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

Guideline for Technical Regulation Volume 2

Design of Thermal Power Facilities

Book 10/12

« Environment Facility »

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List of Acronyms/Abbreviations

AH	Air Heater
API	American Petroleum Institute
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CPI	Corrugated Plate Interceptor
DO	Dissolved Oxygen
DONRE	Department of Natural Resources an Environment
EIA	Environment Impact Assessment
EP	Electrostatic Precipitator
GGH	Gas-Gas Heater
JIS	Japanese Industrial Standard
MLSS	Mixed Liquor Suspended Solid
MOST	Ministry of Science and Technology
MONRE	Ministry of Natural Resources an Environment
MOSTE	Ministry of Science, Technology and Environment
NOx	Nitrogen Oxides
OECD	Organization for Economic Co-operation and Development
PPI	Parallel Plate Interceptor
SEA	Strategic Environmental Assessment
SOx	Sulfur Oxides
SS	Suspended Solid
SV	Sludge Volume
SVI	Sludge Volume Index
TSS	Total Suspended Solid

Chapter-1. Comparison between Technical Regulation and Technical Guideline of environmental facility

The article number of this guideline is shown in the Table-1 contrasted technical regulation with technical guideline for easy understanding.

Table- 1: Comparison between Technical Regulation and Technical Guideline of environmental facility

Technical Regulation		Technical Guideline	
Article 219.	Laws and Regulations Related to Environment	Article 219.	Laws and Regulations Related to Environment
-1.	Article 219-1. Related Laws, Regulations, OCVN and TCVN	-1.	Article 219-1. Related Laws, Regulations, OCVN and TCVN
Article 220.	Facility to Prevent Air Pollution	Article 220.	Facility to Prevent Air Pollution
-1.	Emission Limit of pollution parameter	-1.	Emission Limit of pollution parameter
-2.	Maximum allowable concentration of air pollution	-2.	Maximum allowable concentration of air pollution
Article 221.	Principle of Effluent Treatment	Article 221.	Principle of Effluent Treatment
-1.	Principle of Effluent Treatment	-1.	Principle of Effluent Treatment
Article 222.	Discharge Standard of Effluent	Article 222.	Discharge Standard of Effluent
-1.	Value of the Parameters of Pollution in Industrial Wastewater	-1.	Value of the Parameters of Pollution in Industrial Wastewater
-2.	Maximum allowable value parameter	-2.	Maximum allowable value parameter
Article 223.	Facility to Prevent Noise	Article 223.	Facility to Prevent Noise
-1.	Noise Limit	-1.	Noise Limit
Article 224.	Facility to Prevent Vibration	Article 224.	Facility to Prevent Vibration
-1.	Vibration Limit	-1.	Vibration Limit
Article 225.	Measures for Effluent	Article 225.	Measures for Effluent
-1.	Dust Prevention of Coal Yard	-1.	Dust Prevention in Coal Yard
-2.	Dust Prevention of Ash Treatment Facility	-2.	Dust Prevention of Ash Treatment Facility
-3.	Effluent from Seawater De-Sox	-3.	Effluent from Seawater De-Sox
Article 226.	Measures for Dust from Coal Un-loading Pier, Coal Yard and Ash Pond	Article 226.	Measures for Dust from Coal Un-loading Pier, Coal Yard and Ash Pond
-1.	Dust Prevention of Truck Hopper	-1.	Dust Prevention of Truck Hopper
-2.	Car Washer	-2.	Car Washer
-3.	Conveyor Gallery	-3.	Conveyor Gallery
-4.	Dust prevention from Ash Damping Area	-4.	Dust prevention from Ash Damping Area
-5.	Coal Dust Prevention	-5.	Coal Dust Prevention
Article 227.	Measures for Thermal Effluent	Article 227.	Measures for Thermal Effluent
-1.	Measure for Thermal Effluent	-1.	Measure for Thermal Effluent

Article 219. Laws and regulations related to environment

Article 219-1. Related laws, regulations, QCVN and TCVN

1. Environmental policy

At first, the overview of environmental policies of Vietnam is organized as follows. Environmental Protection Act (Law on Environmental Protection was enforced on 1994 as a basic framework for environmental policy in Vietnam. Environmental regulations such as the air quality standards (TCVN 5937, 5939-1995), water quality standards (TCVN 5942, 5943, 5944-1995) and emission regulations such as emission standards (TCVN 5939-1995), water emission standard (TCVN-5945-1995) and other emissions criteria from pollution sources established in 1995, although Ho Chi Minh city and Hanoi city which were becoming increasingly industrialized had establish environmental regulations by themselves to an earlier before enforcement of the law and deal with environmental issues until then. Now these uniform environmental standards are being revised to respond to changes in circumstances surrounding the regulatory environment for economic growth in recent years. The Amended Environmental Protection Act (Revised Law on Environmental Protection) has passed the National Assembly of Vietnam in 2005 and still valid. Currently, some of the environmental standards enacted in 1995 have been revised and the rest of has been replaced with Vietnam National Technical Regulation (QCVN-05: 2009/BTNMT, etc.).

2. Environmental administration

MOSTE (Ministry of Science, Technology and Environment) which was established in 1992 was in charge of environmental administration in Vietnam and was the responsible agencies which are responsible for the overall technical and environmental concerns such as scientific research, technology development, equipment standards, industrial property rights protection and environmental protection, etc. MOSTE (Ministry of Science and Technology) was divided into MOST (Ministry of Science and Technology) and MONRE (Ministry of Natural Resources and Environment) in August/ 2002 and all matters related to the environment have been transferred to MONRE. MONRE is responsible for overseeing the work done at the National level such as development of documents related to the environment preservation policy, confirmation of status of compliance with environmental laws and regulations, environmental impact assessment (EIA), management of resource.

On the other hand, DONRE (Department of Natural Resources and Environment) which has been installed in the each provinces or central municipalities is charge the environmental administration at the local level. DONRE has been placed under the provincial People's Committee and assist the People's Committee in the management of land use, water resource use, natural resource use, environment, climate, waterway, measurement and map. DONRE is in a position to directly monitor

compliance with environmental regulations and has been monitoring of air quality or water quality, plant inspection and registered for land or water.

3. Vietnamese laws, regulations and ordinance pertaining the thermal power project

(1) Environmental laws

1) Law on Environmental Protection

The environmental Protection Act passed the National Assembly of Vietnam on November/29/2005, promulgated by President's ordinance 29/2005/L/CTN on December/12/2005 and entered into force on July/1/2006. Environmental Protection Act is consisting of all 15 chapters and 136 sections, the overall of chapter-3is consisting by SEA (Strategic Environmental Assessment: paragraph 14~17) and EIA (Environmental Impact Assessment: paragraph 18~23).

2) Decree 80/2006/ND-CP

This is the decree dated Augst/09/2006 "relating to details and guidelines on the implementation of some sections of the Environmental Protection Act". This decree consists of 3 chapters and 25 sections, and it includes SEA and EIA in Section-2 and Chapter-1 and 12 detailed regulations pertaining to environmental protection. A list of projects that need EIA report preparation is provided in Annex-1 of Decree 80/2006/ND-CP and a list of projects that need EIA report preparation and across sectors and provinces reviewing and approving by MONRE in Annex-2. According to these two rules in Annex, "Thermal power projects exceed 50MW" shall establish EIA report and "Thermal power plant with design power of exceed 300MW to less than 500MW and which is located less than 2km from the city or residential area" and "Thermal power project more than 500MW" shall be reviewed and approved as shown in Table-2 and 3.

Table- 2: Appendix-1: List of project to making of Environmental impact Assessment Report

Original No.	Projects	Size
1	Project on key national works	All
2	Projects using part or the whole of land areas of or adversely affecting nature conservation zones, national parks, historical-cultural relic areas, natural heritages and famous scenic places, ranked or not yet ranked, which are protected under decisions of provincial/municipal People's Committees	All
3	Projects involving risks of directly and badly affecting water sources in river basins, coastal areas and areas having protected eco-systems	All
4	Projects on nuclear power plants	All
30	Projects on thermo power plants	Capacity of 50 MW or more
31	Projects on hydropower plants	Reservoir with a capacity of 1,000,000 m^3 or more
32	Projects on building high-voltage power lines	50 km or more in length

Table- 3: Appendix-2. List of inter-industry and inter-province projects which Ministry of Natural Resources and Environment has authority to appraised and approve Environmental Impact Assessment Report

(1)	Projects using part or all of the land of a national park, a natural conservation zone, an ecosphere reserve zone, a world heritage site or an historical and cultural site which has been classified at the national level.
(2)	Nuclear power plant projects, thermo-nuclear power plant projects, and nuclear reactor projects.
(3)	Thermo-power plant projects with a design output capacity of from 300 to 500 MW less than 2 kilometers from an urban or concentrated residential zone; other thermo-electric plant projects with an output capacity of from 500 or more MW.
(4)	Hydro-power plants [or] irrigation works with a reservoir with a capacity of 100,000,000 cubic meters or more of water, or which affect the surface water supply and ground water of two or more provinces and cities under central authority.
(5)	Projects for which protective forest in catchment areas, estuaries or coastal areas, or specialized use forests of 20 hectares or more or natural forest of 200 hectares or more will be cut or destroyed pursuant to a plan for conversion of land use purposes approved by the Government.
(6)	Aquaculture projects on a sandy area of 100 hectares or more.
(7)	Petrochemical refinery projects; projects for manufacturing basic chemicals, plant protection agents, washing detergents, additives [or] chemical fertilizer with an output capacity of from 20,000 tons of product per year; projects for a plant manufacturing batteries with a design output capacity of from 300,000 Wh per year; projects for a plant manufacturing cement with an output capacity of from 1,200,000 tons of cement per year; projects for a manufacturing plant or factory producing radioactive substances or emitting radioactive waste.
(8)	Projects for mining petroleum and gas; projects for mining solid minerals with an output capacity of from 500,000 cubic meters per year (including earth, loose stone and base ore); projects for mining radioactive [and/or] rare earth metals; projects for exploitation of underground water with an output capacity of from 50,000 cubic meters per 24 hours, and for exploitation of surface water with a design output capacity of from 500,000 cubic meters per 24 hours.
(9)	Projects for the construction of infrastructure of an industrial zone, export processing zone, high-tech zone, industrial group, tourism zone and entertainment zone with a land area of 200 or more hectares; projects for the construction of a port for ships of a tonnage of 50,000 DWT or more; projects for [production of] refined steel with a design output capacity of from 300,000 tons of product per year.
(10)	Projects for the recycling of hazardous waste, [and/or] the treatment and disposal of hazardous waste.
(11)	Projects with one or more items of a project set out in paragraphs 1 to 10 above.
(12)	Other projects stipulated in Appendix I lying within the area of two or more provinces and cities under central authority.

3) Decree 81/2006/ND-CP

This is a decree relating to administrative penalties in the area of environmental protection dated on Augst/9/2006. This is consisting all 5 chapters and 44 sections. Section-9 stipulates that the penalty for violating the rules relating to the EIA and SEA.

4) Decree 21/2008/ND-CP

This is issued by the Vietnamese government in February/2008, which is revision and supplement to Decree 80/2006/ND-CP.

5) Circular 08/2006/TT-BTNMT

This is the circular "Guidance for SEA, EIA and environmental initiatives" issued by MONRE on September/8/2006. In the section-3 of this circular, details for development, assessment and approval of EIA report, audit and certification relating to the implementation of the content of EIA report has been provided.

6) Circular 05/2008/TT-BTNMT

This is the circular dated December/8/2008 issued by MONRE. The detailed guideline for implementation of a number of matters relating to SEA, EIA and environmental protection stipulated in Environmental Protection Act and Decree 21/2008/ND-CP.

7) Others

Other legal documents that are referenced in the EIA report are the Water Resources Act (The Water resources Law: passed through the Vietnam National Assembly on May/20/1998), Land Act (The Land Law: passed through the Vietnam National Assembly on November/26/2003) and the like.

8) Solid waste management related laws

There is something like the following lows shown in Table-4 as solid waste management laws.

Table- 4: Related laws of solid waste

1.	Decree 59/2007/ND-CP	:2007/4/9	Decree for solid waste management
2.	Circular 12/2006/TT-BTNM	:2006/12/26	MONRE circular regarding guideline for implementation and procedure of application, registration and approval of solid waste
3.	TCVN 6696	:2000/	Solid waste-Common requirement for environmental protection, sanitary landfill
4.	TCVN 6705	:2000/	Non-hazardous solid waste-classification
5.	TCVN 6706	:2000/	Hazardous waste-classification

Article 220. Facility to prevent air pollution

Article 220-1.Emission limit of pollution parameter

1. National technical regulation on emission of thermal power industry: QCVN 22/2009/BTNMT

Cmax (maximum allowable concentration of air pollution parameters in thermal power industrial) is calculated as follows;

$$Cmax = C \times Kp \times Kv$$

C concentration of pollution parameters as basis for calculating maximum allowable concentration of emissions gas in thermal power industrial is stipulated by type of fuel in Table-5 below;

Table- 5: C concentrations of pollution parameters of emissions gas in thermal power industry (QCVN 22/2009/BTNMT)

No.	Parameters	Concentration (mg/Nm3)			
		A (Existing Plant)	B (New Plant)		
			Coal	Oil	Gas
1	Total dust	400	200	150	50
2	NOx (Calculated by NO_2)	1,000	- 650 (The volatile content of coal > 10%) -1,000 (The volatile content of coal ≤ 10%)	600	250
3	SO_2	1,500	500	500	300
Note: Depending on the type of used fuel, the allowable maximum concentrations of pollution components NOx, SO_2 and dust on emission gas in thermal power is given in Table-6. These concentration values calculated at standard conditions. For thermal power used coal, the concentration of excess oxygen (O_2) reference in emission gas is 6%; for gas turbines the concentration of excess oxygen (O_2) reference in emission gas is 15%.					

Kp is the power factor in proportion with total design capacity of thermal power plants as shown in Table-6.

Table- 6: Power factor Kp (QCVN 22/2009/BTNMT)

Power generation capacity (MW)	Kp
P ≤ 300	1
300 < P ≤ 1200	0.85
1200 < P	0.7

Kv is the area factor, regional factor which corresponding to the placement of thermal power plants location as shown in Tabl-7.

Table- 7: Area factor Kv (QCVN 22/2009/BTNMT)

Partition of region, area		Kv
Type 1	Interior of special urban(1) and urban type(1); special-use forests(2); natural heritage, vestige of historic and cultural is ranked(3); thermal power plants have distance to the boundary of the area above 05km.	0.6
Type 2	Interior of urban type2, 3, 4 (1); suburbs of special urban, suburbs of urban type1 there are the distance to the boundary of interior is greater than or equal to 05km, thermal power plants have distance to the boundary of the these areas below 05km.	0.8
Type 3	Industrial Park; Urban type5(1); suburbs and outskirts of urban type2,3,4 there are the distance to the boundary of interior is greater than or equal to 05km; thermal power plants have distance to the boundary of these areas below 05km(4).	1.0
Type 4	Rural	1.2
Type 5	Rural mountainous	1.4

Legend:

(1) The Urban shall be determined as stipulated in Decree No.42/2009/ND-CP May/7/2009 by the Government on classification of urban areas;

(2) Special-use forests shall be determined by the Law on Protection and Development of Forests December/14/2004 include: national parks, natural reserves, area of landscape protection, forest research, experimental science;

(3) Natural heritage, vestige of historic and cultural were the UNESCO, the Prime Minister or Ministries of managing decision making establishment and ranked;

(4) In case the source of emissions there is the distance to more 2 regions, smaller than 02km, shall be to apply K_V factor of region, which have smallest factor;

(5) The distance stipulates in Table-7 are calculated from the emission source.

2. National Technical Regulation on Ambient Air Quality: QCVN 05/2009/BTNMT

The regulation of ambient air quality of Vietnam is shown in Table-8.

Table- 8: Maximum allowable ambient air quality (QCVN 05/2009/BTNMT)

No.	Parameter	1hr-Averaging Time	3hr-Averaging Time	8hr-Averaging Time	Annual Averaging Time
1	SO_2	350	—	125	50
2	CO	30,000	10,000	5,000	—
3	NOx	200		100	40
4	O_3	180	120	80	—
5	Suspended particulate matter (TSP)	300	—	200	140
6	Particulate matter ≤ 10μm (PM10)	—	—	150	50
7	Pb	—	—	1.5	0.5
Note: En dash (-): No stipulation					

Article 220-2.Maximum allowable concentration of air pollution

1. System configuration of environmental equipment for coal-fired boiler

The flue gas treatment measures for thermal power generation plant in Japan are located on the top level with a global perspective, which is practical and reliable technology. Thermal power generation Japan has become a very small SOx and NOx emission value per unit of electricity generation compared with 6 countries in the OECD by promoting measures against fuel and equipment. However, the requirement is increasing on a par with advanced environmental measures against coal-fired thermal power plant in order to further preserve the local environment. It is required comprehensive gas treatment measures, since flue gas from coal-fired thermal power plant has high concentration of sulfur oxide, nitrogen oxide and dust. In addition, environmental facility has been increasing as shown in Fig-1 as of coal-fired facilities; the cost reduction measures are required.

The cases requiring dust concentration of less than 10mg/m^3N against conventional number of 10mg/m^3N and sulfur oxide of less than 50ppm are increasing for the suburban type coal-fired plant. In this case, the wet type EP has been put into practical systems adding a wet type EP at outlet of absorber of desulfurization unit in order to further improve the performance of dust removal. However, recently it is often adopted a low temperature EP which is capable to increase economic performance in combination with the dry EP without installation of the wet type EP, desulfurization facility and GGH (gas gas heater), since such facilities configuration increase the complexity and cost. This system is established upstream of the EP and is aimed to improve the performance of EP. It can be achieved a significant improvement in EP performance at a temperature around 90^{o}C, since electrical resistivity of coal ash is greatly reduced, the back corona phenomenon can be completely

eliminated and normal charging state is secured against coal dust collection which previously could not be used extremely poor. It can be reduced the dust concentration at outlet of stack less than number of mg/m^3 by adoption of the very low-temperature type EP.

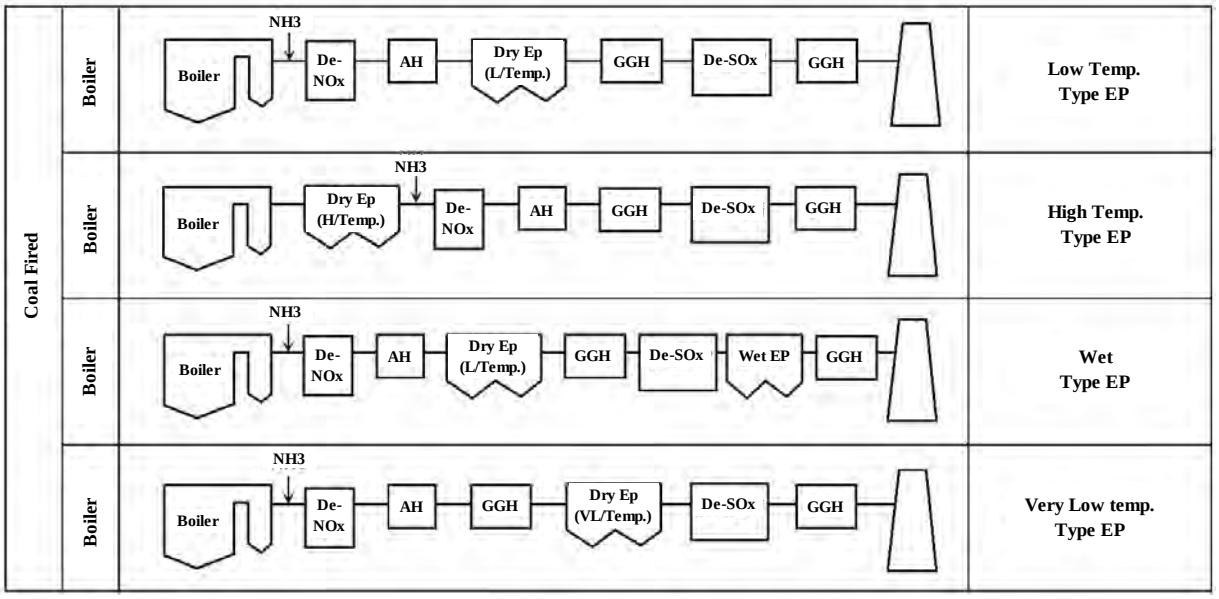


Fig- 1: Flue gas treatment system for coal-fired thermal power plant

Reference: P-91 of Journal (No.649: Oct. /2010): TENPES

1.1 Denitrification

The main fuel gas denitration process which has been commercialized is shown in Fig-2.

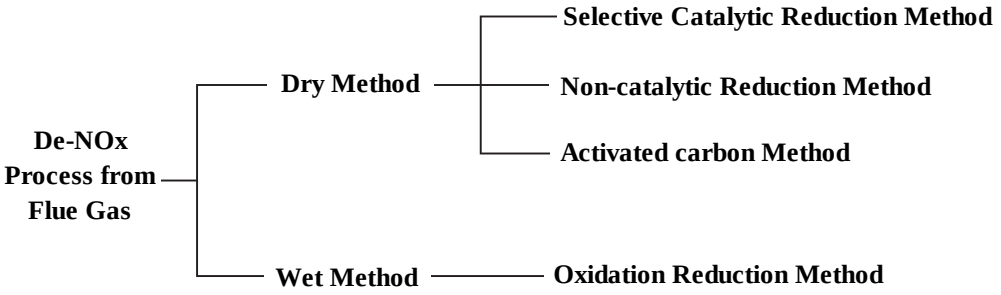


Fig- 2: Denitration process

Reference: P-92 of Journal (No.649: Oct. /2010): TENPES

The selective catalytic denitrification process which conducts reaction in the presence of a catalytic using ammonia (NH_3) as agent for dry method are most commonly used, since the facility is simple and it is totally unnecessary post-processing because no byproduct. Furthermore, selective catalytic reduction process has been adopted as mainstream of denitration facility for thermal power plant for business as shown in Fig-3, since high performance is obtained by a simple process and simple

maneuvers.

1.1.1 Denitration facility for boiler

The denirration facility for boiler has been established subsequent spread in 1990s upon request such as diversification of heavy oil, coal, residual oil, heavy residual oil into the background of energy situation. In recent years, biomass fuel which has been attracting attention as measures for global warming and an alternative to fossil have been made efforts to use as new energy source. Denitration performance and evaluation of the impact of biomass co-firing has been proven in various tests, is in intensive support for commercialization.

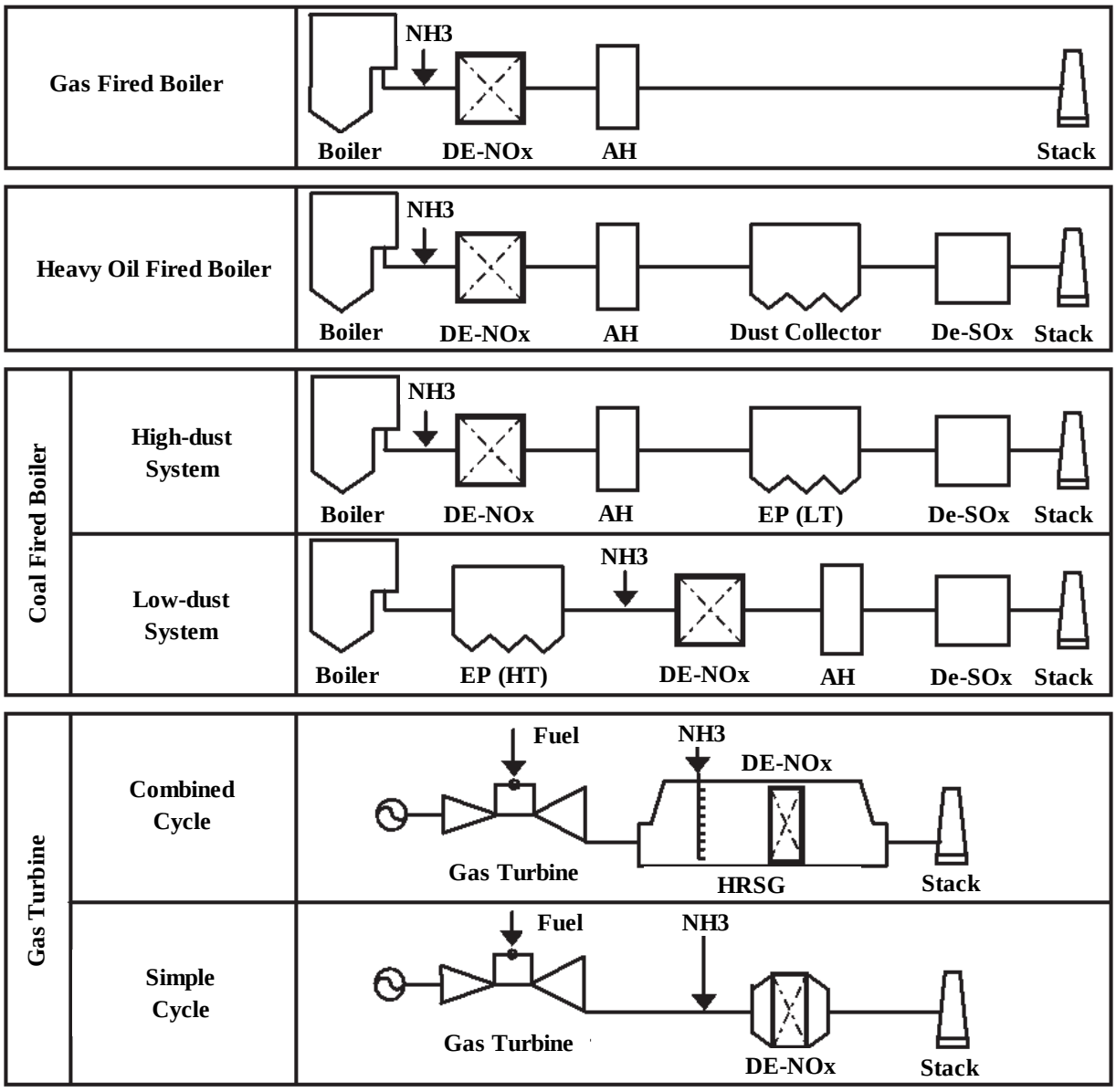


Fig- 3: Denitration process flow

Reference: P-93 of Journal (No.649: Oct. /2010): TENPES

1.1.2 Denitration facility for gas turbine

The denitration equipment for gas turbine combined cycle has been installed subsequently spraeded widely in the 1990s. On the other hand, the denitrization equipment for simple gas turbine has not spread from the viewpoint of energy saving, though several plants were established in the 1990s.

1.1.3 Trends of denitrification technology

This section describes the recent technical development in coal-fired denitration after 40 year have been put into practical use of selective catalytic reduction system for NOx removal equipment.

(1) Regeneration of catalyst

The catalytic performance is degraded through a period of time from start of operation. It was required to replace catalysts in order to stably operate the plant up to now. However, the catalyst recycling techniques have been studied and some partial catalyst regeneration technology is imposed by type and form in the viewpoint of cost reduction of catalyst and environmental protection.

(2) Large grain ash

In the recent years, a problem of the catalyst clogging has been seen due to flying ash from boiler with relatively large particle size. It is necessary ingenuity to prevent the ash with large particle size from reaching denitration facility with large hopper or to prevent reaching to the catalysts by means of installing mesh at the entrance of the catalysts.

(3) Low SO_2 oxidation catalyst

With the diversification of coal-fired thermal power plants, a high concentration of sulfur oxides (SOx) context in the flue gas when using with high sulfur coal as fuel for thermal power plant. On the other hand, in case of denitration catalyst mainly composed of titanium and vanadium oxide which has large application results, following problems tend to occur due to the produced high concentrations SO_3 , since it has also slight function to oxide SO_2 (side reactions) apart from NOx reduction function.

1) Precipitation of acidic ammonium sulfate in the wake of AH
2) Corrosion of equipment at low temperature part such as AH
3) Occurrence of purple smoke

Therefore, when using these fuels, NOx catalytic that inhibited SO_2 oxidation as much as possible are required while maintaining function for NOx reduction (denitration).

(4) Ammonia uniform distribution technology

Technique to disperse NH_3 as the reduction agent in the reactor uniformly is used as a way to

measure the efficiency of denitration equipment for further strict regulations in the future. Generally, the method is employed to installed multiple nozzles in the flue gas duct prior to the reactor by gridding the NH_3 injection nozzle, since homogeneous mixing is limited if NOx distribution in the flow of nozzle is large. So recently, a new effect is being made to take place in the effective dispersion in mixer by installing a flow mixer (static mixer) in front of denitration facility. In addition, attempts to optimize the required number and position of the mixture have been made by flow model and computer simulation in order to ensure uniform mixing of NH_3.

2. Desulfurization

2.1 Summary of desulfurization technology

Flue gas desulfurization equipment has been installed in Japan in earnest since the 1970s, which continued well established into 2000s. Its mainstream is wet limestone-gypsum method which absorbent is cheap and markets of byproduct are stable. Facilities which have following features have been installed, though the number of facility tends to decrease since the beginning of 2000s with the slowdown in electricity demand, if browsing by age and status of installation of flue gas desulfurization for domestic thermal power plants for business use.

1) Large capacity of facility; series according to the boiler
2) High efficiency; high efficient desulfurization, high concentration of absorbent, high efficient oxidation system
3) Pursuit of more compact and rationalization; adoption of very low temperature EP, rationalization of the installation position of BUF

2.2. Desulfurization system

The mainstream processes of flue gas desulfurization is wet limestone-gypsum, there are the activated carbon absorption method, electric beam method, semi-dry method as other processes. Also the wet limestone-gypsum method is divided into several systems according to the gas properties and emission regulations. Here is a typical process outlined below;

(1) Dry activated carbon method

This method has not only the absorbent function of activated carbon but the simultaneous desulfurization and denitrification method using as a catalyst. The block flow is shown in Fig-4 and 5. This method has the features that re-heating equipment is not required, no drop of humidity in the flue gas, it is possible to recover sulfuric acid or sulfur as byproduct in addition to the simultaneous desulfurization and denitrification method.

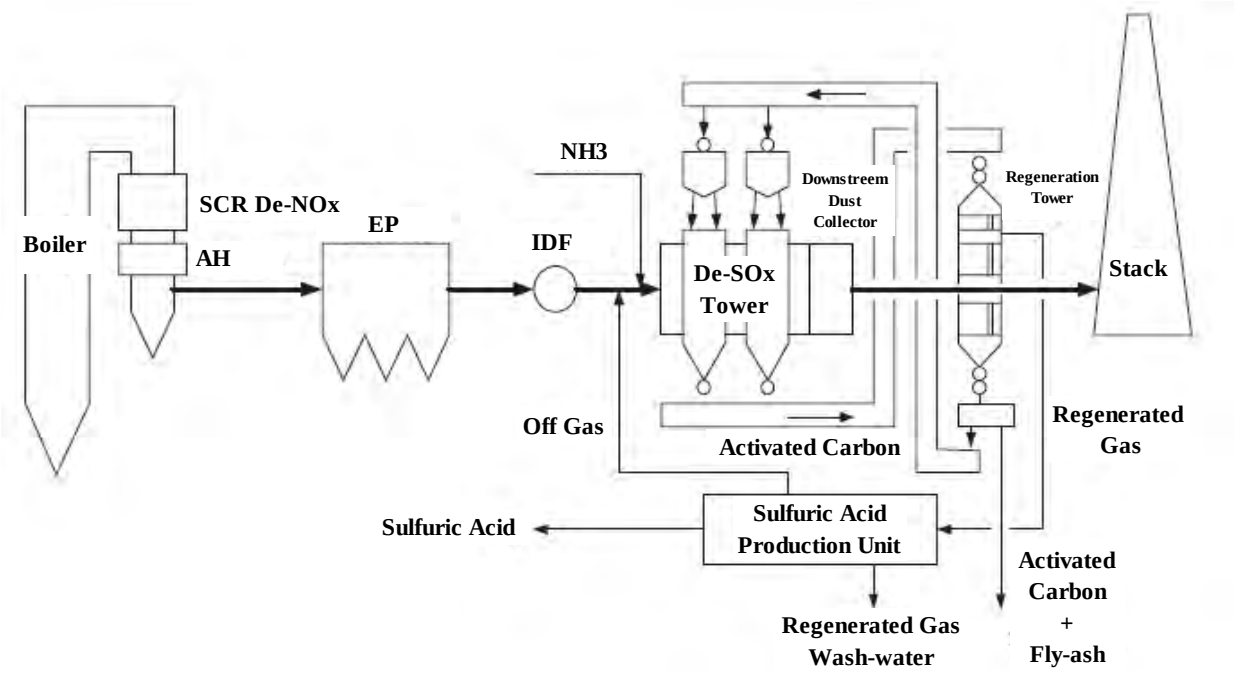


Fig- 4: Activated carbon absorption system flow (Isogo)

Reference: P-44 of Journal (No.579: Dec. /2004): TENPES

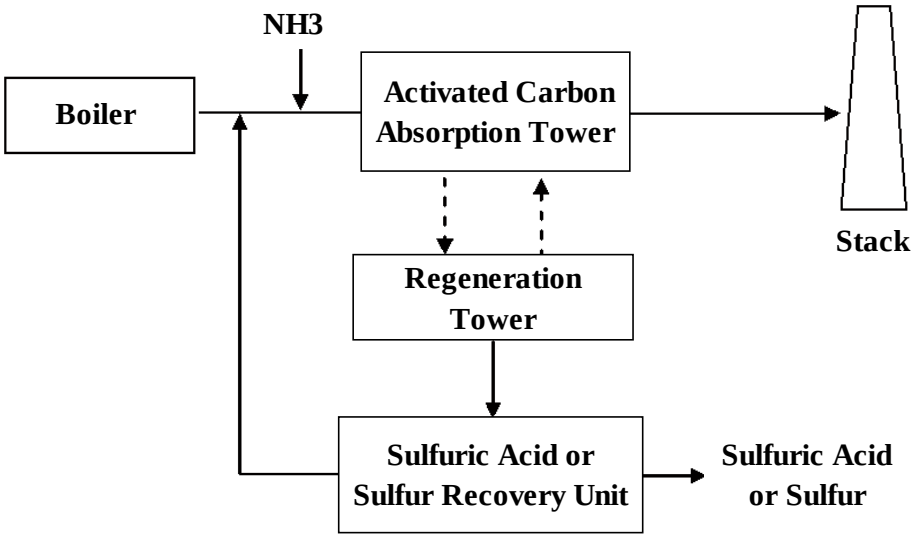


Fig- 5: Activated carbon absorption block flow

Reference: P-94 of Journal (No.649: Oct. /2010): TENPES

(2) Wet limestone-gypsum method

1) For conventional coal-fired systems

The wet limestone-gypsum method is the method to react slurred limestone ($CaCO_3$) with SO_2 in the absorption tower and recover gypsum absorbed SO_2 as the byproduct. The main block flow

is shown in Fig-6 and 7.

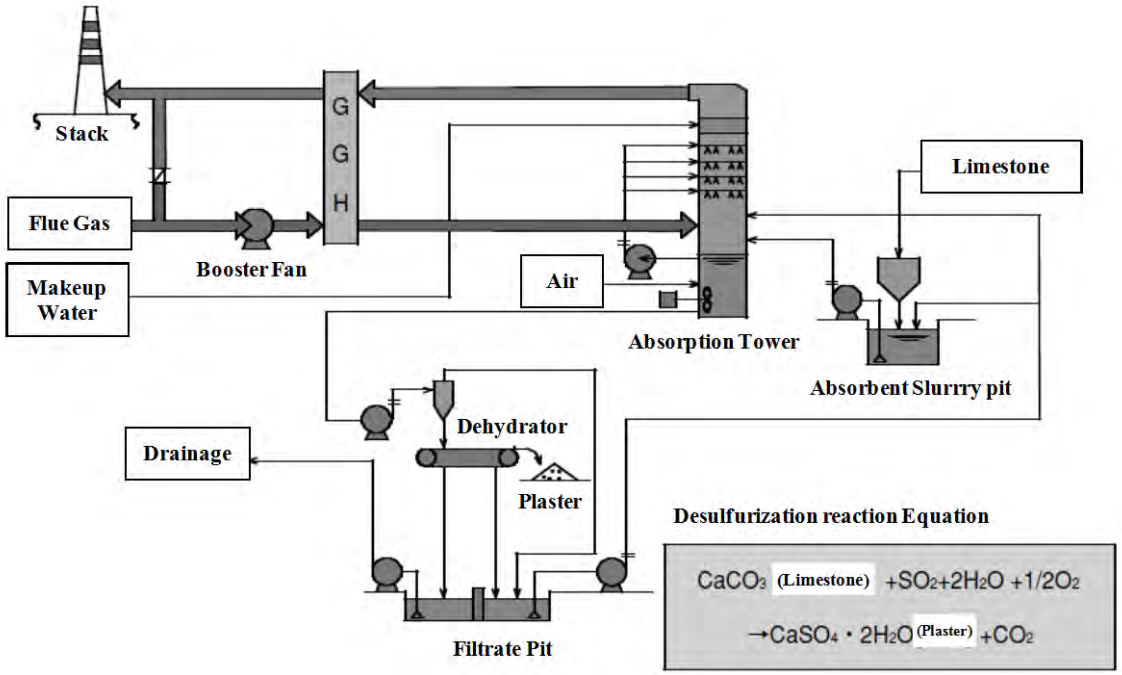


Fig- 6: System diagram of desulfurizer by Lime-Gypsum method (IHI)

Reference: P-23 of Journal (No.570: Mar. /2004): TENPES

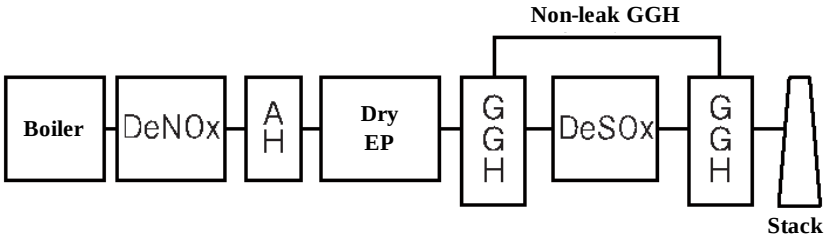


Fig- 7: Block flow of Limestone-Gypsum method

Reference: P-94 of Journal (No.649: Oct. /2010): TENPES

2) For very low temperature EP systems

The environmental facility with a low temperature highly efficient dust removal system are being adopted for recent most stringent emission regulations such as less than 10mg/m_3N dust concentration at outlet as away to support more rational in terms of equipment. The main block flow is shown in Fig-8.

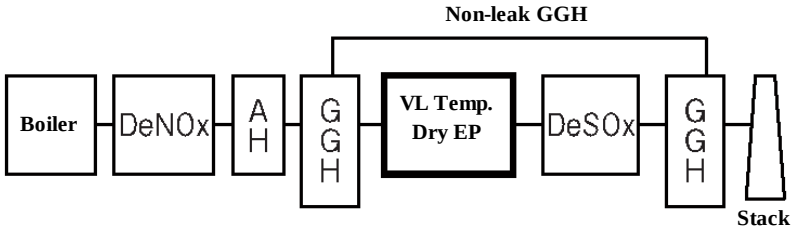


Fig- 8: Block flow of very low temperature EP environmental system

Reference: P-94 of Journal (No.649: Oct. /2010): TENPES

3) For heavy oil-fired systems

The concentration of SO_3 is higher in the flue gas, since much sulfur is contained in the heavy-oil fuel. There is a way of injecting ammonia into the flue gas duct as a high SO_3 concentration measures. The main flow of the environmental facility which conducting ammonia injection is shown in Fig-9.

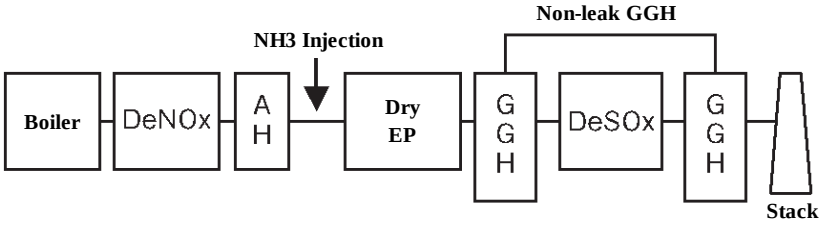


Fig- 9: Block flow of ammonia injection environmental system

Reference: P-95 of Journal (No.649: Oct. /2010): TENPES

3. Dust collection

3.1 Summery of dust collection technology

The dust collection system for the thermal power plant facility for business use is shown in Fig-10. The dry type EP as the ammonia injection method is adopted for heavy-oil fired thermal power plant and the wet type EP in the wake of the wet desulfurization equipments have been used depending on the concentration of sulfur in the fuel. The low temperature dust collection method, very low temperature dust collection method and high temperature dust collection method for the coal-fired thermal power plant. The very low temperature EP has become mainstream in new coal-fired power plants, the method to provide wet type electrostatic precipitator in the wake of the wet desulfurization equipments have been used.

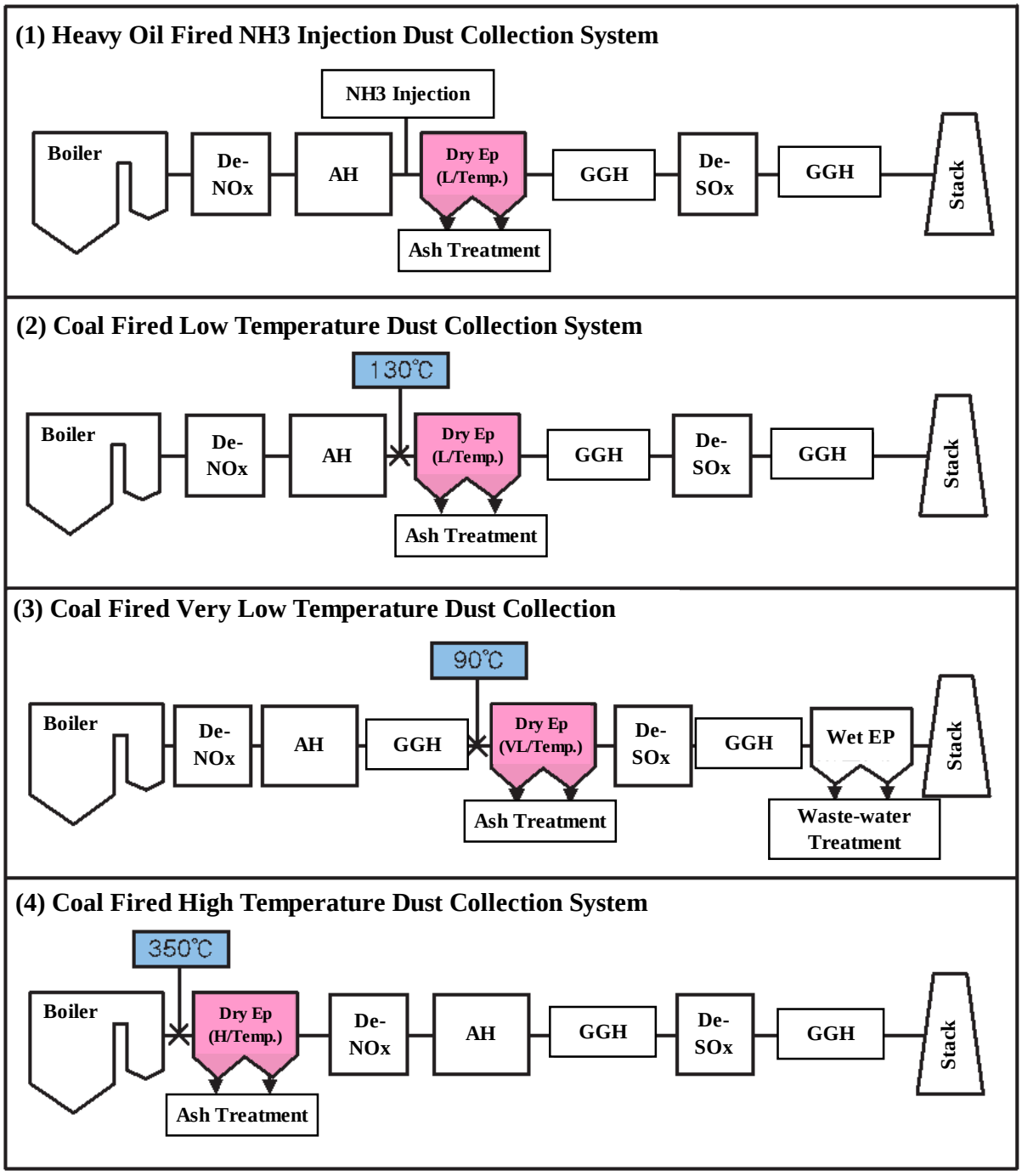


Fig- 10: Dust collection technology for commercial thermal power plants

Reference: P-96 of Journal (No.649: Oct. /2010): TENPES

3.2 Trends in dust collection technology

(1) EP for coal-fired thermal power plant

Coal used in the coal-fired power generation facility is more than 99% overseas coal, and is imported from Australia, Indonesia, China and Russia. Recently, a change of type of fuel coal for thermal power plants is carried out in the short time. The electrical resistivity of fly ash dust generated when

burning overseas coal is higher than $10^{11}\Omega$cm. An abnormal performance degradation of dust collection due to the reverse ionization in the electric precipitator is experienced even in very lower temperature depending on the type of coal. It is necessary measures such as selection and blending of coal. Inlet and outlet damper system and moving electrode system is used as the EP for the coal-fired thermal power plant, since an instantaneous increase of dust concentration at the time of dust collection becomes a problem when hammering (re-scattering due to hammering) to suit the requirement to decrease the outlet dust concentration.

1) Inlet and outlet damper system

   The no-charge hammering method which providing the dampers in inlet and outlet of electric precipitator, stopping gas flow in the dust collection chamber by hammering and hammering after stop to charging of the discharge electrode is used in order to prevent a momentary increase in dust concentration due to hammering. The dust collection performance after hammering can be expected to improve, since the effect of dust removal on dust collecting plate is improved by no-charge hammering.

2) Moving electrode system

   The schematic structure of the moving electrode system is shown in Fig-11 and 12. Dust collection is performed by the moving electrode connected divided into dust collection electrode strips in the final zone, connecting by a chain and collecting dust while moving at a speed of about 0.5m/min. Re-entrainment is hard to occur, since collected dust on the dust collection electrode will be removed by scraping brush provided in hopper rather than by hammering. In addition, it is possible to achieve high performance regardless of the electrical resistivity of dust and miniaturize the electric precipitator by completely brushing off. In principle, there is no re-entrainment in moving electrode system due to hammering. It is possible to halve the outlet dust concentration compared with the traditional fixed-electrode system by means of applying the moving electrode method to the final zone of electric precipitator.

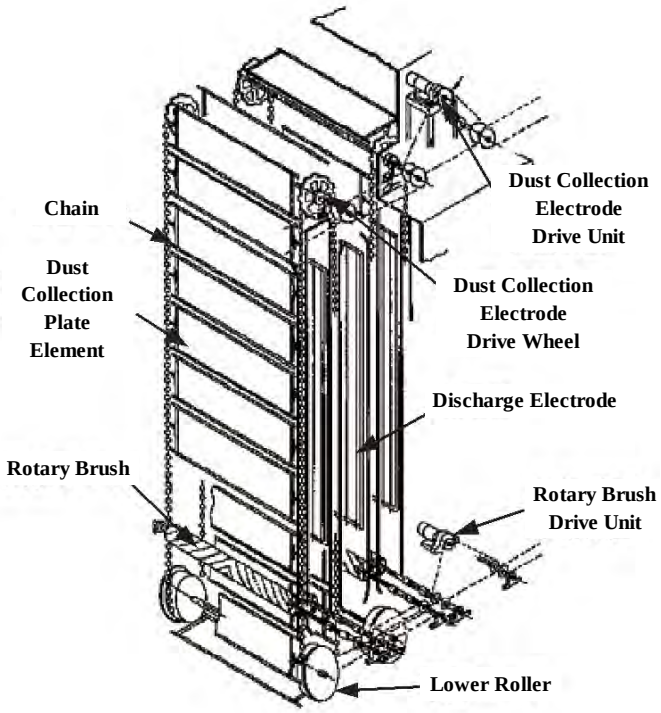


Fig- 11: Moving electrode system (Hitachi)

Reference: P-97 of Journal (No.649: Oct. /2010): TENPES

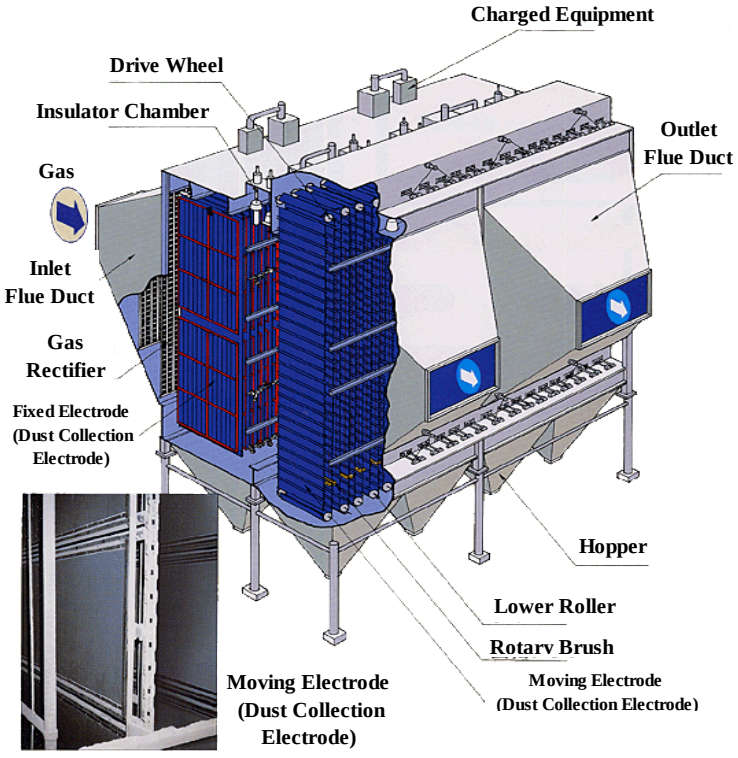


Fig- 12: Moving electrode system (Hitachi)

http://www.hitachi-pt.co.jp/products/energy/dustcollection/dry_type/mobile_electrode.html

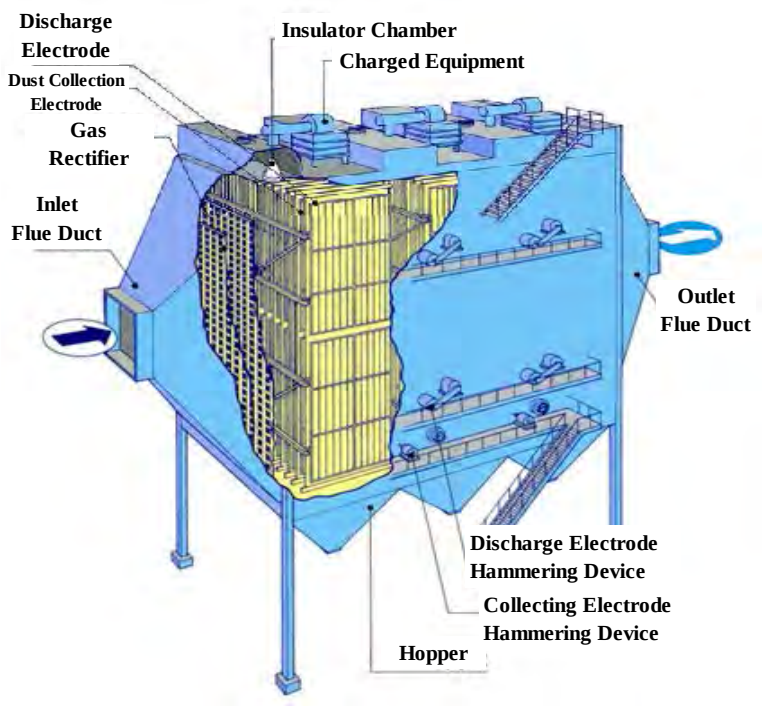


Fig- 13: Fixed electrode system (Hitachi)

http://www.hitachi-pt.co.jp/products/energy/dustcollection/dry_type/index.html

(2) Bag filter for coal-fired thermal power plant

Bag filter is the device for collecting dust in the flue gas by woven and non woven filter cloth as shown in Fig-14. It is called the bag filter because a cylindrical filter cloth is hung. A number of cylindrical filtration cloths have been installed in the each room of the large bag filter to separate the dust collection chamber and the dust collection hopper is arranged at the bottom of the dust collection chamber to collect removed dust. The principle of dust collection of the bag filter is to filtrate and collect dust contained in the processed flue gas by deposited dust layer deposited on the surface of the filter cloth or inside of filter cloth (the primary dust layer). Generally, the filtration rate of flue gas through the filter cloth is about 0.3~2mm/min, pressure loss is 1~2kPa. Since the pressure loss increases if collected dust layer on the filter cloth becomes thick, the collected dust must be brush off intermittently. Dust removal is performed by 1) to flow gas from the back of filter cloth, 2) to concussion, etc. In the most cases, it can be achieved more than 99% of dust collection rate and about 10mg/m^3N of the outlet dust concentration.

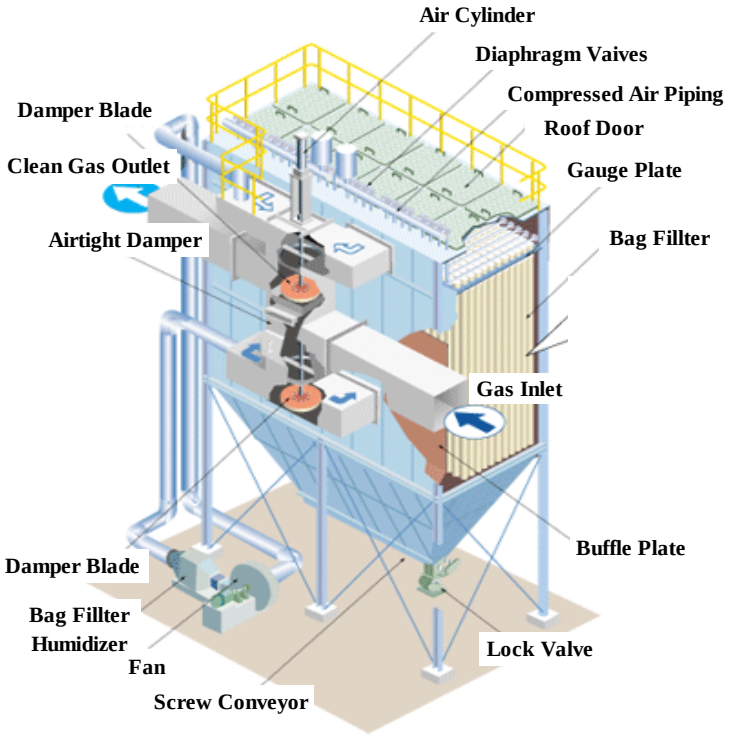


Fig- 14: Bag filter system (Hitachi)

http://www.hitachi-pt.co.jp/products/energy/bugfilter/architecture/index.html

(3) Co-firing of woody biomass

In an effort to suppress emissions of CO_2, coal-fired power generations facilities which are implementing of are planning co-firing woody biomass have been increased. Woody biomass which wood chips or sawdust is processed to pellets is mixed with coal on a conveyor to transport coal, pulverized in a mill and used as fuel. In coal-fired power plants that are currently co-firing woody biomass, which can be operated without special modifications. It is necessary to focus the effect of co-firing to dust collection of woody biomass in future.

(4) Firing of residual oil and petroleum coke

The use of residual oil containing 3~5% sulfur and petroleum coke has increased in the private power generation facilities incidental to petroleum refining facility. The method to collect sulfur as ammonium sulfate powder (ammonia sulfate) by the ammonia injection for residual oil combustion, the method to use the dry type EP for dust collection and the wet type EP for sulfuric acid mist in the flue gas from desulfurizer is applied. In the ammonia injection method, the gas temperature control system by water spray has been taken, since an adherence problem if the gas temperature in dust concoctions is too high causes deterioration of ammonia sulfate, altering of the discharge electrode and deposition of dust on collection plate.

Article 221. Principle of effluent treatment

Article 221-1. Principle of effluent treatment

1. Wastewater discharged from each process is made based on the water coming into that process, chemicals, fuel oil, combustion products are added to, corrosion products is added from the surface in contact with water, in addition, the indirect contacting is contaminated by leaked materials and is contaminated from dust by contacting with air. On the other hand, only the amount of leaked water is reduced, further evaporation to the atmosphere, to be reduced by the deposition of the contact surface. In case of rain, contamination from contacted objects on the way to a stream of rain is added and an amount of water equivalent to evaporation and percolation is reduced.

   Wastewater from washing water is based on the raw water, in addition to it, chemicals used in chemical cleaning is added and corrosion products or scale from cleaning surface is added. On the other hand, water equivalent amount of evaporation and leakage is reduced. The direction of wastewater discharged from the emission source is shown in Fig-15. In addition to the suburban drainage, there must be disposed of as industrial waste in the form of sludge cake other than lost due to evaporation into the atmosphere, infiltration to underground and absorption to absorbent.

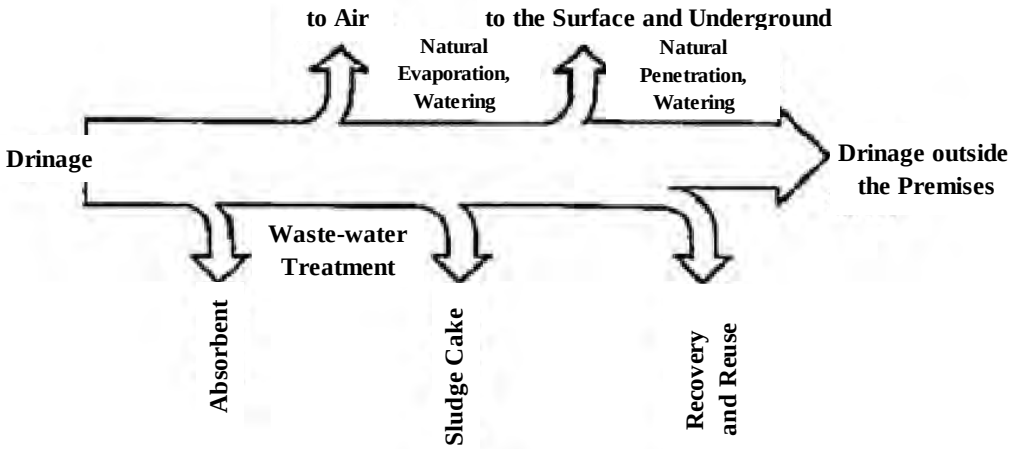


Fig- 15: Direction of drainage

Reference: P-39 journal of (No.609: Jun. /2007): YEMPES

2. Nature and treatment of wastewater

   Wastewater is discharged from the various process and quality and amount discharged from there varies significantly depending on operation conditions as whether that the process is operating or stop, degree of load. In addition, the water temperature for processing as a major factor is up to something high. There is a huge range for the concentration of contained oil depending on the emission conditions such as discharge source, rain operation even if oil-containing wastewater. Then, the wastewater treatments to treat wastewater discharged to have a certain quality regardless of its

volume or quality.

3. Operation unit of wastewater treatment

(1) Neutralization and pH adjustment

Neutralization is performed in order to conform to emission standard of pH. Neutralization means the reaction to produce water and salts by adding acid and alkali, treatment of wastewater must be within a pH range of emission standard. On the other hand, it is called pH adjustment in order to proceed with a particular reaction in the wastewater treatment process; it is performed to remove the metal ions as mainly hydroxides. In this case, it must be noted that the results vary widely depending handled by adjusting pH. If developing the wastewater neutralization curves, it can be know the characteristics of the wastewater other than determination of the amount of chemicals required for neutralization and pH adjustment. Neutralization curve describes the variation as an amount of neutralization agent for the horizontal axis and pH value of the effluent taken up for the vertical axis. Fig-16-I shows the notarization hydrochloric acid with caustic soda; Fig-16 shows the case that containing metal ions and rise in pH has become loose under the influence of containing metal ion. Actually, pH adjustment of wastewater is an operation that metal ions in the wastewater can be aggregated and precipitated as hydroxide. In fact, Fig-16 shows an example neutralization curve of wastewater. Typically, hydrated lime, caustic soda, sulfuric acid and hydrochloric acid are used as neutralization agent used in the neutralization and pH adjustment.

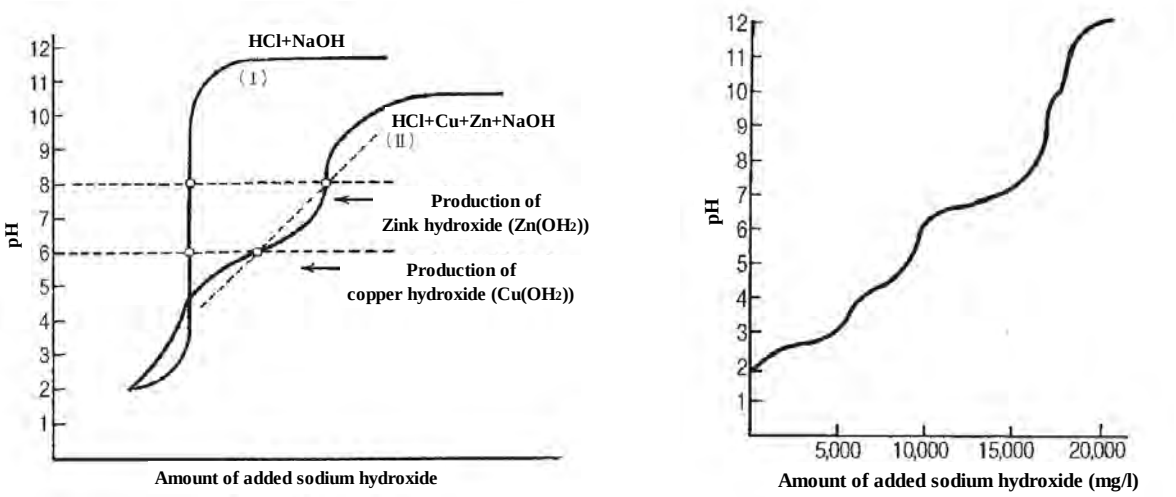


Fig- 16: Neutralization curve

Reference: P-41 of Journal (No.609: Oct. /2007): TENPES

(2) Coagulation

Flocculation is a method for generating flock by adding a coagulant in water, removing SS or colloidal turbidity constituents which cannot be removed by filtration. Fig-17 shows the particle aggregation model. In the coagulation of the wastewater, hydroxide may be generated by adjusting pH in order to remove metal ions. Fig-18 shows the relationship between pH and each hydroxide.

Recently, the circular sedimentation tank which has high efficient precipitation performance is used, though there is a transverse type and circular type for the flocculation sedimentation tank. A structural example of thickener is shown in Fig-19 and 21. Wastewater containing a cohesive flock is flow into the center. It has the construction to overflow supernatant from top circle catchment; sludge has been scraped to center bottom by rake and discharge sludge.

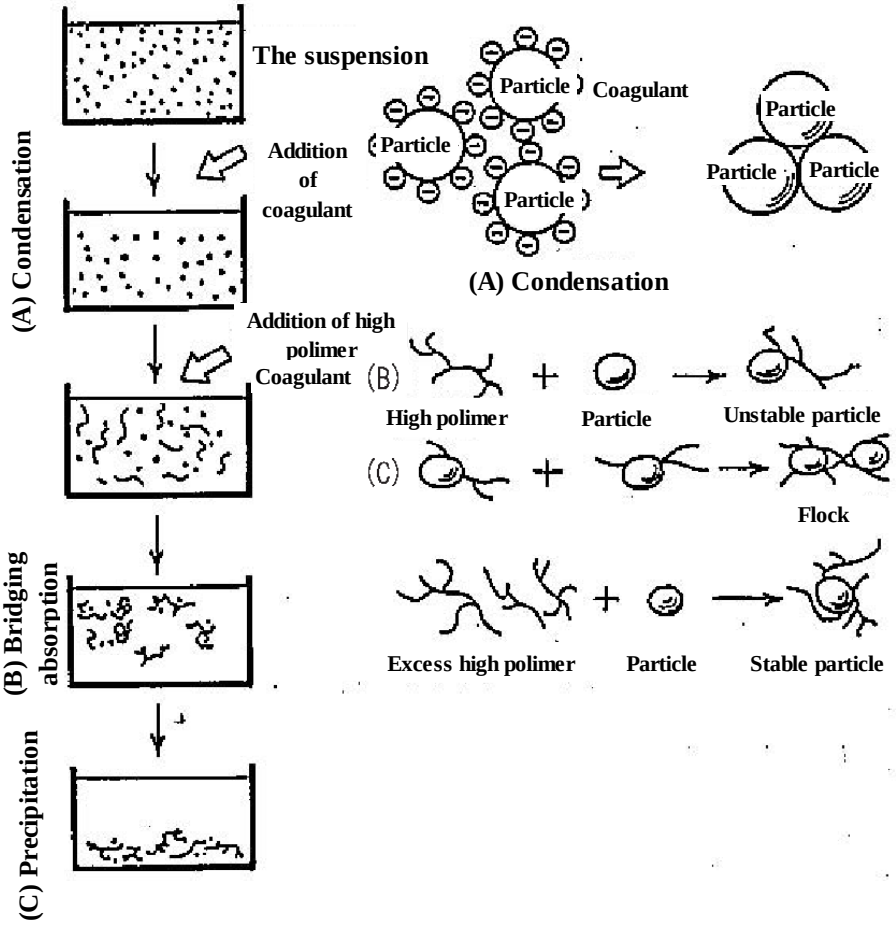


Fig- 17: Particle aggregation model

Reference: P-41 of Journal (No.609: Oct. /2007): TENPES

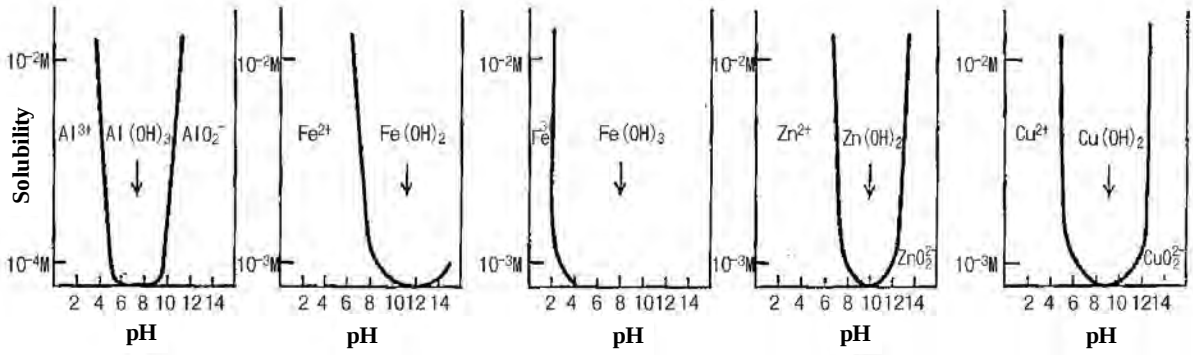


Fig- 18: Relationship between pH and hydroxide

Reference: P-42 of Journal (No.609: Oct. /2007): TENPES

(3) Filtration

Usually, filtration is performed in order to further removal of traces of SS which cannot be removed by flocculation. There is a form of pressure type, gravity type, upward flow type, downward flow type, single-layer type and dual-layer type as the filter for filtration, the pressure type, downward flow type and dual-layer type filter is often used for wastewater treatment facility in the power plant. Fig-20 and Photo-1 shows a construction example. Wastewater will be fed at the top and traces of the SS are removed during filtration through the layer. When the differential pressure rises to catch a SS, backwash water is put from the bottom, wash out filtration layer to remove the SS and it makes allow water passage again.

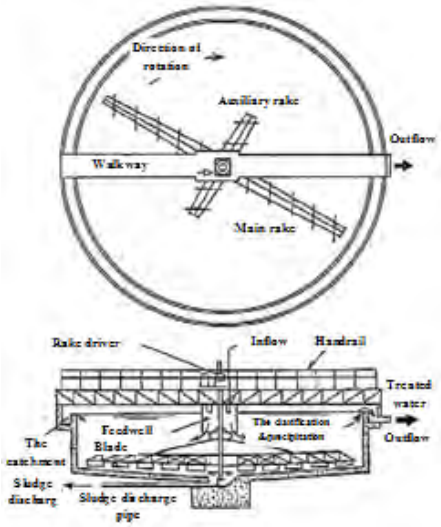


Fig- 19: Typical construction of thickener

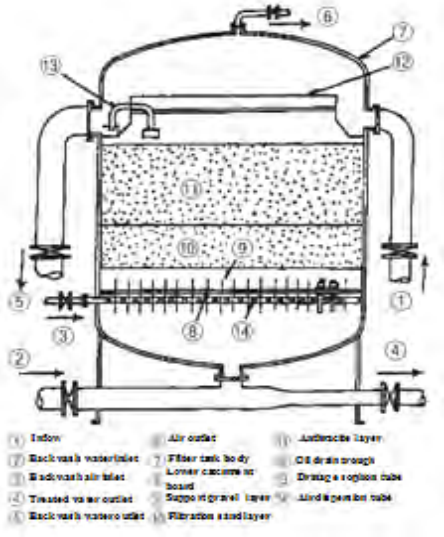


Fig- 20: Typical construction of filter

Reference: P-42 of Journal (No.609: Oct. /2007): TENPES

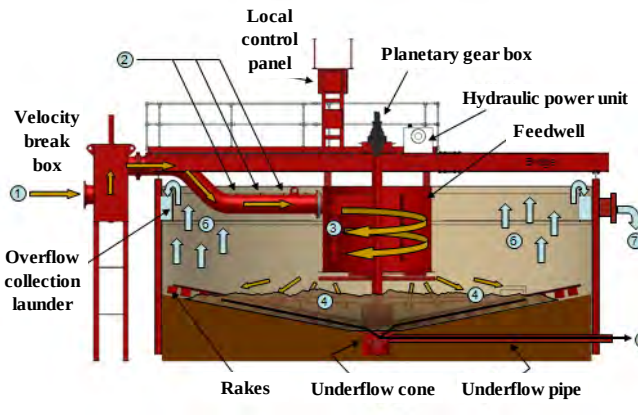


Fig- 21: Thickener

http://www.mclanahan.com/content/australasia/how-it-works-thickener

Photo- 1: Filter

http://www.eg.aktio.co.jp/product/kan/dojyou/djo08/index.html

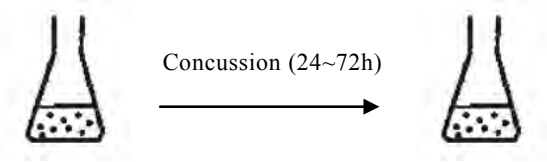
(4) Activated carbon absorption

Activated carbon has ability to absorb and remove organic, oil, coloring ingredient, odor components from wastewater and used for advanced treatment of higher wastewater treatment. This has been adopted in some cases of advanced wastewater treatment for COD and oil in thermal power plant wastewater. It is important to understand the absorption capacity of activated carbon when applying the activated carbon to wastewater treatment. This is the reason why the organic matter cannot be removed by activated carbon depending on the type of organic matter. Usually, absorption properties of activated carbon are presented in the form of absorption isotherm. When collecting wastewater in an Erlenmeyer flask, shaking for 24~72hours with changing the amount of addition of activated carbon, measuring the water side concentration after saturation, calculating the absorbed amount, plotting them as shown in Fig-22, usually it is obtained a linear relationship. This figure reveals the following. Measurement examples for wastewater are shown in Fig-22.

1) It is possible to estimate the necessary amount (kg/m^3-wastewater) of activated carbon from the value of the equilibrium absorption concentration correspondents to the CO concentration of wastewater.
2) It indicates that easy to absorb if the slope of A-B is smaller and hard to absorb if A-B is greater.
3) The steep slope in the lower concentration side less than the equilibrium refraction point "B" indicates that the hard absorptive components exist.

General wastewater is a multi-component system, in which some components are easy to absorb and some are difficult to absorb. In extreme cases, sometimes it rises vertically like BD, "Crit" at the inflection point may be the limit of water quality, which is non-absorptive in case less than "Crit".

Inflection point "B" may be moved due to type of activated carbon or pretreatment of wastewater as shown Fig-24. The breakthrough curve is obtained by flowing water through the column filled with activated carbon in order to find the amount of water and time to pass in the activated carbon equipment as shown in Fig-23. The construction of activated carbon tower is filled with granular activated carbon in stead of filter material similar to the filter.



Wastewater	L (ℓ)	Wastewater	L (ℓ)
Initial concentration	Co (mg/ℓ)	Equilibrium concentration	Co (mg/ℓ)
Activated carbon	W_1 (g)	Activated carbon	C_1
	W_2 (g)		C_2
	W_3(g)		C_3

Fig- 22: Measurement of equilibrium

Reference: P-43 of Journal (No.609: Oct. /2007): TENPES

Equilibrium absorption

$$\begin{cases} q_1 = \dfrac{L(C_0 - C_1)\times 10^{-3}}{w_1} \\ q_2 = \dfrac{L(C_0 - C_2)\times 10^{-3}}{w_2} \\ q_3 = \dfrac{L(C_0 - C_3)\times 10^{-3}}{w_3} \end{cases}$$

Equilibrium relation (absorption isotherm)

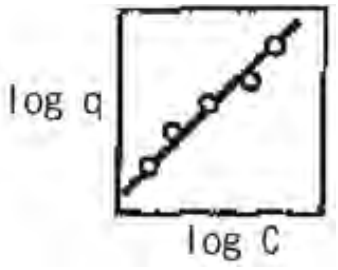


Fig- 23: Equilibrium relation q vs. c

Reference: P-43 of Journal (No.609: Oct. /2007): TENPES

Freund lich formula $\cdots q - AC^{1/n}$

(5) Synthetic absorbent treatment

It is known that COD in the desulfurization wastewater is the dithionite acid which is generated as byproduct when producing gypsum in the desulfurization facility and N-S compound which is generated in the reaction process of NOx and SOx, since there may be several 10mg/ℓ of matters which cannot be removed by coagulation and absorption. An absorption-regeneration system by a synthetic absorbent absorption may be adopted in order to process this COD which is hard to treat. The concentrated COD wastewater caused by regeneration is processed by thermal acid decomposition.

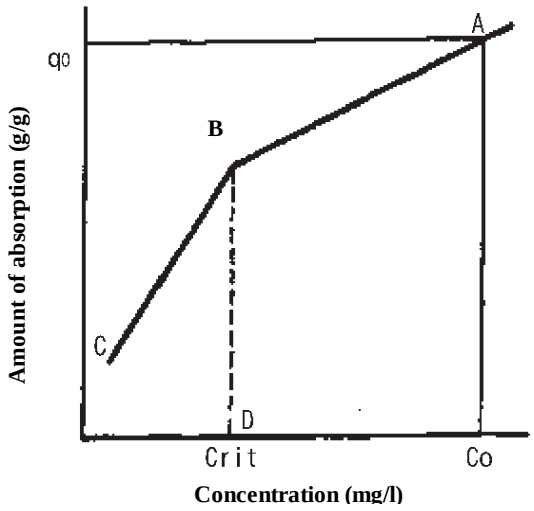


Fig- 24: Equilibrium for wastewater

Reference: P-43 of Journal (No.609: Oct. /2007): TENPES

(6) Gravity type separation and emerging

The gravity separation applying the buoyancy of the floating oil is used for the treatment, since the

effluent from power plant contains oil. Rate of rise of the oil droplets is expressed as following Stokes equation as in the case of sinking particles.

$$V = \frac{g(\rho_w - \rho_o)D^2}{18\mu}$$

Where

V	: emerging speed of particles	(cm/sec)
g	: acceleration of gravity	(cm/se^2)
ρw	: density of drainage	(g/cm^3)
ρo	: density of emerged particles	(g/cm^3)
D	: diameter of particles	(cm)
μ	: viscosity coefficient of therrainage	(g/cm・sec)

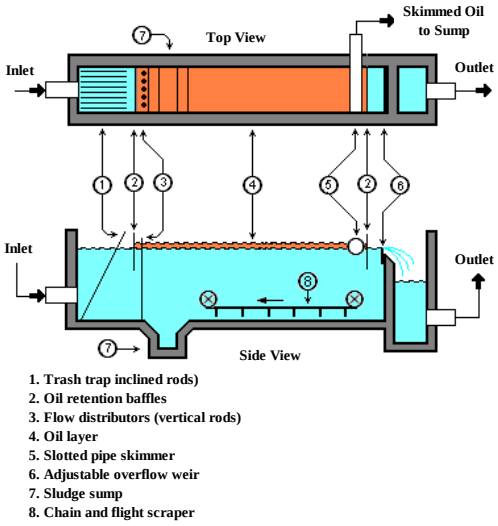


Fig- 25: API type oil separator

http://en.wikipedia.org/wiki/File:API_Separator.png

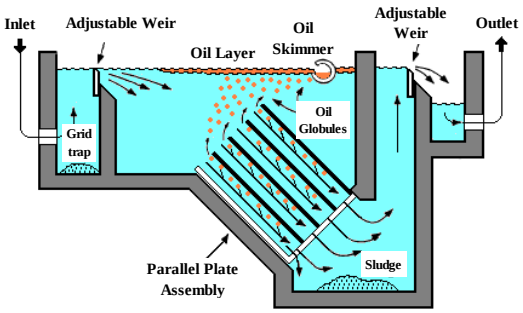


Fig- 26: CPI type oil separator

http://en.wikipedia.org/wiki/File:Parallel_Plate_Separator.png

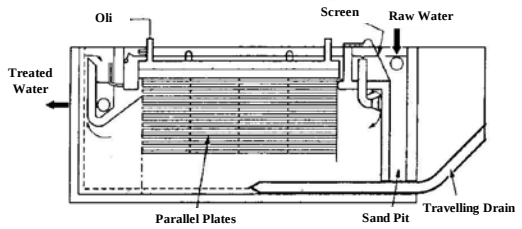


Fig- 27: PPI type oil separator

http://tegalrejo.indonetwork.co.id/1909715/oil-separator-crossflow-ppi.htm

There are API type (established by American Petroleum Institute), PPI type (established by Shell), CPI (improved machine of PPI) as the oil floating separation device and the typical construction is shown in Fig-25, 26 and 27. The limit of removable oil diameter is 150μ in API, 60μ in PPI and CPI as shown in Table-9. An example of particle size of oil droplets in the wastewater is shown in Fig-28.

Table- 9: List of gravity type floating separation operation

Operation unit	Summery	Footprint	Limit removal particle size	Floating rate
API Type	Separation of liquid flowing in a laminar flow in a rectangular tank.	1	150μ	0.9mm/sec
PPI Type	Making it short distance by installing a number of parallel plates into the tank.	1/2	60~30μ	0.2 mm/sec
CPI Type	Placing Colgate parallel plates in 45 degree to the direction of flow considering coursing.	1/3	60~30μ	0.2 mm/sec

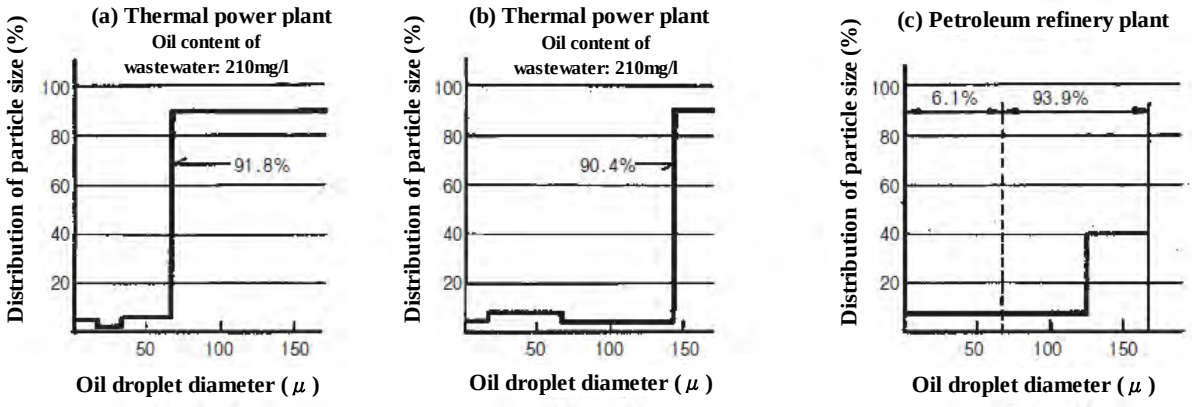


Fig- 28: Example of particle size of oil droplets in the wastewater

Reference: P-44 of Journal (No.609: Oct. /2007): TENPES

(7) Activated sludge method

Organic matter in drainage is decomposited by the effect of aerobicgradation in activated sludge. When continuing to blow air in the long-term into drainage, brown and hazy suspended solids is caused, it will be precipitated immediately after stopping of aeration and supernatant water is left. If removing precipitated sludge (activated sludge) and adding new wastewater and aerating, wastewater will be cleaned in the relatively short time. That allows the continuous purification is the activated sludge process. This process is caused by microorganisms, which are described as follows;

$$\text{Chios} + O_2 \rightarrow CO_2 + H_2O - \Delta Q \quad \cdots\cdots\cdots\cdots(1)$$

$$\text{Chios} + O_2 \rightarrow (\text{cellular material}) + CO_2 + H_2O - \Delta Q \quad \cdots\cdots\cdots\cdots(2)$$

$$(\text{cellular material}) + O_2 \rightarrow CO_2 + H_2O + NH_3 - \Delta Q \quad \cdots\cdots\cdots\cdots\cdots(3)$$

Here, CxHyOz shows the organic matter in wastewater. Equation (1) shows oxidation of organic matter, equation (2) shows synthesis of cellular material, equation (3) shows oxidation of cellular material. In other word, contaminant in wastewater will eventually become carbon dioxide gas, water and cellular body of aerobic organisms. Much type of organisms appears into activated sludge depending on the type of wastewater. Generally, the basic group of organisms of activated sludge is classified into the following four groups.

1) Bacteria
2) Fungi
3) Protozoa
4) Metazoan animal

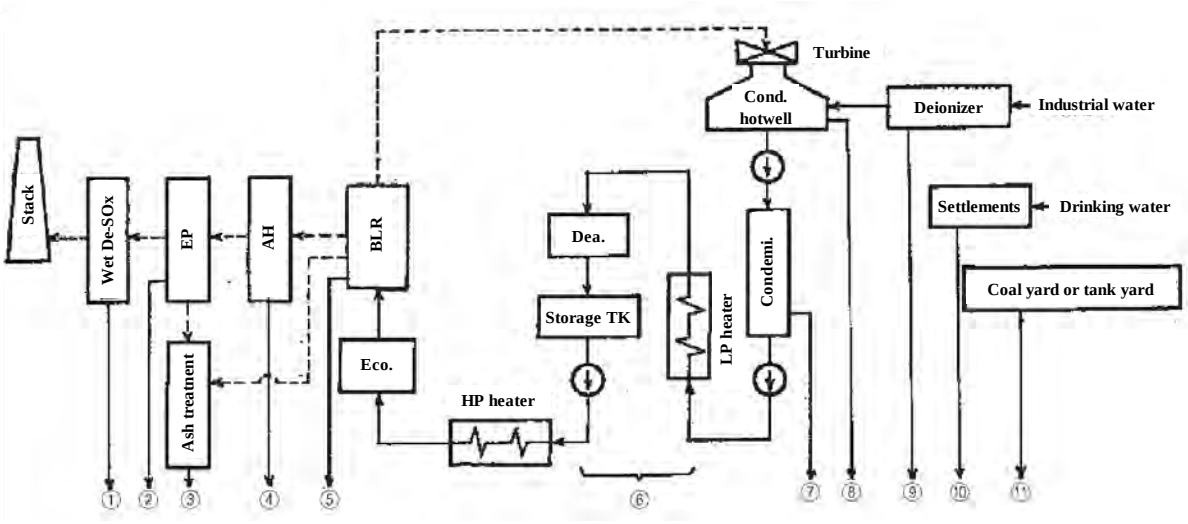
The activated sludge is complicated matter which aerobic bacteria, organic or inorganic suspended solids and colloid are added, in addition, adhering to the surface of various protozoan, metazoan animals and algae, although the activated sludge is formed mainly by aerobic bacteria. Majority is the very small flock; it will become larger flock, is aggregated and precipitated immediately, if leaving quietly. Smells is almost odorless and slightly earthy smell. It must be conformed to the "construction standard for human septic waste tank" based on Building Standard Law, which details of processing method and structure are descried in that if processing wastewater by activated sludge method.

1.3 Basic drainage and wastewater treatment

1.3.1 Types, quantity and quality of wastewater

There is the regular wastewater that discharges with the constant daily operation of the plant and the irregular discharge with periodic inspection and repair work in the power plant. Fig-29 shows the system of thermal power plant, source of wastewater and name of wastewater. If it can be understand

the water quality of each wastewater, it can be treated properly and manage proactively.



1. Desulfurization wastewater (regular)	5. Chemical cleaning wastewater (irregular)	8. Condenser leak test wastewater (irregular)
2. EP washing wastewater (irregular)	5.Boiler blow water (irregular)	9. Water demineralizer regeneration wastewater (regular)
3. Ash treatment wastewater (regular)	6. Unit drain wastewater (regular)	10. Drainage (regular)
4. AH washing wastewater (irregular)	7. Condensate demineralizer regeneration wastewater (regular)	11. Rainwater from coal yard and tank yard

Fig- 29: Types of wastewater in thermal power plant

Reference: P-45 of Journal (No.609: Oct. /2007): TENPES

(1) Regular drainage

1) Drainage

An amount of drainage is said 50ℓ/person-day for flush toilets, 10~15ℓ/serving-day for kitchen, and 15~190m^3/day as the result of survey. Table-10 shows an example of water quality.

Table- 10: Example of kitchen drainage

		A	B	C
pH	—	4.5	7.2	7
SS	ppm	98	48	300
BOD	ppm	262	200	400
COD	ppm	60	200	—
Oil	ppm	21	30	100

Reference: P-45 of Journal; (No.609: Oct. /2007): TENPES

2) Water demineralizer regeneration wastewater

An amount of wastewater is said 6~15% and 10~360m_3/day as the result of survey. Table-11 shows an example of water quality.

Table- 11: Example of water demineralizer regeneration wastewater

pH	10~12
SS	800 ~ 1,000ppm
COD	20 ~ 40ppm

Note: SS=about 100ppm at pH6

Reference: P-45 of Journal (No.609: Oct. /2007): TENPES

3) Condensate demineralizer regeneration wastewater

An amount of wastewater is said 100~250m_3/ tower-time for a 350MW class, usually 3~4 towers are re-generated once every 4~5 days in H-OH type and once every 25~30 days in NH_4-OH type. It was 15~570m^3/day as the result of survey. Table-12 shows an example of water quality.

Table- 12: Example of condensate demineralizer regeneration wastewater

pH	3~10
SS	30 ~ 50ppm
NH_4	800 ~ 1,000ppm

Reference: P-45 of Journal (No.609: Oct. /2007): TENPES

4) Desulfurization wastewater

An amount of wastewater is said 0.5~1.0m^3/day-MW for oil-fired and 0.7~2.3m^3/day-MW for coal-fired in thermal power plant. It was 50~960m^3/day as the result of survey. Table-13 shows an example of water quality. A high T-N is characterized for heavy oil, Orimulsion, residual oil and high metal such as Mg, Hg, Aℓ ion for coal-fired, which is characterized by high F.

Table- 13: Water quality example of desulfurization wastewater

		Oil Fired Thermal Power	Coal Fired Thermal Power
pH	—	2.6	1.6
SS	ppm	43	115
COD	ppm	32	18
Fe	ppm	8	38
Mn	ppm	0.8	5
Mg	ppm	—	122
Ni	ppm	0.7	0.9
Al	ppm	—	255
Zn	ppm	1.2	3
F	ppm	1.3	327
T-N	ppm	632	40

Reference: P-46 of Journal (No.609: Oct. /2007): TENPES

5) Ash treatment wastewater

Dry type ash treatment is being applied as water-free method in oil-fired plant. Water recirculation tends to applied in coal-fired plant. An amount of wastewater was 4~450m^3/day for wastewater from EP, 50~8,000m^3/day for wastewater from coal ash treatment as the result of survey.

6) Miscellaneous wastewater

It is impossible to grasp amount and quality of miscellaneous wastewater from turbine room floor, boiler room floor and cooling water system. It was 27~1,737m^3/day as the result of survey.

(2) Irregular drainage

1) AH washing wastewater AH

An amount of wastewater is 1,000~2,000m^3/time and 4,000m^3/time at large, is said to be discharged in three to five hours. It was 200~4,000m^3/time as the result of survey. Fig-30 shows the change in water quality in the time after the start of washing.

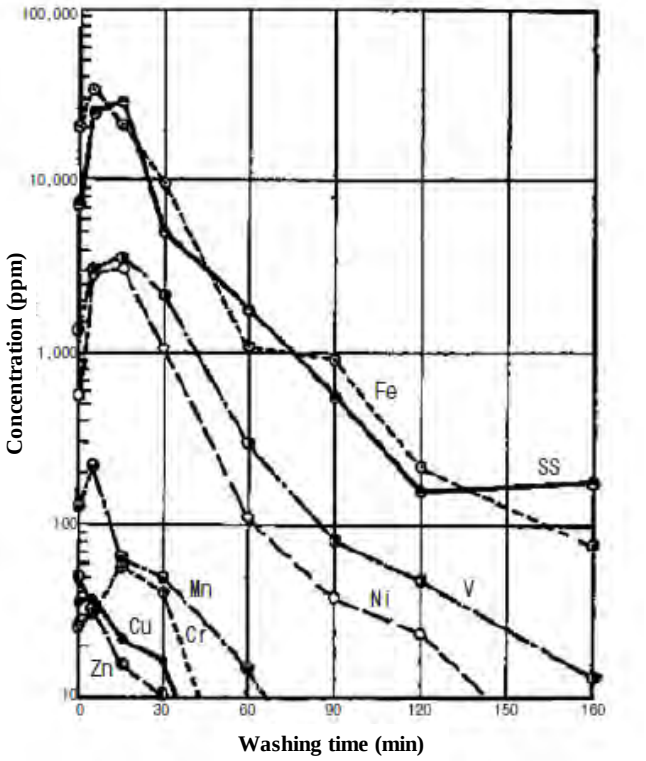


Fig- 30: Water quality example of AH washing

Reference: P-46 of Journal (No.609: Oct. /2007): TENPES

2) EP washing wastewater

An amount and quality of wastewater is similar to AH washing wastewater. An amount of wastewater was 400~3,000m^3/time as the result of survey.

3) Wastewater after equipment standby and startup

An amount of wastewater in storing boiler and clean-up at the star-up is said 200~4,000m^3/day. It was 190~1,600m^3/time for wastewater from devices reservation and 350~10,000m^3/time for wastewater from start-up as the result of survey. Water quality is about that containing several tens to several hundreds mg/ℓ hydrazine (N_2H_4) in the pure water, the COD will be approximately 1/2 concentration of N_2H_4.

4) Chemical cleaning wastewater

An amount of wastewater is generally complementary capacity to about 10 times the boiler, which is said to be discharged to several tens of hours. It was 300~2,700m^3/time as the result of survey. Table-14 shows an example of wastewater due to hydrochloric acid and organic cleaning.

Table- 14: Water quality example of chemical cleaning drainage

		Hydrochloric acid drainage	Organic acid drainage
pH	—	< 1	< 4
SS	ppm	< 100	< 100
COD	ppm	500 ~ 30,000	20,000 ~ 50,000
Fe	ppm	100 ~ 20,000	1,000 ~ 10,000
Cu	ppm	0 ~ 2,000	0 ~ 1,000
Color	—	Black-brown	Black-yellow
Odor	—	Pungent odor	Specific odor

Reference: P-46 of Journal (No.609: Oct. /2007): TENPES

(3) Rainwater

An amount of rainwater from tank yard or coal stock yard is determined by yard area and rainfall. In the tank yard, almost all rainwater will be discharged, since floor is usually made of concrete, however, in the cal stock yard, it is often used for sprinkle water within the system, since runoff coefficient is different due to ground, gravel and concrete floor.

1.3.2 Wastewater treatment system and equipment management

Power plant has many types of wastewater, an amount and quality of wastewater is also uneven. Therefore, it is difficult for the wastewater treatment system to treat all in a single batch process and some equipment is often uniformed. However, there are some patterns, since wastewater treatment system is not uniformed unlike the feed-water system or boiler water system. The example to divide depending on the nature of wastewater is described in this section. It is important to manage to be able to demonstrate its ability always by understanding equipment in order to perform wastewater treatment properly.

(1) Common wastewater treatment system

Common wastewater treatment system is shown in Fig-31. All of variety of wastewater are led to effluent storage tank, amount and quality of water is equalized after storing primary. In the wastewater storage tank, the precipitation of SS is prevented along with iron and sulfur to oxidize and aeration. Then, the flock is formed in the flocculation tank and precipitated in the sedimentation tank while adjusting pH in the pH adjusting No.1 tank, adding coagulant and performing air oxidation. The treated water is discharged through a flow meter after neutralization, if necessary, conducting an activated carbon absorption filtration. In addition, wastewater is circulated back to the reservoir, if treated water quality is poor. Precipitated flock is dehydrated and removed as sludge cake after concentration in the thickener. Operation of processing device is carried out controlling the changes in wastewater capacity, the amount of chemicals for coagulation and sedimentation, pH

condition, state of the flock of flocculation tank and sludge in the sedimentation tank. Sludge is withdrawn intermittently from the sedimentation tank to the thickener and operation of dehydrator is carried out to measure the amount of sludge in the thickener. The operation conditions of dehydrator are set depending on the water content of sludge cake.

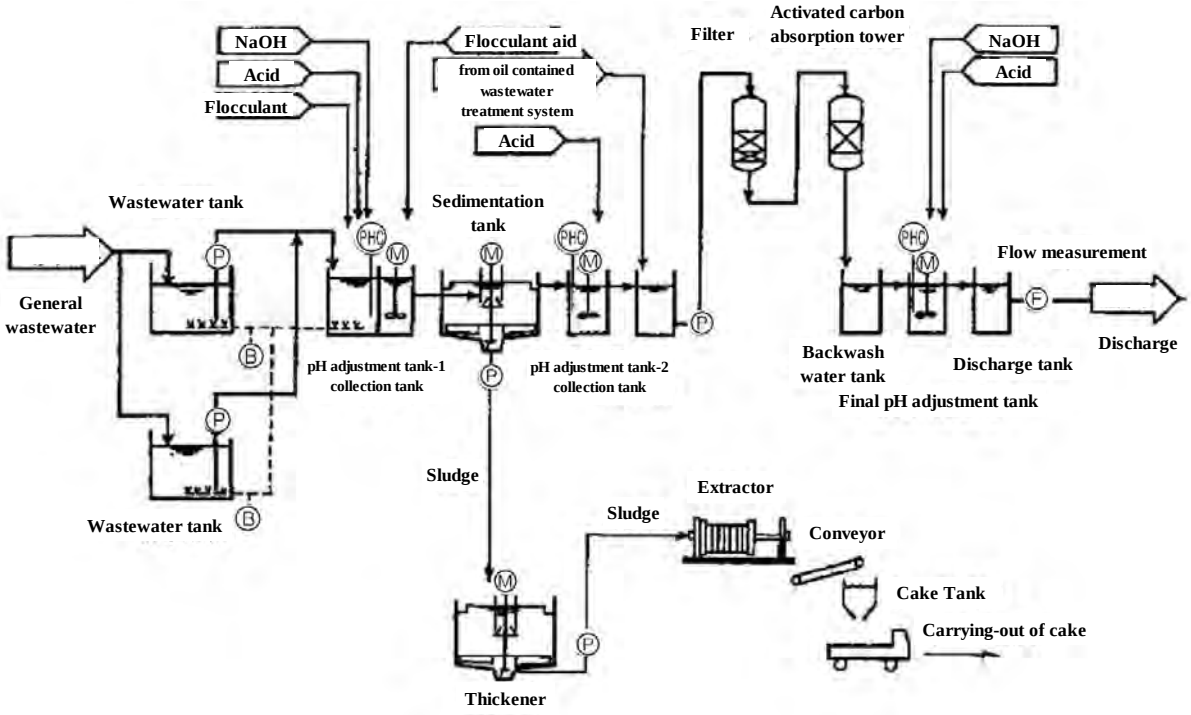


Fig- 31: Example of general wastewater treatment system

Reference: P-47 of Journal (No.609: Oct. /2007): TENPES

(2) Oil-containing wastewater treatment system

Example of oil- containing wastewater treatment system is shown in Fig-32. Wastewater is separated by API gravity separation method at first, in addition is separated by PPI or CPI method. The treated water is discharged through a flow meter after making activated carbon absorption filtration, if necessary. In addition, wastewater is circulated back to the reservoir, if treated water quality is poor. The oil separated by the gravity separation device is recovered. The operation of processing device is usually carried out to be capable to accept continuously and the separated oil on the water surface is extracted by API or CPI intermittently. It is possible to remove oil droplet sufficiently by the gravity separation, since oil droplet diameter of actual wastewater in the power plants has at least 60~120μ as shown in Table-9. Therefore, it is important to grasp the changing state of the oil flowing when the oil removal performance is deteriorated.

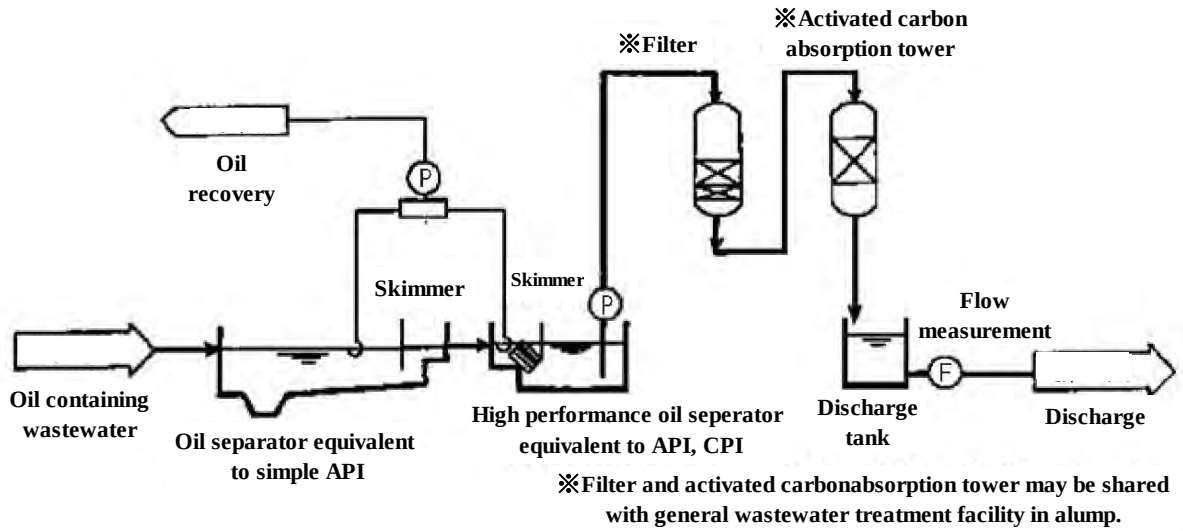


Fig- 32: Example of oil-containing wastewater treatment system

Reference: P-47 of Journal (No.609: Oct. /2007): TENPES

(3) Drainage treatment system

Drainage treatment system is shown in Fig-33. Wastewater from various places is led to the aeration tank after removing large suspended solids in the wastewater or floating material on the surface by screen first, storing temporary in the adjusting tank and adjusting amount and quality of water. It is well processed by activated sludge processing by feeding air to the aeration tank and returning sludge from the sedimentation tank. Then, activated sludge is sent to precipitation tank and precipitated. The top clear water is discharged after filtration, activated carbon absorption and final chlorine disinfection as the tertiary treatment through a flow meter. The sediment in the precipitation tank will be led to sludge storage tank and concentrated, and then it will be transported and disposed by the vacuum transporter. Operation of processing equipment is usually able to keep it always accept drainage and increase the amount of work to do if water level rises adjustment tank. The screen is always inspected in order to ensure the state of scraping of sediments. The aeration state is monitored in order to supply sufficient air for activated sludge and keep uniform aeration by inspecting the clogging of aeration tube, etc. in the aeration tank. The sedimentation is monitored and the amount of sludge is controlled in the sedimentation tank. In addition, MLSS (SS in the aeration tank), SV (sludge volume), SVI (sludge volume index) are calculated to determine the quality of activated sludge. These studies are performed according to the test method of sewer.

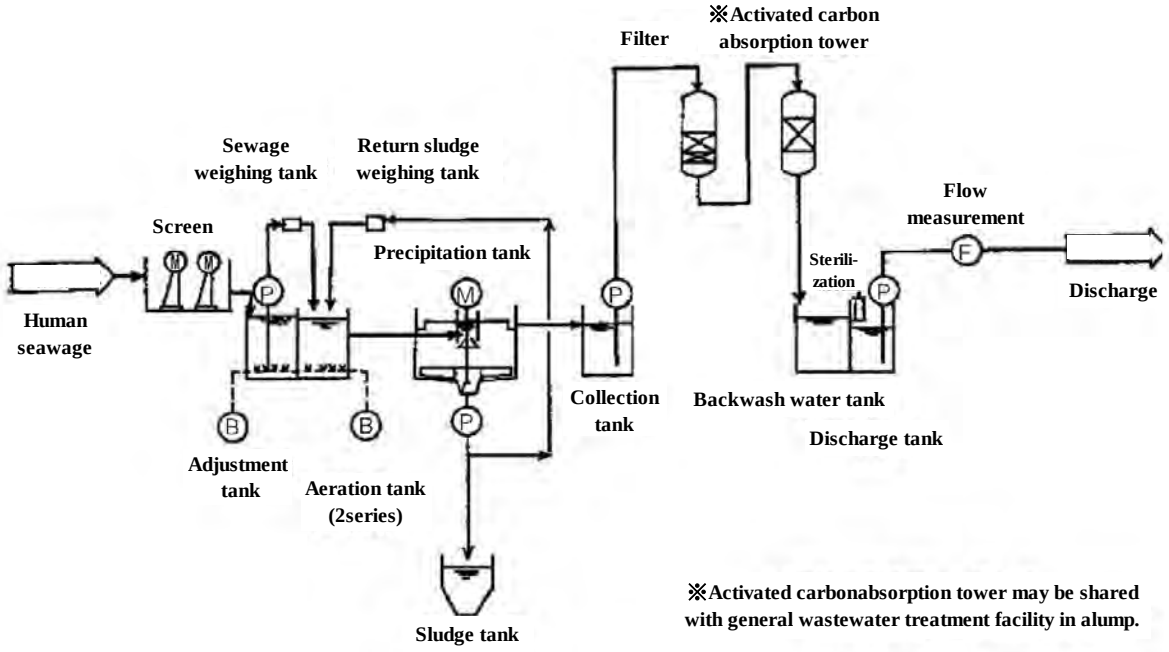


Fig- 33: Example of drainage treatment system

Reference: P-48 of Journal (No.609: Oct. /2007): TENPES

(4) Desulfurization wastewater treatment system

Desulfurization wastewater treatment system for coal-fired power plant is shown in Fig-34. The coagulation and sedimentation or membrane process is usually performed for fluoride removal prior to the coagulation system in coal-fired plant. The desulfurization wastewater is reserved temporary, uniformed water amount and quality aims to prevent the precipitation of SS such as gypsum by aeration. The process is performed by removal of COD components by absorption such as Jiochin acid or N-S compounds in the absorption tower after removal of fluorine, iron, calcium by coagulation and sedimentation and filtration. Recently, Selen treatment, nitrogen treatment fluorine absorption treatment will be established in that process. The treated water is finally discharged through a flow meter by neutralizing and adjusting pH. In addition, wastewater is circulated back to the reservoir, if quality of treated water is poor. The precipitated sludge in the sedimentation tank is led to thickener and concentrated, dehydrated in dehydrator to sludge cake, and then it is taken out. Operation of processing device is performed continuously and the management of amount of chemical injection, processing pH, state of the flock of flocculation tank, amount of sludge in the sedimentation tank is performed similar to common wastewater treatment facility. Apart from this, backwash and regeneration of filter and COD absorption tower, management of decomposition conditions for regeneration wastewater is performed. It is important to perform daily operation with a good understanding of desulfurization method in order to carry out fluoride treatment, COD treatment, nitrogen treatment, selenium treatment, etc. which is not included in conventional wastewater treatment.

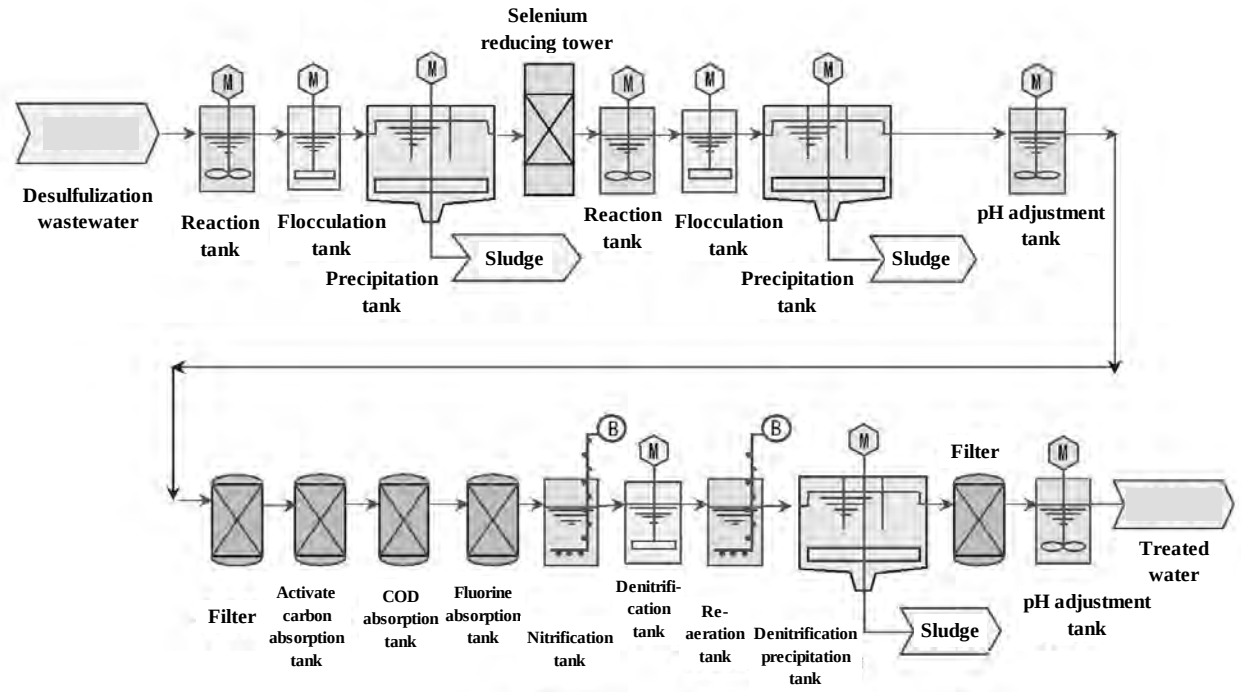


Fig- 34: Example of desulfurization wastewater treatment system

Reference: P-48 of Journal (No.609: Oct. /2007): TENPES

Article 222. Discharge standard of effluent

Article 222-1. Value of the Parameters of Pollution in Industrial Wastewater

4.1.2.2. Environmental regulations to be applied to thermal power project

(1) National technical regulation on industrial wastewater: QCVN 24/2009/BTNMT

There is no dedicated wastewater regulation for the thermal power plant in Vietnam; it is regulated by common national technical regulation for a common industrial effluent limit. This regulation is also applied for the effluent from coal yard, ash pond effluent other than thermal effluent. The maximum allowable contaminants in the industrial wastewater (Cmax) is calculated as follows (however, Cmax=C is applied for the temperature, pH, odor, color, coliform count, total α radioactivity, total β radioactivity).

$$Cmax = C \times Kq \times Kf$$

"C" is the emission level of pollutants in the industrial wastewater as shown in Table-15.

Table- 15: National technical regulation on industrial wastewater (QCVN 24/2009/BTNMT)

Parameter	Unit	C values	
		A	B
Temperature	^{0}C	40	40
pH	—	6.0-9.0	5.5-9.0
Odor	—	Not unendurable	Not unendurable
Color (Co-Pt in pH=7)	—	20	70
BOD_5 (at 20^{0}C)	mg/l	30	50
COD	mg/l	50	100
Suspended Solids	mg/l	50	100
Arsenic	mg/l	0.05	0.1
Hydragyrum	mg/l	0.005	0.01
Lead	mg/l	0.1	0.5
Cadmium	mg/l	0.005	0.01
Chromium(VI)	mg/l	0.05	0.1
Chromium(III)	mg/l	0.2	1
Copper	mg/l	2	2
Zinc	mg/l	3	3
Nickel	mg/l	0.2	0.5
Manganese	mg/l	0.5	1
Forrum	mg/l	1	5
Stannum	mg/l	0.2	1
Cyanide	mg/l	0.07	0.1
Phenol	mg/l	0.1	0.5
Mineral oil	mg/l	5	5
Vegetable animal oil	mg/l	10	20
Excess chloride	mg/l	1	2
PCB	mg/l	0.003	0.01
Chemical plant protection organic phosphorus	mg/l	0.3	1
Chemical plant protection organic chloride	mg/l	0.1	0.1
Sulfur	mg/l	0.2	0.5
Fluoride	mg/l	5	10
Chloride	mg/l	500	600
Ammonium (calculated by Nitrogen)	mg/l	5	10
T-N	mg/l	15	30
T-P	mg/l	4	6
Coliform	MPN/100ml	3,000	5,000
Total of radioactivity α	Bq/l	0.1	0.1

Parameter	Unit	C values	
		A	B
Total of radioactivity β	Bq/l	1.0	1.0

- Column A is the regulated "C" value parameters of pollution in industrial wastewater when discharged into a receiving source which is a water source for used by people;

- Column B is the regulated C value parameters of pollution in industrial wastewater when discharged into a receiving source which is not a water source for used by people ;

- Chloride parameters do not apply to any receiving source which is salt water and or brackish water.

Where, column A is applied, if the industrial wastewater is discharged to the area of the water source for domestic water. In addition, column B is applied, if the industrial wastewater is not discharged to the area of the water source for domestic water. In case the discharge of industrial wastewater to saline or brackish water area, the chloride level is not applied. Kq is defined as follows according to the destination of discharge of industrial wastewater.

Table- 16: Kq in case releasing industrial wastewater to river, spring canal, channel, stream and trench (QCVN 24/2009/BTNMT)

Flow rate in the place where industrial wastewater is discharge to Q (m^3/s)	Kq
$Q \leq 50$	0.9
$50 < Q \leq 200$	1.0
$200 < Q \leq 1,000$	1.1
$1,000 < Q$	1.2

"Q" as shown in Table-16 is the average flow rate of 3 months of most dry season in the river, spring, canal, stream and trench where industrial wastewater is discharge to (base on the data of weather stations). "Kq=0.9" is applied if there is no data about flow rate of such river, spring, canal, stream and trench, or Kp is decided by means of determination the flow rate of the 3 month in most dry season by the agency specified by the Department of Natural Resources and Environment in such region.

Table- 17: Kp in case releasing industrial wastewater to pond or lake (QCVN 24/2009/BTNMT)

Capacity in the place where industrial wastewater is discharge to V (m^3)	Kq
$V \leq 10x10^6$	0.6
$10x10^6 < V \leq 100x10^6$	0.8
$100x10^6 < V$	1.0

"V" as shown in Table-17 is the average flow rate of 3 months of most dry season in the pond or lake where industrial wastewater is discharge to (base on the data of weather stations). "Kq=0.6" is applied if there is no data about flow rate of such pond or lake, or Kq is decided by means of determination the flow rate of the 3 month in most dry season by the agency specified by the Department of Natural Resources and Environment in such region. In case of coastal area in the place where industrial wastewater is discharged to, Kq=1.3 is applied to the coastal area where are not available for the protection of marine life, water sport and activity, Kq=1.0 is applied to the coastal area where are available for the protection of marine life, water sport.

(2) National Technical Regulation on Domestic Waste Water: QCVN 14/2008/BTNMT

National technical regulation on domestic wastewater QCVN14/2008/BTNMT is applied to the drainage from power plant. The maximum allowable contaminants in the drainage (Cmax) is calculated as follows (however, Cmax=C is applied for the temperature, pH, coliform count).

$$Cmax = C \times K$$

"C" is the emission levels of pollutants in the drainage as set out in Table-18.

Table- 18: Emission regulation for pollutants in wastewater C (QCVN 14/2008/BTNMT)

No.	Parameter	Unit	C values	
			A	B
1	pH	—	5-9	5-9
2	BOD_5 (20°C)	mg/l	30	50
3	Total suspended solid (TSS)	mg/l	50	100
4	Dissolved solid	mg/l	500	1,000
5	Sulfur (H_2S conversion)	mg/l	1.0	4.0
6	Ammonia (Nitrogen conversion)	mg/l	5	10
7	Nitrate (NO_3^- : Nitrogen conversion)	mg/l	30	50
8	Animal and plant fat	mg/l	10	20
9	Surface active agent	mg/l	5	10
10	Phosphate(PO_4^{3-}:Phosphate conversion)	mg/l	6	10
11	Coliform count	MPN/100ml	3,000	5,000

"K" is stipulated depending on the type of facility such as service facilities, public facilities, housing, business type, size and required area as shown in Table-19.

Table- 19: Coefficient K corresponding to the type of service facility, public facility and complex housing (QCVN 14/2008/BTNMT)

Type of facility	Size and required area of facility	K
1. Hotels and restaurants	hotel in 50 rooms, 3 stars and more	1.0
	Less than 50 rooms	1.2
2. Representative institutions, office, school and research facility	10,000m^2 and more	1.0
	Less than 10,000m^2	1.2
3. Department stores and supermarket	5,000m^2 and more	1.0
	Less than 5,000m^2	1.2
4. Market	1,500m^2 and more	1.0
	Less than 1,500m^2	1.2
5. Restaurants and food shops	500$m^2$and more	1.0
	Less than 500m^2	1.2
6. Production facilities and military camps, etc.	500 peoples and more	1.0
	Less than 500 peoples	1.2
7. Multifamily residential	50 units and more	1.0
	Less than 50 units	1.2

(3) National Technical Regulation on Surface Water Quality: QCVN 08/2008/BTNMT

Table-20 shows water quality regulation for surface water quality.

Table- 20: Water quality regulation for surface water (QCVN 08/2008/BTNMT)

No.	Parameter	Unit	Allowable Value			
			A		B	
			A1	A2	B1	B2
1	pH	—	6-8.5	6-8.5	5.5-9	5.5-9
2	Dissolved oxygen (DO)	mg/ℓ	≥ 6	≥ 5	≥ 4	≥ 2
3	Total suspended solid (TSS)	mg/l	20	30	50	100
4	COD	mg/l	10	15	30	50
5	BOD5 (20^oC)	mg/l	4	6	15	25
6	Ammonia ($NH+_4$: calculated by Nitrogen)	mg/ℓ	0.1	0.2	0.5	1
7	Chloride (Cl-)	mg/ℓ	250	400	600	—
8	Fluorine (F-)	mg/ℓ	1	1.5	1.5	2
9	Nitrite ($NO--_2$: calculated by Nitrogen)	mg/ℓ	0.01	0.02	0.04	0.05
10	Nitrate (NO_3^-)	mg/ℓ	2	5	10	15

No.	Parameter	Unit	Allowable Value			
			A		B	
			A1	A2	B1	B2
11	Phosphate (PO_4^{3-})	mg/l	0.1	0.2	0.3	0.5
12	Cyanide (CN^-)	mg/l	0.005	0.01	0.02	0.02
13	Arsenic (As)	mg/l	0.01	0.02	0.05	0.1
14	Cadmium (Cd)	mg/l	0.005	0.005	0.01	0.01
15	Lead (Pb)	mg/l	0.02	0.02	0.05	0.05
16	Chrome (Cr^{3+})	mg/l	0.05	0.1	0.5	1
17	Chrome (Cr^{6+-})	mg/l	0.01	0.02	0.04	0.05
18	Copper (Cu)	mg/l	0.1	0.2	0.5	1
19	Zinc (Zn)	mg/l	0.5	1.0	1.5	2
20	Nickel (Ni)	mg/l	0.1	0.1	0.1	0.1
21	Iron (Fe)	mg/l	0.5	1	1.5	2
22	Mercury (Hg)	mg/l	0.001	0.001	0.001	0.002
23	Surface active agent	mg/l	0.1	0.2	0.4	0.5
24	Oils and grease	mg/l	0.01	0.02	0.1	0.3
25	Phenol	mg/l	0.005	0.005	0.01	0.02
26	Organochlorine insecticide					
	Aldrin+Dieldrin	µg/ l	0.002	0.004	0.008	0.01
	Endrin	µg/ l	0.01	0.012	0.014	0.02
	BHC	µg/ l	0.05	0.1	0.13	0.015
	DDT	µg/ l	0.001	0.002	0.004	0.005
	Endosulfan (Thiodan)	µg/ l	0.005	0.01	0.01	0.02
	Lindan	µg/ l	0.3	0.35	0.38	0.4
	Chlordane	µg/ l	0.01	0.02	0.02	0.03
	Heptachlor	µg/ l	0.01	0.02	0.02	0.05
27	Organophosphate insecticide					
	Paration	µg/ l	0.1	0.2	0.4	0.5
	Mlathiion	µg/ l	0.1	0.32	0.32	0.4
28	Herbicide chemical					
	2,4D	µg/ l	100	200	450	500
	2,4,5T	µg/ l	80	100	160	200
	Paraquat	µg/ l	900	1,200	1,800	2,000
29	Total radioactive active α	Bq/ l	0.1	0.1	0.1	0.1
30	Total radioactive active β	Bq/ l	1.0	1.0	1.0	1.0
31	E.Coli	MPN/100ml	20	50	100	200

No.	Parameter	Unit	Allowable Value			
			A		B	
			A1	A2	B1	B2
32	Coliform	MPN/100ml	2,500	5,000	7,500	10,000

Note:

A1: This is applied to daily life water and use for A2, B1 and B2.

A2: This is applied to daily life water (after appropriate treatment), protection of underwater flora and fauna, and use for B2 and B2.

B1: This is applied to irrigation water or other uses that require equivalent water quality, and use for B2.

B2: This is applied to water transportation or other use that do not require high water quality.

(4) National Technical Regulation on Coastal Water Quality: QCVN 10/2008/BTNMT

National Technical Regulation on Coastal Water Quality is shown in Table-21.

Table- 21: National Technical Regulation on Coastal Water Quality (QCVN 10/2008/BRNMT)

No.	Parameter	Unit	Allowable Value		
			Aquaculture, aquatic creatures protection area	Seaside resort, water sport area	Other areas
1	Temperature	^{o}C	30	30	—
2	pH	—	6.5-8.5	6.5-8.5	6.5-8.5
3	Dissolved oxygen (DO)	mg/l	≥ 5	≥ 4	—
4	Total suspended solid (TSS)	mg/l	50	50	—
5	COD ($KMnO_4$)	mg/l	3	4	—
6	Ammonia ($NH+_4$: calculated by Nitrogen)	mg/l	0.1	0.5	0.5
7	Fluorine (F-)	mg/l	1.5	1.5	1.5
8	Sulfide (S^{2-})	mg/l	0.005	0.01	0.01
9	Cyanide (CN-)	mg/l	0.005	0.005	0.01
10	Arsenic (As)	mg/l	0.01	0.04	0.05
11	Cadmium (Cd)	mg/l	0.005	0.005	0.005
12	Lead (Pb)	mg/l	0.05	0.02	0.1
13	Chrome (Cr^{3+})	mg/l	0.1	0.1	0.2
14	Chrome (Cr^{6+})	mg/l	0.02	0.05	0.05
15	Copper (Cu)	mg/l	0.03	0.5	1
16	Zinc (Zn)	mg/l	0.05	1.0	2.0
17	Manganese (Mn)	mg/l	0.1	0.1	0.1
18	Iron (Fe)	mg/l	0.1	0.1	0.3

No.	Parameter	Unit	Allowable Value		
			Aquaculture, aquatic creatures protection area	Seaside resort, water sport area	Other areas
19	Mercury (Hg)	mg/l	0.001	0.002	0.005
20	Oil and grease	mg/l	0	0	—
21	Mineral oil	mg/l	Not detectable	0.1	0.2
22	Phenol (total)	mg/l	0.001	0.001	0.002
23	Organochlorine insecticide				
	Aldrin+Dieldrin	µg/ l	0.008	0.008	—
	Endrin	µg/ l	0.014	0.014	—
	BHC	µg/ l	0.13	0.13	—
	DDT	µg/ l	0.004	0.004	—
	Endosulfan (Thiodan)	µg/ l	0.01	0.01	—
	Lindan	µg/ l	0.38	0.38	—
	Chlordan	µg/ l	0.02	0.02	—
	Heptachlor	µg/ l	0.06	0.06	—
24	Organophosphate insecticide				
	Paration	µg/ l	0.40	0.40	—
	Mlathion	µg/ l	0.32	0.32	—
25	Herbicide chemical				
	2,4D	µg/ l	0.45	0.45	—
	2,4,5T	µg/ l	0.16	0.16	—
	Paraquat	µg/ l	1.80	1.80	—
26	Total radioactive active α	Bq/ l	0.1	0.1	0.1
27	Total radioactive active β	Bq/ l	1.0	1.0	1.0
28	Coliform	MPN/100ml	1,000	1,000	1,000

Article 222-2. Maximum allowable value parameter

1. Maximum allowable value of the parameters of wastewater must be referred to prescribe in the Table-15, 18, 20 and 21.

Article 223. Facility to prevent noise

(1) National Technical Regulation on Noise : QCVN 26/2010/BTNMT

The environmental regulation for noise is shown in Table-22.

Table- 22: Environmental regulation for noise (dB (A))

No.	Zones	06:00~21:00	21:00~06:00
1	Special zones	55	45
2	Normal zones	70	55

Special zones : Medical facilities, libraries, nurseries, schools, churches, meeting place, the inner area of the temple surrounded by a fence and the defined in a separately and specially.

Normal zones : Multifamily housing or adjacent house, hotels, rest houses, including an area of government agencies.

(2) Standard related to the allowable noise level in the work place : TCVN 3985: 1999

This standard stipulates maximum allowable noise level in the work place such as factory and office. This is applied to control noise level generated during the process of work and workers affected by plant and machinery. Generally, the allowable noise level must not exceed 85dBA during 8 hour work shift and 115dBA at maximum. In addition, it must not exceed following allowable limit as shown in Table-23 for the entire period.

Table- 23: Allowable noise level

Hours	Allowable noise level (dBA)
4	90
2	95
1	100
30 minutes	105
15 minutes	105
—	Maximum 115
Non-working hour of the work day	Less than 80

2. Noise prevention measure

2.1 Noise control plan

There are a number of sources in the thermal power plant and the propagation paths and their impact is complicated. Therefore, comprehensive study is needed as a whole power plant when planning not only a single source. The general procedures for noise control plan of the power plant are shown in Fig-35. The most effective and economical plan is advanced in the form of determination the amount of each source volume to satisfy all the objectives in terms of the power plant site boundary repeating the loop within the dotted line in Fig-34. In providing noise control plan, selection of equipments to be taken measure and proposed measures is particularly important and enough effects

may not obtain if failed it. It is preferable to use a definite value of noise as possible, since the measurement accuracy becomes as the precision of predicted.

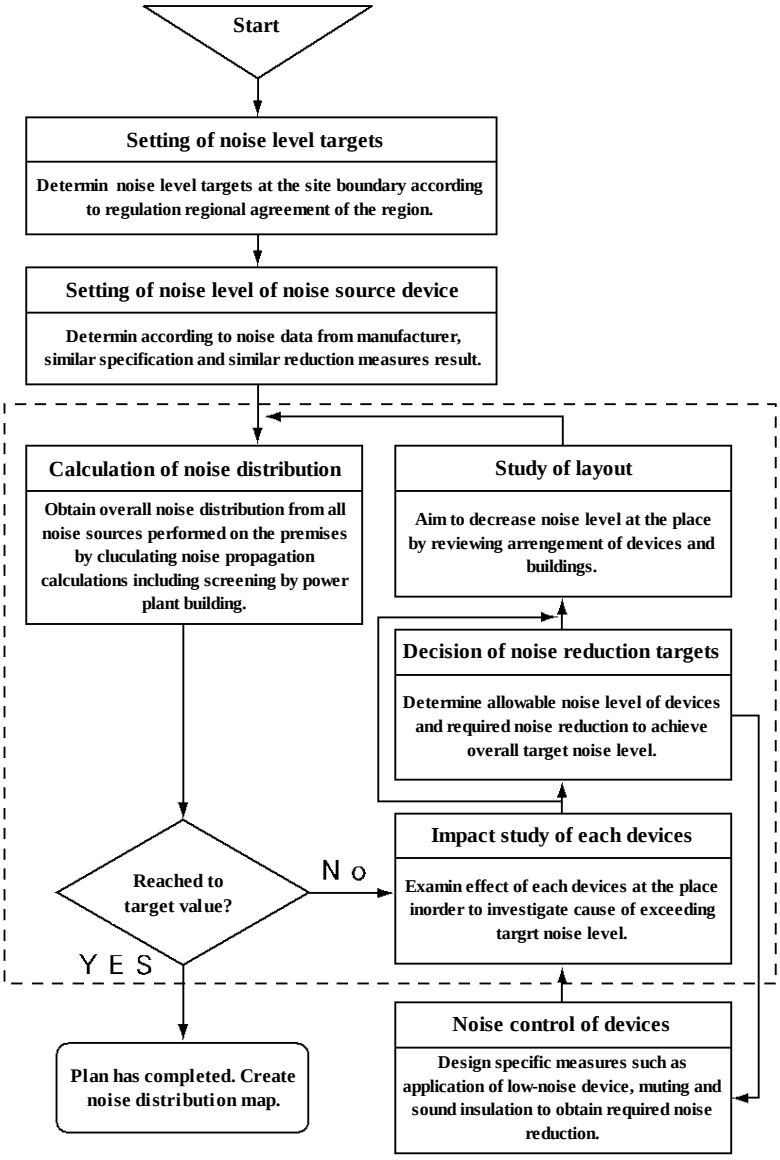


Fig- 35: Practices of noise control plan

Reference: P-61 of Journal (No.557: Feb. /2003): TENPES

2.2 Noise prevention technology

2.2.1 Concept of measures

Sound waves emitted from the source is propagated as a change in air pressure, the sound is perceived to the human ear as pressure changes. The nature of noise that is already apparent in the field of audio engineering in this propagation process is used for noise prevention techniques and is taken advantage of mixing and combination of this. Measures are divided into 3 kinds ad follows;

1) Measures for noise source
2) Measures for propagation paths
3) Measures for noise receiving side

and is considered as shown in Fig-36 and 37.

2.2.2 Measures for noise source

This is a measure to reduce noise and vibration itself from sound device and is the basic for noise control. Noise generation, which are divided into the generated sound by vibration of object and the generated sound due to the flow, mechanism and basic measures of these are as follows;

(1) Noise generated by flow (air sound)

This is a major cause of noise such as fan, air compressors, valves, etc., pressure fluctuations caused by the flow of fluid in the fluid and the sound is generated.

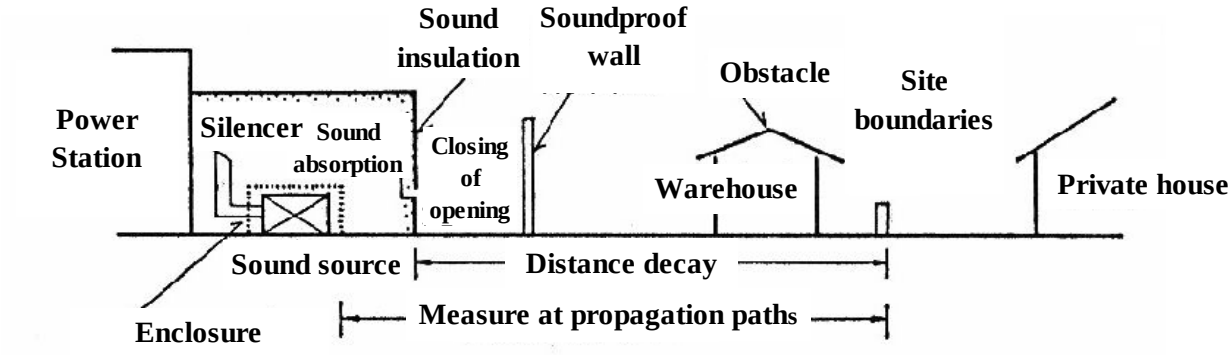


Fig- 36: Concept of noise prevention measures

Reference: P-62 of Journal (No.557: Feb. /2003): TENPES

It is effective in lowering velocity to reduce generated sound, since power of generated sound is proposed to the velocity.

(2) Noise generated by vibrating objects

Pressure fluctuations are excited by the vibrations in the fluid in contact with object and sound is generated. Power "W" of generated sound is generally given by equation (1).

$$W = \rho c u^2 s = U^2 R \cdots\cdots\cdots (1)$$

Here, "u" is the vibration velocity at radiation surface, "s" is the area of radiation, "c" is the speed of sound, "ρ" is air density, "U (=us)" is the volume velocity, "R (=ρc/s)" is the radiation resistance. A reduction of radiated noise is supposed according to the equation (1) as

follows;

2) Reduction of vibration velocity "u"
   a. To reduce excitation force (impact force, imbalanced force, friction force and electromagnetic force, etc.).
   b. To reduce transmission power.
   c. To increase rigidity and weight of body.
   d. To suppress the vibration.
3) Reduction of radiation area "s"

There is measure such the change of operation method of device other than 1) and 2) (changes on operation pattern, stopping at night) among these.

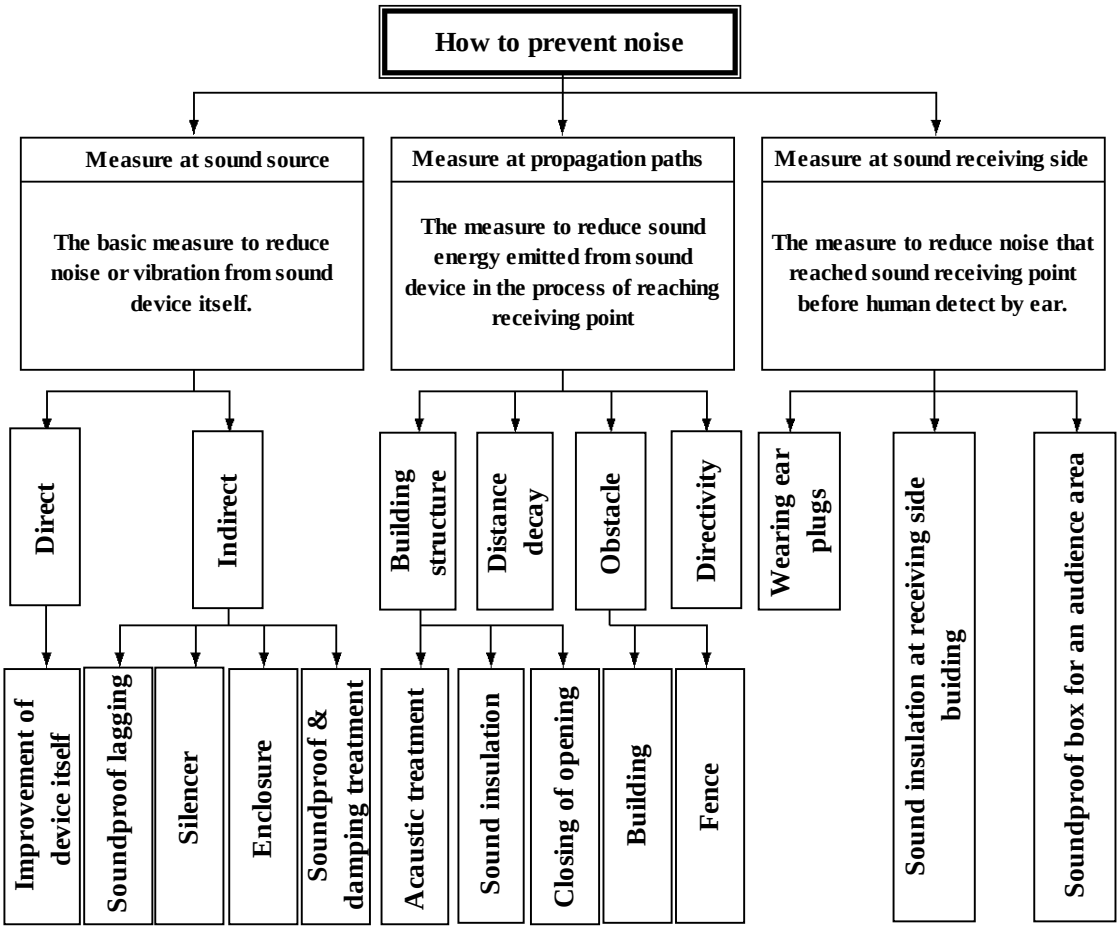


Fig- 37: Method to prevent noise

Reference: P-62 of Journal (No.557: Feb. /2003): TENPES

2.2.3 Measure for propagation paths

This is the measure to reduce the sound energy reaching the receiving point in the process of propagation of sound waves emitted from a source device, if it is difficult to implement sound source measure. There are the propagation in the air as air pressure fluctuation and the propagation in the

solids as vibration as for the noise propagation, there are the following manner as measures to prevent;

1) To reflect the energy of sound and vibration which have been propagated. (isolation, prevention of vibration)
2) To absorb sound and vibration energy as heat energy. (sound absorption, acoustic damping)
3) To change direction of sound propagation. (directional)
4) To take bigger distance from the boundary. (with the attenuation characteristic)

There are general prevention techniques for each as shown in Fig-38;

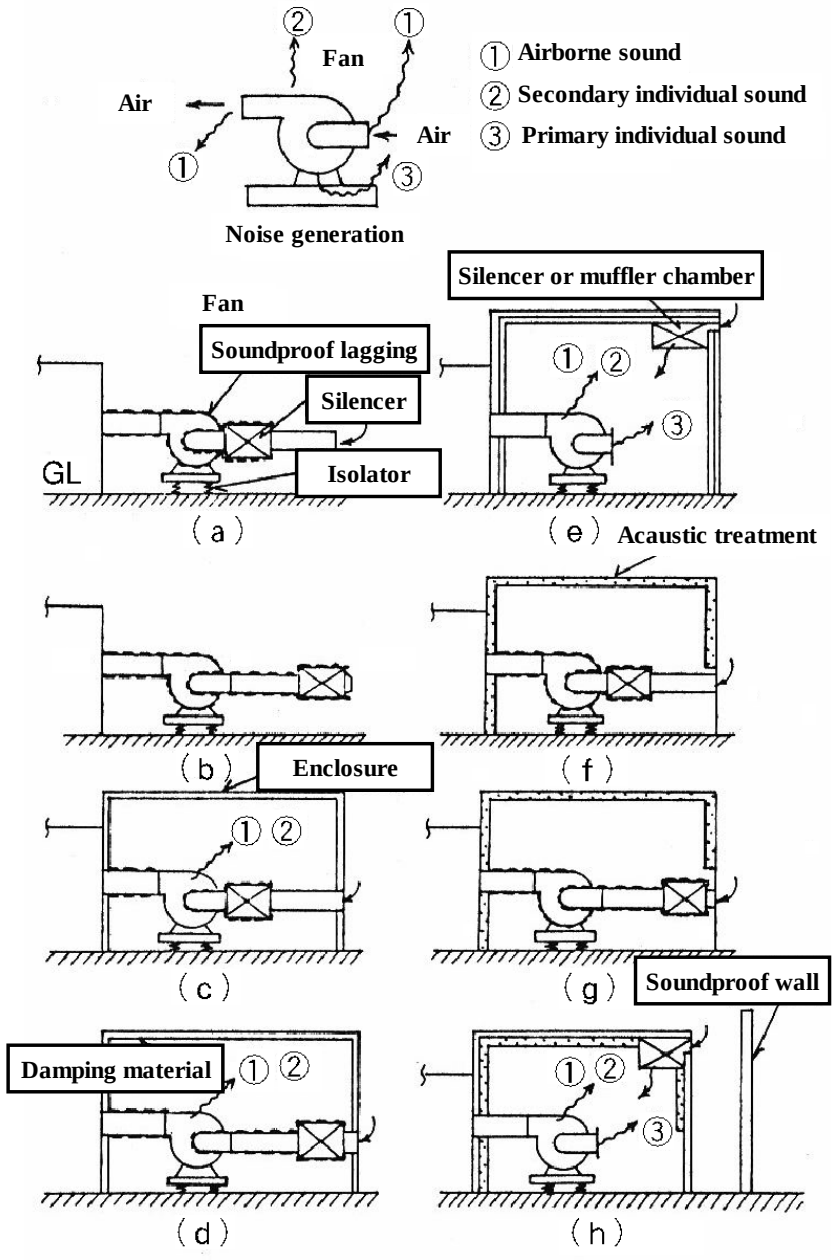


Fig- 38: Method to apply measures preventing noise

Reference: P-63 of Journal (No.557: Feb. /2003): TENPES

1) Air noise measurement

a. Noise insulation by building exterior wall

b. Acoustic treatment of interior

c. Enclosure (soundproof cover)

d. Soundproof lagging

e. Soundproof wall

f. Silencer

2) Measure for solid noise

a. Vibration (vibration isolation)

b. Damping (vibration damping)

These application methods are shown in Fig-38.

2.2.4 Measures for noise receiving side

This is considered only in a passive measure and a last action, since these measures is to reduce perceived by the ear before the sound reaches to the sound receiving point. There are methods such as measures to prevent in Fig-37.

2.3 Noise prevention technology for thermal power plant

Though there are many configuration equipments for thermal power plants, major equipment causing the noise that affects to the outside is as follows;

1) Boiler (including coal mill)
2) Turbine building
3) Transformer
4) Fan (FDF, De-Sox fan)
5) Pump
6) Coal handling facility (unloader, etc.)
7) Others

For these major equipments, measures according to the respective devices are taken in order to meet the target value at boundary. Causes and countermeasures for the current status of this noise level are described as below.

2.3.1 Boiler

Boiler noise contains peripheral noise of fan, pump, coal pulverizer, etc. other than the noise of main

boiler (furnace wall sound transmission such as combustion sound and gas, air, steam flow sound). When considering the noise reduction of the boiler, the plan is established as for this comprehensive sound, since it is impossible to separate it. Boiler noise of many of the boiler is 85db (A) at the bottom, 75~80dB (A) at the top, which varies by type. Almost modern boilers have been considerably reducing noise by storing in the boiler building, soundproof walls and soundproof lagging. Fig-39 shows the example of measures for turbine building.

2.3.2 Turbine building

Noise from the turbine building is a large number of sound transmissions of sound equipment that is installed inside such as the turbine, generator, and feed-water pump. Noise level of the turbine building surface is between 65~70dB (A), since it does not change significantly by the output of a turbine generator and each plant has almost identical building wall structure. Fig-39 shows the example of measures for turbine building.

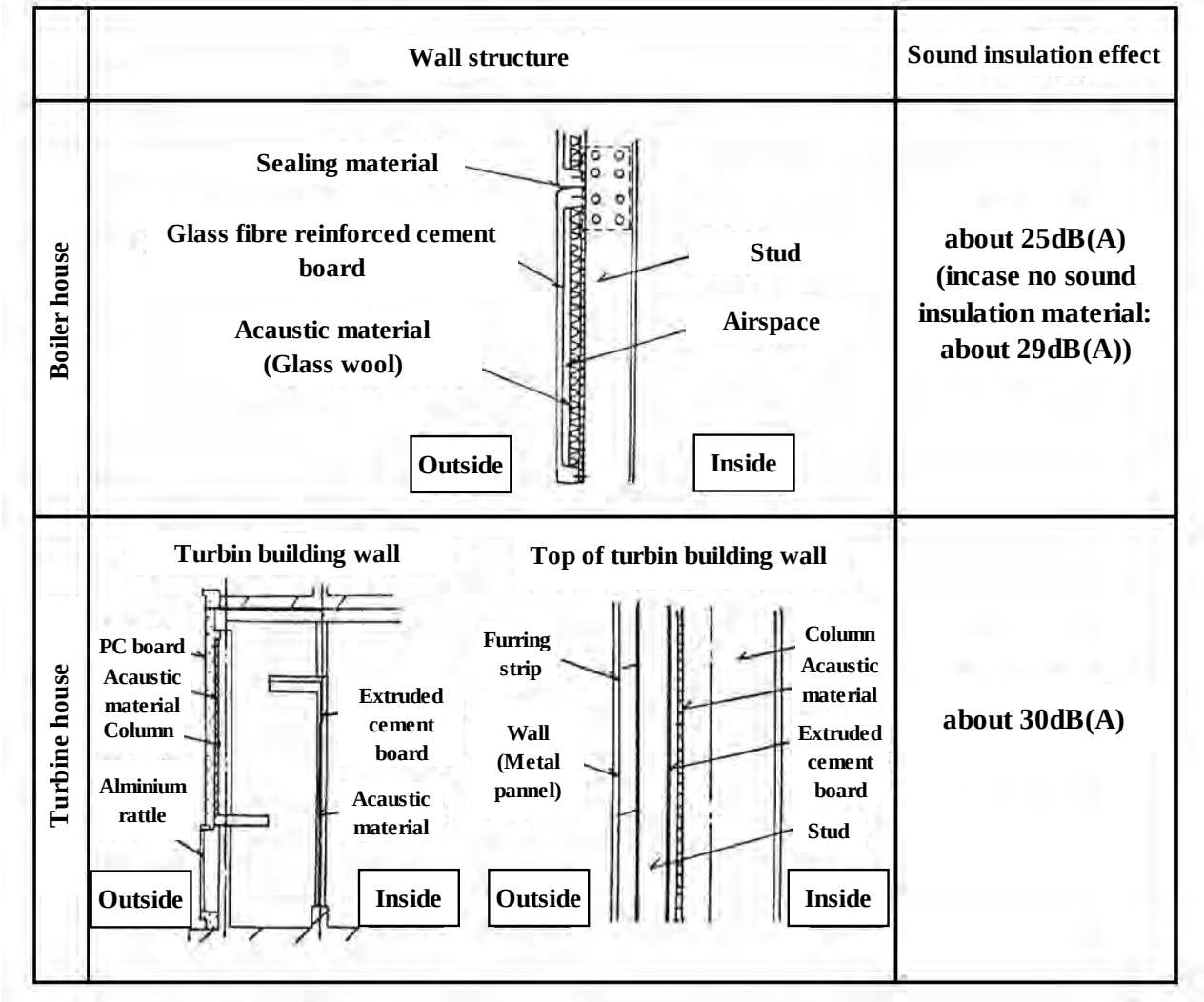


Fig- 39: Measures for noise prevention of boiler and turbine building

Reference: P-64 of Journal (No.557: Feb. /2003): TENPES

2.3.3 Transformer

Noise of transformer is due to magnetostriction and cooling fan, noise from the former appear generally higher and its frequency of the main component is the harmonics of 50 and 60Hz. Noise level is 80~85Hz at unit side. The method shown in Fig-40 is selected as measures to reduce noise of transformer itself depending on the reduction level. In addition, noise reduction of cooling fan is measured by 1) lowering the fan speeds, 2) installing the duct silencer.

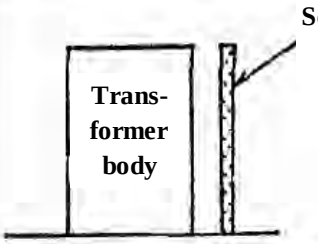
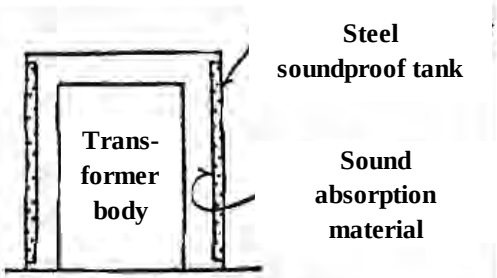
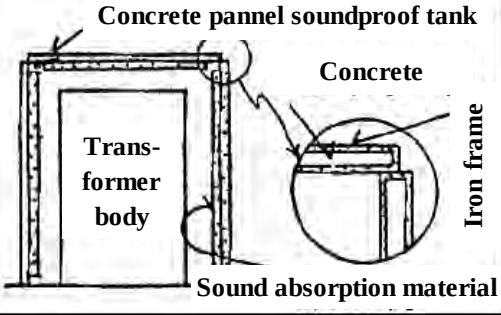
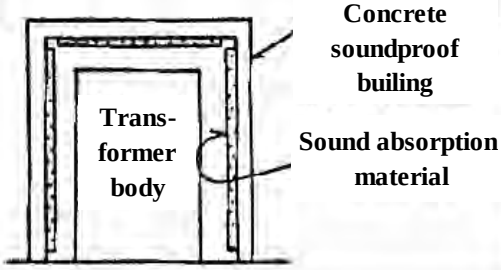
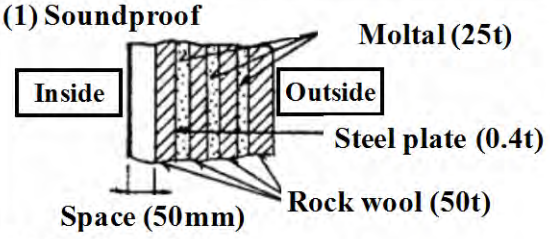
Noise reduction method	Noise reduction (dB(A))	Structure
Soundproof wall system	5～10	
Steel plate soundproof tank system	10～20	
Concrete pannel soundproof tank system	20～30	
Concrete soundproof building system	30～40	

Fig- 40: Measures for noise prevention of transformer

Reference: P-64 of Journal (No.557: Feb. /2003): TENPES

2.3.4 Fan

Noise of fan can be classified into two, which comes from the drive system for rotating blades and hydrodynamically and occurs by rotating blades hydrodynamically. Usually, the latter is a major source. Noise generation has been bigger due to the increase of flow volume and pressure of fan in the power plant. Therefore, measures as shown in Fig-41 are taken for most of large fan at present and the noise level has been around 80~85dB (A) at unit side. Generally, the occurrence of the fan noise level that is not taken any action is given by the equation (2).

<table>
<tr><th rowspan="2">Target</th><th colspan="2">Content of noise measures</th></tr>
<tr><th>Fan</th><th>Motor</th></tr>
<tr><td>FDF</td><td>(1) Soundproof
 

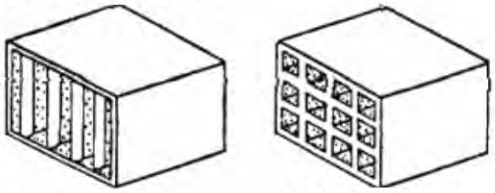
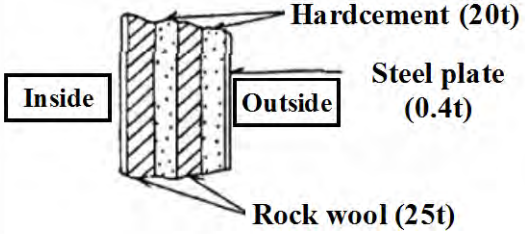
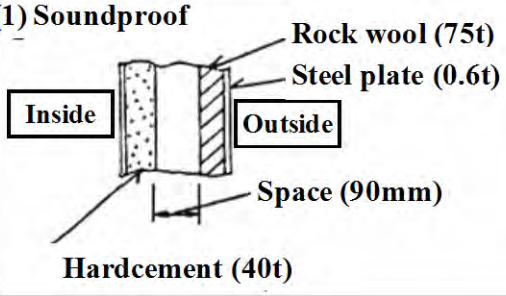
(2) Suction silencer
 
</td><td>All closed outside draft type (enhenced silencer is required)</td></tr>
<tr><td>IDF</td><td>(1) Soundproof
 
</td><td>All closed inside cooling type</td></tr>
<tr><td>De-SOx Blower</td><td>(1) Soundproof
 
</td><td>All closed inside cooling type</td></tr>
</table>

Fig- 41: Measures for noise prevention of main fans

Reference: P-65 of Journal (No.557: Feb. /2003): TENPES

Table- 24: Specific sound level

Type	Specific sound level			
	LSAdB(A)		LScdB(A)	
	upper~lower	range	upper~lower	range
Turbo fan	14~26	12	15~27	12
Airfoil blower	4~19	15	12~27	15
Radial blower	10~24	14	16~28	12
Multi-blade fan	13~23	10	23~31	8
Axial blower	21~38	17	26~42	16

Reference: P-65 of Journal (No.557: Feb. /2003): TENPES

$$L_{PA} = L_{SA} + 10\log Q \cdot P_T \cdots\cdots (2)$$

Here, L_{SA} is specific sound level dB (A) (shown in Table-24), "Q" is flow rate (m_3/min) and "P_T" is total pressure (mmAq). As can be seen from the equation (2), it is difficult to lower the generated sound, since the outline of noise level is determines if the fan specifications (Q, PT) are determined. However, it is possible to reduce L_{SA} (noise reduction) by including the follows;

1) To change shape of blades, the exit angle and numbers
2) To increase the clearance of tongue
3) To incline the tongue into skew shape
4) To change shape of casing

A variety of research and development have been performed in each manufacturer.

2.3.5 Pump

A wide variety of pumps are used in the power plant and those which affects impact to outside are the circulation pump when installing near the boundary. Those of 60~70dB (A) has been a lot due to the application of low noise motor and installation of the enclosure, though noise of the circulation pump which does not take any action is around 90~95dB (A) at the unit side. Noise level of pump is given by the equation (3).

$$L_{PA} = L_{SA} + 10\log Q \cdot H \cdots\cdots (3)$$

Here, "Q" is flow rate (m^3/min); "H" is total head (m). Measure as for the pollution source is same as fans.

2.3.6 Coal handling facility

In coal-fired thermal power plant, mechanical noise such as coal unloader, stacker, reclaimer and conveyor which is installed outdoor has a relatively large extent 75~85dB (A). Measures such as installation of enclosure at noise generation part, application of low noise rollers, and application of damping steel sheet have been taken.

3. Low-frequency noise measure

3.1 Low-frequency noise and its effects

Generally, it is said that the ultrasonic frequency sound audible to human ears is approximately 20Hz~20,000Hz. On the other hand, sound waves below 20Hz are called ultra-low-frequency sound. The low-frequency sound which is added the sound of the area that is not perceived as very low sound with ultra-low-frequency sound, the sound with frequency approximately 1Hz~100Hz is called the low-frequency sound. There are effects of low-frequency sound such as “physical impact” which rattletraping of joinery, “sleep impact” which interfereing sleep, “psychological and physiological impact “which sensing of tightness, vibration, headaches, nausea due to the perception of low-frequency sound.

3.2 Low-frequency noise prevention plan

3.2.1 Development of low-frequency noise prevention plan

Study and planning of prevention measure is advanced in the same manner as in Fig-43. It is necessary to perform the sufficient prediction beforehand, to consider the removal of the causes and to consider of acoustic ways such as installation of silencers if this is difficult. Especially a study of the economic measures will be a point of sound source, since wavelength of low-frequency sound is too long to avoid large prevention device in the acoustically reduction,

3.2.2 Prospect of low-frequency noise

It is similar as noise except the excess attenuation (attenuation due to air absorption or ground surface absorption) and the directional attenuation, though the prediction is made using a computer in the calculation as part of preventive measures.

3.2.3 Target value of measure

The goal of prevention measure is to be reduced rattletraping of the windows and doors. However, it is set by reference to such measures and past examples in Fig-42 and 43 in general, since the legal regulation of noise so as not established at present.

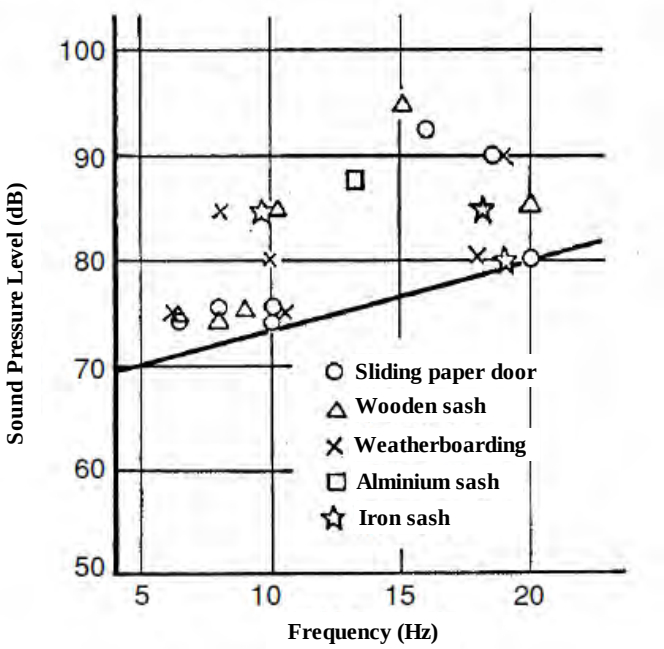


Fig- 42: Value that window and door begin to rattletrap

Reference: P-66 of Journal (No.557: Feb. /2003): TENPES

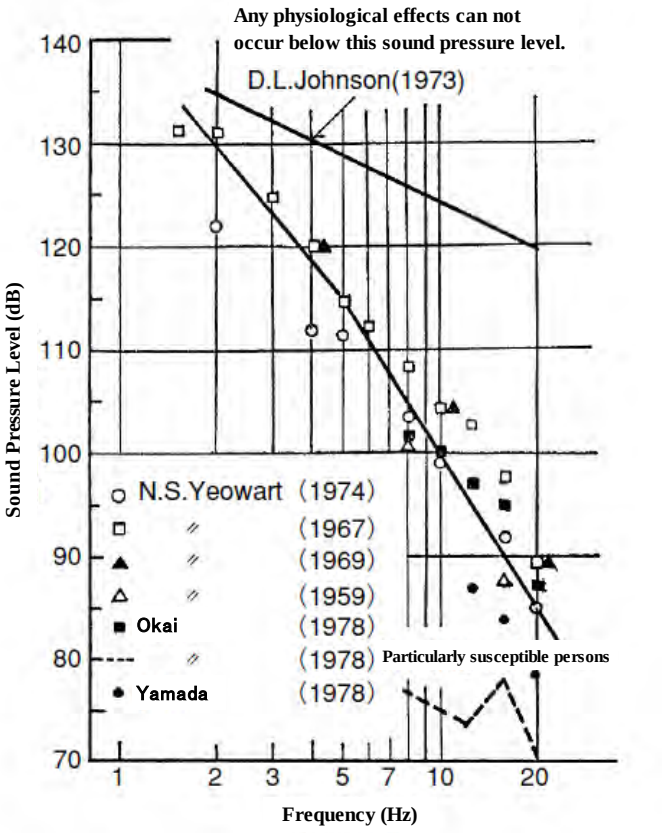


Fig- 43: Sensitivity threshold of extremely low-frequency silence

Reference: P-66 of Journal (No.557: Feb. /2003): TENPES

3.3 Cause and prevention of low-frequency sound

3.3.1 Cause of generation

Generally, low frequency sound is often emitted by the mechanism as shown in Fig-44. One is the case that sound is emitted by the vibration of objects or flow. The other one is the case that sound waves are propagated in the air or through the structure body, it resonates with air column or structure and amplified sound is emitted.

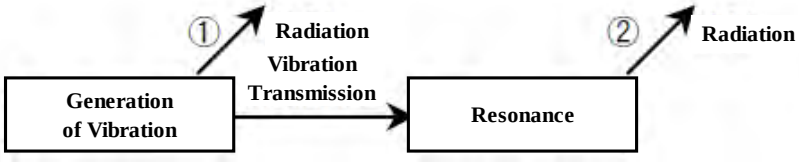


Fig- 44: Radiation mechanism of low-frequency air vibration

Reference: P-66 of Journal (No.557: Feb. /2003): TENPES

Generally, sound arising from such machine often belongs to the former and those arising from the structure often belong to the latter.

3.3.2 Prevention

Sources of ultra-low frequency sound have become apparent that a particular machine or structure. Ultra-low frequency sound is caused by malfunction such as resonance mostly, though sound occurs mechanically as a compressors and diesel engines. Therefore, the prevention measures to remove the cause may be main measure, which is differs from the sound source abatement technology. Generally, the following methods are adopted;

1) Removal and improvement of defects
2) Removal of cause of generation
3) Change and improvement of operating conditions

If ultra-low frequency sound is generated mechanically, the muffler is installed. Fig-45 shows an example of a silencer which is used for anti-resonant low-frequency sound. It must be noted that audible effects by the measure on the propagation path such as providing fence or enclosing in the building is not expected, since the wavelength of low-frequency sound is long unlike the noise. Table-25 shows the main causes and technology to prevent of low-frequency sound.

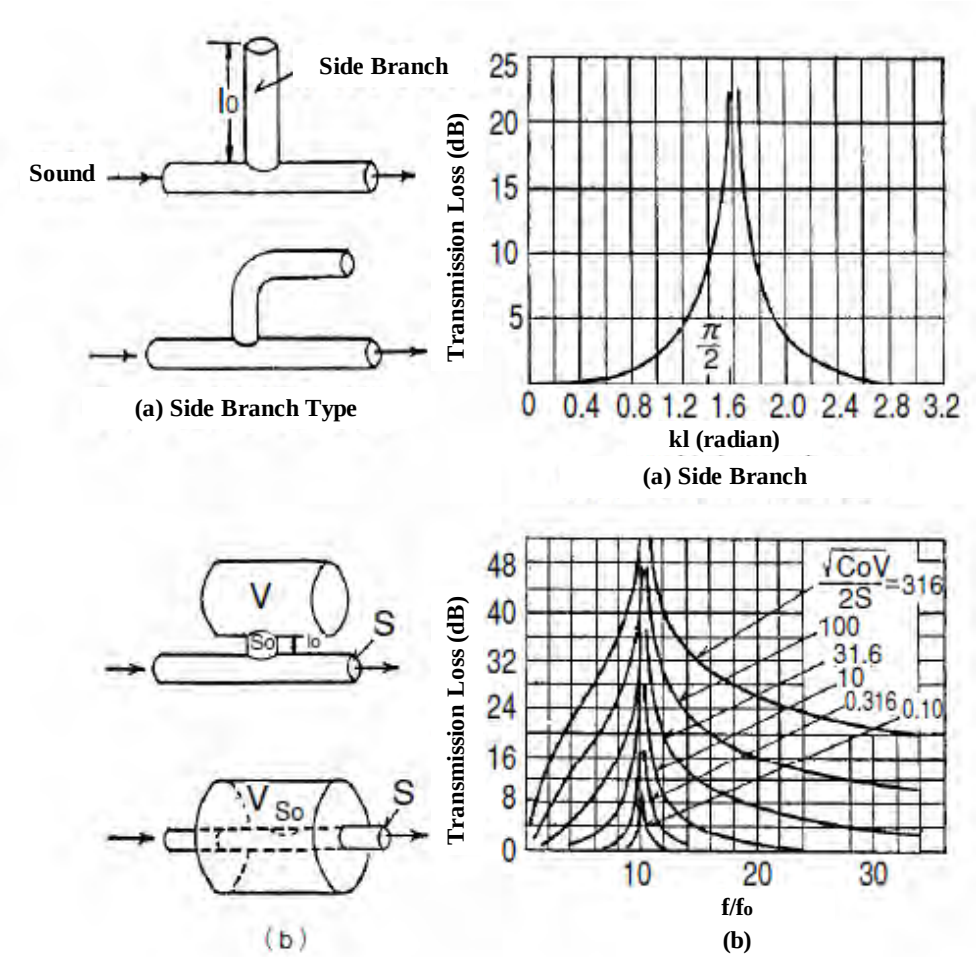


Fig- 45: Example of a resonance type silencer

Reference: P-67 of Journal (No.557: Feb. /2003): TENPES

Table- 25: Protection technology for low-frequency air vibration

Type	Cause of generation	Soundproof technology
Fan	Vibration of duct wall ,etc, by surging, rotating stall and fluctuating flow	Silencers, bypass pipes, stall prevention, reinforced ducts, rectifier plates
Compressor	Compression and expansion of airing the cylinder due to the rotation	Side branch type, expansion type silencer
Vacuum pump	Air vibration caused by rotation	Side branch type, expansion type silencer
Diesel engine	Compression and expansion due to the rotation of combustion gas	Expansion type silencer, modification of pipe
Vibrating screen	Structural vibration due to rotation	Reduction of vibration area, air balance, reinforcement
Various furnaces	Air vibration due to combustion or resonance,	Anti-resonance baffle, change of combustion state, muffler

Type	Cause of generation	Soundproof technology
Boiler	Karman vortex resonance	Modification after removal of cause, anti-resonance baffle
Dum	Vibration of water, cavity resonance	Prevention of water vibration, prevention of resonance
Bridge	Vibration resonance	Changing the mode of vibration, removal of excitation force
Tunnel	Pressure change of air	Absorber of pressure change, reduction of power speed of train
Large structures (Soundproof fence e.g.,)	Resonance of structures	Excitation force

Reference: P-67 of Journal (No.557: Feb. /2003): TENPES

3.4 Low-frequency sound measures of thermal power plants

Exhaust of Compressor, fan, diesel engine, etc. and the surface vibration of large equipment and structure are considered as a source of low-frequency noise in the thermal power plant. As these measures, the installation of side branch type or expansion type silencer, reinforcement of duct and structure (increasing stiffness) and the like. Since the silencer can be obtained reduction of noise 10~40dB, problems are solved approximately. If the cause of noise is rotating stall and surging, the installation of the bypass tube or rectifier plate, changing the method of operation (speed control) is taken.

3.5 Noise originates from workplace sites with high-powered equipment such as the steam turbine, generator, and high-pressure steam. The noise from these sources is continuous and averages about 90~105 decibel acoustic dB (A) in the production area. The noise is reduced by a thick cover of insulating material and dispersed by soft insulating material. The impact of noise is negligible beyond 500 m from the generation site. The noise from high-pressure valves is intermittent and intentionally designed to attract the attention of the operators. The noise generated can be as high as 110~120 dB (A) and last for 5~10 minutes. A computer simulation model was used to capture the noise dispersion. The radius of the area with noise levels of 60 dB (A) or higher is less than 250 m from the center of the Project. However, the Project will be equipped with noise reduction equipment for steam exhaust valves. With this equipment, the noise level within 50 m of the generation site is 45~60 dB (A). Viet Nam's noise standard (TCVN 5949–1995) allows the maximum noise level in public and residential areas at60 dB (A) from 6 a.m. to 18 p.m., 55 dB (A) from 18 p.m. to 22 p.m., and 45 dB (A) from 22 p.m. to 6 a.m. The World Bank standard allows 70 dB (A) for industrial zones at all times (as shown in Table 25 and 26).

Table- 26: World Bank Standard for Noise

Receptor	Maximum allowable log equivalent (hourly measurement in db(A))	
	Day (07:00~22:00)	Night (22:00~07:00)
Residential, industrial, educational	55	45
Industrial, commercial	70	70

Note-1: dB (A) =decibel acoustic

Source: World Bank Handbook for Pollution Prevention and Control

Table- 27: Permissible Noise Level (db (B)) (TCVN 5949-1998)

Area	Time of Day		
	06:00~1800	18:0022:00	22:00~06:00
Quiet Areas (hospitals, libraries, senatorial, school, etc.)	50	45	40
Residential Areas (houses, administrative offices, hotels, apartments, etc.)	60	55	45
Commercial and Service Areas	70	70	50
Small Industrial Factories Intermingled with Residential Areas	75	70	50

Note-1: dB (A) =decibel acoustic

Source: World Bank Handbook for Pollution Prevention and Control

Article 224. Facility to prevent vibration

1. Target equipment

   Sources of vibration from the facility installed in the power plant may be as follows;

   1) Compressor
   2) Mill and crasher
   3) Screen and classifier
   4) Emergency diesel generator

2. Anti-vibration

   The measures are taken to cut off the source of vibration in order to prevent the resonance due to transmitting vibration to the foundation and building. Therefore, the measures are taken to absorb vibration from equipments by means of isolating equipments with foundation by spring type or air absorber type isolator as shown in Photo-2, 3, 4, 5, 6, 7 and Fig-46 and 47.

Photo- 2: Isolated base for compressor

http://www.boushin.co.jp/products/01_sangyo.html

Photo- 3: Isolated base for compressor

http://www.boushin.co.jp/products/01_sangyo.html

Photo- 4: Anti-vibration spring mounts

http://www.engrreview.com/Editorial_pages/2011/01_january_11/products_07.html

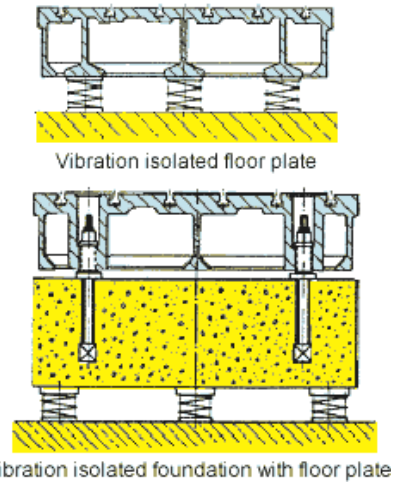


Fig- 46: Vibration isolator

http://www.itbona.com/itbona/stolle/vibrationisolation.htm

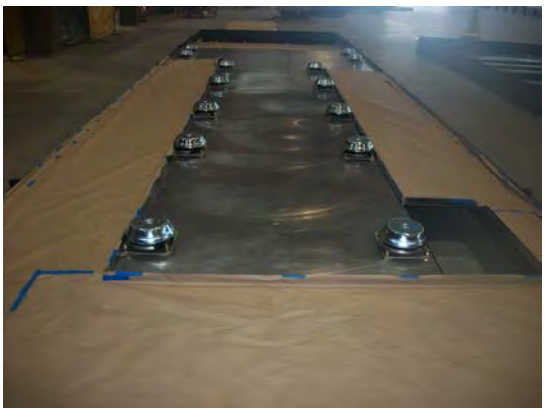


Photo- 5: Vibration isolator for gen. set

http://vibrationisolators.blogspot.com/2011/03/vibration-isolators-for-genset-in.html

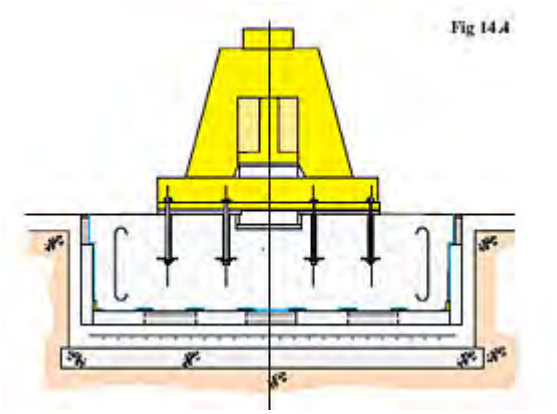


Fig- 47: Vibration isolator for gen. set

http://www.farrat.com/products/alternative_arrangements.html

Photo- 6: Coal mill spring mount

http://www.gerb.co.jp/index.php?id=575&no_cache=1&tx_photogals_elementid=1575&tx_photogals_image=4&MP=503-507

Photo- 7: Coal screen base

http://vibratingscreen.en.china.cn/selling-leads/detail,1109573717,WZSM-Pulverized-Coal-Screen.html

3. National Technical Regulation on Vibration: QCVN 27/2010/BTNMT

The environmental regulation for vibration of construction work level is shown as below. Sources of vibration and shock must not exceed the prescribed value in the Table-28.

Table- 28: Maximum allowable value of vibration acceleration level for construction work

No.	Zones	Applying time in a day	Allowable vibration acceleration (dB)
1	Special zones	06:00 ~ 18:00	75
		18:00 ~ 06:00	Base level
2	Normal zones	06:00 ~ 21:00	75
		21:00 ~ 06:00	Base level

Moreover, sources of vibration and shock of production and service activities must not exceed the prescribed value in the Tabl-29.

Table- 29: Maximum allowable value of vibration acceleration for production and service activities

No.	Zones	Applying time in a day and allowable vibration acceleration (dB)	
		06:00 ~ 21:00	21:00 ~ 06:00
1	Special zones	60	55
2	Normal zones	70	60

The vibration acceleration of the provisions in Table-28 and 29 must be vibration levels measured at the stable state, mean value of the maximum value measured at periodical or intermittent shaking,

mean value of the figures measured 10 times every 5 seconds when shaking happened rather than a stably or equivalent (L10). In addition, the definition of a special zone, a normal zone and basic level are as follows;

Special zones	: Medical facilities, libraries, nurseries, schools, churches, meeting place, the inner area of the temple surrounded by a fence and the defined in a separately and specially.
Normal zones	: Multifamily housing or adjacent house, hotels, rest houses, including an area of government agencies.
Basic level (background level)	: Vibration acceleration level that has measured during no activities such as production, commerce, service and construction in areas subject to evaluation.

Article 225. Measures for effluent

Article 225-1.Dust prevention in coal yard

1. Measures to prevent coal dust scattering

1.1 Environmental impact of coal dust

The construction of coal-fired thermal power plant has been promoting in the recent construction of thermal power plants in terms of diversification. Therefore, it is necessary prediction and prevention measures of coal dust scattering in the process of dealing coal. Environmental impact of coal dust is given to environment such as air, soil and water, its main problem is to give human physiological changes in air quality. The coal dust changes to dust and alters air quality, affecting the respiratory tract of the human body through air. The smaller the particle size of dust, an influence is large. Dust with particle size 10μ or less is defined as suspended particulate matter, which is set environmental regulation.

1.2 Occurrence of coal dust

The coal handling and occurrence of coal dust in the coal-fired thermal power plant is shown in Fig-48.

1) Unloading by unloader
2) Transportation by conveyor
3) Stacking by stacker
4) Coal storage
5) Discharging by reclaimer
6) Others (replacement or compression by bulldozer, etc.)

The coal handling is consisted by above works. (It is called “unloading, storing and transportation of coal “summarized these. Other than a closed system of these to the atmosphere (for example, such as those of the continuous unloader, tube type conveyor and conveyor enclosed by gallery) is candidate when predicting atmospheric dispersion.

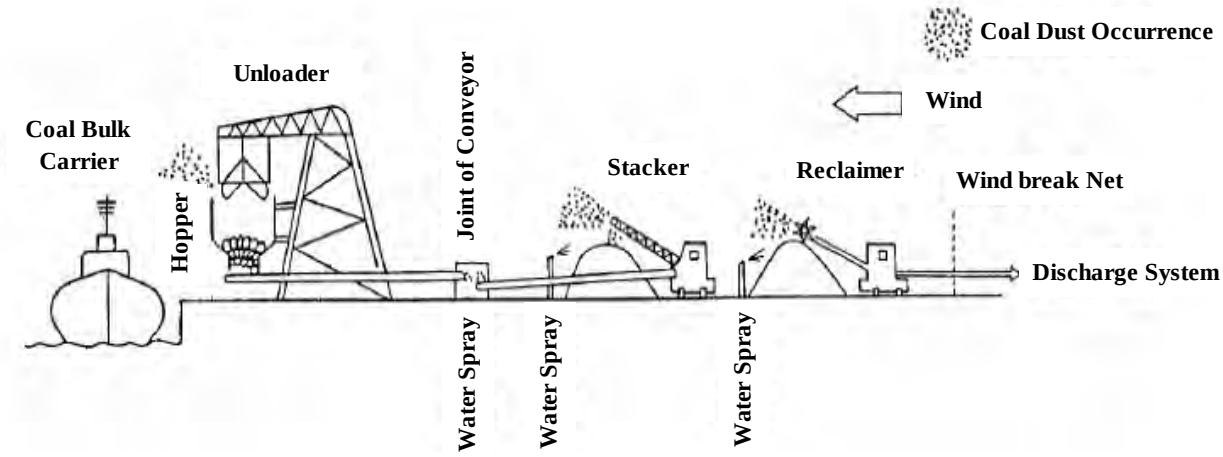


Fig- 48: Overview of coal handling and coal dust occurrence

Reference: P-68 of Journal (No.557: Feb. /2003): TENPES

1.3 Prevention of coal dust scattering

The primary cause and process of coal scattering is shown in Fig-49. The point of measures to prevent coal dust scattering is the measures for pollution source in same manner as other environmental measures. Measure to prevent coal dust generation such as removal or reduction of dust generation factors is important, since it is almost impossible to prevent the spread and to collect if they have once occurred.

1) To reduce the wind speed
2) To sprinkle
3) To enclose

Basically, measures as described above are taken. The typical prevention measure for coal dust scattering in the coal-fired thermal power plant are described and shown in Table-30.

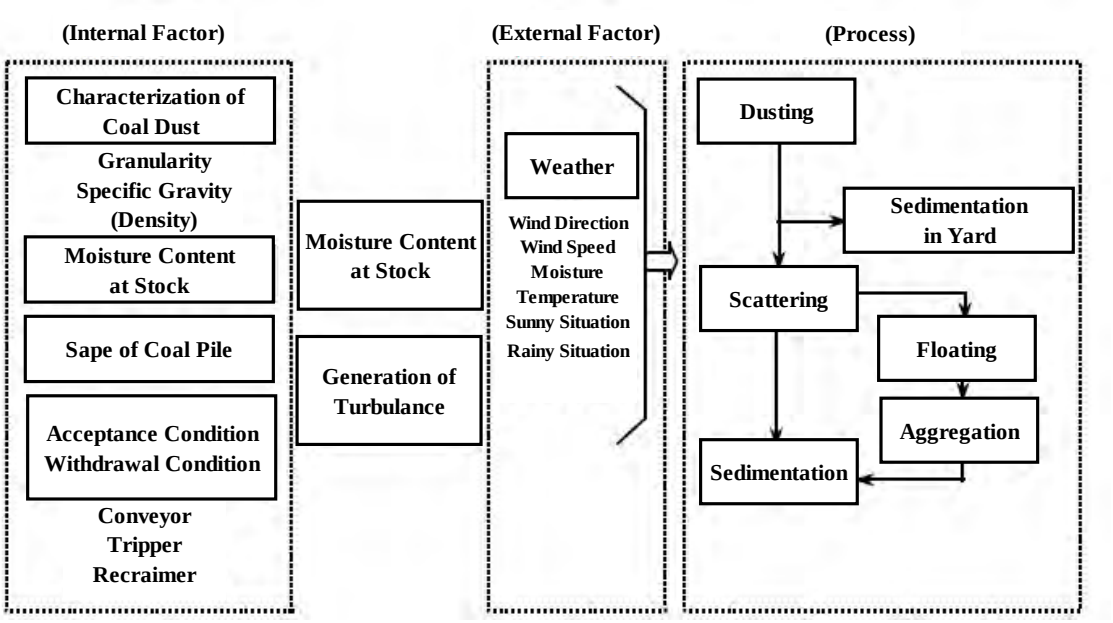
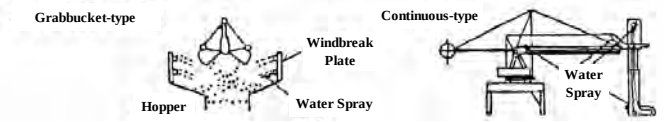
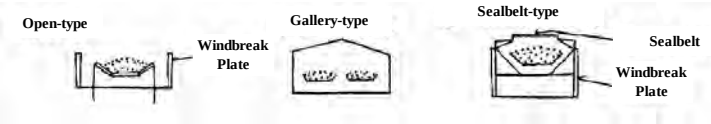
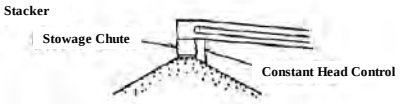
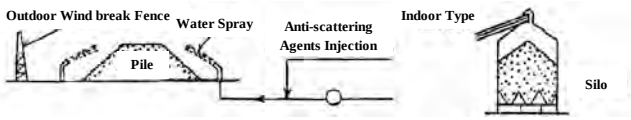
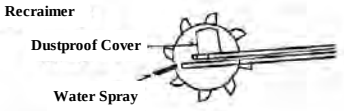


Fig- 49: Factors and processes of coal dust scattering

Reference: P-68 of Journal (No.557: Feb. /2003): TENPES

Table- 30: Examples of measures to prevent coal dust scattering

Facility	Main Measure to Prevent Coal Dust	Concept
Un-loader	-Wind break fence -Water spray equipment	
Conveyor	-Wind break fence -Gallery-type, Tube-type -Seal-belt-type	
Stacker	-Stowage chute -Water spray equipment -Constant head control	
Coal storage	-Wind break fence -Water spray equipment -Indoor Coal Storage	
Reclaimer	-Wind break cover -Water spray equipment	

Reference: P-69 of Journal (No.557: Feb. /2003): TENPES

1.3.1 Measure for coal unloading facility

In case of the club bucket type unloader which is often used conventionally for unloading coal from carrier, coal dust scattering occurs due to taking up in the wind while coal was dropped, since coal is grasped in the hold and is brought up to a hopper about 20m in height. Therefore, the sprinkler system and wind breaking plate has been installed in the hopper. The continuous unloader has recently come to be adopted, since it is possible to enclose except for the excavation part in the hold. The sprinkle equipment has been provided for the excavation part and transit part of conveyor in the machine.

1.3.2 Measure for conveyor line

Gallery type which enclose whole conveyor, tube type and seal belt type if it is not applied these are adopted for a conveyor line. The sprinkler system or bag filter dust collector is installed for transit portion of the conveyor.

1.3.3 Measure for stacker

The stacking chute, sprinkler, constant control is adopted for the measures, since the part of coal falling is exposed to wind on the stacking stacker and coal dust scattering occurs.

1.3.4 Measure for coal stock yard

The coal dust scattering causes from stored coal surface by wind in the outdoor type coal stock yard. Measures such as installation of the wind break fence and establishment of the tree belt are taken in order to weaken wind in the coal stock yard. Also, the tree belt has the supplement effect to catch coal dust. In addition to the sprinkle facility, the spraying equipment for coating a surface of stored coal by anti-flying agent (surfactant) may be provided as a measure against strong winds. Not only from the standpoint of preventing coal dust scattering, the indoor type coal storage yard (dome, silo, etc.) has been adopted, even if not enough coal storage area.

1.3.5 Measure for reclaimer, etc.

A new coal surface which is easy to scatter appears when discharge coal by reclaimer or bulldozer by cutting out the coal pile. Measures installing windproof cover, sprinkler systems and other are taken, since there is leakage from reclaimer bucket, scattering due to movement and rising and lowering of the blade portion of the bulldozers, other than scattering from here.

1.3.6 About anti-scattering agent (surface activate agent)

When dealing with the foreign coal, some coal rejects water due to high water-repellent. If adding surfactant in the spray water, wetting to the surface of coal particle is accelerated to promote by the reduction effect of surface tension and penetration, as the result it triggered further fine coal aggregation and scattering effect is exerted. There are two types of surfactant, the permeability type which is used when handling coal and coating type which is used during storing coal.

1.4 Forecasting of coal dust scattering

It is necessary to select effective arrangement of coal storage yard and measures to prevent coal dust scattering for much less environmental impact on lowering the amount of coal dust to the

surrounding area by means of forecasting of coal dust made airborne when constructing coal-fired thermal power plant. It is necessary to forecast the scattering phenomenon (coal dust scattering from unloading, storing and transportation facility), diffusion, sedimentation and deposition phenomena (advection and descent to the ground to the surrounding areas of airborne coal dust) and wind forecasting approach to affect these phenomena is required. The prediction of wind is difficult to generalize, since it varies greatly depending on the terrain, building and arrangement of coal yard. It is required to predict by wind tunnel experiments, etc. depending on the individual subjects. It is possible to predict with a general purpose numerical analysis of diffusion, sedimentation, deposition phenomenon. The outline for forecasting method of coal dust scattering is shown in Fig-50.

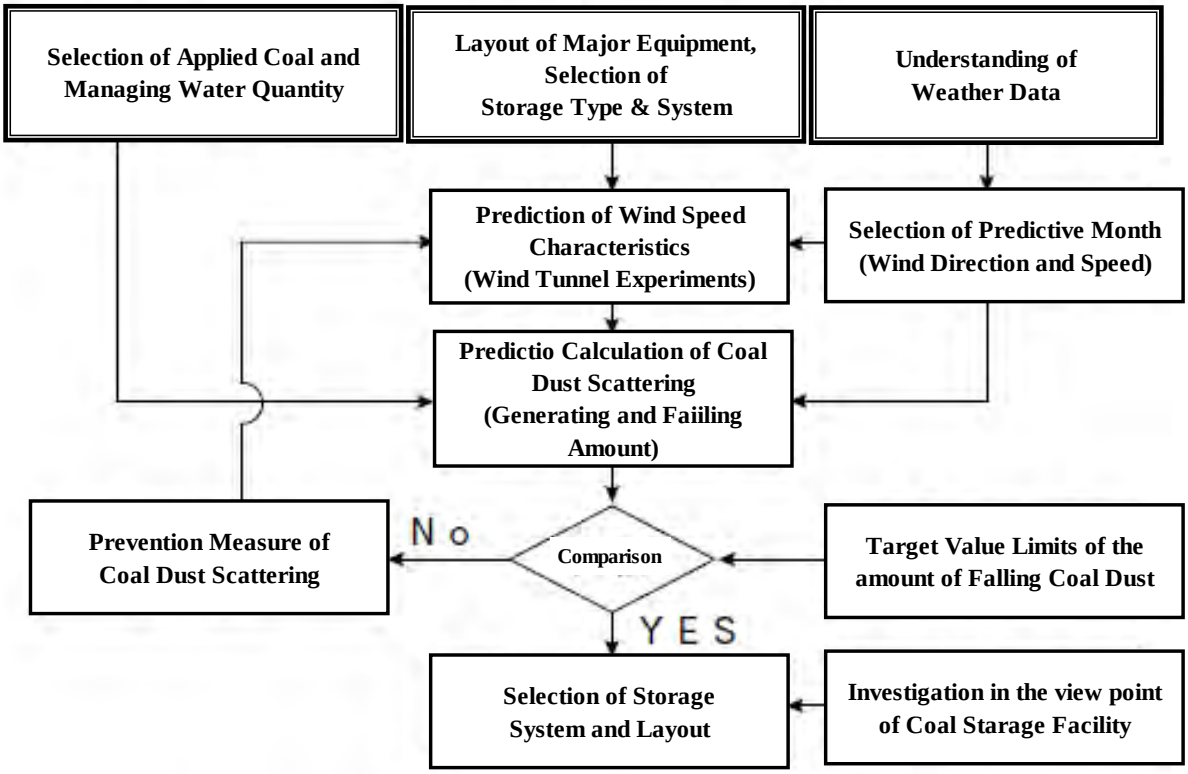


Fig- 50: Summery of coal dust scattering prediction method

Reference: P-70 of Journal (No.557: Feb. /2003): TENPES

Article 225-2. Dust prevention of ash treatment facility

1. It is necessary to recycle as valuable resources as stated in the Guideline for coal ash handling equipment, which the coal ash is available for cement raw materials and gypsum is for plaster board. Improvement of the degree of reuse can be reduced unnecessary scattering of ash at the power plant.
2. It is necessary to transport ash by closed pressure transportation equipment or vacuum transportation equipment, gypsum by covered conveyor, storage must be done in silo in order to prevent scattering of ash and gypsum.
3. It is necessary to prevent the scattering of clinker ash into the environment by transport after humidification or by water flow.

4. It is necessary to transport ash by the dedicated vessel, wagon, vehicle and pipe conveyor, and it is necessary to prevent the scattering of ash even when loading by using special dust-proof equipment.

Article 225-3. Effluent from seawater De-SOx

1. Summary

Seawater is used as a solvent to remove SO_2 in the flue gas and then absorbed SO_2 is returned to the soluble sulfate by aeration, which is discharged into the sea as shown in Fig-51.

2. Feature

1) The absorbent is only seawater and no need chemicals
2) The process is simple and easy operation and maintenance
3) No by-products after absorption
4) Absorbent can be discharge into the sea after aeration

3. Reaction formula

$$SO_2+H_2O \rightarrow HSO_3^- + H^+$$

$$HSO_3^- +1/2O_2 \rightarrow SO_4^{2-} + H^+$$

$$CO_2+H_2O \rightarrow HCO_3^- + H^+$$

$$HCO_3^- + H^+ \rightarrow CO_2 +H_2O$$

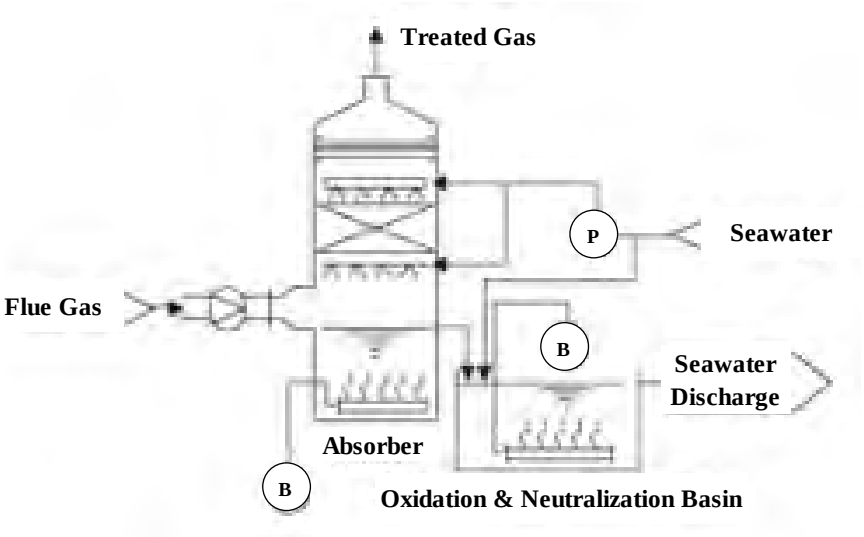
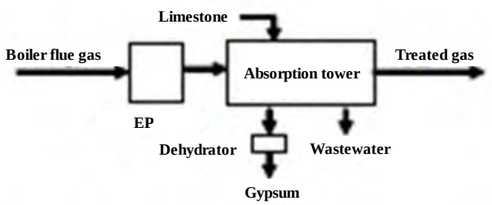
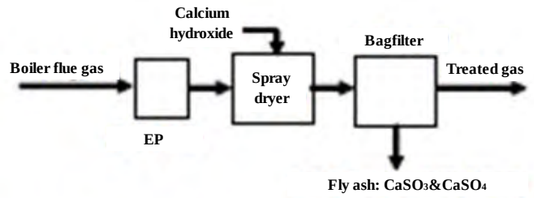
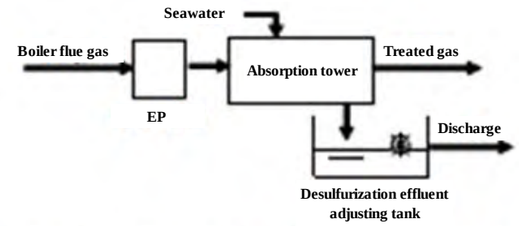


Fig- 51: System flow of seawater desulfurization method

http://www.fkk.co.jp/?p=1109

The nature of seawater desulfurization method compared with a typical wet and dry method is organized in Table-31.

Table- 31: Comparison of different methods of flue gas desulfurization for coal-fired boiler

Process		Limestone-gypsum method	Spray dry method	Seawater method
Summery		 **SO2 including in the boiler flue gas is contacted with the wet absorbent that includes limestone in the absorption tower and removed. Gypsum is recovered as the byproduct of desurfurization reaction.** **[Reaction formula]** $SO_2+2H_2O+CaCO_3+1/2O_2 \rightarrow CaSO_4 \times 2H_2O+CO_2$	 **SO_2 including in the boiler flue gas is contacted with the wet absorbent that includes calcium hydroxide in the spray dryer and removed. Calcium sulfite ($CaSO_3$) and calcium sulfate ($CaSO_4$) including fly-ash as the byproduct of desulfurization reaction is removed in the doenstream bagfilter .** **[Reaction formula]** $SO_2+Ca(OH)_2 \rightarrow CaSO_3+H_2O$ $CaSO_3+1/2O_2 \rightarrow CaSO_4$	 **SO_2 including in the boiler flue gas is contacted with seawater. Seawater effluent after desulfurization is reduced COD by dilution or aeration and discharged to ocean .** **[Reaction formula]** $SO_2+H_2O \rightarrow SO_2^{2-}+2H^+$ $SO_2^{2-}+2H^+ 1/2O_2 \rightarrow SO_4^{2-}+2H^+$
Desulfurization coefficient		90~99%	60~80%	90~98%
absorbent		Limestone (Cheap and easy to purchase)	Hydrate lime (higher price than limestone)	Seawater
Byproduct		Plaster (use for cement additives, gypsum board, raw materials for soil improvement or disposal)	Ash, $CaCO_3$ and $CaSO_4$ (usually, disposal, examples of its use to the construction or road material).	Low pH wastewater (seawater after desulfurization, ocean discharge by usual diluted seawater)
Installation area		Base	Small	Large
Delivery experience		Many (mainstream of desulfurization in the world)	Few (application examples in the USA and North America)	Few (recently, proven cases in Southeast Asia)
Features	Advantage	・Absorbent is cheap. ・There is market for byproduct.	・Typically, GGH is omitted. ・It can be no drainage.	・Essentially, seawater as absorbent is free. ・System is simple.
	Disadvantage	・Wastewater treatment facility is required. ・Usually, GGH is required.	・Relatively low desulfurization efficiency. ・Excess absorbent is required. (high Ca/S ratio) ・Large cost of absorbent and high operation costs.	・Usually, GGH is required. ・Large amount of wastewater. ・Large power consumption, high operation costs.
Application		High desulfurization efficiency is required and applied to relatively large capacity, since the main reason is cheap absorbent and can be purchase stably.	This is applied to the facility which is not relatively large scale, small desulfurization load and low required efficiency.	Installation is limited to coastal areas. In addition, the possibility of application will depend on the wastewater regulation to the ocean.

Article 226. Measures for dust from coal unloading pier, coal yard and ash pond

1. Environmental measures for dust from coal unloading pier and coal yard must be performed considering as follows;

(1) Guideline for coal fuel handling facility: Article 54-2-10 “environmental measures”

(2) Guideline for environmental facility: Article 225-1 “dust prevention in coal yard”

(3) Guideline for environmental facility: Article 225-2 “dust prevention of ash treatment facility”

Article 227. Measures for thermal effluent

5. Measures for thermal effluent

5.1 Discharge and dilution of thermal effluent

5.1.1 Discharge of thermal effluent

The concept of condenser cooling water system in the thermal power plant is shown in Fig-52. Large amount of cooling water taking in from the seawater intake removes heat from the steam as it passes through the condenser, water temperature rises about 7°C and is discharge from the outlet. This is the so-called thermal effluent. Amount of this thermal effluent (cooling water) may vary depending on conditions such as the scale of power plant, steam condition, water temperature; the relation defined by the equation (4) between condensate temperatures is holds. In the recent performance on a scale of 1,000,000kw thermal power plants, the amount of thermal effluent is 45m^3/s in steam turbine power plants, 30m^3/s in combined cycle power plants, 70m^3/s in nuclear power plants.

$$Q = W(i_E - i_C) \Big/ c \times (T_2 - T_1) \cdots (4)$$

Here, Q indicates the amount of cooling water (kg/h), W is the amount of turbine exhaust (kg/h), i_E is the enthalpy of the turbine exhaust (kcal/kg), i_C is the enthalpy of the condensate (kcal/kg), c is the specific feat of cooling water (kcal/kg・°C), T_1 is the inlet temperature of condenser (°C), T_2 is the outlet temperature of condenser (°C).

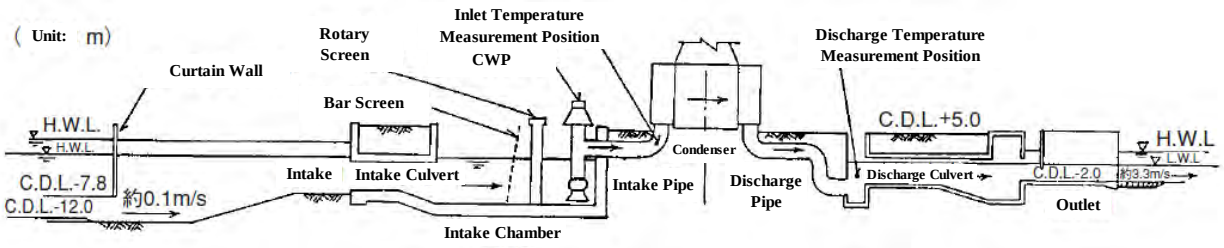


Fig- 52: Schematic drawing of Condenser Cooling Water System

Reference: P-70 of Journal (No.557: Feb. /2003): TENPES

5.1.2 Diffusion and cooling of thermal effluent

Diffusion and cooling process of water discharge from the outlet to the sea is as shown in Fig-53. The temperature of the thermal effluent which is released to the sea surface is 7°C higher than the natural condition (environmental temperature) and has spread thin due to low density. The thermal effluent spread to sea area, loses heat and finally back to the environmental temperature gradually. Its process is performed by a complicated combination of the following three symptoms.

1) Heat transfer by the flow of drainage
2) Mixing and dilution with ambient cold seawater (eddy diffusion, joint virtual water and tidal mixing)
3) Heat radiation from sea surface to air

The effect on the vertical water temperature rises is so much larger than the horizontal thermal diffusion and it spreads in a thickness of about 2~3m from the sea surface in general. Generally, most of the thermal effluent temperature rise is reduced during the thermal effluent emerge to surface, since diluted mixture with subscription the surrounding cold seawater is increased when discharging water in the sea at faster than discharging to surface. The thermal effluent spreading and rising to near sea level diffuse horizontally in a form similar as surface discharge.

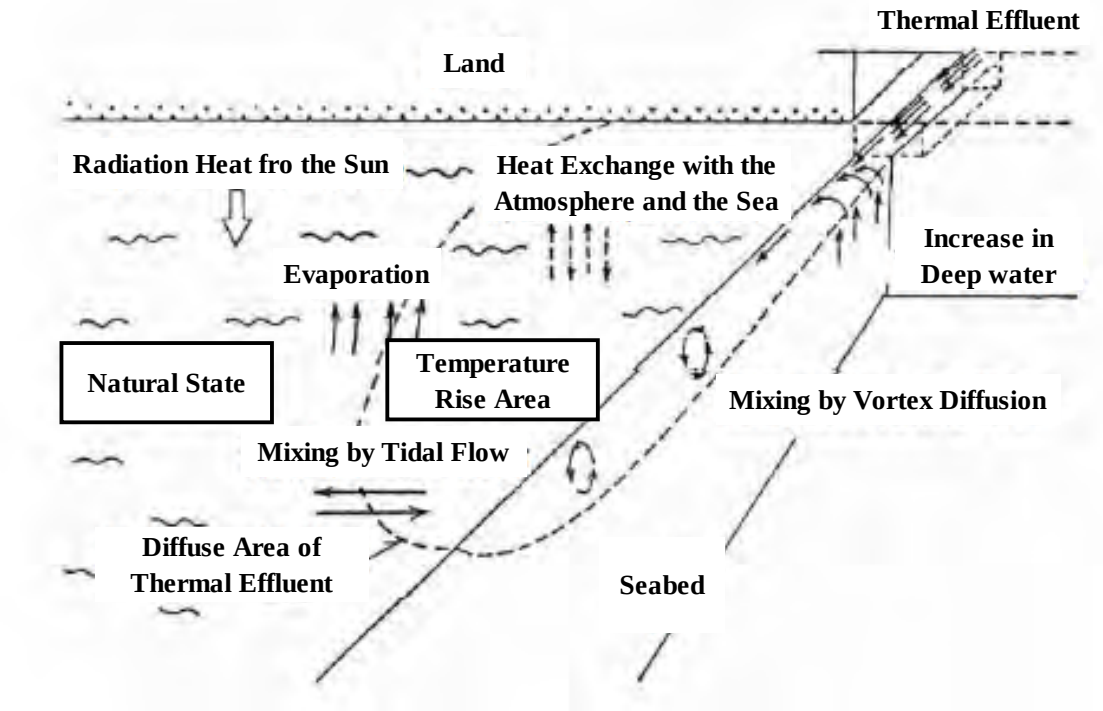


Fig- 53: Spreading and Cooling Process of Thermal Effluent

Reference: P-71 of Journal (No.557: Feb. /2003): TENPES

5.2 Effects and measures of thermal effluent

Impact on the natural environmental due to thermal effluent discharge may be considered primarily as follows;

1) Water temperature
2) Flow direction and velocity
3) Marine animal
4) Marine plants

The most appropriate measures for intake and discharge are taken to the characteristics of the location of power plant in order to reduce impacts. The following methods are applied to measures to prevent effects due to thermal effluent.

5.2.1 Deep-water intake system

Generally, the temperature stratification is formed to a depth of 3~4m below sea level in summer in Japan, surface temperature is expected to be 2~4^{o}C lower than lower layer. This system is to minimize the difference between environmental temperatures near the outlet as much as possible by means of sucking in low temperature seawater from low layer focusing on water temperature stratification. In the modern power plants this method is increasingly adopting in the viewpoint of preventing recirculation of thermal effluent into the intake. Typical shape is shown in Fig-54, 55, 56 and Photo-8.

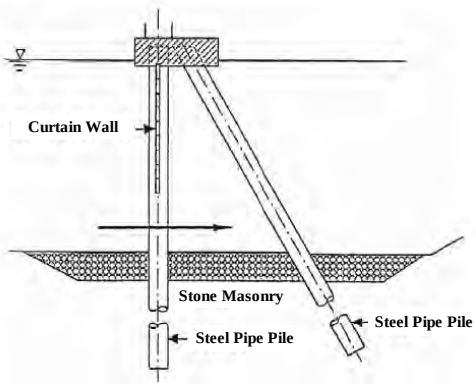


Fig- 54: Curtain wall intake facility

Reference: P-71 of Journal (No.557: Feb/2003): TENPES

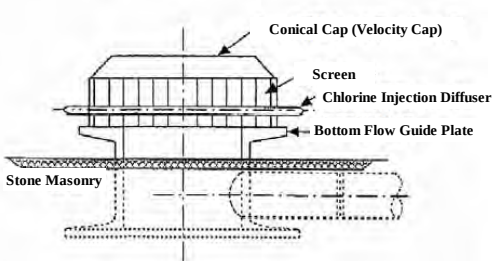


Fig- 55: Deep-water intake

Reference: P-71 of Journal (No.557: Feb/2003): TENPES

Photo- 8: Curtain wall intake facility

http://www.smcon.co.jp/works/engineer/kasen/shin-nagoya.html

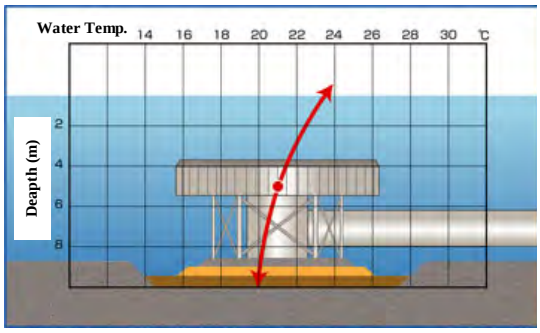


Fig- 56: Deep-water intake facility

http://www.tobata-kyoka.co.jp/060kankyo/kankyotaisaku.htm

5.2.2 Measures when discharging thermal effluent

The surface discharge system has an advantage that it can reduce impediments to the ship and low impact on benthic organisms since low discharge velocity; however, there is disadvantage that it is difficult to reduce temperature rise and diffusion. Therefore, it is promoted the mixture cooling by devising the discharge method, which the effects due to thermal effluent is performed.

(1) Porous oblique outlet dam

This is the method to minimize temperature rise by diluting and mixing forcibly with cool water at the lower part of sea in relatively deep water depth by means of providing the porous oblique outlet dam in front of discharge (provided the hole in the bottom weir) and extruding thermal effluent from the front of this weir. The typical shape of it is shown in Fig-57.

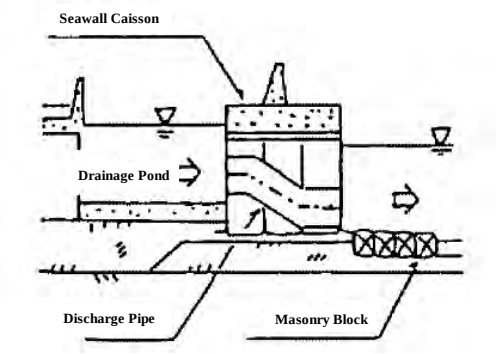


Fig- 57: Typical construction of porous oblique outlet dam

Reference: P-72 of Journal (No.557: Feb/2003): TENPES

(2) Discharge in water (deep discharge)

If the depth is deeper near the outlet or discharge of water, the thermal effluent is released directly into deeper part or led to more than 10m water depth and discharge water jet from the nozzle of tube-shaped porous branch provided at the tip. The temperature is reduced sufficiently by means of jet diffusion and gravity mixture during flowing up to surface in order to obtain dilution effect. This method is selected the proper use depending on the circumstances of seabed or sea area condition with a porous oblique outlet dam. The typical shape is shown in Fig-58 and 59. Sufficient care must be taken to prevent scouring of the seabed due to fast flow rate of discharge, though it is possible to reduce the impact on shallow marine wildlife in case of these methods. In addition to the above, there is a cooling tower system to discharge waste heat directly into the atmosphere via cooling tower.

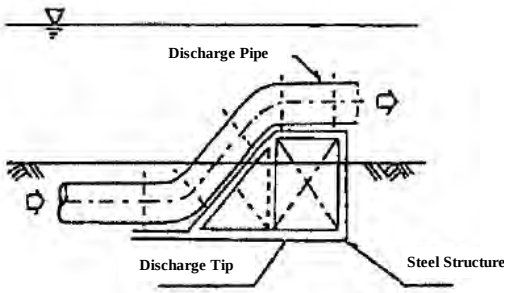


Fig- 58: Multi PipeType (Parallel Discharge)

Reference: P-72 of Journal (No.557: Feb/2003): TENPES

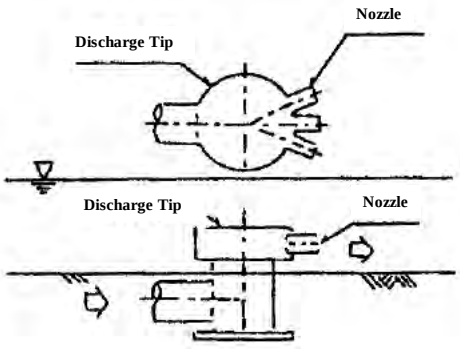


Fig- 59: Multi PipeType (Radiation Discharge)

Reference: P-72 of Journal (No.557: Feb/2003): TENPES

Chapter-3. Reference International Technical Standards

The reference international standards for designing environmental facility are organized in Table-32.

Table- 32: Reference International Technical Standards

Number	Rev.	Title	Content
ISO 14001	2004	Environmental management systems -- Requirements with guidance for use	ISO 14001:2004 specifies requirements for an environmental management system to enable an organization to develop and implement a policy and objectives which take into account legal requirements and other requirements to which the organization subscribes, and information about significant environmental aspects. It applies to those environmental aspects that the organization identifies as those which it can control and those which it can influence. It does not itself state specific environmental performance criteria.
ISO 14004	2004	Environmental management systems -- General guidelines on principles, systems and support techniques	ISO 14004:2004 provides guidance on the establishment, implementation, maintenance and improvement of an environmental management system and its coordination with other management systems. The guidelines in ISO 14004:2004 are applicable to any organization, regardless of its size, type, location or level of maturity. While the guidelines in ISO 14004:2004 are consistent with the ISO 14001:2004 environmental management system model, they are not intended to provide interpretations of the requirements of ISO 14001:2004.
ISO 14005	2010	Environmental management systems -- Guidelines for the phased implementation of an environmental management system, including the use of environmental performance evaluation	ISO 14005:2010 provides guidance for all organizations, but particularly small- and medium-sized enterprises, on the phased development, implementation, maintenance and improvement of an environmental management system. It also includes advice on the integration and use of environmental performance evaluation techniques.
ISO 14006	2011	Environmental management systems -- Guidelines for incorporating ecodesign	ISO 14006:2011 provides guidelines to assist organizations in establishing, documenting, implementing, maintaining and continually improving their management of condensing as part of an environmental management system (EMS). ISO 14006:2011 is intended to be used by those organizations that have implemented an EMS in accordance with ISO 14001, but can help in integrating condensing in other management systems. The guidelines are applicable to any organization regardless of its size or activity. ISO 14006:2011 applies to those product-related environmental aspects that the organization can control and those it can influence.

Number	Rev.	Title	Content
ISO 14015	2001	Environmental management -- Environmental assessment of sites and organizations (EASO)	—
ISO 14020	2000	Environmental labels and declarations -- General principles	This International Standard establishes guiding principles for the development and use of environmental labels and declarations. It is intended that other applicable standards in the ISO 14020 series be used in conjunction with this International Standard.
ISO 14040	2006	Environmental management -- Life cycle assessment -- Principles and framework	ISO 14040:2006 describes the principles and framework for life cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements
ISO 14050	2009	Environmental management -- Vocabulary	ISO 14050:2009 defines terms of fundamental concepts related to environmental management, published in the ISO 14000 series of International Standards.
ISO/TR 14062	2002	Environmental management -- Integrating environmental aspects into product design and development	ISO/TR 14062:2002 describes concepts and current practices relating to the integration of environmental aspects into product design and development. ISO/TR 14062:2002 is applicable to the development of sector-specific documents.
ISO 140063	2006	Environmental management -- Environmental communication -- Guidelines and examples	ISO 14063:2006 gives guidance to an organization on general principles, policy, strategy and activities relating to both internal and external environmental communication. It utilizes proven and well-established approaches for communication, adapted to the specific conditions that exist in environmental communication. It is applicable to all organizations regardless of their size, type, location, structure, activities, products and services, and whether or not they have an environmental management system in place
ISO 14064-1	2006	Greenhouse gases -- Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals	ISO 14064-1:2006 specifies principles and requirements at the organization level for quantification and reporting of greenhouse gas (GHG) emissions and removals. It includes requirements for the design, development, management, reporting and verification of an organization's GHG inventory.
ISO 14064-2	2006	Greenhouse gases -- Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements	ISO 14064-2:2006 specifies principles and requirements and provides guidance at the project level for quantification, monitoring and reporting of activities intended to cause greenhouse gas (GHG) emission reductions or removal enhancements. It includes requirements for planning a GHG project,

Number	Rev.	Title	Content
			identifying and selecting GHG sources, sinks and reservoirs relevant to the project and baseline scenario, monitoring, quantifying, documenting and reporting GHG project performance and managing data quality.
ISO 14064-3	2006	Greenhouse gases -- Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions	ISO 14064-3:2006 specifies principles and requirements and provides guidance for those conducting or managing the validation and/or verification of greenhouse gas (GHG) assertions. It can be applied to organizational or GHG project quantification, including GHG quantification, monitoring and reporting carried out in accordance with ISO 14064-1 or ISO 14064-2. ISO 14064-3:2006 specifies requirements for selecting GHG validators/verifiers, establishing the level of assurance, objectives, criteria and scope, determining the validation/verification approach, assessing GHG data, information, information systems and controls, evaluating GHG assertions and preparing validation/verification statements.
ISO 14065	2007	Greenhouse gases -- Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition	ISO 14065:2007 specifies principles and requirements for bodies that undertake validation or verification of greenhouse gas (GHG) assertions. It is GHG programme neutral. If a GHG programme is applicable, the requirements of that GHG programme are additional to the requirements of ISO 14065:2007.
ISO 14066	2011	Greenhouse gases -- Competence requirements for greenhouse gas validation teams and verification teams	ISO 14066:2011 specifies competence requirements for validation teams and verification teams. ISO 14066:2011 complements the implementation of ISO 14065. ISO 14066:2011 is not linked to any particular greenhouse gas (GHG) programme. If a particular GHG programme is applicable, competence requirements of that GHG programme are additional to the requirements of ISO 14066:2011.
ISO Guide 64	2008	Guide for addressing environmental issues in product standards	ISO Guide 64:2008 provides guidance on addressing environmental issues in product standards. It is primarily intended for product standards writers. Its purpose is ▪ to outline the relationship between the provisions in product standards and the environmental aspects and impacts of the product, ▪ to assist in drafting or revising provisions in product standards in order to reduce potential adverse environmental impacts at different stages of the entire product life-cycle, ▪ to emphasize that taking into account environmental issues in product standards is a complex process and requires balancing competing priorities, ▪ to recommend the use of life-cycle thinking when defining environmental provisions for a product for which a standard is being drafted, and

Number	Rev.	Title	Content
			▪ to promote the future development of relevant sector guides for addressing environmental issues in product standards by standards writers, consistent with the principles and approaches of ISO Guide 64:2008. Whenever a new product standard is drafted or an existing product standard is revised or intended to be revised, the project managers and their technical committee chairman/convenors are encouraged to actively promote the application of this Guide. Furthermore, at any stage in the standard development process, experts are encouraged to include environmental issues in their comments. In order to take account of the diversity of products and their specific environmental impacts, as well as the need for relevant environmental knowledge, it is useful for standards writers to involve environmental experts in the work. The project managers and their technical committee chairman/convenors might wish to take into account other relevant, current sector-specific guidance and environmental provisions identified in related standards.
ISO 19011	2011	Guidelines for auditing management systems	ISO 19011:2011 provides guidance on auditing management systems, including the principles of auditing, managing an audit programme and conducting management system audits, as well as guidance on the evaluation of competence of individuals involved in the audit process, including the person managing the audit programme, auditors and audit teams. ISO 19011:2011 is applicable to all organizations that need to conduct internal or external audits of management systems or manage an audit programme. The application of ISO 19011:2011 to other types of audits is possible, provided that special consideration is given to the specific competence needed.

Chapter-4. Reference Japanese Technical Standards

The reference Japanese industrial standards for designing environmental facility are organized in Table-33.

Table- 33: Reference Japanese Technical Standards

Number	Rev.	Title	Content
JIS K0216	2008	Technical terms for analytical chemistry (Environmental part)	This stipulates definitions of key terms and related terms about hazardous substances of water, air or soil, environmental health and safety management.
JIS B8530	1979	Glossary of Terms for Pollution Control Equipment	This stipulates terms of the pollution control equipments.
JIS B9909	1994	Expression of the specification for dust collectors	This stipulates how to represent the specifications for the dust collector which is used to separate particles in the gas collection process.
JIS B9910	1994	Methods of measuring performance for dust collectors	This stipulates how to measure the performance when using a dust collector which is used to separate particles in the gas collection process.
JIS K0094	2011	Sampling method for industrial water and industrial wastewater	This stipulates sampling and involved work when collecting industrial water and industrial effluent.
JIS K0410-3-1	2000	Water quality—Sampling — Part1: Guidance on the design of sampling programs	This shows general guideline for the purpose of the water quality management including sediment and sludge, sampling plan and identifying pollution sources and water testing.
JIS K0410-3-10		Water quality—Sampling — Part10: Guidance on the sampling of waste waters	This shows the details of domestic wastewater and industrial wastewater sampling, sampling plan, and sampling technique. The target is all types of wastewater, industrial wastewater, raw and treated living wastewater.
JIS B9945	1987	Testing Methods of Filtration Equipments for Dewatering	This stipulates test items and test methods needed to understand the performance during the use of pressure dehydrator, diaphragm pressure dehydrator and vacuum dehydrator.
JIS R3421	2006	Textile finished glass fabrics for bag filter	This stipulates glass cloth treated suitably for use for a dry dust collector.
JIS Z8908	1998	Filter fabrics for dust collection	This stipulates how to represent appearance and quality of nonwoven and woven fabrics for dry type dust collecting filter.
JIS Z8909-1	2005	Test method of filter media for dust collection Part1: Filter efficiency	This stipulates performance test methods for dust collection of nonwoven and woven fabrics for dry type dust collecting filter.
JIS Z8909-2	2008	Test method of filter media for dust collection—Part2: Test on durability under simulated running conditions	This stipulates test method to evaluate the durability of nonwoven and woven fabrics for dry type dust collecting filter.

Number	Rev.	Title	Content
JIS Z8909-3	2008	Test method of filter media for dust collection—Part2: Test for durability under high temperature	This stipulates test method to evaluate the mechanical properties before and after thermal exposure of nonwoven and woven fabrics for dry type dust collecting filter.
JIS Z8910	2007	Test method of filter media for dust collection—Sampling and test method for fabric filter durability	This stipulates method how to sample and test from the baghouse filter cloth in order to measure durability of the dry filter.
JIS B8392-6	2006	Compressed Air—Part6: Test methods for gaseous contaminant content	This stipulates selection of the test methods in the available methods for measuring gaseous pollutants in the compressed air.
JIS K0099	2004	Methods for determination of ammonia in flue gas	This stipulates how to analyze ammonia in the exhaust gas.
JIS K0102	2008	Testing methods for industrial wastewater	This stipulates testing methods of discharged wastewater from factories.
JIS K0103	2011	Methods for determination of sulfur oxides in flue gas	This stipulates how to analyze sulfur oxides in the exhaust gas.
JIS K0106	2010	Methods for determination of chlorine in flue gas	This stipulates how to analyze chlorine in the exhaust gas.
JIS K0107	2002	Methods for determination of hydrogen in flue gas	This stipulates how to analyze 排 hydrogen chloride in the exhaust gas.
JIS K0109	1998	Methods for determination of hydrogen cyanide in flue gas	This stipulates how to analyze hydrogen cyanide in the exhaust gas.
JIS K0121	2006	General rules for atomic absorption spectrometry	This stipulates general rules for performing quantative analysis using atomic absorption spectrometer.
JIS K0151	1983	Non-dispersive Infrared Gas Analyzer	This stipulates how to detect the concentration by deviation method, by non-dispersive wave or positive filter type analyzer.
JIS K0301	1998	Methods for determination of oxygen in flue gas	This stipulates how to analyze oxygen in the exhaust gas.
JIS K0304	1996	Methods for determination of carbon dioxide in air	This stipulates how to analyze how to measure carbon dioxide in the atmosphere accurately.
JIS Z8808	1995	Method of measuring dust concentration in flue gas	This stipulates how to measure dusts concentration in the exhaust gas in the flue gas duct, chimney and duct.
JEAG 3603	2007	Guidelines for flue gas treatment facility	This stipulates the necessary matters which must be observed by people involving in the construction and operation and maintenance of flue gas treatment facility such as safety, design, installation, inspection, operation.
JEAG 5001	2005	Guidelines for preventing noise and vibration in power plants	This describes various measures such as measuring method special consideration of measurement noise and vibration of electrical equipment in hydro power plant, substation and switching yard and design for reduction facility, in order to proceed even as much as possible to reduce and prevent noise and vibration in designated area by Noise Control Act, Vibration Regulation Act and rural regulations in Japan.

Chapter-5. Reference TCVN

The reference Vietnamese national standards for designing environmental facility are organized in Table-34.

Table- 34: Reference TCVN

Number	Rev.	Title	Content
TCVN 3985	1999	Acoustics. Allowable noise levels at workplace	Tiêu chuẩn này quy định mức ồn cho phép tại các vị trí làm việc chịu ảnh hưởng của tiếng ồn trong các cơ sở sản xuất và cơ quan
TCVN 4923	1989	Protection against noise. Means and method. Classification	Qui định việc phân loại các phương tiện và phương pháp chống ồn, được sử dụng tại chổ làm việc của các cơ sở sản xuất các nhà máy, vùng dân cư và các công trình công cộng
TCVN 5067	1995	Air quality. Weight method for determination of suspended dusts content	Qui định phương pháp xác định hàm lượng từng lần (30 phút) và trung bình ngày đêm (24 h) của bụi không khí bên ngoài phạm vi các xí nghiệp, công nghiệp với kích thước hạt từ 1 đến 100 Mm
TCVN 5126	1990	Vibration. Permisible values at workplaces	Ap dụng cho rung tác động lên cơ thể con người tại chỗ làm việc trong dải tần số từ 0,7 đến 90 Hz và quy định giá trị rung cho phép
TCVN 5136	1990	Noise. Methods of measurement. General requirements	Quy định các phương pháp đo đặc tính ồn của máy
TCVN 5942	1995	Water quality. Surface water quality standard	Qui định giới hạn các thông số và nồng độ cho phép của các chất ô nhiễm trong nước mặt. Nước bề mặt trong tiêu chuẩn này là nước thiên nhiên trong sông, hồ, ao, suối, kênh, nước giếng lộ thiên hoặc nước trong các hồ chứa nước tự nhiên hoặc nhân tạo
TCVN 5943	1995	Water quality. Coastal water quality standard	Qui định giới hạn các thông số và nồng độ cho phép của các chất ô nhiễm trong nước ven hồ. áp dụng để đánh giá chất lượng của vùng nước hồ để giám sát tình hình thải của các khu dân cư, của các hoạt động sản xuất kinh doanh, dịch vụ
TCVN 5944	1995	Water quality. Sampling. Guidance on sampling from natural lakes and man-made lakes	Trình bày những nguyên tắc chi tiết áp dụng để vạch kế hoạch lấy mẫu, cho các kỹ thuật lấy mẫu và bảo quản mẫu nước lấy từ hồ ao tự nhiên và nhân tạo
TCVN 5945	2010	Industrial waste water. Discharge standards	Tiêu chuẩn này quy định giá trị giới hạn các thông số và nồng độ các chất ô nhiễm trong nước thải của các cơ sở sản xuất, chế biến, kinh doanh dịch vụ...
TCVN 5949	1995	Acoustics. Noise in public and residental areas. Maximum permitted noise level	Qui định mức ồn tối đa cho phép tại các khu công cộng và dân cư. áp dụng để kiểm soát mọi hoạt động có thể gây ra tiếng ồn trong khu công cộng và dân cư. Không áp dụng cho mức ồn bên trong các cơ sở sản xuất công nghiệp và phương tiện giao thông đường bộ

Number	Rev.	Title	Content
TCVN 5971	1995	Ambient air. Determination of the mass concentration of sulfur dioxide. Tetrachloromercurate (TCM)/pararosaniline method	Qui định phương pháp đo phổ quang kế để xác định nồng độ khối lượng của lưu huỳnh dioxit trong không khí xung quanh từ 20 microgam/m3 đến khoảng 500 microgam/m3
TCVN 5972	1995	Ambient air. Determination of the mass concentration of carbon monoxide. Gas chromatographic method	Qui định phương pháp sắc ký khí để xác định nồng độ khối lượng của cacbon monoxit trong không khí xung quanh từ các nguồn khác nhau
TCVN 5976	1995	Stationary source emission. Determination of the mass concentration of sulfur dioxide. Performance characteristics of automated measuring methods	Qui định dầy đủ một loạt những giá trị của đặc tính của các hệ thống đo tự động để đo liên tục nồng độ khối lượng của SO2 trong khí thải nguồn tĩnh
TCVN 5977	2009	Stationary source emissions. Manual determination of mass concentration of particulate matter	Tiêu chuẩn này mô tả một phương pháp chuẩn để đo nồng độ bụi trong khí thải ở khoảng nồng độ từ 20mg/m3 đến 1000mg/m3 ở điều kiện tiêu chuẩn
TCVN 5978	1995	Air quality. Determination of mass concentration of sulphur dioxide in ambient air. Thorin spectrophotometric method	Mô tả phương pháp trắc quang dùng thorin để xác định nồng độ khối lượng của lưu huỳnh dioxit trong không khí xung quanh
TCVN 6138	1996	Ambient air. Determination of the mass concentration of nitrogen oxides. Chemiluminescence method	Qui định phương pháp phát quang hoá học để xác định nồng độ khối lượng của nitơ oxit trong không khí xung quanh cho tới xấp xỉ 12,5 mg/m3 và của nitơ dioxit cho tới xấp xỉ 19 mg/m3 ở nhiệt độ 25oC và áp suất 101,3kPa
TCVN 6152	1996	Ambient air. Determination of the particulate lead content of aerosols collected on filters. Atomic absorption spectrometric method	Qui định phương pháp phân tích hoá học các mẫu chì từ không khí xung quanh đã tích góp trên cái lọc trên cơ sở phân huỷ bằng axit và đo quang phổ thụ nguyên tử
TCVN 6157	1996	Ambient air. Determination of the mass concentration of ozone. Chemiluminescence method	Qui định phương pháp phát quang hoá học để xác định nồng độ khối lượng ozon trong không khí xung quanh
TCVN 6627-9	2000	Rotating electrical machines. Part 9: Noise limits	Tiêu chuẩn này quy định mức công suất âm thanh trọng số A lớn nhất cho phép đối với máy điện quay phù hợp TCVN 6627-1:2000 (IEC 34-1), có phương pháp làm mát theo IEC 34-6 và cấp bảo vệ theo IEC 34-5 và có các đặc tính như sau: thiết kế tiêu chuẩn, điện một chiều hoặc điện xoay chiều, không có những thay đổi đặc biệt về điện, cơ và âm để làm giảm mức ồn; công suất đầu ra danh định từ 1kW (hoặc kVA) đến 5 500 kW (hoặc kVA); tốc độ không vượt quá 3 750 vòng/min
TCVN 6696	2009	Solid wastes. Sanitary landfill. General requirements to the environmental protection	Tiêu chuẩn này quy định các yêu cầu kỹ thuật chung về bảo vệ môi trường đối với địa điểm, quá trình thiết kế, xây dựng, vận hành khai thác và giám sát các tác động đến môi trường sau khí đóng bãi đối với các bãi chôn lấp hợp vệ sinh dùng để chôn lấp chất thải rắn thông thường.
TCVN 6705	2009	Normal solid wastes. Classification	Tiêu chuẩn này áp dụng cho các chất thải rắn thông thường để phân biệt các nhóm loại chất thải rắn, phục vụ cho việc quản lý chất thải một cách an toàn đối với con người, đảm bảo vệ sinh môi trường và đúng với các quy định về quản lý chất thải rắn.

Number	Rev.	Title	Content
TCVN 6706	2009	Hazardous wastes. Classification	Tiêu chuẩn này áp dụng để phân biệt các chất thải nguy hại theo đặc tính của chúng, phục vụ cho việc quản lý chất thải nguy hại một cách an toàn, hiệu quả và theo đúng với các quy định về quản lý chất thải nguy hại. Tiêu chuẩn này không áp dụng cho chất thải phóng xạ.
TCVN 6750	2000	Stationary source emissions. Determination of mass concentration of sulfur dioxide. Ion chromatography method	Tiêu chuẩn này quy định phương pháp xác định nồng độ khối lượng của lưu huỳnh đioxit phát ra từ các thiết bị đốt và các quá trình kỹ thuật và định rõ đặc tính quan trọng nhất của phương pháp
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)	Tiêu chuẩn này quan tâm đếm tiếp xúc toàn thân của con người với rung động và chấn động theo khía cạnh về độ tiện nghi và sự khó chịu của người cư trú.
TCVN 7171	2002	Air quality. Determination of ozone in ambient air. Ultraviolet photometric method	Tiêu chuẩn này quy định phương pháp trắc quang dùng tia cực tím (UV) để xác định ôzôn trong không khí xung quanh. Phương pháp này dùng để xác định nồng độ ôzôn trong khoảng từ 2 Mg/m3 đến 2 mg/m3. Tiêu chuẩn này dùng điều kiện quy chiếu 25oC và 101,25kPa; Tuy vậy, nhiệt độ quy chiếu 0oC và 20oC cũng được chấp nhận. Để hiệu chuẩn, tiêu chuẩn này quy định phương pháp trắc quang cực tím làm phương pháp chuẩn đầu vì tính chất đặc trưng và độ đúng cho ôzôn. Phương pháp chuẩn thứ, gồm cả các phương pháp không UV, được phép dùng khi đã được hiệu chuẩn theo phương pháp chuẩn đầu UV
TCVN 7172	2002	Stationary source emissions. Determination of the mass concentration of nitrogen oxides. Naphthylethylenediamine photometric method	Tiêu chuẩn này quy định phương pháp trắc quang dùng để xác định nồng độ khối lượng của nitơ oxyt trong khí xả từ ống dẫn hoặc ống khói. Phương pháp này được dùng để xác định nồng độ khối lượng của nitơ oxyt trong khí xả của qúa trình đốt, quá trình xử lý bề mặt kim loại và từ các phản ứng của hoá chất hữu cơ, sau khi rửa đuổi, loại nitơ bằng khử và/hoặc loại nitơ xúc tác, trước khi thải vào khí quyể. Tiêu chuẩn này áp dụng cho dải nồng độ từ 5 mg/m3 đến 1000 mg/m3 tính theo NO2 với thể tích mẫu 1000 ml
TCVN 7725	2007	Ambient air. Determination of carbon monoxide. Non-dispersive infrared spectrometric method	Tiêu chuẩn này quy định phương pháp đo phổ hồng ngoại không phân tán để phân tích liên tục và ghi lại nồng độ cacbon monoxit trong không khí xung quanh.
TCVN 7726	2007	Ambient air. Determination of sulfur dioxide. Ultraviolet fluorescence method	Tiêu chuẩn này mô tả phương pháp huỳnh quang cực tím sử dụng hệ thống phân tích tự động để lấy mẫu và xác định nồng độ sunfua dioxit trong không khí xung quanh.
TCVN7878-1	2008	Acoustics. Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedures	Tiêu chuẩn này xác định các đại lượng cơ bản để sử dụng cho mô tả tiếng ồn trong môi trường dân cư và mô tả các phương pháp đánh giá chính.

Number	Rev.	Title	Content
TCVN 7878-2	2010	Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of environmental noise levels	Tiêu chuẩn này mô tả cách xác định mức áp suất âm bằng phép đo trực tiếp, bằng phép ngoại suy các kết quả đo từ các phép tính trung bình, hoặc bằng cách loại trừ để làm cơ sở cho việc đánh giá tiếng ồn môi trường.
TCVN 8018	2008	Acoustics. Noise control design procedures for open plant	Tiêu chuẩn này quy định quy trình để kiểm soát tiếng ồn của những nhà máy mà phần hở là chủ yếu.
QCVN 05: 2009/BTNMT	2009	National technical regulation on ambient air quality	Quy chuẩn này quy định giá trị giới hạn các thông số cơ bản, gồm lưu huỳnh đioxit (SO_2), cacbon (CO), nitơ oxit (NO_x), ôzôn (O_3), bụi lơ lửng, bụi PM10 (bụi ≤ 10μm) và chì (Pb) trong không khí xung quanh.

Chapter-6. Referenced Literature and Materials

The referenced books, literatures, standards to establishing this guide line are organized as follows.

1. Interpretation of technical regulation for thermal power facility(10/Jul/1007): NISA (Nuclear and Industrial Safety Agency) of METI (Ministry of Economy, Trade and Industry)
2. Consideration of the institutionalization of bilateral credits by installing ultra supercritical coal-fired power plant in Vietnam (Mar/2011): METI Japan
3. Decree No.80/2006/ND-CP: Detailing and Guiding the Implementation of a Number of Articles of the Law on Environmental Protection
4. Treatment of flue gas and ash from thermal power plant (Journal No. 363: Dec/1986): TENPES (Thermal and Nuclear Engineering Society of Japan)
5. Environmental measure (Journal No. 473: Feb./1996): TENPES (Thermal and Nuclear Engineering Society of Japan)
6. Flue gas treatment system (Journal No. 549: Jun/2002): TENPES (Thermal and Nuclear Engineering Society of Japan)
7. Dust collection facility (Journal No. 550: Jul/2002): TENPES (Thermal and Nuclear Engineering Society of Japan)
8. Other environmental measure (Journal No.557: Feb/2003): TENPES (Thermal and Nuclear Engineering Society of Japan)
9. Outdoor facility—Environmental facility (Journal No.568: Jan/2004): TENPES (Thermal and Nuclear Engineering Society of Japan)
10. Introduction of IHI flue gas desulfurization plant in Taiwan (Journal No.570: Y.Ishimaru: Mar/2004): TENPES (Thermal and Nuclear Engineering Society of Japan)
11. Dry activated coke desulfurization system of Isogo thermal power station new unit No.1 (Journal No.579: M.Enami: Dec/2004): TENPES (Thermal and Nuclear Engineering Society of Japan)
12. Management of wastewater, effluent and waste oil in the power plant Journal (No.609: Jun/2007): TENPES (Thermal and Nuclear Engineering Society of Japan)
13. Environmental facility (Journal No. 649: Oct/2010): TENPES (Thermal and Nuclear Engineering Society of Japan)