When lubricant oil pressure is outside the stipulated range, performance of oil can not be demonstrated and operation status of gas turbine is unstable by vibration and damage in bearings. Therefore, it must be checked carefully oil pressure at daily patrol and inspection. It must be referred to paragraph 1 of Article 168 of this guideline regarding point to be checked at daily patrol and inspection.

5. Mechanical and thermal parameters of gas turbine exceed allowable limitation.

When gas turbine is during staring and mechanical and thermal parameters of gas turbine exceed allowable limitation, it must be stopped gas turbine to protect it. Sample of mechanical and thermal parameters of gas turbine are shown as follows ;

(1) Vibration (It must be referred to paragraph 3 of Article 185 of this guideline.)

(2) Over speed

(3) Bearing metal temperature

(4) Lubricant oil supply and return temperature

(5) Lubricant oil pressure

(6) Exhaust gas temperature

(7) Deviation of blade path temperature etc.

Article 197. Purge of gas duct

It must be conducted purge of gas turbine to exhaust unburned gas and prevent explosion before burning fuel in combustion chamber. Sample of purging procedure of gas turbine is shown as follows;

It must be confirmed gas turbine is under turning (Turning equipment is operated.)

It must be confirmed following items.
- HRSG outlet gas shutoff damper or gas turbine outlet damper is opened if they are installed.
- Ammonia gas dilution air fan is started.
- Gas turbine starting motor is started.
- Compressor inlet guide vane (IGV) is opened.

It must be confirmed turning motor is stopped.

It must be confirmed revolution speed of gas turbine is gotten to regulated speed.

It must be confirmed operation status of gas turbine and turning motor.
- Abnormal noise
- Vibration

It must be confirmed regulated time of purge is passed.

It must be confirmed following items.
- Compressor IGV is closed.
- Gas turbine starting motor is stopped.

It must be confirmed following items.
- Ammonia gas dilution air fan is stopped.
- HRSG outlet gas shutoff damper or gas turbine outlet damper is opened if they are installed.

It must be confirmed that revolution speed of gas turbine is stopped and gas turbine is rotated by turning equipment.

Figure 197-1 Sample of purging procedure of gas turbine

Article 198. Stop of start up

It must be stopped gas turbine urgently by operation of protection equipment or operator in the following cases:

1. Gas temperature at inlet of gas turbine increases over allowable limitation against startup diagram;

It must be referred to following Table 198-1. When ignition signal is inputted as described in A in Figure 198-1, fuel is started supplying and combustor is ignited. Gas turbine is changed to warm-up mode after confirming ignition by flame detector. Warm-up mode is conducted to reduce thermal impact of hot parts. It heats hot parts by keeping low fuel flow for regulated term and low combustion temperature. Gas turbine is changed to acceleration mode after completing warm-up mode. In acceleration mode, fuel flow is controlled to operate gas turbine at regulated acceleration ratio.

When gas temperature at inlet of gas turbine increases over allowable limitation against startup diagram, there is a possibility that fuel flow control system is broken down. Therefore, it must be stopped gas turbine urgently and maintained it.

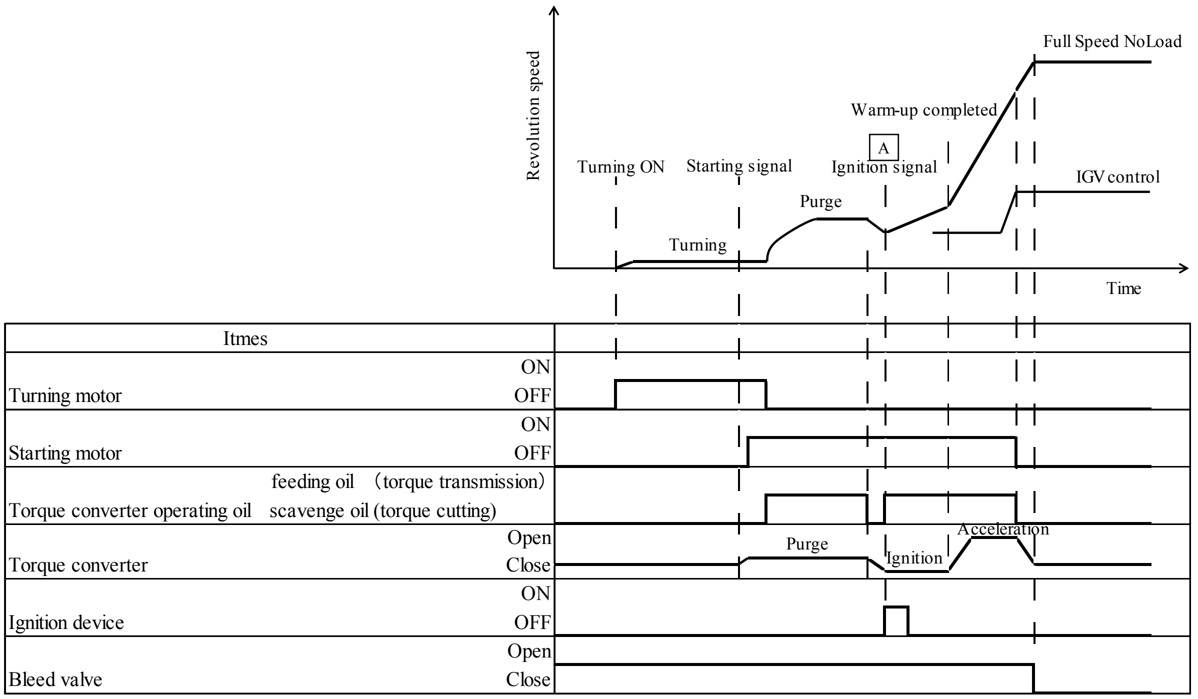


Figure 198-1 Sample of starting process flow of gas turbine

2. Noises of metal when stroke together (grinding, click) and generator becomes more vibrant;

When confirming noises of metal (grinding, click) and generator becomes more vibrant, there is a possibility that following parts are damaged.

- Rotor blade of gas turbine and compressor
- Gas turbine and compressor casing
- Rotor
- Bearing etc.

The cause of this trouble is guessed as follows ;

- Contact with rotor blade and casing
- Defect in bearing lubricant oil system etc.

When confirming above trouble, it must be stopped gas turbine urgently and maintained it.

3. Starting equipment load exceeds allowable limitation;

Type of starting equipment is shown as follows ;

- Torque converter + driving device (motor, diesel engine etc.) type
- Thyristor type (Electric power is supplied to generator by thyristor convertor and generator is used as motor)

When starting equipment load (torque converter + driving device type) exceeds allowable limitation, following cause is guessed.

- Fixing of gear between gas turbine and starting equipment

Therefore, it must be stopped gas turbine urgently and maintained it.

4. Axial rotating frequency reduces less than stipulated value after removing starting equipment;

When axial rotating frequency reduces less than stipulated value after removing starting equipment, there is a possibility that flame of combustor is lost or fuel control system is broken down. Therefore, it must be stopped gas turbine urgently and maintained it.

5. Instability in gas turbine's air compressor is occurred;

When revolution speed of axial flow compressor (gas turbine) and pressure ratio are low, mass flow at downstream stage is increased and flow is disproportional. When this situation is gotten worse and balance between upstream and downstream stage is broken up, there is a possibility that rotating stall and surging are occurred. Therefore, it must be prevented rotating stall and surging by controlling IGV and bleed valve at compressor and decreasing mass flow of downstream stage. It must be referred to Figure 198-1 regarding bleed valve. When instability in gas turbine air compressor is occurred, there is a possibility that compressor is damaged, and it must be stopped gas turbine urgently.

6. Outlet air pressure of air compressor goes under allowable limitation.

There is a possibility that cause which outlet air pressure of air compressor goes under allowable limitation is rotating stall or surging. Therefore, it must be referred to paragraph 5 of this article.

Article 199. Emergency stop

When gas turbine is occurred tripping conditions, it must be stopped gas turbine urgently to protect gas turbine, auxiliary equipments and power plant staffs. It must be confirmed interlock system is operated certainly. Moreover, it must not be started gas turbine until root cause of tripping is confirmed and maintenance is completed. Point to be checked after tripping gas turbine is shown as follows;

1. Point to be checked after tripping gas turbine
   (1) It must be confirmed that each valve is following condition.
      1) Fuel shutoff valve : Full closed
      2) Fuel relief valve : Full opened
      3) Fuel flow control valve : Full closed
      4) Fuel pressure control valve : Full closed
      5) High and low pressure bleed valve : Full opened

6) Combustor bypass valve : Full closed

(2) It must be confirmed compressor IGV is closed completely.

(3) It must be confirmed following pumps are started automatically and bearing lubricant oil is supplied.

1) Turning oil pump

2) Auxiliary oil pump

(4) It must be confirmed ammonia dilution air fan is stopped and ammonia injection shutoff valve is closed completely.

(5) It must be confirmed vibration during decreasing of rotational frequency of gas turbine.

(6) It must be confirmed turning system of gas turbine is operated at regular intervals after tripping.

(7) It must be confirmed transmitted alarms is normal and irregular alarms are transmitted.

(8) It must be confirmed condition of gas turbine and auxiliary equipments are normal by visual check.

(9) It must be re-started gas turbine after root cause of tripping gas turbine is confirmed and maintenance is completed.

Article 200. Load reduction of gas turbine

It must be reduced output or stopped gas turbine at the Owner's judgment in consideration of status of the equipment in cases that,

1. Stop valve, regulating valve and compressor intake pressure reducing valve are stuck;

When fuel flow control (regulating) valve (main fuel control valve) is stuck, combustion status of gas turbine is changed. Countermeasure in this case is shown as follows;

Following alarms are transmitted.
- Deviation of main fuel control valve travel (lift)
- Defect in main fuel control valve

↓

It must be confirmed operation status of each fuel valve and combustion status.
- Main fuel control valve travel : Fixed (assumption)
- Pilot fuel control valve travel
- Operation status of fuel pressure control valve
- Blade path temperature, exhaust temperature and deviation of blade path temperature

↓

After confirming above operation status, it is assumed that the cause is fixing of main fuel control valve or defect in control system.

↓

After inspecting by maintenance group, it is confirmed maintenance work can not be done under operation.

↓

It is decided for tripping gas turbine urgently according to following provision.
- When main fuel control valve is stuck and power plant load is decreased, combustor bypass valve is closed and main fuel flow is excess. Therefore, there is a possibility that burner nozzle is burned out by flashback (back fire).

↓

It must be stopped gas turbine urgently.
It must be referred to Article 199 of this guideline point to be checked after tripping gas turbine

Figure 200-1 Countermeasure in case that main fuel valve is stuck

2. Surface temperature of turbine body, combustion chamber, and exhaust duct exceeds allowable limitation and change of operating mode cannot reduce it;

When surface temperature of turbine body, combustion chamber, and exhaust duct exceeds allowable limitation, there is a possibility that combustion and exhaust temperature are increased. Therefore, it must be confirmed following operation status of each fuel valve and combustion status.

- Main fuel control valve travel
- Pilot fuel control valve travel
- Operation status of fuel pressure control valve
- Blade path temperature, exhaust temperature and deviation of blade path temperature

If the worst happens, it must be stopped gas turbine urgently to prevent burnout of it.

3. Inlet air temperature of high-pressure air compressor exceeds allowable limitation, as well as in case that normal water feeding standard is violated;

Air and feeding water are very important to operate power plant safely and stably. When above conditions are occurred, it must be maintained them promptly because they has an impact on stable operation of power plant. If it can not be maintained under operation or power plant is damaged due to continual operation of power plant, it must be stopped power plant and maintained it.

4. When some online protection devices, indicators or meters are broken;

When there are some faults in online protection devices, indicators or meters which operates to stop equipment, there is a possibility that gas turbine is not stopped safely and stably. Therefore, if defect in them can not be maintained under operation, it must be stopped power plant and maintained it immediately.

Article 201. Fire extinction of soot

When soot in heater or economizer of water system burst into flames or soot burst into flames in stopped gas turbine and such situation causes dangerous change of parameters, it must be conducted fire fighting rapidly to keep to a minimum of damage of power plant. Point to be checked and procedure of fire fighting of gas turbine is shown as follows;

1. Point to be checked and sample procedure
   (1) It must be confirmed transmitted alarms, informed related group of a fire and gone in a hurry to gas turbine field
   (2) It must be confirmed situation of a fire and informed fire station.
   (3) It must be stopped gas turbine urgently referring to Article 199 of this guideline after informing load dispatch center and purged fuel gas piping.
   (4) It must be established fire fighting team by power plant staff promptly and started early extinction.
   (5) It must be followed reader’s directions of fire fighting team before fire station arrives and followed fire station’s directions after it arrives.
   (6) It must be paid attention to lack of oxygen when using carbon dioxide extinguishing system.
   (7) It must be put on rescue suit if necessary.
   (8) It must be discharged hydrogen in generator to prevent expansion of damage if necessary.
   (9) It must be confirmed extinction of a fire and informed related group and load dispatch center.
   (10) It must be confirmed damaged parts and repaired them rapidly by maintenance group.

Article 202. Ventilation system

It must be conducted purge of gas turbine to exhaust unburned gas and prevent explosion after stopping gas turbine. It must be referred to Article 197 of this guideline regarding sample of purging procedure of gas turbine. As well as purge of gas turbine, it must be purged fuel header and burner with inert gas or air by sequence system (program). Process flow of purging fuel header and burner with nitrogen is shown as follows;

It must be confirmed fuel gas supply shutoff valve is closed completely.

↓

It must be confirmed fuel gas purge vent valve is opened completely.

↓

It must be confirmed following provisions.

- Fuel gas header pressure is less than regulated value.
- Regulated time is passed.

↓

It must be confirmed fuel gas purge vent valve is closed completely.

↓

It must be confirmed nitrogen purge origin valve of fuel gas piping is opened completely.

↓

It must be confirmed nitrogen purge valve of fuel gas piping is opened completely.

↓

It must be confirmed following provisions.

- Fuel gas header pressure is over regulated value.
- Regulated time is passed.

↓

It must be confirmed fuel gas purge vent valve is opened completely.

↓

It must be confirmed regulated time is passed.

↓

It must be confirmed fuel gas purge vent valve is closed completely.

↓

It must be confirmed nitrogen purge valve of fuel gas piping is closed completely.

↓

It must be confirmed nitrogen purge origin valve of fuel gas piping is closed completely.

Figure 202-1 Process flow of purging fuel header by nitrogen

Article 203.

(Nothing)

Article 204. Observation operation

It must be carried out analysis operation staus of gas turbine regularly based on following observations and indicators on meter measurement during operation.

1. Corresponding gas turbine power more than specified.

It must be confirmed following provisions regading power output of gas turbine durng operation.

- Deviation of between actual power output and target one
- Fluctuation of power output

When above conditions is gotten worse, there is a possibility that following equipment or system is broken down. It must be confirmed operation status of them and maintained rapidly when detecting defects in them.

- Combustor
- Fuel control system
- Compressor
- IGV control system etc

2. The level of contamination and backup stability of the compressor.

When compressor is operated for a long time and contamination in intake air is attached to compressor blades, compresor can not demonstrate performance and it is deteriorated as time goes by. Therefore, it must be checked operation status of compressor and washed compressor blades in water periodically. Moreover, it can be installed HEPA filter to eliminate contamination in intale air. It must be refferred to Article 191 of this guideline regarding HEPA filter.

3. The effect of heat transfer.

Heat insulrating materials are installed outside of gas turbine casing to block off heat release. It must be checked installation status of heat inslurating materials at daily patrol and inspection.

4. The uneven temperature measured in the turbine.

It must be monitored operation status regarding temperature to operate gas turbine safely and stably and confirmed thay meet acceptable value during operation. Sample of important monitoring items (watch list) regarding temperature is shown as follows ;

(1) Exhaust gas temperature

(2) Blade path gas temperature

(3) Deviation of blade path gas temperature

(4) Bearing metal temperature

(5) Bearing return oil temperature

(6) Temperature inside gas turbine enclosure

5. The pressure of fuel and air (gas fumes) in the characteristics.

It must be monitored operation status regarding pressure to operate gas turbine safely and stably and confirmed thay meet acceptable value during operation. Sample of important monitoring items (watch list) regarding pressure is shown as follows ;

(1) Fuel supply pressure
(2) Exhaust gas pressure
(3) Bearing oil pressure
(4) Over speed shutoff oil pressure
(5) Control oil pressure
(6) Emergency shutoff oil pressure

6. Vibration of turbines, compressors, generators and stimulation. Checking of the limited number of deviation parameters against passport machine must not exceed the value given by the manufacturer.

It must be referred to Article 208 of this guideline regarding vibration.

Article 205.

(Nothing)

Article 206.

(Nothing)

Article 207. Check of gas turbine control system at load dump

It must be checked regulated operation of gas turbine control system by shedding load suddenly (load dump test) through disconnecting generator from power grid. It must be referred to Article 144 of Vol.5 Inspection Guideline regarding point to be checked at load dump test.

Article 208. Check of vibration

It must be paid attention to transition of vibration of normal gas turbine operation and starting and stopping of gas turbine and referred to paragraph 3 of Article 185 of this guideline regarding sample vibration value at alarming and stopping gas turbine. And, it must be referred to Article 174 of this guideline regarding vibration during rising of rotational frequency and rubbing. Point to be checked when going up vibration of gas turbine is shown as follows;

It must be checked following provisions after confirming transmitted alarm.

- Vibration value
- Bearing oil pressure
- Bearing metal temperature
- Bearing supply and return oil (scavenge oil) temperature
- Bearing return oil (scavenge oil) flow
- Differential expansion

↓

It may be started turning oil pump when fluctuating bearing oil pressure.

↓

It must be kept present output when changing gas turbine output.

↓

It must be informed load dispatch center of emergency decrease of gas turbine output if vibration value is not within acceptable value.

↓

It must be confirmed operation status of gas turbine after decreasing output.

↓

It must be stopped gas turbine urgently after informing load dispatch center if vibration value is not within acceptable value.

↓

It must be referred to Article 199 of this guideline regarding emergency stop of gas turbine.

Figure 208-1 Point to be checked when going up vibration of gas turbine

Article 209.

(Nothing)

Chapter 8 Diesel Generator

Article 210. General provision

A diesel generator for “emergency power” should supply power to maintain the security and function of electrical equipment in the power station to prepare for the next plant start-up, when the commercial power supply is lost.

AC power source is commonly switched from receiving power supply to emergency power supply automatically after the diesel generator terminal voltage is established.

For this reason, technical regulation requires prevention of damage to the components of diesel generators.

Thus, a diesel generator is recommended to be capable of operating continuously for more than 60 minutes at the rated load, quantity is to be capable of operating in more than two hours, and the voltage is to be established as soon as possible in order to protect the facility during outage. Arrow of Figure 210 shows emergency power supply from the diesel generator.

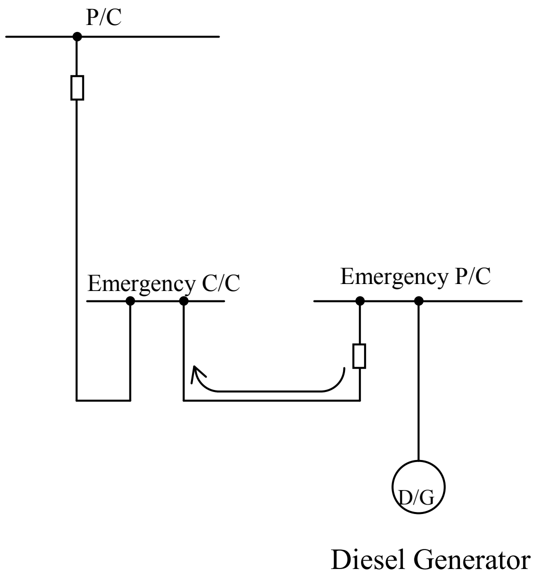


Figure 210 An example of electrical connection of a diesel generator

Article 211. Operating conditions of diesel generator

1. Principles of diesel generators

Many diesel generators are driven by diesel engines of four cycles with superchargers.

The fuel of diesel engines is injected into the combustion chamber with compressed air, applying high pressure of approximately 10 to 500MPa.

Cycles of diesel engines are repetitions of intake, compression, expansion and exhaust in the same cylinder.

The air is compressed rapidly with high temperature and fuel is injected into this compressed air in the cylinder. This injection causes a blast-ignition at the same time of the injection; and energy by expansion is transformed to rotating energy. Exhaust gas is emitted outside of the machine.

2. Fuel supply system

   (1) Leakage from oil pipes

   Leakage from oil pipes, etc is inspected for safety and stable combustion. If there is a leak, bolts or pipes or packing are tightened or repaired or replaced.

(2) Amount of fuel

In order to continue operation during emergency, the amount of fuel in the fuel tank is inspected. If there is a shortage, fuel should be replenished.

(3) Fuel oil filter

A fuel oil filter is inspected by checking the difference pressure of the filter. If it is over the certain value, it is replaced for stable combustion.

(4) Characteristics of the fuel

Operations of diesel engines are greatly influenced by the characteristics of the fuel in the operating performance and durability.

Therefore, it is necessary for fuel oil to have good flammability, less hazardous combustion products.

Following items are recommended to be checked

1) Viscosity

In the combustion of fuel oil, it is necessary for atomized fuel oil to have uniform and appropriate size of the fuel particles.
Viscosity affects the atomization of the fuel.
Optimum viscosity for the combustion is determined by considering operating conditions and the design such as combustion chamber shape and dimensions.

2) Residual carbon and ash

Amount of these items do not influence the combustion directly. However, these items are difficult to burn in the combustion chamber; therefore, these substances promote the wear of each part and stick the piston ring as sediment in the cylinder.

3) Sulfur content

There is sulfur as compounds with hydrocarbon polymer, and this sulfur is reacted to sulfurous acid gas (SO_2) by the combustion, finally changed to sulfuric acid gas (SO_3) by combination with moisture.
This sulfuric acid causes corrosion and abrasion of cylinder liners and piston rings.

4) Moisture

High moisture contaminants cause decrease of heat generation, stain, valve stick.
Moreover, corrosion and abrasion of cylinder liners and piston rings may be caused, as mentioned above.

5) Cetane number

Cetane number indicates the ignitability of the fuel oil, therefore this number affects the start-up performance of the diesel generator, because knocking may occur if this value is too small.
It is desirable that the cetane number is not less than 45, because nitrogen oxides in the exhaust gas are increased and starting performance is deteriorated.

3. Lubrication system

(1) Equipment in the lubrication system

In general, following equipment is installed in the lubrication system of diesel engines.

1) A main oil pump to supply lubrication oil in operation
2) An oil tank to store lubricants during stop
3) An equipment to keep the lubricant clean
4) An apparatus for adjusting the temperature of the lubricating oil
5) Flow indicator or oil pressure gauge device or situation can be seen in the appropriate position.

(2) Quality of the lubricating oil

Specifications of the lubricating oil should be conformed to the design value of the manufacture.

The performance of lubricating oil is required in various items, because operating conditions are stringent.

1) Fundamental functions of the lubricating oil

Fundamental functions of the lubricating oil are as follows:

a. Antifriction

To prevent abrasion due to metal contact

b. Engine cleaning

To prevent the adhesion of parts by sludge

c. Engine cooling

To prevent the overheat of parts

d. Engine sealing

To prevent the leak the combustion gases from the chamber

e. Corrosion prevention of the engine

To prevent the corrosion of the parts by combustion products such as water, acid

2) Fundamental properties of the lubricating oil

To satisfy functions above, following properties are required as lubricating oil properties for a diesel engine.

a. Viscosity

Viscosity is one of the most important properties. The effect of anti-friction is due to forming fluid film on the surface, and the degree of viscosity should be enough to form this film. Lower viscosity reduces film strength, causing metal contact.

However, too high viscosity causes increase of film resistance on the surface, and engine performance is reduced as a result.

Temperature in a diesel engine depends on the operating conditions. Particularly; temperature difference between startup and normal operation is large. Therefore, the characteristic of viscosity is required not to be varied too much by the temperature.

b. Dispersibility for cleaning

Dispersibility for cleaning means the performance to prevent aggregation of material produced by the combustion or oxidation. It is necessary to use a lubricant with excellent dispersibility for cleaning.

Some of the lubricating oil sludge-generated ash and unburned carbon, by, is dispersed as fine particles. Dispersibility for cleaning can be improved by the addition of dispersant cleaning, institutions harsh institution high output high degree of supercharging, operating conditions,

c. Acid neutralizing

Sulfur content in the fuel becomes sulfurous acid gas by combustion, and some become anhydrous sulfuric acid.

As for exhaust gas, sulfurous acid gas is corrosive to metal but not very strong, on the other hand, sulfuric anhydride produces highly corrosive sulfuric acid by reaction with the condensed water.

In order to prevent corrosion caused by these harmful substances, the lubricating oil is required to have the function of neutralizing acid by alkali.

"Alkalinity value" is the reasonable indication which evaluates this acid neutralizing (mg KOH/g). Many additives to improve the alkalinity value are identical to those for improving the dispersibility for cleaning.

d. Oxidative stability

Lubricating oil oxidizes associated with the oxygen in the atmosphere and its characteristic is altered. This oxidation reaction rate is faster in the higher the temperature condition.

Oxidation of lubricating oil causes increase of viscosity at first, worse hue next and, c black sludge at last. This sludge may clog oil holes, and piston ring may stick.

Therefore, the addition of antioxidants is recommended in order to stop this oxidation.

4. Cooling system

(1) Water quality

If cooling water is used, it is necessary to inspect water quality in advance in order to prevent scale, clogging, and corrosion.

Detail items and standard should be shown from the manufacturer, but items may be the following.

1) pH

2) Conductivity [μS/cm]

3) Hardness($CaCO_3$) [ppm]

4) Alkalinity($CaCO_3$) [ppm]

5) Silica SiO_2 [ppm]

6) All irons Fe [ppm]

7) Ammonium ion. NH_4^+ [ppm]

8) Chlorine ion Cl^- [ppm]

9) Sulfate ion SO_4^{2-} [ppm]

10) Hydrogen sulfide H_2S [ppm]

(2) Water flow

In order to maintain the temperatures at diesel generators and surroundings, water flow is inspected by an instrument such as a flow meter.

5. Generator

(1) Inspection of lubricating oil

Quantity of lubricating oil is checked by an instrument such as a level gauge.

(2) Inspection of the ground wire connection

Disconnection of the grounding system causes disasters such as electrification. Therefore, the presence of corrosion or disconnection at the grounding wires and terminals should be inspected.

If there is a slack at a terminal, it should be tightened.

6. Other items to be noticed

(1) Light load operation

In operating diesel engines, cares should be taken during light load operation. If the load is light, fuel combustion may not be good enough because fuel injection pressure is low.

In addition, temperature of piston, cylinder, and lubricating oil cannot rise enough, oil may drip from exhaust pipes, or there may be black smoke in the exhaust gas due to imperfect combustion.

Article 212. Control system

Microprocessor based modules is generally installed to enable direct interface with engine control.

Therefore, circumstance such as temperature, humidity etc should be cared.

Control systems can also be designed and built using (PLC) programmable logic controllers for schemes where a more complex switching or operation is required.

1. Function

Control system of a diesel generator is classified as follows:

(1) Speed control

Speed is controlled by the governor. The fuel control valve is adjusted by the governor output signal.

(2) Electric control

Voltage is measured by the voltage transformer and controlled by the AVR.

(3) Starting and shutdown controls

The process stipulated in Article 214 of this guideline is controlled. In general, a diesel generator starts with low voltage detection by a relay. After start of the diesel generator and establishment of voltage, a synchronizing system may be used to remove human reaction time from the starting time, or the case that personnel is not available such as at remote controlled or automatic starting cases.

(4) Diesel engine and generator protection and alarm systems

Diesel engine and generator protection and alarm are performed.

2. Check items

(1) Panel indication

Panel indication is checked considering following points.

1) Alarms of failure on the panel and inside the panels such as processor
2) Operating condition
3) Panel damage
4) Indicating values of instruments

(2) Cabinet (inside the panel)

Cabinet (inside the panel) is checked considering following points.

1) Alarms of failure at the processors or the controllers
2) Operating condition
3) Damage inside the panel
4) Condition of wirings and connections
5) Circumstance (Temperature, humidity, existence of moisture or dust, odor)
6) Condition of cooling fans and air filters

(3) Battery (If equipped)

Battery is used for start-up. Following points are considered when it is checked.

1) Voltage
2) Condition of electrodes
3) Liquid level
4) Condition of wirings and connections
5) Circumstance (Temperature, humidity, existence of moisture or dust, odor)
6) Damage of each part
7) Measurement of internal resistance

(4) Instrument

1) Damage or distortion ,or pollution, or corrosion of each part

2) Indicating value

Article 213. Operation after overhaul

Following items are recommended to be inspected before the operation after overhaul to prevent hindrance during operation.

1. Conditions of each part

Following items are recommended to be inspected before operation after overhaul.

(1) Items stipulated in Article 212 and Article 216 of this guideline.

(2) Connection of wirings at terminals

(3) Conditions of installation (bolts, couplings, etc)

Operating hours are specified so that temperature of each part of the engine and generator becomes constant.

2. Speed control test

Device test for the speed control is recommended to be performed to confirm the operating conditions of the speed control device of the diesel engine if speed control device is inspected.

3. Start-up and shut down test

Start-up and shut down test is recommended to be performed to verify the performance of the diesel engine starting in the cold state.

Moreover, minimum starting pressure measurement is recommended to be performed, if necessary.

(1) Compressed air start

Minimum compressed air pressure to start or the possible number of start is checked without charging air.

(2) Electric start

Start-up performance is verified by pushing the start button.

4. Load operations

Load operation is necessary to confirm the performance of the diesel engine by continuous operation for a predetermined period of time after overhaul. Test loads are selected at full load, 75%, and 50% load, in general. During this test, vibration and noise and emission should be measured to confirm the compliance with QCVN 22/2009/BTNMT, TCVN 5949 and TCVN 6962.

In addition, test items are determined, considering testing purposes and tested the type and the usage of diesel engine.

Following are examples of test items.

- Calibration records of the instruments
- Output
- Rotating speed
- Fuel consumption

- Amount of lubricating oil consumption
- Pressure
- Temperature
- Flow of cooling fluid circulation system, total head loss
- Measurement of exhaust gas temperature and back pressure
- Exhaust gas analysis
- Vibration and noise
- Speed control
- Governor performance

Article 214. Safety of diesel generator start-up

As stipulated in Article 210 of this guideline, a diesel generator is used as emergency power supply for the plant security. Therefore, following items are recommended to be satisfied as starting performance.

1. The generator is capable of starting more than three times during outage.

When starting the diesel engine, crankshaft is rotated by the starter motor, and combustion cycle starts.

When starting the diesel engine of large capacity, compressed air is blown into the cylinder in order to move the piston directly.

Therefore, start-up devices such as battery voltage or compressed air pressure are inspected for emergency.

2. The voltage of the generator is established as soon as possible seconds after it started.

In general, a diesel generator starts with low voltage detection by a relay. After the diesel generator start and establishment of voltage, a synchronizing system may be used to remove human reaction time from the starting time, or the case that personnel is not available such as at remote controlled or automatic starting cases.

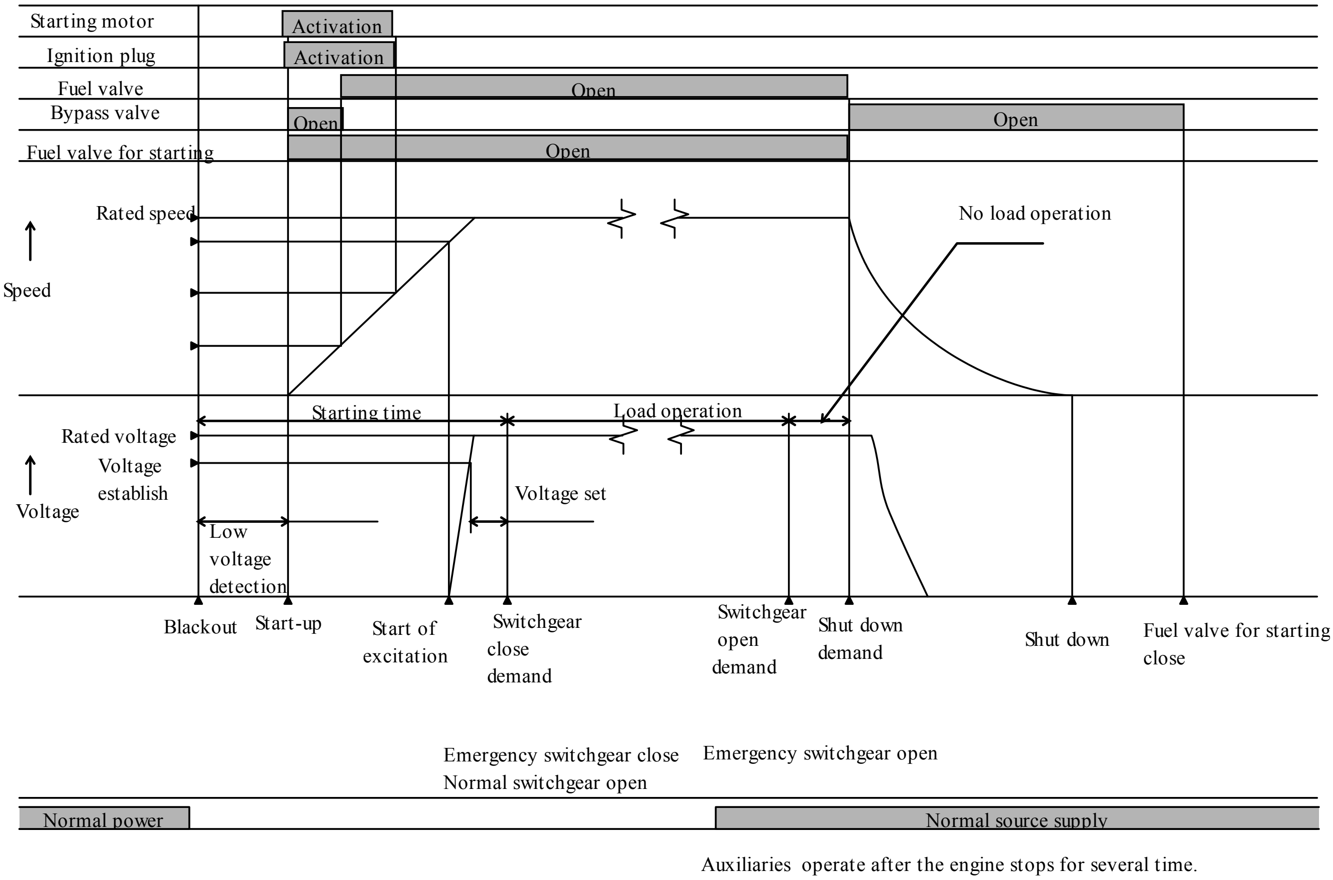


Figure 214 An example of diesel generator start-up and shutdown

Article 215. Check of vibration

The mechanism of diesel engine is to convert reciprocating piston movement, generated from the heat energy of combustion gas, to the rotating movement by the crankshaft. Ignition of a diesel engine is self ignition by high compression ratio. In order to obtain high compression ratio, a diesel engine requires long crankshafts. This long movement of crankshafts is the source of vibration and noise of the engine.

Moreover, changes of combustion pressure generate torque fluctuations and also cause torsional vibration.

In the case of long crankshaft, this torsional vibration may destruct crankshafts, in faster speed operation.

Thus, vibration should be checked in order to prevent harmful effects on structure and performance.

Allowable value of vibration should be shown from the manufacturer.

Article 216. Check of pipeline system

Pipeline system may be classified to cooling water, lubricating oil, fuel, exhaust gas and compressed air system.

1. Cooling water

Water leak from the pipes, flow of water etc are checked. When there is a leak, bolts or packing are tighten.

2. Lubricating oil

Oil leak from the pipes, flow of oil etc are checked for fire prevention and safe operation. If there is a leak, bolts or pipes or packing are tightened or repaired or replaced.

3. Fuel oil

Oil leak from the pipes, flow of oil etc are checked for fire prevention and safe operation. If there is a leak, bolts or pipes or packing are tightened or repaired or replaced.

4. Exhaust gas

Odor and noise from pipes etc are checked. Exhaust gas contains toxic gas such as nitrogen oxides and carbon monoxide, therefore, if there is a leak, bolts or pipes or packing are tightened or repaired or replaced.

5. Compressed air

If a diesel generator uses compressed air system for start-up, air leak from the pipes may cause failure of start-up. Therefore, if there is a leak, bolts or pipes or packing are tightened or repaired or replaced.

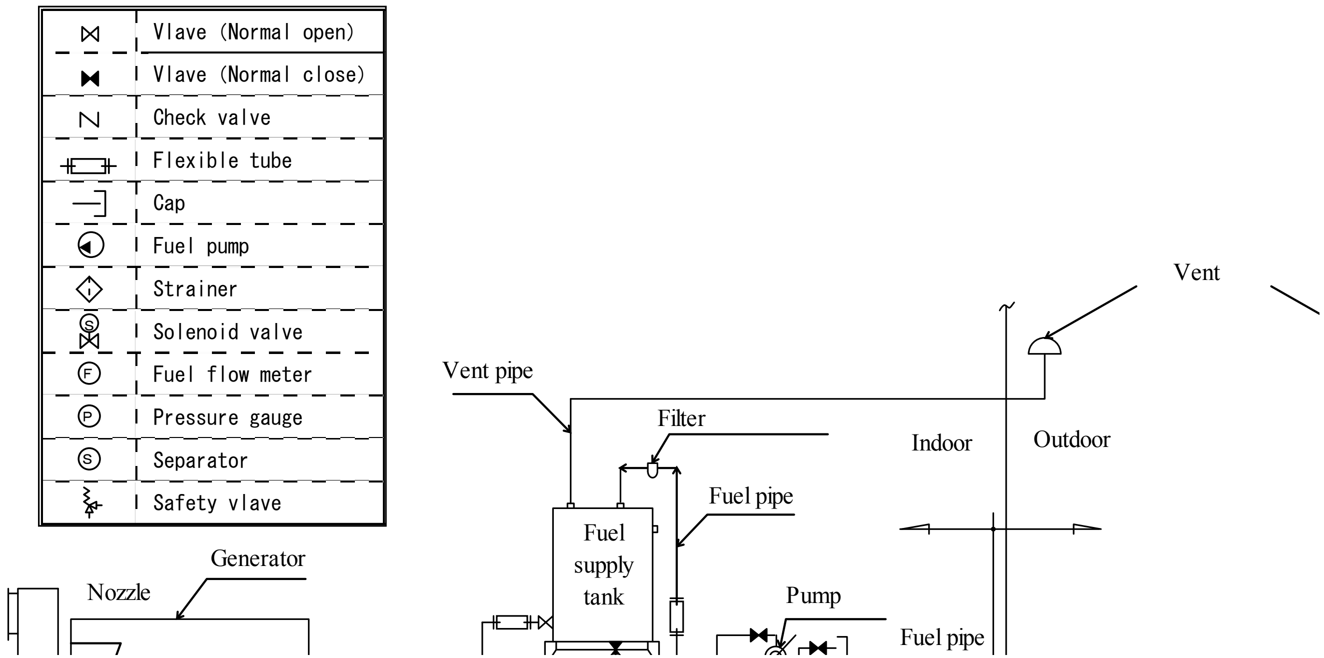


Figure 216 An example of fuel pipe line

Chapter 9 Automation and Thermo-measuring Equipment

Article 217. General provision

Article 217 of Technical regulation (operation and maintenance) requires check of conditions of all automatic equipment and instruments.

Moreover, as stipulated Article 222 of Technical regulation (operation and maintenance), disconnecting or maintaining protectors during operation is prohibited for the purpose of safety.

Therefore, if a measuring instrument is used for protection or control, it should be inspected, calibrated, and adjusted by the end of periodic inspection or completion inspection, and before the plant operation as stipulated Article 222 of guideline (Inspection). The power station should consider other means to eliminate all potential errors from measuring processes.

During plant operation, following are the examples of daily inspections by maintenance staff of power plant instrumentation in addition to the inspections by operating personnel.

1. Inspection by monitoring or alarming devices

Abnormal conditions of measurement and control devices are checked by using the monitoring devices, such as recorders, alarm and monitoring unit, operation console panel, control panels and VDT in the central control room.

In addition, operating conditions that occurred in the past could be stored in some automatic control equipment by log automatically.

2. Inspection of pneumatic automatic control equipment

Conditions of air (cleanliness, pressure), leakage from the pipes and activation of each pneumatic component is checked. Pneumatic automatic control equipment is composed of mechanical components with moving parts; therefore, high frequency of trouble may happen. The control valves are inspected carefully considering their open and plant operation condition, because some of control valves may have a direct impact on plant operation. Figure 217-1 shows an example of check point of pneumatic control equipment.

3. Inspection of electrical and electronic automatic control equipment.

It is required to avoid exposing electrical and electronic automatic control devices to high temperature and humidity as well-known.

Therefore, the control devices are installed in the room controlled under the clean and appropriate temperature and humidity, such as a relay or computer room.

As described in Article 258-1,258-2 of design guideline, inspections of environmental conditions such as humidity, temperature are important.

Main inspection items inside the cabinet are as follows:

- As for power supply, it is checked that the values of voltage, current and the temperature are within allowable value.
- As for cooling fans, conditions of rotating sound, dust accumulations etc are checked.

- As for input and output terminals shown in Figure 217-2, vibration and sags are checked.
- Status of the front display on the control modules shown in Figure 217-2 is checked.

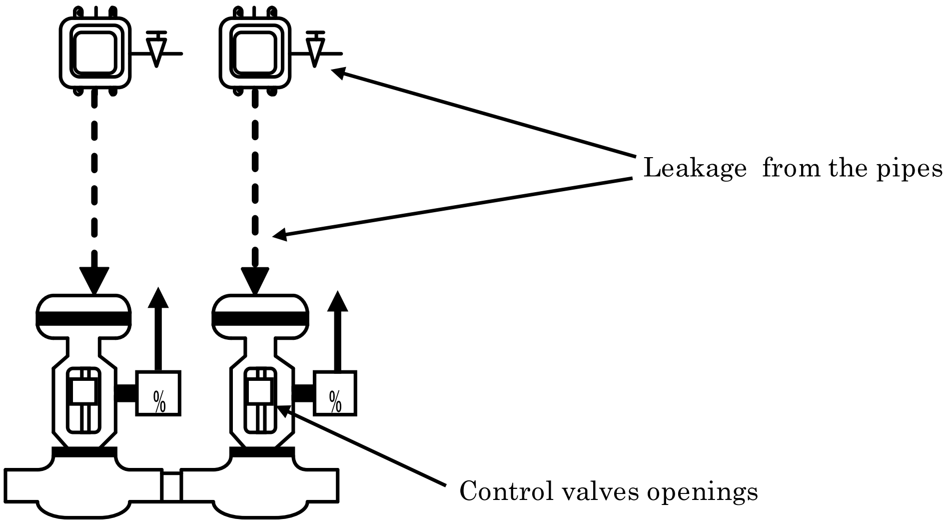


Figure 217-1 An example of check points of pneumatic control equipment

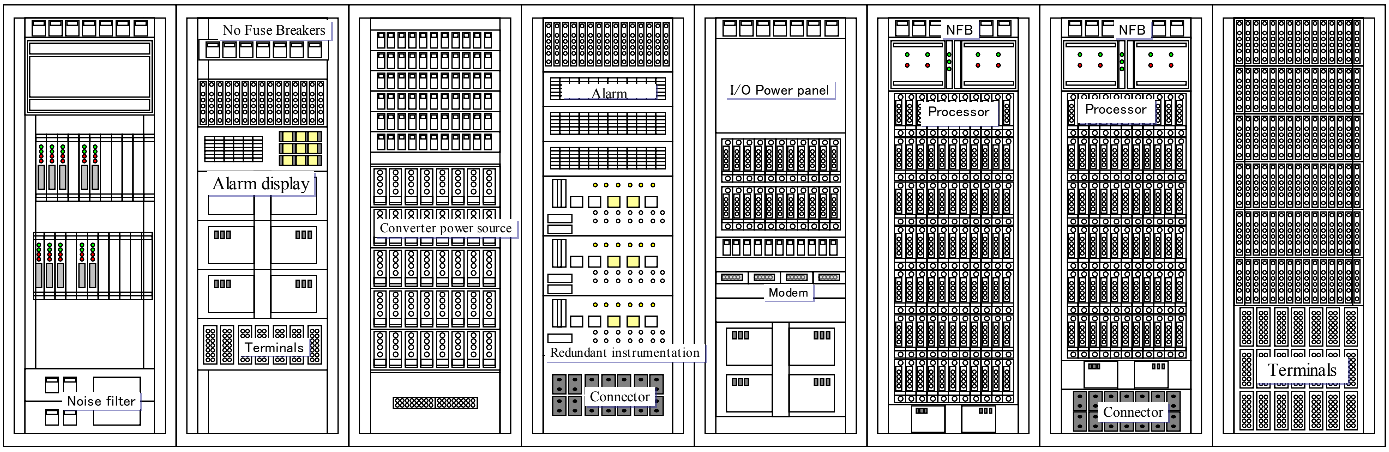


Figure 217-2 An example of front view of electronic automatic control equipment

4. Switching the instrument

However, if an instrument for protection fails although it was inspected or repaired, following measures may be taken according to the condition.

Redundant instrumentation may be used for critical control signals for the unit, such as air flow, or steam pressure etc.

In this case, measures may be taken by the following procedure.

(1) To verify the instrument which becomes abnormal
(2) To verify the automatic switching to the normal side instrument
(3) To exclude that redundant instrumentation at this time
(4) To confirm the condition of the instrument

(5) To repair or replace the instrument

Following conditions may be the sign of lifetime.

1) When failure frequency becomes higher
2) When it becomes difficult to obtain replacement parts
3) Repair has become impossible technically
4) When performance is reduced and the safety can not be maintained
5) Significant increase of maintenance costs due to performance degradation

(6) To calibrate and adjust the instrument

(7) To be restored to redundant instrumentation after confirming that the deviation of the two instruments is within allowable value.

5. Shut down the equipment or the unit

If the process value cannot be measured and the equipment or the unit cannot be controlled, the equipment or the unit may be shut down by an operator according to the condition.

First priority is security and safety.

For example, if furnace draft cannot be measured and controlled, the unit should be shut down in order to prevent implosion or explosion of the boiler. Therefore, the unit should be shut down by an operator immediately, and the draft meter should be repaired or replaced, in this case.

Figure 217-3 shows an example of redundant instrumentation and Figure 217-4 shows an example of air flow failure.

However, if the failed instrument is not a critical signal for the unit, or the unit can be protected and controlled by another method, the unit does not have to be shut down.

For example, when the condenser level meter fails, however the condenser level is controlled by other level switches, the turbine and the unit do not have to be shut down.

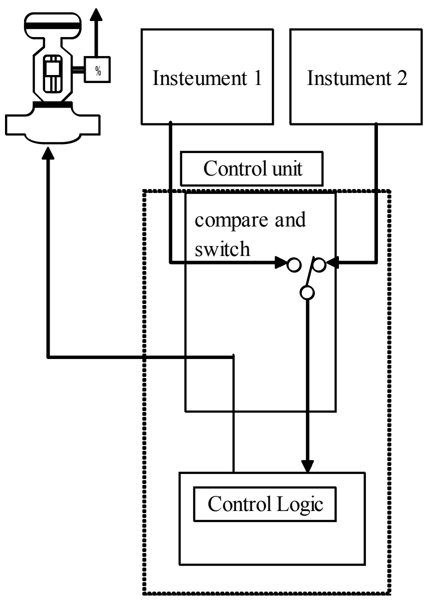


Figure 217-3 An example of redundant instrumentation

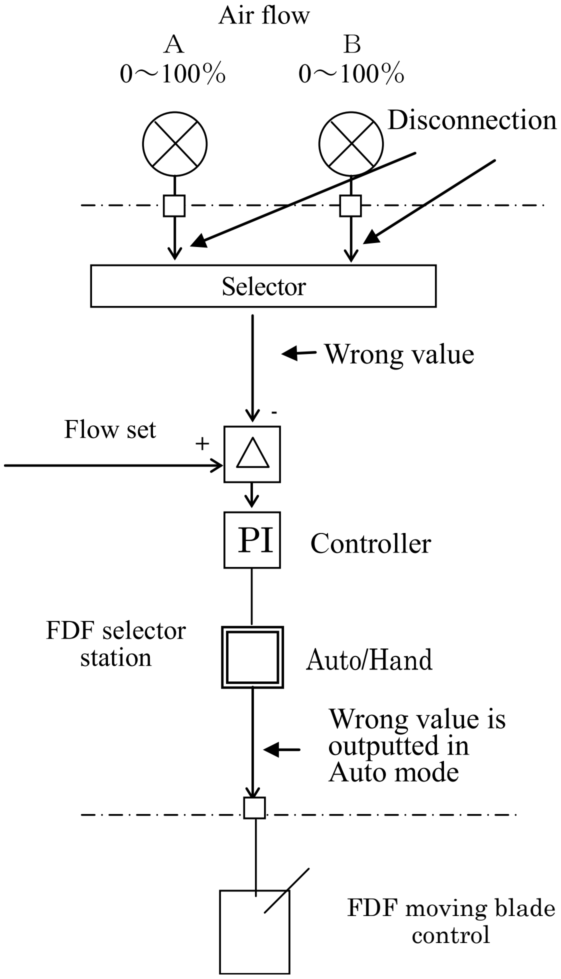


Figure 217-4 An example of air flow failure

Article 218. Standby power supply

To the load as shown in Table 218, a constant voltage constant frequency (CVCF), or Uninterruptible Power Source (UPS) or redundant power supply system combining DC and AC redundant power supply using battery may be used as stabilized power supply. DC power is changed to AC power, using the thyristor type inverter.

In the case of CVCF, the inverters are controlled so that the same frequency and phase is available as the power supply. When a failure occurs in the inverter, power to the load is switched from the inverter to the power supply of commercial frequency automatically without interruption.

Figure 218-1 shows an example of CVCF system and circuit, Figure 218-2 shows redundant system of DC and AC power supply at the control unit.

As for voltage dips and short interruptions, IEC61000-4-11 is referred. However, according to IEC60038, hardware of control device should operate in the voltage of 10% deviation from the rated value, as described in Article 258-1, Article 258-2 of design guideline.

Table 218 Examples of loads requiring stable power supply

Device	Processors or functions	State at the outage (in the case without measures)
1. Automatic control device	- Boiler automatic control device - Automatic load control equipment	- Operation mode is switches to manual operation from automatic operation mode. - Operation terminal is locked at the same time.
2. Automatic burner control device	- Burner control logic	- The operation of solenoid valve using multiple coils will be locked in position.
3. Computer	- Computer central processing unit - External storage device - Process I / O device - Peripheral typewriter, CRT, etc.	- Computer processing is suspended at the time of power failure - Data is saved, and remains within predetermined period of time in the core memory

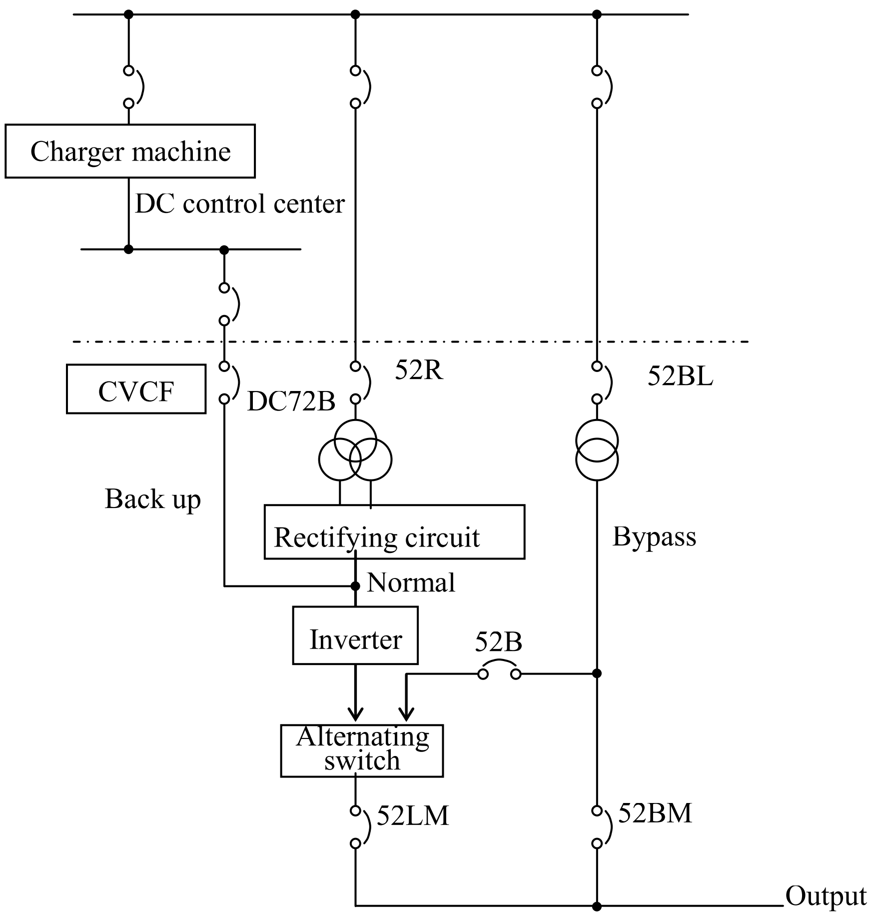


Figure 218-1 An example of power supply using CVCF

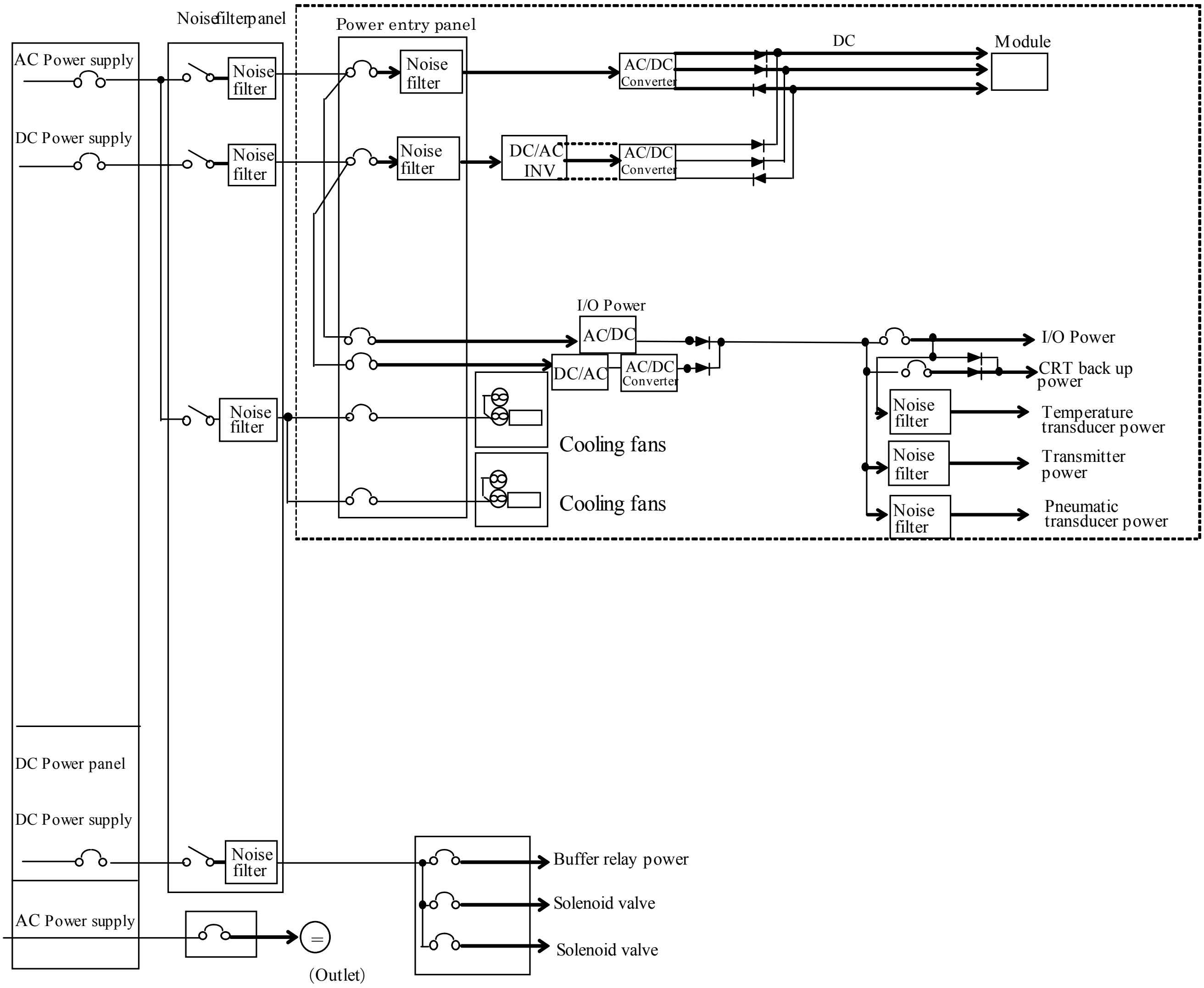


Figure 218-2 An example of redundant system of DC and AC power supply

Article 219. Insulation resistance of power and instrumentation cables

The insulation of electric wires and cables is deteriorated by mechanical, chemical and electrical factors. Therefore, insulation resistance of power and instrumentation cables should be measured to prevent electric failures and damage to human bodies and to secure accurate measurement in the case of control cables.

The values of insulation resistance are required in the Article 242 of the Vol.2 of technical regulation. However, these values are minimum requirement; therefore, the value of insulation resistance is recommended to be much higher than these values and higher than the value the manufacture recommends.

1. Deterioration of insulation

In general, the lifetime of electric wires and cables is approximately ranged from 15 to 30 years according to the condition.

Following factors deteriorate insulation resistance.

(1) Electrical factors (Such as overvoltage or overcurrent)
(2) Inundation to the wire and cable (Causing deterioration physical / electrical as a result)
(3) Mechanical factors (impact, compression, bending, twisting, tensile, vibration, etc.)
(4) Thermal factors (Lowering of low-temperature properties, due to high temperature)
(5) Chemical factors (Electrical degradation due to chemical degradation and physical properties tree oil, due to chemicals)
(6) Salt deposition, ozone and ultraviolet light (Lowering insulation performance)
(7) Damage by small animals (such as rats and termites)
(8) Deterioration caused by microorganisms such as mold
(9) Poor construction work (terminal and the connection process, the installation process, etc.).

Moreover, combination of the above (1) to (9) may also promote the degradation of electric wires and cables.

2. Measurement of insulation resistance

(1) Applied voltage for measurement

Applied voltage for measurement of the insulation resistance is selected according to the voltage of the relevant electric circuit in order to protect equipment.

Measurement voltage is referred to the inspection guideline Article 149. In addition, voltage of 25 to 50V is used for explosion proof equipment and telephone lines, 100 or 125V is used for control equipment.

(2) Procedure for measurement

Article 149 of inspection guideline is referred. The following are examples of procedures in detail.

1) Preparation

- To check that the wirings to be tested are not charged
- The insulation resistance tester which is described in (1) is prepared.
- Transceivers or mobile phones to contact with the personnel in the field side are prepared.
- To remove the connection at both the field side and panel side terminals
- Wirings of the field side were disconnected from the terminal covered with vinyl tape, and remain insulated..

2) Test

Insulation resistance is measured by the insulation resistance tester while disconnecting the terminals of the equipment side. Insulation resistance is measured between following terminals.

- (1) and (2): between conductor wires
- (1) and (4), (2) and (4): between the conductor wire and the ground
- (1) and (3), (2) and (3): between the conductor wire and the shield
- (3) and (4): between the shield and the ground

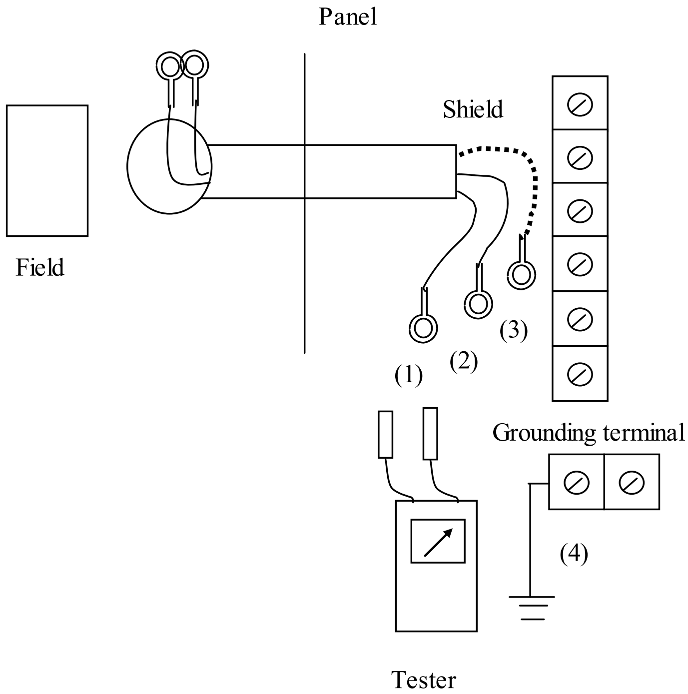


Figure 219 An example of insulation resistance measurement

In addition, after measurement, discharging charges in the cable to the ground is necessary. After the discharging, cables are connected to terminals.

3) Result

a. Measurement data should be recorded and monitored for long period

b. If the insulation resistance is below the allowable value, following measures are taken..

- To dry from time to time
- To use a space heater
- To clean the equipment
- To prevent water penetration at outdoor equipment

Article 220.

(Nothing)

Article 221.

(Nothing)

Article 222. Working mode of protection, measurement system

The meaning of the Article 222 of the technical regulation is "Do not disconnect or do maintain protectors during operation for the purpose of safety”.

"Protectors" means "all protectors" used in power stations or factories, not limited in a certain process value such as electricity.

Needless to say, disconnecting protectors causes disasters such as fires, or explosions, or destruction of facilities due to high pressure, high electric current, high temperature etc.

Moreover, repairing or calibrating online may cause not only loss of protection but also disaster by wrong activation of control unit.

As described in Article 244 of design guideline, control can be considered as a part of protection as follows:

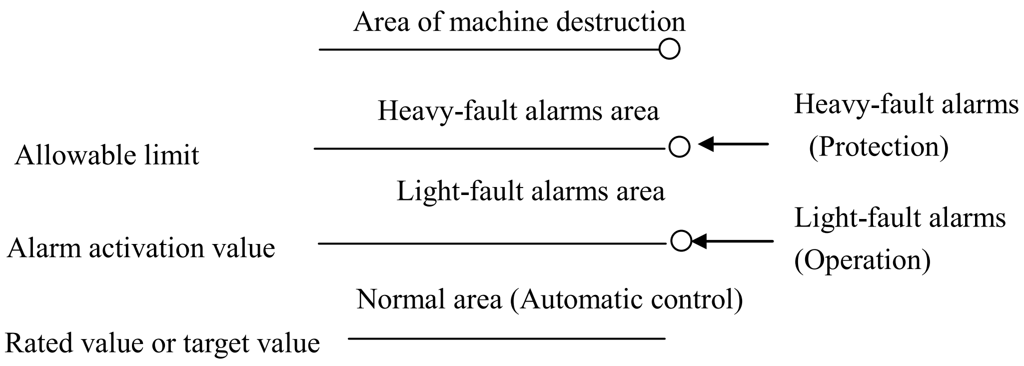


Figure 222-1 Concept of operation, control, protection

In addition, Figure 217-4 shows an example of online calibrating, and air flow meter during operation has this kind of risk. If virtual high value is outputted to the controller during calibration due to no usage of the redundant meter or forgetting to switch to the redundant system, excessive fuel to the real air flow is supplied to the boiler. This excessive fuel may cause explosion at the furnace.

However, each machine can have one or more operating modes determined by the type of machine and its application. When a hazardous condition can result from a mode selection, an unauthorized and/or inadvertent mode selection should be prevented by suitable means. (For example key operated switch and access code are used.)

Article 223. Information archive

The meaning of the Article 223 of the technical regulation is “operation of protectors must be recorded and analyzed for the purpose of safety in all cases, especially in the case that a protector does not operate over the set value”.

Items of records are required to contain following items.

1. Items of operating protectors
2. Operating time
3. Operating value
4. Operating conditions

As for analysis of electrical failures in the power system, a power plant is recommended to be equipped with an automatic oscilloscope because the waveform of voltage and current, conditions of switchgears and activation of protection devices can be recorded.

The operation of protectors may be alarmed to an operator, and also recorded to the log as contact signals.

Therefore, as stipulated Article 258 of design guideline, the function of SCADA (Alarm management, trend analysis and reports) may be utilized because operating time and analog value is necessary in order to analyze. Figure 223 shows examples of signal flows.

The reason why a protector does not operate over the set value may be assumed as follows:

- The process value cannot be detected by the instrument of a protector.
- Working mode of a protector is not correct.
- The logic of the protection circuit is not correct.
- In the case of temporally signals, holding time or output time is not adequate.
- In the case of using digital processors, calculation period is not adequate.
- The set value of the protector is not correct.
- A protector is disconnected.
- Failure of a processor or instrument

During analysis, these points and operating condition of the unit may be considered.

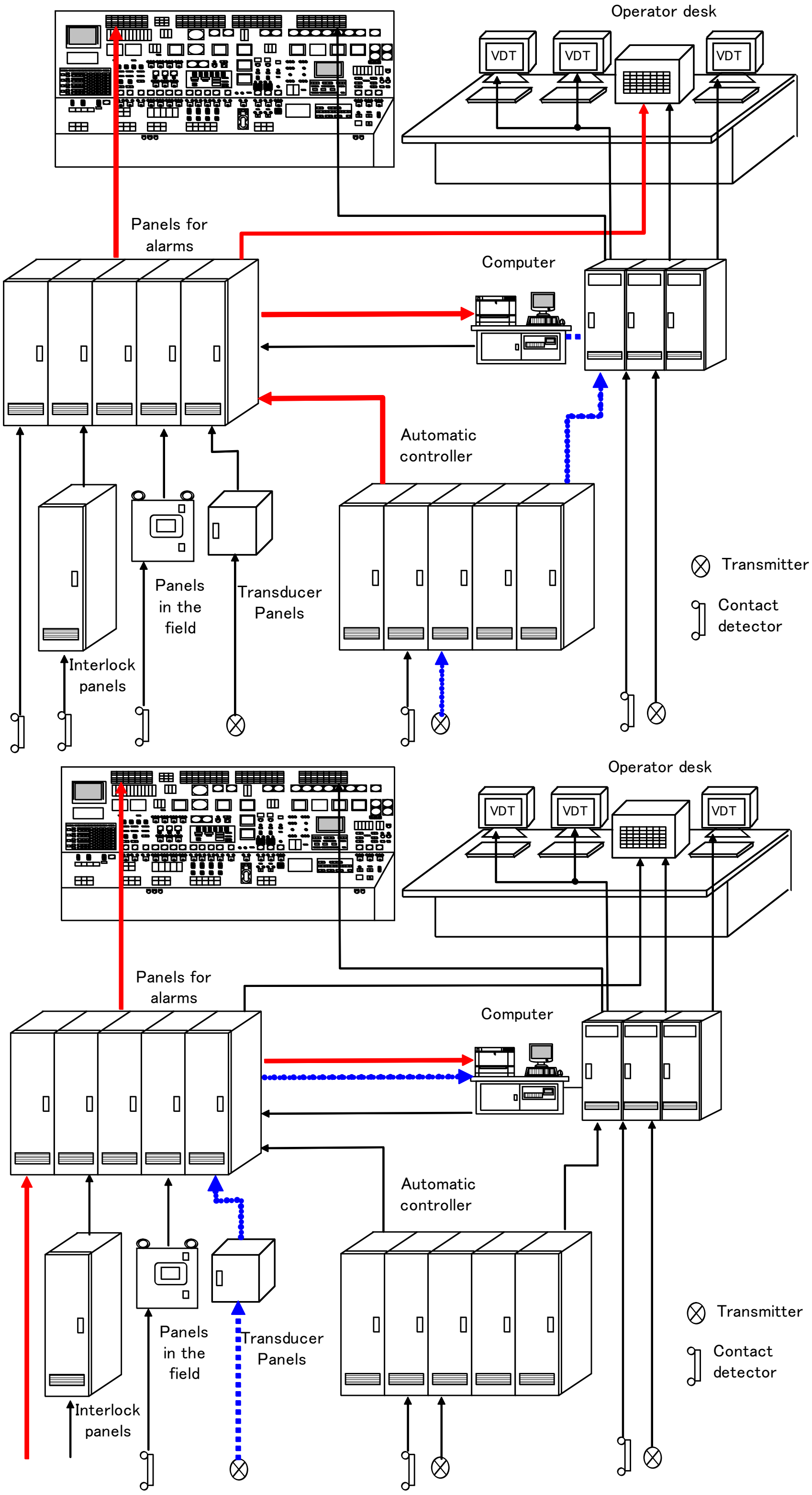


Figure 223 Examples of signal flow

Chapter 10 Water Treatment and Hydration

Article 224. General provision

Purpose of water quality management is to prevent scale buildup and corrosion etc. of boiler, steam turbine and auxiliaries due to water and steam quality and keep high efficiency of power plant at all times. Structure, temperature, pressure and operation status of power plant are different in various ways. And, in recent years, efficiency of power plant is enhanced by high temperature, high pressure, increasing in size and combined cycle system and type of boiler operation is diversified by fluctuation of electric power supply-demand situation. Therefore, there is a possibility that trouble which power plant is stopped due to scale buildup and corrosion is caused if water quality of condensed water, feed water and boiler water are not managed strictly. Thus, water quality management is very important to maintain and enhance the reliability of power plant. It must be referred to Article 142 of this guideline regarding sample of water quality management standard.

Article 225. Water treatment

It must be operated and maintained water treatment system adequately to maintain water quality and operate power plant stably. Water treatment system of power plant is composed of feed water (make up water) treatment system, condensate demineralizer and chemical dosing equipment. And, it must be managed these equipments by daily patrol and inspection. Point to be checked at daily patrol and inspection is shown as follows;

1. Feed water treatment system
   (1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.
   (2) Pump (Chemical injection pump, filtrate pump, purified water pump, waste water pump etc.)
      1) Pump outlet pressure etc.
      2) Abnormal noise, abnormal odor, vibration and leakage
      3) Heating, abnormal noise and oil leakage for bearing
      4) Level, change in color and leakage for lubricant oil
      5) Leakage and corrosion of piping
      6) Leakage and corrosion of valves
      7) Corrosion and peeling for painting
   (3) Tank (Purified water tank, chemical tank)
      1) Level of purified water or chemical etc.
      2) Leakage and corrosion of tank body
      3) Leakage and corrosion of piping
      4) Leakage and corrosion of valves
      5) Corrosion and peeling for painting
   (4) Tower (H-tower, OH-tower, vacuum degasifier tower)
      1) Electric conductivity and silica concentration of H-tower and OH-tower outlet etc.

2) Vacuum and water level of vacuum degasifier tower etc.
3) Leakage and corrosion of tower body
4) Leakage and corrosion of piping
5) Leakage and corrosion of valves
6) Corrosion and peeling for painting

Photo 225- 1 Feed-water treatment system

2. Condensate demineralizer

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) Pump (Coil cooling water pump, makeup water pump, waste water pump etc.)

It must be referred to paragraph 1 of this article regarding pump of condensate demineralizer.

(3) Condensate polisher and electromagnetic filter

1) Sodium concentration and electric conductivity of condensate polisher etc.
2) Differential pressure and flow of electromagnetic filter etc.
3) Leakage and corrosion of condensate polisher and electromagnetic filter body
4) Leakage and corrosion of piping
5) Leakage and corrosion of valves
6) Corrosion and peeling for painting

(4) Tank (Chemical tank, resin tank, coil cooling water tank)

It must be referred to paragraph 1 of this article regarding tank of condensate demineralizer.

Photo 225-2 Condensate demineralizer

3. Chemical dosing equipment

(1) It must be conducted daily patrol and inspection according to procedures developed by each power plant.

(2) Pump (Ammonia dosing pump, hydrazine dosing pump etc.)

It must be referred to paragraph 1 of this article regarding pump of chemical dosing equipment.

Photo 225-3 Chemical pump

(3) Tank (Ammonia tank, hydrazine tank)

It must be referred to paragraph 1 of this article regarding tank of chemical dosing equipment.

Article 226.

(Nothing)

Article 227. Safety for chemical agent

Equipment, devices and vehicles must be safe for loading, storing and transporting caustic soda, ammonia, hydrazine, chlorine, lime chloride, strong acids, other corrosive chemicals and their solution in technological process. It must be strictly abided by safety technical rules when using chemicals and the above-mentioned chemical solutions. Danger to public health regarding some chemicals is shown as follows;

1. Caustic soda

(1) Inhalation

Cough, sore throat, short breath

(2) Skin

Reddening, pain, burn injury, bulla

(3) Eye

Reddening, pain, bleary eyes, burn injury

(4) Oral intake

Stomach ache, burn injury, nauseous, vomit

2. Ammonia

(1) Inhalation

Burning sensation, cough, feeling of smothering, sore throat, short breath

(2) Skin

Reddening, burn injury, pain, bulla, cold injury (in case of touching liquid ammonia)

(3) Eye

Reddening, pain, burn injury

3. Hydrazine

(1) Inhalation

Cough, burning sensation, headache, head trip, nauseous

(2) Skin

Reddening, pain, burn injury

(3) Eye

Reddening, pain, burn injury

(4) Oral intake

Burn injury, stomachache, diarrhea, vomit

Article 228. Wastewater treatment

Waste water quality management is different from quality management of boiler water and makeup water. It plays a major role in environmental protection of power plant. It must be treated all kinds of waste water properly and complied with waste water quality standard and agreement with local authority. Waste water is composed of steady waste water and unsteady one. Steady waste water is waste water which each equipment of power plant discharge continuously and by fits. Unsteady waste water is waste water which discharges at periodic inspection.

Table 228-1 Category of waste water

Category		Oil-fired	Coal-fired	LNG-fired
Steady waste water	Waste water of water treatment system	X	X	X
	Waste water of unloading and transporting coal	-	X	-
	Waste water of ash handling system	X	X	-
	Waste water of De-SOx system	X	X	-
	Domestic waste water	X	X	X
Unsteady waste water	Rainwater of coal stock yard	-	X	-
	Waste water at starting of power plant	X	X	X
	Waste water at washing air heater	X	X	-
	Waste water at washing electric precipitator	X	X	-
	Waste water of chemical cleaning	X	X	X
	Rainwater of tank yard	X	X	-

It must be referred to Article 222 of Vo1.2 Design Technical Regulations regarding waste water quality regulation in Vietnam.

Photo 228-1 Wastewater treatment equipment

Article 229. Chemical analyses

Chemical analyses in power plant must satisfy the following content:

1. Corrosive and residue condition of water treatment and thermo equipment must be had thorough grasp on.

It must be checked corrosive and residue condition of water treatment and thermo equipment at daily operation and inspection. It must be referred to Article 225 of this Guideline regarding point to be checked at daily operation and inspection.

2. Quality of water, steam, remaining salt, chemicals, organic fuel, ash, slag, gas and oil must be defined;

It must be checked quality of water, steam, remaining salt, chemicals, organic fuel, ash, slag, gas and oil during operation or periodic inspection to operate power plant safely and stably. It must be referred to article 142 of this Guideline regarding quality of water, steam and remaining salt and article 102 of this Guideline regarding quality of gas and oil. It must be refilled according to manufacture recommendation regarding chemicals. It must be complied with relevant regulations regarding ash and slag.

3. The gas infection of rooms, manholes, tunnels and other works must be checked;

It must be checked the gas infection of rooms, manholes, tunnels and other works periodically according to relevant regulations. In addition, it must be checked oxygen concentration to prevent oxygen deficiency before going into manholes, tunnels etc. It must be referred to Article 126 of this Guideline regarding risk of oxygen deficiency.

4. Discharge water quality must be defined.

It must be referred to Article 228 of this Guideline regarding discharge water quality.

Article 230. Boiler water

It must be maintained the quality of boiler water to prevent erosion and destruction of boiler tubes and damage of steam turbine blades. It must be referred to Article 142 of this Guideline regarding quality of boiler water and Article 225 of this Guideline regarding point to be checked at daily patrol and inspection of chemical dosing equipment.

Article 231. Discharge of boiler water

1. During boiler starting up

It must be conducted blow outside boiler at feed water rate 25% of ECR through outside blow valve of water separator drain tank by BFP booster pump system during boiler cold clean up. It must be judged completion of blow by turbidity and total iron according to water quality standard of condensate demineralizer. After above blow, it must be changed water separator drain system from outside boiler to condenser return and enhanced water quality through condensate demineralizer.

2. During boiler operation

Impurities in feed water are condensed in steam drum in drum boiler. Impurity concentration is kept within acceptable value by blowing feed water from drum and steam quality to steam turbine is maintained. On the other hand, impurities in feed water are supplied to steam turbine with steam because drum is not installed and impurities are not discharged by drum blow in once-through boiler. Thus, it must be made use of high quality feed water meeting acceptable value in once-through boiler.

Chapter 11 Pipelines and Valves

Article 232. Inspection before operation

Pipeline and valves are damaged by various causes. Major root cause of damage of pipeline and valves are shown as follows:

1. Major root cause of damage of pipeline and valves
   (1) External root cause
      1) Earthquake
      2) Typhoon
      3) Tidal wave
   (2) Internal root cause
      1) Resonance with vibration of connected equipment
      2) Stress by binding pipeline
      3) Thermal stress at startup, stop and load change of power plant
      4) Corrosion due to fluid in pipeline and valve
      5) Thermal impact due to back flow of drain

It must be checked status of pipeline, valve and auxiliaries to prevent above damage at daily patrol and inspection. Point to be checked at daily patrol and inspection is shown as follows;

2. Point to be checked at daily patrol and inspection
   (1) Pipeline and valve
      1) Leak
      2) Corrosion
      3) Breakage
      4) Loose and defluxion of bolts
      5) Overheat etc.
   (2) Thermal insulation
      1) Defluxion
      2) Breakage etc.
   (3) Fixed frames, brackets and sliding supports
      1) Corrosion
      2) Breakage
      3) Loose and defluxion of bolts etc.

Article 233. Inspection in operation

It the must be conducted following items at an appropriate time, when pipelines are operated under existing regulations:

1. The thermal expansion by readings of indicators must be checked. Pipelines must not be stuck and vibration must not be increased;

When thermal expansion of pipeline is blocked, excessive stress is occurred in pipeline and pipeline is damaged. In addition, vibration of pipeline is occurred and pipeline is damaged by fatigue fracture. Thus, it must be confirmed status of thermal expansion of pipeline compared to design value and measurement record up to the present when measuring movement of pipeline.

2. Metal conditions must be monitored periodically and the shortcomings of welded seams must be checked;

It must be checked metal conditions and shortcomings of welded seams at daily patrol and inspection to detect defects in pipeline early. And, it must be referred to paragraph 1 and 4 of this article.

3. The tightness of valves and jointed flanges must be observed;

It must be checked leak form valves and jointed flanges at daily patrol and inspection to operate power plant stably and maintain efficiency of power plant. In addition, it must be checked loose of bolts of valves and jointed flanges by test hammer to prevent leak from them, and retightened bolts by torque wrench when detecting loose of them.

4. The working temperature mode of metal in each startup and stop must be checked.

Thermal stress is occurred at startup and stop of power plant and it is repeated every startup and stop. And they are accumulated as time goes by, there is a possibility that pipelines are damaged regionally. Thus, it must be confirmed pipelines is not overheated by using portable thermometer etc.

5. Maintenance

When detecting defects in valves and pipelines during operation of power plant and standby system or standby equipment is installed, it must be changed from operating system (equipment) to standby system (equipment) and maintained damaged parts. When standby system or standby equipment is not installed, it must be maintained under operation or stopped power plant if necessary. In addition, it must be referred to TCVN 6158 (1996) regarding technical requirements for vapor and hot water pipelines.

Article 234. Safety of pipelines system

When connecting low-pressure pipeline with high-pressure one, it must be opened valve gradually confirming status of low-pressure one. There is a possibility that low-pressure pipeline is damaged when opening valve quickly. As well as connecting low-temperature pipeline with high-temperature pipeline, it must be opened valve gradually confirming status of low-temperature one.

Article 235.

(Nothing)

Article 236. Check of thermal insulation

It must not be touched abnormal temperature rises of thermal insulation surface and heat leaks part directly to prevent burn injury. When there is a possibility that abnormal temperature rises of thermal insulation surface and heat leaks are conducted, it must be checked temperature by portable thermometer. Major piping and valve installed with thermal insulation are shown as follows;

1. Boiler
   (1) Steam piping (main steam piping, reheat steam piping, high temperature turbine bypass piping), safety valve

2. Steam turbine

(1) Steam piping (main steam piping, reheat steam piping, high temperature turbine bypass piping), feed water piping, main valves (MSV, CV, RSV and CRV)

Photo 236-1 Steam turbine

3. Gas turbine

(1) LNG piping, LNG valve

Photo 236-2 LNG piping

Article 237.

(Nothing)

Chapter 12 Auxiliaries for Thermo-mechanical Section

Article 238. Confirmation before start-up

After repairing or stopping operation over period set by the Owner, status of protectors, automatic and safety equipment, valves and meters must be checked before energizing auxiliaries for operation. Because it must be stopped these auxiliaries safely and stably by protectors and safety equipment etc. when they have troubles and are stopped urgently. Point to be checked at inspection of protectors, automatic and safety equipment, valves and meters are shown as follows;

1. Protectors, automatic and safety equipment

(1) Corrosion

(2) Breakage, crack, deformation

(3) Loose and defluxion of bolts etc.

2. Valves and meters

   (1) Leak

   (2) Corrosion

   (3) Breakage

   (4) Loose and defluxion of bolts etc.

Article 239. Protection of auxiliaries

It must be prohibited from energizing auxiliaries after any stop due to the fault of protectors to stop auxiliaries until the fault is removed. Because there is a possibility that auxiliaries are damaged by energizing them. Point to be checked at energizing auxiliaries is shown as follows;

- It must be confirmed maintenance of auxiliary is completed.
- It must be confirmed pertinent auxiliary is not under another maintenance work.
- It must be prepared staring of auxiliary if it is started after energizing it. (e.g. Filling water in pump)
- It must be informed central control room of energizing auxiliary.
- It must be conducted operation test for protector of auxiliary and confirmed that it is operated stably if necessary.
- It must be informed central control room and returned to normal operation after confirming that repaired auxiliary is normal.

Article 240.

(Nothing)

Article 241. Pressure reducer and attemperator device

It must be prohibited from operating pressure reducer and attemperator when safety valve at depressurized steam point is locked or broken. Because it can not be reduced fluid pressure and auxiliary body and piping etc. are damaged when fluid pressure is raised suddenly. Thus, it must be confirmed status of safety valve at daily patrol and inspection.

Article 242. Check of vibration

Vibration of auxiliaries metered in bearings must not exceed rated value in power plant’s regulations. Thus, it must be checked vibration of rotary machine such as pump etc. periodically by potable vibration meter. It must be measured following 3 places when measuring vibration of pump and confirmed measured value is met acceptable value. In addition, vibration of large size auxiliaries such as FDF, BFP etc. can be confirmed by auxiliary’s vibration monitoring system in central control room.

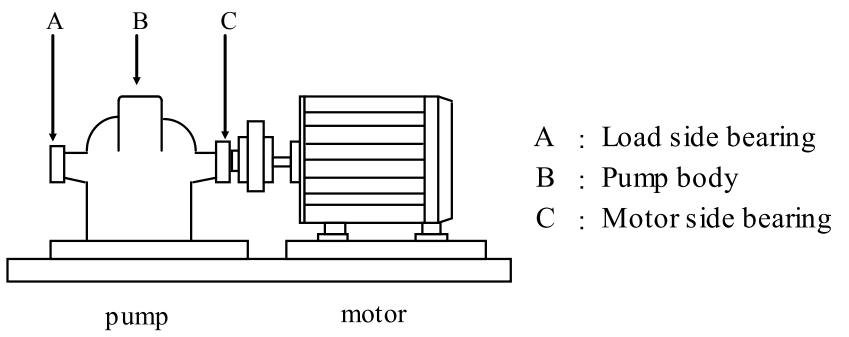


Figure 242-1 Measuring point of vibration of pump

Chapter 13 Environmental Protection Facilities

Article 242-a1 De-NOx and De-SOx equipment

Consistency of NOx and SOx in gas emission to atmosphere must not exceed allowable values specified by Vietnam government. It must be referred to QCVN 5 : 2009 (National technical regulation on ambient air quality) and QCVN 22 : 2009 (National technical regulation on emission of thermal power industry) regarding allowable values. It must be operated De-NOx and De-SOx equipment at all times and complied with above regulations in case that the gas emission doesn't meet the values without these equipments. In addition, countermeasure in case of rise in NOx concentration due to defect in De-NOx equipment inlet NOx gauge is shown as follows ;

Case : NOx concentration due to defect in De-NOx equipment inlet NOx gauge

↓

Alarm of “A-De-NOx equipment outlet NOx concentration high” is transmitted.
Alarm of “Chimney inlet NOx concentration high” is transmitted.

↓

It is confirmed following conditions.
- Indicating value of A-De-NOx equipment inlet NOx gauge is decreased.
- A-side ammonia flow rate is decreased compared to B-side one.

↓

It is judged that A-De-NOx equipment inlet NOx gauge has defect according to above conditions.

↓

It must be controlled A-De-NOx ammonia flow control valve by manual referring to valve opening of B-side control valve.

↓

It must be requested load dispatch center to keep present load of power plant and maintenance group to repair damaged A-De-NOx equipment inlet NOx gauge.

↓

After maintaining damaged NOx gauge, it must be confirmed status of repaired one and returned power plant to normal operation.

Figure 242-a1-1 Countermeasure in case of rise in NOx concentration

Article 242-a2 Monitoring of consistency of NOx and SOx

In power plants, it must be watched over the operating mode of De-NOx and De-SOx equipment strictly so that gas emission meets environmental standards. It must be referred to paragraph 1 and 3 of Article 152 of this Guideline regarding point to be checked at operating and daily patrol and inspection of De-NOx and De-SOx equipment.

Article 243. Dust precipitator

Dust content in gas emission to atmosphere must not exceed allowable calculated values for each power plant. It must be referred to QCVN 5 : 2009 (National technical regulation on ambient air quality) and QCVN 22 : 2009 (National technical regulation on emission of thermal power industry). It must be operated dust precipitator at all times and complied with above regulations in case that the gas emission doesn't meet the values without these equipments. In addition, countermeasure in case of rise in dust content is shown as follows;

Alarm of “dust content high” is transmitted.

↓

It is confirmed following conditions.
- Boiler outlet dust content is increased.
- Operation status of dust content gauge is normal.
- Operation status of electric precipitator is normal.

↓

It is judged that relevant equipments have no defect and boiler outlet dust content is increased due to fuel property.

↓

It must be confirmed combustion status of boiler and conducted required combustion adjustment.

↓

It must be taken following countermeasures for electric precipitator.
- Hammering of collecting electrode and discharge electrode
- Adjusting of charging voltage and discharge current

↓

It must be requested load dispatch center to reduce load of power plant rapidly if necessary.

Figure 243-1 Countermeasure in case of rise in dust content

Article 244. Monitoring of dust precipitator

In power plants, it must be watched over the operating mode of dust precipitator strictly so that gas emission meets environmental standards. It must be referred to paragraph 2 of Article 152 of this Guideline regarding point to be checked at operating and daily patrol and inspection of dust precipitator.

Article 245. Ash and slag disposal system

It must be ensured during operation of ash and slag disposal system that:

1. To dispose of in a timely manner and continuously

   (1) General

   Amount of emission for ash and slag depends on fuel consumption (power plant load) and ash content in fuel. Because timing of disposing ash and slag depends on amount of emission for them, it must be paid attention to amount of emission for them during operation of power plant.

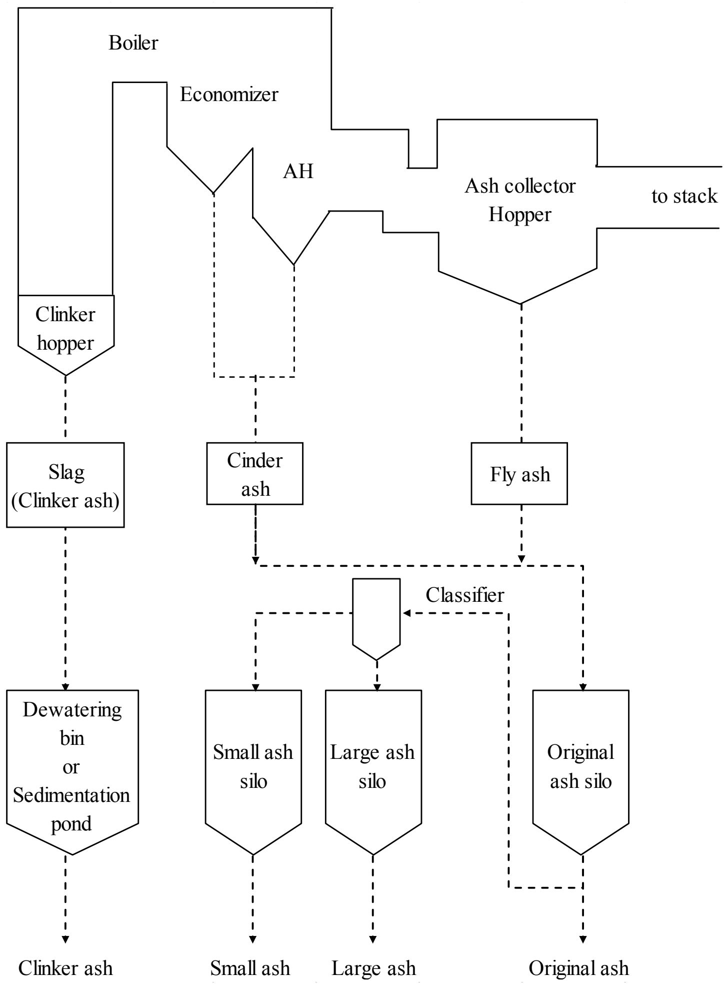


Figure 245-1 Process flow of coal ash

(2) Slag (Clinker ash)

Slag (Clinker ash) are discharged at clinker hopper (boiler bottom) after fuel is burnt in furnace of boiler. They are disposed at periodical interval by disposal system. When disposing slag from clinker hopper, there is a possibility that they are blocked up at disposal system. In this case, it must be paid attention to safety for operator and disposal system and taken countermeasure for clearing the blockage.

Photo 245-1 Slag disposal system (Chain conveyor type)

(3) Cinder ash and fly ash

Cinder ashes from economizer and AH and fly ashes from ash collector such as electric precipitator are discharged at each hopper. They are disposed at periodical interval by disposal system. When disposing these ashes from each hopper, there is a possibility that they are blocked up at disposal system. In this case, it must be paid attention to safety for operator and disposal system and taken countermeasure for clearing the blockage.

Photo 245-2 Fly ash disposal system (Vacuum transportation system)

2. To keep safety for equipment and works inside and outside of ash and slag disposal system;

(1) Basic policy

It must be conducted daily patrol and inspection according to procedures developed by each power plant to protect operator and this system.

(2) Rotary machine

Following many rotary machines are included ash and slag disposal system. It must be paid attention to them at daily patrol and inspection.

1) Crasher
2) Pump
3) Blower
4) Classifier

(3) High temperature

There is a possibility that slag, cinder ash and fly ash are high temperature because they are discharged from boiler or ash collector. Thus, it must be paid attention to them when contacting them directly.

3. To prevent water source, air and surrounding areas from being contaminated by ash and wastewater.

(1) General

It must be complied with relevant regulations in Viet Name to protect the environment.

(2) Ash

Because there is a possibility that ashes are flied in all directions, it must be taken countermeasure of anti-scattering for ash such as fence etc.

(3) Wastewater

It must be referred to Article 248 of this Guideline and Vol.4 Technical Regulation regarding discharge of wastewater.

Article 246. Check of ash and slag disposal system

It must be checked operation of ash and slag disposal system by daily patrol and inspection. Point to be checked at daily patrol and inspection is shown as follows;

1. It must be conducted daily patrol and inspection according to procedures developed by each power plant.
2. Testers, protection equipment and interlocks
   (1) Operation test (if necessary)
   (2) Leakage and corrosion of piping
   (3) Leakage and corrosion of valves
   (4) Corrosion and peeling for painting
3. Pump (ash sluicing (disposal) pump, clinker hopper make up pump, wastewater pump etc.)
   (1) Pump outlet pressure etc.
   (2) Abnormal noise, abnormal odor, vibration and leakage
   (3) Heating, abnormal noise and oil leakage for bearing
   (4) Level, change in color and leakage for lubricant oil
   (5) Leakage and corrosion of piping
   (6) Leakage and corrosion of valves
   (7) Corrosion and peeling for painting
4. Strainer before pump (ash sluicing (disposal) pump, clinker hopper make up pump etc.)
   (1) Differential pressure etc.
   (2) Leakage and corrosion of piping
   (3) Leakage and corrosion of valves
   (4) Corrosion and peeling for painting

Article 247. Ash pond

It must be checked following provisions regarding operation of ash pond.

1. Checking elevation of the surfaces

It must be checked elevation of the surfaces of ash pond periodically and confirmed variation per hour.

2. Checking depth of settling area

It must be checked depth of settling area of ash pond periodically and confirmed variation per hour.

3. Environmental monitoring

(1) Monitoring effluent

When ashes are reclaimed ash pond in marine, effluent in this ash pond is discharged. It must be checked water quality of effluent, confirmed it complies with relevant regulation and discharged effluent to sea.

(2) Countermeasure of anti-scattering for ash

When ashes are reclaimed ash pond, there is a possibility that they are flied in all directions. Thus, it must be taken countermeasure of anti-scattering for ash such as cover soil and fence etc.

(3) Others

It must be complied with relevant regulations in Viet Name to protect the environment.

4. Effective utilization

Ash is applied to following field for effective utilization to eliminate amount of discharging ash to ash pond and reduce cost of ash pond. It is recommended that effective utilization for ash

(1) Land reclamation : Land reclamation for housing site and farmland, land fill material etc.

(2) Building material : Cement admixture, alternative cement clay etc.

(3) Fertilizer : Soil improvement additive, potassium silicate fertilizer etc.

(4) Others : Artificial fish reef, marine structure etc.

Photo 247-1 Ash pond

Article 248. Discharge of wastewater of ash and slag disposal system

Wastewater is discharged from ash and slag disposal system and includes hazardous substance. Thus, it must be treated them by wastewater treatment system, confirmed quality of them is complied with relevant regulations and released them into rivers or common water ditches. In addition, it must be referred to Article 228 of this Guideline regarding wastewater treatment system and waste water quality regulation in Vietnam.

Part 6
Electrical Equipment of Power Plants and Grids

Chapter 1 General Provision

Article 249. Documentation

Technical regulation (Operation and Maintenance) requires keeping and maintaining documentation shown in table 249 in each power plant.

These minutes, records, and results are essential in the expansion or removal or operation and maintenance of facilities.

Moreover, these items prove the following.

1. The facility is consistent with the design.
2. Operation, maintenance, inspections, and installation of the facility conform to the regulations.
3. The regulations or manuals to secure security and to protect people and environment are established and implemented.
4. The water source and surrounding environment are protected.
5. Other regulations related with the facility are satisfied.

For example, according to circular 17/2009/TT-BTNMT, land use rights and house and land-attached asset ownership (below referred to as certificates) should be registered .Certificates; and registration of changes after grant of certificates should be kept by the power station.

Moreover, law on fire prevention and fighting requires the electricity-supplying agencies, organizations and individuals to guide measures to ensure fire prevention and fighting for electricity consumer safety. In order to conform to this law, documentation of "Plan for layout of firefighting equipment and means" is required.

Table 249 Examples of documentation

Regulation requirement	Examples
1. Minutes on granting land.	- The alignment agreement text, - Connection agreements - Profile of compensation - Profile of land allocation
2. Minutes on set up foundation and profile of boring holes.	- Foundation drawings - Profile of boring holes (depth, diameter etc) - Profile of piles (depth, diameter etc) (if used)
3. Minutes on check and acceptance of underground works.	- Records of construction - Records of measures for safety - Results of environment measurement (under ground water, concentration of oxygen ,etc) - Lists of piles which indicate underground objects - Diagrams of piles which indicate underground objects

Regulation requirement	Examples
4. Minutes (or records) on settlement of houses, works and foundations for installing equipment	- Profile of land allocation - Documents of machine allocation (house allocation) - Foundation diagrams - Results of load calculation on the floors or foundations
5. Check-list on testing equipment	- Inspection manual - Operation manual - Manuals issued by the manufacturers
6. Completed work documents	- Testing records or drawings, explanations - Catalog - Installation guide documentation - Manuals and drawings issued by the manufacturers
7. Technical history of houses, works and equipment.	- Records of operation, maintenance and repair by manufacture - Records of removal (machines, houses, etc) - Records of expansion (machines, houses, etc)
8. Plan for layout of firefighting equipment and means	- Layout of fire extinguishers, sprinklers, and fire hydrants - System table for disaster prevention - Manuals for firefighting
9. Records of engineering work	- Operation and troubles treatment procedures (manuals). - Reports on electrical failure - Reports of accidents - Records and reports operation and maintenance - Education and Training Performance Report - Results and records of environment measurement (Emission, -drainage, noise, vibration etc)
10. Results of Completion Inspection and Periodic Inspection	- Results and records of interlock test - Results and records of protective device test - Results of insulation resistance - Calibration records of instruments - Results and records of inspection (Generator, motor, switchgear, etc) - Results and records of acceptance (Completion Inspection) - Results and records of test run

Chapter 2 Generator and Synchronous Compensator

Article 250. General provisions

Since generators and synchronous compensators are connected to power system directly and take an important role in stable power supply, at least appropriate operation shown in this chapter should be taken to prevent damage to each component and operational malfunction,

Article 251. Exciter

1. General

Generators should be capable of continuous rated output at the rated power factor over the ranges of ±5% in voltage and ±2% in frequency according to IEC60034-3.

An exciter controls the generator terminal voltage, or reactive power.

Its power source is supplied from the dc magnetizing current to the field windings of the synchronous generator and ultimately inducing ac voltage and current in the generator armature.

There are two basic kinds of exciters

- Rotating exciters
- Static exciters

The amount of excitation to maintain the output voltage constant is a function of the generator load. As the generator load increases, the amount of excitation increases.

Moreover, reactive lagging power factor loads require more excitation than unity power factor loads, while leading power factor loads require less.

Exciter capacity is specified by generator field current and ceiling voltage which is determined by transient response improvement during power system failure.

Ceiling voltage is expressed by the field voltage at the time of a no-load rated voltage as 1 p.u. (100%) to improve transient stability, higher ceiling voltage is required.

2. Exciter type

(1) AC exciter with rotating rectifiers (Brushless exciter)

Brushless excitation system is widely used because it dose not require slip-rings, commutators and brushes, therefore it is practically maintenance free for brushes and so on.

A brushless exciter is a rotating-armature type synchronous generator on the generator axis.

As shown in Figure 251-1, it rectifies output current of an AC exciter by thyristors, using the output current from permanent-magnet generator (PMG) connected to the same axis of the generator as field current of AC exciter.

Even in the case of failure, the generator excitation source may not be lost, as long as the generator is rotating because PMG is magnetized with the permanent magnet.

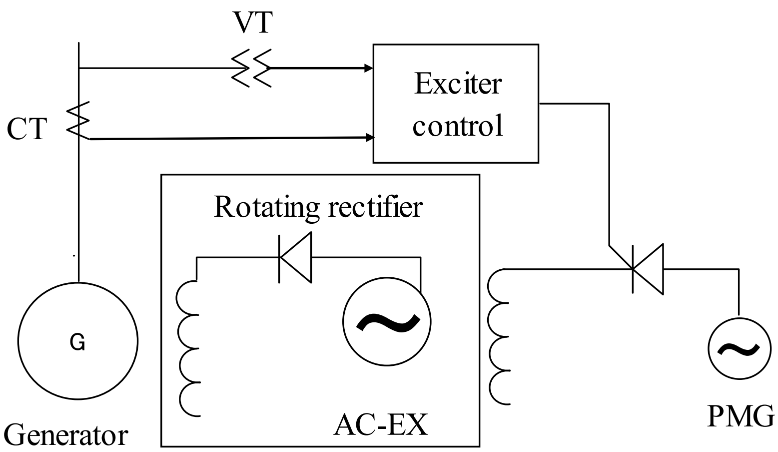


Figure 251-1 An example of brushless exciter

(2) AC exciter with stationary rectifiers (Commutatorless exciter)

As shown in Figure.251-2, brushes and collector rings are added to the items of brushless exciter.

However, rectifiers are installed at stationary area.

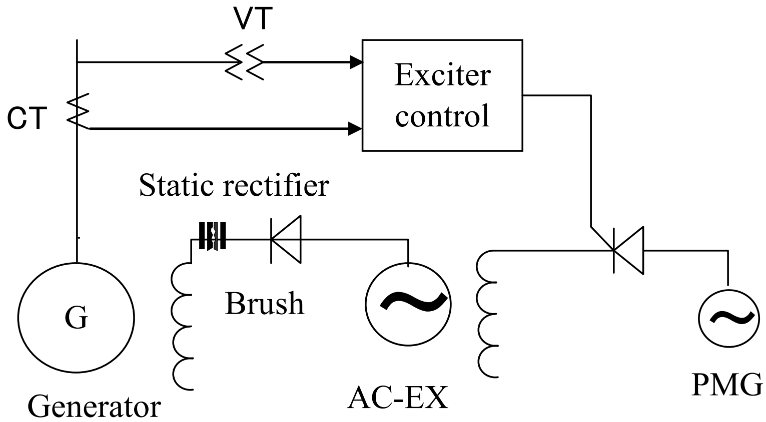


Figure 251-2 An example of commutatorless exciter

(3) Static exciters

Since static excitation has no moving exciter parts, the generator axis can be shortened and maintenance associated with having other rotating machines will be eliminated, as shown in Figure 251-3.

Generator field current is supplied from the generator output and rectified from the AC current to DC current by power thyristors, and finally fed to the rotor through slip rings.

Having no AC exciter provides faster transient response and better transient stability with the help of Power System Stabilizer (PSS: referred later), but has a risk of source power lost in the case of failure.

Brushes and collector rings require periodic maintenance such as check of abrasion at the contact, spring pressure (contact pressure) for field adequate current transmission.

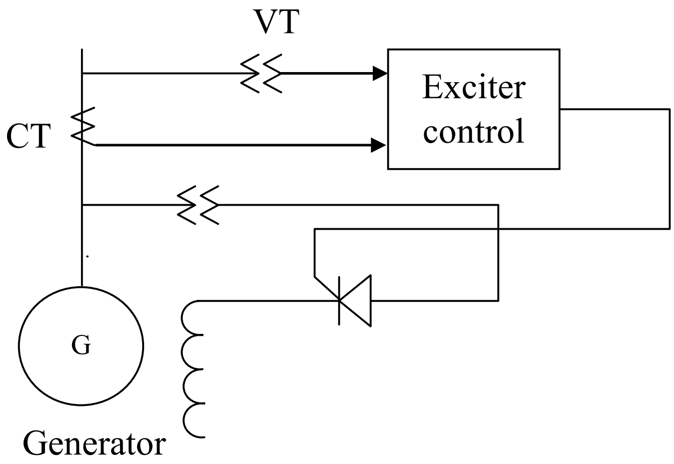


Figure 251-3 An example of static exciter

3. Automatic Voltage Regulator (AVR)

The automatic voltage regulator (AVR) is an exciter control function maintaining the generator terminal voltage at a constant level. Digital controlled AVR is common these days. To protect the generator and its connecting power system, the following AVR functions from (1) to (9) are recommended to be retained depending on conditions. The specification of these functions should satisfy grid requirements, by considering transient stability.

(1) Under excitation Limiter (Recommended)

The Under excitation Limiter is used to limit under excitation of a generator during AVR operation. This function gives the "excitation increase" signal to the AVR when the generator is excited below a set point. This function prevents generator stator core-end over heating and generator fall out of synchronism, as mentioned in the guideline of Article 262.

(2) Over excitation Limiter (Recommended)

Over excitation Limiter is used to protect an excessive field temperature rise caused by over excitation of a generator during AVR operation. This function sends the "excitation decrease" signal to the AVR when the excitation exceeds a set point.

For brushless exciters, field current assumption may be required to apply this function because field current detection is impossible.

(3) Overexcited Reactive-power Limiter (Recommended especially for brushless exciters)

The Overexcited Reactive-power Limiter is used to limit the reactive power (reactive current) of a generator during AVR operation, thereby limiting over excitation of the generator.

This function is especially used for brushless exciters.

This function sends the "excitation decrease" signal to the AVR when the reactive power (reactive current) exceeds a set point.

(4) Voltage-per-Frequency Limiter (Recommended according to the requirement)

The magnetic flux in the major transformer or the generator stator is proportional to its voltage/frequency ratio.

The Voltage-per-Frequency Limiter is used to prevent the major transformer and the generator from over excitation by limiting the V/F value of the generator during AVR operation.

This function may be used not only during normal operation but also during start-up and shut down.

This function sends the “excitation decrease” signal to the AVR when the V/F value exceeds a set point.

(5) Sequential Control (Recommended)

Sequential control has functions of starting and normal stop of excitation and generator voltage detecting functions for voltage build-up sequence or synchronizing control.

(6) Cross Current Compensator (Recommended according to the condition)

Cross Current Compensator gives the voltage dropping characteristic against reactive current to a generator under AVR operation, for stable parallel operation and proper distribution of reactive power. This function is especially used for generator parallel operation such as cross-compound system or low voltage synchronization.

(7) Power System Stabilizer (PSS) (Recommended to static exciters)

Though a generator output power is decided by the turbine mechanical torque, a generator output power also can be changed by changing excitation value transiently.

A PSS detects the changing of generator output power, controls the excitation value, and reduces the power swing rapidly.

When power deviation is detected in the generator, the PSS quickly suppresses it by controlling the excitation and improve the damping of electric-mechanical resonance mode between the generator and the tie-line. It provides supplemental control signal to AVR by detecting instantaneous deviation of the generator output power.

In this way, the PSS expands the dynamic stability range of the parallel operation of a generator with a power system.

For static exciters, the PSS is recommended to be specified because the response of the static exciters is so quick that the generator damping torque may become negative and may result in unstable in the case of fault.

(8) Automatic Reactive-power Regulator (AQR) （Recommended according to the requirement）

The Automatic Reactive-power Regulator automatically regulates the reactive power (in stricter forms, reactive current) of a generator. The reactive-power can be regulated to a value given by the following equations:

Q = a (constant reactive power control)

Q = b * P (constant power factor control)

Q = a + b * P (combined type of the above two)

This function enables reactive power distribution according to the generator power.

(9) Line-drop Compensator (Recommended according to the requirement)

Line-drop Compensator supplies the compensation signal corresponding to a line drop to the AVR to maintain the voltage at a constant level at a fixed point in the transmission line.

4. Points of maintenance during operation

Failure of exciter components such as a brush or a collector ring may cause field loss or loss of synchronization .Thus; these items are recommended to be inspected carefully not only in the periodic inspection but also in daily inspections.

In addition, a spark monitor for brushes and collector rings is available from some manufactures and this device may help the detection of failure at the exciter.

(1) Brush

To prevent failure, field current at the contact between the brush and the collector ring should not be concentrated in a small contact point.

Generally, brush is made of carbon, therefore, following items are recommended to be inspected.

1) Check of abrasion at the contact
2) Check of contacting with collector rings
3) Adjustment of contacting pressure
4) Condition of brush holder
5) Cleaning
6) Periodic exchange

Even in operating, brushes are recommended to be exchanged alternately in the certain number specified by manufacturer.

(2) Collector ring

1) Abrasion on the surface
2) Cleaning

(3) Rectifier and panels (In the case of static exciters or commutatorless exciters)

Rectifier and panels are checked considering following points.

1) Alarm of failure at the panel
2) Operating condition
3) Damage at rectifiers, inside the panel
4) Condition of wirings and connections
5) Circumstance (Temperature, humidity, existence of moisture or dust, odor)
6) Condition of cooling fans and air filters

Article 252. Seal oil standby equipment

1. Standby seal oil pump

In general, the seal oil supply system should be installed to have standby pumps to prevent hydrogen leaks.

For the purpose of safety ,the generator should be shut down and purged when a standby (emergency) seal oil pump is not available.

2. Nitrogen seal

Nitrogen seal system is recommended to be installed, considering emergent conditions when the standby seal oil pump does not operate, such as fires, or, excessive vibration, or excessive hydrogen pressure.

When nitrogen seal system is operated, hydrogen inside the generator is emitted through the pipe which is stipulated in design guideline Article 234-3, for the purpose of safety.

Therefore, capacity of nitrogen is designed to keep the axial seal during hydrogen emission.

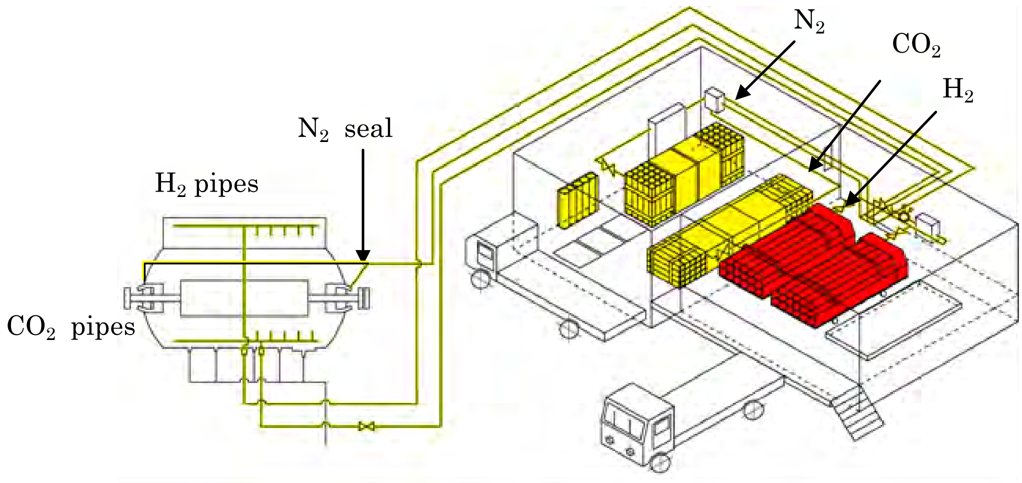


Figure 252 An example of nitrogen seal system

Article 253. Cooling system

1. General

For any generator, a failure of the cooling system can result in rapid deterioration of the stator core lamination insulation, and/or of stator and rotor winding conductors and insulation.

For this reason, the cooling medium such as hydrogen, demineralized water and air should be cooled and maintained at the specified temperature by cooling water, and recirculated in the generator properly.

It is also important to be careful of condensation on pipes and cooler surfaces in the generator and see that water is not being carried into the windings, causing rust or corrosion of metal parts. In the amount of cooling water may have to be reduced to prevent condensation, or mixed with the warmer discharge water through a bypass connection to raise its temperature.

For this reason, an automatic cooling water flow and temperature control system is recommended to be installed to reduce the range of temperature. Moreover, temperature inside the generator should be monitored by an operator.

Cooling water quality shown from the manufacture should be maintained according to the material of the coolers.

Generator cooling is classified by cooling medium as follows.

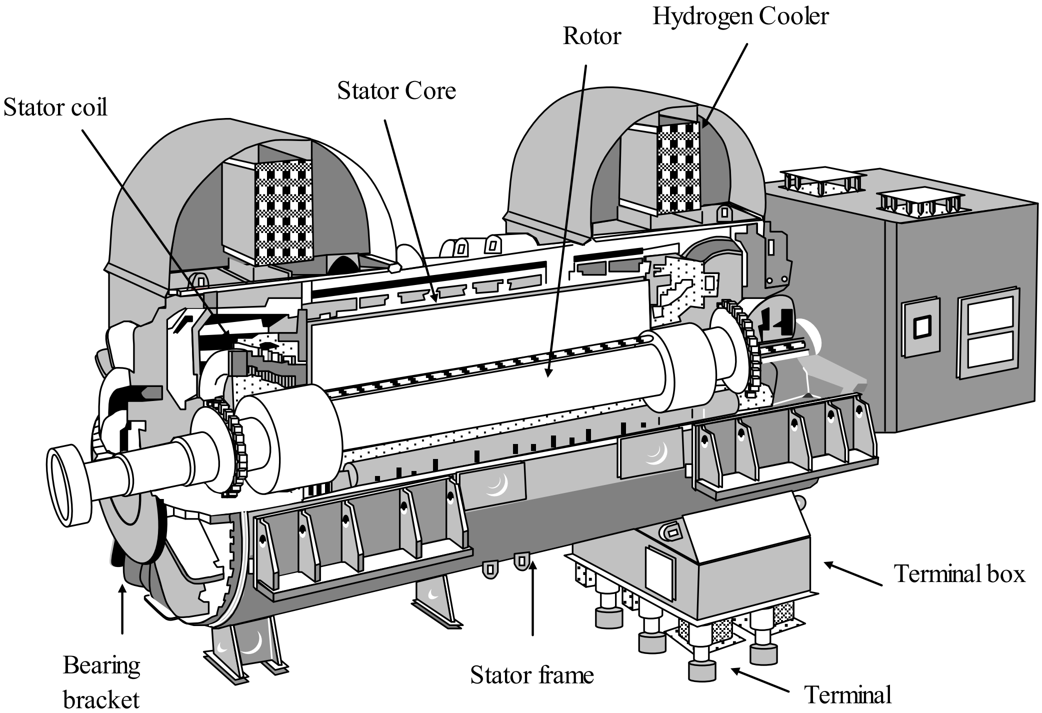


Figure 253 An example of hydrogen cooled generator

2. Water-cooling generator

Water cooling has high cooling capability because stator winding is directly cooled with demineralized water and the other part of the generator is cooled directly with hydrogen gas.

Therefore, this cooling system is used for the generators of large capacity.

Temperature, conductivity and flow quantity are to be monitored to prevent stator insulation degradation.

Water quality standard is to be shown from the manufacture, whose items are assumed to be as the following to prevent corrosion.

(1) pH

(2) Conductivity [μS/cm]

(3) Silica SiO_2 [ppm]

(4) All irons Fe [ppm]

(5) Ammonium ion. NH_4^+ [ppm]

(6) Chlorine ion Cl^- [ppm]

(7) Sulfate ion SO_42^- [ppm]

(8) Hydrogen sulfide H_2S [ppm]

*Aside from mentioned above, harmful substance such as bacterium, algae, slime, shells should be eliminated to prevent cavitation and pipe clogging.

3. Hydrogen cooled generator

The stator is cooled by hydrogen with indirect or direct method. The rotor is cooled directly by hydrogen. For indirect stator cooling generators, the coolant cools the stator by relying on heat transfer through the insulation.

Hydrogen is used for cooling in most medium-large generators rather than air for several reasons.

(1) Inherently better heat transfer characteristic (1.51 times).

(2) Better the heat transfer with higher hydrogen pressure.

(3) Less windage loss than air due to 1/14 density.

(4) Suppression of partial discharge with increased hydrogen pressure.

(5) Longer machine lifetime expected because of its chemical stability compared with air.

However, to prevent hydrogen leaks as stipulated Article 252, 253, 256, and 257 of this guideline, seal oil equipment and hydrogen facilities should be installed to a hydrogen cooling generator.

4. Air cooling generator

This cooling system is used for small capacity machines due to less cooling capability of air. Since an air cooling generator is equipped with no seal oil equipment or hydrogen facilities, it requires less maintenance compared with a hydrogen cooling generator.

The system of ventilation should preferably be a closed air circuit system. If an open air system is specified or agreed on, care should be taken to avoid contaminating the ventilation passages with dirt to avoid overheating and pollution of insulated surfaces.

Article 254.

(Nothing)

Article 255. Filter

Filters are used to clean the cooling water, seal oil, cooing air etc. therefore; they are polluted by foreign material according to the operation time. The pollution of filters can be identified by flow or difference pressure.

Thus, technical regulation (operation and maintenance) requires “appropriate measures” to filters at the proper time in order to prevent clogging or reduced flow.

“Appropriate measures” means cleaning or exchanging of filters. Some oil filters may have a stand by filter or auto cleaning system, therefore, the instruction manual from the manufacturer is referred.

Article 256. Hydrogen purity

The explosion range of hydrogen purity is between 4% (in air by volume, %) and 75% (in air by volume, %). This is the reason the Guideline of Technical Regulation Article 264 stipulates some items.

If the purity meter indicates correctly and purity in the generator decreases, a part of hydrogen in the generator should be emitted and replaced with hydrogen of high purity.

If this purity cannot be maintained, the generator should be shut down and the hydrogen should be emitted as soon as possible.

Moreover, higher hydrogen purity reduces generator mechanical (windage) loss because of its low density.

Therefore purity inside the generator is recommended to be maintained as high as possible.

The detection method is mentioned in Article 248 of the design guideline. (Measurement equipment for generator)

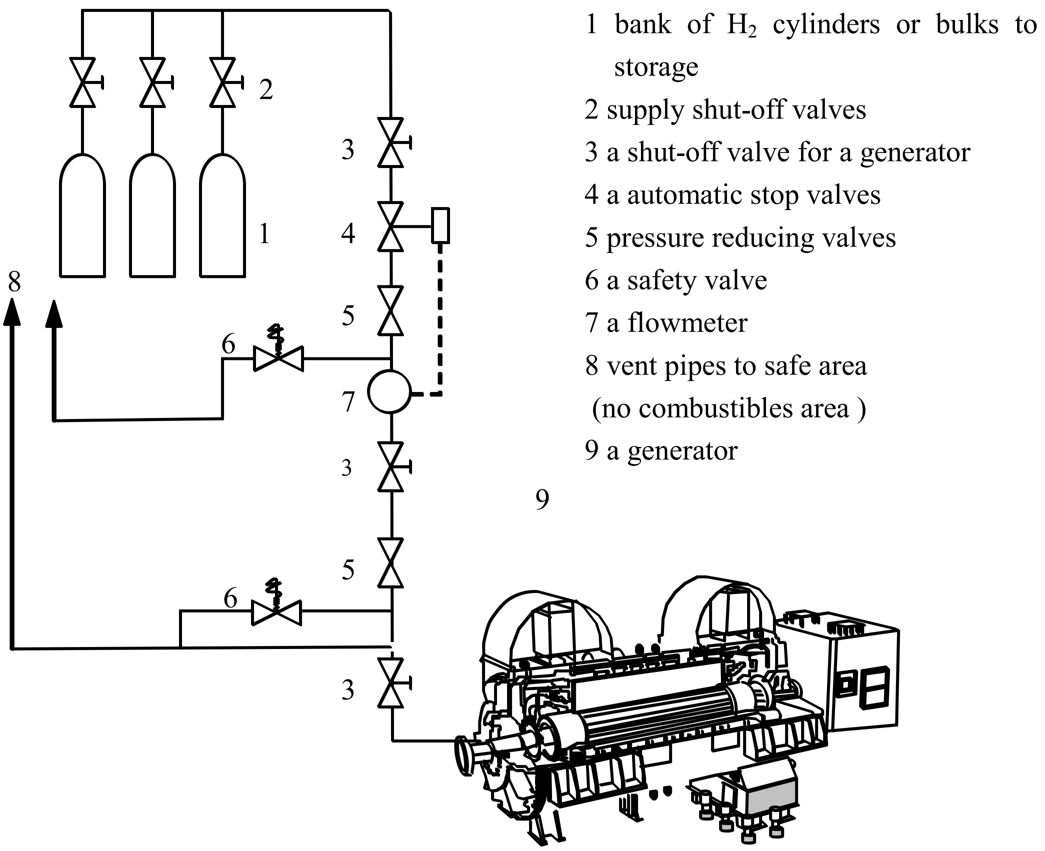


Figure 256 An example of hydrogen supply system

Article 257. Seal oil pressure

Article 257 of technical regulation (operation and maintenance) means that the generator is prohibited from operating at a hydrogen pressure greater than the pressure capable of being covered by the seal oil.

Generally, seal oil pressure is maintained by pressure control valve and stand-by (emergency) pump.

For safety, if seal oil pressure cannot be maintained properly, the generator should be shut down and hydrogen inside the generator should be emitted to prevent explosion, as stipulated Article 252 of this guideline.

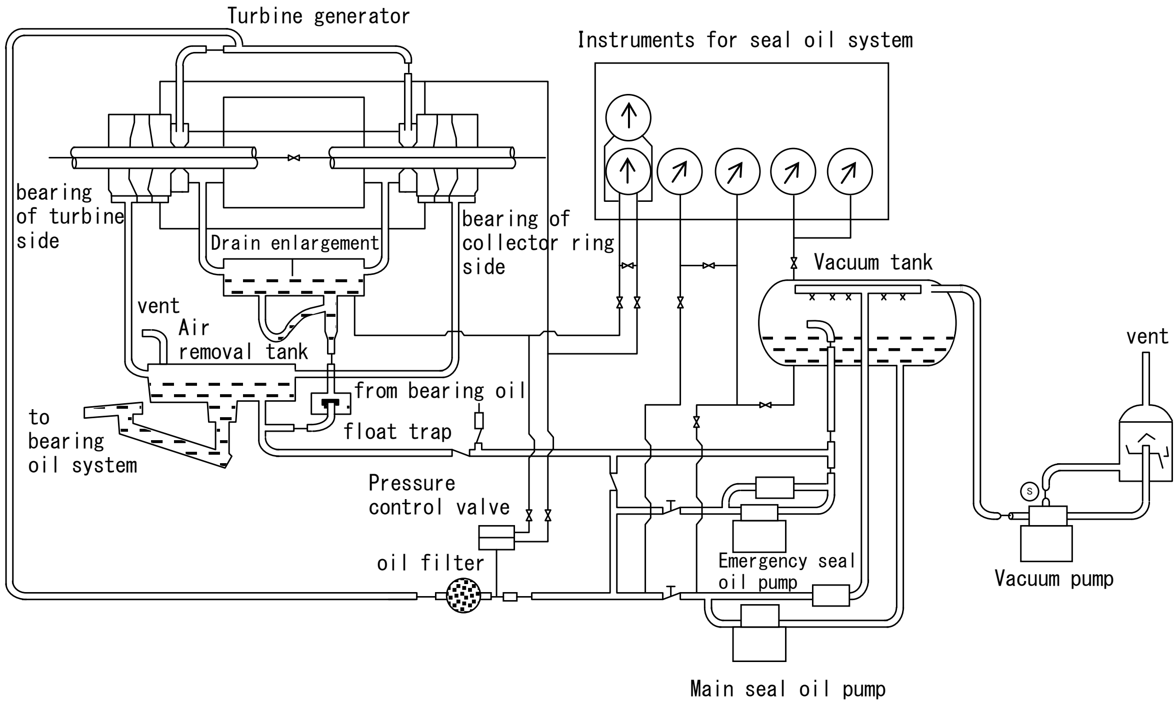


Figure 257 An example of seal oil system

Article 258.

(Nothing)

Article 259. Overload operation

For any generator, over heat causes rapid deterioration of the stator or rotor insulation and may cause fault or fire consequently.

However, generators should be designed to withstand over current in certain time because power system failure or turbine governor activation may cause over current.

According to IEC 60034-3, generators with rated outputs up to 1200 MVA should be capable of carrying a stator current of 1.5 per unit (p.u) for 30 seconds, without damage.

For ratings greater than 1200 MVA, agreement should be reached on a time duration less than 30 seconds, decreasing as the rating increases, to a minimum of 15 seconds, the current remaining at 1.5per unit for all ratings.

The generator should be withstand the value which is combinations of over current and time that give the same degree of additional heat above that caused by 1 p.u current.

Thus, for generators up to 1200 MVA,
$(I^2 - 1)\, t = 37.5$ s, or $I = \sqrt{37.5/t + 1}$ (p.u)
Where

I: the stator current per unit (p.u);

T: its duration in seconds.

This relationship applies values of t between 10 and 60 seconds.

It should be recognized that that the number of operations to this limit conditions will not exceed two per year.

Article 260. Unbalanced operation

Negative-sequence current is generated from unbalanced load.

The cause of unbalanced load may be unbalanced connection of single phase load, transmission line impedance unbalance or fault in the power system.

When a generator is operated under unbalanced load, negative-sequence current flows in the stator coil, generating the revolving magnetic field which revolves in the opposite direction at the same speed of the rotor. This causes eddy current of double frequency flows on the surface of the rotor and the rotor wedge. This makes the rotor overheated especially in the part in which the eddy current concentrates. If the unbalance becomes serious, burning or strength deterioration may be caused by local overheating.

Over current of negative-sequence current in the generator is protected by the protective relay.

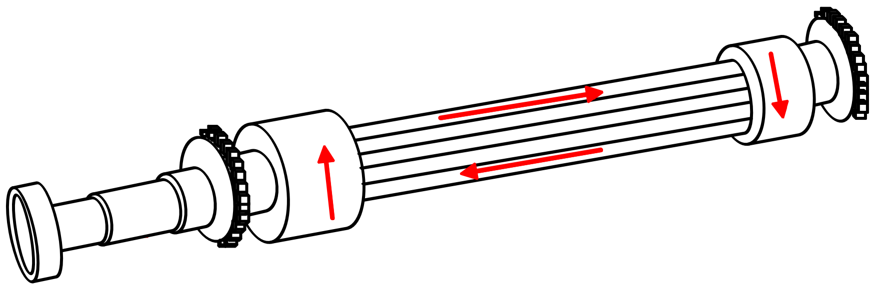


Figure 260 An example of current on the rotor surface caused by negative-sequence current

1. Continuous unbalanced load resistance

Negative-sequence current generated from unbalanced connection of single phase load or transmission line impedance unbalance is continuous.

The permissible limit of continuous unbalanced load is greatly affected by the material and structure of the equipment and cannot be specified in one manner. Table 260shows the permissible limit proposed by IEC 60034-1 or JEC 2130.

2. Short period unbalanced load resistance

At the time of short period unbalance load such as by one-1ine ground and line short circuit, the double frequency eddy current flows on the rotor surface and the rotor overheats for the same reason mentioned above.

Fault current is not continuous because protecting relays and switchgears shut down it quickly. Table 260 also shows the short period permissible limit proposed by IEC 60034-1 or JEC 2130.

Table 260 Negative-sequence current limit

	Continuous limit Maximum value of I_2/I_n	Short time limit Maximum value of $(I_2/I_n)^2 * t$ during failure
Indirect cooling rotor		
Air cooling	0.1	15
Hydrogen cooling	0.1	10
Direct cooling rotor		
≦350MVA	0.08	8
≦900MVA	*1	*2
≦1250MVA	*1	5
≦1600MVA	0.05	5
Where I_N: Rated current I_2: Negative-sequence current	Note: * 1 $\dfrac{I_2}{I_n} = 0.08 - \dfrac{S_N - 350}{3 * 10^4}$ * 2 $(I_2/I_n)^2 * t = 8 - 0.00545 - (S_N - 350)$ S_N : Apparent power (MVA)	

Article 261. Motor mode of operation

In the case of a synchronous generator, motor mode of operation is prohibited in principle, because if a generator turns into a motor, prime movers and the generator may be damaged, and also power system may become instable.

However, during start up, a synchronous generator may be used as a starting motor according to the design condition.

1. During operation

Protection of prime movers and generators and prevention of power system instability should be considered by referring design condition. The control logic or plant interlock is recommended to be reflected this design condition by the manufacturer.

(1) Prime movers

In the case of a steam turbine, when a generator turns into a motor, moving blades of the turbine may be overheated by the windage loss.

In the case of a gas turbine, when a generator turns into a motor, it may be a suggestion of abnormal conditions in the fuel system such as “flame-off” in addition to overheat at moving blades.

(2) Generator

When a generator turns into a motor, or a motor turns into a generator, synchronizing current may flow due to the change of phase angle. If this current is large, this current may cause deterioration of the generator.

Moreover, voltage may be fluctuated by this large current and may cause power system instability.

2. During start up of the unit

In the combined cycle system, a synchronous generator may be used as a starting motor to pressurize the air in the compressor as shown in Figure 261.

In this case, prime movers and the generator should be designed and controlled to overcome the prime movers and the generator problems, which are described in this Article.

Therefore, advice from the manufacturer is recommended to be considered and the control system and plant interlock are to be reflecting these design conditions.

In addition, harmonic current and electromagnetic interference from the thyristor starting system are recommended to be noticed as described in Article 18-1 of design guideline.

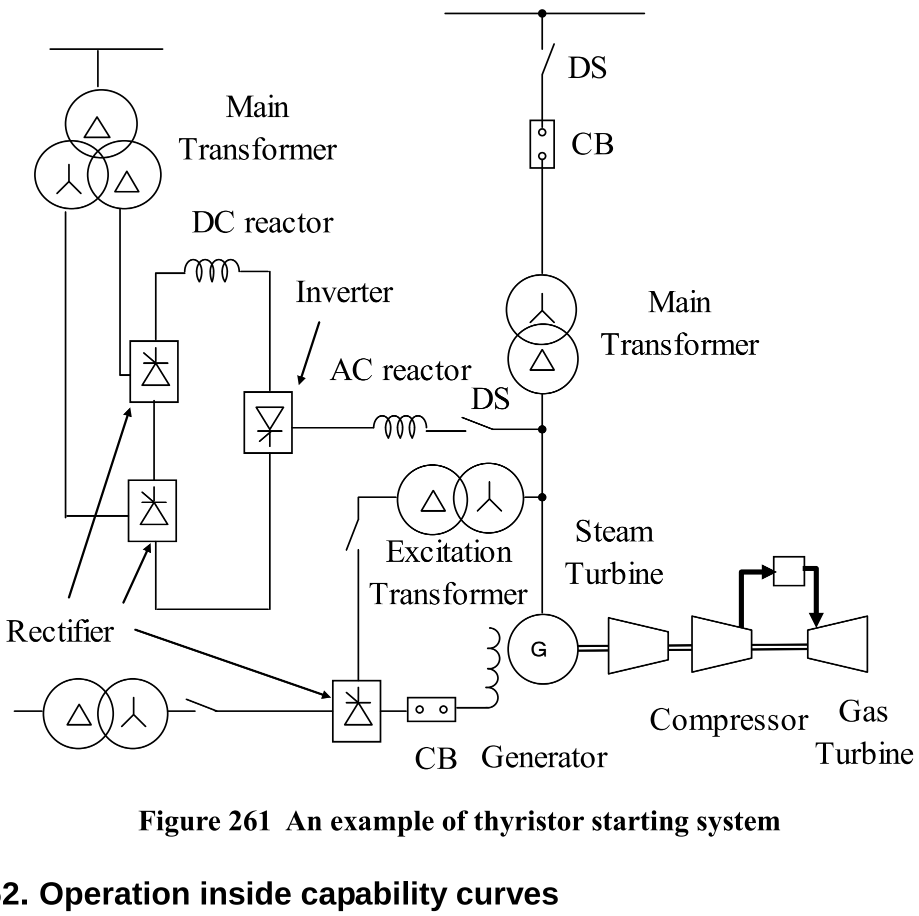


Figure 261 An example of thyristor starting system

Article 262. Operation inside capability curves

The generator capability curve describes real and reactive power capability of a generator.

Figure 262-1 shows an example of the generator capability curve .This curve is divided into parts (1), (2), and (3),

(1) Range restricted by rotor coil temperature
(2) Range restricted by stator temperature
(3) Range restricted by stator core end part temperature

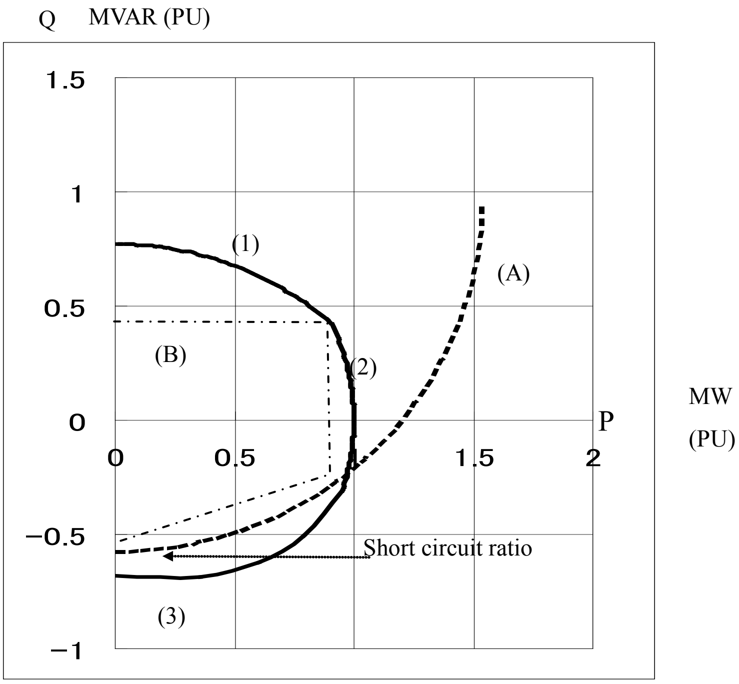


Figure 262-1 An example of generator capability curve

Overheating of the rotor or stator may cause insulation failure, shorting of turns and ground faults.

The generator operation is also restricted by the generator steady state stability, which is shown (A).

Therefore, an example of operation range is shown as inside (B).

(1) Range restricted by rotor coil temperature

The restrictions by rotor coil temperature may be obtained under the conditions of a constant field current.

Cooling medium condition such as hydrogen pressure, hydrogen temperature for hydrogen cooling or air temperature for air cooling should be maintained to prevent overheat.

As for the generator terminal voltage, the continuous operation within ±5% of the rated voltage is prescribed by IEC60034-3.

In over excited condition, the generator terminal voltage should be controlled not to exceed + 5% of the rated voltage by Automatic Voltage Regulator.

(2) Range restricted by stator coil temperature

Restriction by the stator coil temperature may be obtained from constant conditions of the stator current. It becomes a circle which passes through rated point P=1.0 (p.u) with the origin of grid as the center of the circle.

(3) Range restricted by the stator core end part temperature

When the generator is operating at a leading power factor, the flux produced by the rotor is weaker and more flux is able to leak out from the ends of the stator core. When this flux leaks out from the ends of the stator core, it passes through the face of each lamination and causes large eddy currents. These eddy currents can cause excessive heating.

As mentioned before, the continuous operation within ±5% of the rated voltage is prescribed by IEC60034-3.

In under excited condition, the generator terminal voltage should be controlled not to exceed -5% of the rated voltage by AVR.

Moreover, in this condition, many auxiliary motors connected with the bus conductor in the power station may face torque shortage, or over current of the rated value.

Although the motor can generally permit the voltage drop up to 10% at the rated frequency according to IEC60034-1, when voltage drop at the power cable is taken into consideration, it is desirable to control the voltage in 5% of degradation as a limit.

In addition, low generator terminal voltage may cause low voltage of control power supply causing wrong activation of control devices, and low voltage of motor power causing lack of torque due to low voltage of house bus..

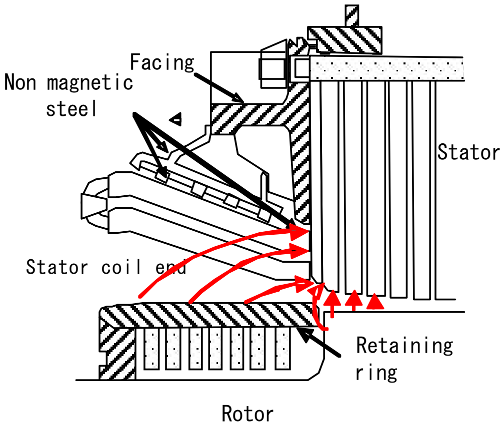


Figure 262-2 An example of magnetic flux at generator stator core end

(A)Range restricted by generator steady state stability

Steady-state instability occurs where there is too much impedance from the plant to the load especially in under excited condition. (Low excitation) During unstable conditions, generators may slip and lose synchronism. To prevent this, it is necessary to reduce the impedance of the generator and transmission line.

Namely, the generator short circuit ratio should be specified considering power system requirements and reactive power operation range although "not less than 0.35" is specified in IEC60034-3.

(B)An example of operation range

AVR excitation controls, such as over excitation and under excitation limiters, are needed to prevent unacceptable conditions being imposed upon the generator. The over excitation limiter prevents the AVR from trying to supply more excitation current than the generator field can withstand. The over excitation limiter limits excitation current before the generator field overvoltage protection operates. The under excitation limiter prevents the AVR from reducing excitation to such a low level that the generator is in danger of losing synchronism, exceeding machine under excitation capability restricted by the stator core end part temperature. The over excitation and under excitation limiters are set to prevent the generator from operating outside its capabilities.

Control details are referred to Article 251 of this guideline..

Article 263. Vibration

1. Amplitude of vibration

Vibration of a turbine generator should not exceed the allowable value, because excessive vibration increases the fatigue of the material and causes failures such as destruction of the rotating parts by the contact between the rotating and the stationary part.

This allowable value should be shown from the manufacturer. However, it is desirable that theses values do not exceed following values, as stipulated in Article 33-1-2 in the design guideline of steam turbine because a turbine and a generator is connected.

Table 263-1 Warning Value of Vibration (Total amplitude value, Exceeding 400MW) (Recommendation)

Measuring Point	Rated Speed	Warning Value	
		Rotating Speed< Rated Speed	Rated Speed ≦Rotating Speed
Bearing	3,000rpm or 3,600rpm	0.075mm	0.062mm
	1,500rpm or 1800rpm	0.105mm	0.087mm
Rotor Shaft	3,000rpm or 3,600rpm	0.15mm	0.125mm
	1,500rpm or 1800rpm	0.21mm	0.175mm

2. Cause of the vibration

Cause of the vibration may be due to lubricating problem, such as improper temperature of bearing lubricating oil (improper viscosity), or contact between rotating and stationary parts, or poor installation, or improper alignment, or weight unbalance, or abnormal condition of bearings . Therefore, during assembly, installation should be adjusted carefully and precisely.

Moreover, in the case of generator, current flows in the rotor and electromagnetic force is applied to the rotor; therefore, air gap unbalance or thermal unbalance in the rotor coil may cause vibration.

Thus, there are many factors of causing generator vibration, therefore advices from the manufactures are recommended to be taken, considering factors described above.

3. Operation

During start-up, rate of speed increase is recommended to be considered to pass critical speed quickly.

Article 264. Prevention of an explosion of hydrogen

1. The "Appropriate measures" stipulated in Article264 of operation technical regulation means measures that the hydrogen purity in the generator do not exceed 4% (in air by volume, %) of the lower flammable limits and not be below 75% of the upper flammable limits always. This is the reason Article 256 stipulates hydrogen purity.
2. The hydrogen cooled generators should be conformed to the following items.

(1) Alarm systems

When hydrogen purity decreases to the range of approximately 85 to 90%, an alarm system is activated so that the generator maintains safety.

When hydrogen pressure fluctuates, an alarm system is activated so that the generator maintains safety.

(2) Seal oil pressure

As stipulated Article 257 of this guideline, hydrogen leak to outside of the generator should be prevented by maintaining seal oil pressure value.

(3) Hydrogen replacement

To prevent a hydrogen explosion, hydrogen of a generator should be replaced by inert gas such as CO_2 .An example of hydrogen replacement is shown in Figure 264-2.

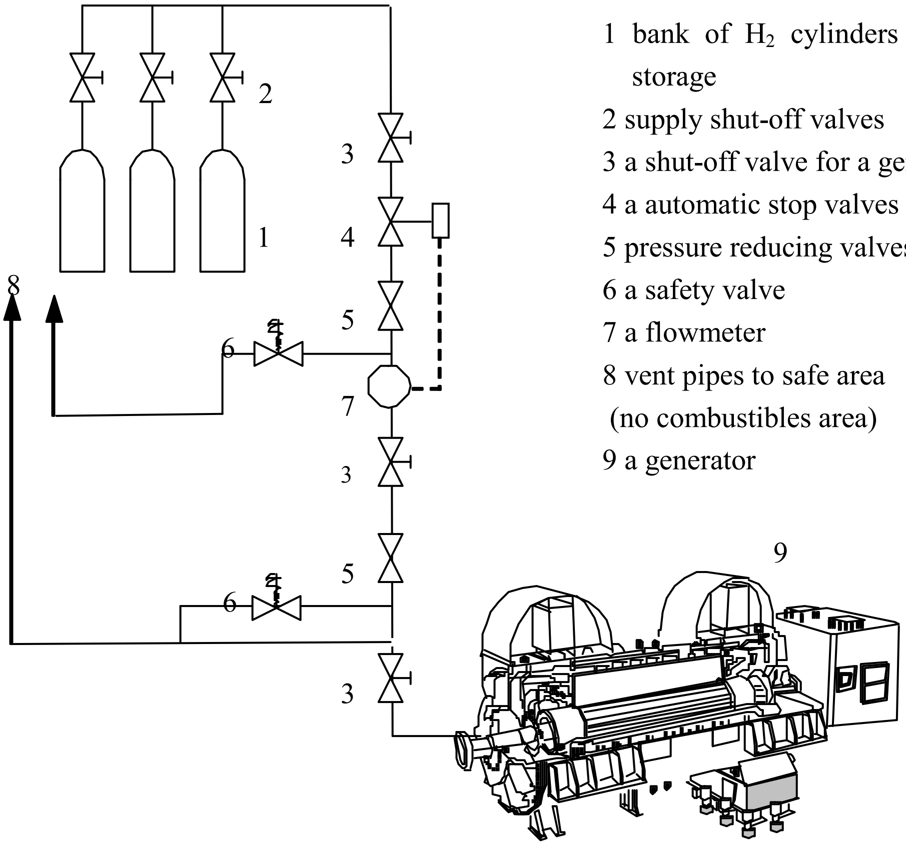
There should be no direct displacement of air by hydrogen.

The purging should continue until the concentration of the purging gas reaches the safe level when monitored at the discharge pipe.

According to established international practice, this is achieved when the content of the monitored inert gas is between 75% and 90% by volume.

During purging operations, all kinds of electrical testing on the generator should be prohibited until the final conditions of air or hydrogen in the generator have been reached.

If a compressed air supply is used to remove the inert gas, the connection to the air supply should be such that air cannot enter the generator except when it is required to do so for this purpose. This can be arranged by suitable interlocking between the supply valves for air, inert gas and hydrogen, or by having an easily disconnectable air pipe. This pipe should be connected only while the inert gas is being removed, and should be disconnected immediately afterwards.



1 bank of H_2 cylinders or bulks to storage
2 supply shut-off valves
3 a shut-off valve for a generator
4 a automatic stop valves
5 pressure reducing valves
6 a safety valve
7 a flowmeter
8 vent pipes to safe area
(no combustibles area)
9 a generator

Figure 264-1 An example of H_2 supply unit

	Initial state	Air emitting and CO_2 charging	CO_2 emitting and H_2charging	H_2 charging (pressurizing to 0.42MPa)	H_2 emitting and CO_2charging
	Air 100% →	CO_2 75% →	H_2 90% →	H_2 98% →	CO_2 90%
existing gas	Air 100%	Air 100%	CO_2 75%	H_2 90%	H_2 not less than 98%
gas to replace	-------------------	CO_2	H_2	H_2	CO_2
required gas purity in a generator	-------------------	CO_2 75%	H_2 90%	H_2 not less than 98%	CO_2 90%
required gas volume in a generator	-------------------	CO_2 1.5VG	H_2 2.0VG	H_2 4.2VG	CO_2 2.0VG

VG : a generator volume

Note: These values are only reference and should be submitted from the manufacturer.

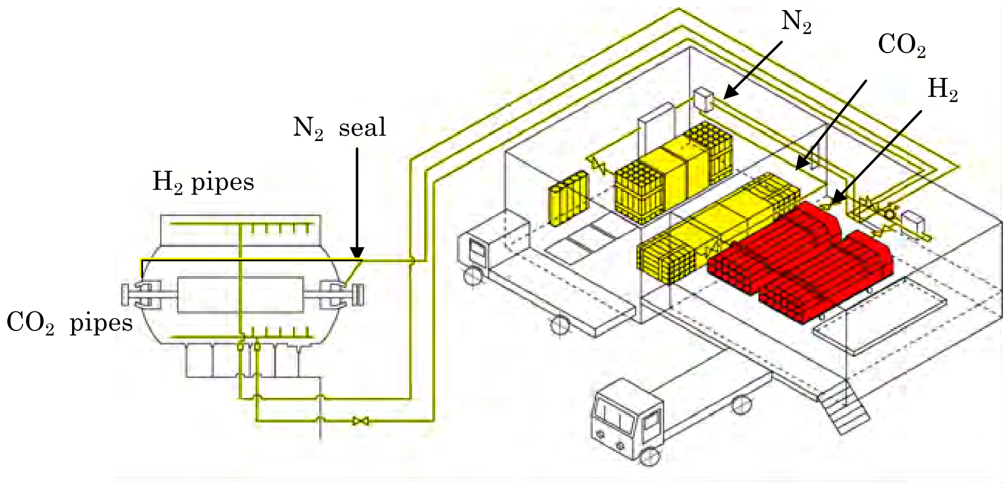


Figure 264-2 An example of hydrogen replacement

Chapter 3 Electric Motor

Article 265.

(Nothing)

Article 265-a1. General

Article 264of technical regulation (operation and maintenance) requires "Appropriate measures for the motors" to prevent damage to the motors.

1. Design

(1) Starting device

In thermal power plants, three-phase squirrel-cage induction motors are widely used due to high reliability and low cost, although their starting current is large.

In the case of squirrel-cage induction motors, it is difficult to limit the starting current, which is approximately from 400 to 800% of full-load current, by connecting resistors in the secondary windings.

Therefore, starting device may be used in the primary circuit according to the condition.

For example, starting device may be used when voltage dips by starting current is so significant that other equipment is shut down. (Approximately 10% dips)

(2) Protection

The electric motors should be protected from overload by fuses, or circuit breakers, or thermal relays, in order to prevent burnout. Overload protection should not activate by starting current. Therefore, protection coordination between starting current and overload current should be performed.

Moreover, electric motors should be protected depending on the operating and design conditions.

For example, if electric motors have a risk of causing hindrance or damage significantly by the open phase of the power supply, protective equipment against loss of phase (if it does not hinder, the alarm device) may be equipped in order to prevent burnout. (Recommendation)

In the case of squirrel-cage induction motors, if the motor speed is controlled, voltage of the motor should be controlled to prevent heat by over-flux. An inverter controller may be equipped with this function.

As for protection, Article 240-3 of design guideline is referred.

(3) Installation

As for installation, Article 16-1 to Article 16-15 and Article 242-1 to 242-5 of design guideline is referred.

In addition, efficiency of motors is recommended to be considered because power consumption by motors is the dominant in electric power consumption. Therefore, initial investment for high efficiency machines contributes to cost cut and environment preservation. Initial cost difference from low efficiency machines may be recovered and may be gained additional benefits depending on the operating condition.

1) High efficiency motor

Motors with long operation hours are recommended to be specified with high efficiency according to IEC 60034-30.

2) Inverter (Speed control)

In a power station, pumps, fans etc are driven by motors. These process values may be controlled by following methods.

a. Dampers or control valves

This is a simple method; however, there is a lot of power loss.

b. Blade or vane control

Radius of moving blade or inlet guide vane is changed.

c. Speed control of motors

In the low speed range, this method by an inverter decreases electric power consumption significantly because power consumption of the load such as fans, pumps and blowers can be reduced to the value which is proportional to the cube of the motor speed, cutting power loss of dampers or control valves. When advanced control is necessary, "vector control", is used.

However, in the low speed, cooling capability of motors decreases significantly, therefore, advices from the manufacturer are recommended to be taken.

In the case of inverter installation, Article 18-1 to 18-2 of design guideline is referred.

2. Operation

(1) Motor start

In the case of squirrel-cage induction motors, the large thermal and mechanical stress occurs in the motors during start-up, as stipulated above. Therefore, the lifetime of the motors depends on number of continuous starts and total number of starts, significantly.

Thus, number of continuous starts and total start number of starts are recommended to be controlled for the security of motors.

Moreover, electric motors of large capacity should not be started at the same time because voltage in the power station may dip significantly.

Significant voltage dip may cause failures such as troubles of control systems.

(2) Normal operation

As for monitoring items, Article 266-a1 is referred.

3. Maintenance

As for maintenance, Article 266-a1 is referred.

Article 266.

(Nothing)

Article 266-a1. Inspection of motor

The fundamental of maintenance is routine inspections in accordance with inspection list items and also supervisory which is performed in the proper period.

This supervisory period and items should be conformed to instruction manuals from the manufacturer.

Table 266 shows an example of inspection items (during operation)

As for disassembly inspection, Article 173 of inspection guideline is referred.

Table 266 An example of inspection items (during operation)

Items
1 Operating condition 1) Voltage, frequency 2) Load current 3) Noise 4) Vibration 5) Temperature 6) Frame, bearing 7) Coil 8) Odor 9) Ventilation condition 10) Surrounding conditions

Items
2. Appearance. 1) Frame 2) Terminals and connection 3. Bearings. 1) Noise 2) Vibration 3) Temperature rise 4) Bearing temperature 5) Amount of oil in bearing oil tanks 4. Lubricated condition 5. Existence or nonexistence of alarms

Chapter 4 TRANSFORMER, AUTO-CONNECTED TRANSFORMER, AND OIL REACTOR

Article 267. General provisions

For the operation of transformer and oil reactor, their stable and durable operation must be maintained by the following items.

(1) Monitoring temperature

During inspection

- The present temperature shall be monitored. It is checked whether it is the appropriate temperature as consider present load and outside temperature. It should be managed not to exceed the maximum temperatures that are specified in manufacturer's instructions and management unit's operation manual.
- The present temperature shall be monitored. It is checked whether it is the appropriate temperature as consider present load and outside temperature. It should be managed not to exceed the maximum temperatures that are specified in manufacturer's instructions and management unit's operation manual.
- The maximum temperature shall be recorded during overload operation was performed, it is checked that whether the special attention level is not exceeded.

(2) Monitoring loaded condition and voltage level

- During inspection, present load and voltage level shall be recorded, and it is checked that whether they are in the proper range.
- During operation, current and voltage of transformers shall be recorded once every 02 hours, the values must be within the limits of the manufacturer.

In addition, if the range is exceeded, warning is emitted.

(3) Examination criteria of insulating oil quality and insulation characteristics

For the quality of the transformer oil, the mineral insulating oil shall be used. Mineral oil is the high molecular compound which is refined from crude oil and its main ingredient is hydrocarbon. The main characteristics of the mineral insulating oil as well as the management criterion about insulating properties of the insulation oil are shown in the following table 267-1 and 267-2.

(4) Keep cooling facilities for cooling, voltage regulator and other facilities in good condition.

- In cooling facilities, it is checked whether there is stench, overheating, abnormal noise, vibration, oil leakage, etc. during the inspection.
- In a voltage regulator during the inspection;
  + It is confirmed there is not abnormal noise when an electric motor is working,
  + Record the operation frequency, and judged whether the present value is a proper value compare with the past trend.
  + Judge operation frequency synthetically by considering the past results, switching pattern, etc. The usual value of operation frequency is about 30 times per day.
  + Check whether the indicator of the tap instruction device is at the regular position.
- In transformer and reactor, it is checked whether there is abnormal noise and oil leakage, the terminal doesn't change color and generate heat, all of the cooling valve is open completely.

Table 267-1 Main characteristic of Transformer oil (Transformer)

[From ETC's manual]

Inspection item	Nominal voltage of system				
	≤15	**15-35**	**110**	**220**	**500**
Breakdown Voltage(kV/2.5mm)	25	30	55	55	60
Dielectric dissipation factor at 90 degrees C (%)	-	-	7	7	5
Acidity (mg_{KOH}/g_{oil})	0,25	0,25	0,20	0,20	0,15
Water Content at 20 degrees C (ppm)	-	-	30 25*	25	20
Acidity (mg_{KOH}/g_{oil})	0.014				

* For 110kV transformers are protected with plastic film

Table 267-2 Main characteristic of Transformer oil (Tap changer)

[From ETC's manual]

Inspection item	Nominal voltage of system		
	≤ 35	**110-220**	**500**
Breakdown Voltage(kV/2.5mm)	25	40	50
Water Content at 20 degrees C (ppm)	-	35	30

Article 268. Firefighting facilities

In order that the fixed firefighting equipment operate normally in the necessary cases, the following items shall be checked in the daily inspection.

- Check whether there is deformation or damage in the fire-extinguishing cylinder, piping, and valve.

- Check whether there is wear or damage in the cover bolt of the fire-extinguishing cylinder, etc.
- Whether the power supply SW and the automatic and manual change SW are in the regular position
- Check whether the voltmeter and the pilot light display the regular state. Oil spill prevention equipment shall be added to the oil draining tank of the transformer in outdoor. Though rain water is exhausted by a drainage pump, it shall be stopped and prevent oil to leak out after oil was detected. In order that the oil spill prevention equipment operates normally in the necessary cases, the items below must be inspected in the daily patrol.
- The control panel of the drainage pump shall be checked whether the current, the automatic and manual change SW and the pilot light are in regular position or state.
- In addition, the start-up test of the pump shall be done 1 time per month, and it is confirmed that it starts normally.
- The start-up test of the pump of the oil detection device shall be done every month, and it is confirmed that it starts operating normally.

Article 269. Numbering and signing

As stipulated in Technical Regulation.

Article 270. Power supply for cooling system

As stipulated in Technical Regulation.

Article 271. On-load tap changer

The operation frequency of the on-load tap changer shall be recorded, and judge whether the present value is the proper value compare with the past trend.

The usual operation frequency of the transformer for power distribution is 30 times per day. The overall judgment is necessary in consideration of the past achievement, switching pattern, etc.

The insulation oil of on-load tap changer deteriorates due to the switching operation in the oil, so the breakdown voltage test shall be carried out periodically and every switching time instructed by the management unit.

The on-load tap changer must also bear the change frequency specified by the manufacturer.

Article 272. Cooling system

As stipulated in Technical Regulation.

Article 273. Forced cooling

As stipulated in Technical Regulation.

Article 274. Auxiliary Oil level

As shown in the ministerial ordinance, the amount of oil in conservator of the transformer shall correspond to the oil temperature in the transformer.

In normal operation, insulation oil in conservator of transformer shall be at the level equal to the corresponding oil temperature in transformer, which specified by the manufacturer.

If the oil leakage occurs and the oil level decreases due to something trouble, it shall be necessary to give a warning at the oil level 1 and to trip the transformer at the oil level 2. The oil level 1 and the oil level 2 should be instructed by the management unit of the transformer based on the values specified by the manufacturer.

Article 275. Overload of transformer

Although actual overload limit and duration of transformer shall be based on the operation manual and instructions of manufacturer as shown in the technical regulation, the overload operation of transformer, the current and temperature limitations, provided in IEC are shown in the following table for reference.

(Reference) [source: IEC60076-7 Loading guide for oil-immersed power transformers)

Table 275 Maximum Current and temperature limits applicable to loading beyond nameplate rating

Types of loading	Distribution transformers (*1)	Medium power transformers (*1)	Large power transformers (*1)
Normal life expectancy loading *2			
Current (p.u.)	1.5	1.5	1.3
Winding hot-spot temperature and metallic parts in contact with cellulosic insulation material (degree C)	120	120	120
Other metallic hot-spot temperature (in contact with oil, aramid paper, glass fiber materials) (degree C)	140	140	140
Top-oil temperature (degree C)	105	105	105
Long-time emergency loading *3			
Current (p.u.)	1.8	1.5	1.3
Winding hot-spot temperature and metallic parts in contact with cellulosic insulation material (degree C)	140	140	140
Other metallic hot-spot temperature (in contact with oil, aramid paper, glass fiber materials) (degree C)	160	160	160
Top-oil temperature (degree C)	115	115	115
Short-time emergency loading *4			
Current (p.u.)	2.0	1.8	1.5
Winding hot-spot temperature and metallic parts in contact with cellulosic insulation material (degree C)	*5	160 *5	160 *5

Types of loading	Distribution transformers (*1)	Medium power transformers (*1)	Large power transformers (*1)
Other metallic hot-spot temperature (in contact with oil, aramid paper, glass fiber materials) (degree C)	*5	180 *5	180 *5
Top-oil temperature (degree C)	*5	115	115

NOTE

*1 : The temperature and current limits are not intended to be valid simultaneously. The current may be limited to a lower value than that shown in order to meet the temperature limitation requirement. Conversely, the temperature may be limited to a lower value than that shown in order to meet the current limitation requirement.

*2 : Normal life expectancy loading

Higher ambient temperature or a higher-than-rated load current is applied during part of the cycle, but, from the point of view of relative thermal ageing rate (according to the mathematical model), this loading is equivalent to the rated load at normal ambient temperature. This is achieved by taking advantage of low ambient temperatures or low load currents during the rest of the load cycle. For planning purposes, this principle can be extended to provide for long periods of time whereby cycles with relative thermal ageing rates greater than unity are compensated for by cycles with thermal ageing rates less than unity

*3 : **Long-time emergency loading**
Loading resulting from the prolonged outage of some system elements that will not be reconnected before the transformer reaches a new and higher steady-state temperature

*4 : **Short-time emergency loading**
Unusually heavy loading of a transient nature (less than 30 min) due to the occurrence of one or more unlikely events which seriously disturb normal system loading

*5 : The limits on load current, hot-spot temperature, top-oil temperature and temperature of metallic parts other than windings and leads stated in the above table should not be exceeded. No limit is set for the top-oil and hot-spot temperature under short-time emergency loading for distribution transformers because it is usually impracticable to control the duration of emergency loading in this case. It should be noted that when the hot-spot temperature exceeds 140 degree C, gas bubbles may develop which could jeopardize the dielectric strength of the transformer

Article 276. Working mode

As the time to record the load of each transformer, it shall be recorded at three points; at nighttime as light load time, and daytime and lightning peak time as peak load time. The time is provided in the following table. However, each time may be changed according to the situation of load.

Table 276 Time table for recording the load of transformer

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Light load time (Nighttime)	5											
Peak time (Daytime)	14											
Lighting peak time	19	19	20	20	20	20	20	20	20	19	18	18

In addition, the following items are required to record.

(1) Daily output

- Daily output shall be recorded from 0:00 to 24:00 at the electric place where patrol is carried out for 24 hours a day, and from 14:00 on the day before inspection to 14:00 on the day of inspection for the electric place where patrol is not carried out all times.

However, the time of recording shall be from 0:00 to 24:00 for the electric place which is monitored and remote controlled by dispatching office all times.

(2) Maximum power

- The maximum power is considered as the greatest amount of watt hour value per hour among all the electric power value measured in a fixed period, However, in the electric place where the recording instrument is not installed, and which does not always supervised, the estimate amount is considered from measurement record.

Article 277. Check of accident

When the gas detection relay operates, the accident can be detected sooner and the cause of the accident can be found by analyzing the gas generated. The cause of accident is classified as the following.

- Overheating of oil : Hydrogen, methane, ethane, ethylene (H_2, CH_4, C_2H_6, C_2H_4)
- Overheating of insulator : H2, CH4, C2H6, C2H4, CO, CO2
- Electric discharge in oil : H_2, CH_4, C_2H_6, C_2H_4, C_2H_2
- Electrical breakdown of insulator : H_2, CH_4, C_2H_6, C_2H_4, C_2H_2, CO, CO_2

When the flammable gas is detected, above troubles can be considered, and gas analysis in the oil shall be done, interior check shall be executed if necessary. Especially, if acetylene or ethylene gas generated by the arc or partial discharge inside of the transformer is detected, the operation of transformer should be stopped, if needed.

In addition, as the primary factor of the gas volume in the gas detection relay increases when there is no trouble in the other relays, the following items can be considered;

- A rubber bag of conservator is damaged, and air invades the conservator
- The air intake from vacuum limits gasket section of releasing pressure pipe
- The air intake from vacuum limits gasket section of conservator

When gas was detected, it shall be checked whether they are from trouble inside of transformer, and shall be decided if it needs to stop operating immediately.

Article 278. Close electric of transformer

By operating differential relays of the transformer, it is separated automatically from the power system, and other relays (gas detection, impact oil pressure, decrease on oil level etc.) shall be checked. If another TR-related relay works with differential relay of the transformer, it is possible to think that some accidents occur in the transformer.

When only differential relay is operated, it is checked whether it is malfunction by the trouble, magnetization inrush, influencing from outside failures and switchboard work etc. When these causes of failures are clear, the transformer is used immediately.

If it was judged the cause was from transformer, an on-site inspection must be performed, the outlines (existence of influences on the equipment by fire, smoke, gushing oil, and breakage of bushing, etc.) of an accident must be investigated, and the cause must be specified by gas analysis or internal check.

Re-operation of a transformer is permitted after fixing, inspecting and removing the cause of failures of transformer to the normal condition.

Article 279. Oil insulator

Protection of oil inside equipment

There are the following methods to prevent oil in conservator of transformer from exposing directly to outside air.

1. Rubber bag type conservator

A rubber bag type conservator is shown in the following figure. The contact of oil and the air is protected by the rubber sack. Moreover, since oil is filled up to the outer packaging cover side, the oil applies pressure on packing such as a cover, a manhole, a hand hole, and bushing, as a result, it can also prevent invasion of humidity.

The air in the rubber bag is connected to the atmosphere through moisture absorbent breather in order to prevent degradation of the rubber bag.

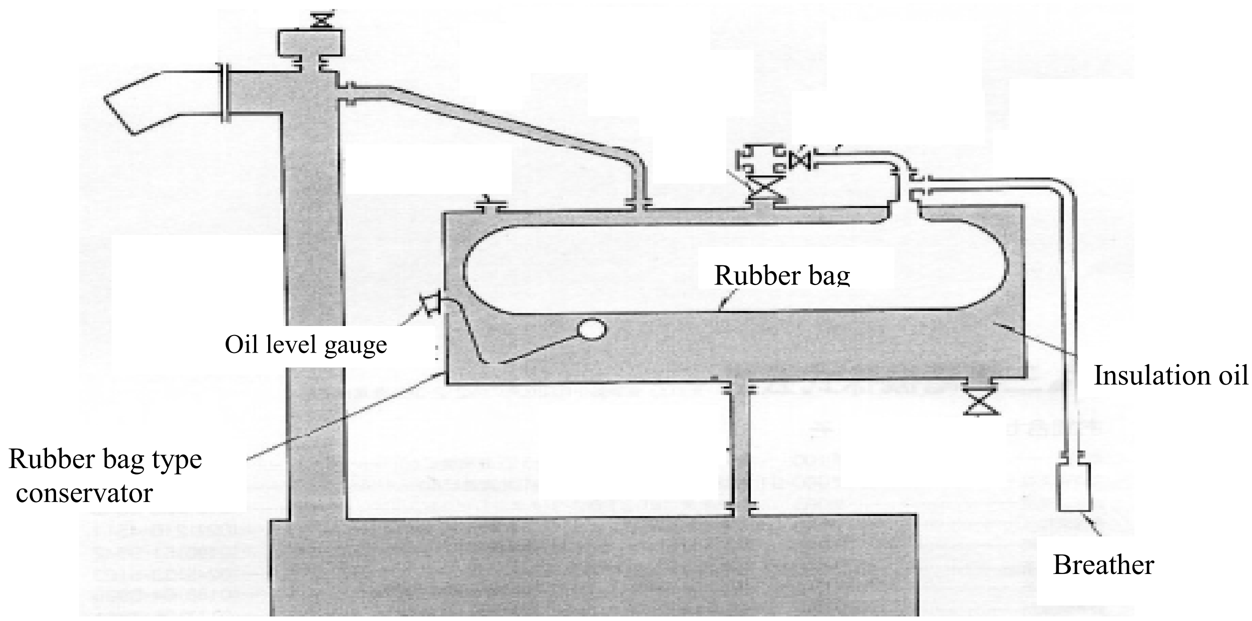


Figure 279-1 Structural drawing of Rubber bag type conservator

2. Diaphragm type conservator

For the diaphragm type conservator, the method of setting rubber film in the conservator to prevent the oil from deteriorating should be applied because the oil should not be exposed to the air. The conservator is similar to the rubber bag type conservator, and the structure is shown in the following figure.

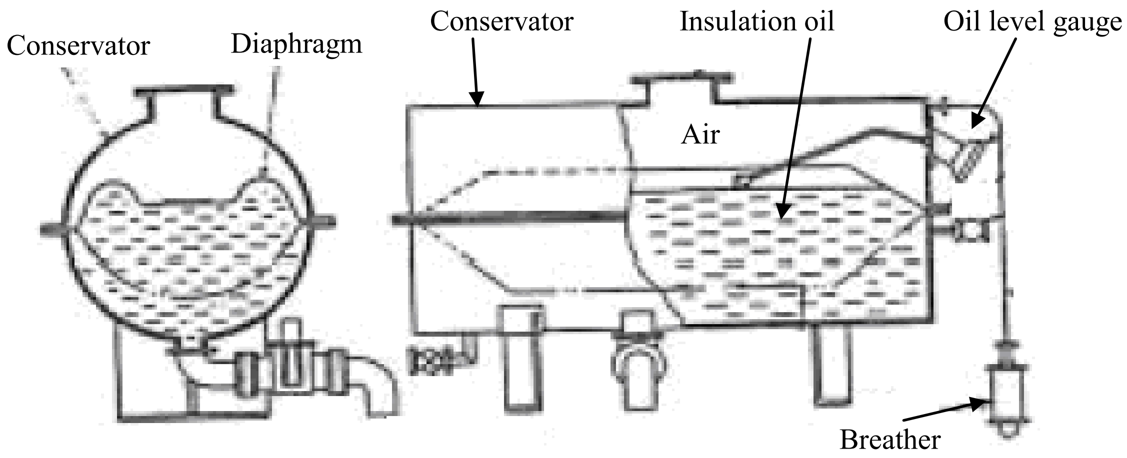


Figure 279-2 Structural drawing of diaphragm type conservator

Article 280. Repairs of the core of the transformer

In case of the repairs of transformer cores, crane device or other appropriate solutions should be used to lift up the inner part or the housing of the transformer according to the weight of transformer and installation situation.

Article 280-a. Passageway for crane truck

When access road is built for crane truck and other transportation used for setting and repairing transformer, the design and examination shall be taken place whether truck can veer on the curve of access, and it is uninfluential to underground installation after having secured the access road to setting equipment beforehand.

Article 281. Inspection of transformer

As stipulated in Technical Regulation.

Chapter 5 DISTRIBUTION NETWORK

Article 282. General provision

For the operation of power distribution network, it must be ensured that it is operated economically and the reliable enough for safety of public and workers. Main items of the operation of distribution network are the followings.

(1) Clarification and preparation of the dispatching order and operation process.

(2) Management of the operation control records.

(3) Monitoring supply and demand condition and the maximum load current.

(4) Monitoring voltage drop, losses and blackout impact.

(5) Balance of power flow in each feeder and phase

Article 283. Exploitation distribution network

As specified in the Technical Regulations.

Article 284. Insulation facilities of Distribution Network

The facilities for lightning are lightning arrestor, ground wire and insulation gap such as strengthening of insulator and ZnO cut out.

Table 284 Recommended places for installation of facilities for lightning

Measurements	The recommended places for the installation
Lighting Arrester	✓ Step Voltage Regulator ✓ Recloser ✓ Both Side of the submarine cable ✓ Tapping point of the SS ✓ High voltage line at every 300m
Ground wire	Above high voltage line
Insulation Gap	Strengthen insulator (Ex. double insulation)
	ZnO cut out
Lightning resistant horn	Along the main road

Article 285. Prevention of the impact from high temperature objects

Refer to article 286.

Article 286. Operating temperature

As it mentioned in the technical standards, a hazardous note should be hanged or a fence should be built around the object that might be over 50 degrees Celsius.

The table below is the maximum temperature of the bus and the connected conductor in a cubicle. There is also raising limitation mentioned in article 87 Volume 3.

In spatial condition, if the open air temperature is over 40C, appropriate temperature management should be done using thermo indicator posted on the bus bar and connected conductor. They shall be attached on the position that can be easily looked from the outside.

To reduce the temperature, it is useful to install compulsion ventilation and to reduce the flow current of the bus bar to shift the load to other feeder.

Table 286 Maximum permissible temperature of conductor and contact part

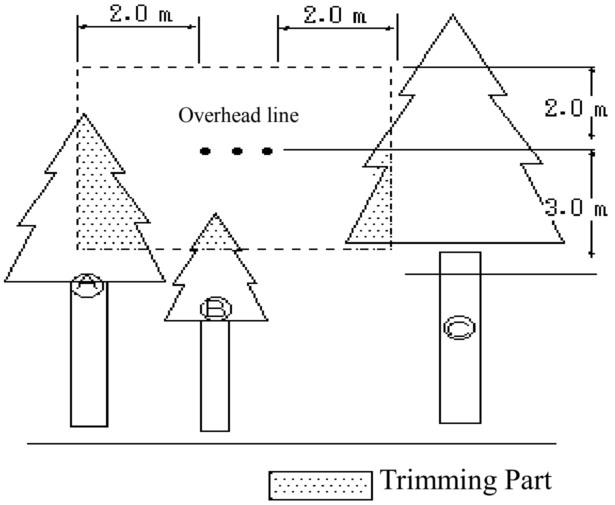
Place		Maximum permissible Temperature [Degrees C]
Bus bar and connected conductor		105
Contact part	Copper contact	75
	Silver contact	105
Joints of terminal and conductor	Copper and copper	80
	Between Tin solder platings	85
	Between silver platings	105

In case of dew inside a wall and surface of the equipment, it is recommended to install the space heater to raise the temperature in the cubicle. It is also effective to install a dehumidifier and desiccants materials in the cubicle.

Article 287. Protection of intrusion

To keep the safety distance between the equipment and tree is the effective prevention measures against the obstacles such as animals and trees. Tree trimming should be done periodically considering the branches grow.

When the target area is in a national park, follow the authority’s instructions to have the permissions.



For example:
Tree trimming range for OPL-35kV

Figure 287 Safety range of OPL for tree

Check periodically to make sure:

- If trees would not touch it because of the strong wind.
- If trees would not grow to the conductor until the next patrol.
- If branches which grow over the conductor would not hang down on the conductor due to the strong winds, heavy rain or snow.
- If there is not dead trees which easily fall down around the conductors.
- If protection pipes would be effective until the next patrol.
- If there is no scratch on the conductor.
- If the visibility of the conductor is not reduced.

Below table shows the general growing length of the trees.

Table 287 Growth rate of trees

Tree species	Growing length a year
Cedar, cypress, pine	Tree age 1-20 years：70cm / year Tree age 20-40 years：35 cm / year
Oak	60 cm / year
Paulownia, Poplar	80 - 90 cm / year
bamboo	200 cm / week

Article 288. Protection of cable trough

Regarding cable troughs and ducts, drainage pump is used to pump out the water. When there are facilities with possibility of oil leakage around it, an oil detector should be installed. The pump should be locked and the alert should be sounded if the detector found oil leakage.

The below listed items should be checked in the patrol

- Check there is no garbage in drainage pit and pump, and confirm it operate properly once a month
- Check the function of oil detector and confirm the proper operation of lock and warning.

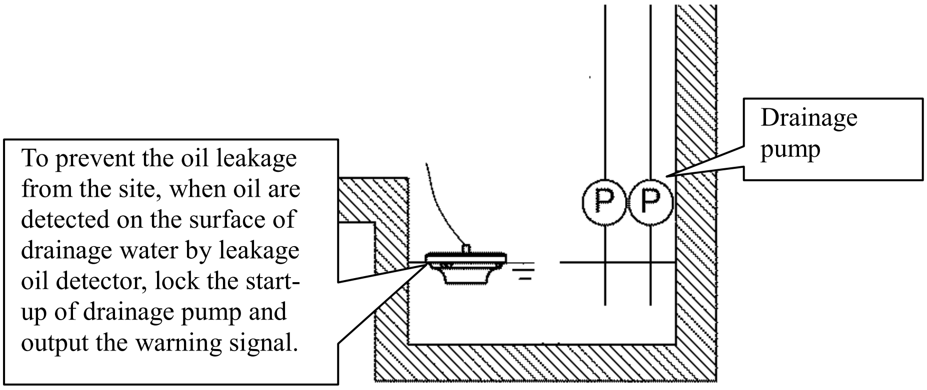


Figure 288 Drainage Pump and leakage oil detectors

Article 289. Oil insulator level

As insulation oil expands and shrinks according to its temperature, the level of the oil surface is fluctuated. The proper management of the oil level should be following the temperature and level curve, but for the tank without this curve, check the oil level of the oil level measurements, and confirm the oil level is appropriate by the level measurements.

And if there is not enough oil in the facilities, conduct the site survey related to the oil leakages, and the facilities should be stopped if the insulation are less than the minimum requirements.

Article 290. Check of heating at joints of bus-bars

The maximum temperature of the connection point of the conductor and bus bar in a cubicle are in article 7 and article 87 in Vol.3. A thermo label should be posted on the main part of the connection and they should be monitored during the site patrol.

Especially during the peak load season, the temperature of the connecting point should be monitored by a infrared camera and confirm the overload conditions

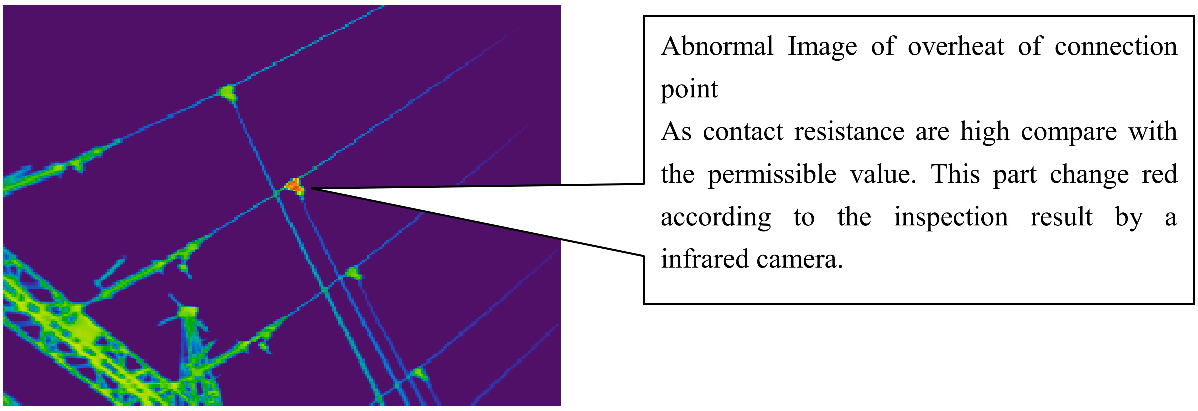


Figure 290 Abnormal Image of overheat of connection point (by Infrared camera)

Article 291. Interlock

Interlocking may be necessary to ensure the correct sequence of operation of equipment, to prevent danger to personnel and to prevent damage to the equipment.

Interlocking may be achieved by both electrical and mechanical methods. In the event of the loss of power supplies, electrical interlocking schemes shall be designed to fail safely.

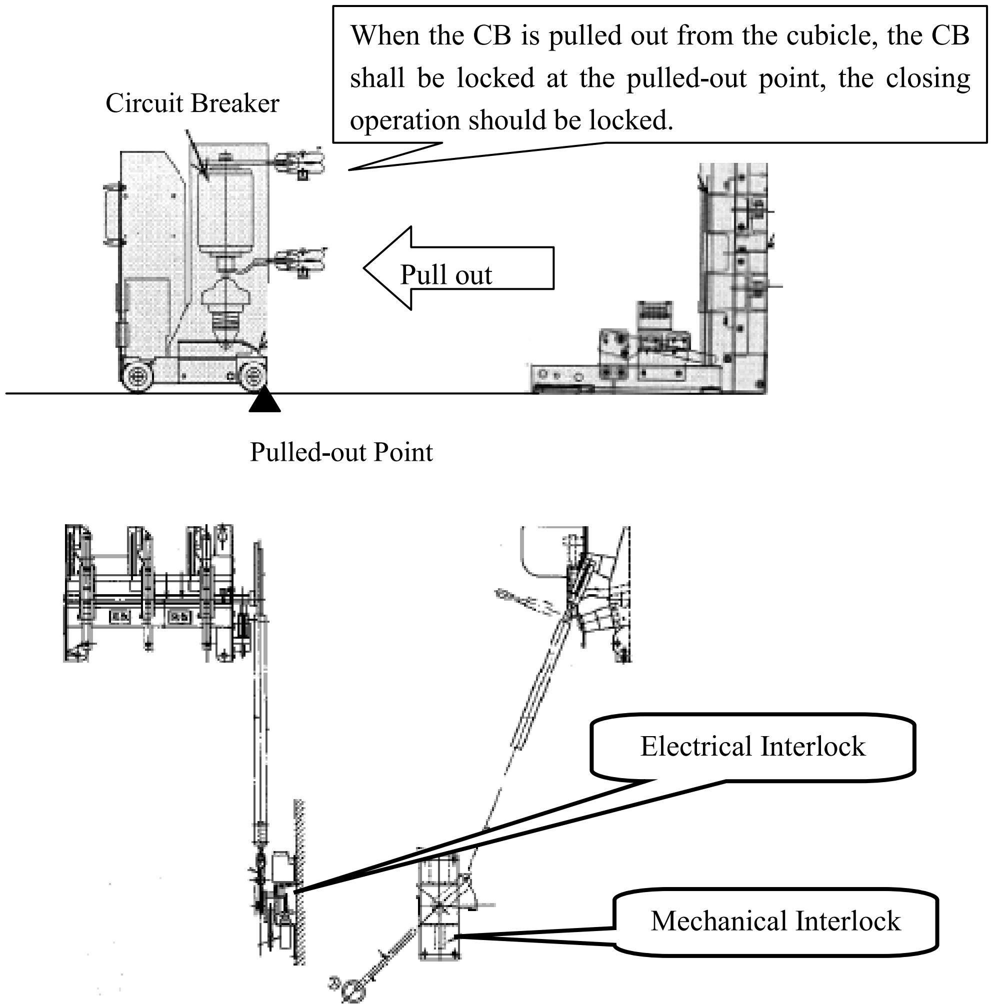


Figure 291 Example of interlock system

Article 292. Prevention of unauthorized operation Protection action error

As cubicles are supplied high voltage power, it should not be built in the place that public persons can touch them easily. The cubicles should be surrounded by fences, or built in the safe area such as inside the electric building or the rooftop. Additionally, to lock the door is recommended to prevent the public persons from opening them easily.

Basically the cubicles should be built at least 3 m away from the outer wall. If it is not satisfied, outer wall should be non- flammable.

Article 293. Ground distribution network

During the electric outage works, watchman should be dispatched to the sites, and plate indicates “DO NOT CLOSE DURING WORKING HOURS” which is locked with a key should be put on the switchgear.

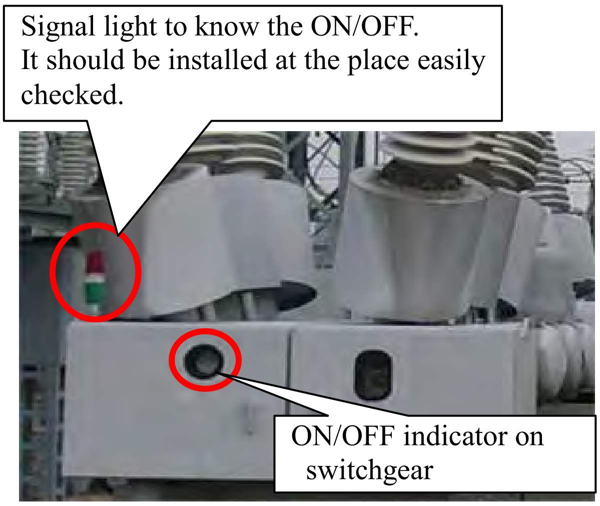
After opening the switchgears on the high voltage line, workers should check the line with an electric checker, and earth it firmly by the short earth to prevent electric shock.

Article 294. Indicator for switching position of breakers

A facility shall be provided to indicate the contact position of the interrupting or isolating equipment (including earthing switches). The method of indication in accordance with the equipment standard shall be specified by the user.

The position indicator shall provide an unambiguous indication of the actual position of the equipment primary contacts.

The device indicating the open/close position shall be easily visible to the operator.



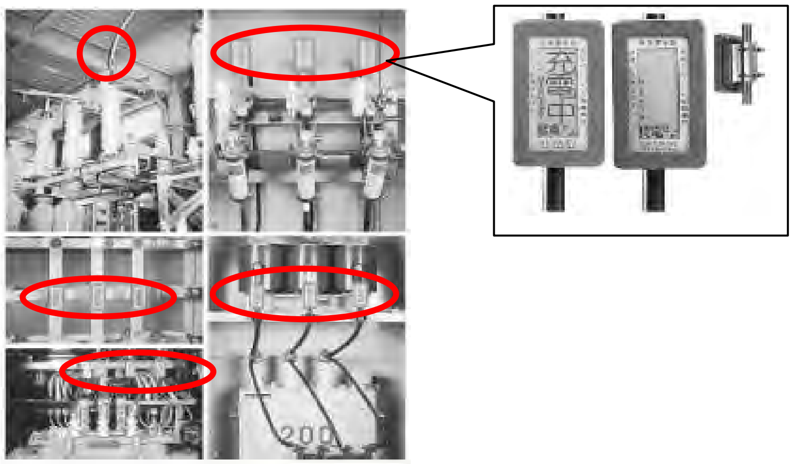


Figure 294 Image of the indicators of switch gear

Article 295. Safety of operation of distribution network

The person responsible for the safety works should require the workers to carry insulation protection equipment and to use insulated instruments. When the workers are ordered to put these protective equipment by the supervisors, they should obey the orders.

Article 296. Inspection and testing

Visual inspections and tests should be conducted from the ground to see the surrounding situation and the condition of the equipment. If it is difficult to judge the conditions from the ground, climb the pole to confirm the condition in detail.

Table 296 Inspection and testing for pole

Equipment	Inspection and testing
Concrete Pole	Check ground situation(loosen, land sank and cave-in) Check the pole condition(cracks, slope and tree touching)
Iron Pole	Check rust, damage, deformation and corrosion.
Wire	Lack of minimum clearance, sag and connection
Transformer	Check the body(rust and oil leaking) Check the bushing(damage, corrosion)
Cable	Check the damage of the outer insulator

Article 297. Maintenance and periodic overhaul

As specified in the Technical Regulations.

Chapter 6 BATTERY SYSTEM

Article 298. Operating voltage

When the following cases occur, the battery system should supply the regulated voltage to the DC bus-bar by the charging equipment without intercepting the power supply, and automatically separate the battery from the circuit.

1. When overcurrent occurs in the battery

When fault occurs in the charging equipment, the fault point should be automatically separated from the circuit without influencing the function of the battery.

Article 299. Inspection

In order to confirm the soundness of new battery system, the in-progress inspection provided in the technical regulation in the Article 39 of section 2 in the volume 5 and the additional inspection (if necessary) should be carried out.

Article 300. Ventilation of battery room

In order to evacuate hydrogen gas generated from the battery during the charge and discharge process, it is necessary to install the ventilation system in battery room of the power plant and the substation according to the installation criteria provided by manufacture in the local regulations and the guidelines in the Article 156 of section 6 of chapter 3 in the volume 3.

Article 301. Control voltage

When an earth-fault occurs in the DC circuit, it shall be detected the fault point promptly, otherwise if the earth fault of remaining pole occurs, a short circuit phenomenon would occurs.

In case that equipment that an earth-fault has occurred can be limited, and DC power supply system is a dual system, the normal equipment that connected to abnormal DC power supply shall be switched over from abnormal DC supply to normal one. Furthermore, equipment that is suspected of earth-fault shall be cut the power supply (if possible) to detect the fault point.

Article 302. Signing and numbering

Refer to the guidelines on the Article 159 of section 6 of chapter 3 in the volume 3.

Article302-a1. Temperature of battery compartment

In general, as for the cell reaction of the battery, the higher temperature of a battery cell is, the more corrosion reaction of the pole plates and the capacity of battery increases. On the contrary, in case of low temperature, it becomes the opposite tendency.

Therefore, it is recommended that the temperature of battery compartment is regulated at 25 degrees Celsius because a battery cell is designed to live the longest at 25 degrees Celsius. In addition, when it is difficult, room temperature shall be regulated from 10 degrees Celsius to 30 degrees Celsius.

Chapter 7 OVERHEAD POWER LINES (OPL)

Article 303. Repair and overhaul (deleted)

Article 304. Implementation of repair and overhaul

1. Implement of repair and overhaul

In case of repairing overhead lines, the cause of faults and abnormal phenomenon shall be analyzed precisely at first, repair according to its cause need to be carried out after that. In repairing the faults,

In addition, the method of repair or overhaul, consider the remaining life of overhead lines, should select the most effective and economical way. The method shall be selected in consider with the effective period of them, because some of effective methods in short term may promote the deterioration of facilities in long term depend on the actual situation.

2. Interval of overhaul

The owner shall, based on periodic inspections of overhead lines, determine a timing and methods of overhauling each facility, and draft the concrete plans of overhaul, and carry out according to the plans. The overhaul plans need to include methods, intervals and locations each equipment.

- Method: replacement or fix etc. The better overhaul method is selected by comparing the economics and reliability of each equipment. Typical overhaul methods on each equipment are shown table below as reference.

Table 304 Sample methods of maintenance and repair each equipment

Equipment	Conditions of equipment	Maintenance and repair
Reinforced concrete pole	Crack	Waterproof painting
	Degradation, damage	Reinforcing, reconstruction
	Inclination	Fixing slope, reconstruction
Steel pipe pole	Rust of steel	Antirust painting
	Degradation, damage	Reinforcing, reconstruction
	Inclination	Fixing slope, reconstruction
Steel tower	Strain of member	Fixing strain, reinforcement, replacement
	Loosening or omission of bolts	Fastening of bolts, installation
	Rust of member or bolts	Waterproof painting, replacement
	Inclination	Reconstruction
Stay	Loosening, rust or corrosion of wire	Fastening of wire, replacement
	Deterioration of ground near basement	Compaction of ground, addition of stay
	Rust or corrosion of rod	Antirust painting, replacement
	Rust or corrosion of accessories	Antirust painting, replacement
Insulator	Insulation failure	Replacement
	Breakage, damage	Replacement
	Corrosion of metal parts	Replacement
	Pollution	Cleaning
Line hardware	Corrosion, damage	Replacement
	Loosening, abrasion	Fastening, replacement
Power conductor lightning conductor	Strand loosening, arcing track, strand snapping	Winding armor rod, compression joint sleeve, replacement
	Corrosion, damage	Replacement
	Vibration	Exchange of type of damper, installation of damper

Equipment	Conditions of equipment	Maintenance and repair
Accessories of conductor	Loosening, abrasion, corrosion, damage	Fastening, replacement
	Discoloration or corrosion of joint sleeve	Replacement
Foundation	Deterioration of ground	Reinforcement, relocation, re-routing
	Outflow or inflow of sediment	Filling, retaining wall
	Degradation or crack of concrete	Replacement of concrete, crack repair
Grounding conductor	Snapping	Re-connection, replacement
	Abnormal condition of clasp or conductor cover	Replacement

- Interval: Referring to the results of periodic inspections, intervals of overhaul shall be set within the expected duration that it is difficult to ensure the lowest expected performance value (the mechanical and electrical strength) of each equipment.
- Location: it is necessary to carefully consider the location of equipment, since the interval of overhaul may be different by aging equipment, the surrounding environment (air temperature, precipitation, the number of thunder day and the distance from sea) of overhead lines and the method of previous overhaul.

3. Synchronized work of maintenance and repair

In case that maintenance and repair of equipment are planned in the same scheduled outage area, they should be considered synchronizing.

In planning the maintenance and repair, it is necessary to be considered shortening of scheduled outage duration and the cost and safety of works.

Article 305. Implementation of design

The design of overhead lines shall reflect the natural conditions such as climate, topography, geological feature and surrounding environment (the height of trees and the distance from sea in the traversing area), since overhead lines are affected the natural environment.

Therefore, the designer of construction should survey and communicate the above mentioned conditions to power company and electric administration enterprise. The main factors in the construction design as follows :

Table 305 Main factors in the construction design

Natural condition	Natural phenomenon	Main design factor
Climate	Wind, rain, thunder, snow	The strength of poles or towers, the strength of conductors
Topography, geological feature	the gradient of ground, the strength and the depth of bearing ground	The figure and the strength of basement
Surrounding environment	The height of trees	The height of poles or towers
	The distance from sea	The insulation strength of insulators

Article 306. Management of materials

Technical materials are relevant documents in article 249 in this Regulation.

Article 307. Checking site

Power network units shall watch over construction sites to confirm whether there is a problem or defect in site works and anticipated situations after site works.

Before starting site works, construction units shall explain the summary of construction works to power network units and communicate the schedule for power network units to watch over site works.

Especially, in places near power plants or substations , it is important to confirm whether there is a problem in construction works and operating transmission and distribution lines, since there are many power lines.

1. Contents of the prior explain
    - a schedule of site works
    - a route of overhead lines
    - a expected problem
    - a range of site works (in case of places near operating power lines)
2. Samples of expected problems
    - A foundation of an operating transmission line is destroyed by the machine used in the earth excavation.
    - Electric shock may occur, because the distance from live parts of operating overhead lines to parts of constructed overhead lines and construction machines is not sufficiently.
    - Power network units are obstructed to go to maintenance because of closed to vehicular traffic in construction works.

Article 308. Safe protection for power network project

Power network management units shall follow the Decree “Protection of safety of high-voltage power grid works (106/2005/ND-CP&81/2009/ND-CP)”.

1. Areas applied safe protection for power network projects

Population quarters, public rally places, industrial parks, hi-tech parks, export processing zones, important defense or security works, historical-cultural relics and scenic places already classified by the State : Technical Regulation Vol. 1.

2. Safety protection
    - Enhanced strength of poles, foundations, conductors and insulators.
    - Raising the height of conductors.
3. Shared information with other agencies and organizations

Table 308 Shared information with other agencies and organizations

Other agencies and organizations	Deadline	Shared information
Local state management agencies in charge of electricity activities and power use and their superior agencies according to regulations	—	Encroachments upon safety corridors of high-voltage power grid works
Managing units or owners of trees	Five working days in advance	The felling or trimming of trees
Owners of trees (Absence; local commune-level Peoples Committees)	Before felling trees	The number of trees to be felled promptly
Organizations or individuals using land where underground cable lines run through or overhead lines stretch (Absence; Local commune-level Peoples Committees)	Three days in advance	The task of periodical repairs
	Before repair	Irregular repairs prompted by incidents

4. Solutions to prevent violation
    - Power network management units check the safety corridors of high-voltage power grid works under their management in order to promptly detect acts of violating regulations on protection of safety of high-voltage power grid works. When the units detect acts of violation, the units request violators to immediately stop their acts and report thereon to and coordinate with local competent state agencies for making written records on, and handling of such acts of violation.
    - Power network management units check, periodically repair and maintain overhead lines. Overhead ines stretching over dwelling houses or projects shall not overload.

Article 309. Information of damage and compensation

If overhead lines pass through cultivating area (plantation, a forestation yard, field, garden, etc.), repair workers may ruin farm crops and plow land, when repairing and recovering are conducted. Power network units shall explain expected damage and the reasonable compensation to relevant farmers carefully to prevent troubles before the works.

Article 310. Handling trees in and out of the safety corridors

If near the fire line may appear some problems such as discharge or melted by the heat. Flammable materials (trees, garbage, etc.) must be removed to prevent catches fire line.

The overhead lines are kept at a distance large enough for trees, depending on the voltage level in order to avoid discharge.

Operational management units shall regularly cut trees to ensure a safe distance is shown in Table 287 in this Guideline.

For trees which grow rapidly in short time handle risk on the safety, if tops of the trees tight and pruning them is not economic efficiency, they shall be cut out and re-planted again.

Article 311. Maintenance of signals and signs

Maintenance of signals and signs

Signals and signs shall be cleaned to be recognized the danger of overhead lines from far and hold brilliant states.

1. Signs on banks of the river where is passed boats and crafts frequently, and traversed by overhead lines

Refer to article 277 in Technical Regulation Volume.1.

2. Light signals and signal paint

Refer to article 124 in Technical Regulation Volume.1.

3. Signs at alert points

In case that construction workers or overhead lines may be damaged in construction works is conducted under overhead lines, protective ropes shall be installed to keep enough distance to live parts and to protect an accidental contact, and signs shall be installed to warn the danger of overhead lines.

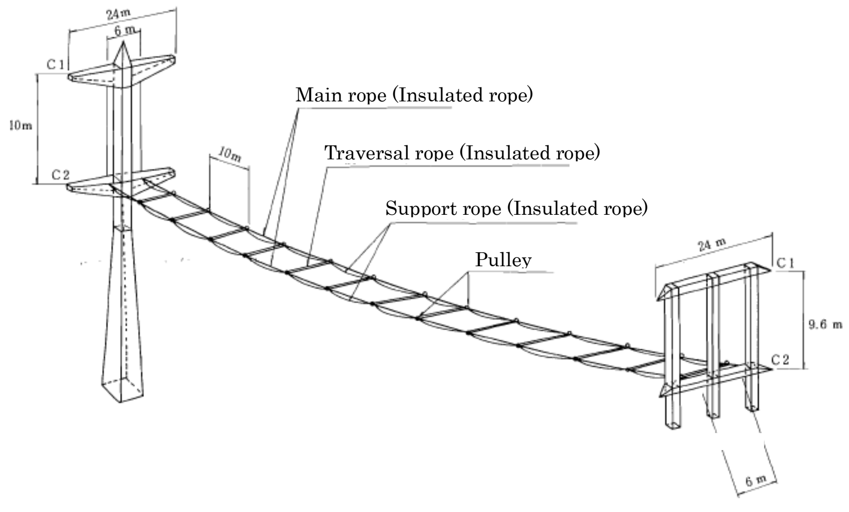


Figure 311 Sample Image of Protective ropes

Article 312. Installation and maintenance of warning plate and barriers

Power network management units shall confirm plates or barriers installed by railway and road managing units to fulfill expected functions.

Figure 312 Sample of warning plate

Article 313. Patrol

Patrol shall be conducted according to “Rule of operation and repair for overhead line”.

Patrol shall be started as soon as possible, on the assumption that the patrollers secure the safety of themselves.

When patrol is conducted, the following tool and device shall be prepared.

- Safety protection device
- Patrol tool
- Other tool or simple repair material

Items of patrol is shown the following table.

Table 313 Sample of records of patrol

The Records of Patrol

Date:

The name of patroller :

The place of patrol

Equipment	Conditions of equipment	The result of patrol
Reinforced concrete pole	Crack	
	Degradation, damage	
	Inclination	
Steel pipe pole	Rust of steel	
	Degradation, damage	
	Inclination	
Steel tower	Strain of member	
	Loosening or omission of bolts	
	Rust of member or bolts	
	Inclination	
Stay	Loosening, rust or corrosion of wire	
	Deterioration of ground near basement	
	Rust or corrosion of rod	
	Rust or corrosion of accessories	
Insulator	Insulation failure	
	Breakage, damage	
	Corrosion of metal parts	
	Pollution	
Line hardware	Corrosion, damage	
	Loosening, abrasion	
Power conductor lightning conductor	Strand loosening, arcing track, strand snapping	
	Corrosion, damage	
	Vibration	
Accessories of conductor	Loosening, abrasion, corrosion, damage	
	Discoloration or corrosion of joint sleeve	
Foundation	Deterioration of ground	
	Outflow or inflow of sediment	
	Degradation or crack of concrete	
Grounding conductor	Snapping	
	Abnormal condition of clasp or conductor cover	
Surrounding situation (Include safety corridor)	Damage of human or other’s possession near overhead lines	
	Damage to human or other’s possession near overhead lines	

Article 314. (deleted)

Article 315. Cleaning of insulator

Polluted insulators may not perform sufficiently for reducing their dielectric strength.

Especially, in case that overhead lines locate in the heavy polluted area (near coast or dusty area), the heavy polluted insulators shall be cleaned or replaced new ones to hold sufficient dielectric strength.

It is also effective to apply anti-pollution insulators which have long creeping distance.

Article 316. Compliance with standard of inspection

Reference to chapter 2 in part 4, chapter 2 in part 5 and chapter 2 in part 6 in Technical Regulation Volume.5.

Article 317. Countermeasure for defection

The contents of failure and shortcoming of overhead line shall be recorded as the following in a diary or a particular book.

The sample of the record of failure and shortcoming is shown in table 317.

Table 317 The sample of the record of failure and shortcoming

Record of failure and shortcoming

Date of detecting: / /

Name of detector:

<table>
<tr><td colspan="2">Name of transmission line</td><td></td></tr>
<tr><td colspan="2">Pole number</td><td></td></tr>
<tr><td colspan="2">Circuit number</td><td></td></tr>
<tr><td colspan="2">Phase number</td><td></td></tr>
<tr><td rowspan="3">Name of facility</td><td>equipment</td><td></td></tr>
<tr><td>item</td><td></td></tr>
<tr><td>detail</td><td></td></tr>
<tr><td colspan="2">Condition of failure or shortcoming</td><td></td></tr>
<tr><td colspan="2">Figure, Photo</td><td></td></tr>
</table>

Article 318. (deleted)

Article 319. (deleted)

Article 320. Restructuring of supporting structures

Chief engineer shall confirm that the specifications (quality, dimensions and strength) of technical materials for restructuring meet approval standards.

In case of using technical materials which have never been adopted, they shall be confirmed that their performance is equal or higher than existing ones by factory test.

Technical materials for approval

1. pole (include steel arm)
2. steel tower
3. insulator
4. power conductor and overhead grounding conductor
5. connection material (sleeve, clamp and line hardware)
6. stay (supporting wire)
7. foundation materials (concrete and rebar)

Article 321. Spare parts

Power network management units should retain spares of important equipment to repair immediately, since overhead lines may be destroyed or damaged due to unexpected natural stress.

1. Kinds of spares

Pole, steel tower, insulator, power conductor, connection materials (sleeve, clamp and line hardware) and stay.

2. Quantity of spares

Quantity for fixing an average fault in consider with past breakdown.

For example, ten poles or four hundred meters of power conductor.

Article 322. Operating management unit

If poles and steel towers of overhead power lines which are appended communication lines and television lines are repaired, management units of each facilities shall share information on works of other units for the following reasons, and related units shall confirm about the safety of own facilities on the works.

- Workers safety: to prevent electric shock due to unexpected touch to live parts.
- Facilities conservation: to prevent facilities from the damage due to misconception.

All related units shall construct communication framework at each shared facility, since they need to share the information for works of other units even in an accidental case. In addition, they shall revise the framework periodically.

- Items of communication framework

  The name of related managing units, their department and representative, and their phone number.

Chapter 8 Power Cable Lines

Article 323. General provisions

Power cables are usually placed in the building, and underground cable works, and less of a problem, but maintenance and overhaul to them shall be done in order to prevent corrosion of metal parts around water or underground and control panels of the associated equipment (barrels of oil and warning systems, etc.)

Power cable lines shall be maintained and overhauled as the following table.

Table 323 Sample methods of maintenance and overhaul for each equipment

Equipment	Conditions of equipment	Methods of maintenance and overhaul
Directly buried cable block	Crack and damage	Concrete cover
	Foreign substance inside block	Cleaning
	Deformation of block hole	Replacement
Cable tunnel, cable room, cable cellar and cable canal	Damage of lid and packing	Replacement
	Corrosion and damage of ladder	Antirust painting, replacement
	Crack and exfoliation of inside wall	Repair by mortar
	Defect of waterproof lid at block edge	Fastening, replacement
	Corrosion of metal parts	Antirust painting, replacement
Cable bridge and cable trough	Corrosion, damage	Antirust painting, replacement
	Loosening or falling off of bolts	Fastening, replacement
Cable rack	Corrosion, damage or loosening of structure and bolts	Antirust painting, fastening, replacement
	Defect of fixed foundation	Repair by mortar, replacement of concrete
Cable, connection box and terminal box	Damage, discoloration	Re-winding tape, replacement
	Oil leakage	Stopping oil, replacement
	Degradation of anticorrosion tape	Re-winding tape, replacement
	Degradation of flame prevention	Replacement
	Defect of metal parts	Antirust, painting, fastening, replacement

Equipment	Conditions of equipment	Methods of maintenance and overhaul
Oil supply tank, oil fill tube and valve	Decrease or degradation of insulation oil	Replenishment, replacement
	Corrosion or oil leakage of oil supply tank	Antirust painting、replacement
	Damage, or dirt discoloration of oil level indicator and oil pressure indicator	Cleaning, replacement
Protective equipment for oil leakage	Crack or damage of concrete wall	Crack repair, replacement of concrete
	Defect of sensor	Adjustment, replacement
Oil pressure alarm system	Defect of device, sensor	Adjustment, replacement
	Defect of power source	Connection of power source, replacement
Grounding conductor	Snapping	Re-connection, replacement
	Degradation or damage of insulation cover	Winding tape, replacement
	Degradation of anticorrosion tape	Winding tape
Draining facility, lighting facility and ventilation facility	Defect of device	Adjustment、replacement
	Defect of power source	Connection of power source, replacement
	Defect of metal parts	Antirust painting、replacement

Article 324. Load cables

The maximum allowable load current of power cable lines shall be determined at the worst heat condition.

In case that additional cables are installed, the maximum allowable load current of other cables in the same section of additional cables shall be revised.

Therefore, the maximum allowable load current shall be understood in both power network management units and load dispatching units.

The maximum load current may be determined by testing results on sites which is carried out in the worst condition.

- Testing site shall be at the section of the highest cable temperature.
- Cable temperature shall be considered with the temperature of inner core based on the temperature outside cable sheath.

Article 325. Temperature in tunnels and cellars

The temperature in cable tunnel (cellar, etc.) where maintenance workers can access shall be 45deg C or below basically, as considering the following items.

- The physical condition of workers who carry out maintenance and repair.

- The overheat of cable (Calculation condition of the maximum allowable load current may be changed as the temperature in cable tunnel increases.).

In case that the temperature in cable tunnel exceeds 45 degrees Celsius, the following items shall be carried out.

- The temperature in cable tunnel is decreased by forcing and cooling ventilation systems
- The operating current is limited not to exceed the temperature of 45deg C in cable tunnel.

Article 326. Overload of cables

It shall be prohibited to use the cable which is over permissible temperature because it is impossible for insulation materials (insulating paper and cross-linked polyethylene) to perform expected insulation strength. Specifications of insulating paper or cross-linked polyethylene of the cable shall be confirmed sufficiently before the operation because the permissible temperature is decided by them. As the point requiring attention in particular, cable permission temperature is not the surface temperature that is lower than the core but the core temperature.

Article 327. Oil pressure

Oil pressure of oil-filled cables shall comply with the value prescribed by the manufacturer.

Article 328. File documents

Related technical materials shall be referred to Article 249 in Technical Regulation as well as Article 328.

Article 329. Supervision of implementation

On cable laying works and assembling works of cable connection boxes, management unit or power company shall check the works during the construction, and confirm that suitable construction is carried out by constructors since it is difficult to check in detail after the works are completed.

Article 330. Protection of metal structures

It is necessary to paint or galvanize the support rack to protect from rust because cable trays, cable racks easily corrode due to be installed in cable canals or cable tunnels with very high humidity environment.

In addition, it is necessary to carry out painting or other countermeasures for the support rack to protect it from the heat in case that the support rack is exposed to sunshine, and it is damaged from the heat by direct sunshine.

Article 331. (moved to Article 276)

Article 332. Checking power cable

It shall be referred to Chapter 6 in Technical Regulation Vol.5 to check the electrical power cable.

When the failure occurs in the cable, the patrol shall be executed to detect the failure point, confirm the facilities damage, and necessary repair or restoration means shall be taken. The patrol shall be executed promptly because the public may reach the danger such as electric shock and a fire, etc. by the failure cable, and the facilities damage may be expanded by unrepaired parts.

The method of patrol

- In case of oil-filled power cable lines, patroller shall check oil supplier unit for the oil level, oil pressure and oil amount, and confirm that there is no oil leakage.
- Patroller shall confirm that there is no civil work such as excavation or pile driving which damages underground cable lines, and there is no shortcoming of cable sections gone out from the underground.
- Patroller shall confirm that there is no defect near cable room, cable cellar and cable well and invisible points of power cable lines.

Article 333. Protection of electrochemical corrosion

Electrolytic corrosion shall be protected by protective covering outer sheath or electrolytic protection. In case of a normal cable, protective covering outer sheath made of synthetic rubber protects electrolytic corrosion. In case that pipe type cable line are placed underground, the line shall be equipped with not only protective covering outer sheath but also an electrolytic protection shown in the following table since a corrosion of steel pipe causes a serious failure.

Table 333 Electrolytic protection

Electrolytic protection	Applicable general cases
Anodic protection	Urban area (This system is adopted which causes little impact to other lines since urban area has low thermal resistance of soil, and there are many other lines adjacently)
Impressed current protection system	Mountain area (This system is effective in case of high thermal resistance of soil, and there are a little other lines)
Anodic protection and impressed current system	Long distance lines
Selective drainage corrosion	The place where cable lines can be easily connected to rails of electrical railway. (This system shall be considered the interference to other lines)

Article 334. Protect of power cable line attach mechanical actions

When the excavation work is done on underground cable, the management unit of the cable shall investigate the construction contractor to the digging depth, heavy civil machines will be used and measures for protecting the cable before carrying the work out, and confirm that the site work can not damage the cable.

The management unit shall not permit the construction work, and the construction contractor shall not carry the work out in case that the work may damage the cable.

In addition, in the permitted construction work, the management unit shall check the safety of the cable, and confirm that the actual situation of the work does not differ from the situation of prior investigation at the construction site.

Article 335. Construction near power cable line

The construction area affecting underground power cable lines must be supervised by the cable management unit are shown in the image below. Engineer's supervision shall be required while performing the pavement rehabilitation and the macadam road paving, etc. .. above the underground cables and offset distance to underground cables shall not be more than 1 m.

In addition, when the distance from the underground cable to the ground surface is 0.7 m or less, the pavement work by heavy civil machine (Iyon, etc.) is prohibited. The use of the heavy civil machine which may damage the underground cable shall be conferred between the management unit and the construction contractor.

When boring or chemical grouting work is carried out within 1m from the cable line, engineer's presence from the management unit shall be conducted in all cases. In case that the work is carried out at more than 1m from the cable line, engineer's presence from management unit may be required depends on the situation.

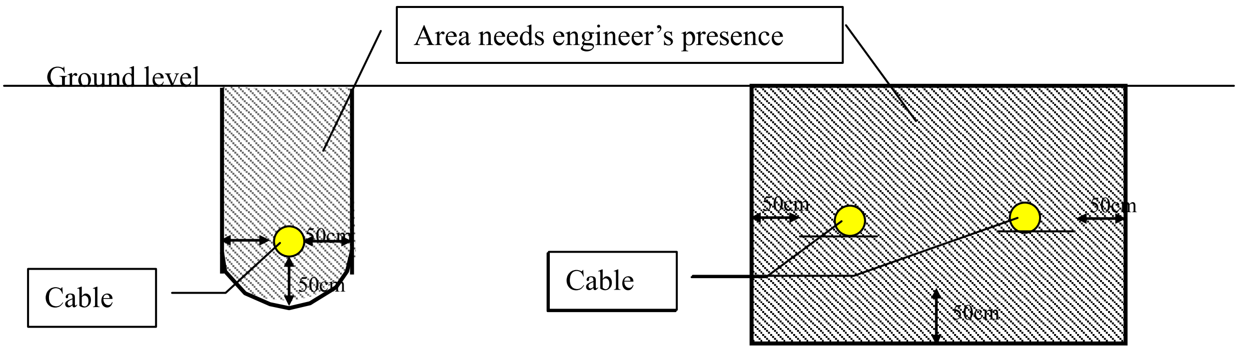


Figure 335 Excavation Area needs Engineer's Presence from management unit

Article 336. Proclaim Information

The power network management unit shall inform the following contents for the people and the construction organization in the region where the cable is laid underground annual, and aim to receive cooperation from the people and the construction organization.

Information content

- The name and contact information of management unit
- The fact that permission of the management unit is necessary in implementation of construction.
- The area where contact to management unit is necessary prior to the construction (The area near the underground cable)
- The contents of the construction in cable corridor informed to the management unit (Construction time, construction place, constructor name, construction outline, heavy civil machine, etc.)

Article 337. Occupational safety

The maintenance work of the cable line shall be carried out after the worker confirm that the temperature, the oxygen concentration and the illumination intensity of the work place satisfy the following items on the labor safety.

Items on labor safety

- Temperature: 45 degrees Celsius or less.
- Oxygen concentration: 18 % or more.
- Illumination intensity: 2 LX or more.

Chapter 9 PROTECTIVE RELAY AND AUTOMATION

Article 338. General provisions

It is necessary to remove promptly the accident that occurs in the electricity system because of the stable operation of the system and the damage reduction of the accident equipment. Therefore, it is necessary to establish the protective relay device to remove quickly an appropriate range of the location that became an accident. The following points are considered in adjusting the setting value of the protective relay device.

- The protective relay device shall work for all kinds of accidents assumed in the state where a system is usually operated.
- The protective relay device should be able to work for the accident that occurs in any location in the system. Therefore, the protection range of each protective relay device should overlap partially.

As for the low-voltage network, the breaker with the overcurrent protection function or the fuse can be applied for the overcurrent protection in consideration of the operation sensitivity and the operation time. In addition to this, the circuit breaker with detective function of leakage current can be applied for the grounding fault protection under the condition that the necessary requirement is satisfied.

Article 339. Responsibility to management and operation

The protective relay device, the automatic monitor and control equipment are categorized based on the importance and the installation place. The charge unit concerning the operation and maintenance is decided by the management responsibility unit.

(Reference) The example of categorization in Japan is as follows

(1) Division in operation

Table 339-1 Categorization of equipment in operation

Classification	Explanations
1st class	a. The devices concerning information used to monitor, control, and record, etc. in central load dispatching center b. While backing up giving function c. The devices used for urgent control in very extra high-voltage system (the devices subject to regional load dispatch center is excluded) d. Automatic control unit for system related to direct current system e. The device that system operation director specifies f. However, the devices related to a and b of 2nd class are assumed to be 3rd class.

Classification	Explanations
2nd class	a. The devices concerning the information used to monitor, control, and record, etc. in regional load dispatching center b. The devices used for urgent control in system subject to regional load dispatching center c. However, the devices related to a, c, and e of 1st class are assumed to be 3rd class.
3rd class	a. The devices related to both range of 1st class and range of 2nd class b. However, the devices mainly used in regional load dispatching center and related to the reference information on operation in central load dispatching center are classified as 2nd class, and excluded from the common devices of1st class and 2nd class.

(2) Division in maintenance

Table 339-2 Categorization of equipment in repair and maintenance

Class		Explanations
A class	(1)	Computing equipment set up in central load-dispatching center and regional load dispatching center
	(2)	Power-supply unit for urgent control unit installed in the system control place, other warnings, indication, record device, and power supply set up in central load dispatching center
B class	(3)	Signal transmission device and data exchange unit that connect transmission way to each equipment However, (9) is excluded.
	(4)	Auxiliary relay for conversion equipment and remote display set up in distribution dispatching center, power plant, substation, customer receiving service by extra high-voltage, or power plant or substation in other company
	(5)	Other
C class	(6)	Remote monitor and control equipment which are installed in central load dispatching center or regional load dispatching center
	(7)	Remote monitor and control equipment, automatic control unit and urgent controller for the system set up in distribution dispatching center, power plant, substation, customer receiving service by extra high-voltage, power plant or substation in other company or dam (including the stream-flow gauging station) However, (10) is excluded.
	(8)	Computing equipment set up in distribution dispatching center and power conversion station
	(9)	Signal transmission device and data exchange unit that connect power station, substation, and dam (the stream-flow gauging station is included)
D class	(10)	Automatic control unit for system related to direct current system is set up in power conversion station

Article 340. Required to ensure operating procedures and operating facilities

The administrative unit shall edit "internal operation maintenance bylaw" for each installation substation of the protective relay device, automatic monitor, and control equipment in consideration of each special condition, notice with related units. The "internal operation maintenance bylaw" shall be distributed to the related units. Statement item of “internal operation conservative bylaw” selects below appropriately as reference.

(Reference) The example of the items mentioned in Japan

Table 340 Description item and content of operation and maintenance by law

Item	Contents
○Scope	
○Categorization of relay device	
- Protection purpose	As for the coexistence device with the transmission line protection and the transformer protection, etc., it is the main protection purposes.
- Classification	The 1st class, the 2nd class, the 3rd class, and the 1st+2nd+3rd class coexistence, etc.(refer to article 336)
○Special item	Special issues on operation and/or maintenance due to specific necessity of device (depend on system configuration, etc.)
○Responsible demarcation point	The one that does not depend on principle in management and maintenance demarcation
○Device summary	Protection method, transmission method, re-closing method, and system configuration, etc.
○Selector switch and lock switch	Name, usage, and range etc. of load dispatching instruction -in case of abnormal condition as well as usual operation Operation procedure in detail
○Display of device operation	Display of relay device, monitor board, system outline, and details etc.
○Treatment procedure when device is abnormal	The state of device in abnormal aspect and necessary operation or procedure etc. It is described in detail.
- Procedure of notice	
- Indication	Display of relay device, monitor board, system outline, and details, etc.
○Influence on related device	The influence given to other devices is described in detail (urgent control units) The method of sharing signal with another device etc.
○The points of concern on work	
○Reference	Name of References and their inventory location, etc.

Article 341. Signing and numbering

Set up the signboard that can show the state clearly by watching in these devices.

In addition to the above, as for the name of each device, in order to prevent misunderstanding, the name which load-dispatching center assigns shall be used.

Article 342. Inspection of related facilities to protective relay and automation facilities

The inspection of the related facilities and equipment shall be carried out in accordance with the relevant requirements in Vol.5.

Work safety concerning during inspection shall depend on the relative regulations.

Units in charge of work management shall develop an annual plan of periodic inspection based on the records in last year and shall manage the progress of inspection. The period of periodic inspection shall be decided in accordance with other relative standards. And inspection procedure and judgment standard are decided in accordance with the regulations in the Vol.5.

Article 343. Inspection of protective relay, automation facilities

[Inspection]

Inspections of protective relay device and automatic supervision and control system are categorized as follows.

a. Routine patrol
b. Periodic inspection and examination
c. Extra inspection and examination

Method and judgment standard of periodic inspection and examination are in accordance with the regulations stipulated in the Vol.5.

The units in charge of inspection are decided according to the following table and these units shall carry out inspection according to the work plan decided by management responsibility unit.

Table 343-1 Units in charge of inspection of protective relay devices

Relay	Item	unit in charge of inspection		Notice Status of components
		Depart of substation	Maintenance section	
	Routine patrol	☑		Live
	Trip test		☑	Dead
	Performance test of each equipment		☑	Dead
	Sequence diagram test		☑	Dead
	External inspection		☑	Dead
	Internal inspection		☑	Dead
	Insulation resistance measurement		☑	Dead
	Test load (Power direction, positive, negative, zero-sequence current and voltage)		☑	Live
	Performance test of grounding fault protective relay, especially in distribution line*1		☑	Live
	Inspection of automatic oscilloscope FR	☑	☑	Live
	Inspection of digital FL	☑	☑	Live

*1: This test is carried out in order to check whether the operating value of grounding fault protective relay is appropriate to make this protective relay work properly in case of grounding fault.

The reason is that actual grounding fault test at the site is necessary to adjust the operating value properly, because, as for the distribution line, the parameters of the line cannot be calculated due to the installation of many cable lines.

Table 343-2 Units in charge of inspection of automatic load-dispatching equipment

Work place	Unit in charge of inspection	Unit in charge of work management
Central load dispatching center	Charge department in head office or central load dispatching center (Determined by the work arrangement)	Manager of the unit
Regional load dispatching center	Charge department of regional office which regional load dispatching center belongs to or regional load dispatching center (Determined by the work arrangement)	Ditto
Hydropower plant substation switchyard	Maintenance section of each facility	Ditto
The work place which covers 2 places or more	It depends on the above-mentioned for every workplace.	Ditto

The extra inspection and examination of the protective relay device are executed in the following cases.

a. When a protective relay device is judged to have carried out unjust operation
b. When the characteristic needs to be checked in setting change of the protective relay device
c. When related equipment or the circuit of the protective relay device are changed and accordingly the examination is needed
d. When abnormality occurs in the protective relay device or abnormality is expected to occur.
e. Necessary cases other than those above

The extra inspection and examination of the automatic supervision and control equipment are executed in the following cases.

a. When automatic supervision and control equipment is judged to have carried out unjust operation
b. When the characteristic needs to be checked in setting change of the automatic supervision and control equipment
c. When related equipment or the circuit of the automatic supervision and control equipment are changed and accordingly the examination is needed
d. When abnormality occurs in the automatic supervision and control equipment or abnormality is expected to occur.
e. When comprehensive inspection of the system is necessary
f. Necessary cases other than those above

[Repair]
When abnormality is found in routine patrol or inspection, unit in charge of operation and administrative unit of the equipment shall execute repair work according to the following procedures

1. Unit in charge of operation shall send notification to related units according to the communication route which is decided beforehand.
2. The related units which receive notification shall carry out necessary action properly.
3. Administrative unit shall carry out repair work and keep its record.

[Setting]
Setting work of the protective relay device and the automatic supervision and the control equipment is carried out as the following procedure.

a. Determination of setting value
b. Procedure of preparation to adjust setting value
c. Adjustment of setting value

a. Determination of setting value
The unit in charge of determination of setting value is defined according to classifications of protective relay devices and automatic supervision and control equipment as well as the rage of network operation. This unit shall decide setting value and notify it to related units through the certain format.

The unit in charge of determination of setting value shall discuss setting value with related units, if necessary.

b. Preparation to adjust setting value

The revised setting value shall be notified to related units according to communication route defined beforehand.

In case that setting has to be changed temporarily due to network switching or accident which occurs in network system, the change of setting value shall be carried out according to the instruction from the unit in charge of operation.

c. Adjustment of setting value

The unit in charge of maintenance shall adjust setting value. And adjustment of setting shall be carried out at the designated time by the certain form. Do not execute it without permission except emergency cases.

Article 344. Secondary winding of current transformer and voltage transformer

The secondary circuit of CT shall be short-circuited, because the high voltage occurs in its terminal when it is open. In addition to this, the secondary circuit of PT shall be open, because the large current flows to its circuit when it is short-circuited. It is necessary to ground the arbitrary one point in the secondary circuit so that the high voltage shall be prevented from occurring on secondary circuit in case of short-circuit between primary circuit and secondary circuit.

Article 345. Requirement of protective relay, automation facilities of operating circuit

As for indicator lamps and selection switches attached to protective relay device or automatic supervision and control equipment, their indications and positions shall be installed to be seen and operated easily.

Moreover, when these equipment are operated, these operations shall be recorded.

Chapter 10 Grounding Equipment

Article 346. General provision

Appropriate grounding work shall be given to iron board or enclosure of the equipment connected to power line according to its nominal voltage in accordance with the relative parts in Vol.1. (exceptional case: as for dry transformers or current or potential transformers, grounding work shall be given to their iron core) But, when equipment with live enclosure is installed with surrounding fence in order to prevent persons from touching it, this requirement on grounding works may not be applied to such equipment. And this surrounding fence also shall be grounded in accordance with the relative parts in Vol.1.

Article 347. (deleted)

Article 348. (deleted)

Article 349. (deleted)

Article 350. (deleted)

Article 351. (deleted)

Article 352. Grounding resistance measurement

It is necessary to measure grounding resistance at the following cases:

a) At periodical measurement in accordance with the relative regulations.

b) After assembly, refurbishment or overhaul of works in power plant, transmission substation and lines.

c) When carrying out maintenance of electrical poles equipped with grounding wire of 110 kV line and above after the insulator is broken or disrupted by electric arc.

d) At other necessary cases

The following methods are given as the measurement methods.

a. Measurement with earth resistance meter
b. Measurement by AC current descent
c. Measurement by different frequent AC current descent

Measurement with earth resistance meter can be suitable for not large area, because buried grounding electrodes and connecting wires between them are necessary for this measurement and the length of these wires are limited to 10 meters. On the other hand, transmission lines are utilized as auxiliary wires for measurement by AC current descent. Consequently, equipment for the measurement can be simplified. In addition to this, accurate measurement can be done by using commercial frequency AC current. In this regard, measurement by AC current descent is more suitable for mesh grounding system at large-scale substation. .

Article 353. Earthing area has high corrosiveness

When earth device is installed at the area with high corrosiveness, it shall be checked periodically whether rust develops on the earth device or not.

If rust often develops on earth device, electric corrosion possibly causes the rust development on the earth device. It is necessary to investigate the causes and take countermeasures against the rust development such as removal of the causes.

Chapter 11 OVER-VOLTAGE PROTECTION

Article 354. (deleted)

Article 355. (deleted)

Article 356. (deleted)

Article 357. Compensation of capacitive

As for applicable capacitive current, maximum capacitive current shall be selected among those calculated under the conditions of normal network structure. And, on the calculation of capacitive current, parameters of network shall be revised if necessary. Accordingly, the capacity of compensative reactor and network construction plan shall be considered again.

Compensation of capacitive current by compensative reactor must be carried out in case where capacitive current exceeds the following values:

Rated voltage of power network (kV)	6	10	15 - 20	35
Capacitive current (A)	30	20	15	10

Article 358. Arc suppression coils

The capacity of arc suppression coil is selected according to capacitive current. The capacitive current shall be calculated accurately according to actual network parameters. Since capacitive current possibly change depending on installation of transmission or distribution lines or restructure of network system configuration, future plan of network development network shall be considered in selecting the capacity of arc suppression coil.

Since capacitive current is relatively large at cable lines, especially underground cable lines, arc suppression coil shall be installed at the substation which three cable lines and more are connected to. Are suppression coil should be connected to network system via insulation transformer, and it should be connected to the neutral point of this transformer.

Article 359. Suppression coils regulator

Reactance of arc suppression coil shall not resonate with capacitance of transmission or distribution lines at network system. The reason is that abnormal voltage may occur under the condition of the above-mentioned resonance. The reactance of arc suppression coil shall be determined so that earth fault current is slightly larger than capacitive current of transmission or distribution line at network system. In this regard, since the capacitive current changes according to network system configuration, reactance of arc suppression coil shall be adjusted by changing its tap.

Apart from the above, in order to improve performance of arc suppression coil, the following method can be adopted.

1) Resistor usually is connected to network in parallel with arc suppression coil
2) This resistor is disconnected in case of earth fault

3) Accordingly, reactance of arc suppression coil resonates with capacitance of transmission or distribution lines of network system.

Article 360. Voltage deviation

It is necessary to determine the permissible value of the neutral point voltage so as not to influence the operation of ground overvoltage relay.

When capacitance of each phase of distribution line is unbalanced or static voltage regulator is installed on distribution line, residual voltage at neutral point may occur. Therefore, if the residual voltage at neutral point becomes larger, the residual voltage shall be restrained within permissible value by taking appropriate countermeasures such as installation of balancer on distribution line

Article 361. Manual regulator for arc suppression coil

Position of manual tap of arc suppression coil shall be determined according to measuring result of actual earth fault current. This earth fault current shall be measured by the following methods.

- Measurement of actual earth fault current (this examination is executed in substation)

Measurement of residual voltage at neutral point (records collected by routine patrol in substation)

According to the above results, position of manual tap shall be determined in order to restrain residual voltage at neutral point within permissible value.

Article 362. Switching operations

In network system of 110kV-220kV with direct grounded neutral, abnormal voltage occurs at neutral point in case that the neutral point becomes isolated. Therefore, system switching shall be executed so that the neutral point never becomes isolated or grounded via arc suppression coil. And manual which shows detailed switching procedure to ensure the above matter shall be prepared.

When disconnecting neutral grounding device, the following things shall be observed in order to prevent neutral point of the concerned network system from being isolated or grounded via arc suppression coil.

- Turn on standby neutral grounding device
- Interconnect the network system with the adjacent one

Ferroresonance may occur at second circuit of potential transformer of which load is quite small. In order to avoid this ferroresonance, the load of 25% of rated load of the second circuit should be connected to the secondary circuit.

Article 363. (deleted)

Article 364. (deleted)

Article 365. (deleted)

Chapter 12 ELECTRICAL INDICATING AND MEASURING INSTRUMENTS

Article 366. Management responsibilities

The electric power company shall execute the inspection of the load dispatching system such as SCADA system at the inspection cycle regulated by the country and the sector level, etc. Moreover, as for the timing of inspections, it is necessary to adjust the timings of inspections for each device to avoid overlapping these inspections from the viewpoint of keeping the reliability of system operation.

As for the timing of the above system inspections in the power station and substation, it is necessary to decide the appropriate inspection timing after discussing with the load dispatching center which implements the supervisory control.

As for the dual system inspection, it is necessary to execute the system switching from active system to stand-by system appropriately before the inspection to prevent the system from stopping. However, in case of the single system in the substation and the power station, the inspection of load dispatching system shall be performed under the direct operation on site instead of the remote operation. Moreover, the workers shall endeavor to shorten the time of inspection not to obstruct the supervisory control operation of the load dispatching center as much as possible.

All load dispatching system inspections shall be performed by an appropriate system and the implementation methods filled the technical requirement provided in the standard and the manufacturer manual etc. of each device. If the inspection result does not meet the criteria of the above requirement, adjustment or replacement of the device concerned shall be carried out to meet the above requirement.

Moreover, it is preferable to perform the counter test between the electric-supply station and the load dispatch center (Sending the simulated input data from the substation or power station to the load dispatching center, and confirming the received data) , and confirm the desired technical requirement is satisfied not only the system unit but also the entire system.

Article 367. Inspection period

Refer to Article 366.

Article 368. Measurement equipment put to work

Refer to Article 366.

Article 369. Checking

Refer to Article 366.

Article 370. Install circuit for measuring equipmentof

As for the electrical indicators and measuring instruments for transformers and transmission lines of 220kV or more, since the concerned transformers and the transmission lines are ranked, the concerned indicators and measuring instruments shall have a high reliability.

Therefore, equipment configuration of measuring system shall adopt independent configuration for each circuit instead of time sharing control of input translator for multi-circuits which is adopted with the measuring instruments of less than 220kV lines etc., and better equipped with two systems..

Article 371. Principle installation of electricity meters

Principle installation of electricity meters comply with Chapter 2-6 measure the electrical system in the Technical Regulations Guide Volume 1

Main equipment shall install electric power meters as well as preliminary equipment for every equipment because the station service power in the power plant is greatly different according to the state of operating of main equipment.

The station service power shall be confirmed not only during normal operation but also in the starting process of each equipment of main equipment. Because it is important to confirm whether the power consumption of each equipment is appropriate.

Article 372. Measure the power consumption

In the substation, the power consumption of the office, station service power and the electric power loss of the substation equipment shall be managed separately.

Article 373. Installed meter at feeders

It is necessary to install the measurement devices for each transmission line and distribution line of 35kV or more in order to manage the power loss, supervise the power flow and confirm the current changes at the time of circuit breaker operation and so on.

Chapter 13 Illumination

Article 374. General provision

1. Luminaires and lamps for indoor and outdoor use

Luminaires and lamps should be properly operated for mainly productivity and safety reason. It is recommended for this reason to operate and maintain the luminaires and lamps depending on manufacturer's instructions, recommendation and the following.

(1) Horizontal illuminance level

The following types of lamps are widely used for illumination and their lifetime is generally from 6,000 to 12,000 hours.

- Fluorescent lamp
- High intensity discharge (HID) lamp

(Mercury vapour lamp, Metal halide lamp, Sodium vapour lamp)

Since illuminance level declines as lamps operate, replacing with new lamps and periodical cleaning of luminaires and these lamps are generally needed to maintain a required illuminance level. In addition, Horizontal illuminance level should not be below minimum maintained illuminance according to the design, International Organization for Standardization (ISO) 8995-1 and ISO 8995-3.

A part of horizontal minimum maintained illuminances according to ISO 8995-1 and - ISO 8995-3 are shown in Table 374-1. It is recommended to conform to these designated values, however, these standards do not give any uniformity of illuminance for each facility of the electric power sector, and accordingly an example of horizontal illuminances for a power plant and substation is shown in Table 374-2.

Table 374-1 A part of horizontal minimum maintained illuminances

Location and activities	Minimum maintained Illuminance (lx)
1 Indoor	-
Entrance, restroom,	100
Archives, storage	100
Corridors, restroom	100
Stairways	150
Canteen	200
Conference rooms	500
Mechanical hall, Auxiliary rooms (e.g. pumps, switchboard)	200
Control room	500
2 Outdoor	-
(1) For working safety during working	-
Coal yard	5
Oil storage tanks	20
Switch yard	50
(2) For zone or activities	-
Low speed traffic (maximum speed: 10km/h)	10
Low speed traffic (maximum speed: 40km/h)	20
Walkways, Patrol	50

Table 374-2 An example of horizontal illuminances for a power plant and substation

Location	Minimum maintained Illuminance (lx)
Control room	500
Turbine floor	200
Auxiliary rooms for relay boards, communication boards and security guards	150
Around high or low voltage switchgears and controlgears	100

Location	Minimum maintained Illuminance (lx)
Auxiliary rooms for batteries and feed water control Around field instrument panel	70
Around auxiliaries for a boiler, turbine, flue-gas desulfurization equipment and coal conveyors, indoor coal yard, oil storage tanks	35
Around auxiliaries for fuel supply, indoor switchyard (substation)	25
Outdoor auxiliaries, Walkways for a boiler, flue-gas desulfurization equipment and coal conveyors, switchyard (substation)	15
Transformer yard	10
Outdoor roads, coal yard	5

(2) Operating voltages

Operating at a rated voltage of the lamp mentioned above is needed because if operating voltages are lower or higher than the rated voltages, this will shorten the lifetime. Also, Lamp flickering or drop-out will occur if an operating voltage is lower than the rated voltage.

(3) Security floodlight

A luminaire and lamp intended to assist with the identification of intruders and to prevent intrusion onto the premises of a power plant and substation is used for security reason. A sodium vapour lamp as a security floodlight is avoided because orange or yellow light produced by it will interfere with the identification of intruders. Recently, perimeter intrusion detection system using laser-sensing or fiber optics, etc. has been utilized to provide reliable perimeter security. It is suggested for security to take the perimeter intrusion detection system into consideration.

(4) Consideration against dust or hazardous substance

A luminaire and lamp should conform to IEC60529 when it is installed or located in the area of dust or hazardous substance.

(5) Applicable Standards

Standards for the lighting such as illuminance level and unified glare rating (UGR) are as follows:

- ISO 8995-1:2002(E)/CIE S008/E: 2001: Lighting of Work Places Part 1: Indoor *1
- ISO 8995-3:2006(E)/CIE S016/E: 2005: Lighting of Work Places Part 3: Lighting Requirements for Safety and Security of Outdoor Work Places *1
- JIS Z 9110: 1979 Recommended Levels of illumination
- JIS Z 9125: 2007 Lighting of indoor work places
- JIS Z 9126: 2010 Lighting of outdoor work places
- IEC 60598-1 1992 Luminaires - Part 1: General requirements and tests
- IEC 60529:2001 Degrees of protection provided by enclosures (IP Code)

Note:
*1 CIE: International Commission on Illumination

2. Obstruction lights for a smokestack

Required obstruction lights (aircraft warning lights) which are intended to reduce the hazards to aircraft by indicating the presence of a smokestack are as stated “Decree on the management of heights of aviation barricades and battlefields for management and protection of Vietnam's airspace” (No. 20/2009/ND-CP). Unless otherwise provided for the decree and related regulations, general matters are as follows:

(1) Lamp types

1) Low intensity red obstruction lights are used to provide conspicuity during nighttime and are operated by a control device such as a photo cell, timer, etc. so the lights will be turned on or off.
2) Medium intensity flashing white obstruction lights are used to provide conspicuity both day and night. The light intensity is automatically controlled by a device that changes the intensity when the ambient light changes.
3) High intensity flashing white obstruction lights are used to provide the highest degree of conspicuity both day and night. The light intensity is automatically controlled by a device that changes the intensity when the ambient light changes.
4) Dual lighting system with above lights

(2) Operation

An Objective such as conspicuity is achieved only when all required lights are operating. Since a partial equipment outages decrease the margin of safety, any outage should be corrected as soon as possible. Recently, a light emitting diode (LED)-based lamps designed to replace medium intensity xenon strobe lamp have been utilized for long lamp life. It is suggested for low maintenance operation to take the LED-based lamps into consideration.

3. Emergency lightings

Unless otherwise provided for laws and related regulations, recommended items are as follows:

(1) Locations where an emergency lighting is installed

- Indoor locations shown in Table 374-2
- Indoor corridors, stairs and walkways
- Surrounding area of an emergency generator
- Surrounding area of an seal oil system for a hydrogen cooled generator
- Walkways from control rooms to outdoor

(2) Horizontal illuminance

It is desirable that horizontal illuminance of floor level of the locations mentioned above is at least 2 lx.

Chapter 14 Hydrogen Generation Station

Article 375.

(Nothing)

Article 376. Check of equipment condition

Each component of electrolytic hydrogen production system is different depending on the type of the electrolytic hydrogen production system. For example, electrolytic hydrogen production system is composed of the following and its process flow diagram is shown in Figure 376-1.

- Water purifier
- Feed water storage tank
- Aqueous solution of potassium hydroxide (KOH) mixing tank
- Direct current (DC) Power supply
- Hydrogen generation unit (Electrolysis module (cell), Electrolyte circulation, Hydrogen gas
- dryer/purifier)
- Compressor
- Hydrogen storage tank (reservoir, receiver)

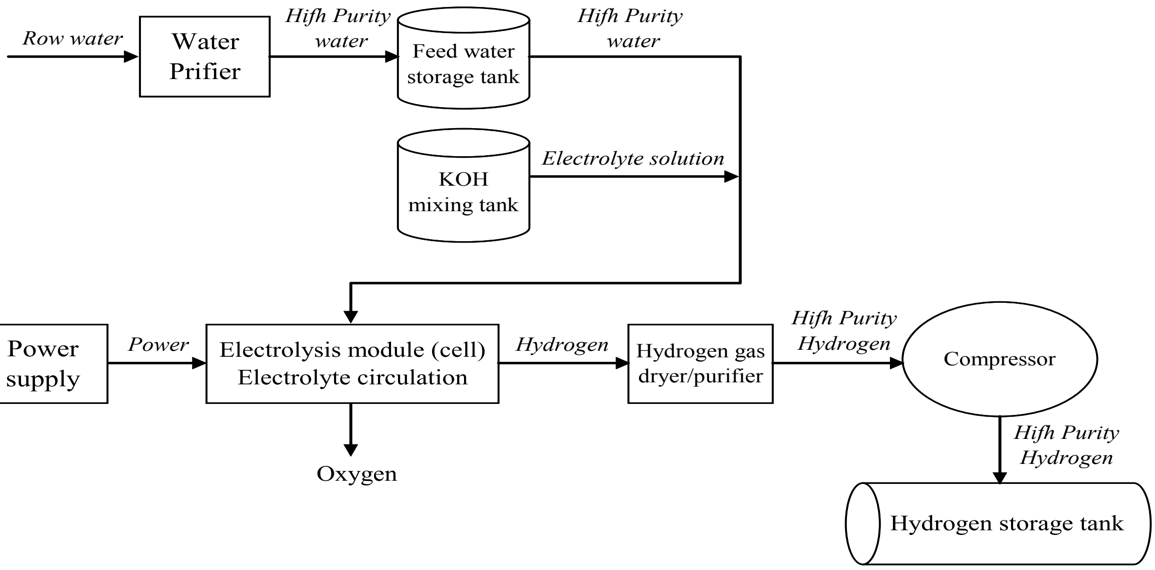


Figure 376-1 An Example of process flow diagram of electrolytic hydrogen production system

Present condition of electrolytic hydrogen production system should be checked for safety and reliable operation before and during operation. Also, normal operating values and allowable operating ranges of each component of electrolytic hydrogen production system which may be specified by manufacturer should be confirmed prior to operation and their operational status should be monitored and maintained within the allowable ranges during operation. When associated alarm devices are activated, operators of the electrolytic hydrogen production system should take corrective actions according to the manufacturer’s manuals and instructions.

The operational status to be checked is listed below, but not limited to, because these are different depending on the type of the electrolytic hydrogen production system. Thus, it is necessary to refer to the manufacturer's manuals and instructions.

- Voltage and current of electrolysis module
- Pressure of hydrogen and oxygen at electrolysis module
- Liquid level at feed water storage tank and aqueous solution of KOH mixing tank
- Pressure difference between hydrogen and oxygen systems
- Temperature of electrolyte and air in dryers
- Purity of produced hydrogen and oxygen
- Pressure of hydrogen storage tank
- Purity of feed water

For reference, a related standard is ISO 22734-1:2008 (Hydrogen generators using water electrolysis process - Part 1: Industrial and commercial applications) which defines the construction, safety and performance requirements of packaged or factory matched hydrogen gas generation appliances, herein referred to as hydrogen generators, using electrochemical reactions to electrolyse water to produce hydrogen and oxygen gas; however, this standard is intended to be used for certification purposes.

Article 377. Protective devices

Protective devices of each electrolytic hydrogen production system are different depending on the type of the electrolytic hydrogen production system. For example, electrolytic hydrogen production system is equipped with the following protective devices.

- Molded case circuit breaker for power supply and motors
- Pressure detecting device and controller of hydrogen and oxygen at electrolysis module
- Hydrogen detection device and controller

It should be ensured that there is not abnormal status of protective devices and alarm devices of electrolytic hydrogen production system before operation according to the manufacturer's manuals and instructions.

When the electrolytic hydrogen production system is tripped during operation, operators of the system should rush to the system within 15 minutes after the trip. Also, the system should not be restarted before ensuring the following:

- Causes of the trip are clarified.
- Necessary service or maintenance is completed.
- The system is ready to operate.
- The surrounding area is clear and staff are safely positioned or removed from the area.
- Tags and locks are removed by the same person who attached them.
- It is notified that the service or maintenance has been completed and the system is ready to operate.
- Safety procedures based on the manufacturer's instructions are taken.

For reference, a related document is IGC 15/06 (Gaseous hydrogen stations) by European Industrial Gases Association (EIGA), which is prepared for the guidance of designers and operators of gaseous hydrogen stations and reflects the best practices currently available and covers gaseous hydrogen, compression, purification, filling into containers and storage installations but production.

Article 378. Safety valve

Pressure circuit of electrolytic hydrogen production system is generally protected by safety valves and the safety valve is normally placed close to a piece of equipment being protected in order to limit pressure drop. For example, the safety valve is installed on the following location:

- After each stage of a compressor unit (to protect the compressor unit from excessive pressure)
- Hydrogen storage tank (to protect the hydrogen storage tank from excessive pressure)
- After a pressure regulator (to protect equipment from the pressure regulator failure)

A set pressure of the safety valve is set lower than the maximum allowable working pressure of a pressure vessel to protect the pressure vessel. Since the safety valve is an important component for safe operation of the system, periodic evaluations are required to confirm proper operation of this valve.

Thus the safety valve should be evaluated by testing and adjusted during maintenance according to the manufacturer’s instructions. As a result, operational characteristics such as the popping (opening) and closing (reseating) pressure must be complied with the manufacturer’s instructions and applicable standard requirement.

External condition of the safety valve is checked by visual inspection and functioning test of the safety valve consists of applying pressure to the safety valve to determine the popping (opening) and closing (reseating) pressure and a practical valve test is usually a bench testing because a controlled environment can be obtained.

The following documents are referred to as guidance for an effective pressure relief valve inspection and maintenance.

- ANSI/API 510-2006 Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration *1
- API Recommended Practice (RP) 576-2009 Inspection of Pressure-Relieving Devices

Note:
*1: This code covers the pressure relief devices.
ANSI: American National Standards Institute
API: American Petroleum Institute

Also, atmospheric discharge or discharge pipes from the safety valve should not terminate at a location where a possibility of accumulation of hydrogen or hazard to personnel can occur.

Article 379. A pre-purge and post-purge

Pieces of equipment and piping from an electrolysis module to a hydrogen storage tank (reservoir, receiver) of electrolytic hydrogen production system are filled with hydrogen gas during operation, but start-up of a new piece of them and a piece of them after maintenance work are filled with air, and hydrogen is flammable in air (flammability limits: 4% to 75% by volume).

Thus a pre-purge and post-purge should be performed with designated inert gases such as nitrogen to prevent a possibility of hydrogen explosion according to the manufacturer's manuals and instructions.

For example, a flow of pre-purge of a piece of equipment of electrolytic hydrogen production system is the following and valves installation shown in Figure 379-1.

- Close isolation valves (1, 2) of a piece of equipment.
- Purge air from a purge inlet valve (3) of the piece of equipment.
- Connect nitrogen supply to the purge inlet valve (3).
- Open the purge inlet valve (3) and a vent valve (4) of the piece of equipment.
- Pressurize the piece of equipment with nitrogen at least a half of a design pressure.
- Operate the piece of equipment at least ten minutes after setting sufficient purge flow.
- Shut down the piece of equipment after oxygen of the purge flow is less than 1% for minimum period of two minutes.
- Close the purge and vent valves (3, 4) and disconnect nitrogen supply

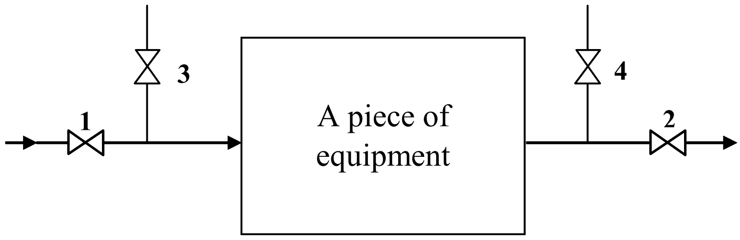


Figure 379-1 An Example of valves installation

For reference, a related document is IGC 122/00 (Environmental impacts of hydrogen plants) by EIGA, which is relevant for sites which produce hydrogen by electrolysis or chemical processes and covers principal impacts and impacts due to compression, desulphurising, reforming, maintenance and storage.; however, this standard concentrates on environmental impacts of hydrogen.

Article 380. Ventilation of the inside of a vessel

When inside check of vessels of electrolytic hydrogen production system is performed, the following items should be taken before or during work except as otherwise provided by Article 100 of national technical regulation on electric safety (QCVN 01:2008/BCT).

- Post-purge of the vessel was performed before work.
- Forced or natural adequate ventilation in the inside of vessel is performing during work.
- Oxygen concentration in the inside of vessel is not less than 19.5% by volume during work. *1
- Oxygen concentration in the inside of vessel is monitored continuously during work
- Oxygen monitors will alarm at 19.5% oxygen. (An advance warning will give enough time to avoid risk to oxygen deficiency because health effects of early stage are difficult to sense in general.)
- Oxygen monitors should be calibrated correctly (according to the instruction manual) in the proper period.

Note:
*1: Hazardous atmosphere is defined that atmospheric oxygen concentration below 19.5 percent or above 23.5 percent by part 1910.146 Permit-required confined spaces of the Occupational Safety and Health Administration (OSHA) standard of the U.S. Department of Labor.

Normal air is approximately 21% oxygen and 78% nitrogen and health effects generally begin at oxygen concentration of 17%. For reference, effect thresholds for exposure to reduced oxygen are shown in Table 380-1. (Source: Appendix 3 Oxygen Deficiency Hazards of Cryogenic Safety Manual by Physics Division of Argonne National Laboratory which is one of the U.S. Department of Energy's largest national laboratories for scientific and engineering research.)

Table 380-1 Effect thresholds for exposure to reduced oxygen

Oxygen (Volume %)	Health Effects
17	- Night vision reduced - Increased breathing volume - Accelerated heartbeat
16	- Dizziness - Reaction time for novel tasks is doubled
15	- Impaired attention - Impaired judgment - Impaired coordination - Intermittent breathing - Rapid fatigue - Loss of muscle control

Article 381.

(Nothing)

Chapter 15 Energy Oil

Article 382. Oil management

1. There are three (3) main types of oil which is essential to be managed for the operation and provision including insulation oil (the oil of transformer), lubrication oil (to be used to lubricate the turbine system and diesel engine) and turbine control oil/hydraulic oil in which the first 2 types are majors.
2. Technical specifications of operation and spare oil must be conformed to the brand which is authorized by the manufacturer of facility.
3. The amount of reserve of oil must be decided in consideration of the brand, amount, distribution, price, delivery time and the like at the planning stage. Moreover, the consumption must be monitored periodically according to the administration manual.

4. The monitoring the pressure, temperature, level, leakage and oil-line switching, and sampling must be performed according the manufacture's O&M Manual appropriately.
5. The nature, cleanliness and degree of degradation of oil must be monitored periodically according to the related standard or Article383, 384, 385 of guideline Vol.4 or Article31-3-10, Article 31-3-11, Article38-2-6, Article38-2-7 of guideline Vol.2.
6. The waste oil must be packed in drums and turn to oil processing plant appropriately. It is desirable to recycle it as long as the properties permitted.
7. The oil-contaminated water or used oil absorbent materials must be treated appropriately so as not to cause environmental pollution.

Article 383. Inspection of insulating oil

1. Inspection of insulating oil

Inspection of insulating oil should be performed in accordance with Articles in Part 2 "Transmission & Distribution Line and Substations" of the volume five of the technical guideline.

2. Polychlorinated biphenyls (PCBs)

PCBs are one of the persistent organic pollutants (POPs) which cause significant threats to human health and the environment, and are considered to be probable human carcinogens. The Stockholm Convention on Persistent Organic Pollutants was held in 2001 to reduce and eliminate 12 particularly toxic POPs eventually and some objectives for PCBs are as follows:

- To take action with regard to the elimination of the use of PCBs in equipment by 2025
- To make determined efforts designed to lead to environmentally sound waste management of equipment contaminated with PCBs as soon as possible but no later than 2028

Thus, the technical regulation bans the use of the electrical equipment with insulating oil which contains PCBs unless otherwise provided the exception of the use of PCBs in a period of transition by ministry of environment. The details of the exception of the use of PCBs should be referred to related documents by ministry of environment.

Article 384. Insulating oil treatment

Since insulating oil usually provides functions of insulation and removal of the heat generated, it is required that insulating oil is refined and free from impurities such as acid, alkali and water.

1. Deterioration of insulating oil

Air movement occurs between atmosphere and electrical equipment with insulating oil by temperature varying when operation and the insulating oil may be gradually contaminated with oxygen and moisture from the air. If there is poor sealing or oil leakage by deterioration of breathers or packing, or looseness of sealing, contamination with oxygen and moisture will be accelerated.

Since oxygen inhibitors in the insulating oil depletes with the passage of time, the oxygen rate in the insulating oil gradually increases, and moreover, oxidation of the insulating oil which contains oxygen and moisture is accelerated by generated heat during operation.

As a result, neutralization or acid number of the insulating oil increases, and sludge will form, and the function of the insulating oil will be deteriorated eventually.

Moreover, insulating oil is deteriorated by electrical factor. If abnormal conditions, such as arc discharge or partial discharge occur, local overheating generates flammable gases such as H_2, CH_4, C_2H_4, C_3H_6, CO, (CO_2) because the transformer insulating oil or its solid insulation is decomposed thermally.

Therefore, these concentrations are recommended to be analyzed by gas chromatograph not only periodically but also after electrical failure.

2. Tests to determine the acid content of insulating oil

An insulating oil sample of already known quantity is titrated with the base potassium hydroxide (KOH) until the acid in the insulating oil has been neutralized. Total acid number is represented as the amount of KOH in milligrams required to neutralize one gram of the insulating oil. A high total acid number shows high acid content in the insulating oil.

The following standards are test methods. An example of classification of insulating oil is shown in Table 384-1. Also, it is important to check the upward trend of this number.

- ASTM D974 - 11 Standard Test Method for Acid and Base Number by Color-Indicator Titration
- JIS C 2101:1996 Testing methods of electrical insulating oils

Table 384-1 An example of classification of insulating oil

Insulating oil condition	Total acid number based on JIS C 2101 (mg KOH/g of oil)
Good insulating oil	Up to 0.2
Marginal insulating oil	0.2 to 0.4
Bad insulating oil	Exceeding 0.4

It is recommended for determination of the overall insulating oil condition to use results of other tests such as the following together taking the manufacturer's instructions into consideration.

- ASTM D877 - 02(2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
- ASTM D924 - 08 Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
- ASTM D971 - 12 Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method
- ASTM D1298 - 99(2005) Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
- ASTM D1500 - 07 Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
- ASTM D1524 - 94(2010) Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field
- ASTM D1698 - 03(2008) Standard Test Method for Sediments and Soluble Sludge in Service-Aged Insulating Oils
- ASTM E203 - 08 Standard Test Method for Water Using Volumetric Karl Fischer Titration

- JIS C 2101:1996 Testing methods of electrical insulating oils
- IEC 60296 Ed. 4.0:2012 (b) Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear

3. Tests to determine the breakdown voltage of insulating oil

The breakdown voltage measurement of insulating oil is a test to measure the electrical breakdown voltage of insulating oil sampled from a transformer. An example of classification of insulating oil is shown in Table 384-2.

Table 384-2 An example of classification of insulating oil

Insulating oil condition	Breakdown voltage based on JIS C 2101
Good insulating oil	Not less than 20kV
Marginal insulating oil	15kV to 20kV
Bad insulating oil	Less than 15kV

4. Dealing with bad insulating oil

If a result of tests indicates bad insulating oil, there are two options which are replacement or reclamation. The reclamation is usually performed with the process which consists of heating the bad insulating oil, filtering it through absorbent, and recirculating it in order to dissolve, purge and filter sludge, etc. It is recommended for dealing with bad insulating oil to take the manufacturer's instructions into consideration.

In addition, following items are recommended to be considered during replacement or reclamation.

- If new oil supplied, the performance such as flash point or dielectric strength may not be improved.
- Using same oil or specified the manufacture is recommended in order to prevent degradation of dielectric strength and cooling capability.
- In principle, replacement or reclamation should be performed when the transformer is not in operation.
- Cares such as locking relays should be taken not to operate the pressure valves or relays accidentally by the pressure fluctuation. (Therefore, the transformer should not be in operation).
- After replacement or reclamation of insulating oil, the gaskets and packing are changed to new ones.

5. Desiccant of breather

A breather has silica gel as desiccant (absorbent) to remove moisture from the air entering the equipment such as conservator tank. When the silica gel turns pink from proper color (blue), it indicates that a saturation point has been reached. Thus, it is necessary that the silica gel including non-indicating silica gel is replaced or regenerated when approximately one-third remains with the proper color. Also, it is necessary to maintain proper oil level for the breather if it is an oil type.

Note: there is other indicating silica gel that the color changes from yellow to green as moisture is absorbed.

Article 385. Hydraulic system oil for turbine

EHC and MHC are main control system for steam turbine. MHC controls governor of steam turbine by mechanical structure composed of lever, cam, link, hydraulic relay and piston etc. MHC has mechanical lag in connection with expanding scale of steam turbine and MHC mechanical structure. Thus, EHC was developed to solve this problem and is main stream of steam turbine control system recently. This system is composed of following equipments.

- Pump (EHC high pressure oil pumps and circulating pump)
- Oil tank
- Oil cooler
- Oil strainer etc.

1. Point to be checked at daily patrol and inspection

Reliable operation of turbine depends on proper management of each equipment by daily patrol and inspection etc. Point to be checked at daily patrol and inspection of this system is shown as follows ;

(1) Pump

1) Pump outlet pressure
2) Abnormal noise, abnormal odor, vibration and leakage
3) Heating, abnormal noise and oil leakage for bearing
4) Level, change in color and leakage for lubricant oil
5) Leakage and corrosion of piping
6) Leakage and corrosion of valves
7) Corrosion and peeling for painting etc.

(2) Oil tank

1) Oil level (high or low)
2) Oil temperature (high or low)
3) Oil leakage
4) Damage and deformation
5) Peeling of painting etc.

(3) Oil cooler

1) Oil temperature
2) Oil leakage
3) Damage and corrosion etc.

(4) Oil strainer

1) Differential pressure
2) Oil leakage
3) Damage and corrosion etc.

2. Condition of hydraulic system oil

Condition of hydraulic system oil for turbine must satisfy used oil limits specified by the manufacturer. Sample of hydraulic system oil for EHC is shown as follows;

Table 385-1 Sample aspect of hydraulic system oil

Items		Aspect
Density	g/cm3	1.14
Ignition point	degree C	254
Auto ignition point	degree C	636
Kinetic viscosity	mm2/s	40.5
Current point	degree C	-20.0
acid number	mgKOH/g	0.02
Chlorine	massppm	21
Color (ASTM)	-	0.5
SAE	-	Grade 3

Reference Vietnamese standard

Number	Issued	Title
QCVN 05	2009	National technical regulation on ambient air quality
QCVN 06	2009	National technical regulation on hazardous substances in ambient air
QCVN 22	2009	National technical regulation on emission of thermal power industry
QCVN 24	2009	National Technical Regulation on Industrial Wastewater
TCVN 3985	1999	Acoustics. Allowable noise levels at workplace
TCVN 4923	1989	Protection against noise. Means and method. Classification
TCVN 5067	1995	Air quality. Weight method for determination of suspended dusts content
TCVN 5126	1990	Vibration. Permisible values at workplaces
TCVN 5136	1990	Noise. Methods of measurement. General requirements
TCVN 5937	1995	Air Quality Standard of Vietnum
TCVN 5938	1995	Air quality-Maximum allowable concentration of hazardous substances in ambient air.
TCVN 5939	1995	Air quality-Industrial emission standards-Inorganic substances and dusts
TCVN 5942	1995	Water quality. Surface water quality standard
TCVN 5943	1995	Water quality. Coastal water quality standard
TCVN 5944	1995	Water quality. Ground water quality standard
TCVN 5945	2010	Industrial waste water. Discharge standards
TCVN 5949	1998	Acoustics. Noise in public and residental areas Maximum permited noise level
TCVN 5971	1995	Ambient air. Determination of the mass concentration of sulfur dioxide. Tetrachloromercurate (TCM)/pararosaniline method
TCVN 5972	1995	Ambient air. Determination of the mass concentration of carbon monoxide. Gas chromatographic method
TCVN 5976	1995	Stationary source emission. Determination of the mass concentration of sulfur dioxide. Performance characteristics of automated measuring methods
TCVN 5977	2009	Stationary source emissions. Manual determination of mass concentration of particulate matter
TCVN 5978	1995	Air quality. Determination of mass concentration of sulphur dioxide in ambient air. Thorin spectrophotometric method
TCVN 6138	1996	Ambient air. Determination of the mass concentration of nitrogen oxides. Chemiluminescence method

Number	Issued	Title
TCVN 6152	1996	Ambient air. Determination of the particulate lead content of aerosols collected on filters. Atomic absorption spectrometric method
TCVN 6157	1996	Ambient air. Determination of the mass concentration of ozone. Chemiluminescence method
TCVN 6399	1998	Acoustics - Description and measurement of environmental noise - how to get the appropriate data to use for the territory
TCVN 6503-1	1999	Gas turbines. Exhaust gas emission. Part-1 : Measurement and evaluation
TCVN 6503-2	1999	Gas turbines. Exhaust gas emission. Part-2: Automated emission monitoring
TCVN 6627-2-1	2010	Rotating electrical machines. Part 2-1:Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
TCVN 6627-2A	2001	Rotating electrical machines. Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles). Measurement of losses by the calorimetric method
TCVN 6627-3	2010	Rotating electrical machines. Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines
TCVN 6627-5	2008	Rotating electrical machines. Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code). Classification
TCVN 6627-9	2000	Rotating electrical machines. Part 9: Noise limits
TCVN 6663-13	2000	Water quality. Sampling. Part 13: Guidance on the sampling of water, wastewater and related sludges
TCVN 6696	2009	Solid wastes. Sanitary landfill. General requirements to the environmental
TCVN 6705	2009	Normal solid wastes. Classification
TCVN 6706	2009	Hazardous wastes. Classification
TCVN 6750	2000	Stationary source emissions. Determination of mass concentration of sulfur dioxide. Ion chromatography method
TCVN 6962	2001	Vibration and shock - Vibration emitted by activities of construction works and industry production - The maximum allowable level in the environment of public and residential areas
TCVN 6963	2001	Vibration and shock- Vibration emitted by construction works and industrial productions - Method of measurement
TCVN 6964-2	2008	Mechanical vibration and shock. Evaluation of human exposure to whole-body vibration. Part 2: Vibration in buildings (1 Hz to 80 Hz)
TCVN 7171	-	Air quality. Determination of ozone in ambient air. Ultraviolet photometric method

Number	Issued	Title
TCVN 7172	2002	Stationary source emissions. Determination of the mass concentration of nitrogen oxides. Naphthylethylenediamine photometric method
TCVN 7704	2007	Boilers. Technical requirement of design, construction, manufacture, installation, operation, maintenance
TCVN 7725	2007	Ambient air. Determination of carbon monoxide. Non-dispersive infrared spectrometric method
TCVN 7726	2007	Ambient air. Determination of sulfur dioxide. Ultraviolet fluorescence method
TCVN 7878-1	2008	Acoustics. Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedures
TCVN 7878-2	2010	Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of environmental noise levels
TCVN 8018	2008	Acoustics. Noise control design procedures for open plant

Reference Japanese standard

Number	Issued	Title
JEC 2130	2000	Synchronous machines
JEC 2137	2000	Induction machines
JIS B 0906	1998	Mechanical vibration ─ Evaluation of machine vibration by measurements on non-rotating parts─General guidelines
JIS B 0907	1989	Mechanical Vibration of Rotating and Reciprocating Machinery ─Requirements for Instruments for Measuring Vibration Severity
JIS B 0910	1999	Mechanical vibration of non-reciprocating machines ─ Measurementson rotating shafts and evaluation criteria ─ General guidelines
JIS B 8003	2005	Internal combustion engines -- Determination and method for the measurement of engine power -- General requirements
JIS B 8042-1	2001	Gas turbines-procurement ─ Part1 : General introduction and definitions
JIS B 8042-4	2003	Gas turbines-Procurement-Part 4: Fuels and environment
JIS B 8042-9	2003	Gas turbines - Procurement - Part 9: Reliability, availability, maintainability and safety
JIS B 8043-1	2000	Gas turbines─Exhaust gas emission─Part 1 : Measurement and evaluation
JIS B 8043-2	2000	Gas turbines ─ Exhaust gas emission ─ Part 2 : Automated emission monitoring
JIS B 8101	2003	Specifications for steam turbines
JIS B 8223	2006	Water conditioning for boiler feed water and boiler water
JIS B 8310	1985	Methods of A-weighted Sound Pressure Level Measurement for Pumps
JIS B 8346	1991	Fans, blowers and compressors─Determination of A-weighted sound pressure level
JIS C 2101	1996	Testing methods of electrical insulating oils
JIS C 4210	2001	Low-voltage three-phase squirrel-cage induction motors for general purpose
JIS C 4212	2000	Low-voltage three-phase squirrel-cage high-efficiency induction motors
JIS C 4411	2004	Uninterruptible power systems (UPS) -- Part 3: Method of specifying the performance and test requirements
JIS K 0410-3-7	2000	Water quality─Sampling─Part 7 : Guidance on sampling of water and steam in boiler plants
JIS K 2213	2006	Turbine oil

Number	Issued	Title
JIS K 2249-1	2011	Crude petroleum and petroleum products - Determination of density - Part1:Oscillating U-tube method
JIS K 2249-2	2011	Crude petroleum and petroleum products - Determination of density - Part2:Hydrometer method
JIS K 2249-3	2011	Crude petroleum and petroleum products - Determination of density - Part3:Capillary pyknometer method
JIS K 2251	2003	Crude petroleum and petroleum products – Sampling
JIS K 2275	1996	Crude petroleum and petroleum products – moisture test method
JIS K 2279	2003	Crude petroleum and petroleum products - Determination and estimation of heat of combustion
JIS K 2283	2000	Crude petroleum and petroleum products ― Determination of kinematic viscosity and calculation of viscosity index from kinematic viscosity
JIS K 2301	2011	Fuel gases and natural gas-Methods for chemical analysis and testing
JIS K 2541-1	2003	Crude oil and petroleum products-Determination of sulfur content Part1: Wickbold combustion method
JIS K 2541-2	2003	Crude oil and petroleum products-Determination of sulfur content Part2: Oxidative microcoulometry
JIS K 2541-3	2003	Crude oil and petroleum products-Determination of sulfur content Part3: Quartz-tube combustion method (Air method)
JIS K 2541-4	2003	Crude oil and petroleum products-Determination of sulfur content Part4: Energy-dispersive X-ray fluorescence method
JIS K 2541-5	2003	Crude oil and petroleum products-Determination of sulfur content Part5: General bomb method
JIS K 2541-6	2003	Crude oil and petroleum products-Determination of sulfur content Part:6 Ultraviolet fluorescence method
JIS K 2541-7	2003	Crude oil and petroleum products-Determination of sulfur content Part:7 Wavelength-dispersive X-ray fluorescence method
JIS K 2609	1998	Crude petroleum and petroleum products ― Determination of nitrogen content
JIS M 8811	2000	Coal and coke-Sampling and sample preparation
JIS M 8812	2006	Coal and coke - industrial chemical analysis
JIS M 8813	2006	Coal and coke - elemental analysis
JIS M 8814	2003	Coal and coke - Determination of gross caloric value by the bomb calorimetric method, and calculculation of net calorific value
JIS M 8820	2000	Coal and coke - Determination of total moisture content of a lot
JIS Z 9110	1979	Lighting of outdoor work places
JIS Z 9125	2007	Lighting of indoor work places
JIS Z 9126	2010	Lighting of outdoor work places

Reference International standard

Number	Issued	Title
ANSI/API 510	2006	Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration
API RP 576	2009	Inspection of Pressure-Relieving Devices
ASME B133.8	2011	Gas Turbine Installation Sound Emissions
ASME B133.9	1994	Measurement Of Exhaust Emissions From Stationary Gas Turbine Engines
ASME BPVC-VI	2010	BPVC Section VI-Recommended Rules for the Care and Operation of Heating Boilers
ASME PTC19.10	1981	Flue and Exhaust Gas Analyses
ASME PTC19.11	2008	Steam and Water Sampling, Conditioning, and Analysis in the Power Cycle
ASME PTC36	2004	Measurement of Industrial Sound
ASTM D95-05	2010	Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
ASTM D877	2007	Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D924	2008	Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
ASTM D971	2012	Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method
ASTM D974	2011	Standard Test Method for Acid and Base Number by Color-Indicator Titration
ASTM D1298	2005	Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
ASTM D1500	2007	Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
ASTM D1524	2010	Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field
ASTM D1698	2008	Standard Test Method for Sediments and Soluble Sludge in Service-Aged Insulating Oils
ASTM D 4304	1993	Standard Specification for Mineral Lubricating Oil Used in Steam or Gas Turbines
ASTM E203	2008	Standard Test Method for Water Using Volumetric Karl Fischer Titration
IEC60034-1	2010	Rotating electrical machines - Part 1: Rating and performance

Number	Issued	Title
IEC60034-3	2007	Rotating electrical machines - Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines
IEC60034-30	2008	Rotating electrical machines - Part 30: Efficiency classes of single-speed, three-phase, cage-induction motors (IE-code)
IEC 60038	:2009	IEC standard voltages
IEC 60296	2012	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
IEC60422	2005	Mineral insulating oils in electrical equipment - Supervision and maintenance guidance
IEC 60529	2001	Degrees of protection provided by enclosures (IP Code)
IEC 60598-1	2008	Luminaires - Part 1: General requirements and tests
IEC 60045-1	1991	Steam turbines - Part 1: Specifications
IEC 60072-1	1991	Dimensions and output series for rotating electrical machines - Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080
IEC 60072-2	1990	Dimensions and output series for rotating electrical machines - Part 2: Frame numbers 355 to 1000 and flange numbers 1180 to 2360
IEC 60072-3	1994	Dimensions and output series for rotating electrical machines - Part 3: Small built-in motors - Flange numbers BF10 to BF50
IEC 61000-4-11	2010	Interpretation Sheet 1 - Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests
IEC 62040-2	2005	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements
IEC 62040-3	2011	Corrigendum 1 - Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements
ISO 334	1992	Solid mineral fuels -- Determination of total sulfur -- Eschka method
ISO 562	2010	Hard coal and coke -- Determination of volatile matter
ISO 589	2008	Hard coal -- Determination of total moisture
ISO 687	2010	Solid mineral fuels -- Coke -- Determination of moisture in the general analysis test sample
ISO 1928	2009	Solid mineral fuels -- Determination of gross calorific value by the bomb calorimetric method and calculation of net calorific value
ISO 1996-1	2003	Acoustics -- Description, measurement and assessment of environmental noise -- Part 1: Basic quantities and assessment procedures
ISO 1996-2	2007	Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels
ISO 2909	2002	Petroleum products -- Calculation of viscosity index from kinematic viscosity

Number	Issued	Title
ISO 2954	2012	Mechanical vibration of rotating and reciprocating machinery -- Requirements for instruments for measuring vibration severity
ISO 3104	1994	Petroleum products -- Transparent and opaque liquids -- Determination of kinematic viscosity and calculation of dynamic viscosity
ISO 3170	2004	Petroleum liquids -- Manual sampling
ISO 3648	1994	Aviation fuels -- Estimation of net specific energy
ISO 3675	1998	Crude petroleum and liquid petroleum products -- Laboratory determination of density -- Hydrometer method
ISO 3733	1999	Petroleum products and bituminous materials -- Determination of water -- Distillation method
ISO 3838	2004	Crude petroleum and liquid or solid petroleum products -- Determination of density or relative density -- Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods
ISO 4260	1987	Petroleum products and hydrocarbons -- Determination of sulfur content -- Wickbold combustion method
ISO 5667-7	1993	Water quality -- Sampling -- Part 7: Guidance on sampling of water and steam in boiler plants
ISO 5667-10	1992	Water quality -- Sampling -- Part 10: Guidance on sampling of waste waters
ISO 6326-1	2007	Natural gas -- Determination of sulfur compounds -- Part 1: General introduction
ISO 6327	1981	Gas analysis -- Determination of the water dew point of natural gas -- Cooled surface condensation hygrometers
ISO 6974-1	2012	Natural gas -- Determination of composition and associated uncertainty by gas chromatography -- Part 1: General guidelines and calculation of composition
ISO 6974-2	2012	Natural gas -- Determination of composition and associated uncertainty by gas chromatography -- Part 2: Uncertainty calculations
ISO 6974-3	2000	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 3: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and hydrocarbons up to C8 using two packed columns
ISO 6974-4	2000	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 4: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line measuring system using two columns

Number	Issued	Title
ISO 6974-5	2000	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 5: Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line process application using three columns
ISO 6974-6	2002	Natural gas -- Determination of composition with defined uncertainty by gas chromatography -- Part 6: Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons using three capillary columns
ISO 6975	1997	Natural gas -- Extended analysis -- Gas-chromatographic method
ISO 6976	1995	Natural gas -- Calculation of calorific values, density, relative density and Wobbe index from composition
ISO 7919-1	1996	Mechanical vibration of non-reciprocating machines -- Measurements on rotating shafts and evaluation criteria -- Part 1: General guidelines
ISO 7919-4	1996	Mechanical vibration of non-reciprocating machines – Measurements on rotating shafts and evaluation criteria – Part4 : gas turbines sets
ISO 8068	2006	Lubricants, industrial oils and related products (class L) -- Family T (Turbines) -- Specification for lubricating oils for turbines
ISO 8217	2010	Petroleum products -- Fuels (class F) -- Specifications of marine fuels
ISO 8754	2003	Petroleum products -- Determination of sulfur content -- Energy-dispersive X-ray fluorescence spectrometry
ISO 8995-1:2002(E)/CIE S008/E: 2001	2002	Lighting of Work Places Part 1: Indoor
ISO 8995-3:2006(E)/CIE S016/E: 2005	2006	Lighting of Work Places Part 3: Lighting Requirements for Safety and Security of Outdoor Work Places
ISO 9029	1990	Crude petroleum -- Determination of water -- Distillation method
ISO 10494	1993	Gas turbines and gas turbine sets -- Measurement of emitted airborne noise -- Engineering/survey method
ISO 10816-1	1995	Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts -- Part 1: General guidelines
ISO 10816-2	2009	Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts -- Part 2: Land-based steam turbines and generators in excess of 50 MW with normal operating speeds of 1 500 r/min, 1 800 r/min, 3 000 r/min and 3 600 r/min
ISO 10816-4	2009	Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts -- Part 4: Gas turbine sets with fluid-film bearings

Number	Issued	Title
ISO 12185	1996	Crude petroleum and petroleum products -- Determination of density -- Oscillating U-tube method
ISO 13909-2	2001	Hard coal and coke -- Mechanical sampling -- Part 2: Coal -- Sampling from moving streams
ISO 13909-3	2001	Hard coal and coke -- Mechanical sampling -- Part 3: Coal -- Sampling from stationary lots
ISO 13909-4	2001	Hard coal and coke -- Mechanical sampling -- Part 4: Coal -- Preparation of test samples
ISO 13909-7	2001	Hard coal and coke -- Mechanical sampling -- Part 7: Methods for determining the precision of sampling, sample preparation and testing
ISO 15550:2002	2002	Internal combustion engines -- Determination and method for the measurement of engine power -- General requirements
ISO 16591	2010	Petroleum products -- Determination of sulfur content -- Oxidative microcoulometry method
ISO 19739	2004	Natural gas -- Determination of sulfur compounds using gas chromatography
ISO 20846	2011	Petroleum products -- Determination of sulfur content of automotive fuels -- Ultraviolet fluorescence method
ISO 20884	2011	Petroleum products -- Determination of sulfur content of automotive fuels -- Wavelength-dispersive X-ray fluorescence spectrometry
ISO 22734-1	2008	Hydrogen generators using water electrolysis process -- Part 1: Industrial and commercial applications

Part 7
LOAD DISPATCH COMMAND – OPERATION

Chapter 1 LOAD DISPATCH COMMAND

Article 386. General provision

National dispatch center, dispatch center region and local domain and all units operate electrical equipment such as transformers, transmission lines, power plants, etc., responsible for securing the following obligations.

1. Reservation of hot standby and spinning reserve

Each operator shall endeavor to secure the following as a supply capability of the supply area.

- - Reserve margin: 8-10%
- - Operation reserve capacity on current day: It is not less than 5% of the anticipation maximum electric power of the operation day.
- - Spinning reserve: It is about 3% of system capacity.

2. Frequency control
   - - About 1-2% of system capacity shall be reserved in principle as frequency control capability (Load Frequency Control Capacity).
   - - Frequency deviation: 95% or more staying in the ranges of 50.0 Hz plus minus 0.1 Hz
   - - Time deviation: Within plus minus 15 seconds
3. Target voltage

The target voltage of power station and substation is determined so that the voltage supplied to consumer may be maintained in an acceptable variation. In addition, each of the following items is taken into consideration of setting up the target voltage of system voltage.

(1) System configuration, arrangement of generator, and capacity of phase modifying equipment.

(2) System characteristic, load characteristic, and performance of voltage adjustment equipment

(3) Permission voltage range of electric power system equipment

(4) Reservation of system stability

(5) Range of permission change of voltage supplied to customer

(6) Conservation of the proper reactive power balance of power system

(7) Reduction of electric power loss

- Voltage range in normal operation mode:

• Voltage level of the electrical system must be determined according to the operating mode, load the largest and the smallest load. In normal conditions, the voltage is allowed to fluctuate in the range from -5% to +5% from the nominal voltage and is determined on the secondary side of the transformer supplying power to the households use electricity and from -5% to +10% at the connection points for power plants

• When the power network is not stable, then the voltage is allowed to fluctuate in the range of -10% to +5%.

• In normal working conditions of the supply power center, during the time when the total load reduction of 30% of the maximum load, the voltage at the busbar must be kept at normal voltage of electrical network

• In normal working conditions of the transmission power network, the voltage at the busbar allows the operator to ± 10%.

- **Scope of voltage fluctuations in power distribution networks (**circular **32-2010** MOIT)

1. In the single incident or in the process of restoring stable operation after the incident, allowing the range of the voltage at the connection point with customers using electricity directly affected by the incident in the range of +5 % and -10% from the nominal voltage.
2. In the critical incident power transmission systems or disaster recovery, allowing the voltage in the range ± 10% of nominal voltage.

- **Scope of voltage fluctuation in the power transmission network (**circular 1**2-2010** MOIT)

1. In the case of electricity transmission system crash elements, serious incidents, in a state of emergency or in the process of restoring the system, allowing the range of the temporary grid voltage is greater than ± 10 % of nominal voltage but not exceed ± 20% of nominal voltage.
2. During the incident, the voltage at the scene of an incident and the neighborhood can reduce the value of 0 in phase with the incident or more than 110% of the nominal voltage in the phase is not a problem for until the problem has been eliminated.

Article 387. Load dispatching instruction

It shall be necessary to install the following devices in the substation and the power station, etc. and the load dispatching center to be operated the power system by a certain load dispatching command at normal and the accidental situations. Details shall depend on a related standard.

(1) The communication equipment for stay in touch

(2) Dispatching data transmission equipment (transmission equipment of telemetering data, switching condition and current and voltage value etc. of equipment to be controlled)

Article 388. Submission of annual schedule on overhauls and repairs

The national load dispatch center settles on the supply and demand program to secure necessary reserved capacity for the demand for Vietnam, and to keep the service reliability. When supply and demand program is settled on, the following items should be taken into consideration.

- Equipment outage program including inspection and repair program etc. on each power plant
- Equipment outage program including inspection and repair program etc. on transmission and substation equipment for bulk power system

Decide the timing of implementation of the above-mentioned equipment outage program of the power plant and the transmission and substation equipment based on the following matters.

Table 388 Consideration matters of developing the equipment outage program

Large item	Detailed item
Guaranty and security of equipment maintenance	- Preservation / check cycle of power equipment - Working condition - Worker and public security
Service reliability	- Power flow - Conservation of proper frequency and voltage - System stability - Influence rate and fault restoration at the time of equipment breakdown - Emergency rehabilitation time - Evade the time when disasters such as heavy load periods, thunder, and typhoon are expected. - Evasion of overlapping equipment outage program in related power system
Electrical power supply and demand	- Conservation of supply and demand balance - Reservation of proper reserve capacity
Rationality	- Cooperation of the stop plan with international consecutive system facilities, the consecutive system facilities between areas and the power supply - The time with little overflow electric power
Other	- Necessity of equipment outage for safety work - The contents of construction such as work period and construction methods

Article 389. Allowable load capacity of electrical equipment and power transmission lines

It is necessary to set the permissible operation capacity of the power equipment and conductors of the power station and the substation equipment, etc. from the viewpoint of the prevention of equipment destruction when operating them.

The system operator and the owner of equipment shall set the above capacity under consideration of the following items.

- Timing of reviewing permissible operation capacity
  + When the rated capacity and the overload capacity of equipment are changed by the equipment replacement and repair (However, the permissible operation capacity is set the minimum value among the permissible operation capacity of various equipment which is series connection)
  + When the overload capacity of the transformer is changed by the result of dissolved gas analysis for transformer etc. (When the overload capacity is changed by the aged deterioration of the equipment)
  + Items to review when the permissible operation capacity was modified.

+ Relay setting for over current protection (prevention of malfunction and failure of the relay operation caused by the change of power flow)

+ Relay setting for automatic load limiter (Automatic load limiter : When transmission line overload is detected, partial load will be limited automatically to resolve the overload)

Article 390. Load curve of hydropower plants

The operation of the hydropower station where is provided the amount of tailwater by the water demand in the downstream shall be followed the below.

- As for the output of the power station, it is calculated based on the amount of tailwater (volume of water for power generation) and in consideration of the effective head, the water turbine and the generator efficiency. The power generation program shall be scheduled along the volume of water for power generation.
- The operator shall operate according to the power generation program, record the operation activities, and keep the record.

Article 391. Keeping of assigned load curves and spinning reserves of power plants

The national load dispatch center develops the total demand curve in the entire system in consideration of the demand change factor of the social environment, the season and the weather etc.

When supply and demand curve for power plant generation is made, it is necessary to consider the following items.

- Select the operating power plant, and decide the economical load dispatch among the above power plant in consideration of the generation characteristic of each power plant.
- Decide the economical load dispatch (load curve) of each generating unit in consideration of the generation characteristic of each power unit according to the above decision.

Moreover, the appropriate operating reserved capacity such as spinning reserve, etc. shall also be secured to do steady supplies against the margin of demand forecast error and the power supply dropout, etc.

Though the power plant operates according to the load curve of the above-mentioned, when the power plant doesn't obtain the load curve by some reasons, the power plant shall report on the situation to the national or the local load dispatch center which has the right to control. The load dispatch center that receives the above report shall send the concerned load curve again or execute dispatch command to control the output of generators in consideration of the demand and supply balance etc.

Article 392. Frequency of power system

Refer to the frequency control of the guideline of Article 386 for the maintenance target of the frequency of the power system.

Article 393. Voltage of power system

Each load dispatch center shall provide the target voltage of power system in which the matter shown in the guideline of Article 386 is considered, and execute operation based on the following items to keep the target voltage of various place and to allocate the reactive power reasonably.

(1) To decrease the reactive power flow of the transmission transformer as much as possible within the range of the target voltage of the transformer.

(2) The system voltage shall be kept high level as much as possible within the range of the target voltage, to decrease the transmission loss and the voltage drop at the time of power system fault.

(3) As for the operation of the interconnection transmission line between local power systems, both dispatch centers shall control the system voltage and reactive power flow concertedly according to the concerned agreement.

Article 394. Stop procedure of various control system

When the various protection systems and the load dispatch systems, etc are stopped, it is necessary to submit the plan that describes the stop device, the stop period, and the stop reason, etc. to the load dispatch center that operates equipment concerned, in order to avoid a decrease service reliability.

In addition, the load dispatch center shall confirm the submitted plan, and decide the stop plan of the system concerned after considering the following matters.

Table 394 Consideration matter when system stop is adjusted

Large item	Detailed item
Service reliability	- Power flow - Conservation of proper frequency and voltage - System stability - Influence rate and fault restoration at time of equipment breakdown - Emergency rehabilitation time - Evasion of the time when disasters such as heavy load periods, thunder, and typhoon are expected. - Evasion of overlapping equipment outage program in related power system
Electrical power supply and demand	- Conservation of supply and demand balance - Reservation of proper reserve capacity
Rationality	- Cooperation of the stop plan with international consecutive system facilities, the consecutive system facilities between areas and the power supply - The time with little overflow electric power
etc	- Necessity of equipment outage for safety work - The contents of construction such as work period and construction methods - Security of worker

Article 395. Unscheduled repair

It is necessary to submit the document that describes the stop equipment, the stop period, and the stop reason, etc. to the load dispatch center that operates equipment concerned when it is necessary to stop equipment by unexpected equipment failure etc.

In addition, the above mentioned procedure can be omitted when emergency situations occur, such as the problem of a human safety and the equipment maintenance, etc.

Article 396. Allowable time in the request

It shall be necessary to describe the following items for the outage period in the application of the equipment outage.

- Required time to the stop operation of equipment under operation
- Required time to the inspection and the repair
- Required time to the restoration operation after the inspection and the repair, etc.

When the stop period changes by extending working hours, it shall be necessary to report prior to the load dispatch center that has jurisdiction, and to obtain approval.

Article 397. Stop of operation

The owner of equipment shall begin the operation of equipment outage and the work after the contacting the load dispatch center that has jurisdiction, discussing a necessary matter among the following items, and obtaining the approval of the load dispatch center.

(1) Responsible person

(2) Area of equipment outage

(3) Work content

(4) Installation place of grounding

(5) Operational procedure of equipment outage

(6) Estimated time of the initiation and termination of working

(7) While work discontinuance condition and emergency restoration estimated time

(8) Other necessary information

Article 398. Fault clearance procedures

The owner of the equipment and the system operator shall make the operation manual to be able to execute the restoration operation promptly for each power station and substation when the failure occurs in the power system. In addition, the following failure modes are targeted.

(1) Transmission line failure (For each circuit and two or more circuit simultaneous failure by the case where the protective relay for transmission lines operates)

(2) Black out failure

(3) Bus failure (For each bus and two or more bus simultaneous failure by the case where the bus protection relay operates)

(4) Failure to operate of circuit breaker (when the bus-bar separation relay and the system separation relay operate)
(5) Transmission transformer failure (when the protective relay operates)
(6) Distribution transformer failure (when the protective relay operates)
(7) Generator failure (when the protective relay operates)
(8) Phase modifier equipment failure (when the protective relay operates)
(9) Other main equipment failure (when the protective relay of starting transformer and the desulfurization equipment transformer, etc operate)

Chapter 2 OPERATION ON ENERGIZING AND DE-ENERGIZING ELECTRICAL EQUIPMENT

Article 399. Connection diagram of equipment

The operator of the equipment for power station and substation equipment shall install the load dispatching panel that can confirm the switching condition etc. of operational target equipment in order to operate the equipment certainly.

For the switching condition of the equipment of the load dispatching panel shall be preferable that the switching condition of a local equipment is automatically reflected online, but in case of off-line information, it shall certainly reflect the switching condition in the panel after operating on site.

Chapter 3 OPERATOR

Article 400. Operator

It is indispensable to perform the unified operation of power generating facility, transmission and distribution and substation facility in order to supply the electric power with stability. This unified operation is carried out by a load dispatch center, a power station, and a distribution company, etc. , and achieves stable electric power supplies.

Therefore, the operator of these organizations shall appropriately be selected among the candidates who not only have knowledge of system operation and various target equipment but also can take proper responses against accidents.

Article 401. Maintenance of equipment for power sector

There are the following two kinds of maintenance of the power equipment.

- Repair: Restoration of a broken, damaged, or failed device to an acceptable operating or usable condition.
- Periodical inspection: Inspection that is carried out periodically and repeatedly.

As for the maintenance, It is desirable to decrease the frequency of equipment outage and to narrow the area of equipment outage in terms of service reliability.

Therefore, it shall be necessary to plan the schedule of repair and inspection with equipment outage in consideration of the following items.

- Simultaneous implementation of work with the same equipment outage (For example, simultaneous implementation of the periodic inspection and the repair)
- Simultaneous implementation of work with the same area equipment outage (For example, simultaneous implementation of inspection of the circuit breaker and cubicle which are stopped with inspection of a transformer)

Article 402. Responsibility for supervise and maintenance of equipment and machineries

The operator of the load dispatching center, the power station and substation shall always grasp the following items using the load dispatching system, etc in order to operate the power system appropriately and smoothly, prevent the fault of various equipment and keep the quality of electricity.

- Operation condition of the generator and the transmission and substation equipment
- Demand and supply balance
- Power system condition of frequency, voltage and the power flow, etc.

Article 403. Inspection of facilities for operation

For smooth supervisory control, the essential equipment for power system operation, such as the SCADA system and attendant communication equipment shall satisfy the specification provided in the related regulations, in addition, these equipment shall carry out the periodic inspection and repair in common with the power equipment. But the inspection contents and quality control, etc. shall observe the related regulations, etc.

Chapter 4 DISPATCHING AND CONTROLLING DEVICES

Article 404. Load dispatching and controlling devices

The provisions of this article shall refer to the Article 403.

Article 405. Telecommunication equipment and remote control system

The provisions of this article shall refer to the Article 403.

Article 406. Operation of telecommunication network, remote system and communication transmission system

The essential equipment for power system operation, such as various control system and the protective relay shall be operated integrally with communication facilities. Therefore, the load dispatching center and the operational section of the power station and substation shall always grasp the condition of communication circuit. In case that the fault of communication circuit occurs, the above operational section shall ask the communication section to repair and maintain it.

When the communication section offers the communication circuit's stop for the power system operation to the load dispatching center, the operator shall stops the operation of related equipment such as the protective relay, etc by the load dispatching instruction. After that, the communication section stops the communication circuit.

Article 407. Documents for load dispatching and controlling devices

It is preferable that the load dispatching center and the operational section of power station and substation equip the related documents that are necessary for operations, in addition compile various equipment operational manual for the daily operation and the accident response, based on the above documents.

Article 408. Protection for landline telecommunication devices

A lot of communication wires that connect to the landline telecommunication devices are joint use of distribution line. Therefore, these devices might be broken by the surge voltage etc. Therefore, it shall be necessary to implement the protective measures which satisfy the related regulations including "Regulations on protecting landline telecommunication devices of power system from voltage impact and hazardous current"

Article 409. Standby supply sources for load dispatching and controlling devices

Both DC and AC power supply for various load dispatching equipment shall be dual system.

In addition, these power supplies shall change to the reserve system without interruption of power supply at the time of the trouble of the active system. For more information about power supply specifications, the related regulations including "Instructions on designing power supply source for dispatching and controlling devices in power system" shall be followed.

Article 410. Inspection of load dispatching and controlling devices

The load dispatching center and the operational section of power station and substation shall inspect the load dispatching and controlling devices according to the Article 403 of guidelines.

In addition, as for confirming of the regular position of various switches and the fault indicators, etc,

It is preferable that regular position of various switches, etc are described in the operational manual and the regular positioning seal (refer to the following figure) is attached to various switches and indicator etc, to confirm quickly and certainly without false recognition.

[The example of attachment of a regular position seal]

- Attachment example to various switches

  The red seal is pasted in regular position of the switch in advance. when the usual position is changed to other place, patroller can easily confirm that the current position is different from the regular position.

Figure 410-1 Attachment example to various switches

- Attachment example to equipment state and fault indicator

The red seal is pasted in regular lighting position of the indicator in advance. If the always switched-off indicator lights up, the patroller can understand that it is necessary to confirm immediately.

Figure 410-2 Attachment example to equipment state and fault indicator